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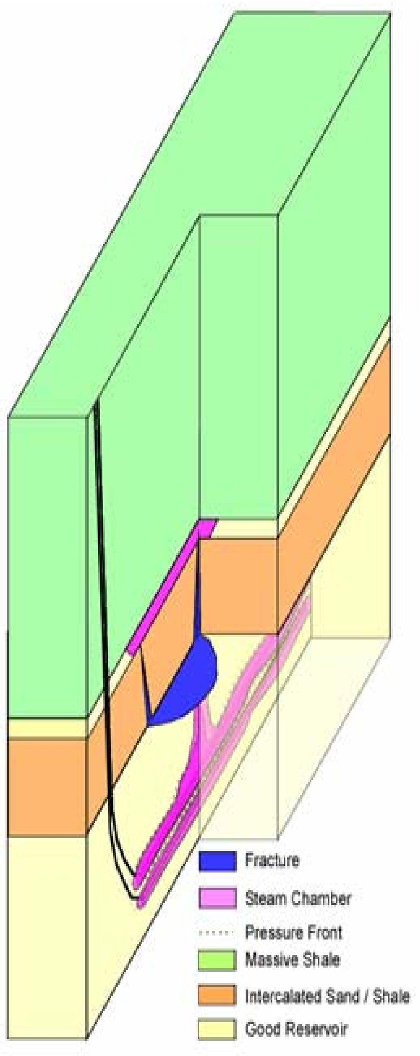

Summary of investigations into the Joslyn May 18th 2006 Steam Release

TEPC/GSR/2007.006 December 2007

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ABSTRACT – About 10 lines explicit, **Objectives**– **Strong points** – **Recommendation(s) and/or conclusion(s)**

Considering that:

- The down-hole pressure at the time of the steam release was much lower than the confining stress at the depth of the 204-I1P1 well pair. Such observation indicates that the steam release was not caused by the opening of a fracture originating from the well depth immediately before the steam release.
- The seismic survey shot in December 2006 – January 2007 over the steam release area allowed a volume of formation affected by the steam release to be mapped. The affected volume is fully disconnected from nearby delineation, monitoring or development wells below the Top McMurray interval. Such observation supports the hypothesis that the steam release is not related to channeling around wells.
- Steam vents are observed at surface more than 30 m away from any surface well locations. Such observation supports the hypothesis that the steam release is not related to channeling around wells.
- Available data does not allow clear conclusions relative to nearby wells' cement bond quality to be drawn.
- No evidence was found, after an extensive investigation of geological and seismic data, of pre-existing seal weakness at the particular location of the Joslyn May 18th 2006 steam release.
- The reservoir analysis of the SAGD behavior of well pair 204-I1P1 suggests that some fracture(s) developed at least 4 weeks before the steam release during a phase of high steam injection/circulation pressure. A water volume of around 1000 to 2600 m3 was stored in this fracture(s) and reservoir connected by this fracture(s) until the final catastrophic failure of the last seal.
- The mechanical constraints prevailing in the Joslyn reservoir are such that tensile fractures should develop primarily in the horizontal direction. Vertical tensile fractures would have directly caused a release with no storage period. The most likely failure mechanism of shale barriers in the present context involves successive shear failures at the edge of horizontally pressurized areas.

The following conclusions can be drawn related to the steam release:

- The technical root cause of the May 18th 2007 surface steam release was the application of an excessive injection pressure during circulation and later phases of SAGD well pair 204-I1P1 startup.
- There has been more than a month between the inadequate actions (excessive pressure) and the observation of negative consequences of these actions. It has not been not been possible to precisely quantify whether the pressure used in the circulation (1800 kPag) was admissible for any duration or not.
- The most likely scenario for the steam release involves:
  - A fast, gravity-driven, local development of a steam chamber to the top of the reservoir, probably involving sand dilation,
  - A lateral extension of the pressured area below the top of the reservoir,
  - A shear failure or series of successive shear failures on the edge of this pressurized area that allowed the steam to breach within the Wabiskaw reservoir,
  - A significant water / steam storage in the SAGD chamber and fracture system,
  - And a catastrophic shear failure of the ultimate, Clearwater seal leading to release of steam at surface on May 18th 2006.

In addition a review of operating practices and safety related data brought to light the following facts and led to the following conclusions:

  - On well pairs in operations and 202-I4P4, the actions being taken to mitigate the effects at surface of the steam release are the update of operating procedures implemented for Joslyn phases 1 & 2 SAGD operations and the development of additional monitoring. This has lowered the environmental and steam chamber confinement risks to a level warranting the continuation of SAGD operations at the present stage.
  - Further assessment of the efficiency of monitoring technologies (mainly surface heave and pressure monitoring) and an analysis of pressure management policies in term of risks vs. rate and recovery are necessary before firming up an optimum long term reservoir management policy on Joslyn. Current plans/expectations call for production at or under 1200 kPag for one to two years, then lowering the pressure to 1000 kPag for the rest of the well life. Geo-mechanical studies are on going to further firm up such plans that will be continuously updated based upon learnings drawn from pressure and other monitoring.

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Reference 3 Seismic Insights in the Joslyn May 18th Steam Release – November 2007 – Th. des Vallieres TEPC/GSR/2007.001.

Reference 4 Reservoir Insights in the Joslyn May 18th Steam Release – November 2007 – A. Delafargue TEPC/GSR/2007.004.

Reference 5 Geo-mechanical Insights in the Joslyn May 18th Steam Release – November 2007 – A. Onaisi TEPC/GSR/2007.003.

Reference 6 Cement Bond Evaluation Insights in the Joslyn May 18th Steam Release – November 2007 – G. Chalier TEPC/GSR/2007.007

Reference 7 Steam Release Incident LSD 09-33-095-12-W4M Volume I Executive Summary prepared by Millennium Solutions Ltd. September 2007 File #04-101

Reference 7 Resuming 204-I3P3 Operations – Information File P. Bergey & al. January 2008 TEPC/GSR/2008.002

Reference 8 TOTAL Joslyn Creek Minifrac Study 20060721 Petroleum Geomechanics Inc. Patrick M. Collins, P.Eng.

1 EXECUTIVE SUMMARY

1.1 Contents

The present report aims at:

1. Summarizing the analysis and conclusions of technical reports investigating the Joslyn May 18th 2006 steam release and 204-I3P3 well pair status from Geological, Reservoir, Seismic, Geo-mechanical, and Cement Bond Evaluation standpoints.
2. Based on these conclusions, determine the technical root cause of the Steam Release.
3. Presenting the most likely scenario for the Steam Release.
4. Presenting a status on issues related to Safe Steam Chamber Operations:
   a. Environmental impact of the steam release
   b. On-going monitoring actions related to Steam Chamber confinement.
   c. Revised operating procedures.
   d. Key learnings related to future SAGD operations on Joslyn.

This report discusses neither steam release root cause(s) from an organizational point of view nor the long term optimization of the pressure management policy.

1.2 Main Conclusions

Considering that:

- The down-hole pressure at the time of the steam release was much lower than the confining stress at the depth of the 204-I1P1 well pair. Such observation indicates that the steam release was not caused by the opening of a fracture originating from the well depth immediately before the steam release.
- The seismic survey shot in December 2006 – January 2007 over the steam release area allowed a volume of formation affected by the steam release to be mapped. The affected volume is fully disconnected from nearby delineation, monitoring or development wells below the Top McMurray interval. Such observation supports the hypothesis that the steam release is not related to channeling around wells.
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- The mechanical constraints prevailing in the Joslyn reservoir are such that tensile fractures should develop primarily in the horizontal direction. Vertical tensile fractures would have directly caused a release with no storage period. The most likely failure mechanism of shale barriers in the present context involves successive shear failures at the edge of horizontally pressurized areas.

The following conclusions can be drawn related to the steam release:

- The technical root cause of the May 18th 2007 surface steam release was the application of an excessive injection pressure during circulation and later phases of SAGD well pair 204-I1P1 startup.

- There has been more than a month between the inadequate actions (excessive pressure) and the observation of negative consequences of these actions. It has not been not been possible to precisely quantify whether the pressure used in the circulation (1800 kPag) was admissible for any duration or not.
- The most likely scenario for the steam release involves:
    - A fast, gravity-driven, local development of a steam chamber to the top of the reservoir, probably involving sand dilation,
    - A lateral extension of the pressured area below the top of the reservoir,
    - A shear failure or series of successive shear failures on the edge of this pressurized area that allowed the steam to breach within the Wabiskaw reservoir,
    - A significant water / steam storage in the SAGD chamber and fracture system,
    - And a catastrophic shear failure of the ultimate, Clearwater seal leading to release of steam at surface on May 18th 2006.

In addition a review of operating practices and safety related data lead us to formulate the following remarks:

- On well pairs in operations and 202-I4P4, the actions being taken to mitigate the effects at surface of the steam release are the update of operating procedures implemented for Joslyn phases 1 & 2 SAGD operations and the development of additional monitoring. This has lowered the environmental and steam chamber confinement risks to a level warranting the continuation of SAGD operations at the present stage.
- Further assessment of the efficiency of monitoring technologies (mainly surface heave and pressure monitoring) and an analysis of pressure management policies in term of risks vs. rate and recovery are necessary before firming up an optimum long term reservoir management policy on Joslyn. Current plans/expectations call for production at or under 1200 kPag for one to two further years, then lowering the pressure to 1000 kPag for the rest of the well life. Geo-mechanical studies are on going to further firm up such plans that will be continuously updated based upon learnings draw from pressure and other monitoring.
- Although proven by several successful pilot / small scale applications, SAGD is not yet fully mature. A significant amount work is still necessary to fine tune equipments and procedures required to operate safely SAGD projects for the long term in the fairly wide range of conditions foreseeable in Alberta (and beyond). Considering such large range of conditions, it is difficult to lay out precise and generic recommendations but it is clear that any project should address the following issues:

    i. Seal; characteristics including maximum admissible pressure.

    ii. Well design: casing, cement, and completion.

    iii. Operating pressure: philosophy including during startup, expected surface heave.

    iv. Overall steam confinement monitoring: philosophy (including link with surface layout design) and means.

    It is expected that these issues be challenging as a whole in some areas (Joslyn being one) while they may be less of a concern in others.

2 JOSLYN SAGD Phase 1 & 2 Project Description Summary

2.1 Location

The JOSLYN SAGD project is located on a group of leases operated by Total E&P Joslyn Ltd. covering 84.7 one-square-mile-sections, ie 217 km^2, 65km North West of Fort Mac Murray.

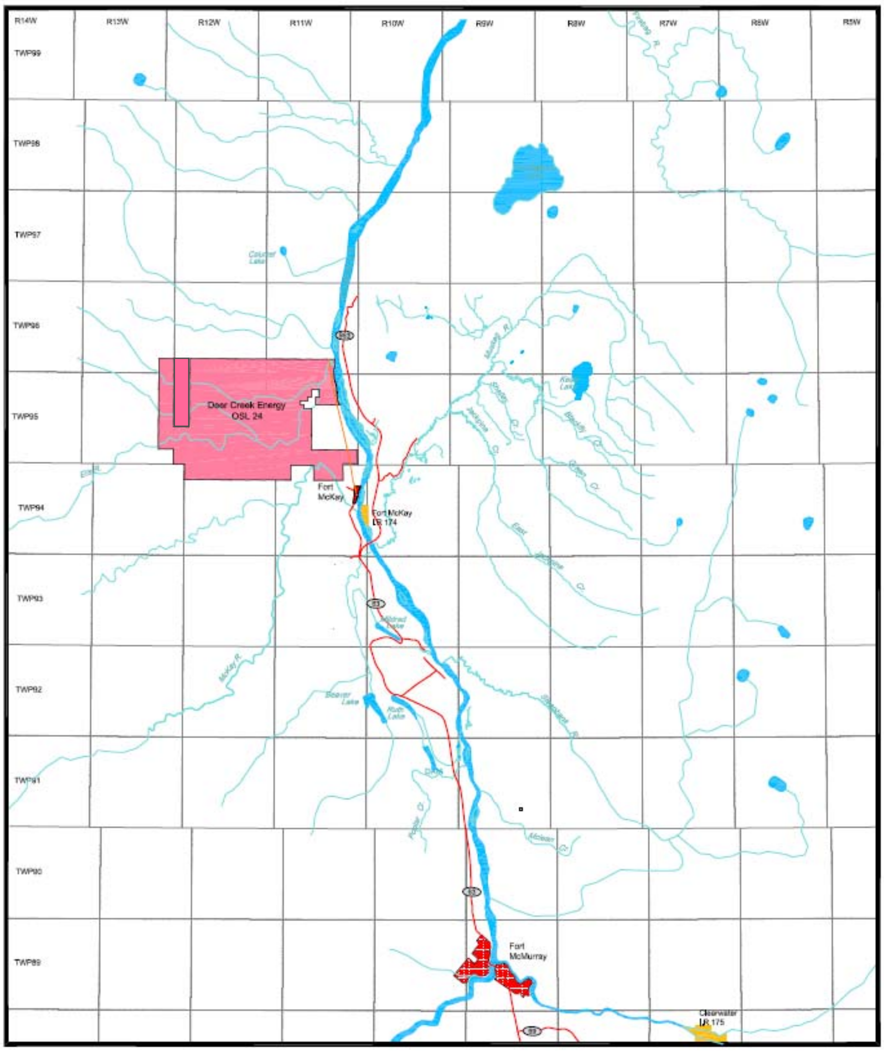


Figure 1 JOSLYN Group of Leases Location

2.2 Project description

The project started with a pilot SAGD well pair (Phase 1) in 2004. Designed for a bitumen production rate of 10,000 b/d from 17 SAGD wells pairs, the commercial Phase 2 started in December 2005. Figure 2 shows the lay out of the project, and the status of the wells at the time of the steam release (May 18th 2006). Of the 18 well pairs of the project, 12 are on SAGD production mode, 2 are on circulation and 4 are shut since the steam release incident.

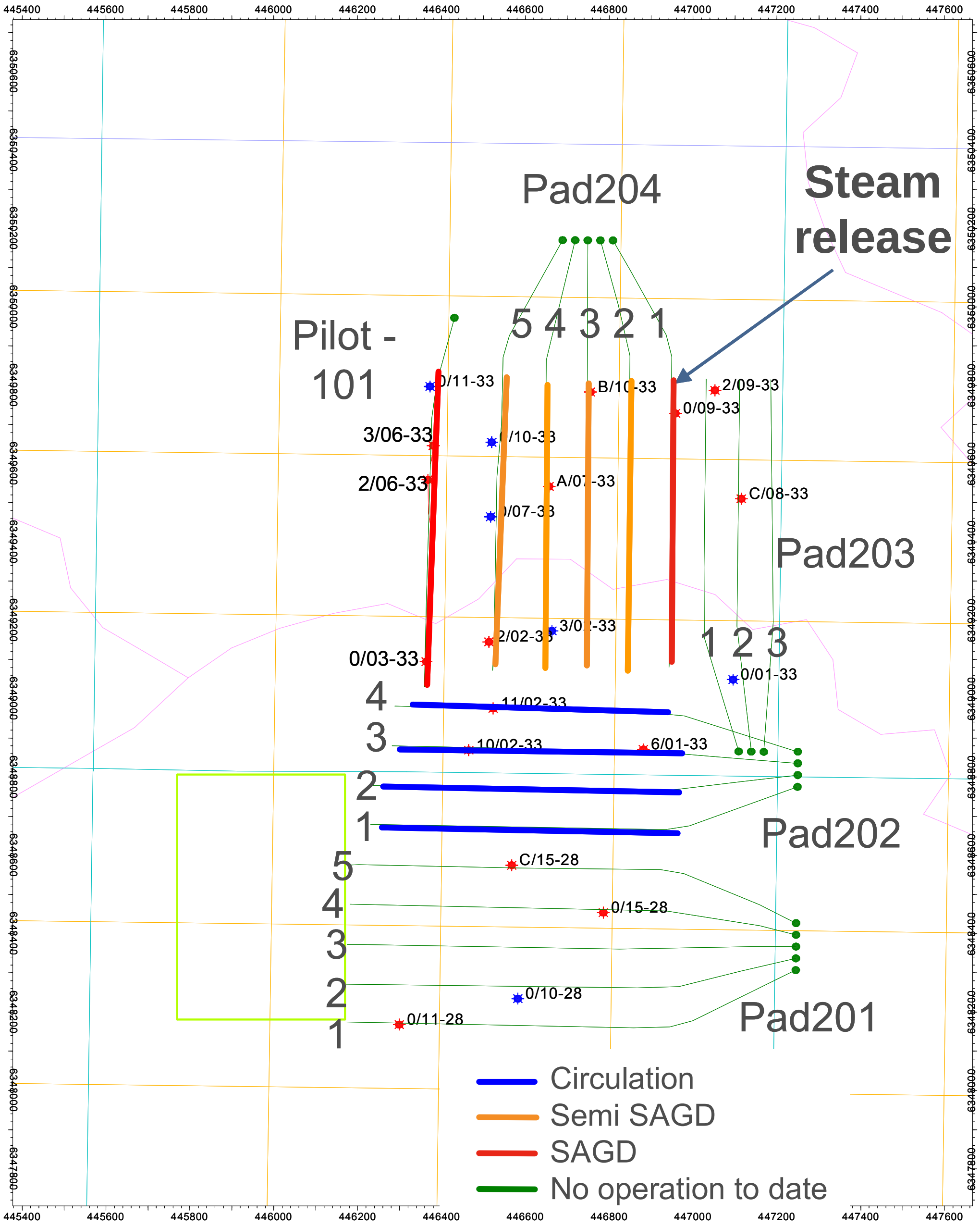


Figure 2 Well Location and Status Map (@ time of steam release)

Figure 3 presents a typical pad process layout while figure 4 present the typical SAGD completion setup used for this project

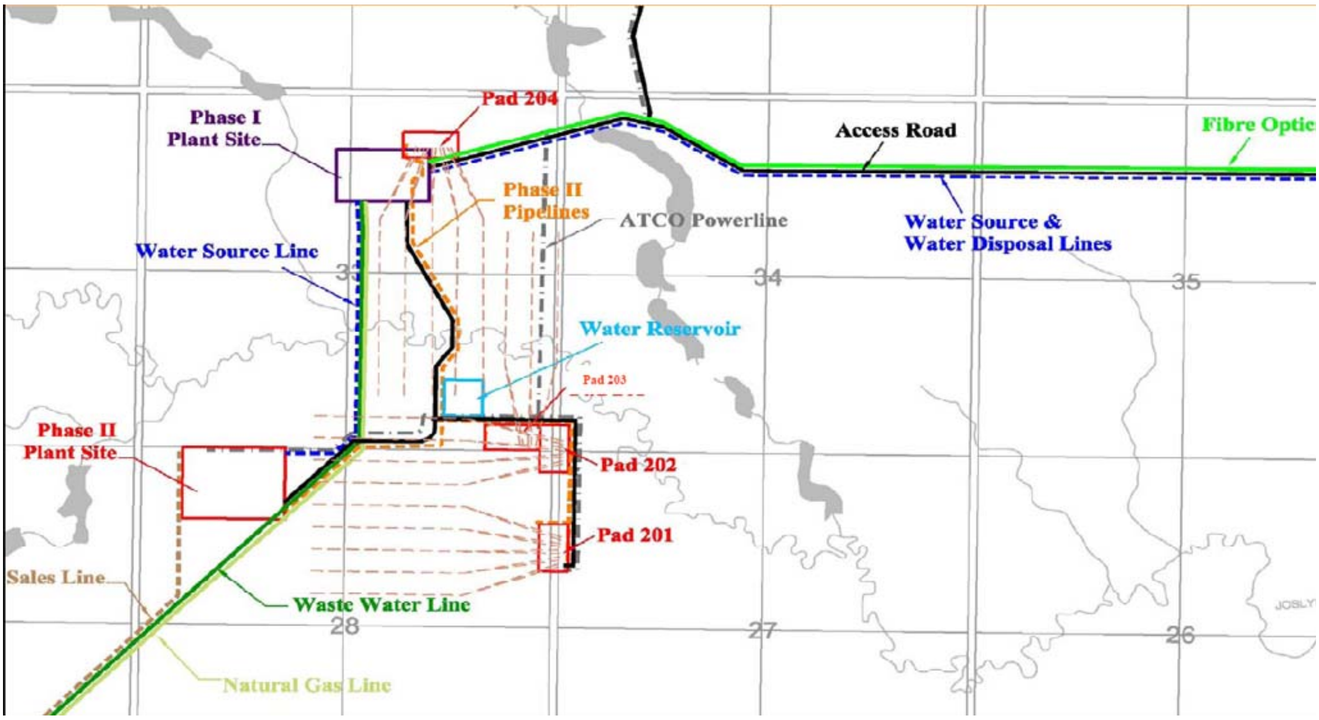


Figure 3JOSLYN SAGD - Road and facilities

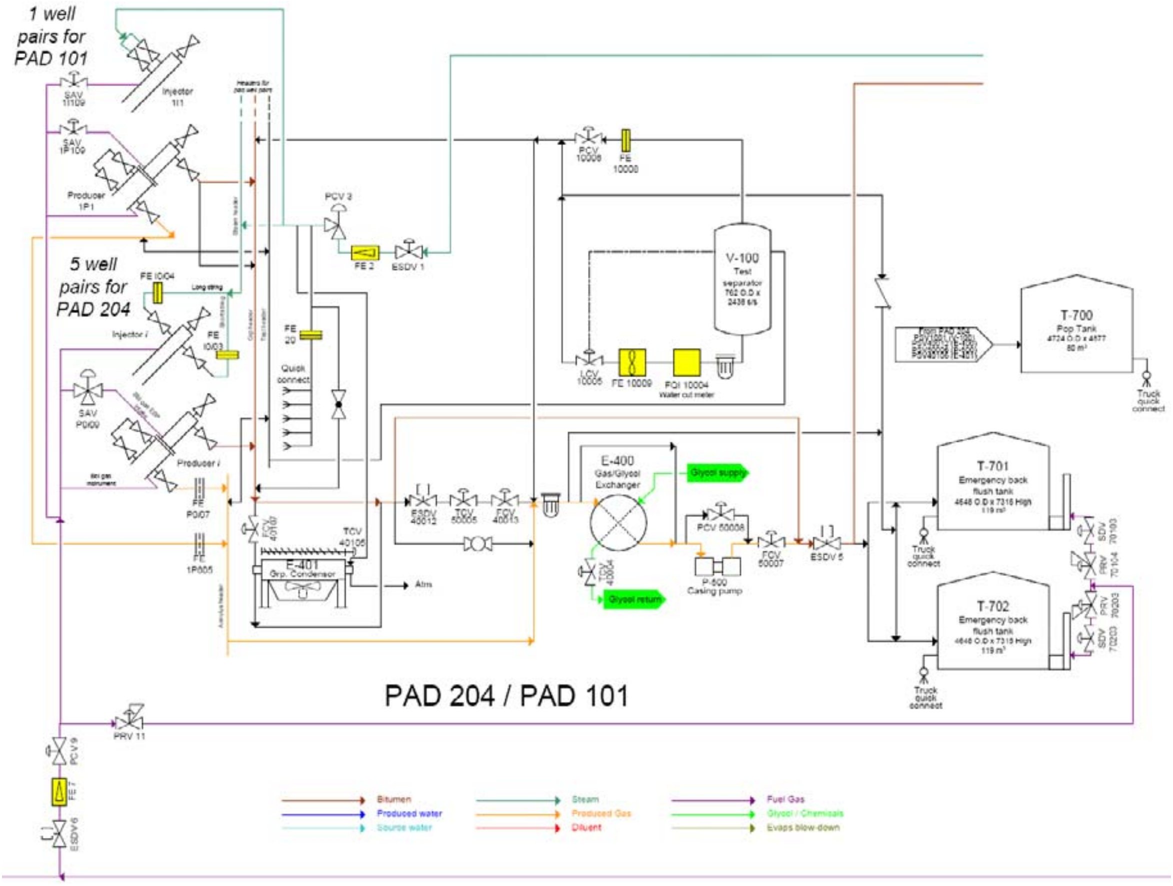


Figure 4: PAD 204 & 101 Process Flow Diagram (at the time of steam release and afterwards)

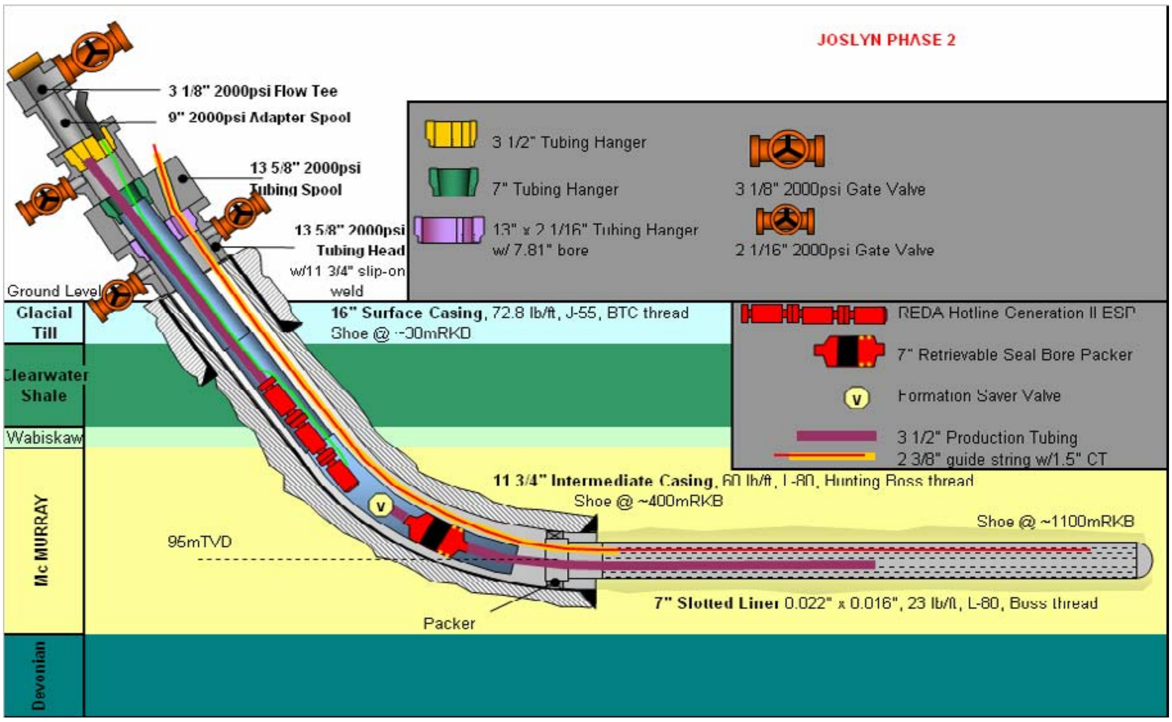
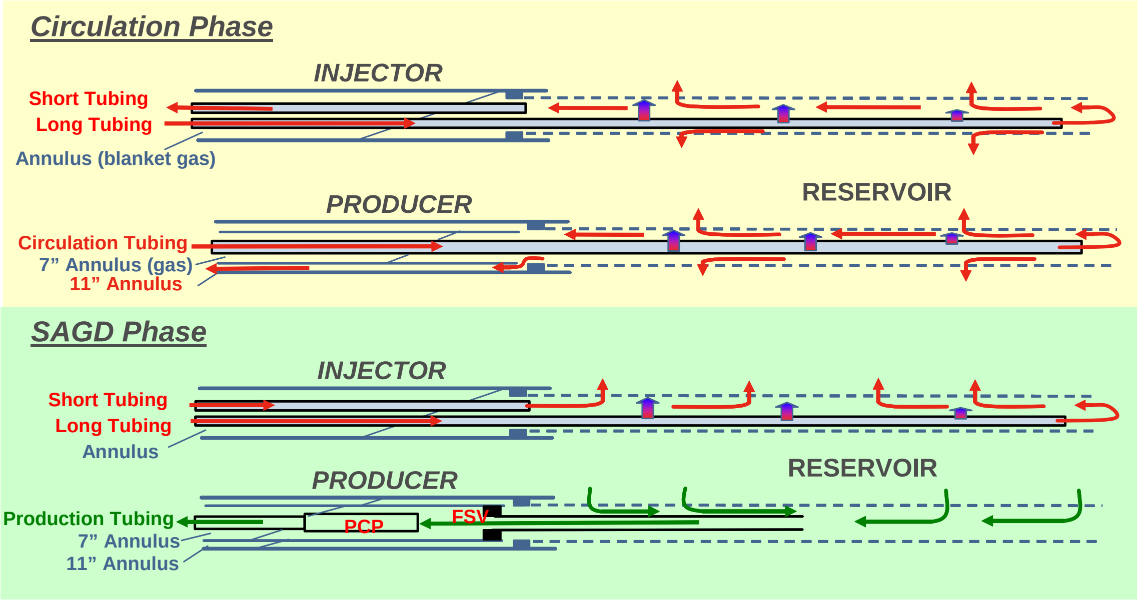


Figure 5 Phase 2 production well schematic



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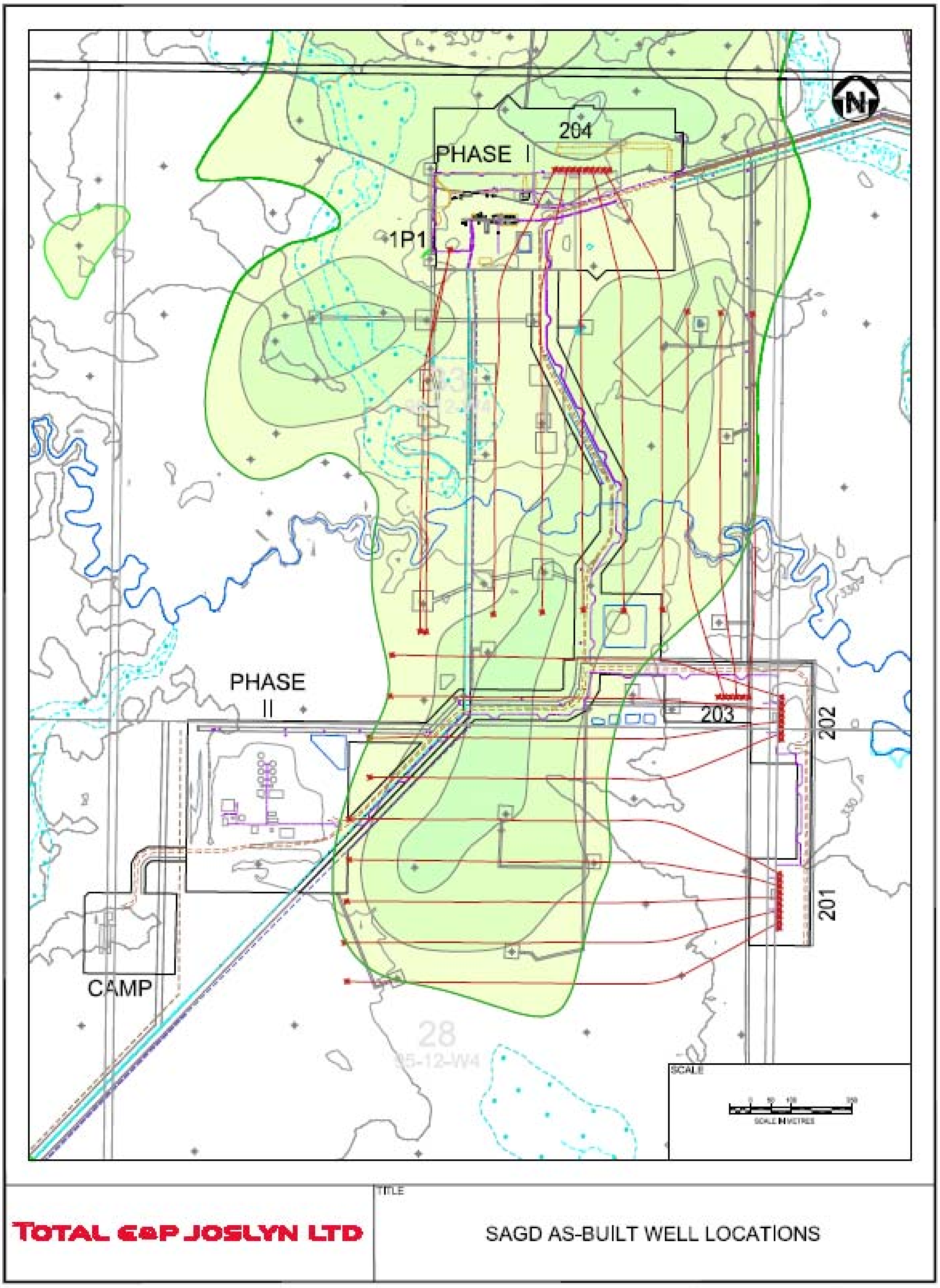


Figure 7 SAGD as build location over a Net Process Pay Map (m)

2.3 Key Project Dates

The key dates related to the JOSLYN thermal development are the following

- January 2003 – Approval of Phase 2 Application
- May 2004 – Start up of the Pilot well pair (Phase 1)
- September -2005 - TOTAL purchase of DCEL, operator of Joslyn project
- December 2005 - Phase 2 Startup
- February 2005 – Submission of Phase 3 Application
- **18 May 2006 Steam release at surface**
- August 2006 – First PCP Metal – Metal installation
- June 2006 – Project technical Review[2].
- August 2006 – Steam Release Task Force report issued to EUB.
- January 2007 – Start of 3D acquisition over the steam release area.
- February 2007 – HAZOP review[2].
- October 2007 – Major CPF Turnaround (including H2S/SCN modifications).
- December 2007 – Drilling of pressure monitoring wells (close to 204-I3P3 seismic anomaly and atop 202-I4P4 well pair).
- December 2007 – Final Steam Release Investigation Report issued to EUB.

Of particular importance is the Steam Release at surface that occurred on Thursday May 18th 2006 at approximately 05:10 AM close from well pair 204 –P1I1 location. The release, some 400 meters from the well pad, created a crater and a disturbed and fractured area of some 165 meters by 65 meters. The steam release was accompanied by dust and rocks ejection that spread over a distance in excess of 300 meters, creating some limited damage to the thermal protection on some steam lines. There were no injuries or other damage. At the time of the release, the well pair in question was just starting to produce, following a lengthy steaming phase to heat up the bitumen in the MacMurray Tar Sands.

The present report summarizes final findings of the in depth studies of this incident.

---

[2] The June 2006 PTR and February 2007 HAZOP review's findings constituted the basis for the bulk of the scope of October 2007 turn-around.

3 STEAM RELEASE ROOT CAUSE ANALYSIS

The root cause analysis relies upon finings related to various technical disciplines. Findings related to each technical field are the subject of individual reports whose main conclusions are summarized in separate paragraph below. Paragraph 3.7 details the root cause analysis rationale and lay out the most likely steam release scenario deduced from these findings.

3.1 Surface Findings

A description of the main geosciences observations made at surface following the steam release can be found in reference 1 (June 2, 2006 field visit report). These observations were based on a visit to the site and an examination of related data, including topographic maps, uncorrected aerial photographs, and preliminary contour maps of the site produced after the blow-out, GPS stations surveyed in the field and selected subsurface log data.

The main conclusions of the report are as follows:

- A significant steam release or “blow-out” event occurred on May 18, 2006 above a horizontal production and injection well pair, located in TOTAL’s Joslyn Phase 2 SAGD Project (Injection well: DCEL et al 204-I1 Daphne 2-33-95-12 and Production well: DCEL et al 204-I1 Daphne 2-33-95-12)
- A central steam vent marked by a crater (Figure 8), appears to be the source of most of the ejected rock and soil volume that spread out over a roughly elliptical shaped area, extending to the south-west. **It is located more than 30 m away from 2/9-33 observation well.**
- Areas with ground uplift and ground subsidence were identified in the field and on preliminary topographic contour maps of the area, produced soon after the event.
- There are several major ground fractures associated with the uplift and subsidence, some of which appear to have been a route for steam venting to surface.
- A secondary steam release area was identified, approximately 50 m south of the main crater. **It is located more than 30 m away from 2/9-33 observation well.**
- There is evidence of ground rotations, tilting, shearing and severe disturbance in the main crater area.
- McMurray Formation oil sands with a strong petroleum odour were obtained from the bottom of the main crater.
- Projectiles consisting of clay, silt, glacial till, peat, Wabiskaw Formation sandstone, and Clearwater Formation shale are scattered throughout the main debris fan that spreads out south-east of the main crater.
- A fine silt covers the forest floor beyond the main blast area. It also coats the sides of trees along the blast affected area, and for some distance into the trees.
- Shale projectiles have travelled in excess of 300 m horizontally from the main crater, some landing along side the main road of the Joslyn processing plant. Some of the projectiles must have had a fairly vertical trajectory, based on damage observed to the coating on a pipeline adjacent to the plant road.
- At the time of the field visit, 15 days after the blow-out, the area near the main crater and the subsidence bowl appeared to be relatively stable as there was no obvious evidence of recurring movements.

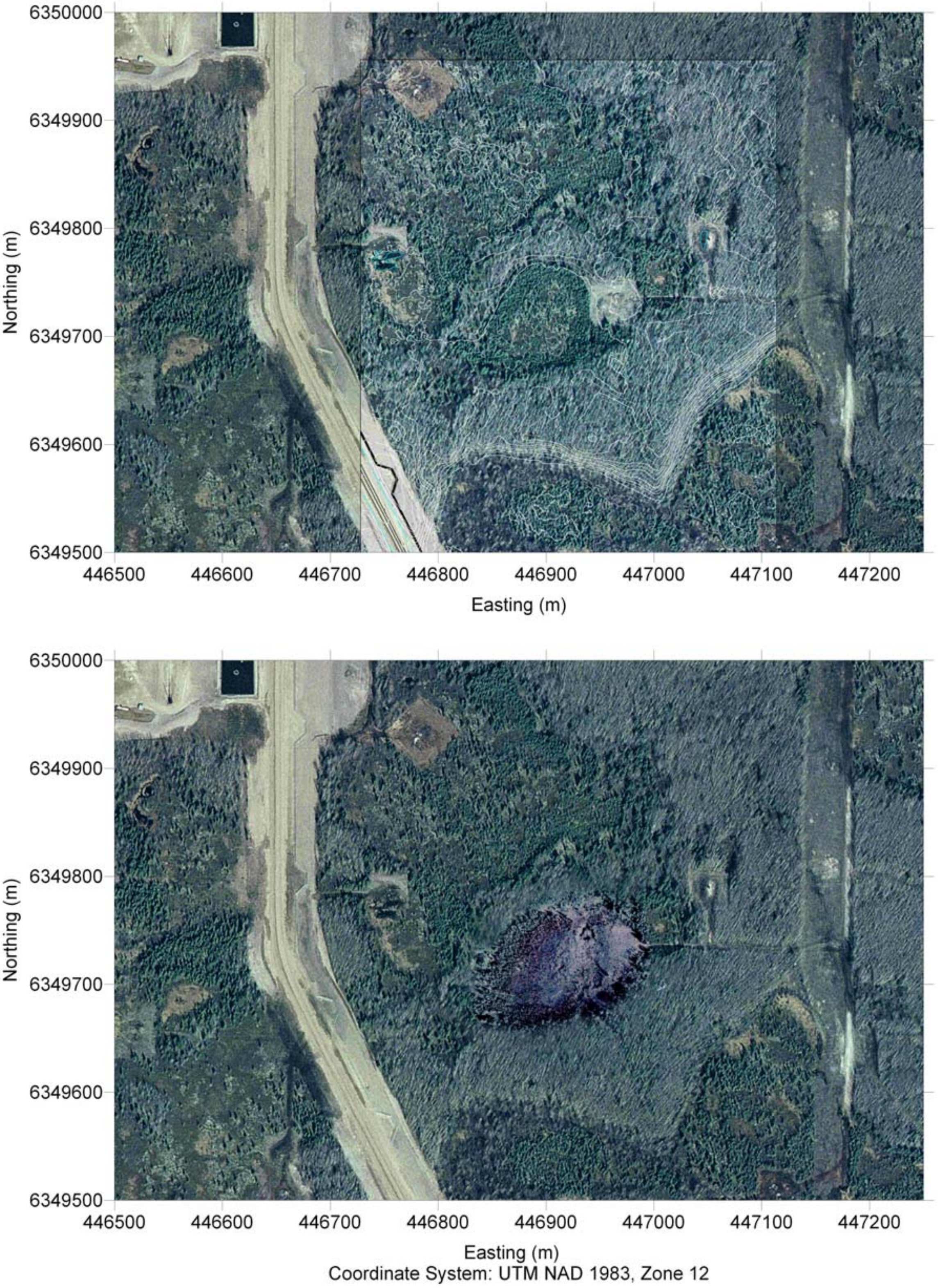


Figure 8 Aerial photography of area before and after steam release

3.2 Geological Findings

Reference 2 details the geology of the steam release area, including the sedimentolological, stratigraphic and structural aspects. The well position aspects are also analyzed as they are important for determining the range of overburden thicknesses

The main geological findings are the following:

- From the injector position at approximately 248 m MSL upwards, the typical geology of the steam release area consists of the following sequence (Figure 9 Well 1AB 09-33-095-12):
    - 18 - 20 m of excellent quality bitumen bearing sands from 248 to 266 - 268 m MSL below ground in the Middle McMurray.
    - 7 – 8 m of lower quality sands from 266 - 268 m MSL to 275 m.
    - A first clear shale barrier at approximately 275 m MSL
    - 19 m of bitumen bearing sand/shale interbeds from 275 m MSL to 294 m MSL (Middle and Upper McMurray). Limited gas saturation occurrences in this interval are possible based upon nearby observations. Such gas occurrences determine limited storage ability in this interval.
    - 1 m of silty mud (Kcw1 interval) from 294 m MSL to 295 m MSL with excellent correlation over the lease acreage. This interval is unlikely to act as a strong seal or as a drain.
    - 5 m of marine mud (Kcw2 interval) from 295 m MSL to 300 m MSL with excellent correlation over the lease acreage. This interval should act as a seal.
    - 2 m of marine fair quality water bearing sand interval from 300 to 302 m MSL with excellent correlation over the lease acreage. Some bitumen saturation is possible in the interval. This interval may present some significant pressure drain and fluid storage ability.
    - At least 22 m of massive shale. This interval constitutes the ultimate seal over the SAGD area (a failure of this particular seal is certain to end up with a surface steam release).
    - 5 to 12 m of Quaternary deposits.

In the absence of clear evidence of fracture in the overburden interval (from top GPP to surface), it is deemed very unlikely that pre-existing fractures constitute a root cause of the May 18th 2006 steam release

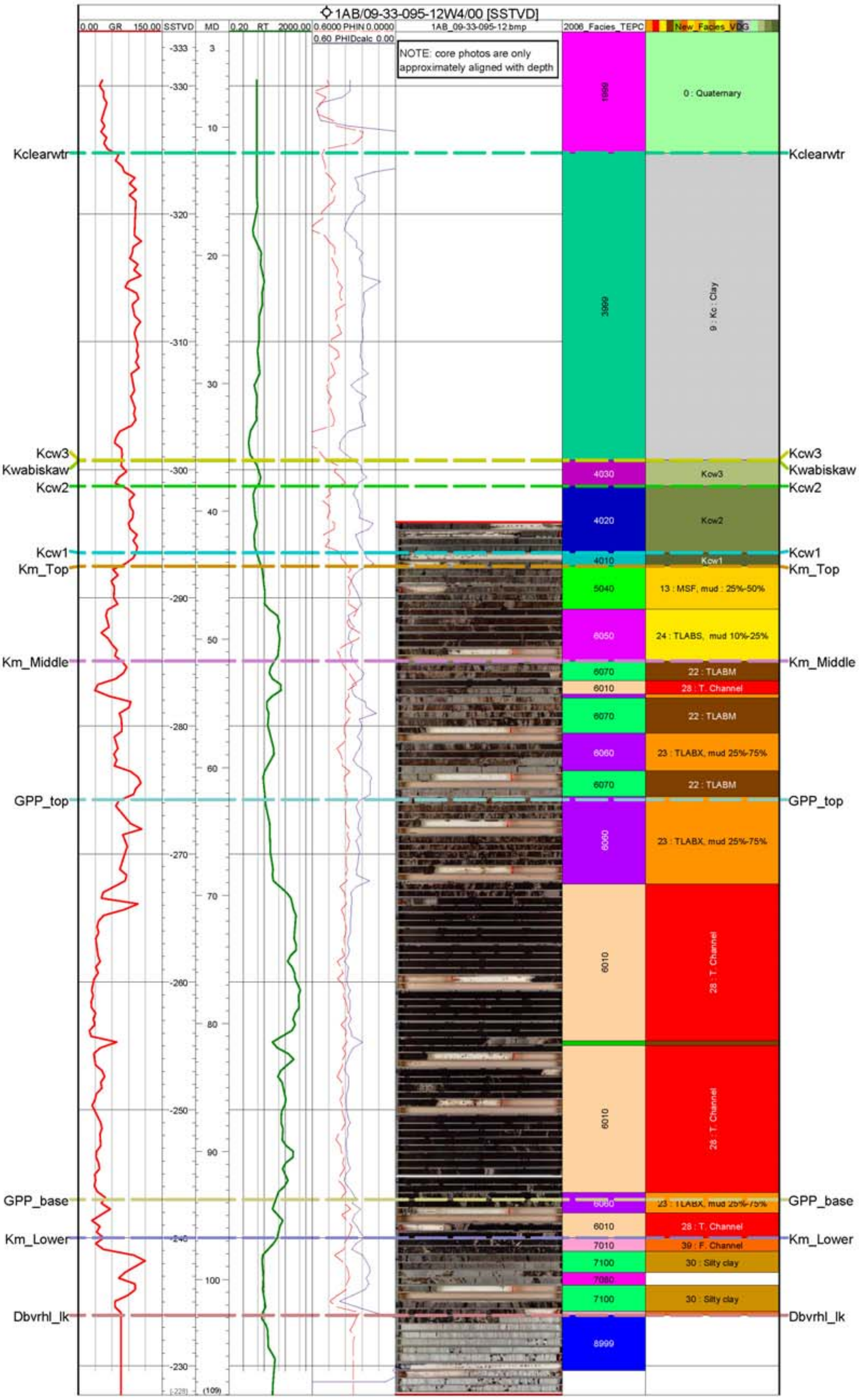


Figure 9 Well 1AB 09-33-095-12

3.3 Reservoir Findings

A detailed review of reservoir findings can be found in reference 3. Key points are summarized hereafter.

The steam release event on May 18th 2006 occurred a few days after the conversion of well pair 204P1 to SAGD mode, more than 5 months after the start of the steam circulation phase. However, the incident has to be traced back to anomalies in well pair behavior that were observed after April 12th 2006. The anomalies, namely a sudden increase of injectivity in the injector well, cannot be related to normal SAGD well pair evolution such as good communication with the producer well, and are attributed to a major subsurface mechanical failure.

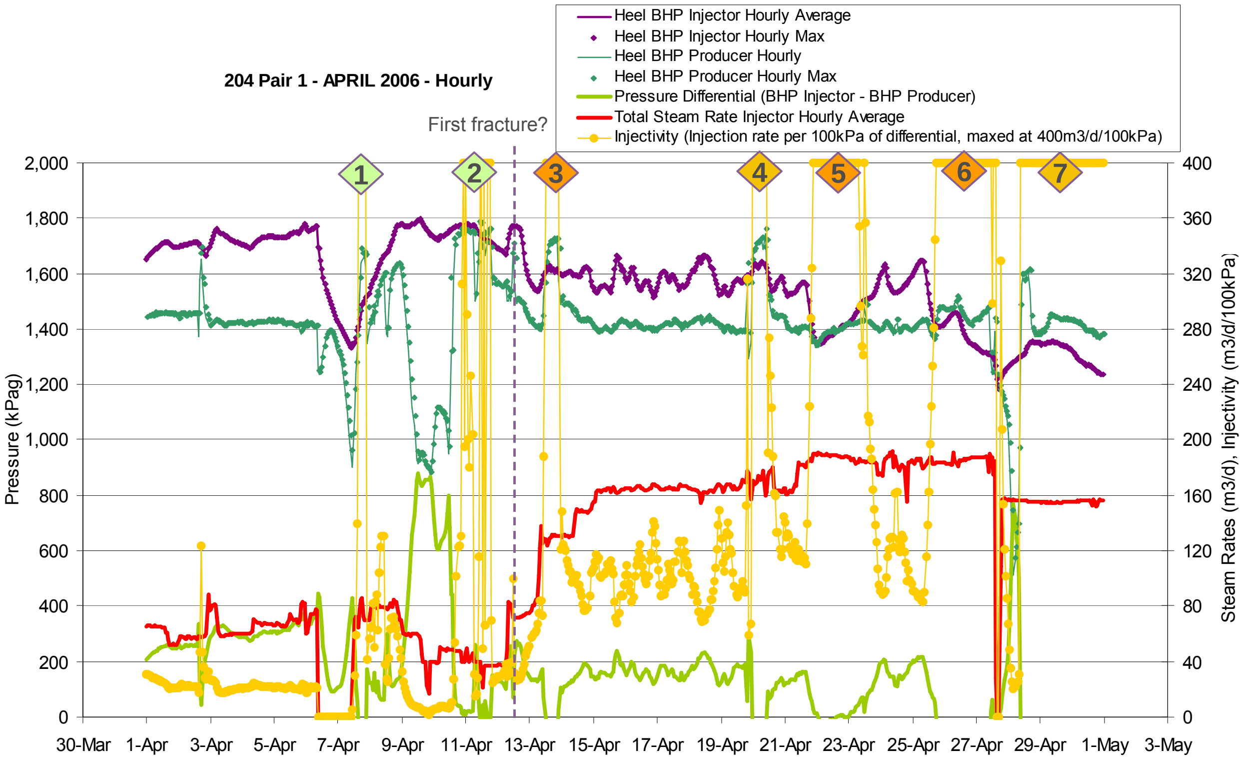


Figure 10: Close up on the increase of injectivity, in April 2006. Injectivity is defined as the ratio of steam rate in the injector over the pressure differential with the producer well (here: maxed out at 200m3/d/100kPa, and sliding over 5hrs). The high injectivity events <1>. and <2> prior to April 13th are not flagged as anomalies (green). Events <3> to <7> are used as evidence of a loss of the pressure confinement of the well pair, of which <3>, <4> and <5> (orange) are related to actual fracturing events. With a dashed line is also indicated the possible time of the first fracturing event,

The cumulative volume of steam lost due to this failure prior to the steam release has been estimated between 1,000 and 2,600 m3 in cold water equivalent. Assuming this volume had condensed in the reservoir and had been flashed back to steam during the release to ground surface, the energy involved in the release would have been in the order of 10^{12} J.

A hydraulic fracture failure would most probably have occurred at the shallowest point of the pressurized zone, above the injector, where the rock is the weakest. Preliminary geo-mechanical analyses suggest that such a failure could not have happened at the depth of the injector and that shale seal failure(s) most likely occurred at the edge of a pressurized area.

The scenario involving the injection pressure propagating from the 204I1 injector (83 m deep) up to the top of the good quality reservoir (68m deep) via normal reservoir mechanisms, prior to the injectivity increase, has been investigated. This pressure propagation over 15 meters seems possible in 4 months, but would clearly involve non elastic rock deformations. It would require:

- Initiation, at particular location(s), of small steam “finger(s)”, driving the injection pressure propagation upward by gravity. This(ese) location(s) would be characterized by better than average reservoir properties or local top(s) in the injector well trajectory,

- Sand shearing/dilation that would significantly increase permeability and thus accelerate the steam chamber growth.

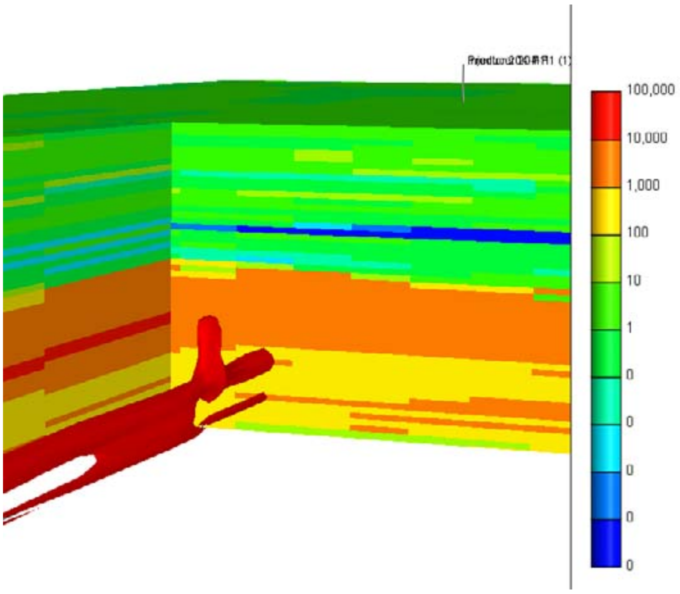


Figure 11 3D exploded view of the model vertical permeability (mD), with the 100 ºC isotherm (red) and the steam finger.

Mobile water at initial reservoir conditions may have participated in the upward pressure diffusion process but it is believed, based upon simulation, that it cannot alone determine, in the required timeframe, the significant pressure increase at shallow depth envisioned to explain the subsequent seal failure and steam release.

Due to the sharp decrease expected in permeability in the reservoir above 68 meters related to an increase of lateral accretion facies, pressure propagation shallower than 68 meters prior to April 12th 2006 would require involvement of true geo-mechanical shale failure as opposed to dilation. Furthermore, steam could certainly not have risen above the shale at 61.5 meters below ground without geo-mechanical failure.

3.4 Seismic Findings

The 3D seismic survey carried out at the Joslyn steam release site has clearly delineated the region in the subsurface that was disturbed by the steam release. The following insights may be drawn from the images:

- No geologic feature was identified on 3D seismic that would suggest that local pre-existing geological conditions (faults, fracture, doline, etc.) played any significant role in the steam release process.

- The shape of the Steam Affected Zone as seen on seismic is unrelated to the position of the observation well and core hole in the vicinity suggesting that this wells did not play a role in the Steam Release process.

- The Steam release Affected Zone as seen on seismic does not extend significantly toward either of the neighboring well pairs (204-I2P2, 203-I1P1).

- The steam release occurred as a series of cycles involving: steam migration upwards to a seal, steam accumulation beneath the seal, and steam puncturing of the seal. The steam was released at the apex of an antiform.

In addition, a seismic anomaly above injector 204-I3 is suggesting that steam may have accumulated at the top of the Middle McMurray, above the pay zone, at the apex of the same antiform.

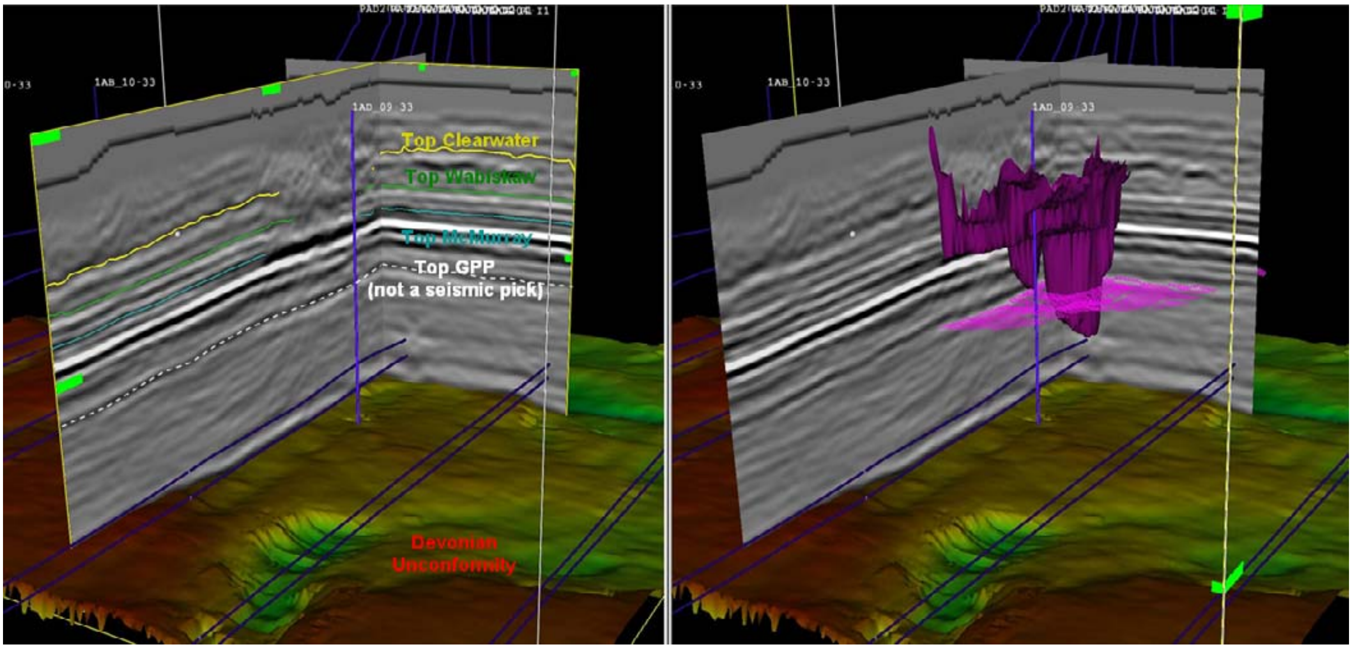


Figure 12 3D view of the steam release affected volume

3.5 Geo-mechanical Findings

The most important results of the study are:

- The pressure applied during the circulation and the semi-SAGD phases is responsible for successive failure events that have ultimately led to direct communication of steam pressure between the injector and the Wabiskaw below the uppermost barrier which is the shale Clearwater formation
- Failure occurred in the Clearwater due to steam accumulation and pressure build up in the Wabiskaw (or UpperMcMurray gas streaks) to values that were much higher than the vertical stress which is equivalent to the weight of the Clearwater inferred from integrating the density log.
- There is a need for monitoring surface heave and pressure in the Wabiskaw (or the McMurray gas streaks). Also further work is needed especially to:
    - Improve the quality of the geo-mechanical data (stresses and mechanical properties)
    - Achieve two-way coupling between the reservoir simulator and the geo-mechanical simulator.
    - Investigate the long term integrity and contribute to monitoring implementation and interpretation

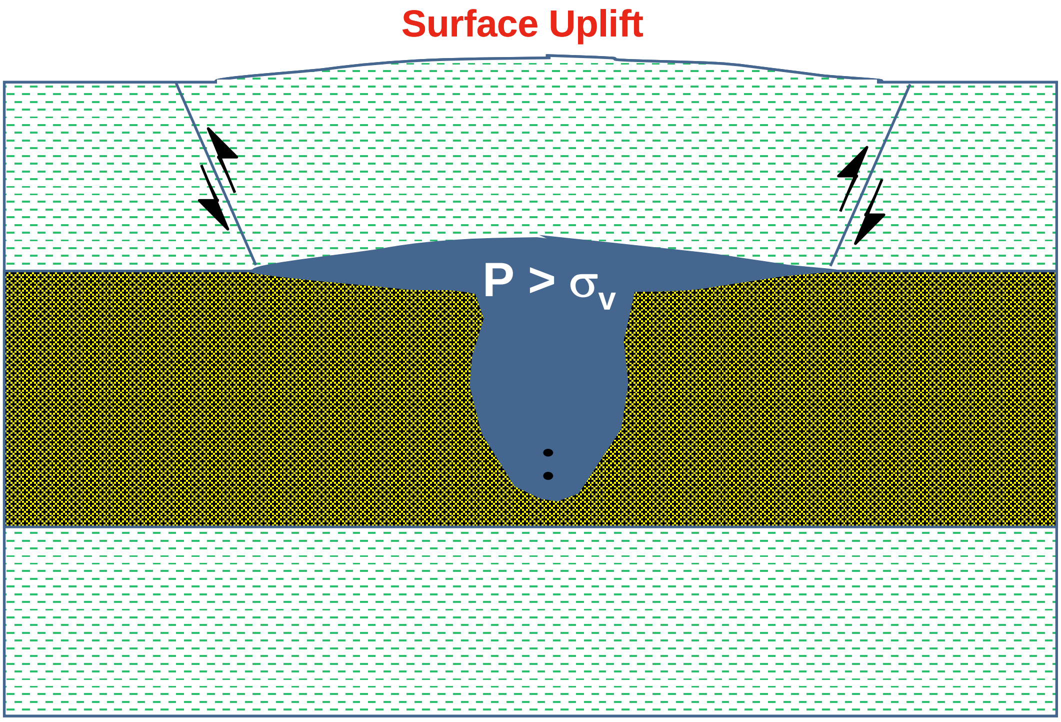


Figure 13 Failure of a shale barrier by shear on the shoulders of a zone with a pressure greater than the vertical stress

3.6 Cement Bond Investigation Report

A systematic review of cement bond data was performed for all wells located in the vicinity of the Joslyn May 18th 2006 Steam Release as part of the overall steam release root cause analysis. The following conclusions can be drawn from this review:

- Injector wells 204-I1 and 204-I3 were logged for Cement Bond evaluation prior to steaming. Unfortunately the logging tool used was not suitable for large casings (>9 5/8”), and no reliable information can be obtained from these logs.
- Daily Drilling Reports (DDR) and Cementing Company Reports are the only other source of information. These reports are however very succinct especially for core holes.
- Cement jobs of Injectors and Producers were completed without major problems, although the cementing practices used were not optimal (short circulation time, insufficient Wait On Cement). Significant cement losses were experienced during cementation, especially in 204-I1, suggesting hole wash-out, but a large excess of cement was used, and returns were still recorded at surface. Nevertheless there is a reasonable doubt regarding the quality of the cement bond achieved in 204-I1.
- No cement losses seemed to have occurred in Injector 204-I3. Cementation is likely to be better but actual bond is impossible to confirm without a reliable CBL.
- After the steam release, completion strings were retrieved from wells 204-I1 and 204-P1. Cement Bond was then evaluated (post steaming) using a more suitable logging tool, the Segmented Bond Tool. Cement Bond was found to be very degraded which is a common observation in thermal wells after steaming.
- Except for B/10-33, core holes were plugged back from TD to surface in a single stage, and reports do not mention that Top Of Cement (TOC) was actually confirmed. It is however a low probability that these plugs failed.
- Cement Jobs in the Observation wells went without recorded problems, but in the absence of CBL it is impossible to confirm the quality of the cement.

- An attempt was made to run a CBL in observation well 100/9-33 closest to the steam release crater, but the bent 2 7/8” casing prevented the tool to go through and logging had to be aborted.
- Five observation wells were logged with a CBL in January 2007 to assess the cement bond,
  - 103/06-33 (OB1AA) at the heel of Pilot Well Pair,
  - 100/10-33 (OB2A) at the heel of 204-WP5,
  - 103/02-33 (OB3C) at the toe of 204-WP4,
  - 100/11-28 (OB05) at the toe of 201-WP1,
  - 100/10-28 in the middle of 201-WP2.

All these CBLs show very good to good zone isolation across the McMurray formation.

Overall, the cement bond review did not brought to light conclusive evidence related to the role that may or may not have played steam channelling at wells in the steam release.

Well name	Well type	Data available	Comments	Cement Bond Evaluation
204-I1	INJ	DDR, pre-steam CBL	Cement Job w/losses, CBL not reliable	unknown, could be poor
		post-steam CBL	Reliable CBL performed under pressure	poor to very poor
204-P1	PROD	DDR	Cement Job OK	unknown
		post-steam CBL	Reliable CBL performed under pressure, but only reached half way	very poor
100/09-33	Observation Well	Sanjel Report	Cement Job OK	unknown
1AB/09-33	Plugged & Abandoned	limited	Cement Job OK, but single stage, no Top Of Cement confirmation	unknown
204-I3	INJ	DDR, pre-steamCBL	Cement Job OK, CBL not reliable	unknown
204-P3	PROD	DDR	Cement Job w/losses, backflow	unknown, could be poor
B/10-33	Observation Well	Sanjel Report	Cement Job OK	unknown
B/07-33	Plugged & Abandoned	Sanjel Report	Cement Job OK w/2 plugs, but no Top Of Cement confirmation	unknown
0/02-33	Plugged & Abandoned	Trican Report	Cement Job OK, but single stage, no Top Of Cement confirmation	unknown

Table 1 Cement Bond Data & Evaluation Summary

3.7 Root cause analysis

3.7.1 Root Cause Analysis Principle

The root cause analysis followed for Joslyn was based upon:

- A screening of failure scenarios to characterize their relevancy to the actual events: demonstrate that they could or could not have occurred based upon a synthetic vision of the conditions that existed in Joslyn reservoir before the steam release.
- Identification of root cause(s) in remaining scenario(s).

This process led to the conclusion that only one failure scenario was likely, and that a single primary root cause could be identified although variations exist around the primary failure scenario in which secondary processes may play a minor role. All steam release observations can be explained in the proposed scenario as illustrated in paragraph 3.9.

3.7.2 Review of Potential Failure Processes

During the research to find a process to explain the Joslyn steam release the following hypotheses were brought forward:

1. Shear failure at the edge of a pressurized area.
2. Leakage within or around wells (e.g. through poor cementation),
3. Pre-existing existing fractures or other structural feature,
4. Erosion or other sedimentary feature,
5. Hydraulic fracture,
6. Thermal failure of shale,

Item 1: shear failure of seal at the edge of a pressurized area.

This process is the main component of the scenario proposed for explaining the steam release. The proposed scenario is described in detail in section 3.9. The following paragraph only summarizes the key points justifying why it is considered as a possible process for the steam release.

Geo-mechanical studies have demonstrated that shear failure at the edge of (a) pressurized area(s) below any of the potential seals in between the top of the reservoir and the ground surface could have occurred between the start of circulation and the steam release. Reservoir studies have demonstrated that the injection pressure front could have reached the top of the reservoir a few months after the start of the circulation due to local SAGD chamber fingering (maybe involving geo-mechanical effects). The hypothesis of shear failure of shale seals is fully compatible with all the steam release observations (only the key observations are listed hereafter):

- The catastrophic steam release at surface occurred during SAGD production at a time when a comparatively low pressure (~ 1400 kPag) was used to circulate injection steam in wells (NB: higher pressures were exerted during earlier circulation and semi-SAGD stages).
- Injectivity increase starting around April 12th 2006 suggesting that a large volume of water was stored underground between that date and the steam release.
- Descriptions of ejected rock suggesting that most of the blow-out events concerned the Wabiskaw – Ground interval.

Items 2-4: local pre-existing weaknesses as primary cause for the steam release.

Based upon the following geological and seismic observations, it is extremely unlikely that local geological conditions (items 2 to 4) could have acted as a conduit for the hot water/steam between the reservoir and the surface. It is difficult to prove with 100% certainty that these conditions played no role whatsoever due to the fact that we cannot investigate the pre-steam release character of the geology.

- Leakage at wells: the 3D high resolution seismic survey showed that the steam affected volume was not linked to the well locations in the area.

- Pre-existing fractures: no evidence was found on core and seismic data suggesting that any structural features existed within the overburden (top GPP to surface) close to the steam release. It should be noted that vertical fractures would be unlikely to be encountered at wells if not present in large number and that the seismic may not be able to catch signs of fractures despite an extremely high resolution.

- Erosion or other sedimentary features: no evidence was found in logs, core and seismic data to suggest that significant erosion or changes in local facies existed within the overburden (top GPP to surface) close to the steam release.

Item 5: hydraulic fracture

The following arguments make a strong case against the hypothesis that a vertical tensile fracture is at the origin of the Joslyn steam release:

- The stress conditions of Joslyn suggest a horizontal extension of a fracture that should not in itself generate a loss of steam confinement.

- The most severe conditions for hydraulic fracture generation and propagation were experienced at the early stages of the 204-I1P1 circulation. In the unlikely case of the development of a vertical hydraulic fracture, such a fracture would have quickly propagated to surface leading to a steam release during early circulation times.

- As illustrated by the result of the Minifrac tests, a very high pore pressure is necessary to initiate a fracture in Joslyn conditions. Although there is a large dispersion in such data and the dynamic of the minifrac and SAGD production conditions are not the same, it is doubtful that the pressure experienced during the 204-I1P1 did breach into the hydraulic fracture opening domain.

As a consequence the hypothesis of a hydraulic fracture is considered unlikely.

Item 6: thermal failure of shale

It is a well known fact that upon heating, clays experience changes in their mineralogical (i.e. chemical) and petro-physical (including geo-mechanical) properties. It could therefore be argued that the degradation of shale barriers played a role in the steam release whether it be by hydraulic fracture or shear failure at the edge of a pressurized area.

The shale degradation would be a comparatively small step in explaining the vertical component and time aspect lacking in the former hydraulic fracture case. Especially it cannot in itself explain the failure of the thick Clearwater shale. Shale degradation assisted hydraulic fracturing is consequently not deemed to be a likely explanation of the steam release.

Thermally induced shale degradation may have played a role in the shale shear failure. The uncertainties on the initial shale properties and related to the simultaneous reservoir and geo-mechanical modeling of a SAGD steam chamber are such that it is difficult to clearly state whether this could or could not be a major aspect of the steam failure process.

Conclusion: of the six possible processes brought forward for explaining the steam release, one (shear failure at the edge of a pressurized area) appears likely and one may constitute an aggravating factor to the

most likely process (thermally induced shale failure). The remaining processes appear unlikely or impossible (pre-existing geologic conditions, hydraulic fracture).

3.8 Steam release root cause

Within the framework of a shear failure at the boundary of a pressurized area, the technical root cause of the steam release is evident: the overpressure applied during the startup of well pair 204-I1P1 (circulation, semi-SAGD and SAGD phases).

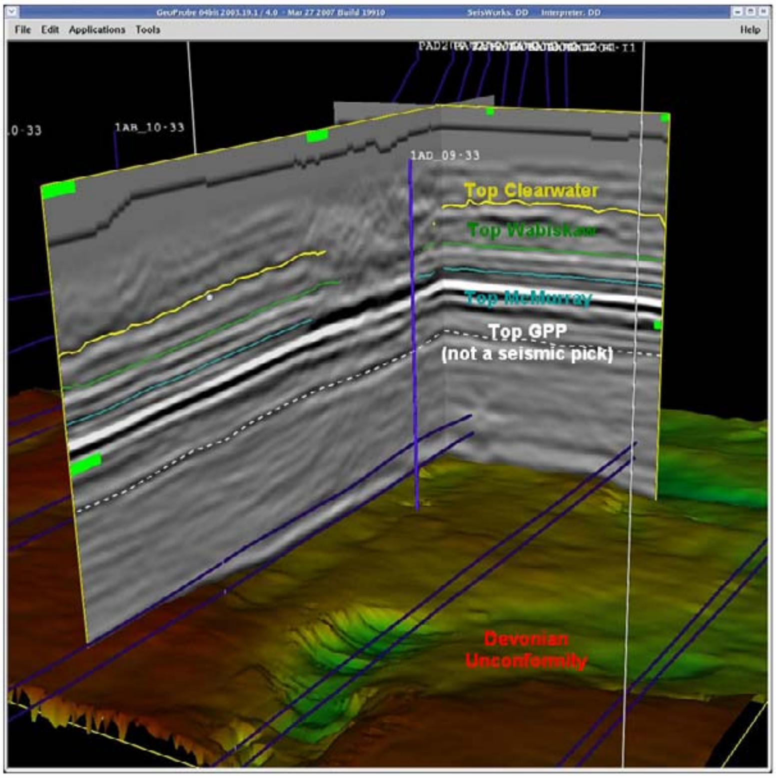
3.9 Most Likely Steam Release Scenario

Disclaimer

Section 3.9 hereafter illustrates the most likely scenario for the steam release in a synthetic manner. It includes drawings built to facilitate a common understanding between various specialties and for non specialists; these drawings are not drawn at scale and may oversimplify some technical aspects. Seismic images are also used to illustrate the proposed scenario; these images were not taken during the steam release process but more than 6 months afterward; they are presented in the framework of an interpretation and should not be seen as straightforward snapshots of what occurred.

Also, the proposed scenario and its variants combines proved aspects of the steam release with others that should be merely considered most likely. It also includes a hypothetical representation of surface heave because proper equipment was not in place to record them. Please refer to references 1 to 5 for more analytical discussions of uncertainties related to the various aspects of the steam release and to paragraph 3.7 for the steam release root cause analysis per se.

3.9.1 Steam movement walkthrough



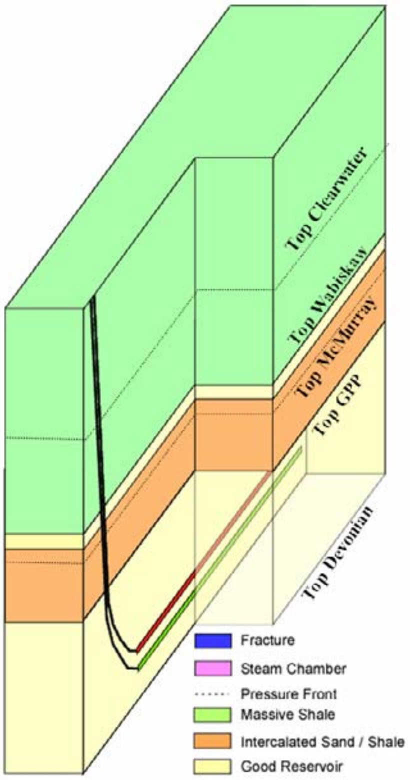


Figure 14 Step 0 - Initial conditions – Before December 2nd 2005

The geology in the vicinity of the steam release can be simplified to the extreme in the following manner:

- A ~28 m thick bitumen bearing Middle McMurray reservoir at the base of which a horizontal SAGD injector and a horizontal SAGD producer are drilled above one another, the producer being close to the reservoir base and the injector about 5 m above the producer.
- A ~25 m thick Middle / Upper McMurray and Wabiskaw interval with alternating shale and bitumen and gas bearing reservoir intervals. This interval is not regarded as a SAGD development target. It presents some potential for long term seal confinement and temporary pressure buffering.
- A 2 m water bearing interval (Wabiskaw 3).
- A massive mostly shaley interval up to surface (~35 m thick, Clearwater and Quaternary).

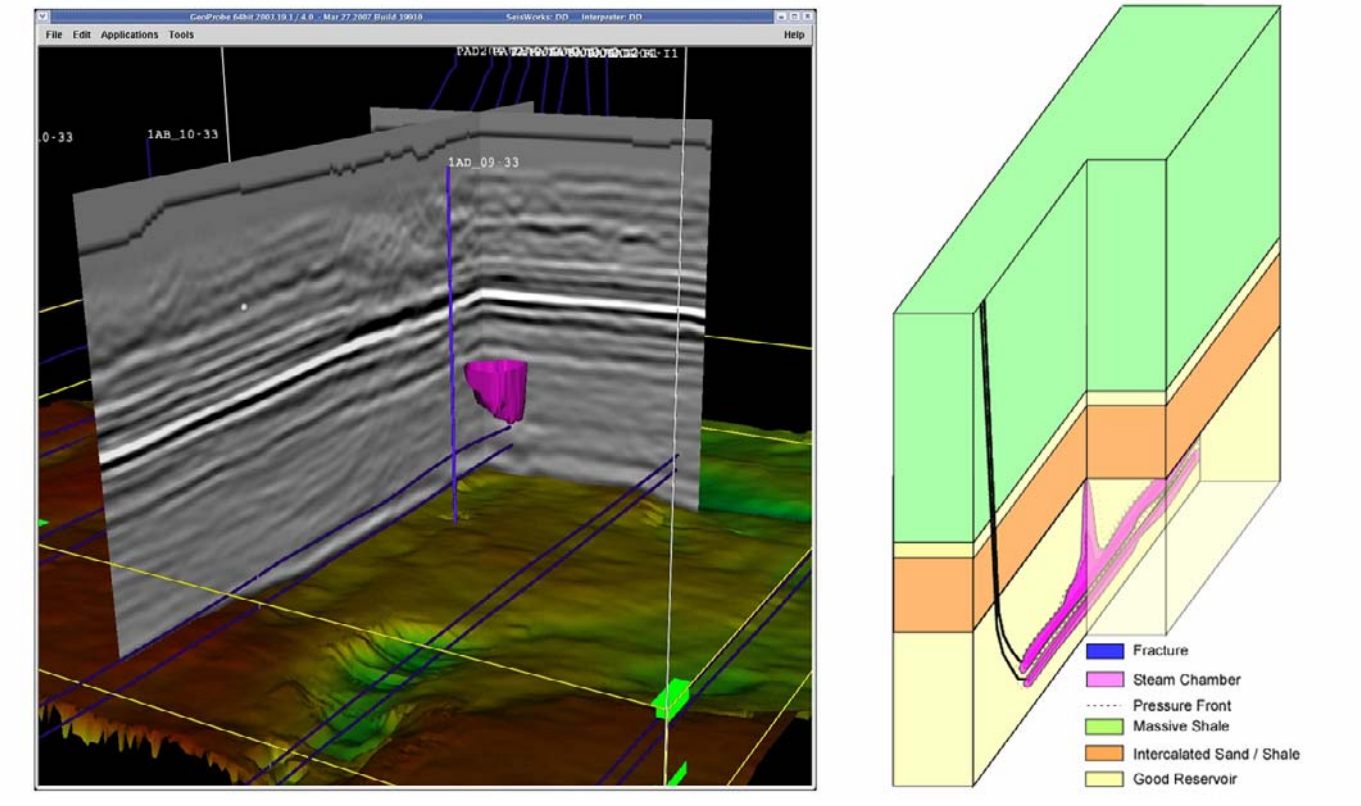


Figure 15 Step 1: Vertical SAGD fingering - December 2nd 2005 to April 12th 2006

The production operations start by circulating steam within the producer and injector. To do so, steam is injected through tubing in the horizontal section of both wells and simultaneously reproduced in the same wells by another tubing or the annulus. Upon circulation startup, the reservoir around both the injector and the producer wells is progressively pressurized by the water leaking off to the formation and heated by thermal conduction from hot fluids circulating within the wells (conductive heating) and by the hot water entering the formation (convective heating). Initially commingled, the pressure and heat fronts progressively separate, the pressure front preceding the heat front.

At some point, probably soon after the start of circulation, more steam entered a particular fraction of the well pair length and a SAGD steam chamber started developing in that location. This higher steam entry was determined by an uncharacterized combination of factors possibly including: particularly good reservoir quality, proximity of the heel, producer - injector distance, erosion or other local geological features within the reservoir interval, etc. The production metering setup at the time did not allow distinguishing between the SAGD production originating from the small chamber and the comparatively limited volume of bitumen “scraped” from the rest of the well-bore.

The small SAGD steam chamber developed vertically because it was driven by the gravity contrast between steam and bitumen / hot water. Higher porosity may also be a cause for a stronger rock dilation permeability improvement in that particular area. The development of a vertical SAGD finger significantly accelerated the vertical propagation of the pressure front.

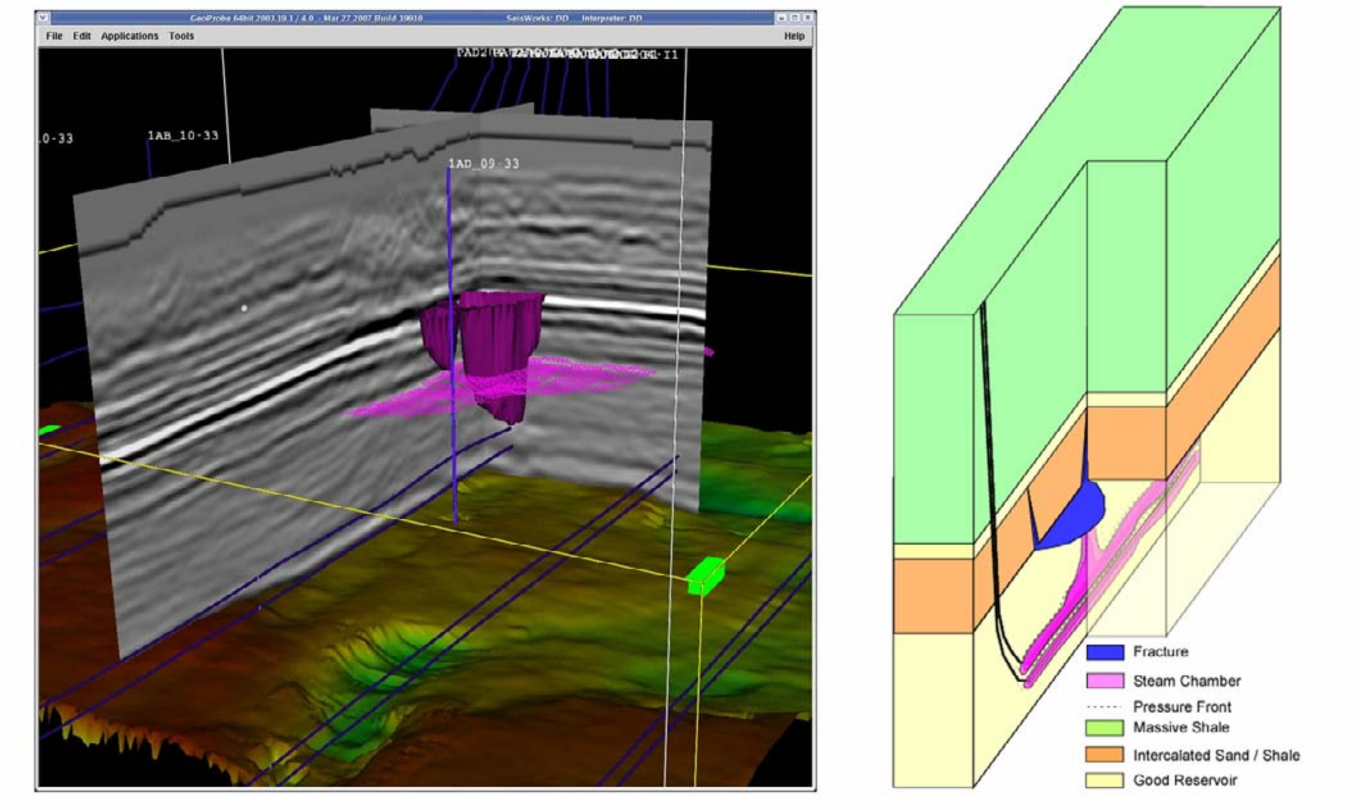


Figure 16 Step 3: Start of fracturing – April 12th 2006

At some point in time, the vertical movement of the local SAGD finger was significantly slowed or fully stopped by the low permeability baffles characterizing the top of the reservoir. The chamber behavior switched from a mostly vertical expansion toward radial growth. On the outside of the steam chamber, the pressure front continued its expansion possibly aided by sand dilation or outright hydraulic fracture. Both phenomena are expected to favor the expansion of the pressurized area in a horizontal plane. Further on, the size and pressure applied below the baffle stopping the SAGD steam chamber reached a point where the shear failure constraint was reached and the baffle actually broke down.

It is thought that the injectivity increase observed on 204-I1 corresponds to the first true geo-mechanical failure but it is unclear whether this first failure actually corresponds to an hydraulic fracture just below the top reservoir baffle or whether it corresponds to the first baffle shear failure at the edge of the pressurized area.

After the first failure, injectivity continued to increase in relation with successive failures until reaching the Wabiskaw or the Upper and Middle McMurray gas streaks.

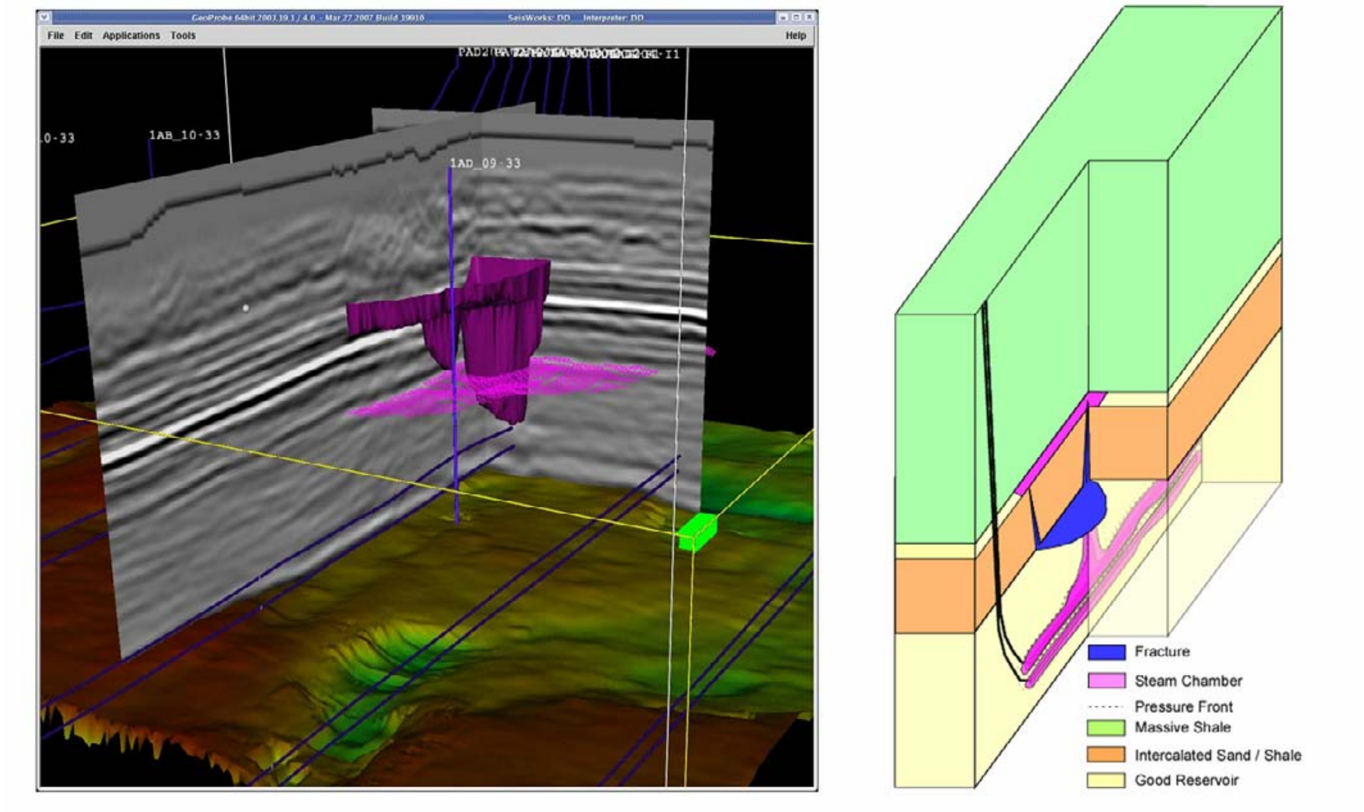


Figure 17 Step 4: Water / steam storage – between April 12th 2006 and May 18th 2006

Reaching the Wabiskaw reservoir or the Upper and Middle McMurray gas streaks opened the well to a high mobility reservoir (this reservoir is filled with very low viscosity water or gas whereas the McMurray is usually filled with immobile bitumen). Hence it was possible to inject a fairly high volume of steam with only a slow pressure buildup in the Wabiskaw (or gas bearing McMurray). A significant fraction of the 1000 – 2600 cold water equivalent m3 of steam “lost” from the well in relation with the injectivity increase probably ended up in the Wabiskaw / gas bearing McMurray. At the same time and unknowingly of what was happening underground, the circulation pressure was reduced and the well switched to semi-SAGD mode, worked over and ultimately put under SAGD production mode.

The progressive pressure buildup within and heating of the Wabiskaw or of the gas-bearing McMurray most probably generated ground surface heave. Such heave may have been detected if adequate monitoring equipment and procedures had been in place.

The volume of steam entering the buffer zone progressively overwhelmed its ability to bleed off pressure laterally (Wabiskaw) or its compressibility (gas bearing McMurray). Pressure built up and progressively jacked up the Clearwater until reaching shear failure conditions at the edge of the pressurized area. At this stage the fluid content of the various subsurface “containers” was probably as follows:

- The steam finger content was very probably similar to a conventional SAGD steam chamber: large steam saturation, some residual oil and residual water within the chamber, and water and oil falls on the edge of the finger or local areas.

- Any fracture in between the McMurray and the Wabiskaw would be mostly filled with high mobility steam moving toward shallow lower pressure areas and maybe some water condensed from steam falling down. The surface to volume ratios of such fractured area is such that significant heat losses were bound to occur in the fracture determining some water content in those fractures.

- It may be argued that the Wabiskaw was filled with both hot water and steam because its limited thickness, high thermal conductivity and high mobility water would make steam condense at a fairly high rate.
- Steam would be the first fluid likely to enter any newly opened fracture in the Clearwater seal both because of its low density pushing it upwards and because of its extremely low viscosity.

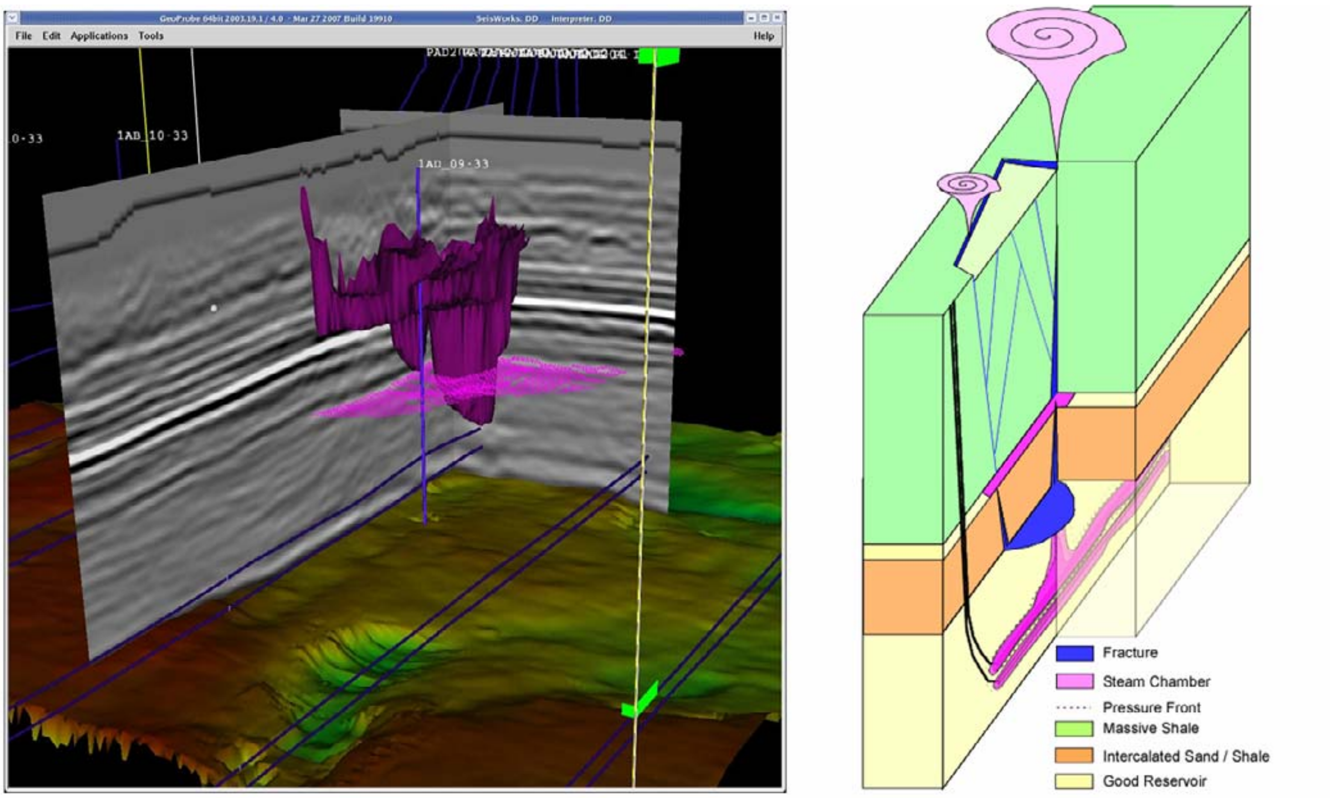


Figure 18 Step 5: Steam release – May 18th 2006

Once shear failure conditions were reached below the Clearwater seal, nothing stopped the fast propagation of shear failure faulting toward the surface even under the reduced circulation pressure applied at the time. Live steam breached the surface quickly followed by a water / steam mix when upward-moving water flashed to steam while depressurizing thus lifting remaining water at high velocity. All rock volumes in blue or pink in the above plot experienced fluid movement at very high velocities. Total rock failure happened along faults / fractures within the Clearwater, Wabiskaw and the McMurray fingers in relation with some extreme velocities. Such complete rock failures are responsible for rock ejection at surface (mostly from the Wabiskaw and upwards but encompassing also some McMurray).

In the aftermath of the steam release, the reservoir pressure was probably reduced to a very low level for all stratigraphic units down to the McMurray allowing air to enter the fault system. The temperature of the heated zones progressively reduced to normal considering their high surface to volume ratio. At the time of the seismic acquisition (> 6 months after the steam release) it is certain that no steam existed anywhere near the steam release area. The above seismic images are only an indication of differences from neighboring areas of water / air / bitumen saturation and rock mechanics properties.

3.9.2 Pressure walkthrough

Building from the Joslyn stress regime (Figure 19), failure conditions were analyzed for Joslyn.

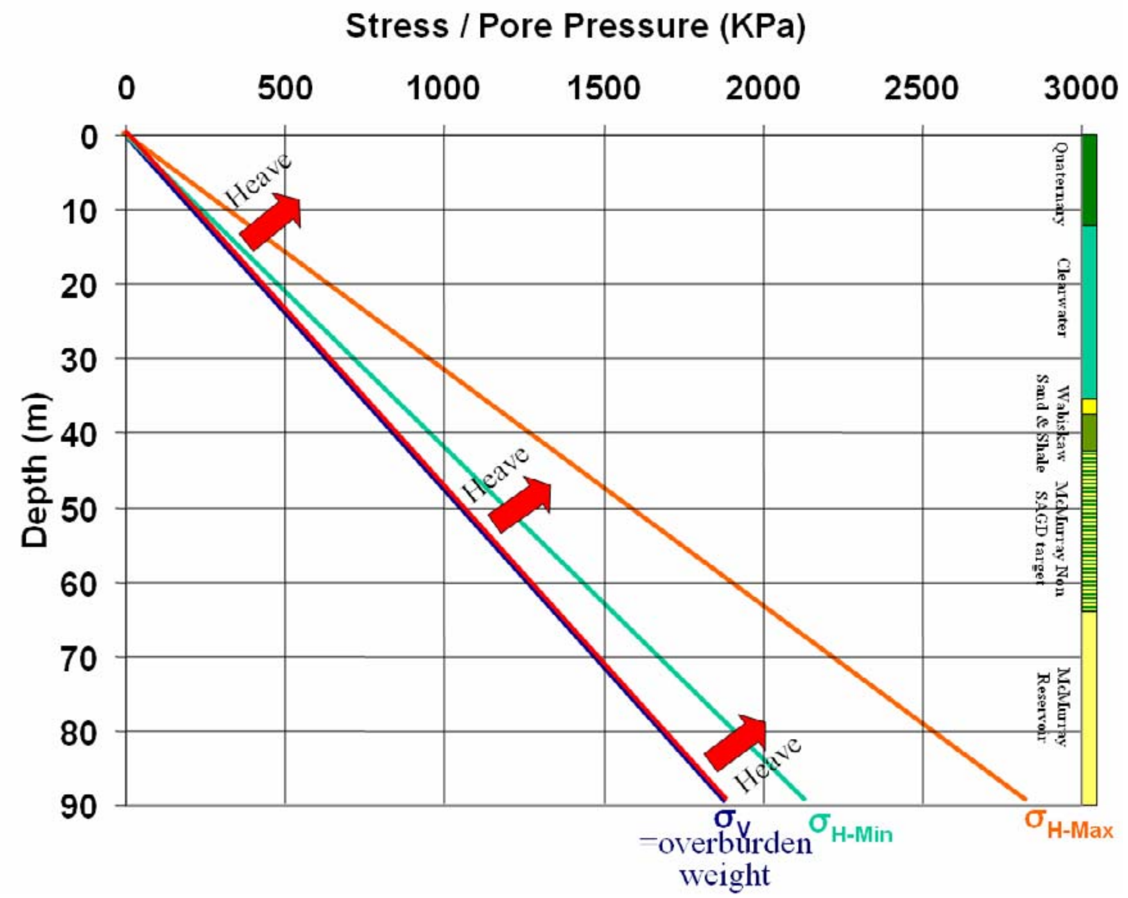


Figure 19: Joslyn Initial Stress Regime

The domain in which failure can happen is summarily described on Figure 20. Four main domains are described:

- No dilation, no failure, no heave domain (in white): in this domain, pore pressures are too low to allow for any geo-mechanical phenomenon to take place.
- Dilation, no heave domain (in light pink): in this domain, limited dilation may occur. Dilation-related permeability improvement will tend to develop in the horizontal direction at a small scale. At a larger scale permeability improvements may depend upon the directions of the Darcean fluxes.
- Dilation and heave domain (dark pink): when pore pressure starts exceeding the overburden weight, heave starts to be significant; in parallel dilation further increases.
- Failure domain (green): under very high pore pressure, the rock may start to be strained to the point of completely loosing cohesion and failing. Failure may be tensile or shear related. Exact failure thresholds for each mode are different and encompass aspects not described in this plot (such as the width of the pressurized area [for shear failure], exact σ_v $\sigma_{h\text{-}min}$ $\sigma_{h\text{-}max}$ conditions, etc.).

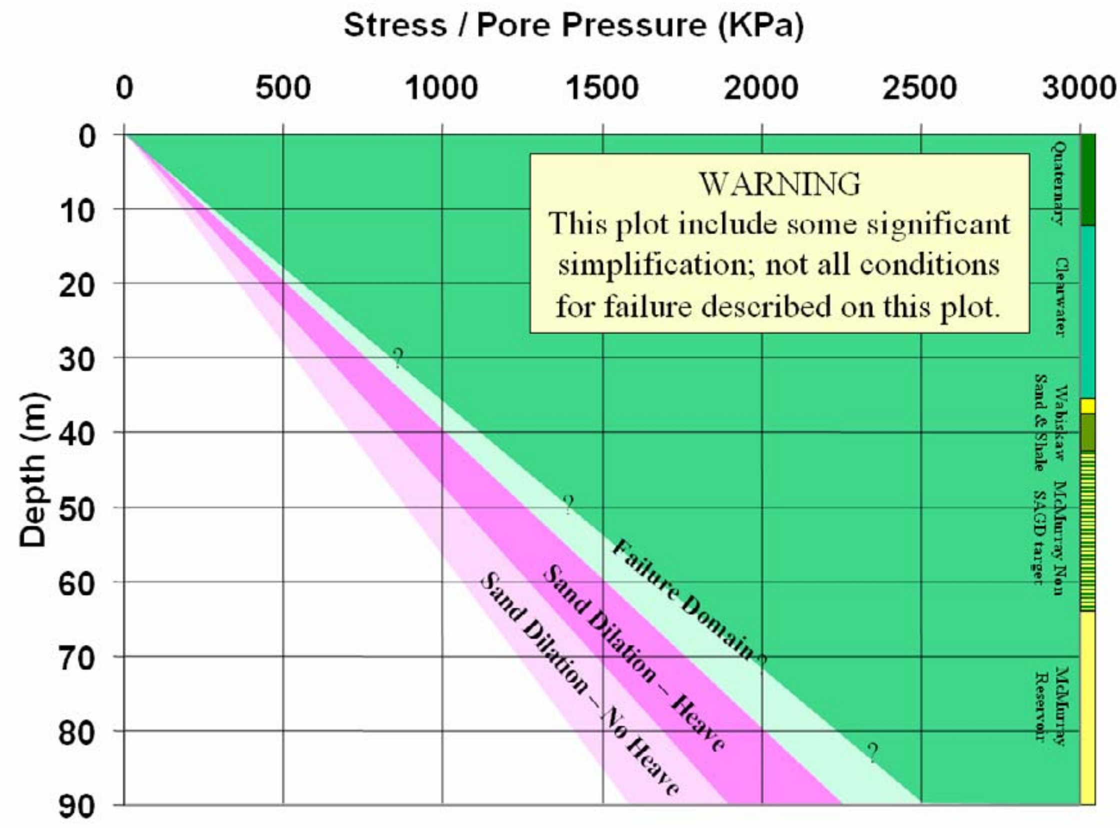


Figure 20: Failure domain summary sketch

The following plots illustrate, on the above sketch, the notional evolution of pressure at the injection well and the point in the distance closest to failure conditions from the circulation startup until the steam release.

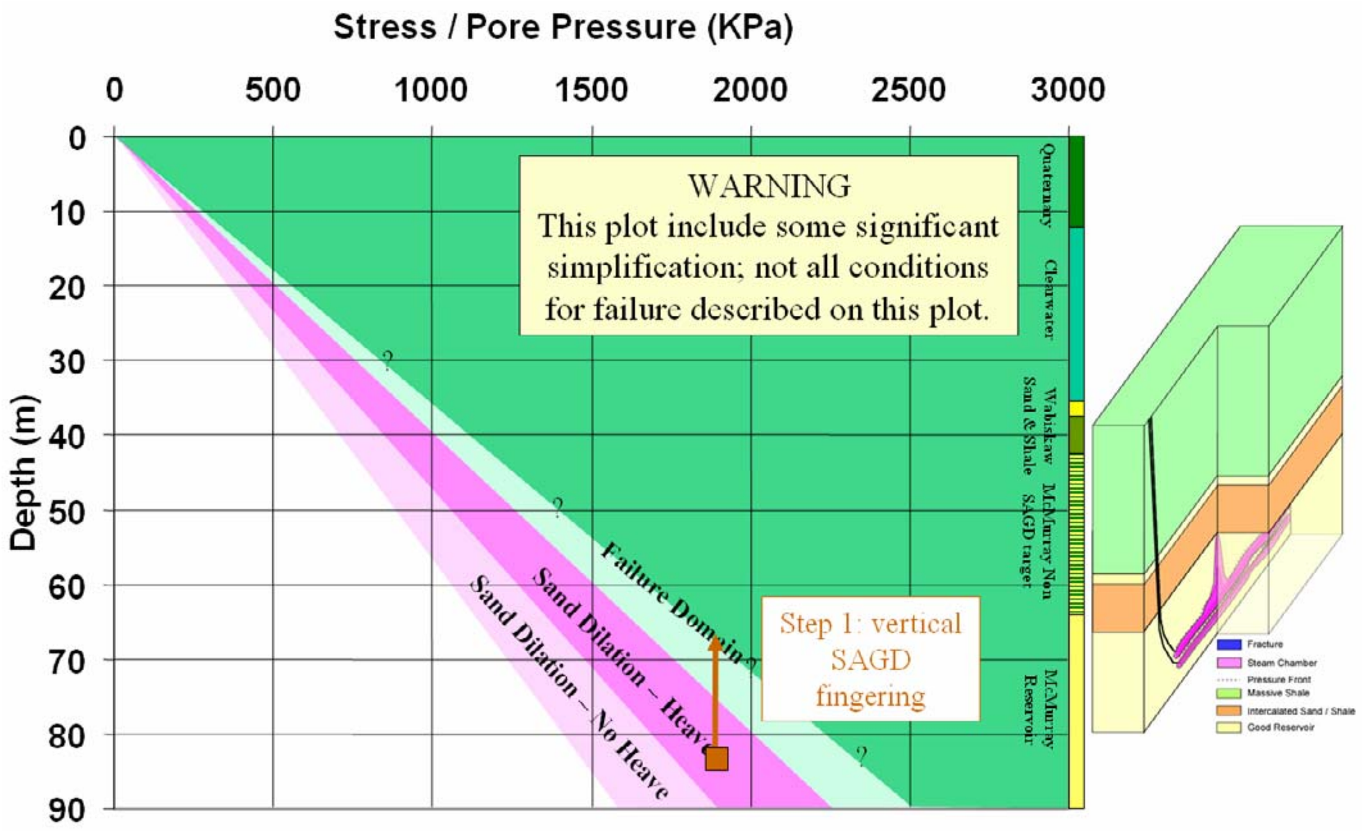


Figure 21 Pressure Walkthrough – Step 1

During step 1, the development of a localized steam chamber allows the volume of rock whose pressure is close to the injection pressure to expand vertically. At this stage, the point where stress conditions are closest to failure conditions is near the apex of the local steam chamber (figured as a brown vertical continuous line arrow).

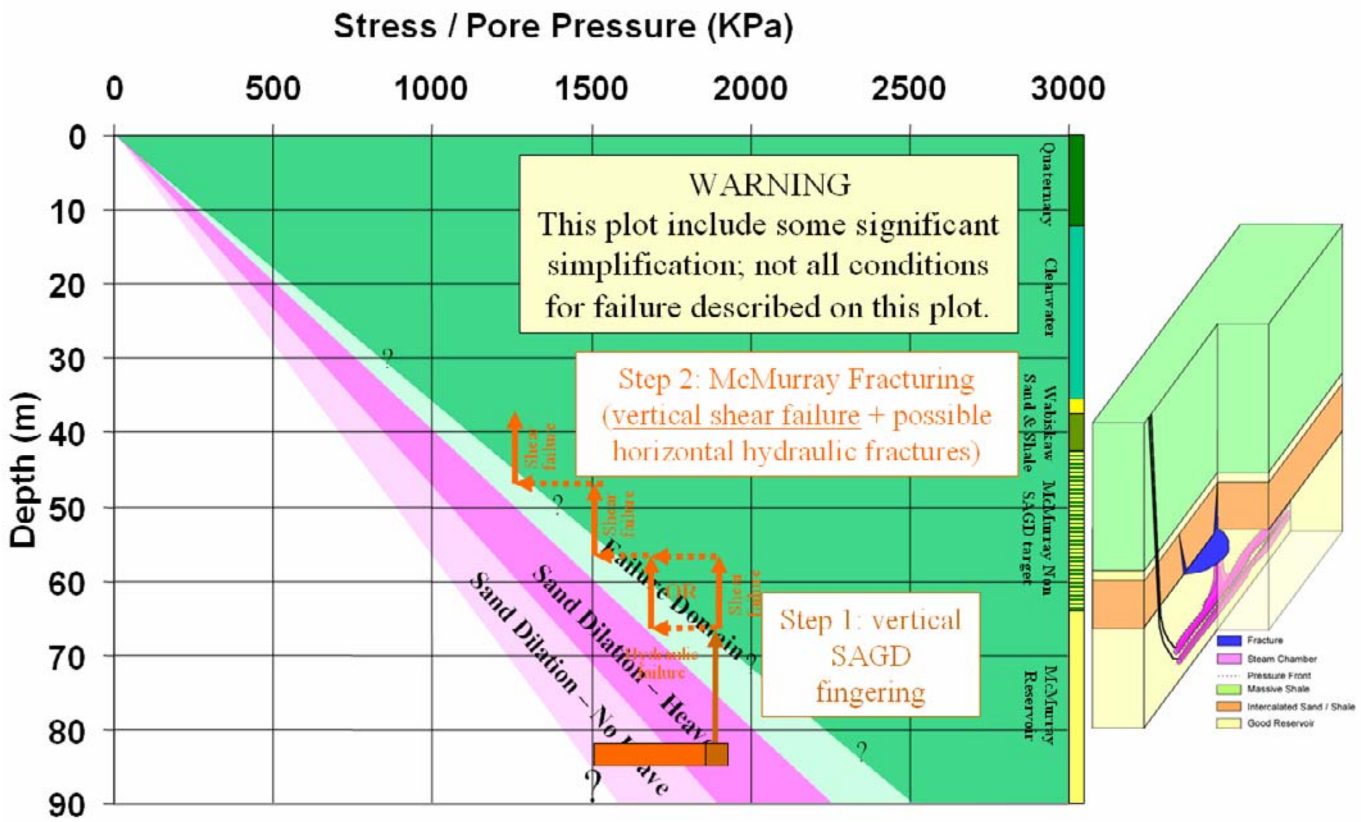


Figure 22 Pressure Walkthrough – Step 2

Between steps 1 and 2 the steam ascent is stopped by the permeability baffles at the top of the reservoir. The pressure front cannot significantly break through these barriers in the considered timeframe due to the low permeability of the baffles. The pressurized area grows laterally possibly aided by hydraulic fracturation (figured as the horizontal dashed orange arrow atop the vertical brown arrow) until it reaches shear failure conditions. Then a vertical shear failure fracture opens allowing access to higher reservoir and potentially lowering the pressure (if the gas saturation allows for storage volume). Successive shale barrier breakage occurs until the steam breaches to the Wabiskaw.

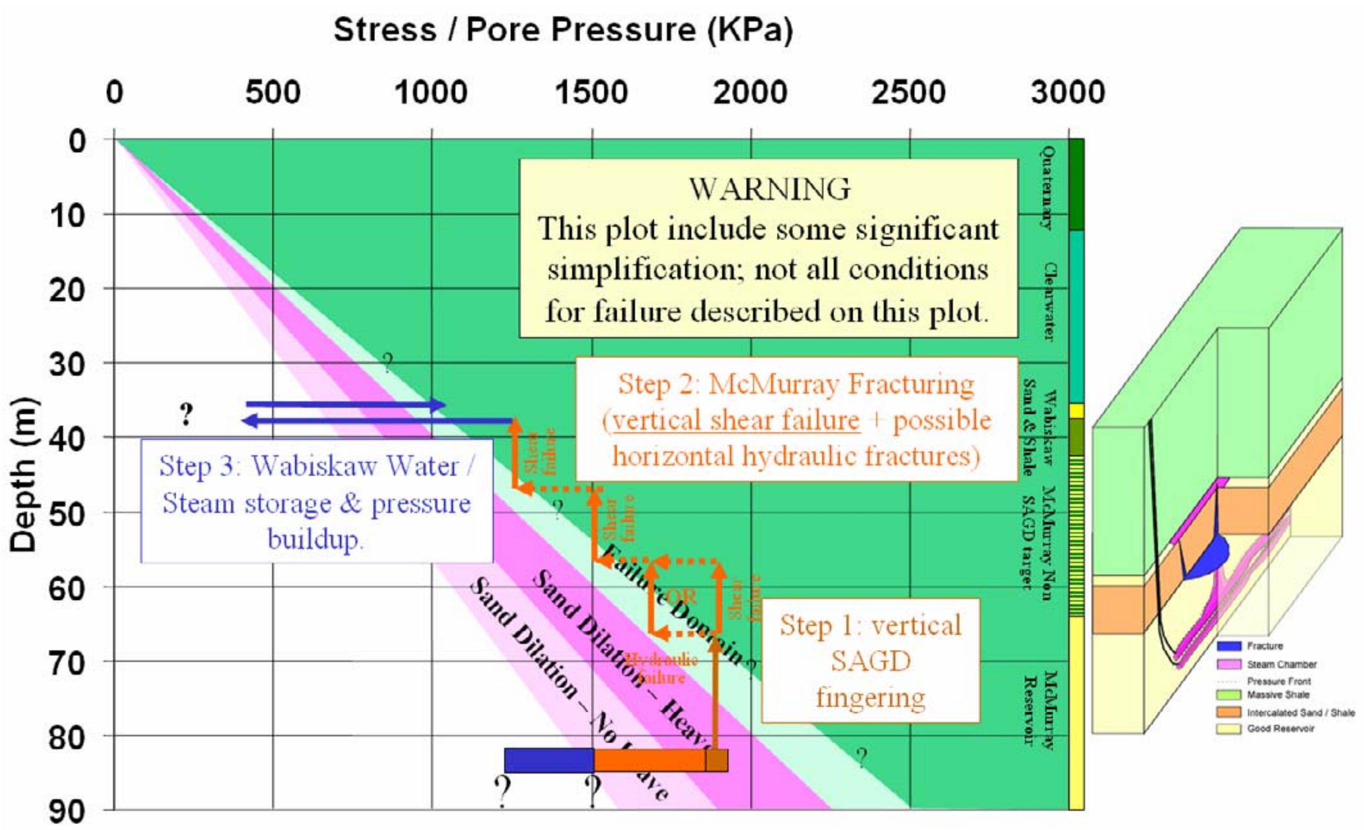


Figure 23 Pressure Walkthrough – Step 3

Step 3: when steam breaches into the Wabiskaw, the pressure at the breach drops because of the high permeability of that reservoir. Further steam entering the Wabiskaw (and most probably, condensing there) progressively saturated the capacity of this reservoir to laterally bleed off pressure.

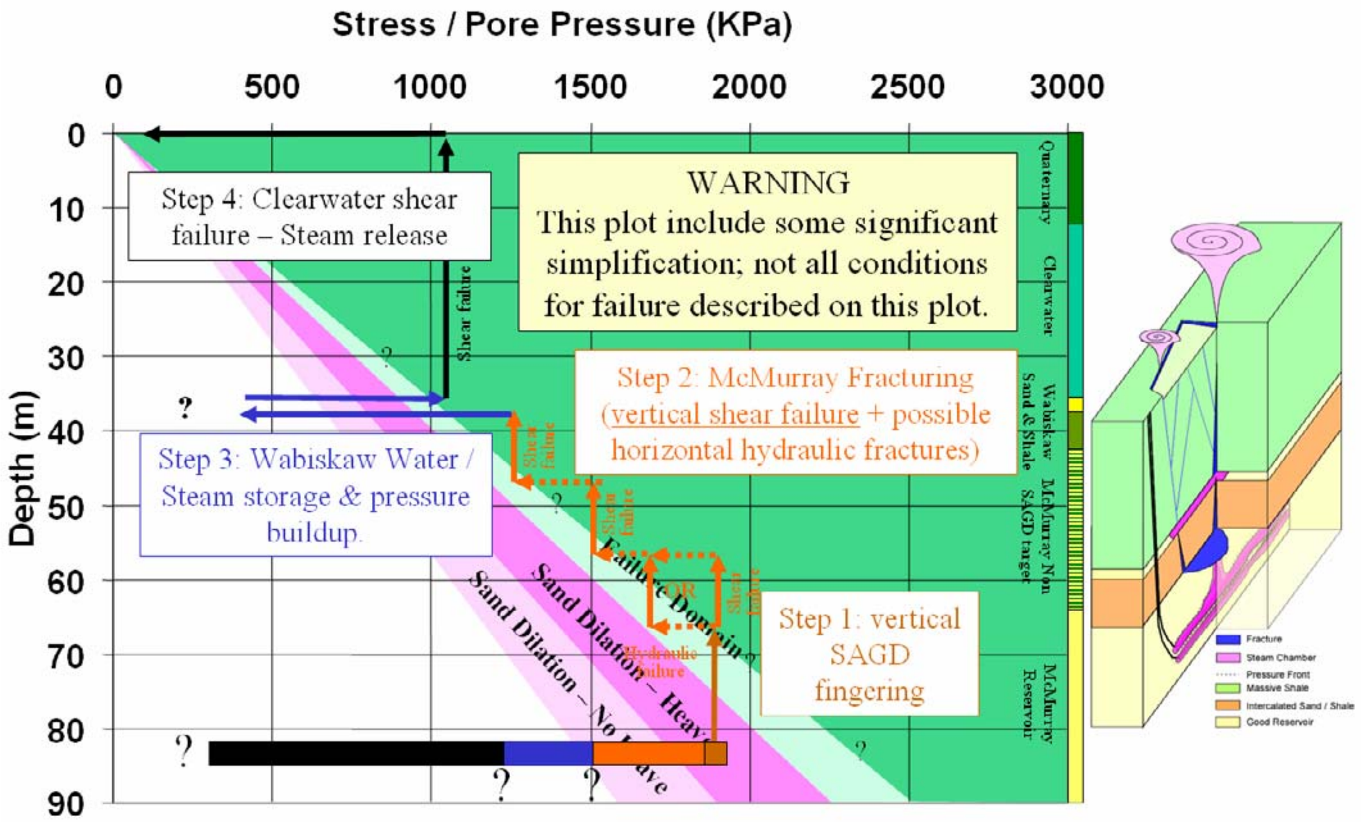


Figure 24 Pressure Walkthrough – Step 4

Step 4: on May 18th 2006 or immediately beforehand, the Wabiskaw pressure and pressurized area reach the point where shear failure conditions are met at the edge of the pressurized area at top Wabiskaw depth. A pseudo vertical fractures opens up toward the surface, steam starts to move up and ultimately breaches at surface leading to catastrophic depressurizing of the global system (down to the McMurray SAGD steam chamber)

3.9.3 Key variations around the base case scenario

The most important variation around the base case scenario involves a higher role for thermal shale weakening in the breach of the upper Middle McMurray – Upper McMurray seal.

The hypothesis that shale be severely degraded with time when under large temperature cannot be excluded. Under such hypothesis, it is conceivable that shale barriers of limited thickness break due to the presence of live steam under them and consequently that the breach from the Middle McMurray reservoir to the Wabiskaw be due to such phenomenon. Successive seal failure could have occurred either by tensile or shear regime.

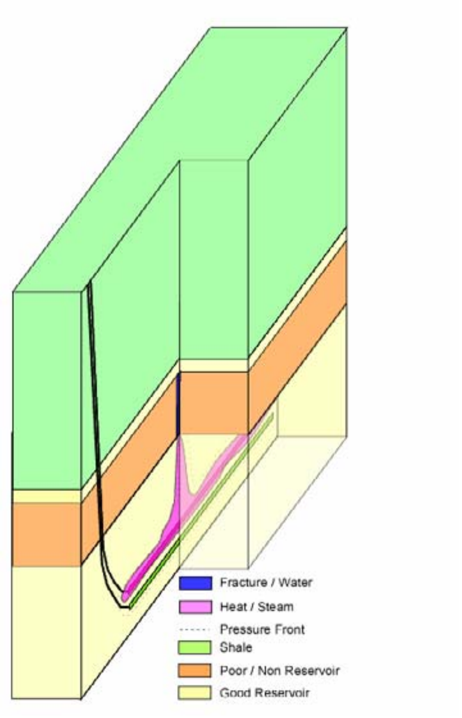


Figure 25 Alternate Hypothesis: Thermal induced shale failure responsible for McMurray seal loss

This mechanism cannot explain the breach of the last Clearwater seal due to the thickness of that particular seal. It however justifies the calibration of the pressure diffusion in the Middle – Upper McMurray interval to be included in future monitoring activities for a safe continuation of Joslyn SAGD operations.

Numerous other steam release scenario variations could be envisioned. Some may include factors such as natural or induced fracture at the depth of the SAGD wells or above. Providing a complete list of such scenario is not practically feasible.

Such scenarios are not deemed likely based, for example, upon the lack of observed natural fracture at the relevant stratigraphic levels in the vicinity of Phase 2 for scenarios involving natural fractures, mini frac data incompatible with tensile fracture at the SAGD well depth for deep fracture scenarios, etc. but it should be clear that such alternate cannot be excluded with absolute certainty on such basis (and/or similar arguments). For example lack of observation of fracture is not an absolute proof that they don't exist (it is only proof that they are extremely rare or do not exist).

There remain and will probably always remain residual doubts about the process by which the steam release occur. In any case, what is very certain is that the high pressure used during the early stage of 204-I1P1 startup played a major role in the steam release.

4 UPDATE ON JOSLYN OPERATING PRACTICE

The following section of the report summarizes the current production, monitoring and procedural principles in place for JOSLYN SAGD operations. These principles are described without distinction between procedures in place at the time of the steam release and procedures introduced following the steam release as the determination of the organizational root causes of the steam release are not the subject of the present report.

In order to monitor the steam chamber development and to ensure steam confinement, extensive monitoring is being done at Joslyn on a continuous, daily and weekly basis. The following table summarizes the main elements of the Joslyn monitoring practices: the main parameters that are being closely monitored (rates, material balance ratios, pressures, temperatures and ground surface heave), the key actors and the monitoring timeframe.

Parameter monitored	First detection level	Check periodicity	Second detection level and periodicity
Rates	Production operators	Continuous	Production engineer, daily; Well Performance Team, weekly
Pressure	Production operators	Continuous	Production engineer, daily Well performance team, weekly
Temperature DTS	Well performance team	Weekly	Production engineer & operators, random (more frequent than weekly)
Temperature (Obs. Wells)	Reservoir Engineer	Monthly	Well performance team, random (less frequent than weekly)
Material balance	Well performance Team	Weekly	Production engineer, random (more frequent than weekly)
Surface Heave	Well performance Team	Random (~ every 2 weeks)	N.A.

The following paragraphs detail the actors and their responsibilities, the definition of the indicators being followed and the principles governing the choice of actions following the observation of a change in behaviour of given indicators.

4.1 Joslyn production and monitoring organization

Figure 26 and Figure 27 present TEPC organization charts.

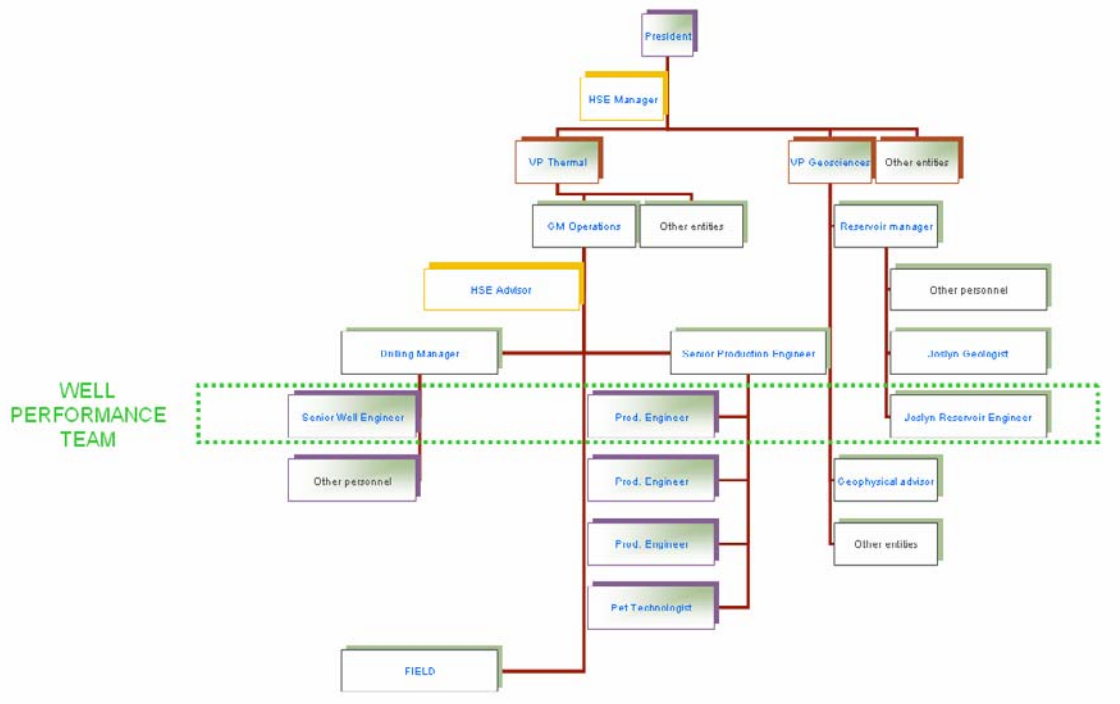


Figure 26 TEPC Simplified Organisation Chart – Calgary. The personnel involved to various degrees in the monitoring aspects of JOSLYN SAGD operations highlighted in blue

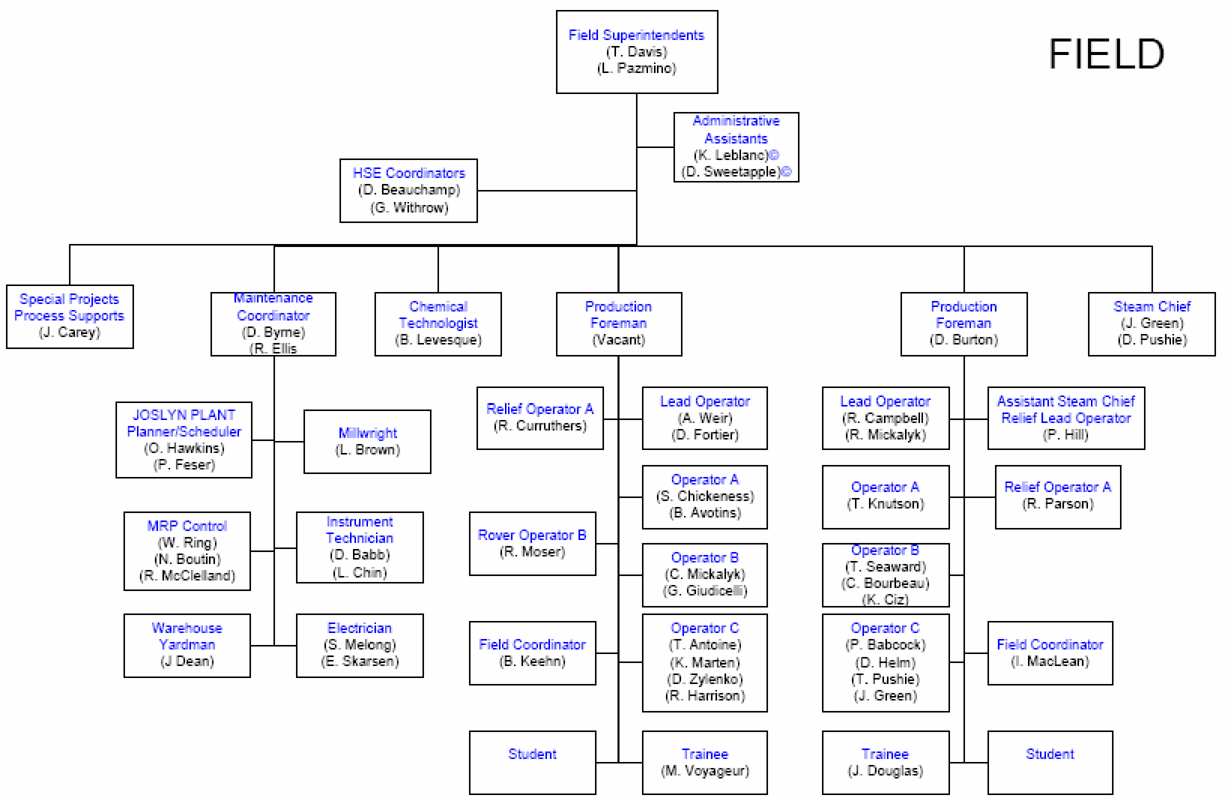


Figure 27 TEPC Joslyn SAGD Field Operations Organisation Chart – Joslyn Site

Personnel involved in HSE monitoring are located both on Joslyn site and in Calgary. HSE monitoring includes several stacked hierarchical levels answering ultimately all to TEPC President. It can be divided into the following groups:

- On site operation staff including RSES: their main HSE responsibility lies in conducting day to day production operations. A designated RSES has ultimate on site HSE responsibility.
- Production and Well Engineering staff: their main HSE responsibility lies in designing and overseeing, from a technical point of view, production operations (including monitoring).
- Geosciences Staff: they provide technical support to the Production and Well engineering staff in geosciences matters, including HSE / monitoring aspects.
- Thermal B.U. and Geosciences management and TEPC President: they ensure an efficient flow and information between various entities and long term availability of means for ensuring safety. The RSES answer to Thermal B.U. management.

As field surveillance is a transverse issue involving well, production and reservoir aspects, a transverse Well Performance Team organisation is in place. The Well Performance Team responsibility is to diagnose and synthesize well and reservoir behaviour and optimize production operations. HSE aspects of field (well and reservoir) surveillance is fully part of the Well Performance Team responsibility.

4.2 Operating Practices: Description and Key Insights

The following paragraph describes JOSLYN SAGD field operating practices and key insights in the matter (in bold blue).

4.2.1 Start-up steaming strategy

The steam rates ramp-up should be very slow and gradual to minimize tubular and reservoir heat stress. Blanket gas should be connected and checked prior to any steam injection to ensure the Bottom Hole Pressures are measured properly.

Usually ~5m3/d (for the injectors and ~700/800 kPa of surface steam injection pressure for producers) are injected in the long string for about 3 hours. Then rates are increased by steps of 10 m3/d (or 50 kPa for producers) every 2 hours until 50m3/d are reached (or 1350 kPa of surface steam injection pressure for producers). The first well returns (predominately water with solids) is produced for a day or two to the PAD's tank until the returns are clean enough to be treated at the plant. The Bottom Hole Pressure increases slowly and takes about 2 days to stabilize at 1200 kPa.

4.2.2 Fluid measurement to and from wells

Fluid produced or injected into wells can be ascertained by different techniques:

- Measurement = direct measurement
- Calculatation = calculation using other measurements
- Engineered Estimatation = estimation based on tests and sampling

Injector data:

- during circulation,

Volumes and Rates	status	methods
Steam injected per well	measured	orifice plate at well head on Long Tubing

		(LT)
Steam returns per well	estimated	Using 90% return and 98% BSW
Bitumen production per well	estimated	Using 90% return and 98% BSW

1. **Orifice plates on Short Tubings (ST) are not considered reliable to measure returns due to the presence of wet steam and bitumen.**

2. 10% Leak-off obtained from Injectivity Tests. 98% BSW obtained from cuts, then re-allocated based on the water rate measured at the plant level.

- during injection,

Volumes and Rates	status	methods
Steam injected per well	measured	orifice plates at well head on LT, ST

Producer data:

- during circulation,

Volumes and Rates	status	methods
Steam injected per well	calculated	(Pad steam total – Injection)/nb of Producers in circulation
Steam returns per well	estimated	using 90% return and 98% BSW
		using 90% return and 90% BSW
Bitumen production per well	estimated	idem

1. During circulation of the injector, BSW is estimated at 98%. During semi-SAGD, BSW of the producer returns is estimated at 90%. Then re-allocated based on the water rate measured at the plant level.

The main limitation during circulation is the lack of direct measurement of injected steam volume in each producer. Future pad design will consider how this might be remedied.

- during production,

Volumes and Rates	status	methods
Liquid produced per well	measured	Coriolis meter on Test Separator
Water produced per well	measured	AGAR watercut meter on Test Sep
Bitumen produced per well	measured	AGAR watercut meter on Test Sep

1. Measured water and bitumen rates are re-allocated based on total rates measured at the Plant level.

Pad data:

Volumes and Rates	status	methods

Steam Injected per pad	measured	Vortex Flowmeter
Liquid produced per pad	calculated	allocation from plant numbers
Water produced per pad	calculated	allocation from plant numbers
Bitumen produced per pad	calculated	allocation from plant numbers

Direct measurement of liquid rate exiting each pad would be very valuable to confirm allocation numbers if reliable technology can be sourced.

4.2.3 Material Balance

Production phase:

Steam: the injected steam volume is obtained from the addition of the long and short string orifice flow meters. There is no steam allocation done on injectors of well pairs in production. This option was preferred as it was deemed more accurate than using a main steam meter at the plant and back-allocate the volumes per well, the reason being that there is some utility steam that is used at the pads that can not be measured.

Water & Bitumen: the daily production volumes are measured at the plant from tanks levels and export/import volumes (currently trucks, then sales and diluent pipelines).

The water is measured at the plant using the same principles.

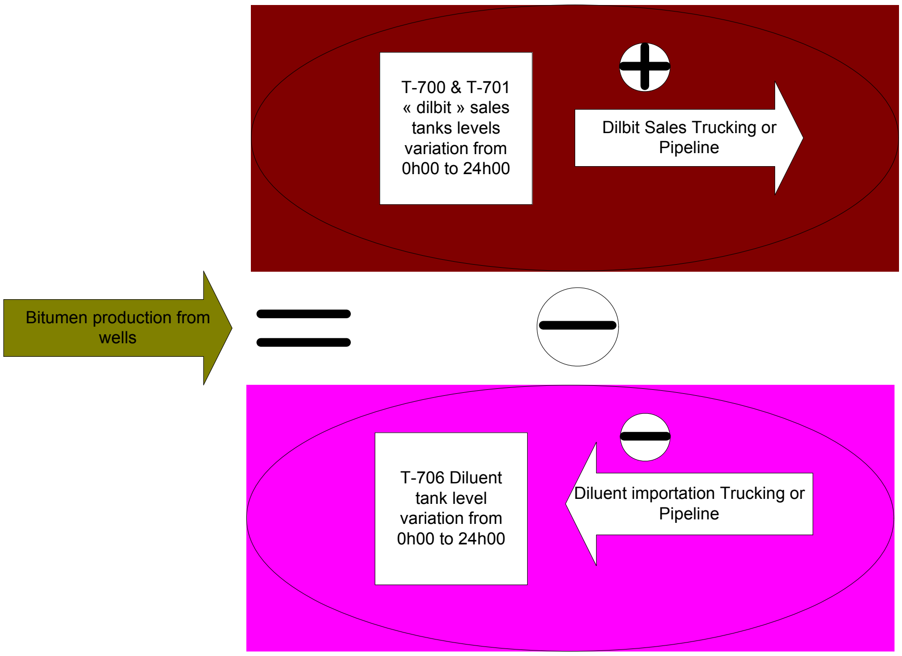


Figure 28 Field level bitumen volume reconciliation

Then these water and bitumen volumes are re-allocated per wells according to allocation factors calculated from the welltests (Total volumes measured by Coriolis meter and water/bitumen fraction measured with microwave based water-cut meters).

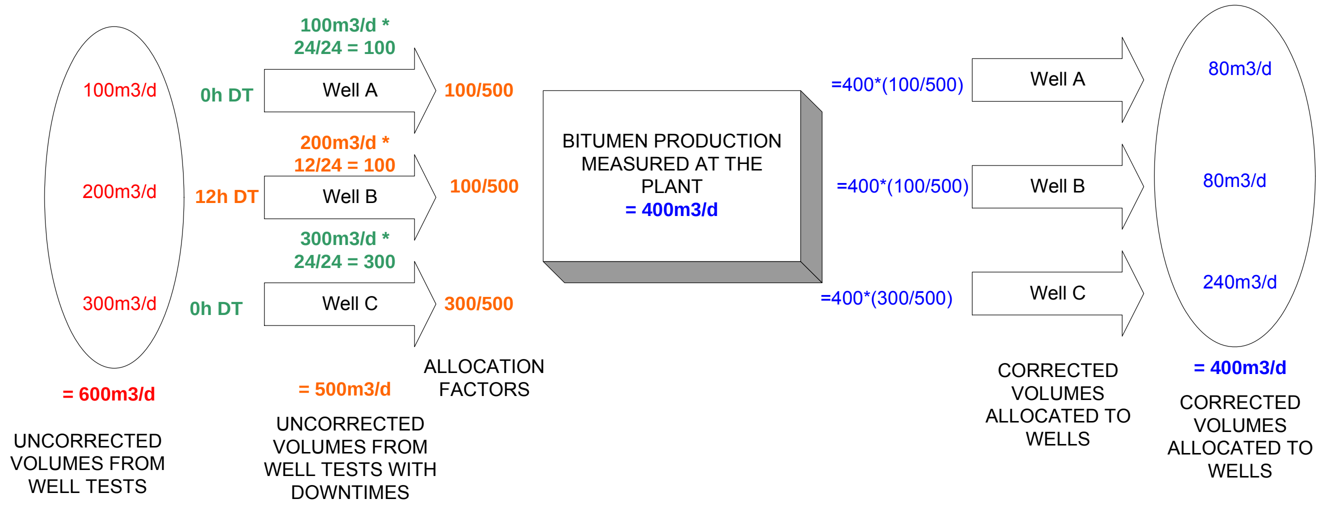


Figure 29 Well test data reconciliation

Circulation and Semi-SAGD phase:

Steam: for injectors, it is identical as in the production phase (Orifice flow meters on the long string). For producers, as there are no steam meters on the long string, an allocation/calculation must be done: The steam allocated per producer is the difference between the steam measured on the main steam meter of the PAD minus every volumes injected down the injectors, divided by the number of producers in circulation.

Water & Bitumen: the condensed steam being wet, the volumes measured with the orifice plates of the producers and injectors are extremely inaccurate. Thus, well-tests are entered based on engineered estimates and they are used to calculate the bitumen and water volumes. Their factors are experience based, according to injectivity tests results and water-cut sampling. The following parameters are used for these welltests: total fluid returns equal 90% of the steam injected in the well pair (10% leak-off in the reservoir is assumed). During the circulation, the watercut is 98%; during semi-SAGD periods it is 90%.

4.2.4 Pressure monitoring at SAGD wells

Injector:

- during circulation,

Pressures	status	methods
Surface Injection Pressure	measured	Pressure Transmitter on LT
Toe Bottom Hole Pressure	estimated	using pressure loss calculation
Heel Bottom Hole Pressure	measured	Blanket gas in casing
Surface Return Pressure	measured	Pressure Transmitter on ST

- during injection,

Pressures	status	methods
Toe Surface Injection Pressure	measured	Pressure Transmitter on LT

Toe Bottom Hole Pressure	estimated	using pressure loss calculation
Heel Bottom Hole Pressure	measured	Blanket gas in casing
Heel Surface Injection Pressure	measured	Pressure Transmitter on ST

The only missing pressure measurement is the bottom hole pressure at the toe of the Injector. **This pressure can be estimated with a reasonable degree of accuracy (+/- 50 kPa) using pressure loss correlation from actual injection rate and surface injection pressure.**

<u>Producer</u>:

- during circulation,

Pressures	status	methods
Surface Injection Pressure	measured	Local Pressure Gauge on 3 ½”
Toe Bottom Hole Pressure	estimated	using pressure loss calculation
Heel Bottom Hole Pressure	measured	Blanket gas in 7” tubing
	measured	Bubble gas in 2 3/8” tubing
Surface Return Pressure	measured	Pressure Transmitter on emulsion line

- during production,

Pressures	status	methods
Heel Bottom Hole Pressure	measured	Bubble gas in 2 3/8” tubing
Pump Intake Pressure	measured	Bubble gas in ½” coil
Surface Return Pressure	measured	Pressure Transmitter on emulsion line

4.2.5 Pressure and Temperature monitoring within the reservoir

Reservoir pressures and temperatures can be monitored independently from the well pairs operating pressures and temperature with vertical observation wells.

In Phase 1 and 2 area:

- 17 cased wells are equipped with Thermocouple strings covering the reservoir interval. Steam chamber presence, top and base depths, temperature, and calculated pressure can be determined at each well location. In addition, signs of heat convection in the warm bitumen above the steam chamber top could be detected to determine the location of a shallower pressure propagation front, or infer some fluid movement in shallow permeable intervals. The temperature data is obtained twice a day.

- 4 cased wells are equipped with 3 to 5 permanent vibrating wire piezometers cemented behind the casing at different depths from reservoir up to the Wabiskaw Kcw3 layer. The pressure is transmitted every day to the operations team and recorded hourly.

4.2.6 Operating pressure over life of well pair

The current plan (post steam release) is to operate all SAGD well pairs during circulation, semi SAGD and the first years of SAGD at 1,200kPa(g). Cpoupled geomechanical / reservoir studies are ongoing to determine the long term pressure limit and when to switch to it. The current plan considers lowering the pressure to 1,000kPa(g) once the steam chambers have reached the reservoir top and /or coalesced. No well pair is in this situation so far, and taking into account the phase 1 well being on production for nearly 3 years, it maybe a few years before reducing the operating pressure and will depend on the individual well pairs and their steam chamber development Continuous monitoring of the SAGD cumulative production and pressure front expansion in the reservoir will allow updating this analysis.

The 1,200kPag target pressure applies to the heel BHP on a real time basis. Steam rates are set accordingly. By construction, the toe BHP should be very close to the heel BHP (<30kPa difference based on Qflow simulations and typically lower than the heel BHP in SAGD mode), and the pressure in the steam chamber should be lower than the injector BHPs by a few tens of kPa, based on UTF and Phase 1 data. There is however also a control of the Toe BHP estimation and of surface injection pressures as part of the well pair monitoring and data quality check.

Historically, the 1,200kPag figure was settled upon after the steam release incident. It was based on a conservative fracture pressure gradient of 20kPa/m, an injector depth of 85 m, and an additional 500 kPa safety margin.

Following the post steam release geo-mechanical review, this 1200 kPag pressure value is perceived to correspond, more to the point, to a depth of 60 m (expected top steam) and the same conservative fracture gradient without additional pressure margin.

Until the long term outlook for the maximum operating pressure limit is more clearly justified by geomechanical studies, the monitoring of potential pre-release warning signs will strongly be relied upon to ensure safety.

4.3 Monitoring indicators and principles governing reactions to behavioural deviations

The following paragraphs detail, with a focus on HSE aspects, the rationale behind the main monitoring items: what is being monitored, how data is recorded and what actions may be undertaken in case of deviation from expected behaviour, etc. Reservoir, Well and Production optimization aspects are not detailed. How all monitoring actions listed hereafter are practically conducted within TEPC organization is the subject of a dedicated Monitoring procedure in the final stage of approval.

4.3.1 Rates and Pressure Monitoring

Day to day monitoring of pressure is a top priority. There is manual and automatic monitoring. At no time will the injector bottom hole pressure at the heel exceed 1200 kPa(g).

- High alarm set point at 1200 kPa
- High Pressure Shutdown at 1250 kPa

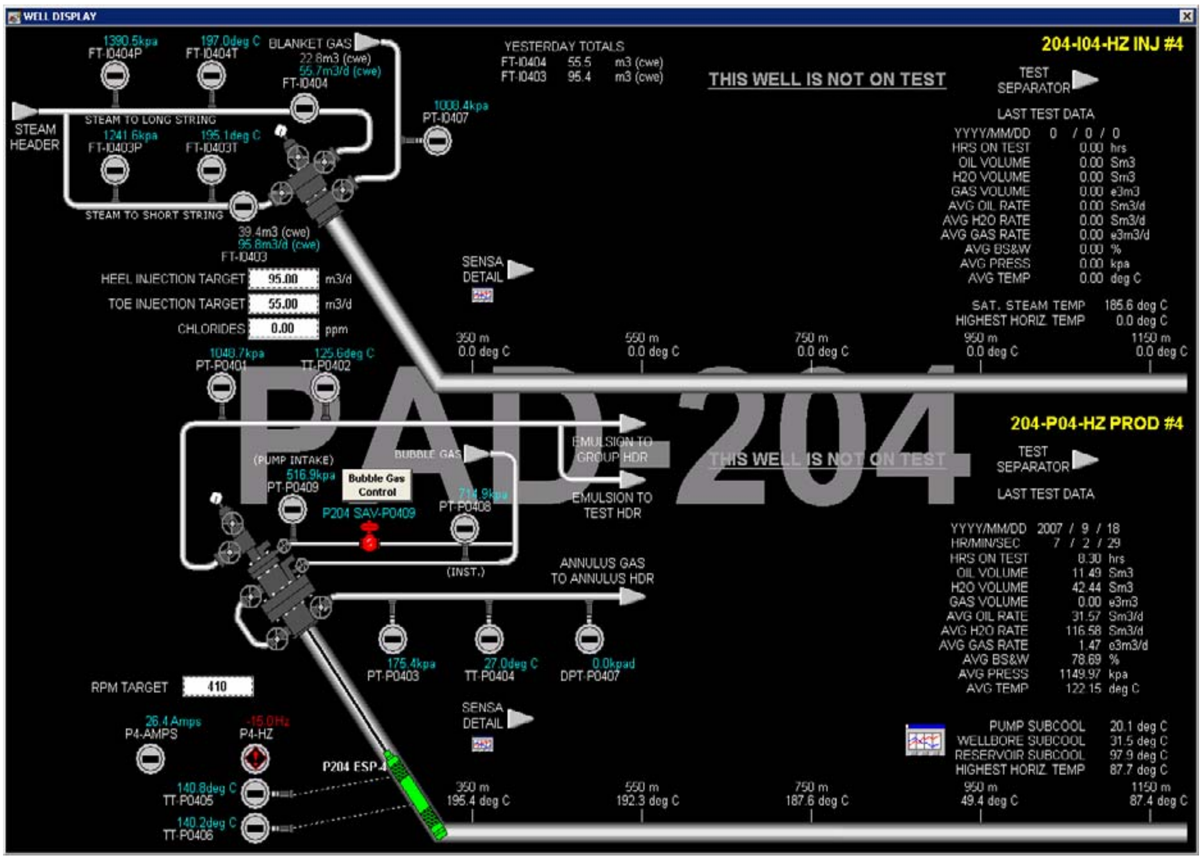
Bottom Hole Pressure is measured at the heel of the injectors with blanket gas and Surface Injection Pressure to the heel is measured with a gauge.

At the toe, only the Surface Injection Pressure is directly measured with a gauge. The toe Bottom Hole Injection Pressure is extrapolated from surface pressure and injection steam rate using actual historical correlations and Q-Flow simulation results. Good correlations and consistent values have been observed to date. Depending on the expected Surface Injection Pressure to the toe for a given steam injection rate and maximum bottom hole pressure of 1200 kPa, an alarm value is set for the Surface Injection Pressure.

Correlation between Steam Injection rates and Injection Pressures is essential and normally very robust in steady-state operation. Any significant deviation from the trend is immediately investigated and injection rates or pressures will not be increased unless the cause of the problem is clearly identified. Validation from the Calgary Well Performance Team is required. Normal practice would be to reduce pressures while investigating the problem.

When a chamber is being developed and steam is injected to bring the chamber pressure up, the pressure build-up gradient is monitored closely. Depending on the size of the chamber, different gradients are expected.

In order for the Calgary production team to monitor this, there is full visibility of the control panel in Calgary via a remote connection (see example below).



WELL DISPLAY

YESTERDAY TOTALS
FT-I0404 55.5 m3 (cwe)
FT-I0403 95.4 m3 (cwe)

THIS WELL IS NOT ON TEST

204-I04-HZ INJ #4

LAST TEST DATA
YYYY/MM/DD 0 / 0 / 0
HRS ON TEST 0.00 hrs
OIL VOLUME 0.00 Sm3
H2O VOLUME 0.00 Sm3
GAS VOLUME 0.00 e3m3
AVG OIL RATE 0.00 Sm3/d
AVG H2O RATE 0.00 Sm3/d
AVG GAS RATE 0.00 e3m3/d
AVG BS&W 0.00 %
AVG PRESS 0.00 kpa
AVG TEMP 0.00 deg C

SAT. STEAM TEMP 185.6 deg C
HIGHEST HORIZ. TEMP 0.0 deg C

HEEL INJECTION TARGET 95.00 m3/d
TOE INJECTION TARGET 55.00 m3/d
CHLORIDES 0.00 ppm

RPM TARGET 410

204-P04-HZ PROD #4

THIS WELL IS NOT ON TEST

LAST TEST DATA
YYYY/MM/DD 2007 / 9 / 18
HR/MIN/SEC 7 / 2 / 29
HRS ON TEST 8.30 hrs
OIL VOLUME 11.49 Sm3
H2O VOLUME 42.44 Sm3
GAS VOLUME 0.00 e3m3
AVG OIL RATE 31.57 Sm3/d
AVG H2O RATE 116.58 Sm3/d
AVG GAS RATE 1.47 e3m3/d
AVG BS&W 78.69 %
AVG PRESS 1149.97 kpa
AVG TEMP 122.15 deg C

PUMP SUBCOOL 20.1 deg C
WELLBORE SUBCOOL 31.5 deg C
RESERVOIR SUBCOOL 97.9 deg C
HIGHEST HORIZ. TEMP 87.7 deg C

Figure 30 Example of Remote Control Panel Display

4.3.2 Material Balance ratios

Table 2 defines the ratios that are being monitored on a well by well basis:

	Voidage Replacement	**Water Balance**	**Fluid Balance**	**Energy Balance**
Instantaneous Ratios , Cumulative Ratios	VRR , CVRR	WSR , CWSR	TFSR , CTFSR	SOR , CSOR
Ratio of	Steam injection minus	Water production	Water + Oil	Steam injection

	water production		production	
To	Oil Production	Steam injection	Steam injection	Oil production
represents	Liquid water fraction in chamber	Water storage in chamber	Fluid storage in reservoir	Thermal efficiency

Table 2: Material Balance Ratios Monitored on a Well by Well basis at Joslyn. The instantaneous ratios are based on rates; the cumulative ratios are based on cumulative volumes. Steam rates are expressed in cold water equivalent volumes.

The most critical ratio for Steam Release prevention is the Water Steam Ratio (WSR) which is an indication of how much water is lost to the reservoir.

If the Water Steam Ratio (WSR) goes below 0.7, it will be investigated closely as this could be an indication of excessive steam being lost. Of course, at early stages of a steam chamber development this ratio is expected to be lower partly because the natural leaking in the reservoir is often higher relative to the chamber size. To further investigate such low WSR values, the Voidage Replacement Ratio (VRR) relates the net water loss to the volume of space created in the chamber by bitumen production. If this ratio is greater than 1 at stable operating pressure and production sub cool, chances are that a large portion of the steam is leaking away from the chamber.

Material balance ratios like WSR are also greatly influenced by operating conditions, e.g. increasing chamber pressure, temporary production shut in. Therefore both the actual ratios and their dynamics with time are monitored and checked versus the operating conditions. Table 3 summarizes how the WSR and CWSR values are typically interpreted.

Water Balance		**WSR** – Inst. Water to Steam Ratio	**CWSR** – Cum. Water to Steam Ratio
To track		Water balance, and variations in time of liquid storage, liquid level and subcool	Cumulative water loss in the reservoir, liquid content of the steam chamber.
Typical values (constant pressure and sub cool)		0.7 – 1.0 WSR = 1 / (VRR / WC – VRR + 1)	0.85 – 1.0 CWSR = 1 / (CVRR / CWC – CVRR + 1)
Too low	Operating strategy	- Chamber filling up, not drained correctly, producer rate too low, liquid level and subcool will increase - Period of increasing chamber pressure - Steam flashing at the pump preventing maintaining low subcool	- Chamber full of water, poor conformance, poor drainage.
	Reservoir anomaly	- poor reservoir quality preventing proper drainage, poor conformance, sections of the drain flooded: revise heel/toe injection rates split. - excessive leak to: an aquifer, a neighboring chamber, reservoir too cold	- Poor reservoir quality: high trapped water saturation in chamber, heterogeneities, producer in shaly area. - Excessive leak to: an aquifer, a neighboring chamber, reservoir too cold (water saturation, sand dilation, fracturing).

		(water saturation, sand dilation, fracturing). Consider reducing pressure.	Consider reducing pressure.
Too high	Operating strategy	- Chamber is emptying, average subcool decreasing, productivity and conformance may improve. Watch for the risk of steam breakthrough/flashing. - Period of decreasing chamber pressure	- Low liquid content in the chamber,
	Reservoir	- Excessive water inflow from: an aquifer, a neighboring chamber.	- Excessive water inflow from: an aquifer, a neighboring chamber.

Table 3. Water Steam Ratio Interpretation Screening Table

In cases where operating conditions make it difficult to identify a reservoir related anomaly, the well pair's operating conditions are immediately modified to clear the ambiguity. For instance:

- On a circulating well pair with higher than expected injection rate. All returns are shut and down-hole pressure is stabilized. The injection rate should decrease to a reasonable leak-off rate.
- On a SAGD well with pressure increasing after a shut down, where the steam rate is higher than expected. The pressure is held constant for a while until it stabilizes. The steam rate should converge to a steady state value that is more easily interpreted.

Reservoir simulations can also be made in order to sort normal transient behaviours and chamber geometry related effects from issues with reservoir confinement.

4.3.3 Temperature Monitoring

At Joslyn, all the producers are equipped with optic fibre cables throughout the length of the well for temperature monitoring. The temperature profiles of each well can be accessed in real time as well as historically.

- On producers on circulation mode, the temperature of steam gives access to pressure all along the well.

- On producers on SAGD mode, the temperature profile along the well is of great help to determine the chamber geometry. See below for a typical view of the optic fibre.

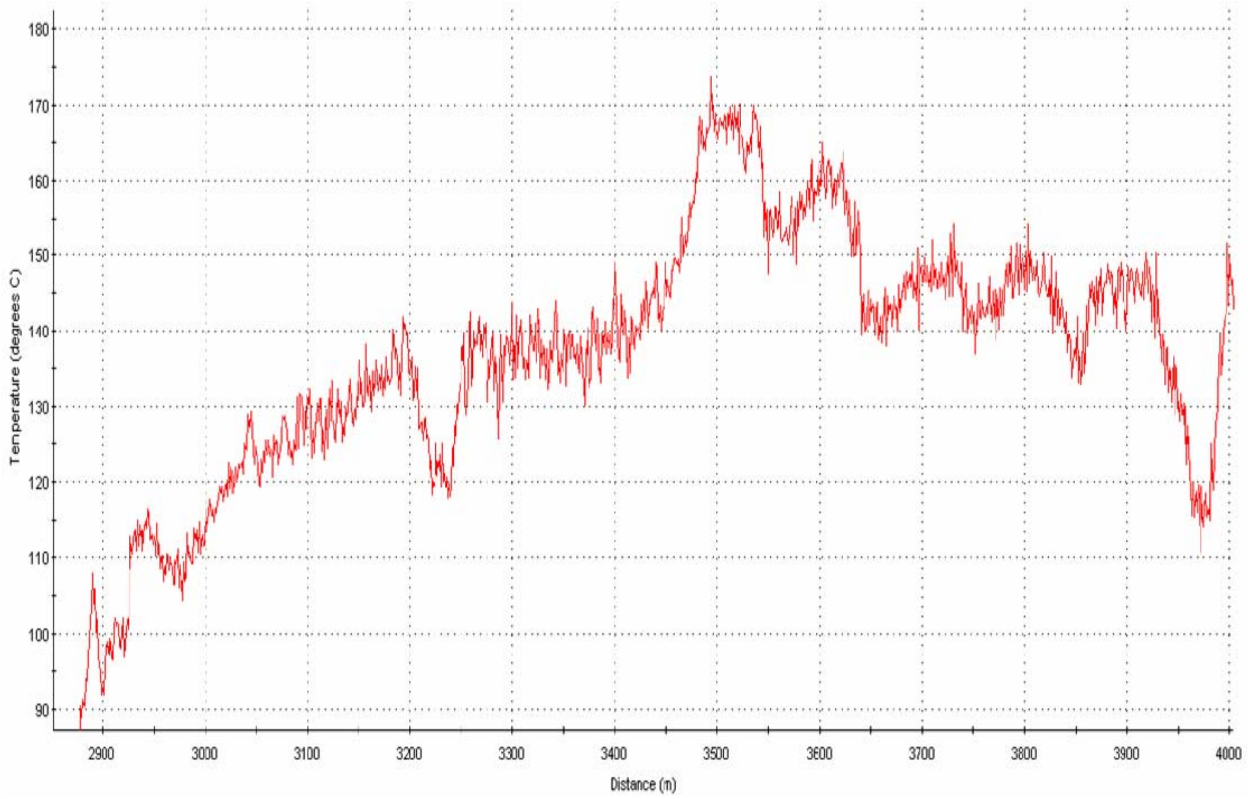


Figure 31 Example of real time optic fibre temperature reading

Production well temperature logging allows inferring SAGD chamber conformance which is an important aspect of SAGD production. Such understanding is background information of interest to managing safety of SAGD operations.

4.3.4 Observation wells (Thermocouples and Piezometers)

Observation wells can be used to assess the vertical movements of the steam chamber and the pressure front ahead of the steam chamber. Figure 32 presents a map of the existing observation wells over Joslyn SAGD. As there are no pressure monitoring wells located close to currently producing SAGD wells, drilling more pressure wells is being considered.

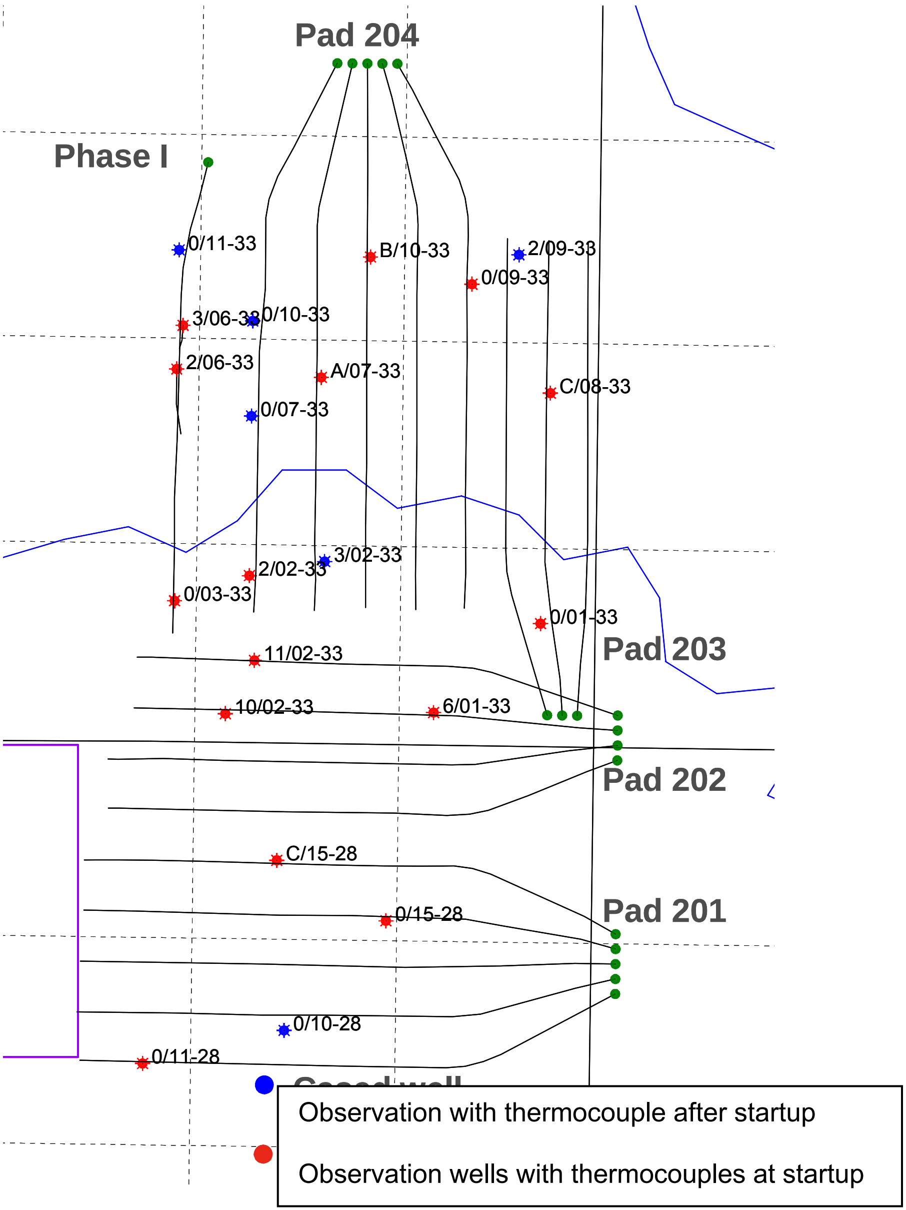


Figure 32 Phase1+2 Observation well lay out.

On a temperature observation well, a section with uniform steam temperature allows for a steam chamber top and bottom to be picked. The shape of the temperature profile above the steam chamber top can be analyzed to relate deviations from purely conductive heat transfer to fluid movement and chamber upward pressure propagation, although this technique does not give a very accurate determination of the top of the chamber pressure. The observation well data can be plotted as seen below.

0

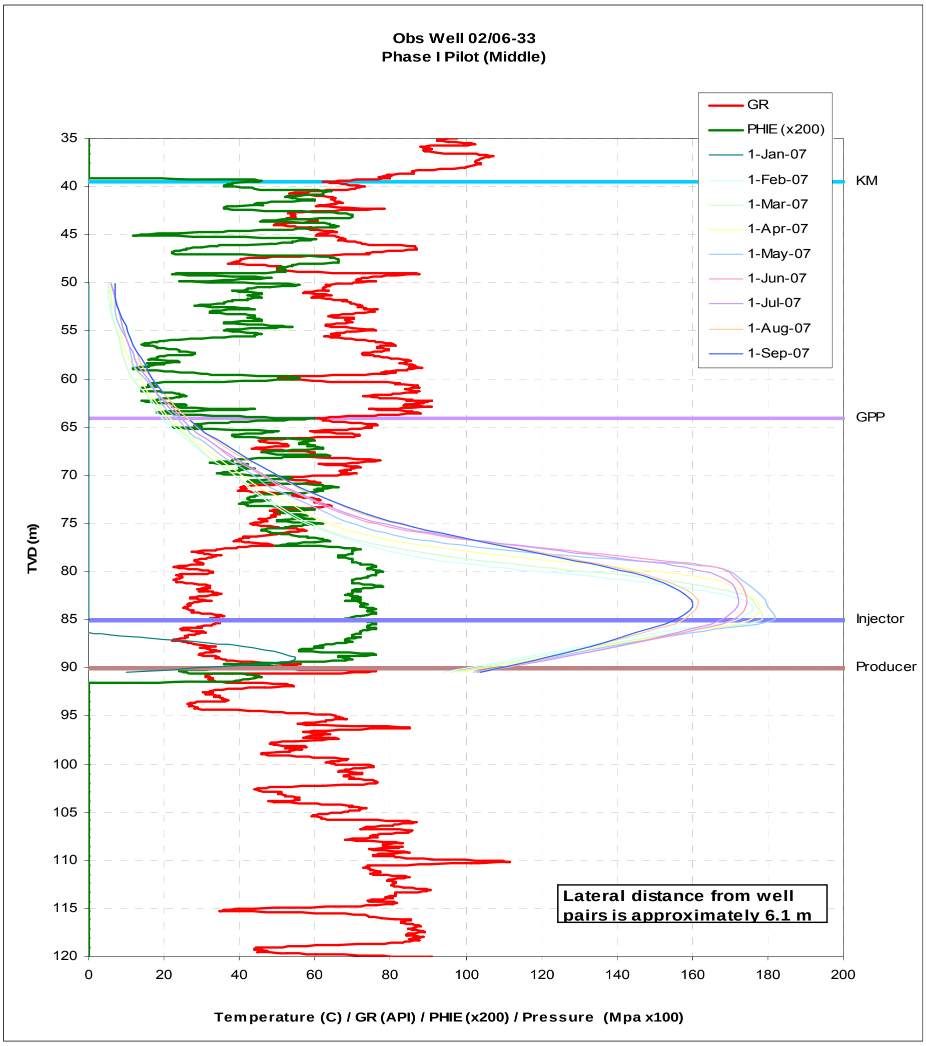


Figure 33 Example of observation well temperature data

The graph X axis is the temperature in Celsius and the Y axis is True Vertical Depth. The Green is porosity and the red is Gamma Ray. The graphs with different colours are temperature plotted against depth. The different colours represent different times. This data can be plotted at any frequency and for any time period needed. If abnormal temperature development is observed vertically or horizontally, an investigation will be performed and steam will be shut in if necessary.

Understanding vertical steam and pressure movement within the reservoir is a key component of long term SAGD safety of operations management.

4.3.5 Surface Heave Monitoring

The SAGD produced formation at Joslyn is very shallow (<100m TVD) and it is therefore anticipated that monitoring ground elevation changes over the area should provide not only valuable information as to what is happening in the reservoir regarding steam chamber development but also potential loss of steam confinement.

Currently all the active well pairs are equipped with heave monuments installed along the horizontal section of the drains. Elevations of all the heave monuments are recorded every 2 weeks with an accuracy of about 1 cm.

In an attempt to expand the monitored area and qualify a system providing real time information, a surface heave monitoring pilot was initiated in the spring of 2007 to evaluate the performance of 2 methods, i.e. tiltmeters and In-SAR (INterferometric Synthetic Aperture Radar).

- Currently 131 **tiltmeters** have been installed to cover the build-up sections of the pilot well pair and well pairs #4 and #5 on Pad 204. Data are recorded continuously and a ground movement video over the last 24hrs is posted on a secured website on a daily basis. Additionally every abnormal event is analyzed and a specific report is provided by a service provider to TEPC.

  The objective of this test is to ascertain if a tiltmeter network covering the build-up sections of SAGD wells could detect a potential cement sheath or casing failure and a steam migration along this leak path. In such a case, sufficient time would be available to shut the steam injection down in the concerned well pair before the steam has any chance to pressure up a shallower layer.

- 60 **In-SAR Double Artificial Corner Reflectors** have also been installed to cover the horizontal drains of these same 3 well pairs and part of the build-up sections. This overlap between the two monitoring networks will allow for comparison of performance of the 2 methods. The main objective of this test is to ascertain the ability of In-SAR to provide data on the steam chamber development over a larger area. Ground movement images are officially provided every 2 weeks, but new data are collected every 2 or 3 days and reviewed by the service provider. In case of abnormal observation, TEPC would be immediately notified.

The first overall objective of this surface heave monitoring pilot at Jolsyn is to establish if the recorded data are reliable (consistency, frequency, resolution etc…). The second objective is to determine how to use these data and correlate them with actual sub-surface events.

With only a few months of historical data from both systems, current monitoring is mainly based on trend follow-up. Any change of trend (inversion or acceleration) would be considered to be an event and would be investigated.

In parallel a data management support system needs to be developed to be able to gather all available information such as ground movement, production data and steam chamber development models. Correlations between these data should allow for a better understanding of ground movement tendencies and possibly predictability once enough historical data are available.

4.3.6 Wabiskaw and/or Upper McMurray Gas Streak Pressure Monitoring

Monitoring the pressure in the water bearing sandy layer of the Wabiskaw or gas bearing UpperMcMurray sandy streaks is another technique being considered to prevent another Steam Release Event. A breach of the intermediate seals below the Wabiskaw would lead to an increase of pressure in the Wabiskaw or Upper McMurray gas streaks that may be detected by nearby monitoring wells.

Considering the shallow depth of the levels considered for monitoring, if a SAGD–related Wabiskaw pressure build-up is detected, actions to be taken may include such drastic actions as emergency steam chamber blow down from production and possibly injection wells.

The feasibility of such a monitoring scheme (meaning of a given pressure value and build-up rate, well spacing necessary to ensure an efficient field coverage, etc.) depends on the layer effective permeability, which has yet to be properly ascertained though testing is in progress.

4.4 Field Production Status Reminder

Following the May 18th 2006 Steam Release at the Joslyn field the following actions were mutually agreed between the operator of the Joslyn field and the AEUB as the official oil and gas production overseeing body:

- Immediate neighbouring well pairs to the well pair closest to the steam release shall be closed pending further notice.

- Steam shall not be injected at pressure higher than 1200 kPag (@ bottom hole conditions) at any time on any well of the Joslyn phase. This requirement specifically addresses all phases of a SAGD operation (circulation, semi-SAGD and SAGD).

Since then,

- TOTAL continued operations starting up all pairs except 204-I1P1 neighbours. The detail of each well status is illustrated on Figure 34 below.

- Operations were suspended from October 2007 on well pair 204-I3P3 as a consequence of the observation of an anomaly on the seismic cube above this well pair. A specific plan was defined and corresponding actions undertaken to allow for further characterisation of the safety situation on that particular well and resuming safely the operations. The details of the action plan, results and way forward is not detailed in the present report.

- TOTAL has issued a request for starting up well pair 202-I4P4 based upon preliminary conclusions of the work documented in the present report (such conclusions and work were not disclosed to AEUB). TOTAL expects to receive approval of this request from the AEUB pending a review of the present report.

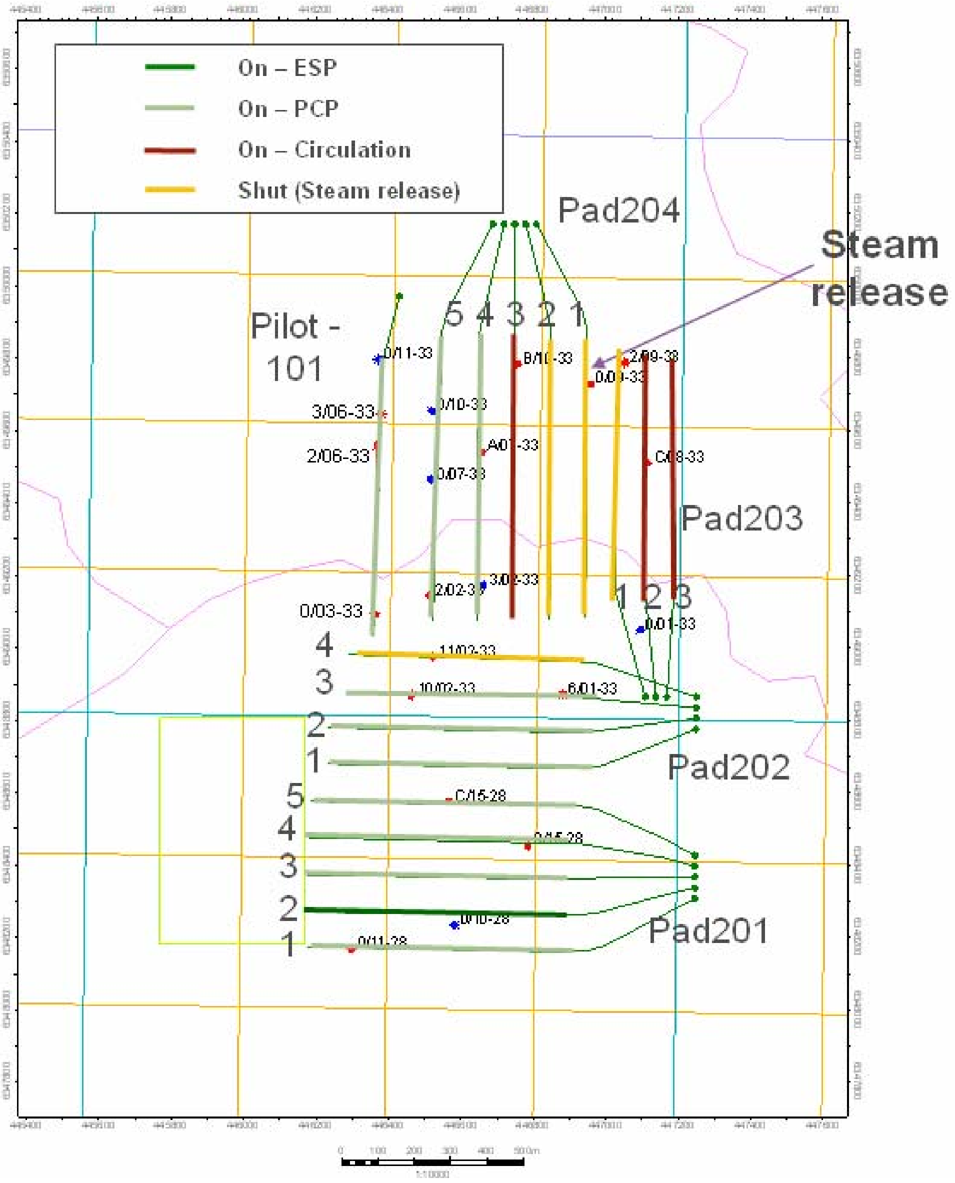


Figure 34: Well Production Status (November 2007)

4.5 Further geo-mechanical studies

Further geo-mechanical studies are on-going to:

- gain a better understanding of all possible mechanisms of steam release to surface, and refine the operating pressure strategy,
- detail the monitoring required to reduce any remaining risk to an acceptable level,

Rather than testing specific scenarios as in the investigation of the steam release incident, a comprehensive assessment of uncertainties on the major parameters will be performed. Modeling will use a coupling between the reservoir and mechanical software (namely CMG Stars and VISAGE), in order to investigate the combined effects of dilation or fracturing and steam chamber pressure propagation. This work is bordering R&D for some parts and true R&D for other parts.

This study will be integrated down the line into a revised overall safety review (re-doing in further details some of what has been done and is presented in the present report):

Part 1 - Alea [probability of negative event happening] characterization

- What are the key factors governing potential steam release (geo-mec, geology, reservoir, cement, etc.)?
- What is the uncertainty on these? How do they combine?
- What is the safe domain (function of admissible probability of occurrence levels)?
- What production would we obtain limiting ourselves to a 100% safe domain?
- If in limited but non nil risk domain, what is the relationship between lowered risks / degraded recovery and lifting ability (i.e. impact of pressure lowering at various time on risks and production)?

Part 2 - Viability of an approach relying upon real time monitoring for ensuring safety

- In case of failure, can we frame the failure behavior (what would happen, how fast would it happen, how much steam would we lose before last seal release, etc.)?
- What monitoring would ensure that failure be detected soon enough to alleviate risks?
  - Based upon failure framing, define Pressure thresholds for real time monitoring.
  - Based upon failure framing define Surface Heave thresholds (absolute lift / lift speed / lift contrast / etc.?) for real time monitoring.
- Define precisely contingency plan for emergency SAGD blow down.

Part 3 - Characterization of the consequences of a steam confinment loss

- Physical consequences of a steam blow out.

4.6 Well integrity improvements

The following is summary of key learnings drawn from JOSLYN Phase 2 project related to well integrity.

From a safety stand-point well integrity involves three main components: intermediate casing, cement sheath and well head.

4.6.1 Intermediate casing

Thermal expansion of cemented casing in SAGD well pairs leads to full-body yielding of tubular sections and introduces potential for operating failure. Structural response in this application is governed by post-yield material properties and tubular geometry (pipe weight, ovality, slot shape and slot density).

A specific and comprehensive study was conducted in 2007 in order to review/confirm existing well casing selection and to make improvements as seems fit for future wells to be drilled at Joslyn. This study confirmed that current casing design was suitable. It is however strongly recommended to use premium connection for future wells rather than semi-premium connections.

4.6.2 Cement sheath

Integrity of the cement sheath around the intermediate casing is not only critical for zonal isolation behind the casing but also critical for the casing integrity itself. It is strongly suspected that poorly cemented casings will sustain significantly higher amount of localized thermal stress, eventually leading to casing connection failures.

TOTAL initiated in 2007 an exhaustive internal study on the behavior of cements in SAGD wells. An in-house simulation software was upgraded to incorporate thermal aspect. Thermal analysis of Joslyn SAGD wells taken into account actual well and completion architectures as well as operating conditions was performed to assess the temperature and temperature gradient that the cement sheath would be exposed to. These load patterns were used as input in the simulator to predict cement response.

From these simulations, it is believed that only a flexible cement can withstand the thermal stress in these wells. The commonly used Thermal Cement Class “G” with 40% Silica flour failed systematically very early on. Physical lab testing confirmed these findings.

In November 2007, during an operators workshop organized at Kananaskis, TOTAL shared these results with the Canadian oil sands industry in order to emphasize the need to investigate the use of flexible cement in SAGD wells despite the significant additional cost. Following this workshop, the cement was identified as the main priority for improvement by 12 participants. A Cementing technical committee (TOTAL, Chevron, ConocoPhillips, Devon, EnCana, Husky, IOR, MEG, Nexen, Pengrowth, Petro-Canada and Shell) has been created to specifically work on this topic.

Regarding the Cement Bond Logging issue, TOTAL pointed out to the SAGD community about 3 years ago that the standard logging tool commonly used by SAGD operators at the time was not suitable for logging large highly deviated casings. Since then several operators have concurred with this assessment and the Baker Segmented Bond Tool or SBT has become more widely used.

Joslyn wells were logged with these not adapted logging tools and therefore we do not have reliable cement bond logs for existing wells. However it has been clearly demonstrated that a good cement bond before steaming does not guarantee a good cement bond after steaming. TOTAL approach would be to first qualify cement that can withstand thermal stress and confirm the nature of the cement bond after steaming. If this can be achieved, the true value of cement bond logging thermal wells will be greatly enhanced.

4.6.3 Well Head

The design of the wellheads needs to allow for repair of leaky valves or seals in an efficient manner without having to kill the well first. This issue is particularly critical for the Injectors. Joslyn injection wellheads are currently being upgraded with Valve Removal Threads (VRT) to be able to easily replace damaged injection valves.

Wellheads for future wells should be designed so that there is full bore vertical access to both injection strings in the Injector so that backpressure valves or blank plugs could be installed to isolate these tubings if need be. This is not possible with current design.

As per TOTAL’s company rules, all eruptive wells should have been built with a dual safety barrier, i.e. a downhole shut-off system in case the primary barrier (wellhead) is not operational any more. Dual barriers are not currently implemented in thermal wells due to cost and temperature limitation of the required downhole equipment. Derogation to continue to operate SAGD wells with a single barrier will be internally discussed within the Company at Headquarters level, but meanwhile Total E&P Canada are actively working with suppliers on the design of a suitable downhole barrier for steam injectors, which are believed to be the real concern as opposed to producers.

4.7 Production, Monitoring, Safety Conclusion

Based upon the conclusions of the studies documented in the present report (and reports in reference) and other studies (e.g. safety status on 202-P4), the Joslyn SAGD operations subsurface safety status can be summed up as follows:

1. On well pairs in operations and 202-P4, the actions being taken to mitigate the effects at surface of the steam release (update of operating procedures implemented for Joslyn phases 1 & 2 SAGD operations and development of additional monitoring) have lowered the environmental and steam chamber confinement risks to a level warranting the continuation of SAGD operations at the present stage.

2. Further assessment of the efficiency of monitoring technologies (mainly surface heave and Wabiskaw / McMurray pressure monitoring) and an analysis of pressure management policies in term of risks vs. rate and recovery are necessary before firming up an optimum long term reservoir management policy on Joslyn. Current plans/expectations call for production at or under 1200 kPag until the pressure front reaches the top of the reservoir, then lowering the pressure to 1000 kPag for the rest of the well life. Geo-mechanical studies are on going to further firm up such plans that will be continuously updated based upon learnings draw from pressure and other monitoring.

3. Although proven by several successful pilot / small scale applications, SAGD is not yet fully mature. A significant amount work is still necessary to fine tune equipments and procedures required to operate safely SAGD projects in the fairly wide range of conditions foreseeable in Alberta (and beyond). Considering such large range of conditions, it is difficult to lay out precise and generic recommendations but it is clear that any project should address the following issues:

   a. Seal; characteristics including maximum admissible pressure.

   b. Well design: casing, cement, and completion.

   c. Operating pressure: philosophy including during startup, expected surface heave.

   d. Overall steam confinement monitoring: philosophy (including link with surface layout design) and means.

   It is expected that these issues be challenging in some areas (Joslyn being one) while they may be less of a concern in others.

5 ENVIRONMENTAL IMPACT OF THE STEAM RELEASE

The risk Assessment Report (Reference 7) is a consolidation of 4 separate environmental investigations that were performed to assess the impacts on the local biophysical components as a result of the May 18th, 2006 steam release event. These reports included (1) a Semi-Quantitative study, (2) Soils Delineation, (3) Surface Water Monitoring, and (4) Groundwater Quality investigations.

5.1 Semi-Quantitative

The semi-quantitative study was performed immediately after the steam release event and focused on determining the extent of the plume area including soils, vegetation and surface water bodies. Aggregate sampling was performed on the displaced material, leaf litter layer, surface soils and on surface water bodies within, down stream and up stream of the plume dispersion area. Water samples were obtained from the Joslyn Creek for four consecutive days after release and a small water body within the vicinity of the release point was sampled once. Representative samples from all matrices were submitted for laboratory analysis.

The results of this preliminary investigative program revealed that the plume of displaced material is comprised of oil sand, Clearwater clays and other subsurface aggregates. This material was dispersed from the source point in a southerly direction to a distance of approximately 1.0 km. The plume has an average width of approximately 0.1 km for the entire length. The depth of the displaced material ranges from over 2 cm near the release point to a fine dusting at the most southerly point.

5.2 Soils Delineation

The soils delineation program was designed for the quantitative delineation of the deposition plume and to determine underlying soils types in such a manner that the results could be used to conduct an Environmental Risk Assessment. The soils delineation program required the collection of background samples and samples from the deposition plume. Over 100 samples were obtained and submitted for laboratory analysis. These samples were analyzed for: BTEX (F1-F4), napthenic acids, major ions and salinity parameters.

Three distinct areas of deposition were identified as a result of the field observations and the practical knowledge of the investigators with depth of deposition being the key indicator. The “Unstable Area” is the area where the release has heaved the suface creating an undulating surface with numerous depressions and fissures. This area is within approximately 75 m of the release point and has an average depth of displaced material greater than 2 cm. This area is deemed by Deer Creek Energy Ltd. as a high risk area that presents a potential fall, entrapment and confined space hazard for both humans and ungulates. Temporary fencing is being placed around the site to act as a physical barrier but fence maintenance issues will ultimately reveal that a removal of the hazard is the best overall solution.

The “Near Deposit Area” is an area within 200m of the release point, down gradient of the Unstable Area where a deposition depth of 2 cm or greater exists.

The “Trace Deposit Area” is an area where the depth of deposition is less than 2 cm and is located beyond 200 m from the release point in a southerly direction. The depth of deposition in the trace deposit area starts at less than 2 cm and extends to the most southerly plume boundary where only a fine dusting on the vegetation was observed. The Trace Deposit Area has a greater aerial extent than the other two combined.

In all cases except for BTEX and two cases where elevated SAR was found, the results of the sample analysis were consistent with the background analytical results.

Most samples were found to have elevated BTEX concentrations in the F2-F4 fractions where the average F2 = 1,200 mg/kg, F3 = 16,000 mg/kg and F4 8,000 mg/kg exist.

5.3 Surface Water Monitoring

In combination with the water sample collection from Joslyn Creek which was performed in May during the semi-quantitative delineation program, water samples were obtained and submitted for analysis (BTEX F1-F2, dissolved metals, PAHs, napthenic acids and routine water quality analysis) in November from Joslyn Creek.

The results of the surface water investigation revealed that there is no evidence to suggest that there has been an impact on Joslyn Creek or the small water body adjacent to the release point as a result of the deposition of the displaced material. During sample collection, no evidence of hydrocarbon sheen was observed and the results of the laboratory analyses revealed that no chemical parameters above the applicable water quality standards or background levels exist in the water samples obtained from these areas.

5.4 Groundwater Investigation

As a result of discussions with Alberta Environment, seven monitoring wells were installed along a transect between the steam release point and Joslyn Creek. The wells were installed at depths between 6.9 and 10.7 metres below grade. All seven wells had similar stratigraphy with only minor lithological variations. Once the wells were developed and purged, water samples were obtained and submitted for laboratory analysis. The laboratory analysis included BTEX, F1 & F2, salinity, PAHs and napthenic acids.

The results of the groundwater investigation revealed that no appreciable hydrocarbon concentration exists in the samples obtained from the groundwater monitoring wells. Where hydrocarbons were detected the concentration is well below applicable guidelines.

5.5 Risk Assessment

An ecological risk assessment based on the results of the Soils Delineation, Surface Water and Groundwater investigation reports was performed by Axiom Environmental Inc. Three key ecosystem elements were identified as ecosystem receptors. These include generic plants, generic invertebrates, and the Meadow Vole (Microtus pennsylvanicus). These were identified because Plants and invertebrates uptake contaminants through soil and the Meadow vole has a high ingestion rate to body weight ratio and the use of the Meadow Vole to develop the Tier 1 Guidelines (AENV 2007a).

Section 8.0 of the Risk Assessment Report presents the recommendations identified as a result of this assessment. Three lists of recommendations were made in this section, one list containing primary and secondary recommendations for each of the deposition areas (Unstable, Near Deposit and Trace Deposit areas). The primary recommendations are listed as follows:

- Unstable Area – The unstable area should be inspected by an appropriate qualified safety professional to determine the limits of the unstable area and the restrictions necessary to ensure worker and public safety.
- Near Deposit Area – The displaced material in the near deposit will require removal, remediation or other management.
- Trace Deposit Area – “Due to the significant ecosystem damage involved in remediating hydrocarbons in the Trace Deposit, and significant uncertainty concerning the relevance of the Alberta Tier 1 Eco-Contact Guidelines to the LFH soils at this site, it is strongly recommended that no attempt at remediation be made for hydrocarbons in the Trace Deposit”. The second recommendation for the Trace Deposit Area is that a vegetation monitoring program be developed and implemented to assess the impact on vegetation in 2008 and 2010.

Deer Creek Energy Ltd. is currently assessing the remediation options for the Near Deposit Area. One preferred option is to move the displaced material back to the release point and use it to stabilize the area of release. This may require additional capping material that is suitable for re-establishing vegetation in the area. The second preferred option is to store the near deposit material on-site for future processing in the Joslyn North Mine processing facility. Once these remediation options have been assessed for effectiveness and practicality, Deer Creek Energy Ltd. will engage both the EUB and Alberta Environment to establish the most reasonably acceptable path forward.

5.6 Conclusions of environmental studies

Four environmental investigative studies have been conducted as a result of the Steam Release event of May 18, 2006. These studies were conducted to determine the aerial extent of the deposition of displaced material, and its affects on the local biota.

It was determined that:

- No adverse surface or groundwater impacts have occurred as a result of the event.
- Hydrocarbon concentrations in the displaced material on the soil surface exceed guideline criterion for fractions F2-F4.
- The unstable area should be assessed for establishing limitations and suitability and stabilized if possible.
- Those areas with a surface deposition of less than 2 cm should not be subjected to remediation attempts as the adverse impacts from vegetation removal to access the hydrocarbons would be detrimental to the local ecosystem.
- Those areas with a deposition depth of 2 cm or greater should be remediated or the displaced material removed.

ADVANCED GEOTECHNOLOGY

SITE RECONNAISANCE OF A SURFACE STEAM RELEASE AT THE TOTAL JOSLYN SAGD PROJECT, NORTHEAST ALBERTA, CANADA

TOTAL E&P CANADA LTD.

AUGUST, 2006 **AGI 10-295**

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PERMIT TO PRACTICE
ADVANCED GEOTECHNOLOGY INC.

Signature ____________________

Date ____________________

PERMIT NUMBER: P 4654
The Association of Professional Engineers,
Geologists and Geophysicists of Alberta

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EXECUTIVE SUMMARY

This report describes a site reconnaissance and preliminary interpretation of ground disturbance associated with a steam release or blowout on May 18, 2006 in the TOTAL Joslyn SAGD project located in northeast Alberta, approximately 60 km north of Fort McMurray. The surface expression of this event is centered approximately 90 m above the injection well depth in the McMurray Formation oil sands, near a north-south oriented SAGD well pair (Injection well – DECL et al 204-I1 Daphne 2-33-95-12 and production well DCEL et al 204-P1 Daphne 2-33-95-12).

An abandoned core hole and an observation well are located in close proximity to the location of the main steam release, which is marked by a triangular shaped crater with a central plug of less-disturbed sediment and rock. Surface uplift and subsidence zones are present in the vicinity of the main steam release zone. Tensile cracks and rotated ground are associated with a major "sinkhole" feature, located adjacent to the main steam release crater. The former is believed to have formed close to the same time as the steam release, in response to the ejection of a significant volume of soil and bedrock. Rock projectiles, some of which originate from the Clearwater shale formation, traveled as much as 300 m horizontally from the main crater, and probably greater than this distance vertically.

Further geophysical, geological and geotechnical investigations are recommended at the site to more completely characterize the mechanics of this blowout, and to aid in the design of mitigative measures and monitoring strategies for continuing operations in the project.

CONCLUSIONS

On the basis of a field reconnaissance visit to the site conducted on June 2, 2006 the following conclusions can be drawn:

1. A significant steam release or “blowout” event occurred on May 18, 2006 above a horizontal production and injection well pair, located in TOTAL’s Joslyn Phase 2 SAGD Project (Injection well: DECL et al 204-I1 Daphne 2-33-95-12 and Production well: DCEL et al 204-P1 Daphne 2-33-95-12)
2. A central steam vent marked by a crater, appears to be the source of most of the ejected rock and soil volume that spread out over a roughly elliptical shaped area, extending to the south-west.
3. Areas with ground uplift and ground subsidence were identified in the field and on preliminary topographic contour maps of the area, produced soon after the event.
4. There are several major ground fractures associated with the uplift and subsidence, some of which appear to have been a route for steam venting to surface.
5. A secondary steam release area was identified, approximately 50 m south of the main crater.
6. There is evidence of ground rotations, tilting, shearing and severe disturbance in the main crater area.
7. McMurray Formation oil sands with a strong petroleum odour were obtained from the bottom of the main crater.
8. Projectiles consisting of clay, silt, glacial till, peat, Wabiskaw Formation sandstone, and Clearwater Formation shale are scattered throughout the main debris fan that spreads out south-east of the main crater.
9. A fine silt covers the forest floor beyond the main blast area. It also coats the sides of trees along the blast affected area, and for some distance into the trees.
10. Shale projectiles have traveled in excess of 300 m horizontally from the main crater, some landing along side the main road to the Joslyn processing plant. Some of the projectiles must of had a fairly vertical trajectory, based on damage observed to the coating on a pipeline adjacent to the plant road.

11. At the time of the field visit, 15 days after the blowout, the area near the main crater and the subsidence bowl appeared to be relatively stable as there was no obvious evidence of recurring movements.

12. The observations described in this report are based on a limited visit to the site and an examination of related data, including topographic maps, uncorrected aerial photographs, preliminary contour maps of the site produced after the blowout, GPS stations surveyed in the field and selected subsurface log data. A comprehensive geological and geotechnical investigation of the setting was beyond the scope of this project.

RECOMMENDATIONS

1. A comprehensive geophysical, geological and geotechnical investigation should be undertaken in the vicinity of the main steam release crater to help understand the cause of the blowout and the possible role of the nearby vertical observation well and the abandoned core hole. This investigative program should include the following major elements:

    - Review of all related geological, geophysical and petrophysical data from the area
    - Coring and sampling of strata down to the base of the McMurray Formation
    - Laboratory testing for basic soil and rock characterization, and geomechanical testing for strength, deformation and permeability
    - Petrophysical logging, including borehole image logs, if possible
    - Monitoring for any recurring surface uplift or subsidence, subsurface pressures and temperatures

2. A quantitative analysis of the rock volume change associated with areas of ground heave and subsidence should be undertaken with digital elevation data derived from the aerial photography taken after the event. Stereo aerial photo pairs should be examined to identify and quantify the extent of other features ground disturbance features.

3. A geomechanical analysis of the blowout should be undertaken to determine the most likely causes of the event and hence the steps that should be taken to prevent a similar caprock failure during future SAGD operations at the facility.

1. INTRODUCTION

1.1 Objectives

The objective of this field reconnaissance visit was to provide a description and photographic record of ground surface disturbance associated with a steam release which occurred on May 18, 2006 at TOTAL's Joslyn SAGD project, Alberta.

1.2 Authorization

This field visit and report were authorized by Mr. Matt Cartwright and Mr. Tim Lloyd of TOTAL E&P as part of a consulting engagement with Pat McLellan, P.Eng., principal consultant with Advanced Geotechnology Inc. (AGI).

2. SITE RECONNAISSANCE VISIT

2.1 General

Mr. Pat McLellan, P.Eng., AGI's principal consultant, visited the Joslyn SAGD blowout site on June 2, 2006 with Ms. Katherine Stasiuk, a contract engineer, working for TOTAL E&P Canada. The day was spent examining ground disturbance features at the blowout site and inspecting the surrounding area. Mr. D, Coombs, a surveyor with U.S.I. of Edmonton, was on-site for a portion of the day to conduct a GPS survey of a number of observation stations selected by Mr. McLellan.

Figure 1 is a map provided by TOTAL of the general Joslyn Creek SAGD project area, including the location of Phase-1 and Phase-2 SAGD horizontal wells. McMurray Formation oil sand pay intervals are shown on this map in green. The blowout occurred adjacent to vertical observation well 9-33-095-12W4M which is located along the alignment of SAGD well pairs: DECL et al 204-I1 Daphne 2-33-95-12 (injector) and DCEL et al 204-P1 Daphne 2-33-95-12 (producer).

Figure 2 is an uncorrected aerial photograph of the site obtained from TOTAL, taken after the blowout, showing the steam release area, damaged vegetation, lease road and trail access, and the adjacent road and pipeline that goes to the Joslyn processing facility. Access to the blowout area was gained by following an east-west trail from the road, on the left side of the photograph.

Figure 3 is a preliminary version of a contour map of surface elevations obtained from TOTAL showing photogrametric processing of new aerial photography taken soon after the blowout. At the time this report was prepared, final versions of the topographic maps (before and after the blowout) for the area had not been provided to AGI by TOTAL. An analysis of the ground elevation changes that resulted from uplift and subsidence over the blowout site was not conducted by AGI.

Figure 4 is a more detailed mapping of the surface features overlain on an uncorrected aerial photograph of the blowout area. Note the presence of the following major features that correspond to notable surface elevation changes due to the blowout as seen in Figure 3:

1. A central steam release or vent area which is roughly triangular in shape with two deep portions, and central plug of less undisturbed bedrock overlain by till,
2. A WNW-ESE trending trough-like depression, with a few deeper portions along its length, that defines the southern boundary of the main crater, and extends away from it,
3. A secondary steam release (vent) area located south of the main blowout crater, and

4. A roughly circular depression, subsidence bowl, or sinkhole-like feature centred just to the NNE of the main blowout crater.

More detailed descriptions of the features shown on this figure are described in the next section of this report.

2.2 Field Observations

2.2.1 Main Crater/Vent Area

The main crater (central steam-release vent) can be seen in Figures 2, 3 and 4. A photograph of the deepest part of the crater on its southern edge is shown in Photo 1 (Appendix A). A small, 0.75 metre diameter opening or tunnel-like feature, as can be seen in Photos 2 and 3, was found on the north side of the crater. Photos 4 through 7 show some of the rock and sediment disturbance that was visible in the south wall of the crater. Photo 55 shows an east looking view of the main crater, including a central plug of rock and soil which was not highly disturbed during the main stream release.

2.2.2 Surface Cracks

At the time of the field visit on June 2, 2006 there were no discrete tensile surface cracks apparent near the main crater area, although there were numerous such cracks visible in the periphery of the subsidence feature located NNE of the crater (Section 2.2.4). There were, however, several linear trough-like features that may have been tensile surface cracks and/or steam release vents that connect to, or are close to the central crater.

The dominant linear feature seen in Figures 3 and 4 is a shallow trough-like depression oriented WNW-ESE (azimuth of 285°-105°). This surface depression varies from approximately 1 to 4 metres wide, and appears to have collapsed and filled in several localities, as shown in Photo 8.

2.2.3 Uplifted Areas

South-west of the western portion of the dominant trough noted above is an uplifted area, as can be seen in Photos 9, 10, 11 and 12. Photo 11 suggests that the southern part was uplifted by 1 metre or more in places. Photo 9 shows another 2 to 3 wide, trough-like feature adjacent to the uplifted area. In some areas south of the main crater (in the secondary steam release area), there is evidence of considerable rock disruption, such as tilted and uplifted strata, in the exposed near-surface rocks (e.g., Photos 13 and 14).

2.2.4 Subsidence Area/Sinkhole

A nearly circular subsidence or "sinkhole"-like feature can be seen just NNE of the main crater and steam release vents in the aerial photographs in Figures 2 and 4. Figure 3 shows ground surface contours of this significant depression. In the field this depression appeared to be about the same depth as the main crater. At the time of writing, an aerial photograph or contour map of the area prior to the surface steam release had not been provided to AGI, so it is not known with certainty whether there was any evidence for any prior surface subsidence in the immediate area, perhaps over a Devonian collapse or dissolution feature at depth below the McMurray oilsands. The latter would appear to be unlikely, however, since there was considerable evidence that the depression developed contemporaneously with the steam release or perhaps immediately afterwards. (*We also understand that in June and July 2006, there was further ground surface movement in the vicinity of this feature, K. Stasiuk, TOTAL, personal communication).*

Photo 15 is a photograph of numerous trees rotated into the subsidence bowl looking north-east from the south side of the crater. Photos 16, 17, 18, 19 and 20 show ground tensile cracks, small grabens and rotated sediment and rock blocks around the subsidence feature.

2.2.5 Secondary Steam Release Area

The aerial photograph in Figure 4 and the preliminary contour map in Figure 3 show an area with significant surface topography disturbance in what appears to be a secondary steam-release area directly south of the main blowout crater. Photo 21 and 22 show some of the disturbed surface in this area, adjacent to the edge of the affected forest. There is strong evidence that steam and ejected sediment, and possibly bedrock, originated from this area. There are 5 or 6 depressions in the vicinity and several spots where circular pits with a diameter of 30 cm or less are present (Photos 23, 24, 25, 26). Photos 27 and 28 show a possible major steam-release area in one large depression, from which material has been ejected. Photo 29 shows blown-over coniferous trees along the southern boundary of the affected area. Photo 54 shows a small pond adjacent to the secondary release area. Only a faint petroleum sheen was present on the water surface at the time of the field visit.

2.2.6 Blast Area

The south-west portion of the blast-affected area is characterized by a relatively flat, sediment-covered area with a scattering of small, which had lost their needles, spruce trees at the time of our field visit (Photos 30, 31, 32, 33, 51). It is most likely that this area was previously a boggy muskeg area, probably with seasonally ponded water. The debris-covered ground is now typically soft and compressible and underlain by water-saturated peat in places. Blocks of brown, fibrous peat are exposed at the surface in small hummocks and adjacent to a couple of ponds. (Photos 34, 35, 14).

2.2.7 Projectiles and Ejected Materials

Photos 36, 37, and 38 are photographs of some of the intact and shattered Clearwater shale blocks which were found alongside the road and pipeline leading to the plant. Photos 39 and 40 show the damage that was caused to the protective insulation shroud on the pipeline by one such projectile that must have had a near-vertical trajectory, since it damaged the west side of the pipeline. Photos 41 and 42 show evidence for shale projectiles that flew as far as 30 metres west of the road, landing in soft peat. At the time of the field visit, these water sensitive clay-rich shales had nearly completely disintegrated, leaving only small piles of clay soil.

Photo 43 and 44 show evidence for the airborne distribution of silt and clay from the main release area. A coating of moist soil, possessing a slight humic odour (but not smelling of hydrocarbon) could be found in the trees south and west of the blast area. Photos 45 and 46 show a coating of fine silt- and clay-size particles coating trees at the boundary of the blast area south of the secondary release area.

Large blocks of glacial till, some possessing columnar jointing, were found about the blast area, typically closest to the main crater (Photos 47, 48, 49).

Photos 50, 52 and 58 show additional bedrock projectiles of considerable size.

Photos 56 and 57 show examples of ejected trees that were propelled some distance and now lie in a horizontal position along the periphery of the blast area.

2.2.8 Observation Well and Core Hole

Photo 53 shows the relatively undamaged metal protective cage around the 9-33-95-12W4 wellhead. A core hole that was apparently located within 5 m of 9-33 could not be found on the debris-covered ground surface.

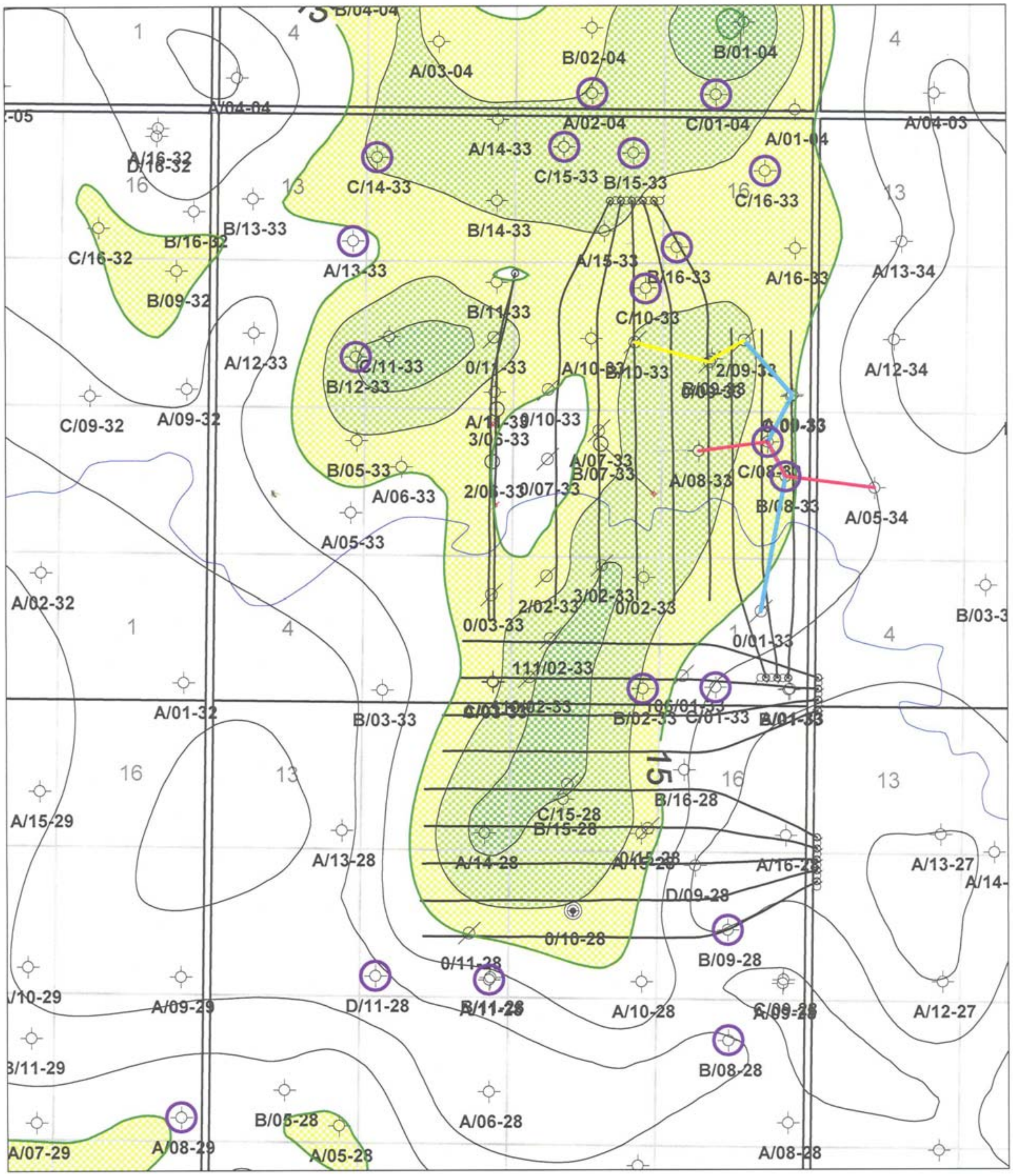

Figure 1: Map of the Total Joslyn SAGD project area showing the location of horizontal wells from Phase 1 and 2 and the main oil sand deposit (in green). Supplied by TOTAL.

Figure 2: Uncorrected aerial photograph of the Joslyn steam blowout, taken after the event. Supplied by TOTAL.

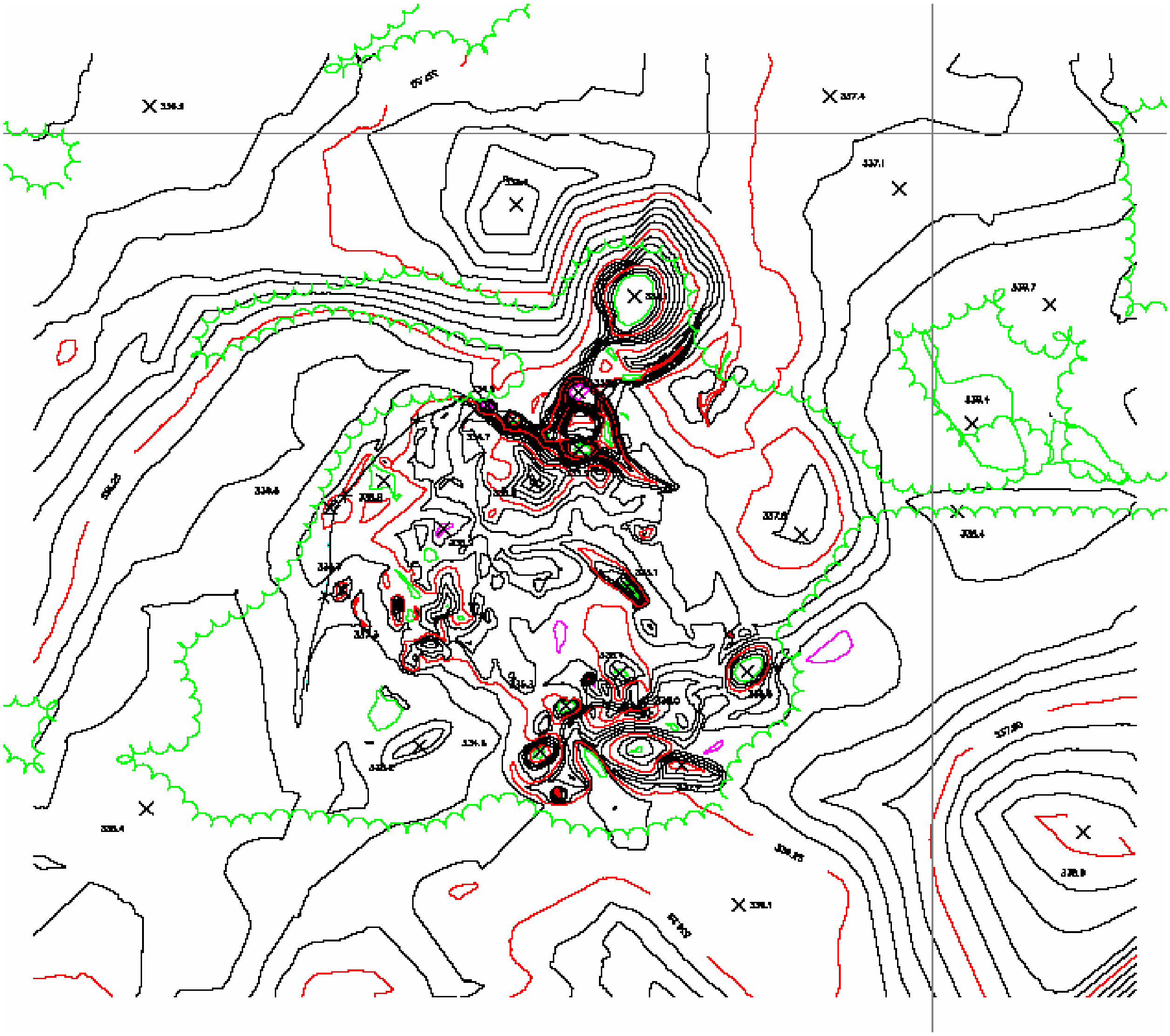

Figure 3: Preliminary map of surface elevation contours obtained after initial photogrammetric processing of aerial photography taken after the steam blowout. Supplied by TOTAL. Scale 1 cm = 12.8 m.

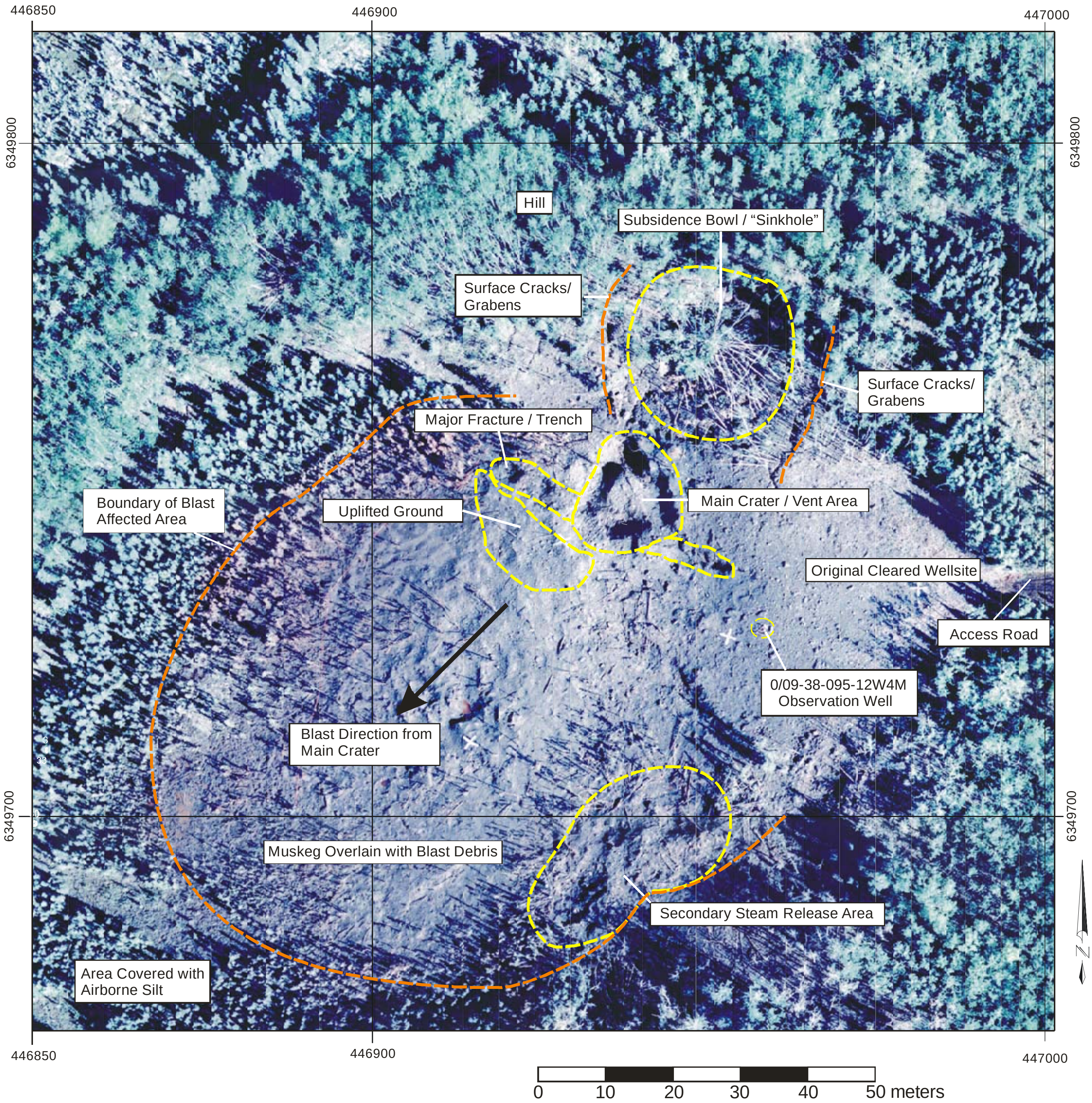

Figure 4: Aerial photograph of steam release area with major surface features identified. Uncorrected aerial photograph from Geographic Air Survey Ltd., Edmonton supplied by TOTAL. Ground feature locations approximate. UTM grid from TOTAL.

APPENDIX A

Field Photographic Record

Photo 1: View into the deepest part of the main crater/vent on its south edge.

Photo 2: View of an opening or tunnel of 0.75 m diameter on the east side of the main crater.

Photo 3: Close-up of the small opening or tunnel shown in Photo 2. The tunnel extended downward for at least another 2 metres by estimation.

Photo 4: View looking south into the edge of the main crater, showing rock deformation features including tilted shale interbeds.

Photo 5: Close-up of the deformed rock along the main crater edge. Poorly cemented soil or rock in this area were damp and in one location, smelled strongly of oil.

Photo 6: Close-up of partially oil saturated sand and silt near the bottom of the main crater shown in Photo 5.

Photo 7: Close-up of the bottom of the main crater looking south showing the vent opening.

Photo 8: Collapsing "fracture-like" or trench feature that trends at 105° away from the main release crater/vent. 15.6 m in length.

Photo 9: View to the west showing a wide trough-like feature with what appears to be uplifted rock and soil in the background.

Photo 10: View looking ESE towards the main crater showing the prominent fracture or trough which marks the edge of the uplifted area on the right. Station 11.

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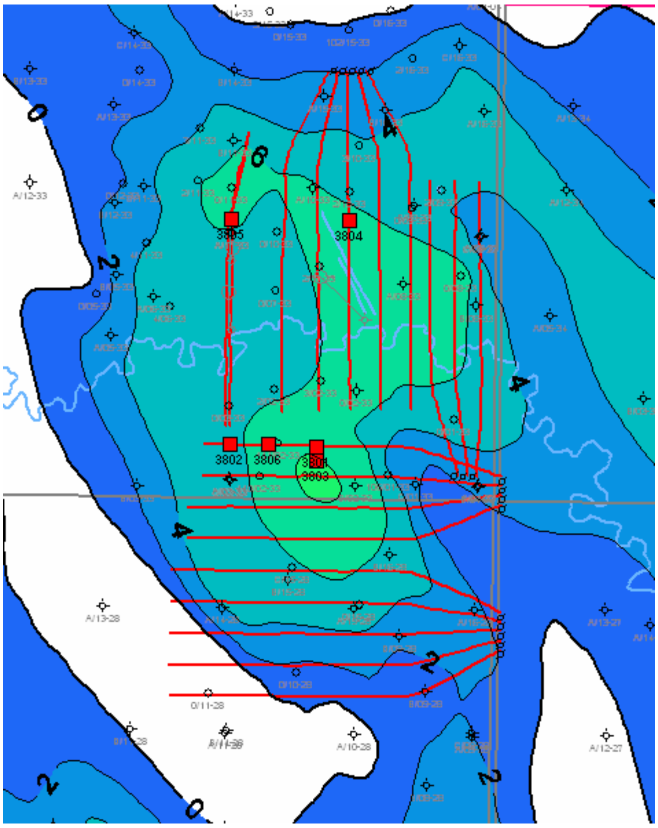

Geological Insights in the Joslyn May 18th 2006 Steam Release

TEPC/GSR/2007.005

December 2007

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ABSTRACT – About 10 lines explicit

Objectives (Aim, Purpose, Target) – **Strong points - Recommendation(s) and/or conclusion(s)**

The aim of the present report is to summarize key geological findings of interest as background for reservoir, seismic and geo-mechanical studies aiming at determining the root causes of the steam release. The main geological findings are the following:

- Based upon data from nearby wells a typical geological column as been defined for use in the investigation of the steam release. No significant variation of such geological column is expected in the vicinity of the steam release for any reasons including erosions or lateral facies variations. This geological column is described in detail in table 1 of the present report.
- In the absence of clear evidence of fracture in the overburden interval (from top GPP to surface), it is deemed very unlikely that pre-existing fractures constitute a root cause of the May 18th 2006 steam release.

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Reference 3 Reservoir Insights in the Joslyn May 18th Steam Release – December 2007 – A. Delafargue TEPC/GSR/2007.004.

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Reference 6 Steam Release Incident LSD 09-33-095-12-W4M Volume I Executive Summary prepared by Millennium Solutions Ltd. December 2007 File #04-101

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1 Introduction

The Joslyn Creek SAGD Project is located in the northwest portion of the company's Deer Creek Oil Sand Lease, approximately 70 km north of Fort McMurray. Bitumen is found primarily in the Middle McMurray Formation, which is up to 35 m thick, and is found at depths ranging from 65 to 110 m. Bitumen is extracted from the sands using SAGD (steam-assisted gravity drainage) technology.

On May 18th 2006, after approximately five months of steam injection into the related portion of the reservoir, steam was released at the surface, above the injection / production well pair 204P1I1 (Figure 13). The release created a large vent formed by fissures approximately 3 m wide, 4 m deep, and 15 to 25 m long. A substantial amount of subsurface material, including pieces of rock up to 1 m in size, was ejected. Most of the material was ejected to the south and southwest, covering an area approximately 170 m by 100 m, while some material landed up to 250 m away. A surface-collapse structure (a depression in the surface approximately 25 m in diameter and 10 m deep) appeared immediately north of the vent. Figure 14 shows two aerial photographs of the area, both before and after the release. More details related to the surface observations made immediately after the steam release can be found in the report "Site Reconnaissance of a Surface Steam Release at the Total Joslyn SAGD Project, Northeast Alberta, Canada, August 2006, AGI 10-295 by Pat. McLellan".

The aim of the present report is to summarize key geological findings of interest as background for reservoir, seismic and geo-mechanical studies aiming at determining the root causes of the steam release.

2 Regional Geology

On the Joslyn Lease, which is comprised of OSL 24, 799 and 452, the bedrock geology and oil sands geology have been mapped (Green et al., 1970; Carrigy and Kramers, 1973; Flach, 1984). In general, progressively younger bedrock formations are traversed from west to east, typically at progressively shallower depths. These strata comprise:

- The limestone and shale of the Upper Devonian Waterways Formation;
- The sandstone and siltstone of the Cretaceous McMurray Formation and
- The shale, siltstone and sandstone of the Cretaceous Clearwater Formation which includes the Wabiskaw Member.

The generalized stratigraphic nomenclature used in northeast Alberta (Wightman et al., 1995) is presented in Figure 15.

The oil sands resource is found within the Cretaceous McMurray Formation. The McMurray Formation consists of a sequence of un-cemented quartz sands and associated shale that reside above the unconformity on the Upper Devonian carbonates of the Waterways Formation.

The McMurray formation is overlain by the Clearwater Formation. Above, the Cretaceous succession is covered by unconsolidated Pleistocene sands, silts, and clays that were deposited by glaciers as they melted and receded from the region at the end of the last ice age.

2.1 Devonian

The shales and limestones of the Waterways Formation do not contain bitumen and are a barrier to fluid flow. The structure on top of the Devonian surface ranges from a high of 245 m MSL in the central area to a low of around 205 m MSL in the north and south (Figure 17). Lower elevations are a result of collapse due to salt dissolution of the underlying Prairie Evaporite Formation (Figure 16). They may be associated with small scale fractures in this particular interval. In areas where the Devonian surface is low, water sands are sometimes present in the Lower and Middle McMurray.

2.2 McMurray

The McMurray Formation is present from approximately 40 to 60 m below ground level to 115 m depth (Figure 18 to Figure 20). The McMurray Formation is comprised of stacked fluvial-estuarine sands and off channel silts and shales. The sands of the McMurray Formation are 90 to 95% quartz. The McMurray Formation was deposited during a rise in sea level caused by transgression of the Clearwater Sea from the north. This interplay between rising sea level and sediment transport from the northeast gave rise to various depositional environments which are described within the McMurray as three informal members including the Lower, Middle and Upper McMurray. These informal divisions correspond to changes in the depositional environments within the McMurray from fluvial at the base (Lower Member) to estuarine in the middle (Middle Member) to marginal marine at the top (Upper Member).

The Lower McMurray, where present, is comprised of predominantly fluvial channel deposits. These channels have in-filled lows on the Devonian (Paleozoic) surface resulting in thicker McMurray intervals. The Lower McMurray sands are up to 20 m thick, coarse to medium grained, and water or bitumen saturated. When they are bitumen saturated they make an excellent ore body.

The Middle McMurray is comprised of thick estuarine channel successions and tidal flat deposits resulting in inter-bedded sands and muds. The estuarine channel sands provide good quality reservoirs. They contain medium to very fine-grained sands and channel thicknesses range from 10 to 35 m. Stacked channel deposits, which reflect a preferred pathway for the fluvial-estuarine system, form the thickest reservoirs. In the development area the stacked channel complex runs in a NW to SE direction.

The Upper McMurray is composed of fine to very fine-grained, finely laminated, upward coarsening sands with considerable marine influence.

Note: What Total E&P Canada calls Upper McMurray (Kmu) is sometimes classified as the Wabiskaw 'D' unit, a part of the Wabiskaw member of the Clearwater Formation by other companies and/or the EUB.

The prospective reservoir is defined as follows. A reservoir quality pay is defined being reservoir with effective porosity fraction times the bitumen saturation fraction equalling or exceeding a fraction of 0.23 (Phie*So > 0.23). This Phie-So parameter correlates to a bulk oil weight of ~8% or ~ 2200 m3/ha-m (1700 bbls/acre-ft) and is seen as the minimum reservoir quality in which economic SAGD operations are possible with the current level of technology. Although reservoir intervals which do not meet this quality cut-off may contribute small volumes of recoverable bitumen in association with higher quality intervals, they are not of a high enough quality to provide economic recovery on a stand alone basis. The net pay thickness is calculated based only on intervals meeting or exceeding the reservoir quality cut off criterion. A minimum of 15 m the economic net pay thickness cut-off is currently used.

The "Gross Process Pay" (GPP) and "Net Process Pay" (NPP) describe the SAGD developable resources as identified at wells. The base of the "GPP" and "NPP" intervals are the same. This base is defined as the lowest section within the McMurray Formation in which there is a minimal 10 m thick interval of reservoir quality with Phie*So>0.23 (Figure 26) in which the horizontal wells will be landed. The top of "GPP" is the highest level the steam chamber is expected to reach based primarily upon core pictures, however, the complete interval may not meet the reservoir quality cutoff criterion. The top of the "NPP" interval is at or below the top of the "GPP" interval and is defined as the highest level steam is expected to reach in which the reservoir quality cutoff criterion is met. The SAGD developable area is mapped as the "NPP" isopach greater than 15 m.

The top GPP is found approximately at 65 to 110 m in the SAGD area. The non-pay McMurray sediments that overlie the intended steam chamber consist of 20 to 25 m of inter-bedded sands and shales of largely estuarine origin. The shale content in these inter-beds increases vertically along with a decrease in vertical permeability. The combination of this upward sequence in the McMurray and the shaley overburden beds of the Clearwater formation create a barrier that will prevent upward hydraulic flow of the steam chamber.

2.3 Clearwater – Wabiskaw Member (Kcw)

The Wabiskaw Member of the Clearwater Formation directly overlies the McMurray formation (Figure 21 and Figure 29) and is comprised of shales, silts and very fine grained sands.. These sands can contain low grades of bitumen and will not contribute to the in-situ recovery of bitumen. The Wabiskaw Member has been divided into three separate units that can be correlated over the lease acreage.

2.3.1 Kcw1

The lowermost unit, Kcw1, overlies the McMurray Fm and is comprised of offshore transition, medium grey mud inter-bedded with 10 to 30% fine grained glauconitic sand; the Kcw1 is very unlikely to act as a pressure seal or as a lateral pressure drain. This unit is typically thin and is depositionally continuous with the Upper McMurray Fm.

2.3.2 Kcw2

The intermediate unit, or Kcw2, is considered to be a sealing unit to a steam chamber. The Kcw2 is an offshore marine shale deposit. It has an average thickness of 4.8m that can be correlated throughout the Joslyn SAGD area and maintains an essentially constant thickness (Figure 4).

The following figures are core photographs of the entire Kcw2 interval, followed by the electrical log response of that well. What can be seen is a partially fissile shale, with mm-scale silt lenses or silt filled burrows. These silt lenses are considered to be unconnected and isolated, or belonging to an indurated zone with very low transmissivity and permeability (see log response Figure 3). Besides these rare lenses, is the predominant shaley lithology, at times of a fissile nature.

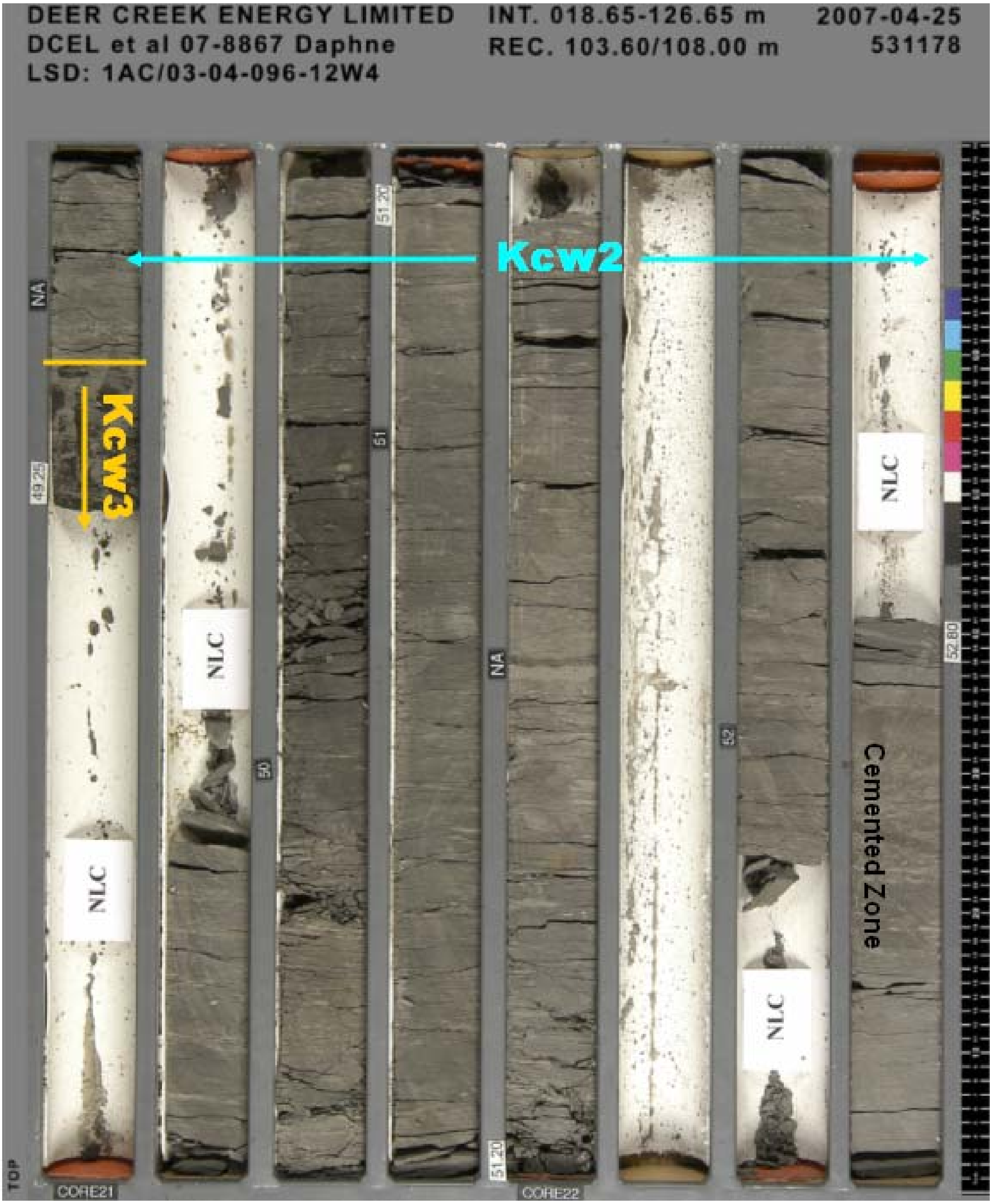


Figure 1: Core photograph of upper Kcw2 interval

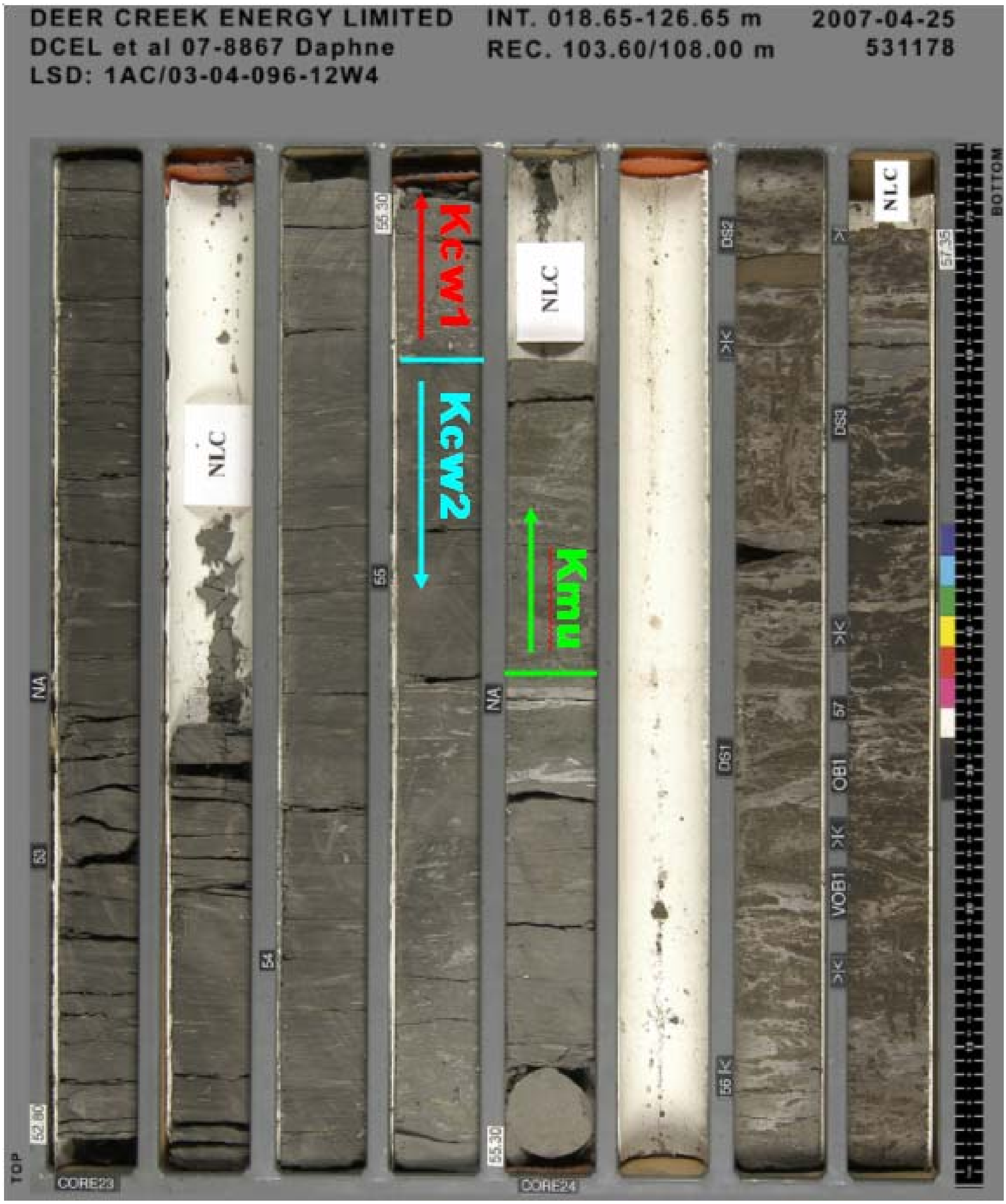


Figure 2: Core photograph of lower Kcw2 interval

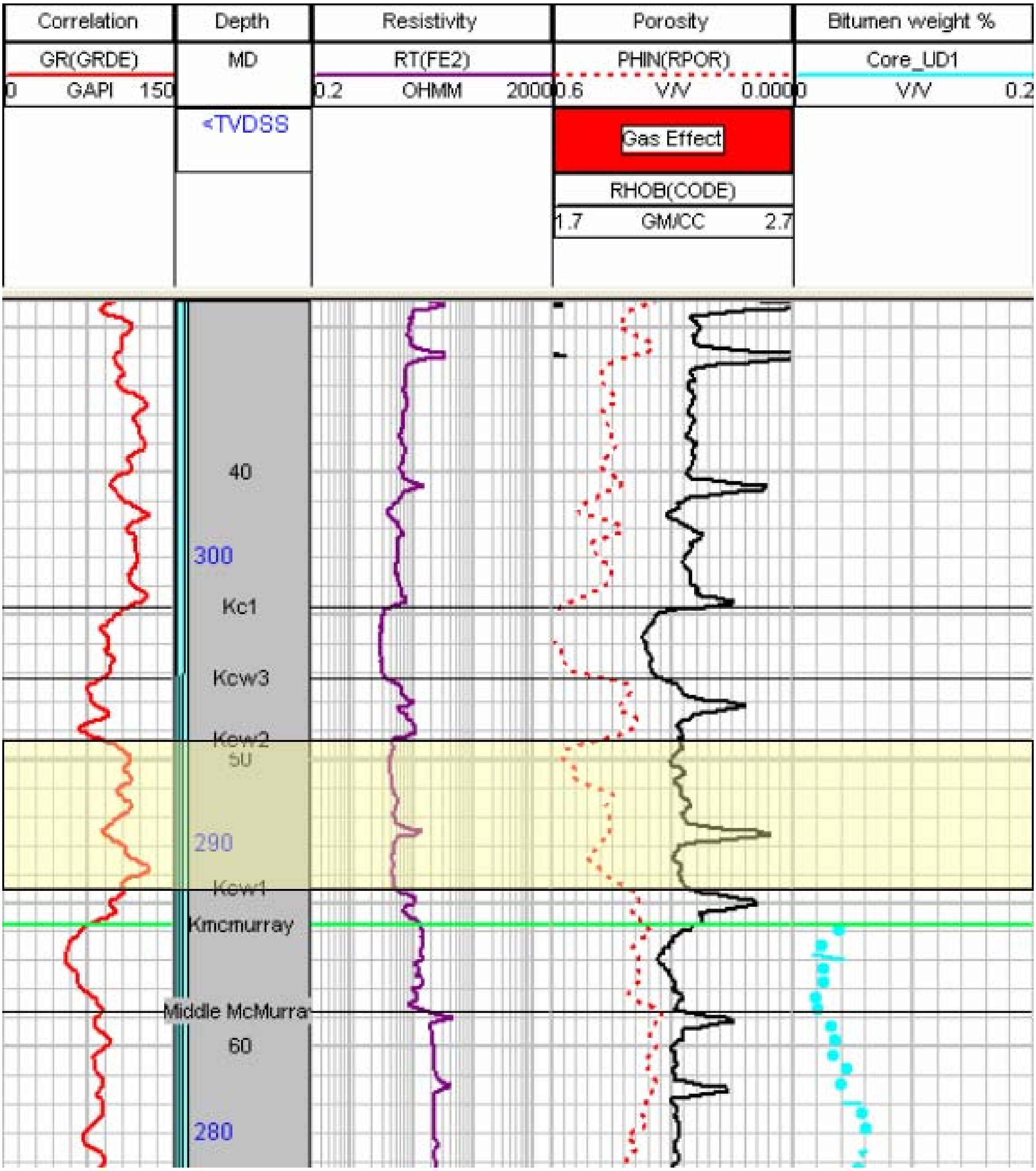


Figure 3: typical log response of upper Cretaceous series in the Joslyn area with Kcw2 highlighted

The gamma log response of the Kcw2 indicates a shale dominated facies, with a Vshale of nearly 85%. The average GRapi of over 100 quantifies this interval as a shale, capable of acting as a steam chamber barrier. The interval at approximately 52.60 - 52.80m MD in the log from Figure 3 does show a decrease in the GRapi towards a siltier value yet it corresponds to a high density zone. This interval can be observed in the core photo in Figure 1, and has been correlated on a lease scale. This interval has been interpreted to be associated with a period of non-deposition related to a Maximum Flooding event, where the formation of a firm ground deposit is possible. While this cemented interval is clearly siltier on the gamma log than the surrounding shale, the neutron-density log indicates it is an indurated or cemented zone. This zone, along with other similar cemented intervals, has been analyzed using X-Ray diffraction techniques and found to be cemented by siderite ($FeCO_3$). Thin sections of the interval show that all porosity has been destroyed by cementation.

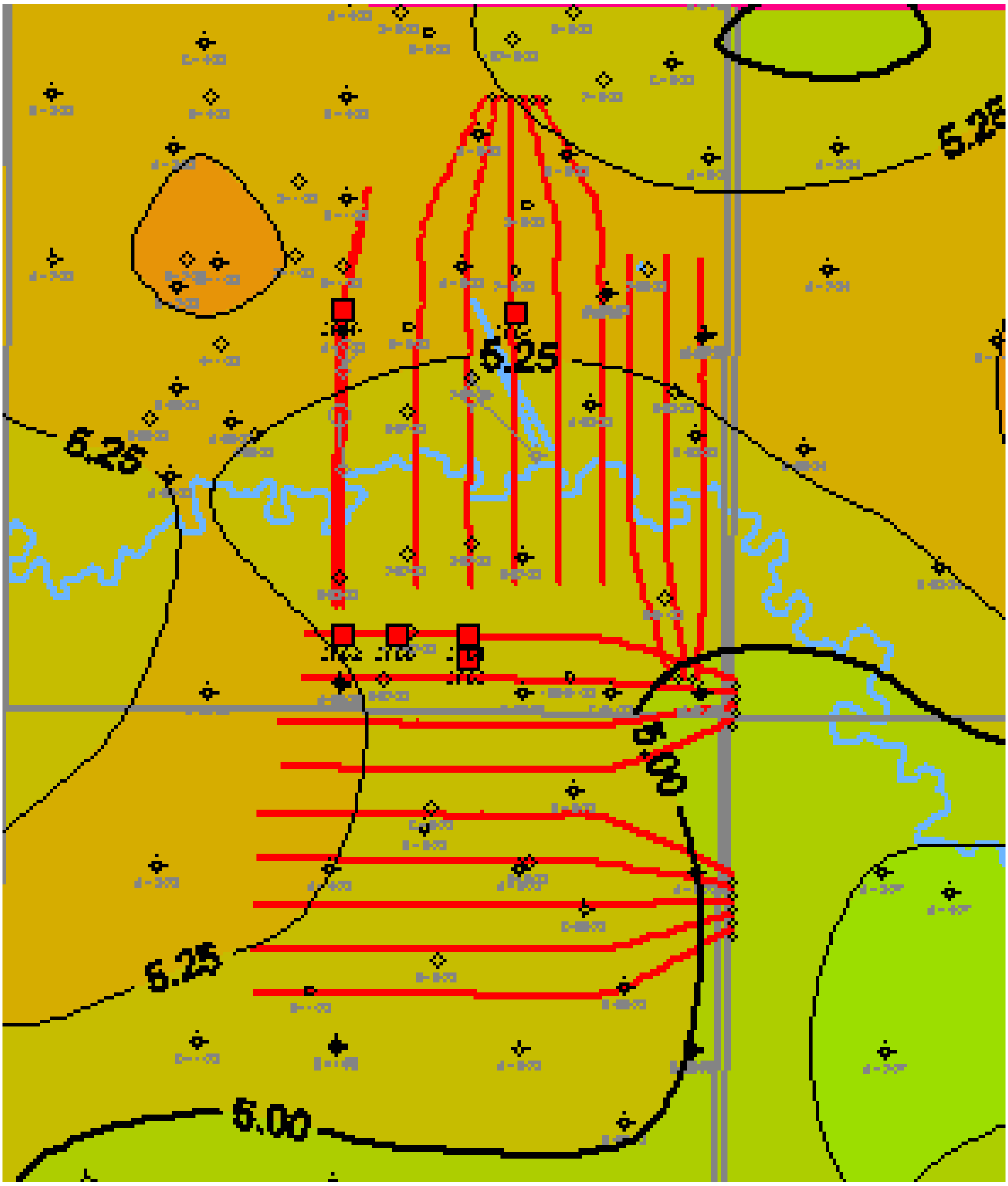


Figure 4: Kcw2 isopach map (in m) over the Joslyn Phase 2 SAGD area

2.3.3 Kcw3

The topmost unit, or Kcw3, is comprised of offshore transition, fine grained sand inter-bedded with 15-25% medium grey wavy mud beds. This unit presents a fairly constant thickness of around 2 m, with a cemented zone observed at approximately 75cm from the base of the unit; Wabiskaw sands and silts show permeability in the 300 – 2000 mD range (Figure 31). This level of permeability may be enough for this unit to act as a lease-scale pressure drain of low to fair quality. TEPC does not consider this interval to be sealing to a steam chamber.

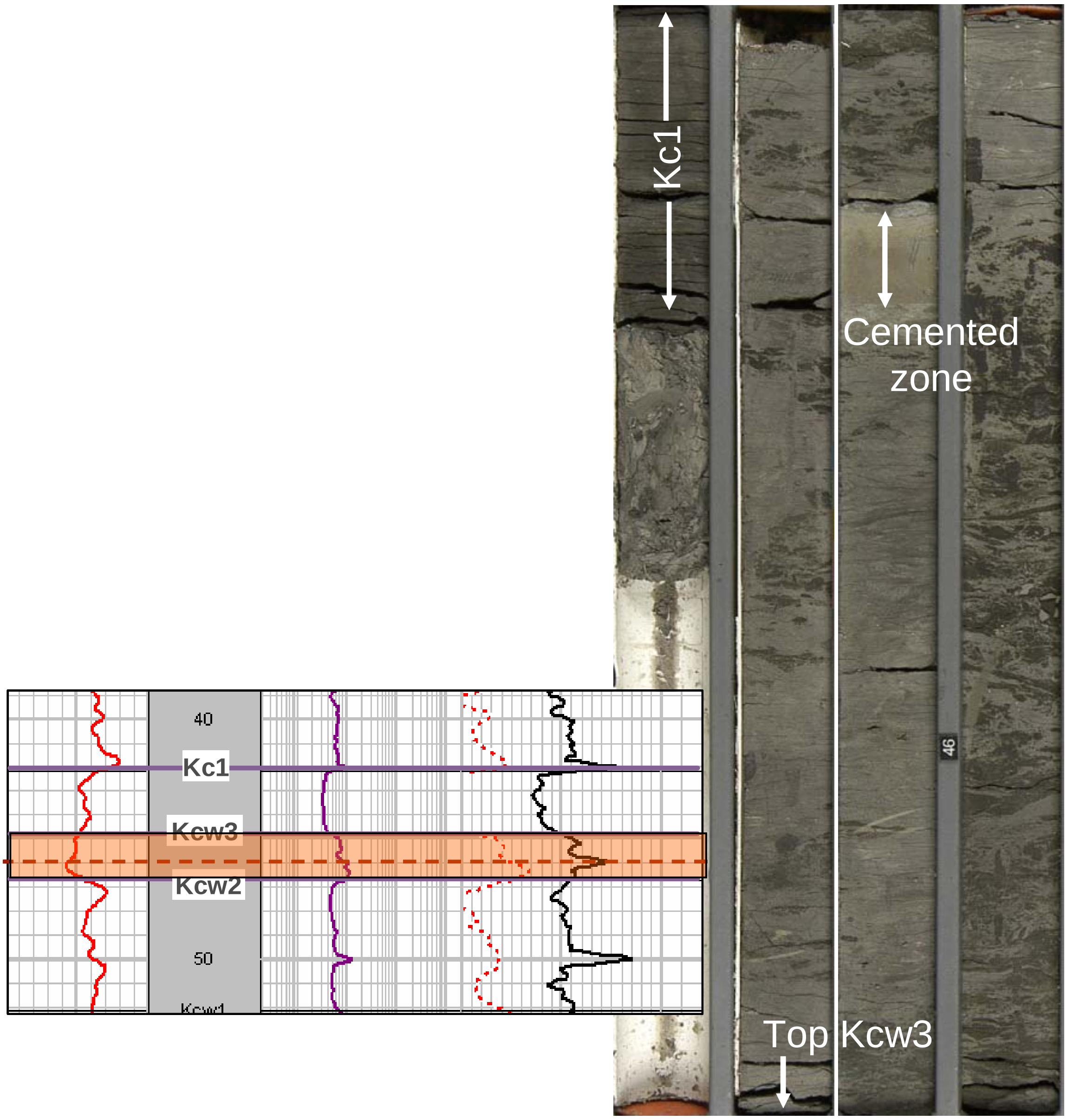


Figure 5: Core photograph and typical log response for Kcw3 interval (highlighted). Dashed line is cemented zone that correlates throughout the Joslyn lease

2.4 Clearwater Shales and Pleistocene

Within the project area, the total overburden thickness is approximately 40 to 60 m with 20 to 30 m being the shales of the Clearwater Formation while the remaining sediments consist of the Pleistocene tills above the Clearwater Formation and the low reservoir quality sands and shales above the GPP top (Figure 22 and Figure 27).

The Clearwater Formation is fully marine in nature. It consists predominantly of marine shales which do not contain bitumen and are considered a barrier to fluid flow.

The Clearwater has been divided up into 4 stratigraphic units which are presented below as described in the TEPC 2008 facies chart:

- **Kc5:** Grey-brown, waxy clay with minor glauconitic sand-silt component, particularly near the erosional contact with the overlying Grand Rapids Formation.

- **Kc4:** Dark grey shale with silt-sand laminae/lenses. Lower contact is commonly marked by black, fissile low-density clay.

- **Kc3:** Greyish-black shale with local low-angle, parallel bedded to x-bedded, glauconitic sandy silt. Lower contact is marked by a dual indurated bed and bound by a black, fissile, low-density clay cap.

- **Kc2:** Dark grey shale with moderate to common silt lenses. Local thin beds of low-density clay. Thin, locally indurated beds. Lower contact may be marked by a thin interval of glauconitic shale and capped by a dual indurated bed.

- **Kc1:** Black, fissile, low-density clay with rare to moderate silt laminae/lenses. Upper contact is commonly marked by an indurated bed.

A difference in nomenclature must be pointed out at this point. The Kc1 as described by TEPC corresponds to the T21 interval that is commonly used by others (including, to Total's knowledge, EUB).

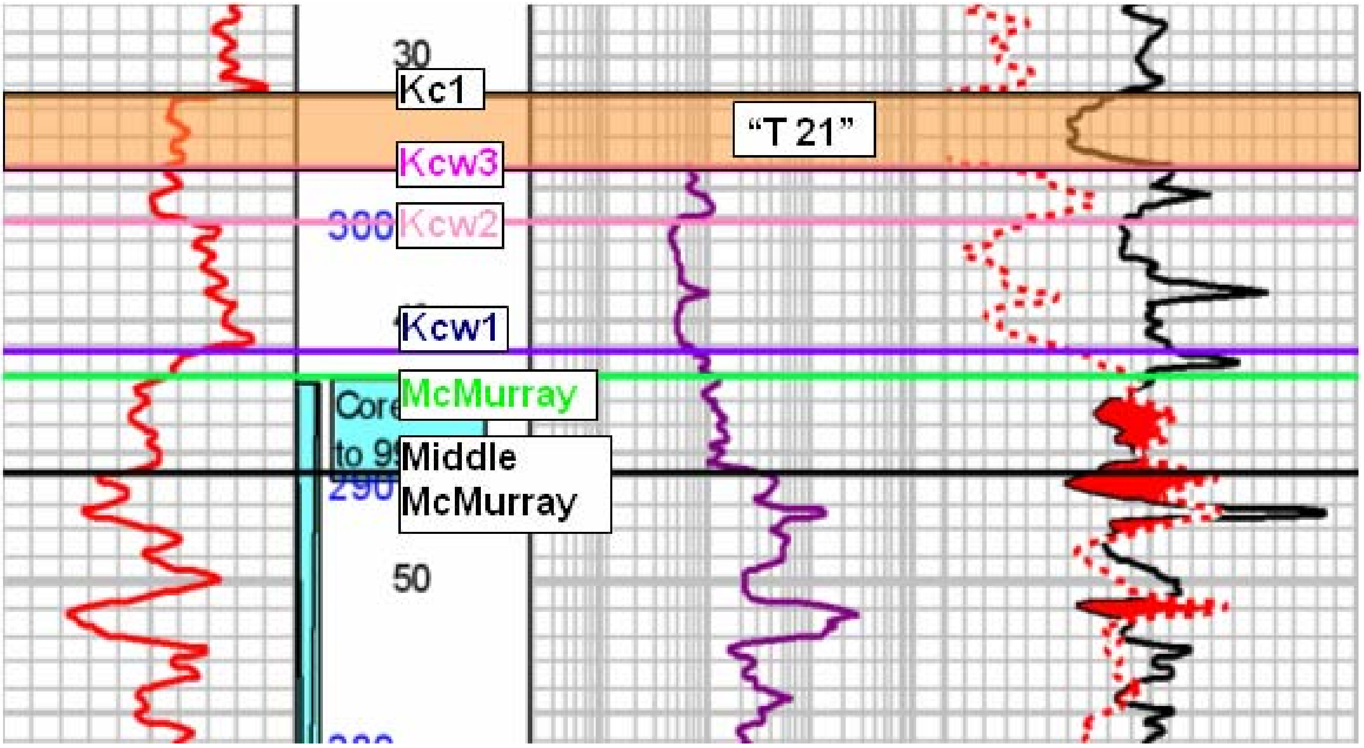


Figure 6: Typical log response with top formation markers as defined by TEPC

The gamma ray log response of the Kc1 does not represent the shaliness of the interval. Core photographs and wet sieve analysis of the unit confirm that it is in fact quite fissile and shale rich.

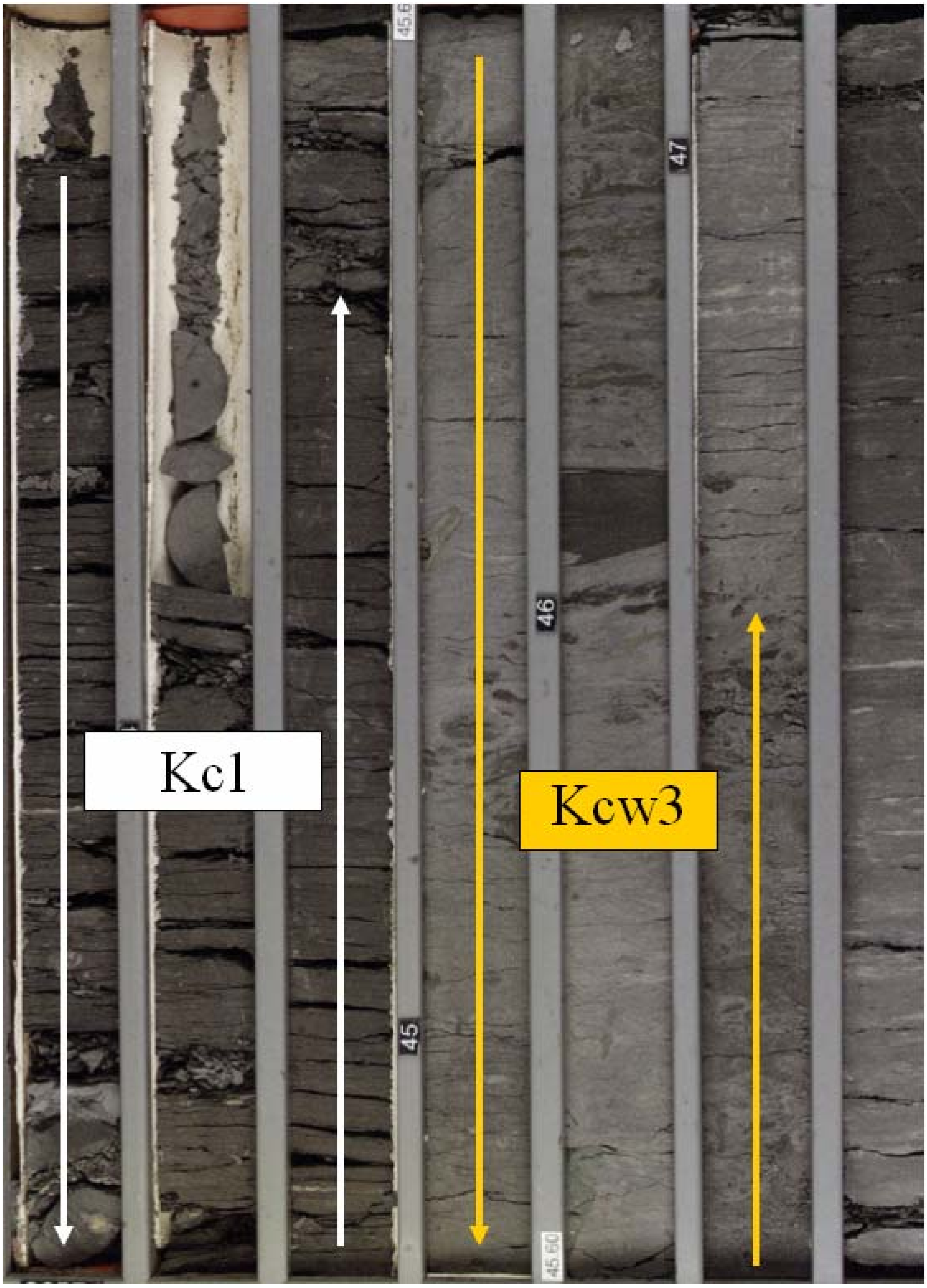


Figure 7: Core photograph of typical Kc1 and Kcw3 interval from well 1AB/08-04-096-12W4

As can be seen in Figure 7, the gamma ray signature of the Kc1 is approximately 75 GR API, a value typically seen in silty sands and not in silty clays. What is also noticed is the extremely low density and high neutron porosity, along with an unusually low resitivity.

Borehole #	Depth (m)	Lithofacies	$N_{\text{effective normal stress}}$ (kPa)	Moisture Content (%)	liquid limit (%)	plastic limit (%)	sand (%)	silt (%)	clay (%)
1AA 08-13-95-12	11.25 - 11.50	Kc1 (Kcb2)	794.6	32.1	200	31.3	2	25	73
1AA 07-13-95-12	9.55 - 9.70	Kc1 (Kcb2)	2033.5	33.7	189.4	34.4	0	21	79
1AB 12-02-96-12	28.25 - 28.40	Kc1 (Kcb2)	1604.1	31.7	180.6	33.3	0	21	79

Table 1: Geotechnical dat a for Kc1 and Kcw2 units

The clay content measured in the Kc1 by the geotechnical study is not in agreement with the electrical logs response, notably the gamma ray log.

It is thought that the Kc1 displays unusual log characteristics, and may possibly be a shale with a lower radioactivity than a classically defined shale, possibly due to an increased organic content.

2.5 Structural geology and gas trapping

Various observations at regional scale suggest that fractures occur in all stratigraphic intervals; such occurrences are extremely rare in the McMurray and above. They are more common in the Devonian in relation with large scale fault re-play and salt dissolution. Karst topography is the primary control for Devonian top structure. No evidence was found that the fractures contained within the Devonian radiate through the McMurray formation. Any collapse structure and associated fracturing has been interpreted to have occurred pre-Cretaceous. This is supported by the onlapping nature of McMurray sediments that can be seen in seismic, the lack of disturbed Lower McMurray sediment and the fact that there are no younger sediments at the base of these Devonian lows. See reference 2 for further details.

A visual inspection of the 15 cored wells closest to the Steam release Area (Figure 13) did not lead to any identification of fracture in the overburden interval (from top GPP to surface); as a consequence, it is deemed unlikely that pre-existing fractures constitute a root cause of the May 18th 2006 steam release.

Strong evidence supporting the quality of a steam chamber seal in the Joslyn SAGD area is the presence of a gas cap at the top of the McMurray Fm and the difference of pressure regime documented in reference 7. This gas cap has been mapped throughout the lease and is being trapped by the Wabiskaw Member, specifically the Kcw2. Gas zones in the Joslyn SAGD area correspond to structural highs observed on the Top McMurray surface (Figure 8). The highs act as structural traps for the gas, which presumably was emplaced while the hydrocarbon pulse was still relatively mobile, or pre-biodegradation.

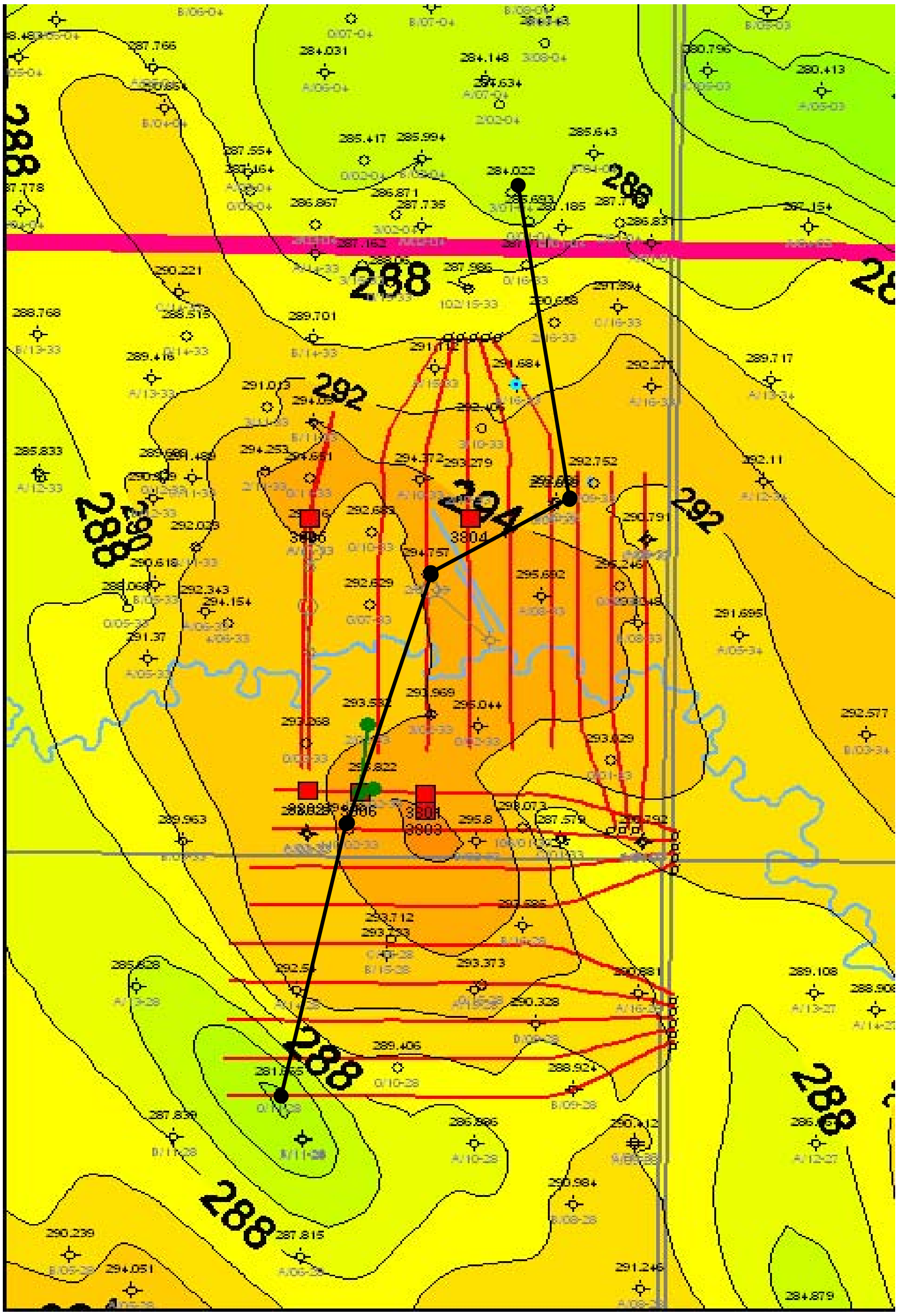


Figure 8: Structural Map of the Top McMurray surface (in m above sea level)

The structural highs observed on the Top McMurray surface are the result of differential compaction observed within the underlying McMurray formation itself. The differential compaction observed has two controls: Lithology of underlying sediments and Devonian structure.

Structural highs correlate very strongly to the zones of high sand content whereby sand dominated intervals will be less compactible than shale dominated zones. The sandier zones have, over time, been compacted less and became structural highs (Figure 9).

Devonian structure has an impact on compaction of sediments by offering more or less sedimentary accommodation space, Devonian lows mean increased sedimentary thickness and increased compaction of sediments over time. Therefore structural highs observed in the McMurray correlate to highs in the Devonian surface when there is a sufficient sand content associated (Figure 10).

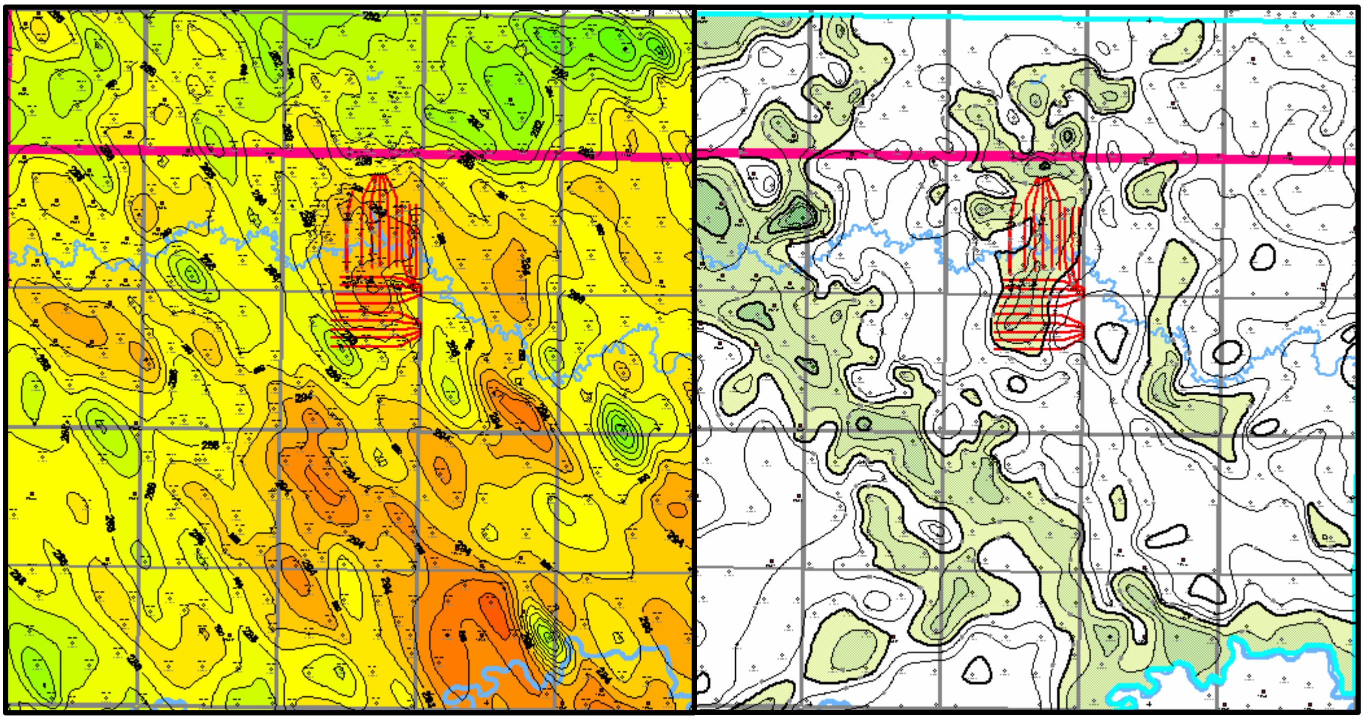


Figure 9: Top McMurray structure map (left) along with NPP map (right) highlighting net sand thickness over 15m

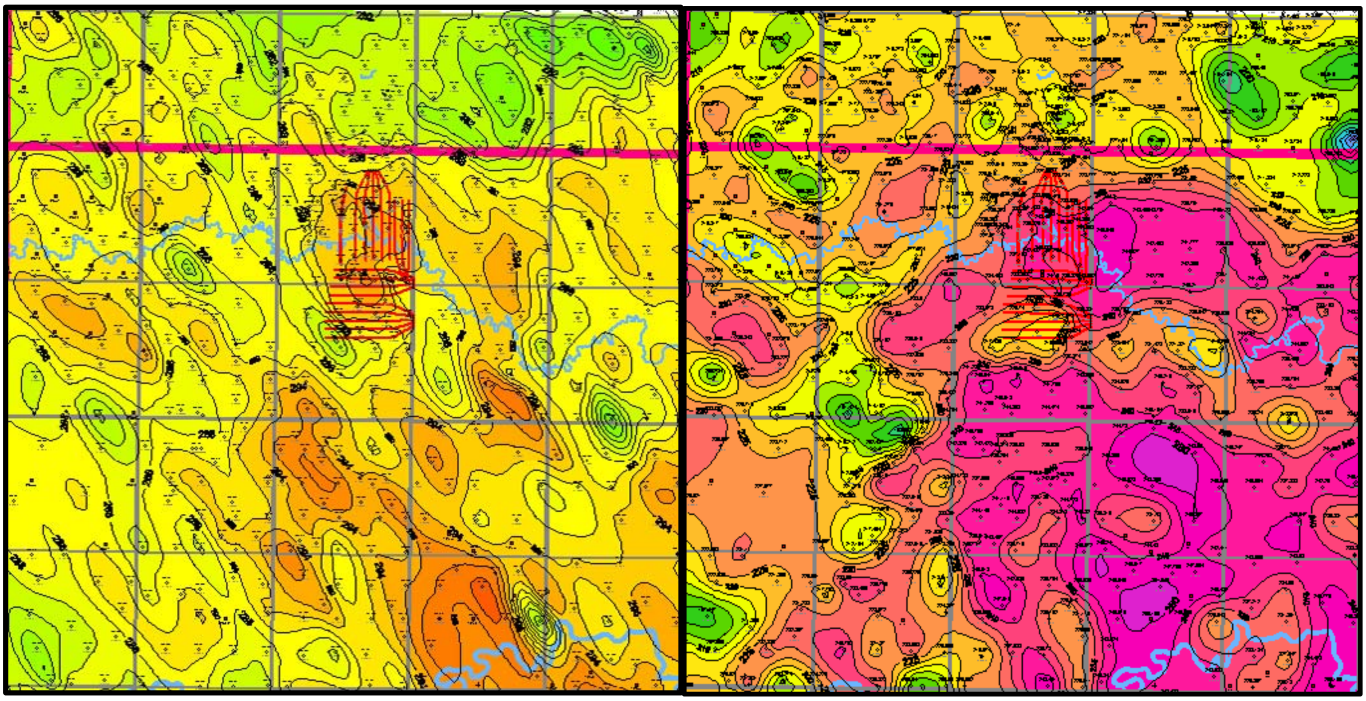


Figure 10: Top McMurray structure map (left) next to top Devonian structure map (right)

A gas cap has been mapped throughout the most of the SAGD area on Joslyn. The thickness of this gas cap is directly controlled by the structural trapping mechanisms described above.

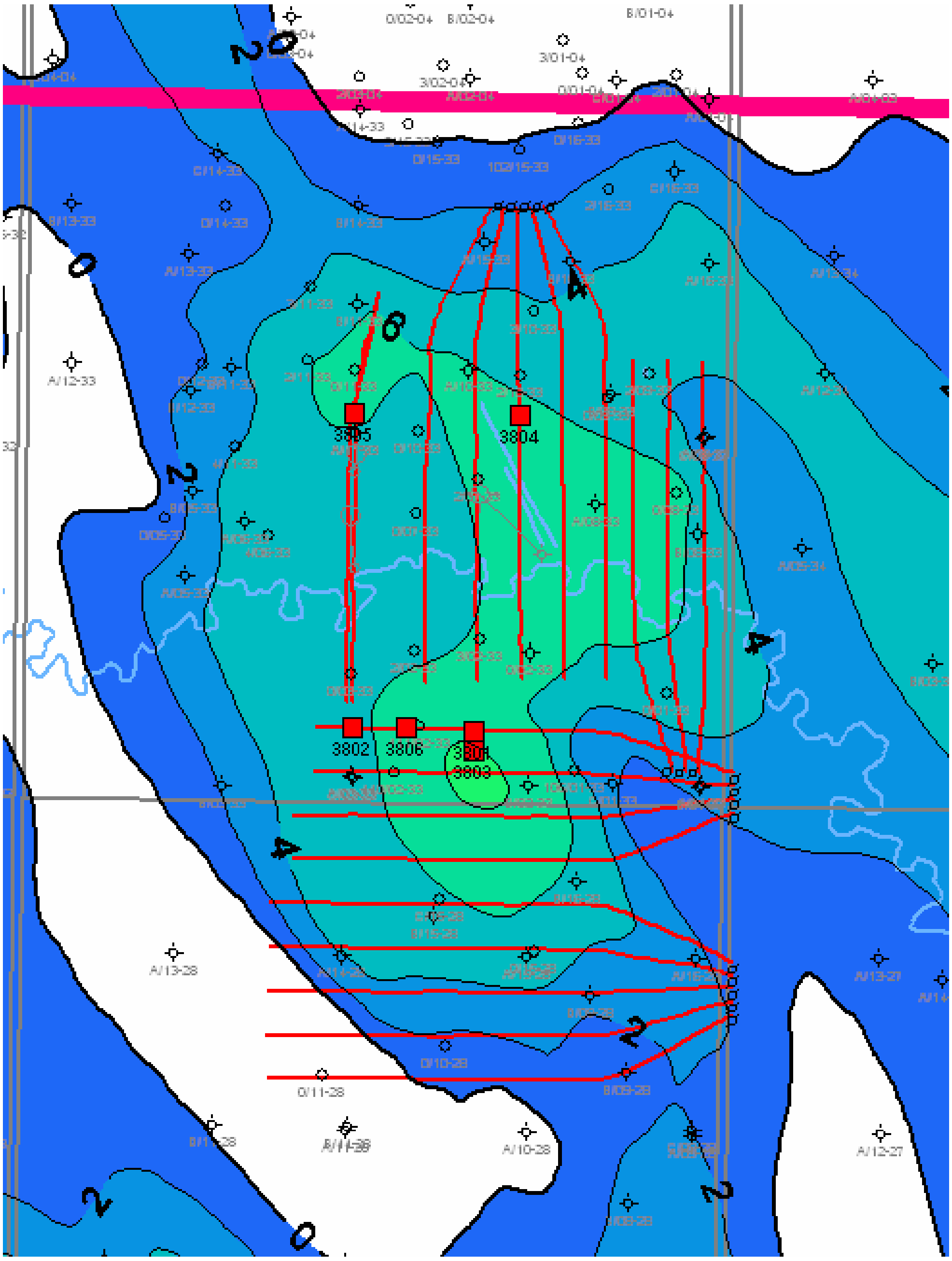


Figure 11: Thickness of mapped gas interval found in the Upper McMurray interval

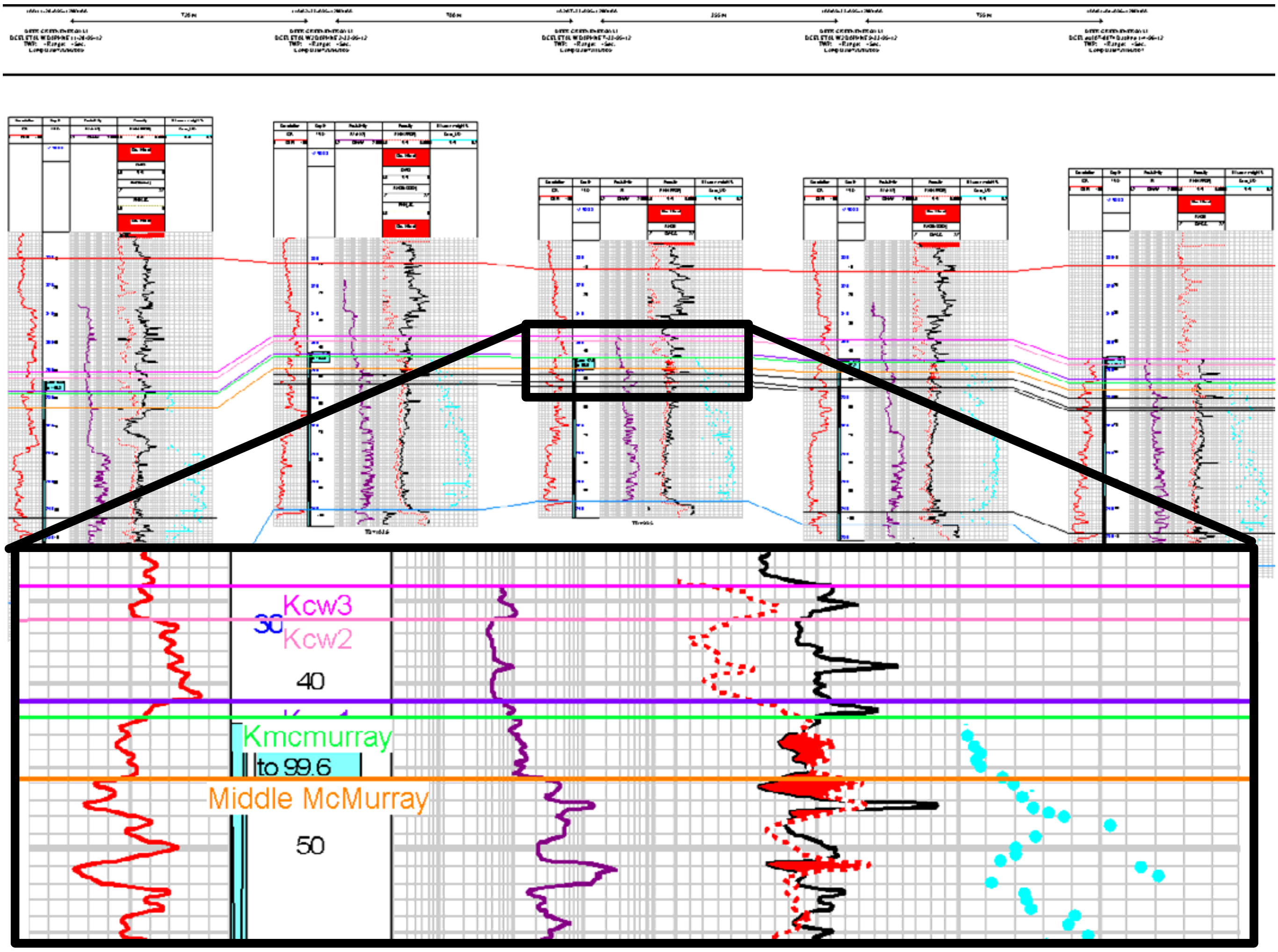


Figure 12: Log cross section through Joslyn Phase 2 SAGD area with upper series enlarged showing gas response on the logs. Section seen on map in Figure 8.

TEPC proposes that the presence of a gas cap overlying the SAGD area sediments and specifically around the steam release area, discounts the possibility of open fractures existing in the sealing interval directly overlying the McMurray formation (Kcw2). It is also argued that a sealing interval that is capable of trapping and containing gas over geologic time should be capable of acting as a seal provided it is not severely heated.

3 Local aspects of the stratigraphy and sedimentology around the Steam Release Area

Figure 32 to Figure 36 illustrate the geological characteristics of the Surface to Devonian interval on wells AA/8-33, 100/09-33, 1AB/09-33, 102/09-33, 1AB/10-33 closest to the steam release area. The facies chart used to describe the cores from these wells is detailed in Plate 1.

Table 2 summarizes the depth and thickness of the stratigraphic units in each of the above wells as well as the range in thickness for each stratigraphic unit. This range is deemed representative of the geological column within the steam release area prior to the steam release; it is extremely unlikely that local erosion events or rapid change in the geology impact significantly such geological description in the vicinity of the steam release.

The detailed analysis of 1AB/09-33 and 100/09-33 core pictures provides the following additional insights:

- The first baffle to steam upward movement probably lies at approximately 266 - 268 m MSL.

- The first clear shale barrier is identified above the baffle at approximately 275 m MSL (top GPP).

There is a second clear shale barrier at approximately 254 – 255 m/MSL.

4 Well geometry

Figure 13 shows the location of all wells in the vicinity of the steam release area. Figure 37 shows a X-section along the well pair length with a projection of neighbouring vertical geological calibration wells.

Figure 37 presents similar information across 204-I1P1 well pair. The production well drain lies in the depth interval from 252.0 to 254.4 m MSL. The injection well drain lies in the depth interval 247.3 – 248.8 m MSL. Along well 204I1 trajectory, the overburden above the injection well ranges between 78.9 to 85.5 m (Note: all these measurements are based on measured data and do not account for uncertainties in the well location data itself); the overburden is in the upper part of this range in the steam release area.

Well location uncertainties are as follows for 204-P1 (drilled first):

- At the heel, vertical error is +/- 0.67m, lateral error is +/- 4.49m.
- At the toe, vertical error is +/- 2m, lateral error is +/- 12.59m.

Well 204-I1 was drilled after well 204-P1 using a magnetic ranging tool that allowed to maintain a strict constrain to the distance between 204-I and 204-P1; 204-P1 and 204-I locations are not independent. Absolute uncertainty on 204-I location is estimated as follows:

- At the heel, vertical error is +/- 0.64m, lateral error (or E-W) is +/- 4.36m.
- At the toe, vertical error is +/- 2m, lateral error is +/- 12.9m.

These uncertainties in the well location are to be taken into account in geo-mechanical analysis aiming at determining field-wide safe operating pressure. They are fairly limited in the particular area of the steam release close to the heel of 204-I1 and 204P1 wells.

5 Conclusions

The main conclusions of the present review of the geology of the steam release area are the following:

- From the injector position at approximately 248 m MSL upwards, the typical geology of the steam release area consists of the following sequence:
    - 18 - 20 m of excellent quality bitumen bearing sands from 248 to 266 - 268 m MSL below ground in the Middle McMurray.
    - 7 – 8 m of lower quality sands from 266 - 268 m MSL to 275 m.
    - A first clear shale barrier at approximately 275 m MSL
    - 19 m of bitumen bearing sand/shale interbeds from 275 m MSL to 294 m MSL (Middle and Upper McMurray). Some limited gas saturation occurrence in this interval is possible based upon nearby observations. Such gas occurrences determine some storage ability in this interval. The shales in this interval are responsible for stopping the vertical movement of steam on 101-I1P1 and with a near certainty everywhere else (such limitation is a major issue for the economic character of SAGD production on Joslyn). However, residual uncertainties remain on the lateral continuity of these shale intervals; as a consequence it is not certain whether or not such shale can stop the pressure from building up toward shallow interval (through water / gas movement).
    - 1 m of silty mud (Kcw1 interval) from 294 m MSL to 295 m MSL with excellent correlation over the lease acreage. This interval is unlikely to act as a strong seal or as a drain.
    - 5 m of marine mud (Kcw2 interval) from 295 m MSL to 300 m MSL with excellent correlation over the lease acreage. Pressure (documented in reference 7) and fluid column data demonstrate that this interval constitute a static seal seal. It is expected that such static steal maintain its seal ability under SAGD conditions as it is far enough from the steam chamber not to be significantly heated.
    - 2 m of marine fair quality sand interval from 300 to 302 m MSL with excellent correlation over the lease acreage. Some bitumen saturation is possible in the interval. This interval may present some significant pressure drain and fluid storage ability.
    - At least 22 m of massive shale. This interval constitutes the ultimate seal over the SAGD area (a failure of this particular seal is certain to end up with a surface steam release).
    - 5 to 12 m of Quaternary deposits.
- In the absence of clear evidence of fracture in the overburden interval (from top GPP to surface), it is deemed unlikely that pre-existing fractures constitute a root cause of the May 18th 2006 steam release.
- Thicknesses to be used in geo-mechanical analysis aiming at determining safe steam chamber operating pressure should consider a horizontal toe well depth uncertainty of around 2 m.

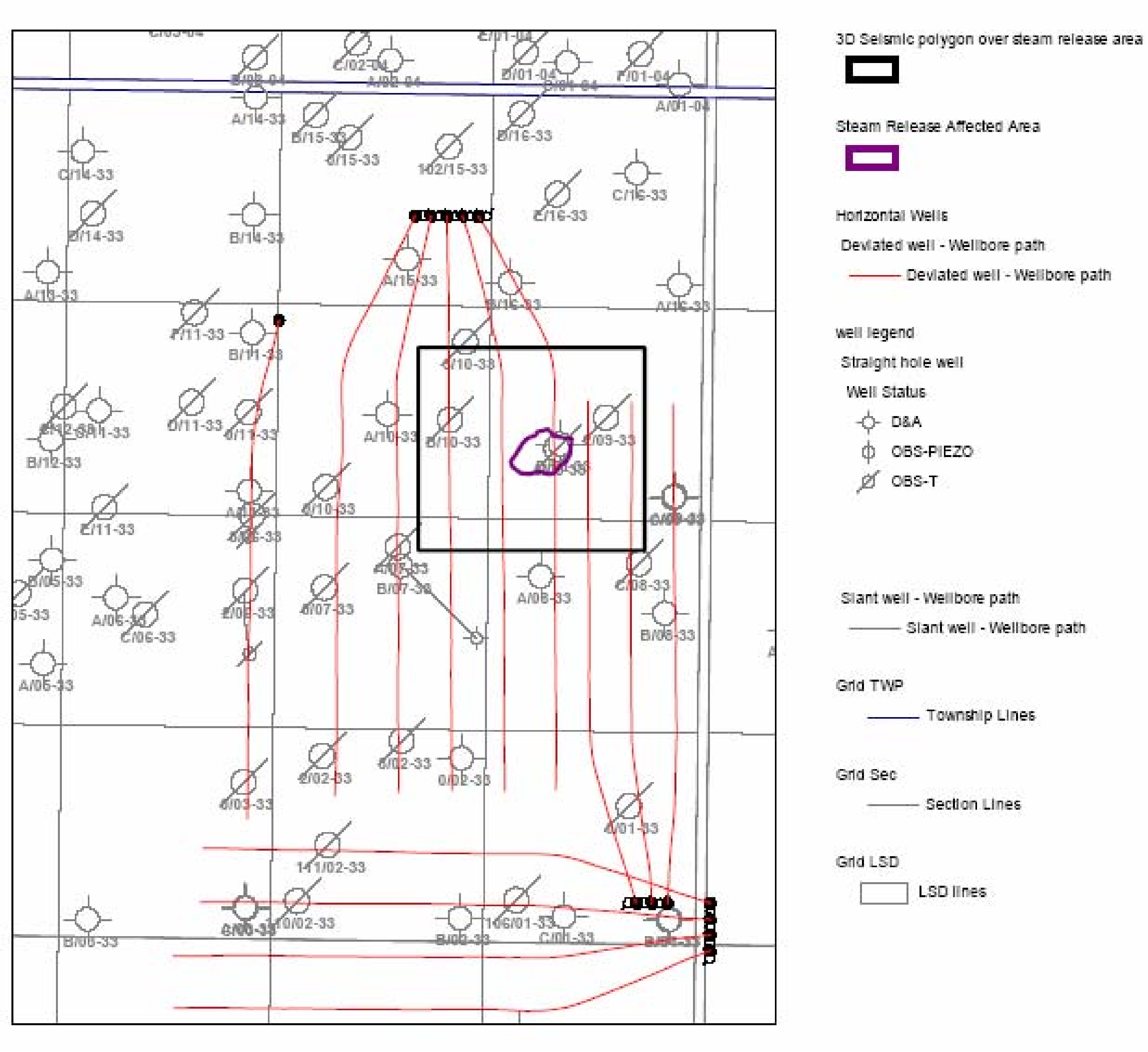


Figure 13 Plan View of Joslyn Phase 2 Development Area

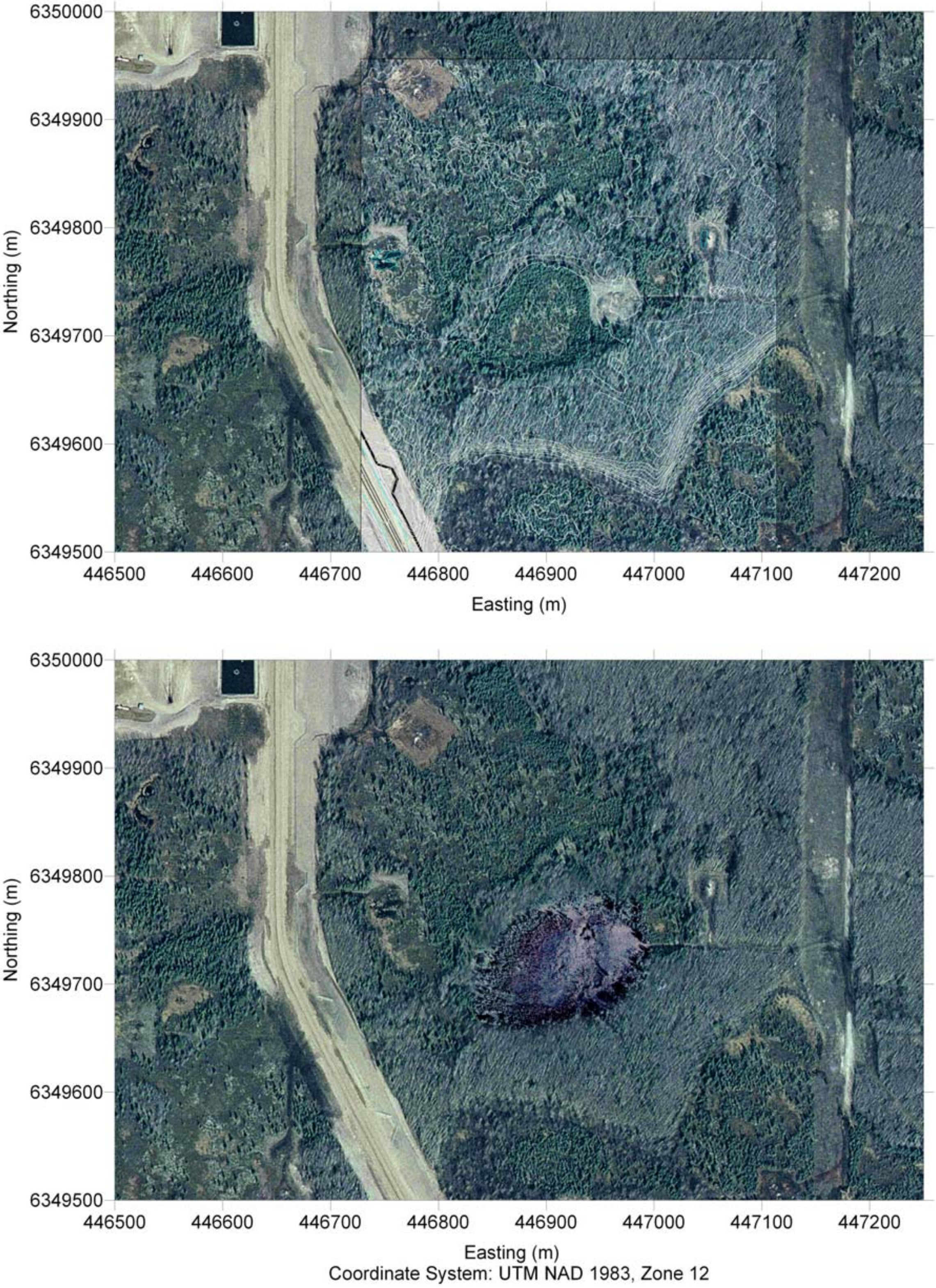


Figure 14 Aerial photography of area before and after steam release

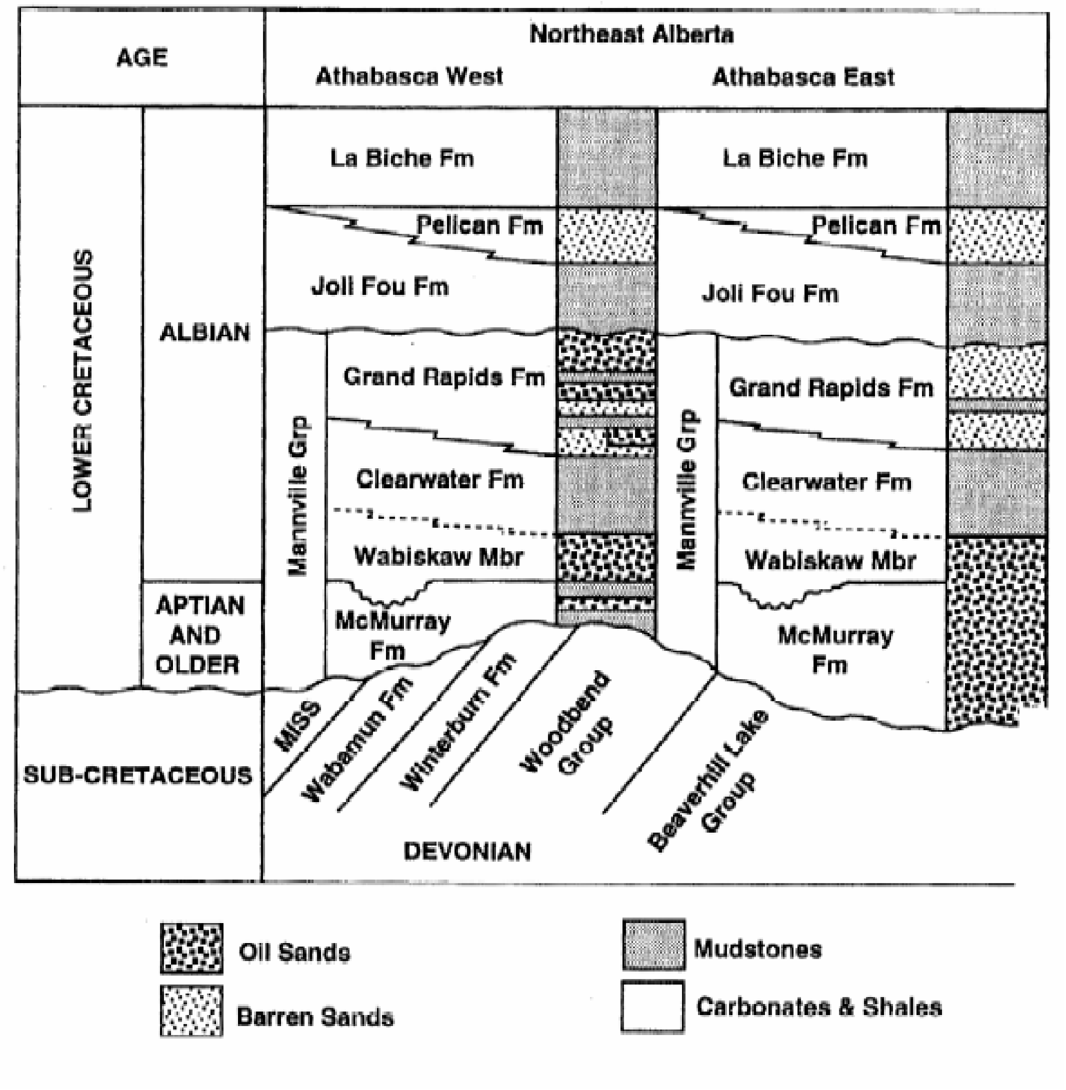


Figure 15: Generalized Stratigraphic nomenclature

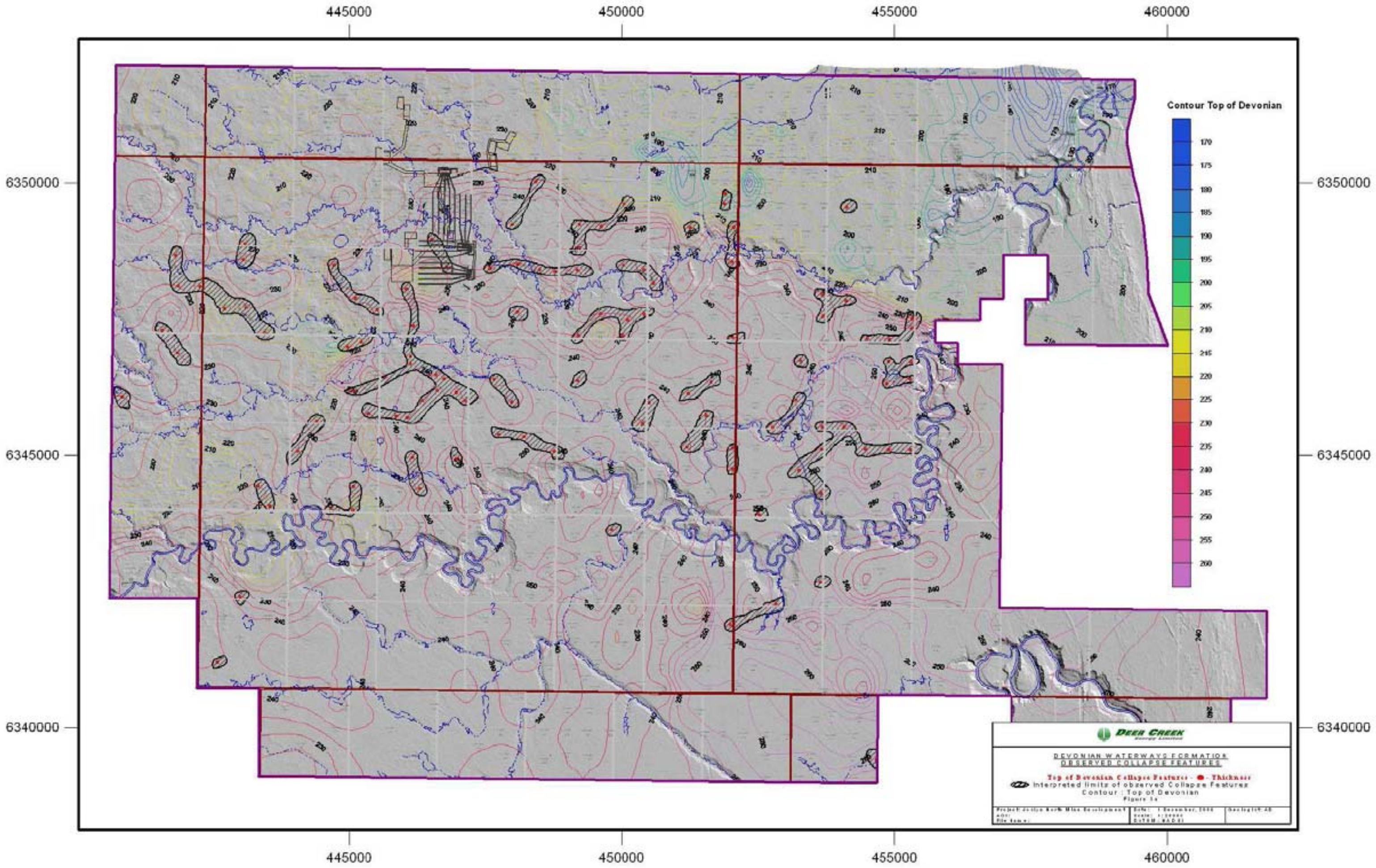


Figure 16 Top Devonian Collapse Structure

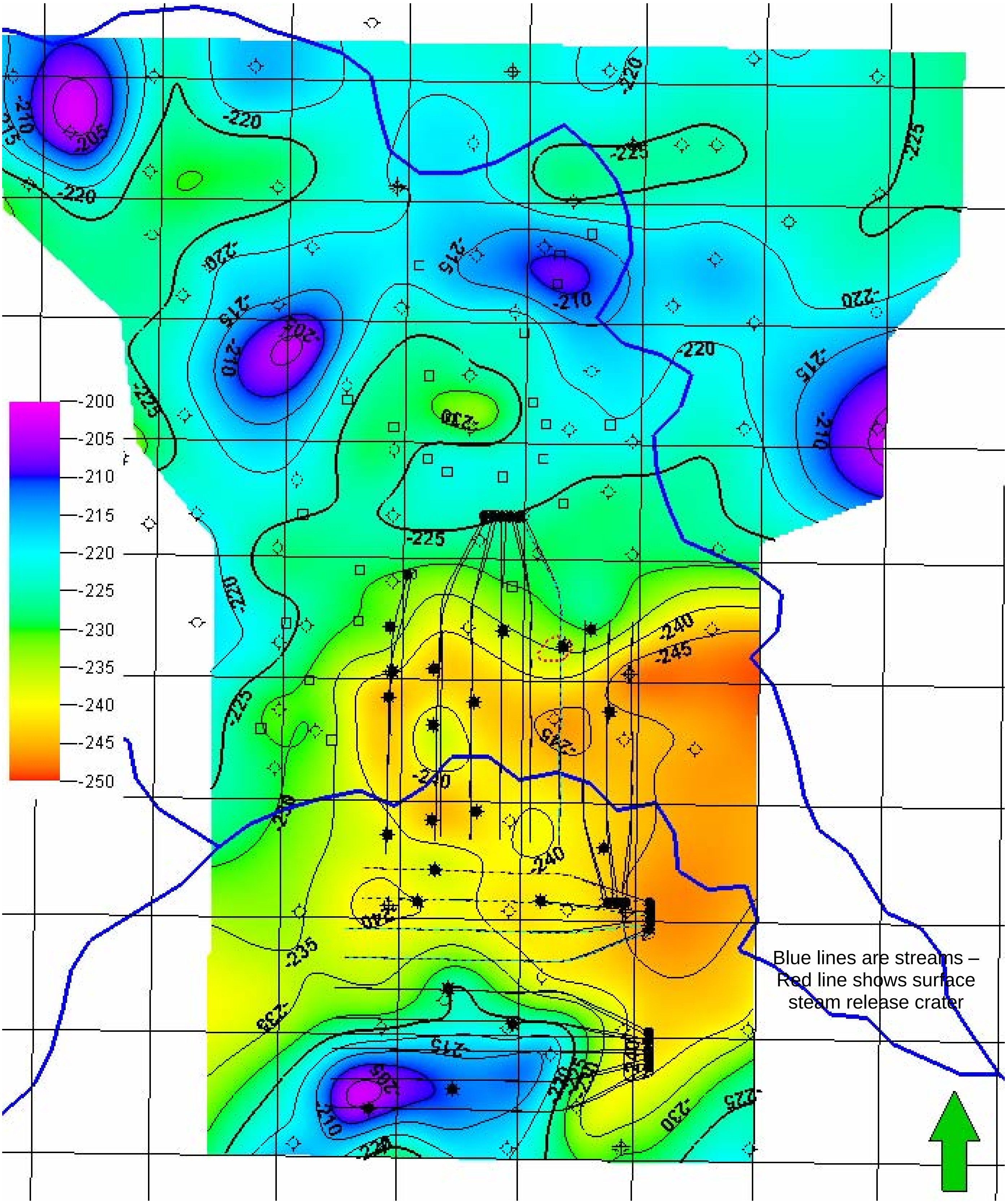
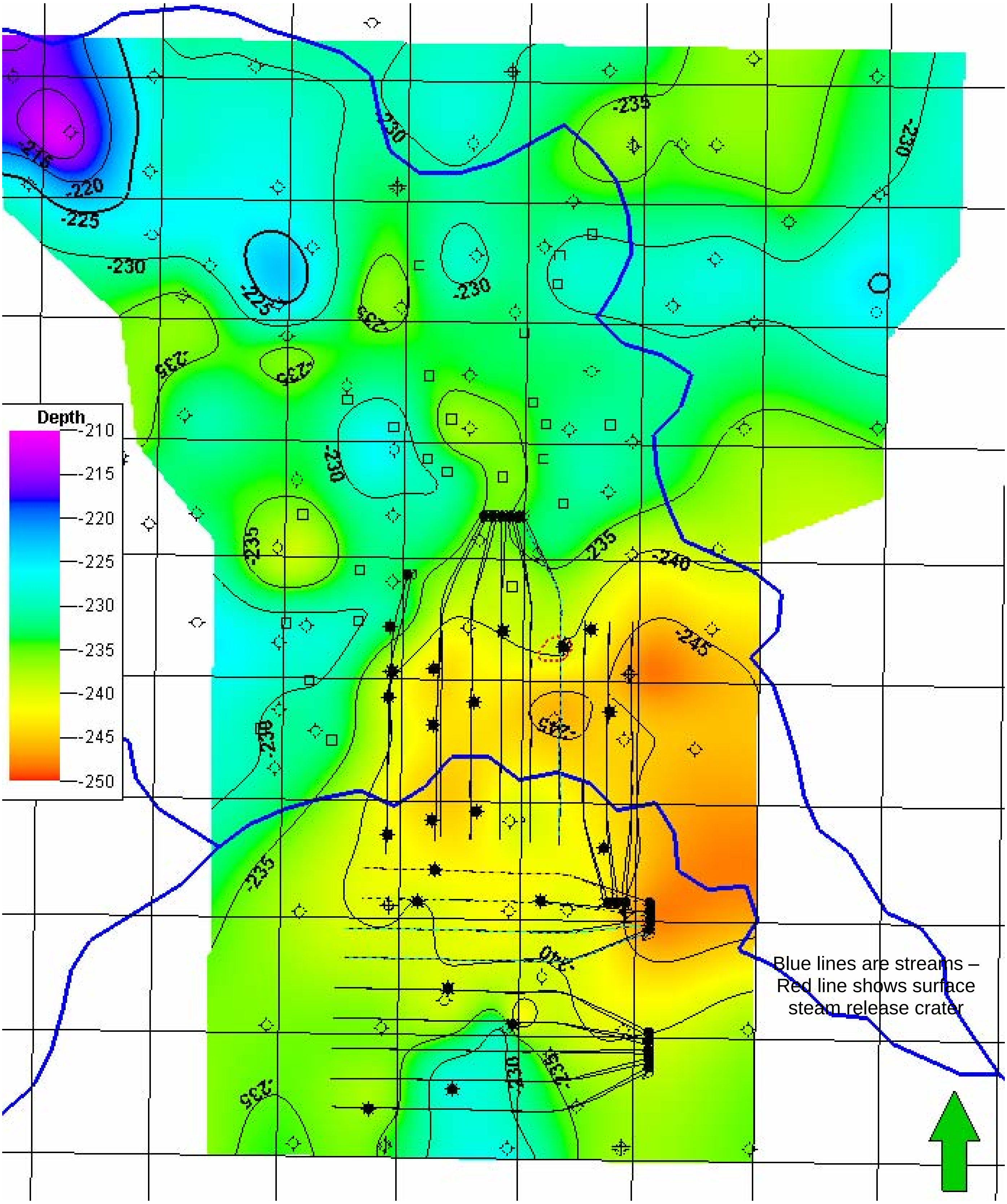
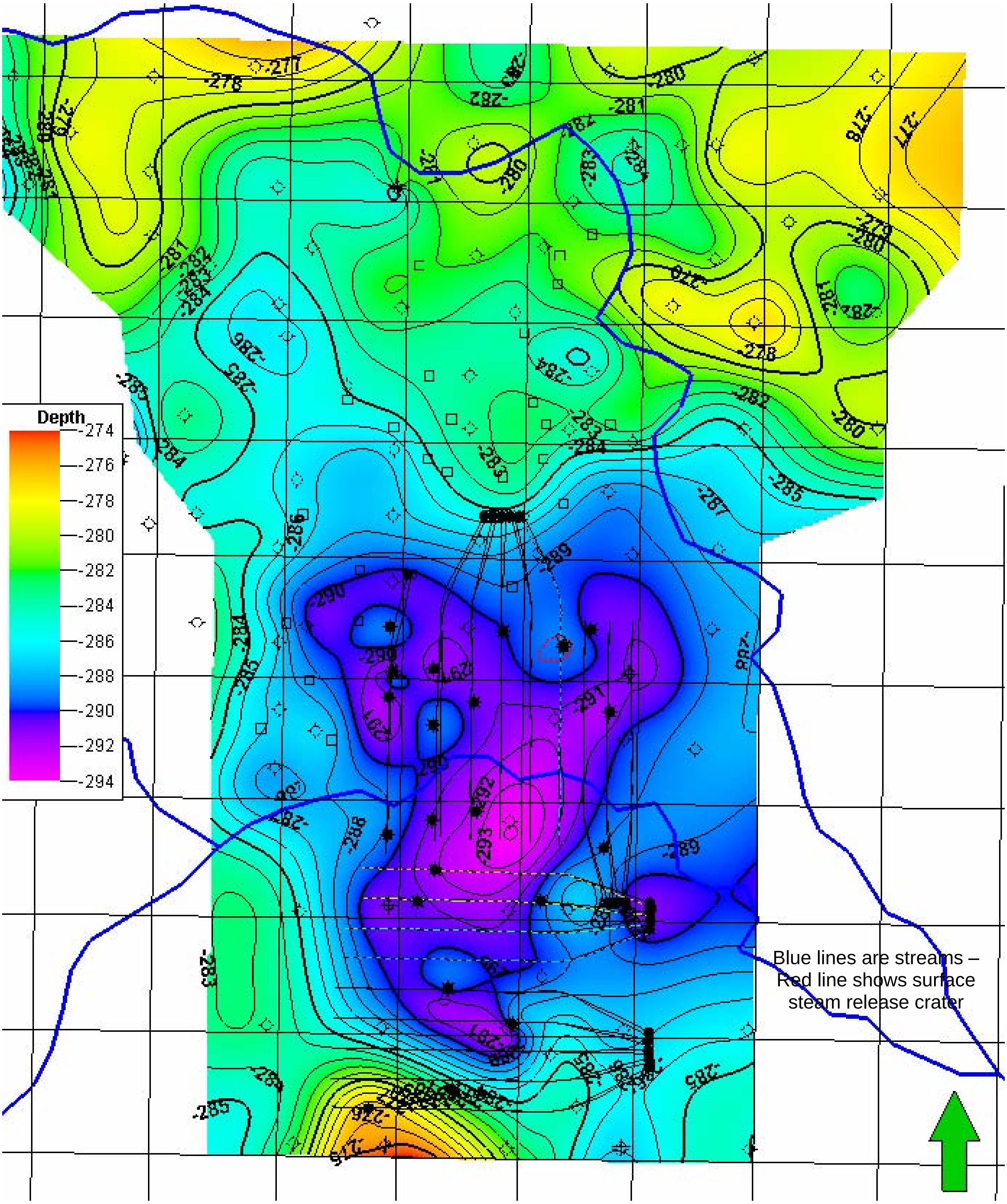


Figure 17 Devonian Depth Map (m)



Blue lines are streams –
Red line shows surface
steam release crater

Figure 18 Lower McMurray Depth map (m)



Blue lines are streams – Red line shows surface steam release crater

Figure 19 Middle McMurray Depth map (m)

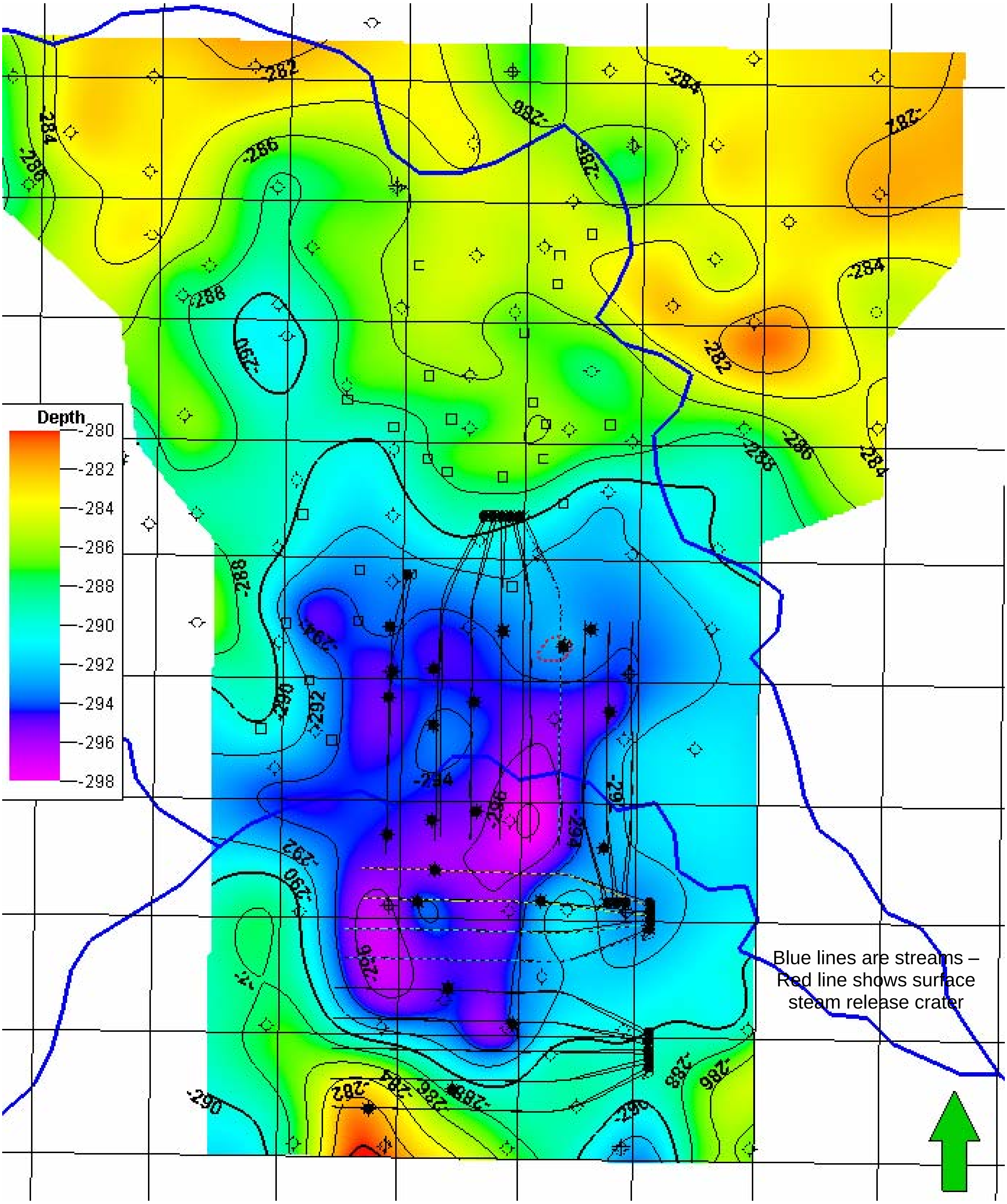


Figure 20 Upper McMurray depth Map (m)

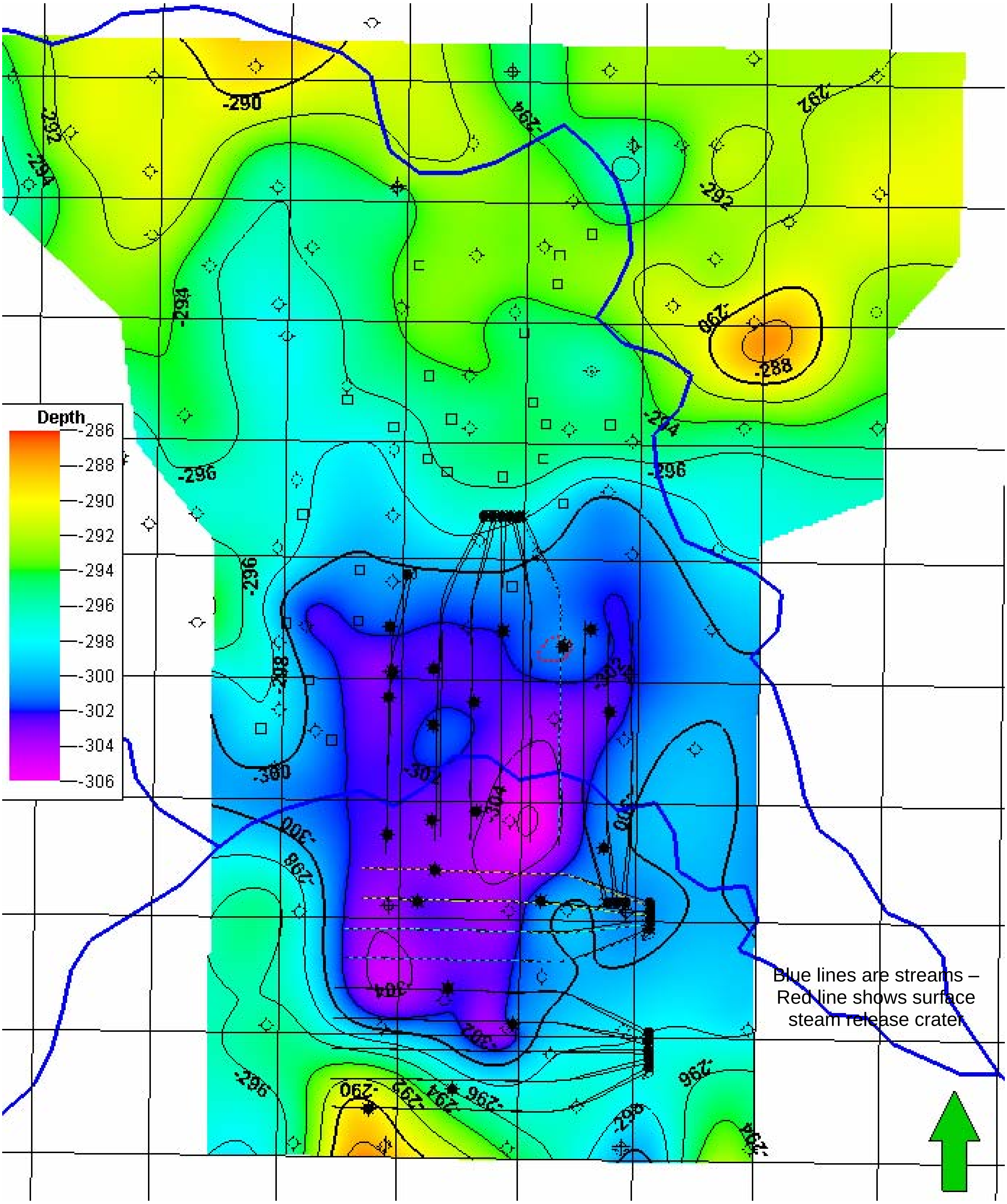
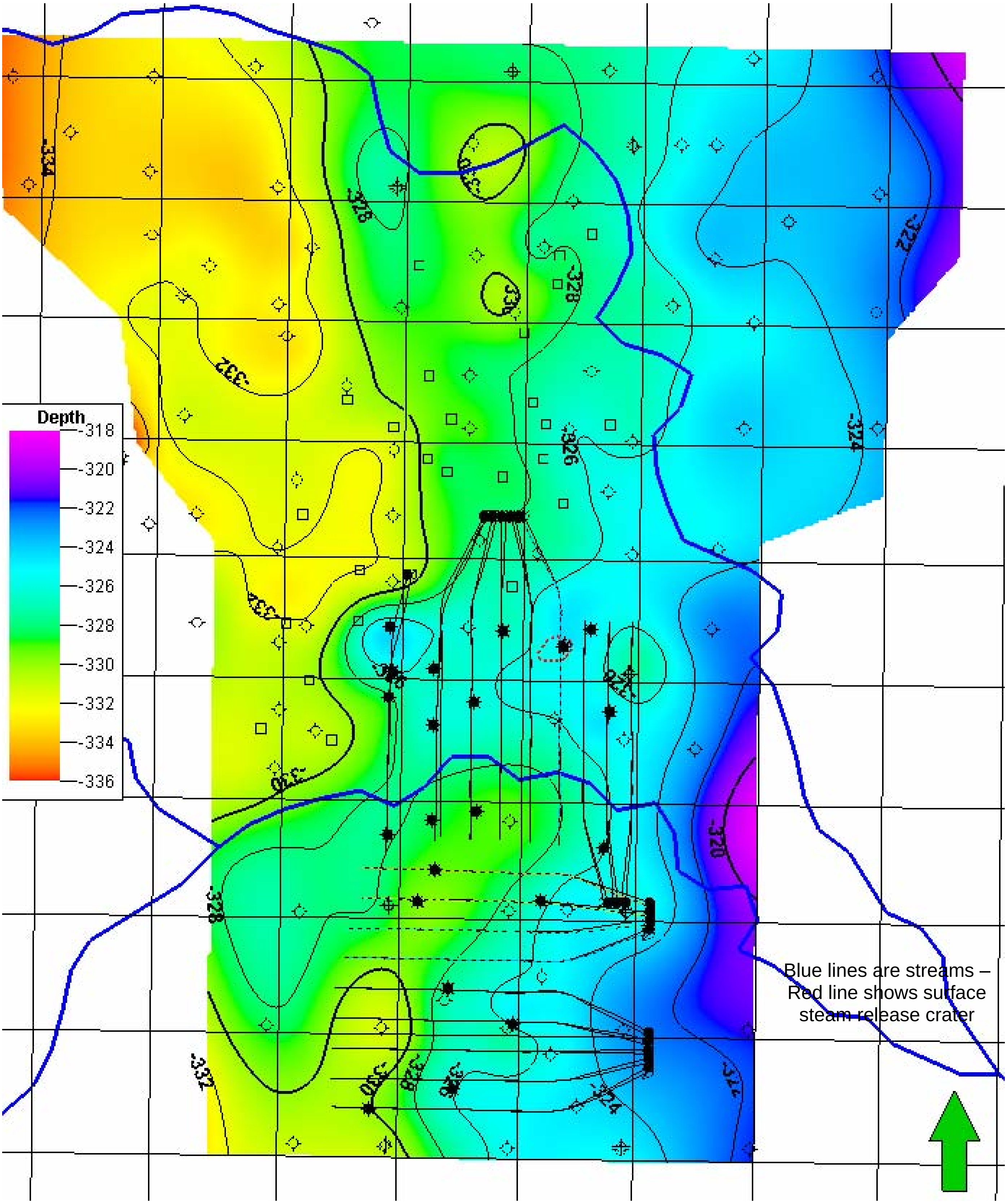


Figure 21 Wabiskaw Depth map (m)



Blue lines are streams – Red line shows surface steam release crater

Figure 22 Clearwater Depth Map (m)

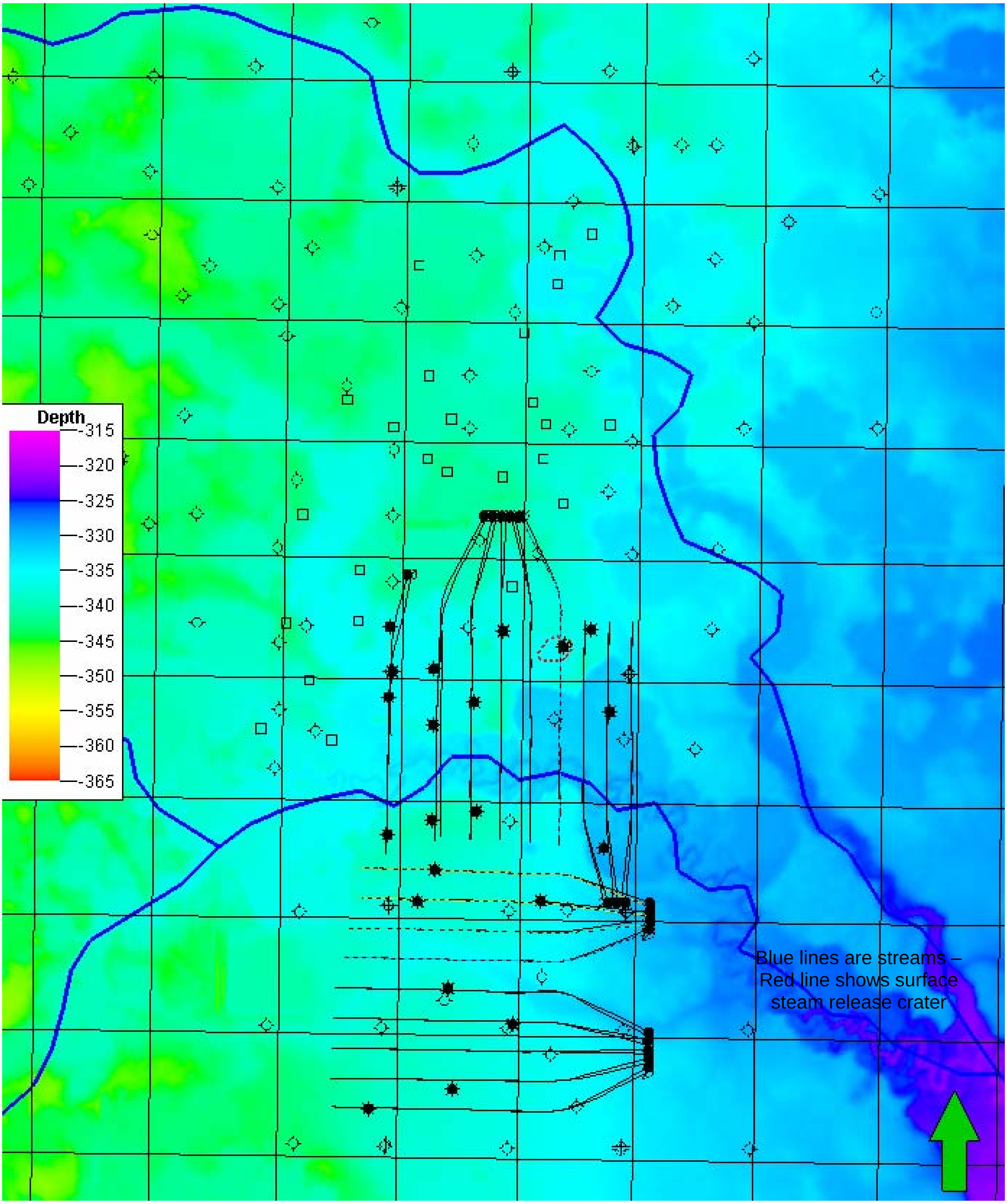


Figure 23 Ground Depth Map (m) – Blue line are streams

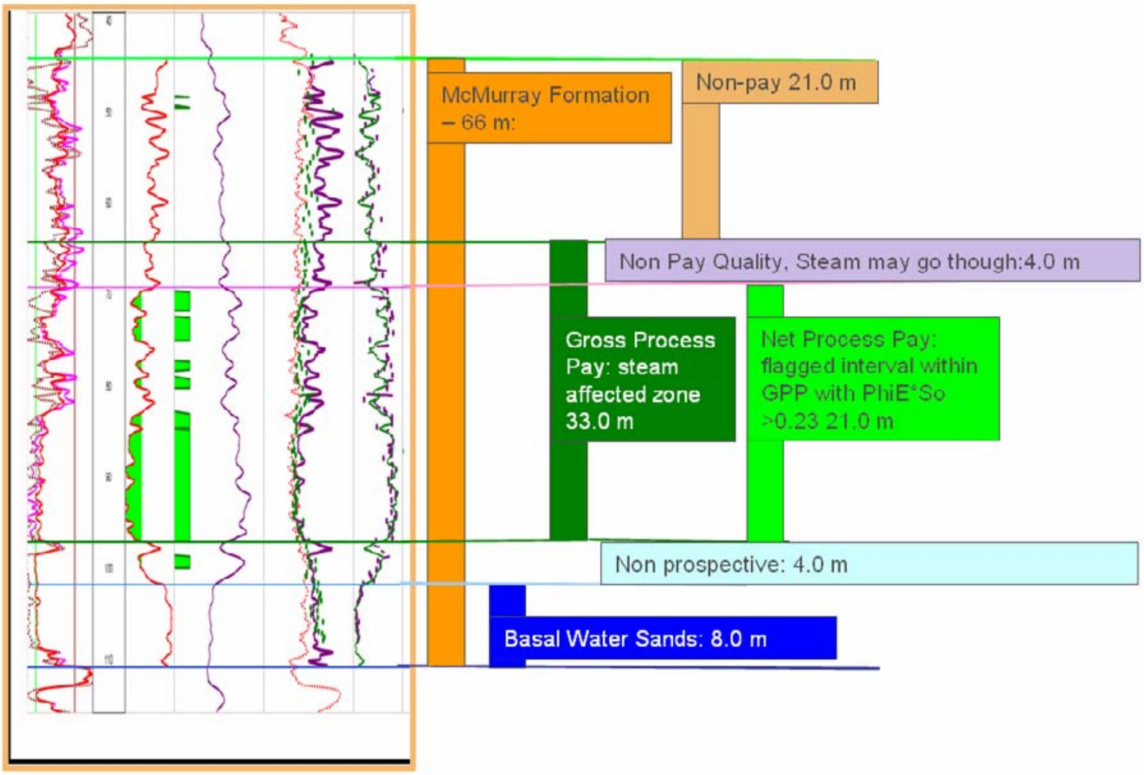
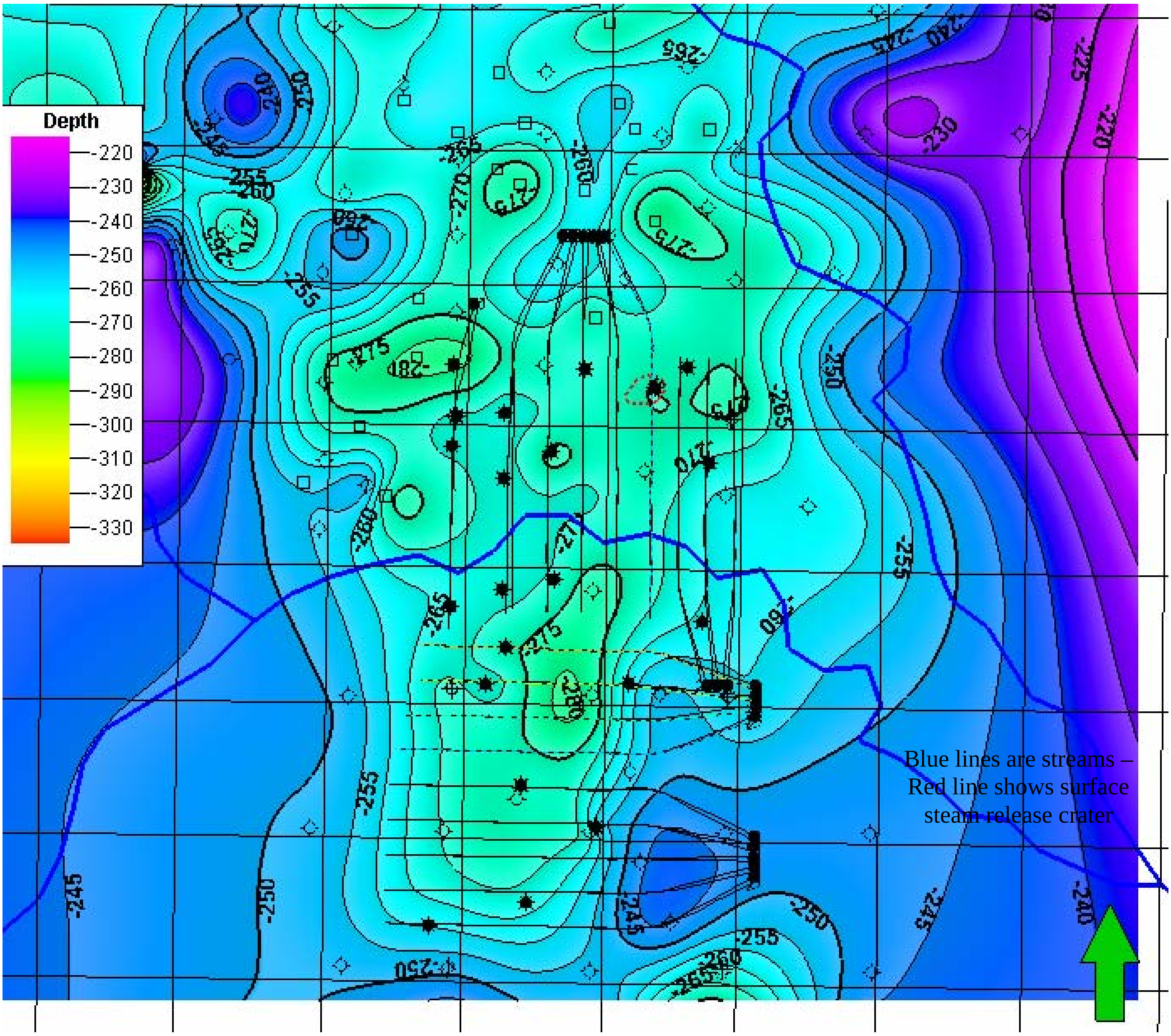
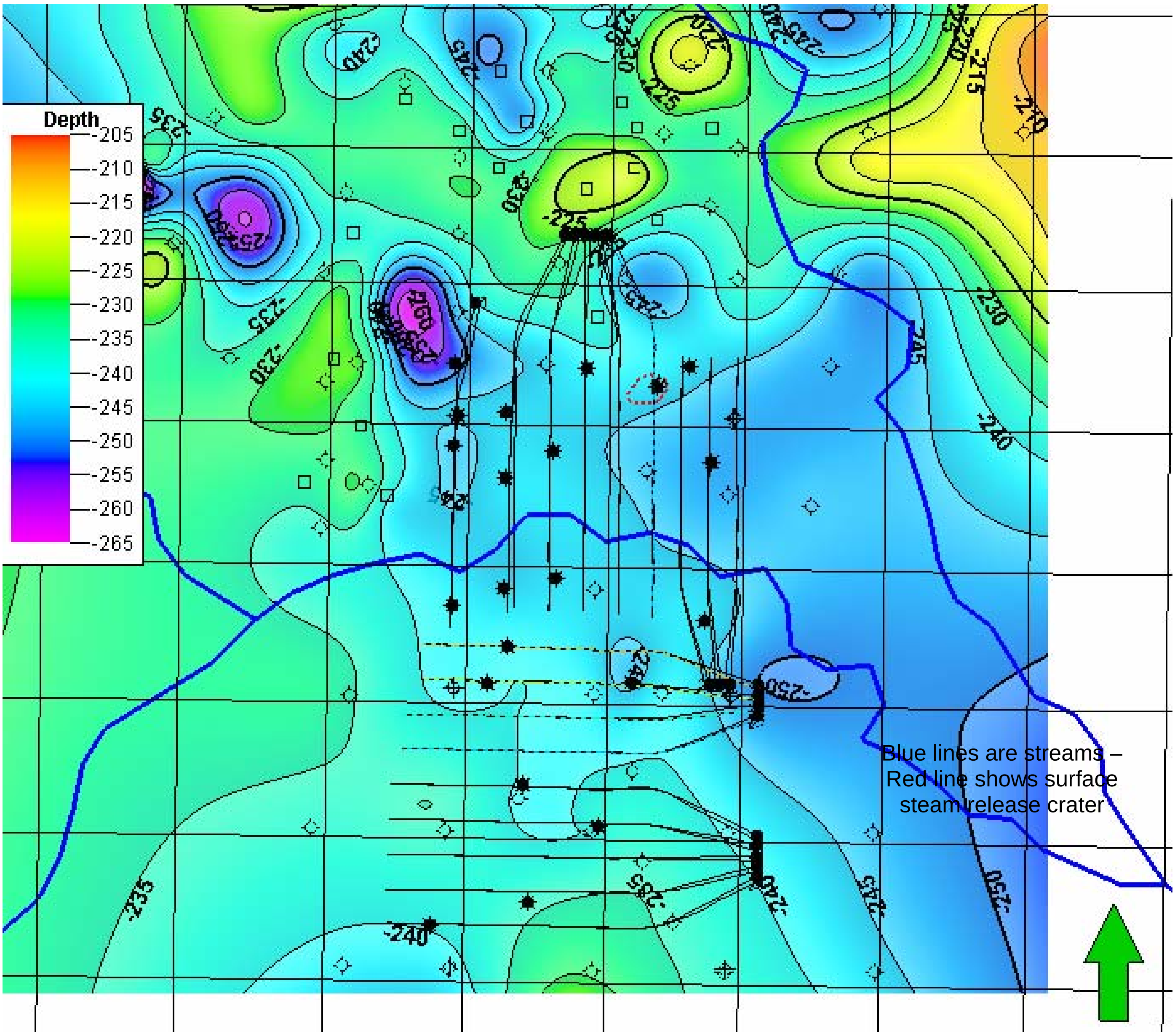


Figure 24 NPP & GPP Definition Sketch



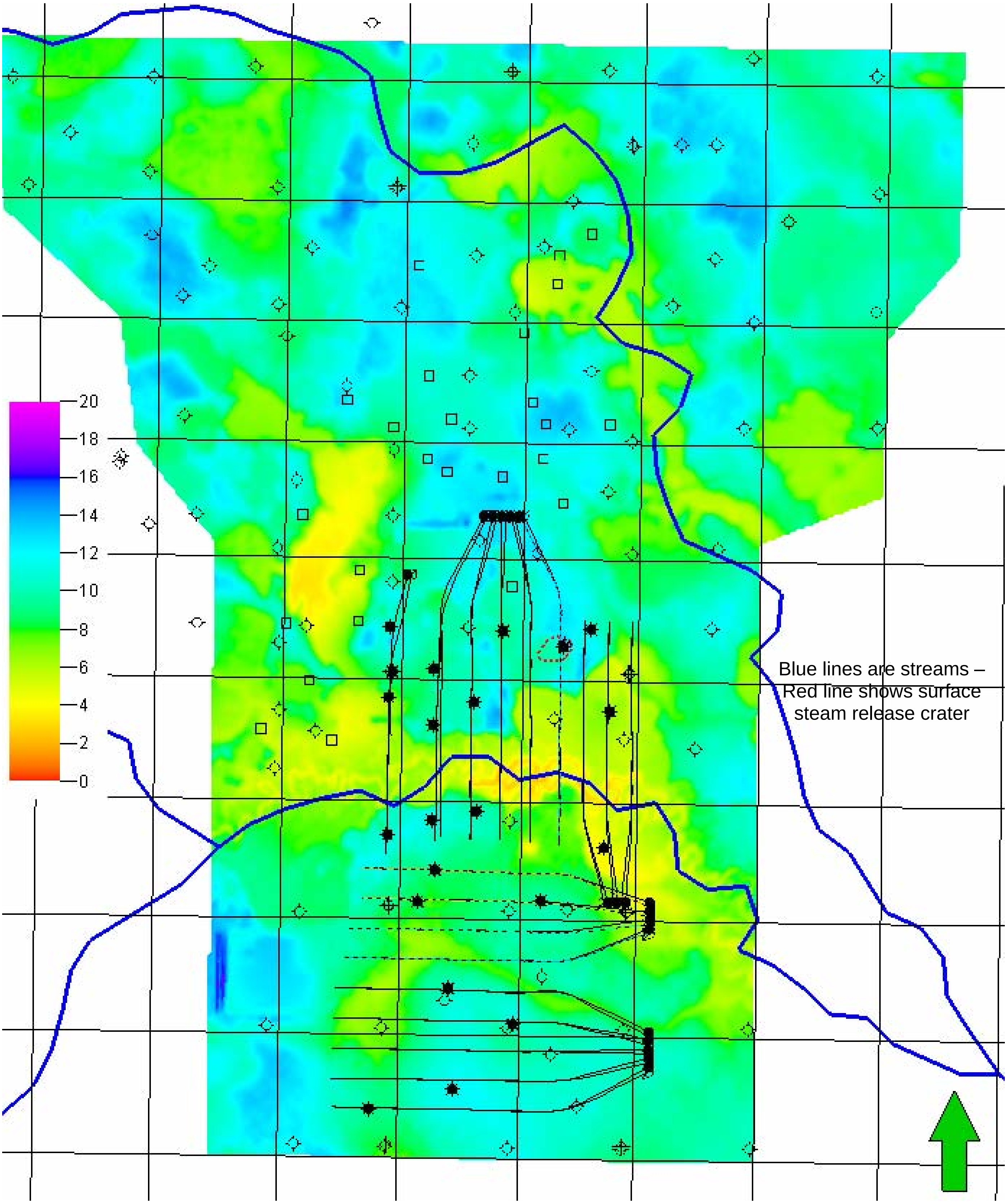
Blue lines are streams – Red line shows surface steam release crater

Figure 25 Top GPP Depth Map (m)



Blue lines are streams – Red line shows surface steam release crater

Figure 26 Base GPP depth Map (m)



Blue lines are streams – Red line shows surface steam release crater

Figure 27 Surface to Top Clearwater Interval Thickness Map (m)

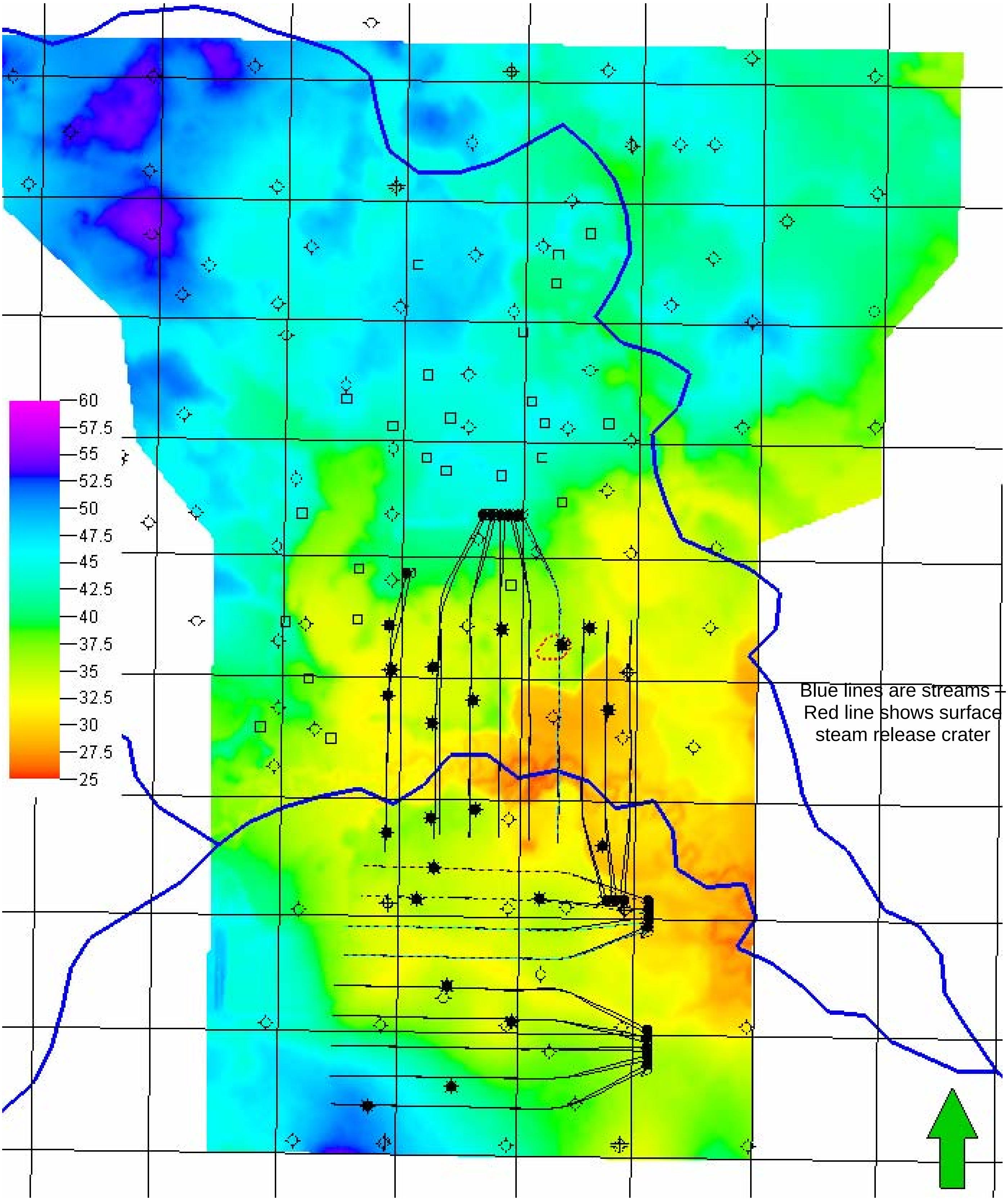
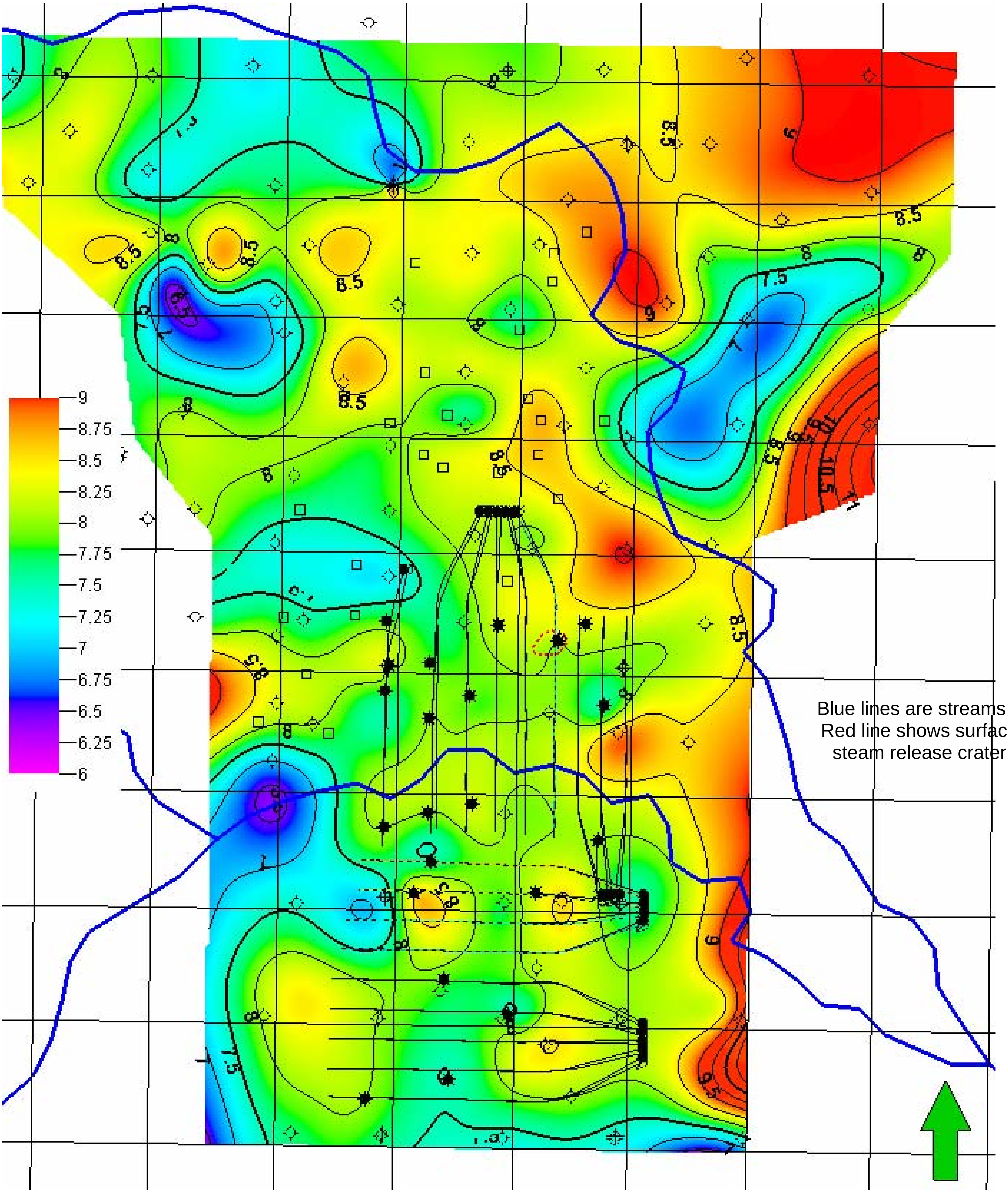


Figure 28 Surface to Wabiskaw Interval Thickness map (m)



Blue lines are streams – Red line shows surface steam release crater

Figure 29 Wabiskaw Thickness Map (m)

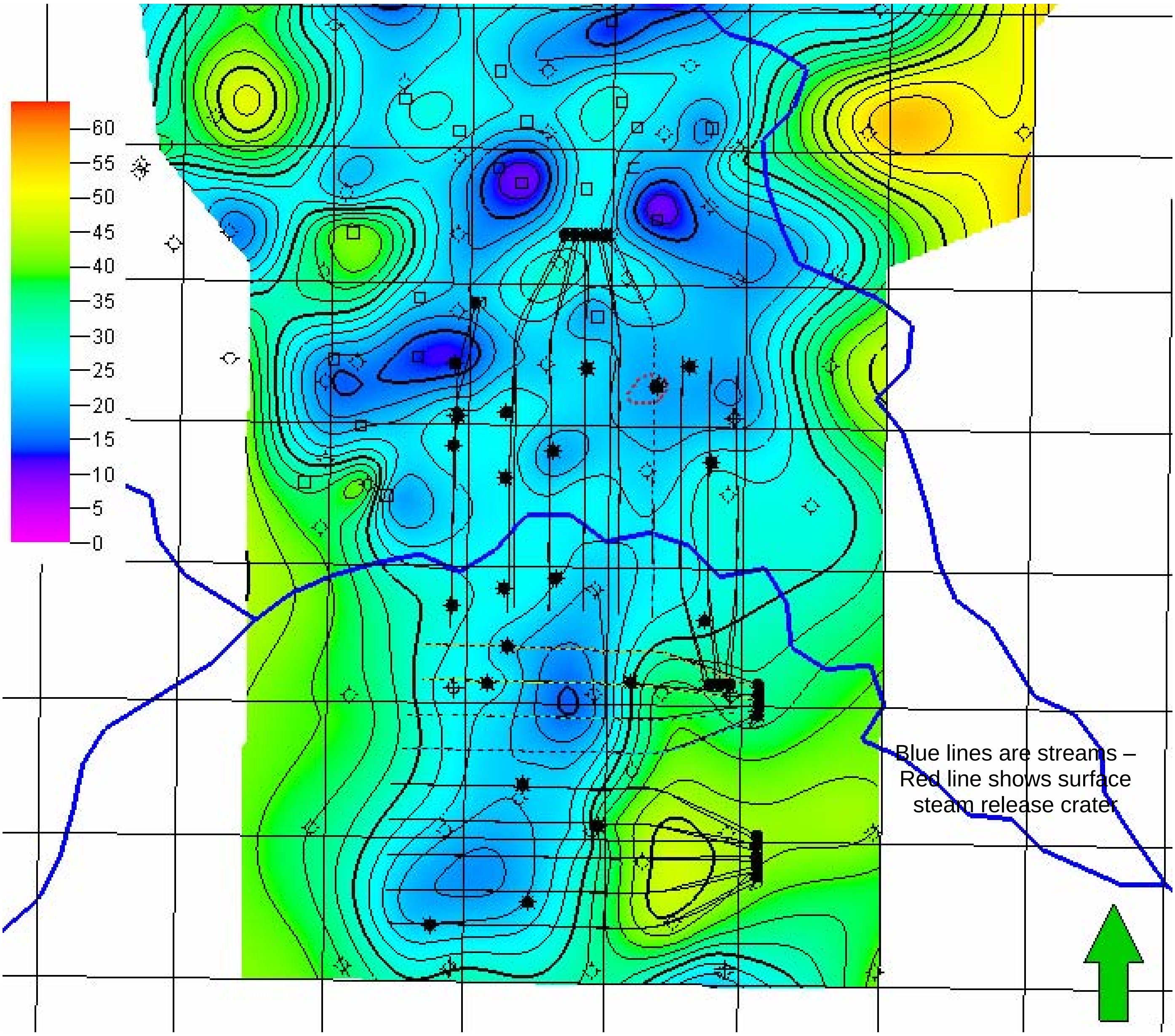


Figure 30 Top McMurray – Top GPP Interval Thickness Map (m)

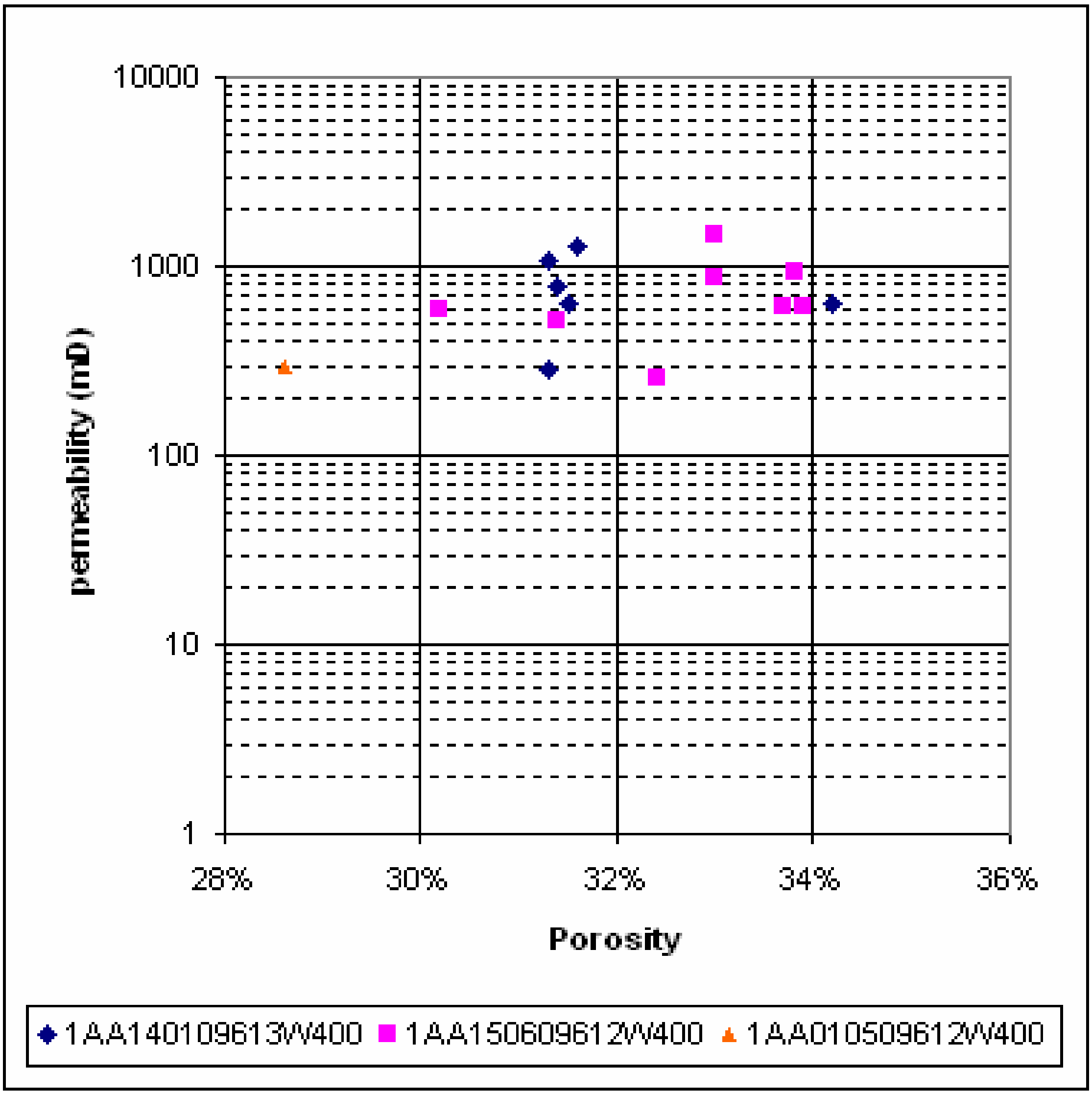


Figure 31 Wabiskaw sands/silts plug permeability

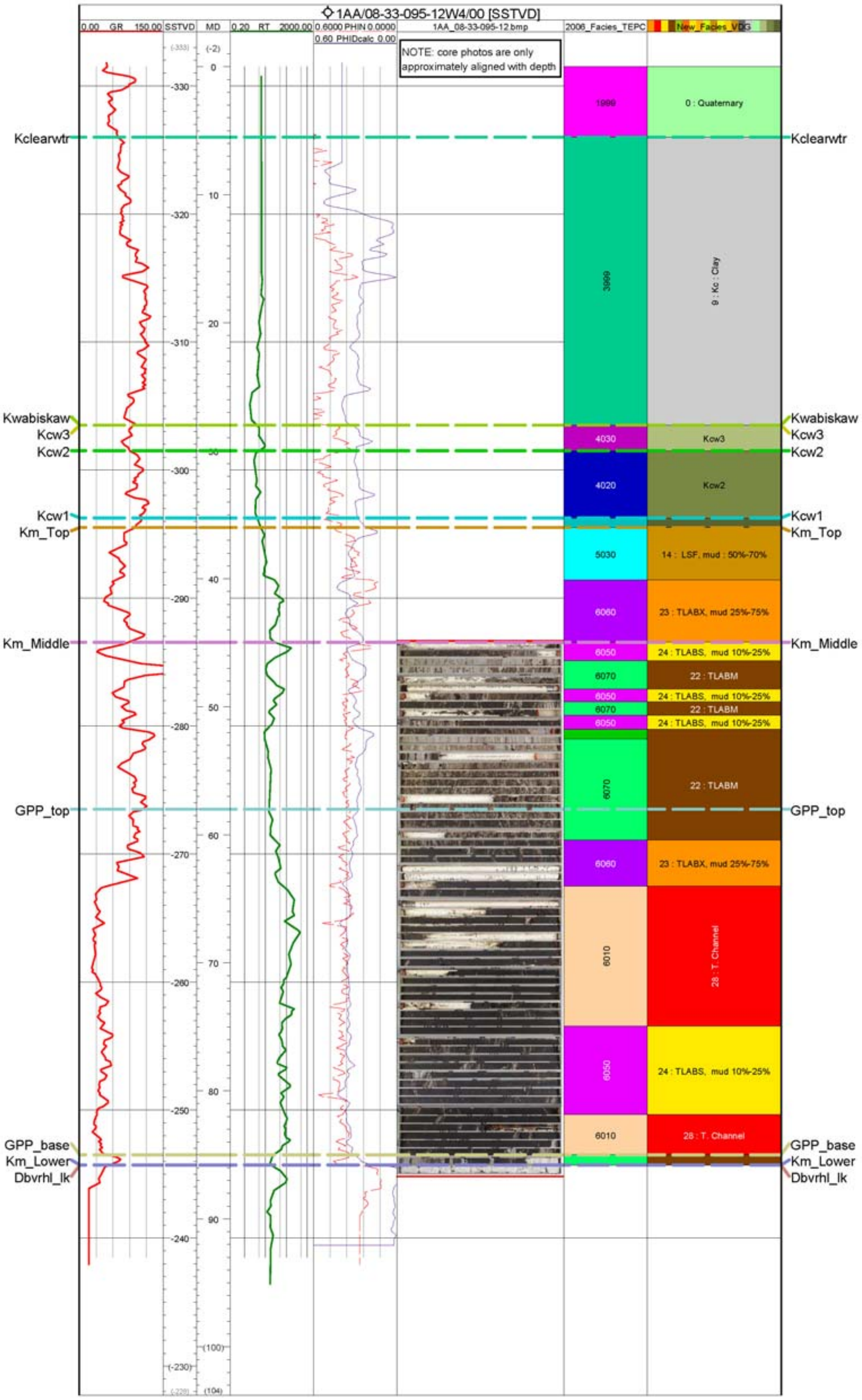


Figure 32 Well 1AA 08-33-095-12

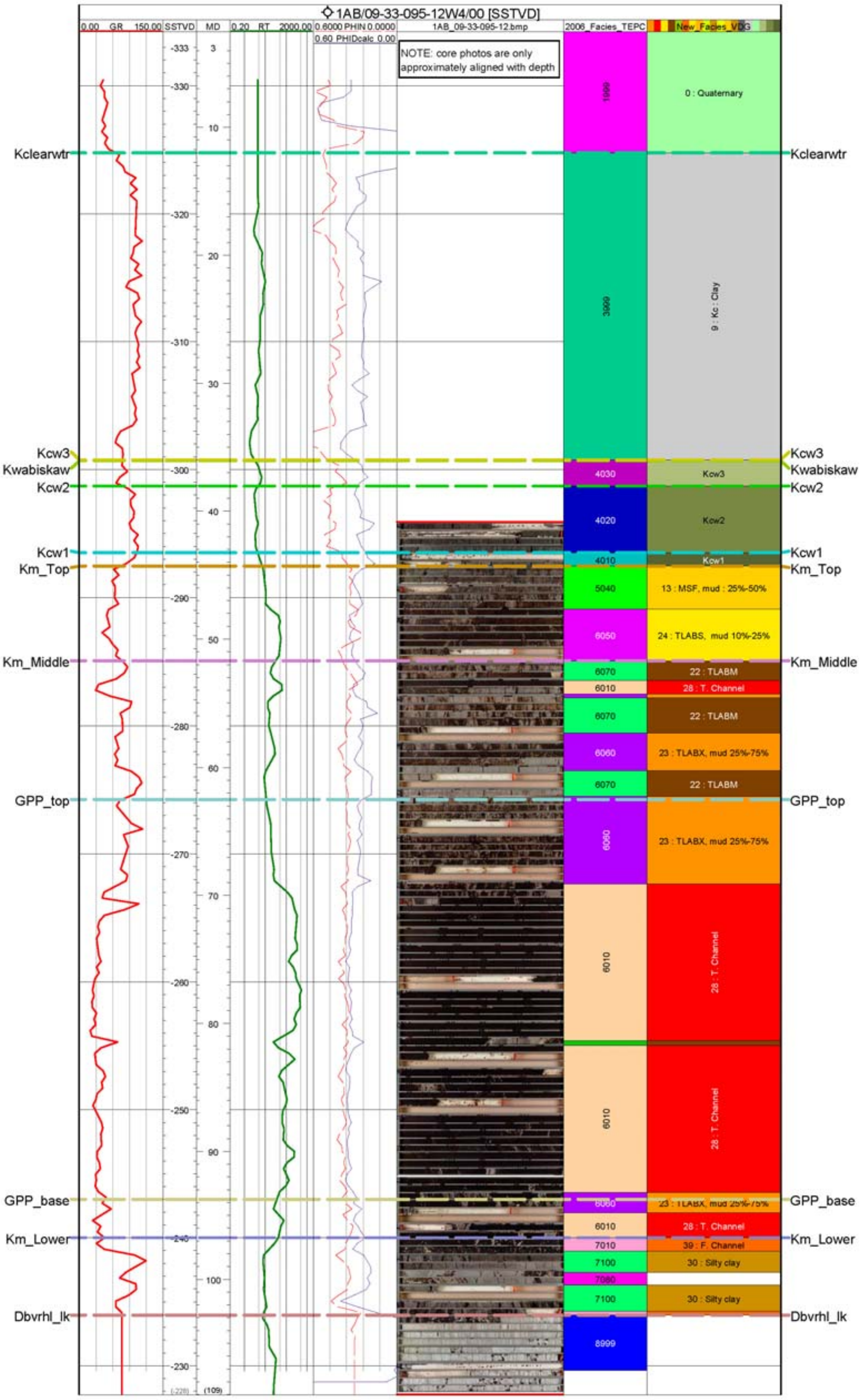


Figure 33 Well 1AB 09-33-095-12

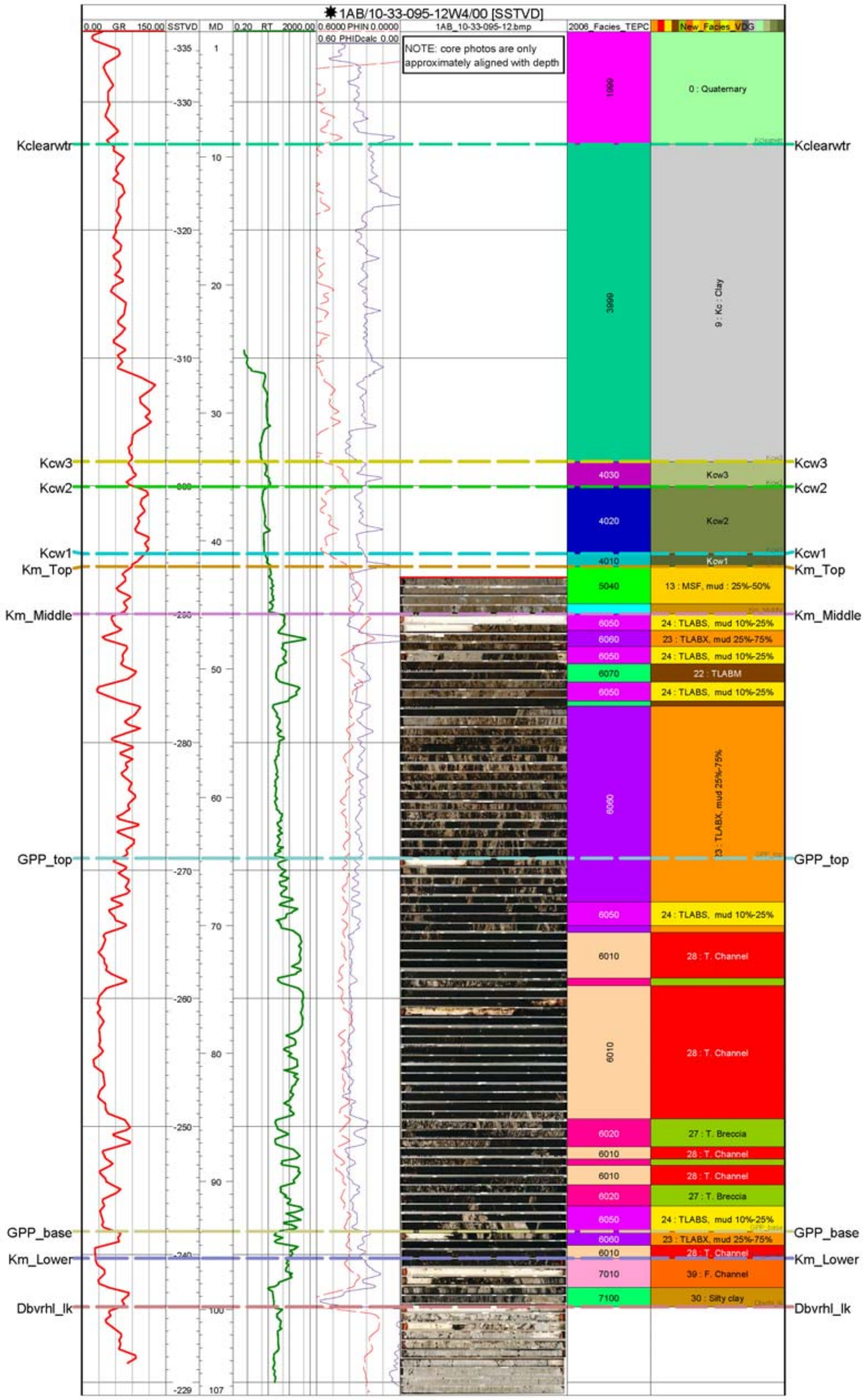


Figure 34 Well 1AB 10-33-095-12

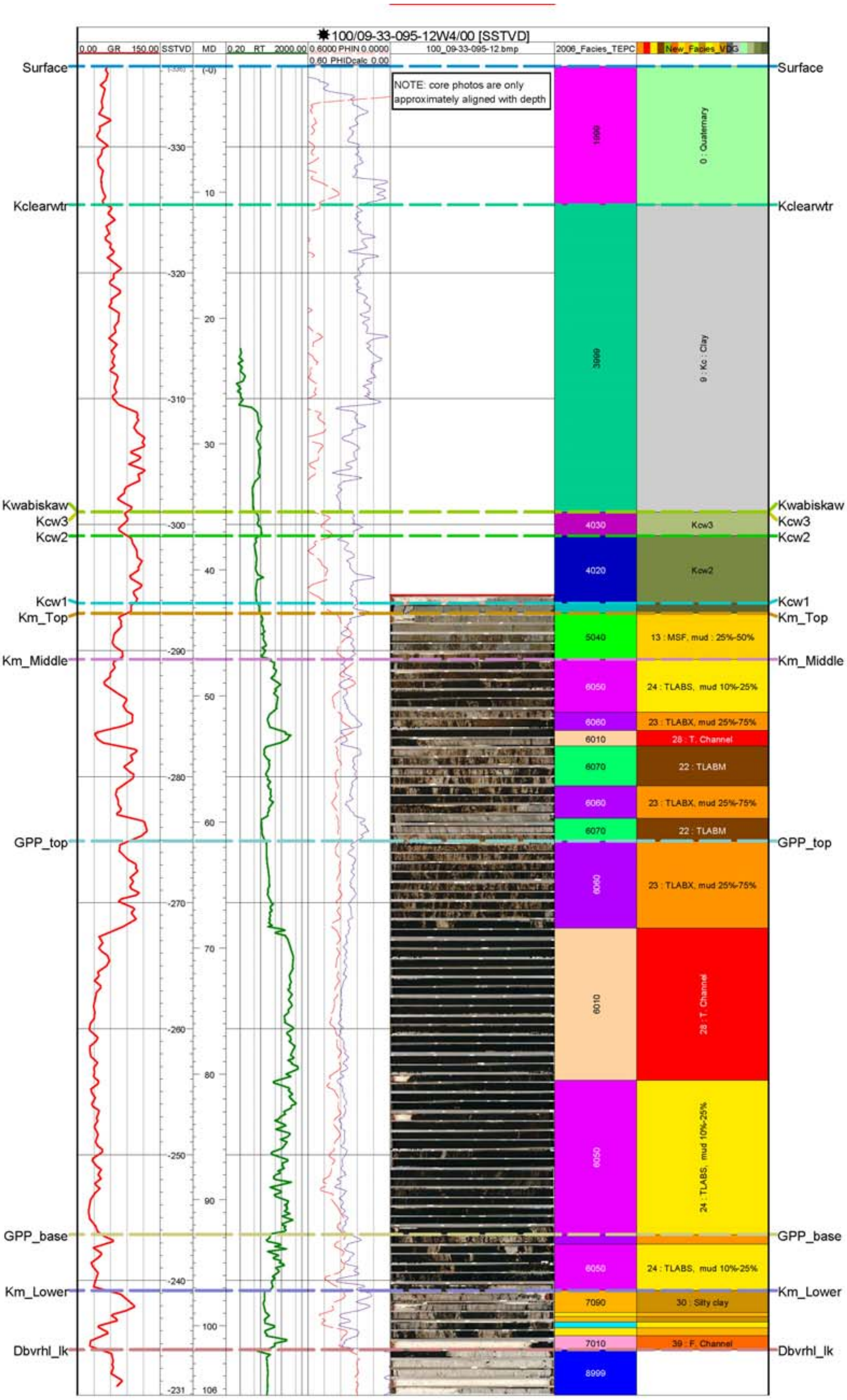


Figure 35 Well 100 09-33-095-12

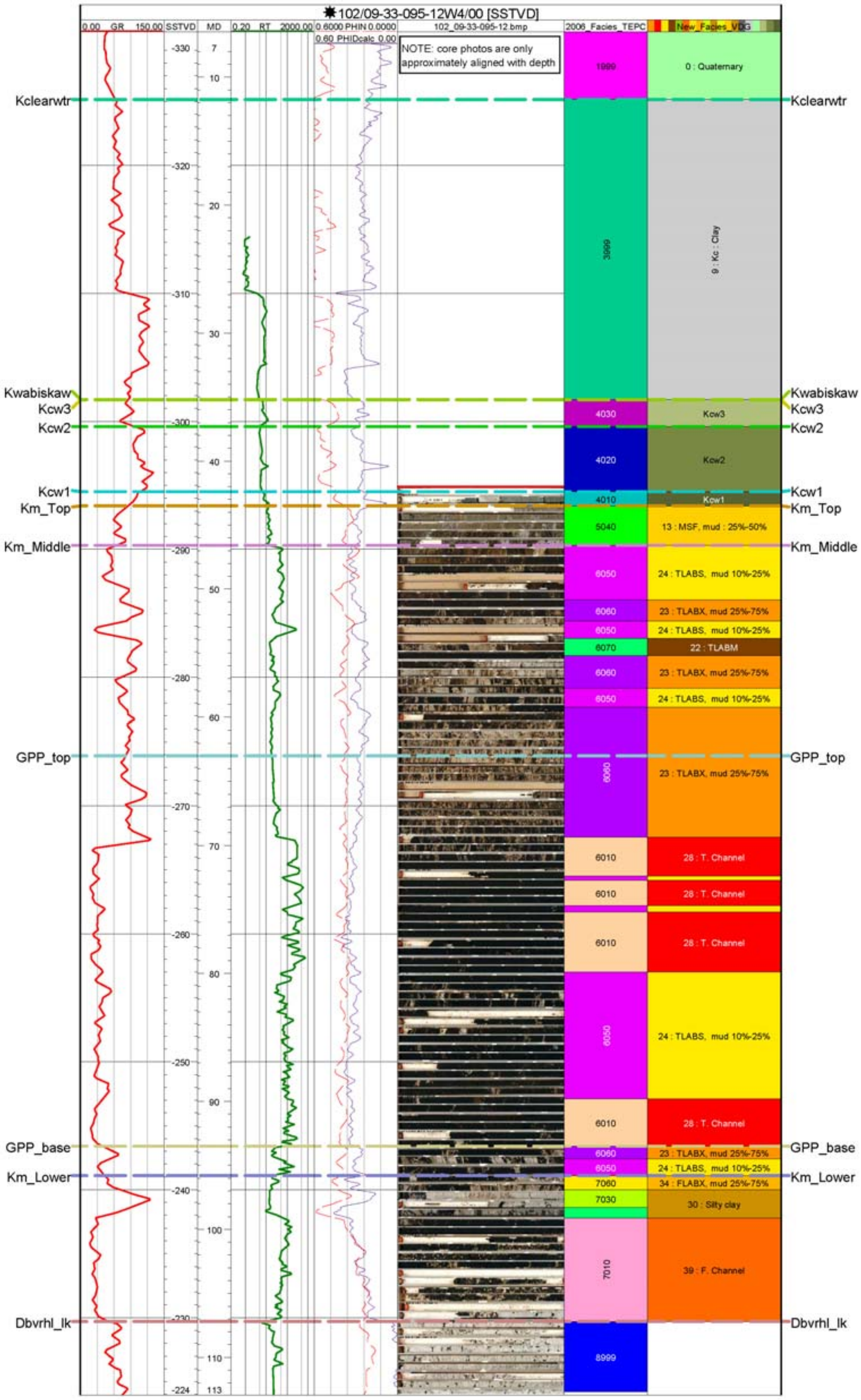


Figure 36 Well 102 09-33-095-12

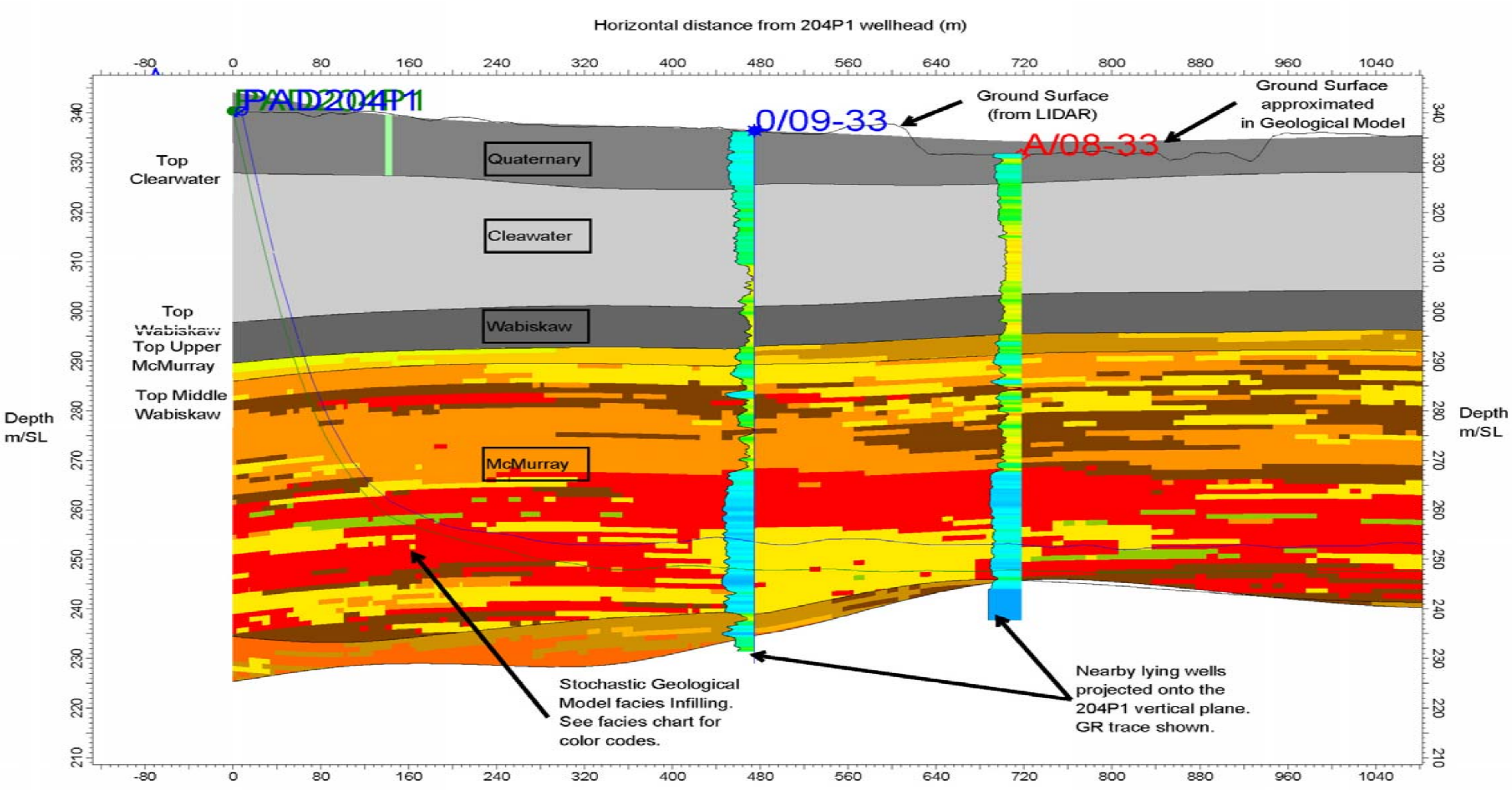
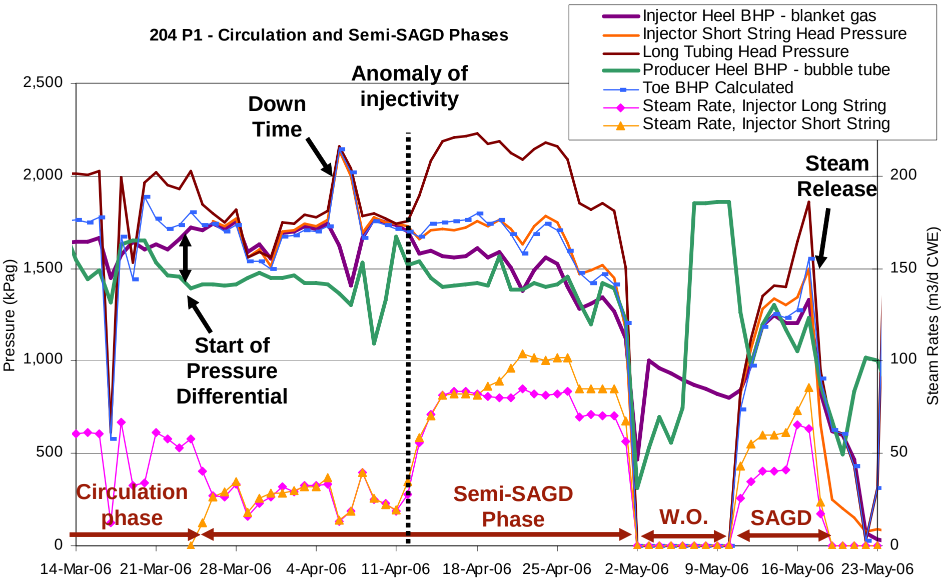


Figure 37 X section across 204-I1P1 pair

Top	AA/8-33			100/09-33			1AB/09-33			102/09-33			1AB/10-33			Thickness Range (m)	Fluid	Description
	m/MS	m/MD	m	m/MS	m/MD	m	m/MS	m/MD	m	m/MS	m/MD	m	m/MS	m/MD	m			
Ground	331.5	0.0		336.4	0.0		336.8	0.0		336.9	0.0		335.7	0.0				Reference for log MD
Quaternary	331.5	0.0	5.5	336.4	0.0	11.0	336.8	0.0	12.0	336.9	0.0	11.8	335.7	0.0	9.0	5.5 - 12.0	Water	
Clearwater	326.0	5.5	22.5	325.4	11.0	24.4	324.8	12.0	24.0	325.2	11.8	23.5	326.7	9.0	24.8	22.5 - 24.8	Water	
Wabiskaw Kcw3	303.5	28.0	2.0	301.0	35.4	1.9	300.8	36.0	2.1	301.7	35.2	2.1	301.9	33.8	1.9	1.9 - 2.1	Water	Offshore transition, fine grained (often glauconitic) sand inter-bedded with 15-25% medium grey wavy mud beds. Moderate to common burrows, typically diplocraterion and astrosoma.
Wabiskaw Kcw2	301.5	30.0	5.3	299.1	37.3	5.3	298.7	38.1	5.2	299.6	37.3	5.1	300.0	35.8	5.3	5.1 - 5.3	NA	Offshore medium grey mud with moderate silt lenses and rare glauconitic sand. Rare to moderate burrows, typically chondrities.
Wabiskaw Kcw1	296.3	35.3	0.8	293.8	42.7	0.8	293.5	43.3	1.1	294.5	42.4	1.1	294.7	41.0	1.0	0.8 - 1.1	Water	Offshore transition, medium grey mud interbedded with 10-30% fine grained glauconitic sand. Moderate to common burrows, typically diplocraterion.
Upper McMurray	295.5	36.0	4.0	293.0	43.5	3.7	292.5	44.3	3.3	293.4	43.5	3.1	293.7	42.0	3.7	3.1 - 4.0	Bitumen, gas saturation in places	Marine, inter-bedded wavy non-parallel steel grey mud beds and fine grained bitumen stained sand. Presence of gas is not uncommon. Sand filled burrows, typically teichnus, and thalassinoides.
Middle McMurray	291.5	40.0	45.8	289.3	47.1	50.1	289.2	47.6	49.2	290.3	46.6	49.2	290.0	45.7	50.3	45.8 - 50.3	Bitumen	Estuarine, mud is light grey parallel to wavy beds, sand is typically very fine to fine grained and bitumen stained.
Lower McMurray	245.7	85.8	0.0	239.2	97.2	4.7	240.0	96.8	6.1	241.1	95.8	11.4	239.7	96.0	3.8	0.0 - 11.4	Bitumen / Water	Fluvial, mud is creamy grey in colour and sand is typically fine to medium grained. Watersands is most likely to occur in this facies.
Devonian	245.7	85.8		234.5	101.9		234.0	102.8		229.7	107.2		235.9	99.8			Water	Contact is typically indurated with Pyrite.

Table 2 Stratigraphy, Sedimentology and Fluid Columns at wells AA/8-33, 100/09-33, 1AB/09-33, 102/09-33, 1AB/10-33

TOTAL E&P CANADA LTD.



Reservoir Insights into the May 18th 2006 Joslyn Steam Release

TEPC/2007.004

December 2007

Identification page

Title : Reservoir Insights into the May 18PthP 2006 Joslyn Steam Release
Author(s) : A. DELAFARGUE
Entity : TOTAL E&P CANADA
Location - Date : Calgary, December 2007 Validated by: P. Bergey, J. M. Feroul

- Chronological reference : - RFS : - Number of Volumes : 1 ☐ CONFIDENTIAL	**Storage Location on the Entity Server**:[1] W:\Entity\Geoscience\0700 - Joslyn\0775 - HSE & Steam Release Incident\2007-09 Steam Release Report\ReservoirAnalysis

Keywords (10 max.- other than title):
Reservoir, Simulation, SAGD, Steam Release, Sand Dilation, Monitoring, HSE

Geographical references: (Country, Region, License, Field, Well(s))
Canada, Alberta, Deer Creek, Joslyn Creek, Township 12W4, Range 095, Well 1AE / 09-33-095-12W4

ABSTRACT – About 10 lines explicit

Objectives (Aim, Purpose, Target) - **Strong points - Recommendation(s) and/or conclusion(s)**

A study was conducted to investigate, from a reservoir engineering perspective, the root cause(s) of the steam release that occurred at surface on May 18th 2006 in the vicinity of pair 204P1.

Production data from the 204P1 pair and other well pairs was analyzed in detail and the following conclusions reached:

- A sudden increase of injectivity started on well pair 204P1 on April 13th, about one month prior to the steam release. The rate and pressure behaviour observed at the time suggest that that this injectivity increase cannot be related to pipe failure or injector / producer reservoir communication (normal SAGD behaviour). Reservoir simulations were performed to demonstrate the last point.
- In relation to this anomaly of injectivity, an estimated volume of 1000 to 2600 m^3 of water had been stored in the subsurface at the time of the steam release.

In addition, as preliminary geomechanical analyses (detailed in another report) suggest that a mechanical failure could hardly have happened at the depth of the injector, it fell under the scope of the present study to identify the possible ways shallower levels could be quickly pressurized without involving true reservoir failure.

The main conclusion of this investigation is that a pressurization of the upper reservoir intervals is indeed possible up to 68 meters depth through steam chamber fingering at high pressure and sand dilation in the steam release area.

These results (and other from seismic, geo-mechanical, etc. studies) are to be integrated in a synthetic steam release analysis report.

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1. Executive Summary

The steam release event on May 18th 2006 occurred a few days after the conversion of well pair 204P1 to SAGD mode, more than 5 months after the start of the steam circulation phase. The incident has to be traced back to anomalies of the well pair behaviour observed distinctively after April 12th 2006. The anomalies, namely a sudden increase of “injectivity” in the injector well, cannot be related to normal SAGD well pair evolutions such as a good communication with the producer well, and are attributed to a major subsurface mechanical failure.

The cumulative volume of steam lost due to this failure prior to the steam release can be estimated between 1,000 and 2,600 m^3 in cold water equivalent. Assuming this volume has condensed in the reservoir and has been flashed back to steam during the release to ground surface, the energy involved in the release would be in the order of 10^{12}J.

A hydraulic fracture failure would most probably have occurred at the shallowest point of the pressurized zone, above the injector, where the rock is the weakest. Preliminary geo-mechanical analyses suggested such a failure could hardly have happened at the depth of the injector and that shale seals failure(s) most likely occurred at the edge of a pressurized area.

Therefore, the scenario where the injection pressure had propagated from the 204I1 injector (83 m deep) up to the top of the good quality reservoir (68m deep) -via normal reservoir mechanism before the injectivity increase - has been investigated:

This pressure propagation over 15 meters seems possible in 4 months, but would most probably involve non elastic rock deformations. It would require:

- Initiation, at particular location(s), of small steam “finger(s)”, driving the injection pressure propagation upward by gravity. This(ese) location(s) would be characterized by better than average reservoir properties or local top(s) in the injector well trajectory,

- Sand shearing/dilation that would significantly increase permeability and thus accelerate the steam chamber growth.

Mobile water at initial reservoir conditions may have participated in the upward pressure diffusion process. But it is believed, based upon simulation, that it cannot alone cause the fast and significant pressure increase at shallow depth envisioned to explain the subsequent seal failure and steam release.

Due to the sharp decrease expected in permeability in the reservoir above 68 meters, pressure propagation shallower than 68 meters prior to April 12th 2006 is considered unlikely without involvement of true geo-mechanical shale failure as opposed to dilation. Furthermore, steam could certainly not have risen above the massive shale at 61.5 meters depth without geo-mechanical failure.

2. Presentation of the Events

2.1 Brief Description of the Pre-SAGD Phases

As in other SAGD projects in Athabasca, steam is circulated in JOSLYN wells to warm-up the reservoir and initiate the fluid communication between the injector and the producer wells. Figure 1 shows how JOSLYN wells are equipped for steam circulation.

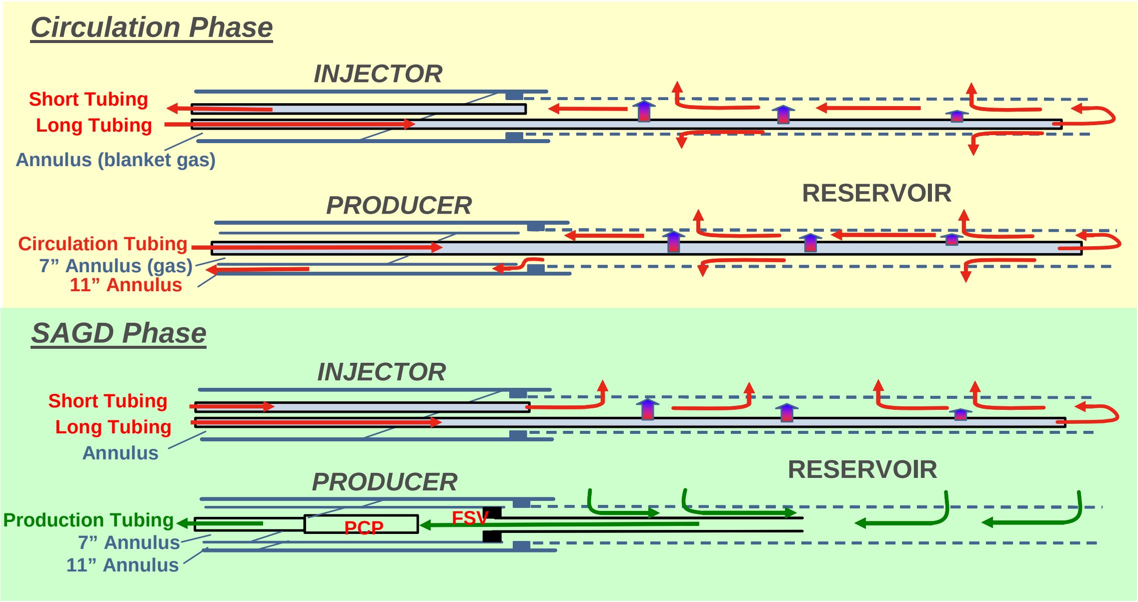


Figure 1. Well architecture during Circulation and SAGD phases.

Circulation phase durations of 5 months are typical for the JOSLYN project (based on the down-hole pressure, the distances between injector and producers, the reservoir quality, and minimum pump rates).

For all well pairs including 204P1, the pre-SAGD period can be split in several phases:

- **Circulation Phase** Both wells are circulated at the same heel BHP. Reservoir is heated by conduction mainly. This phase typically lasts for about 3-4 months.

- **Circulation Phase with Pressure Differential**. Both wells are kept in circulation, but the heel BHP of the producer is lowered to about 300kPa lower compared to the one of the injector one. This forces the fluid communication between the injector and the producer. This phase typically lasts for a few days.

- **Semi-SAGD Phase**. Once the communication between the two wells is clear, i.e. most of the steam injected in the injector is pushed to the producer well; the returns on the injector are shut. The short string is used for steam injection instead. The producer is kept on circulation and the pressure differential is maintained. This phase allows a much faster but less uniform heating of the reservoir.

Once the pressure differential is initiated, the interference between the wells, or “bitumen breakthrough”, is detected mostly through either a decrease of injector BHP under a constant injection rate, or an increase of injection rate under a constant pressure differential.

2.2 Monitoring/Metering during Pre SAGD phases in 2006

2.2.1 Pressure

The following pressure measurements are acquired on a continuous basis:

- Injector long string head pressure.
- Injector short string head pressure. It is more useful when the short string is used for steam injection (semi SAGD and SAGD phases) that for circulation returns.
- Injector Heel BHP – through the blanket gas
- Producer Heel BHP – through blanket gas (circulation or semi-SAGD) or bubble tube (SAGD).

The injector toe BHP is not measured. During circulation it should be a little higher than the heel BHP due to the direction of flow along the liner. Pressure loss calculations performed on Q-flow thermal well bore simulator have recently been used to estimate toe BHP from Injector long string head pressure and long string steam injection rate. According to those calculations, the 2200 kPag pressure measured at surface on 204I1 long string is in good agreement with a bottom hole pressure of 1800 kPag. For clarity sake, only BHP will be quoted hereafter as they are the reading relevant to subsurface aspects as opposed to production control aspects.

2.2.2 Temperature

The following temperature measurements are acquired on a continuous basis:

- Well head Temperatures
- Producer Temperatures from well head to toe, using a SENSA optic fibre.
- Observation wells equipped with Thermocouple strings. The observation well 0/09-33 located at the heel of 204Pair1 was not equipped (its thermocouple string was mistakenly installed on the neighbour well 2/09-33).

2.2.3 Steam Rates

- Injector Long String Injection rate (orifice plate)
- Injector Short String Injection rate (orifice plate, for semi SAGD and SAGD phases only)

Please note that the steam injection rate in the producer is not measured when on circulation.

2.2.4 Water and Oil Rates

The wells in circulation or semi SAGD cannot be tested. The water rate and oil cuts are unknown.

2.3 204P1 Circulation History

2.3.1 Summary

The daily pressure and rates history of 204P1 is shown on Figure 2, and Figure 3 focused on the last weeks before the steam release. The dates are summarized in Table 1 below:

Table 1. Main Dates of the pair 204P1 Circulation History

Phase	Start Date	End Date	Duration (days)
Circulation – no Pressure differential	**Dec 2, 2005**	**Mar 22, 2006**	**110**
Circulation - with pressure differential	**Mar 22, 2006**	**Mar 26, 2006**	**4**
Semi-SAGD	**Mar 26, 2006**	**May 2, 2006**	**37**
Work Over	**May 2, 2006**	**May 11, 2006**	**9**
SAGD with ESP pump	**May 11, 2006**	**May 18, 2006**	**7**

2.3.2 Circulation Phase Highlights

Down-hole pressures in injector and producer have been raised from around 1200kPag to 1700kPag over the first month. 204P1 and 204P3 are the first wells of phase 2 to be started. The injected steam rates are high and unsteady, probably due to operational issues. The injected steam rate in the producer and the rates of the steam and water condensate returns are not known so it is difficult to guess the amount of steam losses in the reservoir at this point.

After a significant down time in February, the pair is put back on circulation, this time on much more stable operating conditions. The injector BHP is around 1700kPag. The surface injection pressure is stable around 2000kPag and the estimated BHP at the toe of the injector -shown on the plot- probably between 1700 and 1800kPag. The long string steam rate is stable and comparable to more recent circulation data.

2.3.3 Semi SAGD Phase Highlights

The injector is converted on dual string injection on March 26, shortly after having reduced the producer pressure to around 1400kPag. The situation is held for a few days. Around 60 m3/d (30 short string +30 long string) of steam is squeezed into the injector. On April 6th, the well head pressure spike (also shown on the estimated toe BHP) is actually due to an injector shutin, during which the surface pressure gauges read the pressure of the surface network, while the injector BHP falls off in a natural way.

On April 12th, the injector pressure falls quite rapidly. Being interpreted as the result of a communication with the producer, the injector steam rate is gradually increased to about 160m3/d (80+80), still without being able to sustain a constant BHP in the injector. During this period, the long string head pressure is very high, essentially because of the pressure losses due to the high injection rates. Indeed, the calculated Toe BHP remains close to 1700kPag.

On April 21st, another distinct decrease of the injector BHP is noticed, requiring a further increment of steam rate up to 180m3/d (100+80).

2.3.4 Work Over Highlights

During the work over, the bubble tube on the producer is disconnected, so the producer BHP reading at 1900kPag is not related to the reservoir.

2.3.5 SAGD Phase Highlights

The start up of the ESP is difficult; the pump cannot be maintained stable and running. The injection pressure is gradually brought up. The steam release occurs once the injector BHP reaches 1300kPag.

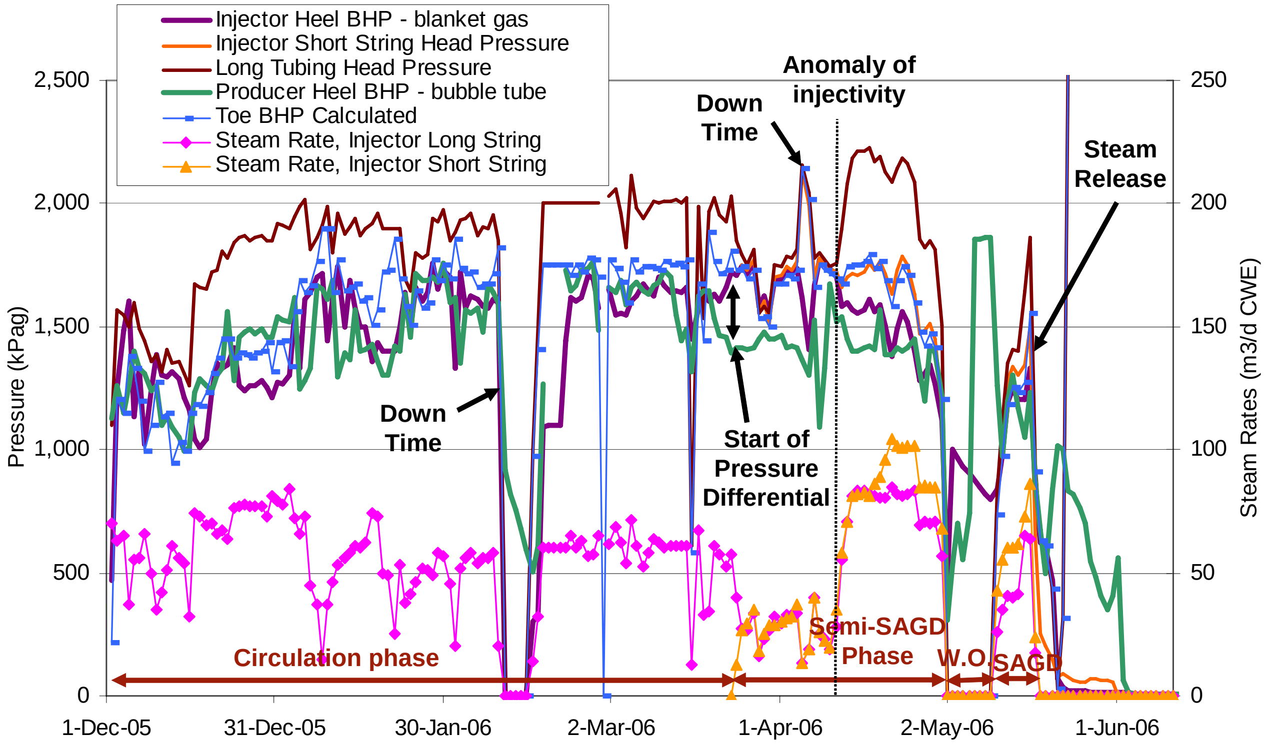


Figure 2. 204P1 - Pressures and Rates History.

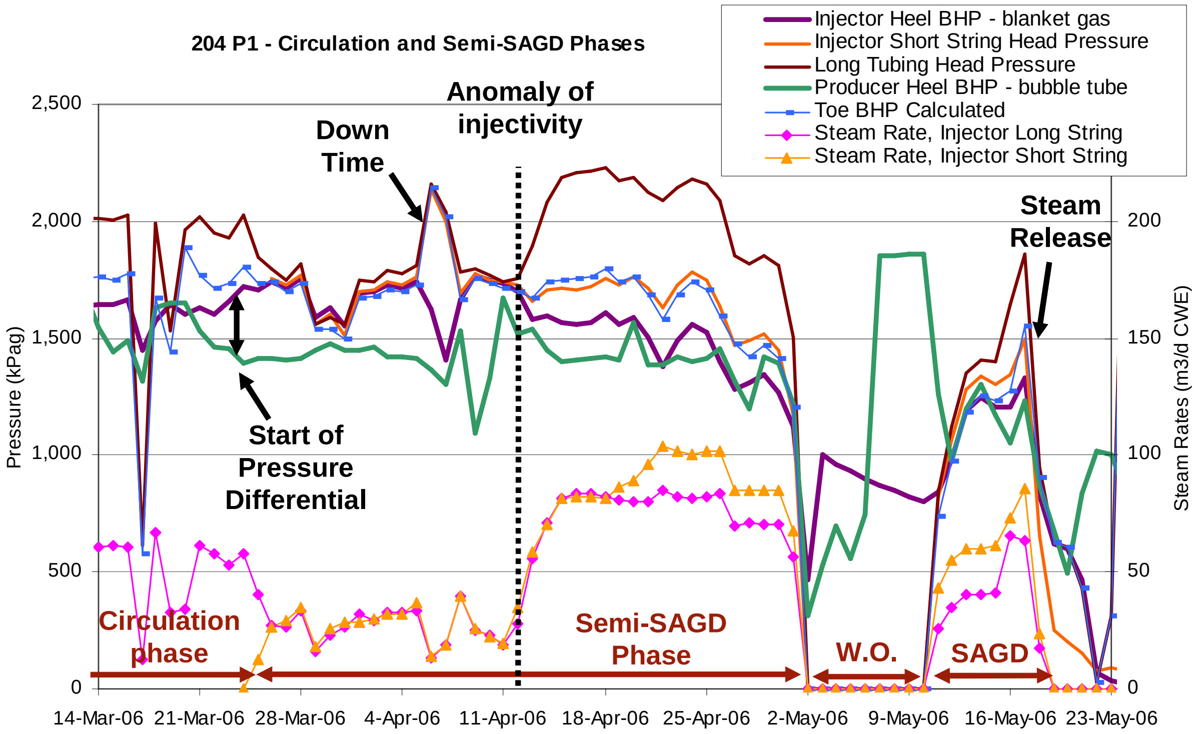


Figure 3. 204P1 - Pressures and Rates History, close up on the Semi-SAGD phase.

2.4 Other wells circulation history

Figure 4 and Table 2 illustrate the well location, status and main elements of each production phase for the phase 2 wells where production operations were started at the time of the steam release. Figure 5 to Figure 12 further illustrate each pair production history.

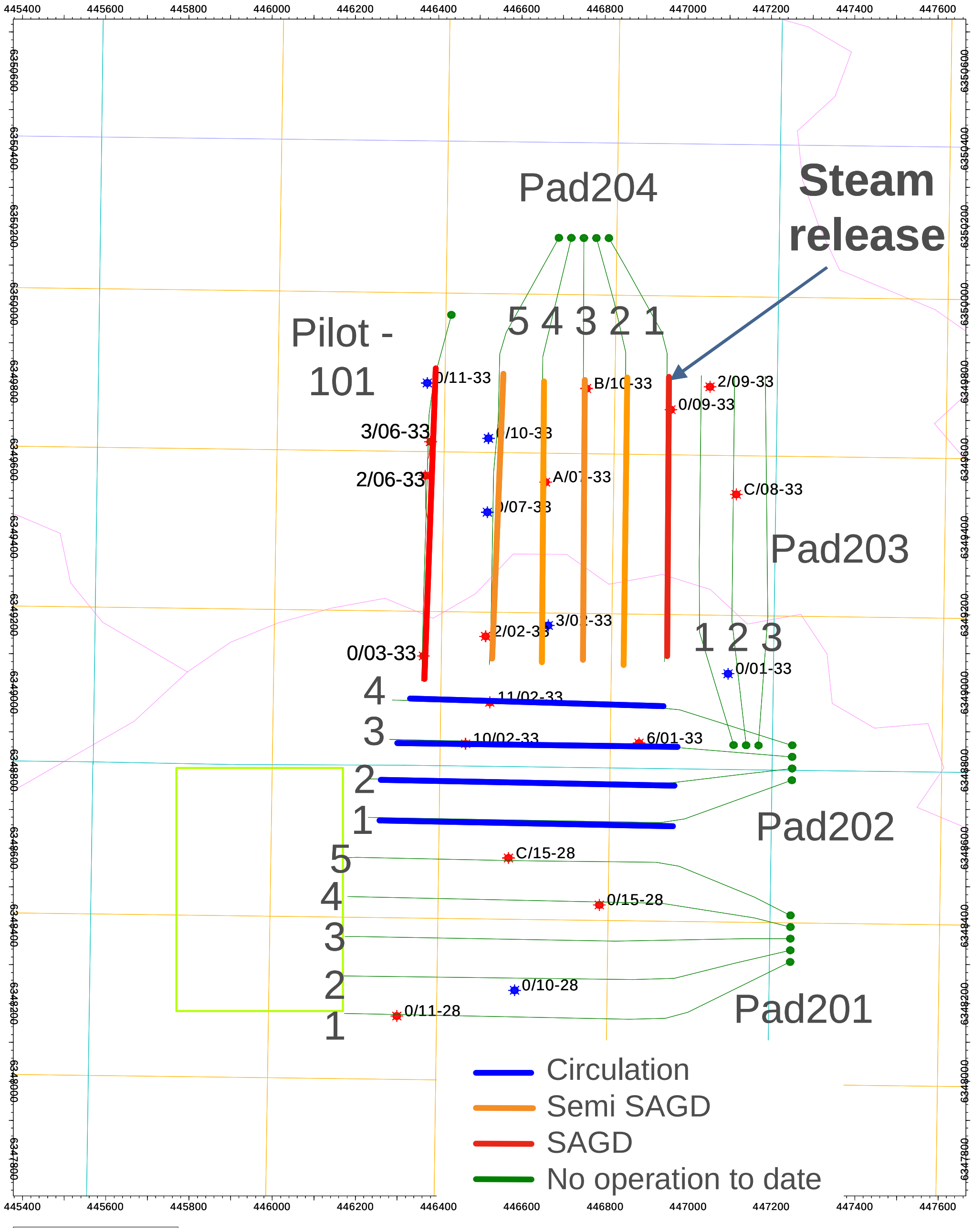
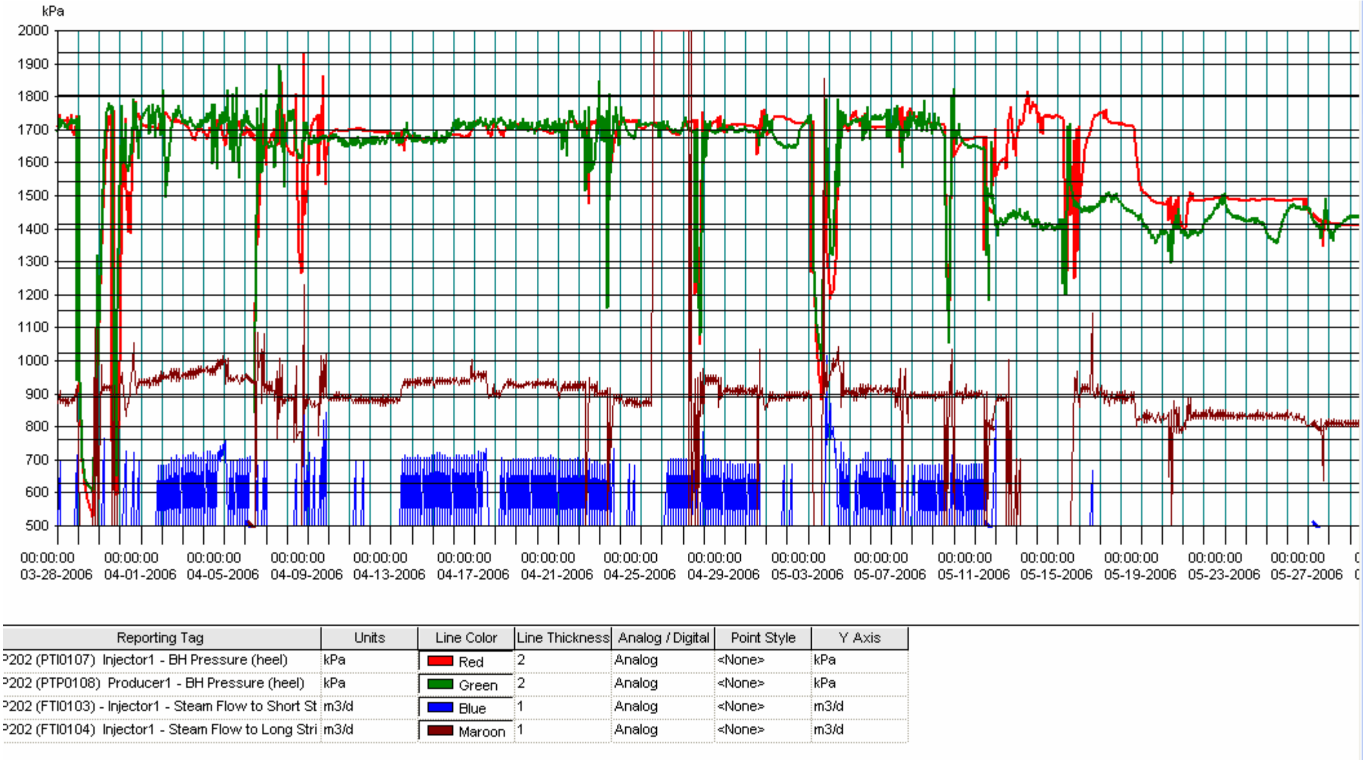


Figure 4 Well Location and Status Map (@ time of steam release)

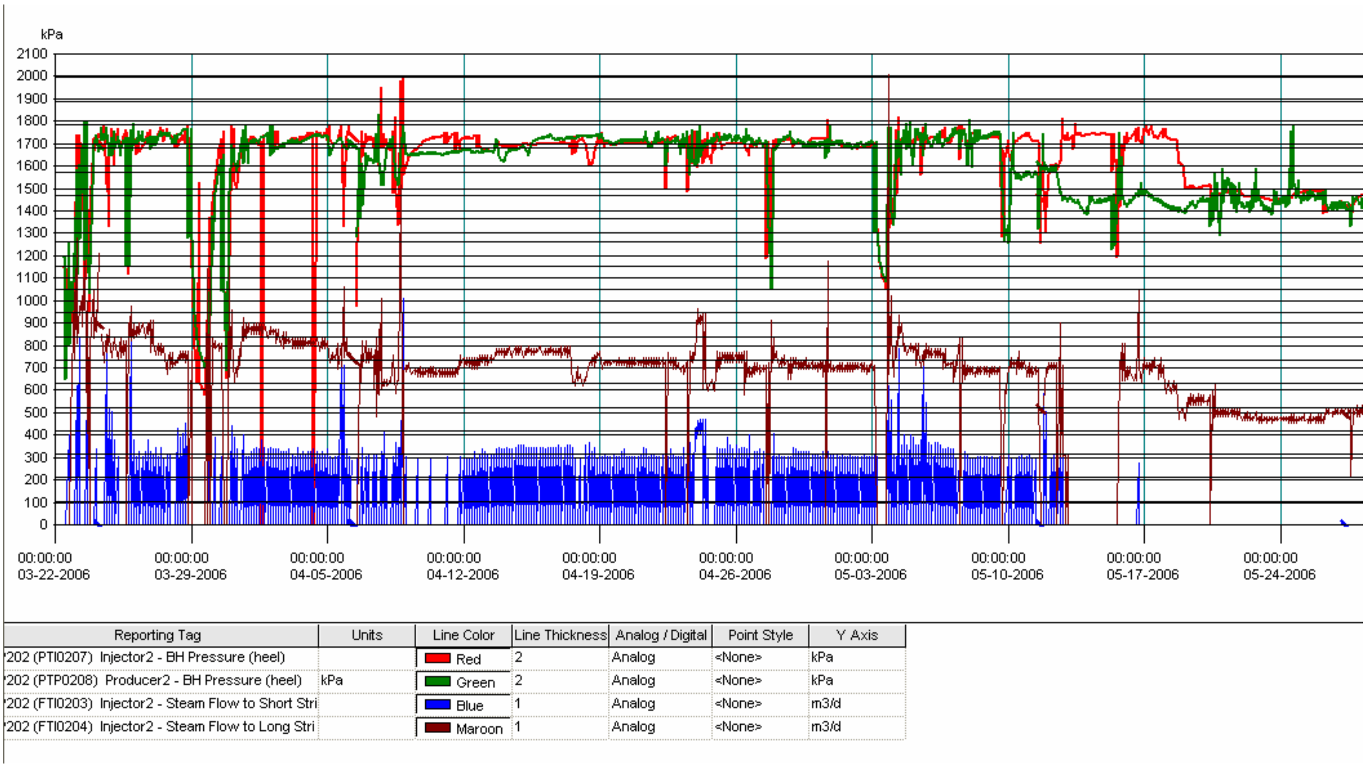
	Start Date	End Date	Duration (days)	Injector - BH Pressure Heel (kPa)	Producer - BH Pressure Heel (kPa)	Injector - Steam Flow Short String (m3/d)	Injector - Steam Flow Long String (m3/d)
202-WP4							
Circulation	3/22/2006			1799	1756		65
204-WP3							
Circulation	3/22/2006			1763	1742		63
204-WP2							
Circulation	3/22/2006			1782	1760		70
204-WP1							
Circulation	3/22/2006			1739	1747		65
204-WP5							
Circulation	2/12/2006	4/1/2006	48	1729	1610		60
Semi SAGD	4/11/2006	5/18/2006	37	1800	1800	45	45
204-WP4							
Circulation	2/12/2006	4/23/2006	70	1815	1853		64
Semi SAGD	4/28/2006	5/21/2006	23	1814	1800	41	37
Circultaion	5/24/2006	8/14/2006	82	1449	1480		46
204-WP3							
Circulation	12/1/2005	3/24/2006	113	1825	1840		46
Semi SAGD	3/24/2006	5/18/2006	55	1813	1830	44	44
204-WP2							
Circulation	2/12/2006	4/27/2006	74	1745	1763		58
Semi SAGG	4/27/2006	5/18/2006	21	1774	1679	27	28
204-WP1							
Circulation	2/12/2006	3/26/2006	42				
Semi SAGG	3/26/2006	5/2/2006	37				
Workover	5/2/2006	5/11/2006	9	NA	NA	0	0
SAGD	5/11/2006	5/18/2006	7	1400	1400	80	60

Table 2 Production operations history for pair other well pairs



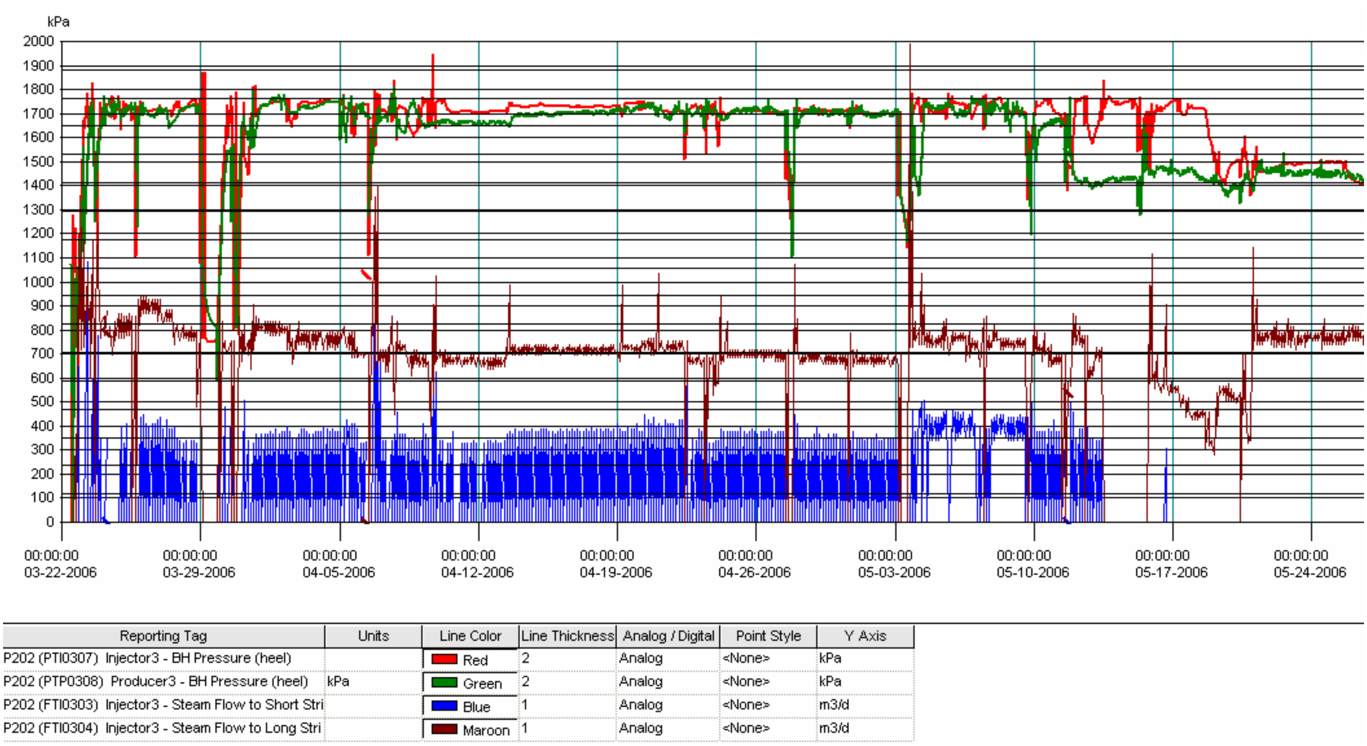
Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
P202 (PTI0107) Injector1 - BH Pressure (heel)	kPa	🟥 Red	2	Analog	<None>	kPa
P202 (PTP0108) Producer1 - BH Pressure (heel)	kPa	🟩 Green	2	Analog	<None>	kPa
P202 (FTI0103) - Injector1 - Steam Flow to Short St	m3/d	🟦 Blue	1	Analog	<None>	m3/d
P202 (FTI0104) Injector1 - Steam Flow to Long Stri	m3/d	🟫 Maroon	1	Analog	<None>	m3/d

Figure 5 202P1I1 operations summary



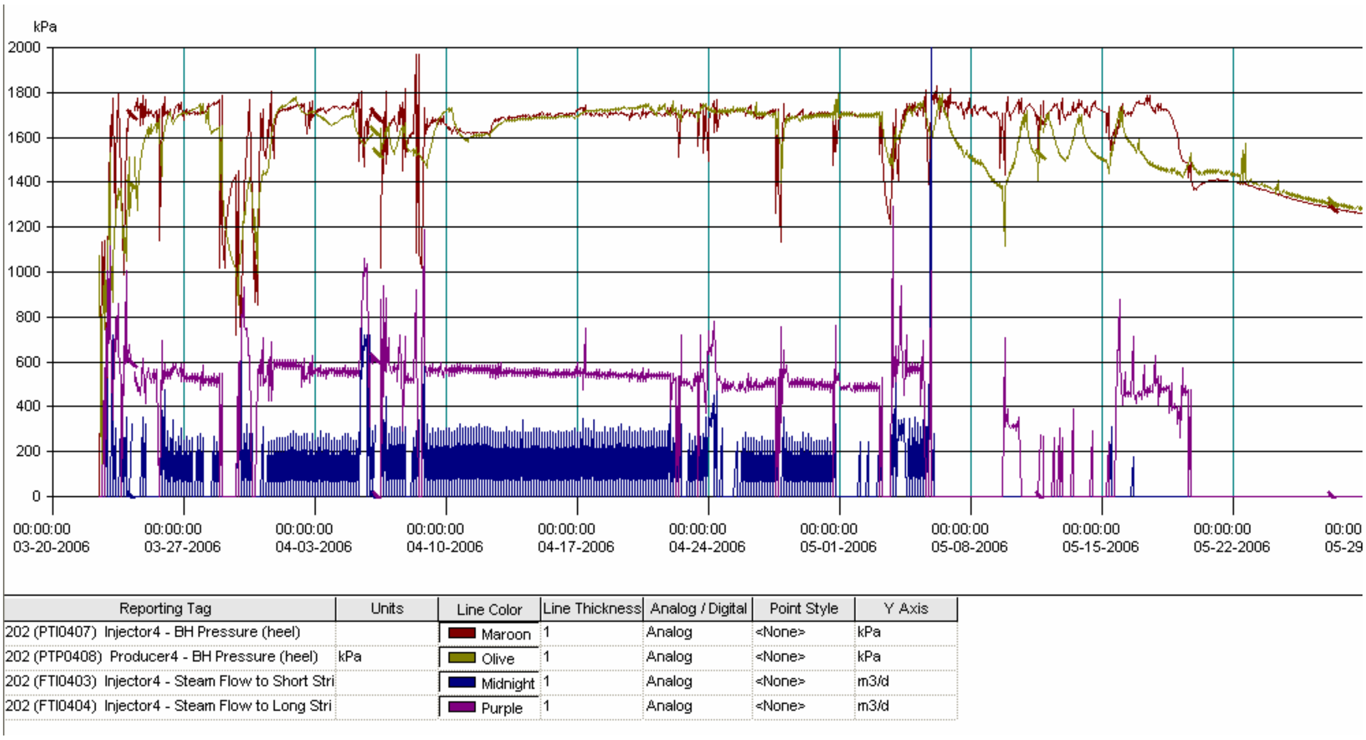
Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
202 (PTI0207) Injector2 - BH Pressure (heel)		🟥 Red	2	Analog	<None>	kPa
202 (PTP0208) Producer2 - BH Pressure (heel)	kPa	🟩 Green	2	Analog	<None>	kPa
202 (FTI0203) Injector2 - Steam Flow to Short Stri		🟦 Blue	1	Analog	<None>	m3/d
202 (FTI0204) Injector2 - Steam Flow to Long Stri		🟫 Maroon	1	Analog	<None>	m3/d

Figure 6 202P2I2 operations summary



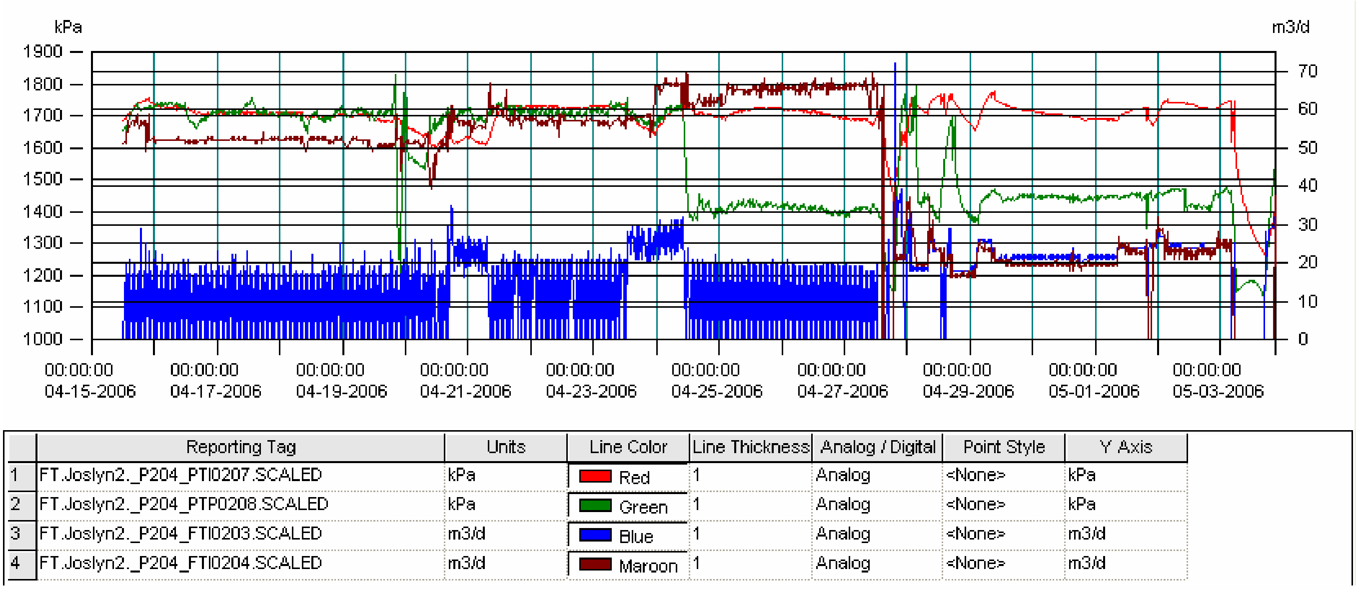
Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
P202 (PTI0307) Injector3 - BH Pressure (heel)		🟥 Red	2	Analog	<None>	kPa
P202 (PTP0308) Producer3 - BH Pressure (heel)	kPa	🟩 Green	2	Analog	<None>	kPa
P202 (FTI0303) Injector3 - Steam Flow to Short Stri		🟦 Blue	1	Analog	<None>	m3/d
P202 (FTI0304) Injector3 - Steam Flow to Long Stri		🟫 Maroon	1	Analog	<None>	m3/d

Figure 7 202P3I3 operations summary



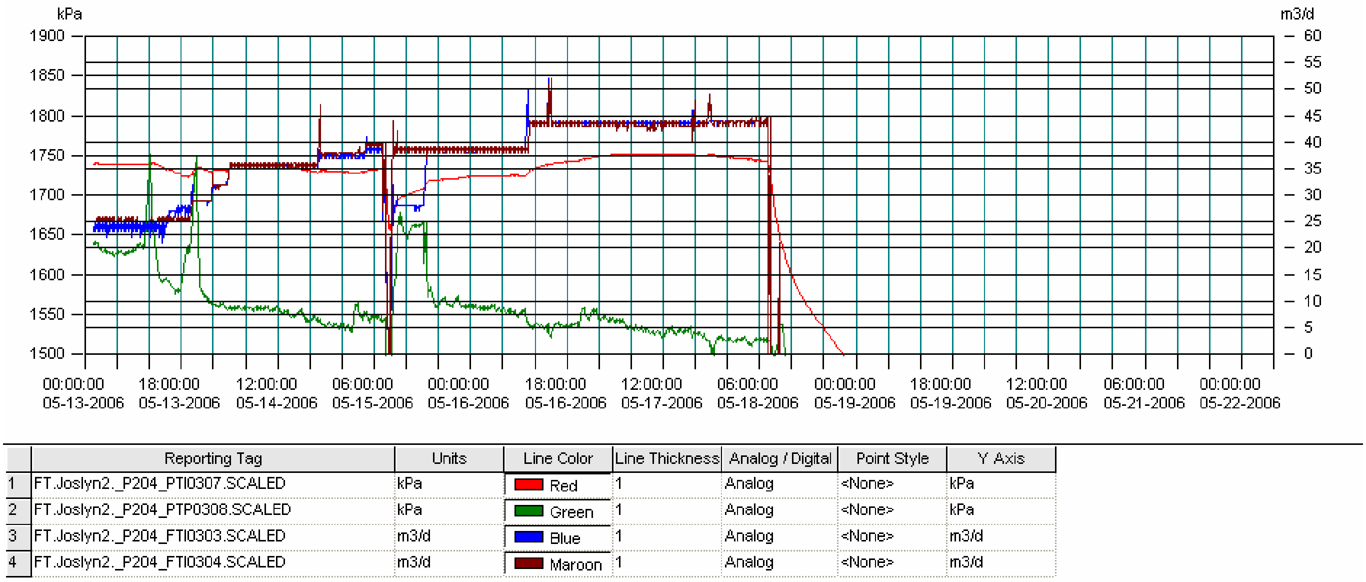
Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
202 (PTI0407) Injector4 - BH Pressure (heel)		🟫 Maroon	1	Analog	<None>	kPa
202 (PTP0408) Producer4 - BH Pressure (heel)	kPa	🟨 Olive	1	Analog	<None>	kPa
202 (FTI0403) Injector4 - Steam Flow to Short Stri		🟦 Midnight	1	Analog	<None>	m3/d
202 (FTI0404) Injector4 - Steam Flow to Long Stri		🟪 Purple	1	Analog	<None>	m3/d

Figure 8 202P4I4 operations summary



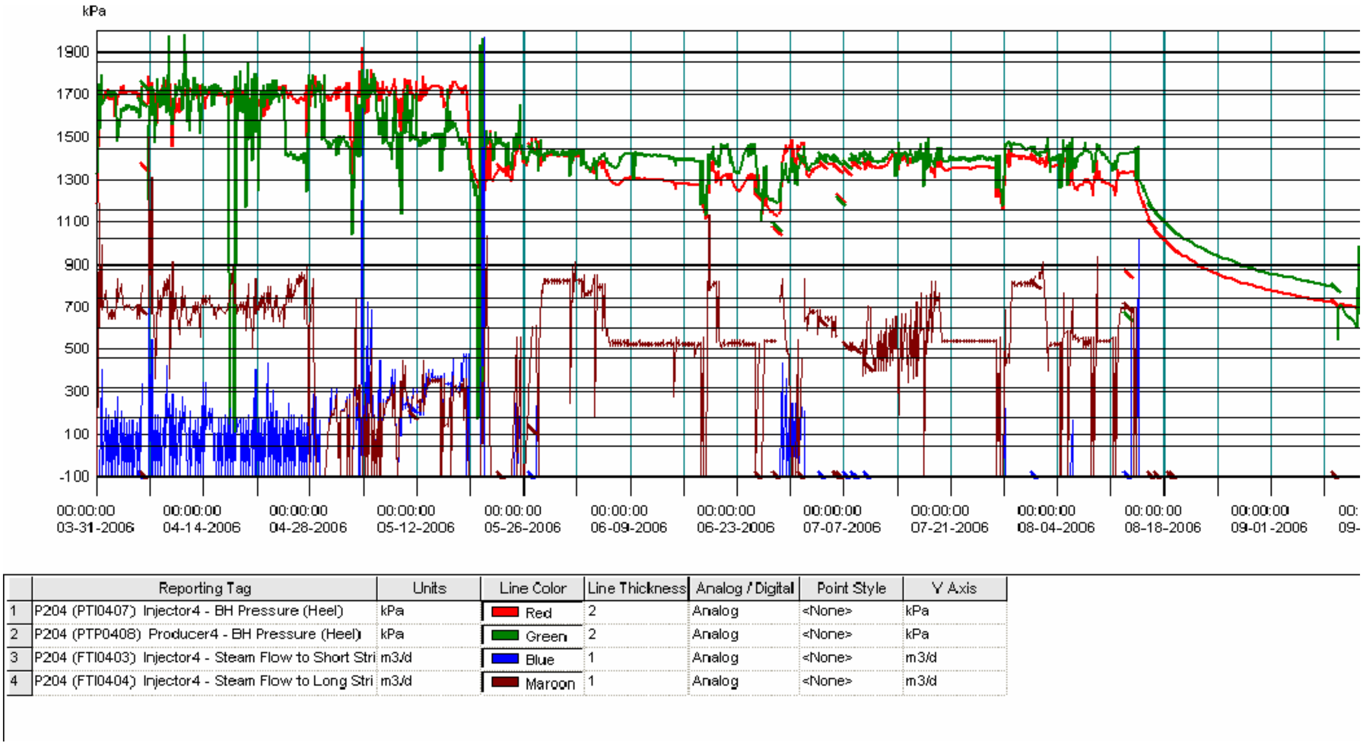
	Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
1	FT.Joslyn2._P204_PTI0207.SCALED	kPa	🟥 Red	1	Analog	<None>	kPa
2	FT.Joslyn2._P204_PTP0208.SCALED	kPa	🟩 Green	1	Analog	<None>	kPa
3	FT.Joslyn2._P204_FTI0203.SCALED	m3/d	🟦 Blue	1	Analog	<None>	m3/d
4	FT.Joslyn2._P204_FTI0204.SCALED	m3/d	🟫 Maroon	1	Analog	<None>	m3/d

Figure 9 204P2I2 operations summary



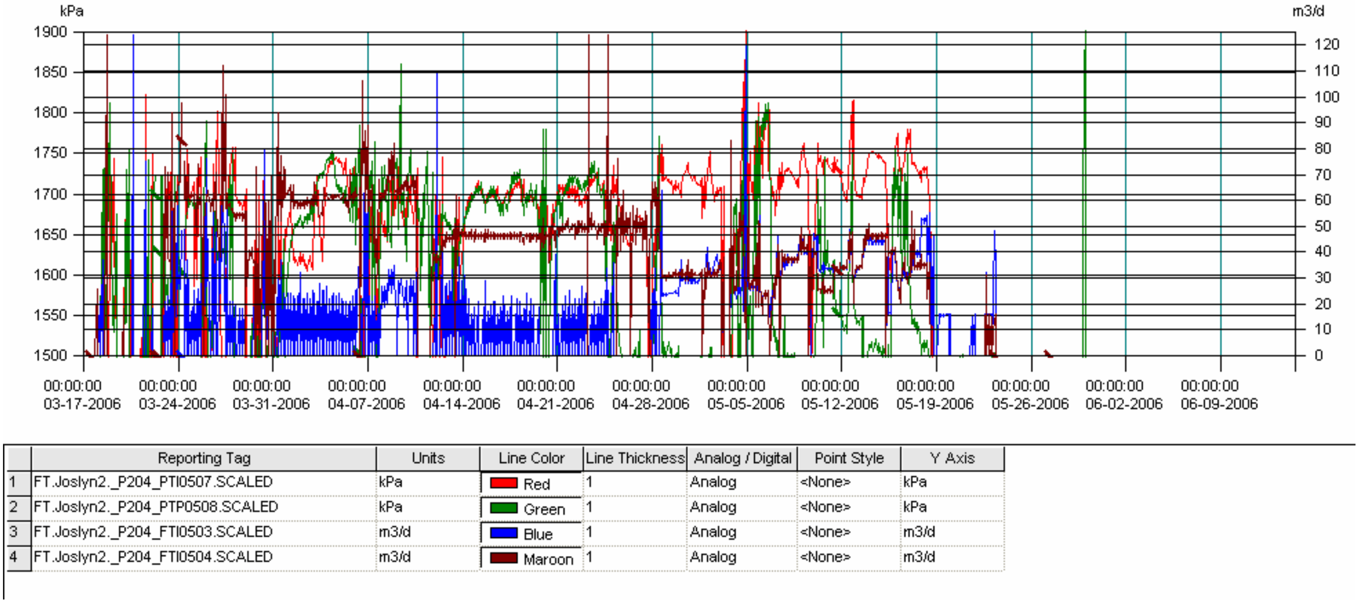
	Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
1	FT.Joslyn2._P204_PTI0307.SCALED	kPa	🟥 Red	1	Analog	<None>	kPa
2	FT.Joslyn2._P204_PTP0308.SCALED	kPa	🟩 Green	1	Analog	<None>	kPa
3	FT.Joslyn2._P204_FTI0303.SCALED	m3/d	🟦 Blue	1	Analog	<None>	m3/d
4	FT.Joslyn2._P204_FTI0304.SCALED	m3/d	🟫 Maroon	1	Analog	<None>	m3/d

Figure 10 204P3I3 operations summary



	Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
1	P204 (PTI0407) Injector4 - BH Pressure (Heel)	kPa	🟥 Red	2	Analog	<None>	kPa
2	P204 (PTP0408) Producer4 - BH Pressure (Heel)	kPa	🟩 Green	2	Analog	<None>	kPa
3	P204 (FTI0403) Injector4 - Steam Flow to Short Stri	m3/d	🟦 Blue	1	Analog	<None>	m3/d
4	P204 (FTI0404) Injector4 - Steam Flow to Long Stri	m3/d	🟥 Maroon	1	Analog	<None>	m3/d

Figure 11 204P4I4 operations summary



	Reporting Tag	Units	Line Color	Line Thickness	Analog / Digital	Point Style	Y Axis
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2	FT.Joslyn2._P204_PTP0508.SCALED	kPa	🟩 Green	1	Analog	<None>	kPa
3	FT.Joslyn2._P204_FTI0503.SCALED	m3/d	🟦 Blue	1	Analog	<None>	m3/d
4	FT.Joslyn2._P204_FTI0504.SCALED	m3/d	🟥 Maroon	1	Analog	<None>	m3/d

Figure 12 204P5I5 operations summary

It can be noted that all phase 2 well pairs started before the steam release experienced circulation at a pressure between 1750 and 1850 kPa. The main difference between those wells and 204P1 is the fact that no sharp increase of injectivity was observed on any of those wells during the circulation and semi-SAGD phase. 204P1 also had a comparatively longer semi SAGD phase and was the only pair switched to SAGD before the steam release.

3. Analysis of the 204P1 pair Anomalies of Injectivity

3.1 Injectivity Concept

In this section, the anomalies of steam rates on the 204I1-P1 well pair during the semi SAGD phase are analyzed from a reservoir standpoint. Their interpretation as the sign of communication with the producer well is discussed, as this explanation is the main one competing with the one invoking fracturing of the formation. For the specific purpose of discriminating between the two, a concept of "injectivity" is used, defined as the ratio of the steam rate in the injector (short+long string) over the pressure differential with the producer, expressed in m3/d/100kPa. The pressure differential is simply the difference between the injector and producer well BHPs.

It has been observed on other wells of phase 2 in semi-SAGD that steam rates are quite directly related to the pressure differential once communication is established with the producer well, and that the ratio of the two mostly depends on the geology of the pair and its maturity. Very high steam rates combined with little pressure differential between the wells would translate into very high levels of injectivity, and therefore hint towards a lack of confinement of the well pair, rather than towards a good communication between the two wells. Before introducing the data, a few caveats *w.r.t* the interpretation of events of infinite injectivity should be recognized:

- Due to the non negligible bitumen reservoir permeability in cold conditions, a part of the injected steam will leak into the reservoir even with no pressure differential with the producer well. Situations with infinite injectivity willl therefore be possible, but should not be taken too seriously as long as steam rates are relatively small (typically 10-30m3/d at Joslyn). Such leak-off could have been substracted from the rates in the calculation of the injectivity, but is has not been for simplicity sake.

- Transient periods of infinite injectivity could be possible, simply due to some lag time between a reduction of the pressure differential and the impact on steam injection rates. This assumption is further addressed in more detail in Section 3.5.

- Transient periods of high injectivity could be possible, simply due to an increase of the injector and producer pressures.

Figure 13 displays the injector and producer BHP, the pressure differential between the wells, the total steam rate in the injector, and the injectivity as defined above. All data are shown hourly, to spot potential spikes and other instantaneous phenomena.

The concomitant increase of steam rate and decrease of injector pressure on April 12th may well be -a priori- explained by a steam breakthrough to the producer. The mechanism would be the following:

- During the circulation phase, the reservoir between the wells is heated, but the bitumen in between is still too cold to be moved and allow fluid communication
- During the semi SAGD phase, a pressure differential starts to push the cold bitumen down toward the producer, until a breakthrough occurs. The communication can occur quite suddenly, since it involves unstable viscous fingering. In particular, 2 days prior to the anomaly, a particularly high pressure differential of 800kPa was applied (due to a producer shut in).
- On April 12th, the communication with the producer is established. The pressure differential between the two wells is sufficient to drive an increase of the steam rate even though both injector and producer pressures are decreasing.

But this explanation can no longer hold past April 13th, for 3 reasons, addressed in the following sections:

1. On April 13th the injectivity is almost infinite for nearly a full day (marker <1> on Figure 13). Similar periods of very high injectivity are observed after April 20st (markers <2_>).
2. After the first anomaly, the injectivity stabilizes around very high values -100m3/d/100kPa- compared to typical injectivity figures.

3. No major breakthrough to the producer is visible on the producer temperature profile during this period.

It is still possible that a pressure and fluid communication could have established between the wells during this period, but not to the extent that it would explain the observed levels of injectivity.

3.2 Periods of Infinite Injectivity

Table 3 details all the events of infinite injectivity shown on Figure 13. The first two spikes of injectivity prior to April 13th, <1. and <2>, are not interpreted as definite anomalies, as they could be related to transient effects, or to low pressure differentials and low steam rates (natural steam leak off in the reservoir).

Apart from those exceptions, at least 5 anomalies of injectivity can be identified with little doubt (markers **<3> to <7>** on Figure 13).

- Anomalies **<3>, <5>** and **<6>** are interpreted as fracturing events. At the beginning of each of these periods, the injection pressure drops suddenly while injection rates and producer pressures trends are unchanged.

- Anomalies **<4>** and **<7>** are triggered by a change of operating conditions, namely an increase of the producer pressure, but nonetheless show a loss of pressure confinement of the well pair.

Table 3. List of the periods of infinite injectivity for well pair 204I1/P1 during the semi SAGD phase. Markers refer to the Figure 13. The events <1>. and <2> prior to April 13th are not clearly flagged as anomalies (green). Events <3> to <7> are used as evidence of a loss of the pressure confinement of the well pair, of which <3>, <4> and <5> (orange) are related to actual fracturing events.

Marker	**Dates**		**duration**	**Injection Rate**	**Pressure Differential**	**Injectivity**	**Anomaly?**	**Injectivity spike related to Well control?**	**Injectivity spike related to Fracturing event?**
	from	to	hours	m3/d	kPa	m3/d/100kPa			
<1>	4/7/2006 13:00	4/8/2006 23:00	34	75	0 to +150	40 to Infinity	Not necessarily (injection pressure increase)	Yes, injector pressure increased, and producer circulation resumed after down time period	Not necessarily
<2>	4/10/2006 19:00	4/11/2006 20:00	25	40	0 to +150	25 to Infinity	Not clearly (low steam rates, natural leak off?)	Yes, producer circulation resumed after down time period	Not necessarily
<3>	4/12/2006 20:00	4/14/2006 2:00	30	75 to 150	-100 to +200	40 to Infinity	**Yes**	Yes, producer pressure increased	**Yes,** drop of injection pressure on April 13th at 12:00
<4>	4/19/2006 21:00	4/20/2006 22:00	25	170	-100 to +150	125 to Infinity	**Yes**	Yes, producer pressure increased	Not necessarily
<5>	4/21/2006 16:00	4/23/2006 20:00	52	185	0 to +130	125 to Infinity	**Yes**	No, injector pressure would not keep up	**Yes,** drop of injection pressure on April 21st at 17:00
<6>	4/25/2006 10:00	4/27/2006 14:00	52	185	-150 to +0	Infinity	**Yes**	No	**Yes,** drop of injection pressure on April 25th at 09:00
<7>	4/28/2006 9:00	4/30/2006 23:00	62	155	-250 to -50	Infinity	**Yes**	No, injector pressure would not keep up	Not necessarily

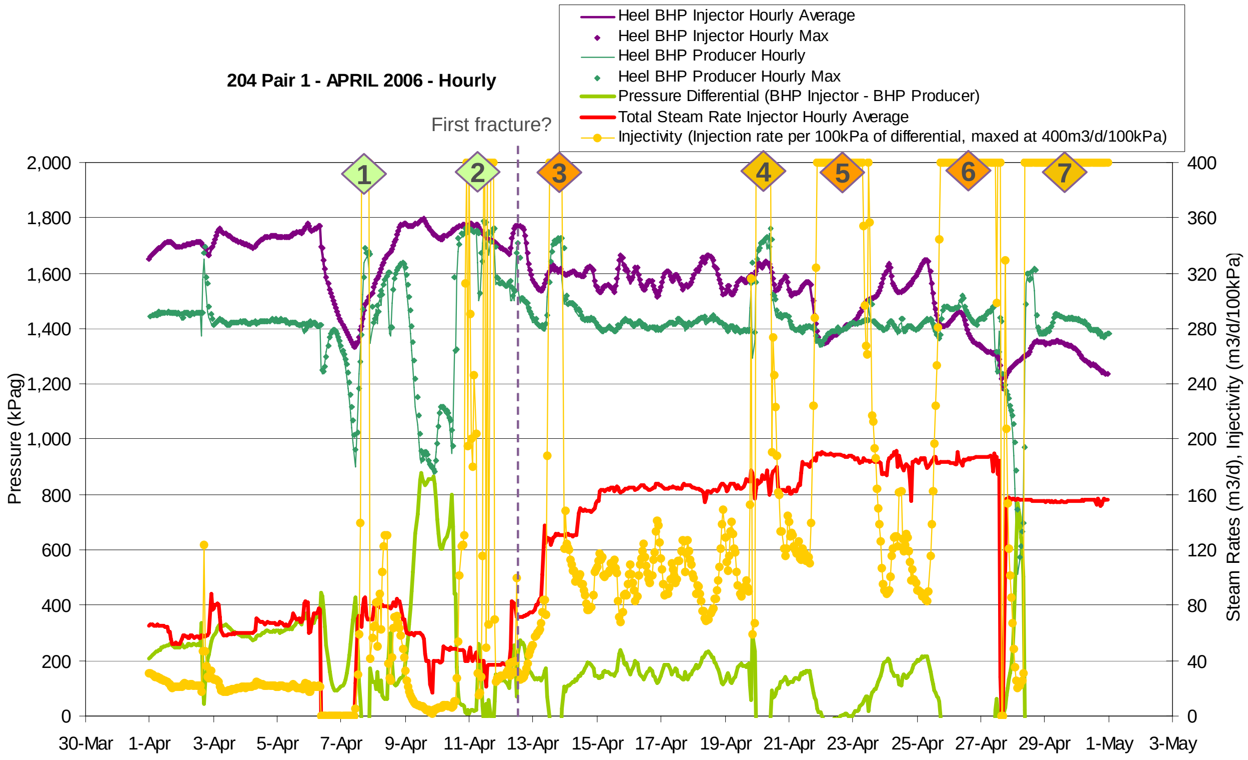

Figure 13. Close up on the increase of injectivity, in April 2006. Injectivity is defined as the ratio of steam rate in the injector over the pressure differential with the producer well (here: maxed out at 200m3/d/100kPa, and sliding over 5hrs). The high injectivity events <1>. and <2> prior to April 13th are not flagged as anomalies (green). Events <3> to <7> are used as evidence of a loss of the pressure confinement of the well pair, of which <3>, <4> and <5> (orange) are related to actual fracturing events. With a dashed line is also indicated the possible time of the first fracturing event,

Probably not all fracturing events show up as clear infinite injectivity periods. It is possible that the first fracturing event could be dated on April 12th at 4pm. Until this time the injector pressure reacts well to the step increase of steam rate (40 to 80m3/d). But after 4pm, the injector BHP decreases very quickly, while the injectivity starts to rise. The behavior of the producer is interesting. Even though few data are available to provide a full interpretation (head pressures, injection rate and so on), there is a very distinct pressure spike at 4pm. Either the producer well has suddenly been put in communication with the injector through a fracture, through a regular channel, or its pressure has been manually changed. It is difficult to say whether the increase of rates from 40 to 80 m3/d (40 m3/d through the short string, 40 m3/d through the long string) has played a particular role in triggering the fracturing. Perhaps the semi SAGD phase itself has accelerated the drainage of the heated bitumen out of the dilated zone by changing the direction of flow in the heel area. It should be noted that injecting steam through the toe tubing only during the circulation phase does not mean that the heel reservoir area was preserved before the semi SAGD phase. Steam quality in the liner and heat losses are actually higher at the heel than at the toe.

3.3 High Sustained Injectivity After April 13th

Injectivity was around 20m3/d/100kPa since the beginning of the semi SAGD phase, and climbed to 100m3/d/100kPa after April 13th. As a comparison, Figure 14 shows a plot of the injectivity on other JOSLYN well pairs. The injectivity is much below 100m3/d/100kPa even at the beginning of the SAGD phase.

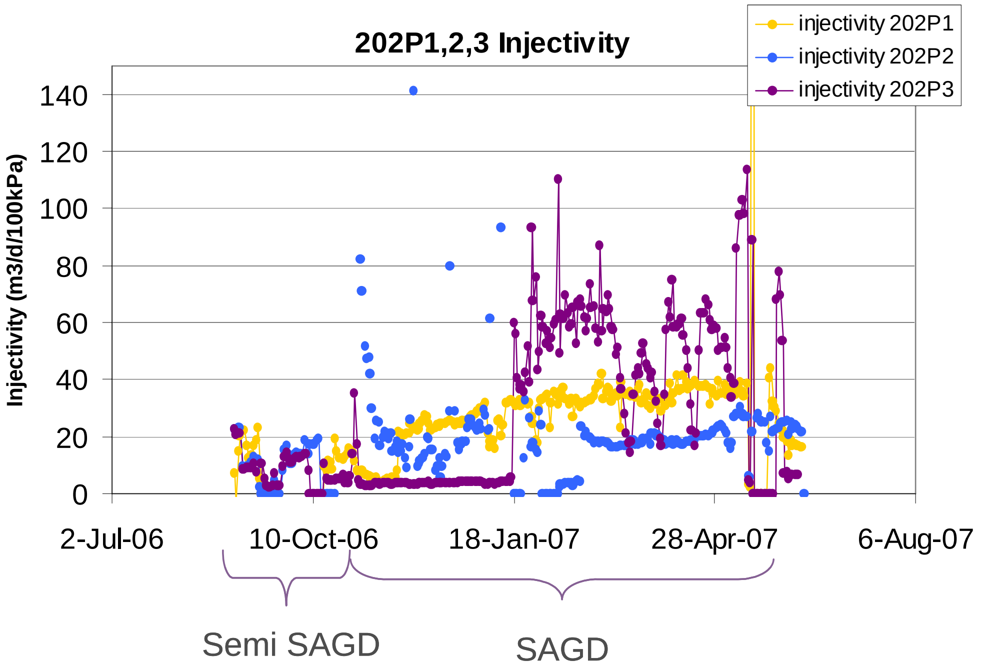

Figure 14. Examples of typical injectivity on other JOSLYN well pairs (pad 202). Injectivity is much below 100m3/d/100kPa during the semi SAGD phase and the beginning of SAGD phase.

3.4 Producer Temperature Profile

At last, fall-off temperature profiles of the 204P1 producer are analyzed for signs of communication with the injector. The fall off profiles are related to the 3 shutin periods between April 6th and May 2nd (SAGD conversion work over), seen on Figure 15 with Temperature plots over time. Special care is given to the interpretation of the data as the fiber was failing during this period subsequently replaced.

Figure 16 shows the temperature profiles of 204P1 producer well, from its fiber optics, from well head to toe, during these shut in periods, and during circulation for comparison. The location of the steam release, close to the heel of the pair, is indicated on the plot. The gamma ray logs of both injector and producer are displayed, as well as the distance from the producer well to the injector and to the average liner level.

During circulation the producer temperature is almost uniform at the saturation temperature of steam (brown curve). On 204P1 the fiber performances gradually degraded during the months prior to the steam release, and the fiber was replaced on April 29th. On a failing fiber, the temperature profile tilts down toward the toe over time in a characteristic fashion (red curve on Figure 15). Despite this issue, a qualitative analysis of the temperature profiles can still be done during shut-ins of the pair. Upon a shut in, the temperature drops more slowly where the reservoir has received more heat than under a pure conductive form. It is the case for instance when:

- A small steam chamber has grown during circulation around the producer,
- A communication with the injector has been triggered during the semi SAGD phase.

Therefore there is a high probability that the hot spots will be the germs for the future steam chamber development. This has been the case so far on other phase 2 well pairs.

The fall off profiles both before April 12th (orange and gold), and after April 29th on the new fiber (blue) show only a narrow hot spot near the mid section of the well. It is not a major hot area that would be expected from the very high injectivity observed after April 12th, and it is of the same width and amplitude before and after. At last, the overall rate of cooling is not much slower on the May fall-off.

This reinforces the presumption that no major steam breakthrough occurred on the producer before the work over.

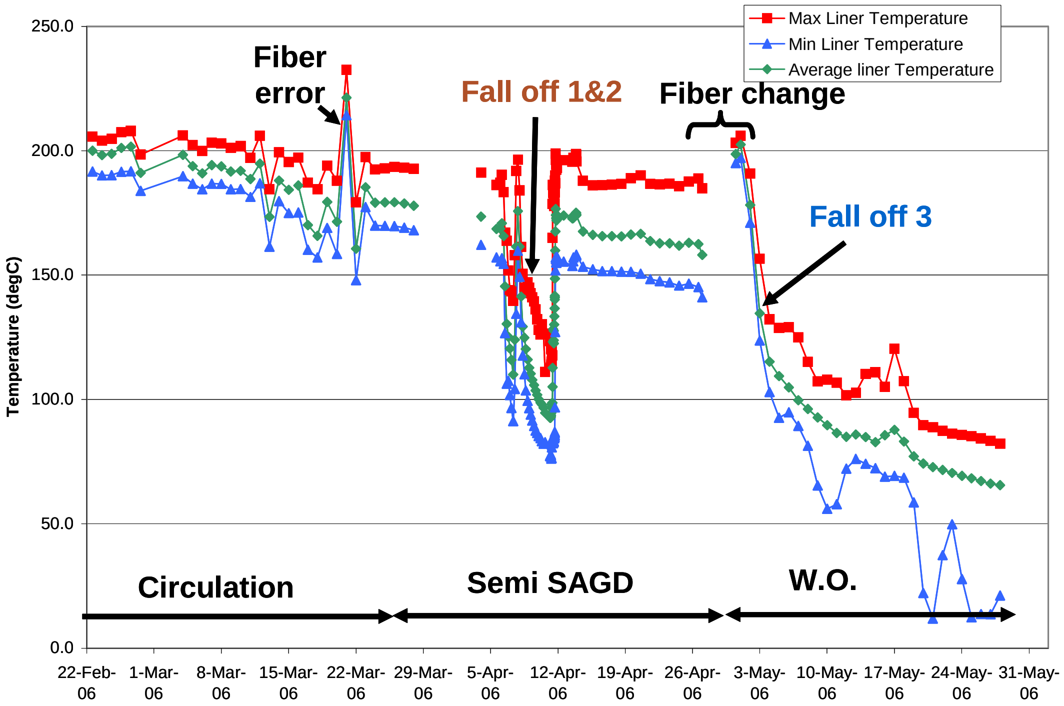

Figure 15. 204P1 Producer Temperature vs Time (minimum, average and maximum temperature between heel and toe). The fall-off profiles picked are reported on the plot.

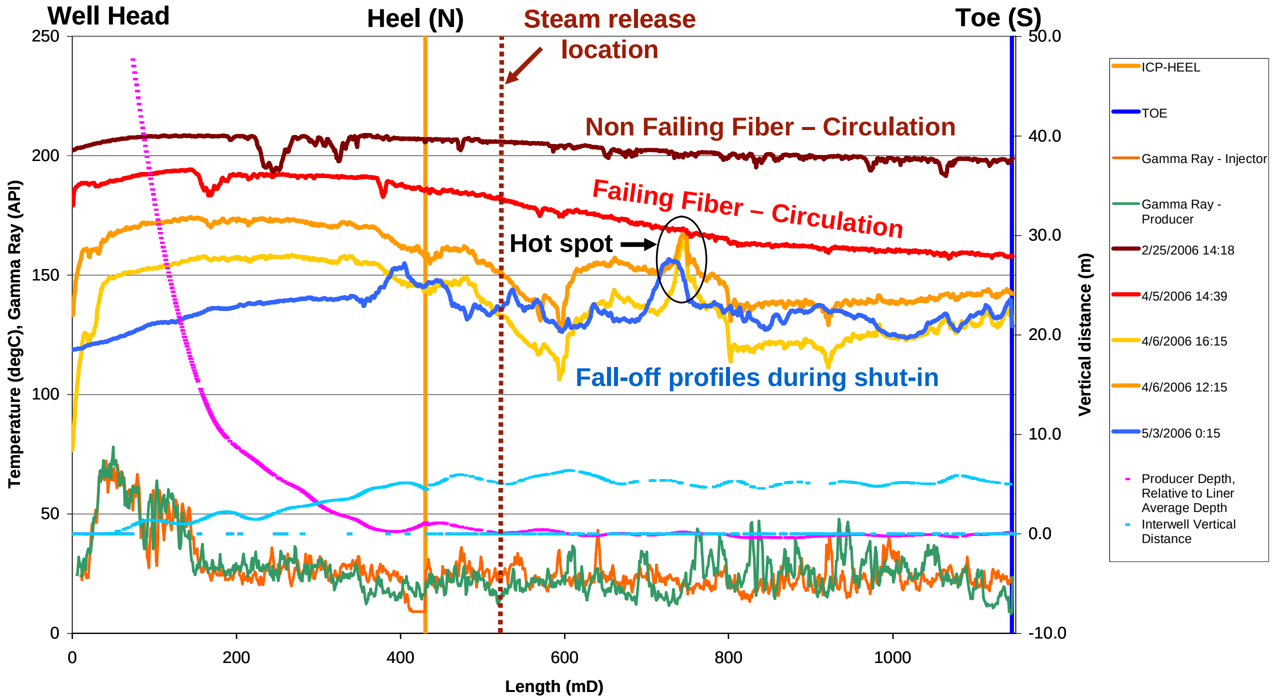

Figure 16 Producer Temperature Profile from optics fiber, from well head to toe. The temperature fall-off profiles taken during a shut in on April 6th and in June do not show large hot sections that a very good communication with the injector well would probably have induced.

3.5 Numerical Modeling of the injectivity anomaly

To further confirm that the anomaly of injectivity is not a consequence of a good communication with the producer well, numerical simulations of the well pair have been performed on a 3D heterogeneous model. The whole injector and producer BHP history was simulated with periods of zero pressure differentials to observe the impact on the steam rates. The model was tweaked to purposely ensure a very good communication between the two wells and reproduce the high steam injection rates observed after April 12th. This required an artificial increase of the vertical permeability in one section of the well pair and an increase of the reservoir permeability to water in cold conditions. Still, as shown on Figure 17, the steam rate would decrease very rapidly in the periods of zero pressure differential.

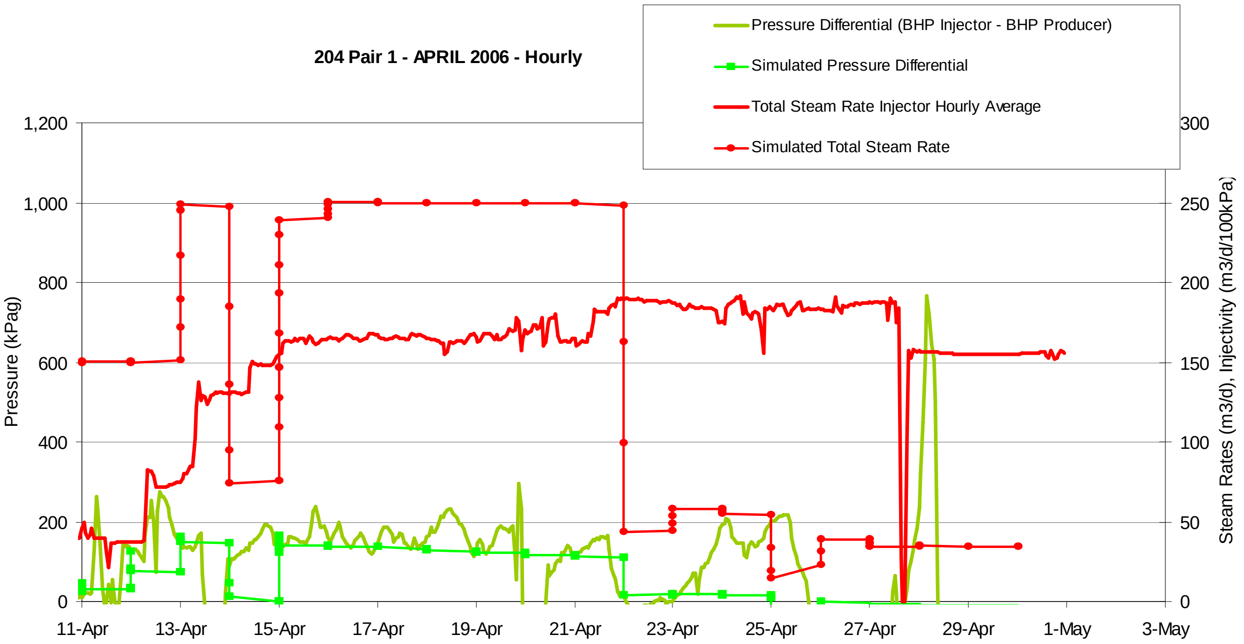

Figure 17. Simulation of the semi SAGD phase. During the periods of zero pressure differentials between the injector and producer, the simulated rates react very quickly unlike the historical rates.

In addition the model lead to unrealistic oil production rates (50m3/d) compared to the plant production of that time. By comparison, a model using more realistic assumptions gives a reasonable match of injection rates prior to the first anomalies of injectivity. An example is shown on Figure 18. The steam leak off rate during circulation and oil rate during the semi SAGD phase are also realistic.

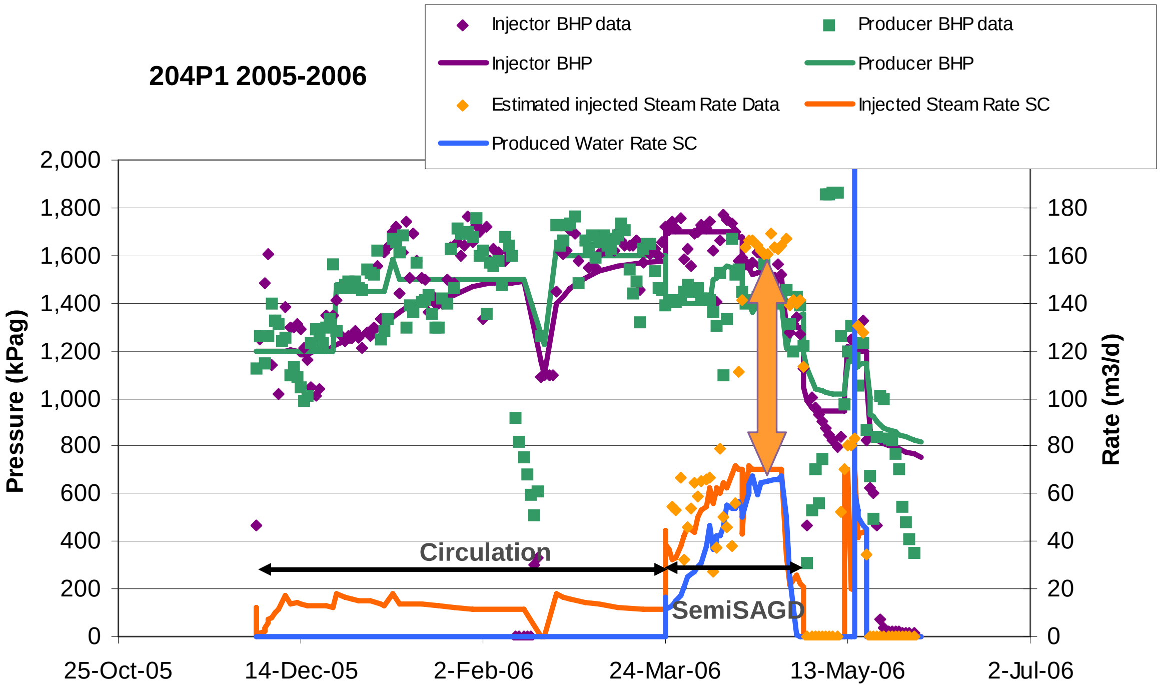

Figure 18. Simulation of the well pair behavior prior to the injectivity anomaly (plain lines), compared to the data (markers). Using realistic parameters, the simulation does not reproduce the injection rate of 160m3/d in April 2006.

4. Material & Energy Balance Evaluations

Given the absence of metering for the fluid returns in circulation and semi-SAGD phases, and the lack of a trustworthy plant water balance on a pad by pad basis, the evaluation of the cumulative water loss to the formation after April 12th cannot be accurately determined.

The cumulative steam volume lost away from the well pair in relation with the anomaly is estimated between 1,000 to 2,600 m^3 CWE, based on a rough assessment of the part of the injected steam during this period that is lost to the reservoir or to the producer well as a normal process. It is also based on the assumption that the injector is the only contributor. The total injected volume is around 3,900m^3, and the “normal losses” are extrapolated in the range of 30-60m^3/d.

In order to check the order of magnitude of the energy released during the incident, let us assume that all the steam lost away from the pair has condensed. This is probable if the invaded volume is very flat like a fracture, where conductive heat losses would be very high (compared to the case of a young well in circulation, a 600m long line heat source that probably requires a net input of 30m3/d of steam to remain on steam conditions). Let us further assume that the temperature drops to about 150 degC, steam enthalpy is then around 640kJ/kg. Upon the release, the water is depressurized to 1atm and flashing back to steam. For an adiabatic flash to atmospheric pressure, steam would flash to vapour-liquid mix of about 10% quality. It would liberate a volume of steam of about 300,000m^3 in gaseous conditions, and an energy of 1.3 10^{12} J, including the sensible heat of the expulsed liquid water.

5. Reservoir Mechanisms for Injection Pressure Upward Propagation

The analysis of 204P1 production data has shown that the incident was a two steps event. The scenario whereby a major reservoir mechanical failure occurs on April 12th as a consequence of a too high injection pressure appears likely. To investigate this possibility and support the geomechanical analyses, it is critical to estimate the depth of the top of the pressurized zone around the injector on April 12th, because that is where the rock is the weakest and the failure most likely occurred. In fact, the preliminary geomechanical studies have suggested that the reservoir could not be fractured at the depth of the injector with a pressure of 1800kPag.

Two mechanisms involving no non-linear mechanical deformations have been investigated to explain a possible rapid upward propagation of the injection pressure during the first 4 months of circulation:

- Injector pressure upward propagation through the mobile water phase in the cold reservoir
- Injector pressure upward propagation through a small but quickly growing steam chamber

In order to discuss the relative likelihood of these possible explanations, it is important to recall that the reservoir quality at the heel of 204P1 is excellent on the vertical observation wells close to the incident area and along 204I1/P1 wells slant sections (gamma ray logs are on Figure 16). It is probably the best of the project area. A channel with very high porosity and oil saturation, no shale, extends from a few meters above the injector up to the depth of 68m. There are no vertical wells to assess the reservoir quality further to the toe of the well pair, so further guesses on reservoir quality comparisons are purely based on geostatistical arguments.

The objective is in fact to determine whether and how the injection pressure could have reached this depth of 68m in 4months.

5.1.1 Pressure Propagation through Mobile Water Phase

A 3D heterogeneous model of 204P1 pair based on the available geological data has been used to investigate the possible propagation of pressure through the mobile water phase. Several sensitivities on the mobile water fraction and its permeability at initial conditions have been performed, some specifically aimed at certain facies. But none could satisfactorily lead to a quick propagation:

- The pressure propagation is at best fast and diffuse in all directions, but the pressure increase at a given point above the injector would be much too low in 4 months,
- The steam leak off rates would be unrealistically high,
- The communication with the producer would occur very early and the oil rate would be unrealistically high (please refer to the discussion in Section 3.5).

5.1.2 Pressure Propagation through a Steam Finger

The upward growth rate of a SAGD steam chamber has been modelled, lab and field tested (Butler). An upward growing chamber boundary should be intrinsically unstable, like a viscous fingering front, but with finger structures not smaller than 5-10m due to the stabilizing effects of heat conduction and steam condensation. The order of magnitude for an upward growth is 10 m/year or more in a reservoir of good quality. Similar growth rate are expected during a circulation phase, where some bitumen can be produced through the circulated fluids and leave room for a chamber to develop by gravity.

A 3D heterogeneous reservoir model of the 204I1/P1 well pair has been used to reproduce the growth of a small steam chamber “finger” in the reservoir of good quality at the heel, using CMG Stars simulation software. With minor modifications (grid size reduction in the well pair direction, change in well model), the model could successfully simulate the vertical growth of such local chamber without leading to excessive leak off rates.

The resulting cumulative bitumen production of 600 m^3 obtained on April 12th 2006 is reasonable when compared to the figure of 2,800m^3 estimated for all pad 204 and 202 wells on circulation during that period[2]. In terms of rates, the analysis of the model is more difficult since there is no bitumen production by construction during the circulation phase (modelled with electrical heaters). So the bitumen rates of 30 m3/d found during the semi SAGD phase should be seen as an upper estimate, which is not very high compared to the rate 30 m3/d of allocated to all pad 202 and 204 wells in April 2006 (60 m3/d).

However, in order to have the injection pressure reaching the top of the sand channel at 68 m in 4 months, the vertical permeability had to be increased significantly to around 50 D, specifically at the heel. The initial sand permeability is considered too low to permit the required chamber growth rate, so the 50 D permeability figure used is directly related to mechanical dilation. In the simulations several techniques were used. Permeability was either set via a higher initial permeability figure, or by using the Stars dilation module, or both. An increase of absolute permeability to 50 D would not be necessary if accompanied with an important increase of the relative permeability to water (not modelled in Stars). In the particular geomodel used, the steam chamber would not necessarily germ at the heel, where in the model the injector is just below the high porosity channel.

The Model facies and temperature cross sections are shown on Figure 19. A 3D view is displayed on Figure 20.

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[2] Oil production per well pair was not measured during circulation or semi SAGD phases. The only well on SAGD at that time was the pilot (phase1) producer and was regularly tested.

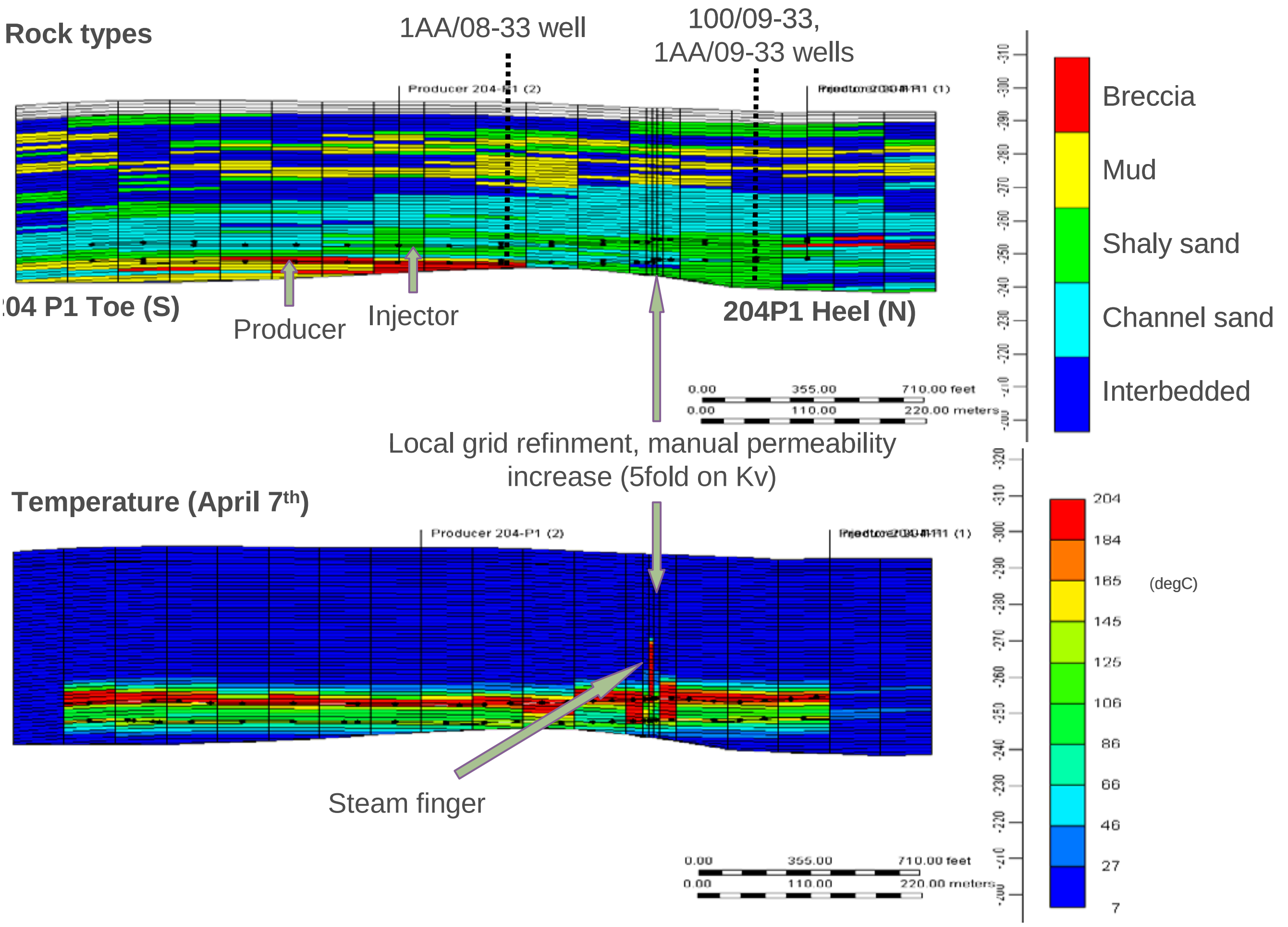


Figure 19. Model cross section along the well pair illustrating the possible development of a "steam finger" upward in the reservoir.

Both Figure 19 and Figure 20 show a connection between the injector and producer wells that indeed does not match the interpretation of the producer temperature fall offs of Figure 16. Such connections are highly dependent on the fine scale characteristics of the model used, and are very difficult to reproduce with accuracy. The goal of this particular simulation was limited to testing the feasibility of a fast growing chamber. The steam and oil rates associated with these communications were compatible with what was observed before April 12th. The oil of the steam finger was actually produced through the producer well (producing it from the injector location was not possible).

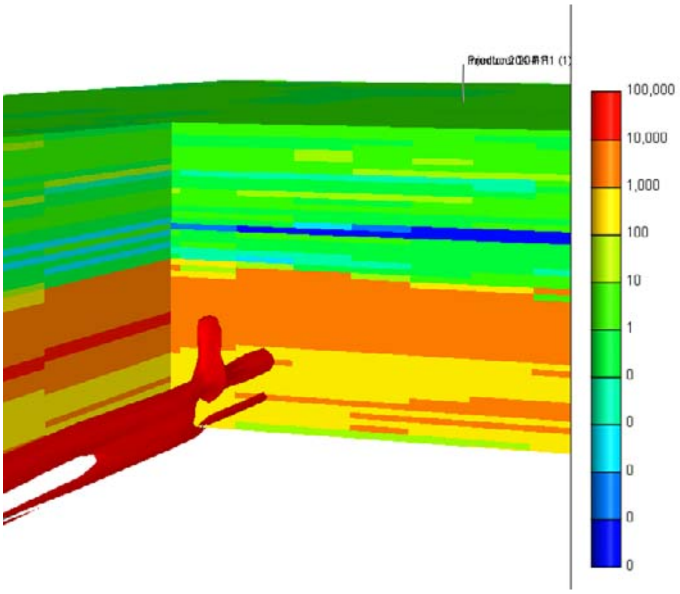


Figure 20. 3D exploded view of the model vertical permeability (mD), with the 100 ºC isotherm (red) and the steam finger.

5.1.3 Conclusion: “Steam finger” with Geomechanical Dilation

To objective was to test the scenario in which the April 12th anomaly is a major subsurface mechanical failure occurring above the injector, say at the top of the channel sands at 68m.

The only possible way the injection pressure could reach such a depth in only 4 months without relying upon true mechanical failure in the reservoir was found to be through the rapid growth of a small steam chamber with some kind of permeability enhancement, most probably through sand shear dilation (Collins 2005). Sand dilation is an irreversible increase of porosity, expected to occur when the pore pressure is high enough to induce rock shearing and a rearrangement of sand grains, but not high enough to provoke a true tensile fracture.

The increase of porosity would not necessarily sign a major anomaly of injectivity and would have two effects:

- It would directly make the sand more permeable, and accelerate the small steam chamber drainage and growth especially in the clean sand, high porosity channel observed at the heel of the pair.
- It would also open some pore space in the coldish area around the steam chamber, let high pressure condensed steam fill this space and further spread the dilation into the cold reservoir. This relative permeability effect would highly depend on the presence of mobile water at initial (temperature and porosity) conditions.

The impact of these two effects -on absolute permeability and relative permeability to water- has not been quantified, but is considered sufficient to yield a chamber growth rate equivalent to the one simulated using a permeability of 50 Darcy with no change of relative permeability. So an increase of absolute permeability to 50D would not be necessary if accompanied with an increase of the relative permeability to water as well.

This explanation is naturally challenged by two common sense observations:

- With a shallower injector depth at the toe (as little as 77m vs. 83m at the heel) and a slightly higher down hole pressure at the toe during circulation, why would the steam release or any of the preliminary phenomena (dilation, fracturing in the reservoir) occur at the heel?

For the present exercise of matching a steam release event at the heel, other factors pointing to the heel have to be invoked. It is reservoir quality in the present scenario, through high initial absolute permeability favouring fast development of a steam finger and high porosity being more prone to mechanical dilation due to a lower friction angle, and possibly to higher permeability to water in initial conditions. Other factors could have played a role a priori like the presence of vertical wells, of the well pair slant section, of natural fracture with high permeability etc. The toe pressure was not measured in the injector, but pressure losses from the toe back to the heel in the liner should be fairly small (<30 kPa) according to Qflow simulations.

- At JOSLYN, dilation is expected to propagate in a preferred horizontal direction due to horizontal stresses being larger than vertical / overburden stress. Then why would dilation help a finger growth in the upward direction?

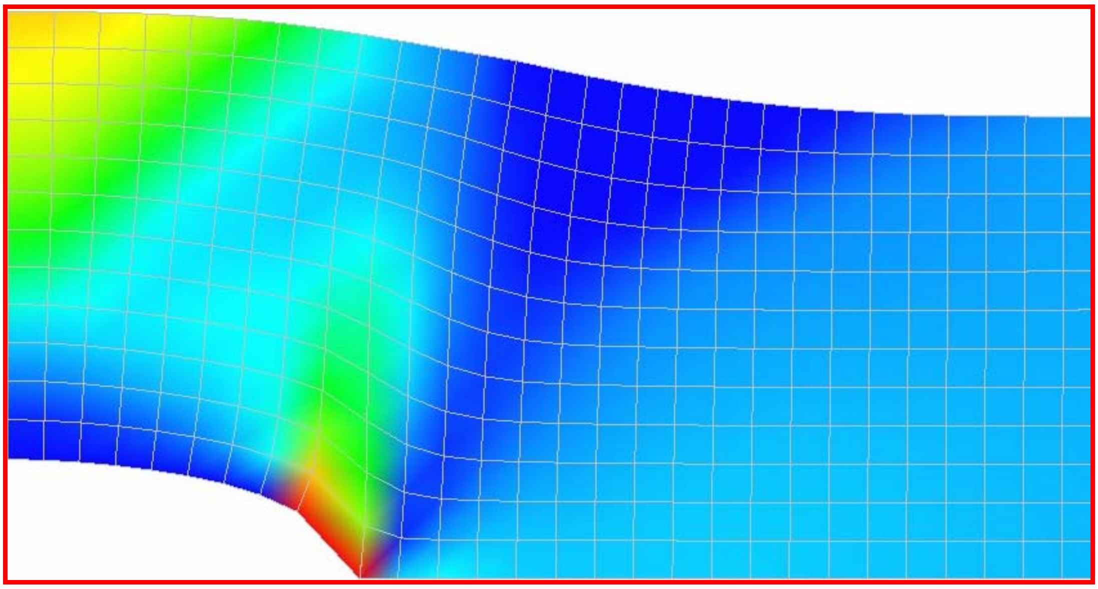
  The upward growth of the chamber would be driven by gravity through the drainage of bitumen thanks to the high permeability. Dilation could also be more effective toward the top where the confinement is the lowest.

Without the presence of a steam finger, dilation would speed up the pressure propagation mostly in the horizontal direction. Simulations using a simple isotropic dilation model without steam finger, but mobile water were run, but showed the same drawbacks as the simulations with mobile water alone. In the case of a finger and gravity being a stronger driver for the steam chamber shape development than dilation, stress induced dilation is just enhancing permeability in the direction determined by natural steam movement until vertical movement is stopped by a shale seal. At this stage lower order dilation would act mostly horizontally helping pressurizing the area just below the seal.

As a conclusion, the propagation of the injection pressure up to the top of the channel sands seems possible in 4 months. The most likely scenario would involve a mix of growing steam finger, sand shearing/dilation, and some mobile water in initial conditions. Due to the sharp decrease in permeability in shale above 68 meters, pressure propagation shallower than 68 meters prior to April 12th 2006 is considered very unlikely without involvement of true geo-mechanical failures as opposed to dilation.

Total E&P Canada Ltd.

Geo-Mechanical Insights into the May 18th 2006 Joslyn Steam Release



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December 2007

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ABSTRACT – About 10 lines explicit

Objectives (Aim, Purpose, Target) – **Recommendation(s) and/or conclusion(s)**

This document reports the outcomes of a rock mechanics study aiming at analysing and identifying the likely causes of steam release that occurred in Joslyn field above the well pair 204-1.

The report describes the different mechanisms of rock failure that can be associated with SAGD operations. The data needed and the way of determining those data for building a geo-mechanical model are then presented. The results of geo-mechanical model combined with reservoir and seismic information are then put together to propose a scenario of steam release.

The most important results of the study are :

1. The pressure applied during the circulation and the semi-SAGD phases of well pair 204-I1P1 start-up is responsible for successive failure events that have ultimately lead to direct communication of steam pressure between the injector and the Wabiskaw aquifer below the uppermost barrier which is the shale Clearwater formation
2. The Clearwater was blown up due to steam accumulation and pressure build up in the Wabiskaw to values that are much higher than the vertical stress which is equivalent to the weight of the Clearwater inferred from integrating the density log
3. It is possible to start up the SAGD at relatively high pressure if a good monitoring is implemented whereby the arrival of the pressure front to the top of oil sand is detected on due time. When this happens, the pressure must be lowered to 1200 KPa or less (more work is needed to determine that pressure margin accurately) in order to preserve the integrity of intermediate low permeability intervals between the top oil sand and the Wabiskaw
4. There is a need for monitoring surface heave and pressure in the Wabiskaw. Also further work is needed especially to:
   a. Improve the quality of the geo-mechanical data (stresses and mechanical properties)
   b. Achieve the two ways coupling between the reservoir simulator and the geo-mechanical simulator.
   c. Investigate the long term integrity and contribute to monitoring implementation and interpretation

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1. Introduction

The Joslyn Creek SAGD Project is located in the northwest portion of the company's Deer Creek Oil Sand Lease, approximately 70 km north of Fort McMurray. Bitumen is found primarily in the Middle McMurray Formation, which is up to 35 m thick, and is found at depths ranging from 65 to 110 m. Bitumen is extracted from the sands using SAGD (steam-assisted gravity drainage) technology.

On 18th of May 2006, after approximately two months of steam injection into a portion of the reservoir, steam was released from the surface, above one of the injection / production well pair. The release created a large vent formed by fissures approximately 3 m wide, 4 m deep, and 15 to 25 m long. A substantial amount of subsurface material, including pieces of rock up to 1 m in size, was ejected. Most of the material was ejected to the south and southwest, covering an area approximately 170 m by 100 m, while some material landed up to 250 m away. A surface-collapse structure (a depression in the surface approximately 25 m in diameter and 10 m deep) appeared immediately north of the vent. Figure 1 shows two aerial photographs of the area, both before and after the release.

The aim of this study was to provide geo-mechanical interpretation of the steam release incident. Geo-mechanical analysis and modelling were performed in light of results from the post incident seismic survey, from reservoir simulations (pressure and temperature diffusion) and from a review of the local geology.

The mechanical model parameters were derived from previous Joslyn geo-mechanical studies and from published data about sand and shale formations analogous to the ones encountered on Joslyn.

2. Summary of geology, reservoir and seismic data

2.1 Geology

Figure 1 shows typical lithology and formations encountered on Joslyn. Figure 2 displays a W-E seismic cross section.

From ground surface and downward, the formations are:

1. Clearwater shale : continuous cap rock of very low permeability
2. Wabiskaw: three layers of aquifer sands, continuous shale and silts. The thickness and other properties of the upper sand and middle shale are very continuous over the area.
3. Upper McMurray bitumen filled (and occasionally gas filled) filed sands / shale alternations.
4. Upper Middle McMurray: alternation of shale and low quality sands (K < 200 md). Shale layers act as local barriers to vertical steam movement and pressure diffusion due to their low permeability..
5. Lower Middle McMurray: good oil sands providing the bulk of HC reserves, permeability of several Darcys.

In the observation well at the he heel of well 204-P1, the top of Wabiskaw/base of Clearwater Shale is located at 35.5m. The Upper McMurray/base Wabiskaw is found at 44 m and the good sand at 68 m vertical depth. The injector 204-I1 varies in depth between 78 and 82 m.

Any steam migrating upward is expected to hit a first silty shale layer at 61.5 m depth and a second one at 57 m.

In summary, 10 to 14 m of good sands separate the injector from the Middle McMurray. The cumulated thickness of layers separating the good sands from the Wabiskaw is 20 to 24 m. This interval includes two silty shale layers with relatively low permeability.

To be able to operate steaming on Joslyn at reasonable pressure safely, it is very important to assess the sealing capacity of the Middle and the Upper McMurray taking into account the geo-mechanical effects. Note that by sealing capacity it is meant the ability to restrain upward steam / water / gas flows into the Wabiskaw to prevent significant pressure build up there. This requires firstly a thorough description of the vertical and lateral permeability distribution over the field is and secondly the ability to predict how the permeability is affected through geo-mechanical phenomena.

2.2 Reservoir data

Prior to steam release, the well pair 204-1 was operated in different phases which are summarized on Figure 3. The main features which characterize each phase can be summarized as follows:

- ***Circulation Phase***
  - During the circulation phase, steam is injected and produced from both the injector and producer wells (through two tubings in the injector and tubing & annulus on the producer).
  - This phase start on Dec. 2nd 2005 and ended March 26th 2006 on 204-1.
  - High pressure with peaks of up to 2200 kPa gauge at surface and estimated 1800 kPa gauge in bottom hole conditions.

- ***Semi-SAGD Phase***
  - During semi-SAGD phase, steam is injected through both strings of the injector while the producer is kept on circulation.
  - Started March 26th, 2006 , the injection pressure was between 1700 and 1800 kPag, the injection rate around 60 m3/day.
  - On April 12th, 2006, sudden increase of injectivity, pressure dropped to around 1600 kPag while the injection rate increased to 160 m3/day.
  - Between April 21st and May 2nd, further drop of pressure to 1300-1400 kPag, keeping high injection rate
- ***Workover period***
  - *From May 2nd to May 11th 2006, the well was shut in for pump installation.*
- ***Production Phase***
  - During normal SAGD production, the producer flows through the pump and tubing to surface.
  - Still high injection rate, even though the pressure was kept below 1300 kPag. The pressure was raised to 1400 kPag which resulted in an increase of injection rate to about 180 m3/day right before the steam release.

Attempts have been made to match the history of pressure and injection rate on the well pair 204-1. The main conclusions of these analyses are the following:

- The volume lost to the formation from April 12th onwards is estimated between 1000 to 2600 m3 cold water equivalent.
- It is possible that a finger shaped SAGD chamber developed during the circulation and start of semi-SAGD phase in a particular section along the well pair

To achieve the matching in the semi-SAGD phase in particular, one has to introduce in the model channels of highly enhanced permeability (50 darcy), which brings strong evidence about geo-mechanical effects having taken place early before the steam release.

2.3 Seismic observations

See reference the Joslyn 3D Seismic Acquisition and Interpretation report for details.

The key conclusion of the interpretation is that the seismic images obtained from the January 2007 seismic survey allow for the clear delineation of the region in the subsurface that was disturbed by the steam release. The following insights may be drawn from the images:

- No geologic feature was identified that would suggest that a local a pre-existing geological condition played a role in the steam release process.
- The shape of the steam release impacted volume appears unrelated to nearby observation wells, suggesting that these wells did not play any part in the steam release. The points where the steam is thought to have punctured the middle and Upper McMurray were between 10 and 40 m from the observation wells.

- The sequence of events suggested by the shape of seismically disturbed volume is the following:
    - Vertical steam migration from the injector well, through the reservoir, to the Upper fraction of the Middle McMurray.
    - Steam accumulation in the Middle McMurray close to geologic marker top GPP, at the apex of an antiform.
    - Steam then broke the seal at this level, and further migrated upwards.
    - The sequence of accumulation, puncturing, and upwards migration was then repeated as the steam worked its way into the Wabiskaw interval.
    - The final seal, in the Clearwater, was punctured after significant energy was stored in the Wabiskaw. Once this seal was punctured, the vents were immediately and catastrophically created and the steam was released at the surface.
- The steam from injector 204-I1 did not reach either of the neighboring well pairs.

Figure 4 portrays a 3D view of the zones above the well pair 204-1 that were affected by the steam release. Chimney like objects of around 30 m width can be clearly seen in the McMurray. Above the chimneys, the perturbed zone expands over more than 100m in the Wabiskaw and in the Clearwater.

Top Wabiskaw

Permeable zone

Interbeded Sand & shale, low K (< 200md)

Lateral continuity of shales not guaranteed

Top clean sand

Injector

Producer

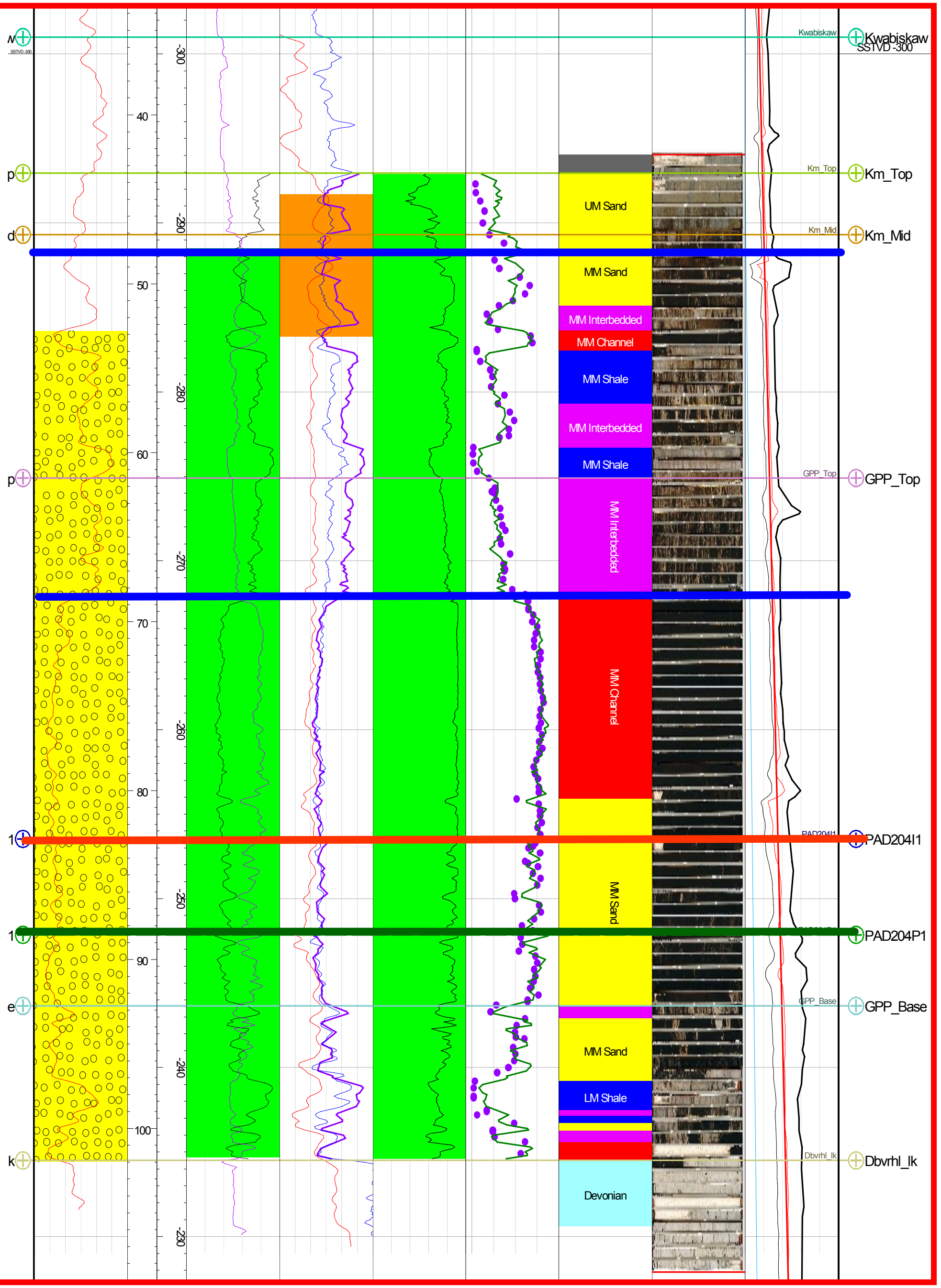
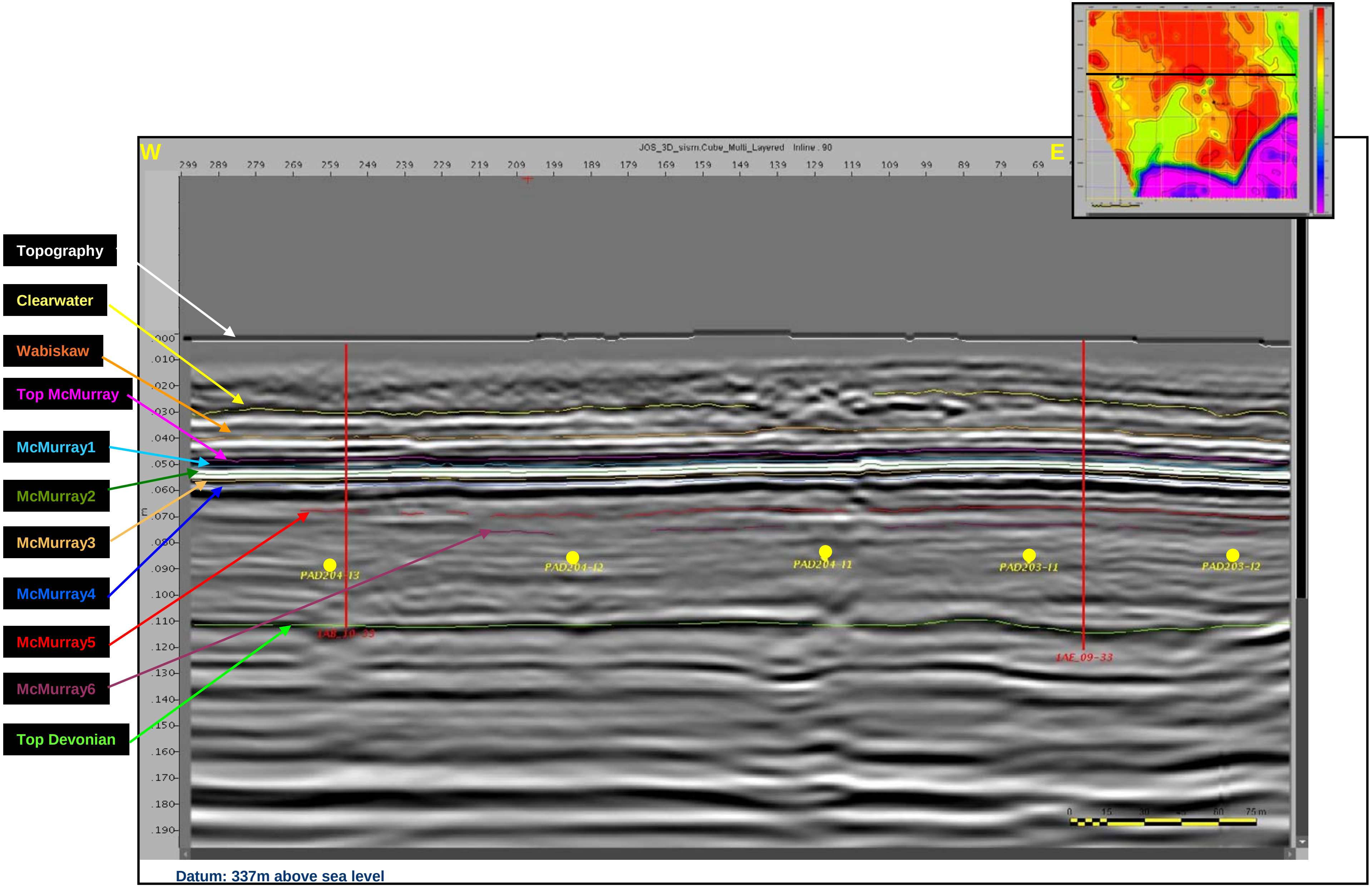


Figure 1. Geology encountered on 100/09-33-095-12W4 (Observation Well close to the heel of 204-P1)



Datum: 337m above sea level

Figure 2. W-E seismic cross section

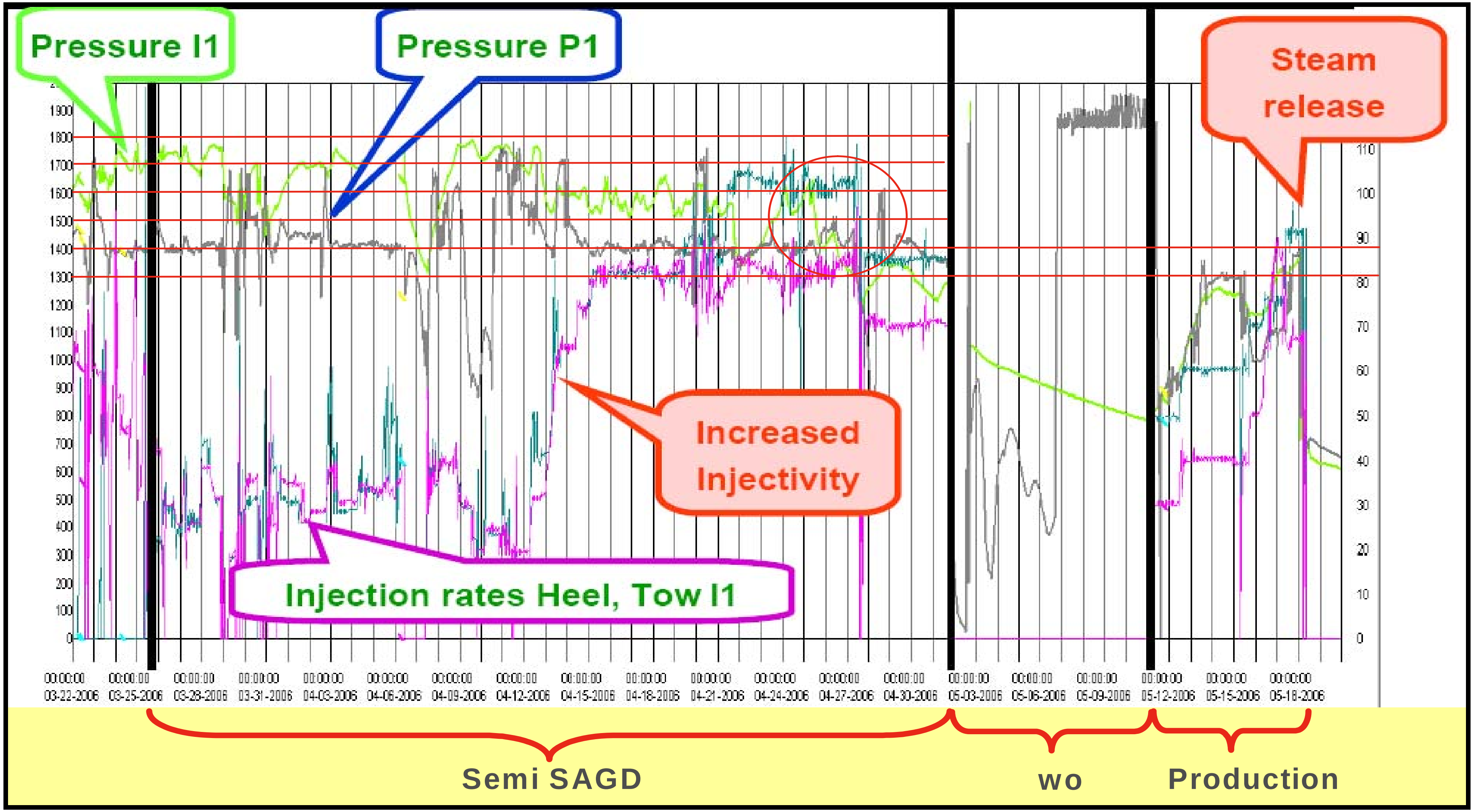


Figure 3. Pressure and rates profiles on well Pair 204-1

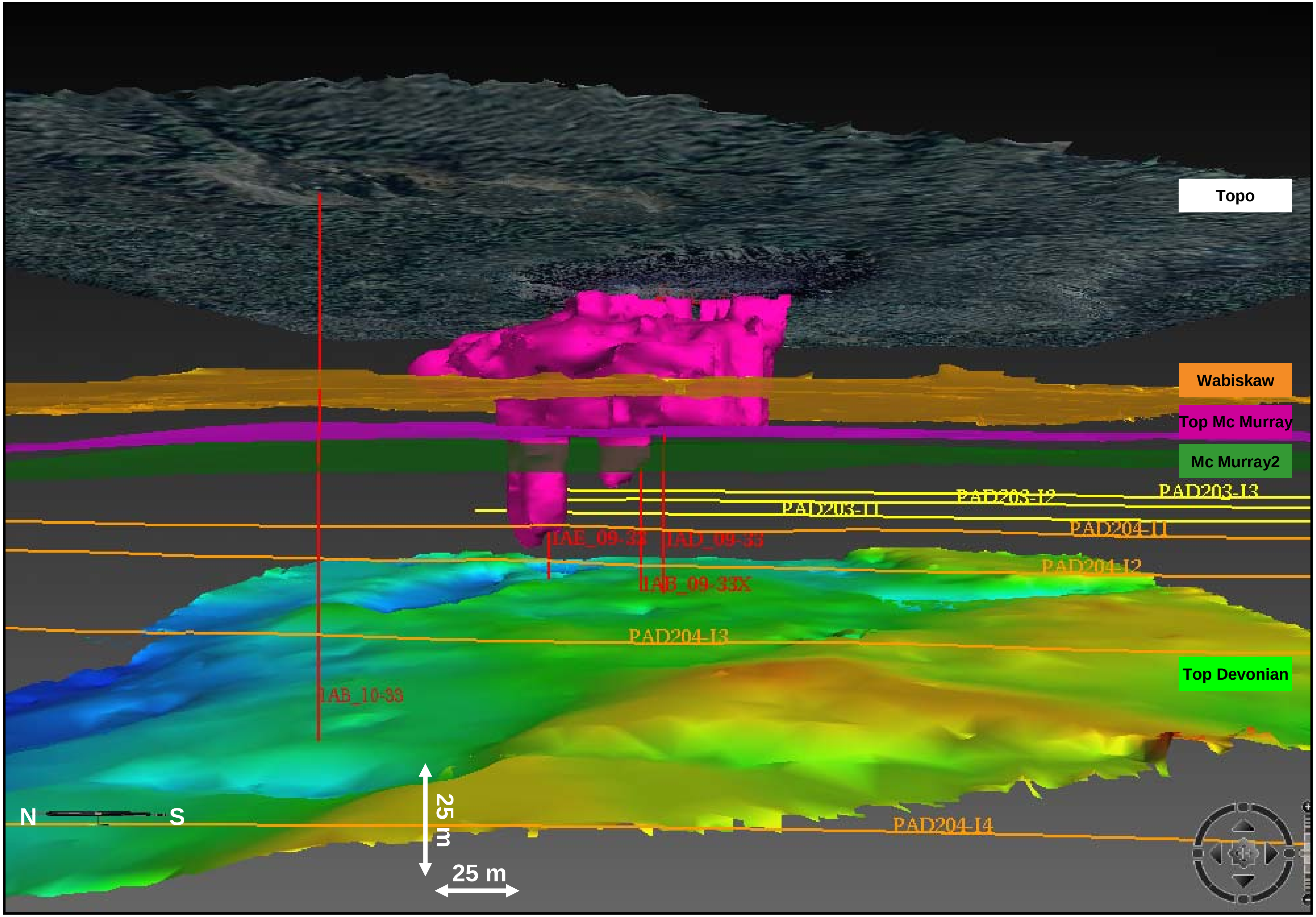


Figure 4. Joslyn 3D view of the steam release inferred from seismic survey

3. Glossary

3.1 Mechanical behaviour of sand and shale materials

3.1.1 Shear failure

Athabasca oil sands are unconsolidated, i.e. their cohesion is almost equal to zero. Due to grains interlocking, those sands own high peak friction angle and undergo important dilation, or increase of porosity, during shearing under relatively low mean effective stresses.

Sand and shale behaviours can be described within the framework of coupled poro-thermo-elasto-plastic theory. An elasto-plastic model involves the definition of a yield criterion on one side and of a flow rule on the other side. In this study, a Mohr-Coulomb (M-C) perfect plastic criterion is used. In terms of principal stresses, and for cohesionless or uncemented rock materials, this criterion is written:

$$\mathbf{f}(\sigma) = (\sigma_1 - \mathbf{Pp}) - \frac{(1+\sin\varphi)}{(1-\sin\varphi)}(\sigma_3 - \mathbf{Pp}) = \sigma'_1 - \mu\sigma'_3 = 0 \qquad \text{Eq. 1}$$

σ_1 and σ_3 are respectively the major and the minor total stresses. Pp is the pore pressure. φ is the friction angle and μ is friction coefficient function of φ. σ' denotes the effective stress which is equal to the difference between the total stress and the pore pressure.

It is worth noticing that, according to the M-C coulomb criterion, the shear failure occurs either by increasing the deviatoric stress (i.e. $\sigma_1 - \sigma_3$) by raising the pore pressure or both. Especially when the pore pressure increases more rapidly than the minor total stress, the effective stress might become null and the sand gets liquefied. Liquefaction is associated with a steep increase of porosity as the sand looses the contacts between grains.

The flow rule relates the rate of plastic deformation to stresses through the definition of a plastic potential as follows:

$$\dot{\varepsilon}^{\mathbf{pl}}_{\mathbf{ij}} = \dot{\lambda}\frac{\partial \mathbf{g}(\sigma)}{\partial \sigma_{\mathbf{ij}}} \qquad \text{Eq. 2}$$

An associated flow rule assumes that f=g. However, for sands, non associated rule is needed to account properly for sand dilation. In this study the flow rule will be:

$$\mathbf{g}(\sigma) = (\sigma_1 - \mathbf{Pp}) - \frac{(1+\sin\delta)}{(1-\sin\delta)}(\sigma_3 - \mathbf{Pp}) = \sigma'_1 - \beta\sigma'_3 \qquad \text{Eq. 3}$$

Where δ is the dilation angle and β is a dilation coefficient function of δ.

According to equations 2 and 3, the volumetric strain rate is related to stress by

$$\dot{\varepsilon}^{\mathbf{pl}}_{\mathbf{v}} = \dot{\lambda}[1-\beta] \qquad \text{Eq. 3}$$

When δ, the dilation angle, is equal to zero, the dilation coefficient β is equal to 1 and the volumetric strain is nul. Therefore, the condition for sand dilation is δ > 0 or β >1, which implies that $\dot{\varepsilon}^{\mathbf{pl}}_{\mathbf{v}}$ is negative (increase of volume).

The total volumetric strain is the sum of the plastic one and the elastic one. Under infinitesimal strain assumption, the change of porosity is related to the total volumetric strain by

$$\phi - \phi_0 = \frac{\varepsilon_v^t}{1-\phi_0} \qquad \text{Eq. 4}$$

3.1.2 Tensile failure

Tensile failure is what happens during hydraulic fracturing of competent rocks. The criterion of tensile fracturing is :

$$\sigma_3 - Pp + T = \sigma'_3 + R_T = 0 \qquad \text{Eq. 52}$$

R_T is being the rock tensile strength.

In unconsolidated sands, more conditions are needed to keep a hydraulic fracture open and propagating. As shown in Figure 5, the pressure in the fracture is equal to the total stress applied to the rock in its vicinity. In the absence of a permeability barrier keeping the fracture pressure overbalancing the pore pressure, shear failure condition prevails whereby the sand dilates and fills up the fracture. A fracture in unconsolidated sands is assimilated therefore to a highly dilated zone.

In oil sand reservoirs, the low oil mobility might act as barrier to pressure transmission when injecting at high rates. This will be investigated later in this report when presenting the results of minifrac tests done on Joslyn. Those tests consist of hydraulically fracturing the formation by pumping water at quite high rate in a well. The tests show also that abnormally high pressures are needed to initiate a fracture, most likely because the formation has to undergo a lot of dilation to establish its injectivity.

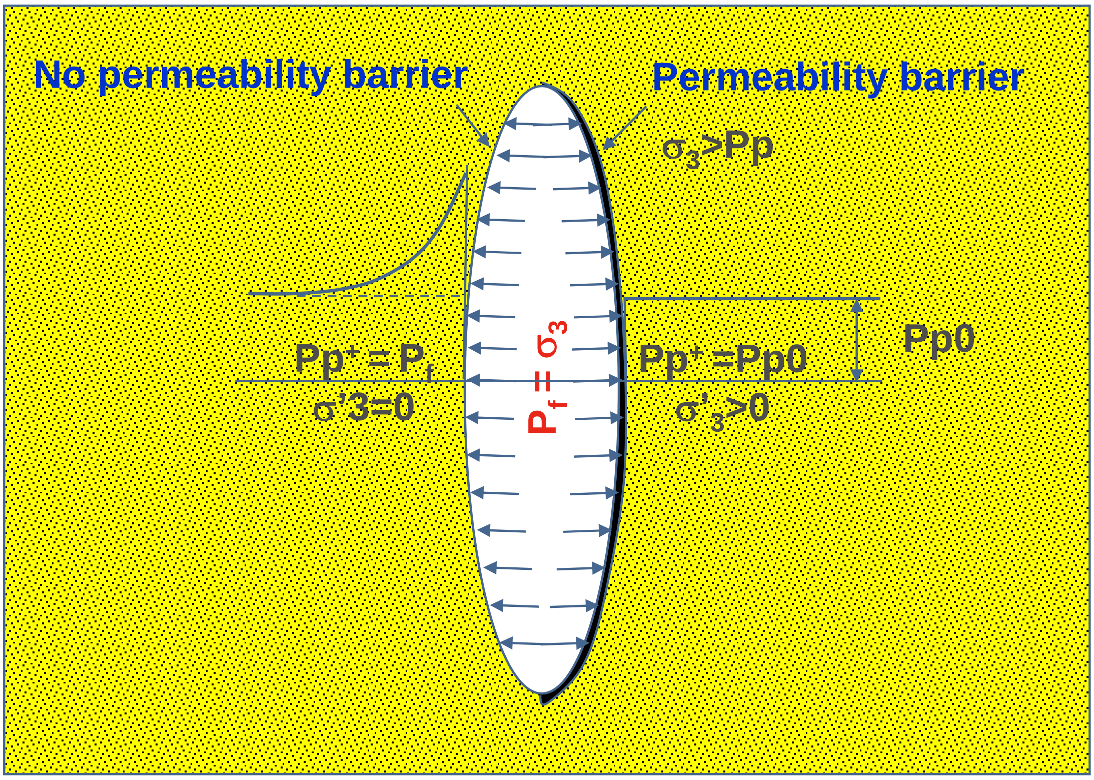


Figure 5. Mechanical conditions in the vicinity of a hydraulic fracture

3.2 Poro-Thermo-Mechanical (PTM) coupling

Rock deformation, pressure and temperature are strongly coupled during SAGD operations in oil sand reservoirs. The most important effects of this coupling are

1. Effect of pressure and temperature on rock deformation inside and outside the steam chamber
2. Effect of rock deformation on permeability (absolute and relative) inside and outside the steam chamber
3. Effect of temperature on the pressure outside the chamber

The constitutive equations of rock and of saturating fluids are:

$$d\sigma_{mn} = \left(K_b - \frac{2G}{3}\right)d\varepsilon_v + 2Gd\varepsilon_{mn} + b_J dP_J + 3\alpha_b K_b dT$$

$$dP_J = \frac{1}{(\phi C)_J}\left[-\phi_J d\varepsilon_v - d\phi_J + \left(\frac{dm}{\rho}\right)_J\right] + 3(\alpha K)_J dT \qquad \text{Eq. 6}$$

Kb,G, α_b : bulk and shear modulus and liner thermal dilation coefficient of the rock

P_J, C_J , ϕ_J , α_J, ρ_J , m_J : pressure, compressibility, porosity, linear thermal dilation coefficient, density and mass per unit bulk volume of Fluid phase J

Note that $\phi_J=S_J\phi$ and $\phi=\Sigma\phi_J$, where S_J is the saturation in fluid phase J.

3.3 Effect of rock deformation on permeability

For oil sands, it is important to make the distinction between the absolute permeability and the relative one. The former parameter is known to increase with porosity. The last one depends on the saturations of the various fluid phases. In the case of two-phase flow (oil + water), the water saturation must go beyond a critical threshold (Swi) for the water phase to become mobile. As far as the water saturation is less than the critical one, the dilation causes an increase of the oil permeability. If on the contrary the water is already mobile prior to injection, the dilation will rather increase the permeability to water. The relation between relative permeability and dilation is therefore strongly dependent on the initial water mobility.

Let us consider the dilation of a sand with a porosity of 30% saturated with oil (single phase) with a compressibility of 7.10^{-7} KPa^{-1} under un-drained and isothermal conditions (dm_o=dT=0). The fluid constitutive equation in this case reduces to

$$dP_o = -\frac{1}{C_o\phi}d\varepsilon_v = -\frac{1}{C_o\phi}\frac{d\phi}{(1-\phi)} \qquad \text{Eq. 7}$$

For a pressure around 800 KPa, a strain of only 0.017 % or a porosity increase of 0.012% is enough to drop the pressure to zero. Once the pressure is null, further dilation causes a reduction of the oil saturation:

$$dS_o = -\frac{d\varepsilon_v}{\phi} = -\frac{d\phi}{\phi(1-\phi)} \qquad \text{Eq. 8}$$

Under drained conditions and two phase fluid (water+oil), the loss of oil saturation is compensated by an increase of water saturation $\left[dS_w = -dS_o = \frac{d\phi}{\phi(1-\phi)}\right]$, which results in an increase of the relative permeability to water.

During steam injection in oil sand reservoirs, dilation is suitable within the reservoir interval as far as it increases the permeability to oil or it enhances the permeability of intra-reservoir barriers. There are certain conditions however under which the sand dilation leads rather to the increase of the relative permeability to water outside the steam chamber. That is especially true at the periphery of the pressurized zone where the dilation is at its maximum. This phenomenon is very important to predict and quantify as it implies quicker transmission of the steam pressure to outside the reservoir limits with all the associated risks in terms of cap rock sealing efficiency.

3.4 Geo-mechanical phenomena associated with SAGD

3.4.1 Sand dilation around steam chambers

Several fronts develop around steam chambers (see Figure 6). The slowest front is the steam one followed by temperature and pressure. Dilation occurs in the chamber itself because of high pressure and temperature there, but also at the periphery of the pressurized zone. A dilation front can thus also be defined. As explained in the previous section, the dilation around the steam chamber might enhance the permeability to water which accelerates the pressure and the steam progression toward the top reservoir where the confining stress is the lowest. In this scheme, the dilation is equivalent to diffused fracturing of the sand.

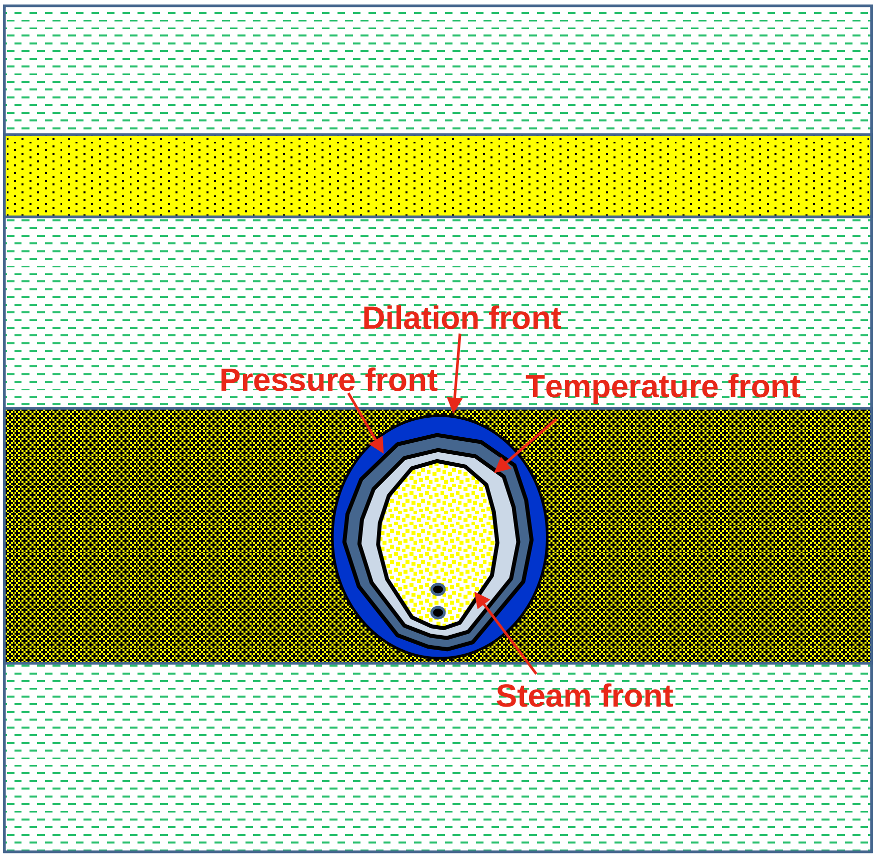


Figure 6. Different fronts developing ahead of a steam chamber

3.4.2 Role of shale barriers

A shale barrier might stop or at least decelerate the upward pressure transmission because of its low permeability. In the short run, the pressure starts diffusing preferentially in the horizontal direction. The integrity of the shale barrier depends then on the surface area of the pressurized zone and on the difference between the pressure and the vertical stress. If the pressure is smaller than the vertical stress, the shale barrier will be stable. If a pressure greater than the vertical stress extends sufficiently at the base of the shale barrier, this last might fail by shear on the shoulders of the pressurized area as illustrated in Figure 7.

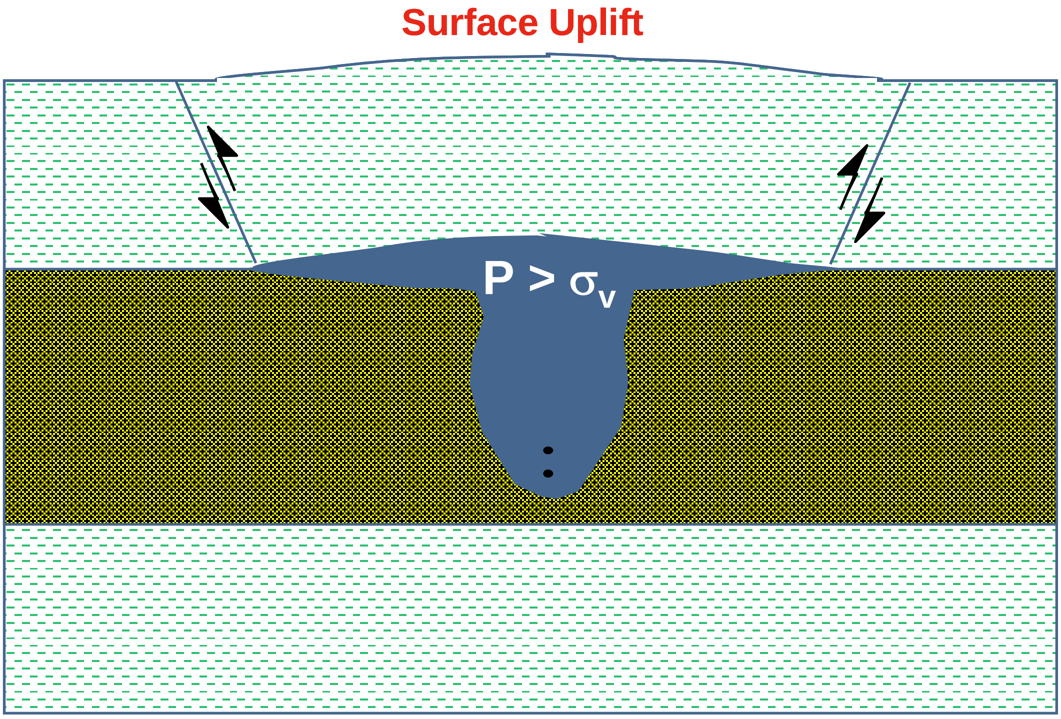


Figure 7. Failure of a shale barrier by shear on the shoulders of a zone with a pressure greater than the vertical stress

In the long run, the integrity of the barrier might be compromised due to temperature increase by heat conduction. This increase of temperature has two possible effects

- Shrinkage of the shale which, by reducing the confinement, might become a source of fracturing
- Increase of the shale pressure due to fluid thermal dilation.

The effect of temperature on pressure can be calculated using the coupled constitutive equation of the fluid under un-drained conditions. For a shale fully water saturated, the equation is

$$dP = \frac{1}{\phi C_w} d\varepsilon_v + 3(\alpha K)_w dT \qquad \text{Eq. 9}$$

If the shale is confined and cannot deform (dεv =0), the pressure might increase by several hundreds kPa/°C. In the reality, the increase of pressure leads to shear failure of the shale accompanied by dilation and increase of the shale permeability.

4. Data for Geo-mechanical Modelling

There are several sorts of PTM coupled models:

1. Fully coupled models : thermal, flow and mechanical equations are solved together
2. One way coupling : pressure and temperature are calculated by the reservoir simulator and fed to the geo-mechanical model to calculate the rock deformation and stresses
3. Staggered or iterative coupling: mechanical and flow problems are solved separately but iterations are performed between the reservoir simulator and the geo-mechanical simulator during which the permeability and the pore volume are changed in the reservoir model according to the results of the geo-mechanical one.

In our study, the one way coupling was used, but in the future it is important to implement the staggered coupling which is the only way to capture the impact of geo-mechanics on steam flow and the corresponding pressure.

4.1 Summary of required data

In general, the data needed to run PTM coupled model are

1. The PTM parameters of all layers of the overburden, of the reservoir and of the under-burden. For the Mohr-Coulomb elastic-perfectly plastic model those parameters are: Young's Modulus, Poisson's ratio, cohesion, friction angle, dilation angle, and coefficient of linear thermal expansion.
2. The in situ stresses : the vertical stress, the maximum and minimum horizontal stresses (σ_v, σ_{hmax}, σ_{hmin})
3. The relation between permeability (absolute and relative) and rock deformation when either fully coupled or staggered coupled models are used.

4.2 Formations Mechanical Properties

Sand properties were derived from published data which show very constant behaviour of sands in analogue fields. Shale properties were derived from both published data and from tests on the Clearwater shale that were carried out by a local rock mechanics laboratory in Calgary.

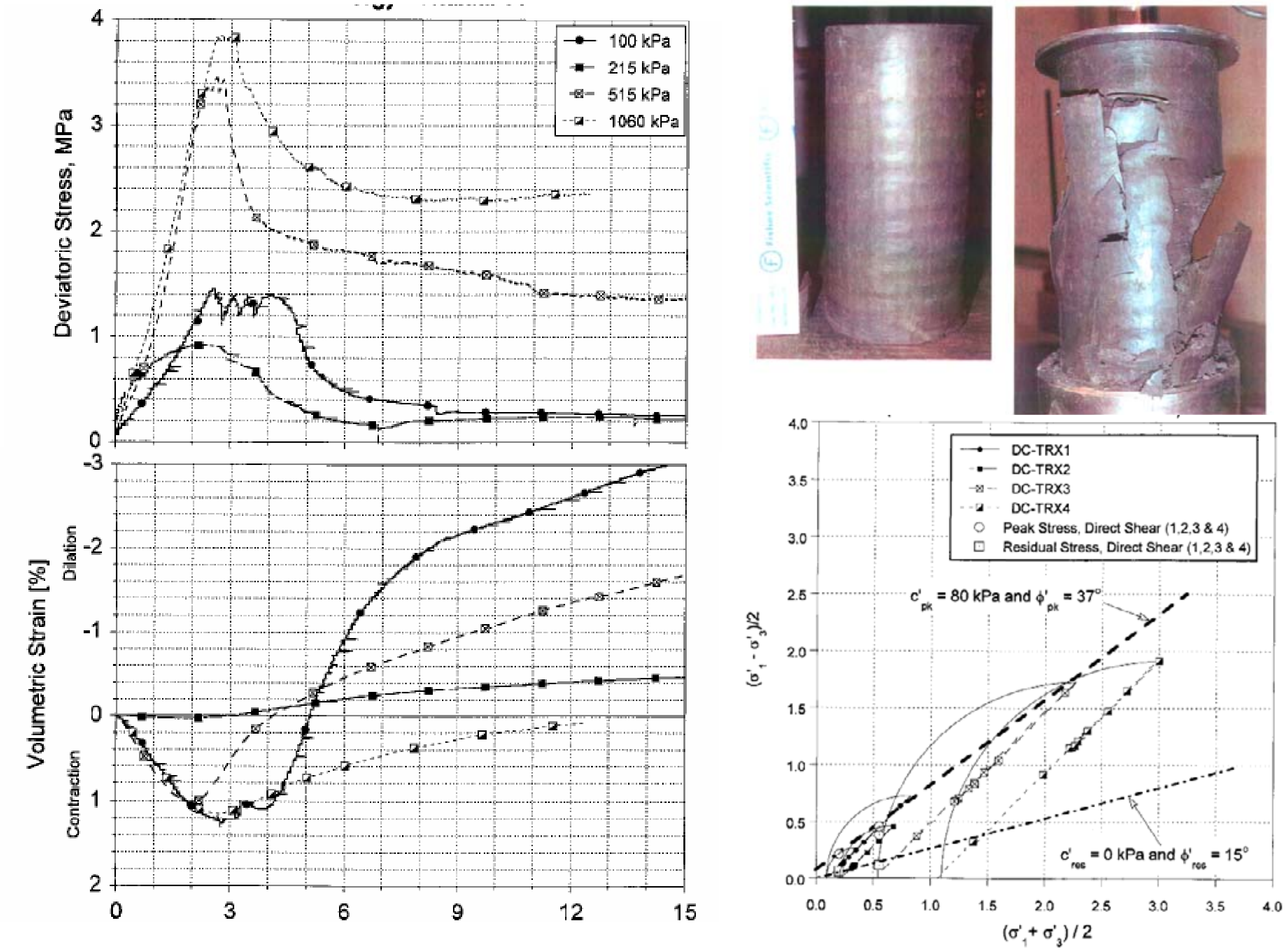


Figure 8 Deer Creek Energy – Results of Triaxial Tests on Clearwater shale samples

The mechanical data used in the geo-mechanical model are summarized in the following Table.

	Young's Modulus	Poisson's ratio	Friction angle	Dilation angle	Cohesion
Reservoir	500 MPa	0.25	45°	35°	0
Cap rock	500 MPa	0.4	30°	20°	0

Table 1 Mechanical parameters used in the Geo-mechanical model

4.3 In-situ stresses

Several minifrac tests were done in well 8-29-95-12W4. A detailed stress study was carried out by P. Collins using the results of the minifracs (see Appendix 1). The calculated stresses were found to be in agreement with data from several fields located in that area.

Figure 9 portrays the interpreted stresses. The vertical stress gradient, derived from the integration of a density log, is close to 21 KPa/m. From the fracture closure pressure, the horizontal minimum stress gradient was estimated to 24 KPa/m and the maximum stress gradient to 31.5 KPa/m.

One of the important stress is the vertical one as it controls the risk of overburden shoulders failure (see §3.4.2). This stress depends on both the densities and the thicknesses of the overburden layers. Care must therefore be taken in calculating this stress as it might vary from location to other throughout the field.

Figure 10 summarizes the stress profiles that were used in the geo-mechanical model based on Collin's study.

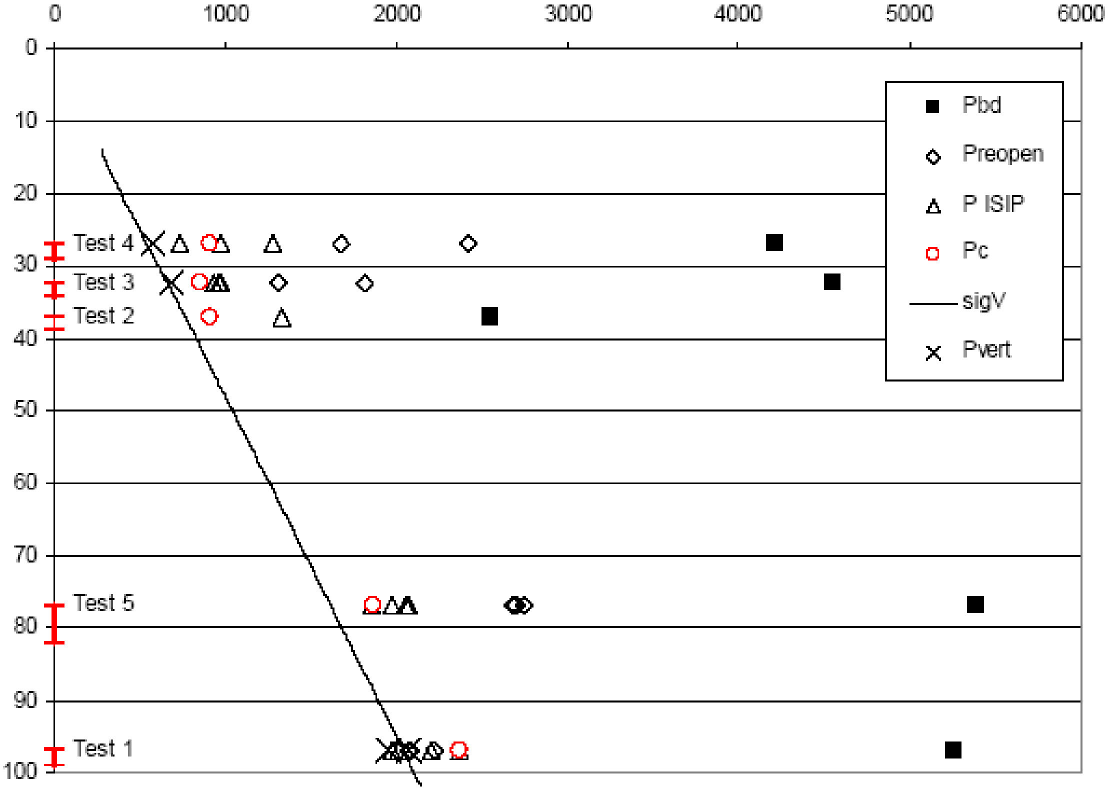


Figure 9. Well 8-29-95-12W4 minifrac stresses (pressure [kPa) vs. depth [m])

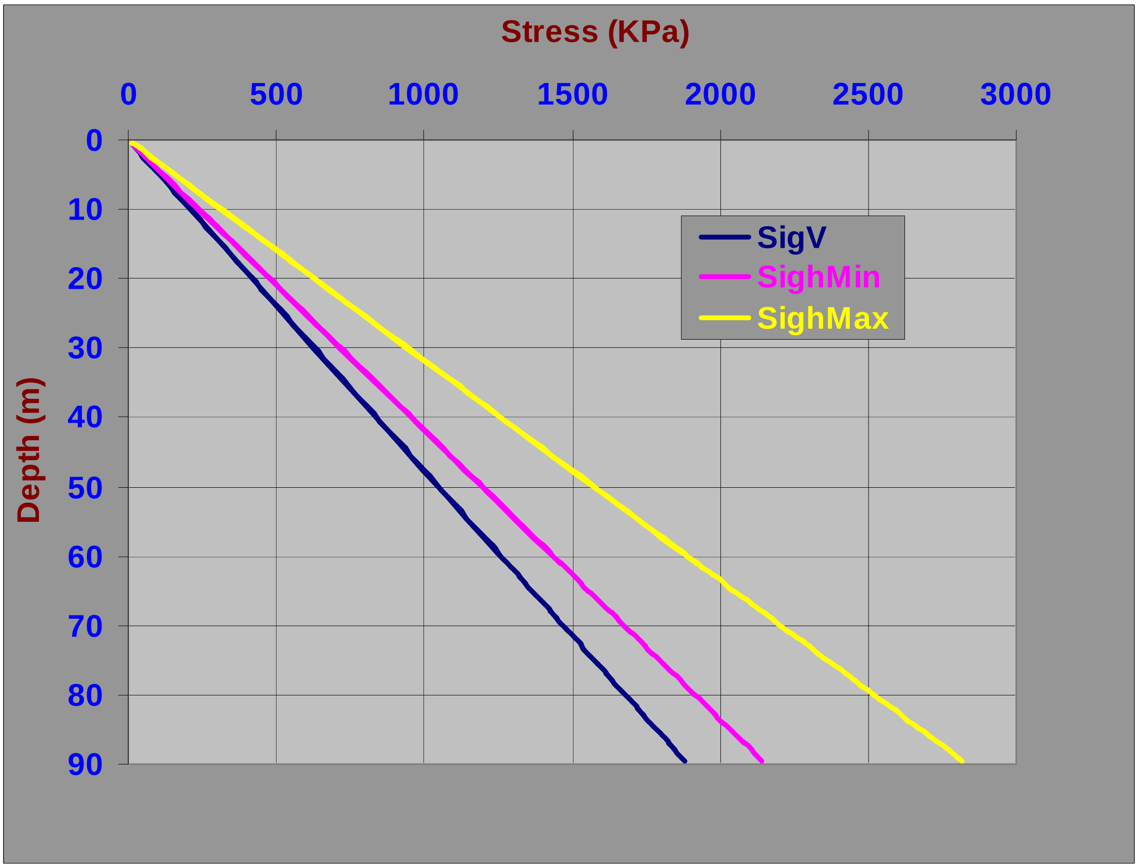


Figure 10 Stress profiles used to build the geo-mechanical model

Comments about the interpretation of minifracs

The minifracs interpreted by P. Collins show some surprising results:

1. The pressure gradients needed to initiate the fracture (Pbd on Figure 9) are abnormally high. Note that the breakdown measured during a minitfrac is usually interpreted as the pressure required for overcoming the wellbore stress.

2. The measured closure pressures are greater than the calculated overburden stress. It is legitimate then to wonder whether the fractures are horizontal and not vertical. In absence of measurements of fracture orientation, it is difficult however to state on this point.

In the following, we try to explain the high breakdown pressures by considering plastic behaviour of the rock at the positions of minifracs.

During a minifrac test, the shear stress, which is related to the difference between the radial stress and the tangential wellbore stress, increases with the pumping pressure. This results in rock dilation. If the dilation created porosity is not filled up by oil, the pore pressure reduces to zero as it was explained in §3.3. Further dilation creates room for increasing water saturation and permeability to water consequently. The high breakdown pressure measured during minifracs can thus be explained by the need before initiating the fracture to dilate the rock sufficiently to allow for the pumped fluid to penetrate into the rock.

Fracture propagation requires two conditions. First, the injection pressure should be higher than the minimum stress. More importantly, there should be no build up of pore pressure through the faces of the fracture to prevent shear failure of the sand there (see §3.1.2 for more details). This is the case during a minifrac test as the fracturing fluid is pumped at quite high rate. Otherwise, the dilation mode prevails over single fracture propagation.

To calculate the dilation strain which takes place during a minifrac test at the breakdown pressure, the finite element well model shown in Figure 11was built. Figure 12 shows the evolution of the maximum wellbore dilation strain with pumping pressure between hydrostatic and breakdown pressures.

For a breakdown pressure around 4700 KPa, the model calculates a strain of 2.23 %. This value will be used as a criterion for either single fracture or dilation failure mode initiation and propagation in oil sands with no initial water mobility.

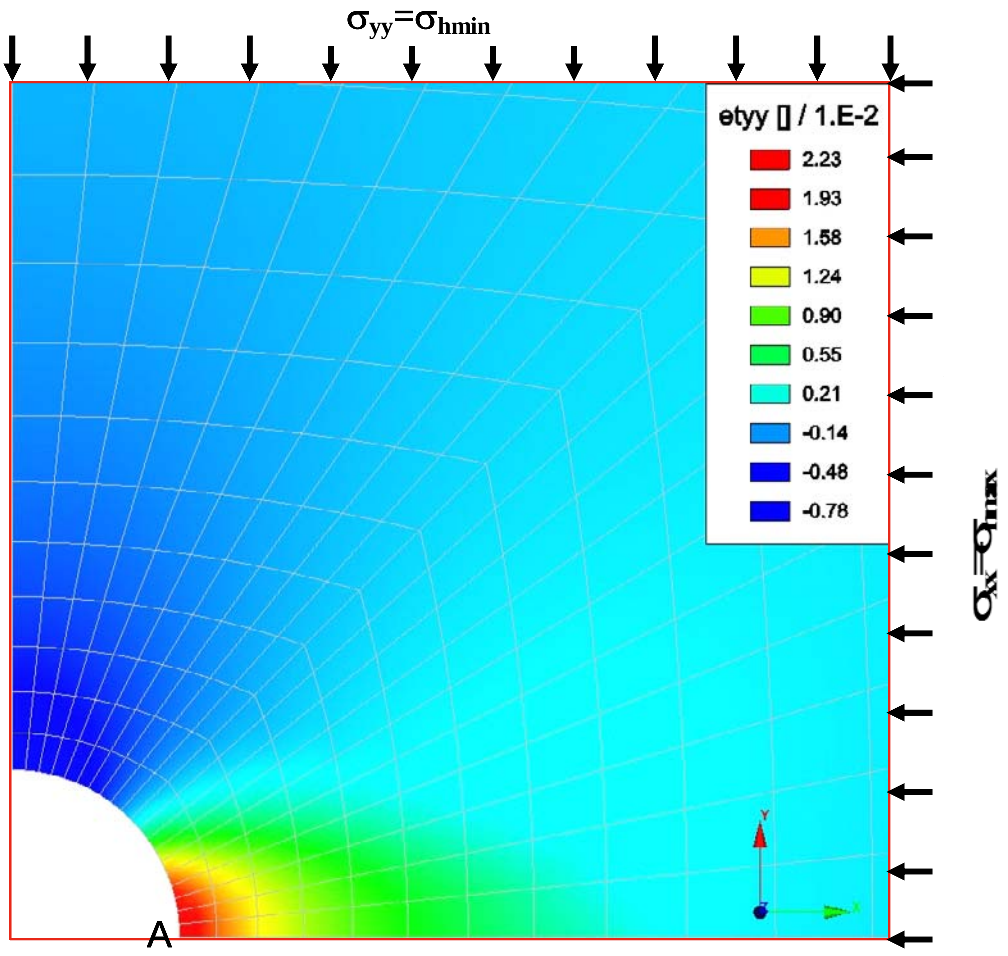


Figure 11. Well model used to simulate the minifrac tests.

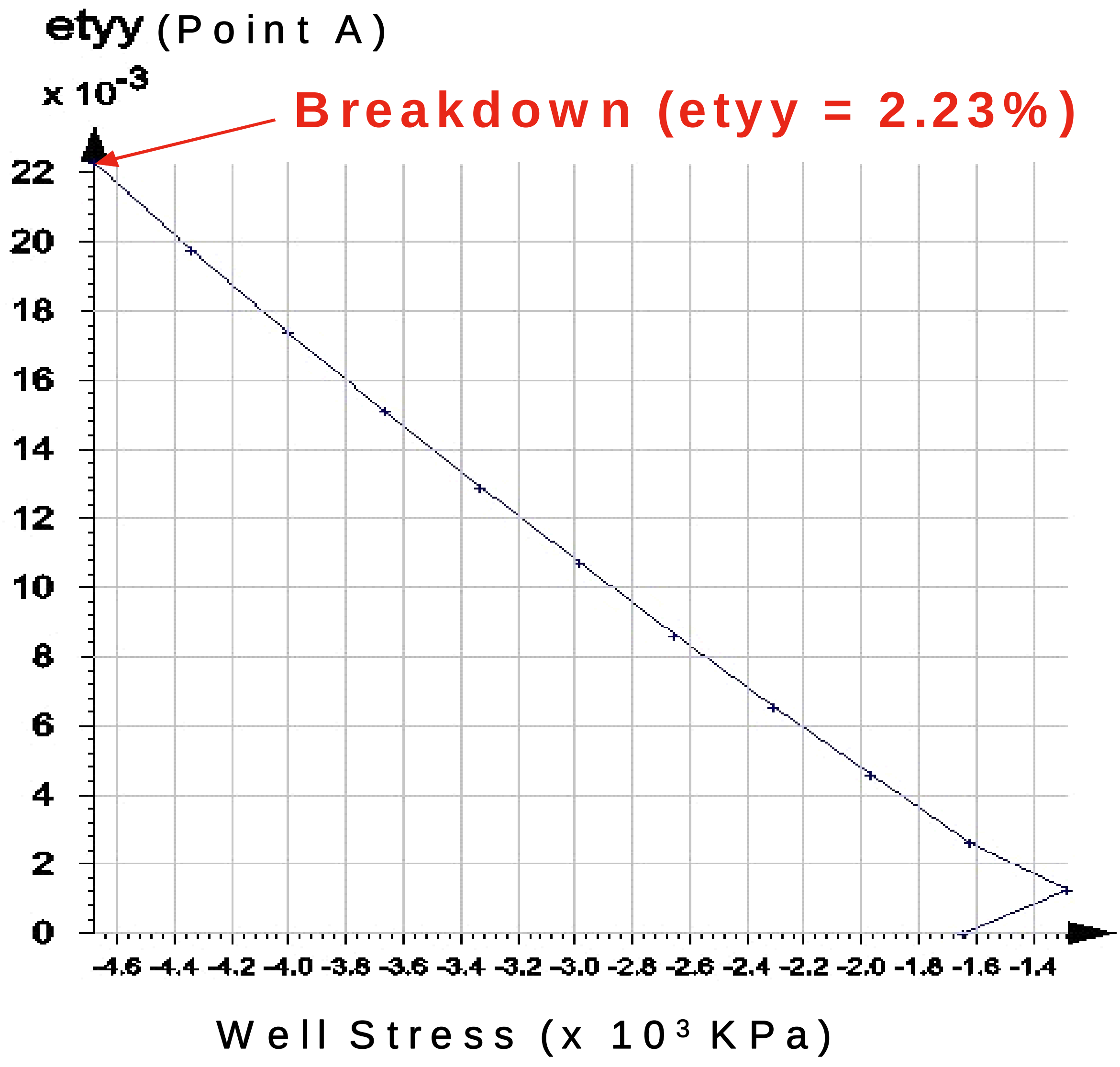


Figure 12. Maximum wellbore dilation strain versus well stress (= – BHP) during a minifrac test

5. Geo-mechanical modelling results

5.1 Dilation strains in the reservoir versus injection pressure

The finite element model shown in Figure 13 was used to calculate the dilation strain around steam injectors on Joslyn as a function of both the injection pressure and the size of the pressurized zone. In this model, no pressure diffusion is allowed above 60 m depth. In this model SigH is aligned with the SAGD pair; the model is not coupled with the reservoir model.

To illustrate the way of interpreting the model results we consider the case of a 30 m wide steam chamber reaching the barrier with 1600 kPag pressure in it. Figure 14 shows the geo-mechanical model results in terms of rock deformations and surface heave.

The main results which can be drawn from this example are:

- The surface heave is only 12 mm, which is quite small.
- The maximum dilation strain takes place at the top of the chamber, where the confining stress is the lowest.
- The vertical dilation strain is much higher than the horizontal one. Indeed, the vertical strain at the top of the pressurized zone is 0.46% while the horizontal strain is around 0.04%, which yields an increase of porosity by 0.5%.
- At the injector depth, the vertical dilation strains are very small as the pressure there is lower than the vertical stress.
- A pressure of 1600 kPag exceeds both the initial vertical and minimum horizontal stresses at the top of the pressurized zone. The model calculates a dilated zone which can be assimilated to a horizontal fracture but with finite permeability.

The same kind of calculation was performed considering injection pressures between 1200 and 1800 kPag. Figure 15 shows the calculated strains around zones pressurized to 1200, 1400, 1600 and 1800 kPag respectively. The size of every pressurized zone is characterized by its width and by its top depth.

Table 2 gives the conditions under which the critical strain inferred from the minifracs (see §4.3 for more details) is attained for every simulated injection pressure.

Pressure (kPag)	Dimensions of the pressurized zone when critical strain is reached	
	Top depth of the pressurized zone	Width of the pressurized zone
1200	**Crirical strain never reached below 60 m depth**	
1400	60 m (first observed barrier)	120 m
1600	60 m	75 m
1800	63 m	30 m
2200	TBD	TBD

Table 2 Conditions for critical strain to be reached around steam injectors

According to those results, quite wide chambers are needed for the sand to reach the critical strain (e.g. 2.23 %).

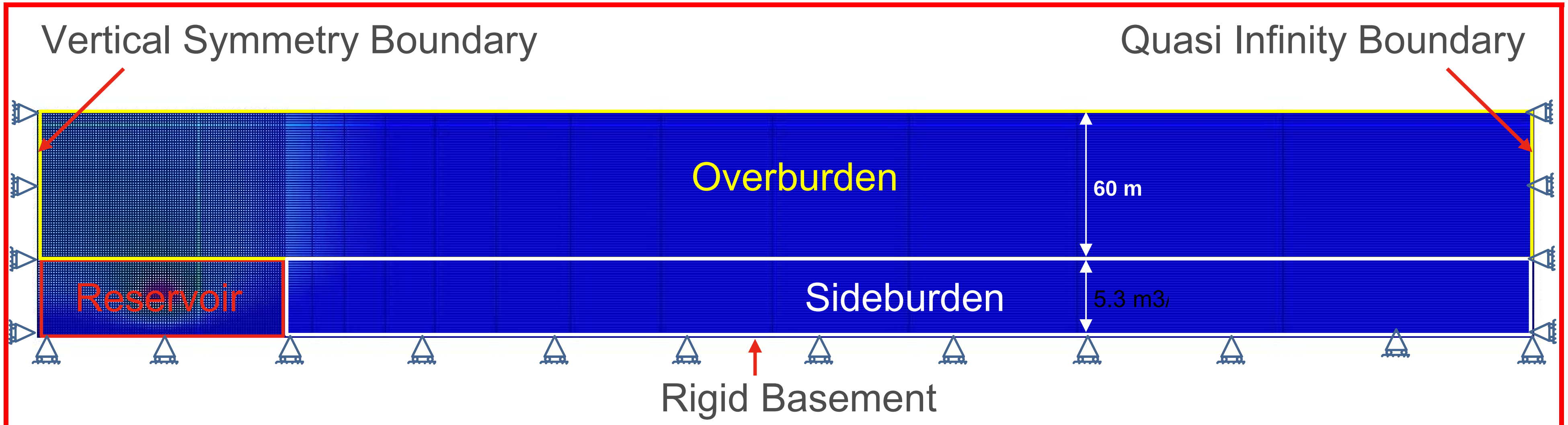
5.2 Shoulder failure of shale or very low permeability barriers

If water penetrates into the shale at a pressure higher than the minimum stress to initiate a fracture, this last has a chance to propagate in opening mode rather than in dilation mode, contrary to what is the case in sands where dilation mode dominates. In general, shales do have some cohesion. Also, the pressure does not diffuse easily at the faces of a fracture propagating in low permeability shale. Those two factors allow the stability of the fracture faces and the fracture itself to remain open.

If tensile fracture cannot be initiated, the only way to break a shale barrier is by shear on the shoulders of an underlying pressurized zone. This last might be either a horizontal fracture or a horizontally developed steam chamber under pressure higher than the overburden stress at the base of the shale.

To investigate the likelihood of shale barrier failure by shearing at their shoulders, a finite element model of 60 m thick overburden was built. A pressure of 1800 kPag, to be compared with the overburden weight of 1560 kPag, was applied to the base of this model. The radius of the pressurized zone was changed by steps of 5 m starting from 15 m.

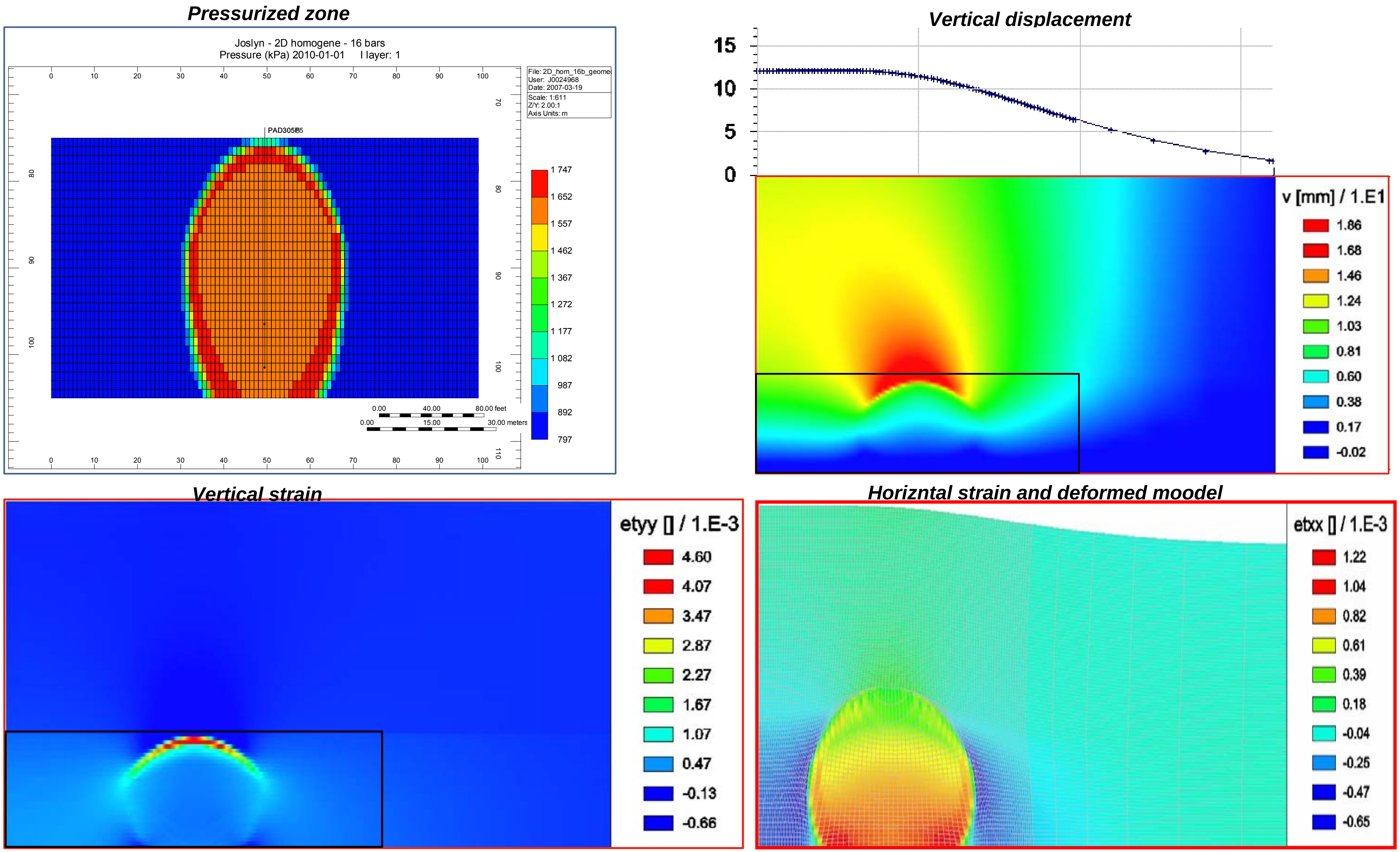
As shown in Figure 16, the plastic shear strain (or norm of plastic deviatoric strain) increases significantly when the pressure diffuses laterally at the bottom of a shale layer. When the radius of the pressurized zone reaches 45 m, plastic shear strain cuts through the whole overburden. At this stage, the bottom of the overburden would have been uplifted by 78.7 cm (see Figure 17). The strains at the entry of the sheared zone are highly tensile (Figure 18 and Figure 19), which means that the shear fault which cuts the shale barrier will be wide open to flow.



Reservoir : 99 x 30 Elements
Overburden : 111 x 60 Elements
Sideburden : 12 x 30 Elements

→ Total of 9990 Elements

Figure 13. Finite element model used to calculate the dilation strains around steam injectors



Pressurized zone

Vertical displacement

Vertical strain

Horizntal strain and deformed moodel

Figure 14. Example of geomochanical model results around 1600 kPag pressurized zone.

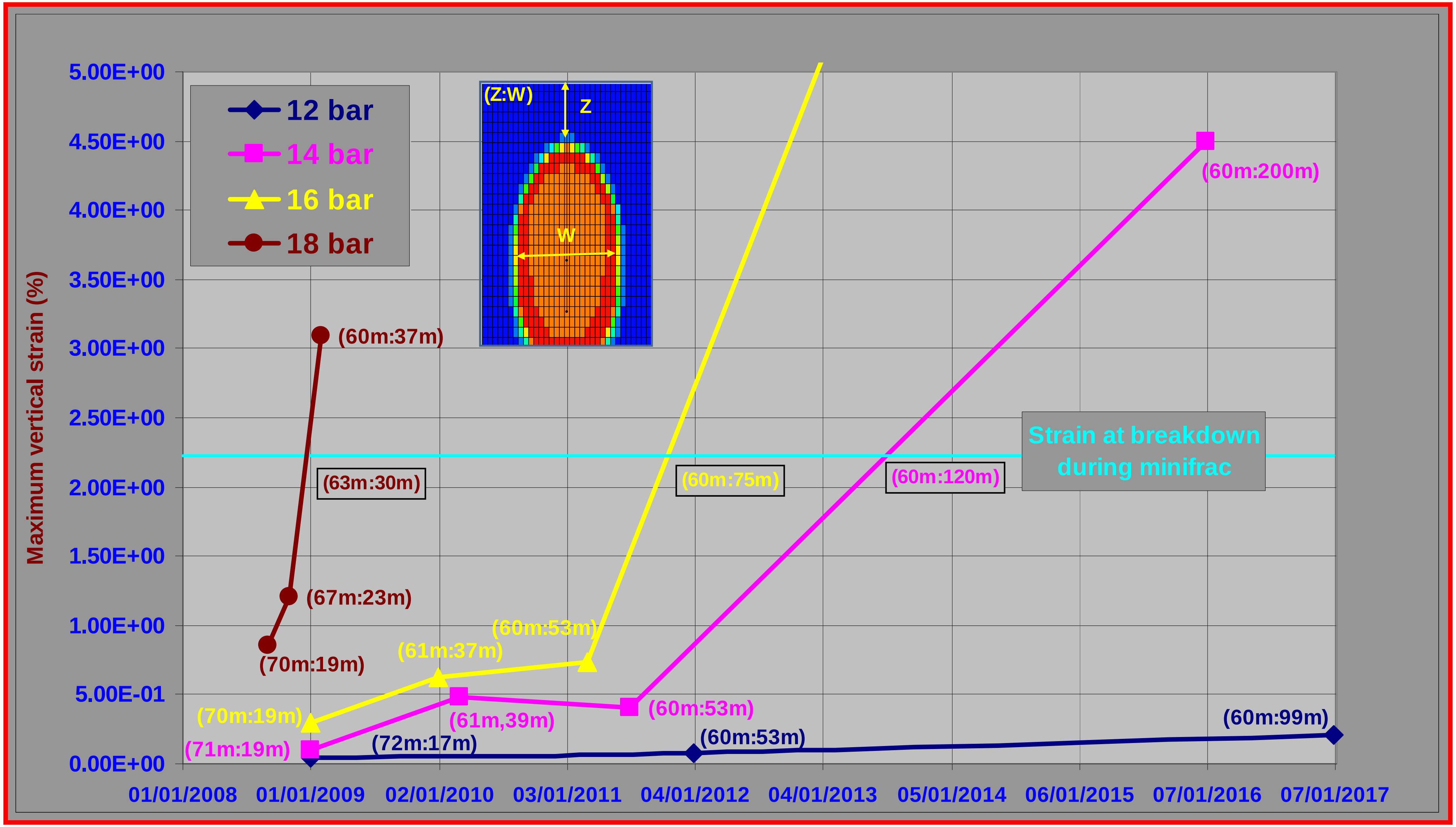
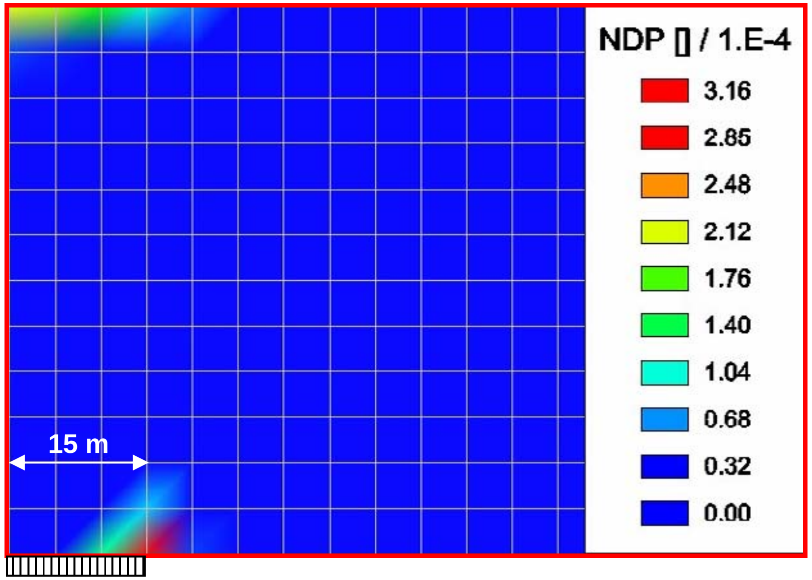
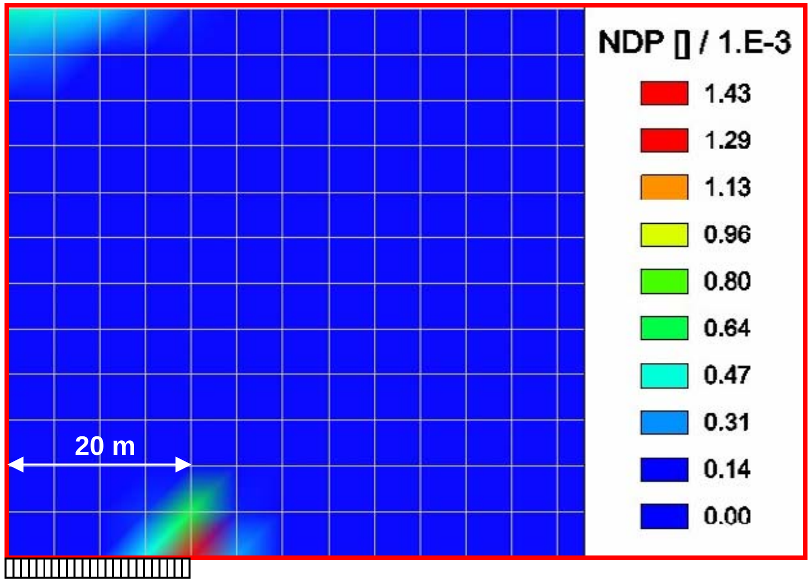
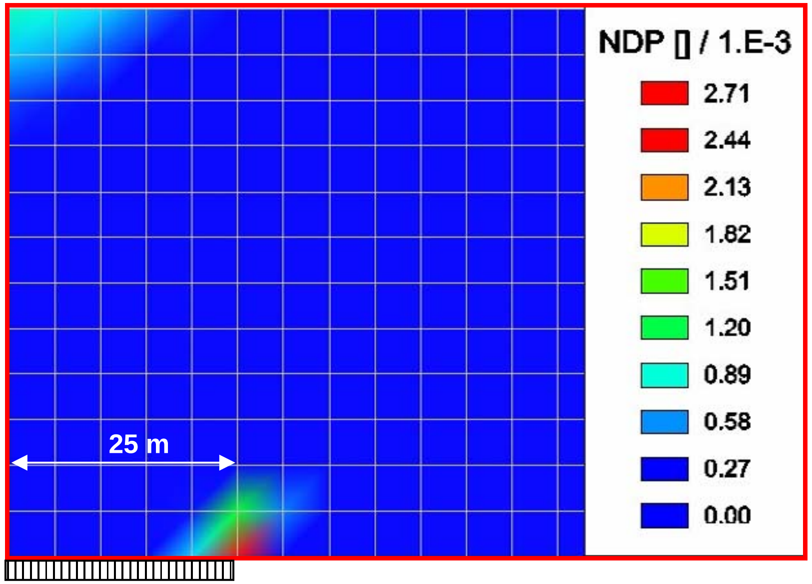


Figure 15. Maximum dilation strain around steam injectors function of the size of pressurized zone and injection pressure


NDP [] / 1.E-4
3.16
2.85
2.48
2.12
1.76
1.40
1.04
0.68
0.32
0.00
15 m


NDP [] / 1.E-3
1.43
1.29
1.13
0.96
0.80
0.64
0.47
0.31
0.14
0.00
20 m


NDP [] / 1.E-3
2.71
2.44
2.13
1.82
1.51
1.20
0.89
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0.27
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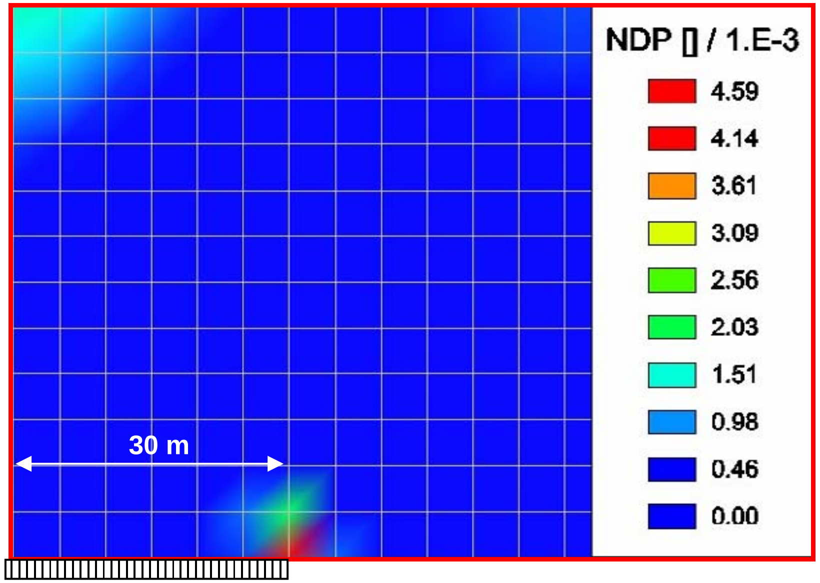
25 m


NDP [] / 1.E-3
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2.03
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0.46
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30 m

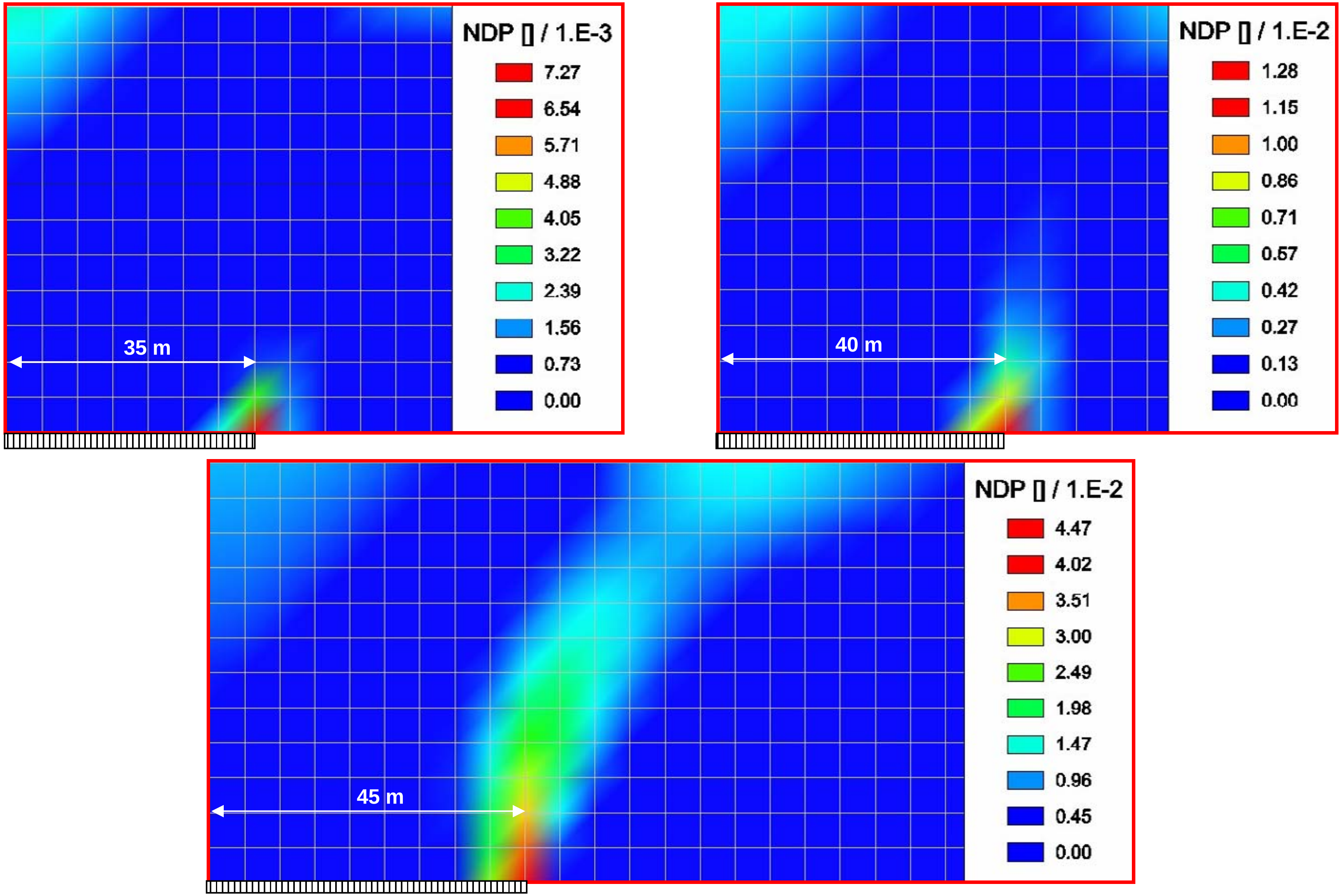

Figure 16. Norm of plastic strain in a 60m thick overburden under 1800 kPag pressure versus the radius of the pressurized zone.

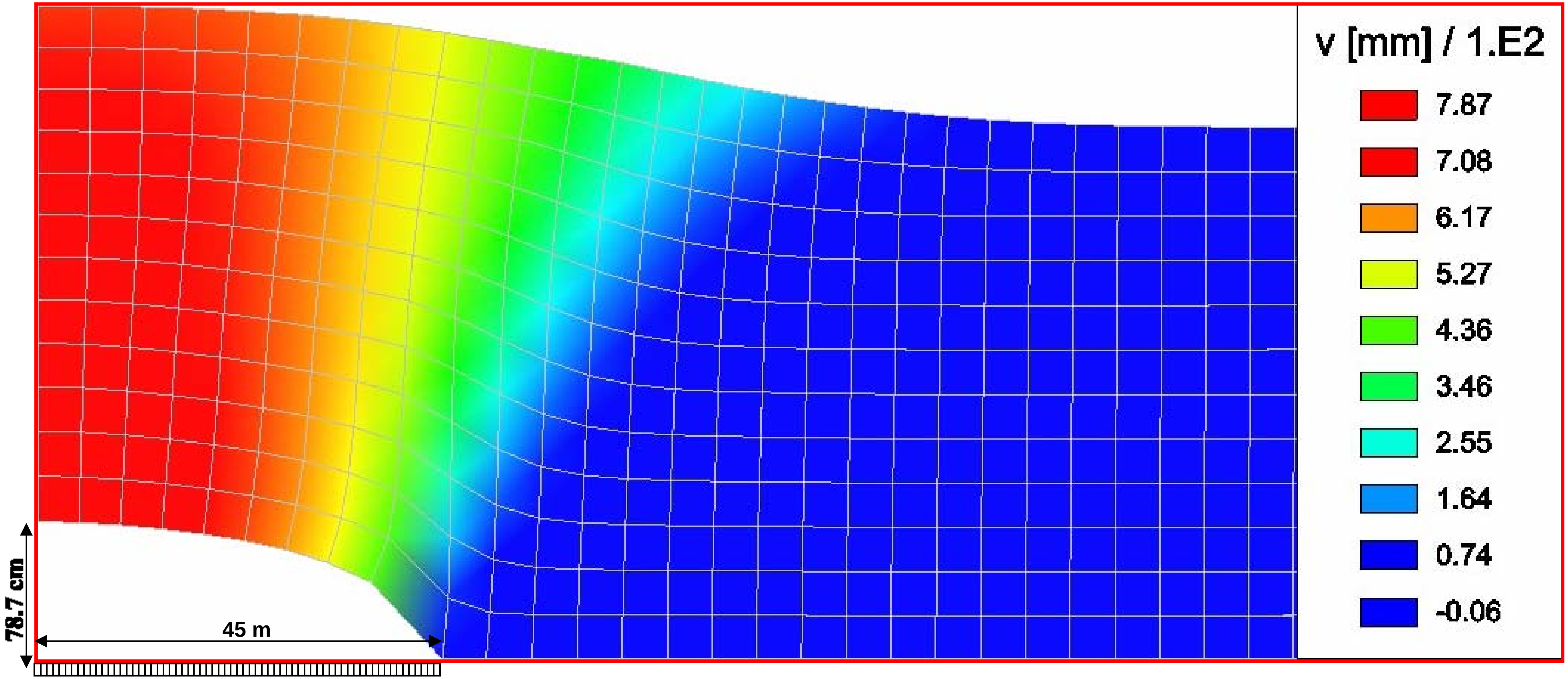

Figure 17. Vertical displacement inside a 60 m thick overburden when a pressure of 1800 kPag is applied on a zone of 45 m radius at its bottom.

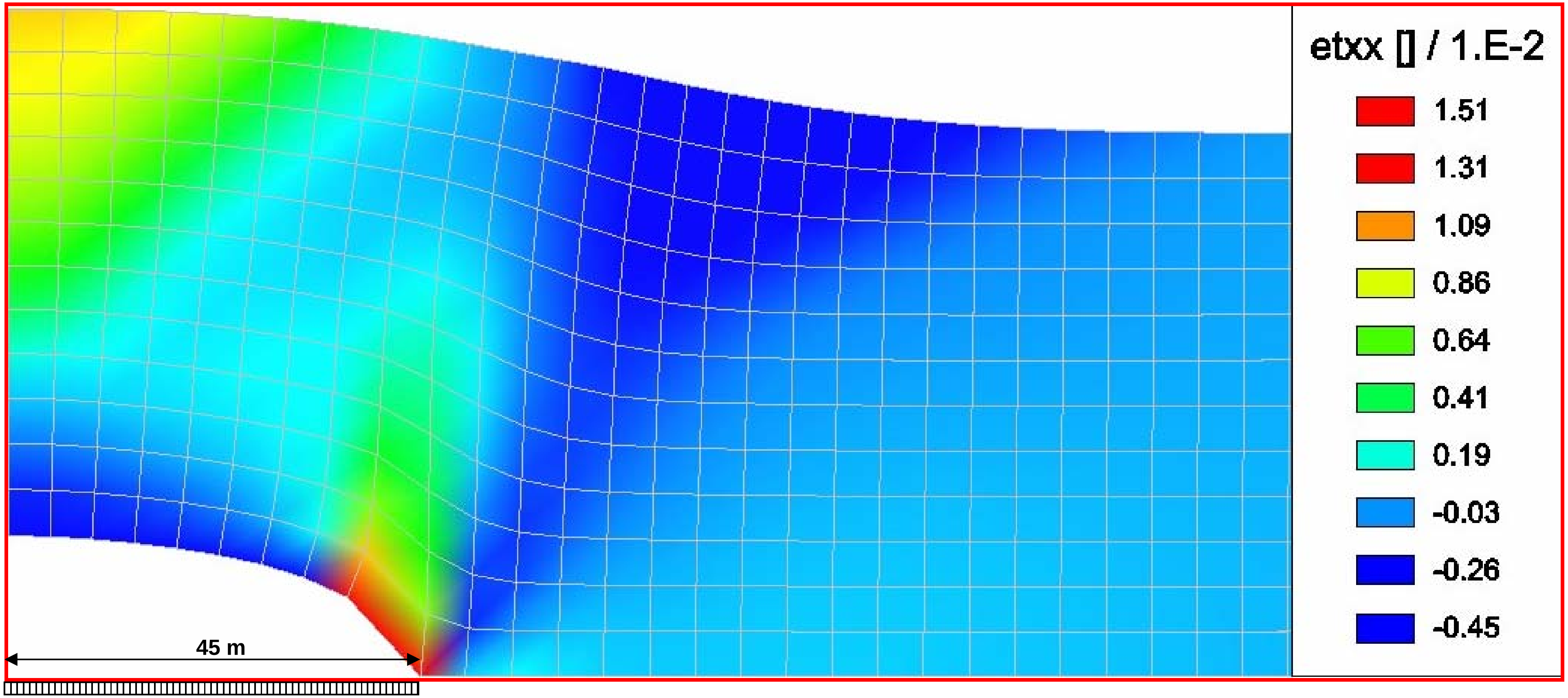

Figure 18. Horizontal strains inside a 60 m thick overburden when a pressure of 1800 kPag is applied on a zone of 45 m radius at its bottom. Positive strains indicate stretching which might lead to fracture opening.

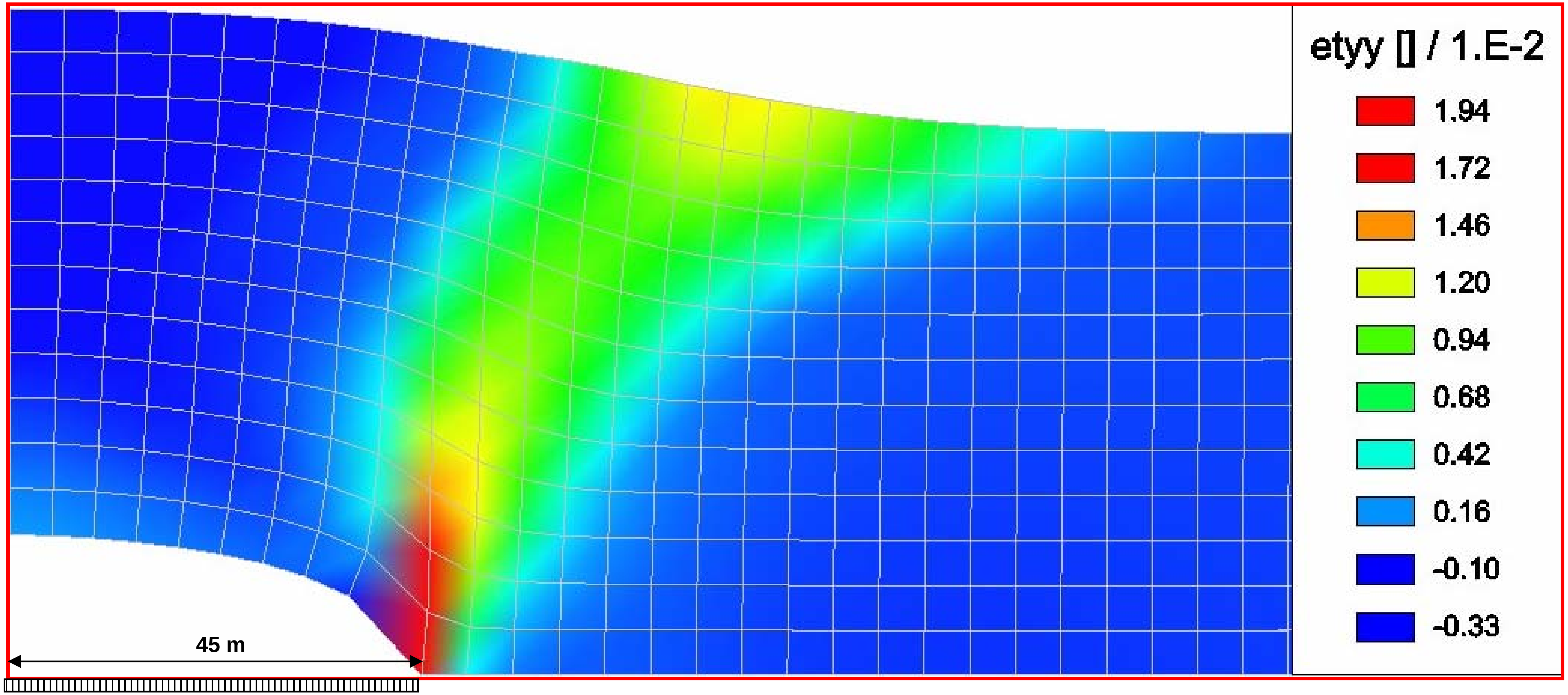

Figure 19. Vertical strains inside a 60 m thick overburden when a pressure of 1800 kPag is applied on a zone of 45 m radius at its bottom. Positive strains indicate stretching which might lead to fracture opening.

5.3 Effect of steam chamber coalescence

Figure 20 to Figure 24 illustrate the modelled heave behaviour when the pressurized area width is increased representing coalescing steam chambers. The modelling approach is similar to what is discussed in paragraph 5.2.

The observed heave varies non linearly with the width of the steam chamber. Heave expected from and maximum pressure applicable to a single well pair (as opposed to a whole pad) are significantly different. In this particular case, heave is especially important because the pressure 1400 kPag is higher than the overburden weight.

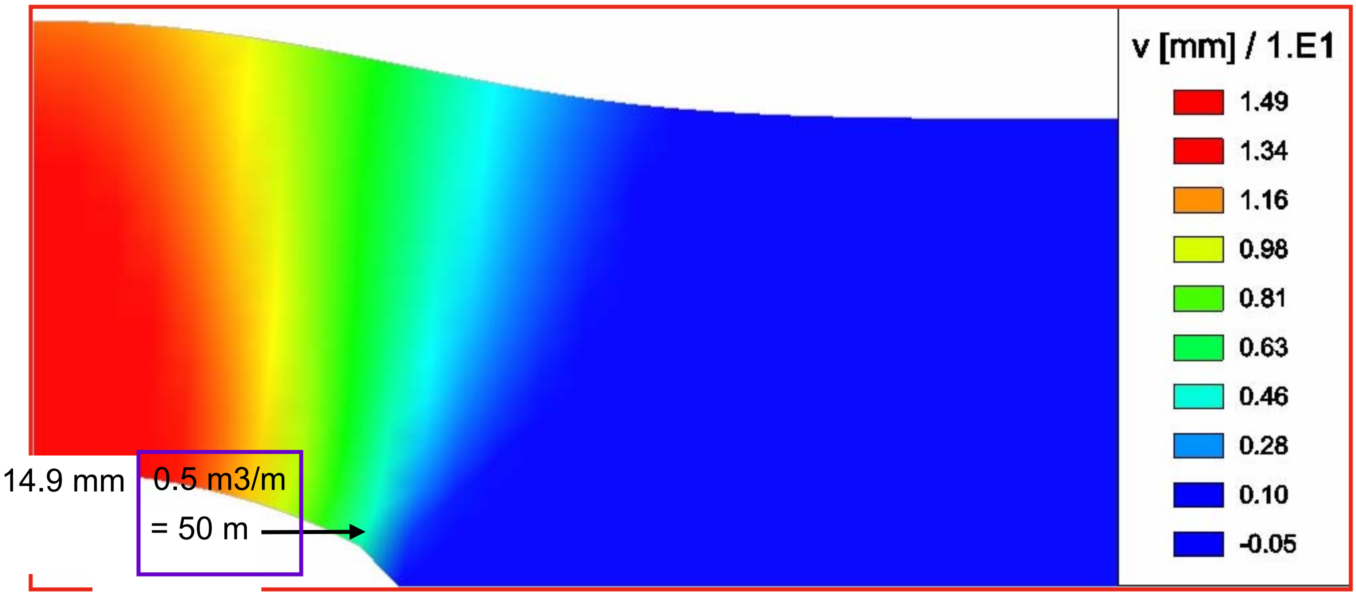

Figure 20 Heave (mm) - 1 Chamber 45 m 1400 kPa

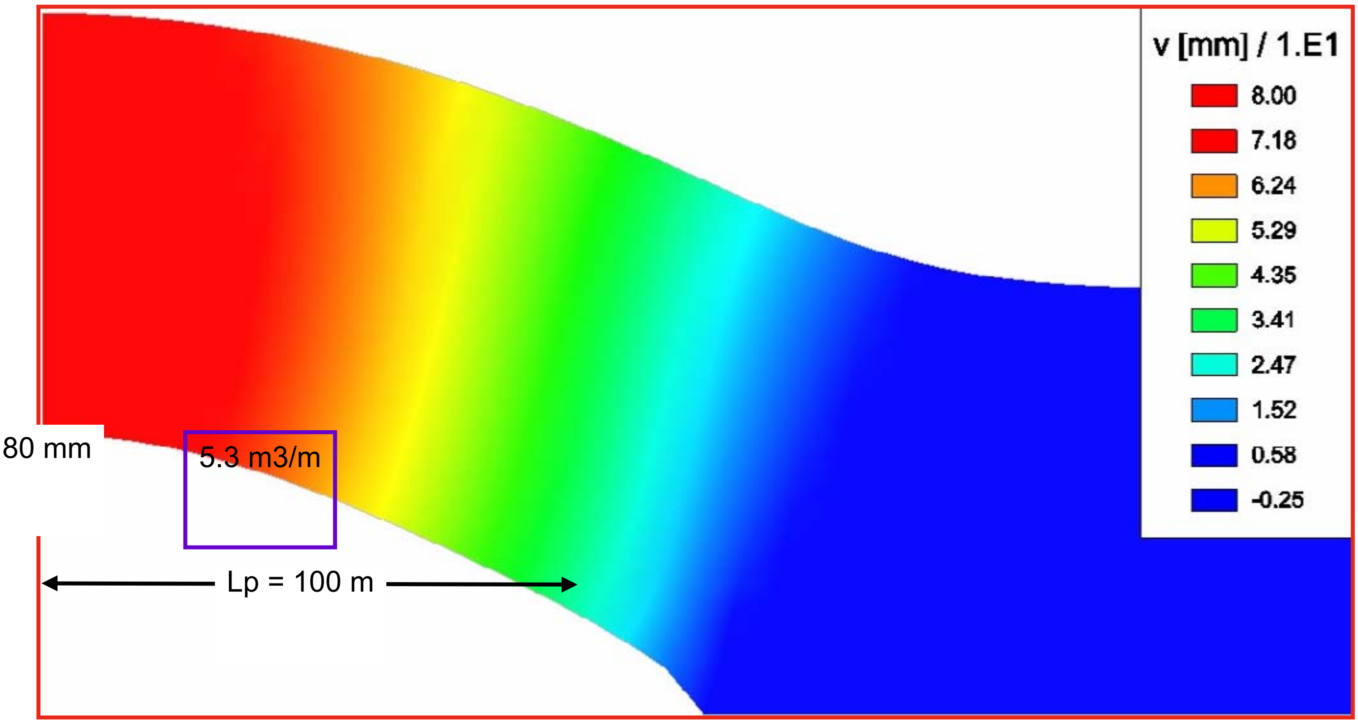

Figure 21 Heave (mm) - 2 Chambers 100 m 1400 kPa

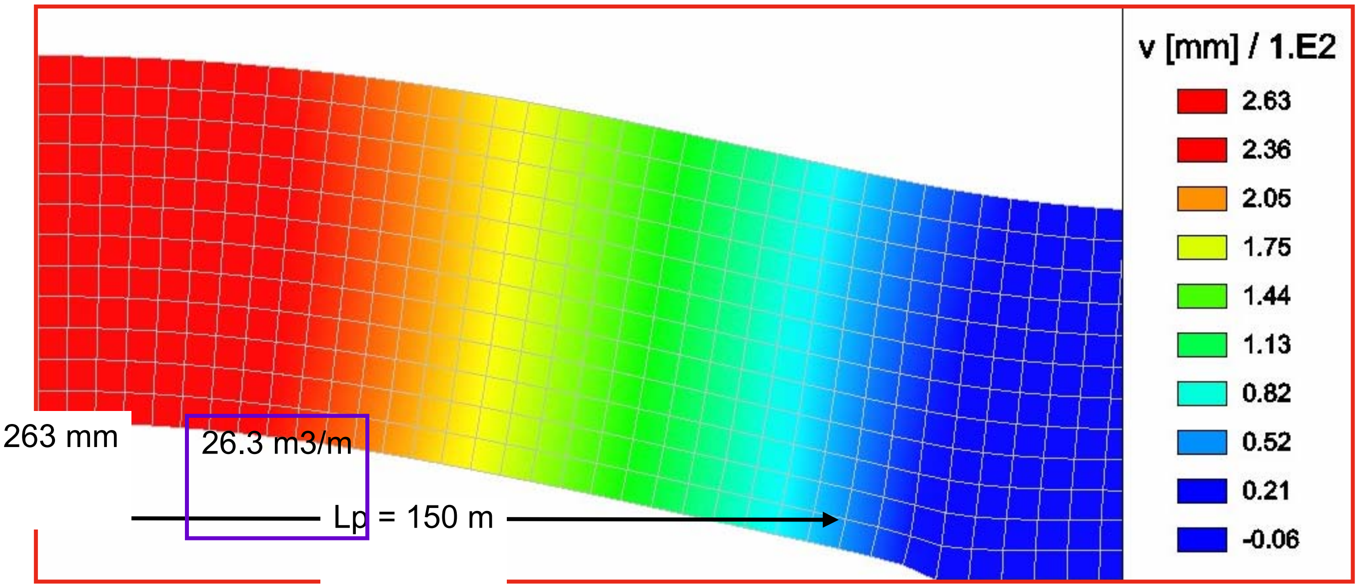

Figure 22 Heave (mm) – 3 Chambers 150 m 1400 kPa

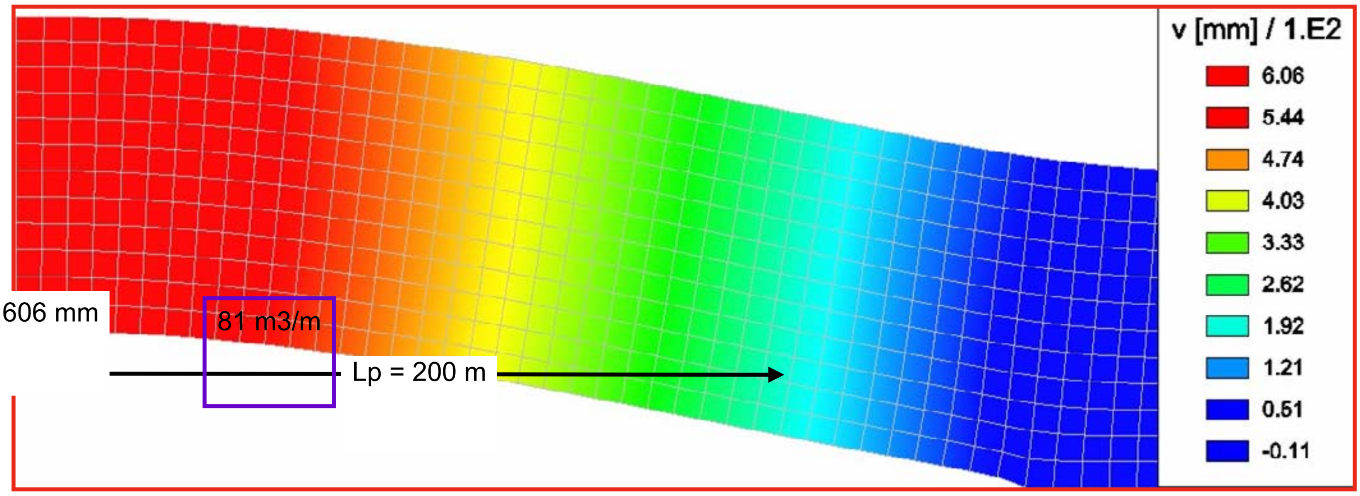

Figure 23 Heave (mm) - 4 Chambers 200 m 1400 kPa

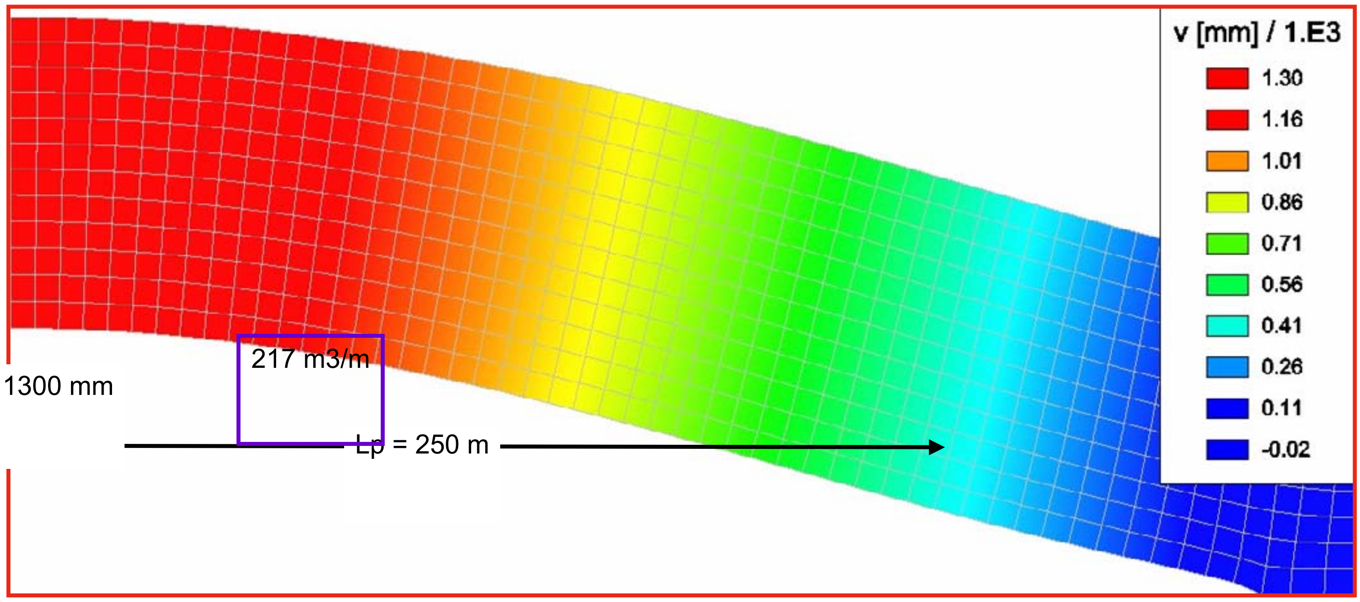

Figure 24 Heave (mm) - 5 Chambers 250 m 1400 kPa

6. Discussion about the likely causes of overburden failure on Joslyn

Figure 25 compares the injection pressure to in-situ stresses during four distinct periods prior to steam release. It can be seen that the injection pressure was higher than the overburden weight and sometimes even higher than the minimum horizontal stress at the injector depth during the circulation phase. Since the start of the semi-SAGD phase, the injector pressure was always less than the horizontal stresses. The injector pressure dropped also below the overburden weight from April 12, 2006.

For the reasons enumerated below, it seems unlikely that the overburden has failed by the propagation of a vertical hydraulic fracture right away from the injector to the ground surface:

1. It took the steam almost six months to breach into the surface which is by far longer than the time needed to propagate an 80 m high hydraulic fracture.

2. The analysis of production data of 204P1 has shown that the incident was preceded by one or several injectivity increases signalling internal blow-outs. This would not have been the case with a vertical fracture.

3. A hydraulic fracture should have propagated when the pressure was at its highest level, namely 1800 kPag, during the Circulation Phase while the real pressure was below 1400 kPag several days before and at the time of the steam release.

4. Steam release was preceded by a blow out, which gave birth to a quite large crater. This explosive character is synonymous of steam energy accumulation at shallow depth prior to the release which cannot be explained should a straight vertical hydraulic fracture was the cause of overburden failure.

5. The seismic shows clearly that the steam migrated upward in the reservoir through a quite large (> 30 m) dilated zone. It broke several low permeability layers in the Middle McMurray before reaching the Wabiskaw. This last being permeable, it allows steam accumulation and pressure build up over significant area at the base of the Clearwater formation until blowing out this ultimate barrier.

6. The seismic suggests the presence of highly inclined shear faults in the Clearwater, one of them probably served as a conduit for steam and rock material release from beneath the subsidence bowl which offsets the fault by about 30m to the N-E.

In conclusion, the assumption of hydraulic fracturing cutting through the whole overburden can be ruled out. Another scenario is proposed in the following section based on the results provided by the geo-mechanical model and by all what has been said in the previous sections about dilation and other failure mechanisms.

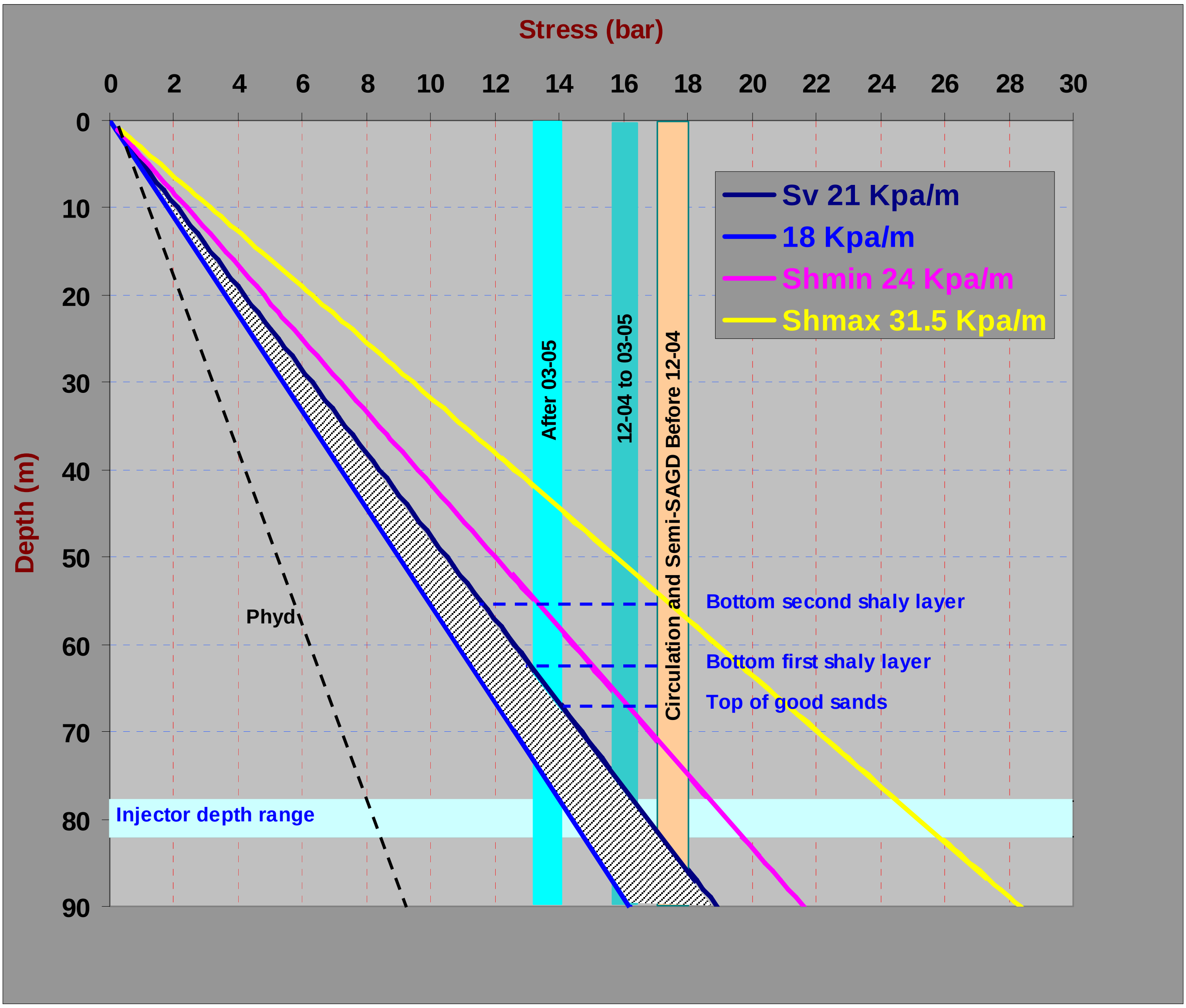

Figure 25. Injection pressure ranges prior to steam release compared to in-situ stresses

7. Proposed scenario for steam release

A scenario for steam release is proposed according to reservoir data, seismic observations and geo-mechanical modelling results.

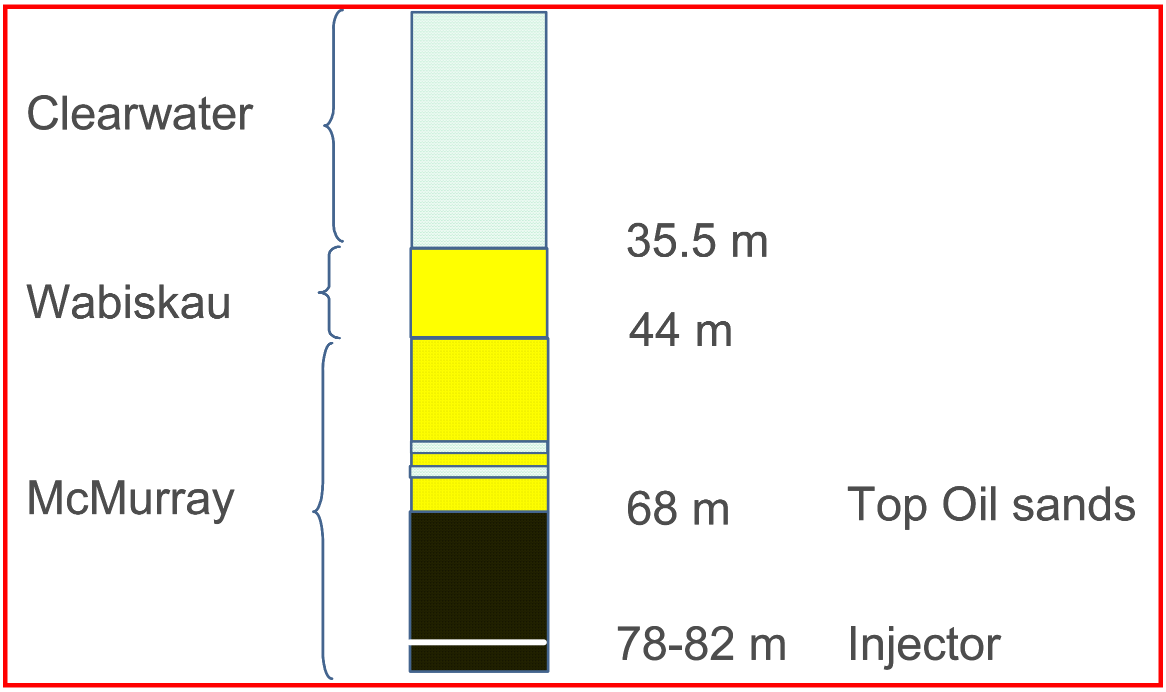

Figure 26. Simplified stratigraphy above Joslyn well pair 204-1.

The geo-mechanical modelling results presented in §5.1 shows that under a pressure of 1800 kPag, the critical strain criterion is reached at 63 m depth. All permeable layers above this depth were therefore prone to significant dilation during the semi-SAGD phase. Also, during the circulation phase which lasted five months, the bottom hole pressure was up to 1800 kPag which can be sufficient to dilate the oil sands between the injector and 63 m depth. The dilation must have enhanced the relative permeability of oil sands to water, which is the more true if the water saturation of the oil sand at the position of steam release was close to the mobility threshold. High permeability to steam in the reservoir during the semi-SAGD phase is consistent with the reservoir simulations where an artificial channel of very high permeability had to be introduced in the model to allow the upward propagation of pressure to 68m. From there, it is fair to assume that at the start of the semi-SAGD phase, there was already a communication between the injector and the upper middle McMurray through the oil sands.

In the upper part of the Middle McMurray there are two possible failure mechanisms. In sand/silty layer of relatively high permeability (~ 200 mdarcy), the main mechanism is dilation. When the steam encounters a shale or a very low permeability interval acting as full or semi-barrier (see schematic in Figure 26), preventing quick pressure diffusion upward, the steam migrates horizontally until shearing that barrier (see §3.4.2 for more details about this failure mechanism). The seismic does suggest that steam had migrated laterally in what can be assimilated to a horizontal fracture somewhere in the Upper Middle McMurray. The geo-mechanical model shows that right at the moment of shearing, the overburden is uplifted by 57 cm, compared to 20 cm due to the horizontal fracture alone. The jump of uplift of the overburden induces more dilation of the sand along the vertical trajectory linking the injector to the fracture. This combined with the communication through the sheared zone between the fracture and the permeable Wabiskaw sands provides a very good explanation for the sudden increase of injection rate accompanied by a pressure drop from 1800 to 1600 kPag which occurred on April 12-13 on well pair 204-1.

The pressure diffusion/dilation process continued in the Wabiskaw which is water bearing and more permeable than the Upper part of the Middle Mcmurray. The seismic shows indeed a wide area (> 100 m) of the Wabiskaw affected by steam.

Figure 27 shows that a pressure of 1600 kPag is enough to break the Clearwater should this pressure diffuses over 50m at the base of this formation. At the time of shearing, the fracture opens by 20 cm (see Figure 28). One possible scenario is that partial shearing of the Clearwater have started on April 27 when the pressure decreased from 1600 to 1400 kPag and then continued to propagate under 1400 kPag. Another scenario might be that the Clearwater was entirely broken immediately before the release under 1400 kPag. In fact, the geo-mechanical model shows that a pressure of 1400 kPag applied over 100 m, which is more consistent with the seismic, is largely sufficient to break the entire Clearwater. .

Figure 30 summarizes the main events observed on the pressure and rate curves of well pair 204-1 and the interpretation of such events according to the above propose scenario.

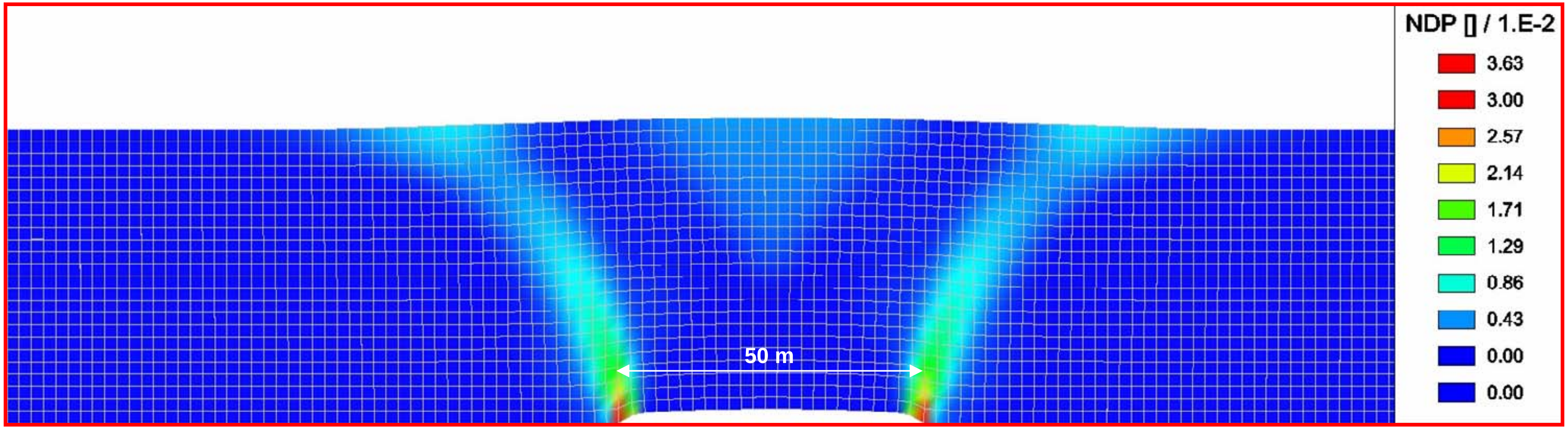

Figure 27. Norm of plastic strain inside a 48 m thick overburden when a pressure of 1800 kPag is applied on a zone of 25 m radius at its bottom.

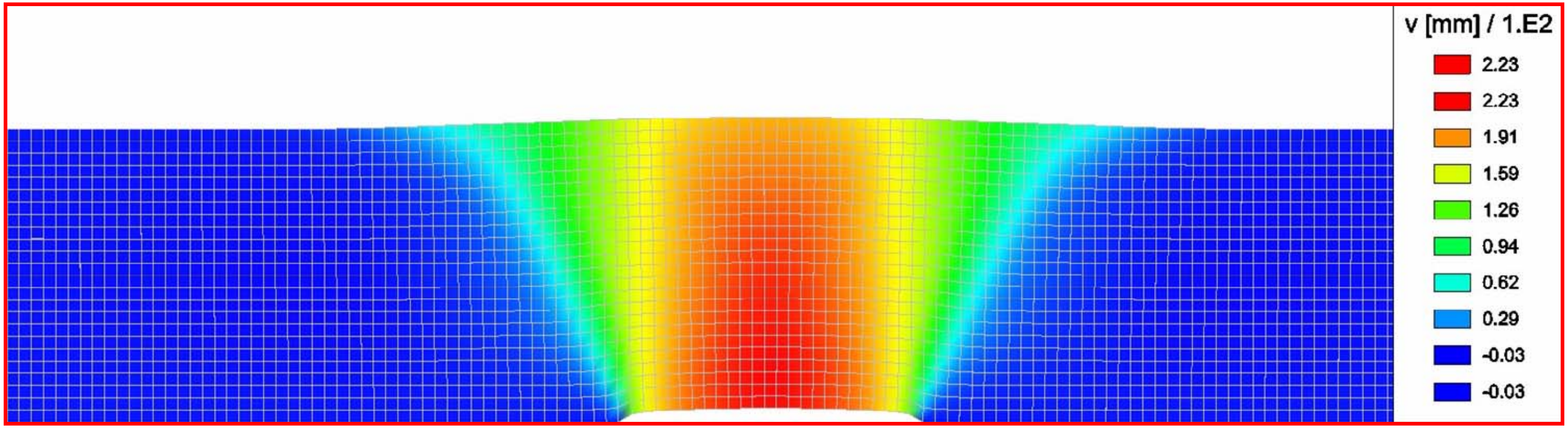

Figure 28. Vertical displacement inside a 48 m thick overburden when a pressure of 1800 kPag is applied on a zone of 25 m radius at its bottom.

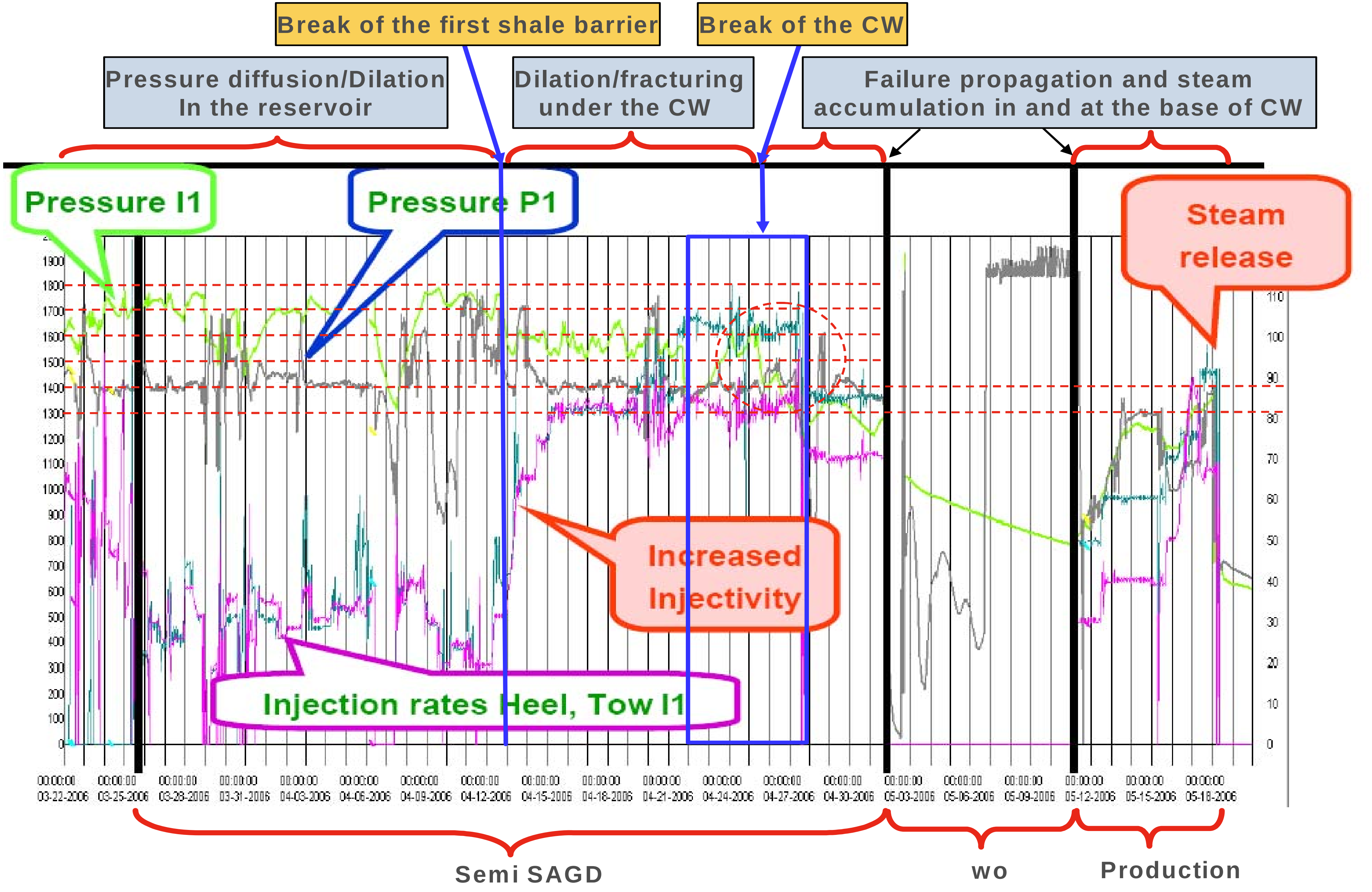

Figure 30. Interpretation of the events observed on the pressure and rate curves of well pair 204-1

8. Monitoring issues

The geo-mechanical model and the seismic tend to prove that two major failure events occurred before steam release. The first one is a horizontal fracture which sheared at its shoulder the upper McMurray establishing an internal blow out between the injector and the Wabiskaw. The second one is the accumulation of steam in the Wabiskaw and 1400 kPag pressure build up over a zone of 100 m width at the base of the Clearwater, which lead to its failure in an explosive manner.

There are two monitoring techniques that can allow anticipating such events and taking appropriate measures to avoid them.

The first technique is the measurement of surface heave. On Figure 31 are plotted the amounts of surface heave versus time or size of zones pressurized under pressures between 1200 and 1800 kPagr. This graph shows that as long as the pressure everywhere is less than the overburden weight, the surface heave follows a linear trend with very small values. As soon as the pressure overcomes the overburden weight, there is a break on the slope of surface heave versus time curve. This break, if detected early, can be used as an alarm for reducing the pressure. Prior to that, the linear trend would have to be calibrated with real measurements.

The second technique is drilling observation wells to monitor the pressure in the Wabiskaw.

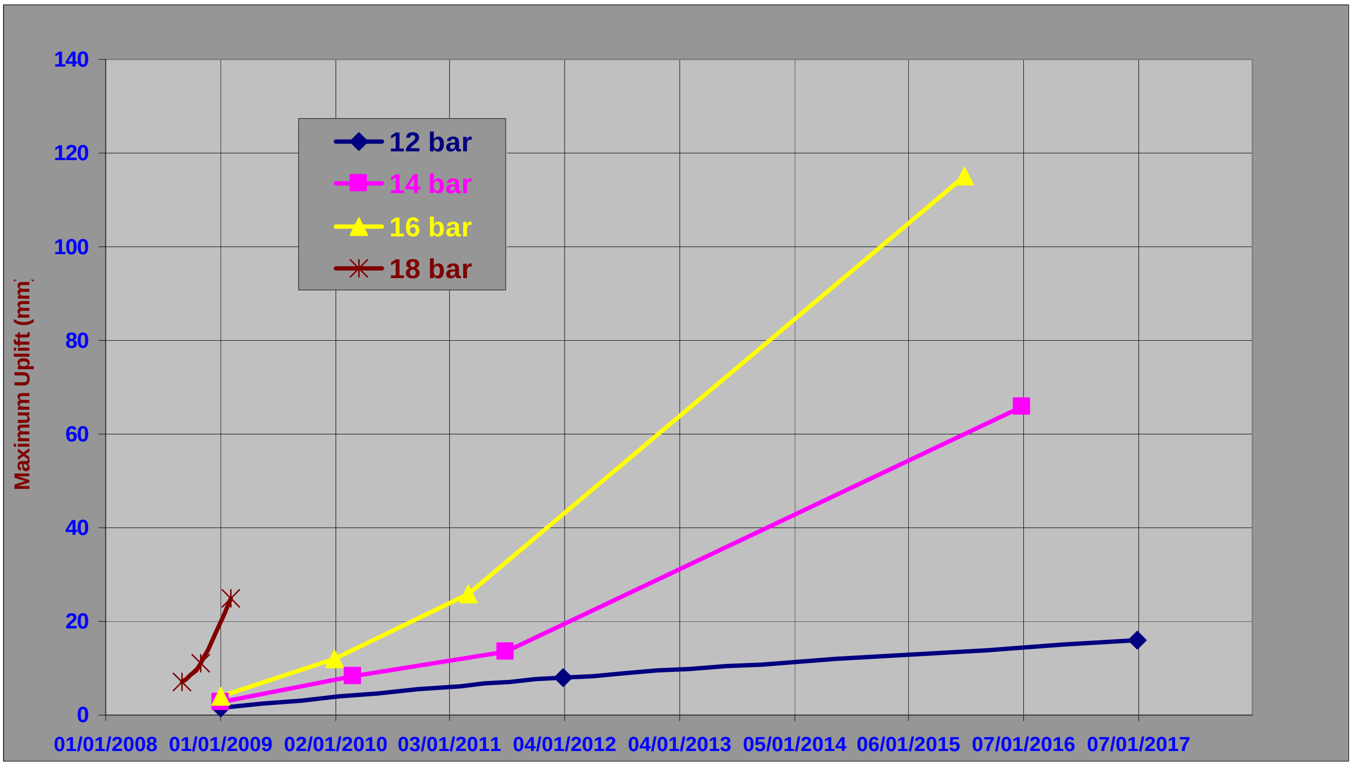

Figure 31. Surface heave predicted by the geo-mechanical model

9. Safe operating pressure

The geo-mechanical study provides evidence that the steam release is linked to the very high pressures that were applied during too long periods in the 204-I1 well.

Normally, sand dilation is desirable as long as it take place in the reservoir itself. This means that sand dilation might be promoted by applying high injection pressure during early start up making sure that such a pressure will not be transmitted to depths shallower than the reservoir top. This can partly done through reservoir simulations and partly through monitoring.

Once the pressure front reaches the top of the reservoir, the pressure must be reduced to avoid reaching the dilation criterion at that depth.

On the long run however, the pressure will diffuse to upper layers. It becomes then important to determine the thickness and the permeability of layers above the reservoir that will not be affected by dilation for a given steam pressure. Those layers provide a first safety barrier against uncontrollable steam migration toward the surface. A second security will be the Wabiskaw drain. In fact, it is important to ensure that the pressure in the Wabiskaw does not overcome the dilation criterion. This will be the case if the permeability of the Wabiskaw is high and the rate of steam arriving to the Wabiskaw is low enough.

Future geological studies must provide a reliable model for permeability of layers above the reservoir before dilation. Reservoir simulations must confirm the amount of steam that can flow through the McMurray interval and at which rate such steam will feed the Wabiskaw. If the flow rate does not overcome the capacity of Wabiskaw to diffuse the pressure, we might consider a dynamic system which acts as barrier against rapid pressure build up in that layer which is the prelude of failure of the Clearwater. Such a dynamic system can be confirmed and followed up through Wabiskaw pressure monitoring.

Appendix 1

TOTAL Joslyn Creek Minifrac Study 20060721

Petroleum Geo-mechanics Inc. Patrick M. Collins, P.Eng.

Prepared for TOTAL E&P Canada Ltd. in July 2006

TOTAL Joslyn Creek Minifrac Study
20060721

Petroleum Geomechanics Inc.
Patrick M. Collins, P.Eng.

Prepared for
TOTAL E&P Canada Ltd.
July 2006

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TOTAL E&P Canada Ltd. Calgary	Tim Lloyd	Deer Creek Energy Ltd.

PLEASE TICK

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KEYWORDS

Joslyn Creek SAGD Project, SAGD, geomechanics, minifrac, microfrac, stress gradients, oilsand, shale, Clearwater Formation

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ABSTRACT

The purpose of this engineering analysis to assess the stress state in the TOTAL Joslyn Creek Thermal Project, which uses the SAGD process to recover bitumen from the oilsand reservoir.

The study included a field program of microfrac (minifrac) test to determine fracture closure stresses. It found that this shallow SAGD project has a stress regime typical of other shallow Athabascan leases, in that the minimum stress is the vertical stress. The minimum horizontal stress is slightly higher than the vertical stress, and the major horizontal stress was inferred to by much higher still.

Stress profiles and stress gradients were provided.

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PREPARED BY:

....
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Petroleum Geomechanics Inc.

ISSUE DATE: July 2006

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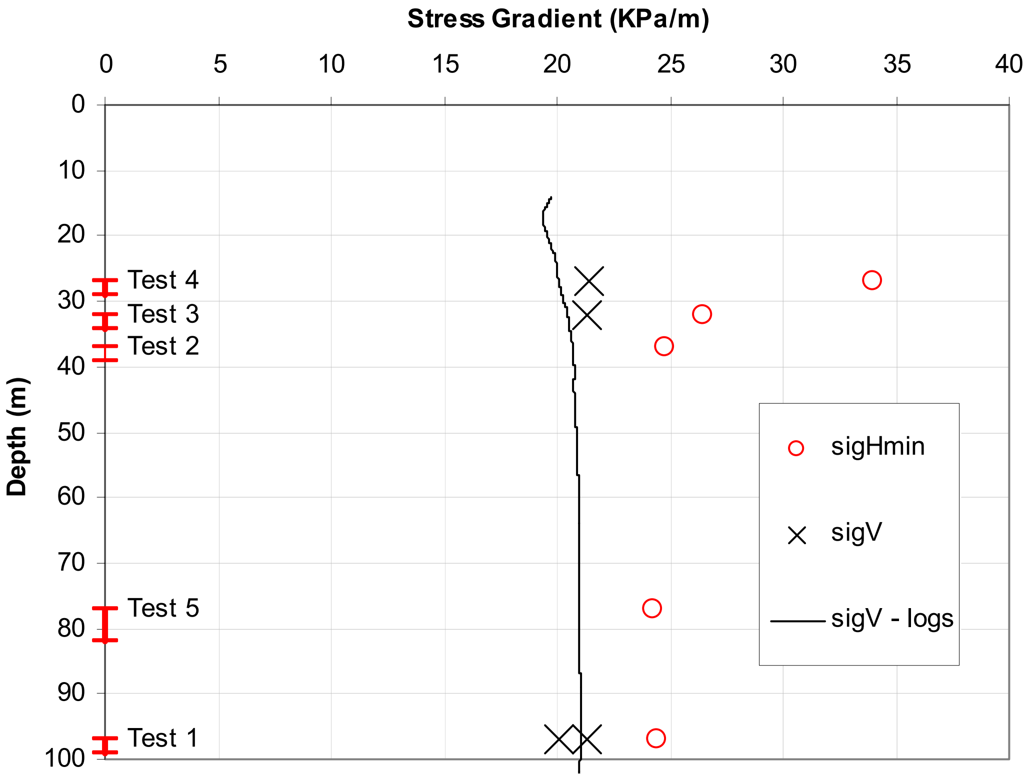
EXECUTIVE SUMMARY

The purpose of this engineering analysis was to assess the rock stresses in above the oilsand reservoir of the TOTAL Joslyn Creek Thermal Project, which uses the SAGD process to recover bitumen.

A stress analysis was done for Well 08-29-095-12W4, in order to quantify the driving forces that exist *in situ* before the SAGD process begins. As is typical for this reservoir, it was determined that the vertical stress was lowest but was comparable in magnitude to the minimum horizontal stress, with the maximum horizontal stress being the largest stress. Stress measurements in the Joslyn Creek area were found to agree with elastic predictions of stress, and regional stress data were found that qualitatively agreed with the stress regime.



CONCLUSIONS

1. **The virgin McMurray reservoir is likely underpressured due to lateral drainage.** The Wabiskaw Formation and adjacent transmissible units are acting as a lateral drain. As a result, this has reduced the pressure at the base of the Clearwater shale and the top of the McMurray to a few hundred kPa. The lateral drainage pattern is consistent with the regional hydrogeological model.

2. **The high horizontal stresses are due to tectonics.** The rock stresses existing in this lease are consistent with the regional stress regime, with the highest stress being horizontal and the vertical stress being almost equal to the minimum horizontal stress. As such, any induced fracture within the formation as a result of steam injection will likely be horizontal. Subsequent heating will increase the horizontal stresses more than the vertical stresses, which will increase the probability that the vertical stress is the minimum *in situ* stress. In this stress regime, the fracture gradient is the vertical stress gradient.

3. **The orientation of the major horizontal stress orientation is likely NE-SW.** The borehole breakout analysis of one well was not compelling evidence, due to the lack of strong breakout features. However, the regional trend is NE-SW throughout the province of Alberta.

4. **No large stress contrast exists between the oilsand & caprock.** This fracture pressure increases with depth; therefore as the steam chamber grows, the depth to the top of the steam chamber will determine the maximum injection pressure. As a result, the injection pressures should decrease as the chamber rises.

1. INTRODUCTION

1.1 Minifrac Tests

There are three common types of induced hydraulic fractures: hydraulic fracture stimulations, minifrac tests, and microfrac tests. Hydraulic fracture stimulations are used to increase the surface area of rock in communication with the wellbore, and as such they are commonly propped open with solids or acidised to create channels that will remain conductive after the fracture closes. Minifracs are small fracture tests conducted prior to the much larger stimulations in order to obtain relevant field data with which to optimize the fracture stimulation. Microfrac tests are very small, over an interval of about 2m, with total fluid injection in the order of 1 cubic metre. The purpose of these tests is to collect stress data.

Microfrac tests are commonly referred to as minifrac tests, as is the convention in this report.

1.2 Equipment

The tests are done on either an open-hole or cased well, using a drilling rig or service rig. Perforating is necessary for cased wells. Packers isolate an interval for subsequent pressurization. In oilsands and these shales, that fluid can be water, as leakoff into the formations is low.

A pumping unit with low flow rates of 4 to 70 litres/min. is required. Generally, a triplex pump is used for this test because of the small injection rates and the need for precision.

Electronic pressure transducer gauges and data collection software for the recording and plotting of data at least every 5 seconds is important to detect the pressure changes that signal fracture opening and closing. Downhole gauges are preferred.

1.3 Procedure

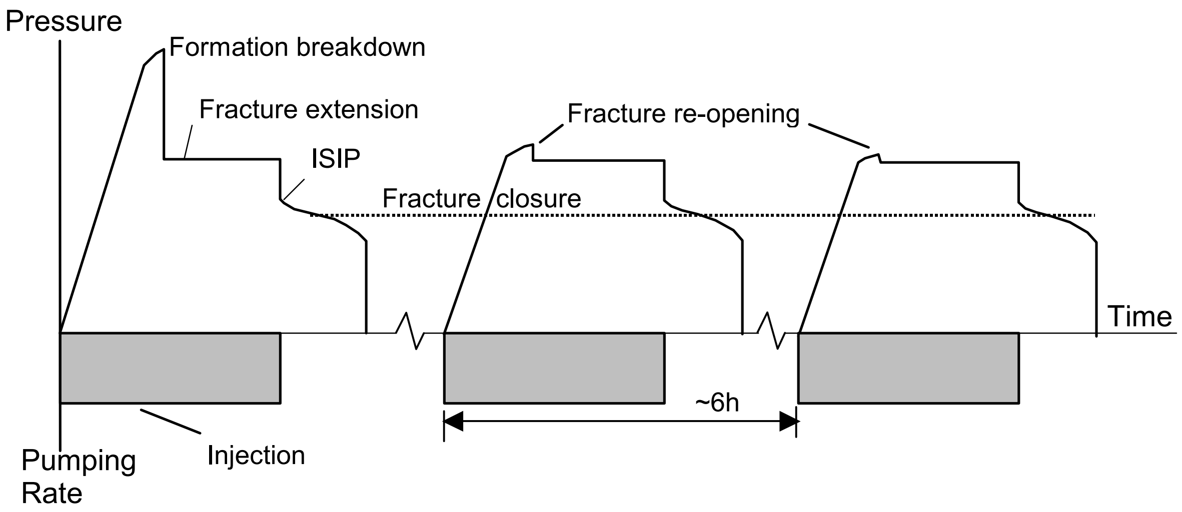
Each test usually consists of three cycles of about 6 hours each, for a total of 18 hours per test, or approximately 3 days for 4 tests. Each test consists isolating one set of perforations and pressuring the interval to breakdown, at the lowest injection rate possible (~4 litre/min) or at a low constant rate until pressure rise shows a definite change in rate of increase. Once the fracture is initiated, injection continues at a constant rate for 15-20 minutes. Shut-in should be instantaneous. Pressure decline is monitored in order to detect the fracture closure pressure. The formation is allowed to rest for one hour. Two more cycles of injection/shut-in/bleed-off are performed at the same interval. Higher rates may be required for the subsequent cycles.

Injection rates:	4 to 70 litres/min
Injected volumes	0.5 to 1.0 m^3 per cycle

For the Joslyn Creek area, breakdown pressures were expected to be as high as 80 kPa/mTVD because of the combined effects of depth, bitumen viscosity, and stress concentrations at the wellbore.

Pressure versus time plot should be similar to **Figure 1.1**. The fracture closure stress, which is equal to the minimum in situ stress, can be determined using conventional fracture analyses.

Figure 1.1: Schematic XLOT Pressure vs. Time Response



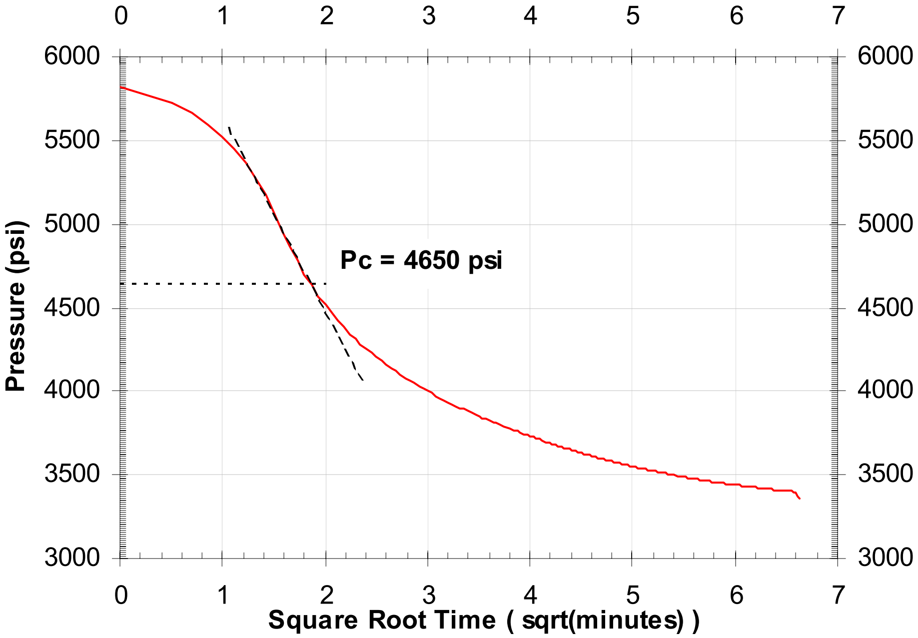
1.3.1 Injection Period

In **Figure 1.1**, the period of injection should be about 10-20 minutes in the fracture extension range, just long enough to generate or re-open the fracture with enough fluid to be able to find the difference between the ISIP and the fracture closure stress after shut-in. For short periods of injection, or in highly permeable formations, these two points will be close together. There is no benefit in prolonging the injection, as this will only make the shut-in period longer. However, this is important: the engineer must be certain that the formation has been fractured in the first cycle, or the entire test will be wrong. If there is does not appear to be a breakdown, the engineer may want to change to a higher injection rate. (Field notes of the test must be complete.)

1.3.2 Duration of shut-in

Adequate time after shut-in allows for a definite pick of the closure pressure. A quick way of doing this on site is to plot pressure vs. square-root(shut-in time) as seen in **Figure 1.2**.

Figure 1.2 Pressure vs. Root Shut-in Time



The curve above the deviation point indicates that the flow is from a fracture to the rock, and the lower portion of the curve is where the flow is from just the wellbore to the rock: radial fluid flow is less effective than linear flow, therefore the pressure fall-off data lies above the straight line. There may be other effects immediately after shut-in that may make the data variable, so it is important to find the deviation from the straight line in the data. This type of plotting should be done for all cycles. Note that it is a subtle change in slope, so sufficient data should be collected to ensure that fracture closure has occurred. After closure has occurred, bleed off the pressure and wait for approximately an hour before the next cycle. This will allow the near-wellbore pressures to decline.

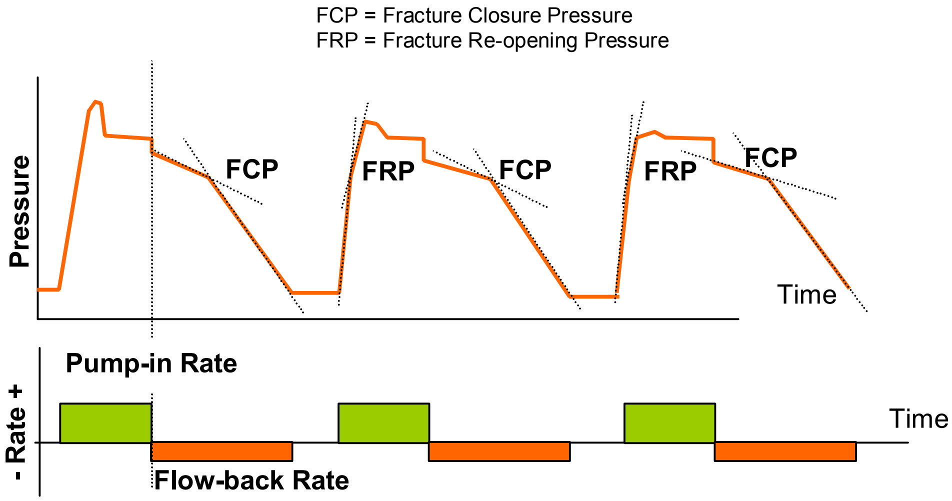
1.3.3 Low Permeability Test

In low permermeability formations, where the shut-in time could be excessive, a flow-back test can be used. Instead of flow to the formation, the test allows a constant flow-back rate to surface. This allows the pressure to fall-off more quickly. Note that the flow-back rate is much less than the injection rate (~20%). Too high of a rate may mask the frac closure pressure (**Figure 1.3**). Fracture closure should be determined with an analysis of the pressure falloff and not just by approximating a kink in the falloff curve, as shown in **Figure 1.3**.

Usually it is not known if this type of test is needed until one cycle of the standard test is attempted. If it appears that the pressure fall-off rate is too long, end the standard test by bleeding off the pressure totally, then begin a new cycle. If the pressure fall-off is too rapid, reduce the flow-back rate for the next cycle. An extra cycle or two may be necessary if there is any doubt in the fracture closure pressure.

The flowback test isn't a good as the standard test because of the complications introduced by the extra factor of fluid flow to the surface in addition to flow to the formation.

Figure 1.3 Constant-rate Flowback Test



1.4 Joslyn Creek Tests

Some leakage of the fracturing water was observed during the minifrac test program. There are two reasons for this. Firstly, these tests were done in an open-hole well. The straddle packer used was inflated to seal the wellbore. However, wellbore rugosity can lead to channelling around the packer. This would be expected to be small, given that the oilsands themselves will tend to seal around an inflating packer.

Secondly, the rated seating pressure for the straddle packer was 1500 psi (10 MPa). This was far in excess of the strength capacity of the rock at this shallow depth; therefore, the seating pressure was reduced to 10% to 20% of that value. This may have resulted in some under-inflation of the packer, which could have resulted in water bypassing the packers.

Large amounts of fluid flow were not seen at surface. Small amounts of leakage were observed, therefore these tests included a component of flow-back, which was considered in the analyses of the results.

2. GEOLOGY

2.1 Introduction

From a geomechanical viewpoint, the geology is important insofar as it strongly correlates with the rock strata's physical properties (thermal, hydraulic, and mechanical) that pertain to this combined reservoir-geomechanical simulation. Furthermore, the pore fluids within each geological unit tend to be either uniform or gradational, in terms of their pressures and physical properties.

The geology was assumed to be laterally uniform, forming an idealized "layer-cake". This simplification is appropriate, given that much of the geology is laterally continuous over the pilot area

2.2 Geological Stratigraphy and its Geomechanical Significance

The idealized stratigraphy was based on logs from Well 8-29-95-12W4. A simple schematic geological profile is shown in **Figure 2.1**. As a generalization, the stratigraphy can be grouped into five major intervals.

2.2.1 Till Overburden

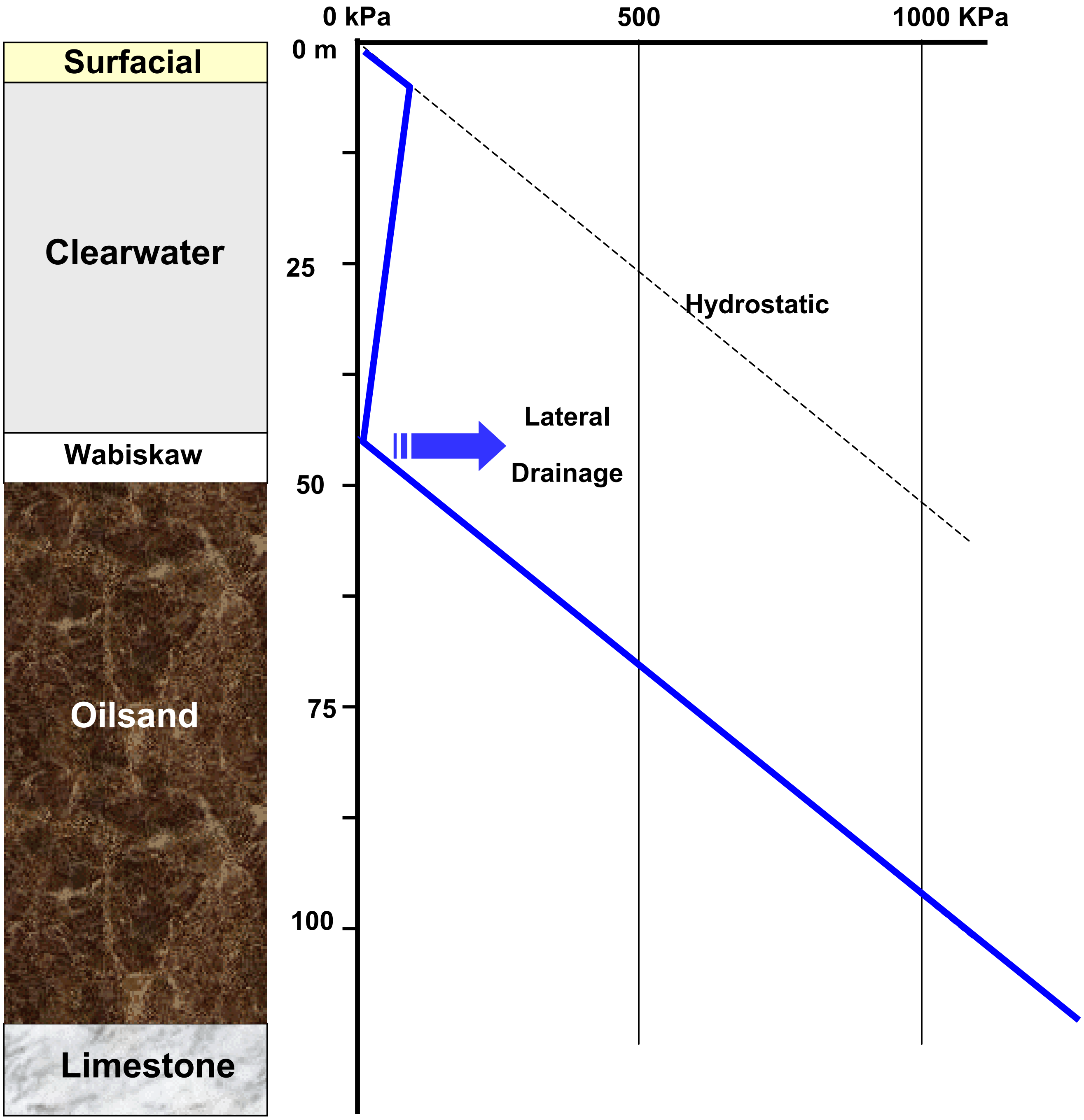
The top interval consists of a thin layer of Quaternary tills, possibly underlain by a thin gravel streak. This gravel layer may or may not be continuous, but it is likely to be linearly extensive. The geomechanical importance of this entire interval is that it applies an overburden load, and that any potential fluid escape into the base of this interval will likely not be contained, due to the discontinuous presence of highly permeable basal gravel. The quaternary till may or may not act as an impermeable layer, depending on whether the till is clay-rich or clay-poor; where the till is clay-poor and therefore permeable, the presence of a basal gravel would be irrelevant.

2.2.2 Shale Caprock

The next interval is the Clearwater Formation, largely consisting of mudstones rather than shales (mudstones lack the prominent bedding-plane fissility of shales). This is the nominal caprock for the SAGD steam injection project. Most argillaceous formations (clayey, e.g.: shales) above reservoirs make good caprocks, not because of their strength, but because the horizontal stresses in shales are usually higher than in reservoir rocks such as sandstones or carbonates. As such, any natural or induced fractures within the reservoir are arrested at the shale contact. However, in tectonically affected regions such as western Canada, this stress difference is smaller.

In a geological time scale, shales are "incompetent" rocks, meaning that they deform and flex rather than fracture when subjected to deformations. This preserves the sealing capacity of the shale, when the deformations are small.

Figure 2.1: Schematic Stratigraphic Profile, with Pressure Profile



2.2.3 Wabiskaw Sands

The third interval consists of the sands with shales, of varying thicknesses, between the rich reservoir sands and the shale caprock. This interval consists of the Wabiskaw sands at the base of, and part of, the Clearwater Formation.

2.2.4 Reservoir Sands and Shales

The fourth interval is the reservoir and shalier oilsands above. With steam injection, the reservoir sands should shear and dilate, resulting in an increase in volume. Furthermore, as the steam chambers continue to expand, the dilated material and the heated zone will push outwards and upwards. This will apply a deformation to adjacent formations, including the caprock.

2.2.5 Limestone Underburden

The last interval consists of the carbonate underburden. This limestone provides a stiff and strong structural base for the reservoir, and ensures that almost no deformation will occur in this formation. Fluid flow into this unit will likely be negligible. The significance of this unit is that the deformations resulting from the SAGD process will be forced upwards and outwards rather than downwards into this formation. Since the overlying formations are laterally restrained, the dominant direction of displacement of the reservoir and the overburden will be upward. Sinkholes are occasionally present.

2.3 Hydrogeology

The regional hydrogeology is one of drainage to the major watercourses that have downcut through the surficial deposits and erodable bedrock, and are now on the more resistant limestone formation below reservoir level. This is shown schematically by Bachu & Underschultz (1993) in **Figure 2.2**, in which the groundwater flow is shown to be vertical towards the permeable and transmissible sandstones at the base of the Clearwater and the McMurray. Once there, the groundwater drains laterally towards the major river systems.

There were no pressure measurements within the Joslyn Creek SAGD Project lease to support this thesis; however, this regional trend is broadly applicable.

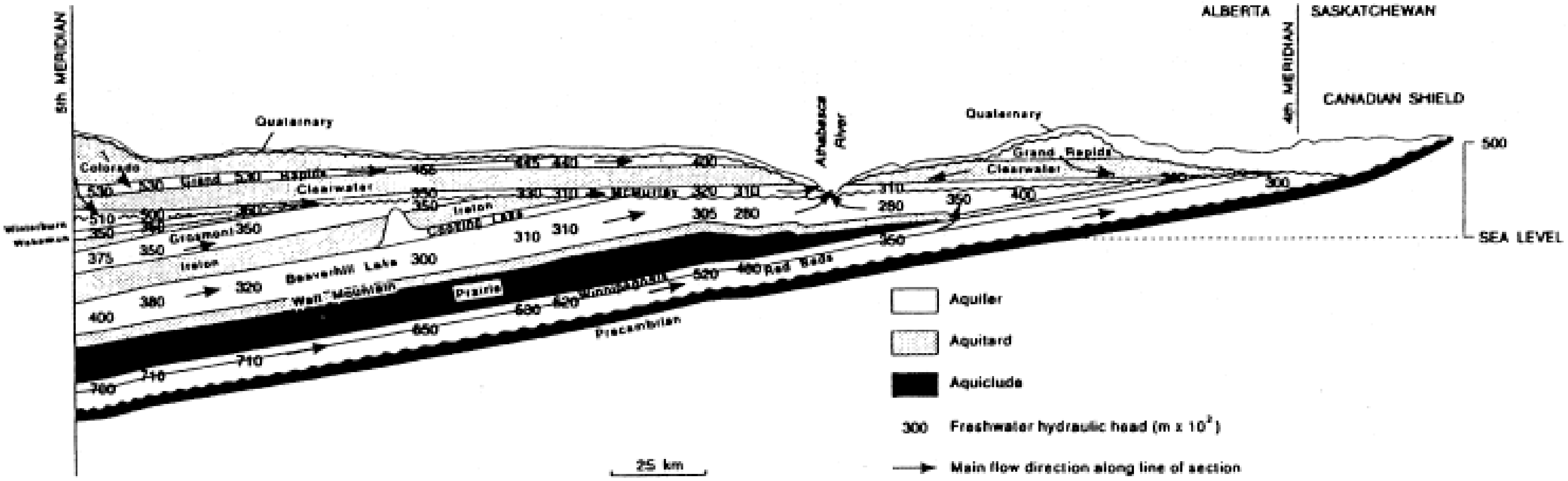
Downward flow to the base of the Clearwater and McMurray is through the Clearwater shale “aquitard”. This is a term used to describe a formation that does allow fluid flow over geologic time. The fact that there is a near-total pressure barrier across the Clearwater, as evidenced by the degree of underpressure beneath, is proof of the adequacy of the Clearwater shale as an impermeable barrier over the lifetime of any SAGD project.

2.4 Areal Location

Well 1AA/08-29-095-12W4/00, in which the minifrac tests were conducted, is located to the south-west of the Joslyn Creek SAGD Project’s pilot area, as seen in **Figure 2.3**. The proximity of Well 8-29 to the pilot area allows these results to be applied to the pilot. Adjustments must be made for differing depths of overburden.

Figure 2.2: Regional Hydrogeological W-E Cross-Section

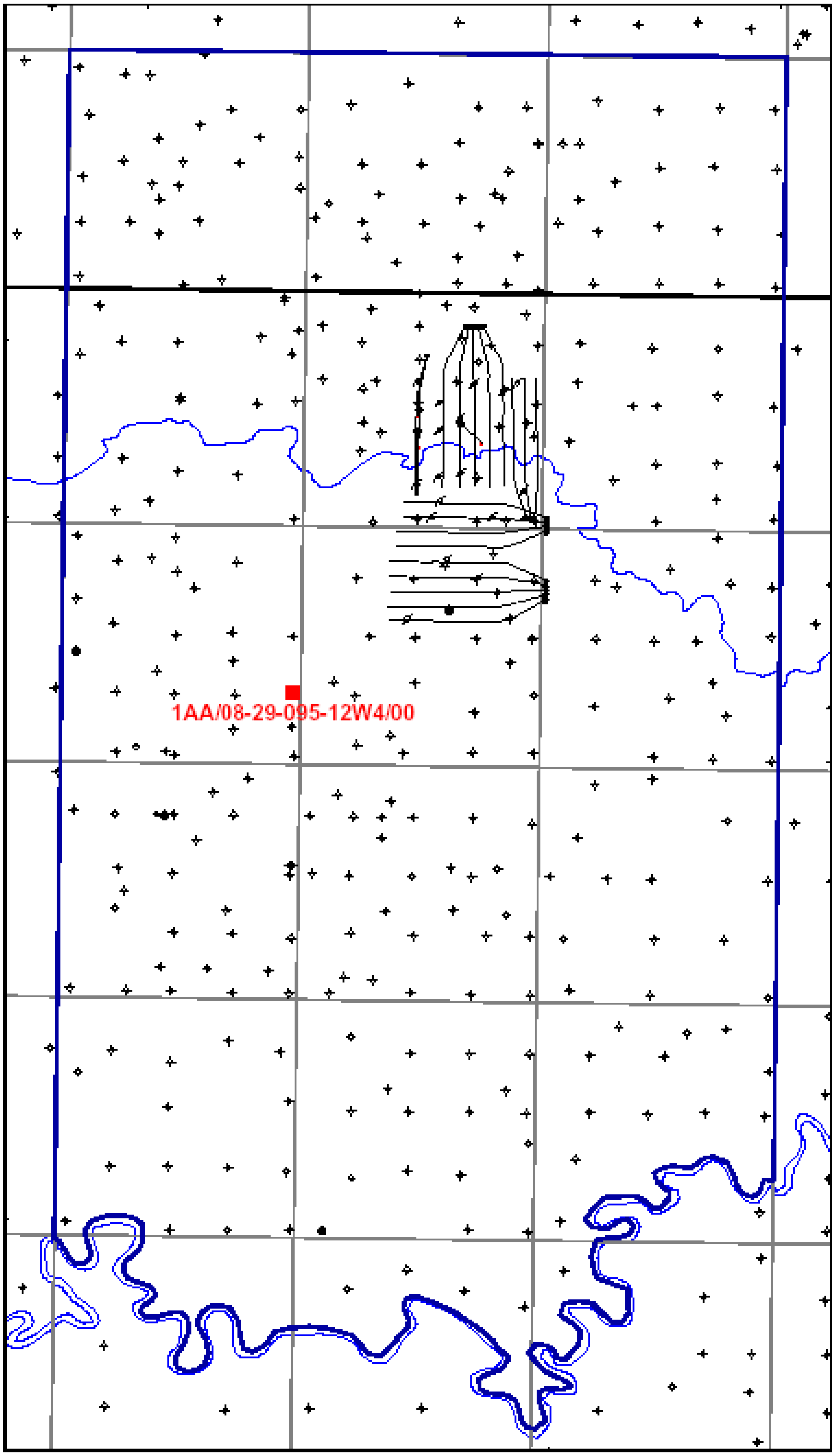
(Arrows show direction of fluid flow)



ref. Bachu & Underschultz (1993)

Figure 2.3 Areal Location of Well 08-29-95-12W4

)



3. GEOMECHANICS OF THE JOSLYN CREEK PROJECT

3.1 Introduction

A geomechanical description of the Joslyn Creek SAGD Project is analogous to our geological description, except that the rock's mechanical properties are of concern, rather than the compositional properties. In addition to the rock's strength characteristics, such as compressive strength and stiffness, the fluid pressures and the rock stresses are as important in the determination of the behaviour of the reservoir and its caprock to the SAGD process. The combination of the inherent strengths and the imposed loads will determine the response of the strata to the injection pressures and the resultant deformations.

3.2 Formation Pressures

Formation pressures were assumed, as shown in **Figure 2.1**. The Wabiskaw Member is assumed to act as a lateral drain. Hydrostatic pressures were assumed within the surficial till and the McMurray Formation below the Wabiskaw. Pressures were assumed to be linear throughout the Clearwater shale.

3.3 Rock Stresses

The state of stress in the rock is important in assessing rock stability, and in predicting the behaviour during SAGD. However, in order to conduct an analysis, the stresses in the rock must be accurately determined and, in particular, the value of the minimum *in situ* stress ("in place" stress). This stress controls the strength and stiffness characteristics of frictional rocks.

For every point within the rock strata, the *in situ* stresses are comprised of three orthogonal principal stresses. The two aspects of the *in situ* stress state that must be determined or inferred from data are the principal stress magnitudes and their orientations. The sources of these data include drilling reports, geophysical logs, evidence of stress-related natural features (e.g.: faults), and field tests. Often, an incomplete data set exists, and reasonable estimates of the missing data must be made in order to establish a range of quantitative values for subsequent analyses.

3.3.1 Stress Orientations from Borehole Breakouts

Oriented elongations of the wellbore cross-section provide information about the orientation of the rock stresses. Elongations in a vertical well can be examined in a borehole breakout analysis to determine the direction of the major horizontal stress, as more completely described in **Appendix F**.

A borehole breakout analysis of dipmeter logs was done for Well 8-29-95W4. The calliper information from logs includes tool orientation data, which is used to determine the azimuthal orientation of borehole elongations. This information is plotted in profile, showing the depths at which borehole elongations occur. These elongations are also plotted in an azimuthal frequency plot. After excluding calliper data that clearly correspond to non-breakout phenomena, the dominant orientation will correspond to the minimum stress orientation.

The breakout data were plotted for Well 8-29-95-12-W4 in **Figure 3.1a**. The plot on the left shows profiles of the three pairs of calliper data, for a 6-arm calliper. For reference, the bit diameter is plotted as a vertical line at 158.8 mm (6.25 inch). Possible breakout events (well depths 40m-45m) are seen in the Clearwater shale where the calliper traces exceed the breakout depth of 5mm. However, where the hole is overgauge, all three callipers are overgauge, which is more indicative of washout. Breakout events can be superimposed upon these, but the evidence for stress orientation is less compelling.

As seen in the extent of overgauge hole, the condition of the hole throughout the Clearwater is not as gauge. This is likely due to the fact that the Clearwater shale was cored, with the core being used for the laboratory work in this caprock shale study. Coring, with its sporadic rates of penetration, would result in a less uniform wellbore geometry than when drilling with consistent and constant drilling parameters.

The azimuths of the borehole breakouts are shown in the centre plot, along with the well inclination (essentially vertical) and the well azimuth. Borehole breakouts are shown as azimuth pairs, i.e. azimuths with their conjugate azimuth, i.e., azimuth+180°. In this plot, all breakout events where the wellbore diameter exceeded the bit diameter by 5 mm were plotted. The azimuth of the Calliper 1-4 is plotted to show the rotation of the dipmeter tool as it traverses from the bottom to the top of the logged interval. In this case, there is almost no tool rotation, even over intervals that are within gauge, therefore the lack of tool rotation over the overgauge interval (50m – 110m) is not a strong indicator of breakout as opposed to other forms of overgauge hole.

The profile in the plot on the right is the gamma ray trace.

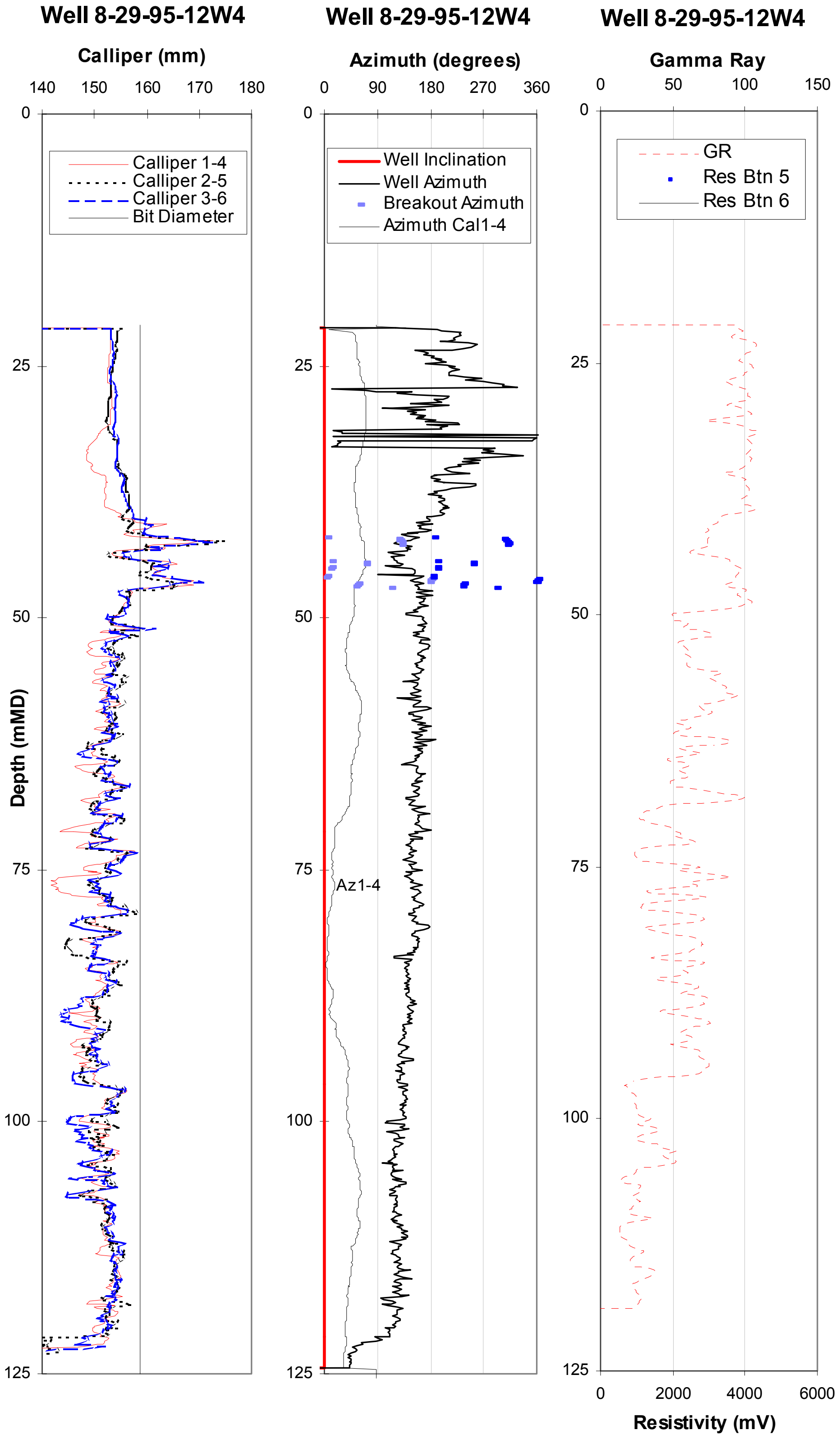
Figure 3.1b is a frequency plot of the elongation events seen in **Figure 3.1a**. Every elongation orientation is plotted in a cumulative radial plot, resulting in a symmetric breakout “rosette”. There is a strong orientation of 0°-180°, with a secondary orientation offset by 50° at 130°-310°. The offset at close to the same spacing as the 6-arm calliper spacing is an indication that the tool failed to rotate for brief episodes where the roughly circular overgauge hole elongated in a different orientation.

Figure 3.1c is a cross-plot of the maximum vs. minimum calliper readings. The dense concentration of points along the y=x axis indicates that the well cross-section was circular, although with a varying diameter. This is indicative of washouts or squeezing.

The cluster of points below the bit diameter, close to the axis, is indicative of wellbore constriction, which has occurred over the entire interval below the Clearwater shale and above the basal limestone. This is not likely to be due to any accumulation of mudcake, since the leakoff into shales and bituminous sands is negligible. Instead, it is either due to elastic squeezing into the wellbore, or as a result of dilation. This could result in some leakage around the packers used in the minifrac tests.

Any dispersion of points away from the y=x axis and parallel to the x-axis corresponds to breakout events. These are absent, indicating that the observed borehole elongations are not stress related. This is to be expected for shallow wells, where the stress levels are far lower than encountered in typical wellbores.

Figure 3.1 a Borehole Breakout Profile for Well 8-29-95-12-W4



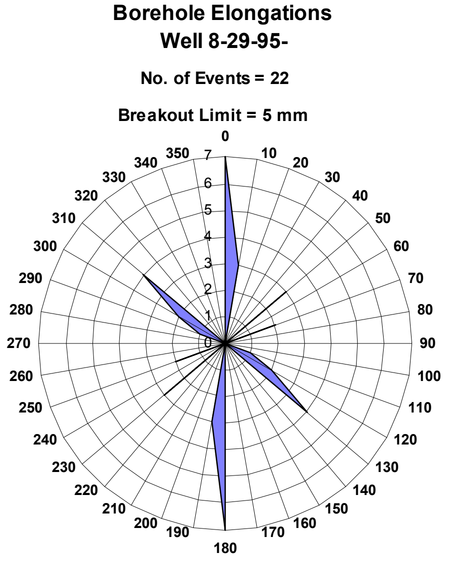


Figure 3.1 b

Elongation Rosette

Figure 3.1 c Max. vs. Min. Calliper

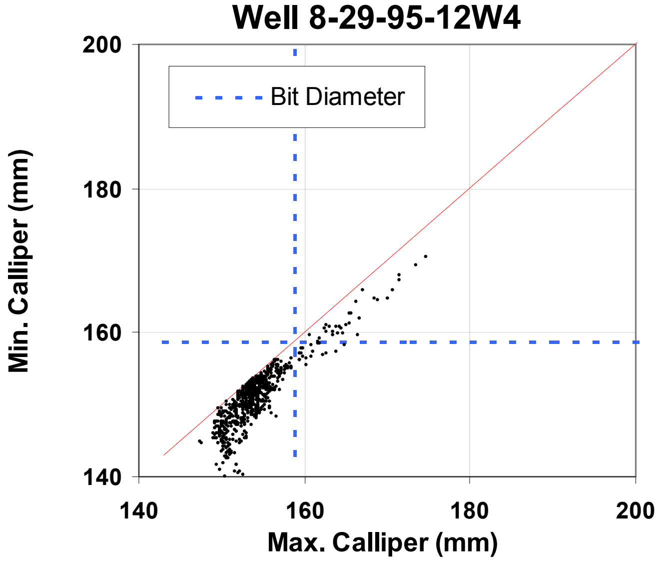


Figure 3.1 d Wellbore Diameter vs. Gamma Ray response, Well 8-29-95-12-W4

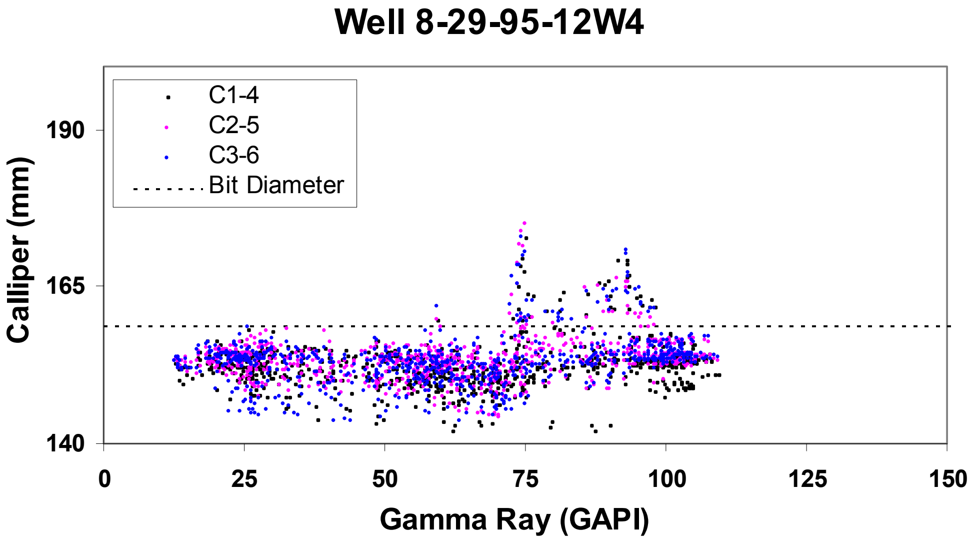
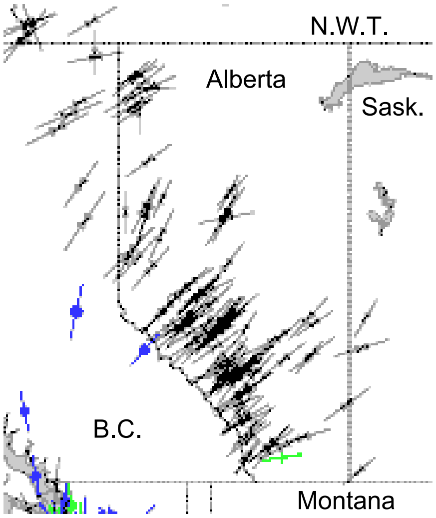


Figure 3.1d is a cross-plot of calliper reading vs. the gamma ray (GR) response. The range of gamma ray response is largely between 20 and 100. Most of the overgauge (i.e. breakout) events occur at the higher values of GR, which should correspond to the shales and mudstones. This is expected, since the shales do not develop an effective mudcake due to their low permeability. Well constriction occurs over the entire GR range, although it is marginally better in the shales.

3.3.2 Regional Stress Orientation

The predominant maximum horizontal stress orientation in Alberta is NE-SW, as seen in **Figure 3.2**. These data are predominantly from borehole breakouts, but also include some seismic focal mechanisms. In all probability, this is the maximum stress orientation at the Joslyn Creek lease, with a possible variance of ± 20°.

Figure 3.2 Stress Directions in Alberta



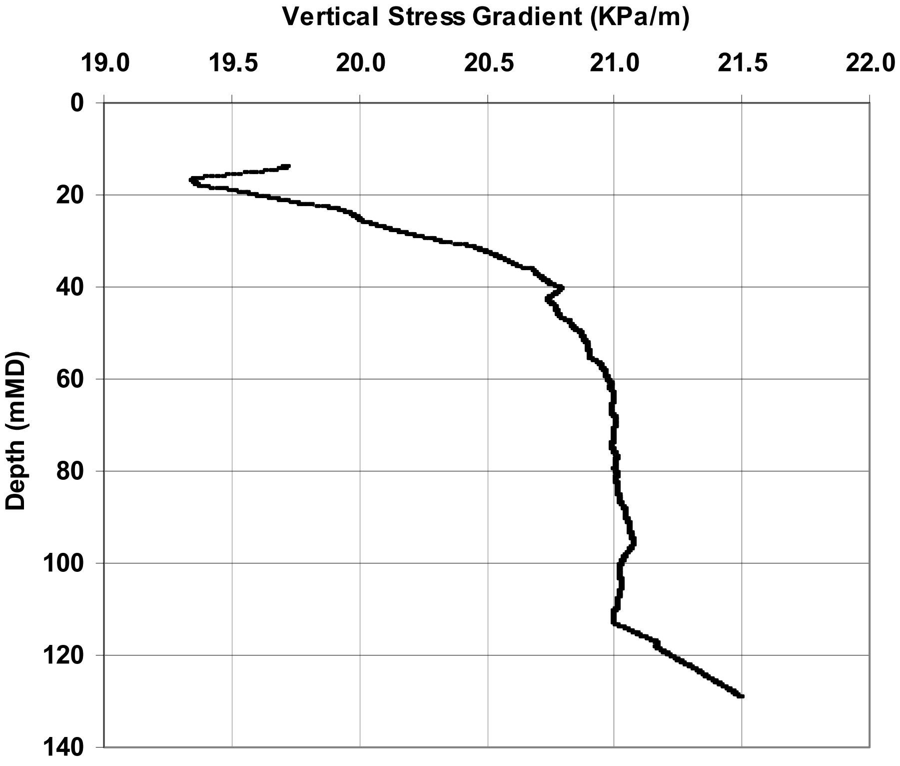
3.3.3 Stress Magnitudes

The rock stresses can be resolved into three principal stresses. One of the principal stresses arises because of the weight of the overlying material and it is often assumed to be vertical. While this is certainly true in quiescent geologic basins where the *in situ* stresses are primarily due to the cumulative weight of sediments, the local principal stresses may be rotated in the presence of faulting. In the case of the Joslyn Creek Project it can be safely assumed that the vertical direction is one principal stress direction because the structures are not highly distorted by post-depositional mechanisms, and the formation dips are low. The other two principal stress directions are usually inferred from borehole breakout analysis of calliper data, although other data can be used instead. The other two principal stresses are orthogonal to the vertical principal stress; therefore, they are both horizontal stresses.

3.3.3.1 Vertical Stress

The vertical stress gradient in the reservoir is approximately 21 KPa/m (0.93 psi/ft). Onshore vertical stress gradients in general do not vary much from 22 KPa/m, but for these shallow depths a lower value is expected. The bulk density log was integrated to provide a profile of vertical stress gradient with depth, as seen in **Figure 3.3**.

Figure 3.3 Vertical Stress by Integrating Bulk Density Log



3.3.3.2 Minifrac Stresses

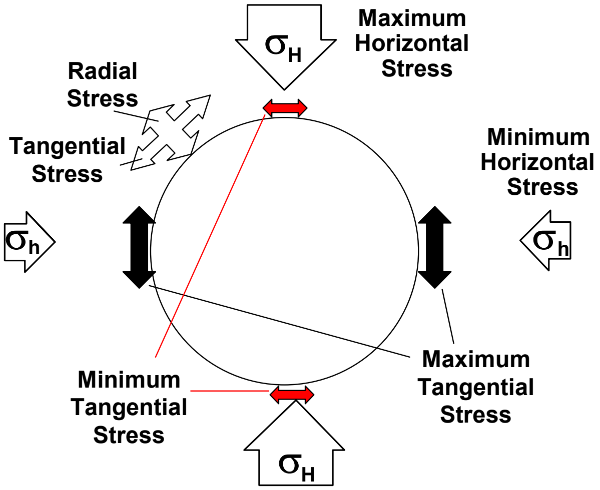
A "minifrac" or "minifrac test" is a miniature hydraulic fracture test. Usually, a minifrac is done prior to hydraulic fracture stimulations in order to get definite values for fracture parameters. These parameters, such as the closure stress and the leak-off coefficient, are needed to re-simulate the main hydraulic fracture treatment just prior to execution. The results are used to optimize the fracture treatment program. Minifracs are usually done over the same interval as the main hydraulic fracture treatment, but much smaller quantities of fluids are injected. No proppants are used.

A "microfrac" test is a smaller version of a minifrac. Usually, this is conducted in either an open-hole or cased well, with a straddle packer isolating a short 2-3m interval. Microfracs are often referred to as minifracs, as in this report.

Stresses around a Wellbore

Where two horizontal stresses are unequal, the drilling of a vertical well causes stress concentrations in the rock, and these changes from the undisturbed *in situ* stress state are usually highest at the wellbore wall. The radial stress there falls to the wellbore pressure, while the tangential stresses vary with respect to the orientation of the horizontal stresses. The minimum and maximum tangential stresses are in the same orientation as the minimum and maximum horizontal stresses, respectively, as shown in **Figure 3.4.**

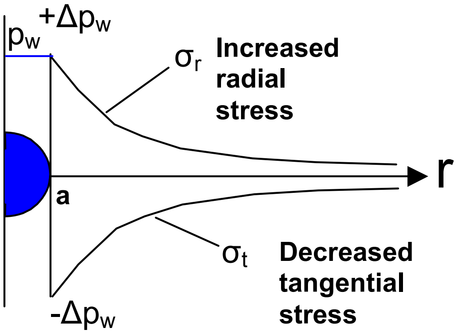
Figure 3.4



In a minifrac test, the test interval is pressurized until the wellbore fractures. Fracturing is reasonable assumed to occur perpendicular to the minimum stress at the wellbore. Injection continues briefly to propagate the fracture a short distance. The well is shut-in, and as the fluids leak off into the formation, the fluid pressure drops and the fracture aperture narrows. Once sufficient fluids have leaked off, the pressure in the fracture is insufficient to hold the fracture open, so the fracture closes. At this moment the flow regime changes from a quasi-lineal flow away from the fracture to radial flow away from the wellbore. An analysis of the declining pressure over time provides the pressure at which this occurs, and this is taken to be the closure stress, σ_c. For most applications, this is taken to be the minimum rock stress acting normal to the fracture.

Minifrac tests fracture the wellbore by increasing the wellbore pressure, which alters the stresses in the rock at the wellbore. Below fracturing pressure, an increase in the wellbore pressure will push outwards on the wellbore wall. This increases the radial stress, while reducing the tangential stress. This effect is most pronounced at the wellbore, and dissipates further away from the well. This is shown schematically in **Figure 3.5** in which the changes in the radial and tangential stresses are plotted schematically.

Figure 3.5 Incremental Stresses resulting from Wellbore Pressurization



The additive effect of the anisotropic horizontal stresses and the stresses induced by pressurizing the wellbore will lead to fracturing the wellbore if the well pressure is high enough. The equation for the *minimum* tangential stress (small red arrows in **Figure 3.4**) is:

$$\sigma_t = 3\sigma_h - \sigma_H - p_w - p_f \qquad [3.1]$$

where:

σ_t	is the minimum tangential stress
σ_h	is the minimum horizontal stress
σ_H	is the maximum horizontal stress
p_w	is the well pressure
p_f	is the formation fluid pressure

Assuming that the tensile strength of unconsolidated sandstone is zero, and neglecting possible tensile properties of the cold bitumen, the formation fails (fractures) when the tangential stress falls to zero:

$$0 = 3\sigma_h - \sigma_H - p_w - p_f \qquad [3.2]$$

The well pressure, p_w, when fracturing initiates in the first cycle of a minifrac test is the breakdown pressure, p_{bd}. An analysis of the pressure transients during the falloff provides the closure pressure, σ_c or p_c. For a vertical well, the minifrac's closure pressure is the minimum horizontal stress. For larger volumes of injected fluid, the fracture would extend into the far-field stresses which are unaffected by the stress concentrations around the wellbore. As such, the fracture would rotate into the horizontal plane if the vertical stress were the lowest *in situ* stress.

Knowing that the closure stress is the minimum horizontal stress, and that the formation fails at the breakdown pressure, the equation can be rewritten as:

$$\sigma_H = 3\sigma_c - p_{bd} - p_f \qquad [3.3]$$

where:

σ_c	is the closure stress
p_{bd}	is the breakdown pressure

In many minifrac analyses, it is a common error to misinterpret all closure stresses as being the minimum *in situ* stress in the field, rather than the minimum *in situ* stress at the wellbore. This is because, at shallow depths in Alberta, the minimum field stress is the vertical stress. Many authors presume that horizontal fractures are created because the vertical stress is smallest. Certainly, the minimum stress *away* from the wellbore is the vertical stress. However, the minimum stress at the wellbore is not the vertical stress during minifracs from a vertical well, since the presence of the pressurized well alters the local stress regime.

During the pressurization of the test interval before fracking, the radial effective stress increases and is equal to the well pressure, as was seen in **Fig. 3.5**. The tangential effective stresses decrease by the same amount, and the intermediate (vertical) stress remains constant. At the point of fracture initiation, the tangential effective stress has fallen to zero, making it the lowest effective stress in the rock at the wellbore. The fracture will therefore be vertical, and the closure stress will then be the minimum horizontal stress, not the vertical stress.

Many authors wrongly assign the closure stress to the vertical stress, which would require a horizontal fracture. It is possible to flip the vertical fracture into the horizontal plane if the volume of the injected fluids is sufficient to extend the fracture away from the wellbore and into the far-field stress regime, where the minimum *in situ* stress is vertical. For microfracs, injected volumes are small, so this is unlikely. It can also occur if the wellbore is damaged and the fracturing fluids pressurize a horizontal plane instead of the vertical wellbore. However, in such a case the breakdown pressures and especially the fracture reopening pressures should be negligible.

These minifrac tests created vertical fractures in most cases, therefore their closure stresses are the minimum horizontal stresses. In some test cycles, it appears that some fractures have reoriented into the horizontal plane.

3.3.4 Analytical Methods

There are several methods of estimating the fracture closure stress from the pressure fall-off data. Each of these tries to identify or to differentiate between different flow regimes discernable in the data, as seen in **Figures 3.6 and 3.7**.

1. pressure vs. square root of shut-in time
2. tandem square root or linear flow plot
3. pressure decay rate
4. log(pressure) vs. shut-in time
5. log(dp) vs. log (dt)
6. pump-in/flow-back test
7. pressure vs. flow rate
8. fracture reopening test
9. Horner plot
10. G-function plot

nomenclature:

P	pressure (usually KPa)
dp	change in pressure
pc	closure pressure

t	time from the start of injection (usually minutes)
ts	time at injection shut-in
$\sqrt{t}$	square-root of time
log	logarithm, base 10

3.3.4.1 ISIP

The instantaneous shut-in pressure ("ISIP") is the pressure in the fracture immediately after shut-in. At this moment, the dynamic pressure losses in the pumping system and along the fracture are nearly zero, so the well pressure is the pressure required to prop the fracture open. For very small fractures, such as minifracs, the fracture aperture will be small, and the ISIP will be a fair approximation of the fracture closure pressure. The ISIP will be above the true fracture closure pressure.

3.3.4.2 P vs. Sqrt(shut-in time)

Plotting p vs. $\sqrt{t}$ assumes that the pressure decline, due to fluid leakoff, should be linear as long as the fracture is open. When the fracture closes, the fall-off data should deviate from a straight line. For the case of zero flowback, the rate of pressure drop should decrease, resulting in a positive deviation; with flowback or leakage, the deviation will be lower and may be negative.

3.3.4.3 Horner Analysis

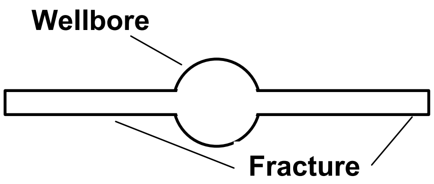
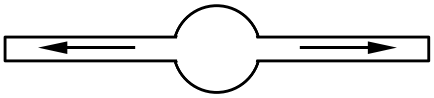
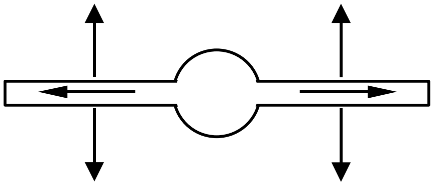
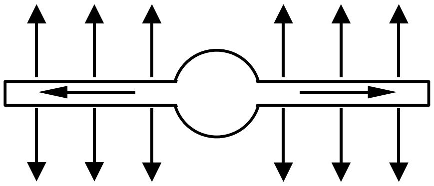
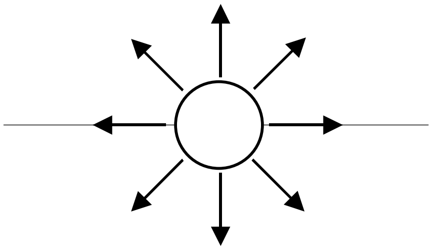
Horner analysis provides an estimate of the minimum extension pressure, and as such is a *lower bound* to the fracture closure pressure. The Horner plot is a plot of pressure vs. Horner time [log(t/(t-ts))]. At lower pressures a semi-log straight line is extrapolated through the reservoir pressure, if possible. This indicates that radial or pseudo-radial flow may be affecting the decline behaviour. Deviation of the Horner data from this straight line intersecting reservoir pressure signifies the start of pseudo radial flow during pressure decline, and the lower bound for the closure pressure. This indicates that the fracture is closed. Data below that pressure need not be considered in the evaluation of closure.

3.3.4.4 Other Methods

Various other methods exist to determine the fracture closure stress from pressure fall-off data (viz. Hannan and Nzekwu, 1992), and some have been used in the analysis of the Joslyn Creek data.

One notable variation from idealized conditions is for fluid flowback during the shut-in period. With a trickle of fluid returning to surface via the well casing, the test fractures closed more rapidly than anticipated. This reduced the quantity of data available for analysis pre-closure.

Figure 3.6 Flow Characteristics for a Well with a Finite Conductivity Fracture

Flow Direction	Flow Regime	Pressure vs. Time Curve Characteristics
	Wellbore storage and skin damage	Log-log straight line Slope m = 1
	Fracture linear flow	Log-log straight line Slope m = 0.5
	Bilinear flow	Log-log straight line Slope m = 0.25
	Formation linear flow	Log-log straight line Slope = 0.5
	Pseudoradial flow	Semi-log straight line

(ref. Hannan & Nzekwu, 1992; after Poon, 1986)

Figure 3.7 Minifrac Pressure Fall-off Flow Characteristics

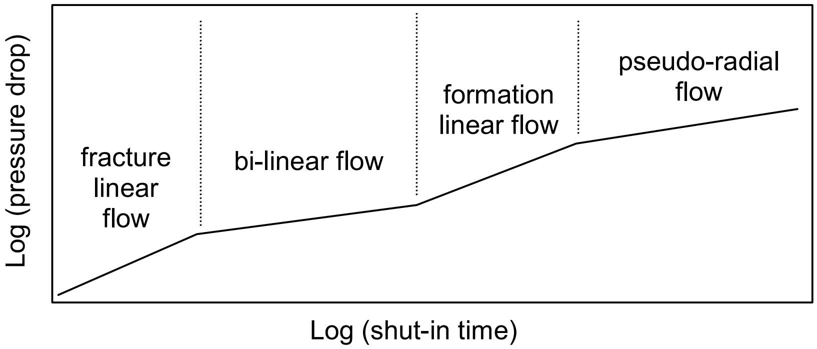
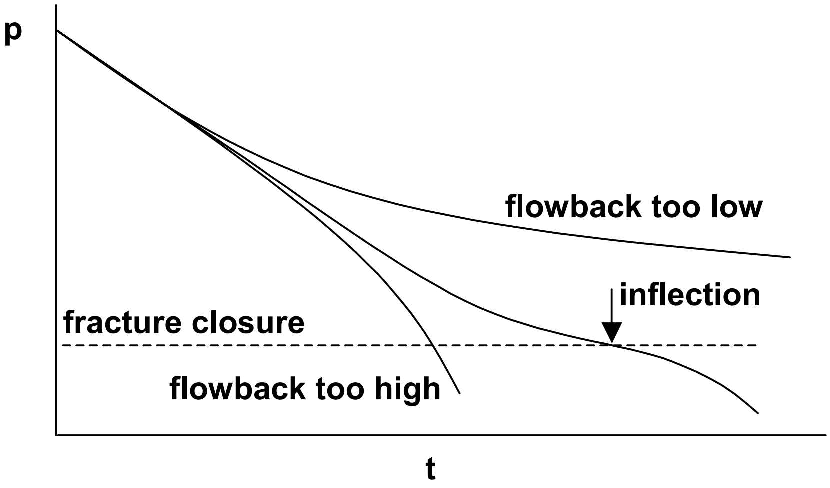


Figure 3.8 Pressure Fall-off with Flowback



3.4 Joslyn Creek Well 8-29-95-12W4 Minifracs

The results of the field program and the subsequent engineering analyses are summarized here. Details are provided in the appendices:

Appendix A	Log of field events
Appendix B	Log-derived geomechanical parameters
Appendix C	Downhole memory gauge data
Appendix D	**Minifrac test results**

3.4.1 Test 1 in Oilsands from 97 to 99m

Cycle 1 exhibitted a very high breakdown pressure, indicating a vertical fracture. In contrast, a horizontal fracture should exhibit little to no breakdown in an unconsolidated formation, i.e. no tensile strength. A small spike after the main spike may indicate a change in the orientation of the fracture from vertical to horizontal. Flowback was observed at the surface casing, therefore closure occurred sooner than expected. As a result, the best indicator of the minimum horizontal stress was the ISIP.

Cycle 2 used a higher injection rate to increase the volume of the fracture at shut-in. The fracture re-opening pressure was barely above the initial propagation pressure, therefore it was likely that fluids were being injected into a horizontal fracture.

Cycle 3 was aborted after the Sanjel pumpers turned the pumps up, not off, at the prescribed shut-in time.

Cycle 4 resembled Cycle 2, indicating that a horizontal fracture was being charged.

3.4.2 Test 2 in Shale from 37 to 39m

Cycle 1 exhibitted good fracture behaviour. However, the rapid pressure falloff after shut-in precluded most analyses. Suspecting a packer problem, the packers were raised and set within the surface casing and pressure tested within the casing. The packers performed well with no leakage.

3.4.3 Test 3 in Shale from 32.2 to 34.2m

Cycle 1 had a high breakdown, and was a successful test.

Cycle 2 was similar in behaviour. The high fracture re-opening pressure is indicative of a vertical fracture in this area at this depth.

Cycle 3 was similar to Cycle 2, although the post-shutin data may have indicated that the fracture had rotated into a horizontal plane.

3.4.4 Test 4 in Shale from 27 to 29m

Cycle 1 was good, but had a rapid drop in pressure after shut-in.

Cycle 2 had a rapid drop in pressure that precluded some analyses. Closure pressures were indicative of a horizontal fracture.

Cycle 3 was unique in that some analyses indicated that the vertical fracture had re-opened for this cycle, with the horizontal fracture remaining closed. The high re-opening pressure would support this theory, which is plausible if the horizontal fracture aperture at the wellbore were able to seal itself with mud solids and clay swelling.

3.4.5 Test 5 in Oilsands from 77 to 82m

Cycle 1 was poor, with rapid closure of the fracture. Wellbore rugosity may have contributed to an imperfect seal between the packers and the oilsand.

Cycle 2 was similar to Cycle 1.

Cycle 3 used a higher injection rate in order to increase the volume of the fracture, which would provide more pre-shutin data. Unfortunately, the Sanjel pumpers began to disassemble their equipment without regard to the shut-in period. When the abrupt drop in downhole pressure was noted, their activities were halted. Unfortunately, that pressure drop adversely affected the results. A fourth cycle was done.

Cycle 4 was successful, despite some flow noted at surface. The ISIP was abrupt, but sufficient pre-closure data were available.

3.5 Summary

The results of all tests performed in oilsand and shale are presented in **Tables 3.1 and 3.2**, and in **Figures 3.10 to 3.12**.

Table 3.1 provides the most complete summary of the field program. It lists the test interval depths, injection rates, and volumes. The formation breakdown and fracture re-opening pressures are next, followed by the propagation pressure. After shutin, the ISIP is noted. Various means of calculating the closure stress were used, and the results listed in terms of pressures and gradients. The pressures at the end of the test were recorded. Finally, the closure stress and the vertical stress are listed, where applicable. Comments pertaining to these tests are listed here and in **Appendix A**.

Figure 3.9 is a pressure profile which shows that the minimum horizontal stress lies just above the line for the vertical stress, derived from integrating the bulk density log. Furthermore, minifrac test results that were determined to be indicative of a horizontal fracture are reasonably in agreement with the trend of the vertical stress line.

With the minimum in situ stress predicted to be vertical, any induced fracture from a horizontal well should be horizontal. Aiding this orientation are the natural bedding planes, which tend to be pene-horizontal. With steaming, the thermal stresses within the reservoir should add to the horizontal stresses, which will increase them further. Similar behaviour was observed in Cold Lake with the CSS process.

Table 3.1 Well 8-29-95-12W4 Minifrac Test Results

											ISIP		Horner		SQRT(shut-in)		P vs Log(Shut-in)		G function		Log(dP) vs. Log(shut-in)				Closure		Horz Frac		
Test &	Int.	Rate	Tinj	Vinj	Pbd		Pre-open		Pprop		P_ISIP		Pc		Pc		Pc		Pc		Pc		Pend		Pc		Pc vert		Commnet
Cycle	m	l/min	min	litres	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m	kPa	kPa/m		kPa/m		kPa/m	
t1c1	97-99	4	18.50	74	5255	54.18			2666	27.48	2372	24.45	1920	19.79	2088	21.53	2070	21.34	2088	21.53	2088	21.53	1035	10.67	2372	24.45	2070	21.34	high end density, mud in pipe; possible flip to horz fracture
t1c2		10	19.92	199			2071	21.35	2446	25.22	2200	22.68	1630	16.80	1996	20.58	1951	20.11	1996	20.58			969	9.99			1951	20.11	low Pre-open; possible horz frac
t1c3		6	30.00	180			2084	21.48	2229	22.97	1971	20.32																	poor; Preopen<Pprop. Abort because Sanjel turned pump up, not off, at end of injection
t1c4		8	17.75	142			2223	22.92	2158	22.25	2015	20.77	1652	17.03															possible horz. frac
t2c1	37-39	4	18.75	75	2547	68.85			1791	48.42	1330	35.95			916	24.76			916	24.76			363	9.81	916	24.76			rapid fall-off --> test packers in csg
t3c1	32.2-34.2	4	20.00	80	4549	141.27			1584	49.19	959	29.78			852	26.46	852	26.46	959	29.78			372	11.55	852	26.46			excellent
t3c2		4	19.92	80			1813	56.31	984.6	30.58	932	28.95	709	22.02	800	24.84	818	25.40	864	26.83	904	28.07	342	10.61					good test
t3c3		4	19.92	80			1314	40.81	1037	32.20	976	30.32	653	20.28	686	21.30	800	24.84	696	21.61			342	10.62			686	21.30	good test; possible horizontal fracture
t4c1	27-29	4	19.92	80	4213	156.06			1909	70.71	1275	47.21			917	33.96					990	36.67	307	11.37	917	33.96			
t4c2		4	19.92	80			1675	62.04	1231	45.59	972	35.99	520	19.26			579	21.44					306	11.34			579	21.44	
t4c3		4	19.83	79			2425	89.81	897.3	33.23	735	27.20	566	20.96	619	22.93	657	24.33					307	11.37					good
t5c1	77-82	12	29.92	359	5382	69.90			2629	34.14	1850	24.03	1492	19.38	1808	23.48					1849	24.01	871	11.31					poor
t5c2		12	30.00	360			2750	35.72	2352	30.55	2071	26.90	1533	19.91	1783	23.16	1748	22.70	1739	22.58	1963	25.49	882	11.45					poor
t5c3		20	18.75	375			2695	35.00	2246	29.17	2049	26.61	1576	20.47	1994	25.90	1867	24.25	2049	26.61			862	11.19	1867	24.25			good injection, followed by Sanjel breaking the pressure line during shut-in
t5c4		12	30.00	360			2681	34.82	2125	27.59	1972	25.60	1566	20.34	1932	25.09	1973	25.62	1932	25.09			882	11.45					good; some flow from surface csg

Figure 3.9 Well 8-29-95-12W4 Minifrac Stresses

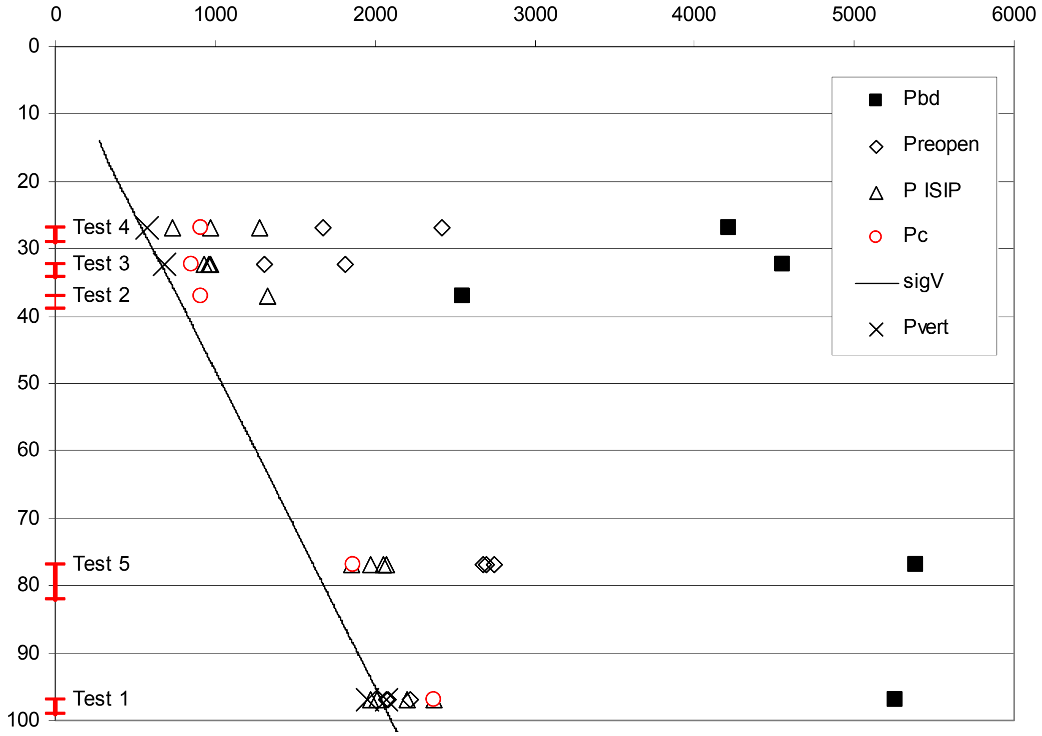


Figure 3.10 Well 8-29-95-12W4 Minifrac Stress Gradients

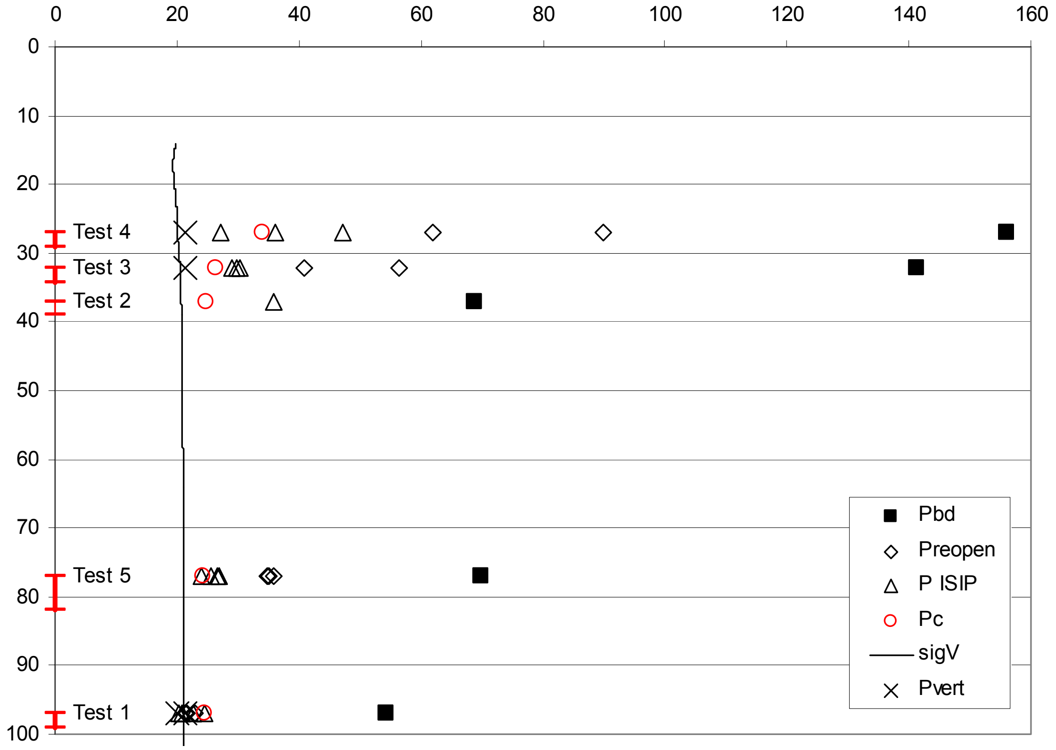


Figure 3.11 Well 8-29-95-12W4 Minifrac, sigHmin and sigV

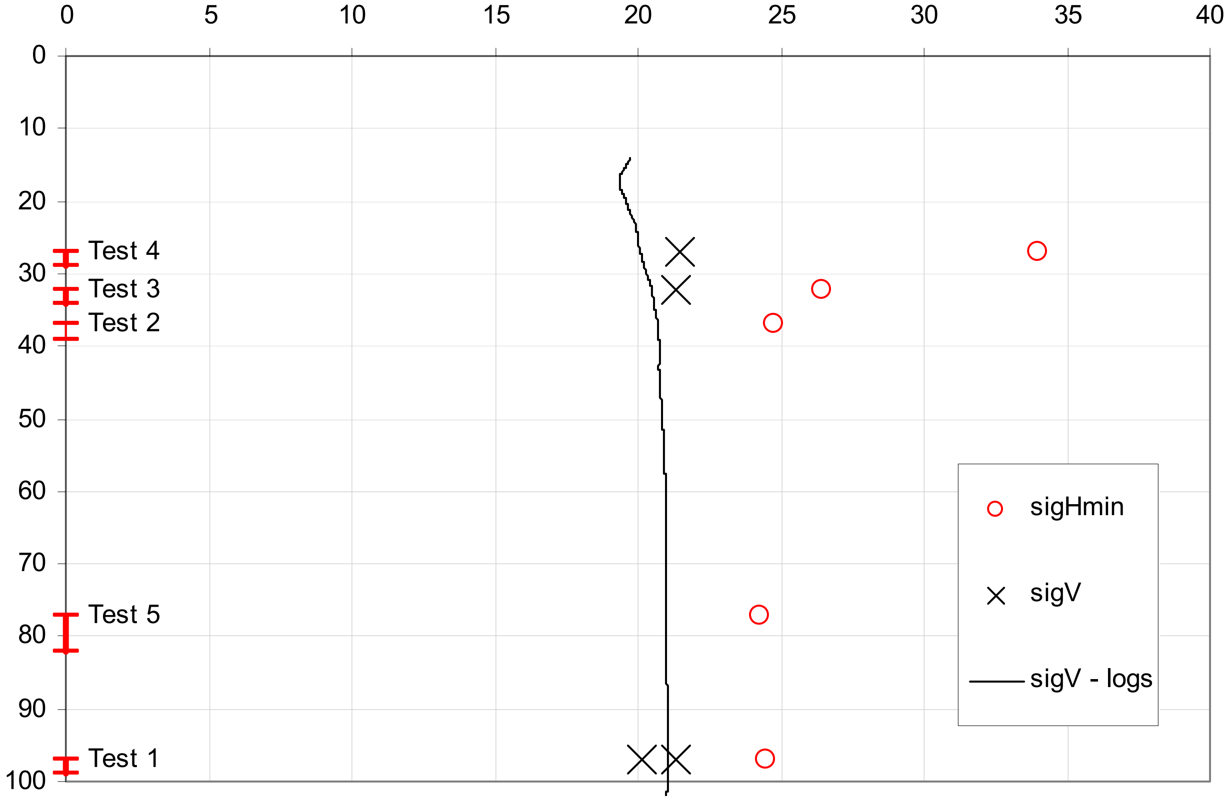


Table 3.2 Well 8-29-95-12W4 Minimum Horizontal Stress

Top Interval m	Min. Horz.Stress KPa	Gradient KPa/m
27	917	33.96
32.2	852	26.46
37	916	24.76
77	1867	24.25
97	2372	24.45

3.6 Log-Derived Stresses

Eaton's Equation of Stress

Rock stresses can be estimated from the elastic properties of the rock, and the formation pressures. Eaton (1969) provided an equation for horizontal stresses in a quiescent depositional basin, i.e. no alteration of stresses or strains other than those imposed by the weight of the overburden and the condition of zero lateral strain:

$$\sigma_h = \frac{\upsilon}{1-\upsilon}\left(\sigma_{vertical} - p_f\right) + p_f \qquad [3.4]$$

where

σ_h horizontal stress (uniform)
ν Poisson's ratio
$\sigma_{vertical}$ vertical stress (σ_v)
p_f formation pore pressure

The vertical stress $\sigma_{vertical}$ or σ_v is known by integrating the bulk density log (e.g.: **Fig. 3.9**). The formation fluid pressures p_f are described in **Figure 2.1**, and are essentially hydrostatic in the surficial till, a negative gradient throughout the Clearwater shale to the underpressured Wabiskaw, and hydrostatic below the Wabiskaw. The dynamic Poisson's ratio can be obtained from the sonic transit times of the shear and compressional sonic waves, as more completely described in **Appendix B**.

Eaton's equation, **Eqn. 3.4,** provides the lateral stress exerted by rock due to its formation pressure and the weight of the overlying material. Under the weight of the overburden, the rock tries to expand laterally, but because it is constrained, horizontal rock stresses build up instead. These horizontal stresses are predicted to be uniform if the rock's elastic properties are assumed to be uniform.

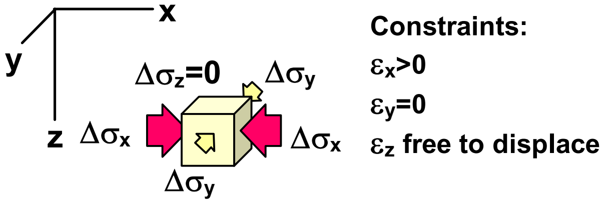
Geophysical logs, including the dipole sonic logs, were processed for Well 8-29-95-12-W4 and the results are shown in **Figure 3.15**. On the right is a profile of the dynamic values of the Young's modulus "E" and Poisson's ratio "ν", determined from the shear and compressional sonic slowness, Δt_c and Δt_s (μs/m) and the bulk density, ρ_b. On the left is a plot of rock stresses and pressures. The blue line is the formation pressure profile. The thick red line is the vertical stress. Using these and the Poisson's ratio, the Eaton's horizontal stress was calculated using **Eqn. 3.4** , and is plotted as the thin black line ["sig h(Eaton)"] adjacent to the formation pressures.

What is most significant is that the Eaton horizontal stress is predicted to be very high in all the formations, but particularly in the Clearwater shale. This is because the log-derived Poisson's ratio is very high in all formations above the limestone, generally within the range 0.38-0.45. As a result, the ratio "$\upsilon/(1-\upsilon)$" in **Eqn. 3.4** is almost unity, making the horizontal stress almost equal to the vertical stress.

Tectonic Strain and Stress

Eaton's assumption is simplistic in that it assumes zero lateral strain. This is a good starting point, however there are strong tectonic effects in place that will increase these horizontal stresses. Tectonic movements apply a lateral strain through the rock strata, and in the case of the Rocky Mountain Orogeny that affects Alberta, this is a positive (compressive) strain. For a horizontal rock stratum experiencing a compressive uniaxial strain only in the "x" direction, ε_x, the stress and strain conditions are described by **Figure 3.13**:

Figure 3.12 Uniaxial Horizontal Strain



Unless this strain is relieved, as might occur as a result of faulting, the horizontal stress increases in the rock, in the direction of straining:

$$\Delta\sigma_x = \frac{E}{(1-\nu^2)}\varepsilon_x \qquad [3.5]$$

Significantly, the stress in the perpendicular horizontal direction also increases to a lesser extent, due to ε_x and the Poisson's effect:

$$\Delta\sigma_y = \nu \cdot \Delta\sigma_x = \frac{\nu E}{(1-\nu^2)}\varepsilon_x \qquad [3.6]$$

The vertical stress remains unchanged: any Poisson's effect in the vertical direction is relieved by a very small upward displacement of all rock strata.

The implications of these equations are significant:

1. First, stresses in areas that have experienced straining, such as from tectonics, will have horizontal stresses that can be very different than those predicted with Eaton's equation, which assumes zero lateral strain.
2. Next, the increases in stress will vary from formation to formation, largely in proportion to their respective Young's moduli, with the stiffer strata being much more affected by strain.
3. Lastly, the stress in the direction transverse to the tectonic strain will also change. In our compressive tectonic regime, the transverse horizontal stress will be the minimum *in situ* stress until such time as the tectonic straining increases both horizontal stresses above the vertical stress.

A tectonic strain was applied to the strata for Well 8-29-95-12-W4 and the results are also shown in **Figure 3.15**. First, the results of the minifrac tests were plotted: the vertical stress, and minimum horizontal stress. Next, an arbitrary strain in one horizontal direction was gradually increased, which resulted in the "sig h (Eaton)" curve diverging into two higher curves: one for the maximum horizontal stress "sig H", and one for the minimum horizontal stress "sig h". This tectonic strain was increased until the trend of the "sig h" curve matched the two measured values of the minimum horizontal stress from the minifrac tests.

The assumption here is that, by matching the minimum horizontal stress predicted by this elastic method to those from the minifrac tests, we have correctly predicted the maximum horizontal stress.

3.7 Cold Lake Stress Measurements

The cyclic steam stimulation (CSS) project at Cold Lake, operated by Imperial Oil (a.k.a. Esso) has taken numerous stress measurements throughout the life of the project. Rock stresses are more important for a CSS project because the process must operate at injection pressures above the fracture pressure. These fractures are horizontal in this reservoir, or become horizontal after a small amount of reservoir heating has occurred.

Once the oilsand formation is fractured, steam readily enters the formation and begins to heat a large volume of rock. After about a month of injection, the well is shut in for a "soak" period of about a month, which allows for the dissipation of heat from the fracture to the formation. Afterwards, the well is switched to production, and the hot bitumen and condensed water are produced. This production phase typically occurs for a few months.

Subsequent cycles of injection, soak, and production recover more bitumen. With every subsequent injection cycle, however, the formation parting behaves less and less like a discrete fracture and more and more like a zone of highly dilated oilsand, with its associated enhanced porosities and permeabilities. Compaction drive then becomes a significant recovery mechanism, as this zone compresses with each production phase. Surface deformations reflect the reservoir volume changes, with heave upon injection and some subsidence upon production, although there is an incremental permanent surface heave at the end of each cycle.

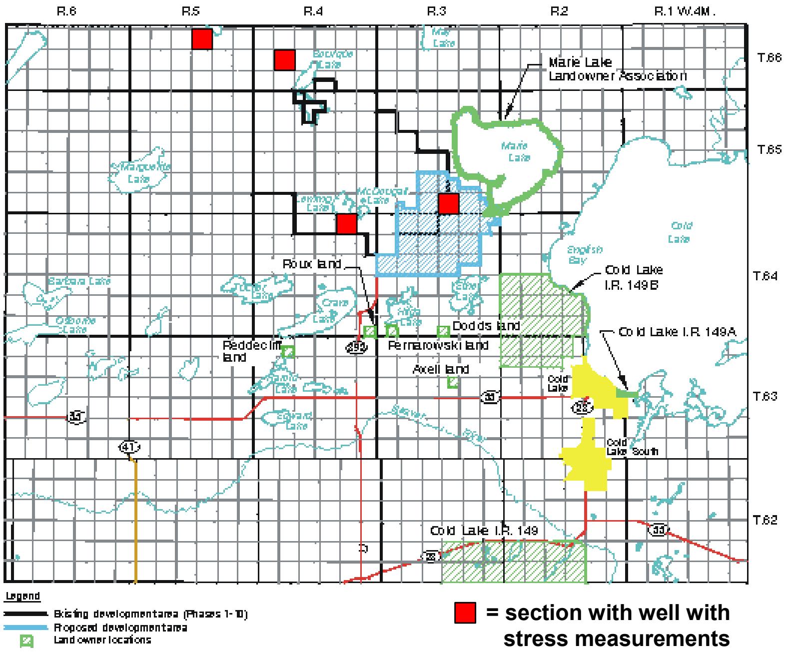
Caprock integrity is a greater challenge with CSS than with SAGD because the process operates at steam injection pressures in excess of the oilsand fracture pressure. As such, there must be a stress contrast between the top of the reservoir and the base of the caprock in order to arrest the propagation of any induced fracture within the reservoir from migrating upward into the caprock. The higher stresses within the caprock, more so than the strength of the caprock, will prevent any fracture from propagating into it.

Recent stress tests were done in the Cold Lake area by Imperial Oil Resources Ltd. to quantify the magnitudes of the three principal stresses. These were done in Wells 8-35-64-4W4, 9-8-66-4W4, 5-15-66-5W4, and 3-3-65-3W4. **Figure 3.14** shows the sections for these wells. **Figure 3.15** and **Table 3.3** show the magnitudes of the two horizontal stresses and the vertical stress. Stress gradients are similar to those inferred from this study, although the vertical stress is slightly lower and the major horizontal stress is slightly higher. Raw data were unavailable for an independent confirmation of their results.

Table 3.3 Stress Gradients from Cold Lake Expansion Project

Stress Orientation	Stress Gradient
Vertical	20 kPa/m
Horizontal, minimum	26 kPa/m
Horizontal, maximum	39 kPa/m –1000 kPa

Figure 3.13 Cold Lake Expansion Project and surrounding area
(ref. Imperial Oil Res. Ltd., Appl. No. 970163; IORL Submission #10235 to the AEUB)



🟥 = section with well with stress measurements

Figure 1. Cold Lake Expansion Project and Surrounding Area (Imperial Oil Resources Limited, Application No. 970163)

Figure 3.14 Cold Lake Stress measurements (4 wells)

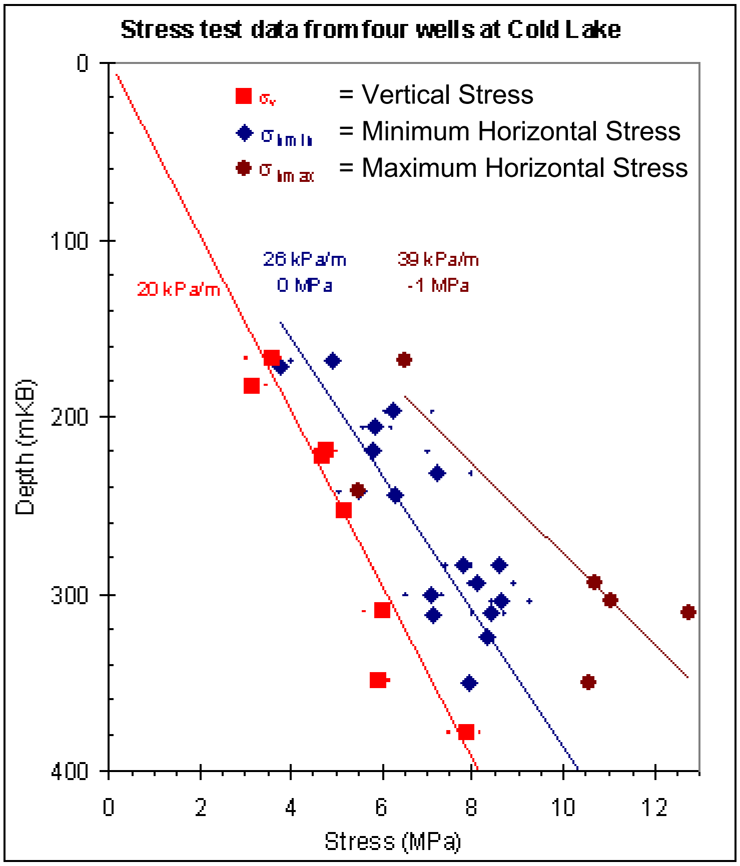


Figure 3.8.2.1 Compilation of in-situ stress measurements at Cold Lake. The wells tested include 8-35-64-4, 9-8-66-4, 5-15-66-5 and 3-3-65-3.

3.8 UTF Project Stress Measurements

Minifrac tests (Hannan & Nzekwu, 1992) were conducted at the AOSTRA UTF Project, now known as the Dover Project operated by Petro-Canada. These tests were conducted in a mudstone (128-130m depth), in interbedded sand and mudstone (134-138m), and in the rich reservoir oilsands (158-160m). These tests were conducted open-hole. The results of these tests are summarized in **Appendix E.**

These minifrac tests found results similar to those of Joslyn Creek. The breakdown pressures were very high, as were the reopening pressures.

Almost all of the tests showed fracture closure pressure gradients ~24 KPa/m, exceeding the vertical stress gradient, indicating that these values were for vertical fractures and the minimum horizontal stresses. No estimates were provided for the maximum horizontal stress.

3.9 Log-Derived Properties

Geophysical logs can be used to derive some geomechanical properties. The method provides a continuous profile of mechanical properties, which is useful in delineating differences between near-uniform zones, and in identifying weaker zones.

However, in this analysis, the rock at any depth is assumed to be homogeneous: there is no allowance for directional variations in the material properties. Furthermore, the extremely small strains associated with sonic sampling usually make the rock appear to be stronger and stiffer than it would be under the larger deformations that would be experienced during drilling. In other words, the "dynamic stiffness" measured from the geophysical logs is usually larger than the "static stiffness" that is associated with the larger strains experienced as a result of deformations associated with the SAGD process.

In unconsolidated sandstones and weaker formations such as mudstones, as found in the TOTAL Joslyn Creek SAGD Project wells, this difference is not as great as for consolidated sandstones. As such, the log-derived properties provide a good measure of the *in situ* properties.

Conclusions are at the front of this report.

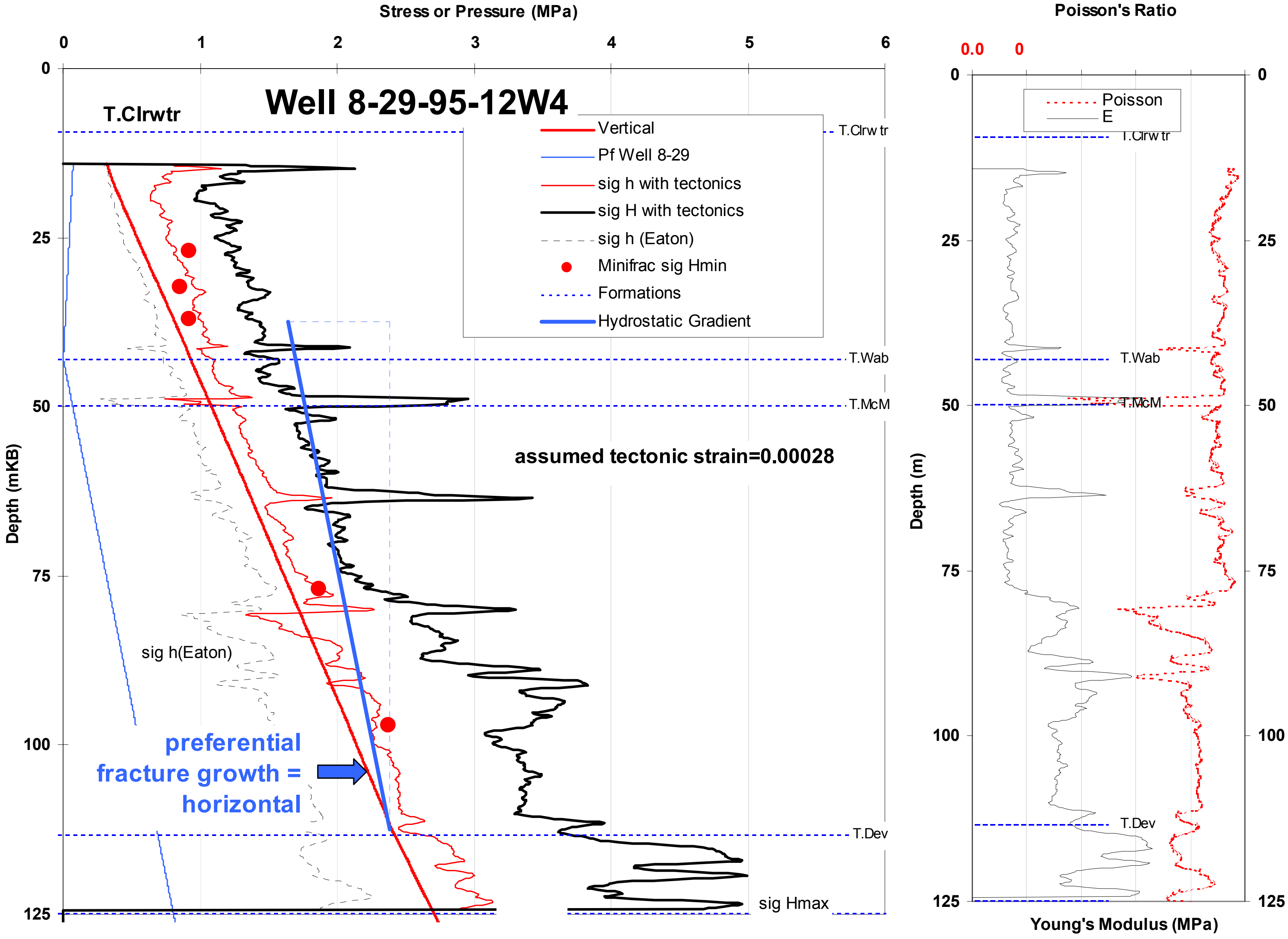


Figure 3.15 Well 8-29-95-12-W4 Rock Stresses and Pressures

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APPENDIX A Log of Field Events

Date	**Time**	**Comment**
11-Dec	10:00	leave for Calgary airport
	15:30	get safety glasses
	17:00	arrive site
	20:00	arrive rig
12-Dec	01:00	shale coring begins
	13:30	shale coring ends
	14:00	end
13-Dec	8h	program prep; lab contact
14-Dec	8:00	Computalog at rig
	(0.5h)	lunch
	16:30	Computalog done logging
15-Dec	8:00	Baker-Hughes on well; rigging-up. No data logger on surface; surface readings must be entered manually every 15 seconds until pressure readings stabilize, in order to monitor test
	(0.5h)	lunch
	14:28	start t1c1 (Test 1, Cycle 1), depth 97-99m (oilsand): good test, but no obvious closure pressure (will process precise downhole data from Baker-Hughes)
	(0.5h)	lunch
	19:29	start t1c2: variable injection pressure; no obvious closure
	22:53	start t1c3: flatline Pinj at overburden pressure; aborted
	23:30	Sanjel turned pump up, not off, at end of injection therefore Test t1c3 aborted.
16-Dec	0:35	start t1c4: flatline Pinj at overburden pressure – possible horizontal frac
	5:00	asked Baker to reduce packer pressure from 600psi; 400psi used
	5:20	ready for t2c1 at 37-39m (Clearwater shale)
	6:30	time check proved the Baker pressure monitor reading at ~13.25 seconds, not 15 seconds
	7:00	Baker packers initially at 600psi; reduced to 400psi over test --> exceeds frac pressure of 350psi
	7:20	pressure falloff too rapid; pull & set assembly into surface csg for pressure test
	(0.5h)	breakfast
	10:00	pressure tested, with packers at 1400psi, to 10MPa and, packers at 300psi, to 2MPa
	10:15	trip assembly for visual check
	11:30	remove datapack
	13:00	download pressure data
	13:15	depth 32.2-34.2m, top off water to surface casing with water truck, circulate through tubing
	14:00	inflate packers to < 300psi (slow process)
	14:36	start t3c1
	15:33	end t3c1; high breakdown, good extension, ISIP; rapid fall-off – excellent test
	16:18	start t3c2
	17:17	end t3c2; good injection behaviour, same ISIP, odd falloff behaviour
	17:30	while waiting for formation to calm, put valve back between string and pump
	17:55	start t3c3
	18:55	end t3c3; similar to t3c2, constant injection pressure, similar ISIP, odd fall-off behaviour at end
		move assembly uphole
	19:48	supper
	21:50	start t4c1
	22:53	end t4c1
17-Dec	0:25	start t4c2

	1:27	end t4c2
	2:56	start t4c3
	3:41	end t4c3
	3:50	bleed packers, trip, increase packer interval to 5m
	7:00	trip in
	8:38	circulate, then set packer
	9:15	packers set; pump down
	9:55	start t5c1
	12:20	end t5c1; false start on c2: frozen lines
	12:34	~10 litres pumped, raising base pressure to 112 psi now, although no immediate increase downhole above 108psi
	12:36	start t5c2
	13:56	end t5c2
		bleed off pressure: no drop from 112 psi
	14:10	start t5c3
	14:29	pump failure, well shut-in. test continues
	14:35	test aborted when Sanjel pumpers broke connection on shut-in system
		Sanjel tank dry; wait on water truck
	17:20	water truck
	17:30	start t5c4
	18:30	stop t5c4, some flow from surface casing
	(19:00-20:00)	dinner
	20:00	retrieve packers & data
	22:30	data downloaded & packer disassembled; leave rig site
	23:00	return radio to Village, acquire full data set from Baker-Hughes, data check for quality & correctness
18-Dec	01:00	end
	07:00	leave for Ft. McMurray (YMM) airport

APPENDIX B Log-Derived Geomechanical Properties

B.1 Introduction

Petrophysical logs can be used to estimate some geomechanical properties. A profile of the Young's modulus "E" and Poisson's ratio "ν" can determined from the shear and compressional sonic slowness, Δt_c and Δt_s (μs/m) and the bulk density, ρ_b (**Figure B.1**). The method provides a continuous profile of mechanical properties, which is useful in delineating differences between near-uniform zones, and in identifying weaker zones

However, the method assumes that the rock is homogeneous: there is no allowance for directional variations in the material properties. Furthermore, the extremely small strains associated with sonic sampling make the rock appear to be stronger and stiffer than it performs under the larger deformations that would be experience during drilling. Never-the-less, this method provides a means of estimating some geomechanical parameters which, when compared with laboratory results, becomes a useful tool with which to evaluate the formations.

B.2 Elastic Parameters, E and ν

The "R_v" ratio of the sonic velocities is defined as the shear sonic transit time divided by the compressional sonic travel time:

$$R_v = \frac{\Delta t_s}{\Delta t_c} \qquad \text{[B.1]}$$

The dynamic **Poisson's ratio,** ν, can be determined from this ratio as:

$$\upsilon = \frac{2 - R_v^{\,2}}{2\left(1 - R_v^{\,2}\right)} \qquad \text{[B.2]}$$

The dynamic Poisson's ratio obtained from the sonic logs is generally smaller than the static Poisson's ratio obtained from geomechanical laboratory core tests since the dynamic value is determined from extremely small-strain deformations. At these strains, very weak cementation bonds are not broken, resulting in stiffer and less plastic deformations. At the larger strains imposed on the rock during destructive laboratory testing, the strength of these weak bonds is easily exceeded and the rock behaves more plastically.

Young's modulus, E, is obtained from the sonic velocity ratio and the rock's bulk modulus:

$$E = \frac{\rho_b\left(4 - 3R_v^{\,2}\right)}{\left(\Delta t_s\right)^2\left(1 - R_v^{\,2}\right)} \qquad \text{[B.3]}$$

The log-derived Poisson's ratio and Young's modulus for Well 8-29-95-12-W4 are shown in **Figure B.2**.

The shale volume, V_{sh}, of the rock was linearly interpolated between the two extreme values of shaliness detected over the entire logged interval. The gamma ray log (GR) was used as a measure of shaliness, although in carbonate sequences and in oilsands the corrected or "stripped" gamma ray is preferred to the gamma ray due to the presence of non-clay radioactive minerals. This can be seen in **Figure B.2** where the gamma ray and stripped gamma ray traces diverge over several intervals. Over those intervals, the gamma ray response alone would give an inflated estimate of shaliness.

$$V_{sh} = \frac{GR - GR_{\min}}{GR_{\max} - GR_{\min}} \qquad [B.4]$$

B.3 Unconfined Compressive Strength

Similarly, a value was calculated for the uniaxial compressive strength (UCS) of the rock, using Young's modulus, the shale volume, and the internal friction angle, as seen in **Figure B.2**. The shale volume, V_{sh}, was calculated based on the gamma ray response; and ϕ is the internal friction angle for rock, interpolated from 50° to 20° on the basis of increasing shale content, V_{sh}. Low values of UCS within the reservoir may be misleading, as any small amount of confining stress would result in a rock of considerable strength, given the friction angle of 50° for a clean oilsand.

Figure B.1 Well 8-29-95-12-W4 Input Parameters

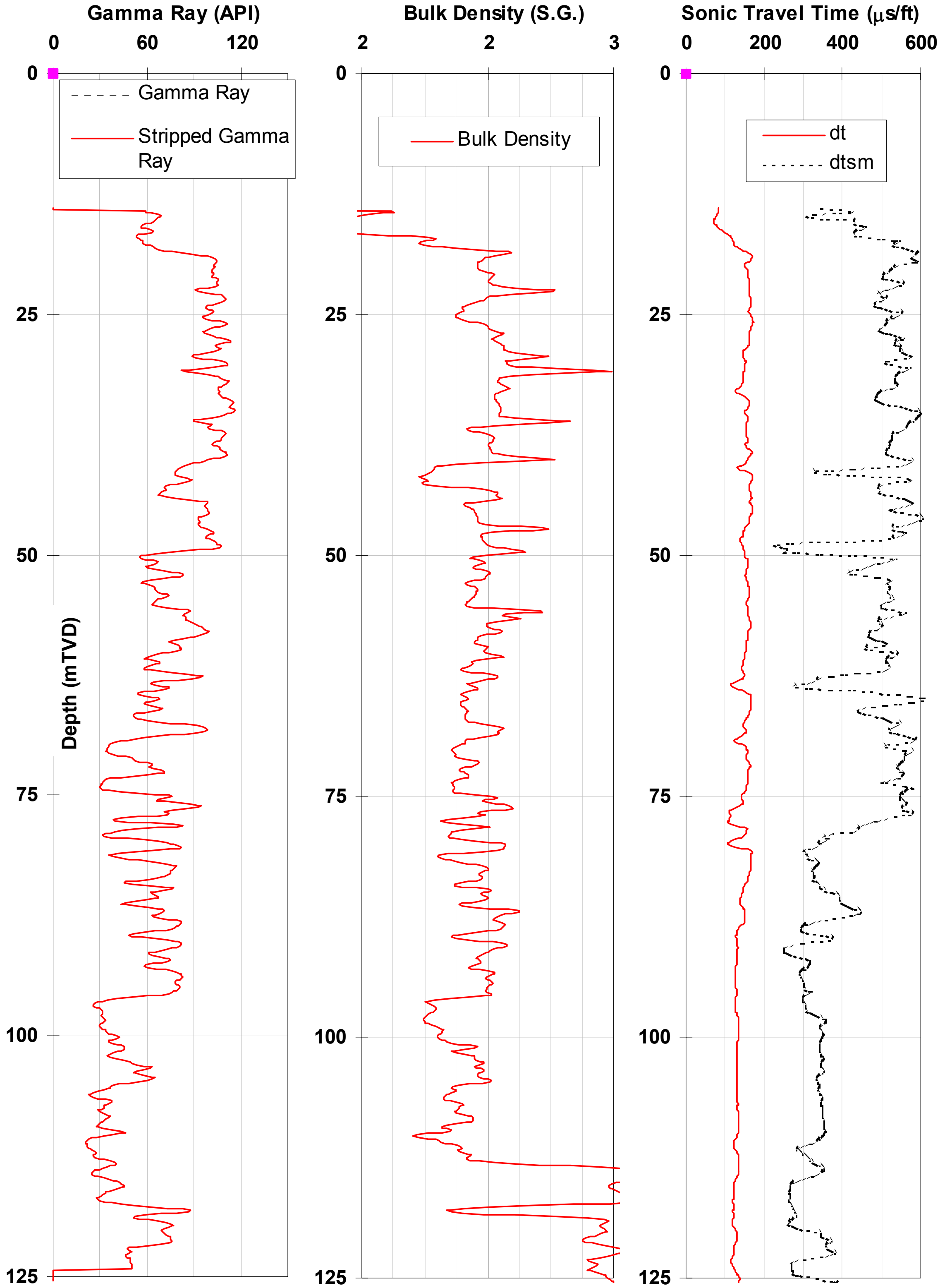
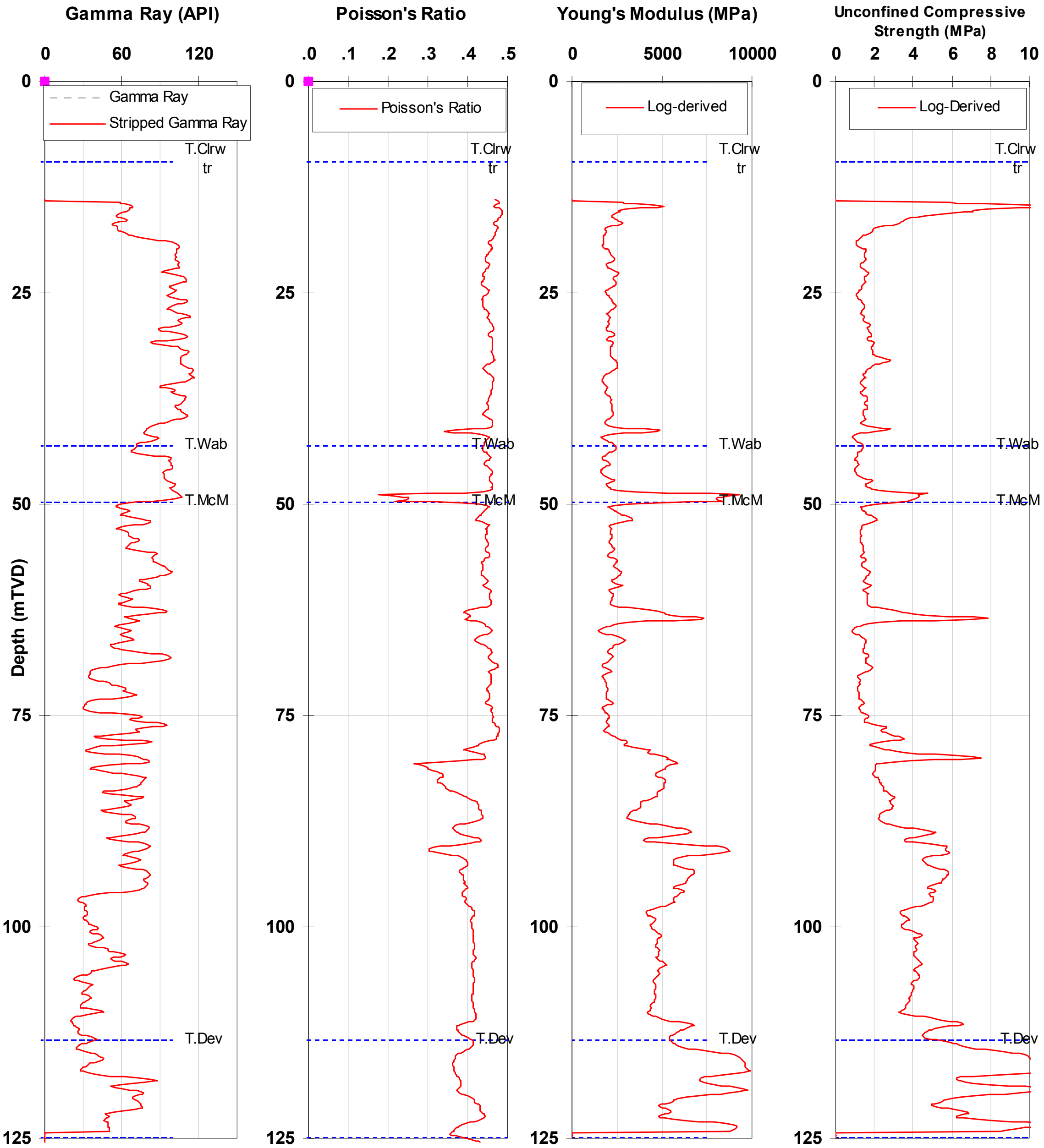


Figure B.2 Well 8-29-95-12-W4 Log-Derived Poisson's Ratio, E, and UCS



B.5 Discussion

Petrophysical logs have been used to derive some geomechanical properties. The largest benefit of the log-derived properties is that they are presented as continuous profiles with depth, providing an insight to the variability and distribution of each property. There is also a significant cost advantage in obtaining these data without having to perform extensive laboratory testing. However, some laboratory testing is always recommended in order to calibrate the log-derived parameters.

There are limitations to log-derived properties:

1. The log-derived properties are largely based on sonic data, and as these are measurements of micro-deformations they may not always be applicable to large-scale deformations. Fortunately, the calculation of the Eaton stress assumes zero strain. Fjaer, et al. (1992) note that the dynamic moduli are significantly higher than static moduli; however, these are for destructive compression tests, . Where the rock has any strain-dependent properties, as would be the case for lightly-cemented clastic rocks, the log-derived properties may not be representative of the rock undergoing larger strains, as would be expected during drilling or drawdown conditions.

2. Next, the derived properties are based on several broad correlations with density, sonic velocity, and shale volume. As such, there will be some difference between the predicted properties and the actual properties, therefore it is essential to conduct a limited number of laboratory tests to calibrate the log-derived predictions. As an example, if the log-derived predictions are generally 30% greater than the laboratory results from core taken at discrete locations, the log-derived values should be scaled down to match the laboratory results. Other assumptions, such as interpolating the rock friction angles on the basis of a shale volume, which is based on the gamma ray, introduced other uncertainties.

The log-derived properties do not take account of rock property anisotropy. Sedimentary rocks in particular have an internal structure that is due to their depositional and post-depositional environments. Typically, rock properties in the horizontal plane are uniform in that they are not dependent upon azimuth, but these properties usually vary significantly form those in the vertical direction. Where rock anisotropy is an issue, e.g.: wellbore stability, the anisotropy should be considered

APPENDIX C Downhole Memory Gauge Data

Figure C.1 Well 8-29-95-12W4 – 1st run (a) Gauge 70024 (b) Gauge 75854

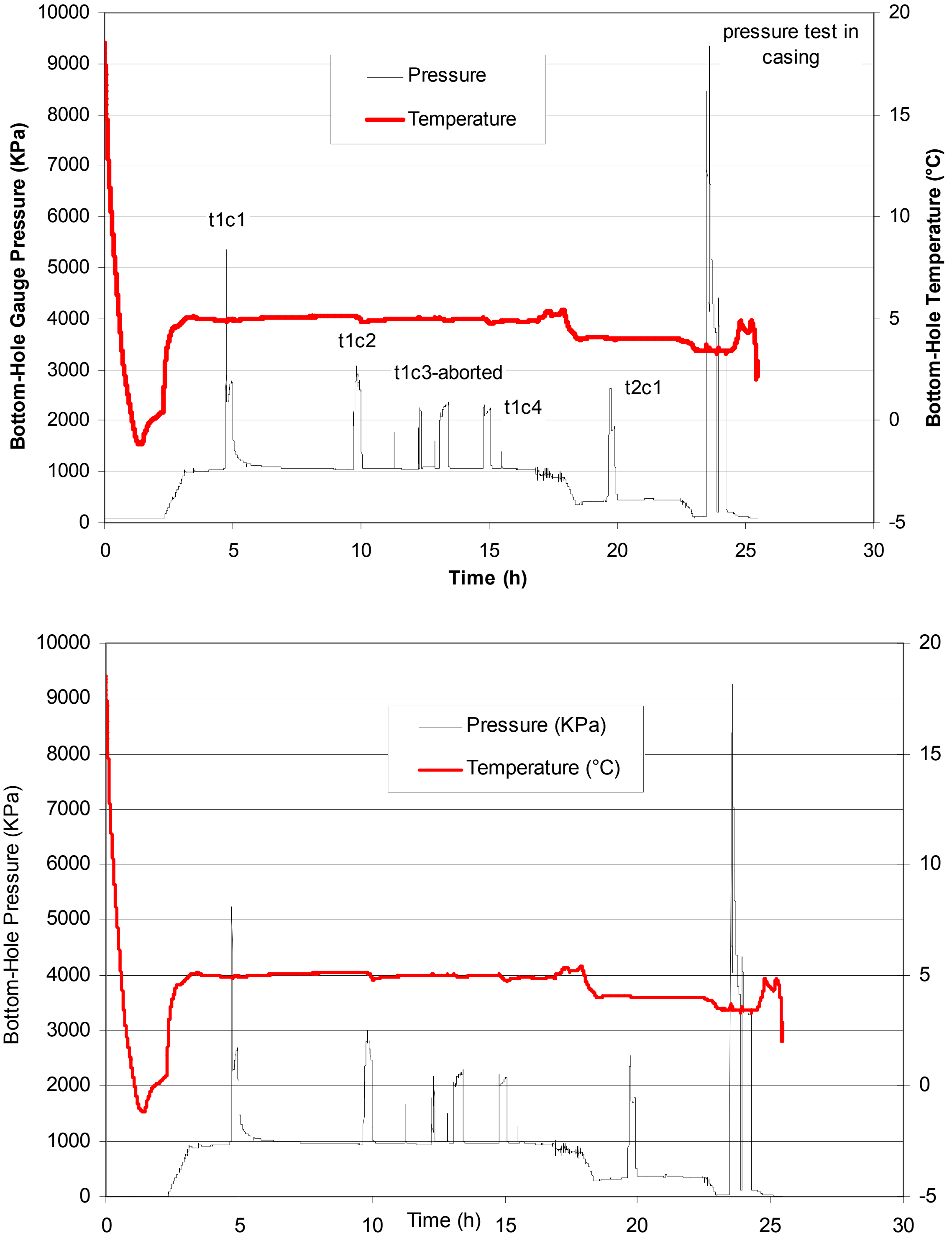


Figure C2 Well 8-29-95-12W4 – 2nd run (a) Gauge 70024 (b) Gauge 75854

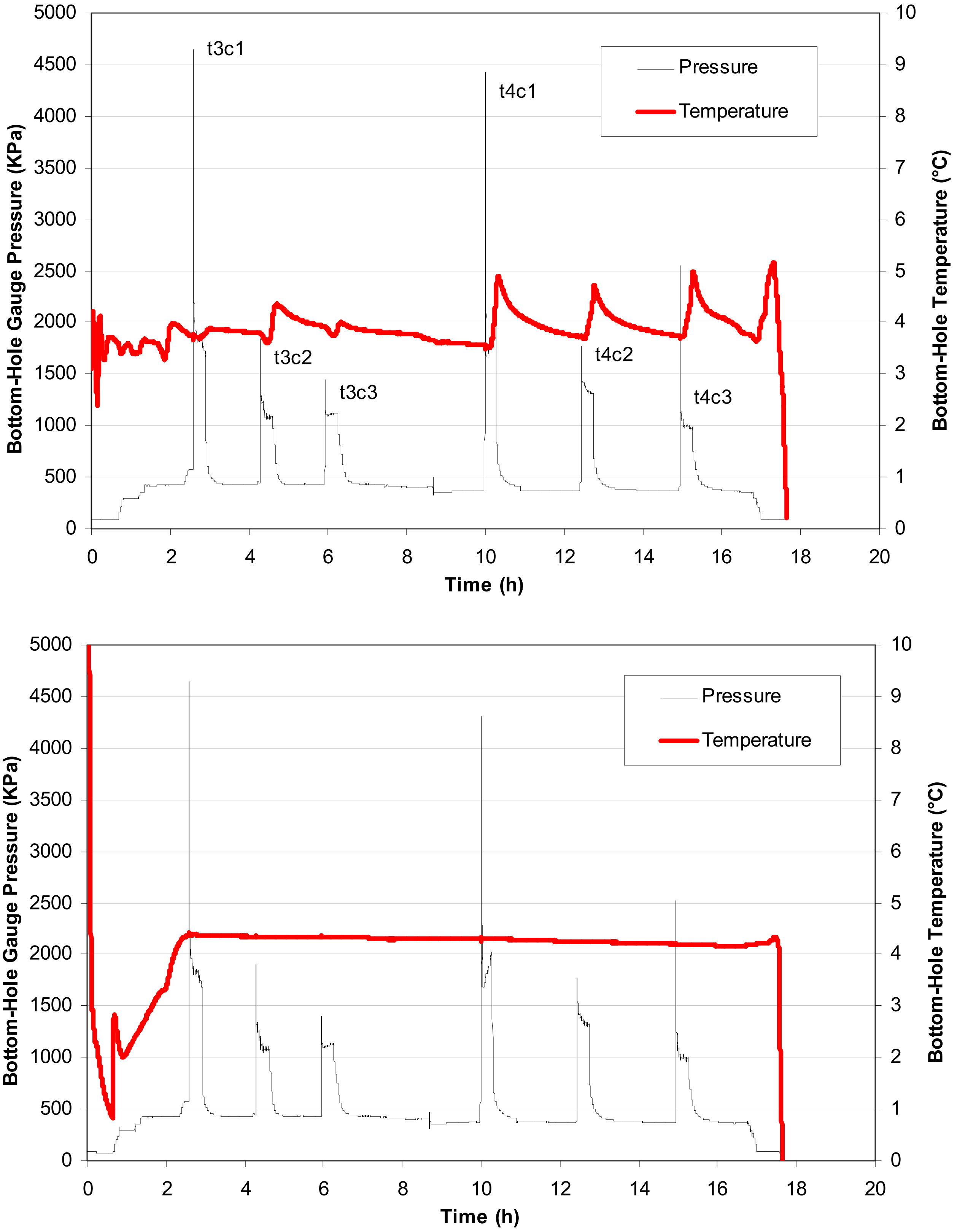
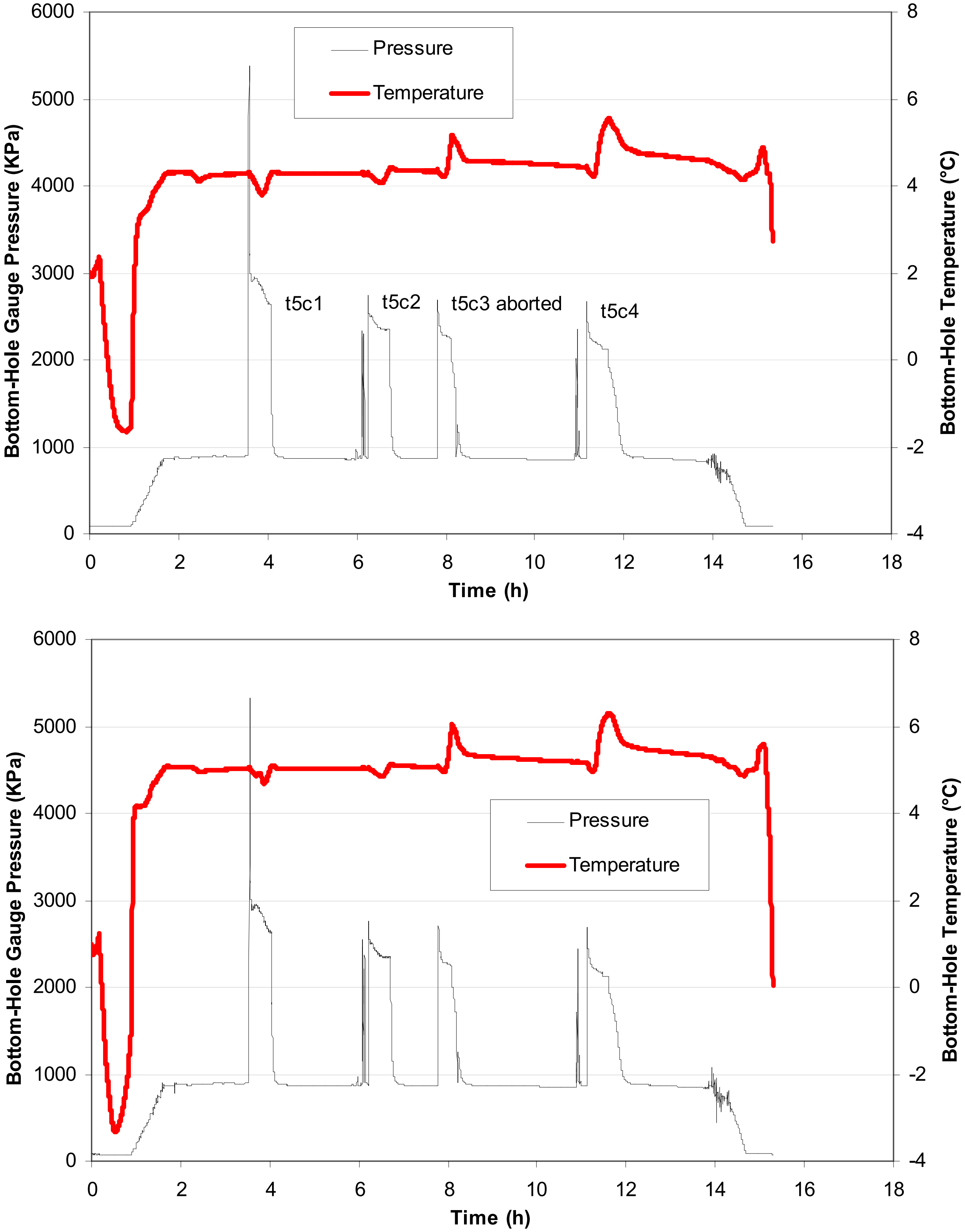
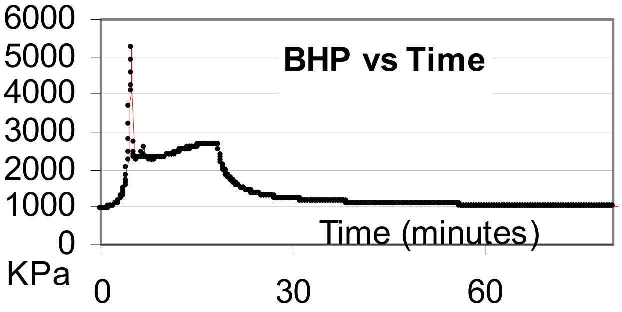


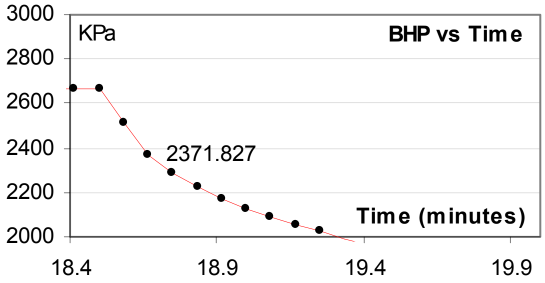
Figure C.3 Well 8-29-95-12W4 – 3rd run (a) Gauge 70024 (b) Gauge 75854

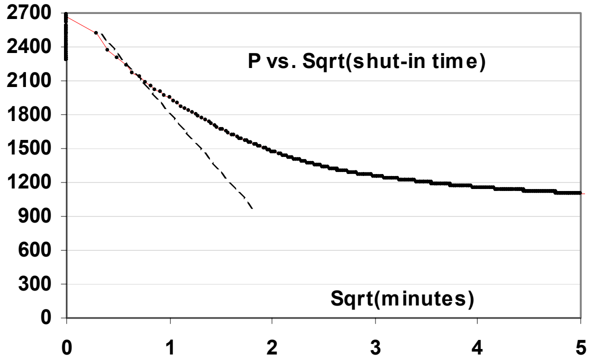


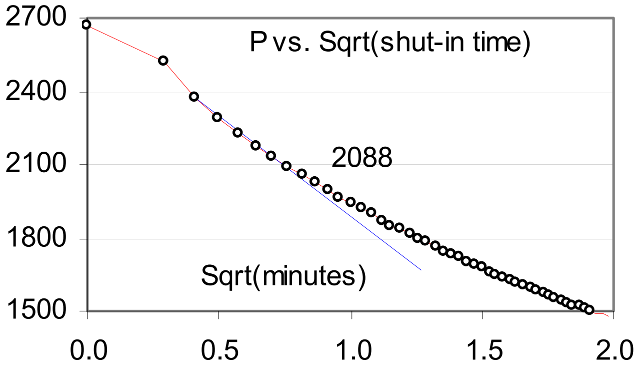
APPENDIX D Minifrac Tests Results

Figure D.1 Test 1 Cycle 1

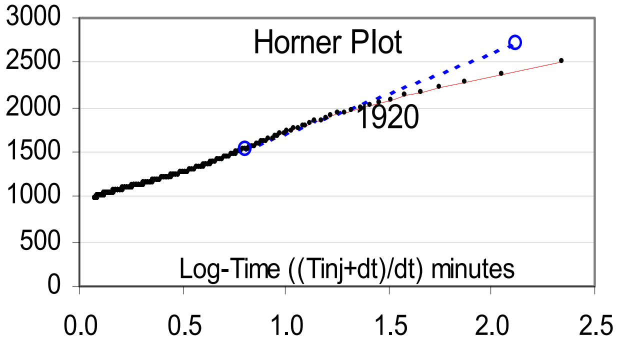


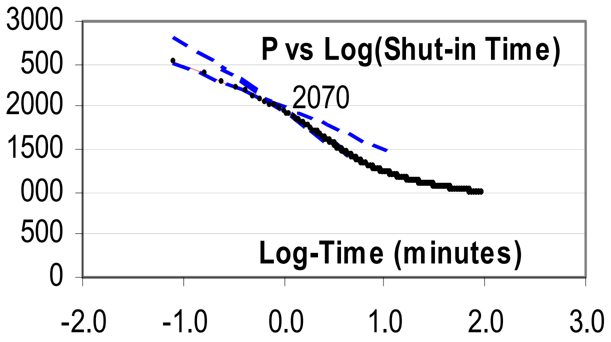






- N.B.: Horner plot provides lower bound to Pc
- Quality of this analysis poor because late time (lower pressure) values deviate from straight line
- Possible frac reorientation from vertical to horizontal at spike at (6.6667s, 2593 KPa)





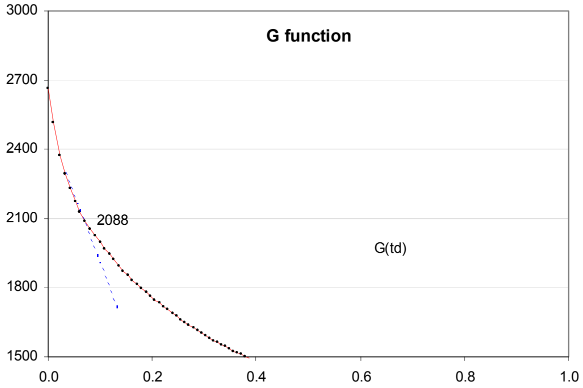
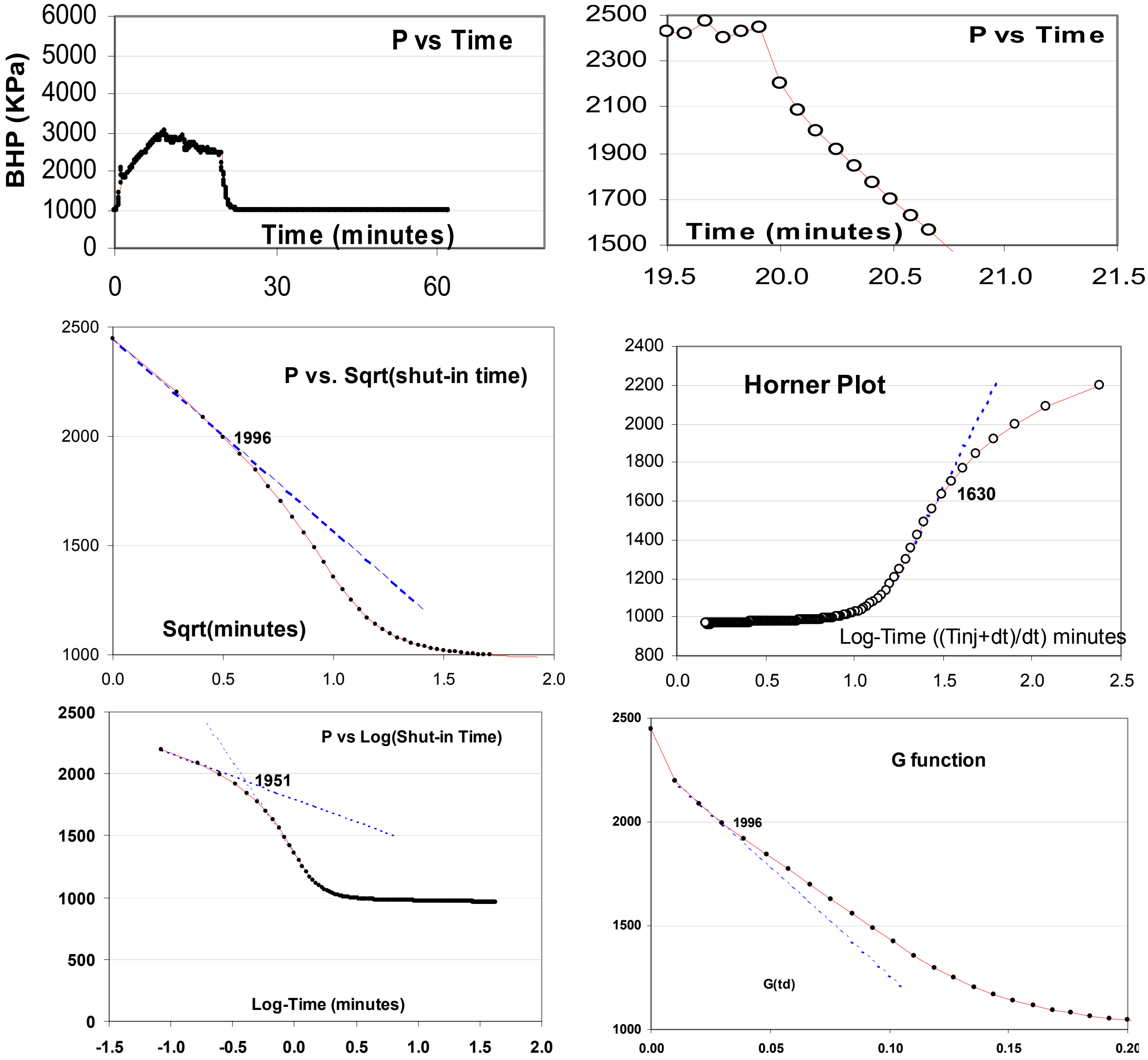
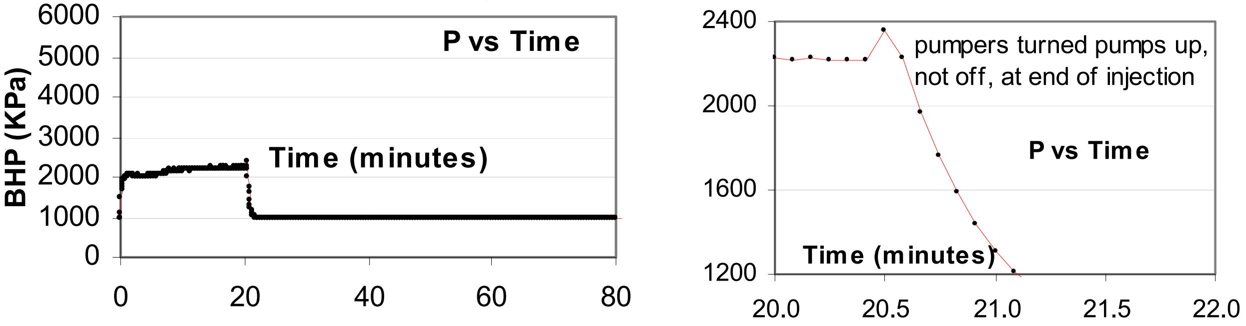


Figure D.2 Test 1 Cycle 2



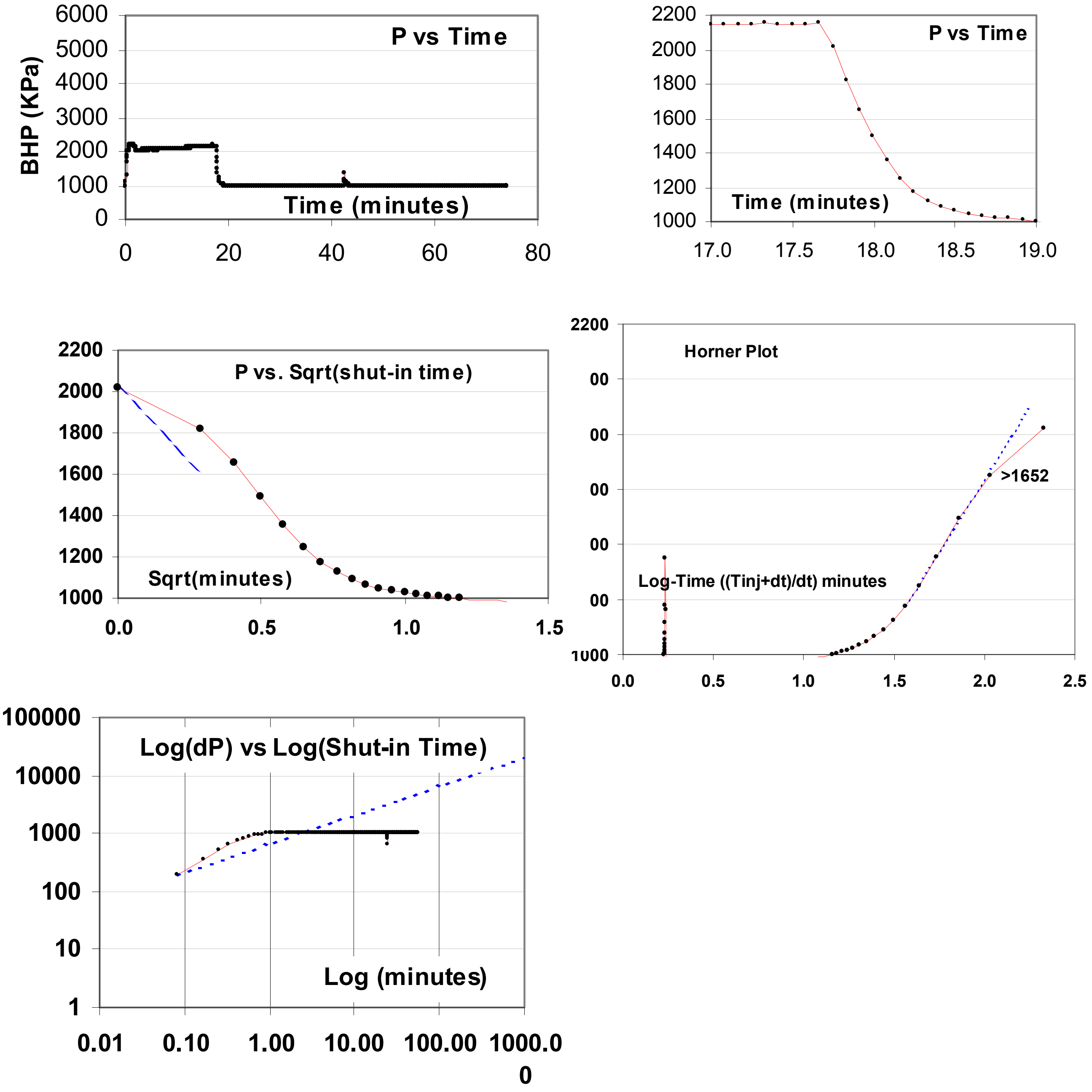
- Rate increased from T1C1 (4 l/min) to 10 l/min to increase fracture storage volume
- Very low re-opening pressure: probable re-opening of a horizontal fracture
- Maximum bottom-hole pressure 3048 KPa (31.42 KPa/m)

Figure D.3 Test 1 Cycle 3



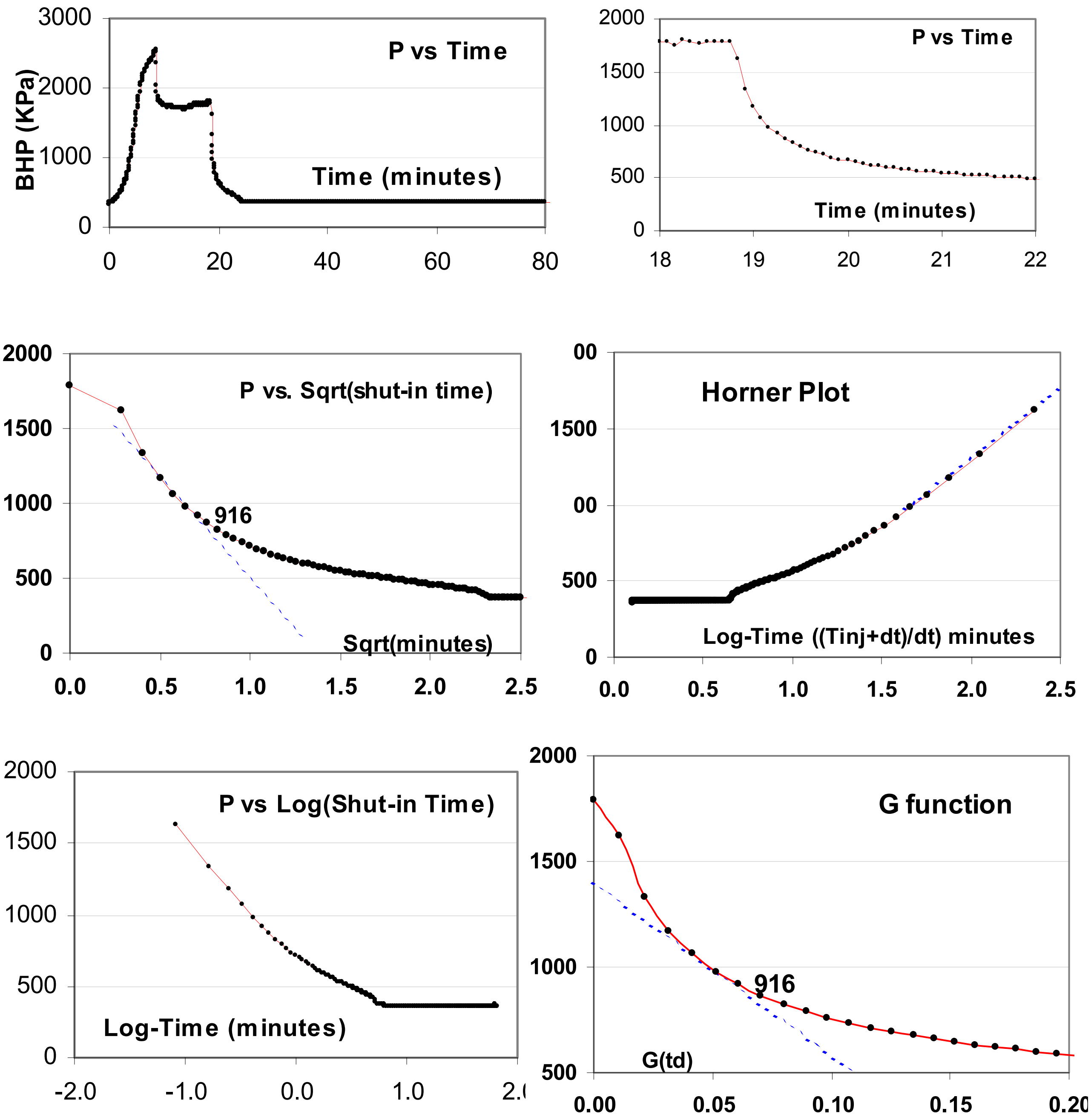
- Sanjel pumpers turned pumps up, not off, at end of injection period
- Cycle aborted
- Pressure bled off

Figure D.4 Test 1 Cycle 4



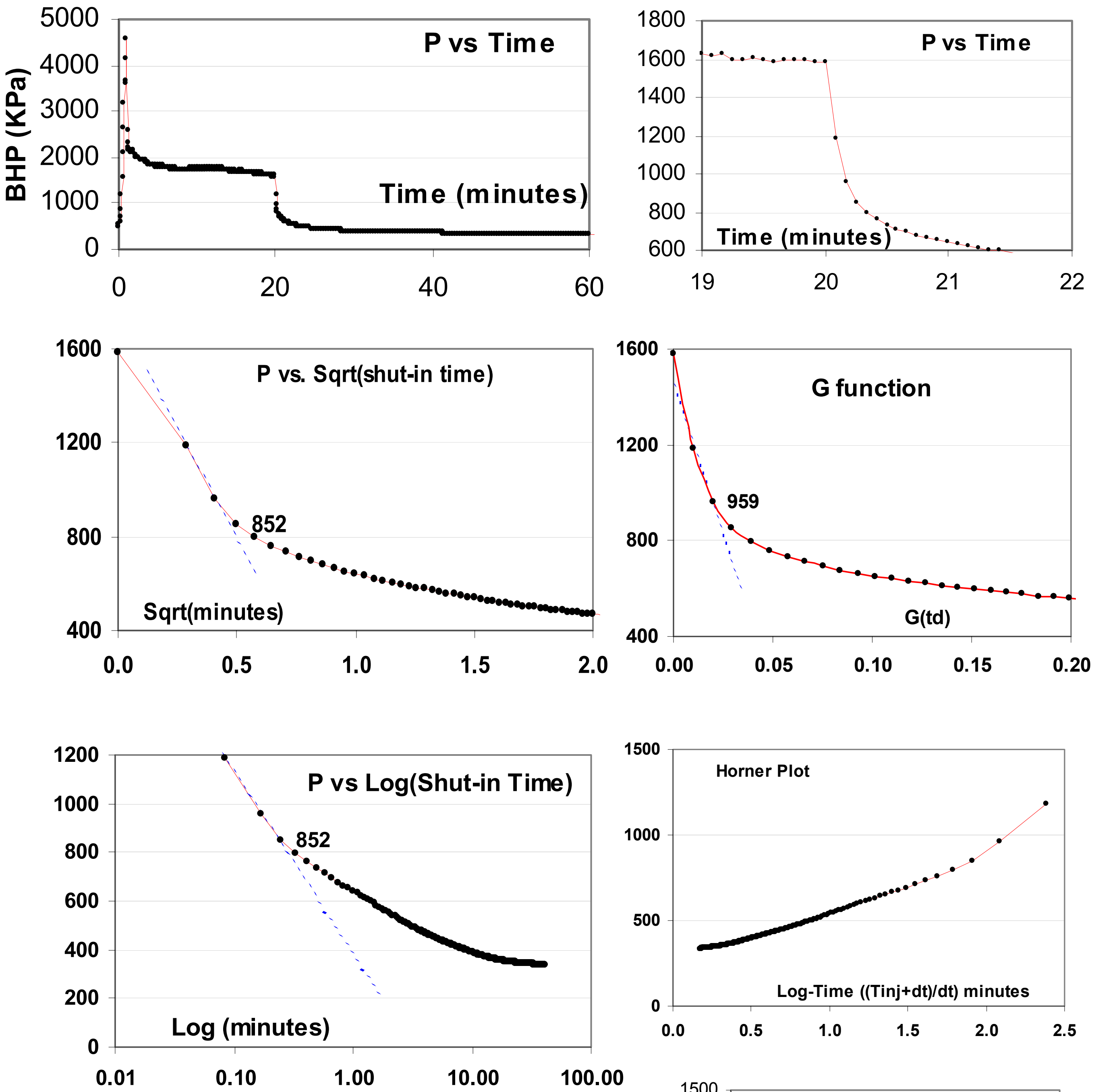
- No peak upon reopening: possible horizontal fracture
- Closure immediately after shut-in: possible leakage past packers
- Insufficient pre-closure data for analysis

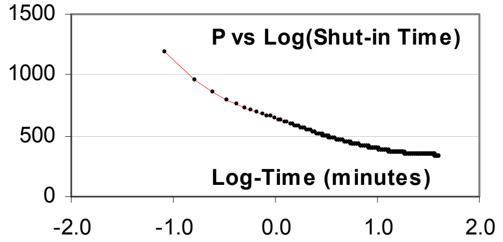
Figure D.5 Test 2 Cycle 1



- Closure soon after shut-in: possible leakage past packers
- Insufficient pre-closure data for analysis
- Packers retrieved to surface for visual inspection

Figure D.6 Test 3 Cycle 1





- Rapid closure
- Inconclusive Horner, log(shut-in time) plots

Figure D.6 Test 3 Cycle 2

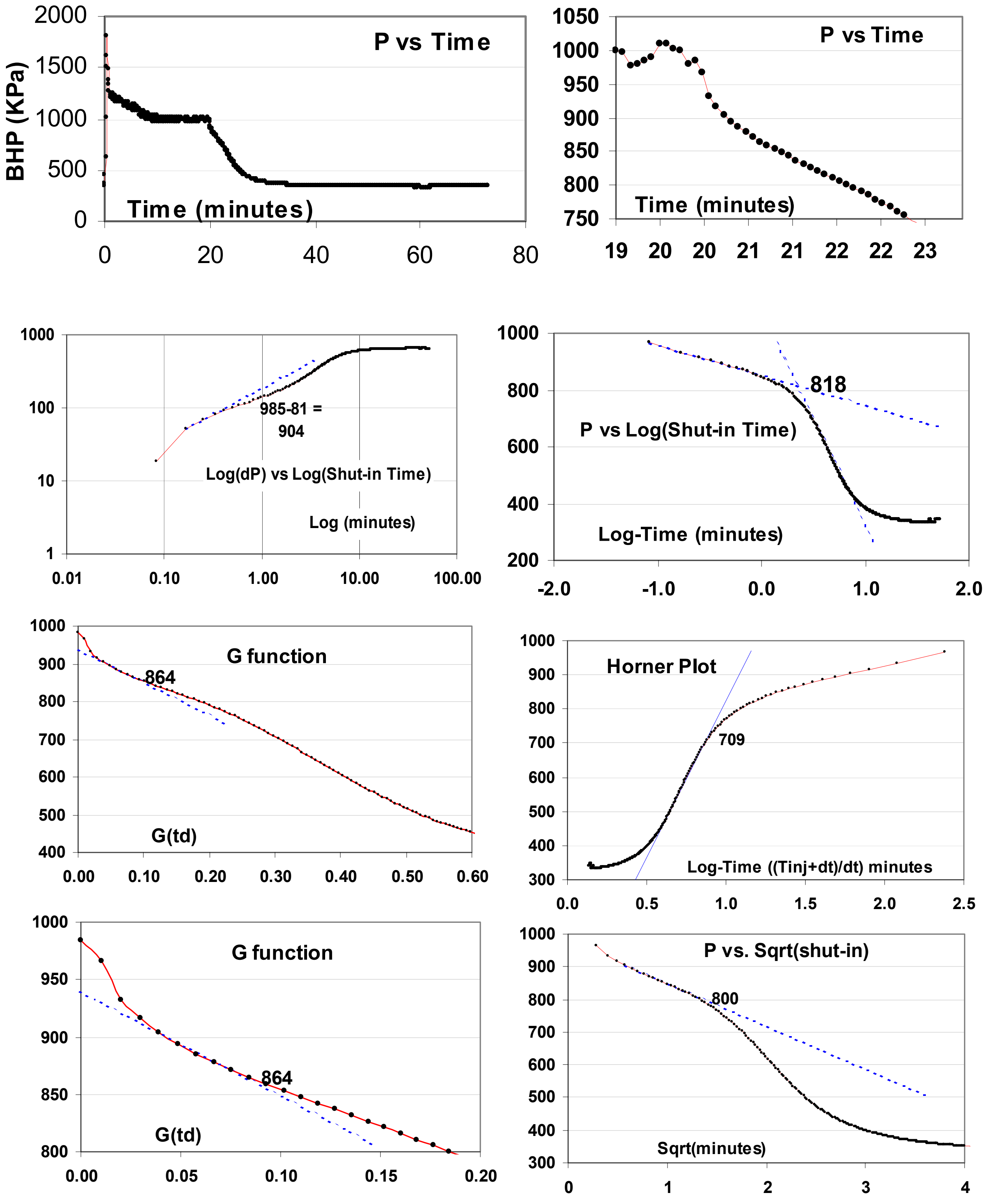
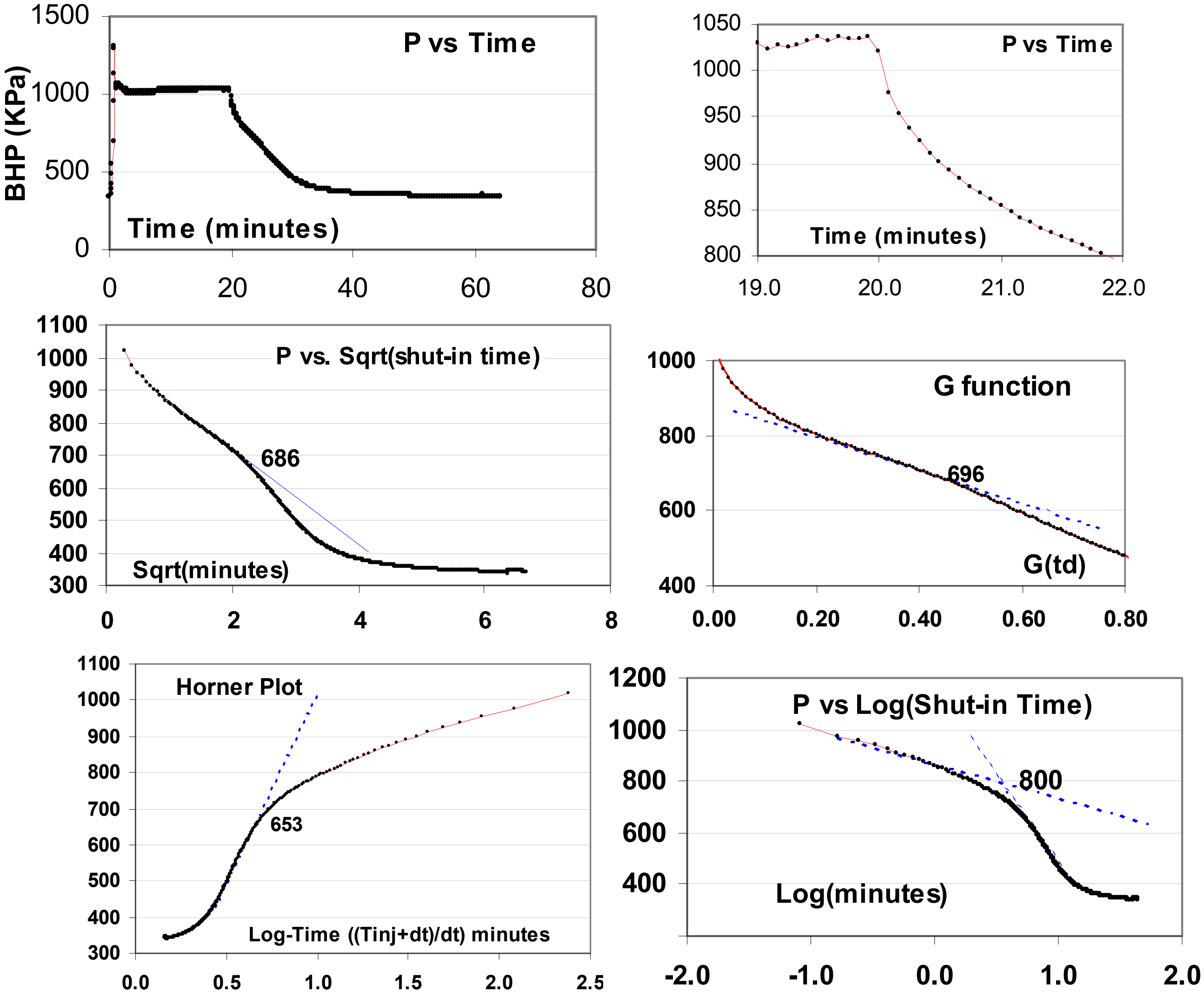


Figure D.6 Test 3 Cycle 3



- Much lower pressures: probable horizontal fracture

Figure D.7 Test 4 Cycle 1

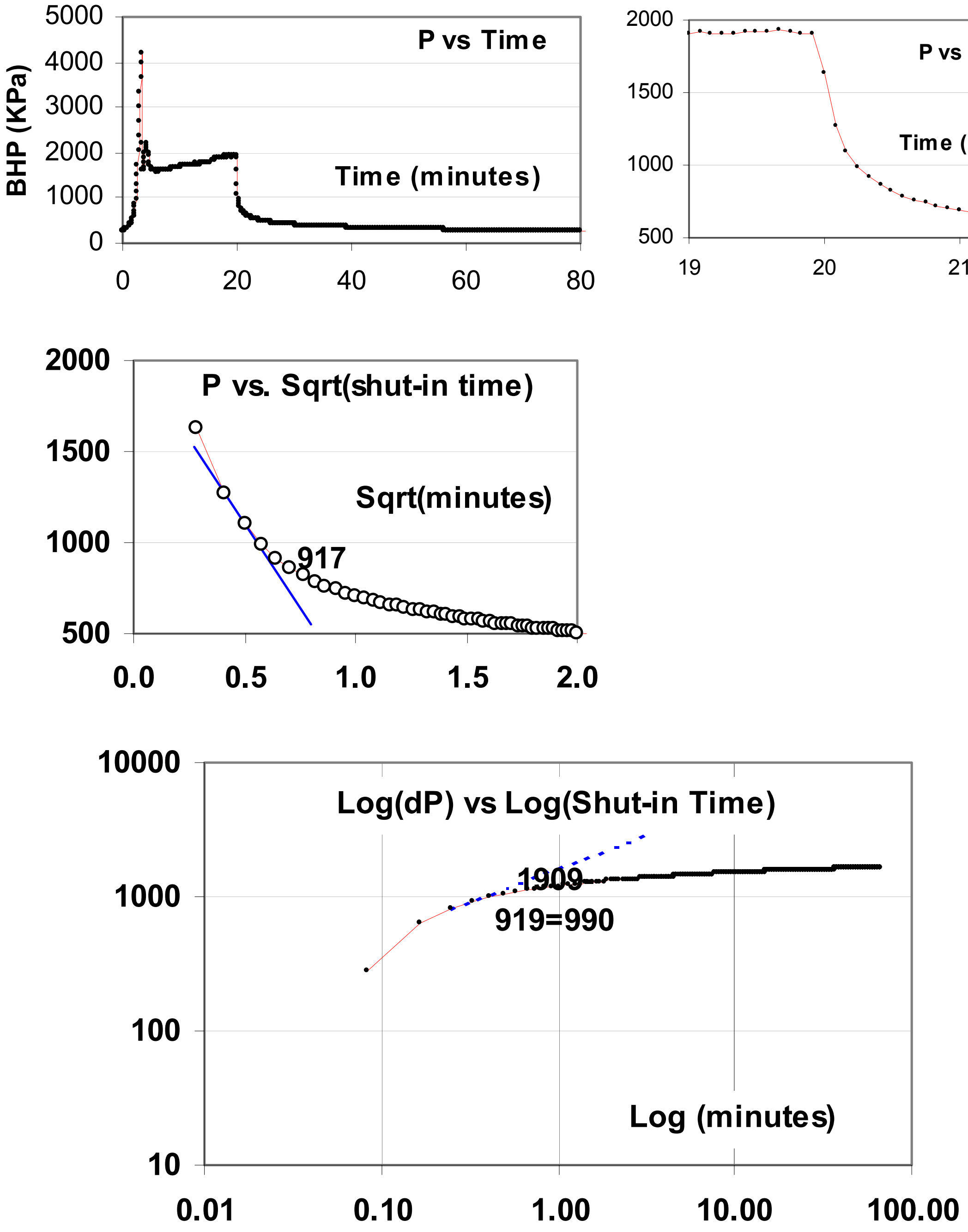
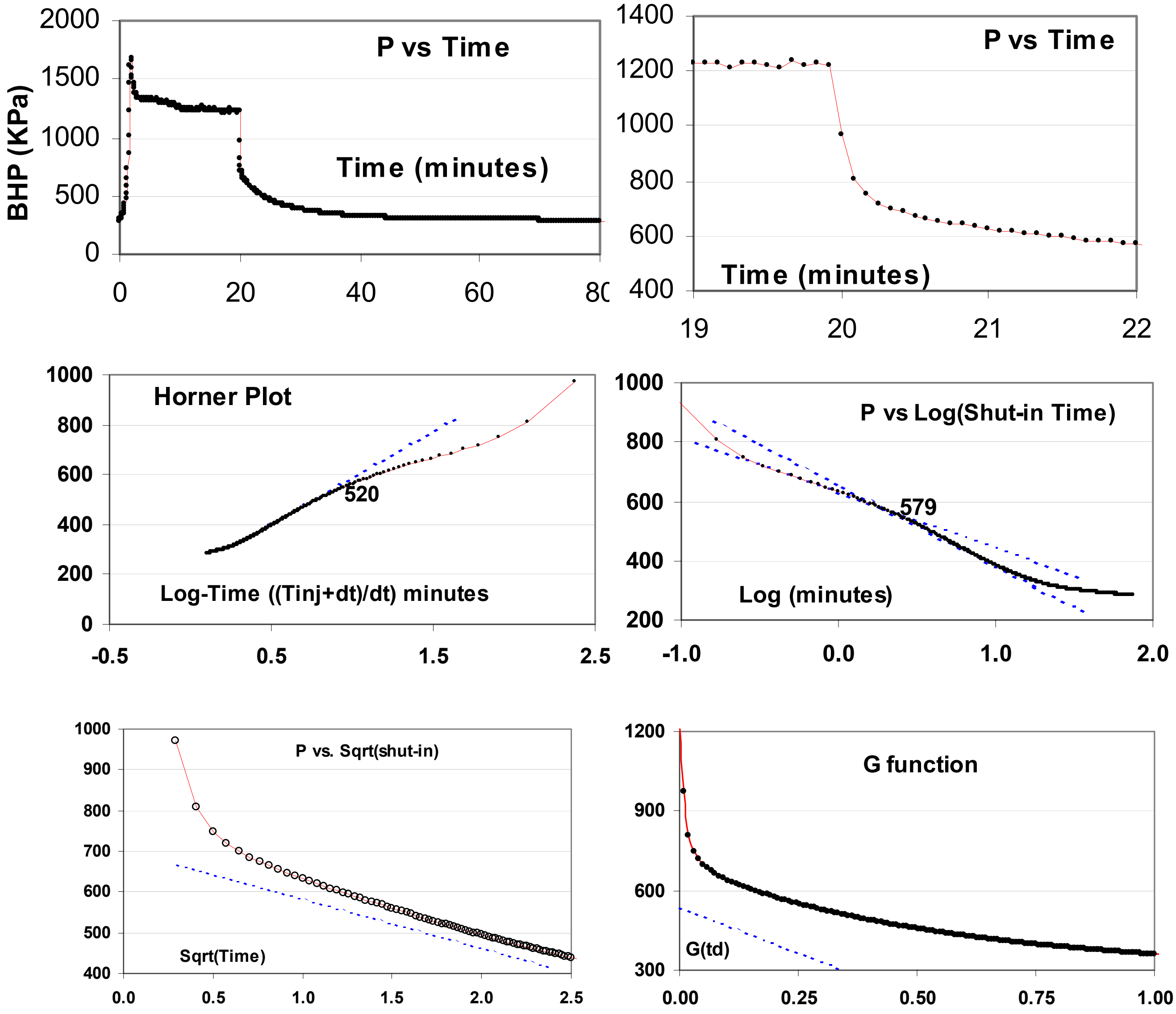
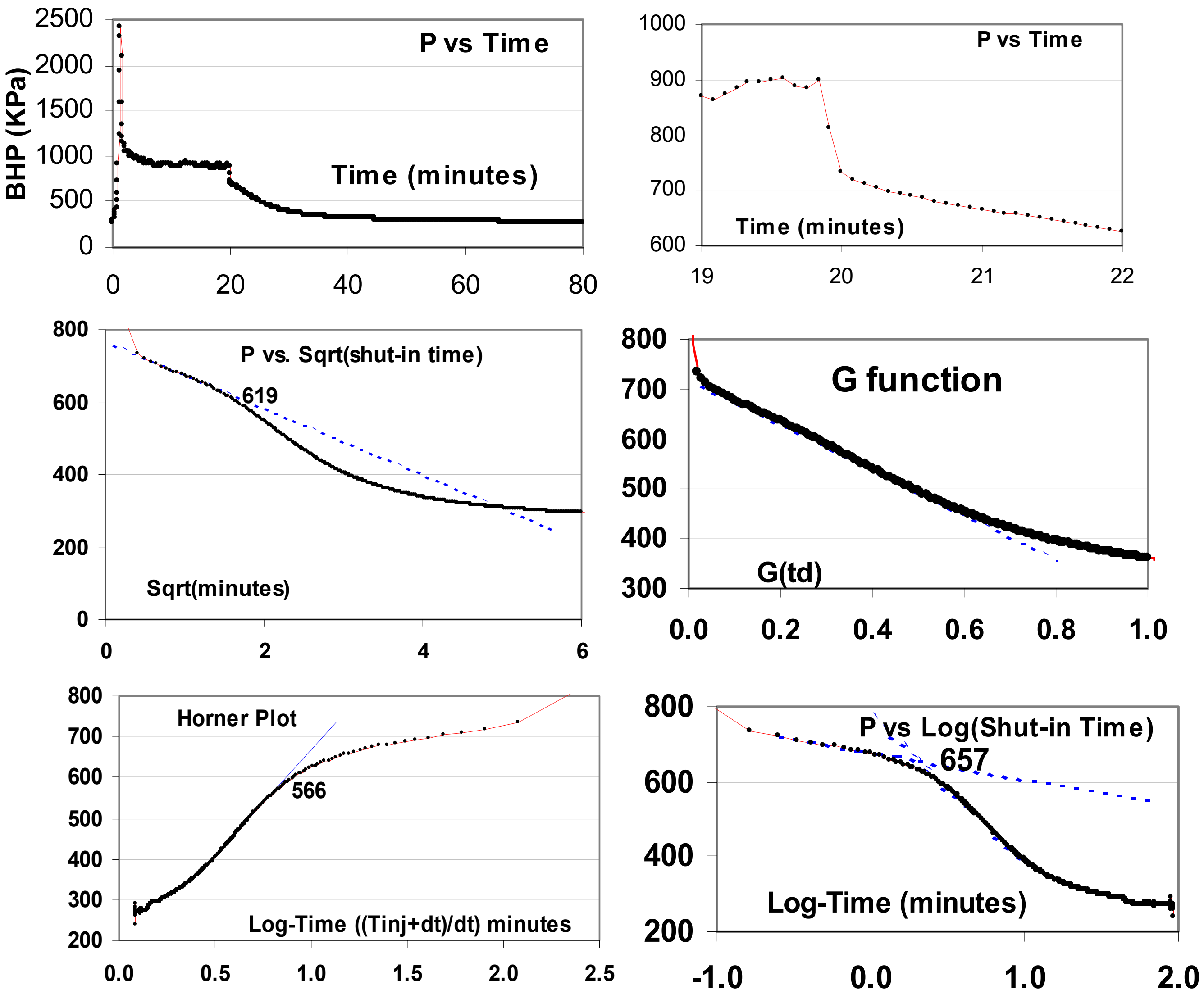


Figure D.8 Test 4 Cycle 2



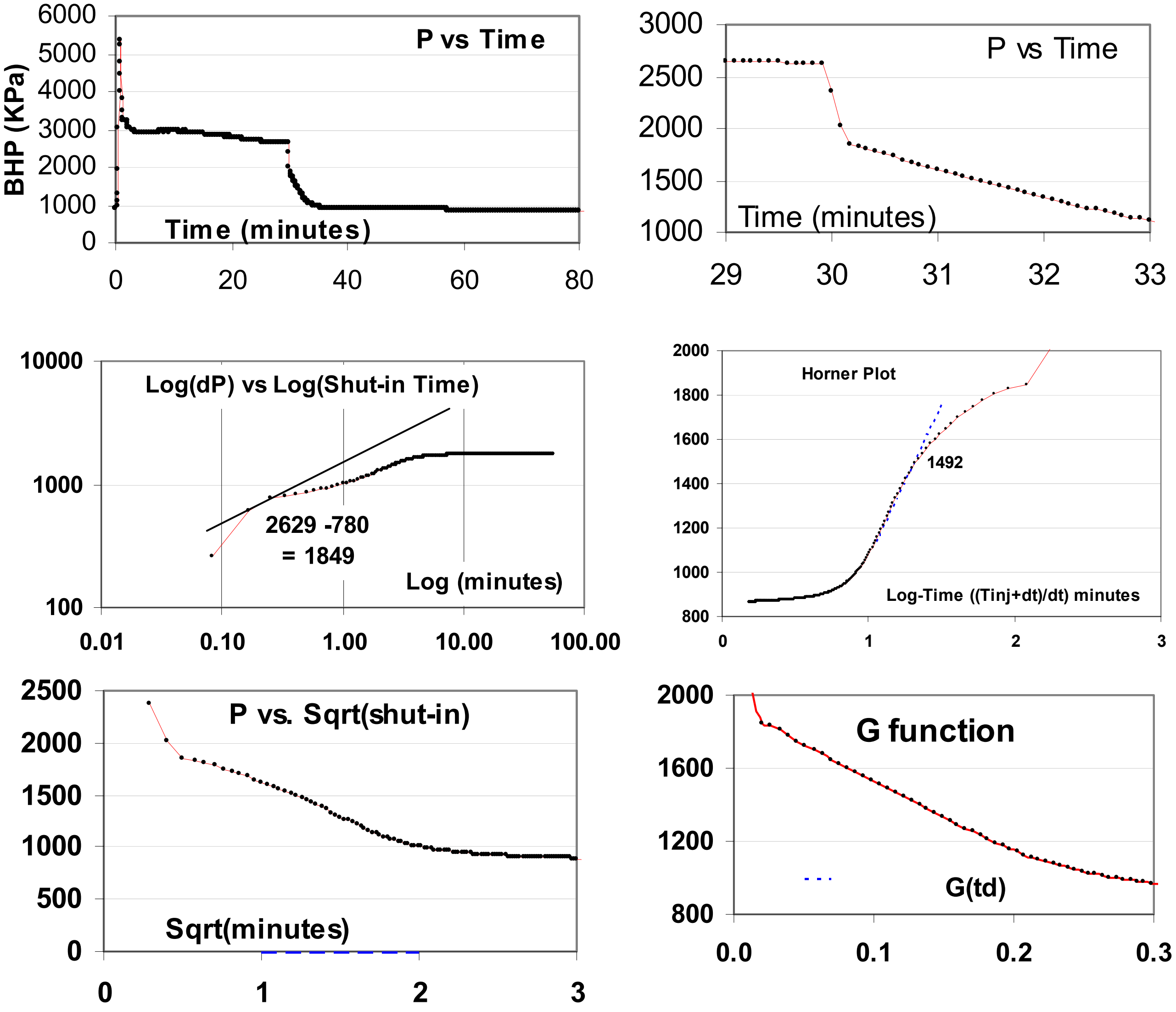
- Some analyses inconclusive

Figure D.9 Test 4 Cycle 3



- G-function inconclusive

Figure D.10 Test 5 Cycle 1



- Very rapid closure
- Inconclusive results

Figure D.11 Test 5 Cycle 2

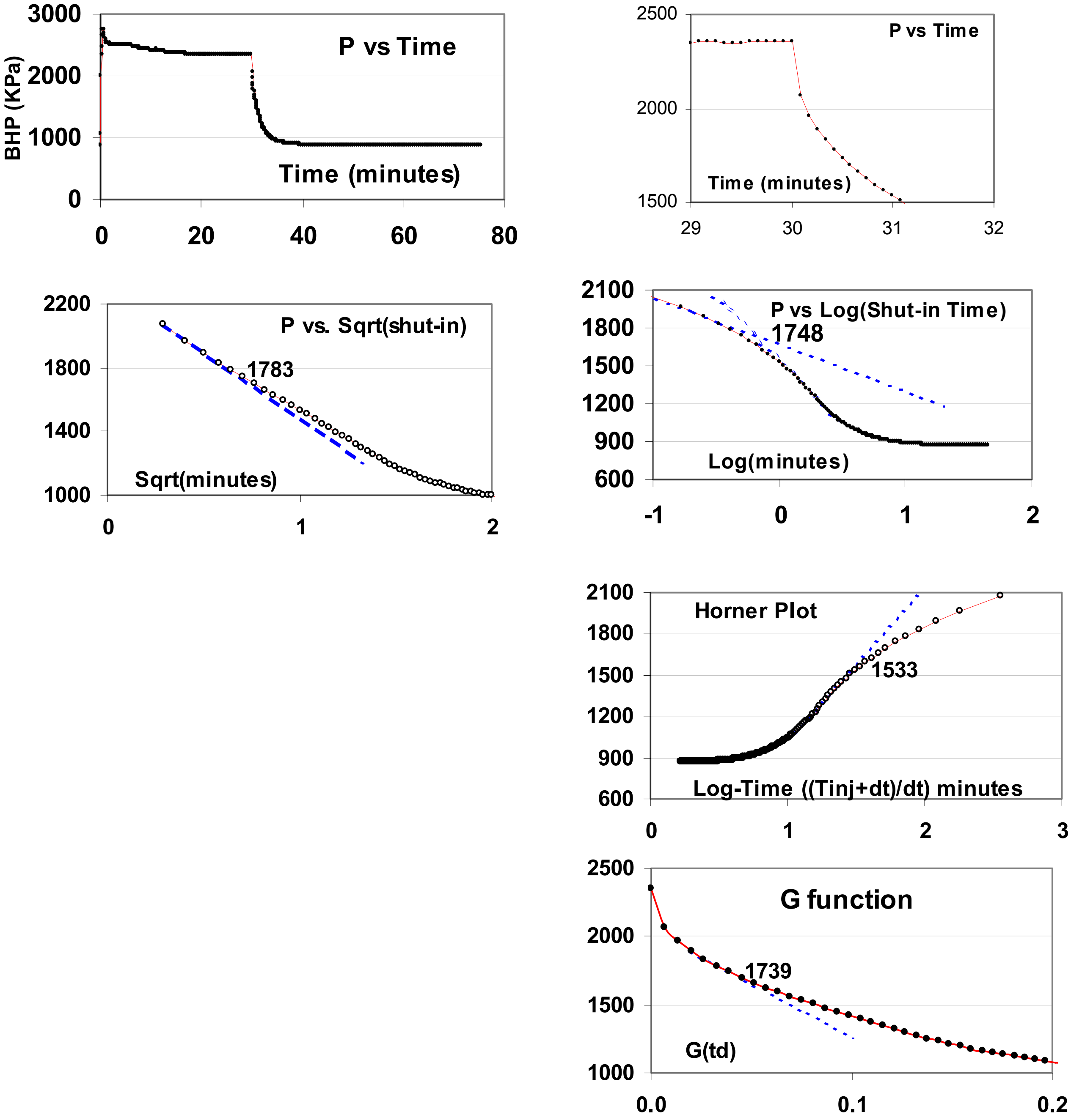
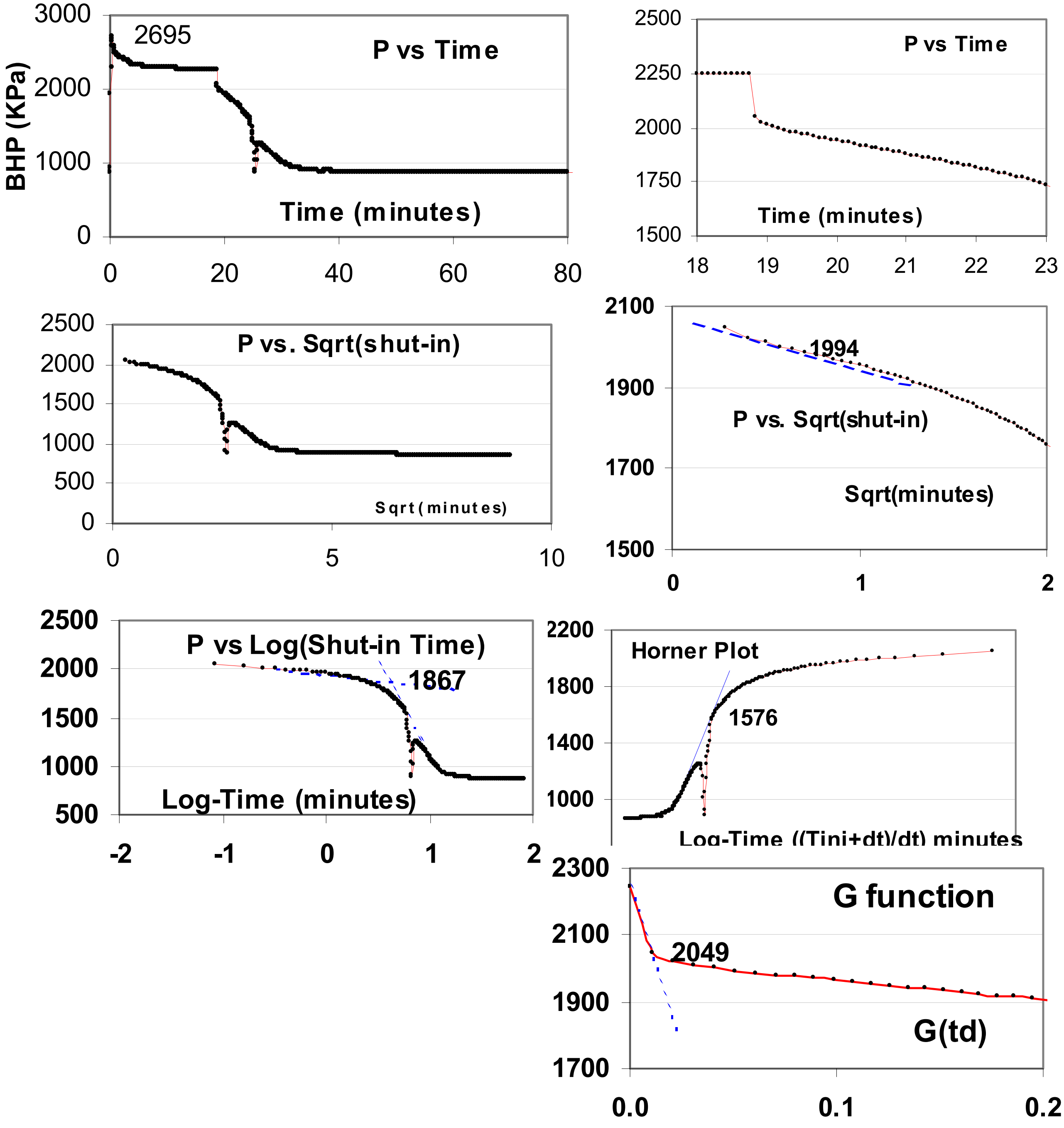
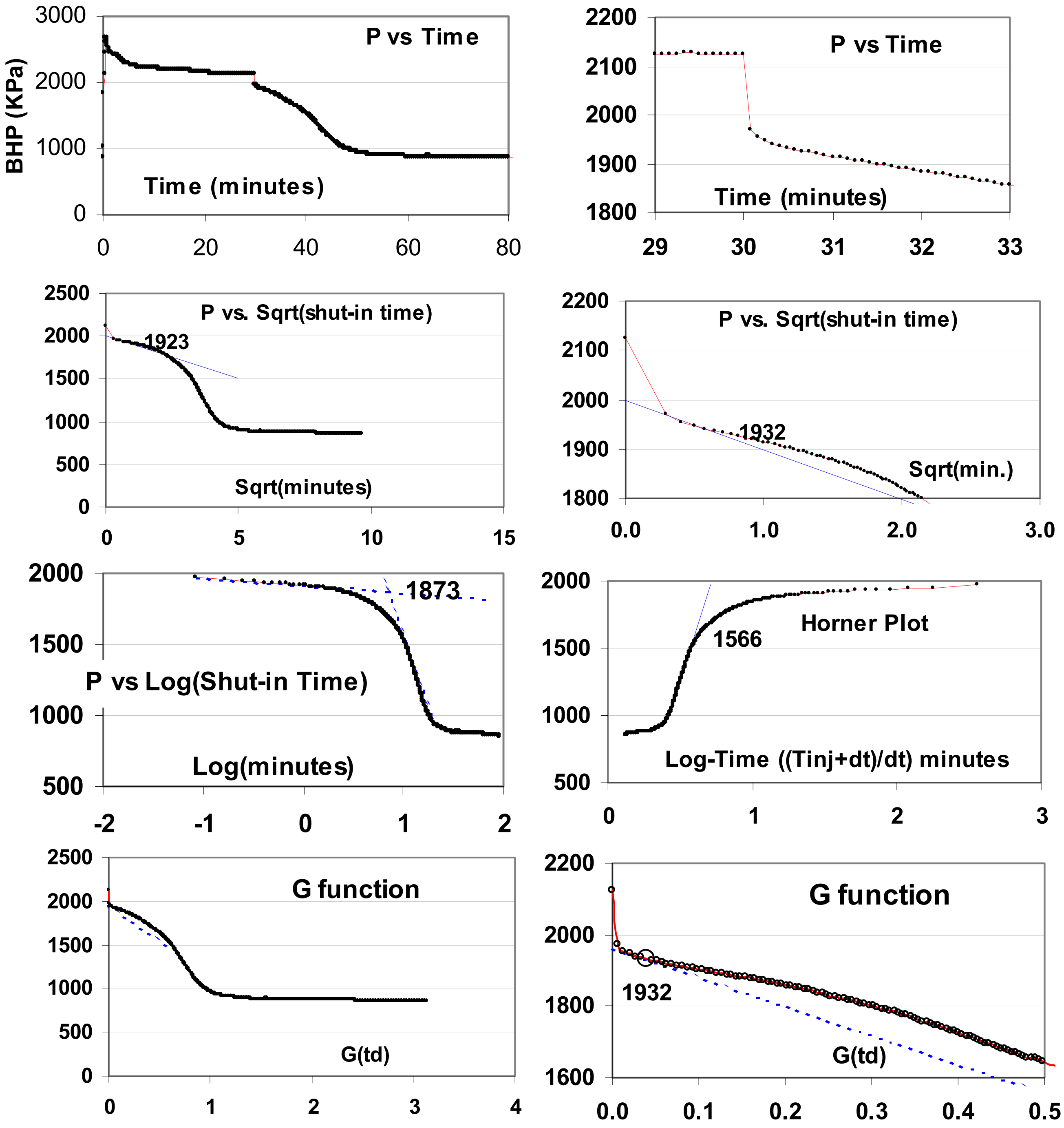


Figure D.12 Test 5 Cycle 3



- Sanjel pumpers broke hydraulic seal mid-test (negative pressure spike)
- Test continued although pressures compromised

Figure D.13 Test 5 Cycle 4



APPENDIX E UTF Stress Data

Table E.1 Comparable Fracture Closure Data, AOSTRA UTF Project

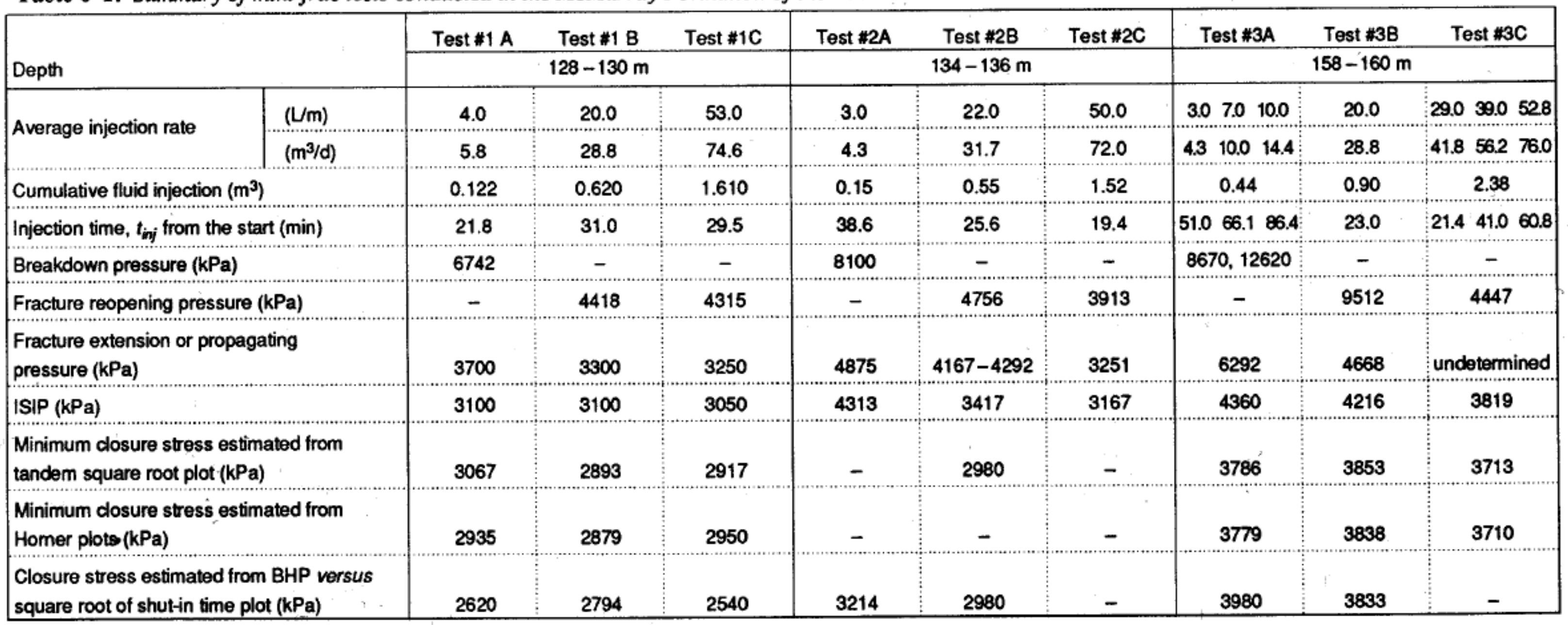


Table 6–1. Summary of mini-frac tests conducted in the McMurray Formation of the Athabasca tar sands.

		Test #1 A	Test #1 B	Test #1C	Test #2A	Test #2B	Test #2C	Test #3A	Test #3B	Test #3C
Depth		128 – 130 m			134 – 136 m			158 – 160 m		
Average injection rate	(L/m)	4.0	20.0	53.0	3.0	22.0	50.0	3.0 7.0 10.0	20.0	29.0 39.0 52.8
	(m³/d)	5.8	28.8	74.6	4.3	31.7	72.0	4.3 10.0 14.4	28.8	41.8 56.2 76.0
Cumulative fluid injection (m³)		0.122	0.620	1.610	0.15	0.55	1.52	0.44	0.90	2.38
Injection time, t_{inj} from the start (min)		21.8	31.0	29.5	38.6	25.6	19.4	51.0 66.1 86.4	23.0	21.4 41.0 60.8
Breakdown pressure (kPa)		6742	–	–	8100	–	–	8670, 12620	–	–
Fracture reopening pressure (kPa)		–	4418	4315	–	4756	3913	–	9512	4447
Fracture extension or propagating pressure (kPa)		3700	3300	3250	4875	4167–4292	3251	6292	4668	undetermined
ISIP (kPa)		3100	3100	3050	4313	3417	3167	4360	4216	3819
Minimum closure stress estimated from tandem square root plot (kPa)		3067	2893	2917	–	2980	–	3786	3853	3713
Minimum closure stress estimated from Horner plots (kPa)		2935	2879	2950	–	–	–	3779	3838	3710
Closure stress estimated from BHP *versus* square root of shut-in time plot (kPa)		2620	2794	2540	3214	2980	–	3980	3833	–

(ref. Hannan & Nzekwu, 1992)

Table E.2 Fracture Closure Gradients, AOSTRA UTF Project

Pc (KPa/m)	Test#1 A	Test #1 B	Test #1 C	Test #2 A	Test #2 B	Test #2 C	Test #3 A	Test #3 B	Test #3 C
ISIP	24.22	24.22	23.83	32.19	25.50	23.63	27.59	26.68	24.17
Tandem sqrt	23.96	23.96	22.79	-	22.24	-	23.96	24.39	23.50
Horner	22.93	22.49	23.05	-	-	-	23.92	24.29	23.48
Sqrt(shut-in)	20.47	21.83	19.84	23.99	22.24	-	25.19	24.26	-

APPENDIX F Stress Orientation from Borehole Breakouts

F.1 Theory

When a borehole is drilled into a rock mass, the initial stress state in the rock is altered in the vicinity of the borehole because of the removal of the support from the drilled rock and its replacement with an internal mud pressure. These changes in stress result in new stress states in the rock that may exceed the strength of the rock. In such cases the rock will fail in some locations, typically in fractured zones at the borehole wall that are diametrically opposed (**Figure F.1**). If this failed rock is removed by the drilling mud, an elongated borehole cross-section, or "breakout", remains. For a vertical well, the orientation of this elongated borehole is normal to the direction of the maximum horizontal stress.

F.2 Horizontal Stress Orientation from Calliper Analysis

Not all borehole elongations are breakouts, however. There are other phenomena that result in wellbores that are not in gauge. **Figure F.2** is a schematic of a few common phenomena that are seen in calliper logs, using a 4-arm calliper as an example. The four arms provide two orthogonal measurements of wellbore diameter, usually referred to as “Calliper 1-3” and “Calliper 2-4”. A six-arm calliper provides three diameters spaced 60° apart: Calliper 1-4, Calliper 2-5, and Calliper 3-6.

Washouts are erosional phenomena, either due to excessive mud velocities, eroded drillpipe, or reactive shales. While stress effects may have some minor effect on the shape of the washout, washouts are poor indicators of stress orientations.

Breakouts are stress-induced failures of the wellbore, and typically are in-gauge in one direction while overgauge in the other. Calliper traces indicate a rough wellbore, with sudden changes in gauge.
Borehole breakouts are characterised by the following features in a calliper log trace:

- elongation (breakout) in one direction,
- in-gauge callipers in the transverse direction,
- irregular (rough) trace of the breakout trace,
- sudden increases and decreases in the breakout trace,
- no tool spiralling throughout the breakout interval,
- tool spiralling above and below the breakout interval,
- no consistent correlation between the breakout axis and the wellbore axis.

Keyseats arise from mechanical erosion of the rock due to the frictional abrasion of the rotating drillpipe. It occurs where the pipe is in contact with the rock: on the inside of dog-legged intervals along the well profile, and on the bottom of straight inclined intervals. One calliper is overgauge, while the other is usually undergauge because of calliper tool eccentricity.

Undergauge wellbores are uncommon. Small amounts (~5 mm) of undergauge in permeable intervals are normal and are caused by accumulated mudcake. Larger amounts of undergauge can be attributed to general rock failure where the failure is not brittle, resulting in dilatant behaviour and a constriction of

Figure F.1 Borehole Breakout Schematic

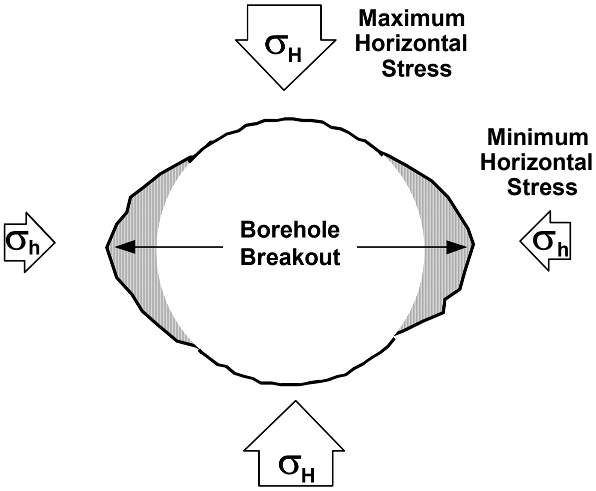
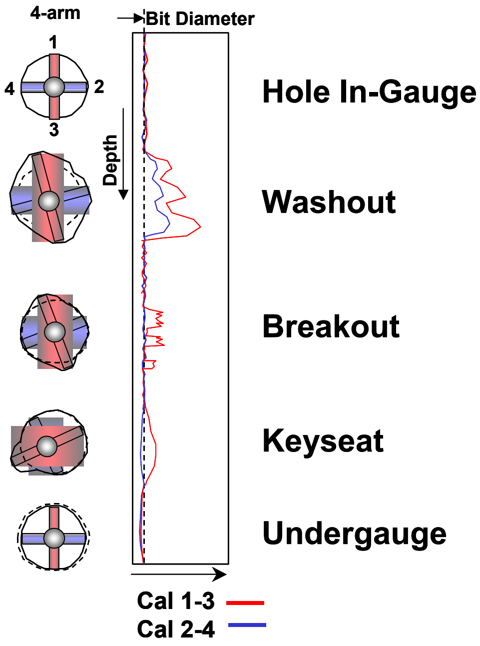


Figure F.2 Calliper Logs and Inferred Wellbore Geometry



the wellbore. In rare cases, wellbore constriction arises because of elastic relaxation of the wellbore due to the stress reduction at the wellbore. Note that some of this constriction would be removed during back-reaming, but time-delayed rock response could continue afterwards.

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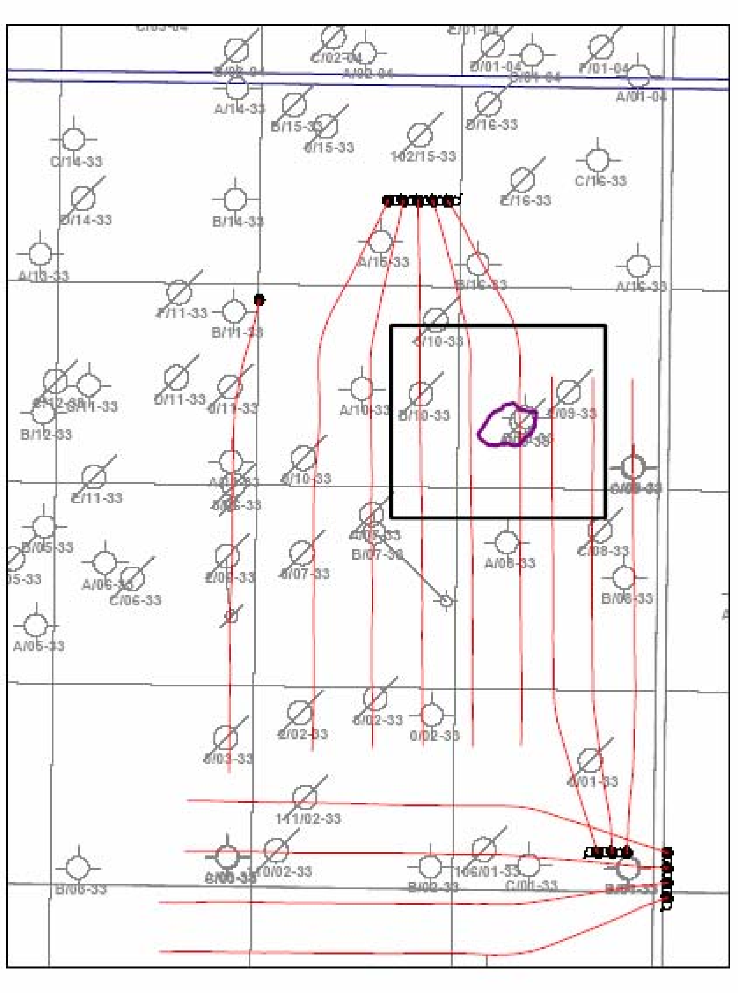

Cement Bond Insights into the May 18th 2006 Joslyn

TEPC/2007.007

December 2007

Identification page

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Author(s) : G. CHALIER
Entity : TOTAL E&P CANADA
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- Chronological reference : - RFS : - Number of Volumes : 1 ☐ CONFIDENTIAL	**Storage Location on the Entity Server**:[1]

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Geographical references: (Country, Region, License, Field, Well(s))
Canada, Alberta, Deer Creek, Joslyn Creek, Township 12W4, Range 095, Well 1AE / 09-33-095-12W4

ABSTRACT – About 10 lines explicit

Objectives (Aim, Purpose, Target) - **Strong points** - **Recommendation(s) and/or conclusion(s)**

A systematic review of cement bond data was performed for all wells located in the vicinity of the Joslyn May 18th 2006 Steam Release as part of the overall steam release root cause investigation. Overall, the available data severely limit our ability to draw clear conclusions relative to the quality of the cement bond in wells close to the steam release area.

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1. Executive Summary - Conclusions

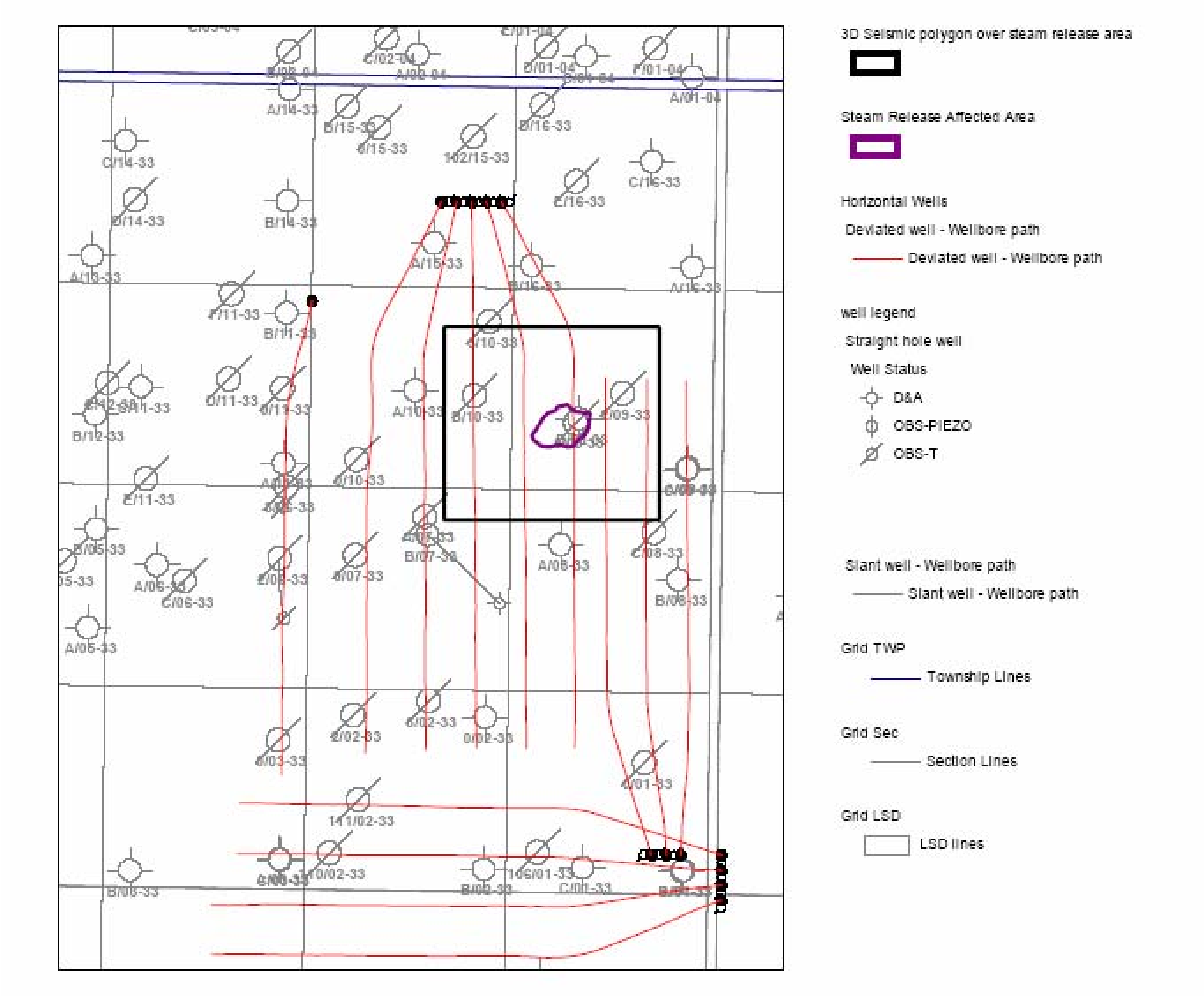
A systematic review of cement bond data was performed for all wells located in the vicinity of the Joslyn May 18th 2006 Steam Release as part of the overall steam release root cause analysis. The following conclusions can be drawn from this review:

- Injector wells 204-I1 and 204-I3 were logged for Cement Bond evaluation prior to steaming. Unfortunately the logging tool used was not suitable for large deviated casings (>9 5/8"), and no reliable information can be obtained from these logs.
- Daily Drilling Reports (DDR) and Cementing Company Reports are the only other source of information. These reports are however very succinct especially for core holes.
- Cement jobs of Injectors and Producers went without major problems, although used cementing practices were not optimal (short circulation time, insufficient Wait On Cement). Significant cement losses were experienced during cementation, especially in 204-I1, suggesting hole wash-out, but large excess of cement was used, and returns were still recorded at surface. Nevertheless there is a reasonable doubt regarding the quality of the cement bond achieved in 204-I1.
- No cement losses seemed to have occurred in Injector 204-I3. Cementation is likely to be better but actual bond is impossible to confirm without a reliable CBL.
- After the steam release, completion strings were retrieved from wells 204-I1 and 204-P1. Cement Bond was then evaluated (post steaming) using a more suitable logging tool, the Segmented Bond Tool. Cement Bond was found very degraded which is commonly observed in thermal wells after steaming.
- Except for B/10-33, core holes were plugged back from TD to surface in a single stage, and reports do not mention that Top Of Cement (TOC) was actually confirmed. It is however a low probability that these plugs failed.
- Cement Jobs in the Observation wells went without recorded problems, but in the absence of CBL it is impossible to confirm the quality of the cement.
- An attempt was made to run a CBL in observation well 100/9-33 closest to the steam release crater, but the bent 2 7/8" casing prevented the tool to go through and logging had to be aborted.
- Five observation wells were logged with a CBL in January 2007 to assess the cement bond,
    - 103/06-33 (OB1AA) at the heel of Pilot Well Pair,
    - 100/10-33 (OB2A) at the heel of 204-WP5,
    - 103/02-33 (OB3C) at the toe of 204-WP4,
    - 100/11-28 (OB05) at the toe of 201-WP1,
    - 100/10-28 in the middle of 201-WP2.

  All these CBLs show very good to good zone isolation across the McMurray formation.

Overall, the cement bond review did not bring to light conclusive evidence related to the role that steam channelling at wells may or may not have played in the steam release.

Figure 1 Observation Wells and Abandoned Core Holes in the area



Well name	Well type	Data available	Comments	Cement Bond Evaluation
204-I1	INJ	DDR, pre-steam CBL	Cement Job w/losses, CBL not reliable	unknown, could be poor
		post-steam CBL	Reliable CBL performed under pressure	poor to very poor
204-P1	PROD	DDR	Cement Job OK	unknown
		post-steam CBL	Reliable CBL performed under pressure, but only reached half way	very poor
100/09-33	Observation Well	Sanjel Report	Cement Job OK	unknown
1AB/09-33	Plugged & Abandoned	limited	Cement Job OK, but single stage, no Top Of Cement confirmation	unknown
204-I3	INJ	DDR, pre-steamCBL	Cement Job OK, CBL not reliable	unknown
204-P3	PROD	DDR	Cement Job w/losses, backflow	unknown, could be poor
B/10-33	Observation Well	Sanjel Report	Cement Job OK	unknown
B/07-33	Plugged & Abandoned	Sanjel Report	Cement Job OK w/2 plugs, but no Top Of Cement confirmation	unknown
0/02-33	Plugged & Abandoned	Trican Report	Cement Job OK, but single stage, no Top Of Cement confirmation	unknown

Table 1 Cement Bond Data & Evaluation Summary

2. Well by Well Cement Job Data Summary

2.1 Well 204-I1 (SAGD injection well)

Sept 12th, 2005: Cement job of 11 ¾" Intermediate Casing

- Casing shoe: 415m BRT
- Casing float collar: 402.6m BRT
- Circulation: 1.25 hrs (this is short)
- Cement:
  - 7m3 pre-flush water,
  - 3m3 VISWEEP,
  - 5m3 scavenger w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
  - 47m3 of Therm-40 EXP @1820 kg/m3 w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
- Displacement: 22.7m3 water, 4m3 good cement returns only (hole wash-out suspected)
- Wait On Cement: 5.75 hrs
- Tag Top Of Cement @402m (Float Collar @402.6m).

First CBL was performed with Tucker 3 1/8" tool on October 21st, 2005 to Top Of Liner (T.O.L.). Quality of cement bond can not be assessed with any degree of certainty. This tool is not suitable to log large casings.

After the steam release, completion was removed and the intermediate casing was logged with the Baker Segmented Bond Tool (SBT) on June 17th, 2006 from 325mMD to surface. SBT log showed poor cement bond all along the casing to very poor with some channelling in the bottom part.

2.2 Well 204-P1 (SAGD production well)

Aug 3rd, 2005: Cement job of 11 ¾" Intermediate Casing

- Casing shoe: 430m BRT
- Casing float: 416m BRT
- Circulation: 0.75 hrs (this is very short)
- Cement:
  - 7m3 pre-flush water,
  - 3m3 VISWEEP,
  - 5m3 scavenger w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
  - 35m3 of Therm-40 EXP @1820 kg/m3 w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
- Displacement: 25.5m3 water, 12m3 good cement returns (no wash-out).
- Wait On Cement: 15.75 hrs
- Tag Top Of Cement @416m (Float Collar @416m).

No CBL was performed pre-steaming.

After the steam release, completion was removed and the intermediate casing was logged with the Baker Segmented Bond Tool (SBT) on June 18th, 2006 from 208mMD to surface (well tractor could not go deeper due to presence of sticky bitumen on the casing walls). Cement Bond Log is very poor in the logged section and most likely all along the wellbore. There seems to be only one single bridge of cement between 59m-65m at the very base of the Clearwater shale, which could provide some hydraulic isolation.

2.3 Well 100/9-33 (Observation Well)

March 1st, 2005: Cement job of 2 7/8” tubing

- Casing shoe: 105m BRT (TD @107.4m)
- Circulation: ? hrs
- Cement:
    - 1m3 pre-flush water,
    - 2.4m3 of Therm-40 EXP @1820 kg/m3 w/0.25%CFL-3 + 2% CaCl2
- Displacement: 0.3m3 water, no circ. loss, 0.5m3 good cement returns
- Tag Top Of Cement ??.

No CBL was performed.

2.4 Well 1AB/9-33 (Plugged & Abandoned)

Feb 4th, 2004: P& A Cement job

- Well TD: 107.2m BRT
- Cement:
    - 2.2m3 of Therm-40 EXP @1730 kg/m3 w/3% CaCl2
- Displacement: ?m3 water, no circ. loss, ?m3 good cement returns
- Tag Top Of Cement ?.
- Top Off.

No CBL was performed.

2.5 Well 204-I3 (SAGD Injection Well)

Sept 1st, 2005: Cement job of 11 ¾” Intermediate Casing

- Casing shoe: 374.5m BRT
- Circulation: 0.75 hrs (this is very short)
- Cement:
    - 7m3 pre-flush water,
    - 3m3 VISWEEP,
    - 5m3 scavenger w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
    - 41m3 of Therm-40 EXP @1820 kg/m3 w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
- Displacement: 21.7m3 water, 12m3 good cement returns
- Wait On Cement: 7.0 hrs
- Tag Top Of Cement @350m (Float Collar @362m).

CBL performed with Tucker 3 1/8” tool on October 21st, 2005 to T.O.L. Quality of cement bond can not be assessed with any degree of certainty.

2.6 Well 204-P3 (SAGD Production Well)

July 5th, 2005: Cement job of 11 ¾" Intermediate Casing

- Casing shoe: 377.44m BRT
- Circulation: 0.75 hrs (this is very short)
- Cement:
  - ?m3 pre-flush water,
  - ?m3 VISWEEP,
  - ?m3 scavenger w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
  - 32.1m3 of Therm-40 EXP @1820 kg/m3 w/0.25%CFL-3 + 0.5% CaCl2 + 1% FWCA-H
- Displacement: ?m3 water, 3m3 good cement returns, some losses ?, backflow.
- Wait On Cement: rig moved to next well
- Tag Top Of Cement @345m (Float Collar @363m).

No CBL was performed.

2.7 Well 1AB/10-33 (Observation Well)

March 1st, 2005: Cement job of 2 7/8" tubing

- Casing shoe: 105m BRT (TD @106.8m)
- Circulation: ? hrs
- Cement:
  - 1m3 pre-flush water,
  - 2m3 of Therm-40 EXP @1820 kg/m3 w/0.25%CFL-3 + 2% CaCl2
- Displacement: 0.3m3 water, no circ. loss, 0.5m3 good cement returns
- Tag Top Of Cement ??.

No CBL was performed.

2.8 Well 1AB/7-33 (Plugged & Abandoned)

April 2nd, 2005: Plugged & Abandoned Cement job

- Well TD: 228m BRT (6 ¼" open hole, deviated)
- Cement Plug#1:
  - 2m3 pre-flush water,
  - 3.8m3 of Therm-40 EXP @1885 kg/m3 w/3% CaCl2
- Displacement: 0.4m3 water, no circ. loss, 0.3m3 good cement returns
- Tag Top Of Cement ??.
- Cement Plug#2:
  - 1m3 pre-flush water,
  - 2.3m3 of Therm-40 EXP @1885 kg/m3 w/3% CaCl2
- Displacement: 0.2m3 water, no circ. loss, 0.5m3 good cement returns
- Tag Top Of Cement ??.
- Top Off: 0.8m3

No CBL was performed.

2.9 Well 0/02-33 (Plugged & Abandoned)

March 3rd, 2001: Plugged & Abandoned Cement job

- Well TD: 118m BRT (5 ½” open hole)
- Cement:
  - 1m3 pre-flush water,
  - 2.7m3 of Therm-40 EXP @1876 kg/m3 w/2% CaCl2
- Displacement: ? water, no circ. loss, 0.5m3 good cement returns
- Tag Top Of Cement ??.
- Top off: 0.3m3

No CBL was performed.

Total E&P Canada Ltd.

SEISMIC INSIGHTS INTO THE MAY 18th 2006 JOSLYN STEAM RELEASE

TEPC/GSR/2007.001 December 2007

Postal Address

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ABSTRACT –

The objective of the project was to delineate the region in the sub-surface that was disturbed by the steam release at the Joslyn Creek SAGD site, and thereby help determine the cause of the release. A three-dimensional, very-high-resolution seismic survey obtained clear images of the sub-surface region disturbed by the steam. The following conclusions may be drawn from the images:

- ➢ No geologic feature was identified on 3D seismic that would suggest that local pre-existing geological conditions (faults, fracture, doline, etc.) played any significant role in the steam release process.
- ➢ The shape of the Steam Affected Zone as seen on seismic is unrelated to the position of the observation wells in the vicinity suggesting that this wells did not play a role in the Steam Release process.
- ➢ The Steam release Affected Zone as seen on seismic does not extend significantly toward either of the neighboring well pairs (204-I2P2, 203-I1P1).
- ➢ The steam release occurred as a series of cycles involving: steam migration upwards to a seal, steam accumulation beneath the seal, and steam puncturing of the seal. The steam was released at the apex of an antiform.
- ➢ A seismic anomaly above injector 204-I3 is suggesting that steam may have accumulated at the top of the Middle McMurray, above the pay zone, at the apex of the same antiform.

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1. INTRODUCTION

1.1 Joslyn Project Background

The Joslyn Creek SAGD Project is located in the northwest portion of the company's Joslyn group of leases, approximately 70 km north of Fort McMurray. Bitumen is found primarily in the Middle McMurray Formation, which is up to 35 m thick, and is found at depths ranging from 65 to 110 m. Bitumen is extracted from the sands using SAGD (Steam-Assisted Gravity Drainage) technology.

On 18th May 2006, after approximately six months after the start of steam injection/circulation in well pair 204-I1P1, steam was released from the surface, in the proximity of the afore mentioned well pair. The release created a large vent formed by fissures approximately 3 m wide, 4 m deep, and 15 to 25 m long. A substantial amount of sub-surface material, including pieces of rock up to 1 m in size, was ejected. Most of the material was ejected to the south and southwest, covering an area approximately 170 m by 100 m, while some material landed up to 250 m away. A surface-collapse structure appeared immediately north of the vent forming a depression in the surface approximately 25 m in diameter and 10 m deep. Figure 1 shows two aerial photographs of the area, both before and after the release.

1.2 3D Seismic Project Objectives

The project had two strategic objectives:

1. Help determine the cause of the steam release.
2. Help continuation of SAGD activities on Joslyn area

Technical objectives were as follows:

1. Delineate the region in the sub-surface that was disturbed by the steam release, in order to map the path taken by the steam / condensed water between the 204I1 borehole[2] and the surface and assess the sub-surface limits of the disturbance (to determine where it occurred and whether the disturbance extended to the neighboring well pairs).
2. Investigate geological features relevant to steam release risks

1.3 Seismic survey

Given the type of target, its depth, and the physical properties of the overlying sediments, it was clear that seismic methods had the best chances of meeting the objectives of imaging the disturbance. The best approach was to implement a specific very-high-resolution 3D seismic over the release area, so that an image of the sub-surface and thereby an aid to the understanding of the steam release could be obtained.

This was a challenge, as normally the upper 100 m are not imaged in classical industrial exploration seismic reflection surveys. The imaging strategy and in particular the field spread that would be required would therefore set a worldwide precedent. To meet the challenge, it was decided not only to acquire a 3D survey, but to acquire it using three-component (3C) sensors rather than using the traditional single-component approach. The 3C approach allows the analysis of compressional-wave (P-wave) reflections from P-wave sources, resulting in a P-P image; as well as the analysis of shear-wave (S-wave) reflections from P-wave sources, resulting in a P-S image.

---

[2] The sharp increase of injectivity evidenced by reservoir analysis on 204I1 suggests that it is steam injected in this particular well that is responsible for the steam release

The purpose of the P-P image would be to delineate the zone of sub-surface disturbance and help determine the cause of the steam release. Analysis of a high-resolution P-P image would meet the project objectives.

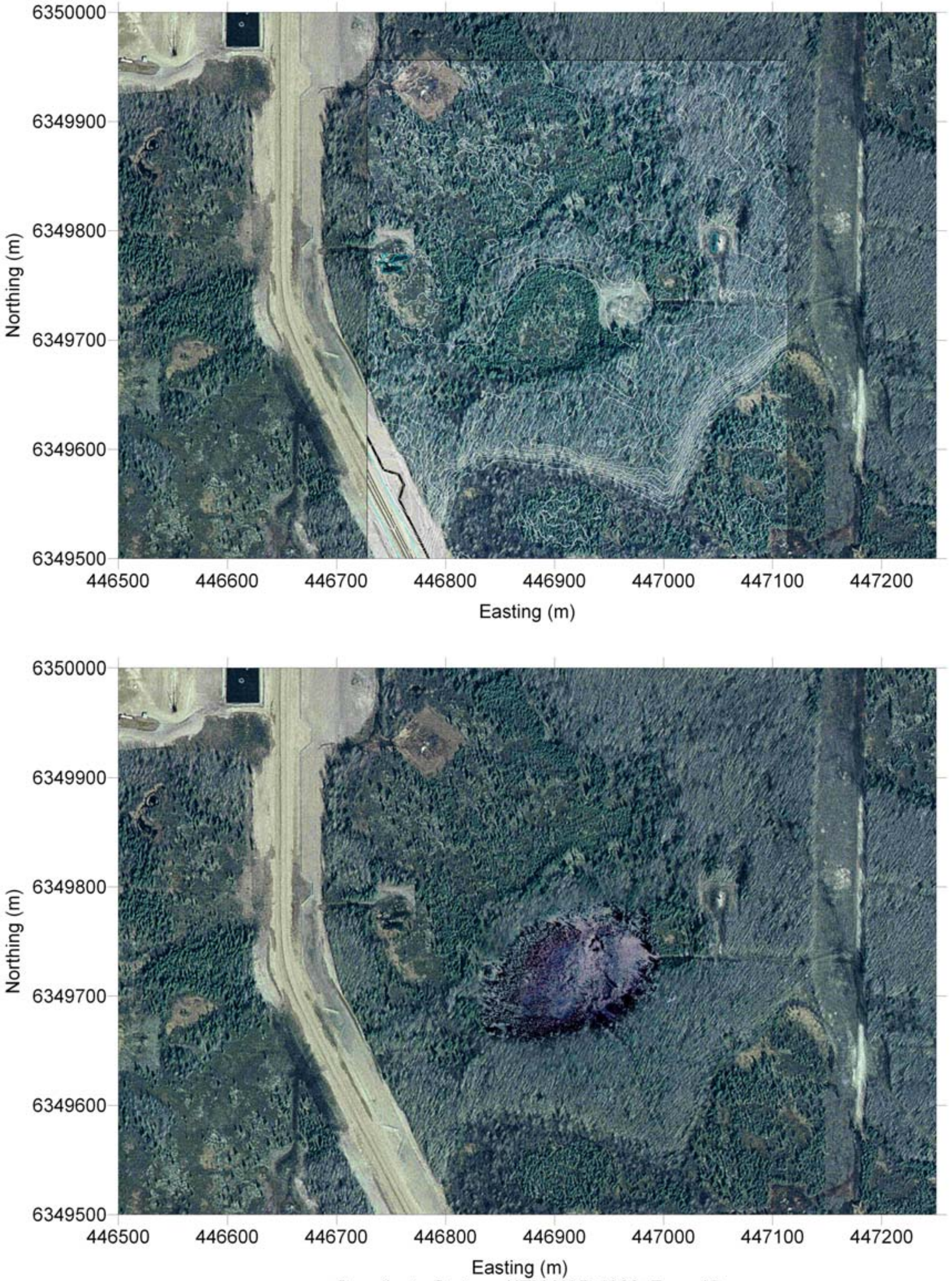
The use of a P-S image sets a precedent for TEPC and is a research project. The purpose of the P-S image would be to provide engineering parameters – the strength moduli of the rocks and sediments – to assess the integrity of the reservoir.

The survey was carried out in two phases:

- A feasibility survey with the objective, if positive, of determining the optimum acquisition parameters for the 3D survey.

- The specific survey - an extremely high-resolution 3D site survey.

This report describes the seismic survey and details the P-P results. The P-S activities represent a research project, and results will be presented separately.



Coordinate System: UTM NAD 1983, Zone 12

Figure 1 : Locations of the study – two aerial photographs of the area, both before and after the release.

2. FEASIBILITY SURVEY

2.1 Overview

The two-dimensional survey was designed to meet two objectives:

- To determine whether a seismic survey would be capable of achieving the imaging objectives discussed above, (i.e., what effect would the disturbed area have on the seismic waves) and if capable,

- To determine suitable acquisition and processing parameters for the 3D survey.

The test survey was itself carried out in two stages. The first stage comprised source tests designed to determine the most appropriate shot parameters for the survey. Once the shot parameters were chosen, the second stage was carried out to obtain two full 2D lines, along with an additional small 3D test response.

Veritas DGC Land (now CGGVeritas) was contracted to acquire the data for the study.

2.2 Line Layouts

Two main 400-m long lines– were laid out for the 2D test survey, as shown in Figure 2. Line 1 was oriented north-northwest to south-southeast, and was located east of the disturbed zone created by the steam release. The second line, Line 2, crossed the center of the disturbed area, and intersected Line 1.

In addition to the above 2D lines, three 50-m lines were implemented for 3D purposes: Lines 3 to 5 were parallel to and north of Line 2.

Line 1's location was chosen to assess the data quality that could be expected outside the disturbed area, while Line 2 crossed the disturbed zone in order to determine the data quality that could be expected inside the disturbed area. Lines 3 to 5 were located to allow an assessment of the data-quality enhancement that could be obtained using a three-dimensional survey.

The majority of the survey area was cleared to a 3-m width using mulchers, except for that portion of the area within and immediately next to the zone of surface disturbance. The few trees that were close to the surface-disturbance area were hand-slashed to a 1-m width.

All five lines were laid out for the source tests. The receivers were then left on the ground following the tests, while the tests were analyzed to determine the best source parameters.

2.3 Location Survey

Tolerances for the location survey were low compared to normal seismic operations: the locations of the receivers had to be accurate within 10 cm. The location surveyors needed to adjust their survey procedures in order to meet these tolerances. Since most of the stations were located within the forest, the survey had to be carried out using conventional total-station equipment (GPS accuracy within forested areas could not meet the desired tolerances).

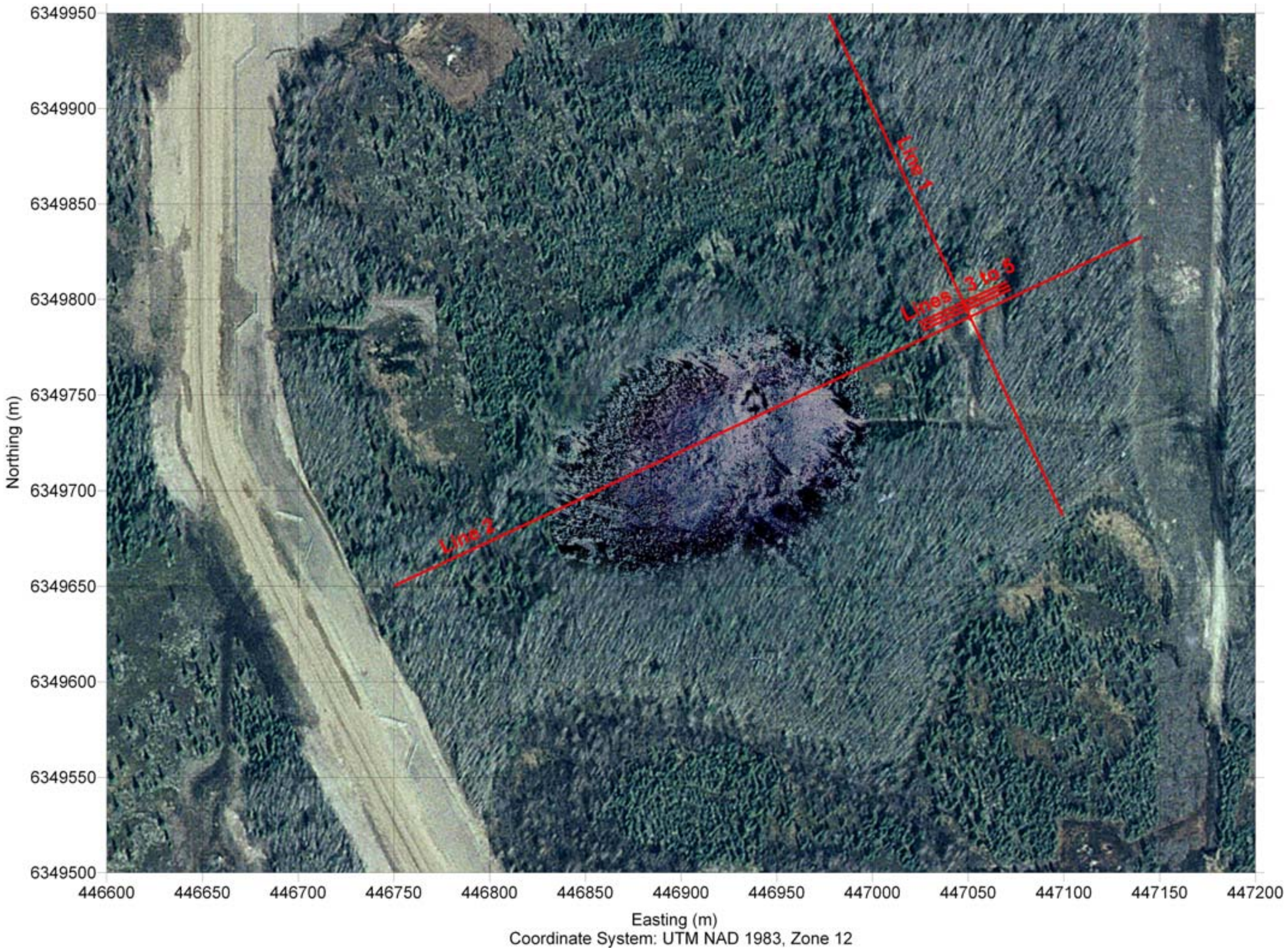


Figure 2 : **Locations of two-dimensional seismic lines acquired for feasibility study**

2.4 Recording Parameters

The parameters for the feasibility survey were identical for both the source tests and the full acquisition. Table 1 shows the receiver parameters.

Receiver Information:	
Geophones / Receivers	SERCEL DSU, three-component digital geophone
Number of Receivers Per Group	Single
Distance Between Receiver Stations	1 m
Type of Base	4-inch spike

Table 1: **Receiver parameters used for the 2D feasibility study**

The SERCEL DSU receivers selected for of the 2D and 3D seismic work are three-component digital geophones: the ground motion is digitized right at the geophone, and sent via Ethernet cables to the recording truck. This results in significantly higher dynamic range and in much higher data quality than would be obtainable with standard, less expensive analog geophones. Figure 3 shows one of the receivers.

Figure 3 : State-of-the-art three-component digital geophones

These were used for the recording, as they provide the highest quality signal available in the industry.

The receivers require specialized planting methods. The units were planted by drilling holes in the frozen ground using hand-held drills, inserting the DSU spike into the hole, and then orienting the DSU using a level and compass. Figure 4 shows the planting process for the DSU.

Figure 4 : Three-component DSU receivers

… are planted by drilling holes in the frozen ground (left), inserting the receivers, then leveling the receivers and orienting them to a common azimuth (right). The receivers are then allowed to freeze to the ground.

2.5 Source Tests

Once the receivers were planted on all five lines, and prior to acquiring the data for the full 2D/3D feasibility study, source tests were carried out to determine the most appropriate source parameters. Test shots were recorded to determine the optimum source. Source-test holes were located in three locations along Line 1: at the center, and approximately 125 m north and 125 m south of the center. At each location, 12 combinations of charge size and depth were tested, as shown in Table 2. Each location was chosen so that shots were not drilled into muskeg. The recording parameters for the source tests are given in Table 3.

Shot hole Depth and Charge size	**5 m**	**8 m**	**12 m**
Detonator alone	2	2	2
Detonator and 30 g Pentolite booster	2	2	2
Detonator and 60 g Pentolite booster	2	2	2
Detonator and 130 g Pentolite booster	2	2	2

Table 2: Number of shots acquired during 2D test survey.

Shots were acquired at each test location, for each combination of shot-hole depth and charge size. At each location, 24 shots were acquired.

Instrument Type/Manufacturer	Sercel 408 LCI
Channels Used	2,850
Group Interval	1 m
Source Interval	2 m
Spread Configuration	All stations live
Record Length	3 s
Sample Rate	1 ms
Filters	450 Hz anti-alias

Table 3: Recording Instrumentation for Source Tests

Three test locations were drilled on Line 1, and one location on Line 2. In all, 96 test shots were acquired. The equipment was laid out on the 18th of November, 2006, and the source-test data were acquired on the 19th of November 2006.

2.5.1 Source Tests Results

The results of the source tests showed clearly that the best source was a single detonator (without an additional explosive charge) at a depth of 5 m.

2.6 2D/3D Feasibility Test Data Acquisition

Immediately following the above conclusions, shot holes were drilled accordingly along Lines 1 and 2, with a 2-m interval. Figure 5 shows the north end of Line 1 after the shot-holes were drilled and loaded. Figure 6 shows the density of equipment used for the 3D test pattern. The recording was then carried out on 22 November, 2006, as per the parameters shown in Tables 1 and 3. In order to obtain a small test of the 3D response of the area, all traces from the five lines were live for every shot during the acquisition.

Figure 5 : Inspection of the shots and receivers

… along the north end of Line 1, prior to the recording of the feasibility tests.

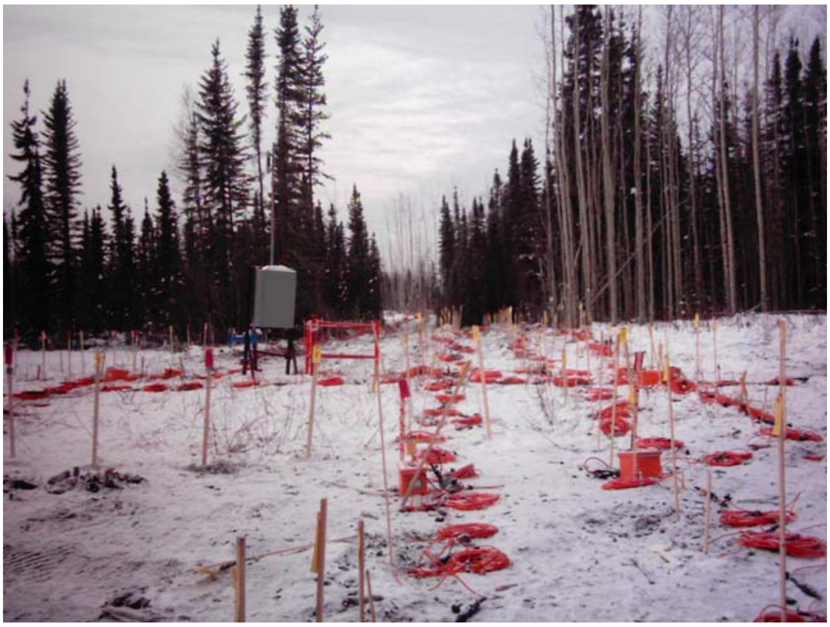


Figure 6: A view of the acquisition spread

… intersection between Line 1 (running from left to right across the figure) with Line 2 (at the left edge of the figure) and Lines 3, 4, and 5

(in the right half of the figure). This view looks west past monitoring well 1AE/09-33-09

2.7 2D Data Processing

A general list of the processing steps carried out or tested on the 2D data is shown below. Since all five lines were live for every shot in the program, the resulting data set was three-dimensional. Therefore the processing stream shown below is similar to that used for the 3D data. For the most part, these are standard processes and will not be discussed in detail here.

- Data demultiplexed / Re-formatted
- Selected vertical component for P-wave processing
- Set geometry
- Sensor tilt correction applied
- Bad traces edited out
- First breaks picked
- Near-surface statics applied using turning-ray tomography
- Performed tomographic refraction static and datum static calculations
- Elevation-only and calculated tomographic statics (P-wave: source and receiver) calculated and applied.
- Adaptive polarization filtering applied to attenuate ground roll energy.
- Proprietary adaptive polarization filtering technique characterizes and removes the ground roll energy by exploiting the fact that the polarization of surface waves is different from the polarization of PP and PS body waves. Adaptive polarization filtering operates only within the ground roll frequency band, preserving signal within this band. This is an adaptive filter that uses Complex Singular Value Decomposition (CSVD).
- Proprietary noise attenuation applied
- Divergence correction (T**N) applied
- Surface consistent scaling applied
- Surface consistent deconvolution applied (tested to stacks with 10,15,20ms operators and 5% pre-whitening)
- Surface consistent scaling applied
- Preliminary velocity analysis carried out (velocity control points at a spacing of 50m)
- Proprietary preliminary surface consistent statics (MASTT) applied
- Spectral whitening applied (if needed)
- Surface consistent scaling applied
- Final velocity analysis carried out (velocity control points at a spacing of 25m)
- Proprietary final surface consistent statics (MASTT, 2nd Pass)
- First break mute applied (different mutes tested and stacked)
- Trim statics applied if tests positive (tested and compared with and without trim statics)
- Pre-stack scaling tested
- Decimation tests will be introduced at this time with shot/stn edit cards.
- Stack
- At this stage stacks will be migrated with and without post-stack noise attenuation applied, as well as with and without decimation tests. Alternate flow carried out to pre-stack time migration stack.
- Proprietary noise attenuation (FX deconvolution for 2D lines and FXY deconvolution for 3D) applied.
- Post-stack Kirchhoff time migration applied.
- Post migration spectral whitening or Zsignal tested.
- Bandpass filter
- Scaling

2.8 2D Survey Results: 3D Parameter Selection

The 2D survey showed clearly that very-high-quality data could be acquired outside the disturbed area. Inside the disturbed area, the data quality was sufficient to infer that a 3D survey would be able to achieve high-quality data in the same region

The 2D data were processed to final stacks and migrated stacks. Sections from the 2D survey will not be shown in this report, since the more detailed 3D results are available.

To determine appropriate acquisition parameters for the 3D survey, decimation tests were carried out on the 2D data. The original shot and receiver separations were 2 m and 1 m, respectively, giving a very-high-resolution 0.5-m sub-surface bin size. Successively lower-resolution test sections were produced by reducing in a step-wise fashion the number of shots and receivers used. This effectively increased the shot and receivers spacing and the sub-surface bin size. At each step, final stacks and migrated stacks were produced, and the effect on sub-surface resolution assessed. Table 4 shows the decimation tests carried out:

Decimation Tests Shot Interval:Receiver Interval	**Shots Removed**	**Receivers Removed**	**3D Bin Size**
Original Data – 1:1	0	0	0.5 m by 0.5 m
2:2	0	Every 2nd	1 m by 1 m
4:2	Every 2nd	Every 2nd	1 m by 1 m
8:2	Every 2nd, 3rd, 4th	Every 2nd	1 m by 1 m
6:3	Every 2nd, 3rd	Every 2nd, 3rd	1.5 m by 1.5 m
4:4	Every 2nd	Every 2nd, 3rd, 4th	2 m by 2 m
8:4	Every 2nd, 3rd, 4th	Every 2nd, 3rd, 4th	2 m by 2 m
6:6	Every 2nd, 3rd	Every 2nd through 6th	3 m by 3 m
8:8	Every 2nd, 3rd, 4th	Every 2nd through 8th	4 m by 4 m
16:16	Every 2nd through 8th	Every 2nd through 16th	8 m by 8 m

Table 4 : Decimation tests used to determine optimum recording parameters.

Note that in the above table, the sub-surface bin size is set by the receiver interval. Different acquisition parameters can result in identical bin sizes, but will also result in different fold coverage within the bins.

Based on the results of these tests, the selected shot and receiver parameters to be used for the 3D survey were the following :

- In-line receiver interval: 3 m
- Receiver line interval: 6 m
- In-line shot interval: 3 m
- Shot-line interval: 6 m
- Shot lines perpendicular to receiver lines
- In-line shots staggered 1.5 m from receiver lines

As a result of the 2D test, a small refinement was made to the selection of sources for the 3D survey. Detonators were to be used as the source for every hole except for those drilled within or close to the disturbed area. In these zones, 60-g Pentolite boosters were added, since it was shown during the test that theses areas were highly attenuative.

In addition the seismic contractor was instructed to drill all shots to a depth of 5 m, except in the following situations:

- If muskeg were encountered during the drilling of a hole, then the shot would be placed at a depth of 5 m, or 2 m below the base of the muskeg, whichever was deeper.
- In areas where tracked drill rigs would not be able to operate and hand drills would be required, the shot would be placed at a depth of 3 m, the maximum depth for the hand drills. This was the case near the area of surface disturbance.

3. 3D HR SITE SURVEY SEISMIC ACQUISITION

3.1 Overview

As per the feasibility tests, Veritas DGC Land (now CGGVeritas) was contracted to acquire the data for the site survey.

The survey area is roughly a 400 x 400 m surface centered on the steam release zone

The operations took place from December 2006 to January 2007, in order to obtain the optimum frozen soil conditions. The work included the following tasks:

- Site preparation
- Topographic location survey
- Shot hole drilling
- Line lay out
- Recording
- Check shot
- Demobilisation and site cleaning

3.2 Site Preparation

Normal seismic operations in forested areas require cut-lines to allow the deployment of sources and receivers. Line widths range from 1 m for hand-carried projects, to approximately 4 m for projects that use tracked drill rigs for drilling shot holes. The acquisition parameters for this survey were such that if lines were cut, approximately 60% of the forest cover would be removed, and the remaining forest would exist as 3-m-by-5-m blocks, separated by 3-m and 1-m wide lines. It was therefore decided to clear-cut the area using mulchers. This clearing was carried out using the contractors that clear drill pads for drill sites.

Prior to any of the area being mulched, large timber (tree diameters greater than 15 cm) was removed and stored north and east of the project site. They were later trucked to a mill for salvage.

The area that surrounded the vent and the surface collapse structure was not cleared by mulchers because the ground surface was too uneven (see Figure 7). Hand slashing crews were used to cut the trees, and the trees were dragged out of the disturbed area using cables attached to an excavator. Once the trees were dragged to a cleared area north of the depression, they were burned.

Mulching of the site was carried out during December 2006. This cleared the entire area except for the area immediately around the zone of surface disturbance. That area was hand slashed between 5th and 9th January 2007.

… the vent is in the foreground, the surface collapse structure is top right of the photograph, and was too uneven to be mulched. This area was hand slashed instead.

Figure 7: The ground around the vent and the surface collapse structure

3.3 Location Survey

The location survey was carried out using real-time-kinematic (RTK) GPS receivers, tied to a local base station near the main vent area (see Figure 8). The coordinate system and datum used were UTM, Zone 12 North, NAD83.

Figure 8 : The GPS base station and radio beacon for the location survey

… were located next to the vent.

Pin flags were deployed for both shots and receivers. Given the accuracy requirements, each shot hole had two flags: the first marked the planned location for the drill rig. After the hole was drilled, a red flag was used to mark the exact hole location. These red flags were then surveyed to obtain their true positions.

The survey was subjected to very strict tolerances: both shot flags and receiver flags were required to be within 10 cm of the planned location. Pin flags were laid out first according to the planned locations, and then independently surveyed to determine their actual positions. Pin flag locations were tested in the field using independent chaining checks, and in the office using post-survey calculations of the planned-versus-actual location errors.

Between one and three survey crews were operating on the site during the course of the survey. The survey began on December 20th, 2007, broke for Christmas December 24th, restarted on December 26th, and continued until January 12th, 2007.

3.4 Shot-hole Drilling

Three types of drills were used on the program. Approximately 80 percent of the holes were drilled using tracked Nodwell 110's, approximately 17 percent were drilled using a tracked FN60 drill, and three percent were drilled by two hand-drill crews. Figure 9 shows the tracked units.

The drillers were instructed to drill the actual shot hole with 25 cm of the pin flag that marked the planned location. This proved difficult at the beginning of the drilling, until the drillers changed their method of orienting the drill rigs. After one day of operations, the drills were meeting the 25-cm requirement. Once the hole was drilled and loaded, the drillers' helpers placed a red flag at the top of the actual hole location. This flag was then surveyed to obtain the actual shot location.

Figure 9 : **Shot holes**

Most of the shot holes on the program were drilled using Nodwell 110s, shown to the left. The smaller FN60 is shown to the right. Note that the shot-hole at the bottom of the right photograph has two pinflags: the blue flag was the pre-drilled shot location; the red flag marks the actual location, which was also surveyed to obtain the highest possible shot-location accuracy.

Each shot hole used a single detonator at a depth of 5 m, except in the following situations:

- Shots drilled into muskeg were placed at a depth of 5 m, or 2 m below the base of the muskeg, whichever was deeper.
- Where hand drills were required, the shot was placed at a depth of 3 m, the maximum depth for the hand drills.
- In the areas immediately within and adjacent to the surface depression and the major fissures, a 60 g booster was used in addition to the detonator.

Figure 10 shows two portions of the site, and demonstrates the very dense layout of receiver and source locations.

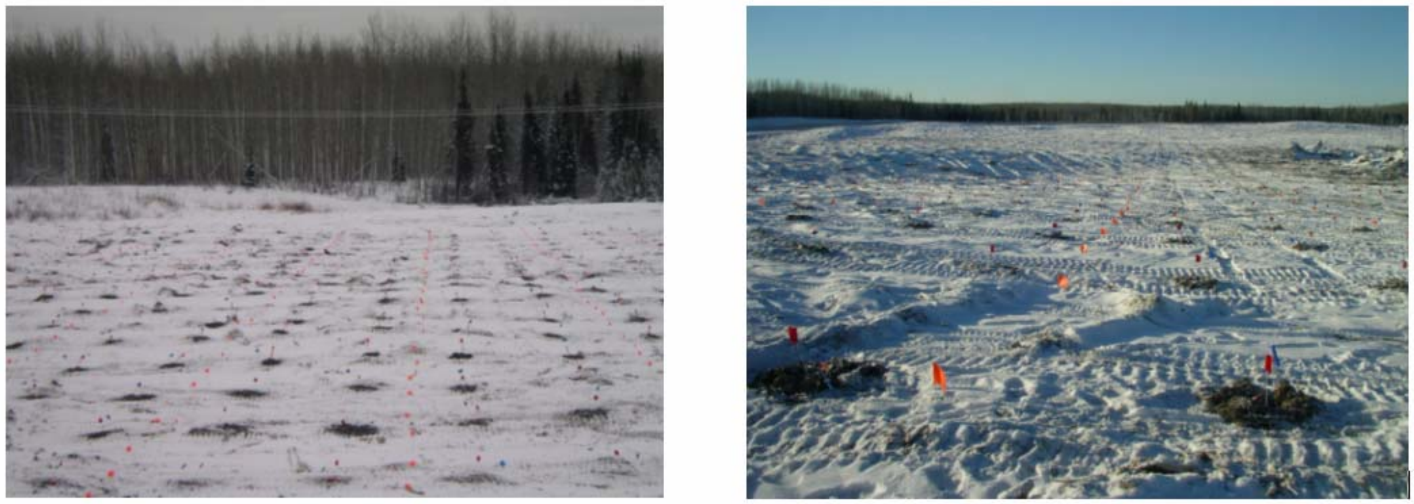


Figure 10 : Views of the site, with line layout and flags

Two views of the site that show the density of surveyed stations and shot locations. Orange pinflags mark the future locations for DSU receivers, while read and blue pinflags mark shot-hole locations. For scale, the two red pinflags in the foreground of the right photograph are 3 m apart.

Shot-hole depths were routinely checked by measuring the length of the loading pole protruding out the top of the hole during loading, and subtracting this from the overall length of the hole. These checks showed that the shots were placed at depths of 5.0 m +/- 0.2 m.

Shot hole drilling with the tracked drills began on December 29th, 2006, and continued until January, 10th, 2007. Hand drilling began January 4th and finished January 11th.

3.5 Line Layout

Figure 11 shows the locations of the shot and receiver lines. In all, 9091 receiver stations were instrumented during the program, and 9247 shot holes were drilled and loaded.

Figure 11: **Layout of the seismic survey.**

Red dots indicate the surface locations of the shots, and yellow circles indicate the receiver locations.

3.6 Recording Equipment

Table 5 shows the shot and receiver parameters used for the 3D survey, while Table 6 shows the recording system and recording parameters.

Geophones / Receivers	SERCEL 408 and 428 DSUs, three-component
Type of Base	4-inch spike
Number of receivers per group	Single
In-line receiver group interval	3 m
Receiver line interval	6 m
Shot size	Detonator only, except as noted in Section 3.4
Shot depth	5 m, except as noted in Section 3.4
Shot pattern	Single hole
In-line shot interval	3 m
Shot line interval	6 m
In-line shot stagger	1.5 m from perpendicular receiver line

Table 5 : Shot and receiver parameters used for 3D survey.

Recording Instrumentation	
Instrument Type / Manufacturer	One SERCEL 408 LCI and one SERCEL 428 LCI
Channels Used	15,000
Spread Configuration	All stations live
Record Length	3 s
Sample Rate	0.001 s
Filters	450 Hz anti-alias
Number of live lines in patch	16 live, with 3-line roll, with roll-on and roll-off

Table 6 : Recording parameters and equipment used for 3D survey.

Receivers were planted by drilling holes in the frozen ground using hand-held drills, inserting the DSU spike into the hole, and then orienting the DSU using a level and compass.

3.7 Check Shots

In addition to the seismic recording, well 1AE/09-33-095-12W4, located approximately 120 m east-northeast of the disturbed area, was instrumented with a 24-channel hydrophone streamer. Hydrophones were used since the well diameter was too small to allow the use of clamping geophones. The hydrophone cable, which had a receiver spacing of 5 m, was lowered to the base of the well, then tied off at the surface. The top two hydrophones remained outside the borehole. The steel-cased borehole was then filled with water to the ground surface. Thermal pipe-heating tape was wrapped around the well-head, and the tape connected to a battery-powered 120-volt-ac supply, in order to keep the water in the borehole from freezing. Figure 12 shows the instrumented well.

Figure 12 : Check shots in action

Check shots were acquired by recording the shots near one well, using a 24-channel hydrophone cable in the well. The hydrophone cable output was patched into the surface recording grid using 24 line taps (the orange cables in the foreground), and recorded along with the signals from the surface receivers.

Surface shots from the 3D acquisition program were recorded by the hydrophones during approximately 25% of the program. The shots within 6 m of the borehole were used to obtain check-shot information.

3.8 Recording Operations

Receiver lines, oriented east-to-west, were laid out beginning at the north end of the site. Outside the disturbed zone, DSUs were dropped from line trucks (pickups) at each receiver flag, while inside the disturbed zone, equipment was carried by hand. The line trucks, approximately 2.5 m wide, were able to fit between stations without driving over equipment (see Figure 13). Equipment layout began 12 January, 2007.

Figure 13: Line trucks between shot stations

Line trucks were able to drive between shot stations, making equipment layout more efficient than if all equipment had to be hand carried or shuttled in ATVs.

It was clear from the results of the feasibility study that no gaps could be allowed to exist in the surface coverage. Therefore both shots and receivers were located within the disturbed zone, including in the vent area and the surface-collapse area (see Figure 14). Shot-holes were drilled to a depth of 3 m by hand-drill crews. The receiver equipment was carried in by hand.

Figure 14: Receiver and shot lines in the field

Both receiver and shot lines extended across the disturbed area so that no gaps existed in the sub-surface coverage. Shots and stations were moved a maximum of three metres, so as to not be located in a crevasse or on the side of a steep slope.

The recording crew operated using only a day shift during the initial equipment layout (two days), until enough equipment was installed so that shooting could begin. Once recording began, the crew was split into a day shift and a night shift. This would allow each crew to shoot through a three-receiver-line swath, and then roll equipment ahead of the spread. The crew size varied throughout the project: it ranged from 35 persons during the initial equipment layout to 45 persons during part of the recording period.

Safety of operations was the top priority during the project. At the start of each shift, a safety meeting was held to discuss the tasks for the shift, as well as any safety concerns that may arise or had arisen on earlier shifts. The primary hazard identified on the site was the rough terrain around the vent and surface collapse area. To mitigate the risk posed by this area, personnel were only allowed to work within the disturbed zone during daylight hours.

Recording began the night of 14 January, and continued until 28 January, 2007. Two shooters and two shooters' helpers were used during each recording shift.

3.9 Site Clean-Up and Demobilization

Equipment pick-up and site clean-up began immediately after the recording finished on 28 January. The site was clean by the evening of 29 January. The crew demobilized the same day.

3.10 Logistical Issues: Very-Low-Tolerance and Very-Large-Channel Survey

It should be noted that a survey of this intensity had never before been attempted anywhere. It is likely that this survey set world records for the number of channels recorded for each shot, and the density of coverage (numbers of shots and receivers per square kilometer).

There were numerous logistical issues that needed to be solved prior to, and during the survey acquisition. Some of these were related to the large number of channels being used, while some of them related to the shallow nature of the target.

First, the tolerances required for the survey were far tighter than those regularly observed in the seismic reflection acquisition industry. In normal operations, distances of a few meters between the station and the shot, or between the station and the receiver are acceptable because of the large bin sizes used. However, the bin size in this survey was 1.5 m by 1.5 m. The shot needed to be within 25 cm of the planned location; as noted above, the drilling crews needed to develop methods to reach this tolerance. The receivers had to be within 10 cm of the station pin flag; therefore crew members were trained during the first day of operations to meet these tolerances. Furthermore, the drillers and recording crew needed to be aware of their location and the direction to follow, since, as shown in Figure 15, the line directions were not always obvious.

Figure 15 : A view of the site from the southwest

The shot and receiver stations were so close together, and located to such accuracy, that from some view angles it was difficult to tell the true directions of the lines.

In normal operations, areas like the zone of surface disturbance would not be instrumented: the area would be left untouched, and instruments would only be placed at the edges of the zone. This type of approach would be acceptable for other oil-sand seismic reflection survey, where targets are significantly deeper than in this project.

However, for the target depths of this survey, no gaps in surface coverage could be allowed. Therefore, safe methods of operating in areas such as the surface collapse structure, for example, needed to be developed (see Figure 16). Shots were drilled in the area using hand drills, and receivers were deployed by hand, following the same spacings used outside the area.

Figure 16 : Issue of trees around surface-collapse structure

Safe work plans were developed to remove the trees from the surface-collapse structure, shown here, so that shot-holes and equipment could be installed. The trees were cut by hand, and pulled from the area using a backhoe. Other areas in the zone of surface disturbance were also hand-slashed to allow safe operations.

The signals from up to 5,000 3C receivers were recorded for each shot in this program, thereby requiring 15,000 live channels. Although SERCEL, the manufacturer of the recording equipment, claimed that this was possible, this number of channels had never been recorded before. SERCEL therefore carried out numerous synthetic model trials of its hardware and software prior to the project, to try to ensure that recording operations went smoothly.

Unfortunately, the recording did not go smoothly. The first shot was fired the night of 14 January. Although the data were recorded and displayed in the recording truck, the acquisition system failed and had to be rebooted, and the data from the shot were lost. This proved to be the start of a large number of system failures that resulted in significant down-time of the recording crew.

Sercel responded by sending one of its technicians to the crew. The technician was not able to solve all of the system problems, and therefore needed the support of SERCEL's France-based development team. The technician and the development team remained involved with the acquisition for all but the last two days of the recording.

Shooting operations also needed to be altered from normal practice. Normally, line-crew members can lay out equipment ahead of the live spread. However, to obtain maximum data quality, no one but shooters and shooters' helpers were allowed on the site during recording, since the noise generated by people walking off the spread could be detected by the recording instruments. Likewise, the recording truck was not allowed to be on the spread, and had to be moved approximately 75 m east of the site.

4. 3D HR SITE SURVEY SEISMIC DATA PROCESSING – PP DATA

4.1 General

In order to get the most reliable and accurate sub-surface imagery possible, a very significant number of processing sequences and parameter tests have been carried out before finalizing the full processing flow.

The first brute stack that came out 2 weeks after the acquisition was completed was very promising, as shown in Figure 17. However, it took four full months, i.e. from February to May 2007, to achieve the final displays.

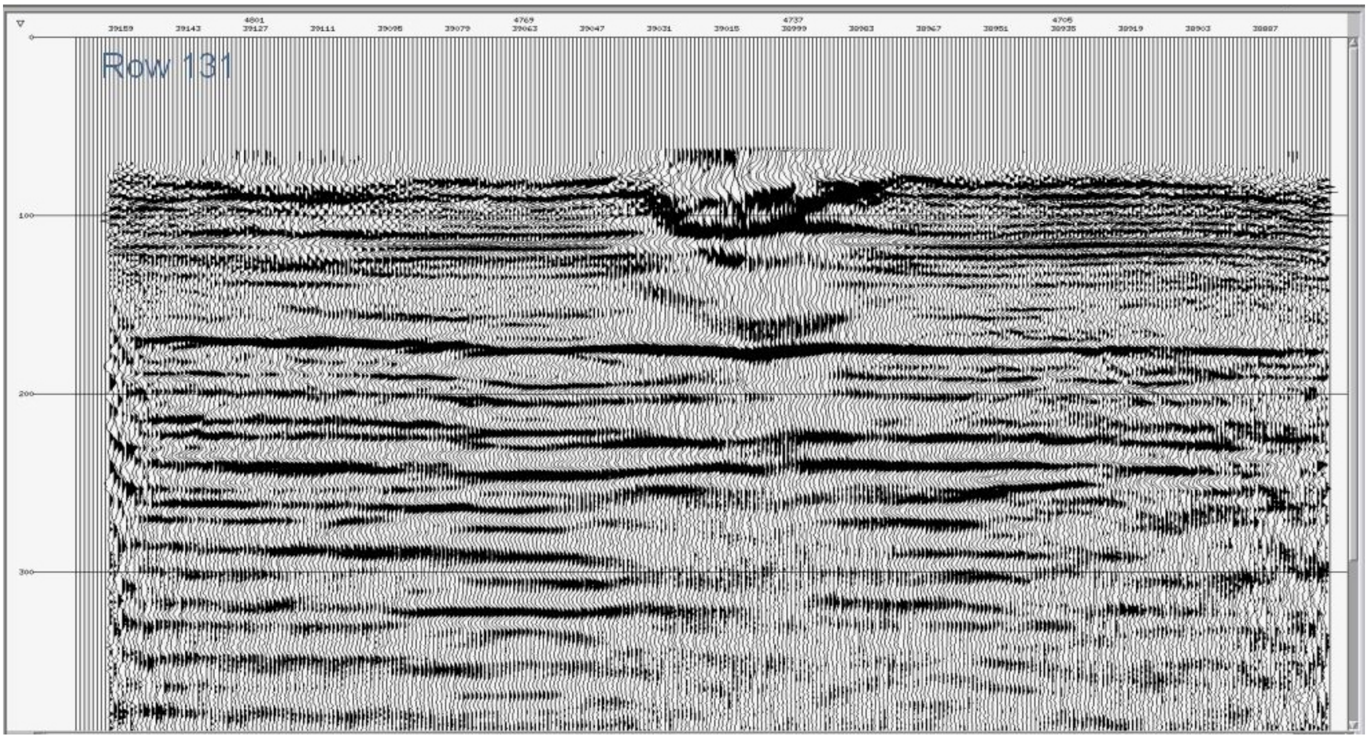


Figure 17 : Initial seismic section produced prior to determining the optimum processing sequence.

A general list of the processing steps carried out or tested on the 3D data is shown below. The processing stream is very similar to that of the 2D flow, since the five 2D lines were processed using 3D routines. For the most part, these are standard processes and will not be discussed in detail here. They are fully described in CGGVeritas's Processing report .

Although the steps presented below represent the final processing flow, many of alternate flows were tested, to determine how to obtain the highest-quality image.

- Data demultiplexed / Re-formatted
- Selected vertical component for P-wave processing
- Set geometry
- Sensor tilt correction applied
- Bad traces edited out
- First breaks picked
- Near-surface statics applied using turning-ray tomography
- Performed tomographic refraction static and datum static calculations
- Elevation-only and calculated tomographic statics (P-wave: source and receiver) calculated and applied.

- Adaptive polarization filtering applied to attenuate ground-roll energy.
- Proprietary adaptive polarization filtering technique characterizes and removes the ground-roll energy by exploiting the fact that the polarization of surface waves is different from the polarization of PP and PS body waves. Adaptive polarization filtering operates only within the ground roll frequency band, preserving signal within this band. This is an adaptive filter that uses Complex Singular Value Decomposition (CSVD).
- Proprietary noise attenuation applied
- Divergence correction (T**N) applied
- Surface consistent scaling applied
- Surface consistent deconvolution applied (tested to stacks with 10,15,20ms operators and 5% pre-whitening)
- Surface consistent scaling applied
- Preliminary velocity analysis carried out (velocity control points at a spacing of 50m)
- Proprietary preliminary surface consistent statics (MASTT) applied
- Spectral whitening applied (if needed)
- Surface consistent scaling applied
- Final velocity analysis carried out (velocity control points at a spacing of 25m)
- Proprietary final surface consistent statics (MASTT, 2nd Pass)
- First break mute applied (different mutes tested and stacked)
- Trim statics applied if tests positive (tested and compared with and without trim statics)
- Pre-stack scaling tested
- Decimation tests will be introduced at this time with shot/stn edit cards.
- Proprietary noise attenuation (FX deconvolution for 2D lines and FXY deconvolution for 3D) applied.
- Post-stack Kirchhoff time migration.
- Post migration spectral whitening or Zsignal tested.
- Bandpass filter
- Scaling
- HDpic
- Pre-stack migration (PSTM) near, mid, far.
- Pre-stack migration (PSTM) angle mute from 0° to 40° with 5° increment .

4.2 Final processing flow

The selected final processing flow for the full interpretation work is as follows:

RE-FORMAT:
Processed length: 1000 ms
Sample interval: 1 ms

GEOMETRY 3D CASE
Bin size: 1.5 x 1.5 M

VERTICAL ORIENTATION AND GEOMETRY ROTATION
Correcting Sensors to Vertical
Sensor Orientation in Field : 250 Degrees
Magnetic Declination Correction: 16.5 Degrees E

NEAR SURFACE STRUCTURE STATICS - 2 LAYER DRIFT COMPUTATION
Method: Grid Tomography
Datum elevation: 400 m asl
Rep. Velocity: 2000 m/s
Weathering velocity: 1000 m/s
Processing datum: surface
Statics were decomposed into short wavelength and long wavelength components.

AMPLITUDE RECOVERY
Type: t **1

EDITING manual trace edits

PRE-DECONVOLUTION NOISE ATTENUATION

Type:	Coherent Noise Attenuation (C.N.A.)	
Frequency:	1/3 – 30/35 Hz	
Velocity:	100/400 m/s [50/100 m/s taper]	
Threshold:	2	
Window length:	1000 ms	
Application gates:	offset	time gate
	0 m	30 – 1000 ms
	25 m	100 – 1000 ms
	61 m	200 – 1000 ms
	95 m	300 – 1000ms
	130 m	400 – 1000ms
	155 m	472 – 1000ms
	200 m	1000 – 1000ms

Type:	Blast – de-burst
Frequency:	out – 30/35 Hz
Threshold:	10
Window length:	1000 ms

Type:	Flash – Spike Attenuation	
Zone size:	10 traces	
Threshold:	2	
Window length:	100 ms	
Scale :	0.25 (spikes are scaled to the rms of the window)	
Application gates:	offset	Time Gate
	0 m	30 – 1000 ms
	127 m	100 – 1000 ms
	318 m	200 – 1000 ms
	442 m	260 – 1000ms

SURFACE CONSISTENT SCALING I

Design gate:	30 - 300 ms at	0 m offset
	100 - 325 ms at	127 m offset
	200 – 370 ms at	318 m offset
	260 – 400 ms at	442 m offset

DECONVOLUTION

Type:	Surface Consistent Minimum-Phase Spiking	
Operator length:	40 ms	
Components applied:	line, source and receiver	
Prewhitening:	5 %	
Design gate:	30 - 300 ms at	0 m offset
	100 - 325 ms at	127 m offset
	200 – 370 ms at	318 m offset
	260 – 400 ms at	442 m offset

SURFACE CONSISTENT SCALING I

Design gate:	30 - 300 ms at	0 m offset
	100 - 325 ms at	127 m offset
	200 – 370 ms at	318 m offset
	260 – 400 ms at	442 m offset

PRELIMINARY VELOCITY ANALYSIS

Type:	Double Square Root Normal Moveout
Method:	Interactive Semblance
Reference:	surface
Analysis density:	50 m grid

FIRST PASS AUTOMATIC SURFACE CONSISTENT RESIDUAL STATICS

Window:	100 - 200 ms
Filter:	20/30 – 200/550 Hz
Max. Static:	+/- 24 ms

FINAL VELOCITY ANALYSIS

Type:	Double Square Root Normal Move-out
Method:	Interactive Semblance
Reference:	surface
Analysis density:	50 m grid

Note: additional velocity control points were situated on and around the disturbed zone on a finer grid.

SPECTRAL WHITENING

Signal frequency:	25/35 –130/140 Hz
Desired frequency:	5/10 – 300/350 Hz
Frequency bands:	10 Hz
Starting frequency:	25 Hz
Gain:	3 db/octave

FINAL PASS AUTOMATIC SURFACE CONSISTENT RESIDUAL STATICS

Window:	100 - 300 ms
Filter:	20/30 – 300/2350 Hz
Max. Static:	+/- 16 ms

CDP TRIM STATICS

Model:	Noise-Attenuated Stack
Window:	90 - 300 MS
Filter:	15/25 – 250/300 Hz
Max. Static:	+/- 6 ms

GATHERS

At this point gathers were created from the above processing sequence to be prepared for Pre-Stack Kirchhoff Migration. A paralle flow continues to Post Stack Kirchhoff Migration

MUTE

A spatially-variant mute function was used.
Representative mute function:

Offset [m]	Time [ms]
38	0
78	50
111	100
120	150
131	200
142	250
152	300
163	350

PRE-STACK SCALING

AGC:	Window 0 – 100 MS Length = 100
Mean:	Window 100-200, 200-400 ms App. Times 200, 300 ms

STACK

Fold compensation:	1/ n

POST-STACK 3D KIRCHHOFF TIME MIGRATION

Dips:	65 degrees
Half-aperture:	105 m
Anti-alias:	100%

END OF POST STACK PROCESSING FLOW.

PP PSTM PROCESSING SUB-FLOW FROM GATHERS:

PP PSTM MIGRATION GEOMETRY

Discreet offset binning

offset planes:	50
maximum offset:	300 m

PSTM VELOCITY ANALYSIS

Method:	interactive semblance
Reference:	surface
Analysis density:	50 m grid

Note: additional velocity control points were situated on and around the disturbed zone on a finer grid.

GATHER PREPARATION

Input:	time gathers
Filter:	3/5 – 350/400 Hz.
Scaling: agc:	window 0 – 100 ms length=100
Mean:	window 100-200, 200-400 ms
app.times:	200, 300 ms

PRE-STACK 3D KIRCHHOFF TIME MIGRATED GATHERS

Dips:	65 degrees
Half-aperture:	105 m
Anti-alias:	100%

MUTE

A spatially-variant mute function was used.

Representative mute function:

offset [m]	time [ms]
38	0
78	50
111	100
120	150
131	200
142	250
152	300
163	350

STACK

Fold compensation: 1/ n

END OF PP PSTM STACK PROCESSING FLOW.

PP PSTM ANGLE MUTE STACK PROCESSING SUB-FLOW FROM PRE-STACK 3D KIRCHHOFF TIME MIGRATED GATHERS

PSTM INTERVAL VELOCITY FUNCTION
Method: Snell-dix

ANGLE MUTE STACK

Application of a surgical mute
Angles: 5 – 15 degrees

TIME VARIANT BANDPASS FILTER
5/10 – 300/350 Hz 0 – 200 ms
5/10 – 250/300 Hz 250 – 400 ms

SCALING
Mean: length 100 ms
overlap 50 %

END OF PROCESSING

Since the target of the survey was much shallower than the targets of most seismic surveys, even of most reflection surveys shot in the Alberta tar sands, special methods were required to ensure the integrity of the shallowest parts of the section. The selection of the 5-to15-degee angle-mute stacks noted above resulted in the best results throughout the target region of the section. Figure 18 shows the same line, 131, as in Figure 17, after the final processing steps were carried out.

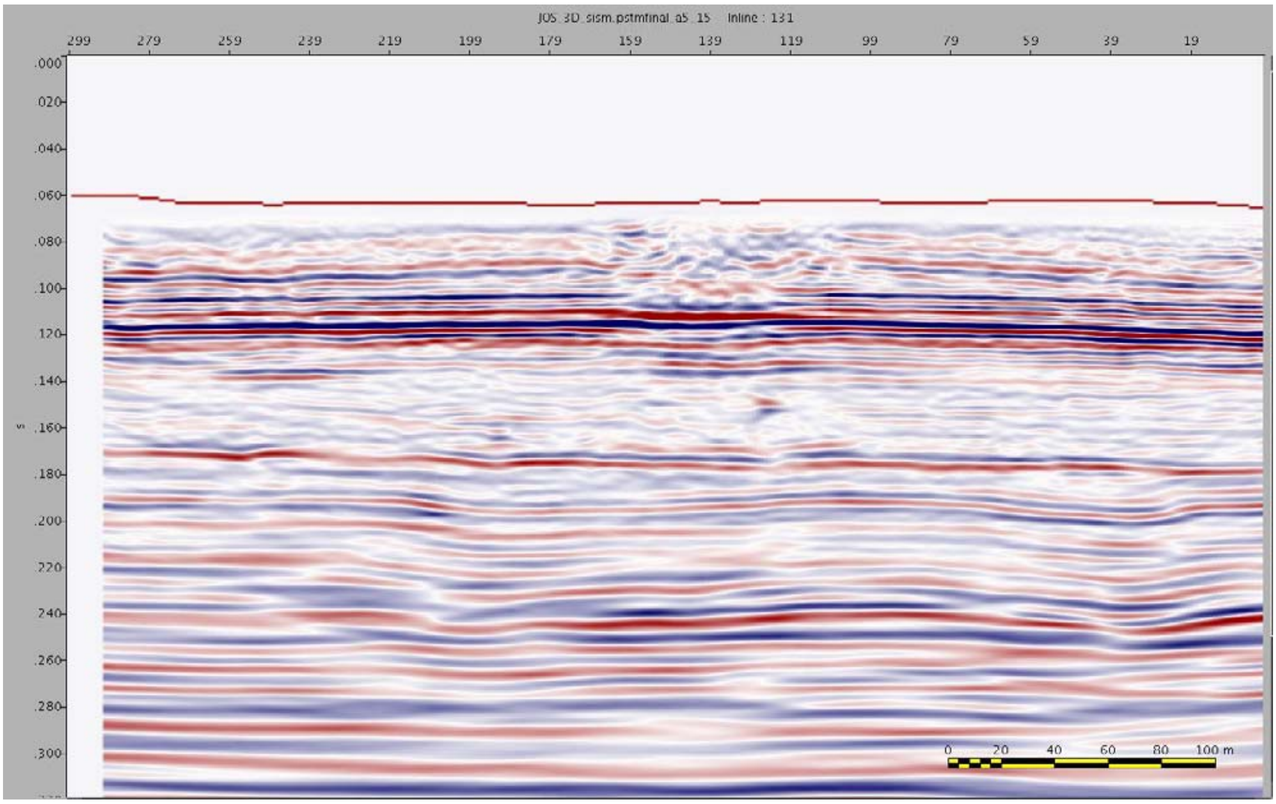


Figure 18 : Final seismic section produced using the optimum processing sequence.

This is the same line as in Figure 17.

5. 3D HR SEISMIC ANALYSIS AND INTERPRETATION – PP DATA

5.1 General

The interpretation work was performed using first a classical Charisma workstation for a preliminary viewing of the seismic cubes issued from the different processing sequences and then Sismage which is TOTAL's proprietary software suite of seismic interpretation tools.

The results are displayed on the attached plates 1 to 71, which can be printed at any desired scale.

5.2 Data Quality

Data quality was exceptionally high at the site, with stacked sections containing a dominant frequency of approximately 250 Hz (see Figure 19 overleaf). Narrow-band filter tests show that coherent signals exist up to a frequency of approximately 350 Hz.

The processing techniques employed overcame two areas where lower-quality data appeared on the raw shot profiles. In the northwest corner, an area approximately 150 m by 200 m (East-West by North-South), the raw profiles displayed lower-quality signals than recorded at most of the site. A comparison of a map of the lower-quality data zone with a high-resolution air-photo (taken prior to the clearing of the area) showed conclusively that the area was covered in muskeg. This was confirmed by a field check of the surface material. For shots inside the zone, an inspection of the raw records showed that the target zone of the survey appeared reasonably clearly on the near traces, outside the ground roll. For shots far outside the muskeg zone, the receivers inside the zone showed almost no usable results, but this did not affect the final images since those parts of the raw records were generally far outside the processing mutes.

The steam-release area represented a second zone of reduced data quality. Generally, shots from within the two depressions resulted in lower frequency content in the far-offset traces. This was likely a result of two factors. First, the disturbed ground was likely not as good a sound transmitter as undisturbed ground. Second, the increased charge size used in the holes within the disturbed zone was shown during the test survey's source tests to result in lower frequency content. However, as noted above for the muskeg area, good-quality images were obtainable within the disturbed zone since only the near traces were used in the final image

However, as a result of the data processing, good-quality images were obtainable both inside and outside this zone, since only near-offset traces (those within the 5-to-15 degree angle mutes) were used. These near traces all had usable signals.

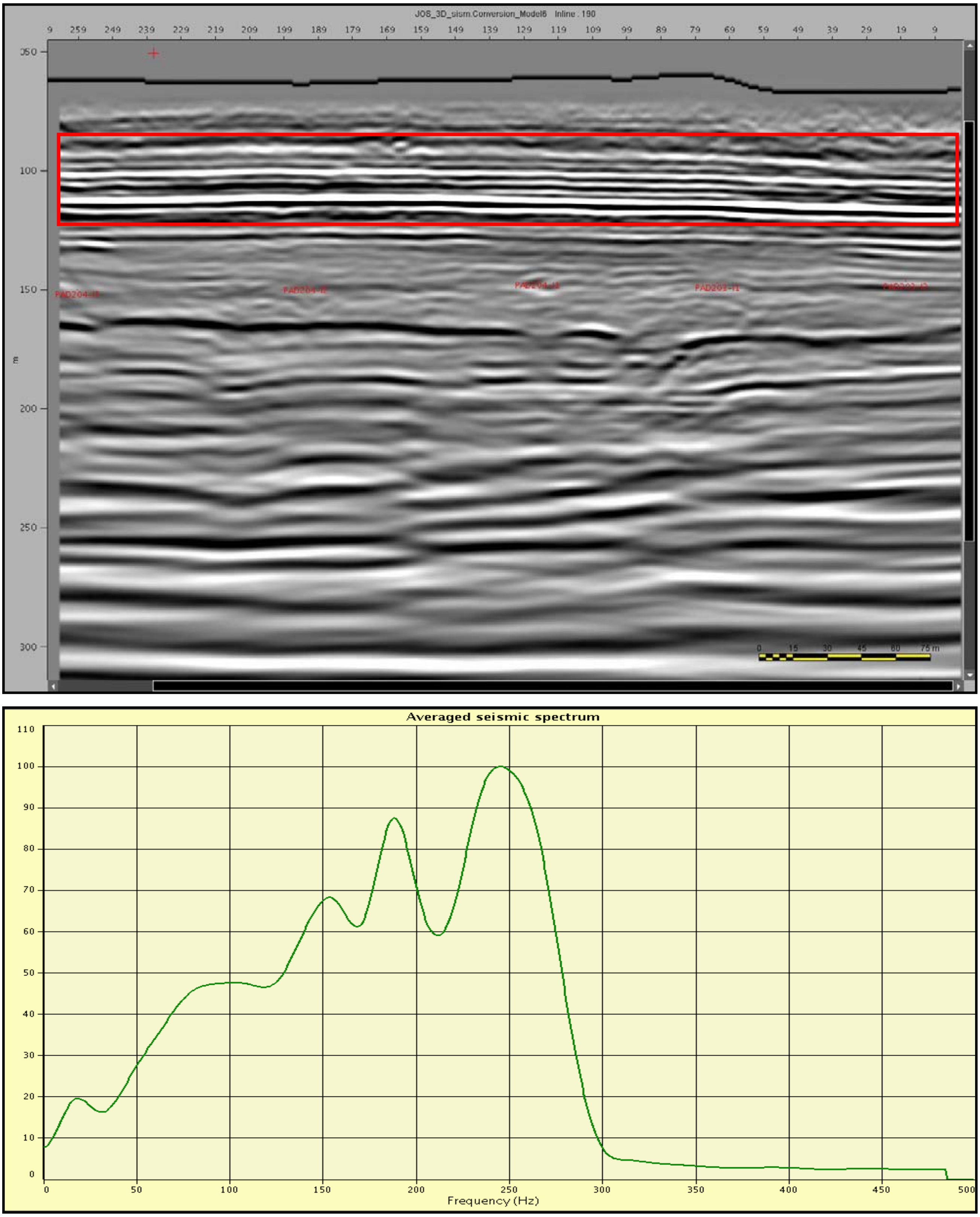


Figure 19 : An example of the average frequency spectrum of the final sections. The frequency spectrum below was computed within the red window displayed on the section above.

5.3 Relationship of Seismic Reflectors to Geologic Units

5.3.1 Geological setting

5.3.1.1 General

The Lower Cretaceous Mannville Group of northeastern Alberta, Canada contains one of the world's richest and most voluminous bitumen resources. The Mannville Group comprises the McMurray Formation which overlies Middle to Upper Devonian carbonates as a major angular, basin wide unconformity. The McMurray Formation is overlain by the Wabiskaw and the thick Clearwater Formation.

The McMurray deposits are mainly concentrated in a narrow north-south oriented sandy fairway, referred to as the McMurray Valley (Ranger, 1994). The continent was located to the south and open marine Boreal Sea to the north during lower Mannville times.

The McMurray Valley reflects the greatest McMurray isopach of the Athabasca Region, the highest net-to-gross, and is believed to have been produced by gradual dissolution and erosion of the underlying Middle Devonian Prairie Evaporite salts before, during and after deposition of the McMurray Formation. The Joslyn Lease is located on the northwestern hinge of this fairway.

5.3.1.2 Joslyn Area

In the Joslyn Area, the major part of the McMurray Formation, ie the Middle McMurray, comprises thick estuarine channel sandstones; they form the main bituminous reservoir. The base of the McMurray formation resting upon the Devonian series is roughly at a depth of 110 m

The Upper McMurray (approximately 40-46 m deep) is composed of marine shorefacies deposits, forming alternating sandstone and shale sheets. Although easier to correlate than the McMurray channel sandstones, these shorefacies deposits are generally thinner and form poorer quality reservoirs, (exhibiting lower bitumen saturation contents and local gas pockets).

Overlying the Upper McMurray is the Wabiskaw formation. This formation is porous and generally composed of silty and sandy clays or silty water bearing sands. Regionally well correlated, its top sandy interval is acting as a regional pressure drain (pressure is bleeding off incised valleys to the East This formation is about 10 m thick at a depth of around 40 m

The Clearwater formation above is composed of highly plastic stiff clay with interbedded sandy or sandy silt layers at the top. The Bottom of the Clearwater is at around 35 m deep and the formation is 30m thick

The Quartenary (2-5 m deep) overlays the Clearwater formation and corresponds to glacial clayey till and above the Muskeg which is composed of black organic spongious soil with woody debris. The thickness of the Muskeg varies from 0.2 to 5 m in depth

5.3.2 Time-to-Depth Conversion

The conversion from time to depth was made using check-shot gathers recorded in well 1AE/09-33-095-12W4, located approximately 120 m east-northeast of the disturbed area. The shot records were recorded using a 24-channel hydrophone streamer, with hydrophones spaced every five meters.

Twelve records from shots close to the well were selected for analysis. For each record, the first arrivals were picked, and the arrival times assigned to the known depths of the hydrophones. Comparisons were made between the first arrivals from each well, to determine the repeatability of the measurements. The data were of sufficiently high quality that the shot closest to the well, at shot station 142145, was used for the time-depth conversion, since its offset from the well was negligible. The shot gather is shown in Figure 20.

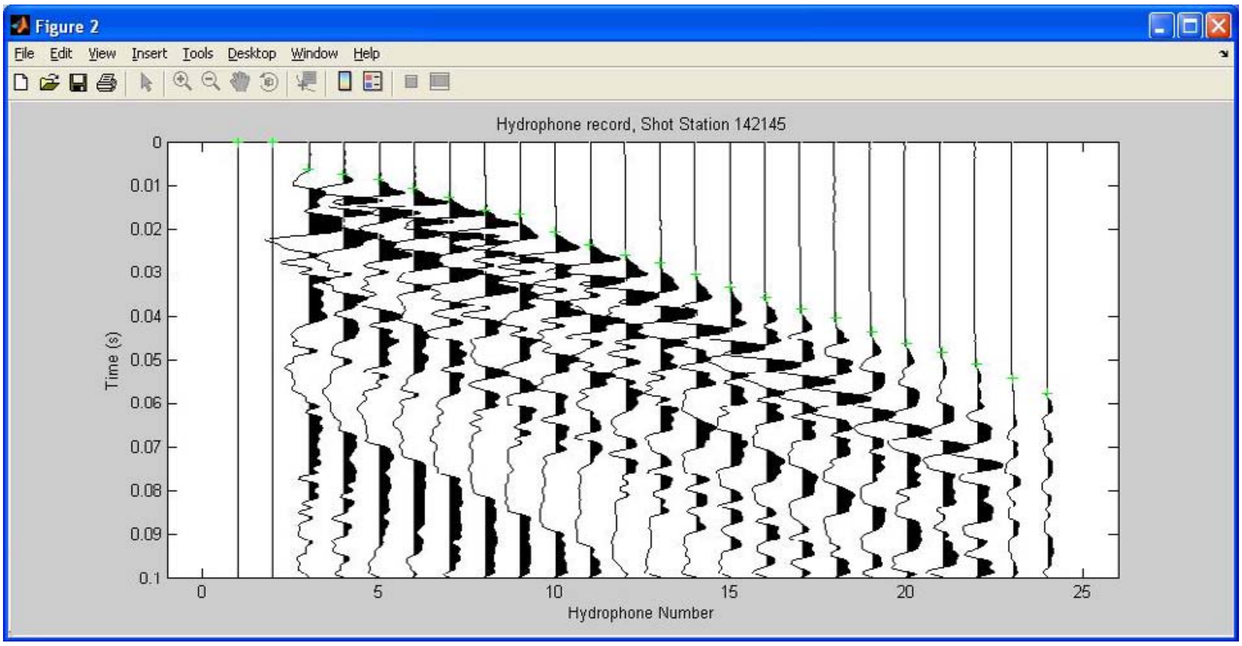


Figure 20 : **Raw first arrival times for check shots, picked on the hydrophone records**

The raw first arrival times for the check shots were picked on the hydrophone records. These were then referenced to ground level using an up-hole time for the shot.

The depths of the hydrophones were referenced to ground level. To reference the arrival times to ground level, an up-hole time for the closest shot was derived from the trace from the nearest DSU (which was 2 m from the shothole at the surface) and added to the arrival times. The up-hole time was corrected for the difference in distance between the hypotenuse (between the shot and the DSU) and the vertical shot depth. The time-depth curve, shown in Figure 21, was then referenced to the seismic datum using the replacement velocity of 2000 m/s.

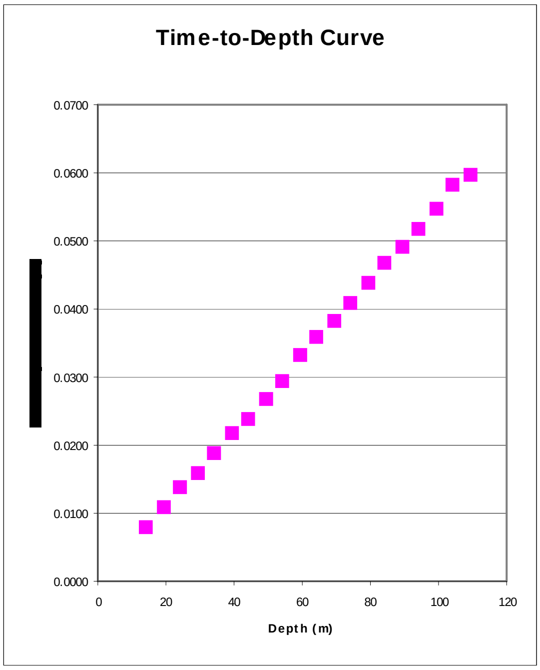


Figure 21 : Time-to-Depth Conversion.

The 3D seismic data were converted from time to depth using the same check-shot information. The seismic volume was first referenced to the surface in time, to obtain a time below the surface. The time vector for each CMP was then converted to a depth vector to obtain an initial raw depth volume. The depth volume was then adjusted using a simple kriging function to ensure that the depths to the Devonian matched those observed in wells.

No sonic logs exist for any of the wells within the project site, and the existing wells are steel-cased, therefore meaningful sonics could not be acquired in them.

5.3.3 Well Ties

Three wells were used to correlate the seismic reflections with geologic units. The well names and their locations are given in Table 7. Well core logs are given in Appendix A.

Well Name	Easting	Northing
1AD/09-33-095-12W4	446,958	6,349,728
1AE/09-33-095-12W4	447,052	6,349,787
1AB/10-33-095-12W4	446,755	6,349,782

Table 7: Wells used to tie seismic data to geologic units.

The coordinates are in UTM, NAD1983, Zone 12.

Depths to the tops of the Wabiskaw, McMurray, and Devonian were taken from the check-shot well's (1AE/09-33-095-12W4) interpreted core log, converted to time and then compared to the seismic data, as shown in Figure 22. The arrows connect the horizon names with the seismic reflections. An analysis of the phase of the Devonian reflection relative to the well pick, worked out from the Sismage workstation, shows that the mean phase difference between the peak of the wavelet and the time-converted pick is approximately 27 degrees. Since phase rotations of this amount generally do not affect the appearance of the data, a phase rotation was not applied to the data.

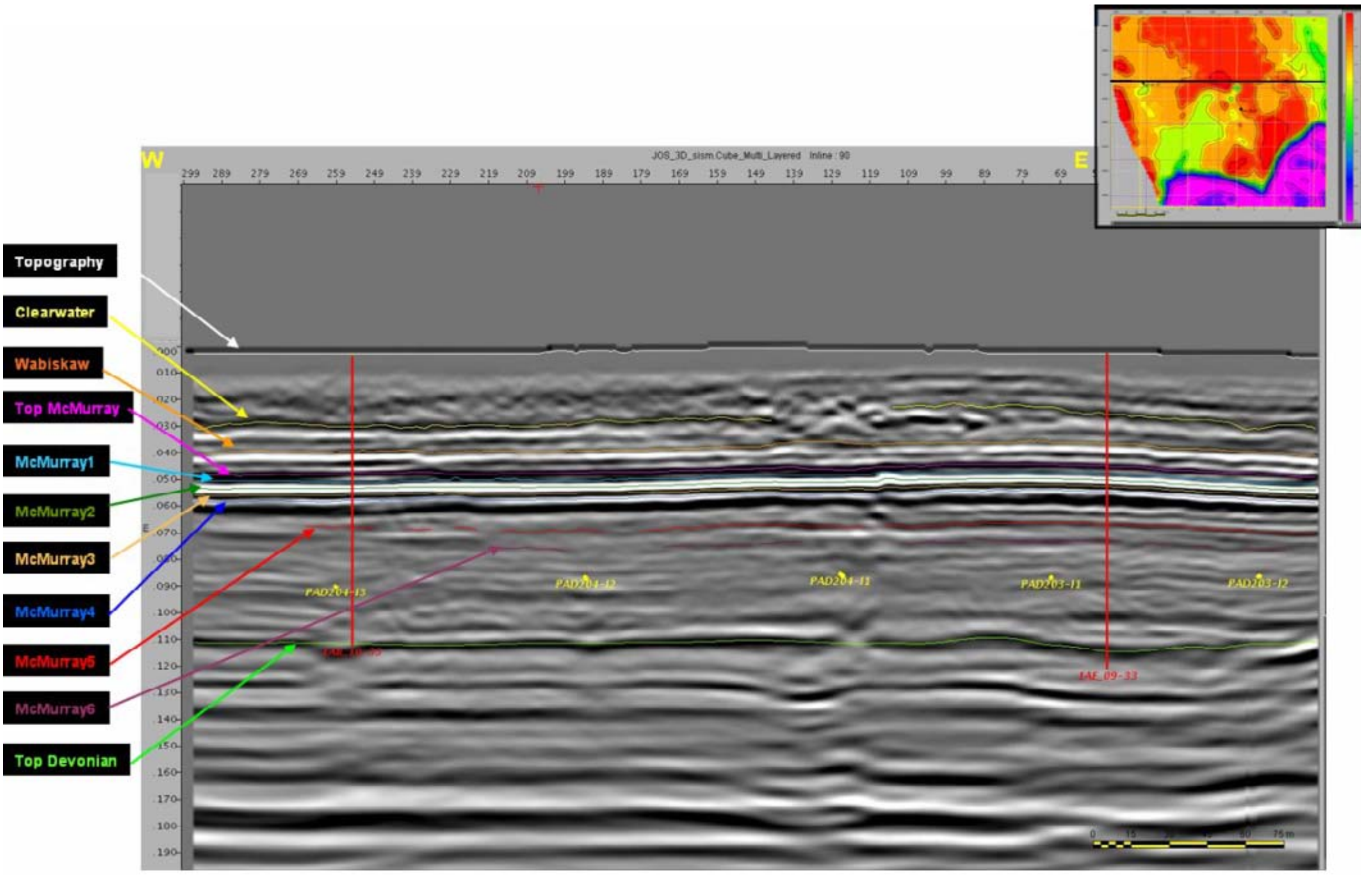


Figure 22 : Depths of geologic horizons in the core log for well 1AE/09-33-095-12W4

These were converted to time and tied to the seismic data. The location map in the top right corner shows the topography of the site, with the line location in black. This image is reproduced in Plate 3.

To correlate the horizons with other wells, the reflections shown in Figure 22 were mapped throughout the data volume, then compared to the horizon depths taken from the other interpreted core logs. The depths were converted to time using the check-shot time-to-depth curve from well 1AE/09-33-095-12W4. Figure 23 compares the correlations for the check-shot well with wells 1AD/09-33-095-12W4, and 1AB/10-33-095-12W4. To correlate the well picks with the seismic at each of the other two wells, a constant time shift was applied to the time-depth curve, to account for variations in topography and near-surface velocities. No stretching was applied to the time-depth curve.

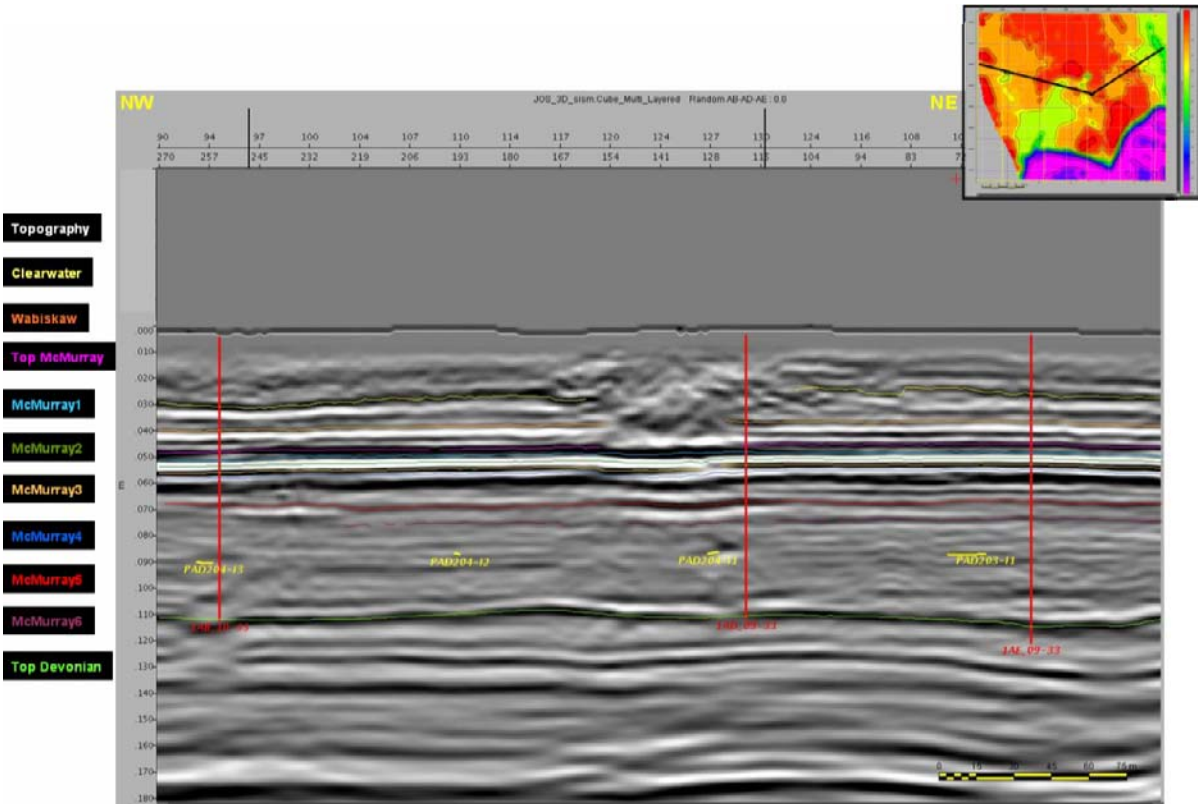


Figure 23 : Well ties across the site

The ties from the well at the east edge of the project site were transferred to the other wells by mapping the associated horizons around the project site. The location map in the top right corner shows the topography of the site, with the line location in black. This image is reproduced in Plate 4. which also shows the Gamma Ray well logs

A series of strong peaks and troughs appear beginning in a 20-m-wide band, beginning at the top of the Wabiskaw. These peaks and troughs likely result from the superposition of a number of very closely spaced reflections, and are likely not independent of one another. A comparison of the core logs with the seismic reflections led to the mapping of additional events, which are listed in Table 8 and displayed in plate 4. It should be noted that in Table 8, the Intra-Clearwater horizon, is an horizon within the Clearwater formation, imaged in the seismic data, with no available geologic correlation in the well data.

Event Name	Geologic Correlation	Peak / Trough	Colour	Depth in 1AE/09-33-095-12W4 Core Log
Intra-Clearwater	Not available	Peak	Yellow	N/A
Top of Wabiskaw	Contact between Wabiskaw and Clearwater	Peak	Orange	35.1 m
Top of McMurray	Contact between McMurray and Wabiskaw	Peak	Purple	43.5 m
McMurray 1	Contact between Middle and Upper McMurray, Top of tidal lateral accretion bed sands, gaseous	Peak	Pink	46.5 m
McMurray 2	Non-gaseous zone in tidal lateral accretion bed sand	Trough	Dark Green	48 m
McMurray 3	Base of tidal lateral accretion sands, gaseous	Peak	Cyan	50 m
McMurray 4	Top of tidal lateral accretion mixed silt / shale unit	Trough	Pink	51.7 m
McMurray 5	Middle of tidal lateral accretion mixed interbedded sand and shale	Peak	Red	63 m
McMurray 6	Top of gross pay zone	Peak	Garnet	70 m
Top of Devonian	Contact between Devonian and McMurray	Peak	Green	107.2

Table 8 : List of seismic events mapped in this report.

The naming convention used in this report is: events that correlate with the tops of geologic units are named accordingly, as for example, the 'Top of Devonian'; and events that are interpreted to correlate with subunits are named after the major unit, followed by a number, as for example, the 'McMurray 1'.

5.4 Seismic Cross-Sections and Maps

Seismic interpretation results are presented in this report in depth. Cross-sections are shown in depth usually with interpreted horizons shown in color. Monitoring wells within ten meters of the sections are shown as vertical yellow lines. The intersections of the seismic sections with the injection and production wells are shown as yellow circles.

Structure maps of the horizons are shown in depth, as are isopachs and dip maps on selected horizons. Each map shows the locations of the monitoring wells, and the surface projections of the injection and production wells.

Plates 1 and 2 are contour maps that show the surface topography in metres above sea level.

Plates 3 and 4 are seismic cross-sections that show the well ties in the site. The location maps in the top right corner of each plate show the line location superimposed on a map of the surface topography.

Plates 5 to 13 show final seismic depth sections, oriented from West to East (left to right). The entire length of every 25th section (every 37.5 m) is displayed, with interpreted horizons shown in color. The location maps in the top right corner of each plate show the line location superimposed on a map of the surface topography.

Plates 14 to 18 show final seismic depth sections, oriented from South to North (left to right), above each of the horizontal well pairs. The location maps in the top right corner of each plate show the line location superimposed on a map of the surface topography.

Plates 19 to 24 show final seismic depth sections that cross the main post-Devonian structure. Plate 19 is oriented parallel to the axis of the antiform, while Plates 20 to 24 cross the structure. The location maps in the top right corner of each plate show the line location superimposed on a depth structure map of the Top of the McMurray surface.

Plate 25 is a detailed portion of a seismic section across the steam-release area. The location map in the top right corner shows the line location superimposed on a map of the surface topography.

Plates 26 to 35 show the depth structure maps for each of the horizons. Reference datum of these maps is +337m.. These can be viewed as topographic maps of each horizon.

Plates 36 to 45 show the isopachs between the surface and the interpreted horizons. They show the thicknesses of the overlying sediments. They look similar to the depth structure maps because the ground surface is generally flat.

Plates 46 and 47 show two isopachs maps; Clearwater to Top of the McMurray and Top McMurray to Devonian Unconformity.

Plates 48 to 53 display horizon dip maps used to detect subtle features that may be difficult to detect by eye. For consistency between the maps, the color scales used are identical.

Plates 54 to 57 are time slices showing coherency centered on selected horizons. These images are useful for delineating the extent of the damaged sub-surface.

Plates 58 and 59 show seismic sections with the outline of the sub-surface disturbance. Plate 58 shows the mechanically disturbed area, while Plate 59 shows the sum of the mechanically disturbed and possible steam release affected zone.

Plates 60 to 67 show perspective views of the three-dimensional zone of sub-surface disturbance.

Plate 68 shows a vertical view of the ground surface, with the sub-surface outline of the disturbed zone, and the surface vent areas displayed.

Plates 69 and 70 show two integrated seismic magnitude map (horizon slice McMurray4 +14m to +16m and +16m to +18m) above the injector wells in the upper middle McMurray.

Plate 71 shows an integrated seismic amplitude map centered on a window (+87m to +97m) around the injector wells in the middle McMurray.

5.5 Interpreted Geologic Structure of Site

5.5.1 General Structure

The overall structure for the horizons above the Devonian is similar from one unit to the next, and is visible in Plates 26 to 34. It correspond to a wide SW-NE antiform. Some of the structure maps (for example, the Top of the McMurray, Plate 28) show a no-data region in the center where steam release affected the horizon. The total relief on each of the horizons is approximately 10 m. The Clearwater (Plate 26) is an exception: it has a relief of approximately 14 m, probably because steam inflated and damaged the unit. The depths from surface to the Top of the McMurray (Plate 28) range from 34 to 46 m.

The overall three-dimensional structure is shown below in Figure 24.

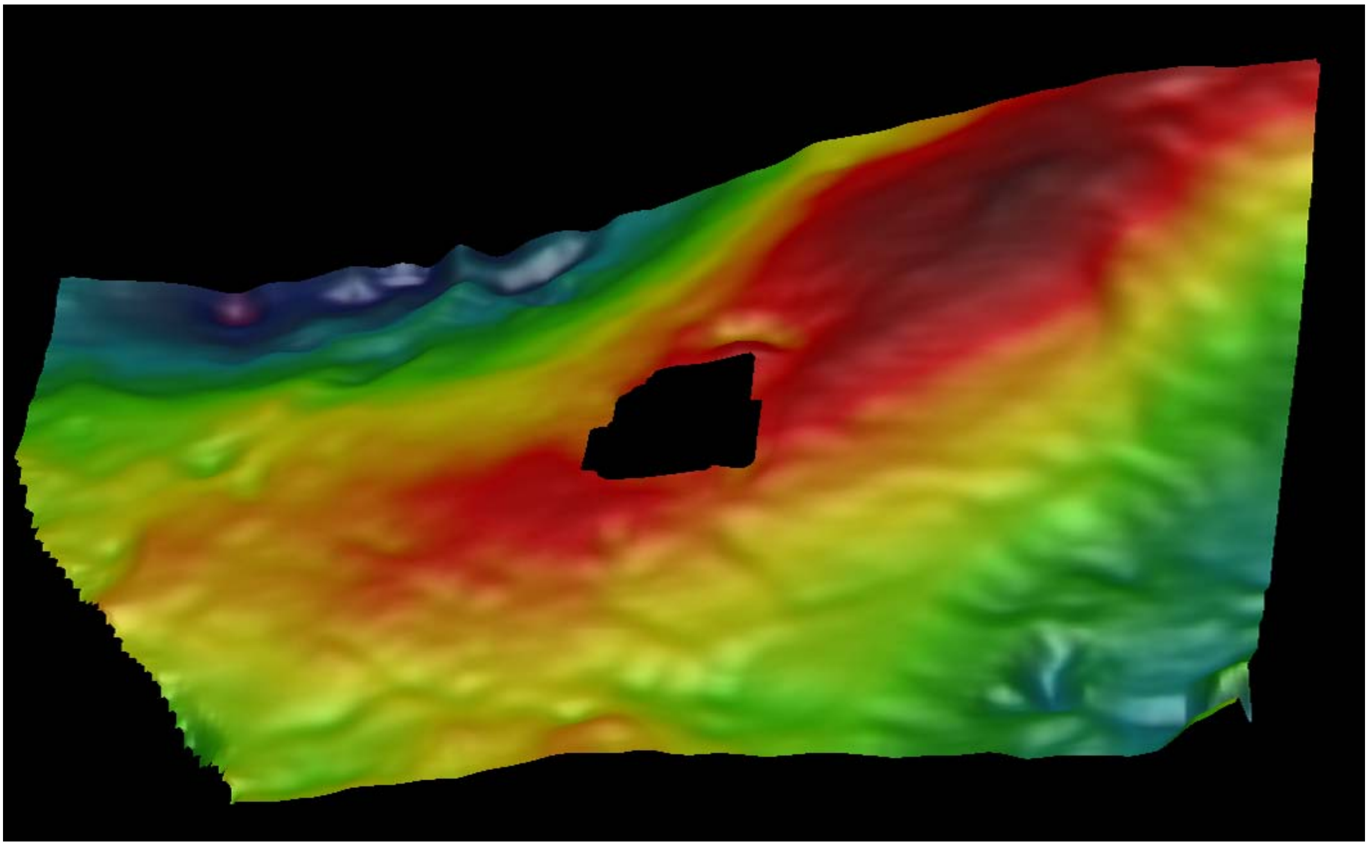


Figure 24 : **A northward-looking perspective view of the structure at the Top of the McMurray.**

The empty portion in the centre of the image corresponds to an area where the Top of McMurray reflector is missing.

5.5.2 Devonian Structure

Plate 35 is a depth structure map of the Devonian Unconformity. A steep bank exists next to a topographic high in the southwest corner of the site. The bank has a maximum relief of approximately 6 m, and runs southeast from the western edge of the site to the southern edge. These features are erosional, and do not appear in the structure maps of the overlying horizons. Figure 25 show a perspective view of the surface.

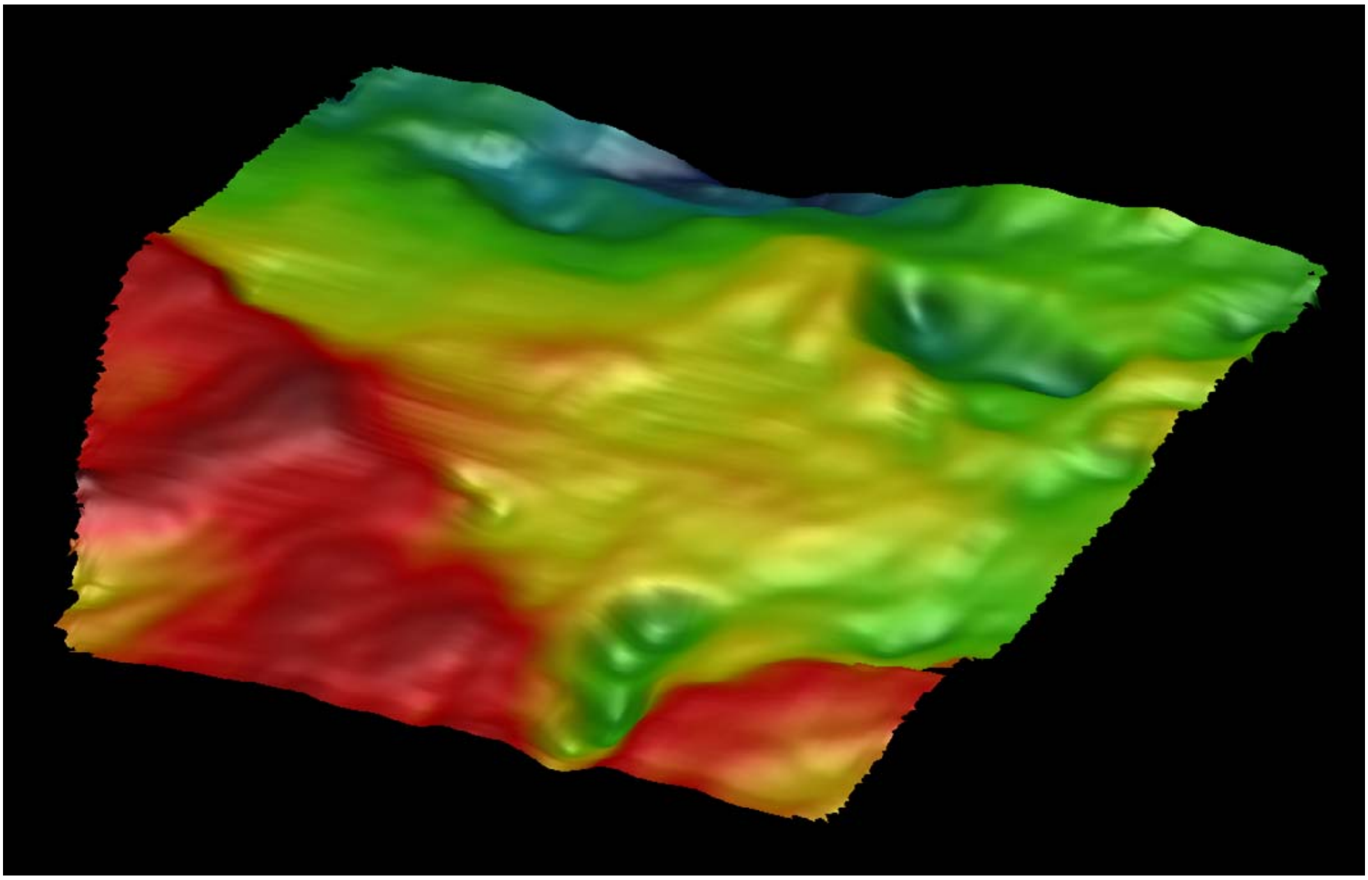


Figure 25 : **A northwest-looking perspective view of the structure on the Devonian.**

The erosional surface is not reflected in the overlying horizons.

Figure 26 presents an interpretation of the Devonian structural map. Blue lineaments are “natural” lineaments related to erosion like canyon (blue dot lines) or Cuesta (discontinuous blue line). White dot lines are showing seismic pull down effects below steamed Pad 204 injector wells. There is no similar anomaly below Pad 203 because steam injection was not started on these wells at the time of the seismic acquisition (January 2007).

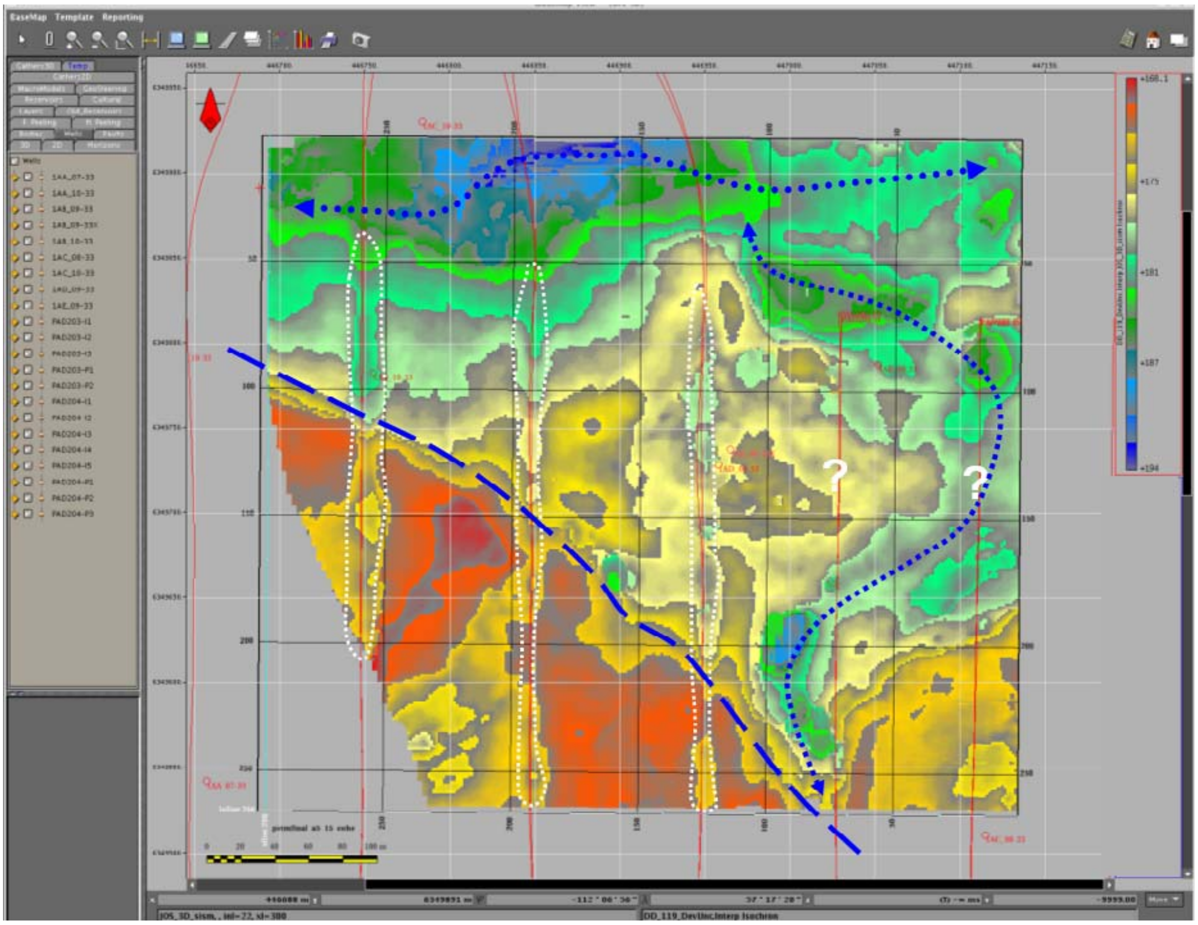


Figure 26 Devonian Unconformity Time structure map showing the main disturb areas (blue: natural related to erosion White: seismic artifact related to bitumen heating effect)

5.5.3 Assessment of Geohazards

Outside the steam-disturbed area, there is no clear evidence of geohazards. Two discontinuities exist, and are discussed below. No faults are visible that would explain the location of the steam release. Rather, the steam release occurred near the apex of the antiform.

A small flexure or possible fracture is visible at the East of the monitoring well 1AE/09-33. Plate 8 shows a very slight discontinuity in the Wabiskaw and Upper McMurray horizons, just east of this monitoring well. Its vertical extent is small and seems to be visible between the intra-Clearwater and the Middle McMurray. This feature is also evident on the dip maps in Plate 48 and 49: it appears as a narrow dark band centred at Easting 447,070, Northing 6,349,775. At the top of the McMurray, the displacement across the feature is approximately 1 ms, which was the sampling rate used to record the seismic data. Therefore the depth displacement across the feature is between 0.5 and 1.5 m. The length of the feature appears to be approximately 60 m.

A second crack or fracture also appears on Plate 7, between cross-lines 228 and 200, as a small eastward-dipping discontinuity. It appears to extend from the Middle McMurray into the Clearwater. It is also visible on the Wabiskaw dip map (Plate 48) at Easting 446,780, Northing 6,349,800. It lies near the injector 204-I3 and may be related to a steam zone as discussed in paragraph 5.6.4 below.

There are a few other dark bands on the McMurray dip map: in the center, and in the northwest and southeast corners. These bands relate either to the disappearance of the reflection (as in the center), or to areas where the reflection changes character and becomes difficult to map. In neither case are they related to slump features or faults.

A word of caution is worthwhile when interpreting dip maps from surveys that have bin sizes that are as small as in this one. Dip maps are created by calculating the gradients of interpreted horizons. Applying a gradient operator to any surface will produce a second surface that is rougher than the first. In this survey, the slopes that exist on most of the horizons are sufficiently gentle that they traverse many traces laterally before the two-way travel time of the horizon changes by 1 ms – one sample. Therefore, a gradient operator will accentuate the dip on a horizon wherever the travel time to that horizon changes by one sample. In effect therefore, many of the darker bands on dip maps are nothing more than one-sample contour lines.

5.6 Sub-surface Steam Affected Zones

5.6.1 General effects of steam on seismic images

Two main effects (well known on the oilsands 4D seismic studies) have been inventoried on our seismic image that can be directly related to **the direct and indirect <u>effects of steam injection (normal SAGD operation)</u>:**

- <u>Pull down effect</u> at the Devonian horizon just below active injector wells evidencing a change of velocity. This effect is mainly related to the change of the state of the bitumen in place (heating and melting >>> change of viscosity). It also could be related to the replacement of the bitumen by the steam. This causes false structures on the time images (pull down effect). This effect is clearly imaged on Plate 7 at the level of the Devonian Unconformity horizon immediately below active injector wells
- <u>Amplitude variation</u> around the injector wells (30m radius). The change of velocity (see above) is creating an impedance contrast characterized on the seismic by an amplitude change. This change can be characterized by **local seismic event reinforcement** (see plate 8 around PAD 204 I3, I2) or **disturbance** (see plate 7 around PAD 204 I3, I2 and I3) creating also a **local resolution decrease**

Two kinds of effect have been inventoried above injector PAD204-I1 on the seismic that could be directly related to **the direct and indirect <u>effects of the steam release (abnormal SAGD event)</u>:**

- <u>Reflections become locally absent or chaotic</u>, and are impossible to follow for more than a few meters. Plate 8 shows an example on the inline 100 above PAD204-I1 between the well and the surface (cross-lines 119 to 149). Plate 9 is showing a similar example near the surface (5 to 35m) on the inline 125 (cross-lines 119 to 149),
- <u>Local amplitude increase /variation</u> around disturbed area. Various explanations can be proposed.
  - Local modification of the petro-acoustic characteristics of the rocks in the area of the disturbance
  - Remaining gas or fluid trap and decompaction in the area of the disturbance

These effects were used to identify areas affected by steam at this site. The zones identified are discussed below.

5.6.2 Sub-Surface Disturbed Zone

Plate 9 shows a clear example of the sub-surface region heavily damaged by the steam release. It extends from the Middle McMurray to the top of the seismic data. Above the McMurray, reflections are short, broken and chaotic, and of widely varying amplitude. The centre of the zone is completely broken, with no continuous reflectors. The edges of the zone are, in some areas, characterized by somewhat continuous, high-amplitude reflections which are interpreted as a steam release effect.

Plates 58 and 59 show the broken or fractured zone in red and the steam affected area (steam release effect) in green.

Plates 60 to 67 show a number of three-dimensional images of the zone from different viewpoints: the body is shown in violet; the Wabiskaw, Top of the McMurray, McMurray 2, and Devonian horizons are shown; as are the injection and monitoring wells. This zone is the result of manual picking of the limits of the chaotic region, and is interpreted as representing the volume that has been mechanically disturbed by the steam. Note that the body extends into the Middle McMurray towards the injection well.

Plate 64 shows a larger zone, defined by the addition of the green region. This region is the result of automatic picking of the combination of high amplitudes and chaotic regions (Sismage "iso5" attribute). It is interpreted as representing the steam-release-effect zone in the upper McMurray, Wabiskaw and Clearwater.

The disturbed zone forms two chimneys below the Top of the McMurray. The restricted lateral extent of the chimneys indicates that the sub-surface disturbance did not extend to the neighboring well pairs, nor did it extend along the full length of injection well pair 204-I1/P1. The three dimensional views in Plates 65 to 67 show that the two monitoring wells that are closest to the release point, 1AD/09-33-095-12W4 and 1AB/09-33-095-12W4, do not intersect the steam chimneys. It is therefore likely that the monitoring wells played no part in the release of the steam.

Constant depth coherency maps provide an additional method of viewing regions disturbed by the steam. Plate 54 shows the coherency (black is coherent, and white incoherent) above the Wabiskaw at a depth of 30 m (Plate 54). Plates 55 to 57 show coherency maps at depths of 40 m (near the base of the Wabiskaw), 50 m (in the Upper McMurray), and 60 m (in the Middle McMurray). It is clear that the signals are more coherent, i.e., less broken, below the Wabiskaw than above it suggesting that the high velocity displacements and related fracturation that occurred on May 18th may be more related to levels above the Wabiskaw than below it

5.6.3 McMurray Steam Punctures

The horizons immediately surrounding the top of the McMurray are laterally continuous across the site, except in the vicinity of the steam release. Plate 25 shows a west-to-east section beneath the surface-collapse structure. It is clear that the top of the McMurray is broken, as are the reflections above and below. Some of the reflections, such as the McMurray 2 and the McMurray 3, have only very short sections that are not continuous. This indicates that the steam likely punctured the geologic units at this exact location. Plates 29 to 32, the depth structure maps of horizons McMurray 4 through McMurray 1, show the very restricted lateral extent of these punctures. Note that the puncture points on one layer do not necessarily lie immediately above or below the puncture points on neighboring layers. This indicates that the puncturing process may have occurred sequentially over a very short time interval, as the steam worked its way upwards by finding the weakest points in the rocks and sediments.

Plate 8 shows that the punctured portions of the reflectors are immediately below the surface collapse structure, which is shown as a depression in the surface topography. Plate 68 is a vertical view of the post-release air-photo, with contours of the vent areas and surface collapse structure overlain in white. The lateral extent of the sub-surface disturbed zone is shown in transparent purple. Small opaque purple zones show the interpreted ejection points.

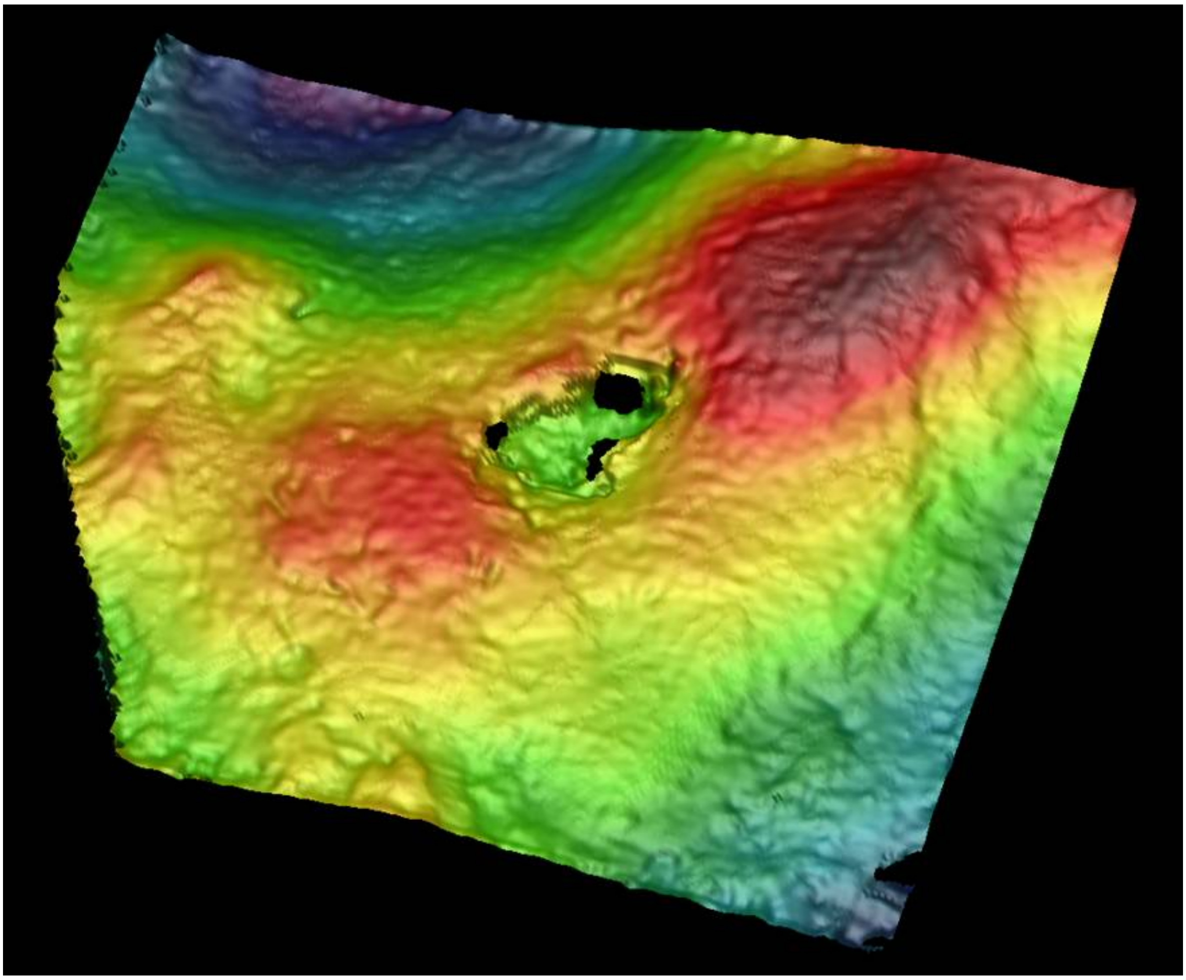


Figure 27 : **A northwest-looking perspective view of the structure on the McMurray 3 horizon, which corresponds to inter-bedded sands and shales. Three punctures are visible in the surface.**

5.6.4 Other Steamed Affected Zones

An anomalously high-amplitude reflection is visible in the Middle McMurray above the well pair 204-I1/P1 . Plate 9, a west-to-east seismic section, shows a 50-m-wide high-amplitude peak and trough between cross-line locations (shown on the x-axis at the top of the plot) 119 to 155, at a depth of 70 m. This reflection is directly below the near-surface zone of disturbance, and is beside the two chimneys below the top of the McMurray. The reflection is interpreted as indicating that steam and or hot water invaded inter-bedded sands and shales that overly the main bitumen channel sands, creating a pressurized zone. The lateral extent of the reflection indicates the extent to which the steam invaded the zone.

A similar anomalously amplitude reflection is visible in Plate 9 at cross-line 250, at 70 m depth. This high amplitude appears to be above the injection well 204-I3, which intersects the seismic image at cross-line 260, at 90 m depth. A small fracture extending from the Middle McMurray to the Clearwater, has been detected above this zone (see Wabiskaw dip map Plate 48) (Easting 446,780, Northing 6,349,800).

Plates 69 and 70 show integrated seismic magnitude maps at McMurray 4 +14ms and +16ms in a 2-m-thick window located just below the McMurray 5 reflection. Since seismic reflectors are not continuous at this level and since the structure is the same as the McMurray 4 horizon above, the maps were created by locating the desired window relative to the McMurray 4. These maps show the lateral extents of the high-amplitude events above injectors 204-I1 and 204-I3.The anomaly above injector 204-I3 seems to have the same extension as the small anticline above at the McMurray 4 level (see plate 32) In the same time this anomaly is slightly parallel to the one above injector 204-I1. It cannot be stated categorically that the high amplitude above 204-I3 is linked to the steaming of that well, but a link is suspected since a careful study of the event indicates a similarity with the anomaly above 204-I1. High amplitudes are also visible in the southeastern-most part of the site above 203-I2, where no steam was injected. However, a close analysis of the high-amplitude reflections above injectors 204-I1 and 204-I3 shows that they display a different character than the high-amplitude reflection above 203-I2 (compare, for example, plate 22 with plate 9).

A smaller, lower-amplitude reflection is visible on Plate 9 just above injector well 204-I2. This anomalous zone is also visible on Plate 71 showing an integrated seismic amplitude map (interval 87 to 97m) centered on the injector wells. Anomalous amplitudes appear along injectors 204-I1 and 204-I2. A similar analysis shows that anomalous zones exist above injector 204-I3, On the other hand no clear anomalies exist along injectors 203-I1 and 203-I2. These last two wells have not been steamed. At the same time clear pull down effect can be seen at the level of the Devonian Unconformity below steam injected wells only (see plate 8 and 9)

Therefore, the seismic response above wells that strongly injected steam for a relatively long period of time – 204-I1 and 204-I3 – shows significant anomalous zones that appear to be steam and/or heat related, and appears within the upper portion of the Middle McMurray. The seismic response above the well that injected steam for a relatively short time – 204-I2 – only shows an anomalous response close to the well. There does not appear to be an anomalous seismic response above the two wells that did not inject steam. It is therefore reasonable to conclude that steam injection (i.e. heat, steam, pressure) creates measurable changes in the seismic characteristics of the reservoir, well before the steam reaches the top of the reservoir.

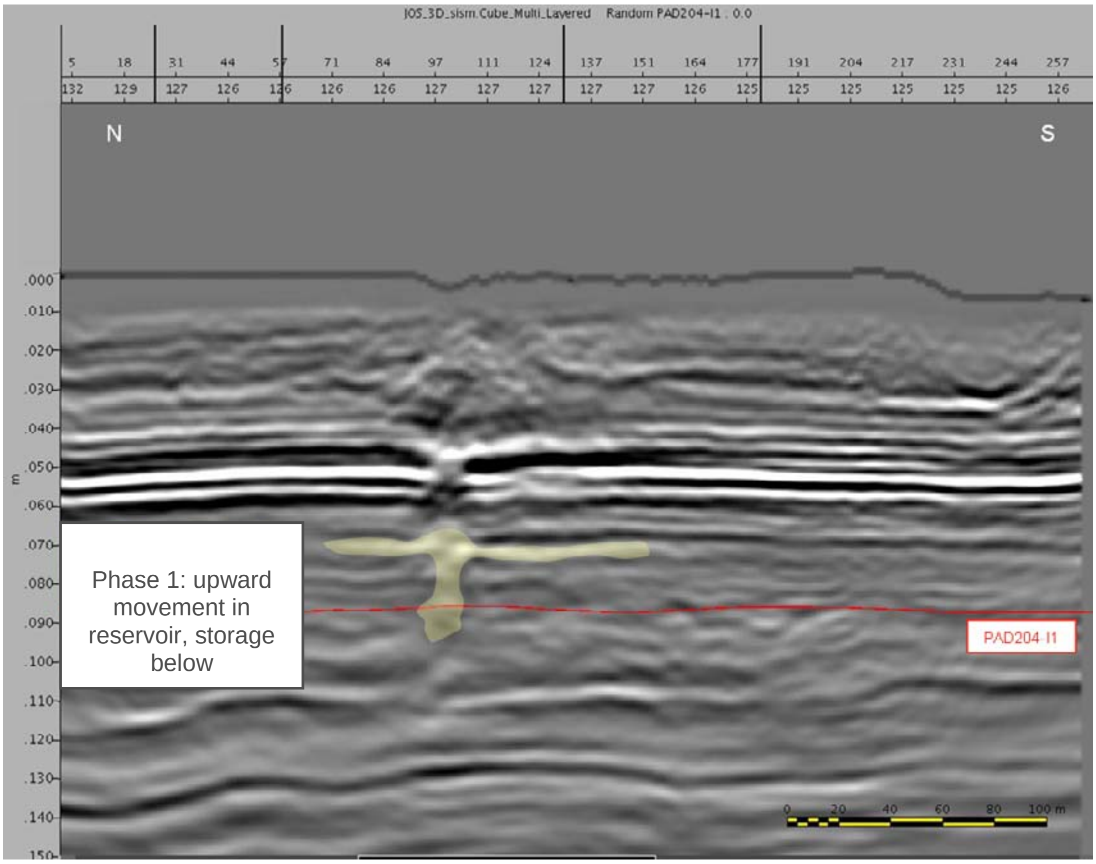
5.7 Steam Release Scenario Walkthrough

It is possible to infer some aspects of the steam release from the seismic images and walk through the steam release scenario. Such walk through draw from results of the seismic study as well as many other studies not detailed in the present report.

From the seismic images, the upwards movement of the steam between the bitumen reservoir and the Middle McMurray appears to have been predominantly through narrow punctures in the sediments. Aside from these punctures, the sediments appear to be largely intact. Above the Top of the McMurray, however, the upwards motion appears heavily chaotic. The steam has affected a large zone in the Wabiskaw and the Clearwater, breaking, moving, and sometimes excavating large amounts of material.

Seismic amplitude maps at the level of injector 204-I1 suggest that he steam was injected along most of the length of the injector. It accumulated, however, below the release area at the apex of a southwest-northeast-trending antiform that exists at the level of the Middle McMurray and above. The steam did not reach the neighboring well pairs.

Seismic amplitude maps on the McMurray 5 reflector suggest that the steam accumulated in the sandy lateral accretion beds facies – thinly interbedded sands and muds – above injector 204-I1 at an upper depth of approximately 62 m. One can infer therefore that steam was initially prevented from rising further by the muddy lateral accretion beds facies, a 1.5-m-thick light grey mud at approximately 61 m depth. This mud layer, and a second 3-m-thick layer between 57 and 54 m depth, probably caused the steam to invade the more sandy facies facies laterally, inflating the sands and effectively storing potential energy there. This is referred to in Figure 27 as ‘Phase1’.



Phase 1: upward movement in reservoir, storage below

Figure 28 : **Walking through the steam release on seismic – Phase 1: upward steam movement in the McMurray reservoir and steam / hot water accumulation below the McMurray seal**

At some point, the steam rose above the muddy lateral accretion beds facies interval. To do so, it either had to create vertical permeability pathways through the mud, or it had to go around the mud, following more permeable sandier portions of the horizon. The seismic image suggests that the steam breached, rather than bypassed, the mud. It is likely that this breach occurred on or about April 12, 2006, when the injection pressure in 204-I1 dropped and the injectivity increased. The breach appears as a dispersed broken reflection at the level of the McMurray 5 reflection.

Once the two levels of the muddier lateral accretion beds facies were breached, the steam would have worked upwards to the level of the McMurray 4 reflector, which correlates in well 1AD/09-33-12-W4 to a channel sand, which is at a depth of 53 m. This channel sand was likely invaded laterally by steam, again storing potential energy.

A small puncture then occurred in the McMurray 4 reflector at a discrete location at a depth of 52 m. The steam then began a sequential puncturing process, as it worked its way catastrophically upward through horizontal layers of interbedded sands and muds. The seismic reflections near the top of the Middle McMurray (horizons McMurray 4 to McMurray 1) are broken only in very restricted locations, typically less than 15 m in diameter, and sometimes less than 5 m. This likely indicates that once the puncture occurred, the overlying layers were not able to contain the steam for long. Since the puncture points are nearly (but not exactly) above one another, one can infer that the time between puncturing of sequential layers was minimal, likely only a few days or less: if the steam had remained between any two layers for a significant amount of time, it would have been able to find weak points over a wider area. This process is referred to as ‘Phase 2’ in Figure 28.

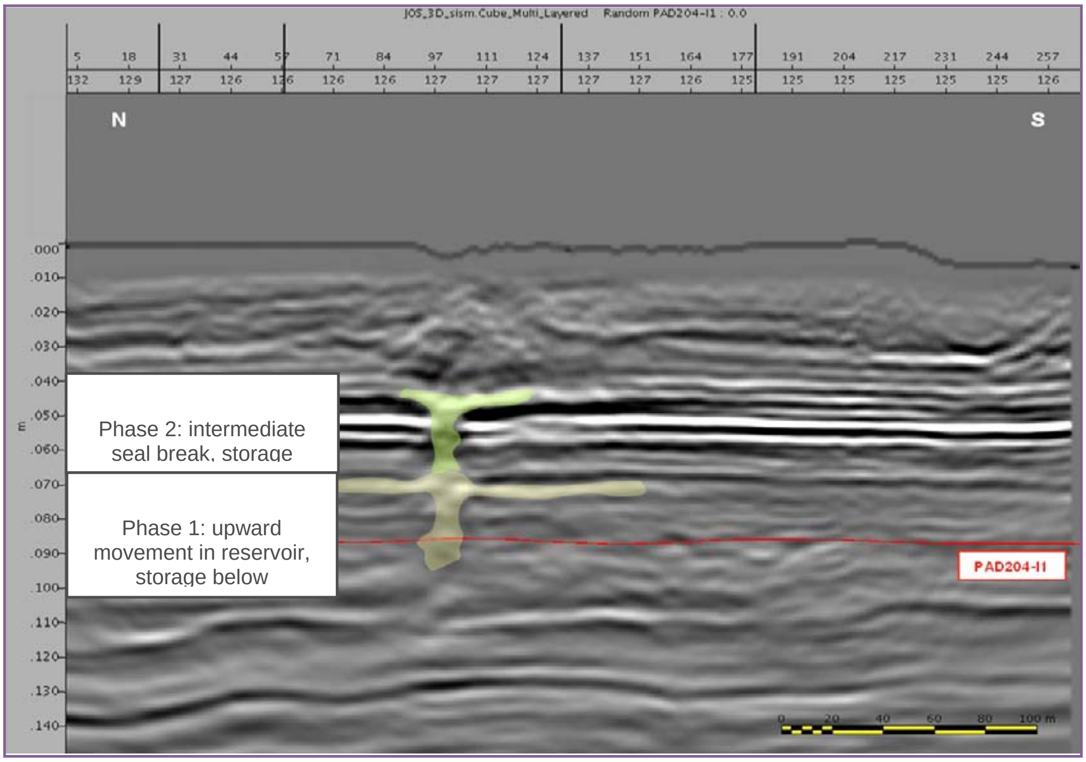


Figure 29 : Walking through the steam release on seismic – Phase 2. This phase involves steam breaking through the McMurray seal up to the Wabiskaw.

A map of the amplitude of the McMurray 1 reflector shows laterally extensive, very high amplitude beneath the steam release zone, suggesting that the steam extensively invaded the Upper McMurray. It also pressurized and inflated the Wabiskaw, and parts of the Clearwater, storing a significant amount of energy. This stage is shown in Figure 29.

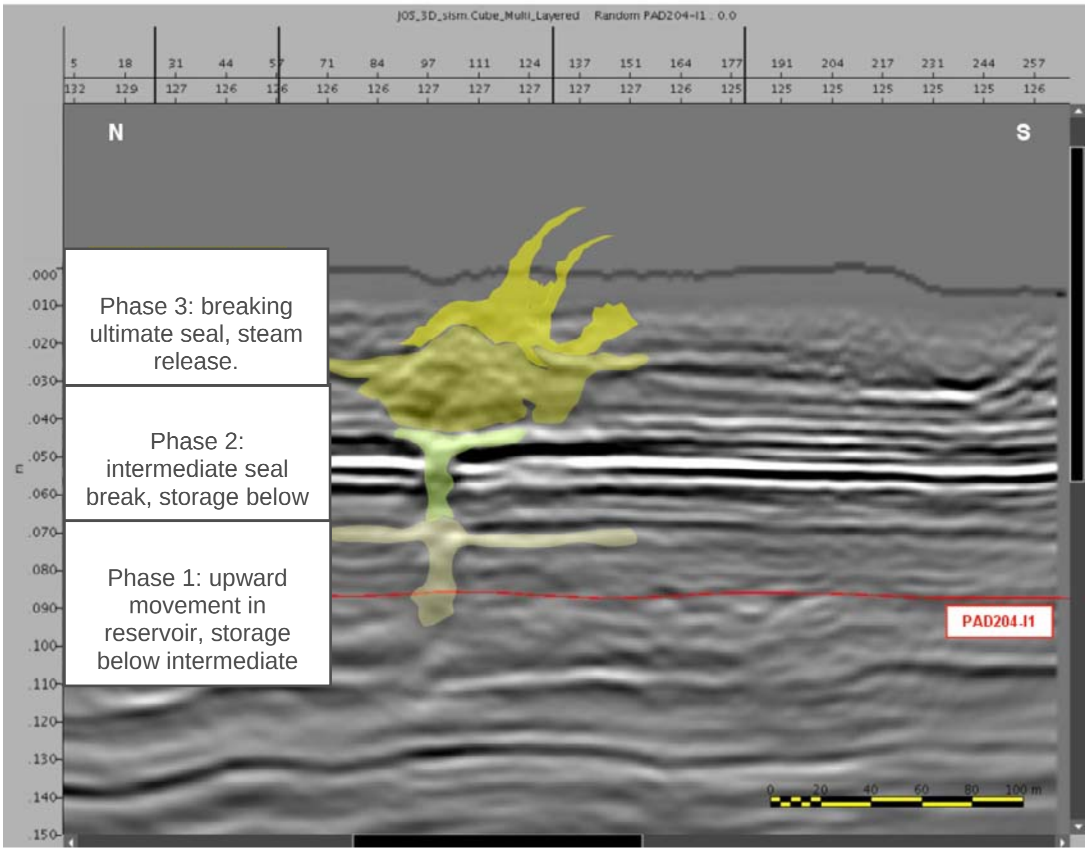


Figure 30 : Walking through the steam release on seismic – Phase 3. This phase corresponds to the ultimate step before and during the catastrophic steam release at surface.

Based on the extent of the damage imaged in the Wabiskaw and Clearwater, the last seal to contain the steam was probably in the Clearwater. Eventually, the seal in the Clearwater was breached, the weight of the overlying material was no longer sufficient to contain the steam, and vents were created at the surface. The steam then began to excavate material from the sub-surface, primarily from the Clearwater, in an energetic, explosive fashion. This is shown schematically in Figure 30. A three-dimensional volume outlining the anomalous seismic response in this area shows that the steam affected up to 500,000 m^3 of the sub-surface. Restricted puncture points are not visible on any of the horizons above the McMurray 1 reflector. This does not mean that the breaching of layers occurred concurrently over a wide area, just that the layers are too damaged to determine where the breaches occurred.

6. CONCLUSIONS

The 3D seismic survey carried out at the Joslyn site was unprecedented in near-surface seismic reflection. Extensive processing of the data has survey produced clear images of the sub-surface from 25 to 125 m depth.

The seismic images obtained allow for the clear delineation of the region in the sub-surface that was disturbed by the steam release. In addition, the following conclusions may be drawn from the images:

1. No geologic feature was identified on seismic that would suggest that local pre-existing geological conditions (faults, fracture, etc.) played any significant role in the steam release process.

2. The shape of the Steam Affected Zone as seem on seismic is unrelated to the position of the observation wells in the vicinity suggesting that those wells did not play a role in the Steam Release process.

3. The Steam release Affected Zone as seen on seismic does not extend significantly toward either of the neighboring well pairs (204-I2P2, 203-I1P1).

4. Sequence of events <u>suggested by this study and other external data</u> during leading up to the steam release were:

   o Steam migrated upwards through the reservoir, at a particular location until reaching a low permeability shale barrier, until it reached the top of the Middle McMurray.

   o It then accumulated in and pressurized the reservoir, at the apex of an antiform.

   o Steam then broke or bypassed the shale barrier at this level, and migrated upwards.

   o The sequence of accumulation, puncturing / bypass and upwards migration was then repeated as the steam worked its way into the Wabiskaw and Clearwater.

   o The final seal, in the Clearwater, was punctured after significant energy was stored in the Wabiskaw and below in the form of steam and hot water. Once this seal was punctured, the vents were immediately created and the steam was released at the surface.

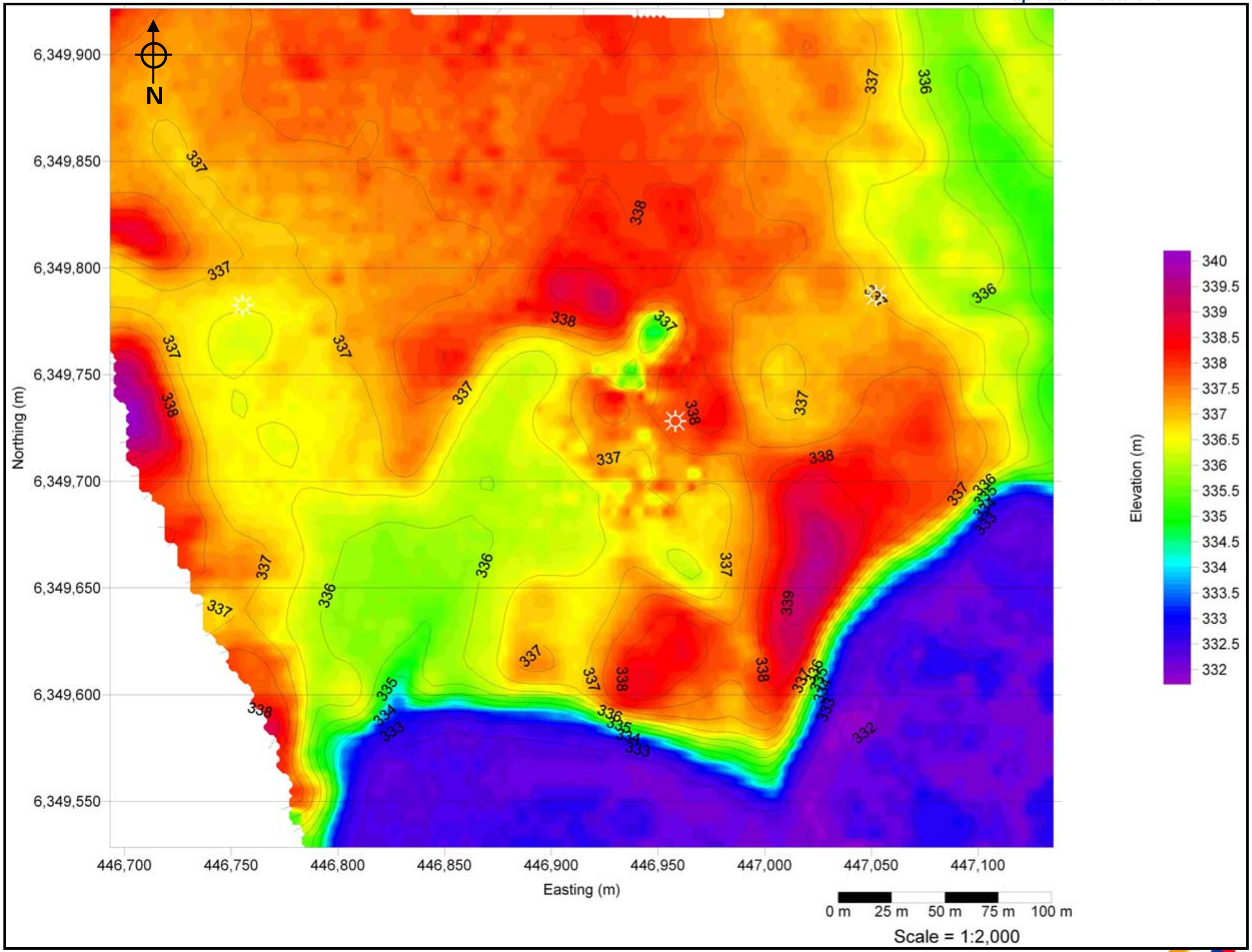
5. A seismic anomaly is visible above injector 204-I3. It is suggesting that steam likely reached the upper portion of the Middle McMurray, above the pay zone, ,.

Site Topography

Map datum: Sea level

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian



DGEP/TDO/TEC/GEO

PLATE # 1

TOTAL

Site Survey Topography

Mapped horizon

- **Topography**
- **Clearwater**
- **Wabiskaw**
- **Top McMurray**
- **McMurray1**
- **McMurray2**
- **McMurray3**
- **McMurray4**
- **McMurray5**
- **McMurray6**
- **Top Devonian**

Map datum: 337m above sea level

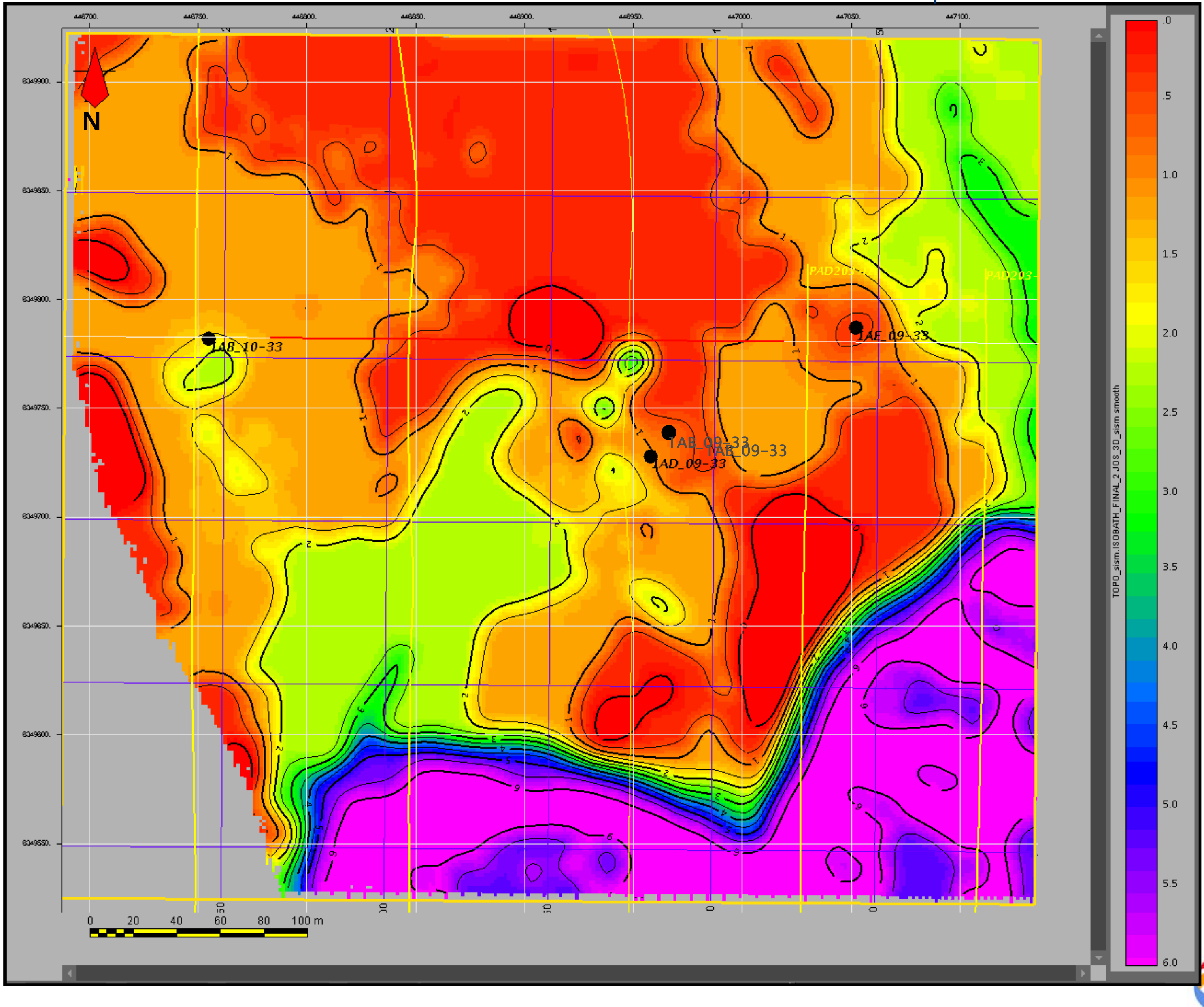
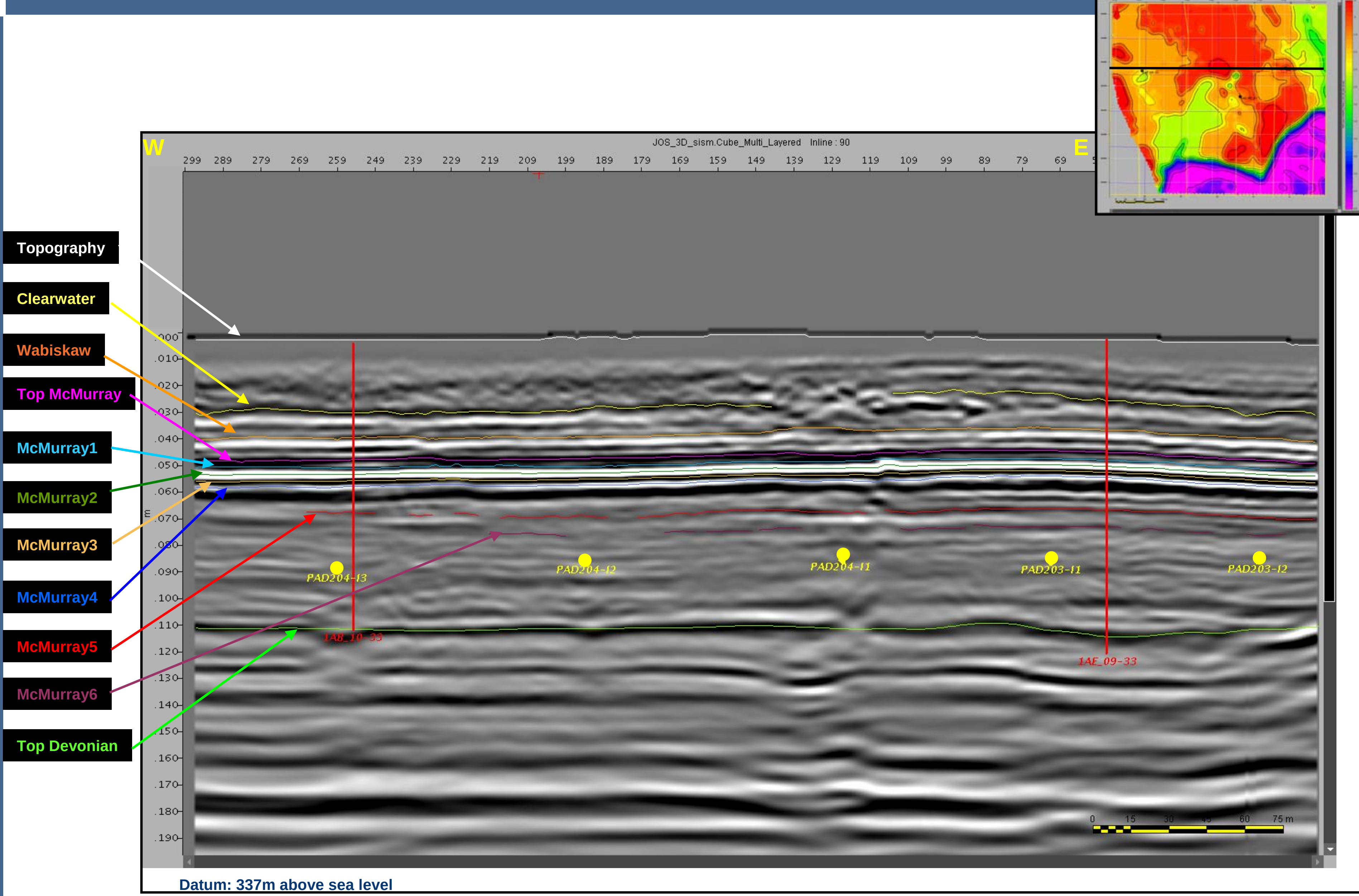


PLATE # 2



Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian

Datum: 337m above sea level

PLATE # 3

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

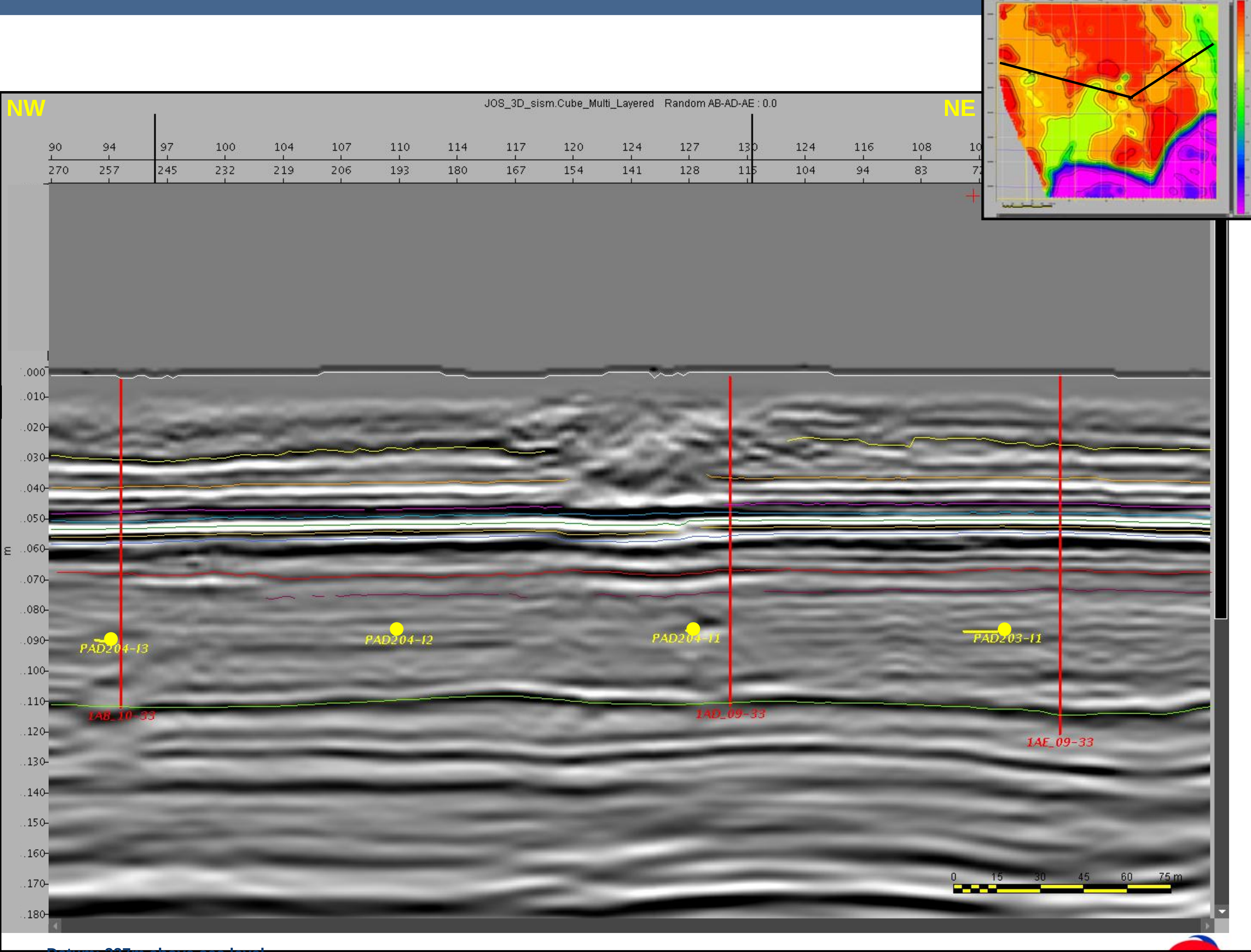
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

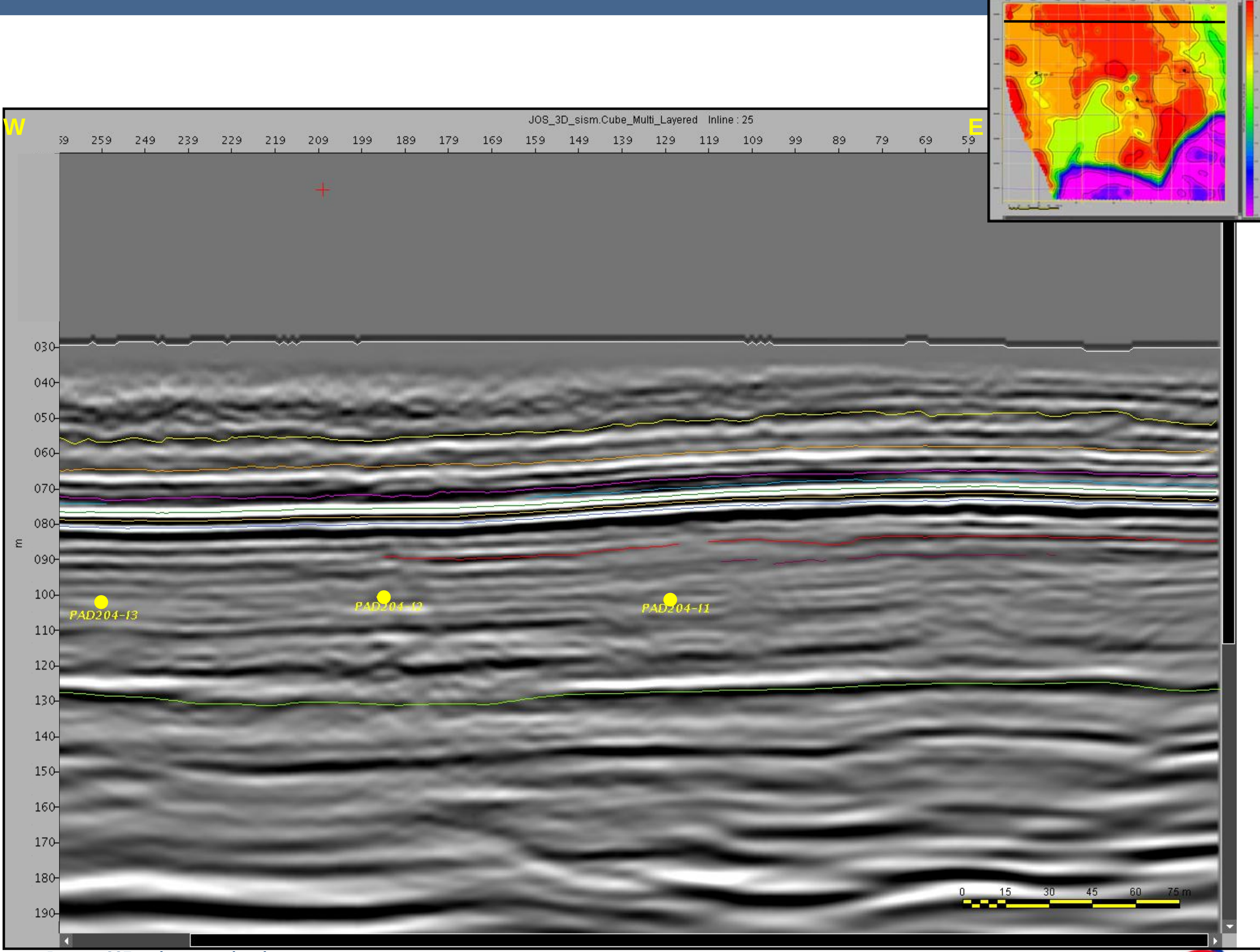
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 5

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

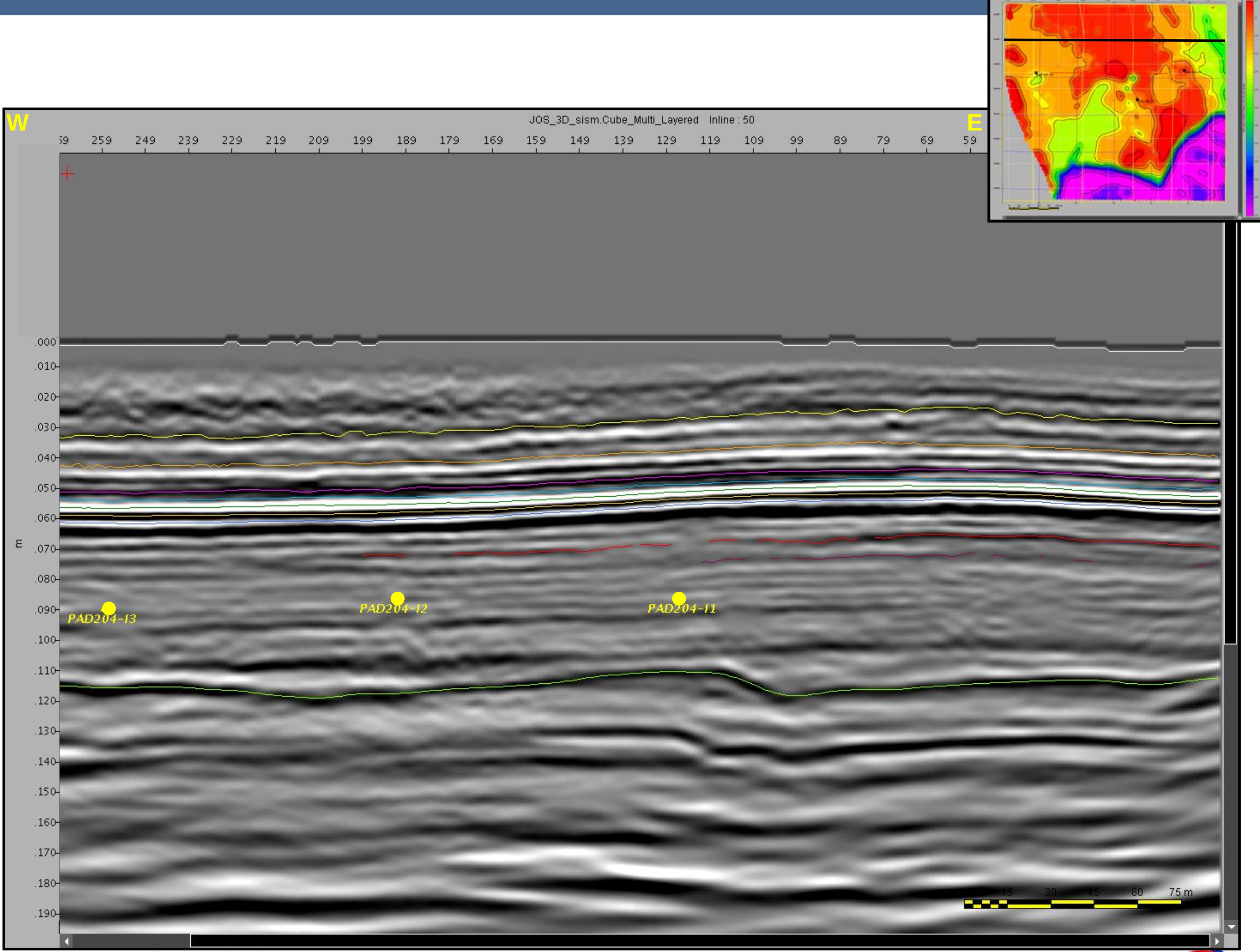
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 6

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

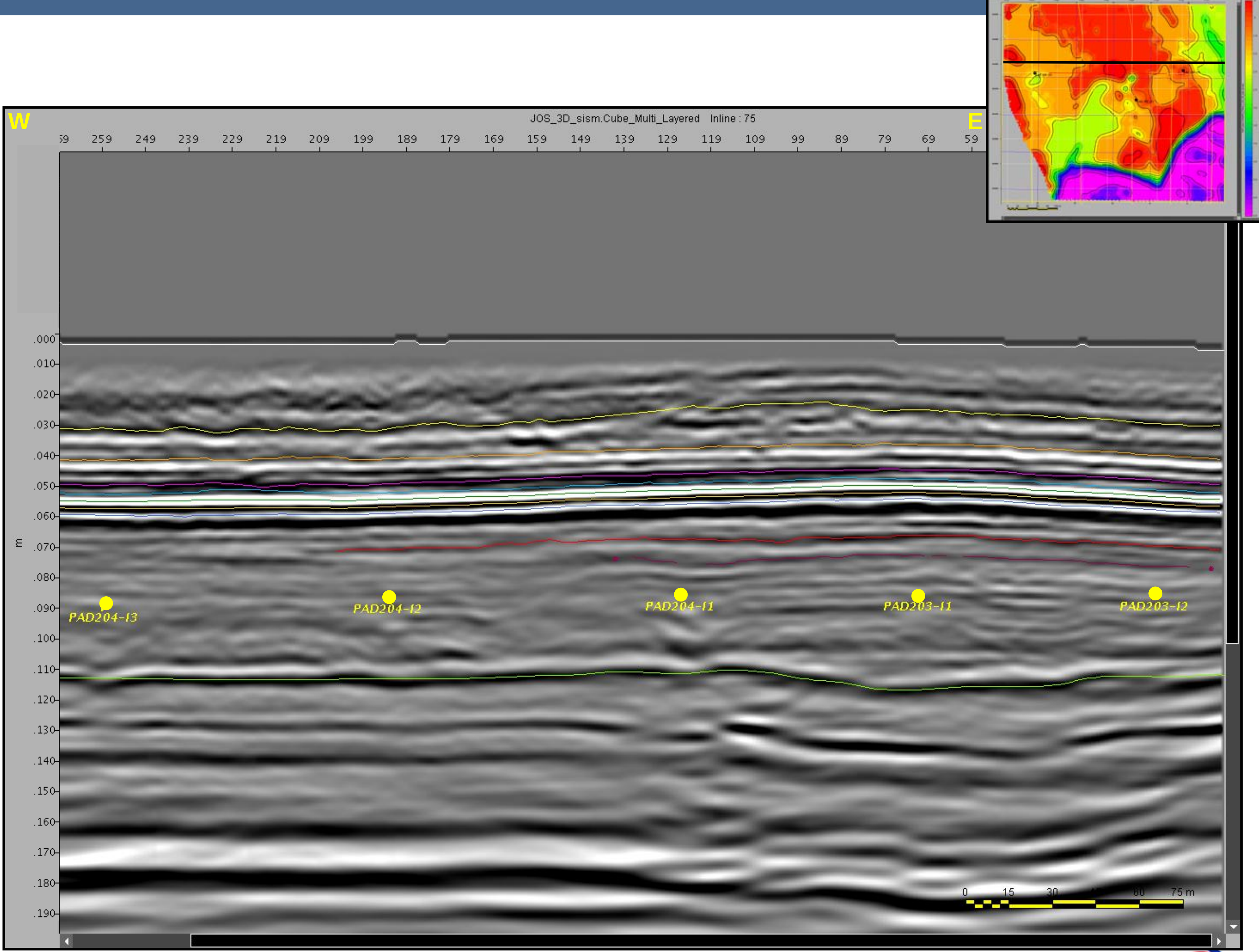
McMurray3

McMurray4

McMurray5

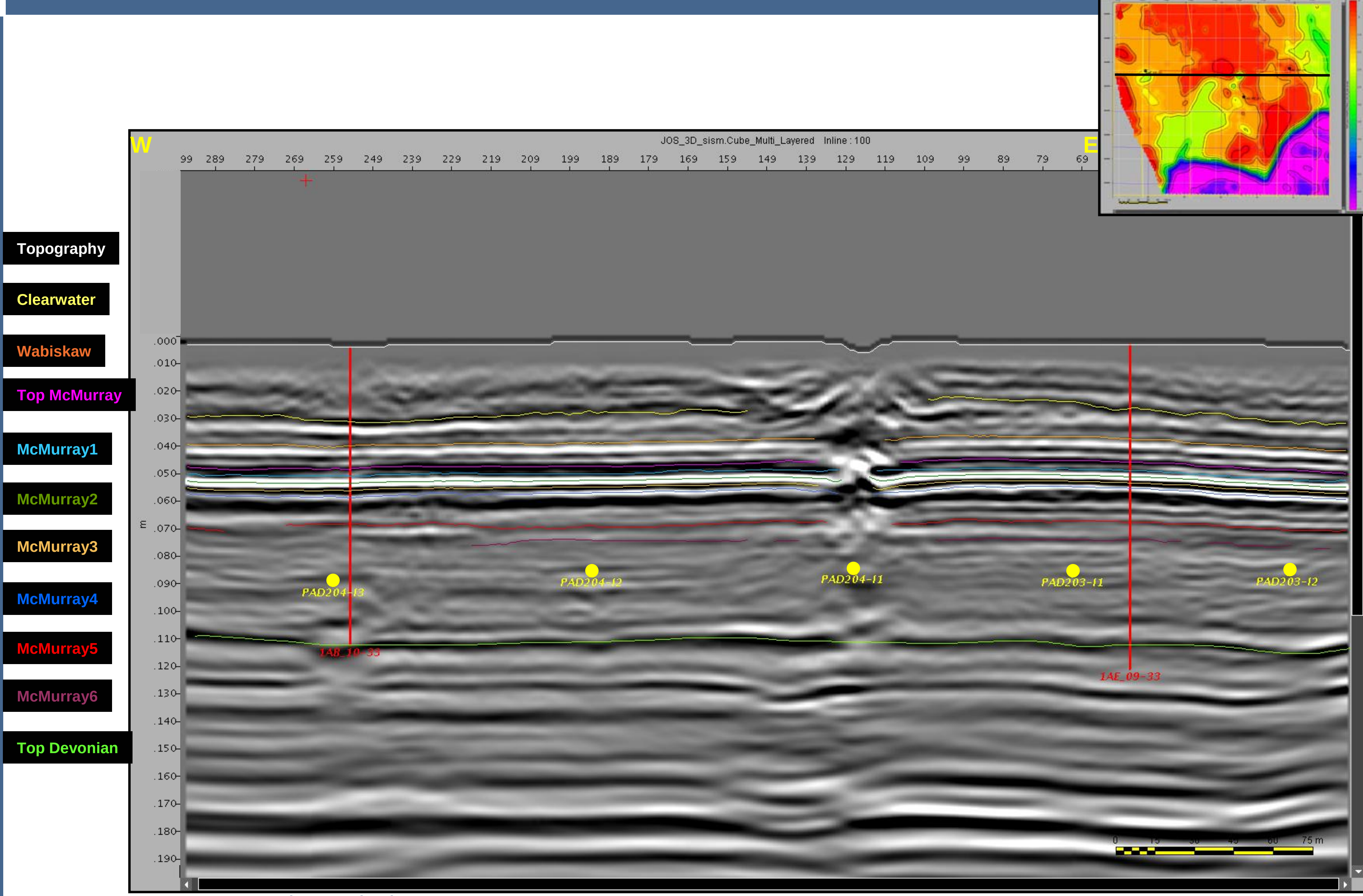
McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 7



Datum: 337m above sea level

PLATE # 8

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

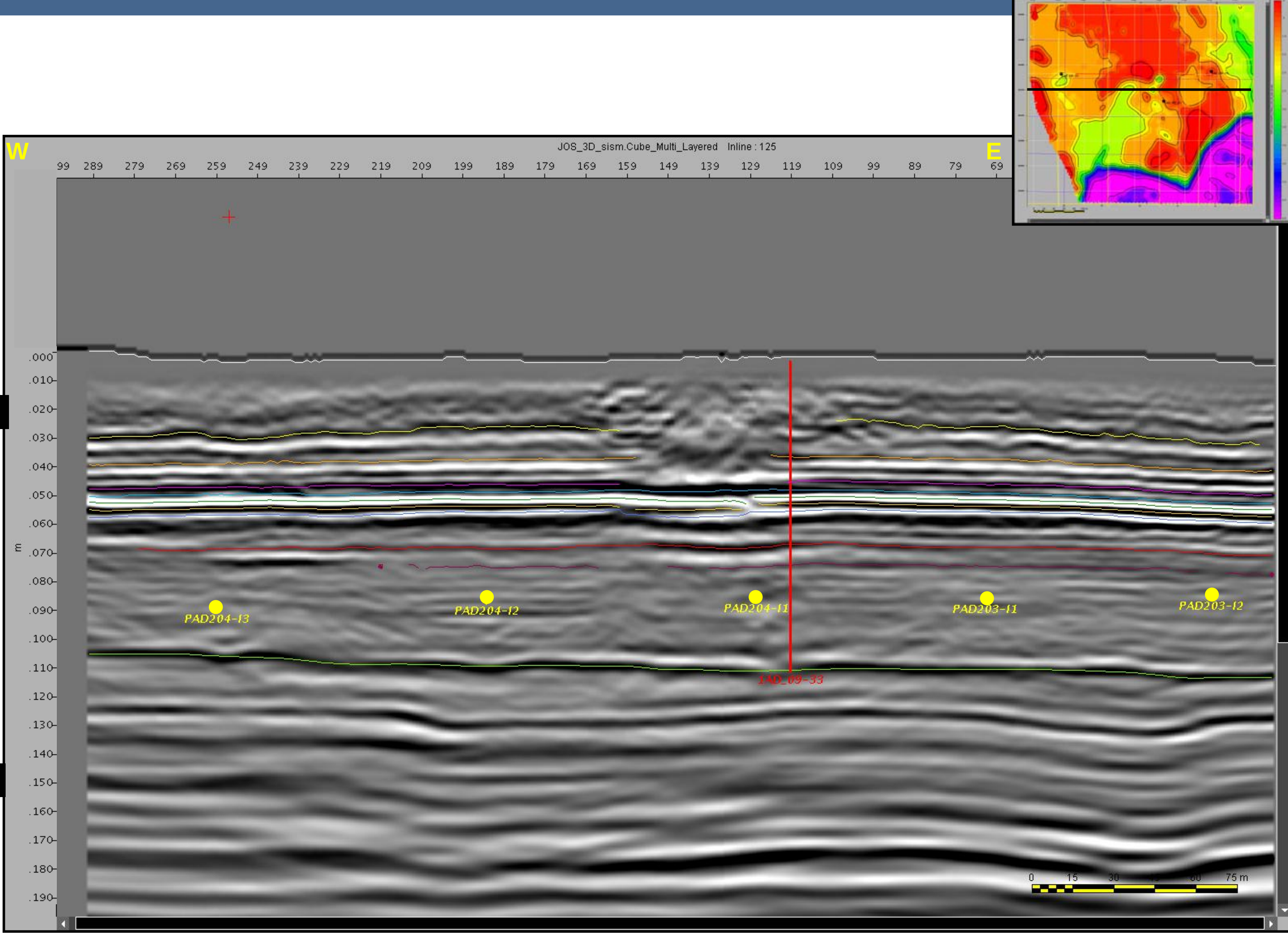
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 9

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

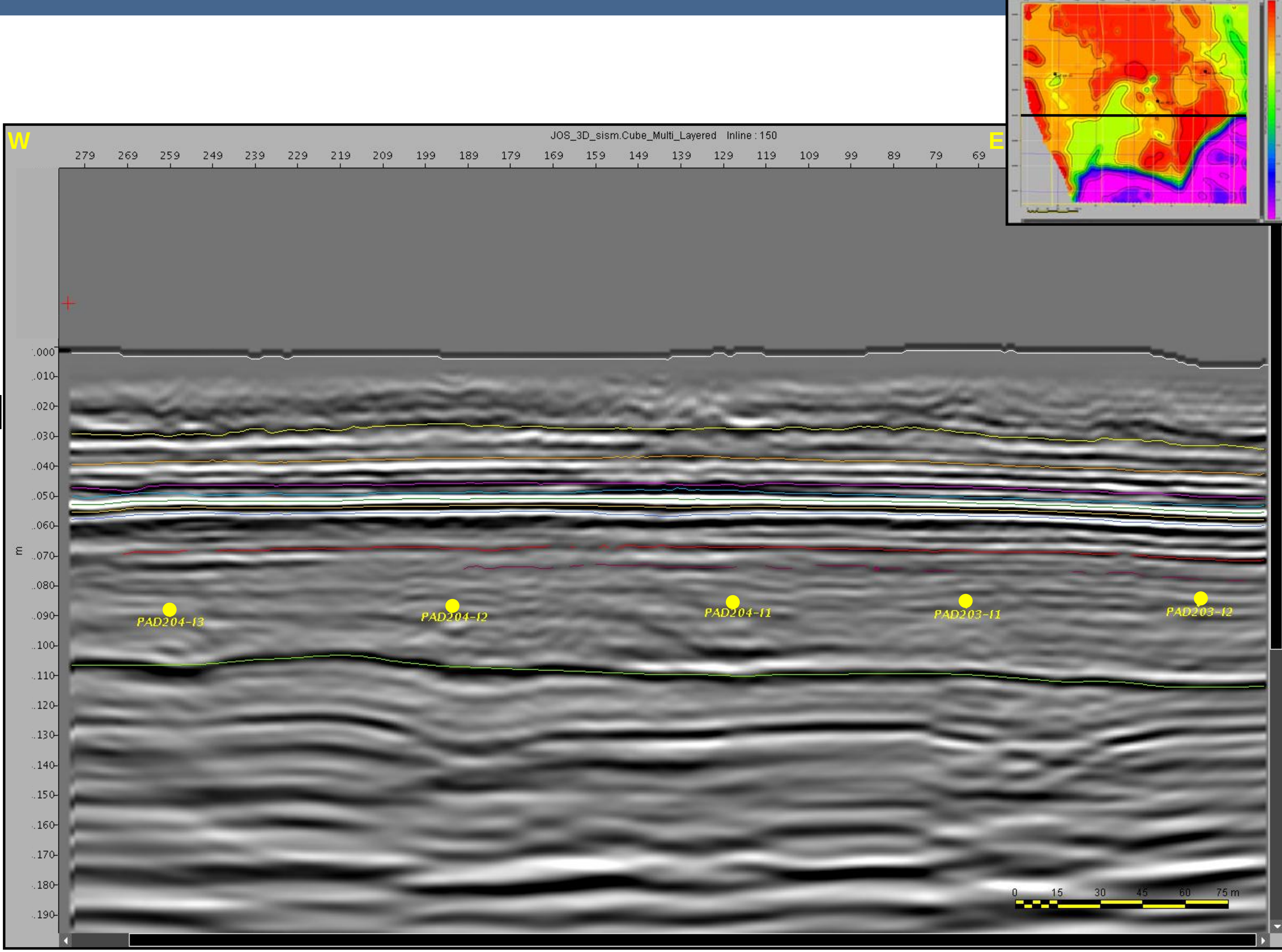
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

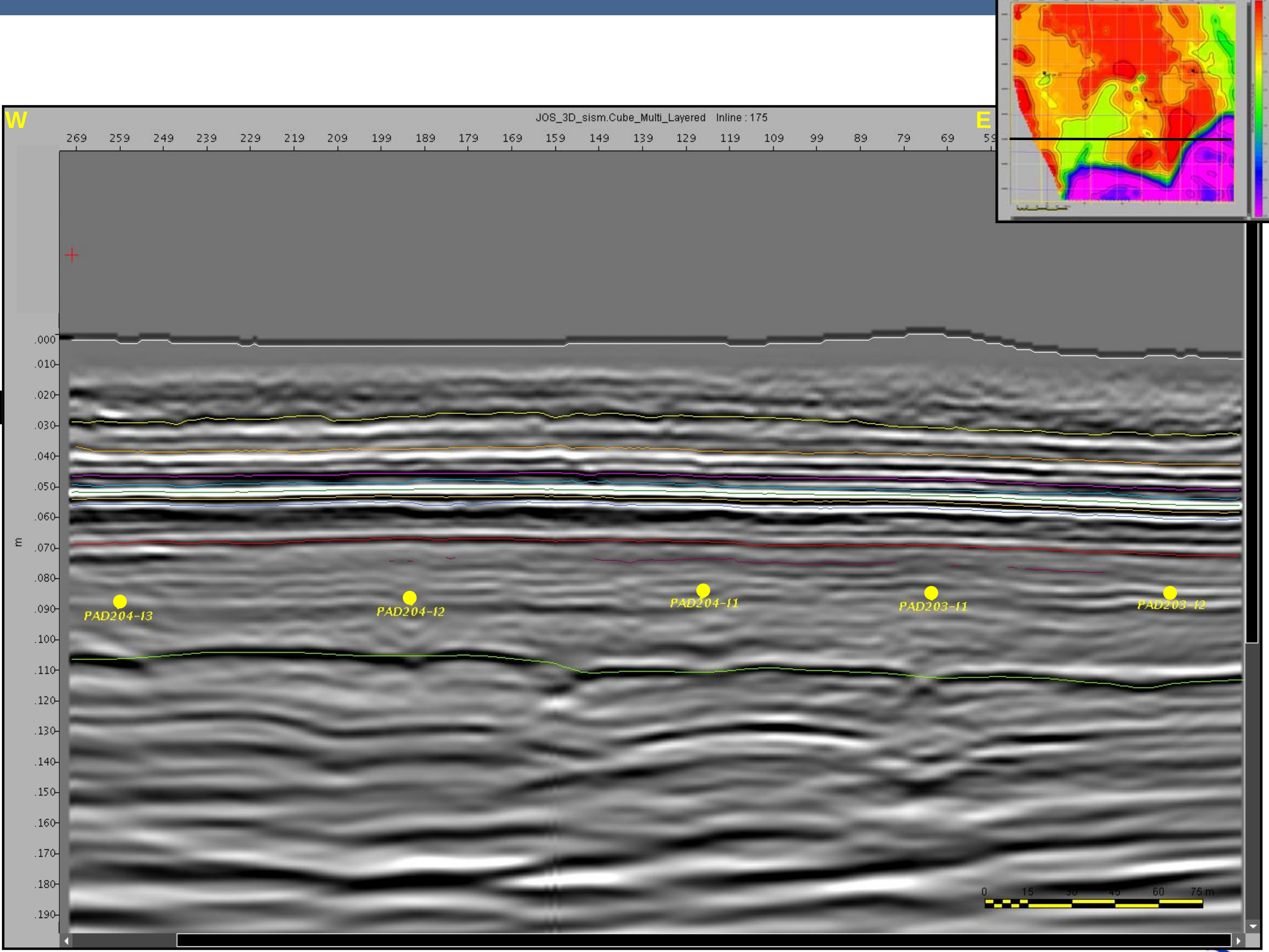
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 11

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

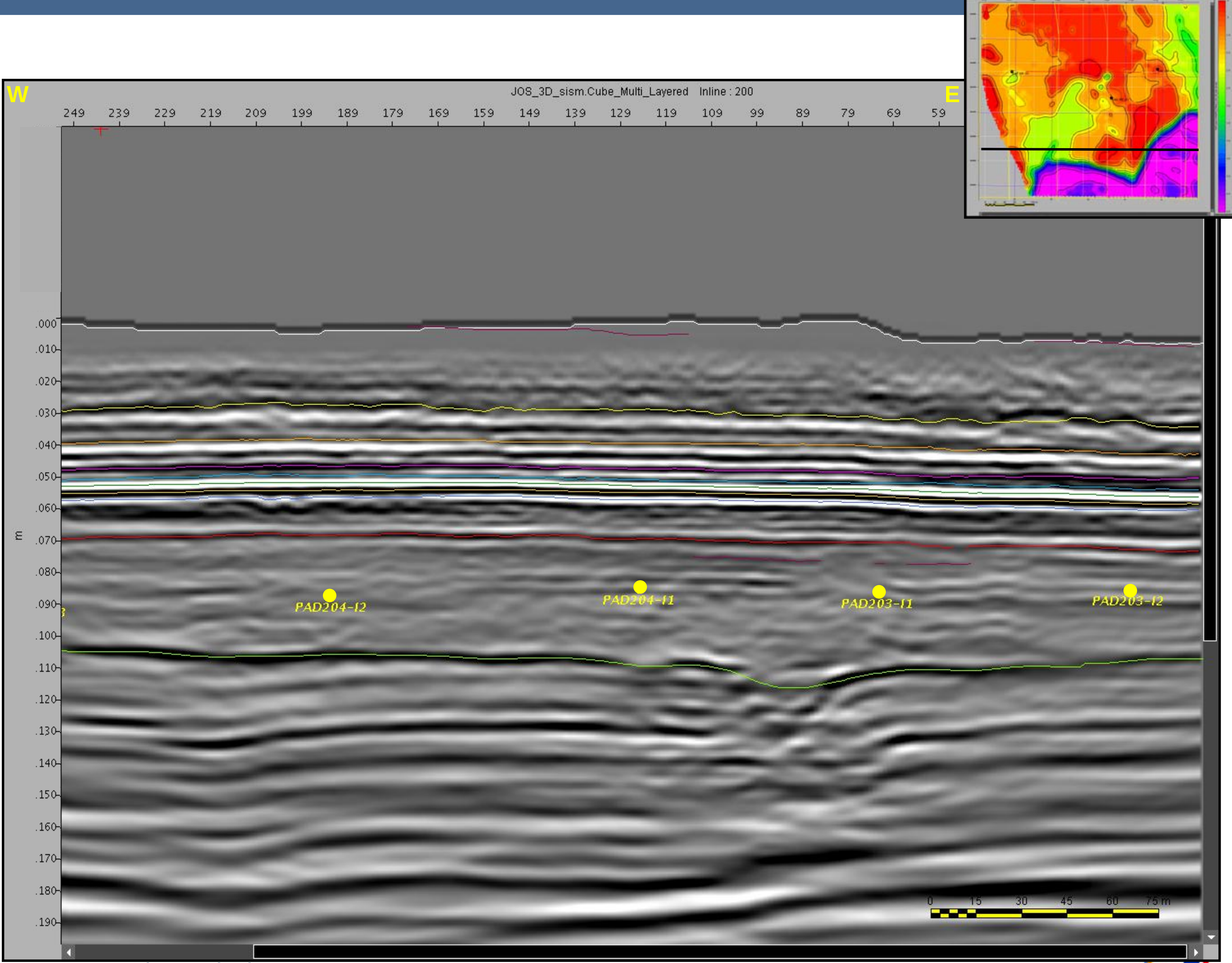
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 12

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

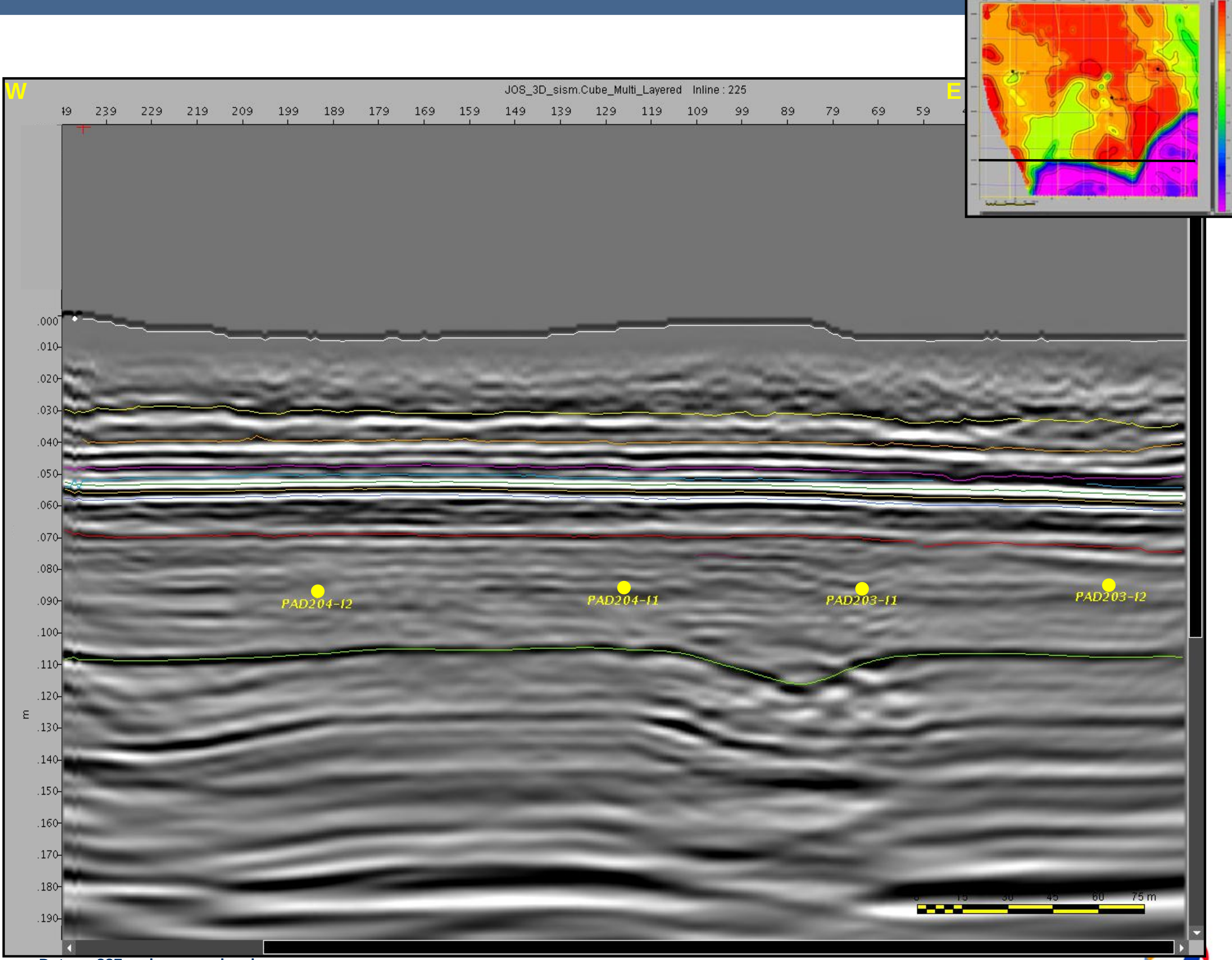
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

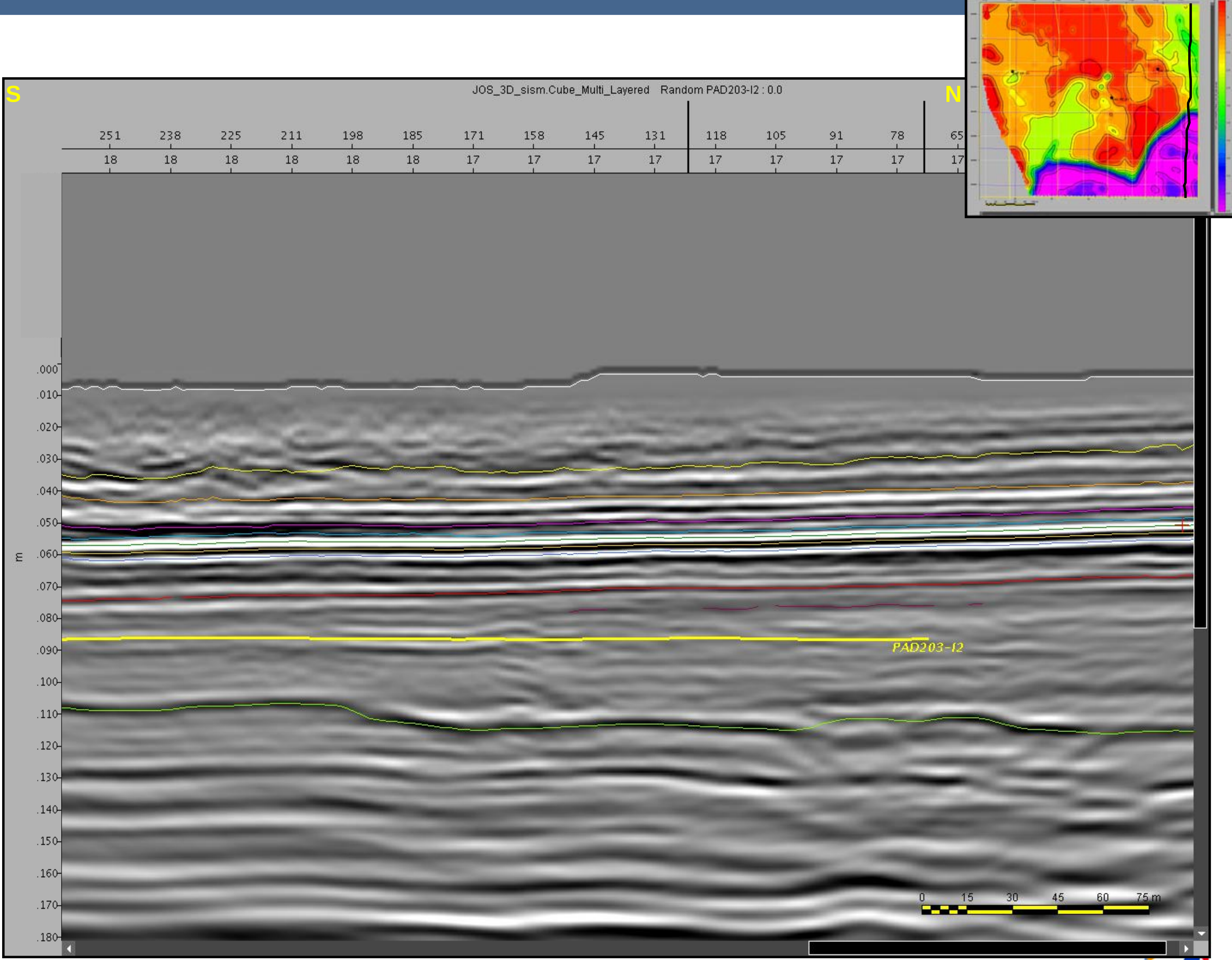
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 14

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

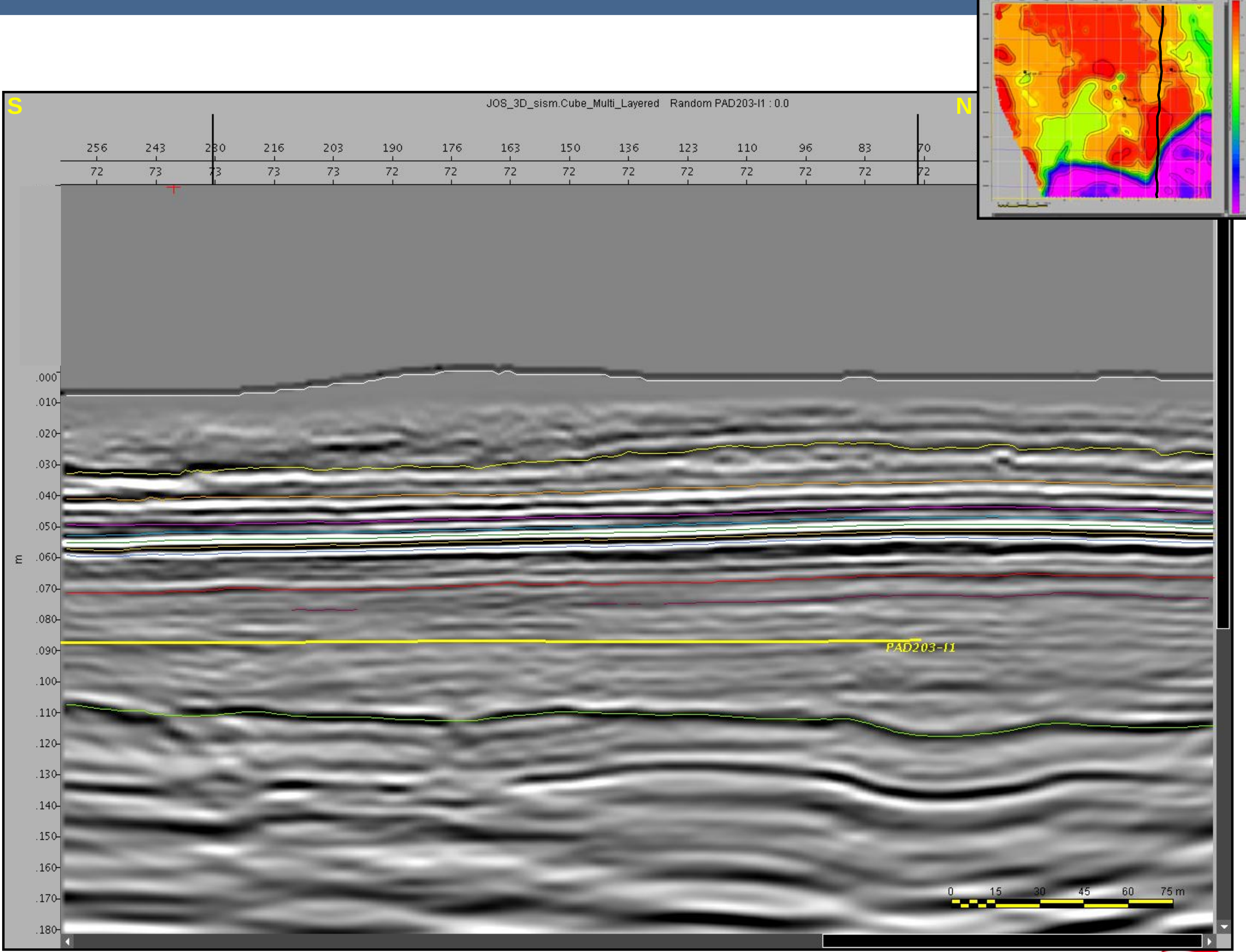
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 15

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

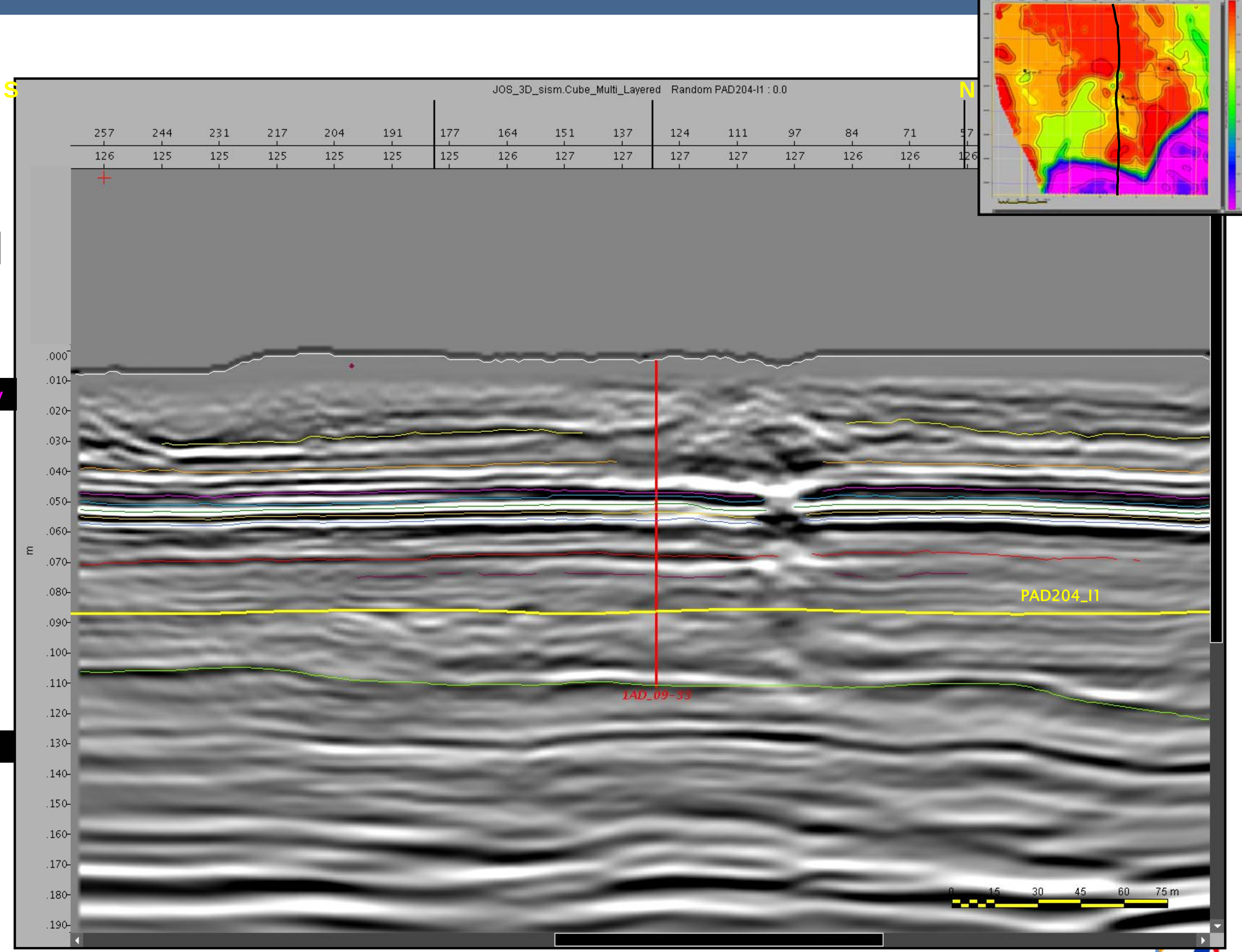
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 16

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

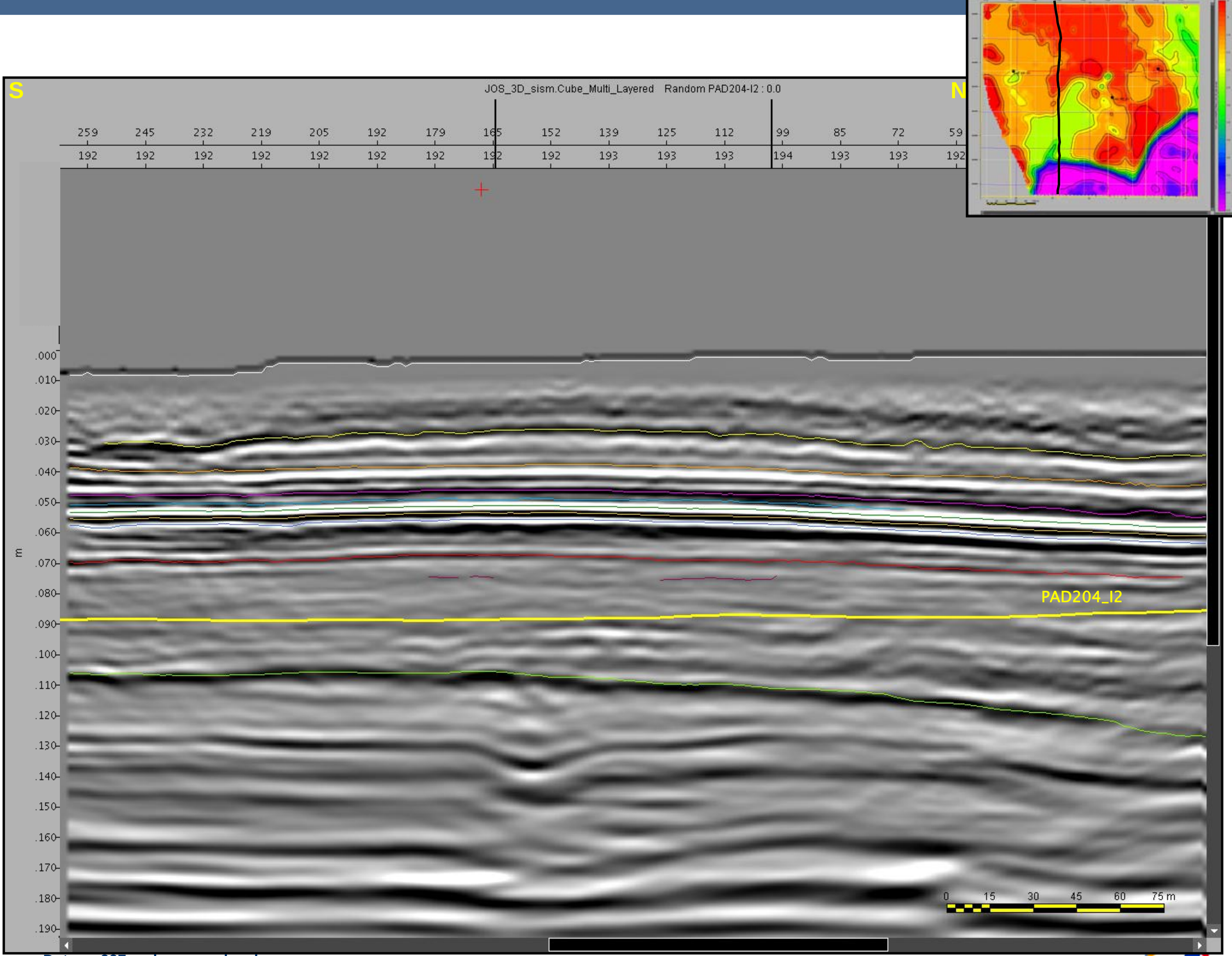
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 17

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

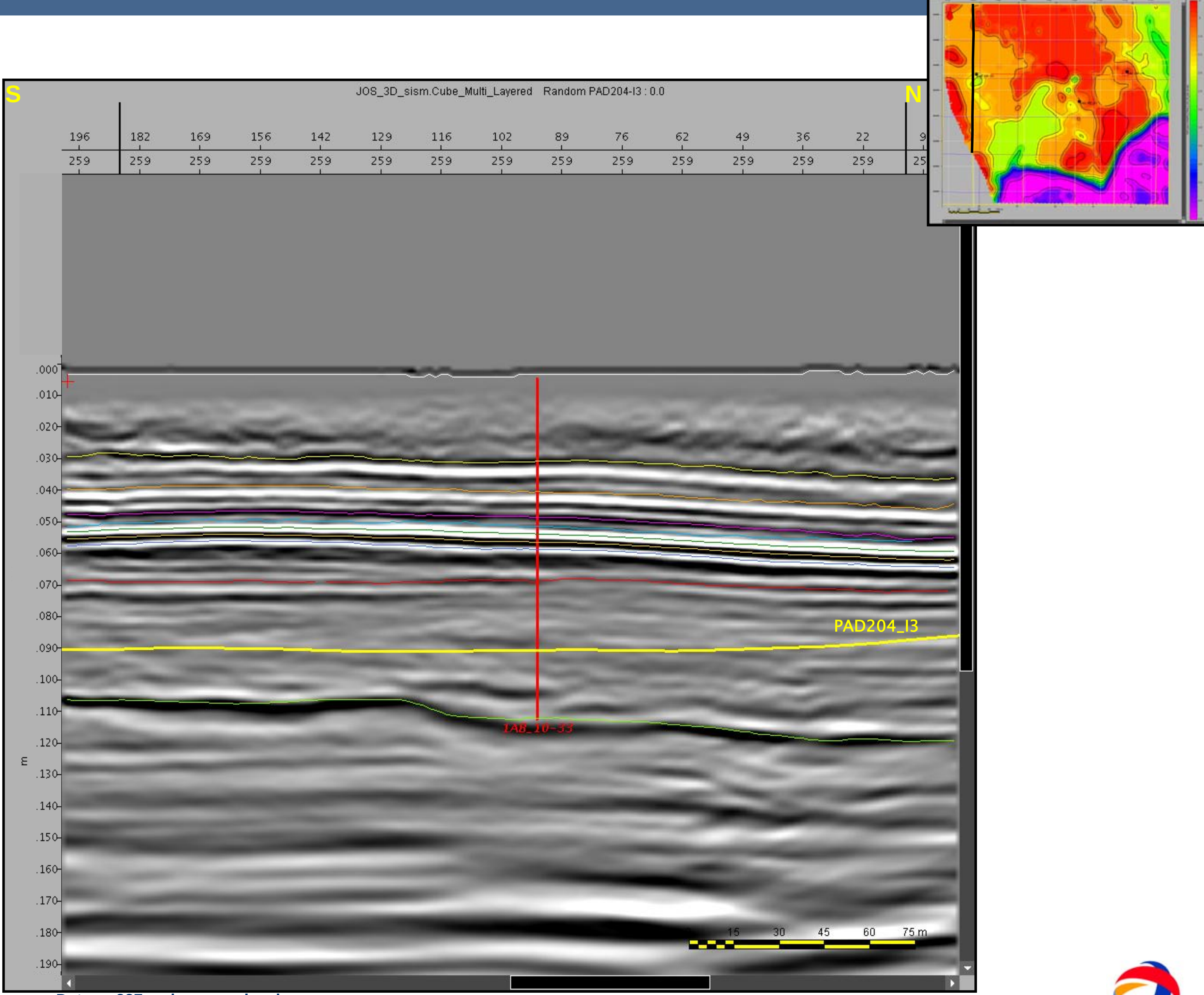
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 18

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

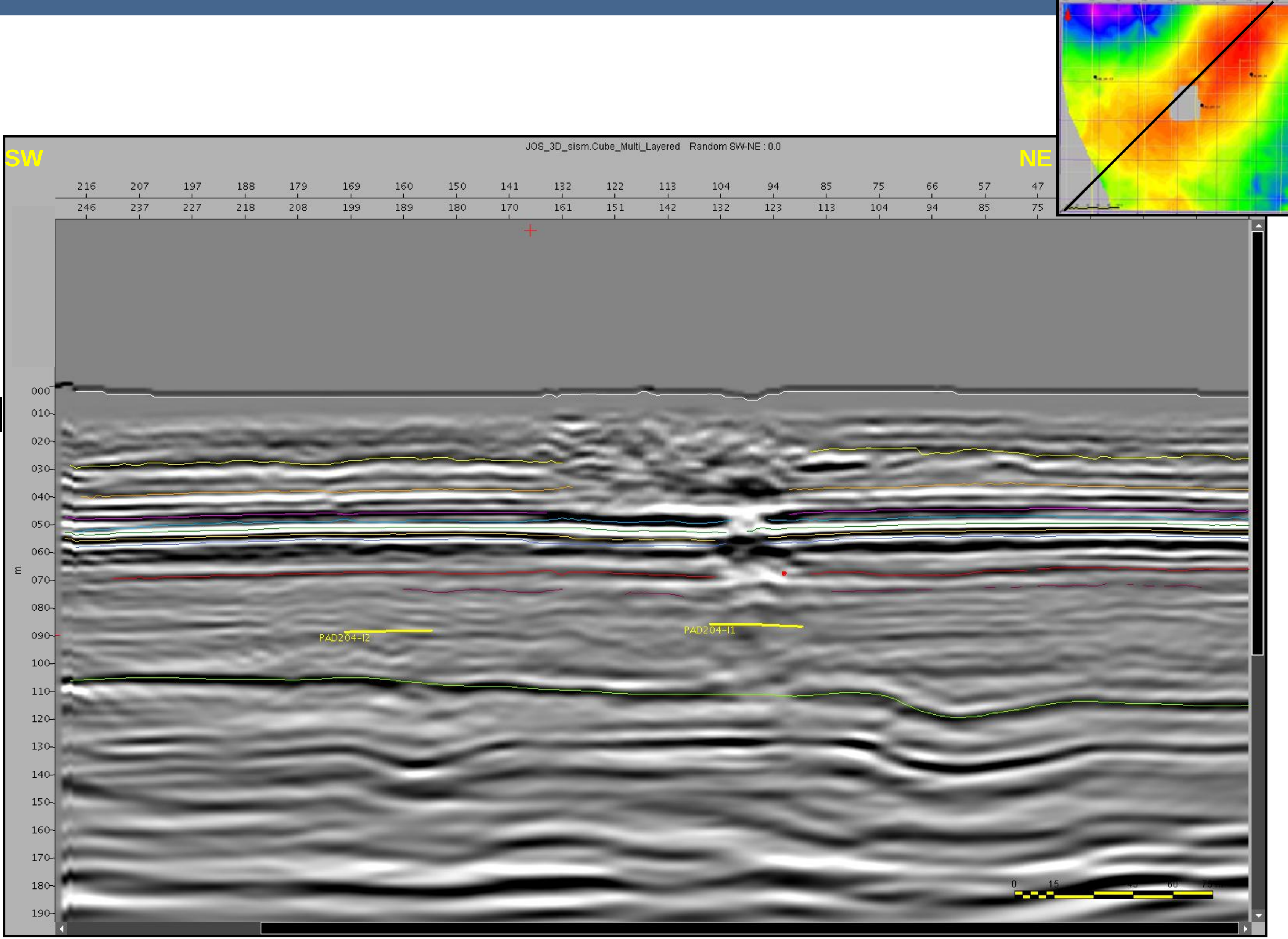
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 19

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

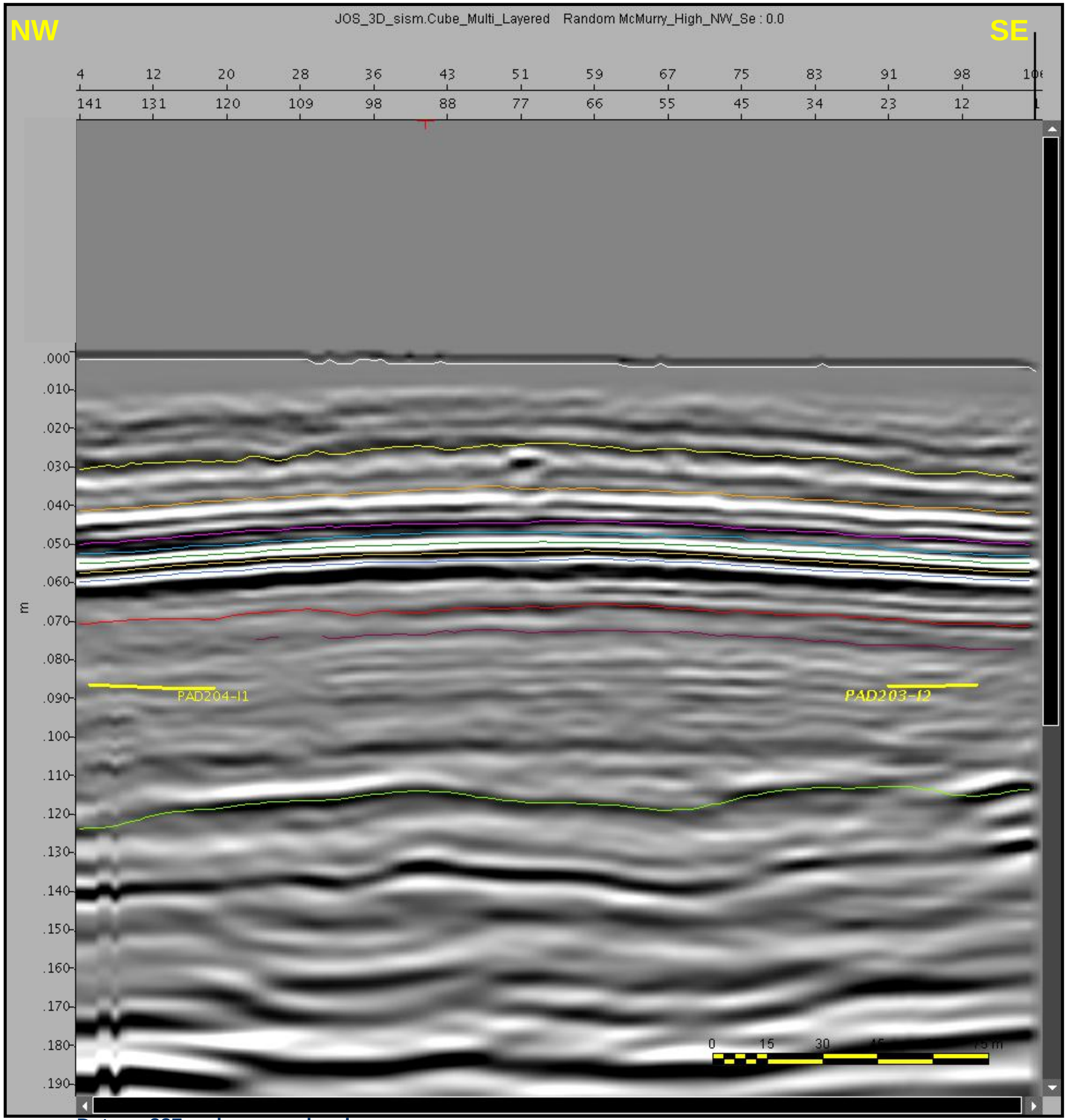
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



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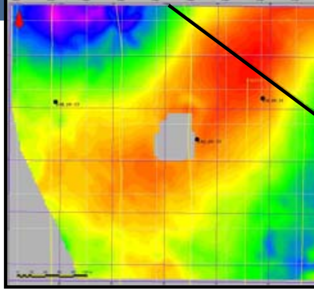
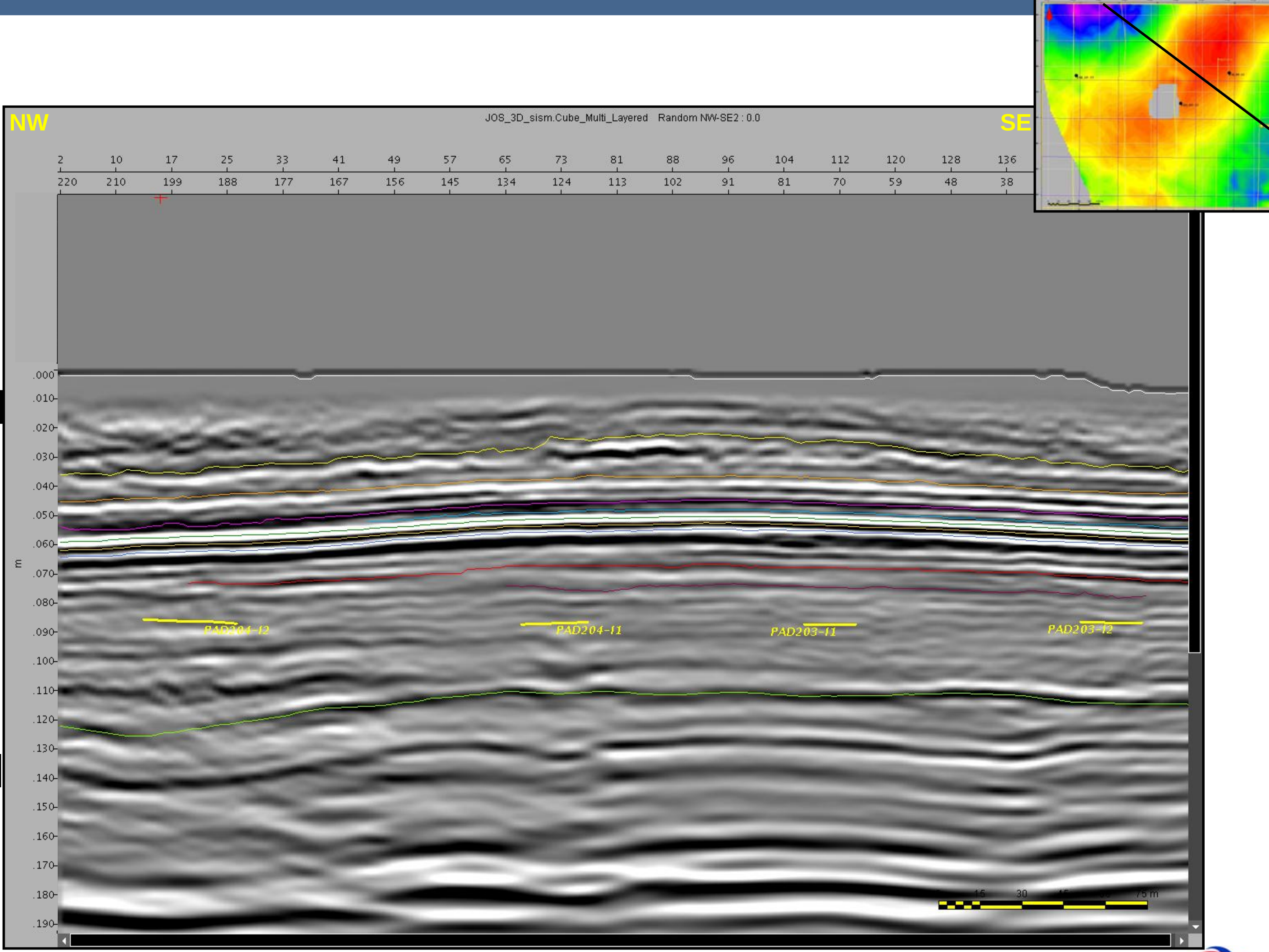


PLATE # 20



Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

McMurray3

McMurray4

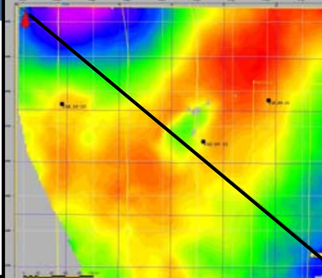
McMurray5

McMurray6

Top Devonian

Datum: 337m above sea level

PLATE # 21



Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

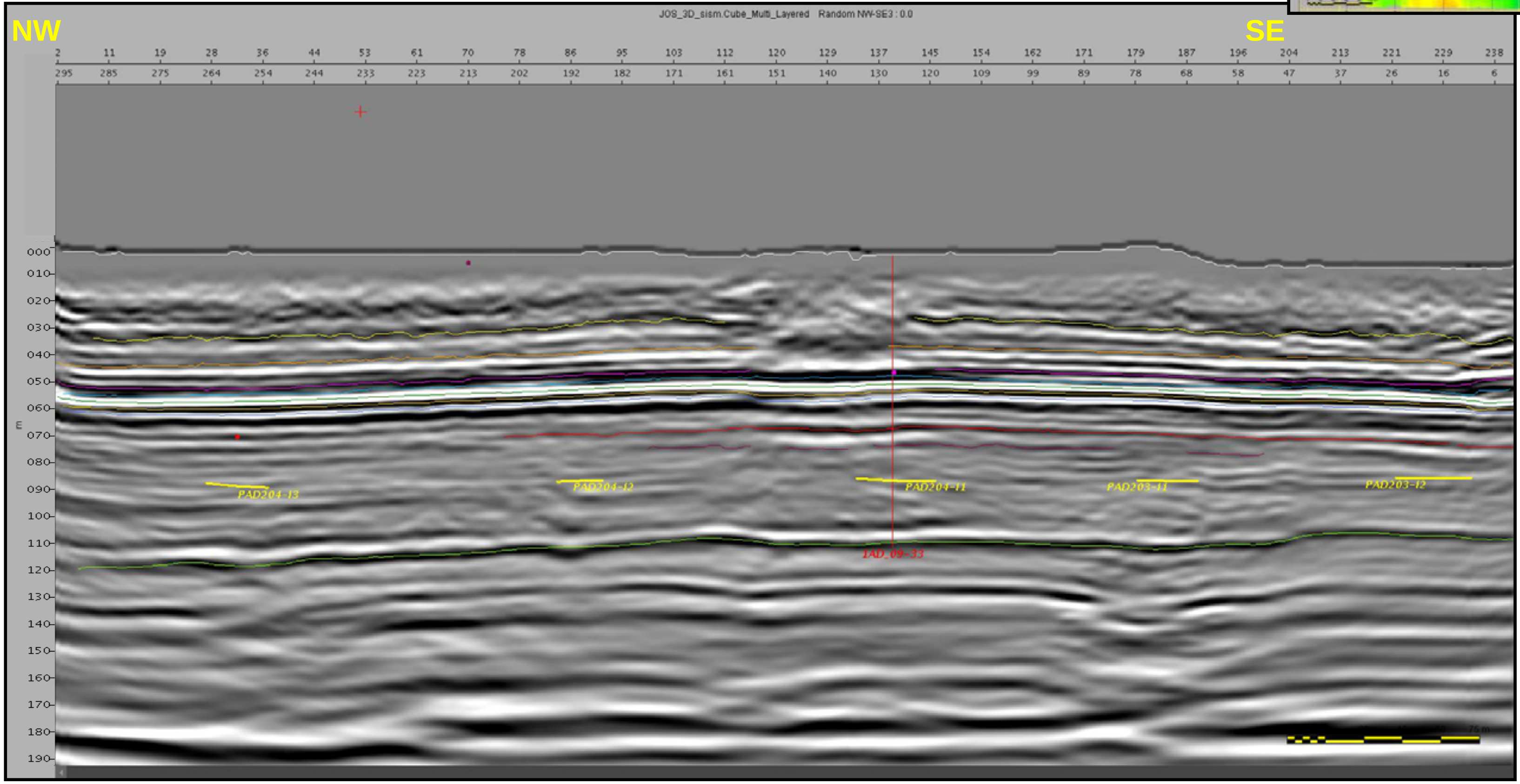
McMurray3

McMurray4

McMurray5

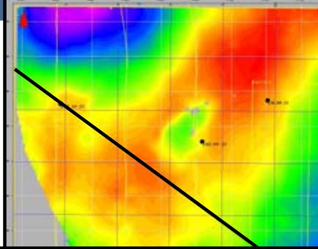
McMurray6

Top Devonian



Datum: 337m above sea level

PLATE # 22



Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian

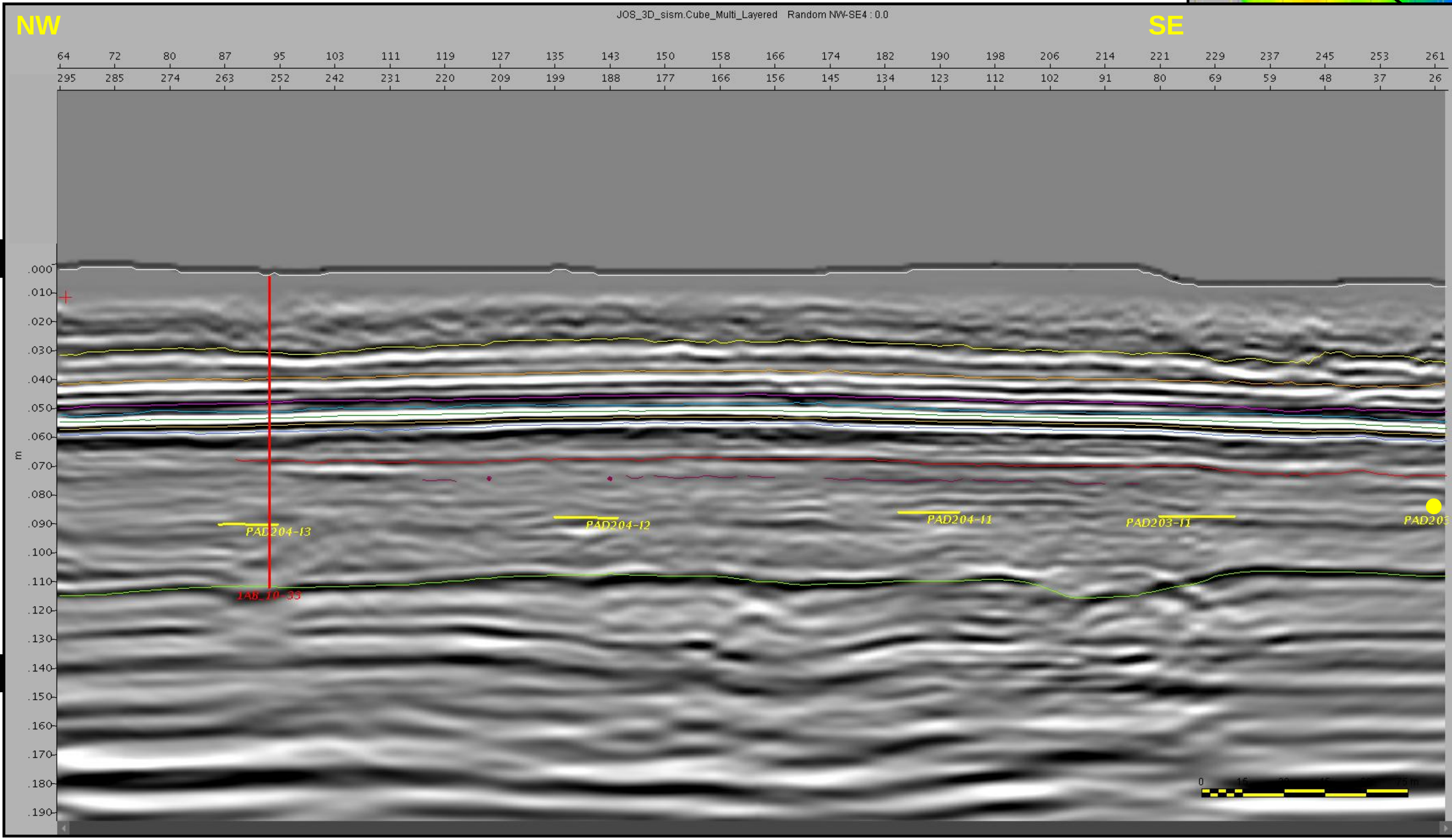


PLATE # 23

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

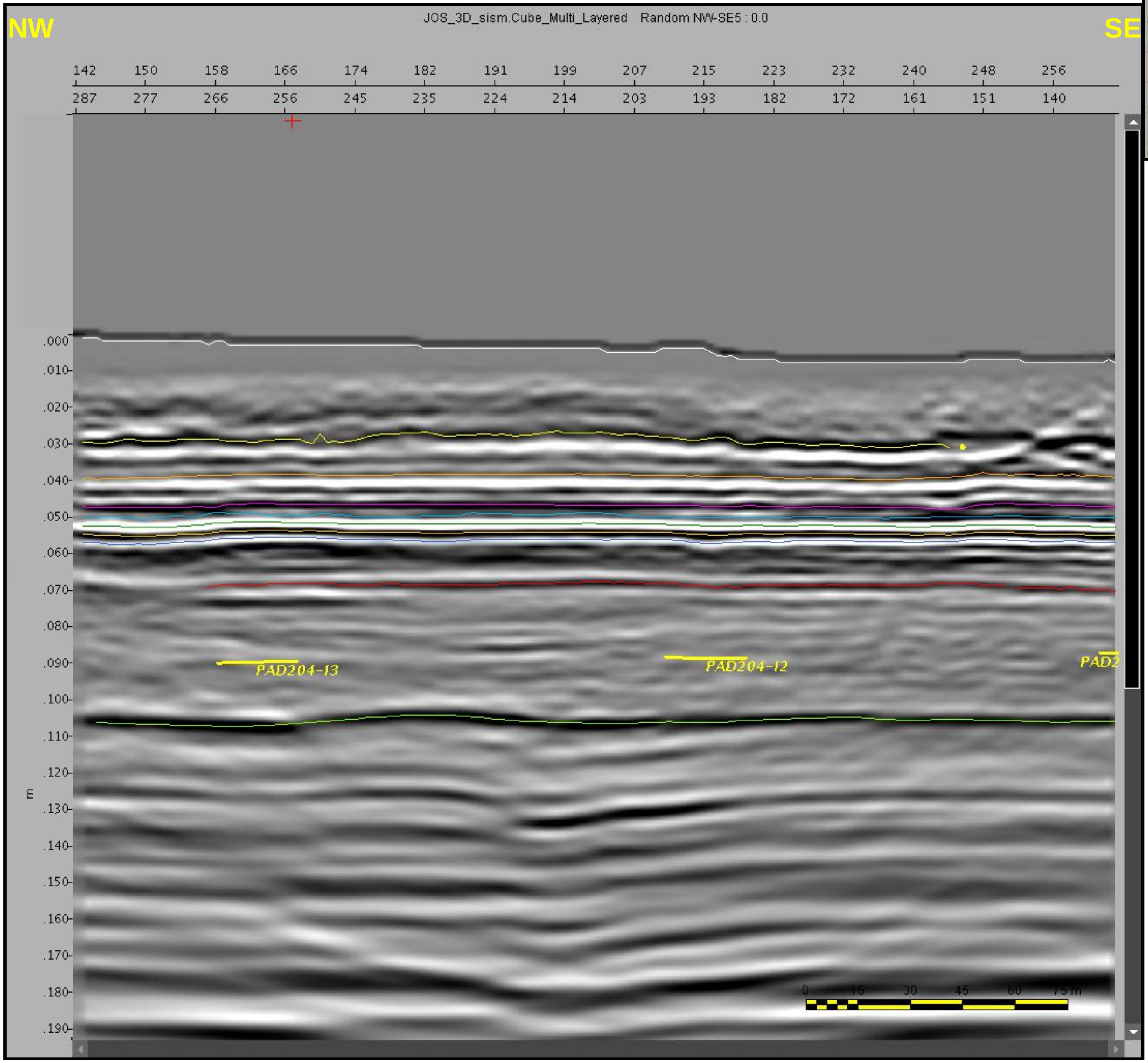
McMurray3

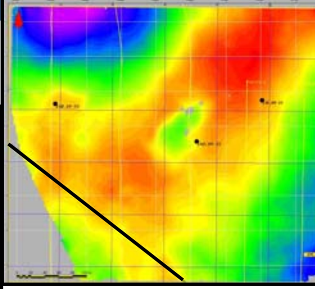
McMurray4

McMurray5

McMurray6

Top Devonian





Datum: 337m above sea level

PLATE # 24

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

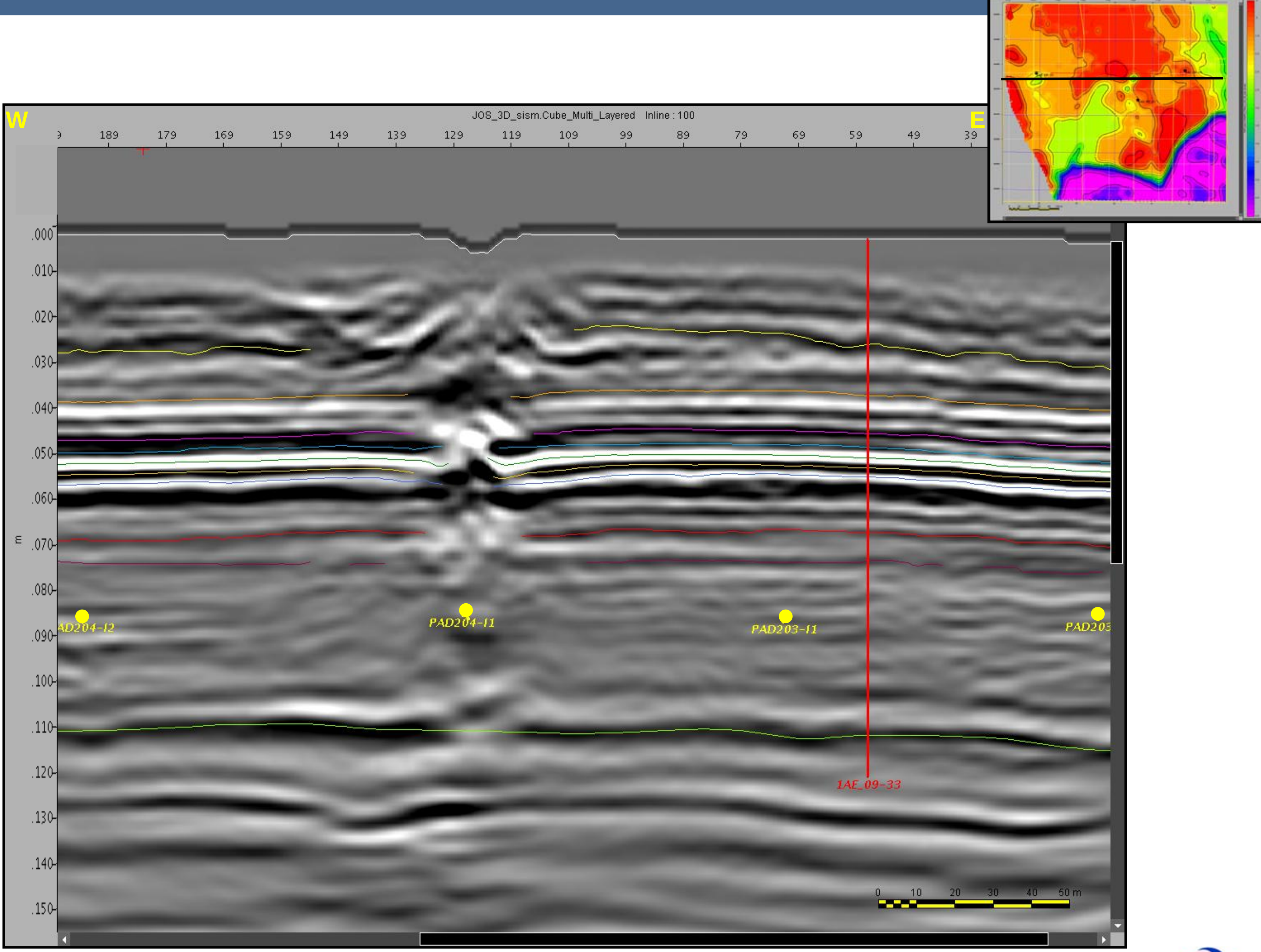
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

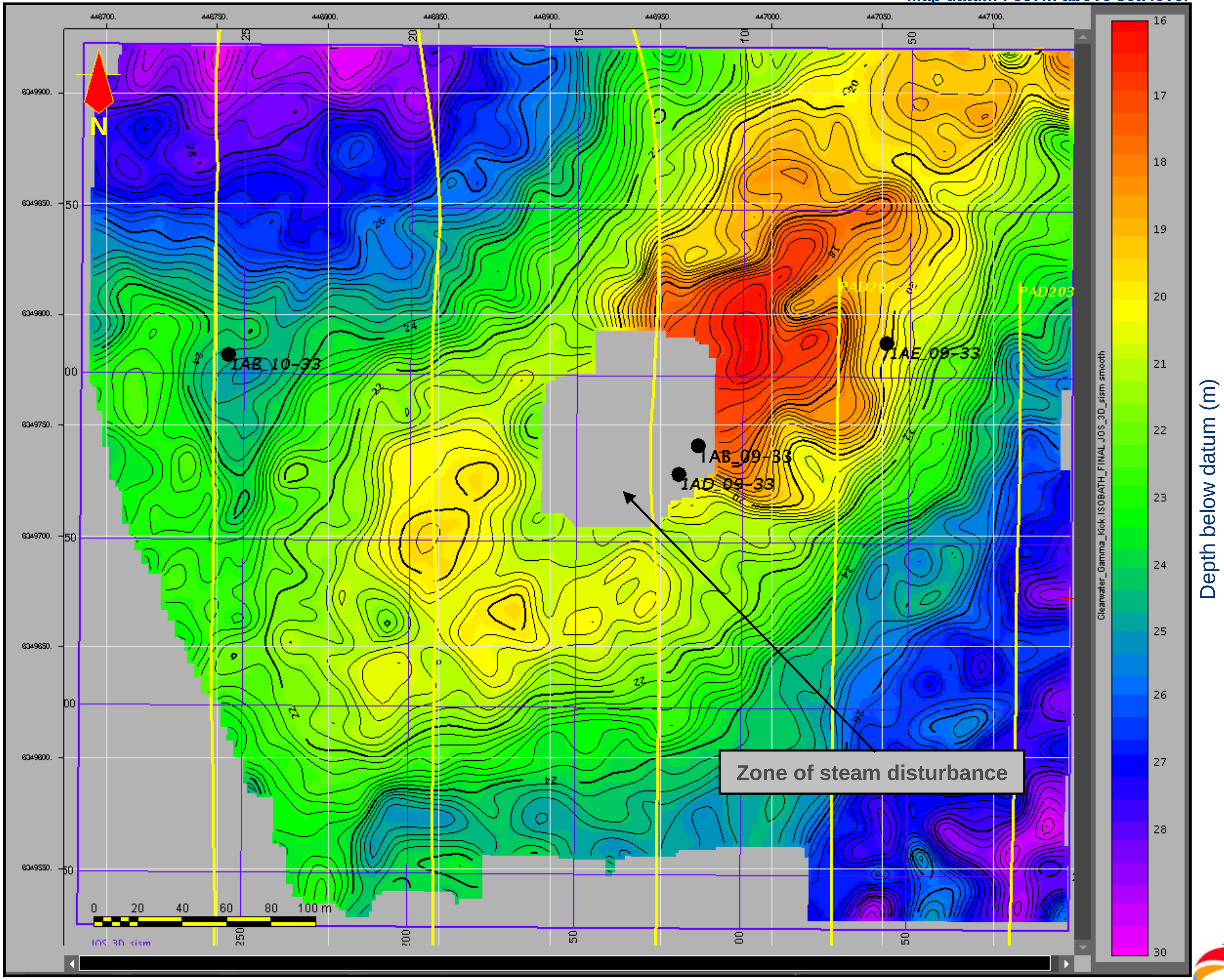
PLATE # 25

Depth Structural Map – Clearwater

Mapped horizon

- Topography
- **Clearwater**
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

Map datum : 337m above sea level



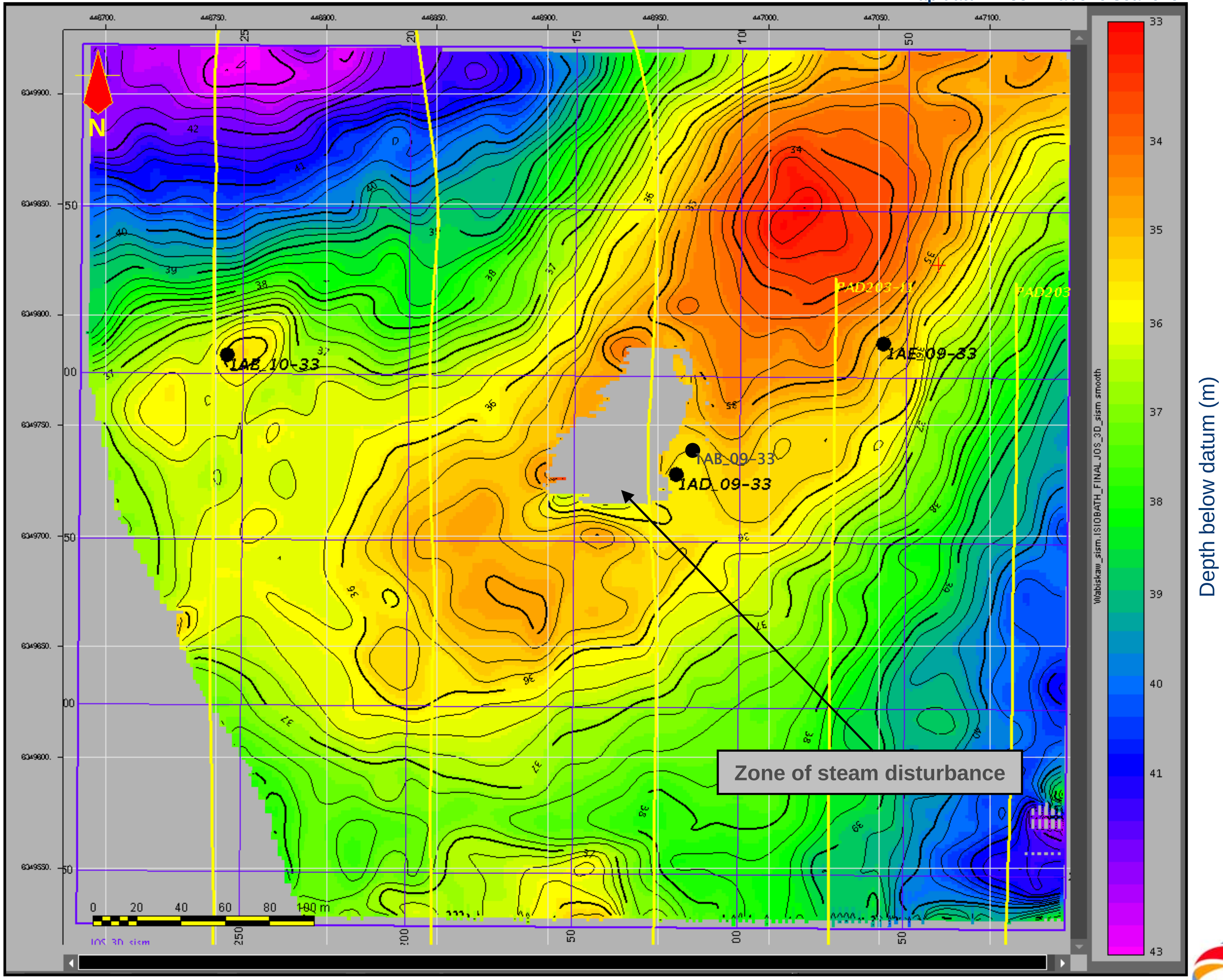
Zone of steam disturbance

Depth Structural Map – Top_Wabiskaw

Mapped horizon

Topography
Clearwater
Wabiskaw
Top McMurray
McMurray1
McMurray2
McMurray3
McMurray4
McMurray5
McMurray6
Top Devonian

Map datum : 337m above sea level



Zone of steam disturbance

DGEP/TDO/TEC/GEO

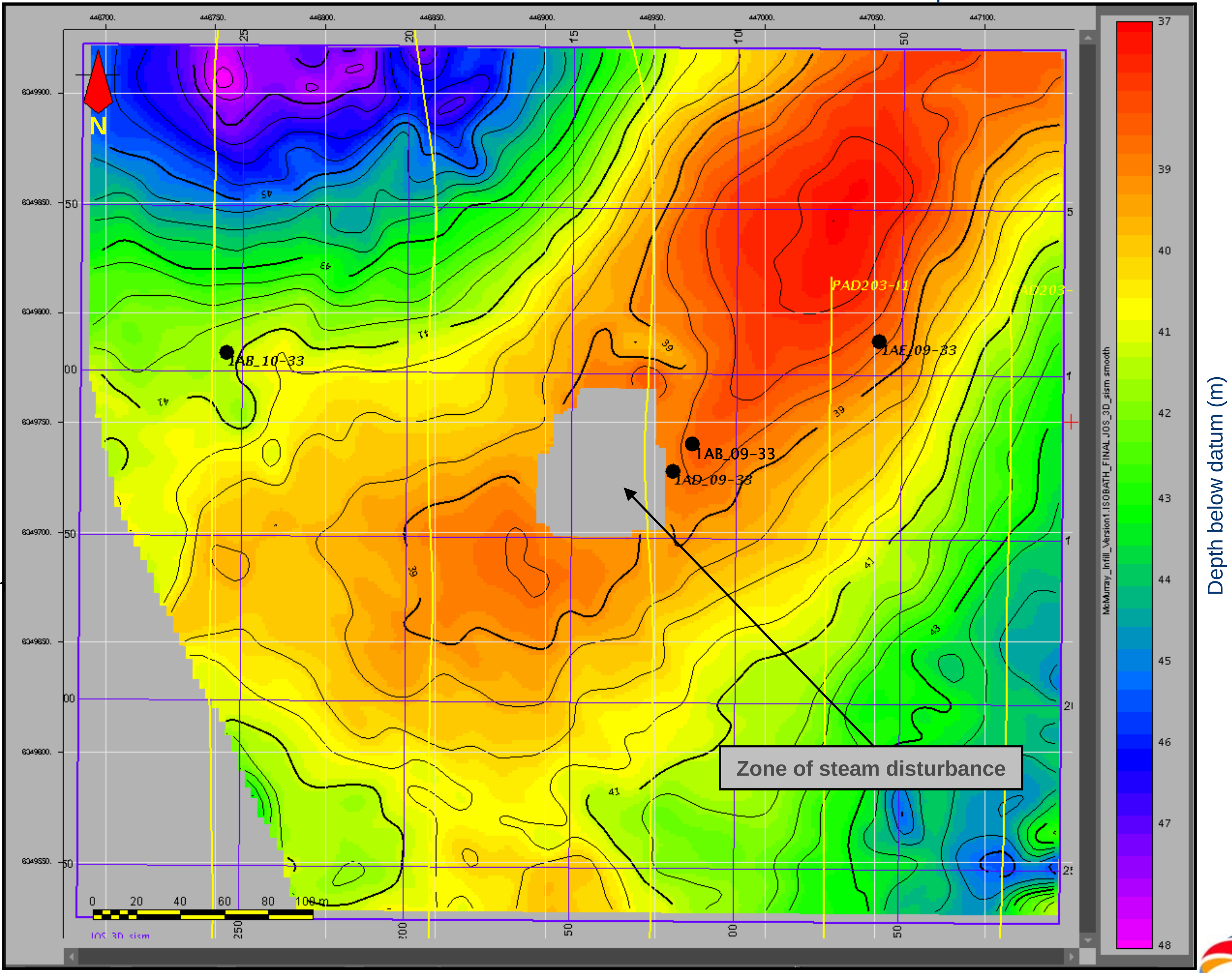
PLATE # 27

Depth Structural Map – Top McMurray

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

Map datum : 337m above sea level



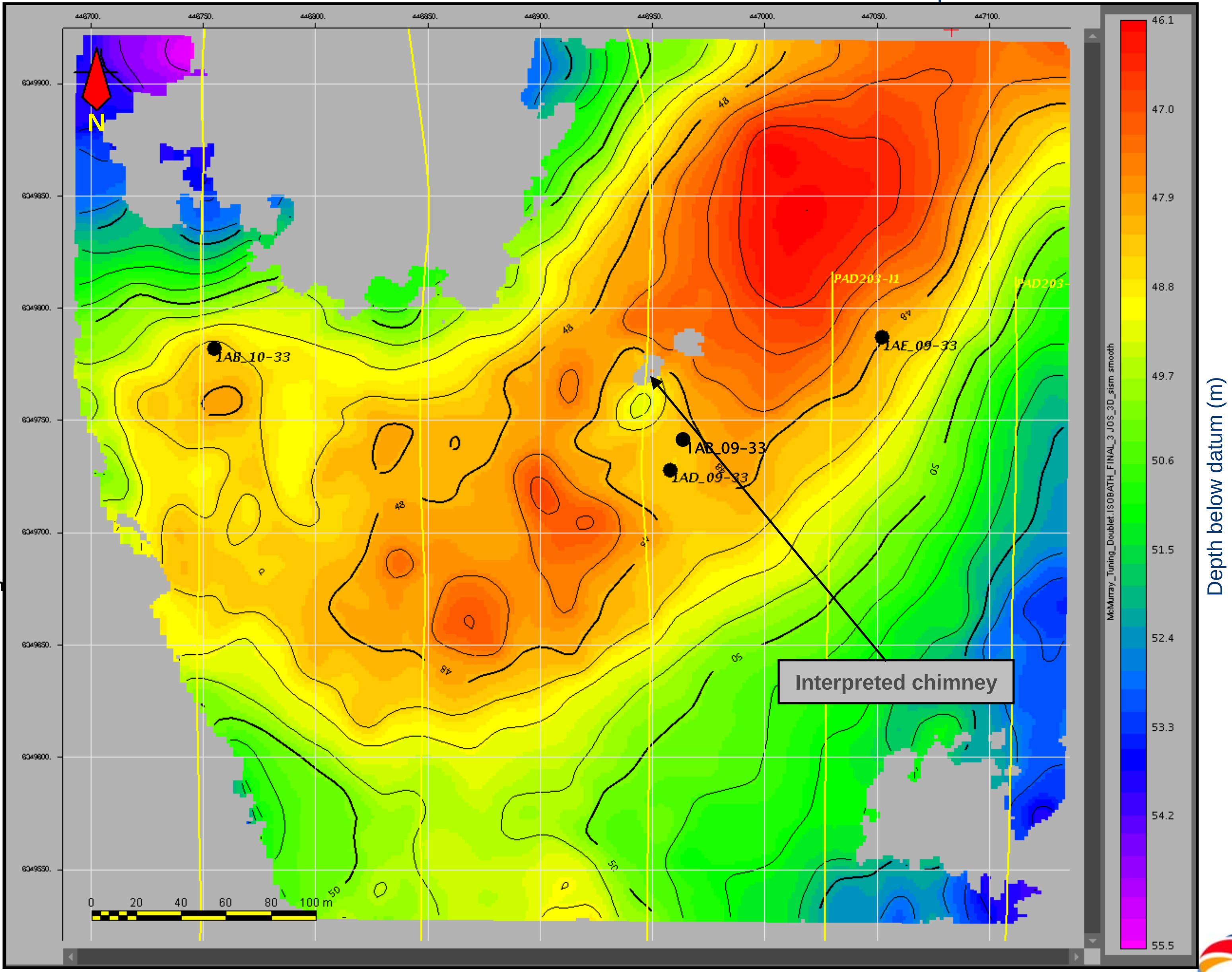
Zone of steam disturbance

Depth Structural Map – McMurray 1

Mapped horizon

- 🟦 Topography
- 🟨 Clearwater
- 🟧 Wabiskaw
- 🟪 Top McMurray
- 🟦 **McMurray1**
- 🟩 McMurray2
- 🟨 McMurray3
- 🟦 McMurray4
- 🟥 McMurray5
- 🟪 McMurray6
- 🟩 Top Devonian

Map datum : 337m above sea level



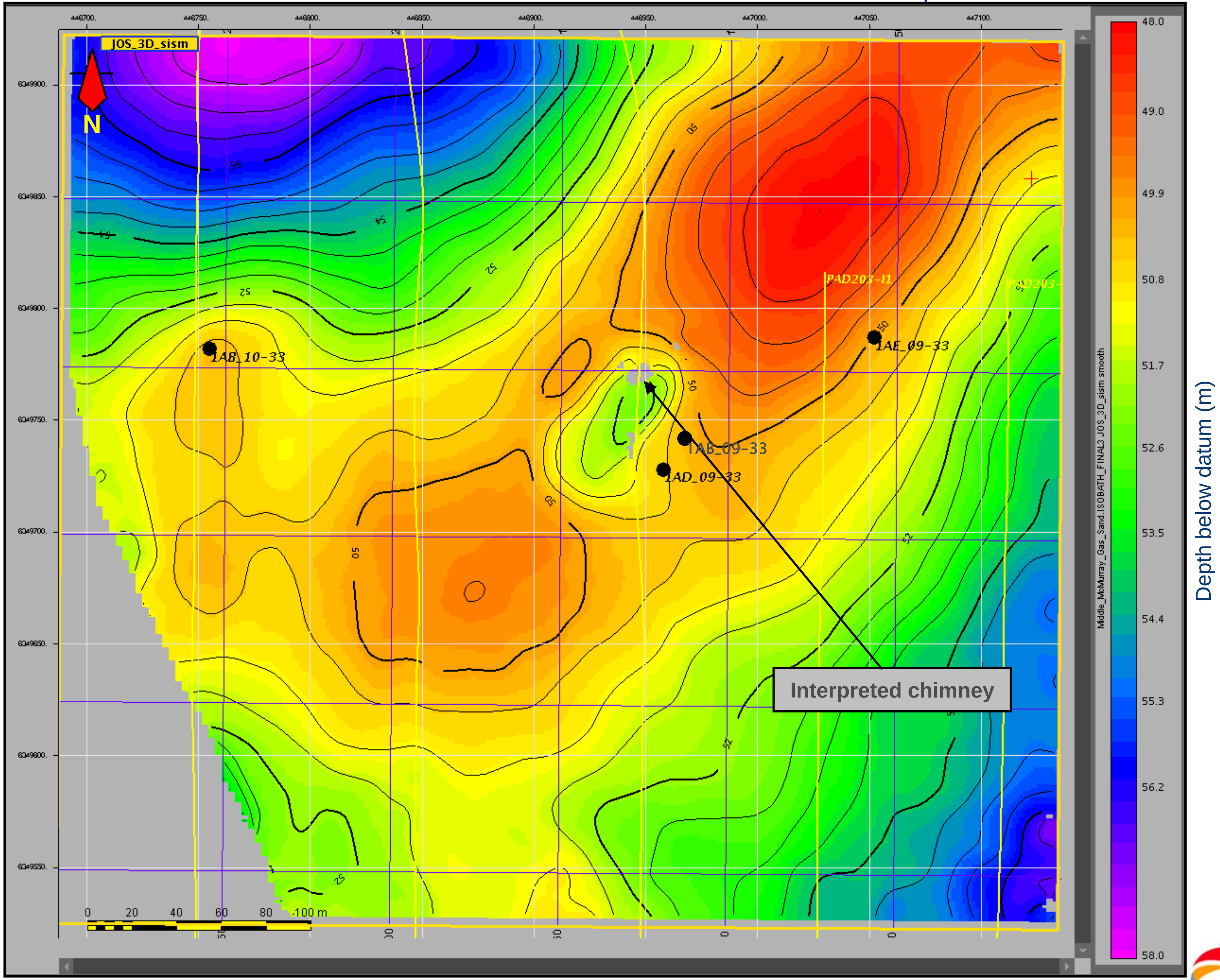
Interpreted chimney

Depth Structural Map – McMurray 2

Map datum : 337m above sea level

Mapped horizon

- **Topography**
- **Clearwater**
- **Wabiskaw**
- **Top McMurray**
- **McMurray1**
- **McMurray2**
- **McMurray3**
- **McMurray4**
- **McMurray5**
- **McMurray6**
- **Top Devonian**

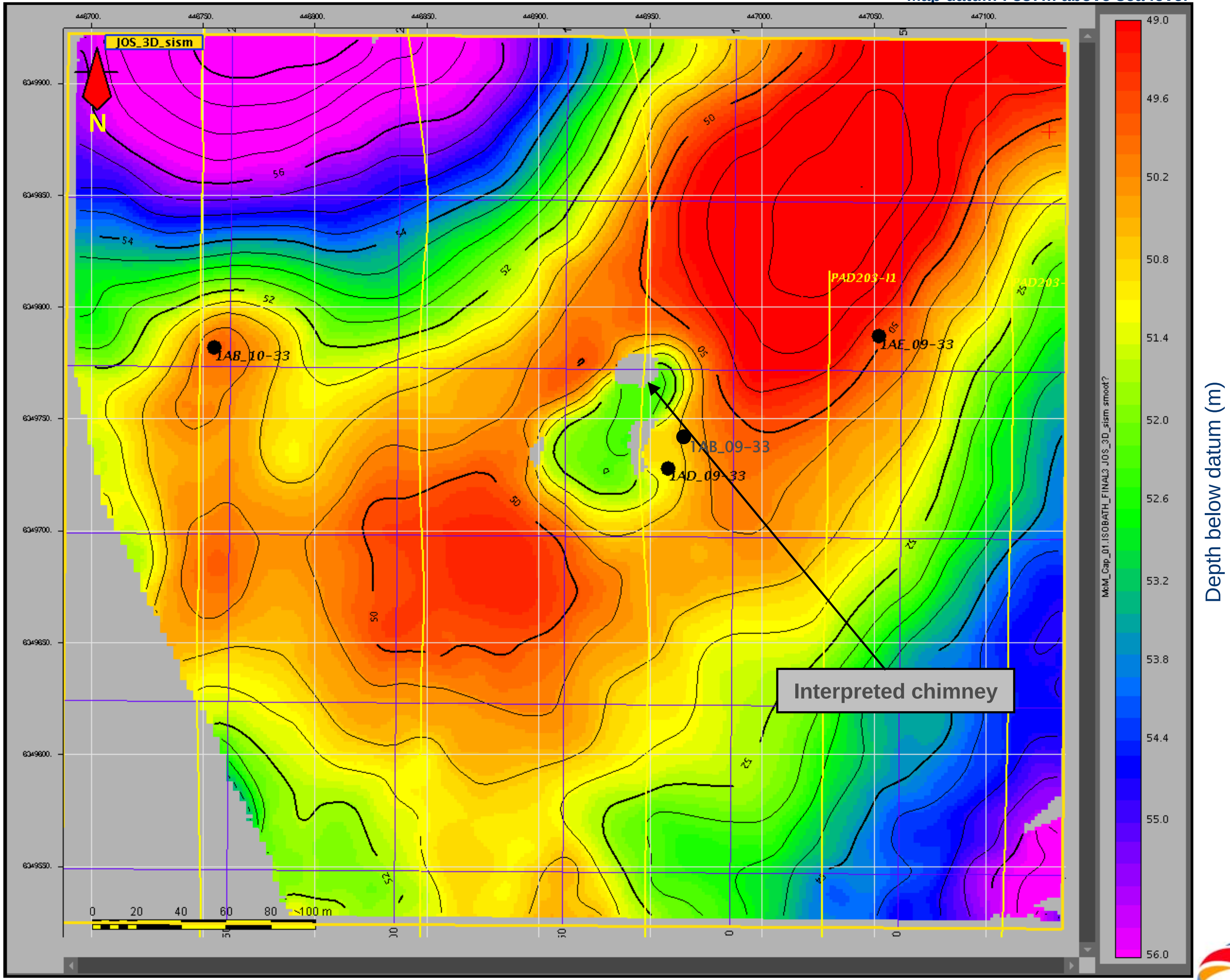


Depth Structural Map – McMurray 3

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- **McMurray3**
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

Map datum : 337m above sea level



DGEP/TDO/TEC/GEO

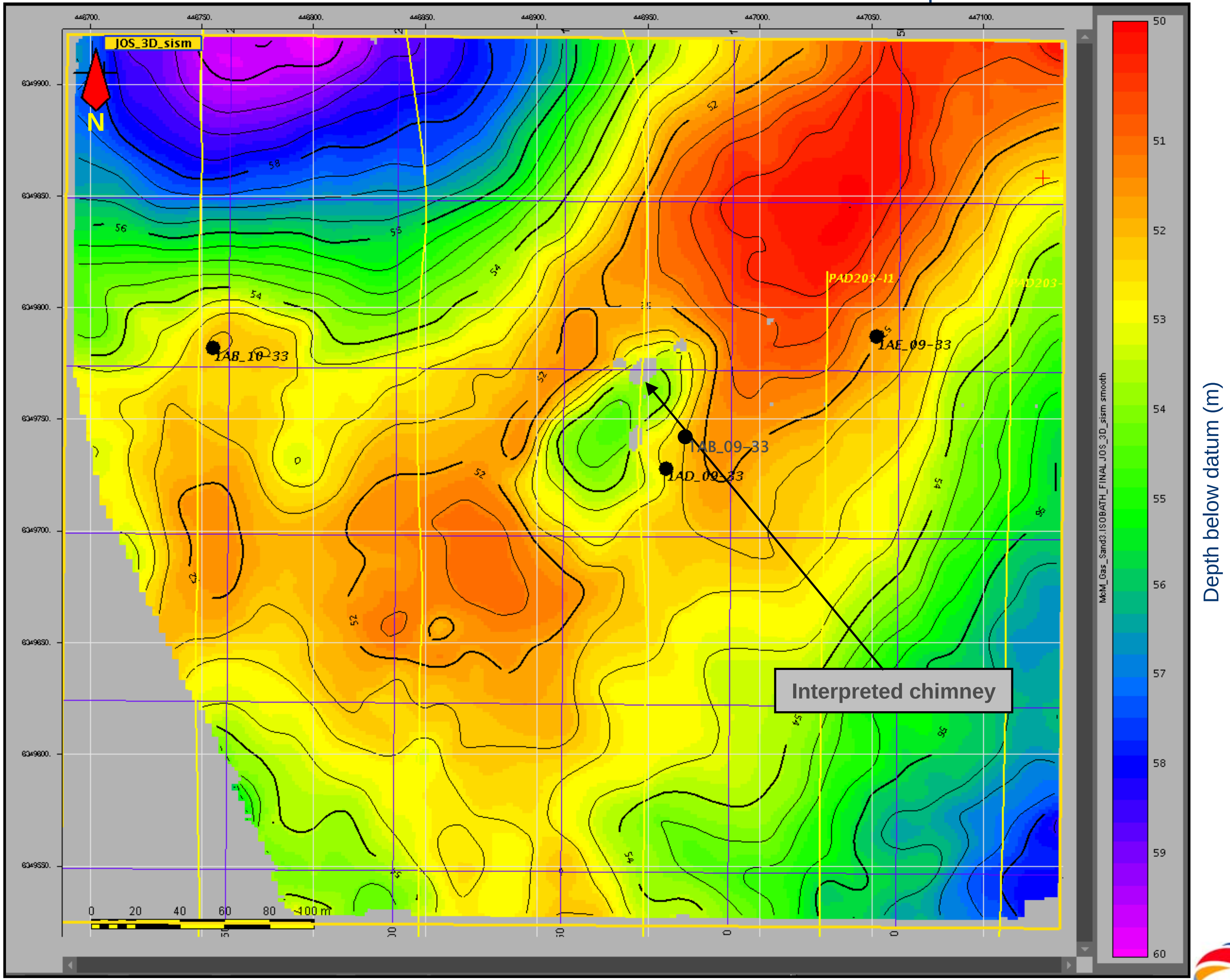
PLATE # 31

Depth Structural Map – McMurray 4

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

Map datum : 337m above sea level



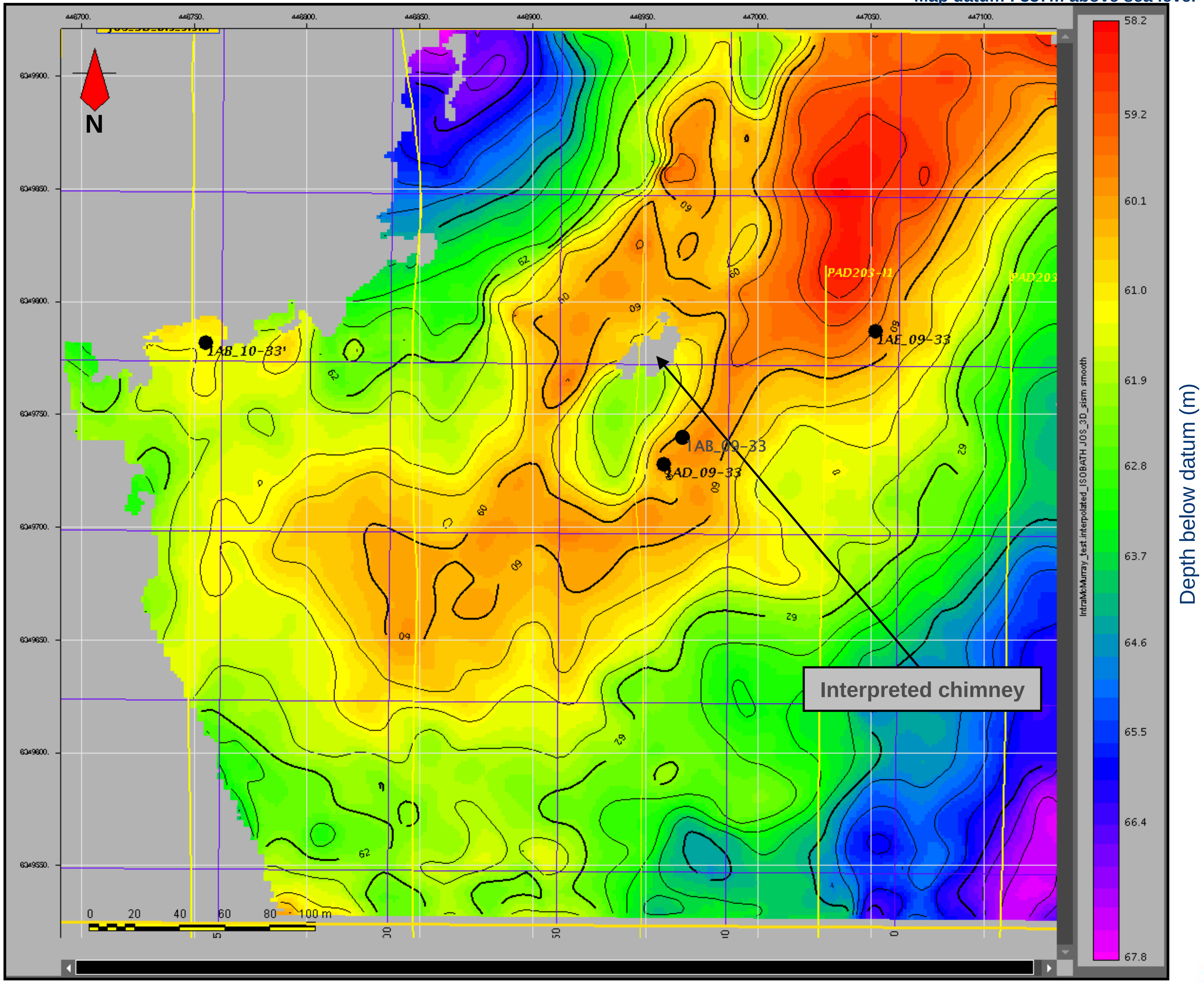
Interpreted chimney

Depth Structural Map – McMurray 5

Map datum : 337m above sea level

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

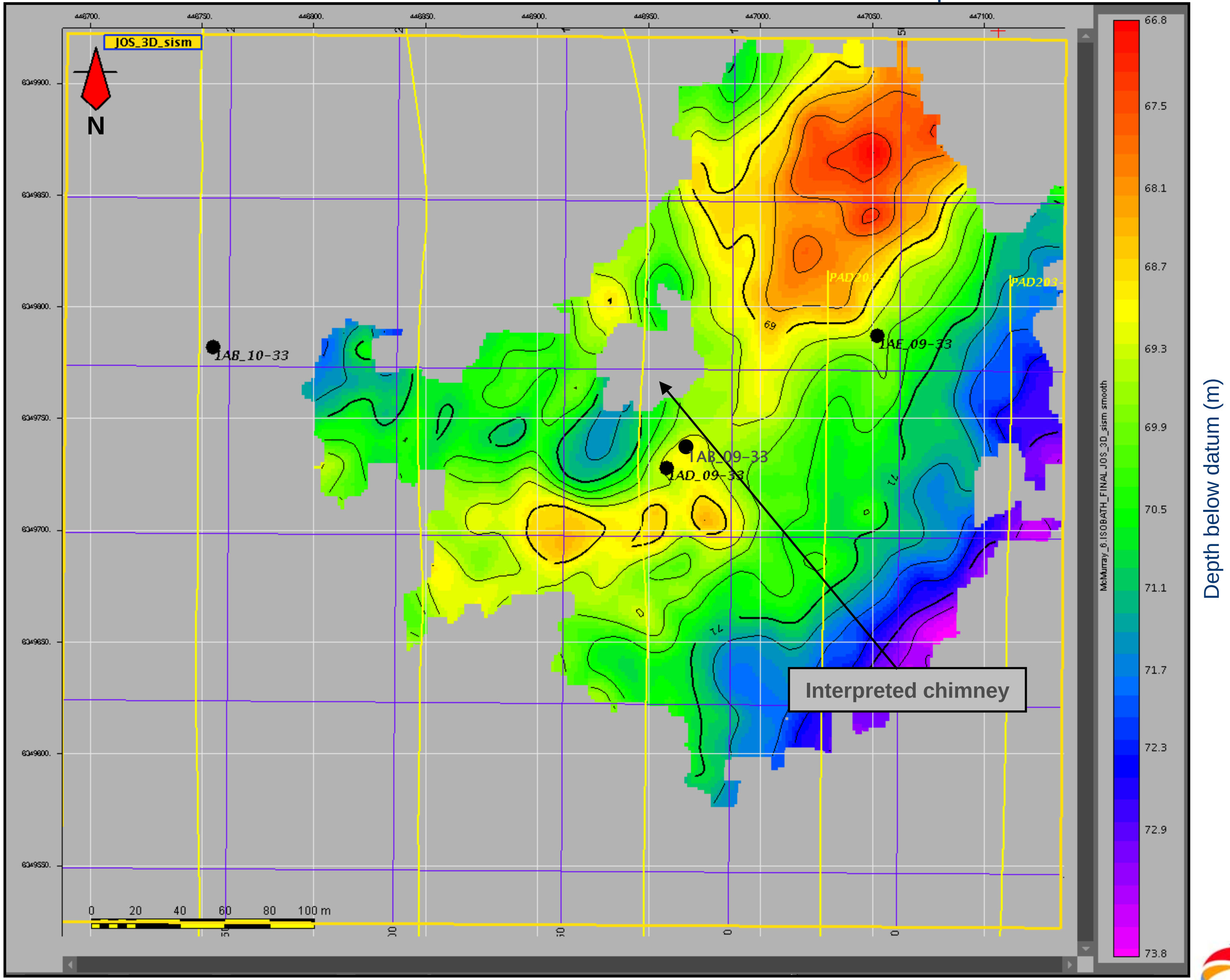


Depth Structural Map – McMurray 6

Map datum : 337m above sea level

Mapped horizon

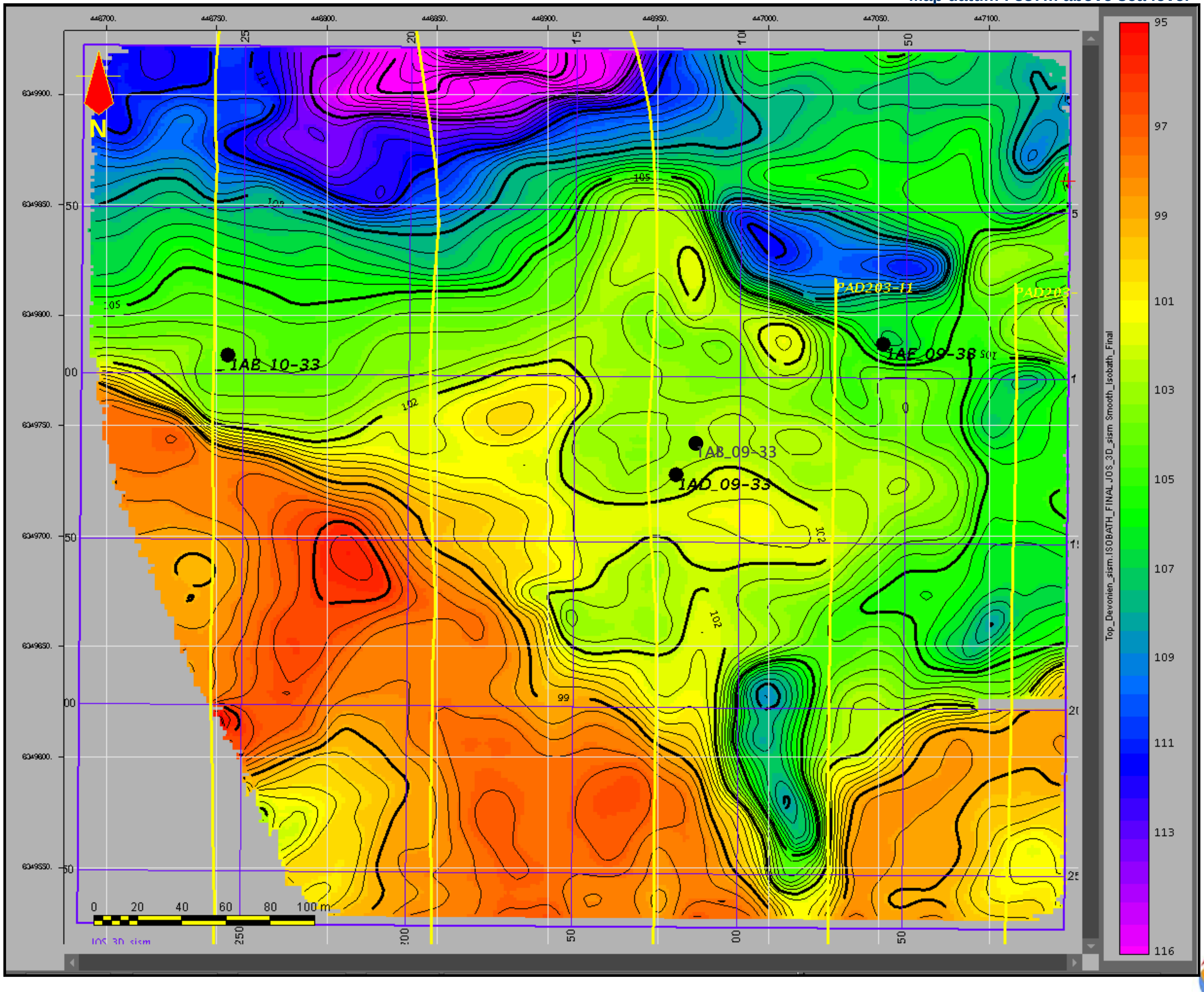
- **Topography**
- **Clearwater**
- **Wabiskaw**
- **Top McMurray**
- **McMurray1**
- **McMurray2**
- **McMurray3**
- **McMurray4**
- **McMurray5**
- **McMurray6**
- **Top Devonian**



Depth Structural Map – Top Devonian

Map datum : 337m above sea level

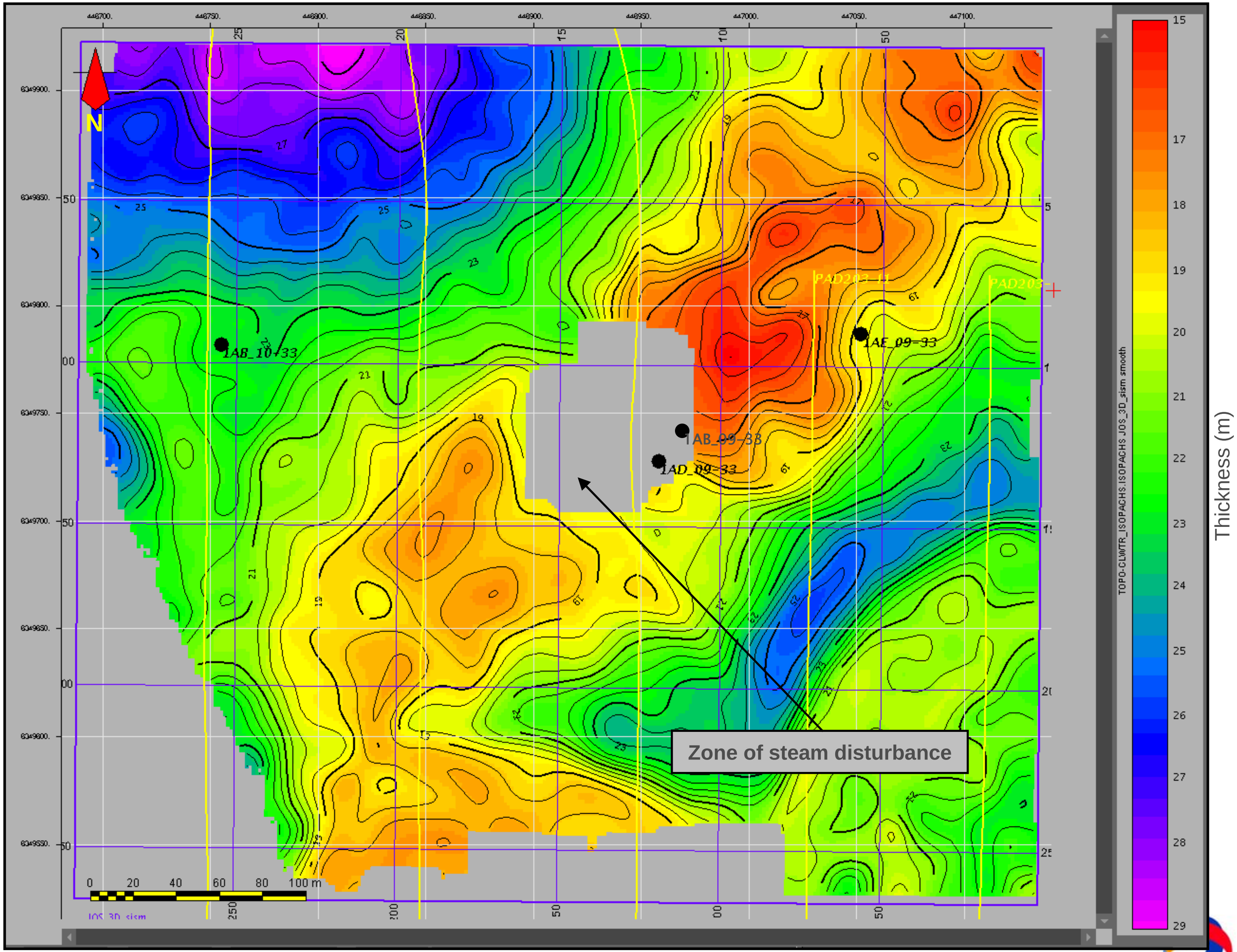
Mapped horizon



Isopach Map – Topography_Clearwater

Mapped horizons

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

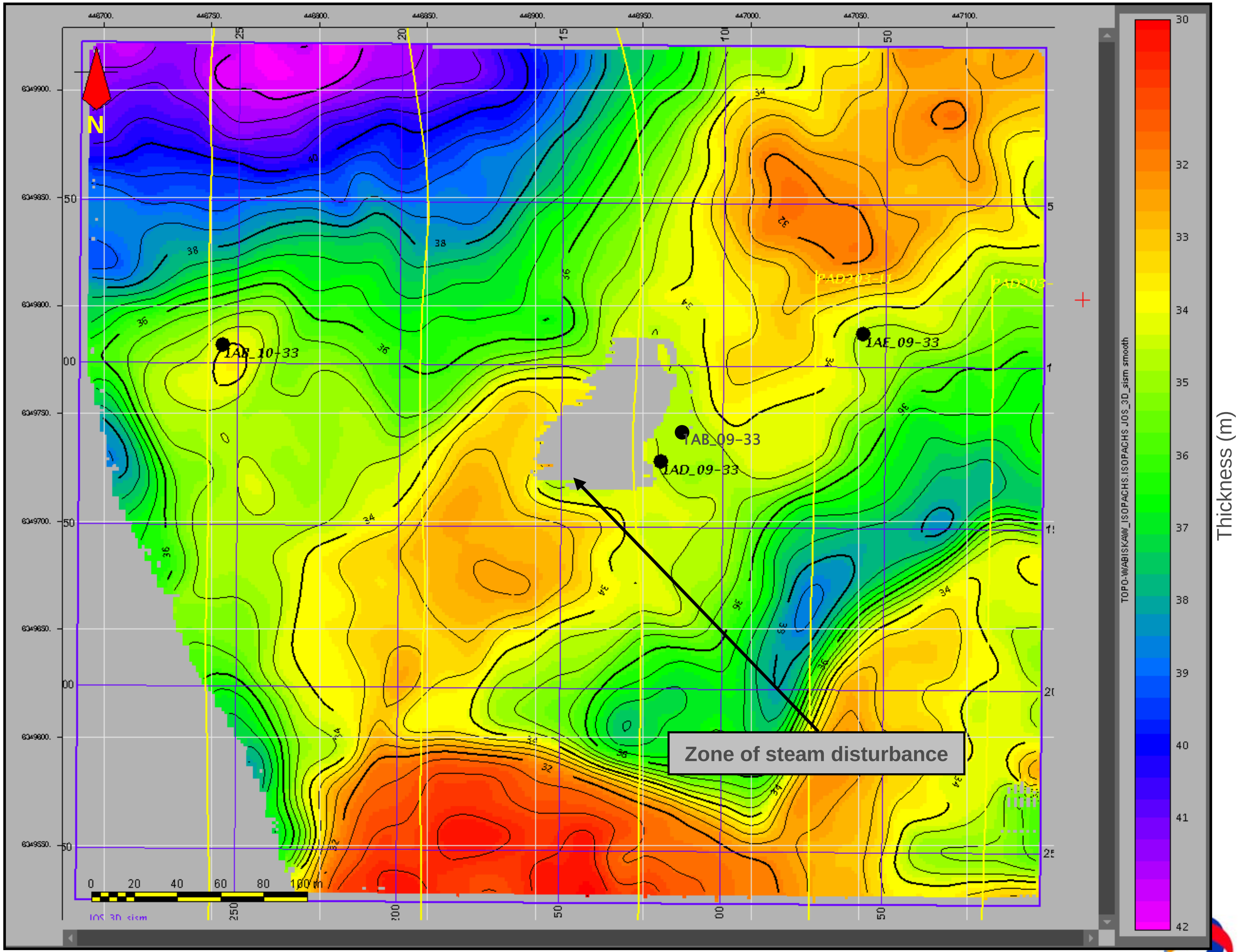


Zone of steam disturbance

Isopach Map - Topography_Top_Wabiskaw

Mapped horizons

🟦	**Topography**
🟨	**Clearwater**
🟧	**Wabiskaw**
🟪	**Top McMurray**
🟦	**McMurray1**
🟩	**McMurray2**
🟨	**McMurray3**
🟦	**McMurray4**
🟥	**McMurray5**
🟪	**McMurray6**
🟩	**Top Devonian**



Zone of steam disturbance

Isopach Map - Topography_Top McMurray

Mapped horizons

- **Topography**
- **Clearwater**
- **Wabiskaw**
- **Top McMurray**
- **McMurray1**
- **McMurray2**
- **McMurray3**
- **McMurray4**
- **McMurray5**
- **McMurray6**
- **Top Devonian**

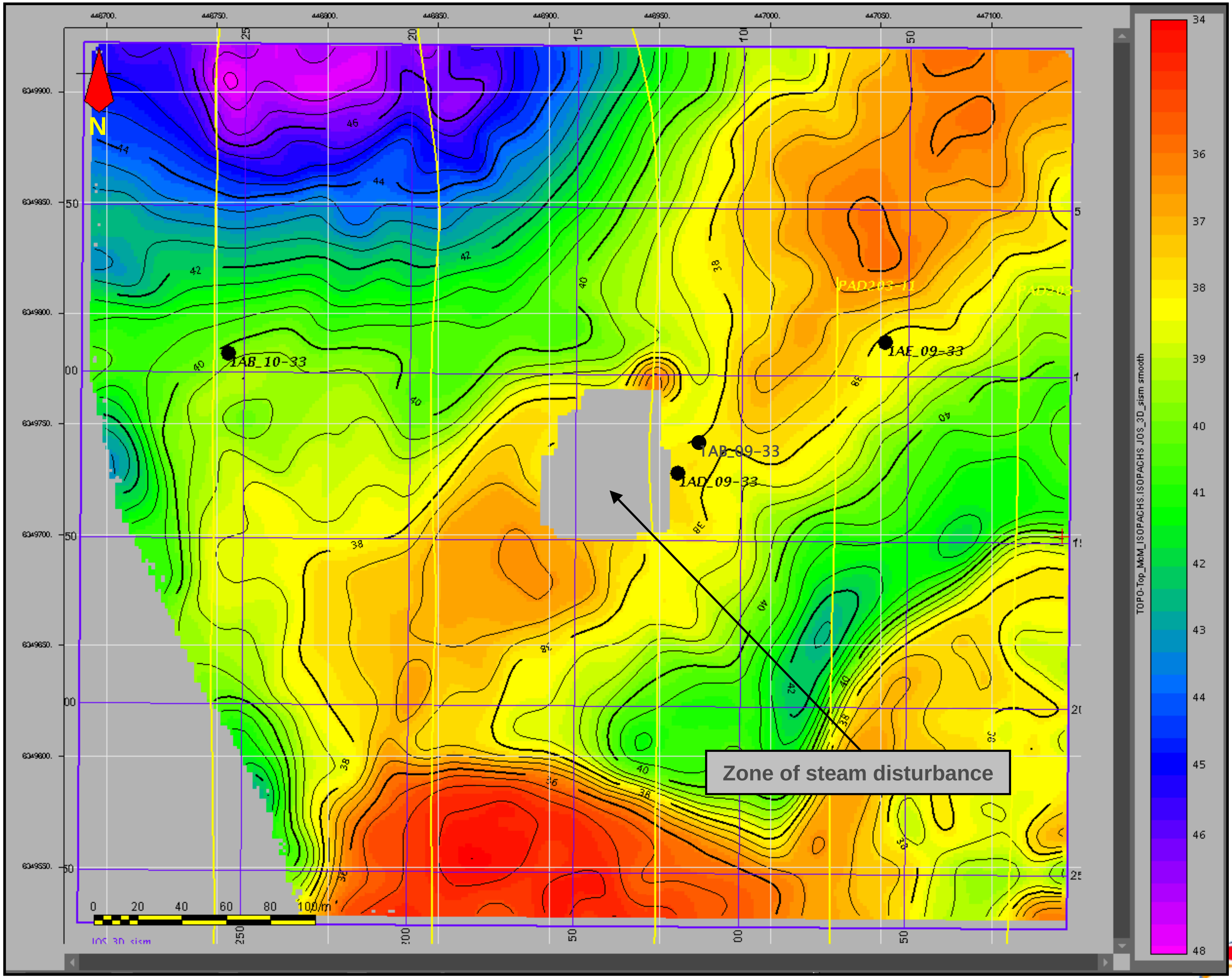


PLATE # 38

Isopach Map - Topography_McMurray 1

Mapped horizons

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

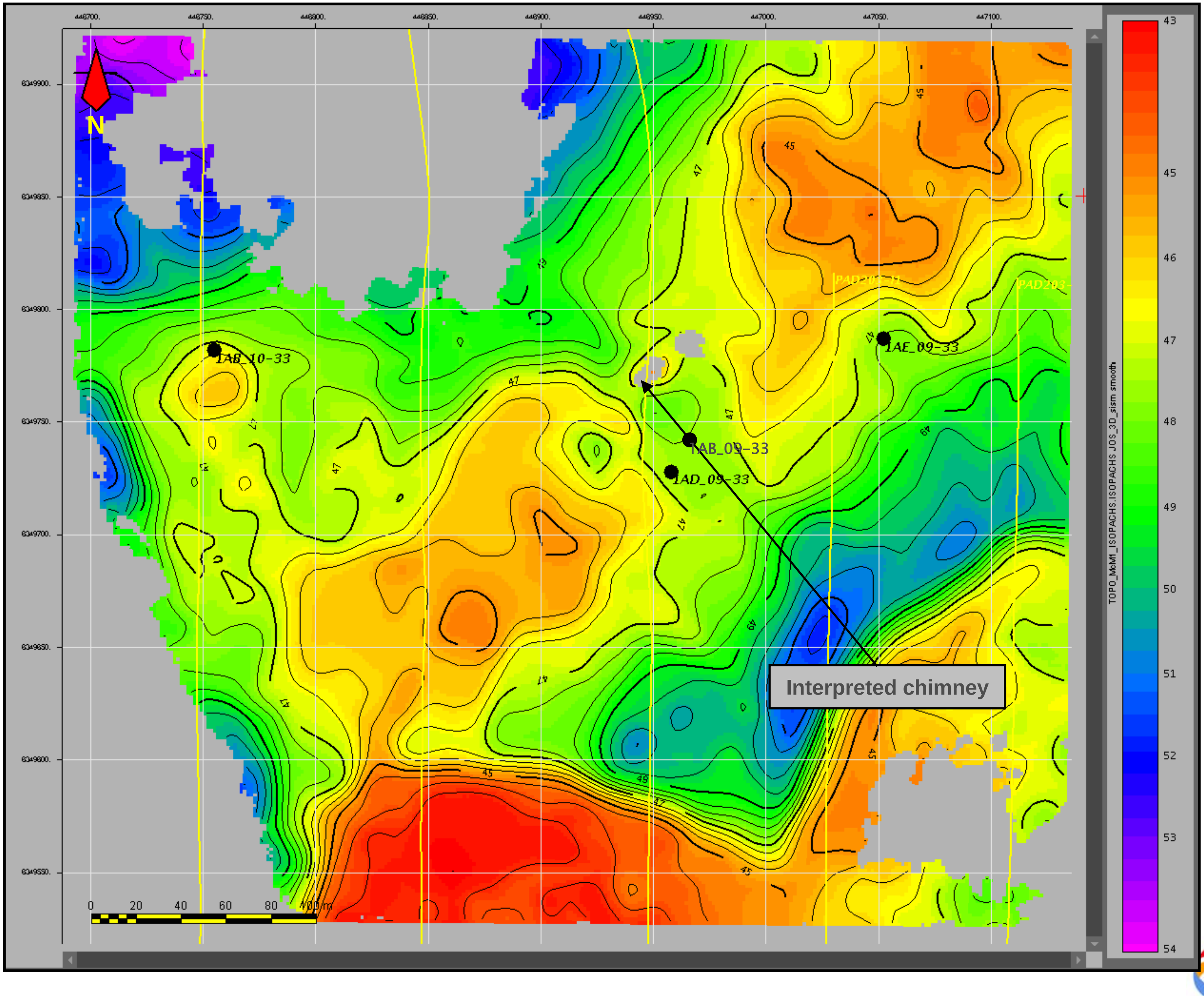
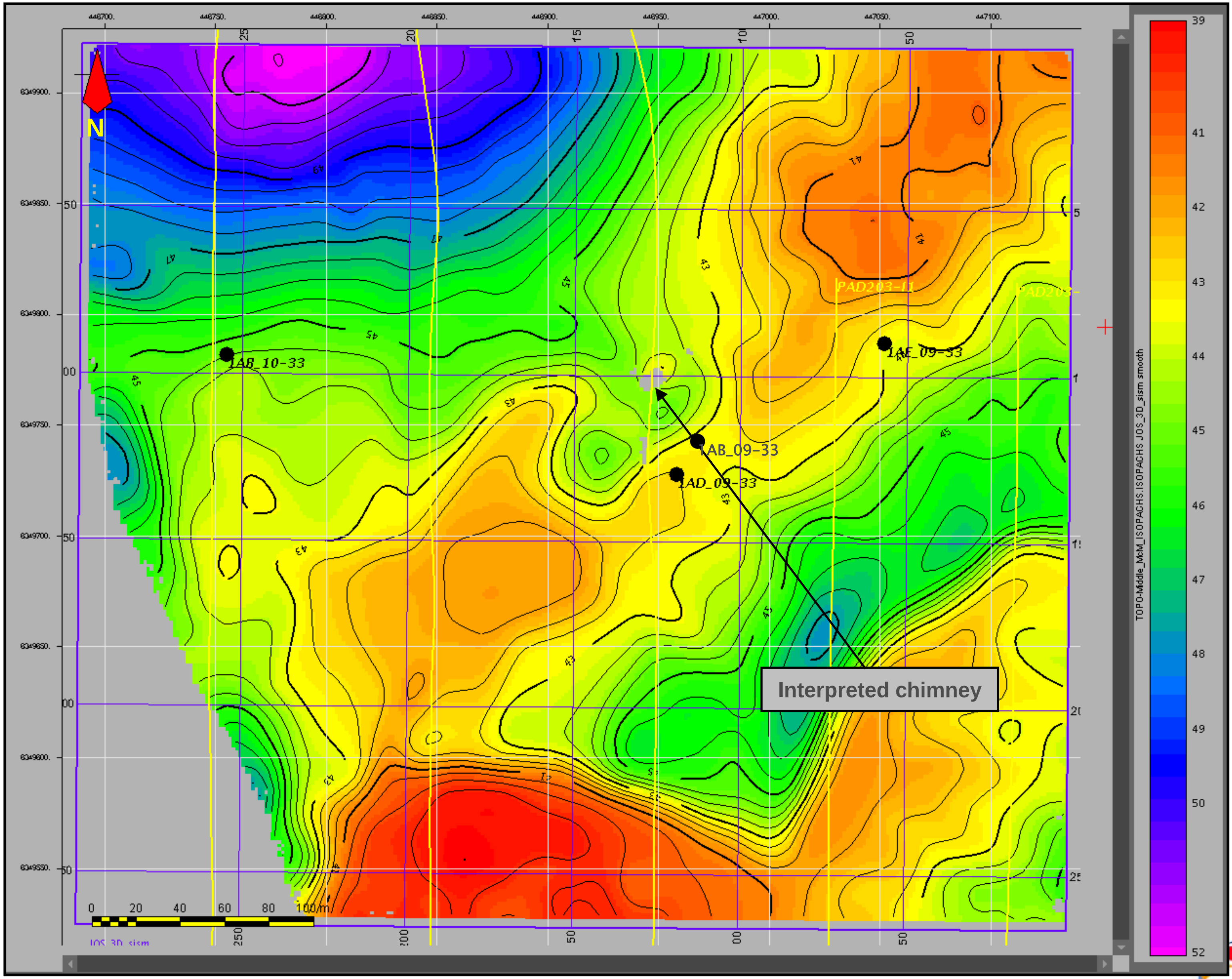


PLATE # 39

Isopach Map - Topography_McMurray 2

Mapped horizons

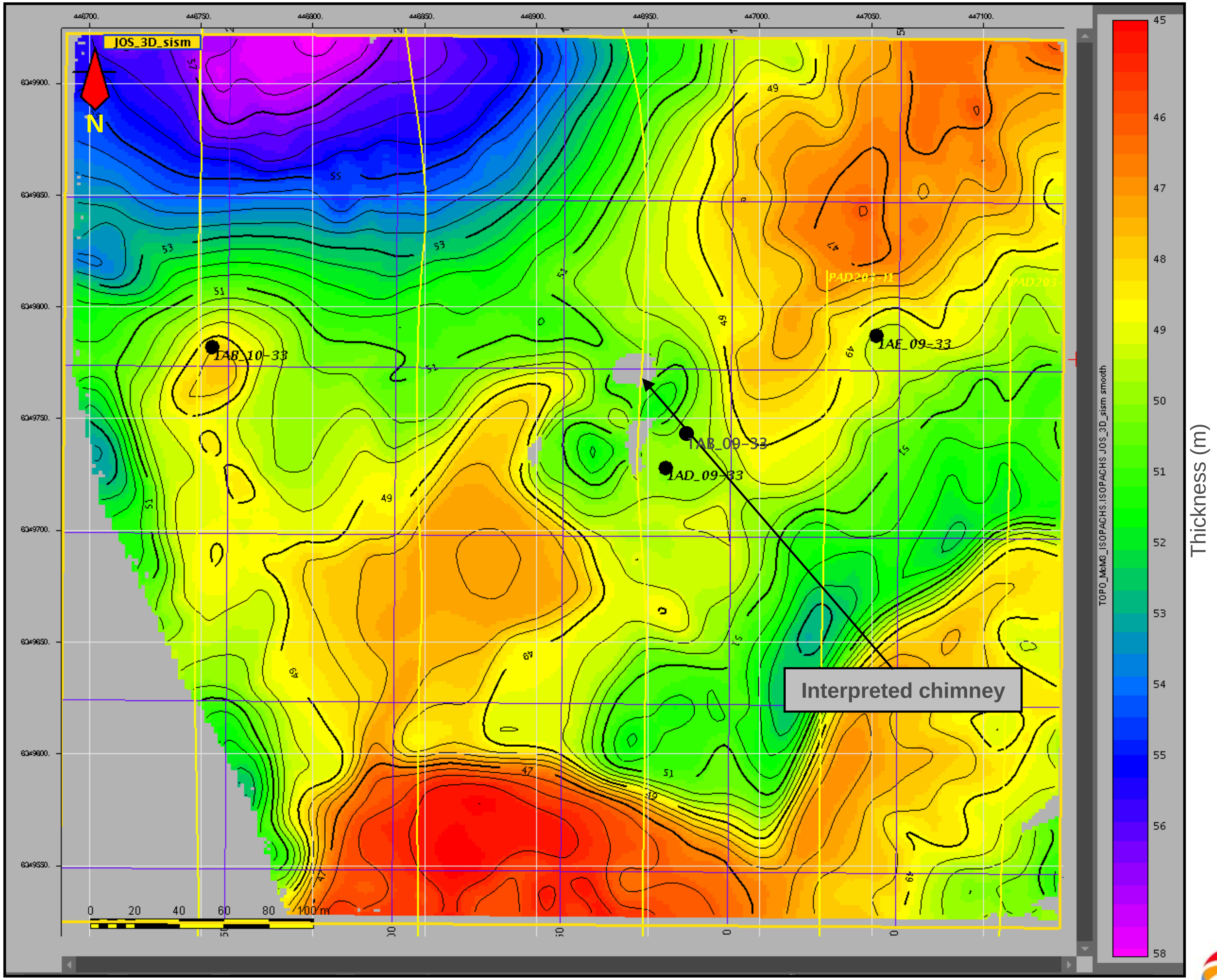
- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian



Isopach Map - Topography_McMurray 3

Mapped horizons

- **Topography**
- **Clearwater**
- **Wabiskaw**
- **Top McMurray**
- **McMurray1**
- **McMurray2**
- **McMurray3**
- **McMurray4**
- **McMurray5**
- **McMurray6**
- **Top Devonian**

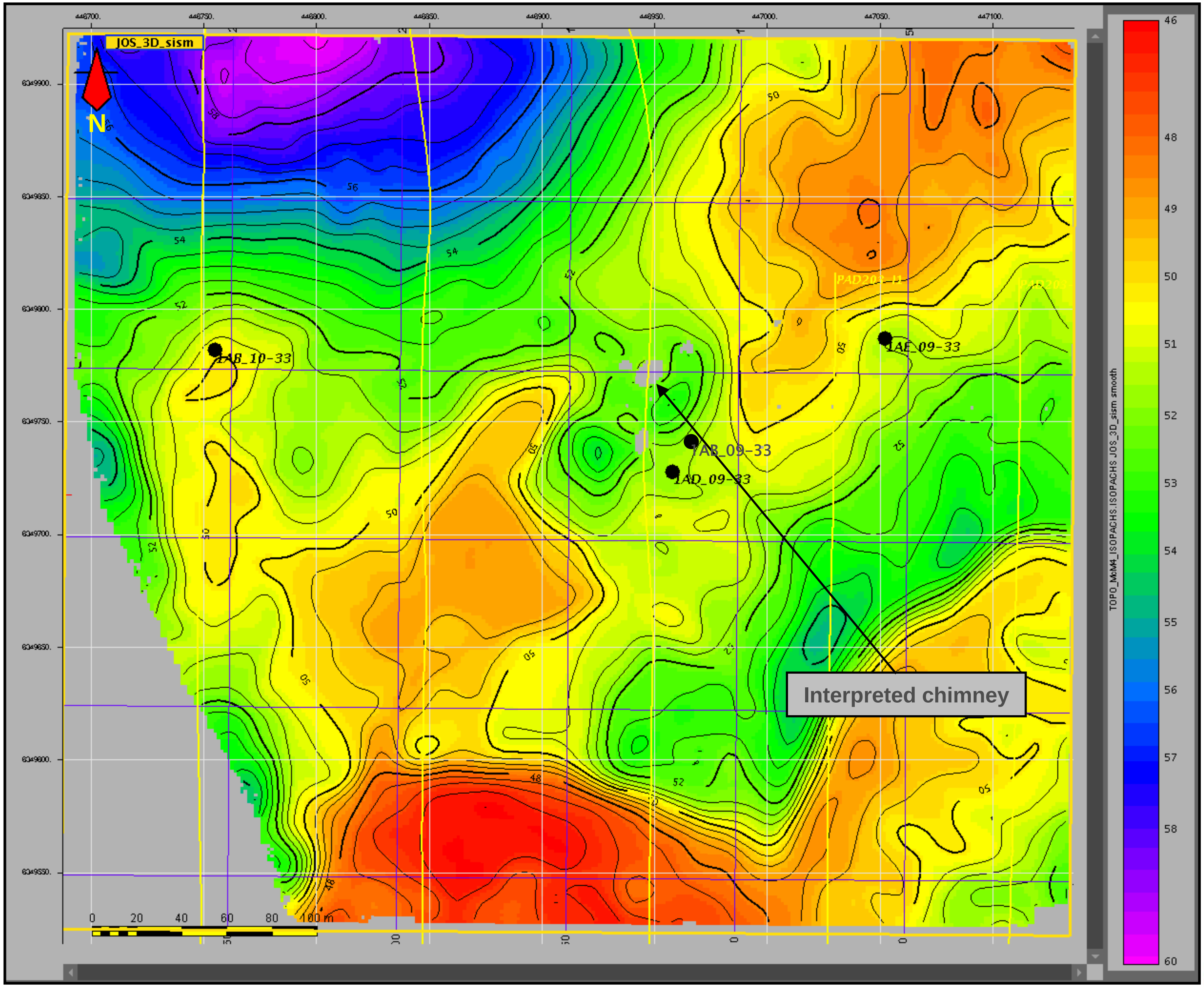


Interpreted chimney

Isopach Map - Topography_McMurray 4

Mapped horizons

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

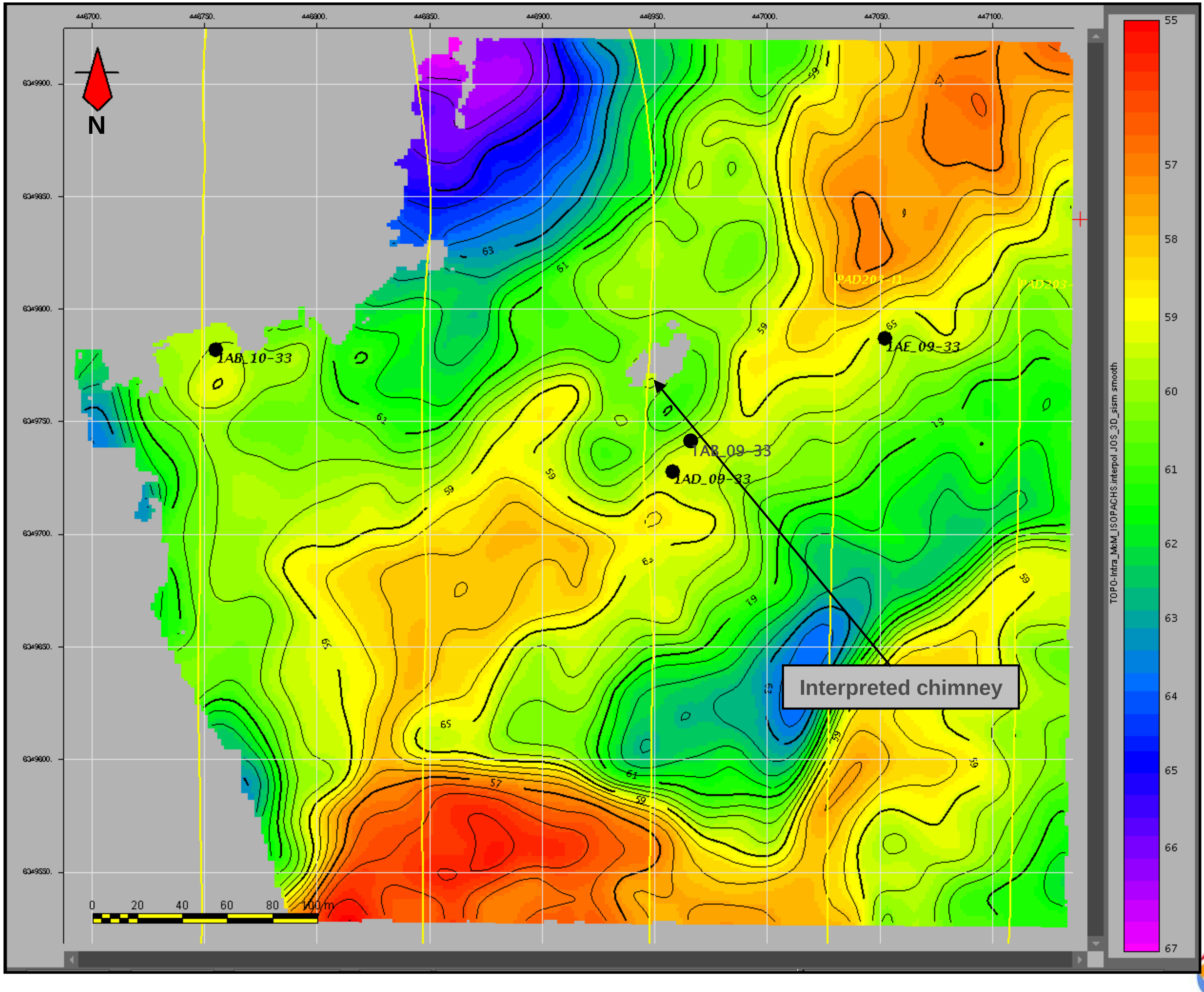


TOTAL

Isopach Map - Topography_ McMurray 5

Mapped horizons

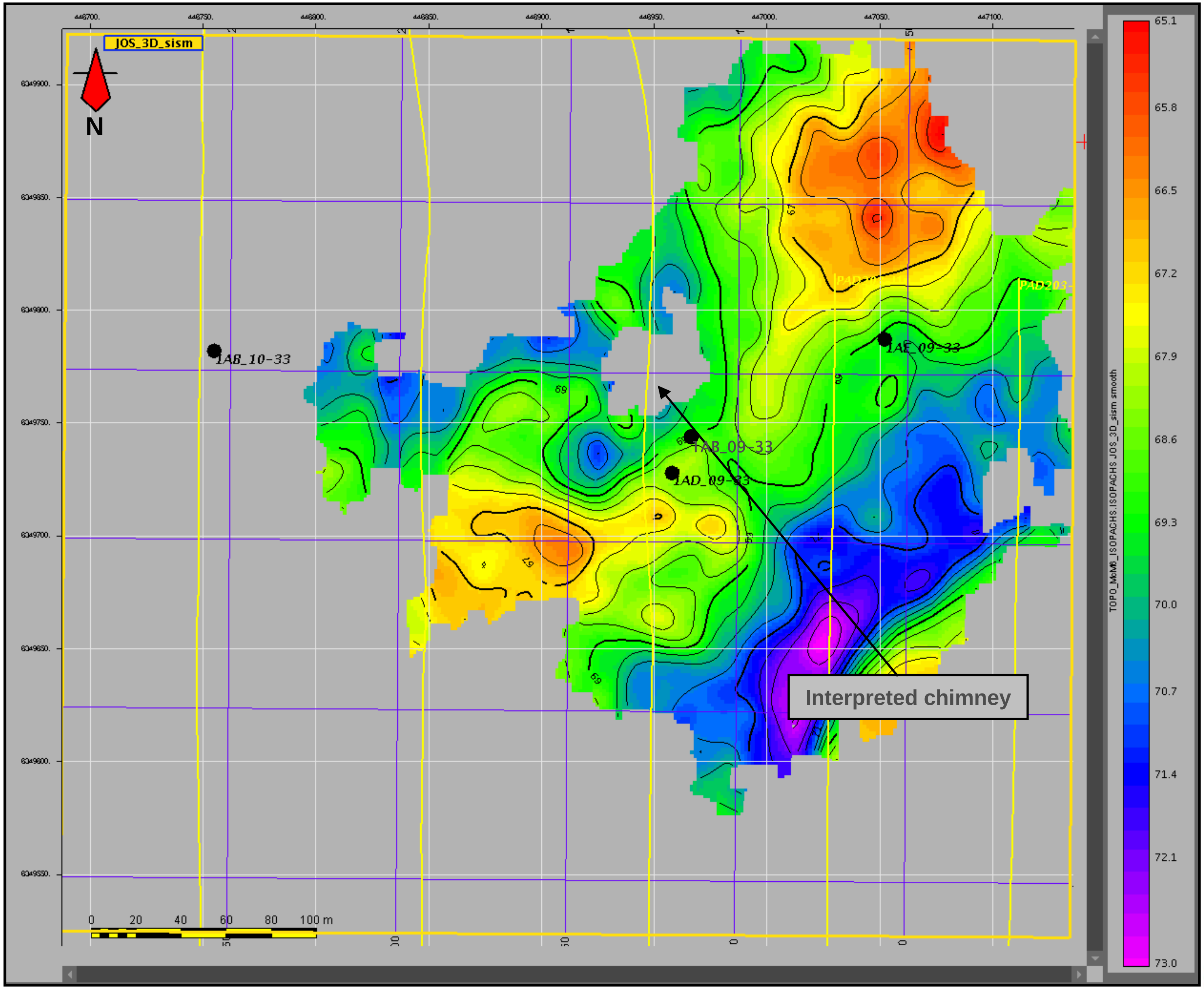
- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian



Isopach Map - Topography_McMurray 6

Mapped horizons

Topography
Clearwater
Wabiskaw
Top McMurray
McMurray1
McMurray2
McMurray3
McMurray4
McMurray5
McMurray6
Top Devonian

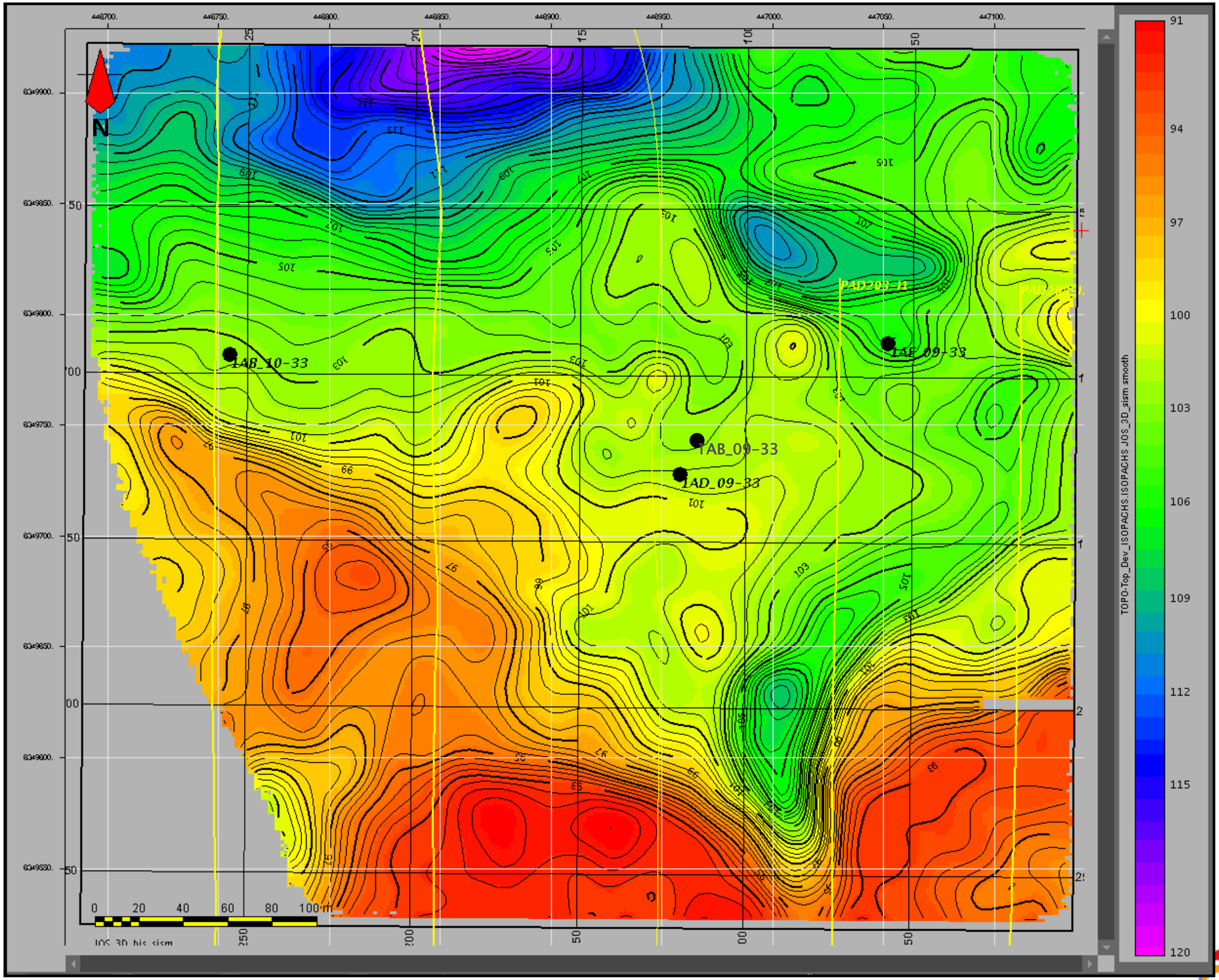


Interpreted chimney

Isopach Map - Topography_Top_Devonian

Mapped horizons

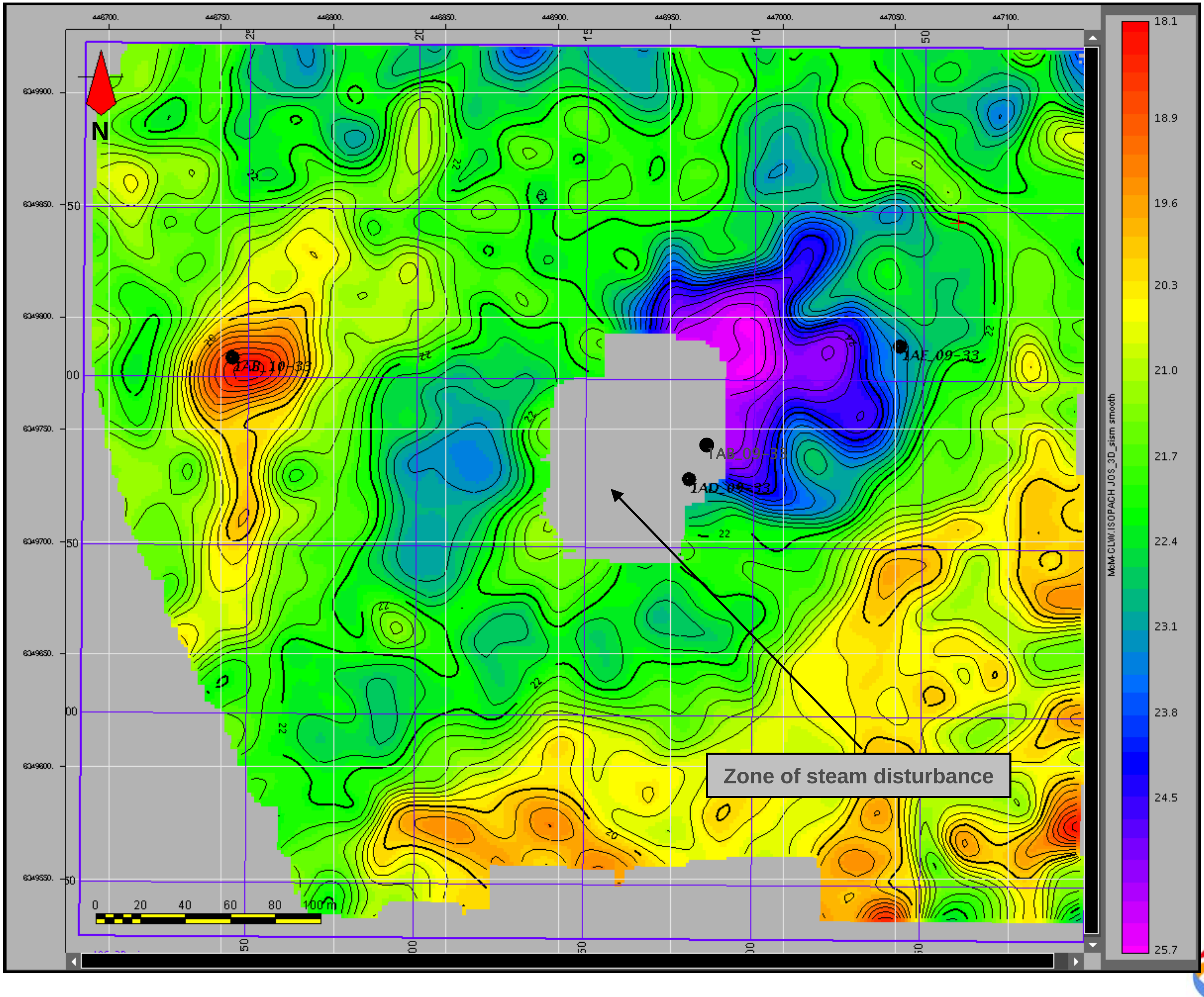
- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian



Isopach Map_Top McMurray - Clearwater

Mapped horizons

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

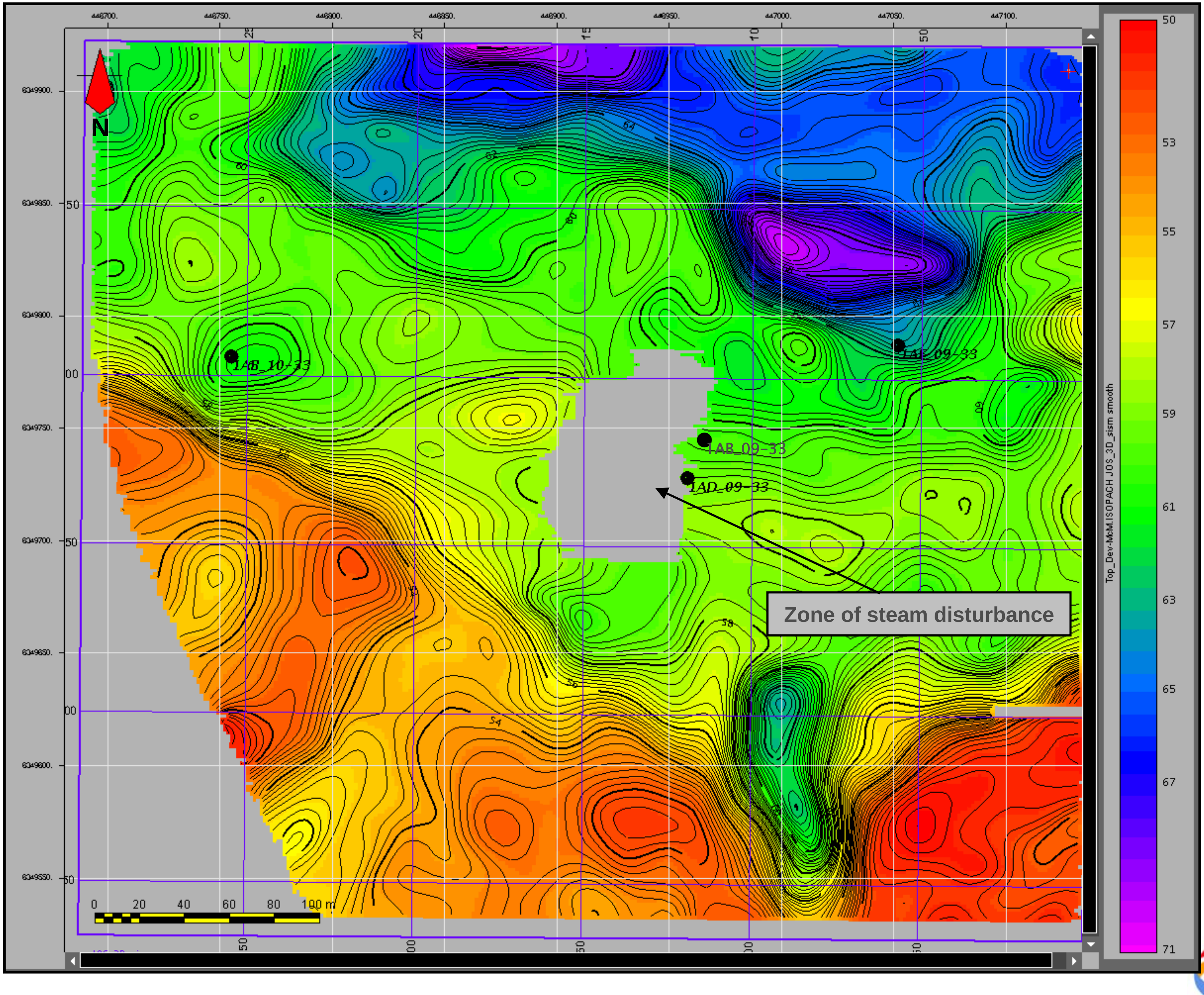


Zone of steam disturbance

Isopach Map_Top_Devonian – Top McMurray

Mapped horizons

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian



Zone of steam disturbance

Dip Map_Top_Wabiskaw

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

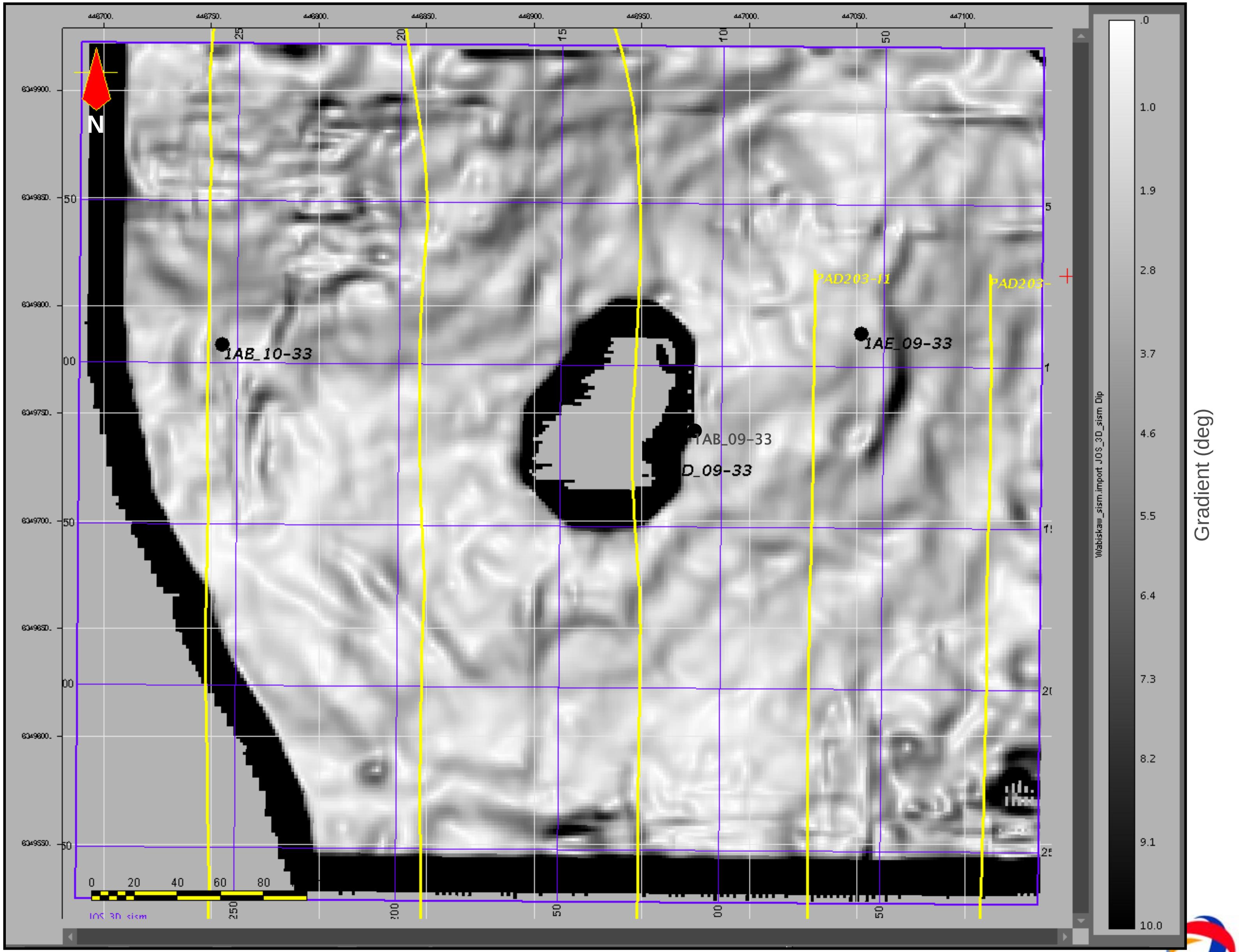
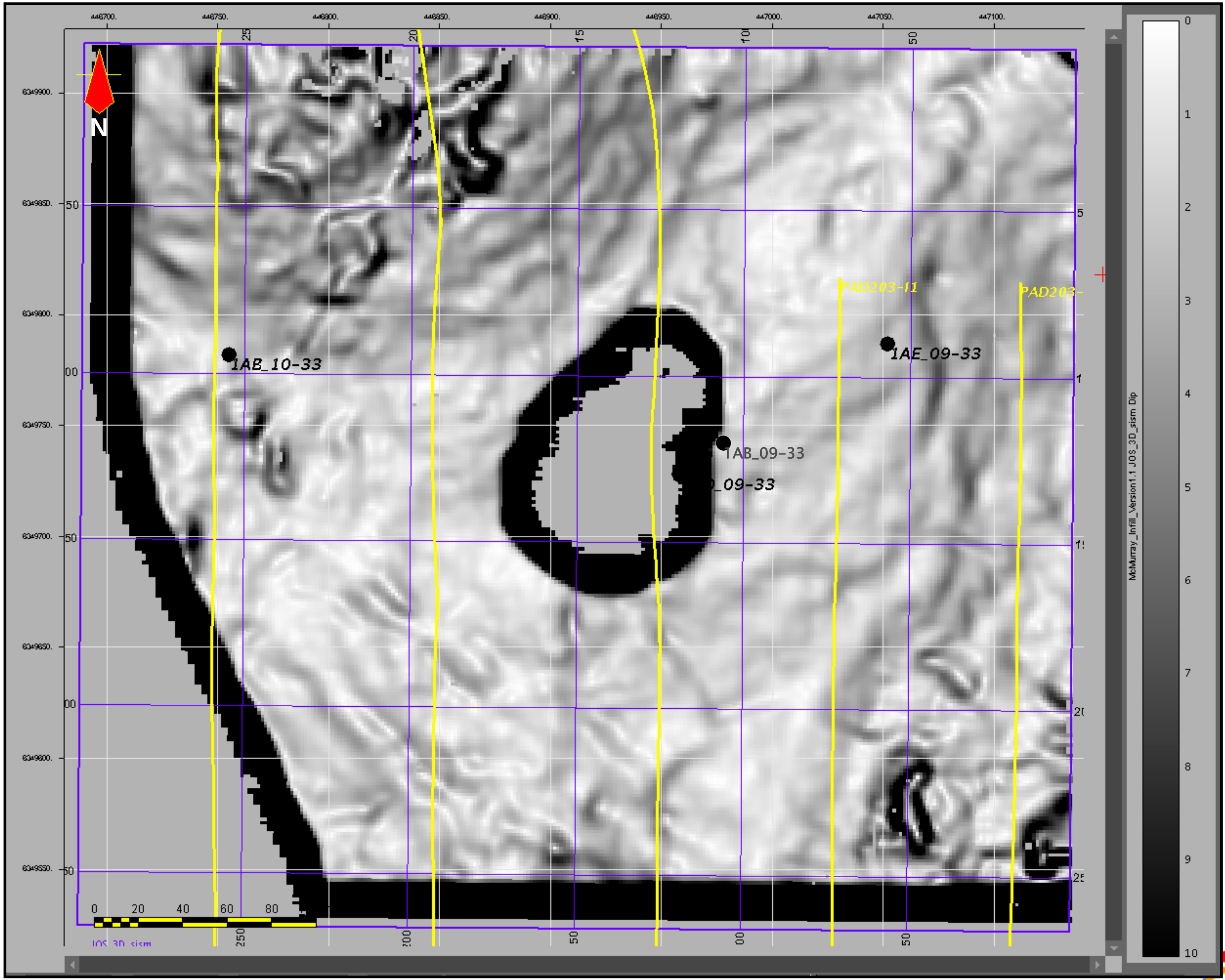


PLATE # 48

Dip Map_Top McMurray

Mapped horizon

Topography
Clearwater
Wabiskaw
Top McMurray
McMurray1
McMurray2
McMurray3
McMurray4
McMurray5
McMurray6
Top Devonian



Dip Map_ McMurray 1

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian

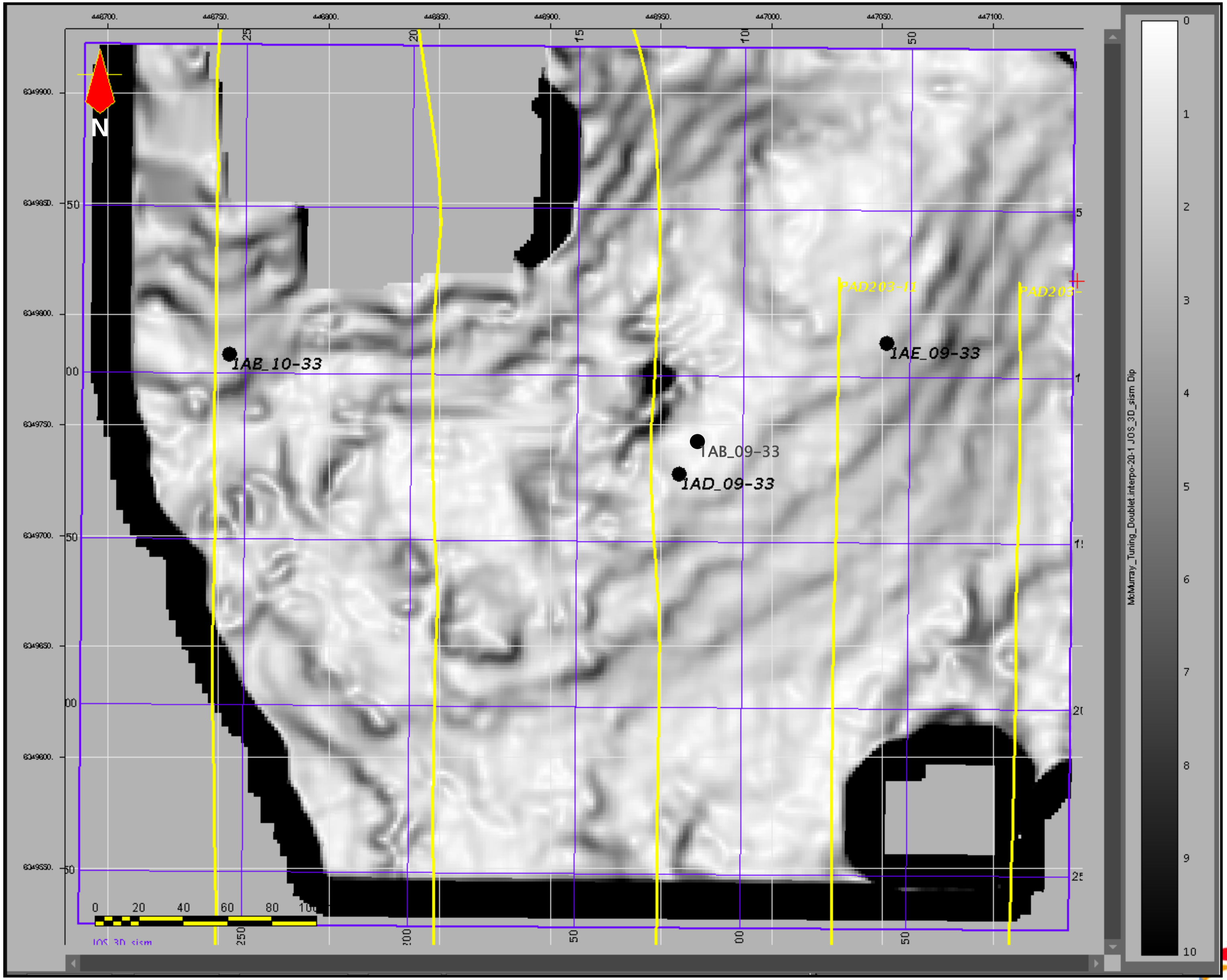
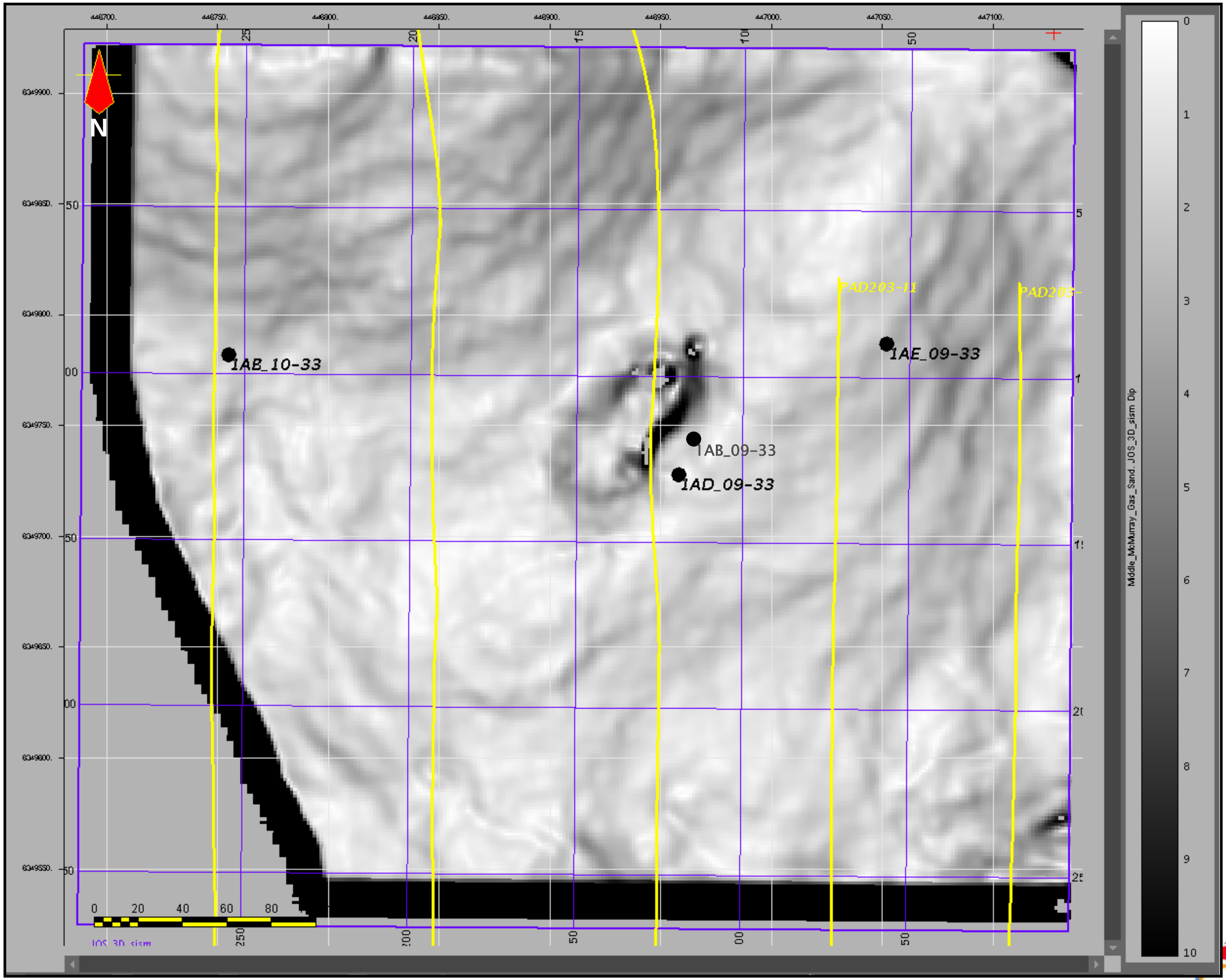


PLATE # 50

Dip Map_McMurray 2

Mapped horizon

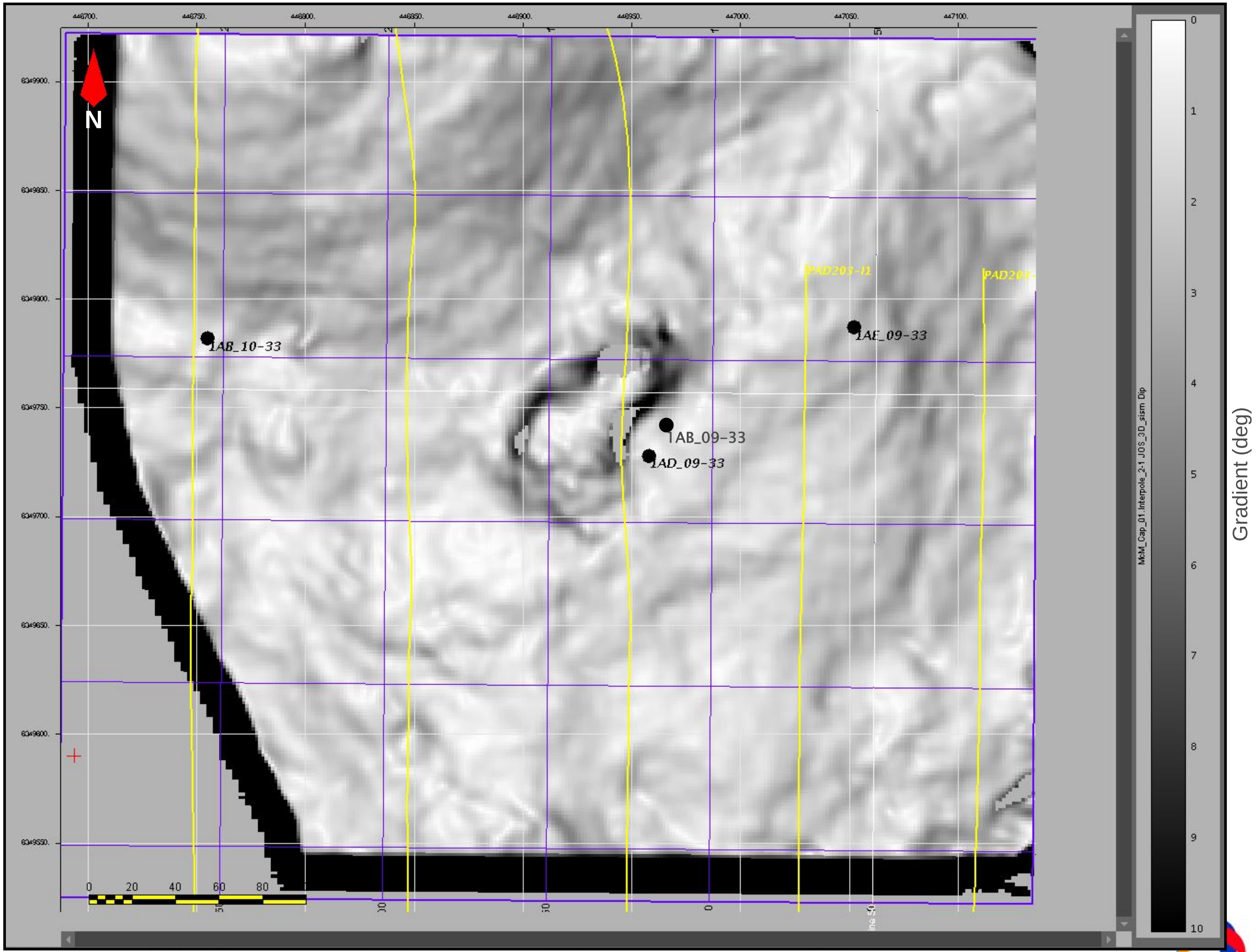
- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- **McMurray2**
- McMurray3
- McMurray4
- McMurray5
- McMurray6
- Top Devonian



Dip Map_McMurray 3

Mapped horizon

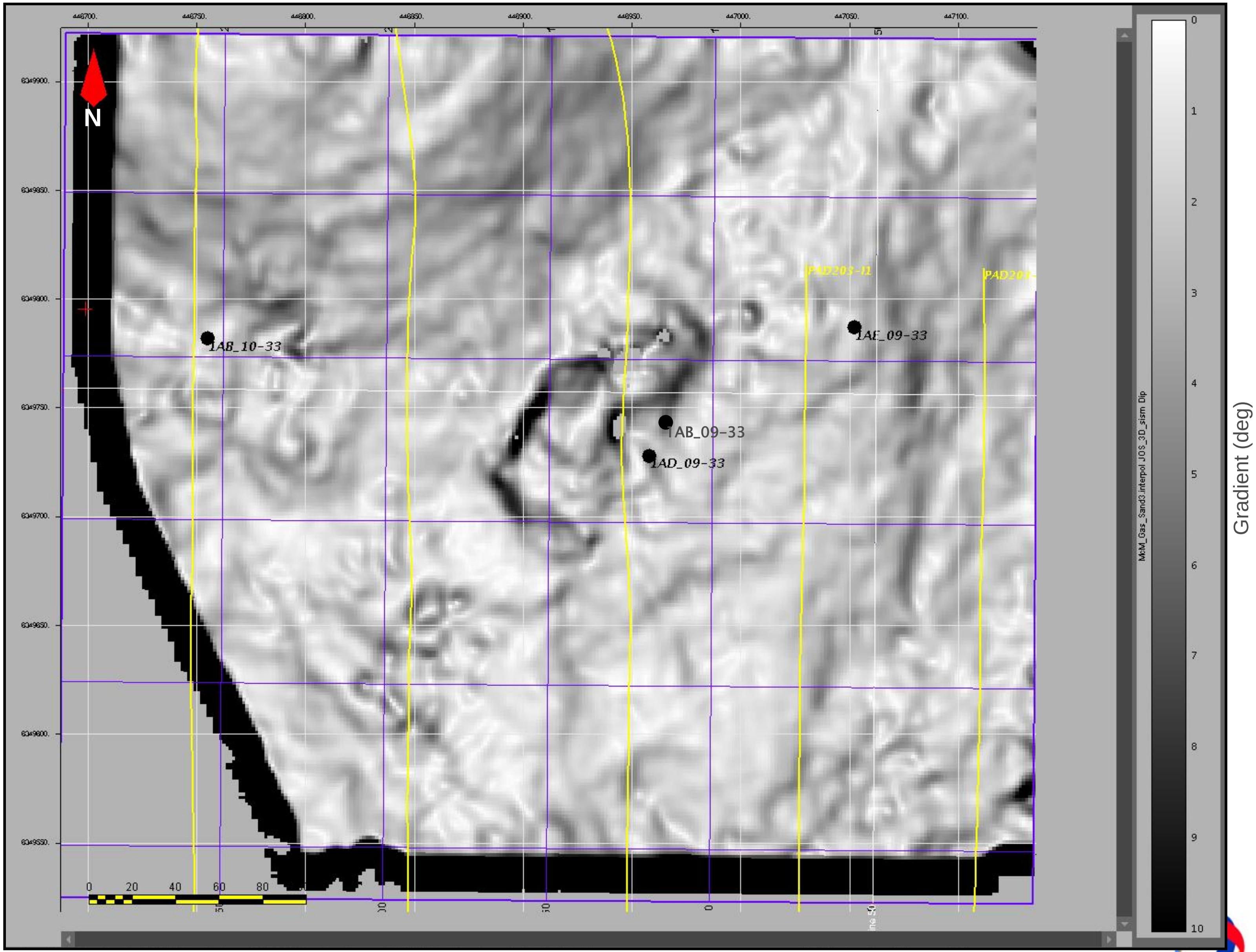
- **Topography**
- **Clearwater**
- **Wabiskaw**
- **Top McMurray**
- **McMurray1**
- **McMurray2**
- **McMurray3**
- **McMurray4**
- **McMurray5**
- **McMurray6**
- **Top Devonian**



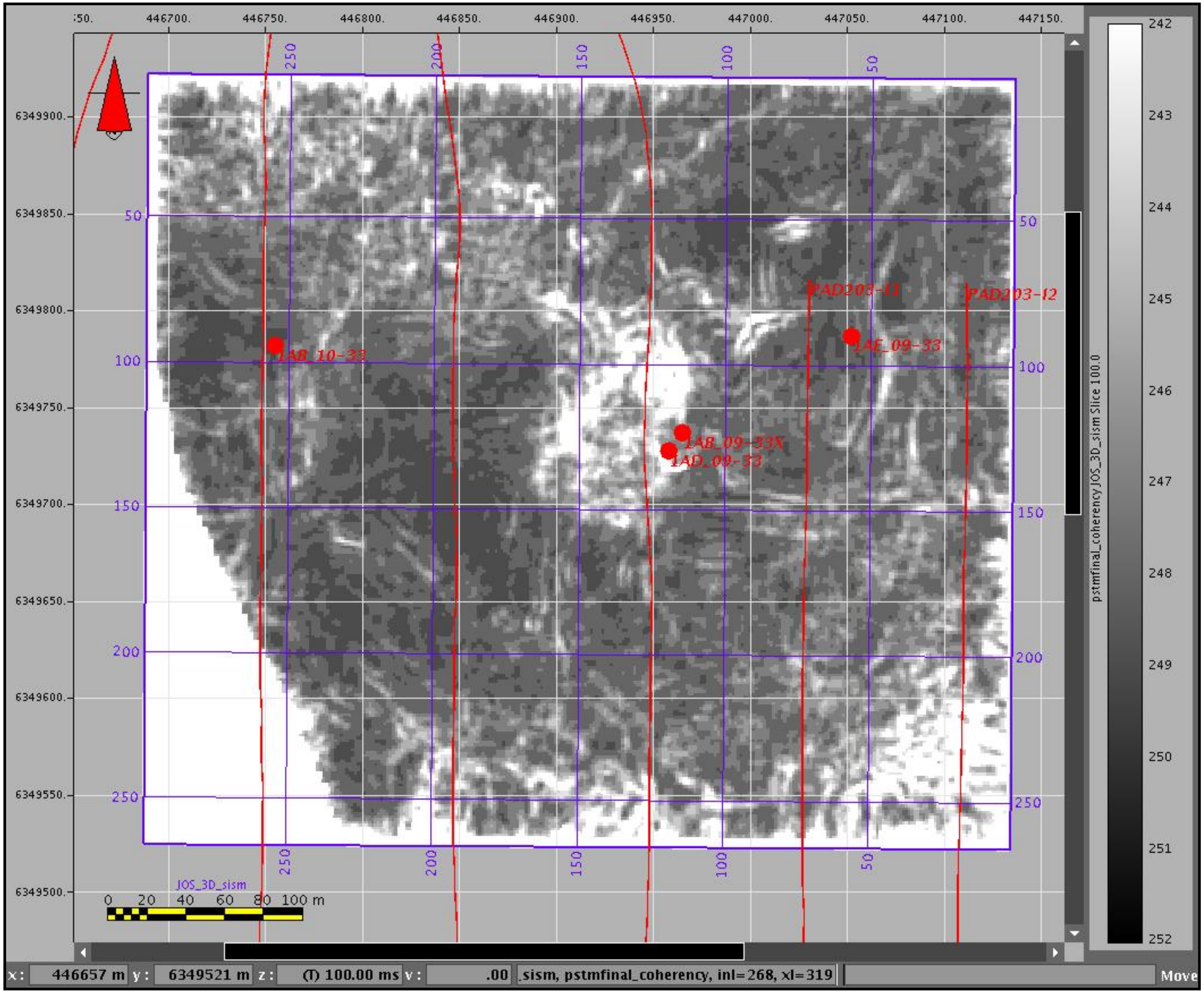
Dip Map_McMurray 4

Mapped horizon

- Topography
- Clearwater
- Wabiskaw
- Top McMurray
- McMurray1
- McMurray2
- McMurray3
- **McMurray4**
- McMurray5
- McMurray6
- Top Devonian

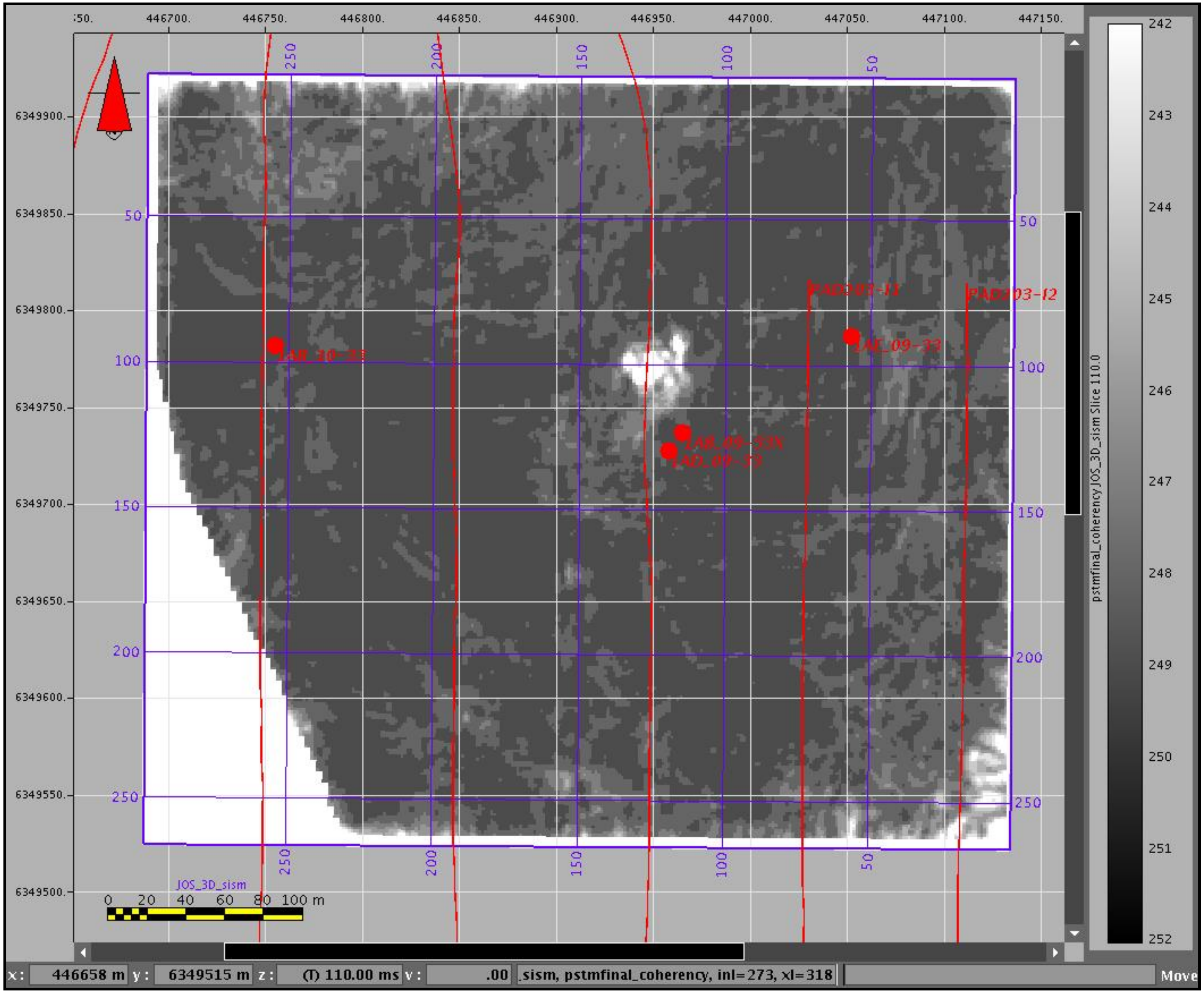


Joslyn 3D – Coherency Volume – Constant Time : 100 ms (~35 m)



x: 446657 m y: 6349521 m z: (T) 100.00 ms v: .00 sism, pstmfinal_coherency, inl=268, xl=319

Joslyn 3D – Coherency Volume – Constant Time : 110 ms (~45 m)

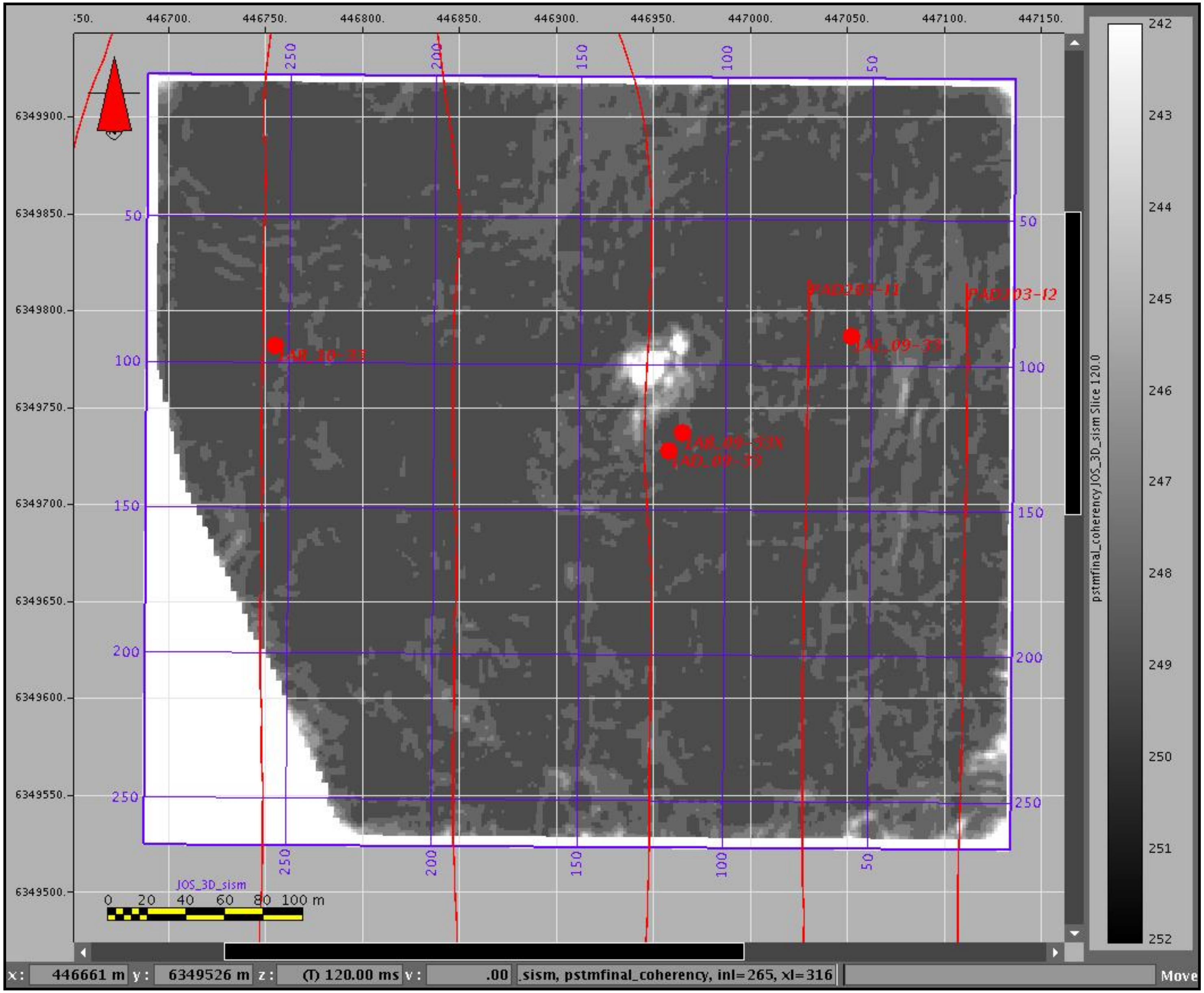


x: 446658 m y: 6349515 m z: (T) 110.00 ms v: .00 sism, pstmfinal_coherency, inl=273, xl=318

DGEP/TDO/TEC/GEO

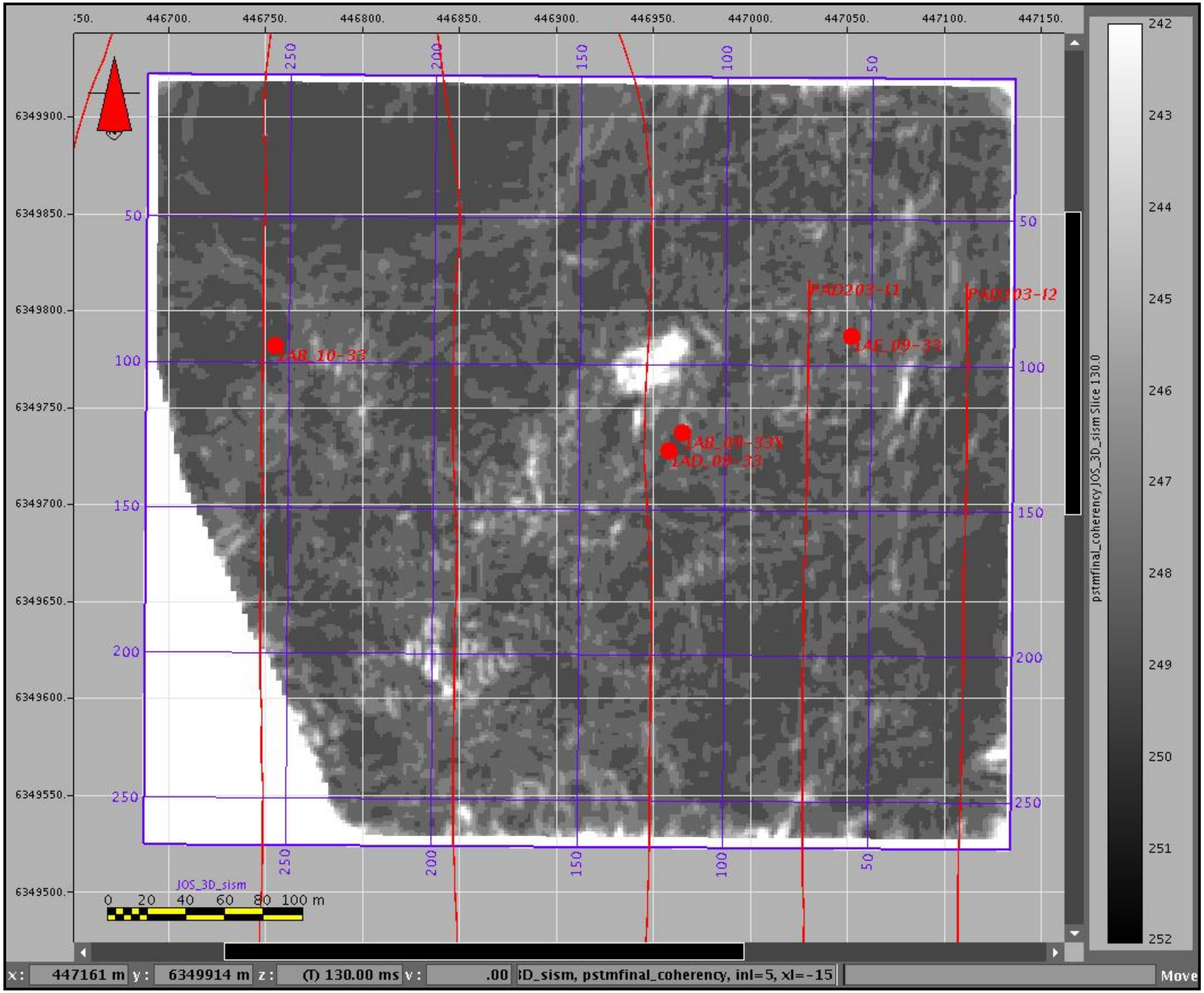
TOTAL

Joslyn 3D – Coherency Volume – Constant Time : 120 ms (~55 m)



x: 446661 m y: 6349526 m z: (T) 120.00 ms v: .00 .sism, pstmfinal_coherency, inl=265, xl=316 Move

Joslyn 3D – Coherency Volume – Constant Time : 130 ms (~65 m)



x: 447161 m y: 6349914 m z: (T) 130.00 ms v: .00 3D_sism, pstmfinal_coherency, inl=5, xl=-15 Move

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

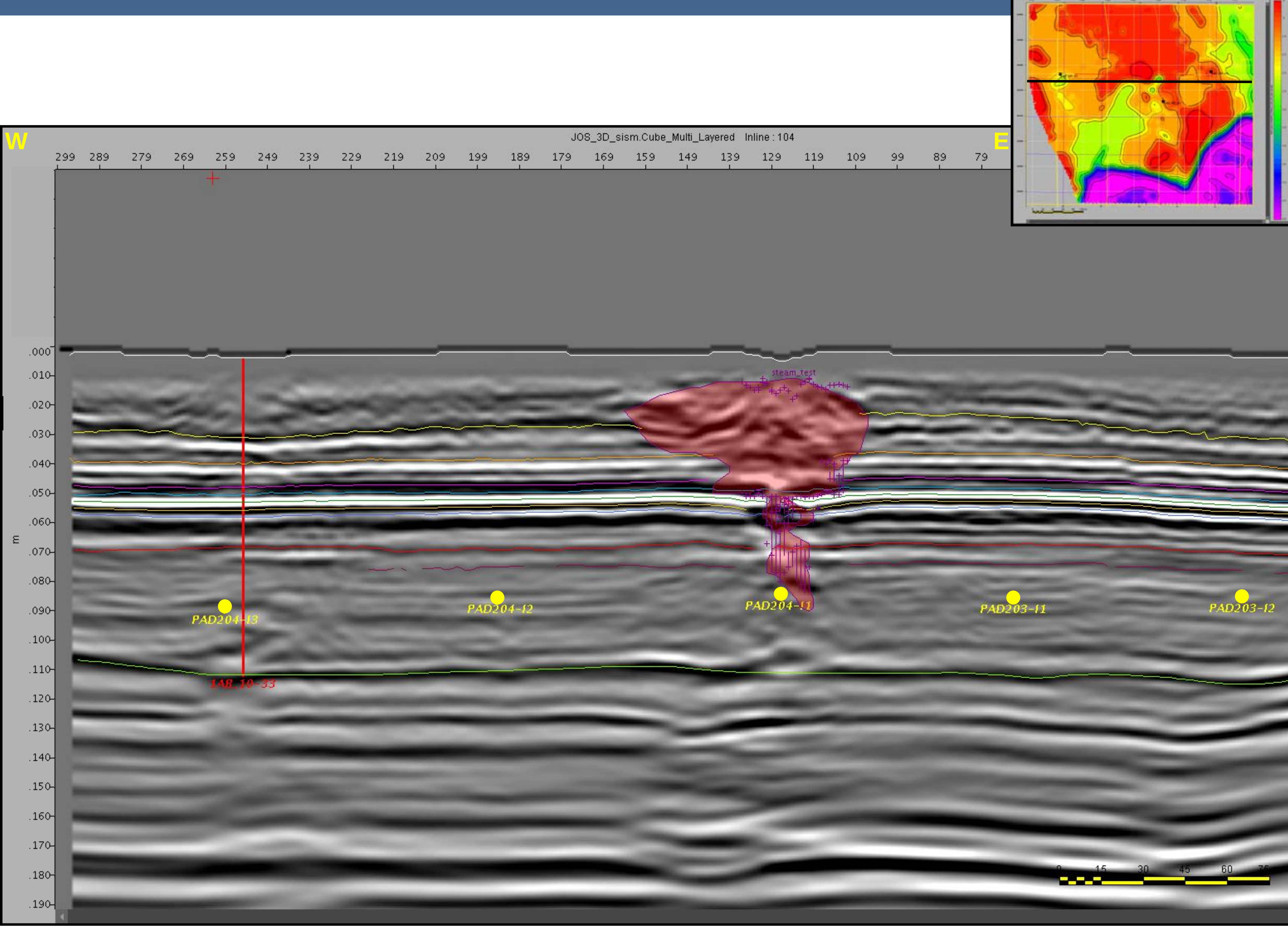
McMurray3

McMurray4

McMurray5

McMurray6

Top Devonian



Datum: 337m above sea level

Topography

Clearwater

Wabiskaw

Top McMurray

McMurray1

McMurray2

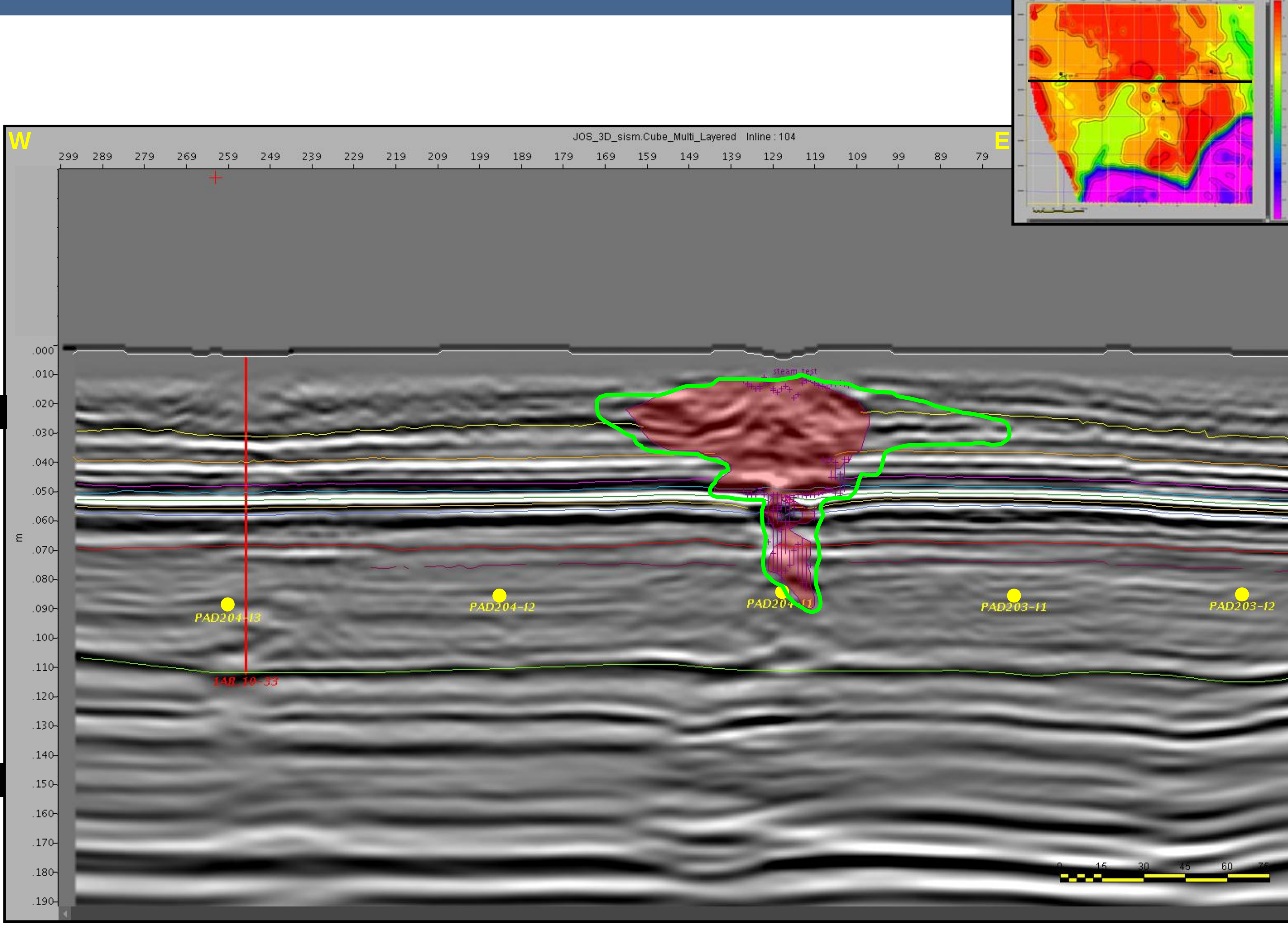
McMurray3

McMurray4

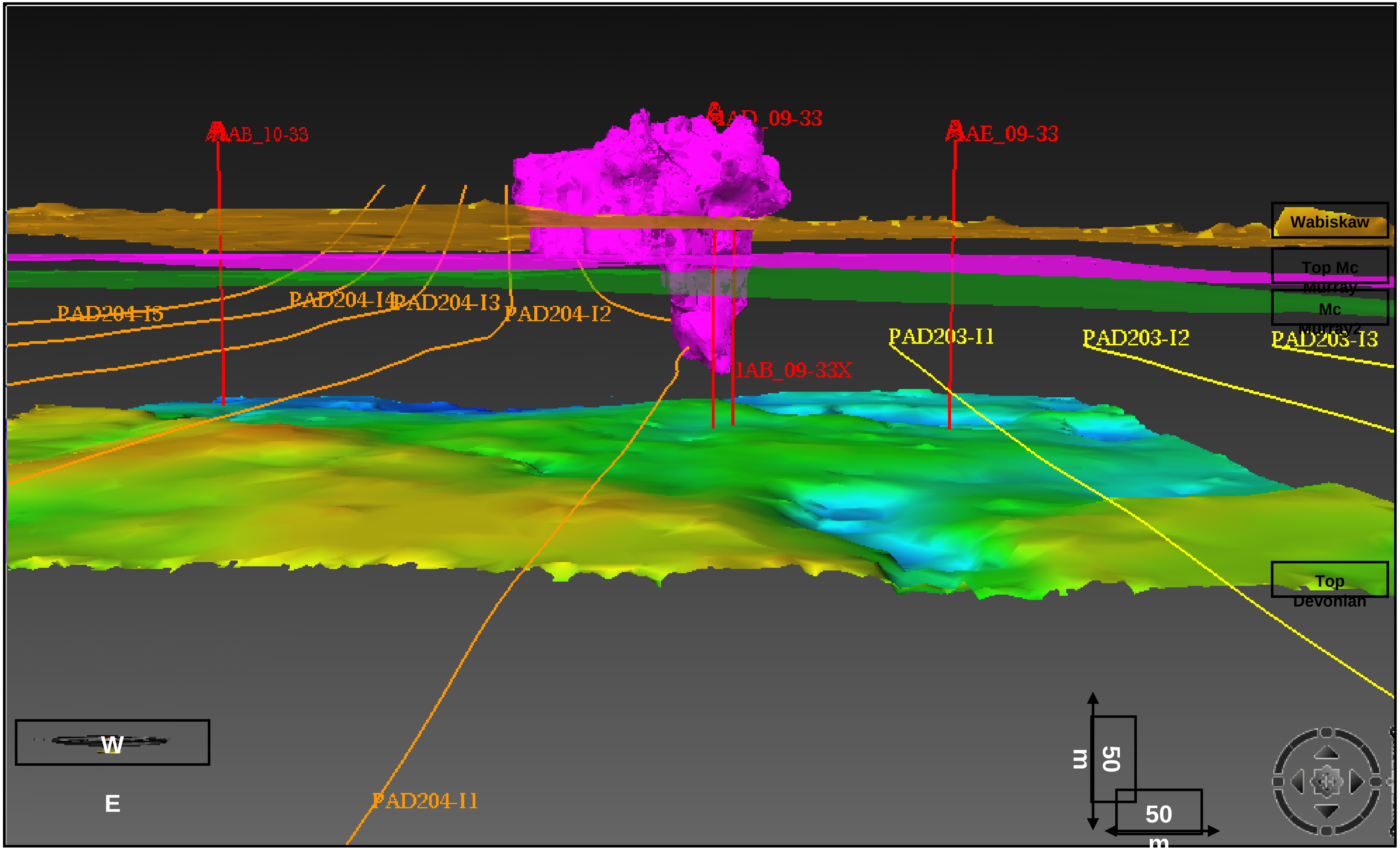
McMurray5

McMurray6

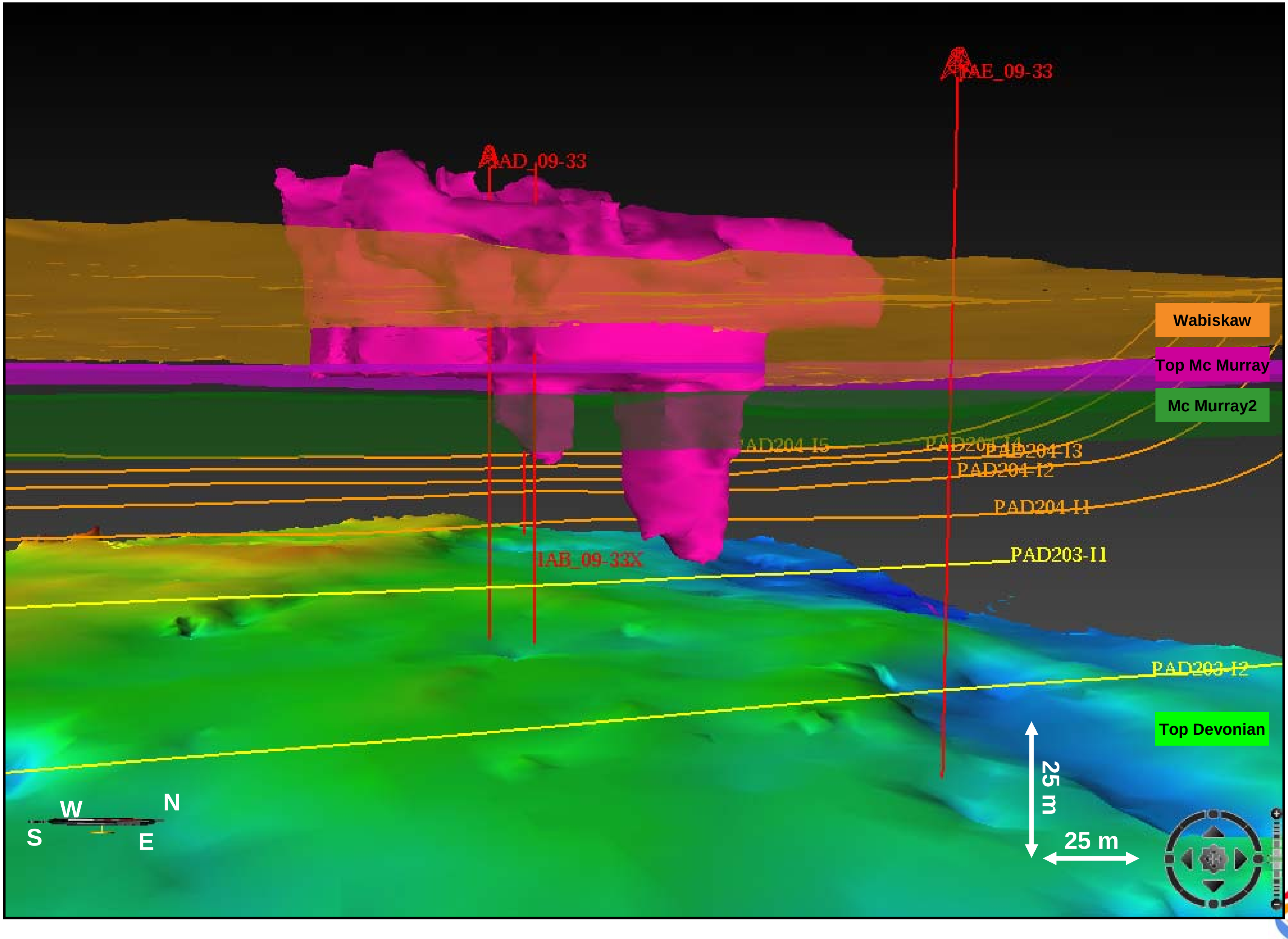
Top Devonian



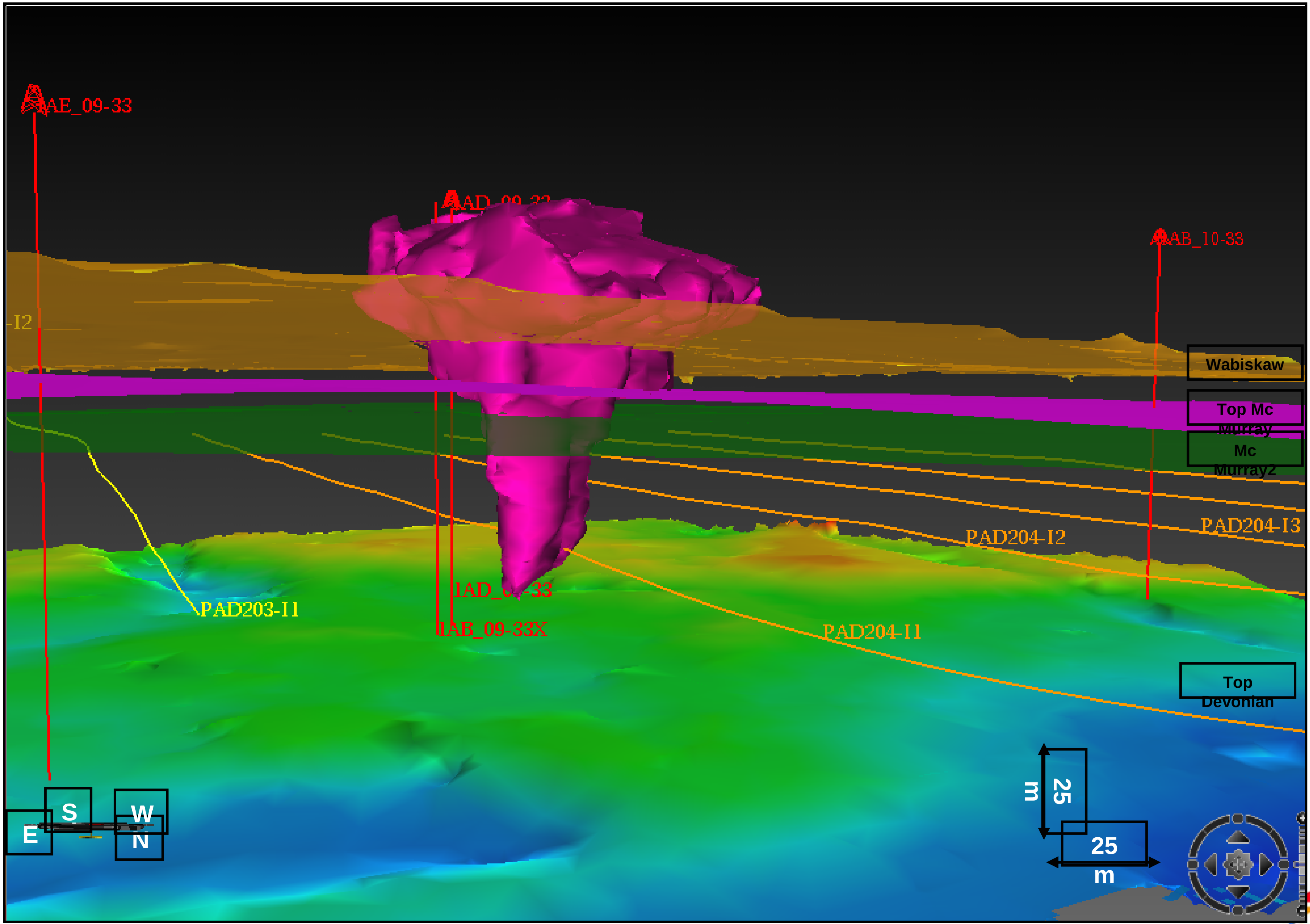
Joslyn 3D – 3D views – Plate 60



Joslyn 3D – 3D views – Plate 61

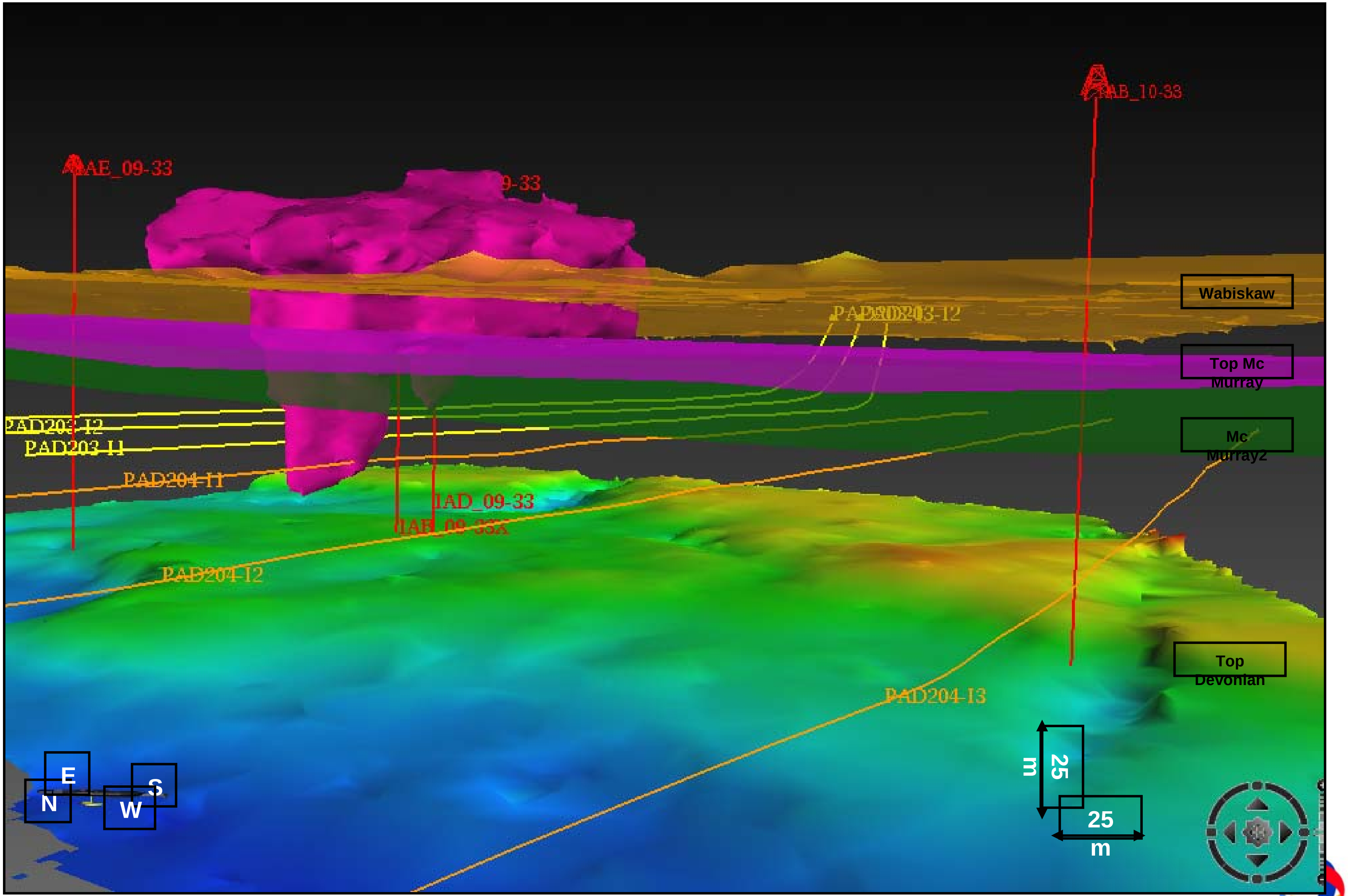


Joslyn 3D – 3D views – Plate 62

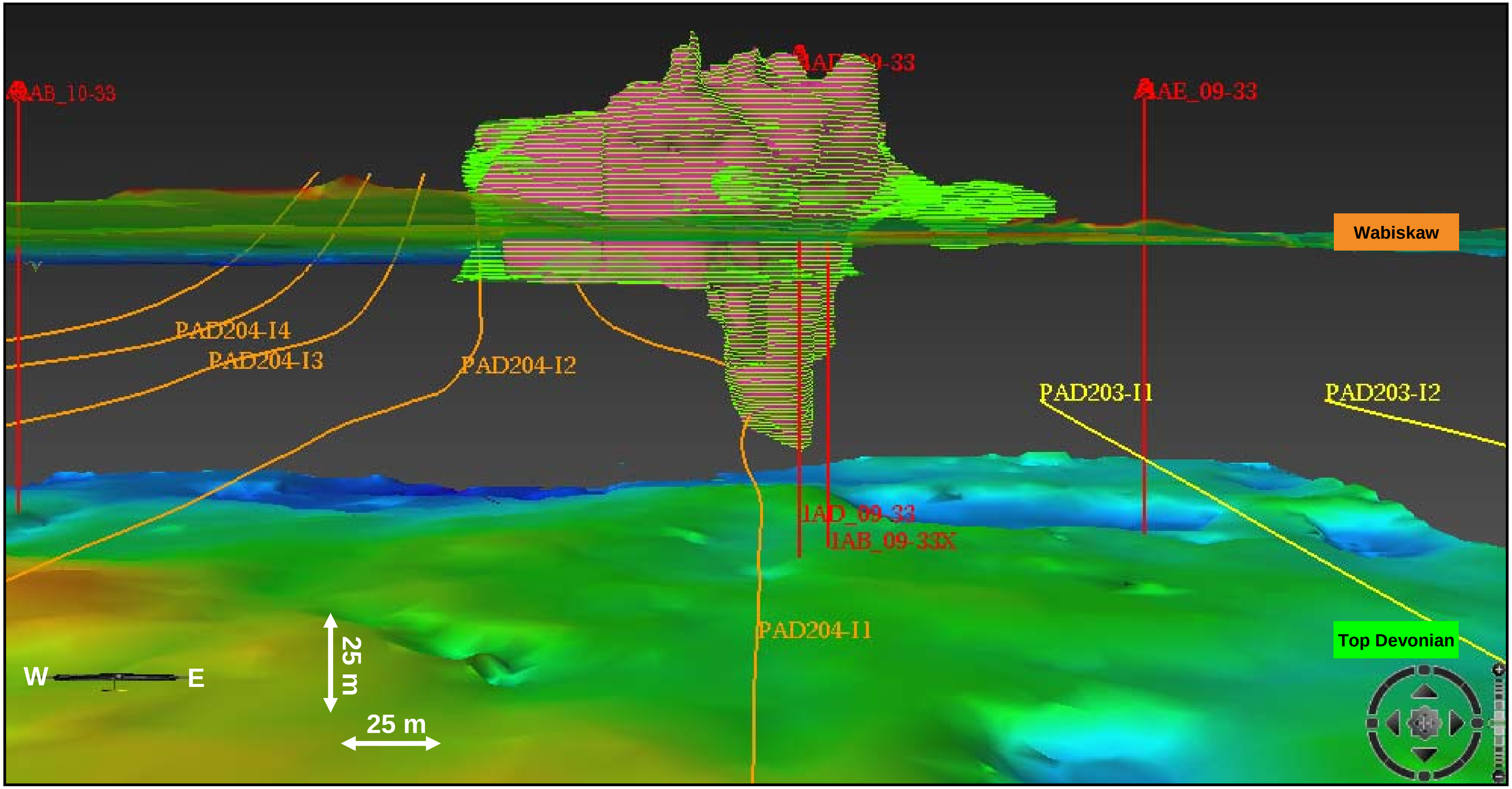


TOTAL

Joslyn 3D – 3D views – Plate 63



Joslyn 3D – 3D views – Plate 64



Joslyn 3D – 3D views – Plate 65

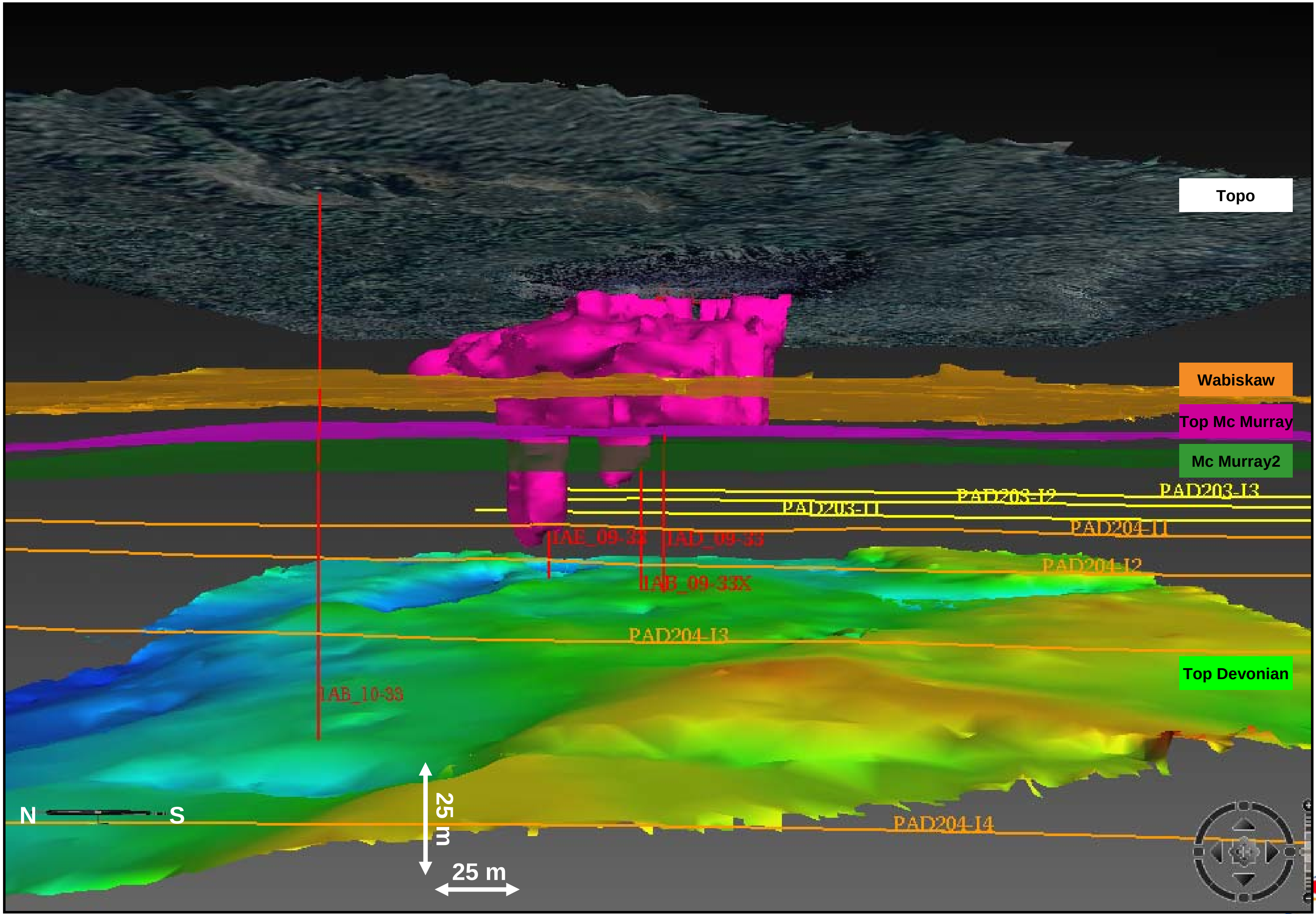
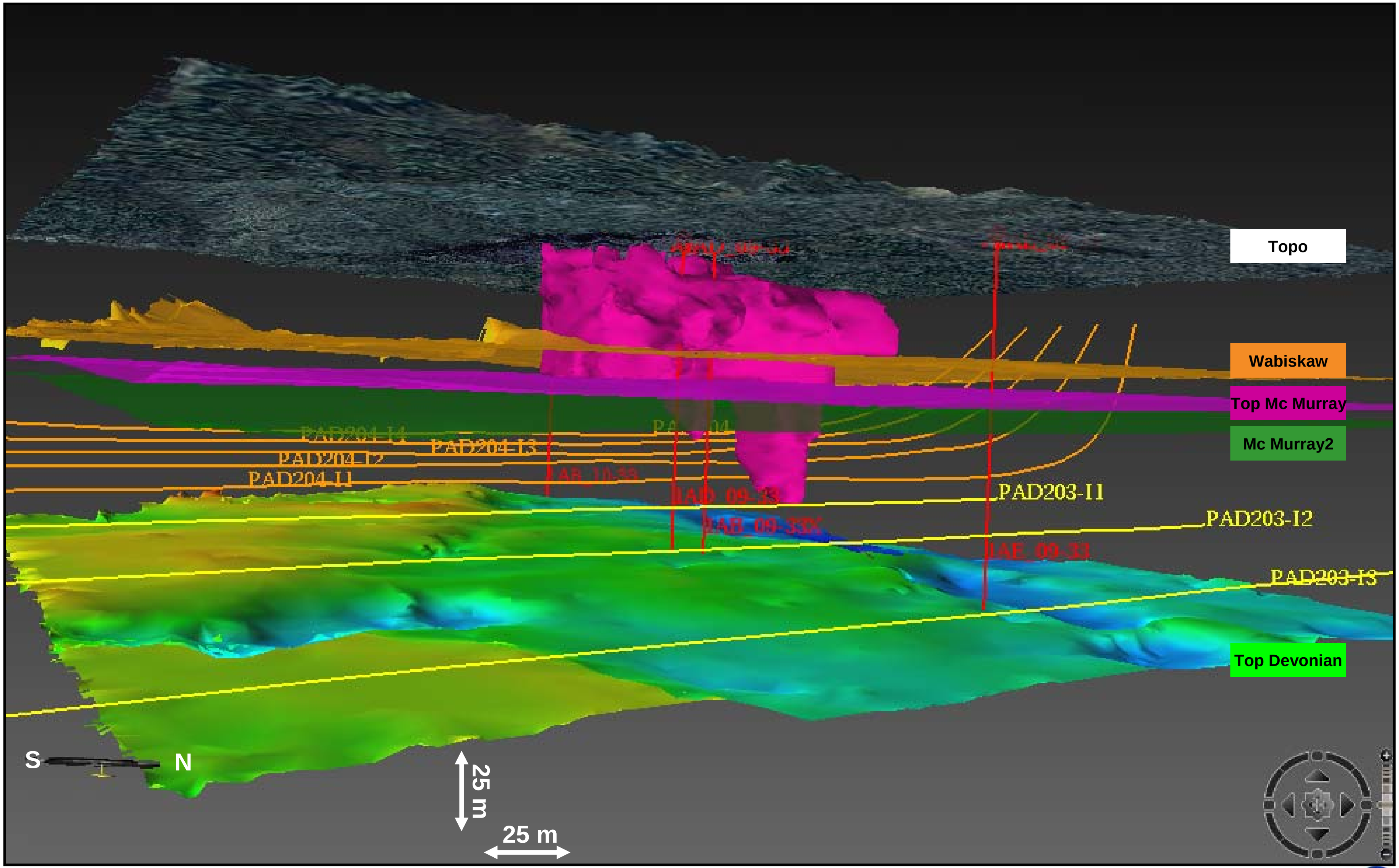
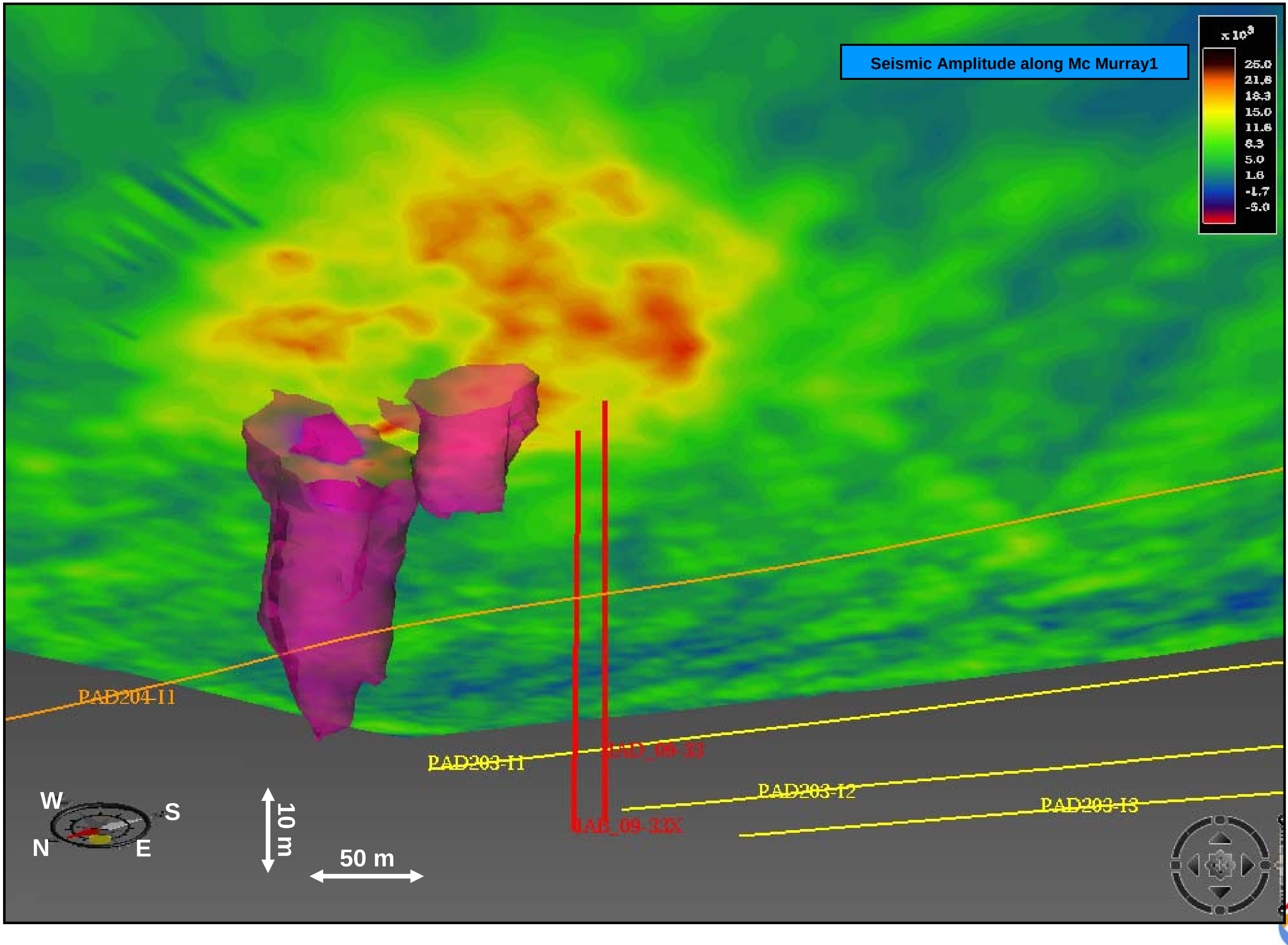


PLATE # 65

Joslyn 3D – 3D views – Plate 66

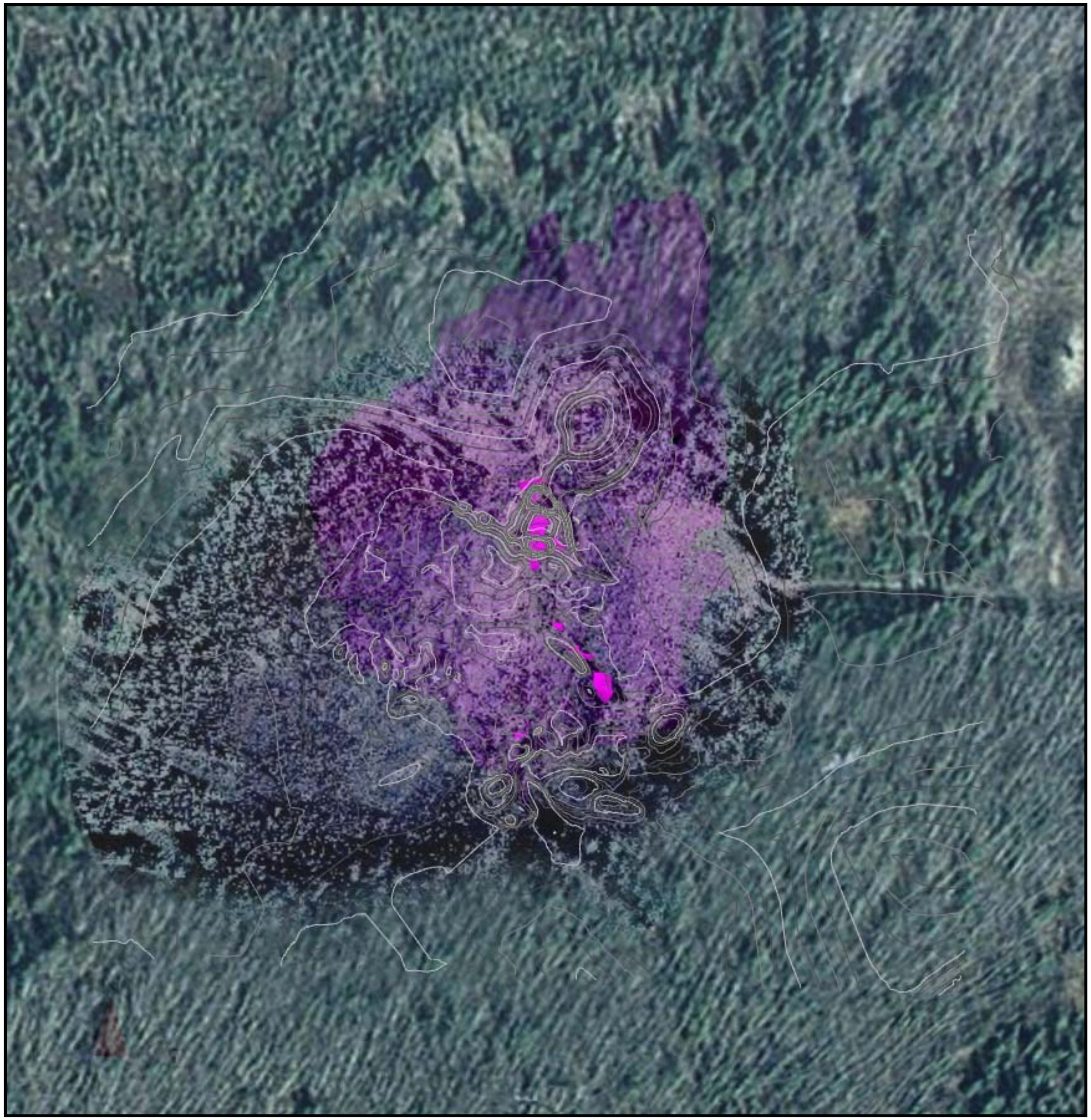


Joslyn 3D – 3D views – Plate 67

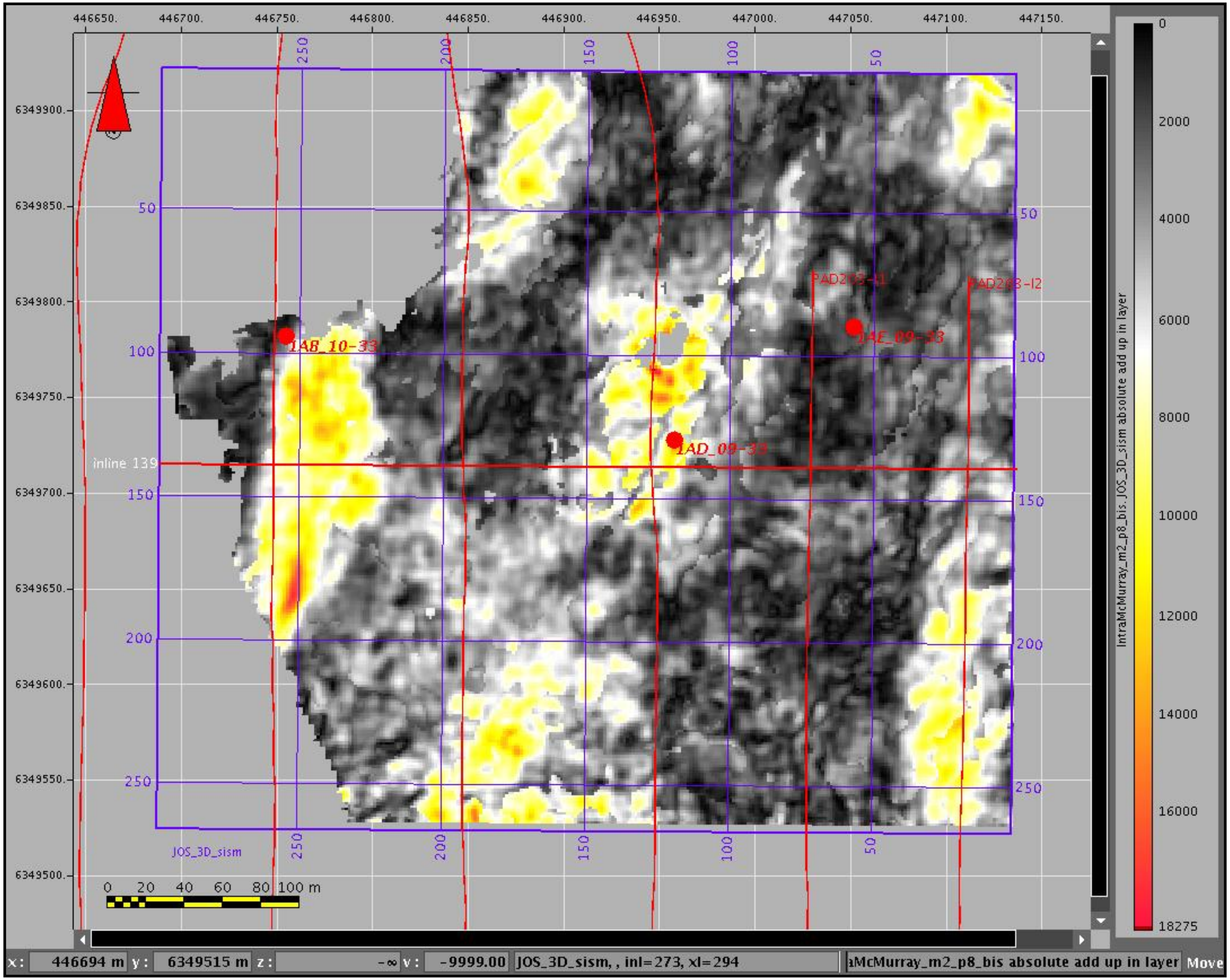


TOTAL

Joslyn 3D – 3D view – Surfaces cracks + “outcropping” steam

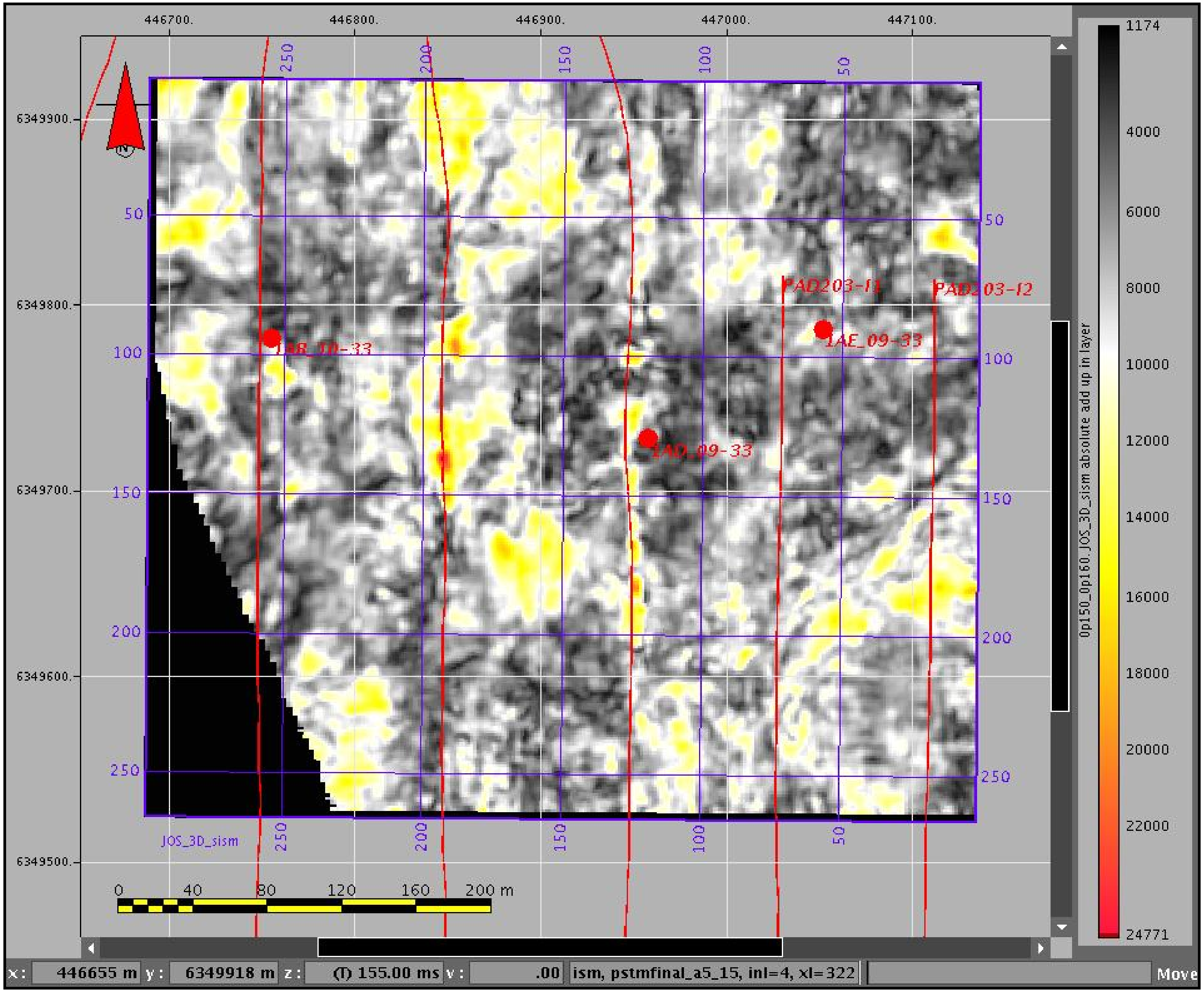


Integrated Seismic Amplitude - Interval : Mc Murray5 +2m – Mc Murray5 + 4m



x: 446694 m y: 6349515 m z: -∞ v: -9999.00 JOS_3D_sism, , inl=273, xl=294 aMcMurray_m2_p8_bis absolute add up in layer

Integrated Seismic Amplitude Interval : 87m- 97 m



x: 446655 m y: 6349918 m z: (T) 155.00 ms v: .00 ism, pstmfinal_a5_15, inl=4, xl=322

DCEL
Steam Release Incident
LSD 09-33-095-12-W4M
Volume I
Executive Summary

Prepared for:
Deer Creek Energy

DRAFT

Prepared by:
Millennium EMS Solutions Ltd.
#208, 4207 – 98 St
Edmonton, Alberta
T6E 5R7

September, 2007
File #04-101

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1.0 INTRODUCTION

1.1 Overview of Steam Release Incident

The Deer Creek Energy Limited (DCEL) Joslyn Project is located approximately 60 km North of Fort McMurray, west of the Athabasca River. This phase of the SAGD facility started injecting steam into the reservoir on April 15, 2006. The plant circulated steam for approximately one month and then started producing bitumen. Three days later, on May 18th, 2006 at 5:15am, a steam release was discovered over well pair 204-P1 (Figure 1). The Energy and Utilities Board (EUB) in Bonnyville and Alberta Environment were notified immediately after control of the release was obtained.

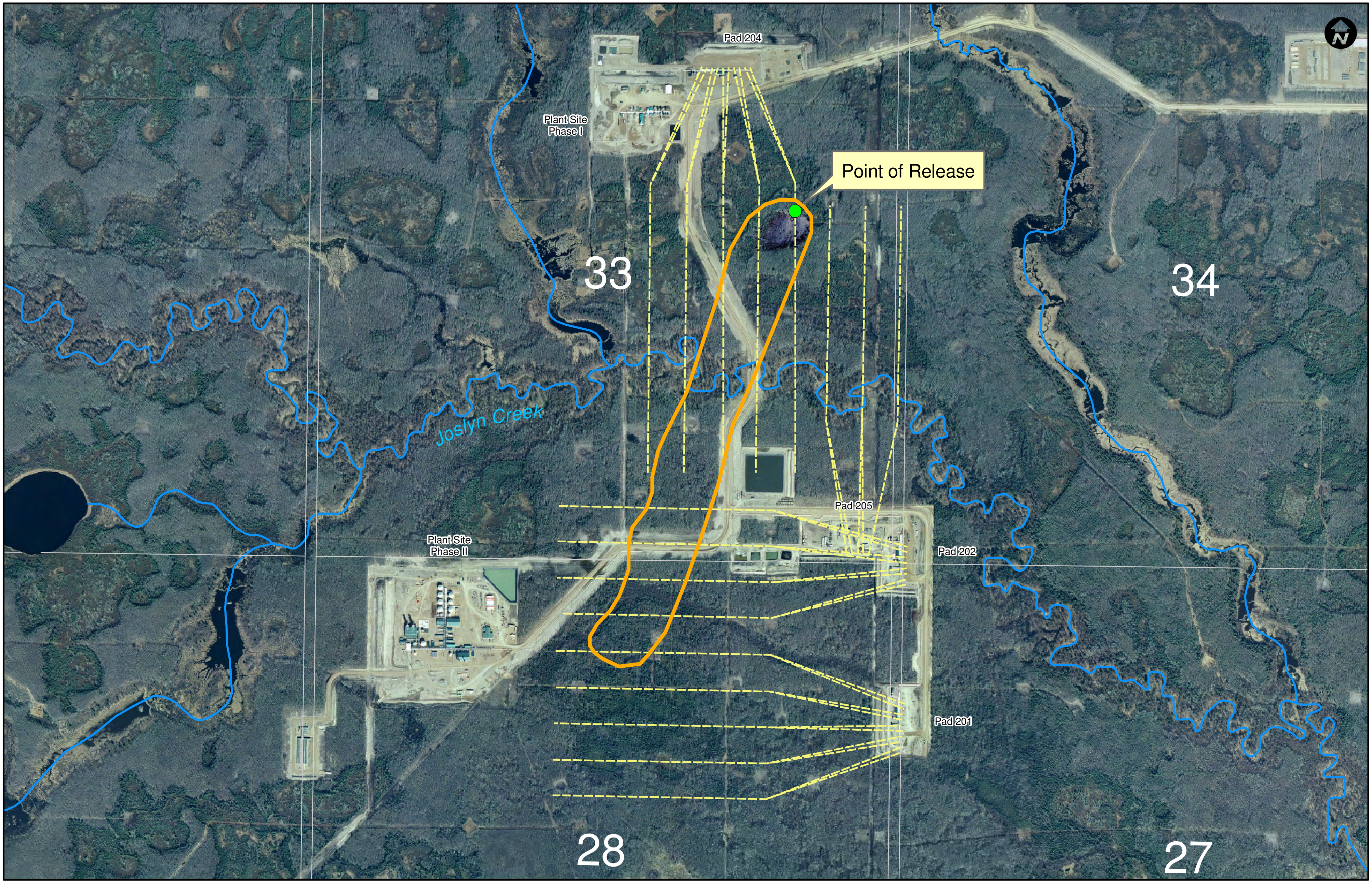
As pressure was released from the steam chamber, subsurface material including oil sands was released to the atmosphere. The majority of this displaced material was deposited to the immediate area but evidence of a fine dusting of material and rock was detected up to 1 km southwest of the release point (Figures 2a and 2b).

Sampling and analysis of the displaced material for an extensive list of parameters, as agreed by Alberta Environment (AENV), identified that the potential contaminants of concern associated with the displaced material were F2, F3, F4 hydrocarbons and sodium adsorption ratio.

DCEL retained Millennium EMS Solutions Ltd. and Axiom Environmental Inc. to

- assess the environmental impacts associated with the steam release incident;
- complete a human health and ecological risk assessment on the impacted area; and
- develop a remedial strategy for the impacted area based on the risk assessment findings.

Soil type and quality, surface water quality and groundwater quality investigations were conducted to complete the assessment of environmental impacts. The results of these studies were used to develop the problem formulation of the risk assessment for human and ecological receptors. Considerations of the physical setting and the risk assessment findings were incorporated into the remedial strategy for the area.



DEER CREEK
Energy Limited
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PROJECT

Deer Creek Energy Limited

TITLE

Steam Release Area

LEGEND

▭ Area of Deposition
- - - SAGD Well Pair

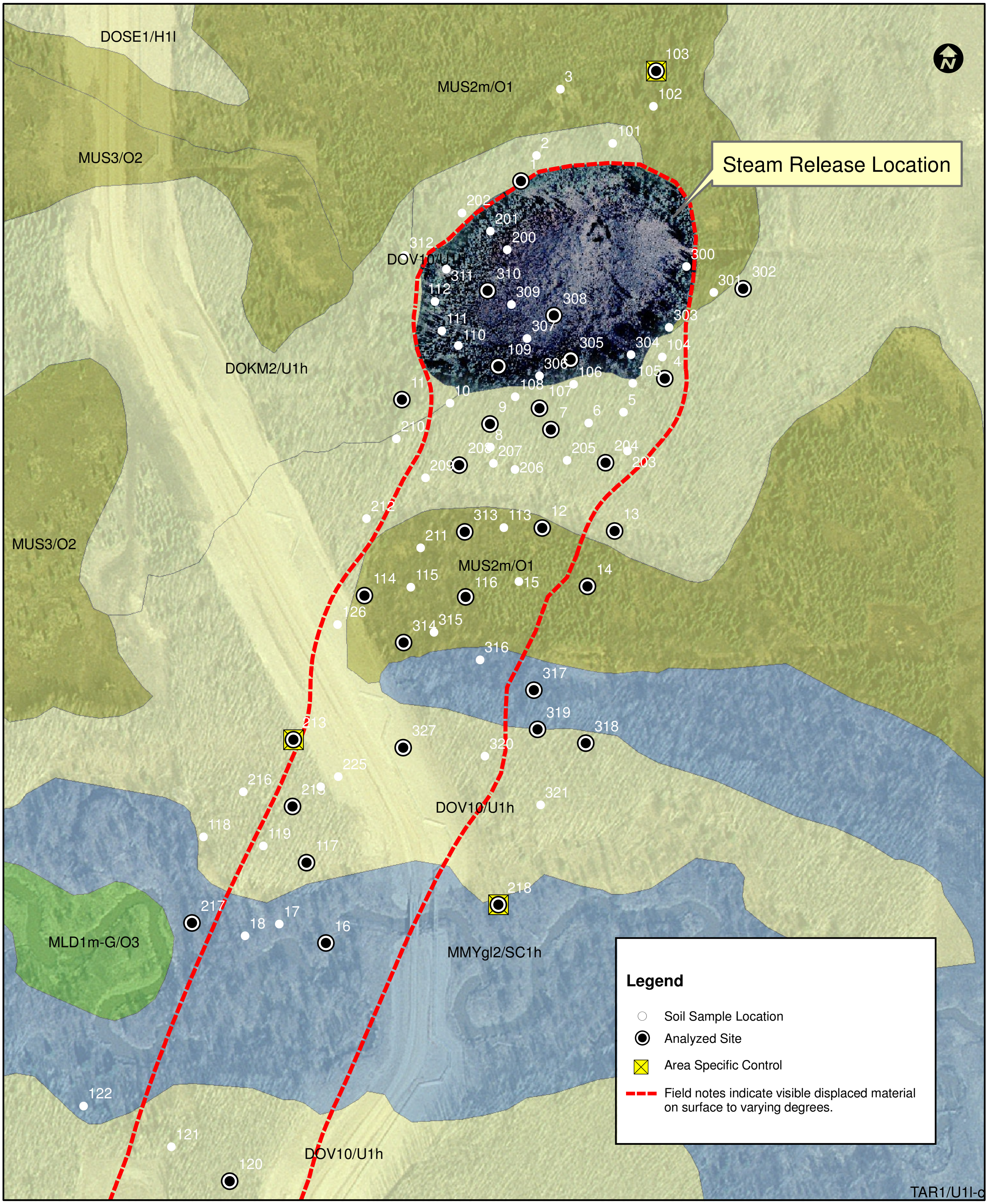
DRAWN	CHECKED	DATE
PS	KY	12Sep06

PROJECTION:
UTM12 NAD83

FILE No.
04-101

SCALE
0 100 200 400
Metres

FIGURE
1



Legend

○ Soil Sample Location

● Analyzed Site

☒ Area Specific Control

- - - Field notes indicate visible displaced material on surface to varying degrees.

Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

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Millennium EMS Solutions Ltd.

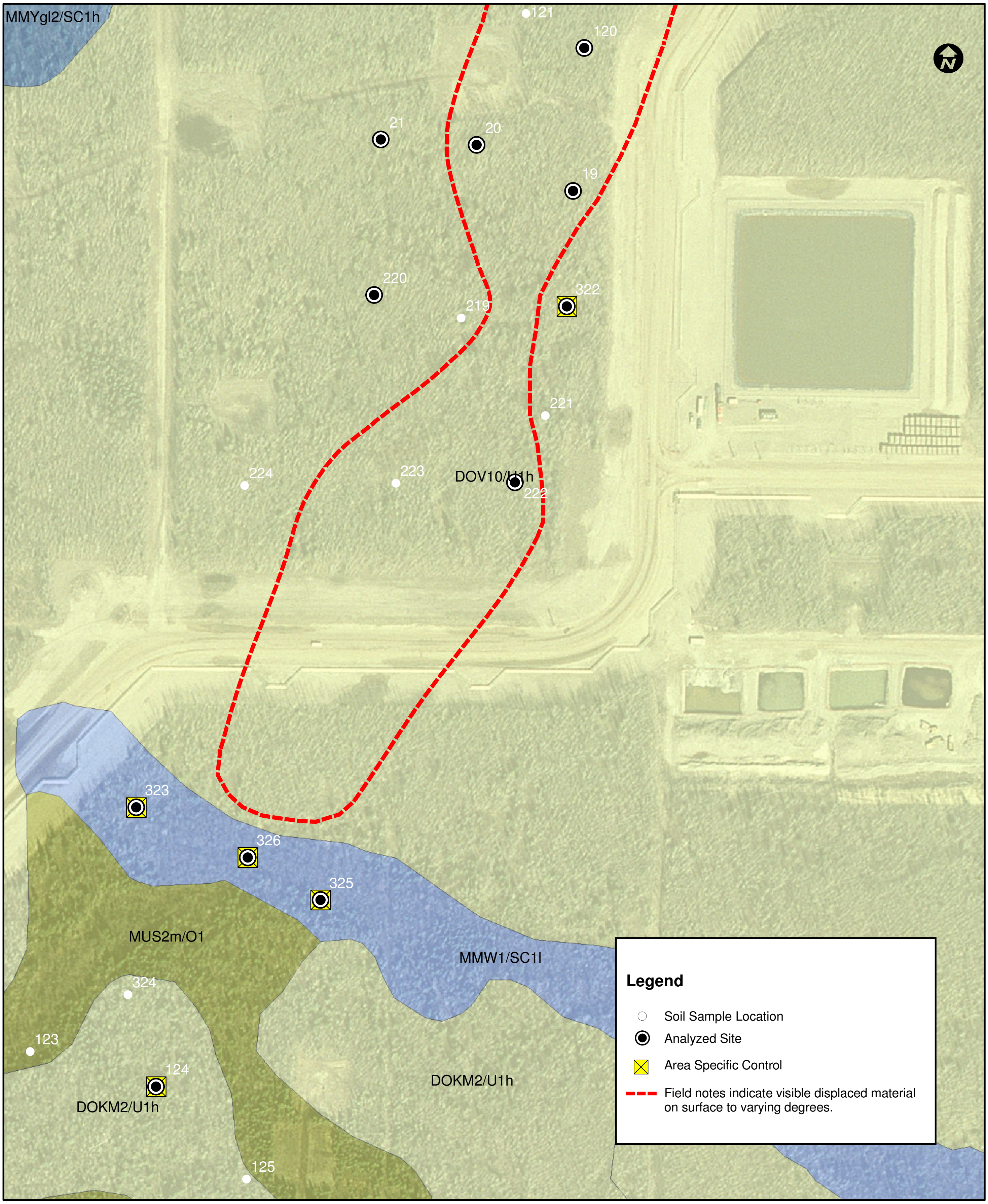
PROJECT
DCEL Steam Release Incident

TITLE
Soil Sampling Locations

DRAWN	CHECKED	DATE	PROJECTION: UTM12 NAD83
PS	RM	08Dec06	FILE No. 04-101

SCALE
0 20 40 80
Metres

FIGURE
2a



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

Deer Creek Energy Limited A wholly-owned subsidiary of TOTAL E&P CANADA LTD	PROJECT **DCEL Steam Release Incident**	DRAWN PS	CHECKED RM	DATE 08Dec06	PROJECTION: UTM12 NAD83 FILE No. 04-101
Millennium EMS Solutions Ltd.	TITLE **Soil Sampling Locations**	SCALE 0 20 40 80 Metres			FIGURE **2b**

2.0 PHYSIOGRAPHIC SETTING OF THE STEAM RELEASE SITE

2.1 Topography

The landscape within the Josyln Project SAGD area varies from flat to gently rolling, and much of it is of low relief. Greatest relief, usually in the order of three to five metres, is found along drainage courses and around small lakes.

At the steam release point and the area down-gradient of the steam release, the area is generally upland. The exceptions are small localized muskeg areas located immediately west of the release point. The relief from the steam release point to Joslyn Creek is approximately 3 – 5 m over a distance of ~ 350m.

2.2 Surface Water

The DCEL lease is transected by two major streams – the Ells River and Joslyn Creek, a major tributary of the Ells. The SAGD Phase II operations are entirely within the Joslyn Creek Watershed.

DCEL has conducted sampling of the Joslyn Creek during baseline data collection for a number of regulatory applications. Water in Joslyn Creek is slightly alkaline, with total alkalinity, conductivity, and concentrations of total dissolved solids generally highest in winter.

2.3 Geologic Setting

The total overburden thickness in the Steam Release area is approximately 35 - 40 m with 30 - 35 m being the shales of the Clearwater Formation while the remaining sediments are Pleistocene tills. The Clearwater Formation is fully marine in nature. It consists predominantly of marine shales which do not contain bitumen and are considered a barrier to fluid flow. The Wabiskaw Member of the Clearwater Formation directly overlies the McMurray formation and is comprised of shales, silts and very fine grained sands.

The McMurray Formation is present from approximately 40 to 60 m below ground level to 115 m depth. The McMurray Formation is comprised of stacked fluvial-estuarine sands and off channel silts and shales. The sands of the McMurray Formation are 90 to 95% quartz.

The underlying shales and limestones of the Waterways Formation do not contain bitumen and are a barrier to fluid flow.

3.0 SOILS ASSESSMENT REPORT (VOLUME II)

3.1 Soil Classification

The nature of the displaced material and method of dispersion resulted in the placement of a layer of displaced material immediately adjacent to the release point and a thin misting down gradient of the steam release location.

The composition of the surface litter layers and shallow surface soil horizons in the potentially impacted area was variable and typically high in organic matter. The soil orders, associated great groups, subgroups and related soil series found within the study area comprised:

1) Luvisols - An Orthic Gray Luvisol of the Dover (DOV) series is the predominant series found in the area. The DOV series is formed on calcareous moderately fine textured till or lacustro-till under forested conditions. The DOV series contains a relatively thick Ae horizon underlain by a transitional AB or BA horizon. Luvisols within the area studied typically contained a relatively thick litter layer underlain by an Ae horizon variable in thickness depending on slope position. A review of the soil physical and salinity results of the area specific controls of the litter/surface layer indicated the following:

    a) slightly acidic pH values in the litter and topsoil horizons (4.5 - 6.1), this pH range is typical of the DOV series (ASIC 2001);
    b) SAR values ranged from <0.1 - 0.2 in the litter horizon;
    c) EC values ranged from 0.12 - 1.28 dS/m in the litter horizon;;
    d) chloride values ranges from <20 - 60 mg/L;
    e) soils in the underlying A horizon were found to be fine grained; and
    f) the perimeter control contained similar soil salinity and textural characteristics as the area specific results.

2) Gleysols - Gleysolic soils are influenced by periodic or sustained saturation by water creating reducing conditions throughout the profile, including the surface horizon. Peaty Rego Gleysols and Peaty Orthic Gleysols were the predominant Gleysols found within the study area. These soils had a thick surface peat layer underlain by moderately fine textured gleyed B and C horizons. The groundwater table was usually within 1.0 m of the ground surface. A review of the soil physical and salinity results of the area specific controls of the litter/surface peat layer indicated the following:
    a) slightly acidic pH values in the litter and topsoil horizons (4.7 - 6.3);
    b) SAR values ranged from 0.4 - 0.8 in the surface peat;
    c) EC values ranged from 0.14 - 0.52 dS/m in the surface peat;
    d) chloride values ranges from <20 – 30 mg/L;

e) grain size analysis was not completed on organic textured materials, however, the underlying mineral material was predominantly fine grained (4 analyses); and

f) the perimeter control contained similar soil salinity and textural characteristics as the area specific results.

3) Regosols - Regosols are seen as juvenile soils that are usually imperfectly to rapidly drained and form in areas of recent deposition or areas of unstable slopes. Regosolic soils were found within the Joslyn confined floodplain. A review of the soil physical and salinity results of the area specific control and perimeter control of the litter/surface peat layer indicated the following:

   a) neutral pH values in the litter and topsoil horizons (6.1-6.7);
   b) SAR values were non-detect in the litter layer;;
   c) EC values ranged from 0.52 - 0.79 dS/m in the litter layer;;
   d) chloride 30 mg/L; and
   e) grain size analysis was not completed on organic textured materials, however, the underlying mineral material was fine grained.

4) Organics - Organic soils are usually saturated with water and occur in poorly drained depressional areas to level basins with raised edges. Organic soils were found in the depressional pockets in proximity to the release location and classed as bog peat Organics. A review of the soil physical and salinity results of the perimeter control of the surface peat layer indicated the following:

   a) slightly acid to acid pH values in the litter and topsoil horizons (3.6 – 5.1);
   b) SAR values were 0.2 in the litter layer;
   c) EC values ranged from 0.18 dS/m in the litter layer;
   d) chloride was 20 mg/L; and
   e) grain size analysis was not completed on organic textured materials.

5) Disturbed Lands - Disturbed lands included site infrastructure located down gradient of the release location. Disturbed lands were composed primarily of borrow material that consisted of clay material the entire depth of the profile investigated.

3.2 Displaced material Characterization

The Displaced material contains elevated concentrations of SAR, EC, and F2-F4 petroleum hydrocarbons that exceed Tier I guidelines. No exceedances of Tier I criteria were recorded for trace metals. Napthenic acid values were variable and within the range of background values. The average concentrations/values of the parameters of concern within the displaced material are:

F2 hydrocarbons	1,170 mg/kg
F3 hydrocarbons	15,880 mg/kg
F4 hydrocarbons	7,900 mg/kg
SAR	26
Electrical conductivity	1.72 dS/m

An estimated 1.9 ha of area in close proximity to the steam release location is covered by a consistent displaced material layer a minimum of 2 cm thick.

3.3 Soil and Surface Litter Quality

3.3.1 Mineral Soils

No exceedances of Tier I criteria were identified in the mineral soil profiles for any of the salinity, petroleum hydrocarbon, trace metal, salinity , PAH or naphthenic acid parameters were recorded for any of the samples analyzed.

3.3.2 Surface Litter / Peat Layer

Four distinct soil series and variants were identified in the study area; all four soil types contained a discernable surface litter/peat layer. All surface litter/peat layers analyzed were compared to representative background results of a similar soil type as opposed to the Tier I criteria as soil criteria are not applicable to this medium.

A high percentage of surface material encountered throughout the investigation contained organic material (twigs, leaf litter, roots, decomposed litter and/or surface peat). In order to estimate natural versus petroleum hydrocarbon results in the surface layer a petroleum hydrocarbon correction factor (based on background analytical) was utilized for each soil type to adjust surface sample results. All F2-F4 values were corrected and evaluated to determine if hydrocarbon results were indicative of a potential impact resulting from the steam release.

Sample locations down gradient of the release location contain elevated F2-F4 petroleum hydrocarbons after application of the appropriate correction factors. A majority of the elevated results are in the F3 fraction, occur immediately down gradient from the release, and are found in the surface litter layer overlying either organic or mineral soils.

Elevated SAR results were recorded in close proximity to the release location in surface profiles located under significant displaced material layers. SAR related issues are isolated to the release location (< 25 m from the perimeter of the release), remained near surface, typically contained elevated sodium and sulphates above typical background values and were located in sample sites with elevated petroleum hydrocarbon results.

PAH compounds, trace metals and napthenic acids were generally not parameters of concern in the surface litter / peat layer.

3.4 Extent of Impact

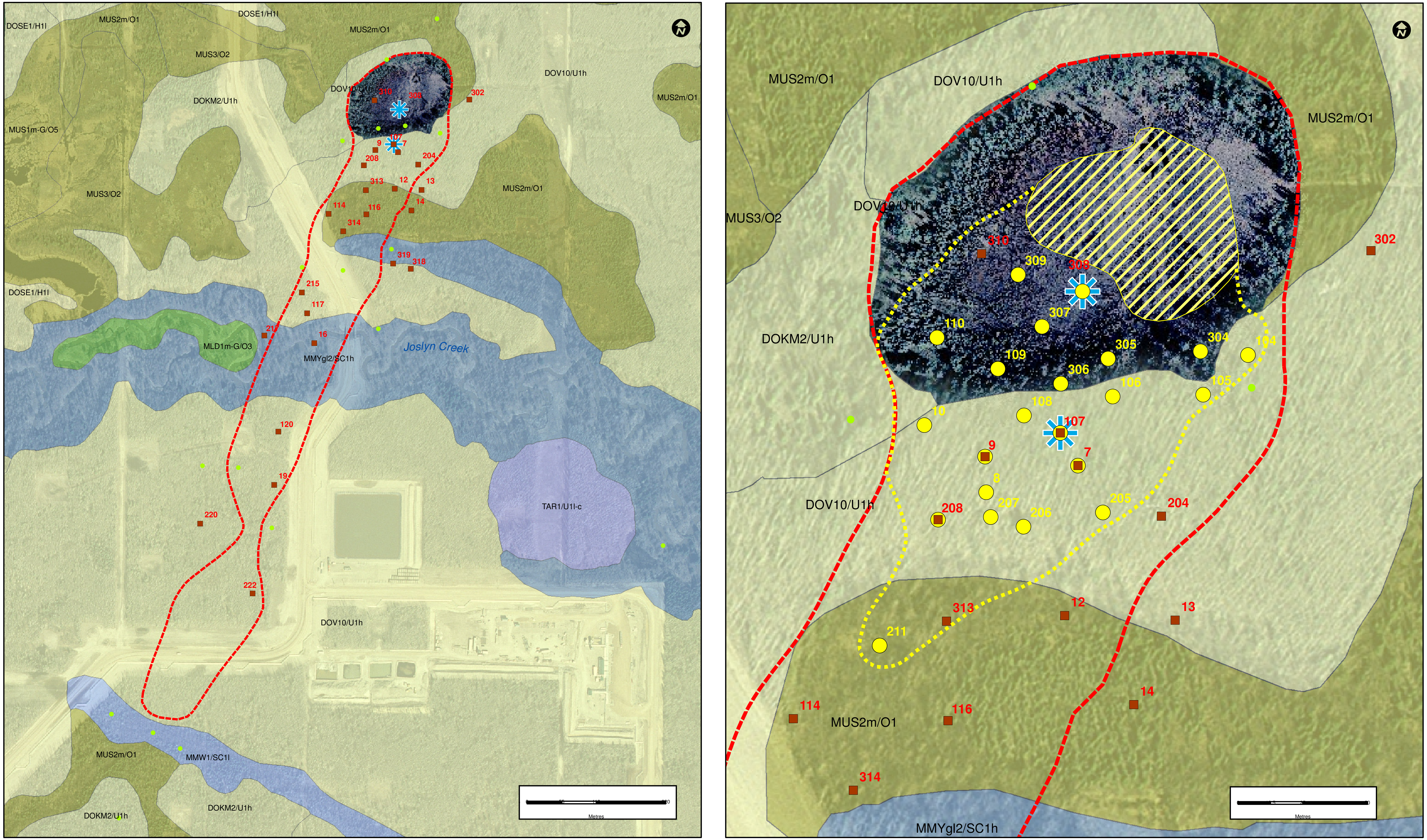
Impacts associated with the steam release have been identified within:

- the displaced material located within the Steam Release disturbance area;
- the displaced material located adjacent to the Steam Release disturbance area; and
- the surface litter / peat layer.

The Steam Release disturbance area may not have been geotechnically stable during the time of the completion of the site assessment and the collection of information from this area may have been an unmitigatable safety hazard to the field crews; therefore, soil sampling was not conducted in this area. Statements regarding the presence and quality of displaced material in this area are inferred from visual evidence obtained from adjacent to the disturbed area only.

The estimated extent of area covered by a consistent layer of displaced material (> 2cm) is outlined in Figure 3. Although the area of instability was not sampled it is included in the aerial extent based on visual indicators. A total area of 1.9 ha is estimated to contain a consistent displaced material layer varying in thickness, 0.41 ha of which is estimated to be in the potentially unstable steam release disturbance area.

Elevated concentrations of F2, F3 and F4 hydrocarbons are present in the surface litter / peat layer extending significantly down-gradient from the mapped distribution of displaced material. The sampling locations containing elevated concentrations of these parameters are shown on Figure 3; an area exceeding Tier I criteria is not shown for the surface litter / peat layer as the Tier I criteria are not applicable to this medium.



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

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Energy Limited
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Millennium
EMS Solutions Ltd.

PROJECT
DCEL Steam Release Incident

TITLE
Hydrocarbon and SAR Exceedances

LEGEND

■	Elevated Hydrocarbon values (F2-F4)
✳	Elevated SAR values
●	Sites Meet Criteria
- - -	Field notes indicate visible displaced material
▨	Area of Instability*
●	Displaced Material > 2cm
·····	Field notes indicate >2cm of displaced material at surface

* Area roped off, contains a visible layer of displaced material at surface

DRAWN	CHECKED	DATE	PROJECTION: UTM12 NAD83
PS	RM	08Dec06	FILE No. 04-101
SCALE			FIGURE 3

4.0 SURFACE WATER QUALITY (VOLUME III)

4.1 Background

The DCEL Joslyn lease is transected by two major streams – the Ells River and Joslyn Creek, a major tributary of the Ells. The SAGD Phase III operations are entirely within the Joslyn Creek Watershed.

DCEL has conducted sampling of the Joslyn Creek during baseline data collection for a number of regulatory applications. Water in Joslyn Creek is slightly alkaline, with total alkalinity, conductivity, and concentrations of total dissolved solids generally highest in winter. Organic parameters such as hydrocarbons, naphthenic acids, and phenols tend to be low in Joslyn Creek. Petroleum hydrocarbon concentrations have been below the detection limit during baseline sampling.

4.2 Surface Water Sampling Results

Surface water sampling was conducted at four locations, as follows:

- in the immediate area of the steam release, 25 m southwest of the well head located within the study area;
- within Joslyn Creek approximately 50 m upstream (west) of the estimated deposition zone, intended to provide comparable background water quality results;
- immediately downstream within Joslyn Creek, approximately 200 m east of the estimated deposition zone; and
- approximately 1.2 km down-stream (southeast) of the estimated deposition zone.

Surface water samples were collected at intervals the week following the steam release and six months later. All samples were analysed for BTEX, F1-F2 hydrocarbon fractions, routine water analysis and metals. The samples collected six months after the steam release event were also analysed for PAHs and naphthenic acids.

Analytical results of the surface water samples collected for this assessment were compared to the current provincial and federal guidelines and background data collected for the Joslyn North Mine Project. All parameters were at, below or within the acceptable ranges of the applicable guidelines or were within the ranges of baseline concentrations measured. No water quality impacts to Joslyn Creek from the steam release event were identified in the week following the event or six months thereafter.

5.0 GROUNDWATER QUALITY (VOLUME IV)

A series of seven groundwater monitor wells were installed along a transect between the steam release point and Joslyn Creek within the deposition zone of the displaced material. The groundwater monitor wells were installed in the clay soils overlying bedrock (sandstone / shale) in the study area. Coarse grained soils representing a potential aquifer were not encountered during the investigations completed.

One monitor well is situated just upstream of the point of release. Three monitor wells are located just around the perimeter of the release area, and three monitor wells are located along the depositional path downstream of the release approaching Joslyn Creek in approximate 100 m intervals. The groundwater monitor wells were developed, sampled and analyzed for BTEX, F1-F2 hydrocarbons, routine (salinity) parameters, PAHs, and naphthenic acids.

The groundwater monitoring program identified:

- BTEX and F1 – F2 concentrations were all below applicable guidelines;
- routine parameters were all at concentrations within the background levels and accepted action limits observed at the Phase I plant site;
- PAH concentrations were all below the applicable guidelines; and,
- naphthenic acids were present at concentrations within background levels and accepted action limits observed at the Phase I plant site.

6.0 HUMAN HEALTH AND ECOLOGICAL (VOLUME V)

6.1 Introduction

A steam release at the DCEL Joslyn Phase II SAGD facility resulted in the deposition of displaced oil sand material from the McMurray formation. Three distinct zones of oil sand deposition on the surface were identified, these being:

- the “Unstable Area” is defined as the steam release disturbance area closest to the release location that could not be entered due to geotechnical instability / personnel safety considerations;
- the “Near Deposit” included that part of the deposit with a thickness of displaced material greater than 2 cm, and is mostly located within 200 m south southwest of the steam release point; and
- the “Trace Deposit” extends out to approximately 1 km from the steam release point, and comprises that part of the deposit with less than 2 cm of displaced material contained within surface litter or peat layers at surface.

A risk assessment was conducted to determine the human and ecological health risks associated with each of these three areas, and to develop risk management recommendations for each area.

6.2 Chemicals of Potential Concern

Displaced material in all three areas is characterized by higher levels of petroleum hydrocarbon fractions F2, F3, and F4, and by an elevated sodium adsorption ratio (SAR). Levels of salinity and trace metals were moderate. Chemicals of potential concern for displaced material in the Unstable Area, the Near Deposit, and the LFH layer in the Trace Deposit are F2, F3, F4, and SAR.

6.3 Exposure Pathways

The risk assessment was primarily based on current Alberta Environment protocols, but drew on other regulatory sources where appropriate. Three complete exposure pathways were identified for hydrocarbon contaminants at the Site:

- contact with plants and soil invertebrates;
- wildlife ingesting soil and food; and
- groundwater transport to receptors in Joslyn Creek.

All three of these pathways were applicable to the Near Deposit and the Trace Deposit, but only the third was complete for the Unstable Area if a soil cap of at least 3 m is placed on this area.

6.4 Risk Management Recommendations

Risk management recommendations based on the conclusions of the risk assessment are provided for each area below.

6.4.1 Unstable Area

The exact limits of the Unstable Area are not currently defined. It is understood that DCEL’s preferred remediation strategy for the Unstable Area is to manage the potential worker and public safety issues in this area by adding a cap of at least 3 m of soil to the Unstable Area, and allow the weight of the cap to help compact the geotechnically Unstable Area. This strategy would fall under the “Exposure Control” option in AENV (2007a, b). The following risk management recommendations are made for the Unstable Area:

1. The Unstable Area should be inspected by an appropriately qualified safety professional to determine the limits of the Unstable Area and the restrictions necessary to ensure worker and public safety.

2. If a cap of 3 or more metres of soil is placed on the Unstable Area, then based on the analysis in this risk assessment, no on-site or off-site risk is anticipated for the Unstable Area under this Exposure Control scenario, and no further action is required in this area. Note, however, that no form of regulatory closure is available under the Exposure Control option.
3. The placed cap would require revegetation; either natural vegetation or through planned reclamation.

6.4.2 Near Deposit

The Near Deposit has similar properties to a mineral soil and contains concentrations parameters of concern that exceed applicable guidelines by an order of magnitude for some parameters. Based on the analysis in this risk assessment, the following risk management recommendation is made for the Near Deposit:

1. The displaced material in the Near Deposit will require removal, remediation or other management.

6.4.3 Trace Deposit

The Trace Deposit is a somewhat unusual contaminant situation, in the following respects:

- the contaminant is only present in the surficial organic LFH layer;
- generic soil quality guidelines for petroleum hydrocarbons were developed using mineral soils, and have little relevance to organic layers; and,
- removing the contaminant from the Trace Deposit would involve removing the entire LFH layer, and likely also the understory vegetation and trees over the extent of the Trace Deposit; which would effectively remove the entire ecosystem in this area.

Considering the relative ecosystem damage likely to be caused by leaving the Trace Deposit in place or removing it, the following risk management recommendations are made for the Trace Deposit:

1. Due to the significant ecosystem damage involved in remediating hydrocarbons in the Trace Deposit, and significant uncertainty concerning the relevance of the Alberta Tier 1 Eco-Contact guidelines to LFH soils at this Site, it is strongly recommended that no attempt at remediation be made for hydrocarbons in the Trace Deposit.
2. However, it is recommended that a qualified field biologist assess the vegetation in the Trace Deposit during the growing season in 2008 and 2010 to assess any impact on the vegetation in that area and confirm that leaving the Trace Deposit in

place is causing less damage to the ecosystem than removing the entire LFH layer and much of the understory vegetation and trees in the area of the Trace Deposit.

7.0 REMEDIAL STRATEGY

In accordance with the Human Health and Ecological Risk Assessment, remedial strategies are presented for the near deposit displaced material and the trace deposit contained in the surface litter / peat. A remedial plan is required for the “near deposit displaced material”. The extent of near deposit displaced material has previously been presented on Figure 3. The displaced material has been characterized as containing elevated petroleum hydrocarbons and SAR with average concentrations/values, as follows:

F2 hydrocarbons	1,170 mg/kg
F3 hydrocarbons	15,880 mg/kg
F4 hydrocarbons	7,900 mg/kg
SAR	26

Remedial options for materials with these characteristics include:

- bioremediation & calcium addition;
- excavation and on-site treatment; or
- excavation and off-site disposal.

The above options are discussed briefly below.

Bioremediation and calcium addition

This process requires two treatment steps, bioremediation of the petroleum hydrocarbons and calcium addition to reduce the SAR value. Given the initial concentrations of recalcitrant F3 and F4 hydrocarbons, it is not expected that these soils will be treatable to meet Tier I criteria; therefore, post treatment eco-toxicity testing and further site specific ecological risk assessments would be required. Again, based on the initial concentrations, there would be a significant probability that the eventual outcome of the eco-toxicity testing and site specific risk assessment would be that the near deposit displaced material would continue to exceed regulatory end-points. Therefore, this approach is not recommended.

Excavation and on-site treatment

Millennium understands that DCEL is proposing to construct an oil sands mine and processing facility at the Joslyn site. The most feasible on-site treatment technology for this material would be to process within the future oil sands processing facility. The recommended approach associated with this option would be to construct a waste storage facility in accordance with Alberta Environment requirements, excavate the near deposit displaced material, place the displaced material into the storage facility and process it when the mine is approved and operational.

Excavation and off-site disposal

Excavation and off-site disposal would involve the excavation and transport to the nearest third party landfill. The disadvantage of this approach is that the nearest third party landfill is a considerable distance from the Joslyn site. Millennium understands that the feasibility of permitting a third party landfill near the Joslyn site is being investigated by a third party company; this facility, if permitted would significantly reduce costs associated with this option.

7.1 Recommended Remedial Action Plan – Near Deposit Displaced Material

The two most feasible remedial options for this site are excavation and future on-site processing or excavation and off-site disposal. Both of these options would benefit from potential future developments on-site or in the local region. Therefore, the recommended remedial plan is to:

1. Submit Notification to Alberta Environment complete with technical details of the intent to construct a temporary waste storage facility;
2. Construct the facility in accordance with the application and conditions stipulated by Alberta Environment, if any;
3. Excavate and place the displaced material into the temporary storage area; and
4. Assess future off-site disposal or on-site processing options as future developments allow.

DCEL
Steam Release Incident
LSD 09-33-095-12-W4M
Volume II
Soil Delineation Program: Summary Report

Prepared for:
Deer Creek Energy

DRAFT

Prepared by:
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December, 2006
File #04-101

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1.0 INTRODUCTION

Millennium EMS Solutions Ltd. (MEMS) has been retained by Deer Creek Energy Limited (DCEL) to assist in the delineation and subsequent remediation action plan development of the lands potentially impacted by the Joslyn Project steam release. The Joslyn Project is located approximately 60 km North of Fort McMurray, west of the Athabasca River. This phase of the steam assisted gravity drain (SAGD) facility started injecting steam into the reservoir on April 15, 2006. The plant circulated steam for approximately one month and then started producing bitumen. Three days later, on May 18th, 2006 at 5:15am, a steam release was discovered over well pair 204-P1 (Appendix B Figure 1). The Energy and Utilities Board (EUB) in Bonnyville and Alberta Environment (AENV) were notified immediately after control of the release was obtained. DCEL, a subsidiary of Total E&P Canada Ltd. (TEPC) conducted a preliminary assessment of the incident which was provided to the EUB for review. The assessment of the incident included preliminary soils and surface water sampling in proximity to and down gradient of the release point.

The following report outlines the methods and findings of the detailed soils delineation program as well as proposed remedial activities based upon a risk assessment and risk management plan.

1.1 Background Information/Reporting

Initial Sampling of potentially impacted area – Soil & Surface water (May 23, 2006)

In response to the release MEMS completed an initial site inspection and limited sampling program of soil and displaced material in proximity to, and down gradient of the release point. Displaced material was defined as subsurface material estimated to be present at ground surface as a result of the steam release. Surface water samples from Joslyn Creek were also collected up and down stream of the portion of the creek located down gradient from the release point. The purpose of the initial site visit and sampling was to investigate the following with respect to soils:

- determine the physical and chemical parameters of the displaced material located in proximity to the release point (four samples of displaced material were collected);
- complete a visual inspection down gradient of the release in order to estimate the visual extent of the displaced material migration;
- collect background soil chemistry for appropriate comparison of the displaced material (one control location, surface soil); and
- determine potentially impacted receptors as a result of the release.

Results of the limited sampling program indicated criteria exceedances in the F2-F4 petroleum hydrocarbon fractions as well as sodium adsorption ratio (SAR) for the displaced material. Table 1 displays the criteria exceedances of the displaced material as well as the analytical results from the control sample collected. A complete analytical report of all parameters is found in Appendix A (Initial AENV findings report).

Table 1 Analytical Results of Surface Material Collected near the Steam Release Point.

Parameters	UNITS	Applicable Criteria*	25 M SW W/C	SW W/C ~ 100 M	SW W/C ~ 200 M	PIPE SAMPLE	CONTROL
Material sampled		-	**DM****	**DM****	**DM****	**DM****	**Clay till**
Petroleum Hydrocarbon Analytical Results							
Sample material	**-**		#1	#2	#3	#4	#5
F2 (C10-C16)	mg/kg	800	**1400**	**1800**	**1800**	410	<5
F3 (C16-C34)	mg/kg	900	**18000**	**19000**	**18000**	**20000**	340
F4 (C34-C50)	mg/kg	5600	**9000**	**9400**	**8900**	**10000**	310
F4G-SG (GHH-Silica)	mg/kg	-	9800	11000	11000	11000	500
Salinity Analytical Results							
Calcium (Ca)	mg/L	-	7	13	17	9	377
Chloride (Cl)	mg/L	-	230	270	300	290	60
Conductivity Sat. Paste	dS m-1	2	1.52	1.68	1.69	1.67	2.12
Magnesium (Mg)	mg/L	-	<3	<3	4	<3	149
pH in Saturated Paste	pH	6.0-8.0	8.6	8.5	8.4	8.2	7.4
Potassium (K)	mg/L	-	6	6	7	6	4
SAR	SAR	4	**40.7**	**35.4**	**28.5**	**43.8**	1.3
Sodium (Na)	mg/L	-	396	471	507	484	118
Sulphate (SO4)	mg/L	-	352	333	215	325	1470
% Saturation	%	-	42.3	40.6	51.9	53.6	41.5
MUST PSA % > 75um	%	-	60	57	52	58	

***AENV 2001 Alberta Soil and Groundwater Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities, Volume 3 Users Guide (AENV 2001).**

DM** - Displaced material collected from ground surface at varying locations down gradient of the release location.

BOLD – Exceeds applicable criteria.

This initial investigation resulted in the preliminary identification of the potential contaminants of concern and quantitative results for concentrations of the parameters within the displaced material. The approximate aerial extent of displaced material was also estimated based upon a visual inspection of the “dusted” area recorded down gradient of the release point. The approximate area of visually affected soils was placed on an orthophoto (Appendix A - Relevant Background Documents, Figure 1). The findings in this report were used to formulate an appropriate work plan for further soil investigation.

Detailed Site Characterization Work Plan – September 19, 2006

Based on the field data and analytical results of the initial investigation, a detailed site characterization work plan was submitted to AENV on behalf of TEPC (September 19, 2006) (Appendix A). The work plan included further delineation of soils, surface water and groundwater. The following report outlines the proposed work plan, methodology, results, and discussions of the horizontal and vertical delineation of potentially impacted soils.

Site Characterization Proposal – Steam Release Report, AENV Comments/Questions (October 5, 2006)

AENV submitted a response to the characterization proposal in which several comments or questions were raised regarding the work completed to date as well as the proposed sampling protocol as discussed in the characterization work plan (Appendix A). Specific responses to the soil related comments/questions are addressed below.

Detailed responses to the comments and questions that are not addressed in the proceeding sections are given below.

Questions in repose to the initial sampling Completed:

1. How was the area of deposition indicated on Figure 4.1 determined?

The initial area of impact was completed on a visual inspection of the ground and vegetation surfaces shortly after the release. Transects were completed down gradient of the release to estimate the distribution of the release.

2. What Stratum of the soil profile or overlying material is represented by the analysis?

Samples 1-3 represent samples of displaced material collected at varying distances down gradient of the release location (Appendix A - Relevant Background Documents, Figure 1). The distances are indicated in the analytical table (Appendix A - Site Characterization Proposal – Steam Release Report, AENV Comments/Questions (October 5, 2006)). Sample 4 is displaced material collected off of an above ground pipe located in proximity to the access road and sample five was a surface sample of clay material taken from a road cut up gradient of the release location.

1. How was the single control sample located?

The location selected was chosen based on location relative to the release and prevailing winds. The control sample was collected in an un-impacted location to approximate the natural hydrocarbon results typical for the area. The purpose of the sample was not to determine absolute control values for the area.

1.2 Topography

The landscape within the SAGD area varies from flat to gently rolling, and much of it is of low relief. Greatest relief, usually in the order of three to five metres, is found along drainage courses and around small lakes.

A majority of the area up and down gradient of the release location is generally upland. The release location and other small pockets of lowland soils are found throughout the area predominantly in proximity to drain ways. The relief from the steam release point to Joslyn Creek is approximately 3 – 5 m over a distance of ~ 350m.

1.3 Soils

The soils in proximity to the steam release area consist of Luvisols, Gleysols, Regosols (and Rego complexes) and Organics in low lying depressional areas.

Orthic Gray Luvisols dominate all upland areas in proximity to and down gradient of the release location. Lower slope and drainage swales are occupied by either Orthic or Humic Gleysols, often with a significant surface peat layer. Regosolic soils and various Rego complexes are confined to the Joslyn creek flood plain and a narrow band along the banks of the flood plain. Various depressional pockets, including the steam release location are dominated by relatively shallow Organic soils dominated by bog peat. Initial soils mapping information was collected from the DCEL Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment - baseline soils map (DCEL Phase IIIA SAGD baseline soils) (DCEL 2005). A detailed discussion on soil classification and chemistry is completed in section 6.1 of the report.

1.4 Surface Water

The DCEL lease is transected by two major streams – the Ells River and Joslyn Creek, a major tributary of the Ells. The SAGD Phase III operations are entirely within the Joslyn Creek Watershed.

DCEL has conducted sampling of the Joslyn Creek during baseline data collection for a number of regulatory applications. Water in Joslyn Creek is slightly alkaline, with total alkalinity, conductivity, and concentrations of total dissolved solids generally highest in winter. In general the dissolved salt concentrations at the upper Joslyn Creek station (west of the Joslyn Creek crossing) have ranged from 310 – 601 mg/L and at the lower Joslyn Creek station(at mouth) ranged from 310 – 512 mg/L.

Generally, organic parameters such as hydrocarbons, naphthenic acids, and phenols were low in Joslyn Creek. Historical concentrations of oil and grease, measured over the period from 1976 to 1979, ranged from <0.1 mg/L to 1.5 mg/L. Since baseline data collection began the recoverable hydrocarbon concentrations have been below the detection limit.

1.5 Geologic Setting

Within the project area, the total overburden thickness is approximately 40 to 60 m with 20 to 30 m being the shales of the Clearwater Formation while the remaining sediments are Pleistocene tills. The Clearwater Formation is fully marine in nature. It consists predominantly of marine shales which do not contain bitumen and are considered a barrier to fluid flow. The Wabiskaw Member of the Clearwater Formation directly overlies the McMurray formation and is comprised of shales, silts and very fine grained sands. These sands can contain low grades of bitumen. Reservoir quality and thickness within the Wabiskaw member are poor and do not contribute to the in-situ recovery of bitumen.

The McMurray Formation is present from approximately 40 to 60 m below ground level to 115 m depth. The McMurray Formation is comprised of stacked fluvial-estuarine sands and off channel silts and shales. The sands of the McMurray Formation are 90 to 95% quartz. The McMurray has three informal members including the Lower, Middle and Upper McMurray. These informal divisions correspond to changes in the depositional environments within the McMurray from fluvial at the base (Lower Member) to estuarine in the middle (Middle Member) to marginal marine at the top (Upper Member).

The depth of the prospective Middle McMurray SAGD zone is approximately 65 to 110 m. The non-pay McMurray sediments that overlie the intended steam chamber consist of 20 to 25 m of interbedded sands and shales of largely estuarine origin.

2.0 PROJECT OBJECTIVES

The soils characterization program was designed to address the following objectives:

1. Provide a detailed characterization of the displaced material (DM) layer.

2. Obtain additional soil physical and chemical background information of representative soil types.

3. Determine the soil quality of surface soils up and down gradient of the release location and compare results to appropriate screening criteria sufficiently, such that a site specific risk assessment and risk management plan can be created.

4. Based upon the findings of the Risk Assessment Program, prepare a remediation action plan appropriate for the remediation and management of the impacted soils.

3.0 SCOPE OF WORK

The scope of work to characterize and delineate the potentially impacted soils was designed to address the project objectives and consisted of the following activities:

- Complete a review of all initial environmental assessment work completed at the release location.
- Complete a review of all applicable soils baseline data within the area to determine site specific soils data for classification and sampling requirements.
- Complete a ground disturbance protocol following MEMS and DCEL procedures as outlined in standard work procedures (SWP's) and ground disturbance protocol documents.
- Complete a site inspection of the estimated area of impact prior to the assessment to determine appropriate sample locations and intervals.
- Sample soils from approximately 100 locations in proximity to, up gradient, and down gradient of the release location utilizing pre-determined spacing requirements (see sections 4.0 and 4.1 for sampling intensity and methods).
- Inspection of the ground surface of the sampling site for determination of displaced material on the litter layer.
- Classification of soils at sampling locations as per the Canadian System of Soil Classification, Third Edition (SQWG 1998).
- Analyze select samples at various locations for BTEX, F1-F4 petroleum hydrocarbons, CCME trace metals, detailed salinity, polycyclic aromatic hydrocarbons (PAHs), napthenic acids and particle size.
- Determine areas of potential impact and based on appropriate screening criteria for the purpose of formulating a site specific risk assessment.
- Determine areas requiring remediation as per the findings of the site specific risk assessment; and
- Prepare a report outlining the findings with respect to:
  - appropriate background soil chemistry for all representative soils located in areas potentially impacted by the release;
  - estimated area of impacted soils down gradient of the release based on background soil values and screening criteria; and
  - recommendations for appropriate site remediation/monitoring based on the findings.

4.0 METHODOLOGY

4.1 Sample Locations

4.1.1 Controls

Controls were selected based upon a review of previous soil baseline data for the area, specifically the DCEL Phase IIIA SAGD baseline soils report. The soils baseline map was superimposed over the release location and surrounding area. Controls were selected based on the soil map units potentially impacted by the release (Appendix B, Figure 1). Control samples were defined as samples collected in areas estimated to be un-impacted by the dispersion of the DM as a result of the steam release. Two types of control samples were used in the determination of soil quality, and include:

1. Perimeter control samples - Control samples taken at greater distances form the release (perimeter controls, > 500 m) which were utilized as checks to ensure the samples deemed as area specific controls maintained similar soil chemical and physical signatures as locations located outside the potential zone of impact.

2. Area specific control samples - Control samples collected relatively close to the estimated potential area of impact (<100 m), however, outside the visual area of potential impact as determined by the detailed assessment. Area specific controls were selected based on a review of soil chemistry (including chromatograms) and detailed field observations of the litter/surface peat layer and the underlying A horizon.

4.1.2 Delineation Locations

Sample transects were completed perpendicular to the estimated area of impact in order to obtain representative soils data within the estimated area of impact as well as outside the approximate boundaries to obtain plume closure. Three distinct sample intensities were utilized to collect soils data along the estimated plume. Sampling intensity was based on the following spacing:

- approximately 40 sample sites within a 50 m radius of the release location, both up and down gradient;
- approximately 30 sample sites completed within 50 m to 300 m down gradient of the release location; and
- approximately 20 sample sites completed between 300 m and 1,000 m down gradient of the release location.

Sampling locations in close proximity to the release location were limited to the perimeter as ground instability was a safety issue. Once the orientation of the first row was decided;

appropriate spacing of subsequent rows and sample points were measured using hand held GPS units (UTM coordinates). Distances were determined by the required sampling intensity based on the radial distance from the release location and/or visual field indicators on the presence or lack thereof of DM. Locations were selected to best represent topography, landscapes, and vegetation of the study area. Boundary sampling points for each row were selected in locations estimated to contain no visual indication of DM at surface, these locations were recorded as possible “plume closure samples” at the field level.

At each sampling location the following site information was recorded:

- GPS points;
- slope (%), slope position and aspect;
- vegetation (type and distribution);
- surface drainage and depth to water table, where possible;
- description of ground surface with respect to presence or lack thereof of DM; and
- any other pertinent information regarding the steam release and surrounding soils and vegetation (i.e. notable displaced material on vegetation).

All sample locations were marked on field scale orthophotos as a tool to ensure appropriate spacing and coverage was achieved at the field level.

4.2 Soil Sampling

Each soil sampling site involved digging a shallow hole with a shovel into the lower part of the B horizon, if present, to approximately 50-60 cm. Below that, a hand auger was used to examine soil materials to approximately 100 cm to120 cm for classification purposes. Care was taken during the pit excavation to minimize disturbance at surface to ensure a representative DM and litter layer sample could be collected.

In locations with shallow water tables (<30 cm) the lower portion of the profile was classified and sampled using a 2 inch dutch auger. To ensure minimal cross contamination of samples the auger was wiped clean in between samples and the outer layer of soil material trimmed prior to sample collection.

Prior to sampling, all four walls of the pit were scraped clean and debris removed from the pit. Sampling depths and intervals varied depending on the soil type. Three sampling interval combinations were utilized depending on the soil type and horizon configuration. Typically, the thickness and composition of the surface litter/peat layer were the drivers in determining which method to use. They are as follows:

- **Method #1** – completed on mineral soils with a LFH/thin surface peat layer (<15 cm in depth). Typically horizons consisted of an LFH, Ae, and Bt horizons.

- **Method #2** – completed on peaty mineral soils and Organics that may or may not have a thin litter layer overlying the surface peat. Typically horizons consisted of Of, Om, BCg or Cg. In this method A horizons were typically absent and substituted by sampling the top 15 cm of the organic material.
- **Method #3** – completed in disturbed areas (road RoW) where clay fill material accounts for the top 50 cm of soil material.

Table 2 displays the three separate sampling methods and appropriate sampling depths.

Table 2 Appropriate Sampling Intervals used for the Soils Assessment.

Desired sample layers (cm) & Sample Labelling Protocol	Method #1	Method #2	Method #3
Displaced material (labelled as DM)	collected if >2 cm, if <2 cm, DM material was composited with the litter layer	collected if >2 cm, if <2 cm, DM material was composited with the litter layer	collected if >2 cm, if <2 cm, DM material was composited with topsoil
litter material (labelled as LFH or Of, Om)	LFH and shallow surface peat (<15 cm) collected if > 2 cm thick, if < 2cm the litter material was composited with the topsoil	LFH collected if > 2 cm thick, if < 2 cm the litter material was composited with the surface peat	LFH layers (if present)
Topsoil (labelled as “1”, i.e. 314 -1)	entire depth of A horizon, includes (Ae, Ah, AB) **or** in cases where the A horizon was absent a B horizon was collected to a maximum thickness of approximately 15 cm	top 15 cm of surface peat material was collected as a discrete sample	top 5 cm of the clay fill material was collected
15 cm interval (labelled as “2”, i.e. 314-2)	a 15 cm thick profile starting from the bottom of the A horizon was collected	a 15 cm thick profile starting from the bottom of the surface peat horizon was collected, typically 15-30 cm	a 5-15 cm profile was sampled in place of the 15 cm increment
30 cm interval (labelled as “3”, i.e. 314-3)	a 30 cm thick profile starting from the bottom of the 15 cm horizon was collected	a 30 cm thick profile starting from the bottom of the 15 cm interval was collected, typically 30-60 cm	a 15-30 cm profile was sampled in place of the 30 cm increment

Upon completion of the plot preparation, site descriptions, and selection of the appropriate sampling method the sampling of the excavated test pits was completed. The following steps outline detailed methodologies for sampling of soils:

1. All sample bags and jars were labelled with project number, site number, sampling depth interval (i.e. 314-1), and date.
2. Prior to collecting the surface peat/litter layer horizon, the bottom of the litter horizon was determined and any mineral particles from the base of the litter layer were removed, if possible. In sampling method #2 this step was not required.
3. Wearing powder free nitrile gloves all DM was carefully scraped/lifted off of the surface of the peat/litter layer and placed into the appropriate sample bag.
4. A portion of the litter layer from each wall was peeled back, removed from ground surface, again inspected for any visible DM and placed into the appropriate sample bag. **Each sample bag consisted of a composite of the four pit walls sampled**.
5. Prior to sampling or measuring the remaining sampling depths, all litter material sloughed from the top and side walls of the mineral profile was removed.
6. Measured from the top of the profile to the desired depth, and marked the depth on the pit walls with a soils knife.
7. Completed an incision around the soils pit at the marked depth with the soils knife. This minimized soils from a lower depth being collected.
8. Using a clean soils knife, soils/peat material from the required depth were collected and placed into a labelled bag.
9. Once the entire sample (soil from all four pit walls) was collected for a particular depth, the sample bag was thoroughly mixed by agitating the contents of the bag. Approximately 1.5 kg of soil was collected for each interval.
10. Once all samples were collected, the test pit was backfilled, replacing differentiated horizons if possible.
11. For each sample bag collected, two 125 mL labelled soil sample jars were packed and placed into a cooler until delivery to the laboratory.

Due to the variability in soil profiles and horizon combinations, guidelines were implemented to ensure consistent and accurate sampling of the desired depth intervals while minimizing compositing samples from two distinct profiles (i.e. peat and clay). Guidelines included the following:

- Topsoil horizons were combined unless a textural discontinuity was encountered (clay to sand), in which case each horizon was sampled separately.
- The 15 and 30 cm depth intervals were deemed as target depth intervals. Soil profiles and textural discontinuities allowed for sampling variation in the thickness of

the bottom two intervals (e.g. 13 cm clay textured Bt underlain by a loam BC would be sampled as a 13 cm interval). The extent of the variation was dependent on the sample location and up to the discretion of the sampler. A target sampling depth of 55-60 cm was maintained to ensure sufficient vertical sampling was completed.

- Surface litter/peat layers that were < 15 cm in thickness were labelled displaying a descending depth increment (i.e. 8 - 0 cm). If the surface layer was >15 cm **or** no discrete surface litter/peat layer was recorded then the thickness of the sample interval was labelled in ascending order (i.e. 0 -16 cm).

4.3 Soil Classification

Soil characteristics were observed and recorded on field forms, following accepted guidelines and classification systems (Expert Committee on Soil Survey (ECSS) 1983 and Soil Classification Working Group (SCWG) 1998).

Soil characteristics recorded at inspection sites included:

- horizon types (per the Canadian soil classification system (SCWG 1998);
- horizon depths;
- soil texture by manual (field) tests;
- structure and consistence;
- colour (Munsell soil colour charts) was completed for some horizons;
- mottles, including appropriate mottle descriptors as per the Canadian soil classification system (SCWG 1998); and
- various pertinent features were described and recorded for horizons if required to aid in soil classification and/or description (i.e. unique till features).

All soils data collected was reviewed and classed to the subgroup level. Further classification to the series/variant level was completed through a review of the DCEL Phase IIIA SAGD soils map and the AGRASID soils database (ASIC 2001) (Appendix B, Figure 3a and 3b).

4.4 Analytical Program

Table 3 summarizes the proposed analytical program for the detailed soils investigation.

Table 3 Proposed Analytical Program for Sampled Soils.

Location	# of samples	Analytical Parameters	Comments
Close proximity to release point	15	BTEX F1 – F4 petroleum hydrocarbons; Detailed salinity; total napthenic acids; trace metals; and PAH's	○ Representative samples of DM and underlying materials (litter layer) were analyzed in the area of highest impact to appropriately characterize the DM and potential impacts displayed by the surface peat/litter layer.
up and down gradient of release	60-65	BTEX F1 – F4 petroleum hydrocarbons	○ Sufficient representative analyses were conducted up and down gradient of the release location to determine which parameters were of concern. ○ All analytical was initially focused on the surface and near surface samples. ○ Areas displaying evidence of DM at surface were targeted.
up and down gradient of release	30-35	Detailed salinity; and particle size analysis	○ Sufficient representative analyses were conducted up and down gradient of the release location to determine which parameters were of concern. ○ All analytical was initially focused on the surface and near surface samples. ○ Areas displaying evidence of DM at surface were targeted.
Controls	10	BTEX F1 – F4 petroleum hydrocarbons; Detailed salinity; total napthenic acids; and particle size analysis	○ Analytical completed on surface and near surface samples to determine range of background soil chemical and physical parameters for discrete soil types

All analytical methods are referenced within the original laboratory reports found in Appendix D.

Due to the high amount of organic materials in the surface samples analyzed a silica gel column clean up was carried out on all surface samples. The CCME method makes silica gel cleanup mandatory for the F2-F4 fractions. The column clean up involves a column, in which a small volume of concentrated extract is passed through a column filled with packed silica gel (same method reference as the F2-F4 petroleum hydrocarbons). All surface sample hydrocarbon analytical results reported reflect the silica gel column clean up.

5.0 SOIL SCREENING CRITERIA

The purpose of the detailed soil sampling program is to determine soil quality and potential area of impact in proximity to and down gradient of the steam release location. The findings are input into a site specific risk assessment as outlined in the submitted *DCEL Steam Release Incident LSD 9-12-95-12 W4M; Section 6.0* (Appendix A). However, in order to formulate the site specific risk assessment, analytical results for potential soil impacts will be screened against the most stringent applicable receptor pathways from Tier 1 soil criteria. This comparison process is not meant to represent remedial objectives but to identify potential impacts based on the standard generic criteria within the Tier 1 framework. Criteria from the following AENV documents were used for hydrocarbon and polycyclic aromatic hydrocarbons (PAH) screening purposes:

- Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities (AENV 2001 criteria) (AENV 2001a); and
- Alberta Tier 1 Soil and Groundwater Remediation Guidelines; Draft for Public Comment (AENV 2006 draft criteria) (AENV 2006).

Salinity, trace metals and various PAH parameters were screened against the following guidelines:

- Salt Contamination Assessment and Remediation Guidelines (Alberta Environment 2001b); and
- Canadian Environmental Quality Guidelines (CCME 2006)

Appropriate soil screening criteria is compared to mineral soil profiles and the DM material only, the aforementioned documents are not applicable to litter/organic material as this medium is not defined as soil. Surface litter/organic analytical results are reported and discussed but not compared to the site specific screening criteria. However, a comparison of background soil chemistry (soil type specific) with potentially impacted analytical results is carried out to estimate potentially impacted surface materials. The methodology of this approach is discussed in section 6.2.1.

A brief description of each guideline and appropriate site specific screening criteria is given below.

5.1 Hydrocarbon Screening Criteria – AENV 2001

ALBERTA SOIL AND WATER QUALITY GUIDELINES FOR HYDROCARBONS AT UPSTREAM OIL AND GAS FACILITIES (ALBERTA ENVIRONMENT 2001A)

For the hydrocarbon parameters of benzene, toluene, ethylbenzene, xylenes and petroleum hydrocarbons F1-F4, the most stringent of the applicable and potentially applicable AENV 2001 criteria were applied. The guidelines specify a land use and a receptor pathway approach providing specific criteria for different parameters. Site criteria were determined by utilizing the following systematic process:

- Identifying the appropriate land use for the site.
- Determine soil texture (fine or coarse grained criteria applies).
- Identify the applicable and potentially applicable pathways.
- Select the strictest criteria for each parameter, from each applicable and potentially applicable pathway.

The site is zoned for natural land use and therefore the site was evaluated under the natural land use category. The soil texture was determined to be **fine** grained. The applicable and potentially applicable pathways are identified in Table 4.

Table 4 Selection of Applicable Exposure Pathways.

Exposure Pathway	Applicable	Potentially Applicable	Not Applicable	Rationale
Protection of Potable Groundwater				Based on the depth of boreholes drilled at the release point, the area is not underlain by a DUA.
Soil Contact (Plants and Invertebrates)				Default pathway, always applicable
Soil Ingestion (Wildlife)				Default pathway, always applicable
Protection of Groundwater for Aquatic Life				A stream is located ~200 m west of the well-site
Protection of Groundwater for Wildlife				A stream is located ~200 m west of the well-site

The most stringent applicable or potential applicable pathways identified in Table 4 were used to determine individual assessment screening criteria for each hydrocarbon compound (Table 5).

Table 5 Hydrocarbon Assessment Screening Criteria - 2001 Criteria

Assessment Criteria (mg/kg)		
Hydrocarbon Parameter	**Applicable**	**Applicable Exposure Pathway**
Benzene	14	Soil Contact (Plants and Invertebrates)
Toluene	300	
Ethylbenzene	450	
Xylenes	1,200	
F1	260	Soil Contact (Plants and Invertebrates)
F2	900	
F3	800	
F4	5,600	

5.1.1 Hydrocarbon Screening Criteria – AENV 2006 Draft

ALBERTA TIER 1 SOIL AND GROUNDWATER REMEDIATION GUIDELINES, DRAFT FOR PUBLIC COMMENT (AENV 2006)

Alberta Environment recently released this document, intended to provide a single, comprehensive source of soil and groundwater remediation guidelines for use in Alberta, for public comment. The guidelines include generic, primarily risk – based soil quality guidelines as well as some judgment-based guideline values for unconditional regulatory acceptance applicable to a wide variety of sites with various exposure pathways. These guidelines, if implemented, will supersede the 2001 hydrocarbon guidelines discussed in section 5.1. Applicable criteria from the 2006 draft for discussion document that will not restrict future land use are presented in Table 6.

Table 6 Hydrocarbon Assessment Screening Criteria - 2006 Draft Criteria.

Assessment Criteria (mg/kg)		
Hydrocarbon Parameter	**Applicable**	**Applicable Exposure Pathway**
Benzene	15	Eco-contact, Wildlife
Toluene	110	Soil Contact (Plants and Invertebrates)
Ethylbenzene	120	
Xylenes	65	
F1	210	Soil Contact (Plants and Invertebrates)
F2	150	
F3	1300	
F4	5600	

5.2 Trace Metals

CANADIAN ENVIRONMENTAL QUALITY GUIDELINES (CCME 2006)

For trace metals, soil quality was screened against the Canadian Environmental Quality Guidelines (CCME 2006). This guideline utilizes a land use approach, providing specific criteria for specific parameters. It was determined that soil quality on site would be screened against the agricultural land use category. Although the steam release location is located in a forested zone this land use is the most appropriate choice given the four options in the CCME guidelines. Arsenic criteria have been based on the Alberta protocol.

5.3 Salinity Criteria

SALT CONTAMINATION ASSESSMENT AND REMEDIATION GUIDELINES (ALBERTA ENVIRONMENT 2001B)

In screening salinity (EC and SAR) the Salt Contamination Assessment and Remediation Guidelines (Alberta Environment 2001b) were used. With this guideline, the salinity of control sites was used to screen soil quality on site. The topsoil and subsoil at control sites are each given rating categories of good, fair, poor or unsuitable (Table 7). The on-site soil quality is then compared against controls that are located in similar physiographic locations. Soils are considered equivalent to controls if the soil quality lies in the same or better soil rating categories. Due to the shallow nature of the investigation a majority of all analyzed samples were screened against applicable topsoil criteria.

Table 7 Soil Quality Guidelines for Unrestricted Land Use (Alberta Environment 2001b).

Parameter		Rating Categories			
		Good	Fair	Poor	Unsuitable
Topsoil	EC dS/m	<2	2 to 4	4 to 8	>8
	SAR	<4	4 to 8	8 to 12	>12
Subsoil	EC dS/m	<3	3 to 5	5 to 10	>10
	SAR	<4	4 to 8	8 to 12	>12

5.4 Polycyclic Aromatic Hydrocarbon (PAH) Criteria

ALBERTA SOIL AND WATER QUALITY GUIDELINES FOR HYDROCARBONS AT UPSTREAM OIL AND GAS FACILITIES (ALBERTA ENVIRONMENT 2001A) AND

ALBERTA TIER 1 SOIL AND GROUNDWATER REMEDIATION GUIDELINES, DRAFT FOR PUBLIC COMMENT OR

CANADIAN ENVIRONMENTAL QUALITY GUIDELINES (CCME 2006)

For PAH’s, soil quality was screened initially against the AENV’s 2001 and draft 2006 Benzo(a)Pyrene (B(a)P) equivalency concentrations.

PAH’s are expressed as an equivalent B(a)P concentration and compared to appropriate B(a)P values for unique land uses and receptors. The guidelines adopt an approach to assessing PAHs that involves converting the concentrations of the eight carcinogenic PAHs to an equivalent concentration of B(a)P and summing them. The most stringent applicable or potentially applicable pathway is then used to determine the assessment criteria for this B(a)P equivalent.

Non-carcinogenic PAH’s not listed in the AENV 2001 or 2006 draft document are screened against criteria from the Canadian Environmental Quality Guidelines (CCME 2006). This guideline utilizes a land use approach, providing specific criteria for specific parameters. It was determined that soil quality on site would be screened against the agricultural land use category as previously discussed in Section 3.2.

6.0 RESULTS

6.1 Soil Classification

A total of 98 sample sites were completed in proximity to, and up and down gradient of the release location. Four sample sites were completed at perimeter locations (>500 m away) to collected undisturbed representative physical and chemical soil parameters (Appendix B,

Figure 2). A correlation of the collected soils data and the detailed baseline soils map from the DCEL Phase IIIA SAGD baseline soils map allowed for classification of the soils to the series/variant level (Appendix B, Figure 3).

Soil classification within the area of potential impact was seen as an important step with regards to soil quality and determination of soils potentially impacted. The nature of the displaced material and method of dispersion resulted in a thin misting down gradient of the release location. The composition of the surface litter layers and shallow surface horizons was variable and typically high in organic matter. Analyses of appropriate control soils data representative of soil types potentially impacted was essential to assist in determining potentially impacted versus background soil chemistry. Below are general descriptions of the four soil orders, associated great groups, subgroups and related soil series found within the study area. Disturbed lands were also investigated down gradient of the release location and are discussed briefly.

Luvisols

Soils of the Luvisolic order generally contain a light coloured eluvial A horizon (Ae) and distinctive illuviated B horizon (Bt). The process that causes this specific horizonation is an eluviation of silicate clays from the A horizon into the underlying B horizon creating a distinctive prismatic or blocky structure. Luvisolic soils generally form under forested conditions in humid to sub humid climates (Soil Classification Working Group (SCWG 1998)). An Orthic Gray Luvisol of the Dover (DOV) series is the predominant series found in the area. The DOV series is formed on calcareous moderately fine textured till or lacustro-till under forested conditions. The DOV series contains a relatively thick Ae horizon underlain by a transitional AB or BA horizon. Gleyed Gray Luvisols of the Kilome (KME) series were recorded down gradient of the release location. KME soils often occur with the DOV series and are imperfectly drained gray Luvisols that share a similar horizon profile as the DOV. Evidence of shallow water movement (mottling and gleying) is often the result of seepage waters perched on finer textured underlying materials.

Luvisols within the area studied typically contained a relatively thick litter layer underlain by an Ae horizon variable in thickness depending on slope position. A transitional horizon below the eluviated A horizon was common, and the underlying Bt horizon(s) also were found to be variable and in many instances two discrete Bt horizons were classified. Table 8 displays a typical DOV series profile found within the area studied.

Table 8 Typical DOV Series Profile Located at Sample Location 221

Horizon	Depth (cm)	Texture	Structure	Consistence
LFH	7-0	-	-	-
Ae	0-5	Silt loam	Fine platy	Friable
AB	5-13	Silty clay loam	Weak sub angular blocky	Friable
Bt	13-40	Clay loam	Strong sub-angular blocky	Very firm
Ck	40-70	Clay	Massive	Very firm

Gleysols

Gleysolic soils are influenced by periodic or sustained saturation by water creating reducing conditions (SCWG 1998) throughout the profile, including the surface horizon. Gleysols often contain characteristics of other soil orders but are defined by the degree of mottling and gleying (evidence of fluctuating or stagnant water table) within the soil profile. Peaty Rego Gleysols and Peaty Orthic Gleysols were the predominate Gleysols found within the study area. Both sub groups occurred in transitional locations between upland and organics. Both the peaty Rego and Orthic Gleysols were classed as variants of the Mamwai (MMW) series, a common Gleysolic complex mapped in the region (DCEL 2006). The MMW series is classed as an Orthic Rego Gleysol over medium texture materials.

The peaty Rego Gleysols were classed as peaty variants of the MMW series (MMWpt). Typically these soils contained a deep surface peat layer 20-30 cm in depth, underlain by either a gleyed BC or C horizon.

The peaty Orthic Gleysols were classed as peaty/Orthic (zo) variants of the MMW series (MMWptzo). These soils had a thick surface peat layer underlain by moderately fine textured gleyed B and C horizons. The groundwater table was usually within 1.0 m of the ground surface. Table 9 displays a typical MMWpt soil profile found within the study area.

Table 9 Typical MMWpt Series Profile Located at Sample Location 325

Horizon	Depth (cm)	Texture	Structure	Consistence
LFH	7-0	-	-	-
Om	7-26	-	-	-
Oh	26-33	-	-	-
Cg_1	33-54	Clay loam	Massive	Very sticky (w)
Cg_2	54-70	Sandy clay loam	Massive	Sticky (w)

(w) – wet consistence

Regosols

Regosolic soils are referred to as weakly developed soils that contain a poorly developed B horizon <5 cm thick that does not meet the classification requirements of any other soil order (SCWG 1998). Regosols are seen as juvenile soils that are usually imperfectly to rapidly drained and form in areas of recent deposition or areas of unstable slopes. Regosolic soils were found within the Joslyn confined floodplain and were classed as Orthic Humic Regosols and mapped within the McMurray (MMY) soils complex that has been previously identified (DCEL Phase IIIA SAGD baseline soils map). The MMY soils series is a Cumulic Regosol (contains buried surface horizons), however the MMY complex mapped in this area contains various subgroups, including; gleyed, and humic variants. Soils within the Joslyn floodplain that are found within the estimated area of impact were classed as humic variants (MMYzh) of the MMY series. Humic is defined by a surface horizon (typically surface A horizon) >10 cm thick. Table 10 displays a typical MMYzh soil profile found within the Joslyn Creek flood plain.

Table 10 Typical MMYzh Series Profile Located at Sample Location 217

Horizon	Depth (cm)	Texture	Structure	Consistence
LFH	6-0	-	-	-
Ah	0-13	Sandy loam	Weak blocky - granular	Loose
C1	13-27	Sandy loam	Granular	Loose
C2	27-65	Loamy sand	Granular	Loose

Organics

Organic soils are composed largely of organic material as a result of long term plant and woody residue accumulation. A minimum of 40 - 60 cm thickness of organic material at surface is required for an Organic soil classification; the range of required depth is dependent on the type of organic material. Classification of organic soils is based on the decomposition stage of the organic material (Fibric, Mesic and Humic). Organic soils are usually saturated with water and occur in poorly drained depressional areas to level basins with raised edges. Organic soils were found in the depressional pockets in proximity to the release location and classed as bog peat Organics as determined by the previous mapping exercise for the area. All Organics encountered were of the Mesisol great group (predominate organic horizon was considered to be of the mesic decomposition stage) and mapped as a Muskeg series (MUS) Organic. Fibric surface horizons were also recorded throughout the study area, additionally numerous MUS inspection sites contained thin leaf litter layers (>2 cm) overlying the peat. A majority of the Organics were underlain by mineral material at <1.2 m in depth, and were therefore classed as Terric Mesisols. Table 11 displays a typical MUS series profile located within the study area.

Table 11 Typical MUS Series Profile Located at Sample Location 13

Horizon	Depth (cm)	Texture	Structure	Consistence
LFH	2-0	-	-	-
Om	0-85	-	-	-
Cg	85-100	Clay	Massive	Very Sticky

Disturbed Lands

Disturbed lands included site infrastructure located down gradient of the release location. Disturbed lands were composed primarily of borrow material that consisted of clay material the entire depth of the profile investigated.

6.1.1 Soil Classification Variability

The initial soils baseline map utilized to assist in soils classification and sample location selection (DCEL Phase IIIA SAGD baseline soil map) was completed at a Survey Intensity Level 1 (SIL1) in the area of the release. The Phase IIIA baseline investigation was completed at an intensity of approximately 1 inspection per 5 ha. The level of detail completed for this assessment corresponds to an SIL 1 survey ratio of approximately 1 inspection per 0.15 ha. The difference in the level of detail between the two investigations has resulted in minor discrepancies with respect to the borders of the soil map units from the Phase IIIA baseline investigation. The increased survey intensity has resulted in a better definition of soil types that are transitional between map units. This has resulted in a discrepancy between soils classified during the investigation and location of these transitional soils within map units on the DCEL Phase IIIA SAGD baseline soil survey map (Appendix B, Figure 3).

For example, the DOV10/U1h and MUS2m/1 soil map units border each other; soils found on the edge of these map units represent transitional soils (MMW Gleysols) rather than either a discrete DOV or MUS series. This is a typical pattern for the area yet, too detailed to discretely map at the acceptable SIL 1 scale. Although an overlap exists, the soil map units do account for the occurrence of these transitional soils (MMW) through a discrete numbering system. The “10” in DOV10/U1h identifies that 10-30% of the soils that occupy that map unit are poorly drained or potentially solonetzic.

6.2 Controls - Soil Chemistry

6.2.1 Natural Organics Correction Factor - Hydrocarbons

As was noted in previous sections a notable litter/surface peat layer naturally high in organics was found throughout the study area. This layer was variable in composition and included; decomposing leaf litter, thin leaf litter underlain by a surface peat horizon (<15 cm), or a surface peat horizon typically composed of fibric material. All petroleum hydrocarbon results were appropriately prepared by a silica gel procedure to attempt to remove the naturally occurring organics (see section 4.0).

The elevated organic material found in these surface layers results in false positives in the F2-F4 hydrocarbon fraction analyses. In order to determine the actual impact as a result of petroleum hydrocarbons, a correction factor for each soil type was utilized for the litter/surface peat layers, as per guidance provided by AENV (2002) and CCME (2002).

The correction factor is soil type specific and is based on the average area specific control values in the F2-F4 range. The correction factor (natural organic content present in the soils) was subtracted from the F2-F4 results of the potentially impacted surface litter/peat layers of the same soil type to obtain values indicative of the impact as a result of petroleum hydrocarbons. The corrected F2-F4 values were then compared to control values to identify areas applicable to the site specific risk assessment.

6.2.2 Dover Series (DOV) - Luvisols

The DOV series Luvisol was the predominate soil type found in proximity to the release point. Four locations collected up and down gradient of the release location were estimated to be un-impacted soils and were located within 100 m of the estimated plume (Appendix B, Figure 2). These included sample locations 322, 124, 103, and 213. A perimeter control (site 263) was collected approximately 1.6 km east of the release location (Appendix B, Figure 1). Sampling methodology #1 was employed to collect all DOV series and DOV variants found in the study area. A review of the soil physical and salinity results of the area specific controls of the litter/surface peat layer indicated the following:

- slightly acidic pH values in the litter and topsoil horizons (4.5 - 6.1), this pH range is typical of the DOV series (ASIC 2001);
- SAR values ranged from <0.1 - 0.2 in the litter horizon;
- EC values ranged from 0.12 - 1.28 dS/m in the litter horizon;;
- chloride values ranges from <20 - 60 mg/L;
- soils in the underlying A horizon were found to be fine grained; and
- the perimeter control contained similar soil salinity and textural characteristics as the area specific results.

Table 12 displays the F2-F4 hydrocarbon results of the surface litter layer for the area specific controls, the estimated correction factor, and the perimeter control as a check of the suitability of the correction factor values calculated.

Table 12 DOV Series Area Specific Controls and Calculated Correction Factors

Parameter	Area Specific Controls				Correction Factor	Perimeter
	103 LFH 6-0 cm	124 LFH 8-0 cm	213 LFH 6-0 cm	322 LFH 2-0 cm		263 LFH 8-0 cm
F2 (C11-C16) (mg/kg)	<5	29	<5	17	**14**	<5
F3 (C17-C34) (mg/kg)	430	660	590	890	**643**	580
F4 (C34-C50) (mg/kg)	440	1000	680	850	**743**	360

6.2.3 Mamwai Series (MMW) – Gleysols & Variants

The MMW series was found along the edges of drain ways and depressional areas within the study area and is seen as a transitional soil between the depressional wetlands and lower to mid slope mineral soils. Three locations collected up and down gradient of the release location were estimated to be un-impacted soils and were located within 100 m of the estimated plume (Appendix B, Figure 2). These included sample locations 323, 325 (salinity only), and 326. A perimeter control (site 261) was collected approximately 1.6 km east of the release location. Due to the extensive surface peat found at a majority of these locations, sampling methodology #2 was used to sample a majority of the MMW series soils. A review of the soil physical and salinity results of the area specific controls of the litter/surface peat layer indicated the following:

- slightly acidic pH values in the litter and topsoil horizons (4.7 - 6.3);
- SAR values ranged from 0.4 - 0.8 in the surface peat;
- EC values ranged from 0.14 - 0.52 dS/m in the surface peat;
- chloride values ranges from <20 – 30 mg/L;
- grain size analysis was not completed on organic textured materials, however, the underlying mineral material was predominantly fine grained (4 analyses); and
- the perimeter control contained similar soil salinity and textural characteristics as the area specific results.

Table 13 displays the F2-F4 hydrocarbon results of the area specific controls, the estimated correction factor, and the perimeter control as a check of the suitability of the correction factor values calculated.

Table 13 MMW Series Area Specific Controls and Calculated Correction Factors

Parameter	Area Specific Controls		Correction Factor	Perimeter
	323 LFH 6-0 cm	326 Om 0-15		261 Of 8-0 cm
F2 (C11-C16) (mg/kg)	39	12	**26**	6
F3 (C17-C34) (mg/kg)	1600	290	**945**	770
F4 (C34-C50) (mg/kg)	750	260	**505**	340

6.2.4 McMurray Series (MMY) – Regosols

The MMY series Regosols were found within the floodplain of the Joslyn creek and were limited in spatial extent within the study area. Only one MMY series sample location down gradient of the release location was estimated to be un-impacted and within 100 m of the estimated plume (site 218) (Appendix B, Figure 2). A perimeter control (site 260) was collected approximately 600 m south east of the release location (Appendix B, Figure 1). Sampling methodology #1 was employed to collect a majority of the MMY series and MMY variants found in the study area. A review of the soil physical and salinity results of the area specific control and perimeter control of the litter/surface peat layer indicated the following:

- neutral pH values in the litter and topsoil horizons (6.1-6.7);
- SAR values were non-detect in the litter layer;;
- EC values ranged from 0.52 - 0.79 dS/m in the litter layer;;
- chloride 30 mg/L; and
- grain size analysis was not completed on organic textured materials, however, the underlying mineral material was predominantly fine grained (2 analyses).

Due to the limited extent of control data available; the area specific and perimeter controls were averaged to determine an appropriate correction factor. Table 14 displays the F2-F4 hydrocarbon results of the area specific and perimeter control surface litter samples and the estimated correction factor.

Table 14 MMY Series Control Data and Calculated Correction Factors

Parameter	Controls		Correction Factor
	260 LFH 3-0 cm	218 LFH 6-0 cm	
F2 (C11-C16) (mg/kg)	<5	18	**12**
F3 (C17-C34) (mg/kg)	230	500	**365**
F4 (C34-C50) (mg/kg)	230	680	**455**

6.2.5 Muskeg Series (MUS) – Organics

The MUS series Organics were found up and down gradient of the release location in low lying depressional areas as well as shallow confined floodplains. The depth of peat found in the study area was between 40-100 cm, and consisted of predominantly fibric material near surface underlain by mesic material to mineral contact. No MUS series sample locations down gradient of the release location were estimated to be un-impacted (site 16) (Appendix B, Figure 2). A perimeter control (site 262) was collected approximately 1.6 km east of the release location. Sampling methodology #2 was employed to collect all MUS series found in the study area. A review of the soil physical and salinity results of the perimeter control of the surface peat layer indicated the following:

- Slightly acid to acid pH values in the litter and topsoil horizons (3.6 – 5.1);
- SAR values were 0.2 in the litter layer;
- EC values ranged from 0.18 dS/m in the litter layer;
- chloride was 20 mg/L; and
- grain size analysis was not completed on organic textured materials.

Implementing a correction factor of the F2-F4 fraction for samples collected of the litter layer for the MUS was not completed due to the following:

1. No area specific controls were available for correlation. A majority of MUS series soils were located in areas estimated to be impacted based on visual and laboratory results.
2. The perimeter control did not contain a thin leaf litter layer similar to that of the MUS samples collected down gradient of the release; therefore a representative comparison of soil chemistry of a litter layer was not possible.

Alternatively, the correction factors from the MMW series Gleysols will be used to assist in the screening process for the surface litter layers of the MUS series soil.

A majority of the MUS soils encountered were located in drainage swales down gradient of the release location adjacent to the MMW series. Both soil types contained similar surface layering composed of a thin leaf litter layer underlain by a fibric/ mesic peat layer. Separation of these two soil types is based on classification at a depth of >40 cm, which is below the area of interest. Essentially the soil chemistry and composition of these two soils are similar near surface and the utilization of the MMW correction factors for the screening of the thin surface layer chemistry of the MUS series is appropriate.

Due to the high variability in the hydrocarbon analytical results from the organic material found underlying the thin leaf litter layer, a comparison of the MUS series F2-F4 results from the surface peat (0-15 cm) is provided in Table 15. The area specific average was calculated from the surface peat (0-15 cm) depth analyzed from the MMW series area specific controls (317, 323, 325, and 326). The table includes all MUS series F2-F4 results from surface peat samples that were located **under a leaf litter**, the un impacted average F2-F4 values of the MMW series surface peat (0-15 cm) results, and the results of the MUS perimeter control. Due to the leaf litter cover these MUS series surface peat samples are estimated not to have been impacted by the release and the elevated F2-F4 values are thought to be naturally occurring.

Table 15 MUS Series Surface Peat Hydrocarbon Results and Perimeter Sample

Location	F2 (mg/kg)	F3 (mg/kg)	F4 (mg/kg)
Average of area specific MMW controls*	**26**	**945**	**505**
Perimeter Control 262 Of 0-15 cm	<5	2000	980
12 Om 0-15 cm	260	360	660
13 Om 0-15 cm	87	1600	1000
14 Of 0-15 cm	130	1000	2400
114 Of 0-15 cm	<5	200	310
308 Of 0-15 cm	37	1200	830
313 Om 0-15 cm	<5	55	750
314 Of 0-15 cm	60	1200	640

*Average determined based on the F2-F4 results of peat samples (0-15 cm) from MMW series sample points; 317, 323, 325, and 326.

6.2.6 Disturbed Soil Profiles

A total of three locations were collected in areas of disturbed soils located down gradient of the release location (access road right of way). All three samples were collected utilizing sampling methodology #3. Sample sites 128, 225, and 327 were all located within close proximity to the access road and were composed of clay fill material the entire depth of investigation, a sporadic thin dusting of DM was recorded at sites 128 and 327 (Appendix B, Figure 2). Site 327 was analyzed for BTEX, F1-F4 hydrocarbons and detailed salinity in the 0-5 cm and 5-15 cm depths (Appendix C). All parameters analyzed met applicable screening criteria. Elevated sulphate values were recorded at both depth intervals, this material is most likely borrow material collected from lower depths and the elevated sulphates are naturally occurring.

6.2.7 Background Soils - Chromatogram Results

A review of the chromatograms of all sample locations and associated horizons estimated to be un-impacted by the release was carried out. The review focused primarily on the surface litter/peat layer results. Appendix D contains all chromatograms for the investigation divided by soil type.

<u>Background Surface Litter Layer– Luvisols (DOV) & Regosols (MMY)</u>

Both the DOV and MMY series contained leaf litter layers of similar composition. Perimeter and area specific litter layer chromatograms displayed a relatively flat signature with a subdued broad spike from approximately C16 with several narrow sharp defined peaks. The extent and number of the sharp peaks was variable. The underlying mineral horizons displayed relatively flat signatures with sharp short peak s) at approximately C30 - C36 (Appendix D, Dover & McMurray chromatograms).

<u>Background Surface Litter Layer/Surface Peat – Gleysol (MMW) & Organics (MMW)</u>

Both the MMW and MUS series perimeter and area specific litter layer/surface peat layers contained similar material. Chromatograms displayed signatures similar to the DOV and MMY series soils. Due to the increased organic material found in the surface peat layers (Of, Om layers sampled at surface) the sharp peaks recorded between C20 and C40 tended to extend vertically higher then those of the DOV and MMY series chromatograms. (Appendix D, Mamwai & Muskeg chromatograms).

6.3 Displaced Material Characterization

Detailed analyses of the DM were completed characterize the material. A total of 4 DM samples were analyzed for BTEX F1-F4, detailed salinity, trace metals, PAH's and napthenic acids (Appendix C). The four samples were collected in close proximity to the release location in areas with an extensive DM layer (>10 cm) overlying the natural soil.

Results of all analyses indicated consistent exceedances of screening criteria for; SAR, EC, and F2-F4 petroleum hydrocarbons. Elevated levels of sodium and sulphate were also recorded within the DM during the detailed investigation.

Results of the PAH analysis indicated non-detect values for a majority of the PAH parameters. However, due to interference from the hydrocarbons the detection limits were raised for all PAH parameters, various detection limits were at or above various screening criteria. Pyrene values of 0.2 - 0.3 mg/kg were recorded in the four DM samples analyzed from the September 2006 sampling. This result exceeded the 2006 AENV draft screening criteria of 0.033mg/L. An exceedance of 1999 CCME guidelines (0.1 mg/kg) was recorded for Phenanthrene at site 308 DM 20-0 cm (0.4 mg/kg).

No exceedances of screening criteria were recorded for trace metals. Napthenic acid values were variable and within the range of background values. Table 16 displays results form both DM sampling events (May and September 2006), applicable site specific screening criteria, and parameter averages.

Table 16 Displaced Material Analytical Parameters of Concern

Parameter	Pyrene (mg/kg)	F2 (mg/kg)	F3 (mg/kg)	F4 (mg/kg)	SAR	EC (dS/m)	Sodium (mg/L)	Sulphate (mg/L)
AENV 2001	-*	900	800	5600	<4	<2	-	-
AENV 2006	0.033	150	1300	5600	<4	<2	-	-
107 DM 13-7 cm	0.3	720	**13000**	**6500**	**11.9**	1.07	268	382
305 DM2 8-0 cm	0.3	**1200**	**14000**	**6800**	**15.4**	1.98	503	951
308 DM 20-0 cm	0.2	**1200**	**14000**	**7800**	**20.5**	**2.86**	770	1600
109 DM 24-15 cm	0.3	810	**11000**	4800	**7.8**	1.27	292	429
May 2006 Initial DM Analytical Results								
25 m SW of W/C	-**	**1400**	**18000**	**9000**	**40.7**	1.52	396	352
100 m SW of W/C	-**	**1800**	**19000**	**9400**	**35.4**	1.68	471	333
200 m SW of W/C	-**	**1800**	**18000**	**8900**	**28.5**	1.69	507	215
Pipe sample	-**	410	**20000**	**10000**	**43.8**	1.67	484	325
AVERAGES ***	0.28	**1168**	**15875**	**7900**	**25.5**	1.72	461	573

1000 – exceeds 2001 AENV petroleum hydrocarbon criteria.

1000 **–** exceeds 2006 AENV draft petroleum hydrocarbon criteria.

* The AENV 2001 criteria utilize a B(a)P equivalency, the values reported in table 16 do not result in an exceedance of the 2001 criteria.

** Not analyzed for in the May sampling investigation

*** Averages based on all 7 DM samples, samples displaying non-detect values were not included in the averaging.

The estimated extent of area covered b y a consistent layer of DM (> 2cm) is outlined in Appendix B, Figure 4. This area was defined by sample locations with a >2 cm thick DM layer at surface. Although the area of instability was not sampled it is included in the aerial extent based on visual indicators. A total area of 1.9 ha is estimated to contain a consistent DM layer varying in thickness, 0.41 ha of which is the estimated area of instability.

An approximation of the total volume of DM material overlying the soil was estimated to be between 1,400 – 1,700 m^3 and was based on the following assumptions:

- the volume calculated was based on the area of instability and down gradient area displaying a consistent DM cover;

- the estimated volume of DM at surface within the are of instability was based on the average DM thickness at sample sites 307 and 308 (average 16 cm thick DM layer); and
- the estimated volume of the DM layer found down gradient of the release was based on an average depth of the DM layer at all sample locations in which a DM sample was collected (Appendix B, Figure 4).

6.4 DM and Potentially Impacted Soils - Chromatogram Results

A review of the chromatograms of the DM, litter layer/surface peat and underlying horizons was carried out to determine if any specific signatures were associated with the DM and/or potentially impacted soils. Appendix D contains all chromatograms for the investigation divided by soil type.

Displaced Material

The DM chromatograms consistently spiked at approximately C14 and displayed a poorly defined broad peak extending from C14 to approximately C50 (Appendix D, DM chromatograms). Small shallow spikes were recorded along the length of the broad peak and the associated troughs relatively shallow. The signature indicated a consistent homogenous sample of unrefined heavy end hydrocarbons typically >F2 fraction.

Potentially Impacted Chromatogram Signatures

Chromatogram results of surface layers that did not contain similar signatures to the respective background results were deemed as potentially impacted. A majority of the potentially impacted chromatogram results displayed signatures similar to the DM material except the height and slope of the peak between C14 – C50 was not as pronounced. The chromatogram results of potentially impacted soils was used as a tool to assist in correlating findings of the criteria screening process carried out in section 6.5 (Appendix D, Potentially impacted chromatograms).

6.5 Potentially Impacted Surface Litter/Peat Layers – F2-F4 Hydrocarbons

Upon a general review of all soil chemistry and field data; a majority of the subsequent residual impacts was found within the litter layer or thin surface peat layers. The following discussion focuses on the litter layer analytical results. Deeper sample intervals are discussed where applicable.

Determination of soil material that may have been potentially impacted by the release was driven by the analytical results (including chromatograms), implementation of the soil specific correction factors, area specific and perimeter control values and field observations of leaf litter/surface peat horizons collected throughout the study area. Potential hydrocarbon impacted surface litter/peat layers are discussed per soil type and displayed in Appendix B, Figure 4, and all hydrocarbon laboratory results are presented in Appendix C.

6.5.1 Dover Series (DOV) – Luvisols

Utilizing the correction factor calculated for the DOV series all DOV series litter layers were evaluated to estimate potential hydrocarbon impacts. For the DOV series only the litter layer was evaluated as no other areas of concern were recorded below this depth that would indicate potential impacts as a result of exposure to the DM. Table 17 displays corrected chemistry results of locations that contain F2-F4 values above screening criteria. All samples with elevated values of F2-F4 hydrocarbons subsequent to application of the correction factor are displayed in the table.

Table 17 Corrected DOV Series Sample Results Exceeding Screening Criteria

Location	Evidence of DM at Surface	F2 (mg/kg)	F3 (mg/kg)	F4 (mg/kg)
DOV Correction Factors	**-**	**14**	**643**	**743**
107 LFH 10-0 cm	Yes	156	857	237
7 LFH 4-0 cm	Yes	346	9357	4057
9 LFH 4-0 cm	Yes	45	1157	457
204 LFH 4-0 cm	Yes	51	1957	957
208 LFH 4-0 cm	Yes	49	757	117
220 LFH 10-0	No	42	4757	2457
222 LFH 6-0 cm	Yes	<5	1257	557
215 LFH 7-0 cm	Yes	12	3857	1457
319 LFH 4-0 cm	No	15	2957	1157
117 LFH 6-0 cm	Yes	15	2057	657
120 LFH	Yes	<5	957	557
19 LFH 2-0 cm	Yes	14	1657	657
20 LFH 6-0 cm	Yes	38	1657	1857
302 LFH	No	<5	1557	207

6.5.2 Mamwai (MMW) and Muskeg (MUS) Series – Gleysols &Organics

Utilizing the correction factor calculated for the MMW and MUS soil series all applicable sample points were evaluated upon applying the soil specific correction factors. For the MMW and MUS series only the surface litter layer was evaluated as no other areas of concern were recorded below this depth that would indicate potential impacts as a result of exposure to the DM. If there was no surface litter layer present then the surface peat layer (0-15 cm) was utilized, if of concern. Based on the results in Table 15 it is MEMS professional opinion that the sampled peat layer (0-15 cm) underlying the litter layer contains variable F2-F4 results that are found to be naturally occurring and within the range of similar control values. Table 18 displays the corrected results of surface litter layer samples locations that contain elevated F2-F4 values for the MMW and MUS series. All samples with elevated values of F2-F4 hydrocarbons subsequent to application of the correction factor are displayed in the table.

Table 18 Corrected MMW and MUS Series Sample Results Exceeding Screening Criteria

Location	Evidence of DM at Surface	Series	F2 (mg/kg)	F3 (mg/kg)	F4 (mg/kg)
MMW Correction Factors	**-**	**-**	**26**	**945**	**507**
318 LFH 7-0 cm	No	MMW	104	1063	695
310 LFH 5-0 cm	Yes	MUS	62	3363	1395
12 LFH 4-0 cm	Yes	MUS	31	1863	485
13 LFH 2-0 cm	No	MUS	17	3263	1995
14 LFH 2-0 cm	No	MUS	134	2163	1295
114 LFH 5-0 cm	Yes	MUS	414	17063	7495
313 LFH 4-0 cm	Yes	MUS	71	1863	695
314 LFH 4-0 cm	Yes	MUS	194	7063	3995

6.5.3 McMurray (MMY) Series – Regosols

Only two MMY series samples were collected from within the estimated area of impact as this soil type was limited to the Joslyn flood plain. Utilizing the correction factor calculated for the MMY soil series all applicable sample points were evaluated upon applying the soil specific correction factors. For the MMY series only the surface litter layer was evaluated as no other areas of concern were recorded below this depth that would indicate potential impacts as a result of exposure to the DM. Table 19 displays the corrected results of the two sample locations that contain F2-F4 values above screening criteria for the MMY litter layer sample. All samples with elevated values of F2-F4 hydrocarbons subsequent to application of the correction factor are displayed in the table.

Table 19 Corrected MMY Series Sample Results Exceeding Screening Criteria

Location	Evidence of DM at Surface	F2 (mg/kg)	F3 (mg/kg)	F4 (mg/kg)
MMY Correction Factors		**12**	**365**	**455**
16 LFH 2-0 cm	Yes	18	**3800**	1610
217 LFH 6-0 cm	Yes	<5	935	845

All sample locations listed in Tables 17-19 that displayed exceedances of screening criteria are displayed in Appendix B, Figure 4. A majority of the surface impacted layers are found within 150 m down gradient of the release location and contain elevated F3 hydrocarbon results.

6.6 Potentially Impacted Mineral Soils – F2-F4 Hydrocarbons

BTEX F1-F4 hydrocarbons were analyzed within mineral soil horizons at up and down gradient locations. No exceedances of applicable screening criteria were recorded at any of the locations analyzed.

6.7 PAH Results – Mineral and Surface Litter/Peat Layers

PAH's were only analyzed in samples underlying a significant layer of DM (> 2cm). This volume of DM was only recorded in close proximity to the release and are therefore discussed based on location relative to the release and not soil type. Detection limits were raised due to the interference of the hydrocarbons (natural and petroleum). Analysis was completed on surface and underlying mineral horizons (A and C horizons). A majority of the results were non-detect. One Naphthalene exceedance was recorded at site 109 Of 0-15 cm (0.05 mg/kg). PAH analyses was not completed on any of the representative controls, therefore comparison of surface litter/peat layers to applicable PAH screening criteria was completed. This value exceeded the 2006 AENV criteria of 0.026 mg/kg (Appendix C, PAH results). This sample interval underlies a 9cm thick seam of DM.

6.8 Napthenic Acids – Mineral and Surface Litter/Peat Layers

Total napthenic acids were analyzed at various locations in close proximity to the release location in surface samples underlying a significant DM layer (>2 cm). A total of nine samples were analyzed, the results varied depending on the depth interval analyzed. The range of results for the surface litter/peat layers (organic material) was between 410-3900 mg/kg (6 samples). The underlying mineral material (3 samples) ranged from 52-99 mg/kg. A MUS series perimeter control displayed a result of 4400 mg/kg in the surface organic layer. A DOV series perimeter control litter layer contained 7700 mg/kg and the underlying mineral horizon contained 73 mg/kg (Appendix C, DOV series results). The range of results recorded down gradient of the release appears to lie within the natural variability for the area.

6.9 Salinity

6.9.1 Surface Litter/Peat Layers

SAR results above typical background values were found in samples immediately underlying a significant DM layer (> 2cm). Two locations in close proximity to the release; site 107 LFH 7-0 cm and site 308 Of 0-15 cm contained SAR values of 5.8 and 15.6 respectively (all background results <4 SAR). Additionally, sodium and sulphate values of these samples and a majority of the other surface litter/peat samples collected in close proximity of the release with an overlying DM layer were elevated with respect to the control values (Appendix C). Table 20 summarizes the elevated SAR values as well as a comparison of the elevated sodium and sulphate values from the surface litter/peat samples collected in close proximity to the release point.

Table 20 Soil Salinity Screening Results

Parameter	**Dov Series Soils – Surface Chemistry**		**MUS Series Soils – Surface Chemistry**	
Site locations	Average DOV control values-surface layers*	107 LFH 7-0 cm	Average MMW control values-surface layers**	308 Of 0-15 cm
SAR	0.4	5.8	0.2	15.6
Sodium (mg/L)	4	180	4	137
Sulphate (mg/L)	54	220	26	254

* Average DOV values based on the analytical results from the area specific controls (103, 124, 213, and 322).
** Average MUS values based on the analytical results from the MMW area specific controls (323 and 326).

6.9.2 Mineral Soils

Detailed salinity was analyzed at various mineral sample depths up and down gradient of the release location. No exceedances of applicable screening criteria were recorded for any of the samples analyzed.

6.10 Trace Metals - Mineral and Surface Litter/Peat Layers

Trace metals were analyzed at various locations up and down gradient of the release location. No exceedances of applicable screening criteria were recorded for any of the samples analyzed.

6.11 Site Specific Analytical Anomalies

The LFH sample form Site 114 (Appendix B, Figure 2) contained F1-F4 analytical results that were not consistent with the contaminant characteristics of the DM. The F1 fraction (510 mg/kg) was elevated in comparison to all background results, and exceeded both the AENV 2001 and 2006 applicable screening criteria. The underlying sample displayed analytical results typical of the MUS series, BTEX and F1 values were both non-detect. The elevated F1 results are seen as a localized anomaly, no adjacent sample points contained elevated F1 results.

7.0 DISCUSSION OF RESULTS

7.1 Mineral Soils Discussion

Based on the soils control data, comparison of BTEX, F1-F4 hydrocarbons, detailed salinity, trace metals, PAH's, and napthenic acids against applicable screening criteria and representative background chemistry, and a review of all collected field data the following conclusions can be made regarding the mineral soil profiles investigated:

- Four distinct soil series and variants were identified in the area potentially impacted by the release. Three of the soil types identified contained mineral soil profiles within the depth of investigation, and included; Regosols (McMurray series), peaty and non-peaty Gleysols (Mamwai series), and Luvisols (Dover series).
- All mineral soils (excluding the disturbed samples) investigated during the delineation investigation contained a litter layer overlying the mineral profile that was typically > 2 cm thick.
- All mineral soil hydrocarbon analytical results met applicable AENV 2001 and 2006 draft soil screening criteria.
- All salinity related analytical parameter met applicable screening guidelines (SAR and EC). A wide range of pH values were recorded, a majority of which were slightly acidic. Typically, surface mineral horizons of Luvisolic soils in the region are acidic and decrease in acidity with depth (ASIC 2001).
- Total napthenic acid results from the mineral profiles located in close proximity to the release location displayed relatively low levels anticipated not to be of environmental concern (52-99 mg/kg).
- No trace metal or PAH results exceeding the applicable screening criteria were recorded during the investigation in any of the mineral soil profiles investigated.

7.2 Surface Litter/Peat Layer Discussion

Based on the utilization of soil specific correction factors (F2-F4 hydrocarbon fractions), soils control data, an evaluation of representative background soil chemistry, and a review of all collected field data the following conclusions can be made:

- Four distinct soil series and variants were identified in the area potentially impacted by the release. Soils include; Regosols (McMurray series), peaty and non-peaty Gleysols (Mamwai series), Organics (Muskeg series), and Luvisols (Dover series). All four soil types contained a discernable surface litter/peat layer at a majority of sample locations.
- All surface litter/peat layers analyzed were compared to representative background results of a similar soil type as opposed to the screening criteria used to evaluate the

mineral soils. Organic and litter layer results are reported and discussed but not compared to screening criteria as soil criteria are not applicable to this medium.

- A high percentage of surface material encountered throughout the investigation contained organic material (twigs, leaf litter, roots, decomposed litter and/or surface peat). In order to estimate natural versus petroleum hydrocarbon results in the surface layer a petroleum hydrocarbon correction factor (based on background analytical) was utilized for each soil type to adjust surface sample results. All F2-F4 values were corrected and evaluated to determine if hydrocarbon results were indicative of a potential impact resulting from the steam release.
- Sample locations down gradient of the release location contain elevated F2-F4 petroleum hydrocarbons upon application of the appropriate correction factors. A majority of the elevated results are in the F3 fraction, occur immediately down gradient from the release, and are found in the surface litter layer overlying either organic or mineral soils. Based on the site specific risk assessment and proposed mitigative measures a portion of these locations may require site remediation or monitoring to address the impacted soil material at surface.
- Elevated SAR results were recorded in close proximity to the release location (2 sample points) and were recorded within surface layers found underlying significant DM layers. SAR related issues are isolated to the release location (<25 m from the center of the release), remained near surface, typically contained elevated sodium and sulphates above typical background values and were located in sample sites with elevated petroleum hydrocarbon results. Based on the site specific risk assessment and criteria development these locations may require site remediation to address the SAR impacted soil material at surface.
- An elevated F1 result was recorded down gradient of the release (approximately 150 m, site 116). This anomaly appears to be an isolated occurrence unrelated to the steam release.
- One PAH exceedance (Napthalene) was recorded in close proximity to the release location in an area with hydrocarbon and SAR impacted surface soils. PAH screening criteria were utilized for screening of the surface litter/peat layers as no appropriate control data for PAH’s was available.
- Total napthenic acid results from the release location displayed a range of results all of which is less then the background value recorded.
- No elevated trace metals were recorded during the investigation in any of the surface samples collected.

7.3 Displaced Material Discussion

Upon review of all soil chemistry, applicable screening criteria, field notes and previous site investigations the following statements regarding the DM can be made:

- Further delineation of the DM material from four samples at the release location indicated elevated F2-F4, SAR, and EC results above applicable soil screening criteria. Sodium and sulphate values above typical soil background values were also recorded. The analytical results collected from the September 2006 investigation displayed decreased chloride and sodium levels as compared to the initial DM sampling completed in May 2006.
- The DM was found predominantly down gradient of the release location. The extent and frequency of the DM on the ground surface dissipated with distance from the release location.
- A refined visual plume of the estimated dispersion path was determined based on visual indicators during the September 2006 investigation. The revised visual plume is slightly narrower and shorter then the estimated area of impact reported in May 2006 (Appendix B, Figure 2).
- An estimated 1.9 ha of area in close proximity to the release location is covered by a consistent DM layer a minimum of 2 cm thick (Appendix B, Figure 4).
- Based on the aerial extent of the DM layer (minimum 2 cm thick), between 1,400 – 1,700 m^3 of DM material is estimated to overly the ground surface immediately down gradient of the release location.

8.0 CLOSURE

The soil assessment methodologies, delineation findings and risk assessment investigation completed provide sufficient information to carry out site specific remedial activities. If you have any questions concerning this report please contact the undersigned at (780) 496-9048.

Yours truly,

Millennium EMS Solutions Ltd.

Reviewed by:

Ryan Muri, B.Sc., P.Ag.
Environmental Scientist

Ian Terry, P.Eng.
Principal

9.0 REFERENCES

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Alberta Environment. 2002. Frequently Asked Questions on the Remediation and Reclamation of Soil and Groundwater. Alberta Environment, Edmonton, Alberta. Report No. SSB/LM/02-2, ISBN: 0-7785-2273-3 (Printed Edition); 0-7785-2275-X (On-line edition), Publication No: I/915. 51 pp.

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SCWG (Soil Classification Working Group). 1998. The Canadian System of Soil Classification. Agric. and Agri-Food Can. Publ. 1646 (Revised, 3rd Edition). 187 pp.

APPENDIX A: RELEVANT BACKGROUND DOCUMENTS

DEER CREEK
Energy Limited

May 25, 2006

Ernie Hui, Regional Director
Northern Region, Alberta Environment,
Twin Atria
#111, 4999 – 98 Ave.
Edmonton T6B 2X3
Ph: (780) 422-4505
Fax: (780) 427-3178

Attention: Mr. Hui

**RE: Deer Creek Energy Limited/Total E&P Canada – Joslyn SAGD Project
May 18 Steam Release Incident – AENV Reference Number 171389**

Deer Creek Energy Ltd (DCEL), a wholly owned subsidiary of Total E&P Canada, advises that an incident occurred at its Joslyn Creek SAGD facility, 60 km North of Fort McMurray, on May 18, 2006 at 5:15am.

A release of steam occurred from underground, unsettling the ground and a few trees over a distance of approximately 100 metres nearby. Steam was released to the atmosphere for approximately 5 minutes.

No injuries occurred as a result of this incident and there was no harmful gaseous emission into the atmosphere.

Both the injector and the producer wells were immediately shut down and pressures were reduced in neighbouring wells, which are currently undergoing steam circulation. All wells are secured.

The causes of the incident are currently under investigation. The Alberta Energy and Utilities Board and Alberta Environment were immediately informed, as was the neighbouring community of Fort McKay. DCEL held a meeting with the Fort McKay IRC and the Chief on Wednesday, May 24.

As a result of the steam release incident, DCEL undertook a water and soil monitoring program as well as monitoring some of the piezometers located in the vicinity of the incident on May 20. The monitoring sites are shown on Figure 1.

In addition, to control potential runoff, DCEL installed some ditch blocks and straw bales along the access road near the Joslyn Creek crossing to ensure containment of potential movement of hydrocarbons. Sorbent booms were also installed on Joslyn Creek downstream of areas affected by the deposition of the sand/shale/bitumen materials. DCEL continued to monitor the area and took additional water samples from the Joslyn Creek on May 21, 22 and 23 during which time, a significant amount of precipitation occurred. During this period DCEL did not observe any visible sheen entering or on the Joslyn Creek at any location. The water samples are currently being analyzed at the lab.

DCEL is in the process of analyzing the preliminary lab results from the sampling program at this time. The preliminary analytical data from sampling completed on Joslyn Creek and the displaced sand/shale/bitumen associated with the release indicate that:

- There has been no change in water quality within Joslyn Creek;
- The displaced soil meets applicable criteria for soil conductance;
- The displaced soil meets applicable criteria for trace metals;
- The displaced soil meets applicable criteria for light end hydrocarbons (BTEX and F1);
- The displaced soil contains concentrations of heavy end hydrocarbons (F2 – F4) that exceed applicable criteria; and
- The displaced soil contains elevated concentrations of sodium which causes the soil to have a SAR value that exceeds applicable criteria.

The preliminary interpretation of the above initial results is that the parameters of concern identified in the displaced soil would tend to possess low mobility in the environment. Control of erosion of the displaced soil and management of its relocation during reclamation work are recommended to be implemented based on these results.

When complete, DCEL will provide a full assessment of the soil and water analysis and recommendations for further assessment or clean-up.

If you have any questions in this regard, please contact the undersigned (403) 538-6368.

Yours truly,

Deer Creek Energy Limited

Don Verdonck

Don Verdonck
General Manager, Operations

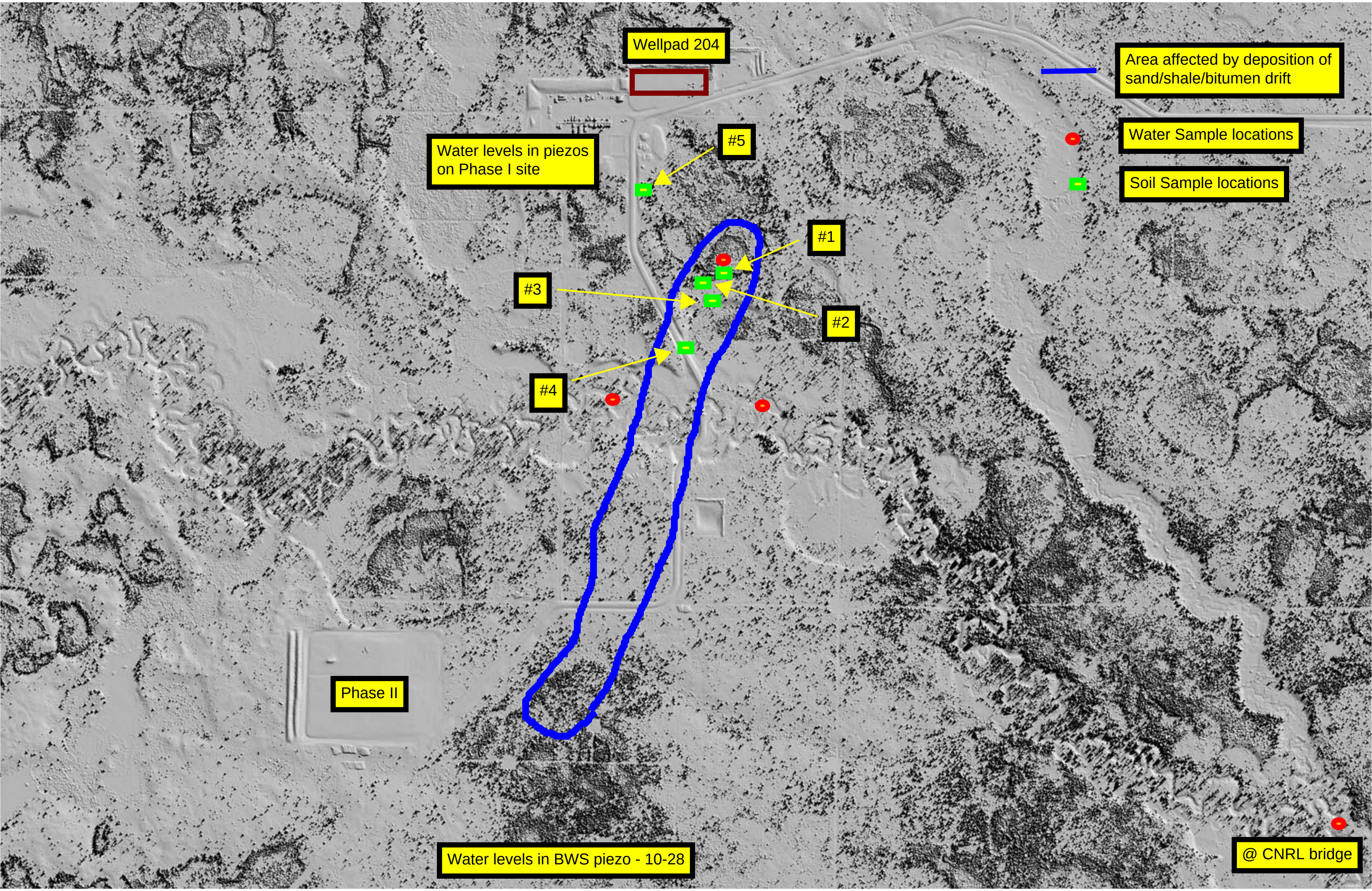

Figure 1 - Locations of Soil, Water and Groundwater Monitoring related to the Steam Release Incident

ETL Enviro·Test LABORATORIES

AUTO - EMAIL EMERGENCY CHEMICAL ANALYSIS REPORT

MILLENNIUM
ATTN: DANE MCCOY

208 4207 98 ST

EDMONTON AB T6E 5R7

Report On: 24-MAY-06 05:22 PM

Lab Work Order #: **L390729**

Date Received: **23-MAY-06**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 230126

Other Information:

Comments:

DOUG JOHNSON
Director of Operations, Edmonton

KAREN HUEBNER
Account Manager

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-1	JOSLYN CREEK U/S								
Sampled By:	CW on 20-MAY-06 @ 00:00								
Matrix:	WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)									
F2 (>C10-C16)									
	F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr:	2-Bromobenzotrifluoride	105		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr:	Hexatriacontane	80		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)									
	Benzene	0.0010		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	Toluene	0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	Xylenes	0.0006		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME									
Total Trace Metals									
	Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
	Aluminum (Al)	1.32		0.01	mg/L		22-MAY-06	QLI	R401078
	Arsenic (As)	0.0034		0.0004	mg/L		22-MAY-06	QLI	R401078
	Boron (B)	0.21		0.05	mg/L		22-MAY-06	QLI	R401078
	Barium (Ba)	0.049		0.003	mg/L		22-MAY-06	QLI	R401078
	Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
	Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
	Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
	Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
	Copper (Cu)	0.004		0.001	mg/L		22-MAY-06	QLI	R401078
	Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
	Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
	Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
	Nickel (Ni)	0.006		0.002	mg/L		22-MAY-06	QLI	R401078
	Lead (Pb)	0.0012		0.0001	mg/L		22-MAY-06	QLI	R401078
	Antimony (Sb)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078
	Selenium (Se)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078
	Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
	Titanium (Ti)	0.053		0.001	mg/L		22-MAY-06	QLI	R401078
	Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
	Uranium (U)	0.0025		0.0001	mg/L		22-MAY-06	QLI	R401078
	Vanadium (V)	0.006		0.001	mg/L		22-MAY-06	QLI	R401078
	Zinc (Zn)	0.007		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals									
	Calcium (Ca)	50.0		0.5	mg/L		23-MAY-06	SYF	R401153
	Potassium (K)	3.3		0.1	mg/L		23-MAY-06	SYF	R401153
	Magnesium (Mg)	13.5		0.1	mg/L		23-MAY-06	SYF	R401153
	Sodium (Na)	34		1	mg/L		23-MAY-06	SYF	R401153
	Iron (Fe)	4.03		0.005	mg/L		23-MAY-06	SYF	R401153
	Manganese (Mn)	0.094		0.001	mg/L		23-MAY-06	SYF	R401153
	SAR	1.1			SAR		23-MAY-06		
Routine Water Analysis									
	Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
	Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
	Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
	Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity									

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-1 JOSLYN CREEK U/S								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
Routine Water Analysis								
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	445		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	170		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	139		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	106			%		23-MAY-06		
TDS (Calculated)	272			mg/L		23-MAY-06		
Hardness (as CaCO3)	174			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	48.2		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.8		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	13.1		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	33		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	87.3		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-2 JOSLYN CREEK D/S								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	100		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	114		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	1.56		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0032		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.21		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.046		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.006		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0010		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-2 JOSLYN CREEK D/S								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
Total Metals - CCME								
Total Trace Metals								
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.050		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0023		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.007		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	<0.004		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	46.3		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.1		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	12.5		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	31		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	3.98		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.085		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.0			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	457		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	172		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	141		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	102			%		23-MAY-06		
TDS (Calculated)	265			mg/L		23-MAY-06		
Hardness (as CaCO3)	167			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	46.2		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.6		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	12.6		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	31		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	83.7		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	98		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	84		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	1.03		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0028		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.22		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.041		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.005		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0008		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.034		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0024		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.005		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	<0.004		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	47.1		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.0		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	12.6		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	31		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	3.21		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.058		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.0			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	8.2		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	459		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	177		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	145		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	97.3			%		23-MAY-06		

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
Routine Water Analysis								
Ion Balance Calculation								
TDS (Calculated)	261			mg/L		23-MAY-06		
Hardness (as CaCO3)	163			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	45.0		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.5		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	12.2		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	29		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	81.1		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-4 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	99		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	87		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	2.33		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0014		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.25		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.061		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.05		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0007		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0008		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0013		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.071		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0047		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.007		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	0.036		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	54.2		0.5	mg/L		23-MAY-06	SYF	R401153

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-4 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
Total Metals - CCME								
Total Major Metals								
Potassium (K)	3.7		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	27.4		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	46		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	1.26		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.056		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.3			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	6		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	7.4		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	560		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	246		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	202		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	109			%		23-MAY-06		
TDS (Calculated)	329			mg/L		23-MAY-06		
Hardness (as CaCO3)	223			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	48.8		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	3.9		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	24.6		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	43		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	81.0		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-5 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL #1								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	1400		5	mg/kg		24-MAY-06		
F3 (C16-C34)	18000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	9000		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	28000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	2.6		0.1	%		23-MAY-06	DDU	R401577

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-5 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
MUST PSA % > 75um	60		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.1		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	62		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	10.7		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	12		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	16		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	6		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.6		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	26		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	230		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	352		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	42.3		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.6		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.52		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	7		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	396		2	mg/L		23-MAY-06	JWU	R401341
SAR	40.7	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-6 SW W/C ~ 100 M								
Sampled By: CW on 20-MAY-06 @ 00:00 #2								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	1800		5	mg/kg		24-MAY-06		
F3 (C16-C34)	19000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	9400		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	30000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-6 SW W/C ~ 100 M								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	6.2		0.1	%		23-MAY-06	DDU	R401577
MUST PSA % > 75um	57		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	5.3		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	71		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	8		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	12.6		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	15		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	25		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	8		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.7		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	28		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	270		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	333		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	40.6		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.5		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.68		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	13		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	471		2	mg/L		23-MAY-06	JWU	R401341
SAR	35.4	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-7 SW W/C ~ 200 M #3								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-7 SW W/C ~ 200 M								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	1800		5	mg/kg		24-MAY-06		
F3 (C16-C34)	18000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	8900		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	29000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	2.5		0.1	%		24-MAY-06	REK	R401573
MUST PSA % > 75um	52		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	60		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	10.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	13		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	17		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	7		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.6		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	24		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	300		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	215		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	51.9		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.4		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.69		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-7 SW W/C ~ 200 M								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
Detailed Salinity								
SAR								
Calcium (Ca)	17		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	7		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	4		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	507		2	mg/L		23-MAY-06	JWU	R401341
SAR	28.5			SAR		23-MAY-06	JWU	R401341
L390729-8 PIPE SAMPLE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs #4								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	410		5	mg/kg		24-MAY-06		
F3 (C16-C34)	20000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	10000		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	30000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	0.8		0.1	%		23-MAY-06	DDU	R401577
MUST PSA % > 75um	58		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.9		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	58		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	9.3		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	11		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	15		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	6		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.5		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-8 PIPE SAMPLE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
Metals in Soil - CCME List								
Vanadium (V)	24		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	30		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	290		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	325		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	53.6		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.2		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.67		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	9		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	484		2	mg/L		23-MAY-06	JWU	R401341
SAR	43.8	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-9 CONTROL								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL #5								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-MAY-06		
F3 (C16-C34)	340		5	mg/kg		24-MAY-06		
F4 (C34-C50)	310		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	650		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	181	G	70-130	%	23-MAY-06	23-MAY-06	AAT	R401937
Surr: Hexatriacontane	111		70-130	%	23-MAY-06	23-MAY-06	AAT	R401937
Prep/Analysis Dates					23-MAY-06	23-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	3.4		0.1	%		23-MAY-06	DDU	R401577
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	5.8		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	99		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	18.9		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	13		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	18		2	mg/kg		23-MAY-06	QLI	R401079

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-9 CONTROL								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
Metals in Soil - CCME List								
Lead (Pb)	9		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.5		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	31		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	60		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	1470		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	41.5		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	7.4		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	2.12		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	377		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	4		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	149		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	118		2	mg/L		23-MAY-06	JWU	R401341
SAR	1.3			SAR		23-MAY-06	JWU	R401341
L390729-10 JOSLYN CREEK D/S MAY 21								
Sampled By: NOT PROVIDED on 21-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005	RAMB	0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Routine Water Analysis								
L390729-11 JOSLYN CREEK D/S MAY 22								
Sampled By: NOT PROVIDED on 22-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Routine Water Analysis								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-12 JOSLYN CREEK D/S MAY 23								
Sampled By: NOT PROVIDED on 23-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Routine Water Analysis								

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
G	Outlier - No assignable cause for nonconformity has been determined.
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank
SAR:Q	Qualified SAR value: actual SAR is lower but is incalculable due to Na, Ca or Mg below detection limit.
SDO:RNA	Surrogate diluted out:% recovery not available

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BTX,F1-ED	Water	BTEX and F1 (C6-C10)	EPA 5030	EPA 5030/8015&8260-P&T GC-MS & FID
BTX-TCLP-ED	Waste	TCLP Leachable BTEX	EPA 5030	EPA 5030/8015& 8260-P&T GC-MS/FID
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
ETL-SAR-ROU-ED	Water	SAR with Routine Analysis		CSSS 18.4-Calculation
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
F2-ED	Water	F2 (>C10-C16)		EPA 3510/8000-GC-FID
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MET1-TOT-CCME-ED	Water	Total Trace Metals	EPA3015	EPA 6020
MET2-TOT-LOW-ED	Water	Total Major Metals	EPA3015	EPA 200.7
METAL-CCME-ED	Soil	Metals in Soil - CCME List	EPA 3050	EPA 6020
N2N3-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3H-Colorimetry
NO2-ED	Water	Nitrite-N		APHA 4500 NO2B-Colorimetry

Reference Information

NO3-ED	Water	Nitrate-N	APHA 4500 NO3H-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity	APHA 4500-H, 2510, 2320
PREP-MOISTURE-ED	Soil	% Moisture	Oven dry 105C-Gravimetric
PSA-MUST-ED	Soil	MUST PSA D50 > 75um	ASTM D422-63-Hydrometer/Sieve
SAR-CALC-ED	Soil	SAR	CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)	CSSS 18.2, 16.2, 18.3
SO4-SAR-ED	Soil	Sulfate (SO4) in saturated paste	APHA 3120 B-ICP-OES

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

230126

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
< - Less than
D.L. - Detection Limit
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

DCEL
Steam Release Incident
LSD 09-33-095-12-W4M

Prepared for:
Deer Creek Energy

Prepared by:
Millennium EMS Solutions Ltd.
#208, 4207 – 98 St
Edmonton, Alberta
T6E 5R7

September, 2006
File #04-101

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1.0 INTRODUCTION

1.1 Overview of Steam Release Incident

The Deer Creek Energy Limited (DCEL) Joslyn Project is located approximately 60 km North of Fort McMurray, west of the Athabasca River. This phase of the SAGD facility started injecting steam into the reservoir on April 15, 2006. The plant circulated steam for approximately one month and then started producing bitumen. Three days later, on May 18th, 2006 at 5:15am, a steam release was discovered over well pair 204-P1 (Figure 1.1). The Energy and Utilities Board (EUB) in Bonnyville and Alberta Environment were notified immediately after control of the release was obtained.

Deer Creek Energy Limited, a subsidiary of Total E&P Canada Ltd. (TEPC) conducted a preliminary assessment of the incident which was provided to the EUB for review. The preliminary information suggests that the reservoir was over pressurized causing a local fracture. The steam vented to surface through a vertical fracture releasing to the atmosphere. The incident investigation is on-going and TEPC would like to perform a 2D and a 3D geophysical program over the impacted area to help provide a scientific explanation as to the cause of the release and determine the structural impacts the release may have had on the subsurface environment. TEPC will ensure that both the EUB and Alberta Environment are provided a summary of all new findings that the investigation reveals. A document which presents additional findings acquired to date is in the preliminary draft stage and will be released upon completion near the end of October, 2006.

1.2 Objectives

The objectives of this submission to AENV are to:

1. Provide a description of the physiographic setting of the study area to AENV;
2. Provide a description of the steam release event and the current level of understanding of the causes / effects of the steam release;
3. Provide the results of the environmental monitoring completed to date associated with the steam release;
4. Present the proposed scope and methodology of the environmental characterization and risk assessment that will be completed within the study area; and
5. Seek comments from AENV in regard to the above in order to increase DCEL's confidence that the work proposed is comprehensive and addresses all of the foreseeable areas of environmental concern relating to the steam release.

2.0 PHYSIOGRAPHIC SETTING

2.1 Topography

The landscape within the SAGD area varies from flat to gently rolling, and much of it is of low relief Figure 2.1. Greatest relief, usually in the order of three to five metres, is found along drainage courses and around small lakes.

At the steam release point and the area down-gradient of the steam release, the area is generally upland. The exceptions are small localized muskeg areas located immediately west of the release point (Figure 2.2). The relief from the steam release point to Joslyn Creek is approximately 3 – 5 m over a distance of ~ 350m.

2.2 Surface Water

The DCEL lease is transected by two major streams – the Ells River and Joslyn Creek, a major tributary of the Ells. The SAGD Phase II operations are entirely within the Joslyn Creek Watershed.

DCEL has conducted sampling of the Joslyn Creek during baseline data collection for a number of regulatory applications. Water in Joslyn Creek is slightly alkaline, with total alkalinity, conductivity, and concentrations of total dissolved solids generally highest in winter. In general the dissolved salt concentrations at the upper Joslyn Creek station (west of the Joslyn Creek crossing) have ranged from 310 – 601 mg/L and at the lower Joslyn Creek station(at mouth) ranged from 310 – 512 mg/L.

Generally, organic parameters such as hydrocarbons, naphthenic acids, and phenols were low in Joslyn Creek. Historical concentrations of oil and grease, measured over the period from 1976 to 1979, ranged from <0.1 mg/L to 1.5 mg/L. Since baseline data collection began the recoverable hydrocarbon concentrations have been below the detection limit.

2.3 Geologic Setting

Within the project area, the total overburden thickness is approximately 40 to 60 m with 20 to 30 m being the shales of the Clearwater Formation while the remaining sediments are Pleistocene tills. A quaternary cross section and bore hole logs from the area surrounding the point of release are included as Appendix A. Further drilling currently underway and will be used to determine the geological setting in the immediate area of the steam release.

The Clearwater Formation is fully marine in nature. It consists predominantly of marine shales which do not contain bitumen and are considered a barrier to fluid flow. The Wabiskaw Member of the Clearwater Formation directly overlies the McMurray formation and is comprised of shales, silts and very fine grained sands. These sands can contain low grades of bitumen. Reservoir quality and thickness within the Wabiskaw member are poor and do not contribute to the in-situ recovery of bitumen.

The McMurray Formation is present from approximately 40 to 60 m below ground level to 115 m depth. The McMurray Formation is comprised of stacked fluvial-estuarine sands and off channel silts and shales. The sands of the McMurray Formation are 90 to 95% quartz. The McMurray Formation was deposited during a rise in sea level caused by transgression of the Clearwater Sea from the north. This interplay between rising sea level and sediment transport from the northeast gave rise to various depositional environments which are described within the McMurray as three informal members including the Lower, Middle and Upper McMurray. These informal divisions correspond to changes in the depositional environments within the McMurray from fluvial at the base (Lower Member) to estuarine in the middle (Middle Member) to marginal marine at the top (Upper Member).

The Lower McMurray, where present, is comprised of predominantly fluvial channel deposits. These channels have in-filled lows on the Devonian (Paleozoic) surface resulting in thicker McMurray intervals. The Lower McMurray sands are up to 20 m thick, coarse to medium grained, and bitumen saturated, making them an excellent ore body.

The Middle McMurray is comprised of thick estuarine channel successions and tidal flat deposits resulting in interbedded sands and muds. The estuarine channel sands provide good quality reservoirs. They contain medium to very fine-grained sands and channel thicknesses range from 10 to 35 m. Stacked channel deposits, which reflect a preferred pathway for the fluvial-estuarine system, form the thickest reservoirs. In the SAGD development area the stacked channel complex runs in a NW to SE direction.

The Upper McMurray is composed of fine to very fine-grained, finely laminated, upward coarsening sands with considerable marine influence.

The depth of the prospective Middle McMurray SAGD zone is approximately 65 to 110 m. The non-pay McMurray sediments that overlie the intended steam chamber consist of 20 to 25 m of interbedded sands and shales of largely estuarine origin. The shale content in these interbeds increases vertically along with a decrease in vertical permeability. The combination of this upward sequence in the McMurray and the shaley overburden beds of the Clearwater formation create a barrier that will prevent upward hydraulic flow of the steam chamber.

The underlying shales and limestones of the Waterways Formation do not contain bitumen and are a barrier to fluid flow.

2.4 Hydrogeologic Setting

There are no aquifers present in the vicinity of the steam release. Investigations related to the Pilot Plant, the Phase 1 and Phase 2 plants, and lease work in general has determined that:

- The glacial drift is comprised of clay till.
- The Wabiska Member of the Clearwater Formation is not an aquifer.

Groundwater flow is generally from west to east toward the Athabasca River. Hydraulic heads tend to be close to the surface in piezometers completed in geological units above the McMurray Formation. The hydraulic head at the base of the McMurray Formation is approximately 30 m below the head in the overlying Quaternary or Clearwater Formation.

Total dissolved solids (TDS) concentrations at the base of the McMurray Formation are in excess of 20,000 mg/L in the northwest portion of the lease and decline to values below 15,000 mg/L in the southeast portions of the lease.

Where the Clearwater is present in significant thickness, as found near the steam release site, the TDS in the surficial materials is significantly elevated as compared to where it is thin or absent. Ionic make up in the Quaternary is calcium/magnesium sulphate while in the Clearwater Formation, in Range 12, the ionic make up is sodium bicarbonate/sulphate

Samples of water from the piezometers were collected in 2004 and subject to analysis for trace organics and dissolved metals. The organic suite consisted of F1 and F2 hydrocarbons, BTEX and phenols. None of these parameters occurred in concentrations that are environmentally significant.

In accordance with the Environmental Protection and Enhancement Act approval for the SAGD operations a groundwater monitoring plan has been developed, accepted and implemented for the Phase I and II plant sites.

The natural groundwater chemistry of the Phase I plant site has TDS, sodium, sulphate and chloride in the ranges of 4,500 to 6,000; 1,200 to 1,300; 1,400 to 2,900 and 140 to 320 mg/L respectively. Monitoring wells closer to the storm water pond show TDS, sodium, sulphate and chloride in the ranges of 540 to 2,800; 120 to 690; 22 to 260 and 20 to 140 mg/L respectively. This appears to reflect infiltration of relatively fresh water from the stormwater pond. Naphthenic acids analysis values range from 1 to 4 mg/L.

The natural groundwater chemistry of the Phase II plant site shows TDS, sodium, sulphate and chloride in the ranges of 3,900 to 6,100; 600 to 1,100; 2,100 to 2,900 and 70 to 140 mg/L respectively.

BTEX have not been detected in the groundwater monitoring wells at either of the plant sites. Phenols in shallow groundwater at the two plant sites are commonly undetectable (LT 0.001 mg/L) however concentrations as high as 0.007 mg/L have been observed.

In summary, the hydrogeological regime in the vicinity of the steam release, based on current information, is as follows:

- It does not appear that there are any significant aquifers present above the McMurray Formation; a 1m thick sand seam over the Clearwater formation has been identified locally at one location.
- The quality of water in the glacial drift is poor and exceeds potable drinking water quality objectives.
- On a more regional basis:
  - Groundwater flow above the oil sands is generally west to east down the regional topographic gradient. Locally, creeks and rivers deflect this pattern.
  - Groundwater tends to flow downward through the oil sands. The volume of this flow is not substantial because of the generally low hydraulic conductivity caused by the oil.
  - Flow in the basal water sand of the McMurray Formation is primarily horizontal and generally trending toward the Athabasca River but through a route that appears very circuitous because of the lobate nature of the deposit.

3.0 STEAM RELEASE INCIDENT

3.1 Description of Incident

On May 18, 2006 at 5:15am a release of steam occurred from underground, unsettling the ground and vegetation over a distance of approximately 100 metres nearby. Steam was released to the atmosphere for approximately 5 minutes.

No injuries occurred as a result of this incident and there was no harmful gaseous emission into the atmosphere.

Both the injector and the producer wells were immediately shut down and pressures were reduced in neighbouring wells, which are currently undergoing steam circulation. All wells are secured.

The Alberta Energy and Utilities Board and Alberta Environment were immediately informed, as was the neighbouring community of Fort McKay. DCEL held a meeting with the Fort McKay IRC and the Chief on Wednesday, May 24.

3.2 Current Understanding of Causes

Our conclusions to date while preliminary are that well 204-I1 was operated at steam pressures, during the injection phase, that exceeded the local fracture gradient, and steam was released via a vertical fracture that propagated to surface. The nearby observation well and corehole may have played a role in providing a conduit of pressure to the caprock. However, the integrity of the observation well is intact and the core hole is not, as yet, located.

3.3 Area Effected by the Steam Release

As pressure was released from the steam chamber, subsurface material including oil sands was released to the atmosphere. The majority of this displaced material was deposited to the immediate area but evidence of a fine dusting of material and rock was detected up to 1 km southwest of the release point (Figure 3.1). Displacement of the material resulted in a surface disturbance of 125 m by 75 m (Figure 3.2).

4.0 ENVIRONMENTAL MONITORING CONDUCTED SUBSEQUENT TO STEAM RELEASE

As a result of the steam release incident, DCEL undertook a soil, surface water and groundwater monitoring program. The monitoring sites are shown on Figure 4.1.

In addition, to control potential runoff, DCEL installed ditch blocks and straw bales along the access road near the Joslyn Creek crossing to ensure containment of potential movement of hydrocarbons. Sorbent booms were installed on Joslyn Creek downstream of areas affected by the deposition of the sand/shale/bitumen materials. DCEL continued to monitor the area and took additional water samples from the Joslyn Creek on May 21, 22 and 23 during which time, a significant amount of precipitation occurred. During this period DCEL did not observe any visible sheen entering or on the Joslyn Creek at any location.

The environmental quality of the soil displaced as a result of the steam release is included in Appendix B, Table B.1 and has been characterized as:

- containing elevated concentrations of petroleum hydrocarbons (specifically fractions F2, F3 and F4); and
- containing an elevated sodium absorption ratio (ratio of sodium to calcium and magnesium).

The soil monitoring that has been completed to date has identified a maximum thickness of displaced soil at the steam release point of approximately 15 cm. The thickness quickly dissipates away from the release point such that the majority of the area affected has had a ‘dusting’ of soil ranging from 1 to 10 mm thick.

Water quality monitoring was conducted on Joslyn Creek on the days and weeks following the release (Appendix B, Table B.2). No measurable change in water quality was observed in this monitoring.

Groundwater levels were obtained from the existing piezometers on the Phase I plant site. There has been no change in water levels due to the steam release incident.

The soil and water quality sampling that has been completed to date is viewed as providing a good understanding of the environmental issues and allows for planning of future detailed soil and water sampling to delineate the environmental effects of the steam release.

5.0 ENVIRONMENTAL SITE CHARACTERIZATION PROPOSAL

The existing soil and water analytical results indicate that the potential contaminants of concern associated with the release are not highly mobile in the subsurface nor are they prone to leaching into surface water systems. The potential contaminants of concern are:

1. elevated concentrations of petroleum hydrocarbons (specifically fractions F2, F3 and F4); and
2. elevated sodium adsorption ratio.

The preliminary site reconnaissance and the soil sampling and analysis program, has resulted in the determination of the extent of the distribution of the displaced soil in the area of the steam release. This provided the initial qualitative results for contaminant species and quantitative results for concentrations of the species within the displaced soil. As stated in section 4, there are areas where the displaced soil contains elevated petroleum hydrocarbon concentrations in the F2 to F4 fractions and in some areas an elevated sodium adsorption ratio was also found.

Based on this information, the environmental site characterization program will focus on the following:

1. provide a detailed characterization of the displaced soil layer; and
2. verify the species of potential contaminants and determine whether they have migrated into the underlying soils or local surface waters.
3. determine if shallow subsurface aquifers exist in the area of the steam release and if they have been impacted by the potential contaminants.

The soils, groundwater and surface water monitoring programs proposed in relation to the points above are discussed in detail in the following sub-sections.

5.1 Soil Sampling Program

Observations made during site reconnaissance indicate that the thickness of displaced soil > 2 cm is mostly limited to area within a 50 m radius of the steam release point.

Soil sampling will be completed via shallow soil pits that are established in a grid pattern across the impacted area and will include soil sampling pits to establish control. These control sample locations will be up-gradient of the release point and at several points lateral to the area of impact. The soil sampling will be undertaken on discrete soil horizons, where possible (i.e. displaced soil layer, LFH, A horizon, 15-30 cm & 30-60 cm). Where the thickness of individual soil layers (i.e. layer must be > 2 cm) does not allow discrete sampling, composite soil samples from adjacent soil horizons will be collected.

Soil sampling will be conducted via hand excavated soil pits. At each soil pit, soil samples will be collected from:

- The displaced soil (if the thickness of displaced soil is >2 cm);
- The LFH layer underlying the displaced soil;
- The topsoil layer; and
- At depths of 15 – 30 & 30 – 60 cm below the topsoil layer.

Detailed observations respecting soil type, organic matter and soil structure will be logged at each soil pit. Observations respecting apparent discolouration of soils underlying the displaced soil layer will also be noted. Should composite soil sampling be required, the displaced soil layer will be composited with the LFH layer, should insufficient material be available in these two layers, a composite of the displaced soil, LFH and topsoil layers will be collected.

A representative number of bulk density analyses will be completed on each of the soil layers.

The program will utilize 40 soil sampling pits within a 50 m radius of the of the steam release point where safe to do so. Also 30 soil pits will be sampled in the area of the down-gradient plume between the distance of 50 m and 300 m and lastly, 20 soil pits will be sampled within the area of the down-gradient plume between the distances of 300 m and 1,000 m from release point. Collected soil samples will be placed into a cooler and submitted directly to the receiving laboratory for analyses.

5.2 Groundwater Assessment Program

The groundwater assessment program will be designed to:

- To determine whether there has been any impact from the steam release on shallow groundwater, and if so, to characterize the nature and extent of the impact;
- To characterize the key hydrogeological parameters for shallow groundwater at the site (depth to groundwater and flow direction);
- In the event of impact being detected, to install sentinel wells between the groundwater contamination and Joslyn Creek, to determine the extent of migration toward the creek; and
- Provide sufficient information to allow for the risk assessment of groundwater quality to potential receptors in the area.

The ground water monitoring network will be installed to intersect the ground water table. This network will use seven new groundwater monitor wells, three of which will be installed within a 50 m radius of the release point to allow for verification that groundwater quality has not been impacted. One up-gradient groundwater monitor well will be installed to acquire background groundwater quality. The remaining three groundwater monitor wells will be located along a transect to Joslyn Creek and will be located at approximately 100m, 200m and 500m from the steam release point. The purpose of the transect installation pattern will be to determine if the groundwater has been impacted by leachate from the surface plume. The groundwater monitor wells will be developed, sampled and tested. The analytical parameters used for water samples will be those that are currently accepted for the Phase 1 & 2 Plant sites (Table 5.1).

The ground and top of monitor well elevations will be determined through a survey of the groundwater monitor wells.

During the installation of the groundwater monitor wells, soil samples will be collected at 0.75 m intervals and retained in the analytical laboratory for future analyses, if required.

5.3 Surface Water Sampling

Concurrent with the groundwater monitoring program, one additional surface water sampling event will be conducted from the previous surface water sampling locations up-stream in Joslyn Creek, within the displaced soil plume and down-stream. The intent of these samples is to collect additional information that verifies the surface water quality has not been impacted by the residue of the steam release.

Additionally, the area potentially impacted by the steam release will be inspected in detail during the soil sampling program. Should wetlands be encountered in this area, representative samples will be collected and submitted for analysis.

5.4 Analytical Program

The analytical parameters used for the soil and water sample assessment are outlined in Table 5.1.

Table 5.1: Analytical Program

Media	# of samples	Analytical Parameters	Comments
Soil	70	F2 – F4 petroleum hydrocarbons; Detailed salinity;	Representative samples of displaced soil and underlying materials will be analyzed to appropriately characterize the area.
Soil	20	Total & leachable napthenic acids Polycyclic aromatic hydrocarbons (PAH's) F1 and BTEX Trace metals	Sufficient representative analyses will be conducted to determine if these are parameters of concern for this location
Groundwater	7	F2 hydrocarbons; F1 and BTEX; Routine potability; PAH's Naphthenic acids Trace metals	Sufficient representative analyses will be conducted to determine if groundwater in the area has been impacted by the potential contaminants
Surface Water	6	F2 hydrocarbons; F1 and BTEX; Routine potability; PAH's Naphthenic acids Trace metals	Sufficient representative analyses will be conducted to determine if the surface water has been impacted by the potential contaminants.

6.0 RISK ASSESSMENT AND REPORTING

6.1 Data Report

A data report will be prepared that provides project scope, methodology, field observations / borehole logs and analytical chemistry data. The data report will form the basis for the risk assessment and mitigative measures report.

6.2 Risk Assessment and Mitigative Measures Report.

6.2.1 Approach

The approach taken to the risk assessment will follow the classic format developed for human health and ecological risk assessment by the Canadian Council of Ministers of the Environment (CCME), Health Canada, the United States Environmental Protection Agency (USEPA) and others.

Essentially, the risk assessment will identify the exposure pathways through which contaminants in the released material could come into contact with human or ecological receptors, and determine what mitigative action or other risk management measures will be required to ensure that the exposure of humans or ecological receptors will be within acceptable levels.

6.2.2 Data Review

The first step in the risk assessment will be a review of all the available relevant site and regional data, and compilation of that data in a form suitable for input into the risk assessment.

6.2.3 Problem Formulation

The problem formulation stage of the risk assessment will start with an identification of chemicals of concern, based on a comparison of the analytical results to applicable guideline values. For some chemicals, including naphthenic acids, no guidelines are currently available, and if these compounds are detected, they will be carried forward into the risk assessment. The next step in the problem formulation will be an exposure pathway assessment - the pathways through which contaminant chemicals in the released material could reach human or ecological receptors will be identified, and complete pathways identified for inclusion in the risk assessment. Also in the problem formulation section, the appropriate land use classification will be identified, and applicable human and ecological receptors selected.

6.2.4 Toxicity Assessment

For each chemical of concern, appropriate toxicological reference values (TRVs) will be determined, where possible, for human and appropriate ecological receptors. TRVs from Canadian or US regulatory agencies (e.g., CCME, Health Canada, USEPA) will be used where available. In the absence of regulatory TRVs (e.g., naphthenic acids), reference values will be developed for this risk assessment where the source data are sufficient.

6.2.5 Exposure Assessment

For each chemical of concern and exposure pathway, an exposure assessment will be conducted to determine the concentration or dose of each chemical of concern to which each receptor might be exposed. Exposure models will be based on the latest CCME (2005) protocols as far as possible/appropriate.

6.2.6 Risk Characterization and Risk Management

The risk characterization step of the risk assessment will involve comparing measured or predicted exposure concentrations or doses to toxicological reference values in order to determine whether contaminant levels are of concern. If contaminant levels are high enough to be of concern, then remediation / risk management recommendations will be made that are consistent with the Alberta Environment (AENV, 2006) 3-Tier framework.

6.2.7 Reporting

A risk assessment report will be generated that will document all the source data, the protocols and methodologies used to analyze the data, and summarize the risk assessment conclusions, risk management recommendations and propose mitigative measures for areas that require remediation.

7.0 CLOSURE

The information obtained to date concerning the steam release incident provides a good basis for determining the scope and direction for further studies and site characterization. We trust that the work plan presented herein meets your requirements.

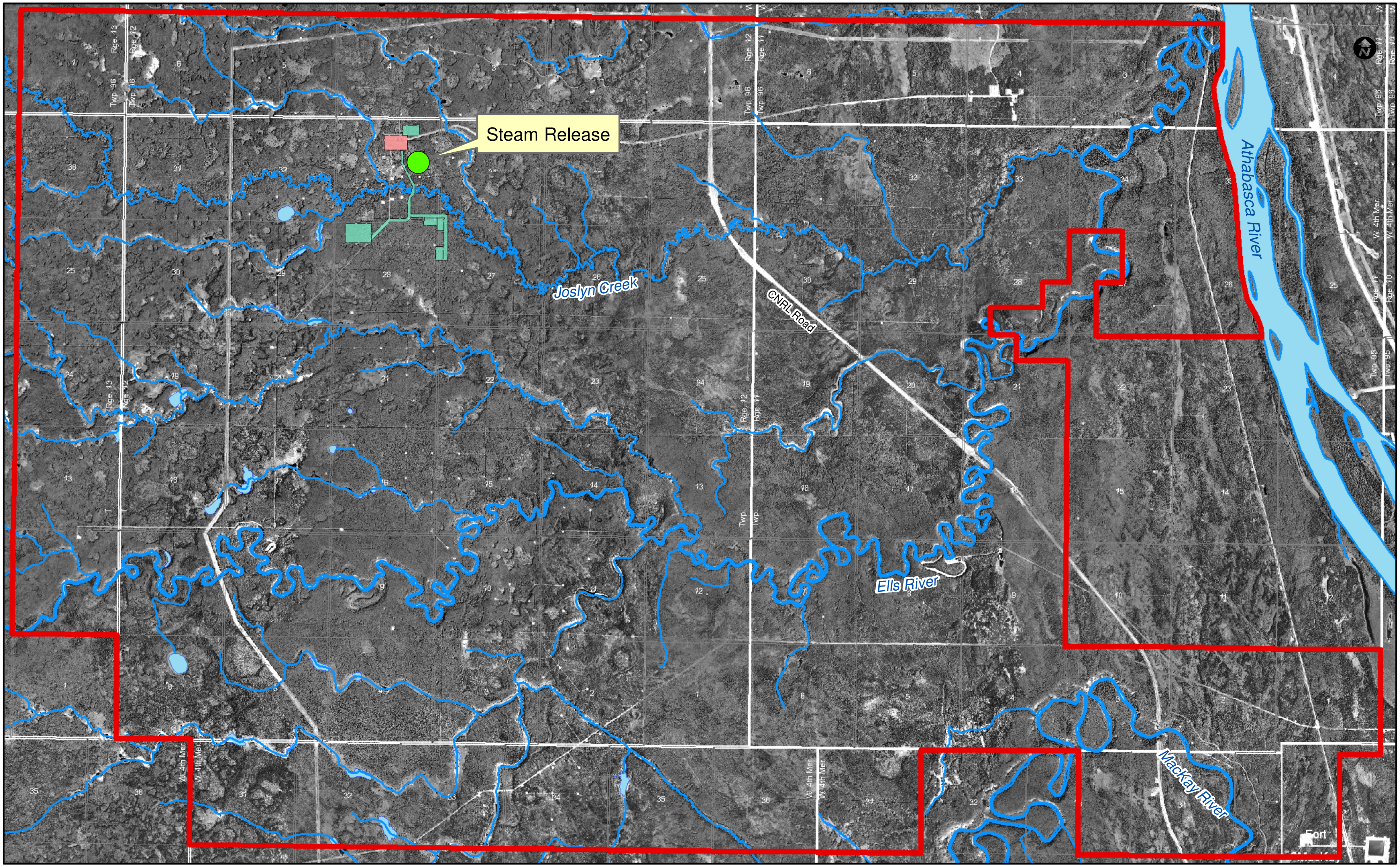
If you have any questions concerning this report please contact the undersigned at (780) 496-9048.

Yours truly,

Millennium EMS Solutions Ltd.

Ian Terry, P.Eng.
Principal

FIGURES



Deer Creek Energy Limited
A wholly-owned subsidiary of TOTAL E&P CANADA LTD

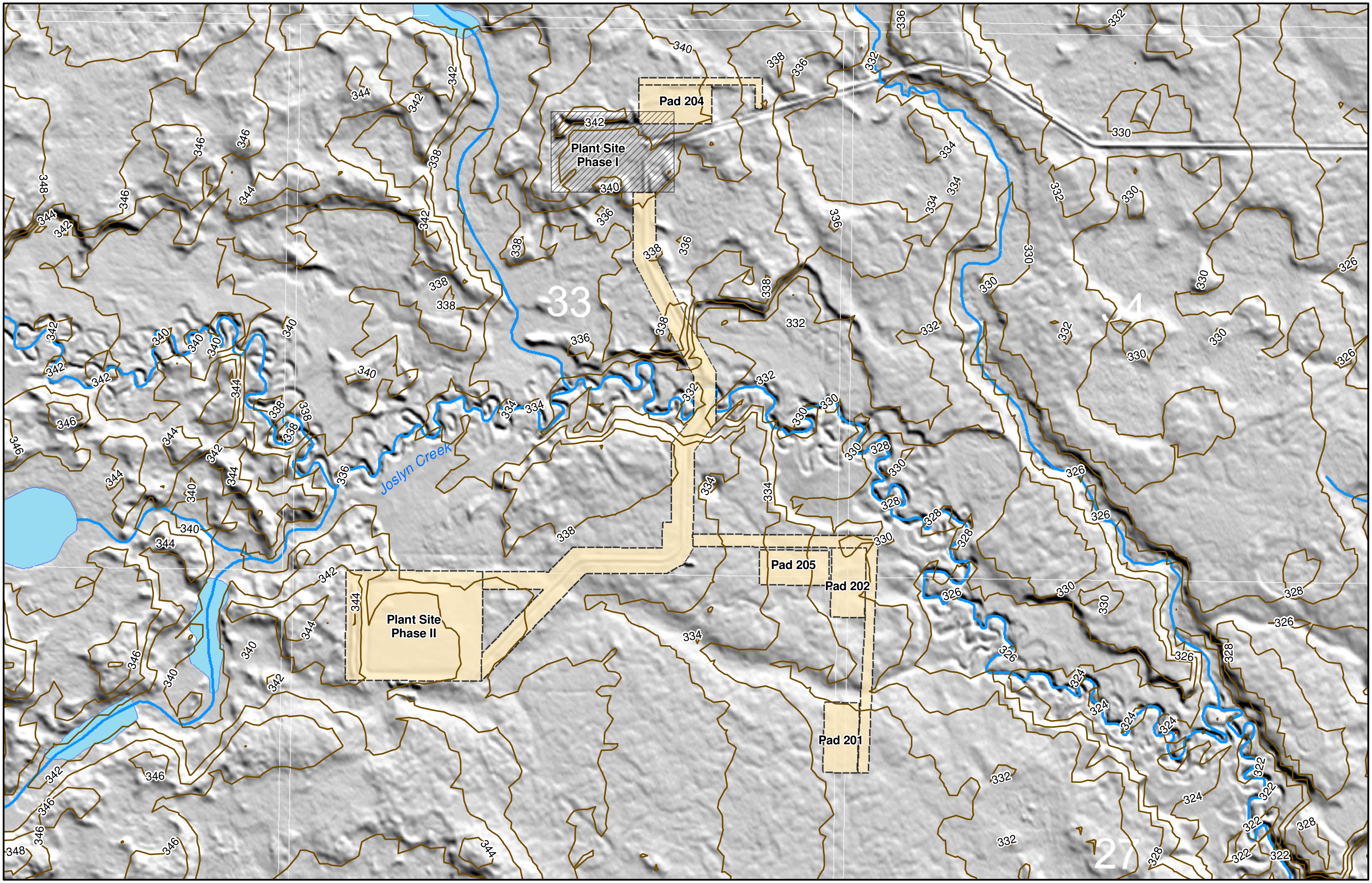
PROJECT
Deer Creek Energy Limited

TITLE
Lease Development

LEGEND
SAGD
🟥 Phase I
🟩 Phase II
Lease Boundary

DRAWN	CHECKED	DATE
PS	KY	12Sep06

PROJECTION: UTM12 NAD83
FILE No. 06-010
SCALE
FIGURE **1.1**



Deer Creek Energy Limited
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PROJECT
Deer Creek Energy Limited

TITLE
Topography of the SAGD Area

LEGEND

Footprint
▨ Phase I
▭ Phase II
— Contour (2m interval)

DRAWN	CHECKED	DATE
PS	KY	12Sep06

PROJECTION: UTM12 NAD83

FILE No. 04-101

SCALE
0 95 190 380
Metres

FIGURE
2.1

PROJECT

Deer Creek Energy Limited

TITLE

Topography of Area Prior to Release

LEGEND

—— Contours (0.5m interval)

DRAWN	CHECKED	DATE
PS	KY	12Sep06

SCALE

0 5 10 20

Metres

PROJECTION: UTM12 NAD83

FILE No. 04-101

FIGURE

2.2

DEER CREEK Energy Limited

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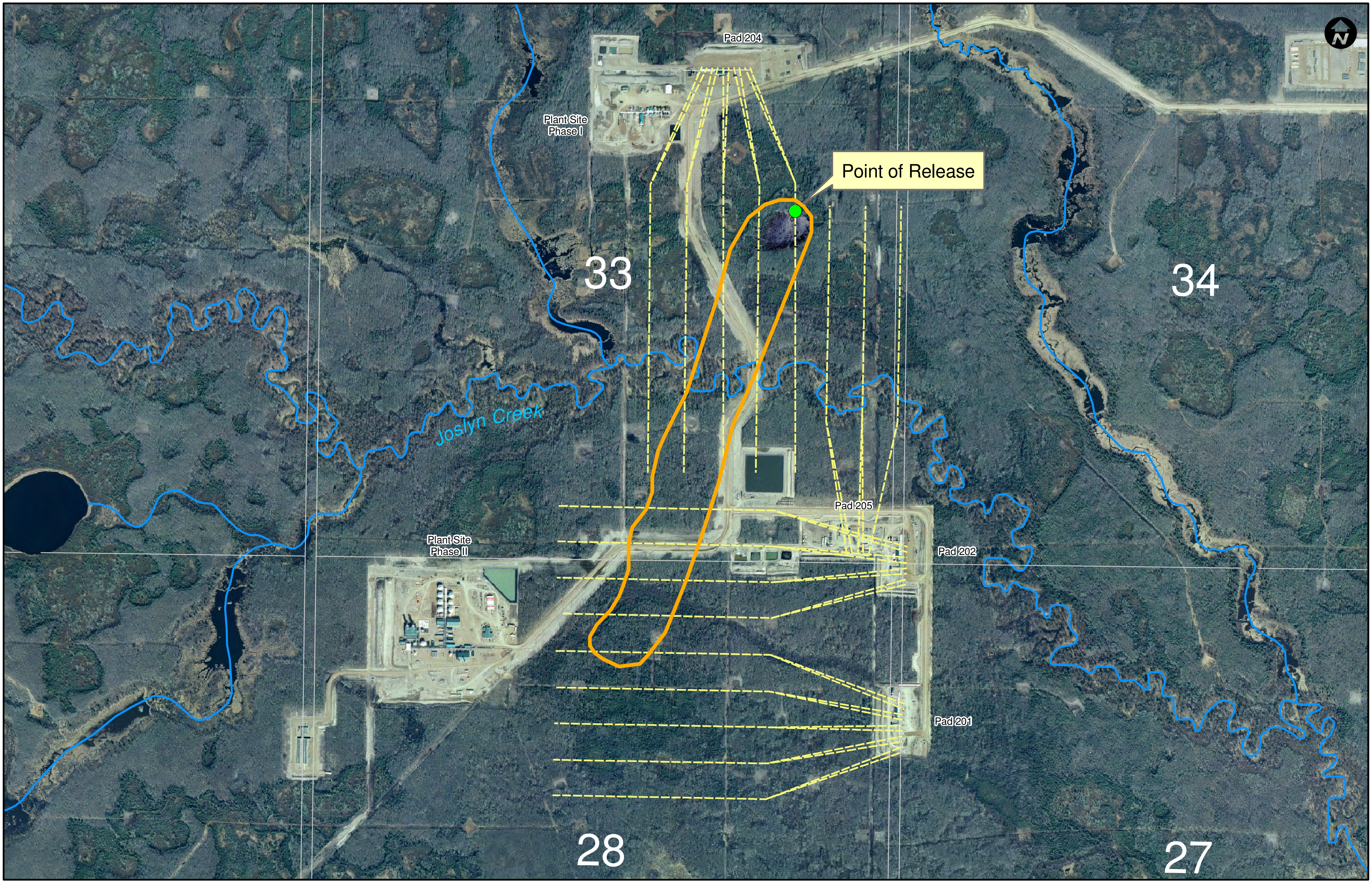

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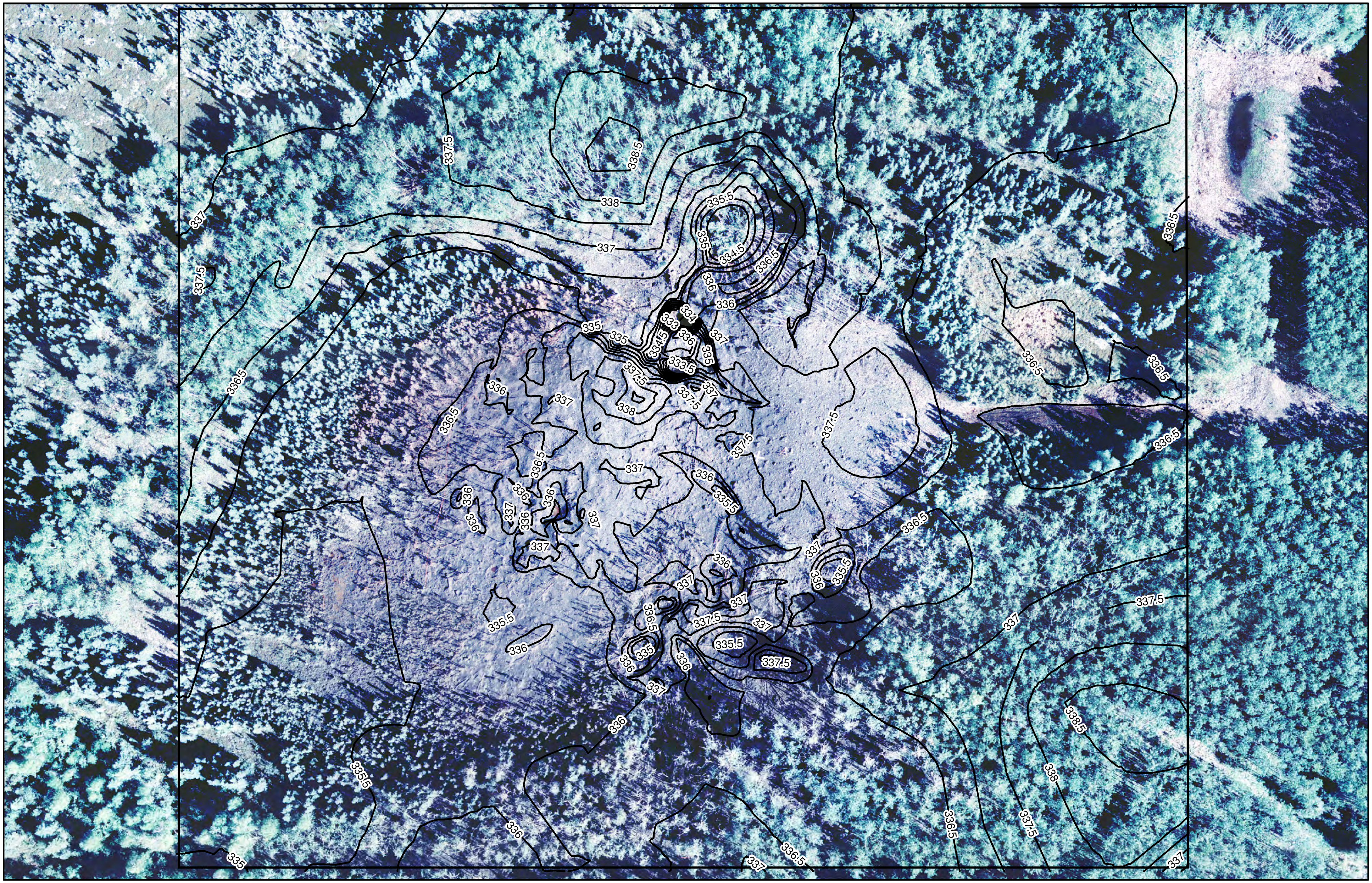
PROJECT
Deer Creek Energy Limited

TITLE
Steam Release Area

LEGEND
▭ Area of Deposition
- - - SAGD Well Pair

DRAWN	CHECKED	DATE
PS	KY	12Sep06

PROJECTION: UTM12 NAD83
FILE No. 04-101
SCALE 0 100 200 400 Metres
FIGURE 3.1



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PROJECT
Deer Creek Energy Limited

TITLE
Topography of Steam Release Area

LEGEND
—— Contours (0.5m interval)

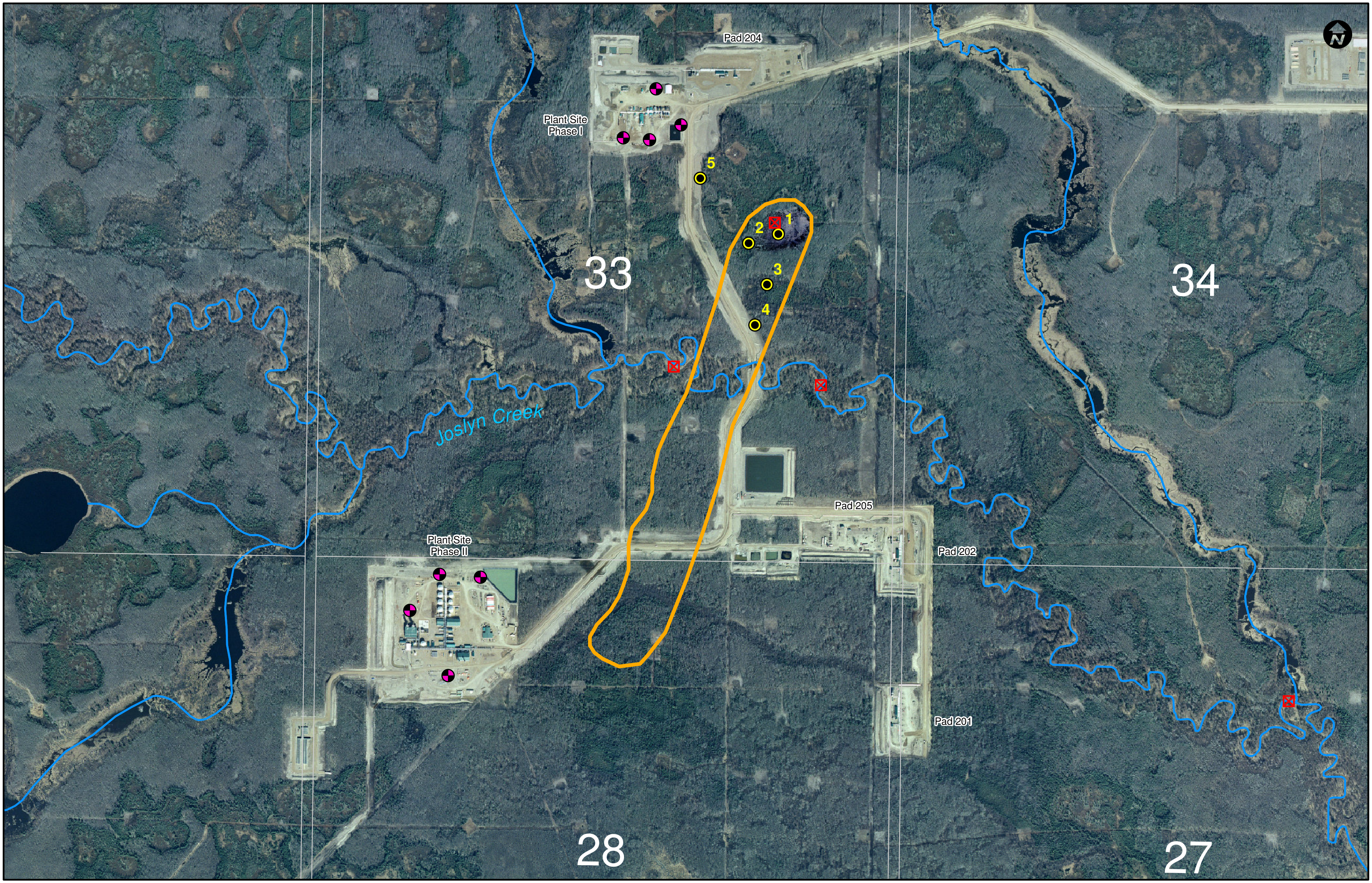
DRAWN	CHECKED	DATE
PS	KY	12Sep06

SCALE
0 5 10 20
Metres

PROJECTION: UTM12 NAD83

FILE No. 04-101

FIGURE **3.2**



PROJECT

Deer Creek Energy Limited

TITLE

Monitoring Locations

DEER CREEK Energy Limited
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LEGEND

▭ Area of Deposition
● Groundwater Monitoring
◉ Soil Sample
☒ Water Sample

DRAWN	CHECKED	DATE
PS	KY	12Sep06

SCALE
0 100 200 400
Metres

PROJECTION: UTM12 NAD83

FILE No. 04-101

FIGURE **4.1**

APPENDIX A: QUATERNARY GEOLOGY

LEGEND:

▨	LEASE BOUNDARY

HOLOCENE

🟩	Ho – ORGANIC TERRAIN (PEAT) >20 cm THICKNESS ARE SHOWN IN AREA OF SOILS AUGER HOLES
🟨	Hf – ALLUVIUM; SAND; SAND AND GRAVEL
🟫	Hc – STEEP BANK COLLUVIUM, INCLUDES AREAS OF OUTCROPPING STRATA
🟦	Ho/Hf – ORGANICS OVERLYING FINE GRAINED FLUVIAL (SILT, CLAY, SAND)

PLEISTOCENE

🟨	Hae – AEOLIAN SAND
🟧	Ppf – PALEOFLOOD SEDIMENT; SAND; SAND AND GRAVEL
🟨	Pfs – GLACIAL OUTWASH, IN PART AEOLIAN, SAND
🟪	Pl – GLACIOLACUSTINE SEDIMENTS; CLAY AND SILT; LACUSTROTILL; MINOR SAND

NOTES:

1. AERIAL PHOTOS INDICATE THE PRESENCE OF NUMEROUS AREAS OF SLOPE INSTABILITY ALONG THE ELLS RIVER.

SCALE
0 25 50 m

SURFICIAL GEOLOGY MAP

W:\Entity\Thermal\Esther\EUB – Steam release requests – update 7–14–06\EUB Request #2 – Kris Geekie\#2\b\surficial_geology.dwg – Steam Release Area – Jul. 14, 2006 9:53am – L0240697

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Calgary, AB, T2P 2Z1
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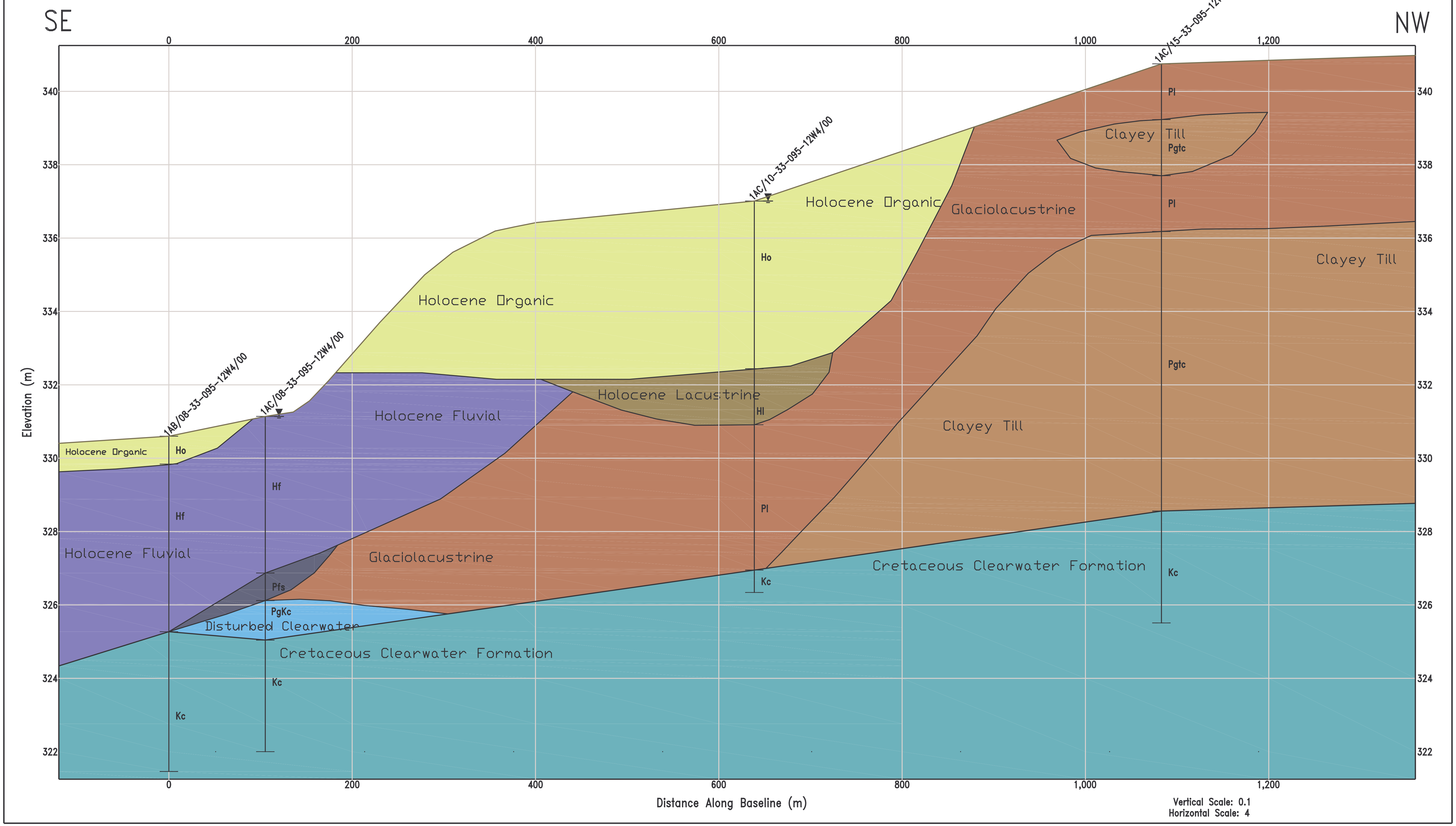
STEAM RELEASE QUATERNARY OVERBURDEN CROSS SECTION A



Logo

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Telephone: (403) 264-3777

BORING NUMBER 1AB/08-33-095-12W4/00

CLIENT Deer Creek Energy Limited
PROJECT NAME Joslyn Lease OB Database
PROJECT NUMBER
PROJECT LOCATION Joslyn Lease

DATE STARTED 18/12/04
COMPLETED 18/12/04
GROUND ELEVATION 330.6 m
HOLE SIZE 6-inch
DRILLING CONTRACTOR
GROUND WATER LEVELS:
DRILLING METHOD CFSSA
AT TIME OF DRILLING ---
LOGGED BY K. Stasiuk
CHECKED BY
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION		
		OL	☰	**MUSKEG** CLAY; some silt; organic; black with pockets of rusty brown PEAT; frozen to 0.61m then wet; low plasticity	0.76	329.84
1 2 3		CI	▧	**ALLUVIUM** Silty CLAY; dark grey with olive and oxidized lenses; black organic streaks; organic lense at ~1.22-1.37m; soft; moisture content greater than plastic limit; intermediate plasticity, fining upward profile		
4		CL-CI	▨	Silty CLAY as above; trace to some fine sand; low plasticity	4.57	326.03
5		CL	▨	Sandy CLAY; silty; trace fine to coarse gravel; medium to dark grey; sample is saturated and highly disturbed; possible alluvium with wet, gravelly lense on top of Cretaceous sediments; low plasticity; moisture content greater than or equal to liquid limit; soft	5.33	325.27
6		CH	▩	**CLEARWATER FORMATION** CLAY; some silt; medium to dark grey; greasy; stiff; moisture content greater than plastic limit; high plasticity; possibly slightly disturbed	6.10	324.50
7 8 9		CH	▩	Silty CLAY; medium to dark grey; scattered shell fragments; crumbled on auger; stiff to very stiff; moisture content greater than or equal to plastic limit; high plasticity; ST between ~8.23-8.43m		

(Continued Next Page)

BORING NUMBER 1AB/08-33-095-12W4/00

CLIENT Deer Creek Energy Limited

PROJECT NAME Joslyn Lease OB Database

PROJECT NUMBER

PROJECT LOCATION Joslyn Lease

DEPTH (m)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
			▨	9.14 321.46
				Bottom of hole at 9.14 m.

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BOREHOLE NUMBER 1AC/08-33-095-12W4/00

CLIENT

PROJECT NAME

PROJECT NUMBER

PROJECT LOCATION Joslyn Creek Lease

DATE STARTED 4/1/06 **COMPLETED** 4/1/06 **GROUND ELEVATION** 331.14 m **HOLE SIZE** 6-inch

DRILLING CONTRACTOR

DRILLING METHOD CFSSA

COORDINATES E 447115m N 6349510m

LOGGED BY K. Stasiuk **CHECKED BY**

NOTES

DEPTH (m)	SAMPLE TYPE NUMBER	FACIES DESCRIPTOR	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
1		Hf	CH	▨	▼ FLUVIAL (ALLUVIUM) SILT and CLAY; organic; brown, grey and black mixture; amorphous MUSKEG lenses; frozen with ice lensing throughout; moisture content is greater than plastic limit; high plasticity; moderate organic odour; mineral soil	
1.52						329.62
2		Hf	CH	▨	CLAY; some silt to silty; medium grey with black organic lenses; isolated wet sand lense; isolated wet sand lense; greasy; frozen with ice lensing throughout	
2.29						328.85
3 4		Hf	CH	▨	Silty CLAY; some sand; fine to coarse grained; medium grey with black lenses; numerous light grey and oxidized mottles; fie to coarse grained mm scale sand lenses; mild bitumen odour; frozen; ice clasts; moisture content is greater than plastic limit; high plasticity	
4.27						326.87
5		Pfs	SW	░	FLUVIAL SAND; fine to coarse grained; some silt; 8-10% fine to coarse gravel; medium grey; dirty; mild organic odour; graineds sub-angular to sub-rounded; dense; moderate to poorly sorted; moist to wet	
5.02						326.12
6		PgKc	CH	▨	DISTURBED CLEARWATER CLAY; some silt; medium to dark grey; occasional light grey mottles; no visible structure; greasy; seems reworked; stiff; moisture content is greater than plastic limit; high plasticity	
6.10						325.04
7 8		Kc	CH	▨	CLEARWATER FORMATION CLAY; some silt to silty; random shell fragments; medium to dark grey; light grey silt lenses mm-cm scale; hard; crumbled on auger; moisture content is less than or equal to plastic limit; high plasticity	
8.38						322.76
9		Kc	CH	▨	Continued from above with ST fragments and dust in sample	

(Continued Next Page)

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BOREHOLE NUMBER 1AC/08-33-095-12W4/00

CLIENT __________ **PROJECT NAME** __________
PROJECT NUMBER __________ **PROJECT LOCATION** Joslyn Creek Lease

DEPTH (m)	SAMPLE TYPE NUMBER	FACIES DESCRIPTOR	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
				▨	9.14 322.00
					Bottom of hole at 9.14 m.

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BOREHOLE NUMBER 1AC/10-33-095-12W4/00

PAGE 1 OF 2

CLIENT

PROJECT NAME

PROJECT NUMBER

PROJECT LOCATION Joslyn Creek Lease

DATE STARTED 4/3/06 **COMPLETED** 4/3/06 **GROUND ELEVATION** 337.01 m **HOLE SIZE** 6-inch

DRILLING CONTRACTOR

DRILLING METHOD CFSSA

COORDINATES E 446785.17m N 6349930.82m

LOGGED BY K. Stasiuk **CHECKED BY**

NOTES

DEPTH (m)	SAMPLE TYPE NUMBER	FACIES DESCRIPTOR	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0		Ho	PT		▼ ORGANIC PEAT; trace MUSKEG; light to medium rusty brown with thin pockets of black fine grained soil; woody debris; spongy; moist to wet	
3.05		Ho	PT		Slightly more fine grained PEAT; increasing in situ compactness (density of unit); wet; moderate gas odour	333.96
4.57		Hl	OH		LACUSTRINE Silty CLAY; trace fine sand; medium rusty brown grading to medium grey with black lenses; rootlets; scattered gastropod shells; soft; spongy; moisture content is greater than plastic limit; intermediate to high plasticity	332.44
6.10		Pl	CH		GLACIOLACUSTRINE Silty CLAY; trace fine sand; medium grey and brown; very soft; moisture content is greater than plastic limit; high plasticity; flowing clay	330.91
7.62		Pl	CI		Some fine sand; random gravel; cm scale gritty horizons; moisture content is greater than plastic limit; intermediate plasticity	329.39

(Continued Next Page)

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BOREHOLE NUMBER 1AC/10-33-095-12W4/00

CLIENT

PROJECT NAME

PROJECT NUMBER

PROJECT LOCATION Joslyn Creek Lease

DEPTH (m)	SAMPLE TYPE NUMBER	FACIES DESCRIPTOR	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
					9.14 — 327.87
10		Pl			No recovery; Kc on upper augers
					10.06 — 326.95
		Kc	ST	× × × × × × × × × × × × × × ×	CLEARWATER FORMATION Siltstone induration; strong
					10.67 — 326.34
					Bottom of hole at 10.67 m.

APPENDIX B: ANALYTICAL RESULTS – SOIL & WATER

Table B.1 Analytical results for soil sampling completed

	UNITS	25 M SW W/C	SW W/C ~ 100 M	SW W/C ~ 200 M	PIPE SAMPLE	CONTROL
Sample Number See Figure 4.1		**#1**	**#2**	**#3**	**#4**	**#5**
Hyrdrocarbon Analytical Results						
Benzene	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005
Ethylbenzene	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
Toluene	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
Xylenes	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
F1 (C6-C10)	mg/kg	<5	<5	<5	<5	<5
F1-BTEX	mg/kg	<5	<5	<5	<5	<5
F2 (C10-C16)	mg/kg	1400	1800	1800	410	<5
F3 (C16-C34)	mg/kg	18000	19000	18000	20000	340
F4 (C34-C50)	mg/kg	9000	9400	8900	10000	310
F4G-SG (GHH-Silica)	mg/kg	9800	11000	11000	11000	500
Benzene	mg/L	<0.005	<0.005	<0.005	<0.005	
EthylBenzene	mg/L	<0.005	<0.005	<0.005	<0.005	
Toluene	mg/L	<0.005	<0.005	<0.005	<0.005	
Xylenes	mg/L	<0.005	<0.005	<0.005	<0.005	
Total Hydrocarbons (C6-C50)	mg/kg	28000	30000	29000	30000	650
Chromatogram to baseline at nC50		NO	NO	NO	NO	NO
Salinity Analytical Results						
Calcium (Ca)	mg/L	7	13	17	9	377
Chloride (Cl)	mg/L	230	270	300	290	60
Conductivity Sat. Paste	dS m-1	1.52	1.68	1.69	1.67	2.12
Magnesium (Mg)	mg/L	<3	<3	4	<3	149
pH in Saturated Paste	pH	8.6	8.5	8.4	8.2	7.4
Potassium (K)	mg/L	6	6	7	6	4
SAR	SAR	40.7	35.4	28.5	43.8	1.3
Sodium (Na)	mg/L	396	471	507	484	118
Sulphate (SO4)	mg/L	352	333	215	325	1470
% Saturation	%	42.3	40.6	51.9	53.6	41.5
Trace Metal Analytical Results						

Table B.1 Analytical results for soil sampling completed

	UNITS	25 M SW W/C	SW W/C ~ 100 M	SW W/C ~ 200 M	PIPE SAMPLE	CONTROL
Sample Number See Figure 4.1		**#1**	**#2**	**#3**	**#4**	**#5**
Antimony (Sb)	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic (As)	mg/kg	4.1	5.3	4.2	4.9	5.8
Barium (Ba)	mg/kg	62	71	60	58	99
Beryllium (Be)	mg/kg	<1	<1	<1	<1	<1
Cadmium (Cd)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium (Cr)	mg/kg	10.7	12.6	10.5	9.3	18.9
Cobalt (Co)	mg/kg	6	8	6	6	6
Copper (Cu)	mg/kg	12	15	13	11	13
Lead (Pb)	mg/kg	6	8	7	6	9
Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum (Mo)	mg/kg	<1	<1	<1	<1	<1
Nickel (Ni)	mg/kg	16	25	17	15	18
Selenium (Se)	mg/kg	0.6	0.7	0.6	0.5	0.5
Silver (Ag)	mg/kg	<1	<1	<1	<1	<1
Thallium (Tl)	mg/kg	<1	<1	<1	<1	<1
Tin (Sn)	mg/kg	<5	<5	<5	<5	<5
Uranium (U)	mg/kg	<40	<40	<40	<40	<40
Vanadium (V)	mg/kg	26	28	24	24	31
Zinc (Zn)	mg/kg	40	40	40	30	40
CCME PAH's						
% Moisture	%	2.6	6.2	2.5	0.8	3.4
MUST PSA % > 75um	%	60	57	52	58	

Table B.2 Analytical results for water sampling completed on Joslyn Creek

	UNITS	JOSLYN CREEK U/S	JOSLYN CREEK CNRL BRIDGE	25 M SW W/C	JOSLYN CREEK D/S	JOSLYN CREEK D/S MAY 21	JOSLYN CREEK D/S MAY 22	JOSLYN CREEK D/S MAY 23
Sample Date		**May 20, 2006**	**May 20, 2006**	**20-May-06**	**May 20, 2006**	**May 21, 2006**	**May 22, 2006**	**May 23, 2006**
Hyrdrocarbon Analytical Results								
Benzene	mg/L	0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
EthylBenzene	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toluene	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Xylenes	mg/L	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
F1(C6-C10)	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
F2 (>C10-C16)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
F1-BTEX	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Routine Water Analysis								
SAR	SAR	1.1	1.0		1.0	1.2	1.2	1.2
Chloride (Cl)	mg/L	4	4		4	3	4	4
Nitrate+Nitrite-N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate-N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite-N	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
pH, Conductivity and Total Alkalinity								
pH	pH	8.1	8.2	7.4	8.1	8.1	8.1	8.1
Conductivity (EC)	uS/cm	445	459	560	457	455	470	485
Bicarbonate (HCO3)	mg/L	170	177	246	172	175	181	187
Carbonate (CO3)	mg/L	<5	<5	<5	<5	<5	<5	<5
Hydroxide (OH)	mg/L	<5	<5	<5	<5	<5	<5	<5
Alkalinity, Total (as CaCO3)	mg/L	139	145	202	141	143	148	153
Ion Balance Claculation								
Ion Balance	%	106	97.3	109	102	104	104	98.5
TDS (Calculated)	mg/L	272	261	329	265	264	273	271

Table B.2 Analytical results for water sampling completed on Joslyn Creek

	UNITS	JOSLYN CREEK U/S	JOSLYN CREEK CNRL BRIDGE	25 M SW W/C	JOSLYN CREEK D/S	JOSLYN CREEK D/S MAY 21	JOSLYN CREEK D/S MAY 22	JOSLYN CREEK D/S MAY 23
Sample Date		**May 20, 2006**	**May 20, 2006**	**20-May-06**	**May 20, 2006**	**May 21, 2006**	**May 22, 2006**	**May 23, 2006**
Hardness (as CaCO3)	mg/L	174	163	223	167	159	167	159
ICP metals and SO4 for routine water								
Calcium (Ca)	mg/L	50.0	47.1	54.2	46.3	45.4	47.2	47.8
Potassium (K)	mg/L	3.3	3.0	3.7	3.1	3.3	3.2	3.2
Magnesium (Mg)	mg/L	13.5	12.6	27.4	12.5	12.4	12.8	12.9
Sodium (Na)	mg/L	34	31	46	31	31	33	34
Sulfate (SO4)	mg/L	87.3	81.1	81.0	83.7	80.5	82.1	80.9
Total Metals - CCME								
Aluminum (Al)	mg/L	1.32	1.03	2.33	1.56	1.79	1.53	1.89
Mercury (Hg)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Silver (Ag)	mg/L	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Arsenic (As)	mg/L	0.0034	0.0028	0.0014	0.0032	0.0036	0.0035	0.0038
Boron (B)	mg/L	0.21	0.22	0.25	0.21	0.20	0.21	0.22
Barium (Ba)	mg/L	0.049	0.041	0.061	0.046	0.054	0.050	0.055
Beryllium (Be)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (Cd)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Cobalt (Co)	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium (Cr)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper (Cu)	mg/L	0.004	0.003	0.003	0.003	0.004	0.003	0.004
Iron (Fe)	mg/L	4.03	3.21	1.26	3.98	4.70	4.51	4.82
Lithium (Li)	mg/L	0.04	0.04	0.05	0.04	0.04	0.04	0.05
Lead (Pb)	mg/L	0.0012	0.0008	0.0007	0.0010	0.0013	0.0011	0.0013
Manganese (Mn)	mg/L	0.094	0.058	0.056	0.085	0.112	0.107	0.115
Molybdenum (Mo)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (Ni)	mg/L	0.006	0.005	0.002	0.006	0.006	0.006	0.006

Table B.2 Analytical results for water sampling completed on Joslyn Creek

	UNITS	JOSLYN CREEK U/S	JOSLYN CREEK CNRL BRIDGE	25 M SW W/C	JOSLYN CREEK D/S	JOSLYN CREEK D/S MAY 21	JOSLYN CREEK D/S MAY 22	JOSLYN CREEK D/S MAY 23
Sample Date		**May 20, 2006**	**May 20, 2006**	**20-May-06**	**May 20, 2006**	**May 21, 2006**	**May 22, 2006**	**May 23, 2006**
Antimony (Sb)	mg/L	0.0006	0.0005	0.0008	0.0005	0.0005	0.0006	0.0006
Selenium (Se)	mg/L	0.0006	0.0005	0.0013	0.0006	0.0005	0.0007	0.0005
Tin (Sn)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Titanium (Ti)	mg/L	0.053	0.034	0.071	0.050	0.062	0.050	0.064
Thallium (Tl)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Uranium (U)	mg/L	0.0025	0.0024	0.0047	0.0023	0.0024	0.0027	0.0027
Vanadium (V)	mg/L	0.006	0.005	0.007	0.007	0.008	0.007	0.008
Zinc (Zn)	mg/L	0.007	<0.004	0.036	<0.004	0.007	0.006	0.007

EnviroTest LABORATORIES

AUTO - EMAIL EMERGENCY CHEMICAL ANALYSIS REPORT

MILLENNIUM
ATTN: DANE MCCOY

208 4207 98 ST

EDMONTON AB T6E 5R7

Report On: 24-MAY-06 05:22 PM

Lab Work Order #: **L390729**

Date Received: **23-MAY-06**

Project P.O. #:

Job Reference: 04-101

Legal Site Desc:

CofC Numbers: 230126

Other Information:

Comments:

DOUG JOHNSON
Director of Operations, Edmonton

KAREN HUEBNER
Account Manager

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-1 JOSLYN CREEK U/S								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	105		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	80		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	0.0010		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	0.0006		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	1.32		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0034		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.21		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.049		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.004		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.006		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0012		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.053		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0025		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.006		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	0.007		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	50.0		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.3		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	13.5		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	34		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	4.03		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.094		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.1			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-1	JOSLYN CREEK U/S								
Sampled By:	CW on 20-MAY-06 @ 00:00								
Matrix:	WATER								
Routine Water Analysis									
pH, Conductivity and Total Alkalinity									
	pH	8.1		0.1	pH		22-MAY-06	PTT	R401032
	Conductivity (EC)	445		0.2	uS/cm		22-MAY-06	PTT	R401032
	Bicarbonate (HCO3)	170		5	mg/L		22-MAY-06	PTT	R401032
	Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
	Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
	Alkalinity, Total (as CaCO3)	139		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation									
	Ion Balance	106			%		23-MAY-06		
	TDS (Calculated)	272			mg/L		23-MAY-06		
	Hardness (as CaCO3)	174			mg/L		23-MAY-06		
ICP metals and SO4 for routine water									
	Calcium (Ca)	48.2		0.5	mg/L		22-MAY-06	JWU	R401039
	Potassium (K)	2.8		0.5	mg/L		22-MAY-06	JWU	R401039
	Magnesium (Mg)	13.1		0.1	mg/L		22-MAY-06	JWU	R401039
	Sodium (Na)	33		1	mg/L		22-MAY-06	JWU	R401039
	Sulfate (SO4)	87.3		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-2	JOSLYN CREEK D/S								
Sampled By:	CW on 20-MAY-06 @ 00:00								
Matrix:	WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)									
F2 (>C10-C16)									
	F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr:	2-Bromobenzotrifluoride	100		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr:	Hexatriacontane	114		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)									
	Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
	F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME									
Total Trace Metals									
	Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
	Aluminum (Al)	1.56		0.01	mg/L		22-MAY-06	QLI	R401078
	Arsenic (As)	0.0032		0.0004	mg/L		22-MAY-06	QLI	R401078
	Boron (B)	0.21		0.05	mg/L		22-MAY-06	QLI	R401078
	Barium (Ba)	0.046		0.003	mg/L		22-MAY-06	QLI	R401078
	Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
	Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
	Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
	Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
	Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
	Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
	Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
	Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
	Nickel (Ni)	0.006		0.002	mg/L		22-MAY-06	QLI	R401078
	Lead (Pb)	0.0010		0.0001	mg/L		22-MAY-06	QLI	R401078
	Antimony (Sb)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
	Selenium (Se)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-2 JOSLYN CREEK D/S								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
Total Metals - CCME								
Total Trace Metals								
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.050		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0023		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.007		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	<0.004		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	46.3		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.1		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	12.5		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	31		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	3.98		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.085		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.0			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	457		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	172		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	141		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	102			%		23-MAY-06		
TDS (Calculated)	265			mg/L		23-MAY-06		
Hardness (as CaCO3)	167			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	46.2		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.6		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	12.6		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	31		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	83.7		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	98		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	84		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	1.03		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0028		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.22		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.041		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.005		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0008		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.034		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0024		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.005		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	<0.004		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	47.1		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.0		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	12.6		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	31		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	3.21		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.058		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.0			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	8.2		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	459		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	177		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	145		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	97.3			%		23-MAY-06		

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
Routine Water Analysis								
Ion Balance Calculation								
TDS (Calculated)	261			mg/L		23-MAY-06		
Hardness (as CaCO3)	163			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	45.0		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.5		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	12.2		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	29		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	81.1		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-4 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	99		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	87		70-130	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	2.33		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0014		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.25		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.061		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.05		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0007		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0008		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0013		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.071		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0047		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.007		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	0.036		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	54.2		0.5	mg/L		23-MAY-06	SYF	R401153

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-4 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: WATER								
Total Metals - CCME								
Total Major Metals								
Potassium (K)	3.7		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	27.4		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	46		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	1.26		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.056		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.3			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	6		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	7.4		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	560		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	246		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	202		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	109			%		23-MAY-06		
TDS (Calculated)	329			mg/L		23-MAY-06		
Hardness (as CaCO3)	223			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	48.8		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	3.9		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	24.6		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	43		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	81.0		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-5 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL #1								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	1400		5	mg/kg		24-MAY-06		
F3 (C16-C34)	18000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	9000		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	28000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	2.6		0.1	%		23-MAY-06	DDU	R401577

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-5 25 M SW W/C								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
MUST PSA % > 75um	60		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.1		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	62		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	10.7		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	12		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	16		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	6		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.6		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	26		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	230		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	352		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	42.3		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.6		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.52		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	7		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	396		2	mg/L		23-MAY-06	JWU	R401341
SAR	40.7	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-6 SW W/C ~ 100 M								
Sampled By: CW on 20-MAY-06 @ 00:00 #2								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	1800		5	mg/kg		24-MAY-06		
F3 (C16-C34)	19000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	9400		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	30000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-6 SW W/C ~ 100 M								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	6.2		0.1	%		23-MAY-06	DDU	R401577
MUST PSA % > 75um	57		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	5.3		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	71		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	8		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	12.6		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	15		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	25		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	8		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.7		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	28		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	270		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	333		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	40.6		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.5		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.68		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	13		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	471		2	mg/L		23-MAY-06	JWU	R401341
SAR	35.4	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-7 SW W/C ~ 200 M #3								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-7 SW W/C ~ 200 M								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	1800		5	mg/kg		24-MAY-06		
F3 (C16-C34)	18000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	8900		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	29000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	2.5		0.1	%		24-MAY-06	REK	R401573
MUST PSA % > 75um	52		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	60		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	10.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	13		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	17		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	7		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.6		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	24		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	300		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	215		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	51.9		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.4		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.69		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-7 SW W/C ~ 200 M								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
Detailed Salinity								
SAR								
Calcium (Ca)	17		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	7		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	4		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	507		2	mg/L		23-MAY-06	JWU	R401341
SAR	28.5			SAR		23-MAY-06	JWU	R401341
L390729-8 PIPE SAMPLE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs #4								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	410		5	mg/kg		24-MAY-06		
F3 (C16-C34)	20000		5	mg/kg		24-MAY-06		
F4 (C34-C50)	10000		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	30000		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	0.8		0.1	%		23-MAY-06	DDU	R401577
MUST PSA % > 75um	58		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.9		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	58		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	9.3		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	11		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	15		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	6		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.5		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-8 PIPE SAMPLE								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
Metals in Soil - CCME List								
Vanadium (V)	24		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	30		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	290		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	325		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	53.6		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.2		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.67		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	9		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	484		2	mg/L		23-MAY-06	JWU	R401341
SAR	43.8	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-9 CONTROL								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL #5								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-MAY-06		
F1-BTEX	<5		5	mg/kg		24-MAY-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-MAY-06		
F3 (C16-C34)	340		5	mg/kg		24-MAY-06		
F4 (C34-C50)	310		5	mg/kg		24-MAY-06		
Total Hydrocarbons (C6-C50)	650		5	mg/kg		24-MAY-06		
Chromatogram to baseline at nC50	NO					24-MAY-06		
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	181	G	70-130	%	23-MAY-06	23-MAY-06	AAT	R401937
Surr: Hexatriacontane	111		70-130	%	23-MAY-06	23-MAY-06	AAT	R401937
Prep/Analysis Dates					23-MAY-06	23-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	3.4		0.1	%		23-MAY-06	DDU	R401577
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	5.8		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	99		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	18.9		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	13		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	18		2	mg/kg		23-MAY-06	QLI	R401079

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-9 CONTROL								
Sampled By: CW on 20-MAY-06 @ 00:00								
Matrix: SOIL								
Metals in Soil - CCME List								
Lead (Pb)	9		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.5		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	31		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	60		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	1470		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	41.5		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	7.4		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	2.12		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	377		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	4		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	149		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	118		2	mg/L		23-MAY-06	JWU	R401341
SAR	1.3			SAR		23-MAY-06	JWU	R401341
L390729-10 JOSLYN CREEK D/S MAY 21								
Sampled By: NOT PROVIDED on 21-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005	RAMB	0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Routine Water Analysis								
L390729-11 JOSLYN CREEK D/S MAY 22								
Sampled By: NOT PROVIDED on 22-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Routine Water Analysis								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-12 JOSLYN CREEK D/S MAY 23								
Sampled By: NOT PROVIDED on 23-MAY-06 @ 00:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Routine Water Analysis								

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
G	Outlier - No assignable cause for nonconformity has been determined.
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank
SAR:Q	Qualified SAR value: actual SAR is lower but is incalculable due to Na, Ca or Mg below detection limit.
SDO:RNA	Surrogate diluted out:% recovery not available

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BTX,F1-ED	Water	BTEX and F1 (C6-C10)	EPA 5030	EPA 5030/8015&8260-P&T GC-MS & FID
BTX-TCLP-ED	Waste	TCLP Leachable BTEX	EPA 5030	EPA 5030/8015& 8260-P&T GC-MS/FID
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
ETL-SAR-ROU-ED	Water	SAR with Routine Analysis		CSSS 18.4-Calculation
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
F2-ED	Water	F2 (>C10-C16)		EPA 3510/8000-GC-FID
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MET1-TOT-CCME-ED	Water	Total Trace Metals	EPA3015	EPA 6020
MET2-TOT-LOW-ED	Water	Total Major Metals	EPA3015	EPA 200.7
METAL-CCME-ED	Soil	Metals in Soil - CCME List	EPA 3050	EPA 6020
N2N3-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3H-Colorimetry
NO2-ED	Water	Nitrite-N		APHA 4500 NO2B-Colorimetry

Reference Information

NO3-ED	Water	Nitrate-N	APHA 4500 NO3H-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity	APHA 4500-H, 2510, 2320
PREP-MOISTURE-ED	Soil	% Moisture	Oven dry 105C-Gravimetric
PSA-MUST-ED	Soil	MUST PSA D50 > 75um	ASTM D422-63-Hydrometer/Sieve
SAR-CALC-ED	Soil	SAR	CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)	CSSS 18.2, 16.2, 18.3
SO4-SAR-ED	Soil	Sulfate (SO4) in saturated paste	APHA 3120 B-ICP-OES

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

230126

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

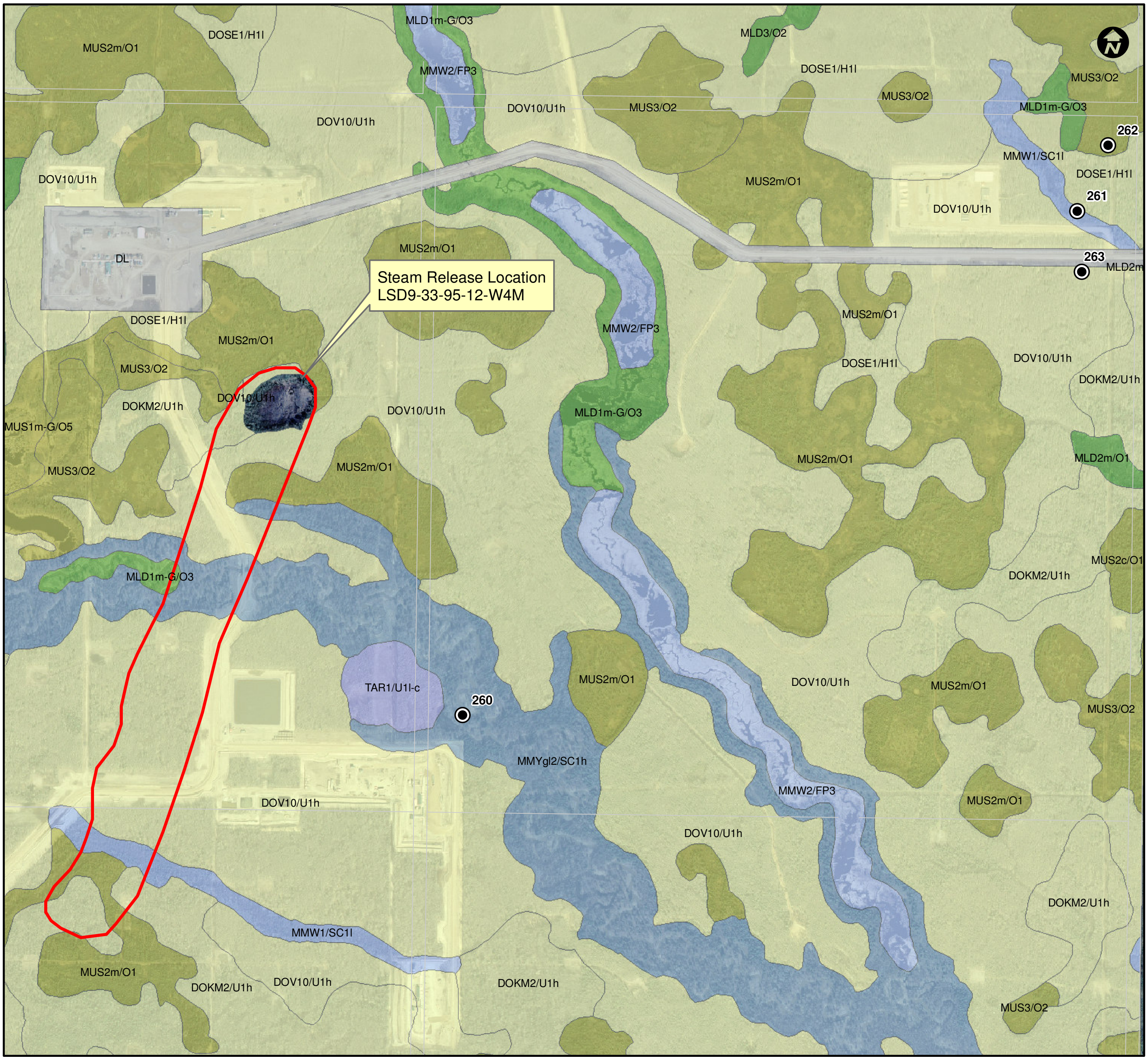
Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
< - Less than
D.L. - Detection Limit
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

APPENDIX B: FIGURES



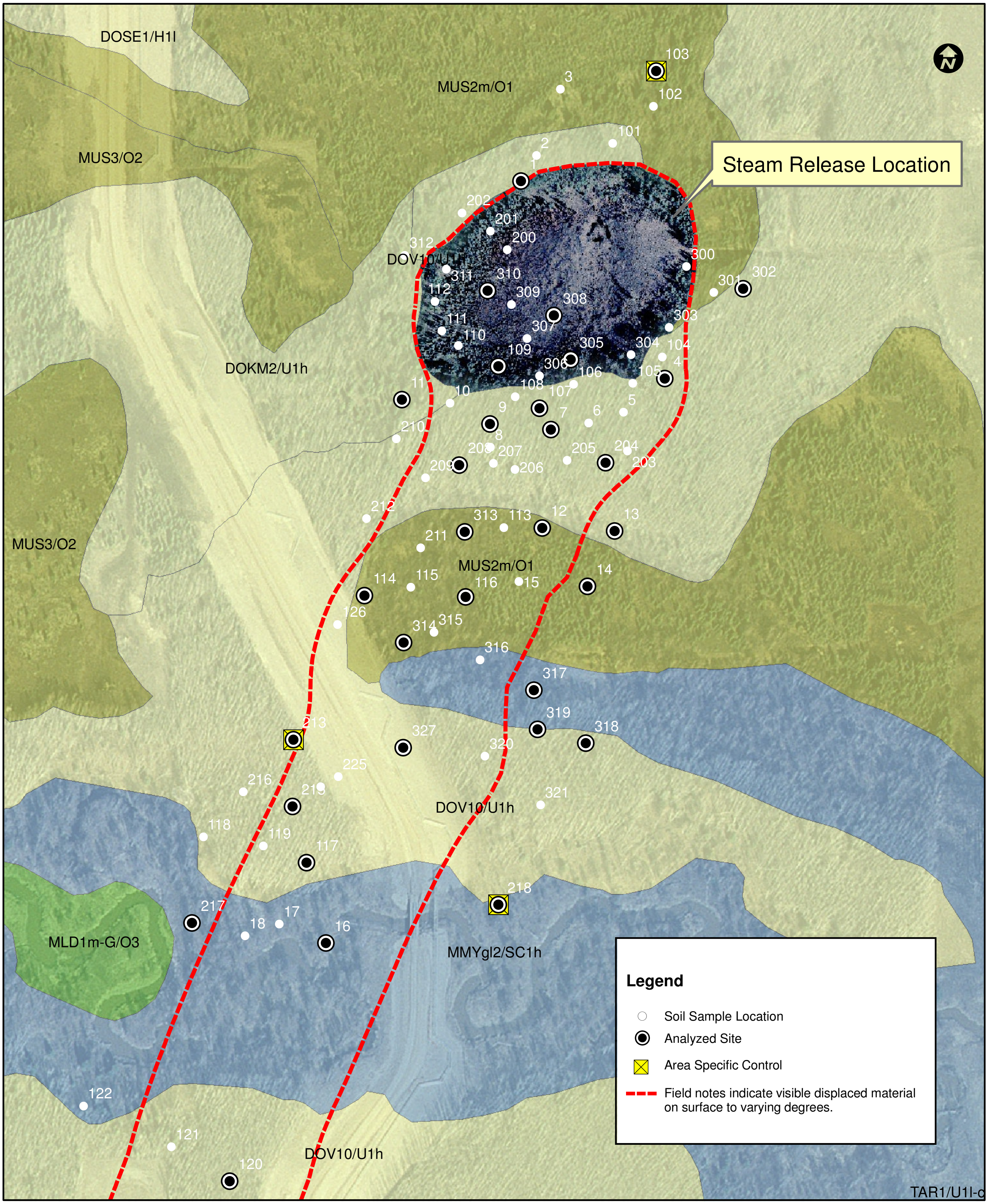
Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

Legend

● Perimeter Control Location

🟥 Initial estimated aerial extent of displaced material
based on visual indicators

DEER CREEK Energy Limited A wholly-owned subsidiary of TOTAL E&P CANADA LTD	PROJECT **DCEL Steam Release Incident**	DRAWN PS	CHECKED RM	DATE 08Dec06	PROJECTION: UTM12 NAD83 FILE No. 04-101
Millennium EMS Solutions Ltd.	TITLE **General Location of Steam Release**	SCALE 0 80 160 320 Meters			FIGURE 1



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

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PROJECT
DCEL Steam Release Incident

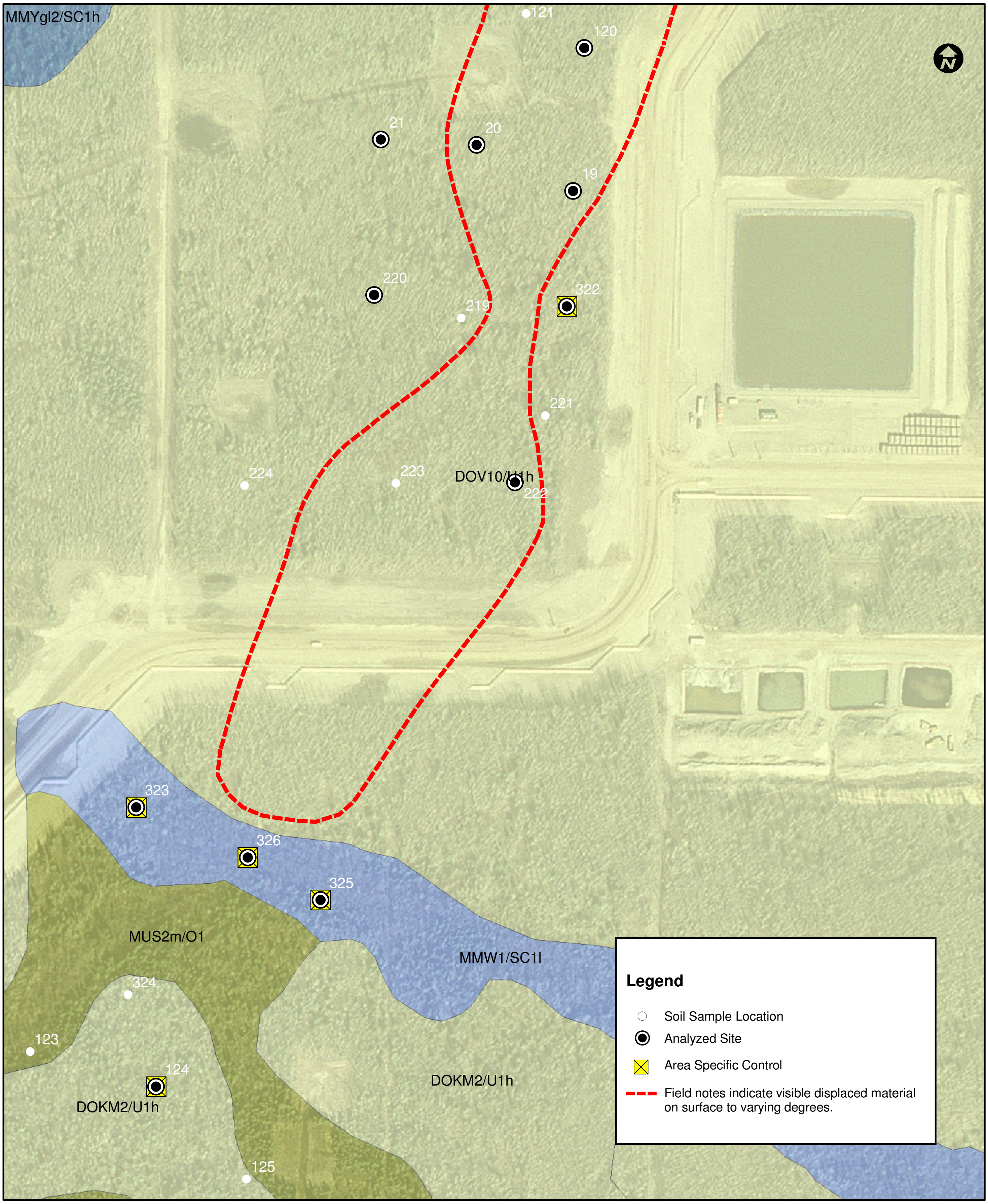
DRAWN	CHECKED	DATE	PROJECTION: UTM12 NAD83
PS	RM	08Dec06	FILE No. 04-101

Millennium
EMS Solutions Ltd.

TITLE
Soil Sampling Locations

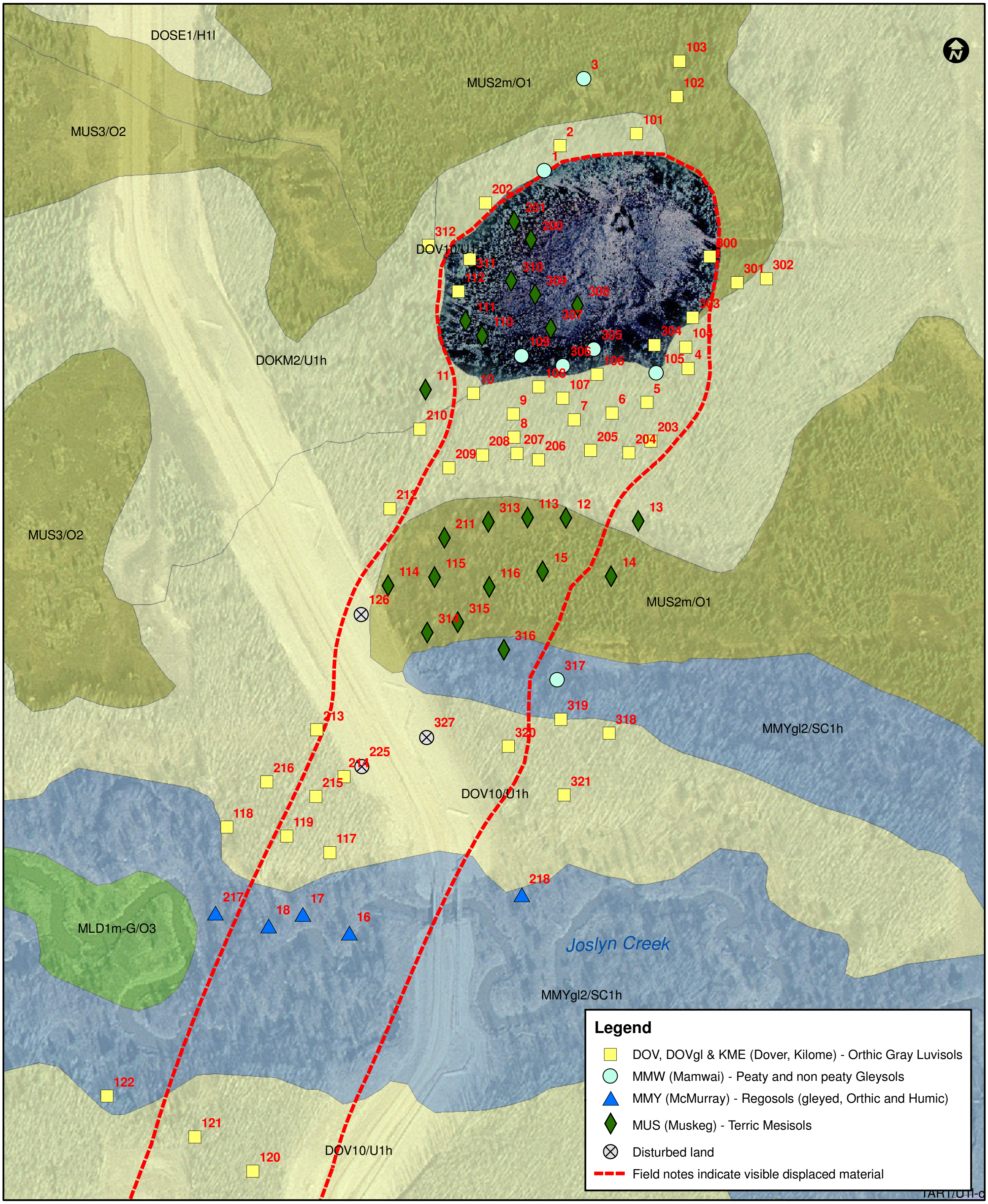
SCALE
0 20 40 80
Metres

FIGURE
2a



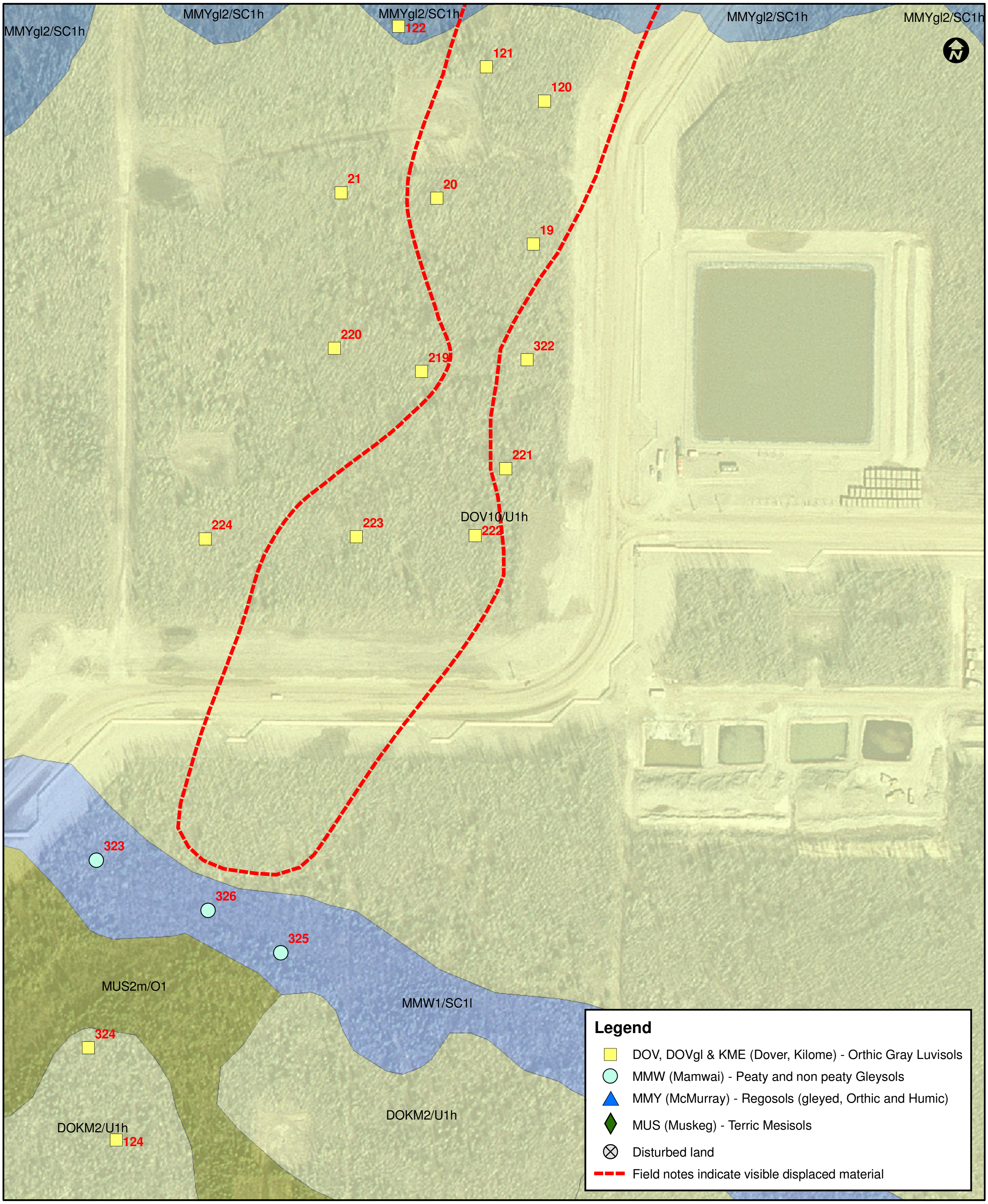
Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

DEER CREEK Energy Limited A wholly-owned subsidiary of TOTAL E&P CANADA LTD	PROJECT **DCEL Steam Release Incident**	DRAWN PS	CHECKED RM	DATE 08Dec06	PROJECTION: UTM12 NAD83 FILE No. 04-101
Millennium EMS Solutions Ltd.	TITLE **Soil Sampling Locations**	SCALE 0 20 40 80 Metres			FIGURE **2b**



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

DEER CREEK Energy Limited A wholly-owned subsidiary of TOTAL E&P CANADA LTD	PROJECT **DCEL Steam Release Incident**	DRAWN PS	CHECKED RM	DATE 08Dec06	PROJECTION: UTM12 NAD83 FILE No. 04-101
Millennium EMS Solutions Ltd.	TITLE **Soil Classification of Sample Points**	SCALE 0 20 40 80 Metres			FIGURE **3a**



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
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Millennium
EMS Solutions Ltd.

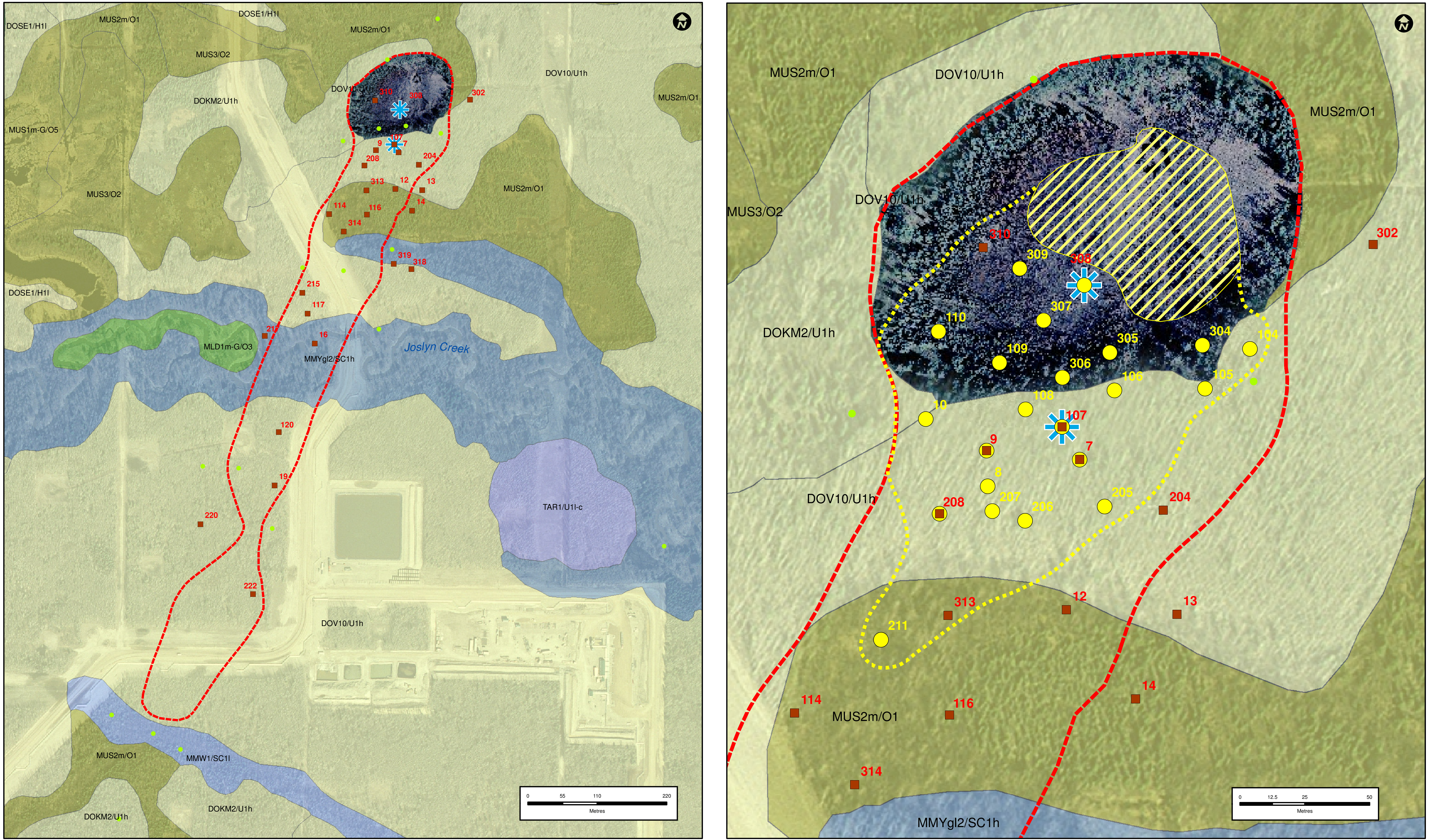
PROJECT
DCEL Steam Release Incident

TITLE
Soil Classification of Sample Points

DRAWN	CHECKED	DATE	PROJECTION: UTM12 NAD83
PS	RM	08Dec06	FILE No. 04-101

SCALE
0 20 40 80
Metres

FIGURE
3b



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

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Millennium
EMS Solutions Ltd.

PROJECT
DCEL Steam Release Incident

TITLE
Hydrocarbon and SAR Exceedences

LEGEND

■	Elevated Hydrocarbon values (F2-F4)
✳	Elevated SAR values
●	Sites Meet Criteria
- - -	Field notes indicate visible displaced material
▨	Area of Instability*
●	Displaced Material > 2cm
·····	Field notes indicate >2cm of displaced material at surface

* Area roped off, contains a visible layer of displaced material at surface

DRAWN	CHECKED	DATE	PROJECTION: UTM12 NAD83
PS	RM	08Dec06	FILE No. 04-101
SCALE			FIGURE 4

APPENDIX C: LABORATORY RESULTS

DOVER SERIES LABORATORY RESULTS

Dover Series Hydrocarbon Analyses

Parameter	**263-1 Control Ae 0-7**	**263-LFH Control 8-0**	**107-1 Ae 0-7**	**107-LFH 7-0**	**7-LFH 4-0**	**7-1 Ae 0-9**	**9-LFH 4-0**	**9-1 Ae 0-4**	**204-LFH 4-0**
Napthenic Acids (mg/kg)	-	-	99	2300	-	-	-	-	-
Benzene (mg/kg)	<0.005	<0.02	<0.005	<0.02	<0.005	<0.005	<0.02	<0.005	<0.02
Toluene (mg/kg)	<0.01	<0.03	0.01	<0.04	<0.01	<0.01	0.03	<0.01	<0.03
Ethylbenzene (mg/kg)	<0.01	<0.03	<0.01	<0.04	<0.01	<0.01	<0.03	<0.01	<0.03
Xylenes (mg/kg)	0.03	<0.03	0.03	<0.04	<0.01	<0.01	0.06	<0.01	<0.03
F1 (C6-C10) (mg/kg)	<5	<5	<5	19	<5	<5	<5	<5	<5
F1-BTEX (mg/kg)	<5	<5	<5	19	<5	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	<5	<5	<5	170	360	<5	59	<5	65
F3 (C16-C34) (mg/kg)	45	580	27	1500	10000	15	1800	13	2600
F4 (C34-C50) (mg/kg)	35	360	6	980	4800	9	1200	<5	1700
Total Hydrocarbons (mg/kg)	80	940	33	2700	15000	24	3100	13	4400
Chromatogram to baseline at nC50	NO	NO	NO	NO	NO	NO	NO	YES	NO

Parameter	**204-1 Ae 0-8**	**208-LFH 4-0**	**208-1 Ae 0-8**	**213-LFH 6-0**	**213-1 Ae 0-9**	**319-LFH 4-0**	**319-1 Ah 0-11**	**327-1[2] 0-5**	**327-2[2] 5-15**
Napthenic Acids (mg/kg)	-	-	-	-	-	-	-	-	-
Benzene (mg/kg)	<0.005	**<0.02**	<0.005	**<0.03**	<0.005	**<0.02**	<0.005	<0.005	<0.005
Toluene (mg/kg)	<0.01	<0.03	<0.01	<0.05	<0.01	<0.03	<0.01	<0.01	<0.01
Ethylbenzene (mg/kg)	<0.01	**<0.03**	<0.01	**<0.05**	<0.01	**<0.03**	<0.01	<0.01	<0.01
Xylenes (mg/kg)	<0.01	<0.03	<0.01	0.15	0.03	<0.03	<0.01	<0.01	<0.01
F1 (C6-C10) (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5
F1-BTEX (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	<5	63	<5	<5	<5	29	8	14	24
F3 (C16-C34) (mg/kg)	12	**1400**	23	590	<5	**3600**	290	750	530
F4 (C34-C50) (mg/kg)	<5	860	7	680	<5	1900	220	500	380
Total Hydrocarbons (mg/kg)	12	2300	30	1300	<5	5500	520	1300	930
Chromatogram to baseline at nC50	YES	NO	NO	NO	YES	NO	NO	NO	NO

Dover Series Hydrocarbon Analyses

Parameter	**117-LFH**	**117-1**	**215-LFH**	**215-1**	**20-LFH**	**20-1**	**120-LFH**	**103-LFH**	**103-1**
Napthenic Acids (mg/kg)	-	-	-	-	-	-	-	-	-
Benzene (mg/kg)	<0.01	<0.005	<0.01	<0.005	<0.02	<0.005	<0.02	<0.01	<0.005
Toluene (mg/kg)	<0.02	<0.01	<0.02	<0.01	<0.03	<0.01	<0.03	<0.02	0.02
Ethylbenzene (mg/kg)	<0.02	<0.01	<0.02	<0.01	<0.03	<0.01	<0.03	<0.02	<0.01
Xylenes (mg/kg)	<0.02	0.03	<0.02	0.01	<0.03	<0.01	<0.03	<0.02	0.02
F1 (C6-C10) (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5
F1-BTEX (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	29	<5	26	<5	52	<5	<5	<5	19
F3 (C16-C34) (mg/kg)	2700	110	4500	18	2300	31	1600	430	120
F4 (C34-C50) (mg/kg)	1400	89	2200	20	2600	47	1200	440	66
Total Hydrocarbons (mg/kg)	4100	200	6700	38	5000	78	2800	870	210
Chromatogram to baseline at nC50	NO	NO	NO	NO	NO	NO	NO	NO	NO

Parameter	**120-1**	**124-LFH**	**124-1**	**220-LFH**	**222-1**	**322-LFH**	**322-1**	**302-LFH**	**302-1**
Napthenic Acids (mg/kg)	-	-	-	-	-	-	-	-	-
Benzene (mg/kg)	<0.005	<0.02	<0.005	<0.02	<0.005	<0.02	<0.005	<0.01	<0.005
Toluene (mg/kg)	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.02	<0.01
Ethylbenzene (mg/kg)	<0.01	<0.03	<0.01	<0.03	<0.01	<0.03	<0.01	<0.02	<0.01
Xylenes (mg/kg)	<0.01	0.47	<0.01	0.04	<0.01	<0.03	<0.01	0.02	<0.01
F1 (C6-C10) (mg/kg)	<5	18	<5	11	<5	<5	<5	<5	<5
F1-BTEX (mg/kg)	<5	18	<5	11	<5	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	<5	29	7	56	<5	17	<5	<5	5
F3 (C16-C34) (mg/kg)	30	660	7	5400	11	*890*	41	2200	17
F4 (C34-C50) (mg/kg)	47	1000	<5	3200	<5	850	53	950	<5
Total Hydrocarbons (mg/kg)	77	1700	14	8700	11	1800	94	3200	22
Chromatogram to baseline at nC50	NO	NO	YES	NO	YES	NO	NO	NO	YES

Dover Series Salinity Analyses

Parameter	**UNITS**	**263-1**	**263-LFH**	**4-LFH**	**107-LFH**	**107-1**	**7-LFH**	**7-1**	204-LFH
Conductivity (EC)	dS m-1	0.14	0.52	0.70	0.84	0.32	0.80	0.29	0.53
SAR	SAR	0.2	0.1	0.7	5.8	1.7	4.1	2.7	0.2
pH in Saturated Paste	pH	4.7	5.3	6.2	5.8	5.1	6.3	4.9	6.7
Calcium (Ca)	mg/L	21	88	92	55	34	59	18	99
Chloride (Cl)	mg/L	<20	50	20	40	<20	40	20	30
Magnesium (Mg)	mg/L	8	31	29	12	8	15	4	25
Potassium (K)	mg/L	8	73	80	60	4	65	4	62
Sodium (Na)	mg/L	5	5	31	180	41	136	50	10
Sulphate (SO4)	mg/L	28	79	99	220	129	134	99	45
Percent Saturation	%	30.0	401	310	576	25.9	442	26.4	832
Particle Size (> 75 um)	%	12	-	-	-	28	-	-	-

Parameter	**UNITS**	208-LFH	213-LFH	327-1[1]	327-2[1]	19-LFH	20-LFH	20-1	**21-LFH**
Conductivity (EC)	dS m-1	0.35	1.28	1.70	1.83	0.9	1.47	0.2	0.49
SAR	SAR	2.4	<0.1	1.2	1.1	<0.1	<0.1	0.3	<0.1
pH in Saturated Paste	pH	5.7	6.1	7.2	7.5	6.3	5.6	5.1	5.2
Calcium (Ca)	mg/L	24	200	318	317	139	200	25	65
Chloride (Cl)	mg/L	30	60	20	20	40	60	30	40
Magnesium (Mg)	mg/L	7	65	90	131	51	87	8	26
Potassium (K)	mg/L	39	204	15	9	102	203	7	80
Sodium (Na)	mg/L	51	6	93	91	5	3	8	2
Sulphate (SO4)	mg/L	49	66	1040	1260	64	64	35	44
Percent Saturation	%	712	525	53.4	55.6	376	670	37.2	454
Particle Size (> 75 um)	%	-	-	-	-	-	-	-	-

Dover Series Salinity Analyses

Parameter	UNITS	124-LFH	124-1	222-LFH	103-LFH[2]	103-1[2]	302-LFH[2]	302-1[2]
Conductivity (EC)	dS m-1	0.77	0.26	0.72	0.35	0.12	0.78	0.17
SAR	SAR	<0.1	0.2	<0.1	<0.1	0.2	<0.1	0.3
pH in Saturated Paste	pH	5.3	5.9	6.7	4.9	4.5	5.8	4.8
Calcium (Ca)	mg/L	93	35	83	39	17	90	22
Chloride (Cl)	mg/L	50	<20	30	<20	<20	50	<20
Magnesium (Mg)	mg/L	59	27	36	11	5	39	10
Potassium (K)	mg/L	107	3	97	83	7	134	5
Sodium (Na)	mg/L	3	7	3	2	4	3	7
Sulphate (SO4)	mg/L	66	45	45	34	21	63	35
Percent Saturation	%	618	44	645	634	43.8	612	28.6
Particle Size (> 75 um)	%	-	-	-	-	-	-	-

1 Sample site 327 is a disturbed sample

Dover Series Trace metals Analyses

Parameters	Units	107-LFH	107-1
Antimony (Sb)	mg/kg	<0.2	<0.2
Arsenic (As)	mg/kg	2.1	3.4
Barium (Ba)	mg/kg	116	65
Beryllium (Be)	mg/kg	<1	<1
Cadmium (Cd)	mg/kg	<0.5	<0.5
Chromium (Cr)	mg/kg	5.2	9.2
Cobalt (Co)	mg/kg	4	4
Copper (Cu)	mg/kg	9	3
Lead (Pb)	mg/kg	6	7
Mercury (Hg)	mg/kg	<0.05	<0.05
Molybdenum (Mo)	mg/kg	1	<1
Nickel (Ni)	mg/kg	11	5
Selenium (Se)	mg/kg	0.5	0.3
Silver (Ag)	mg/kg	<1	<1
Thallium (Tl)	mg/kg	<1	<1
Tin (Sn)	mg/kg	<5	<5
Uranium (U)	mg/kg	<2	<2
Vanadium (V)	mg/kg	18	20
Zinc (Zn)	mg/kg	40	20

MAMWAI SERIES LABORATORY RESULTS

Mamwai Hydrocarbon Analyses

Parameter	261-LFH	261-1	109-LFH	109-1	305 LFH	305-1	317-1	318-LFH	318-1
Napthenic Acids (mg/kg)	-	-	2300	56	500	52	-	-	-
Benzene (mg/kg)	<0.02	<0.005	<0.02	<0.005	<0.02	<0.005	<0.02	<0.02	<0.005
Toluene (mg/kg)	<0.04	<0.01	<0.03	<0.01	<0.04	<0.01	<0.04	<0.04	<0.01
Ethylbenzene (mg/kg)	<0.04	<0.01	<0.03	<0.01	<0.04	<0.01	<0.04	<0.04	<0.01
Xylenes (mg/kg)	<0.04	0.04	0.41	<0.01	<0.04	<0.01	<0.04	<0.04	<0.01
F1 (C6-C10) (mg/kg)	<5	<5	18	<5	<5	<5	<5	<5	<5
F1-BTEX (mg/kg)	<5	<5	18	<5	<5	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	6	<5	46	<5	58	<5	34	130	<5
F3 (C16-C34) (mg/kg)	770	39	410	<5	420	17	*1000*	2000	75
F4 (C34-C50) (mg/kg)	340	34	280	<5	400	23	510	1200	99
Total Hydrocarbons (mg/kg)	1100	73	750	<5	880	40	1500	3300	170
Chromatogram to baseline at nC50	NO	NO	NO	YES	NO	NO	NO	NO	NO

Parameter	323-LFH	323-1	326-1
Napthenic Acids (mg/kg)	-	-	-
Benzene (mg/kg)	<0.02	<0.02	<0.03
Toluene (mg/kg)	<0.03	<0.04	<0.05
Ethylbenzene (mg/kg)	<0.03	<0.04	<0.05
Xylenes (mg/kg)	<0.03	<0.04	<0.05
F1 (C6-C10) (mg/kg)	<5	<5	<5
F1-BTEX (mg/kg)	<5	<5	<5
F2 (C10-C16) (mg/kg)	39	14	12
F3 (C16-C34) (mg/kg)	1600	1700	290
F4 (C34-C50) (mg/kg)	750	760	260
Total Hydrocarbons (mg/kg)	2400	2500	560
Chromatogram to baseline at nC50	NO	NO	NO

Mamwai Salinity Analyses

Parameter	Units	261-1	11-LFH	109-LFH	109-1	305 LFH	305-1	318-LFH
Conductivity (EC)	dS/m	0.68	0.60	0.69	0.53	1.12	-	0.53
SAR	SAR	1.3	1.0	2.6	1.4	3.9	-	<0.1
pH in Saturated Paste	pH	6.0	6.0	6.4	7.4	6.6	-	6.1
Calcium (Ca)	mg/kg	90	59	68	71	106	-	79
Chloride (Cl)	mg/kg	40	40	30	<20	50	-	30
Magnesium (Mg)	mg/kg	40	26	31	25	50	-	20
Potassium (K)	mg/kg	6	69	12	<2	30	-	86
Sodium (Na)	mg/kg	59	37	105	55	193	-	3
Sulphate (SO4)	mg/kg	283	95	194	185	333	-	49
Percent Saturation	%	62.7	905	375	38.7	403	-	565
Particle Size (> 75 um)	%	-	-	-	19	-	57	-

Parameter	Units	318-2	323-LFH	325-1	326-1	326-1
Conductivity (EC)	dS/m	-	0.52	0.14	0.48	0.48
SAR	SAR	-	0.4	0.8	0.5	0.5
pH in Saturated Paste	pH	-	6.3	4.7	5.6	5.6
Calcium (Ca)	mg/kg	-	70	13	48	48
Chloride (Cl)	mg/kg	-	30	<20	20	20
Magnesium (Mg)	mg/kg	-	31	4	26	26
Potassium (K)	mg/kg	-	34	2	29	29
Sodium (Na)	mg/kg	-	15	13	18	18
Sulphate (SO4)	mg/kg	-	51	30	93	93
Percent Saturation	%	-	419	30.7	535	535
Particle Size (> 75 um)	**%**	2	-	-	-	-

Mamwai Trace Metals Analyses

Parameters	Units	109-LFH	109-1	305 LFH	305-1
Antimony (Sb)	mg/kg	<0.2	<0.2	0.3	<0.2
Arsenic (As)	mg/kg	1.3	6.2	0.9	2.1
Barium (Ba)	mg/kg	148	143	87	71
Beryllium (Be)	mg/kg	<1	<1	<1	<1
Cadmium (Cd)	mg/kg	<0.5	<0.5	<0.5	<0.5
Chromium (Cr)	mg/kg	4.9	22.0	1.4	8.6
Cobalt (Co)	mg/kg	3	7	2	3
Copper (Cu)	mg/kg	8	6	7	3
Lead (Pb)	mg/kg	<5	10	<5	<5
Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05
Molybdenum (Mo)	mg/kg	<1	<1	1	<1
Nickel (Ni)	mg/kg	6	13	6	7
Selenium (Se)	mg/kg	1.1	0.4	1.3	<0.2
Silver (Ag)	mg/kg	<1	<1	<1	<1
Thallium (Tl)	mg/kg	<1	<1	<1	<1
Tin (Sn)	mg/kg	<5	<5	<5	<5
Uranium (U)	mg/kg	3	<2	8	<2
Vanadium (V)	mg/kg	10	40	7	16
Zinc (Zn)	mg/kg	40	40	20	20

MUSKEG SERIES LABORATORY RESULTS

Muskeg Series Hydrocarbon Analyses

Parameter	**262-1**	**308-1**	**310-LFH**	**310-1**	**12-LFH**	**12-1**	**13-LFH**	**13-1**
Napthenic Acids (mg/kg)	4400	600	3900	410	-	-	**-**	-
Benzene (mg/kg)	<0.04	**<0.1**	**<0.03**	**<0.05**	<0.005	**<0.03**	**<0.02**	**<0.02**
Toluene (mg/kg)	<0.08	<0.2	<0.06	<0.1	<0.01	<0.06	<0.03	<0.04
Ethylbenzene (mg/kg)	<0.08	**<0.2**	**<0.06**	**<0.1**	<0.01	**<0.06**	**<0.03**	**<0.04**
Xylenes (mg/kg)	<0.08	<0.2	<0.06	<0.1	<0.01	<0.06	<0.03	<0.04
F1 (C6-C10) (mg/kg)	71	<5	<5	<5	<5	<5	<5	<5
F1-BTEX (mg/kg)	71	<5	<5	<5	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	<5	37	88	24	57	40	43	87
F3 (C16-C34) (mg/kg)	**2000**	1200	**4300**	1300	**2800**	260	**4200**	**1600**
F4 (C34-C50) (mg/kg)	980	830	1900	880	990	360	2500	1000
Total Hydrocarbons (mg/kg)	3100	2100	6300	2200	3800	660	6700	2700
Chromatogram to baseline at nC50	NO	NO	NO	NO	NO	NO	NO	NO

Parameter	**14-LFH**	**114-LFH**	**114-1**	**116-1**	**313-LFH**	**313-1**	**314-LFH**	**314-1**
Napthenic Acids (mg/kg)	**-**	-	**-**	-	-	**-**	-	**-**
Benzene (mg/kg)	**<0.02**	<0.01	**<0.03**	**<0.05**	<0.01	**<0.05**	**<0.02**	**<0.04**
Toluene (mg/kg)	**0.54**	<0.02	<0.05	<0.1	<0.02	<0.1	<0.03	<0.07
Ethylbenzene (mg/kg)	**<0.03**	<0.02	**<0.05**	<0.1	**<0.02**	**<0.1**	**<0.03**	**<0.07**
Xylenes (mg/kg)	2.5	<0.02	<0.05	**4.5**	<0.02	<0.1	<0.03	<0.07
F1 (C6-C10) (mg/kg)	**560**	<5	<5	39	<5	<5	<5	<5
F1-BTEX (mg/kg)	560	<5	<5	35	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	**160**	**440**	<5	25	97	55	**220**	60
F3 (C16-C34) (mg/kg)	**3100**	**18000**	200	*1300*	**2800**	750	**8000**	1200
F4 (C34-C50) (mg/kg)	1800	**8000**	310	830	1200	930	4500	640
Total Hydrocarbons (mg/kg)	5600	26000	510	2200	4100	1700	13000	1900
Chromatogram to baseline at nC50	NO	NO	NO	NO	NO	NO	NO	NO

Muskeg Series Salinity Analyses

Parameter	Units	308-LF	308-1	308-2	310-LFH	310-1	14-LFH	14-1
Conductivity (EC)	dS/m	0.19	0.57	0.27	0.73	0.12	0.59	0.15
SAR	SAR	0.8	**15.6**	3.9	**4.7**	Incalculable - Low Cations	NA	NA
pH in Saturated Paste	**pH**	**5.9**	**5.8**	6.3	6.1	**5.4**	3.9	3.5
Calcium (Ca)	mg/kg	31	6	9	44	<5	51	<5
Chloride (Cl)	mg/kg	<20	20	20	30	<20	40	<20
Magnesium (Mg)	mg/kg	11	<3	4	16	<3	35	<3
Potassium (K)	mg/kg	<2	8	4	38	7	100	12
Sodium (Na)	mg/kg	20	137	56	143	23	16	4
Sulphate (SO4)	mg/kg	51	254	79	172	32	63	16
Percent Saturation	%	619	2070	2580	295	1980	577	1820
Particle Size (> 75 um)	%	-	-	-	-	-	-	-

Parameter	Units	116-1	116-2	313-LFH
Conductivity (EC)	dS/m	0.4	0.22	0.67
SAR	SAR	1.0	0.7	0.5
pH in Saturated Paste	**pH**	5.1	5.6	6.1
Calcium (Ca)	mg/kg	49	33	88
Chloride (Cl)	mg/kg	20	<20	<20
Magnesium (Mg)	mg/kg	29	15	46
Potassium (K)	mg/kg	37	4	24
Sodium (Na)	mg/kg	37	19	25
Sulphate (SO4)	mg/kg	93	61	240
Percent Saturation	%	470	472	317
Particle Size (> 75 um)	%	-	-	-

Muskeg Series Trace metals Analyses

Parameters	Units	308-LF	308-1	310-LFH	310-1
Antimony (Sb)	mg/kg	<0.2	<0.2	<0.2	<0.2
Arsenic (As)	mg/kg	1.5	0.8	3.2	1.5
Barium (Ba)	mg/kg	69	27	67	35
Beryllium (Be)	mg/kg	<1	<1	<1	<1
Cadmium (Cd)	mg/kg	<0.5	<0.5	<0.5	<0.5
Chromium (Cr)	mg/kg	2.7	2.7	7.0	7.7
Cobalt (Co)	mg/kg	2	1	4	2
Copper (Cu)	mg/kg	5	3	10	4
Lead (Pb)	mg/kg	<5	<5	6	<5
Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05
Molybdenum (Mo)	mg/kg	1	<1	<1	<1
Nickel (Ni)	mg/kg	5	5	11	7
Selenium (Se)	mg/kg	0.4	0.2	0.3	0.3
Silver (Ag)	mg/kg	<1	<1	<1	<1
Thallium (Tl)	mg/kg	<1	<1	<1	<1
Tin (Sn)	mg/kg	<5	<5	<5	<5
Uranium (U)	mg/kg	<2	<2	<2	<2
Vanadium (V)	mg/kg	5	5	17	9
Zinc (Zn)	mg/kg	30	20	40	30

MCMURRAY SERIES LABORATORY RESULTS

McMurray Series Hydrocarbon Analyses

Parameter	260	260-1	260-2	16-LFH	16-1	217-LFH	217-1	218-LFH	218-1
Napthenic Acids (mg/kg)	-	-	-	-	-	-	-	-	-
Benzene (mg/kg)	<0.01	<0.005	<0.005	<0.02	<0.005	<0.02	<0.005	<0.01	<0.005
Toluene (mg/kg)	<0.02	<0.01	<0.01	<0.03	<0.01	<0.04	<0.01	<0.02	<0.01
Ethylbenzene (mg/kg)	<0.02	<0.01	<0.01	<0.03	<0.01	<0.04	<0.01	<0.02	<0.01
Xylenes (mg/kg)	<0.02	<0.01	<0.01	<0.03	<0.01	<0.04	<0.01	<0.02	<0.01
F1 (C6-C10) (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5
F1-BTEX (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10-C16) (mg/kg)	<5	<5	<5	18	<5	<5	<5	18	<5
F3 (C16-C34) (mg/kg)	230	260	140	4700	150	1300	150	500	86
F4 (C34-C50) (mg/kg)	230	93	66	2600	120	1300	91	680	67
Total Hydrocarbons (mg/kg)	460	350	210	7300	270	2600	240	1200	150
Chromatogram to baseline	NO	NO	NO	NO	NO	NO	NO	NO	NO

McMurray Series Salinity Analyses

Parameter	Units	260-1	260-2	16-LFH	16-1	16-2	217-LFH	218-LFH
Conductivity (EC)	dS/m	0.14	0.13	0.6	0.21	-	1.02	0.52
SAR	SAR	0.1	0.2	0.1	0.4	-	<0.1	0.1
pH in Saturated Paste	pH	5.0	4.6	6.7	4.9	-	6.4	6.1
Calcium (Ca)	mg/kg	28	22	73	20	-	102	72
Chloride (Cl)	mg/kg	<20	<20	30	30	-	30	30
Magnesium (Mg)	mg/kg	6	6	24	4	-	43	26
Potassium (K)	mg/kg	9	4	72	17	-	142	80
Sodium (Na)	mg/kg	3	5	5	8	-	<2	5
Sulphate (SO4)	mg/kg	30	38	40	49	-	32	105
Percent Saturation	%	74.8	50.6	316	65	-	781	328
Particle Size (> 75 um)	%	25	34	-	34	54	-	-

DISPLACED MATERIAL LABORATORY RESULTS

Displaced Material Hydrocarbon Analyses

Parameter	2001 Criteria	2006 Criteria	107-DM	305-DM2	305-DM1[2]	308-DM	109-DM
Napthenic Acids (mg/kg)	-	-	-	44	-	-	-
Naphthenic Acids:Leach. (mg/L)	-	-	-	-	1.0	-	-
Benzene (mg/kg)	**0.073**	**0.011**	<0.005	**0.021**	-	<0.005	<0.005
Toluene (mg/kg)	**0.86**	**0.13**	0.01	0.02	-	0.01	0.02
Ethylbenzene (mg/kg)	**0.19**	**0.027**	<0.01	<0.01	-	<0.01	<0.01
Xylenes (mg/kg)	**25**	**3.6**	<0.01	0.07	-	<0.01	2.0
F1 (C6-C10) (mg/kg)	**260**	**210**	<5	87	-	<5	110
F1-BTEX (mg/kg)	-	-	<5	87	-	<5	110
F2 (C10-C16) (mg/kg)	**900**	**150**	**720**	**1200**	-	**1200**	**810**
F2-Naphth (mg/kg)	-	-	720	1200	-	1200	810
F3 (C16-C34) (mg/kg)	**800**	**1300**	**13000**	**14000**	-	**14000**	**11000**
F3-PAH (mg/kg)	-	-	13000	14000	-	14000	11000
F4 (C34-C50) (mg/kg)	**5600**	**5600**	**6500**	**6800**	-	**7800**	**4800**
Total Hydrocarbons (mg/kg)	-	-	22200	22000	-	23000	16700
Chromatogram to baseline	-	-	NO	NO	-	NO	NO

exceeds screening criteria **BOLD**

Displaced Material Salinity Analyses

Parameter	UNITS	2001 Criteria*	107-DM	305-DM2	308-DM	109-DM
Conductivity (EC)	dS m-1	<2	1.07	1.98	**2.86**	1.27
SAR	SAR	<4	**11.9**	**15.4**	**20.5**	**7.8**
pH in Saturated Paste	pH	6-8.5**	7.8	7.6	7.9	7.4
Calcium (Ca)	mg/L	-	28	62	78	75
Chloride (Cl)	mg/L	-	30	50	60	60
Magnesium (Mg)	mg/L	-	7	11	17	19
Potassium (K)	mg/L	-	14	16	13	10
Sodium (Na)	mg/L	-	268	503	770	292
Sulphate (SO4)	mg/L	-	382	951	1600	429
Percent Saturation	%	-	45.9	53.6	50.8	48.8
Particle Size (> 75 um)	%	-	-	-	-	-

exceeds screening criteria **BOLD**

* AENV Salt Contamination and Remediation Guidelines 2001

** pH range adapted from the AENV 2006 Tier 1 Draft Criteria

Displaced Material Trace metals Analyses

Parameters	Units	Criteria 2006 AENV Draft	CCME 2006	107-DM	305-DM2	308-DM	109-DM
Antimony (Sb)	mg/kg	**20**	**-**	<0.2	<0.2	<0.2	<0.2
Arsenic (As)	mg/kg	**17**	**17**	3.2	4.0	4.4	3.6
Barium (Ba)	mg/kg	**750**	**750**	74	72	245	664
Beryllium (Be)	mg/kg	**5**	**-**	<1	<1	<1	<1
Cadmium (Cd)	mg/kg	**10**	**10**	<0.5	<0.5	<0.5	<0.5
Chromium (Cr)	mg/kg	**64**	**64**	11.2	10.5	22.4	10.6
Cobalt (Co)	mg/kg	**20**	**-**	5	6	7	6
Copper (Cu)	mg/kg	**63**	**63**	10	11	12	12
Lead (Pb)	mg/kg	**70**	**70**	6	6	7	8
Mercury (Hg)	mg/kg	**12**	**6.6**	<0.05	<0.05	<0.05	<0.05
Molybdenum (Mo)	mg/kg	**4**	**-**	<1	<1	<1	<1
Nickel (Ni)	mg/kg	**50**	**50**	16	16	25	16
Selenium (Se)	mg/kg	**1**	**-**	0.4	0.3	0.2	0.5
Silver (Ag)	mg/kg	**20**	**-**	<1	<1	<1	<1
Thallium (Tl)	mg/kg	**1**	**1**	<1	<1	<1	<1
Tin (Sn)	mg/kg	**5**	**-**	<5	<5	<5	<5
Uranium (U)	mg/kg	**-**	**-**	<2	<2	<2	<2
Vanadium (V)	mg/kg	**130**	**130**	21	22	23	23
Zinc (Zn)	mg/kg	**220**	**200**	40	40	40	40

exceeds screening criteria **BOLD**

PAH LABORATORY RESULTS

PAH B(a)P Equivalency Calculations as per the AENV 2001 and 2006 Tier I Guidelines

Parameter*	**CCME 2006**	**AENV**	**AENV**	**107-DM**	**107-LFH**	**107-1**	**109-DM**	**109-LFH**	**109-1**
	Tier I'94	**2001**	**2006**	**DM**	**LFH**	**Ae**	**DM**	**LFH**	**BCgk**
		Natural	**Natural**	**13-7**	**7-0**	**0-10**	**24-15**	**15-0**	**0-16**
Benzo(a)anthracene (mg/kg)	*0.1*	-	**-**	<0.2	<0.1	<0.01	<0.2	0.07	<0.01
Benzo(b)fluoranthene (mg/kg)	*0.1*	-	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01
Benzo(k)fluoranthene (mg/kg)	*0.1*	-	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01
Benzo(a)pyrene (mg/kg)	*0.1*	-	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01
Indeno(1,2,3-cd)pyrene (mg/kg)	*0.1*	-	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01
Dibenzo(a,h)anthracene (mg/kg)	*0.1*	-	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01
Total B(a)P equivalent**	**min.[1]**	**4.3**	**0.069**	**0**	**0**	**0**	**0**	**0.007**	**0**
	max.[1]	**4.3**	**0.069**	**0.52**	**0.26**	**0.026**	**0.52**	**0.086**	**0.026**

Parameter	**CCME'99**	**AENV**	**AENV[1]**	**305-DM2**	**305 LFH**	**305-1**	**308-DM**	**308-1**	**310-LFH**
	Tier I'94	**2001**	**2006**	**DM2**	**LFH**	**Cg**	**DM**	**Of**	**LFH**
		Natural	**Natural**	**8-0**	**8-28**	**28-60**	**20-0**	**0-15**	**5-0**
Benzo(a)anthracene (mg/kg)	*0.1*	-	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	0.04
Benzo(b)fluoranthene (mg/kg)	*0.1*	-	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Benzo(k)fluoranthene (mg/kg)	*0.1*	-	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Benzo(a)pyrene (mg/kg)	*0.1*	-	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Indeno(1,2,3-cd)pyrene (mg/kg)	*0.1*	-	**-**				<0.2	<0.04	<0.03
Dibenzo(a,h)anthracene (mg/kg)	*0.1*	-	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Total B(a)P equivalent*	**min.[1]**	**4.3**	**0.069**	**0**	**0**	**0**	**0**	**0**	**0.004**
	max.[1]	**4.3**	**0.069**	**0.52**	**0.086**	**0.086**	**0.52**	**0.104**	**0.088**

PAH Compound	Relative Potency
Benzo[a]anthracene	0.1
Benzo[b[fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[a]pyrene	1
Indeno[1,2,3-cd]pyrene	0.2
Dibenzo[a,h]anthracene	1.1
Individual PAH (compare to criteria) see table below	
B(a)P Toxic Equivalent Total 2001 = 4.3 mg/kg	
B(a)P Toxic Equivalent Total 2006 = 0.069 mg/kg	

* All PAH compounds contain B(a)P equivalency values as listed in the AENV 2001 Tier I guidelines.

** Values based on the B(a)P equivalency sum as calculated form the calculation in the 2001 Tier I guidelines.

[1] Min equivalency value uses zero in place of <D.L. Max uses detection limit in place of <D.L.

CCME PAH Criteria Comparison

CCME PAH's	CCME 2006	AENV 2006 Natural	107-DM DM 13-7	107-LFH LFH 7-0	107-1 Ae 0-10	109-DM DM 24-15	109-LFH LFH 15-0	109-1 BCgk 0-16	310-1 Of 0-15
Naphthalene	*0.1*	**0.026**	<0.2	<0.1	<0.01	<0.2	**0.05**	<0.01	<0.04
Quinoline	-	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01	<0.04
Phenanthrene	*0.1*	**-**	<0.2	<0.1	<0.01	<0.2	0.05	<0.01	<0.04
Pyrene	*0.1*	**0.033**	**0.3**	<0.1	<0.01	**0.3**	<0.01	<0.01	<0.04
Benzo(a)anthracene	*0.1*	**-**	<0.2	<0.1	<0.01	<0.2	0.07	<0.01	<0.04
Benzo(b)fluoranthene	*0.1*	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01	<0.04
Benzo(k)fluoranthene	*0.1*	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01	<0.04
Benzo(a)pyrene	*0.1*	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01	<0.04
Indeno(1,2,3-cd)pyrene	*0.1*	**-**	<0.2	<0.1	<0.01	<0.2	<0.01	<0.01	<0.04
Dibenzo(a,h)anthracene			<0.2	<0.1	<0.01	<0.2	<0.01	<0.01	<0.04

CCME PAH Criteria Comparison

CCME PAH's	CCME 2006	AENV 2006 Natural	305-DM2 DM2 8-0	305 LFH LFH 8-28	305-1 Cg 28-60	308-DM DM 20-0	308-1 Of 0-15	310-LFH LFH 5-0
Naphthalene	*0.1*	**0.026**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Quinoline	-	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Phenanthrene	*0.1*	**-**	<0.2	<0.01	<0.01	**0.4**	<0.04	0.07
Pyrene	*0.1*	**0.033**	**0.3**	<0.01	<0.01	**0.2**	<0.04	<0.03
Benzo(a)anthracene	*0.1*	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	0.04
Benzo(b)fluoranthene	*0.1*	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Benzo(k)fluoranthene	*0.1*	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Benzo(a)pyrene	*0.1*	**-**	<0.2	<0.01	<0.01	<0.2	<0.04	<0.03
Indeno(1,2,3-cd)pyrene	*0.1*	**-**	-	-	-	<0.2	<0.04	<0.03
Dibenzo(a,h)anthracene			<0.2	<0.01	<0.01	<0.2	<0.04	<0.03

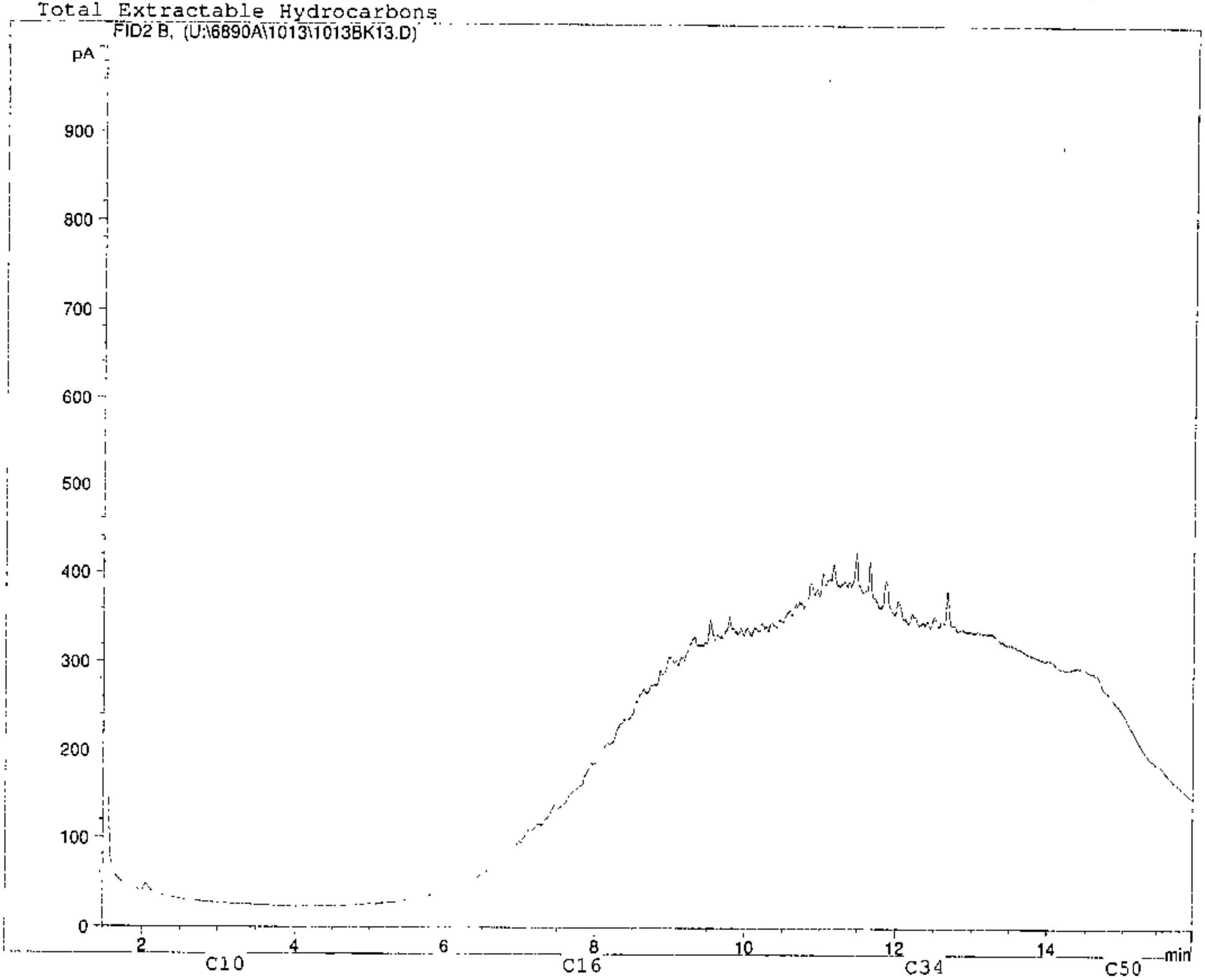
APPENDIX D: CHROMATOGRAMS

DISPLACED MATERIAL CHROMATOGRAMS

Client ID: 308-DM

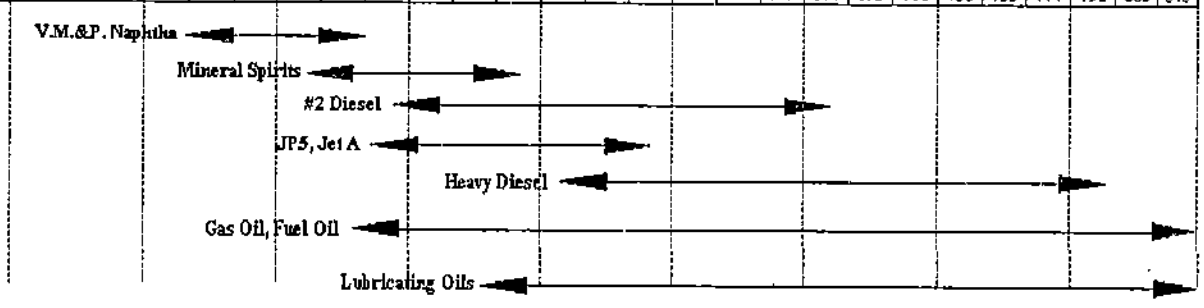
Sample ID: L437987-10 40
Injection Date: 10/13/2006 9:56:24 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

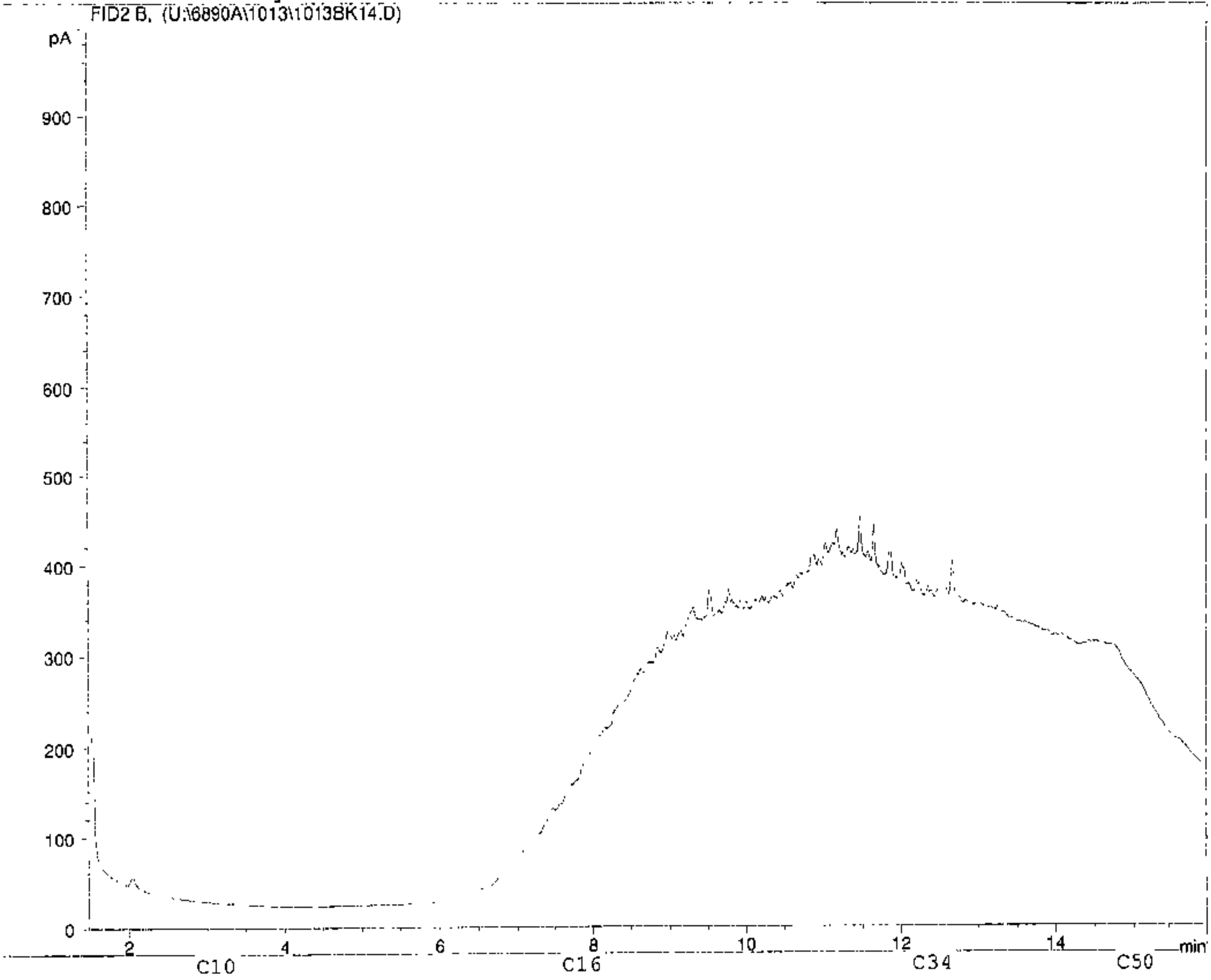


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 107-DM

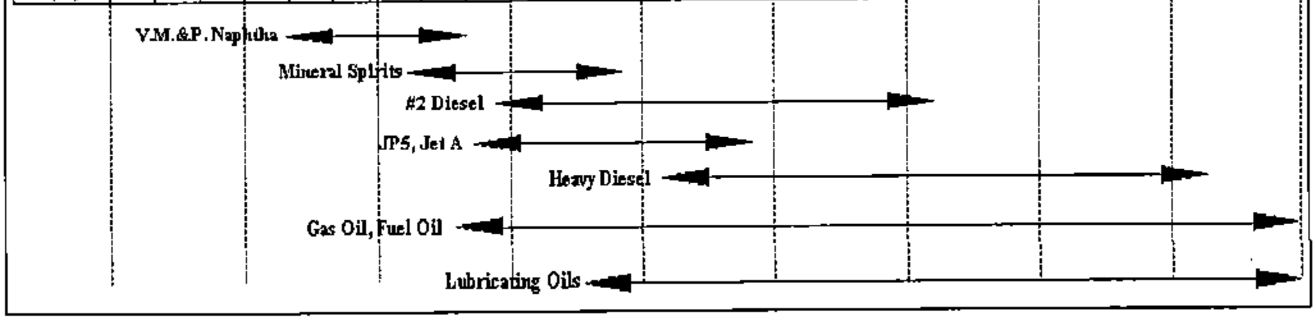
Sample ID: L437987-61 40
Injection Date: 10/13/2006 10:21:23 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

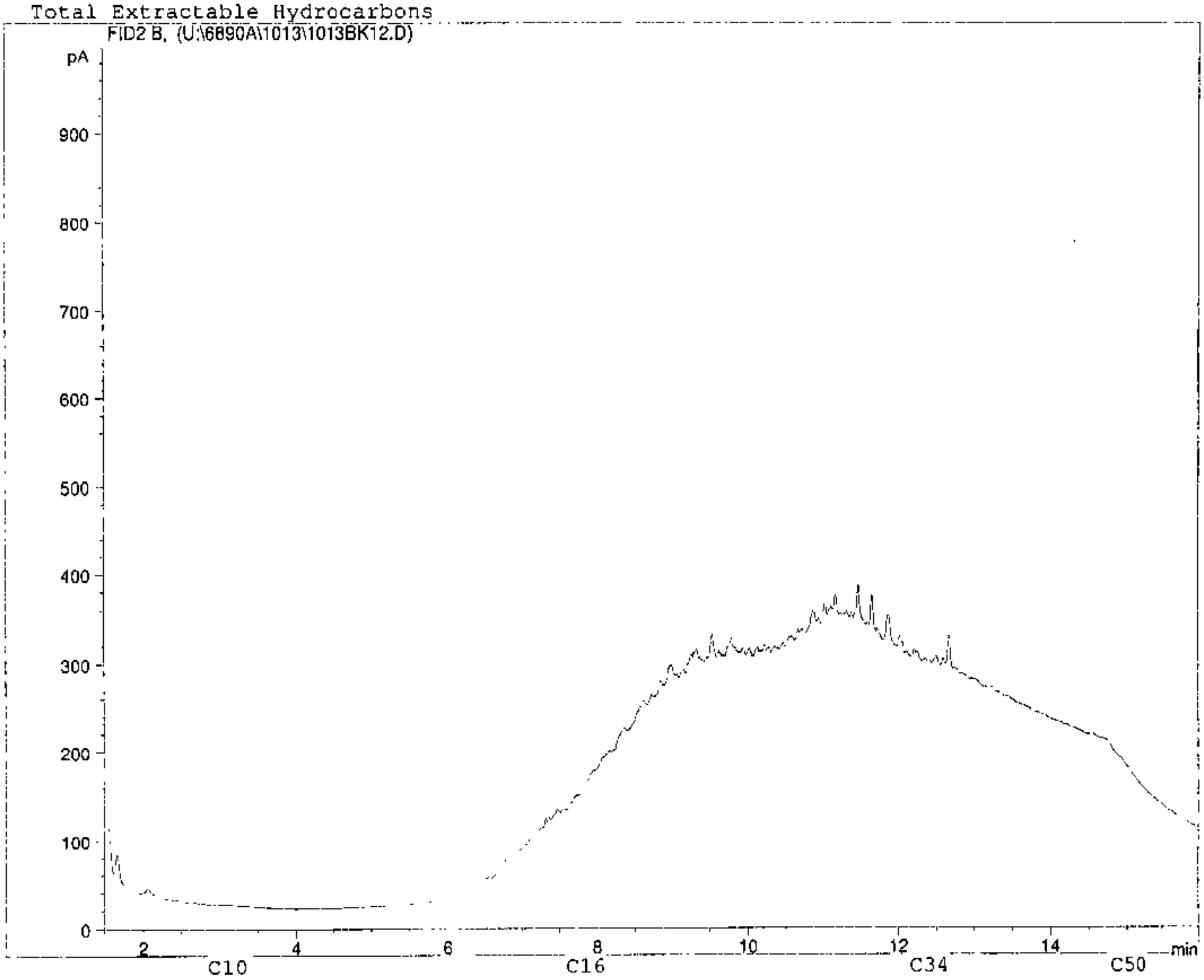


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 305-DM2

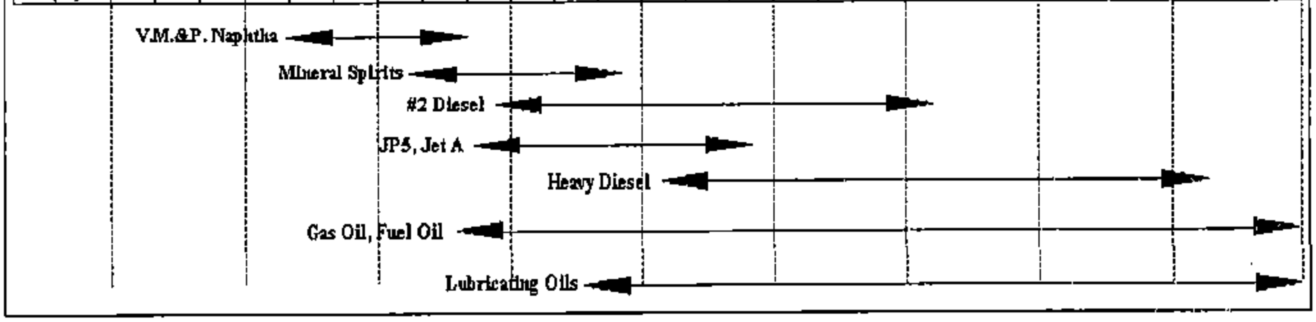
Sample ID: L437383-71 40
Injection Date: 10/13/2006 9:31:26 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

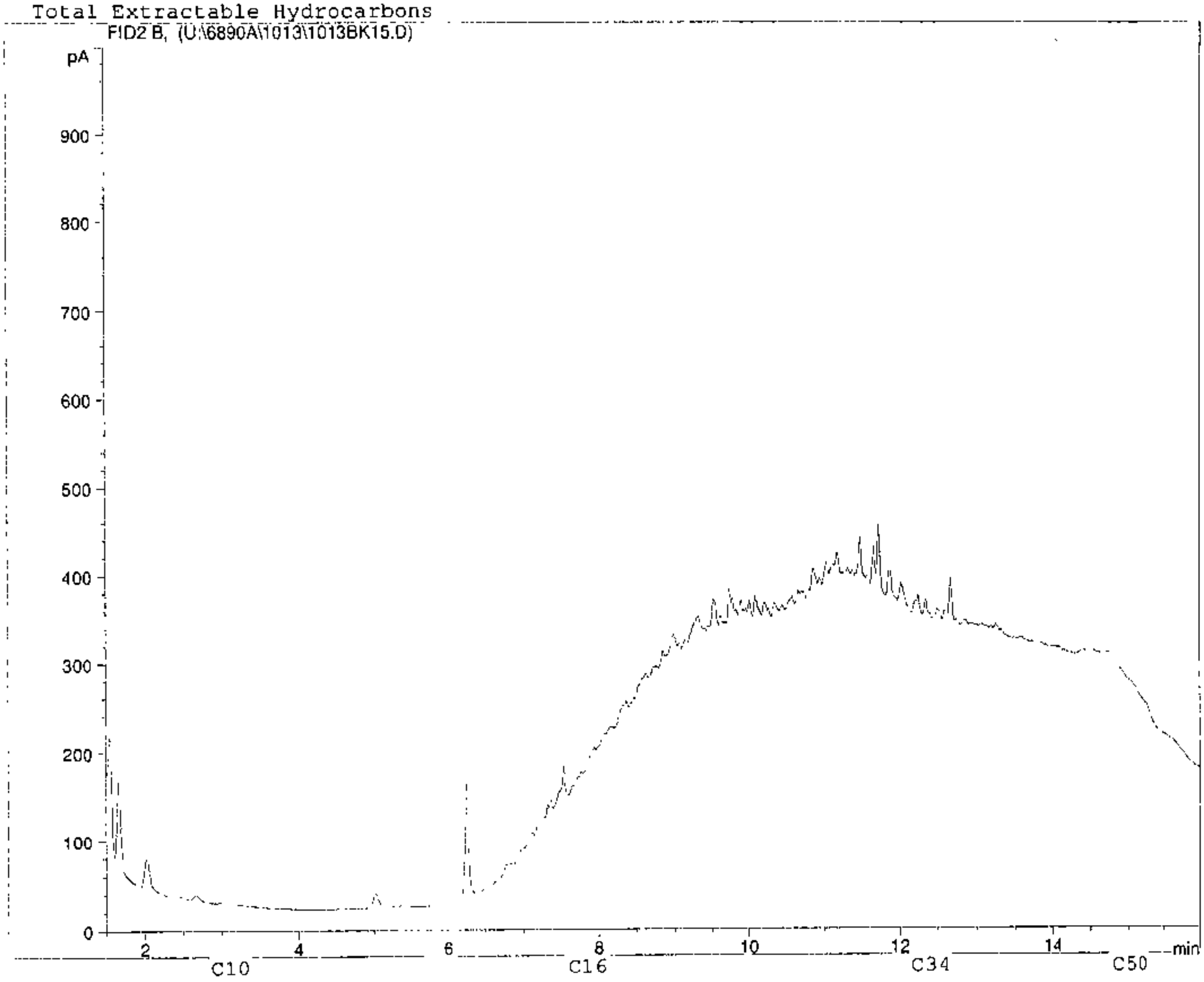


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 109-DM

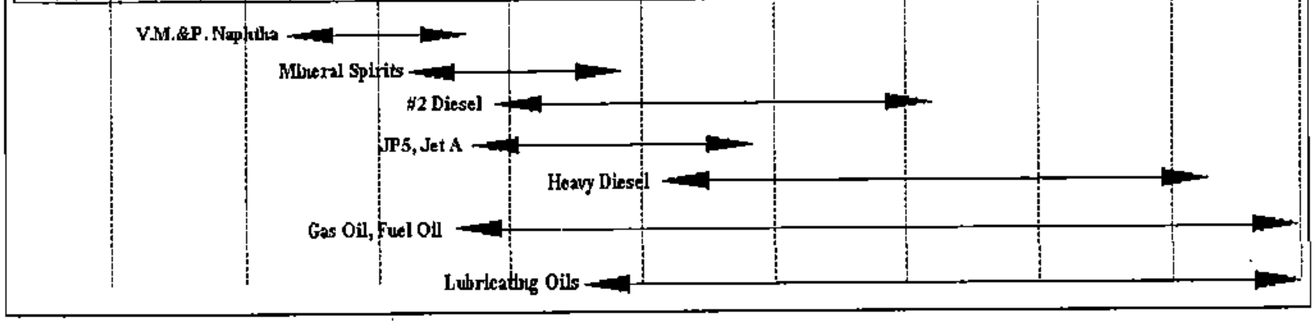
Sample ID: L437987-71 40
Injection Date: 10/13/2006 10:46:13 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



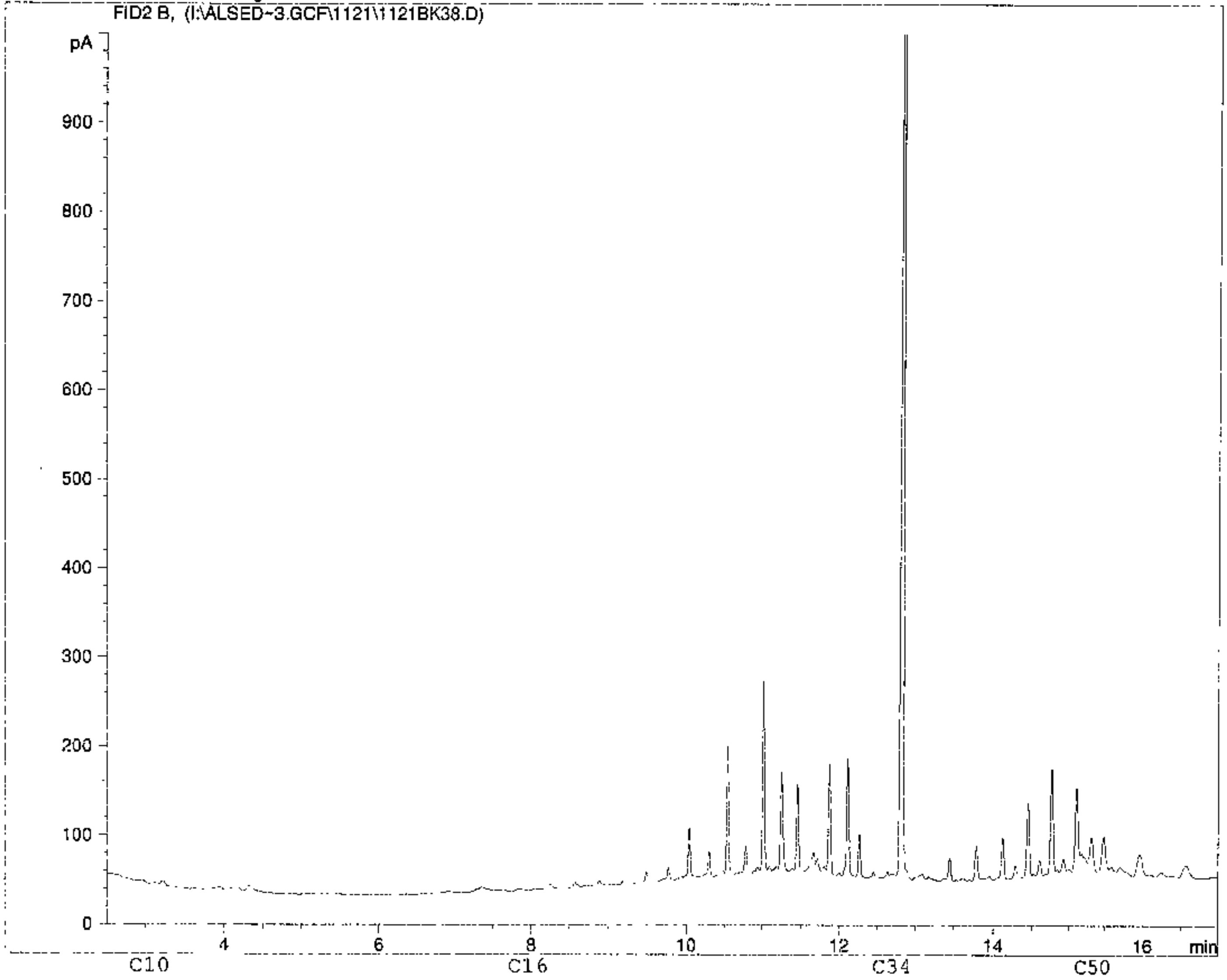
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

BACKGROUND SURFACE LITTER LAYER– LUVISOLS (DOV) & REGOSOLS (MMY) CHROMATOGRAMS

Client ID: DGW263 LFH

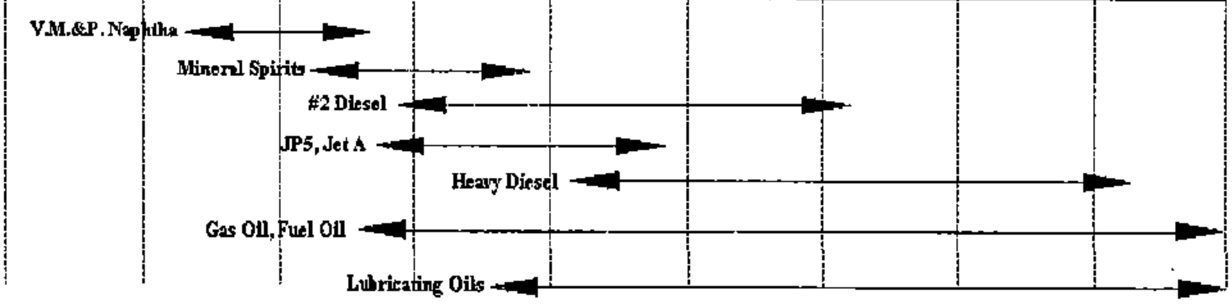
Sample ID: L450940-12 4 SGC
Injection Date: 11/22/06 8:30:19 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

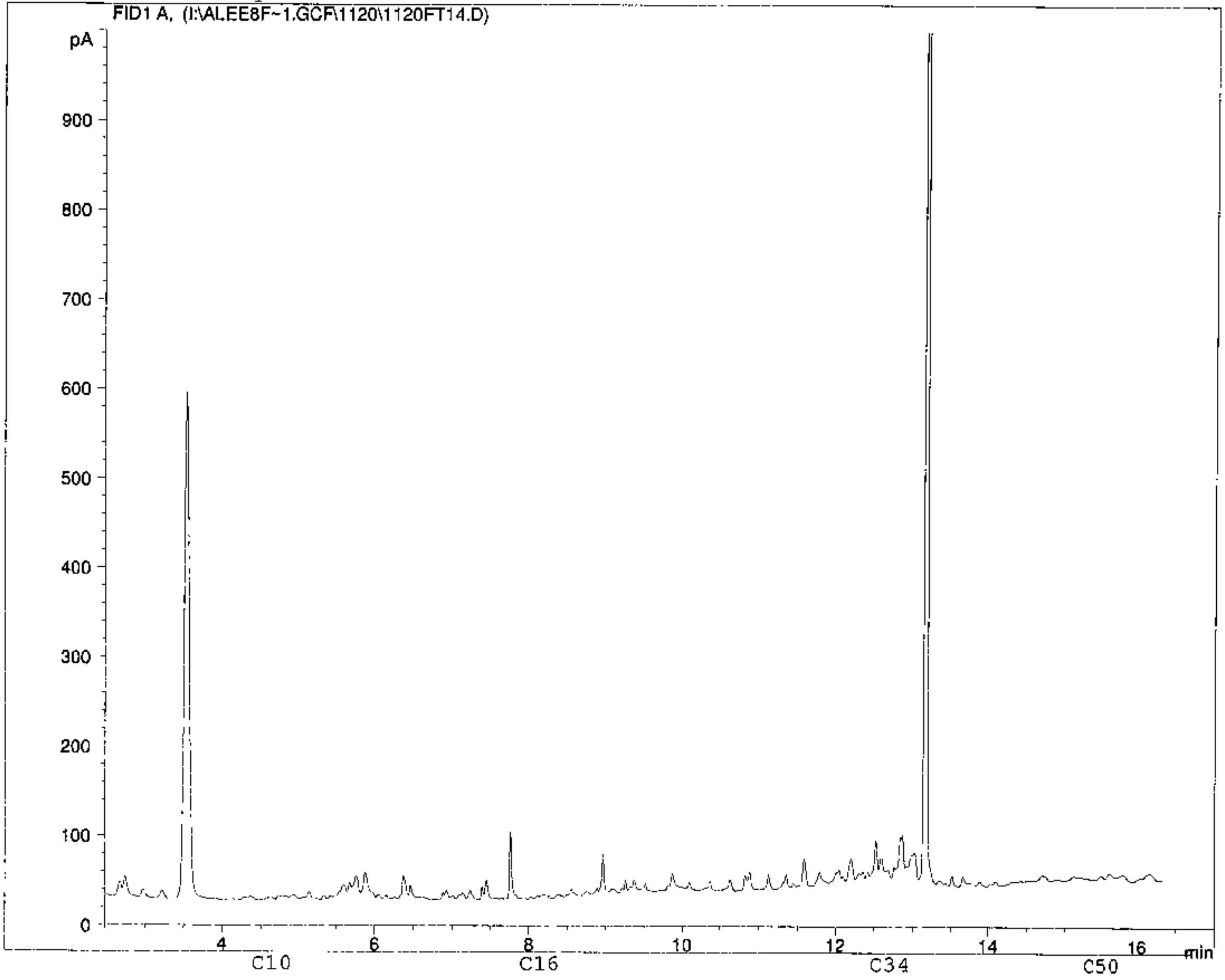


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW263 1

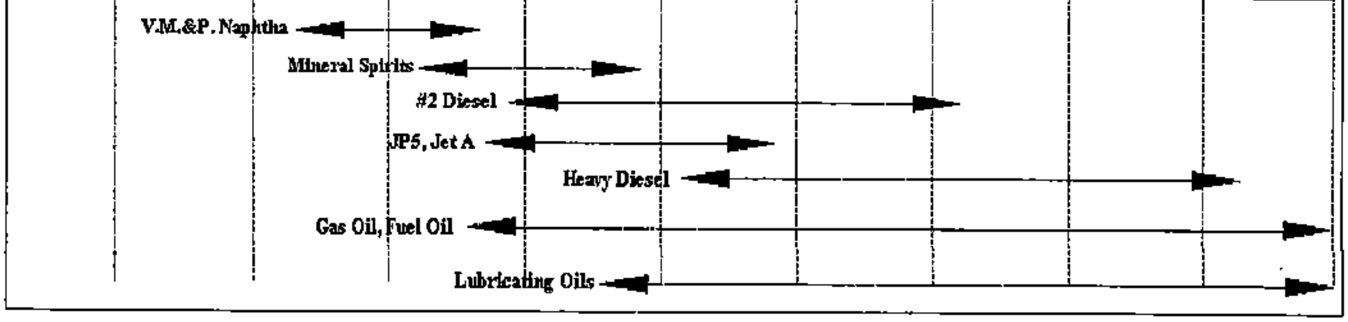
Sample ID: L450940-13 4
Injection Date: 11/20/2006 9:11:35 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

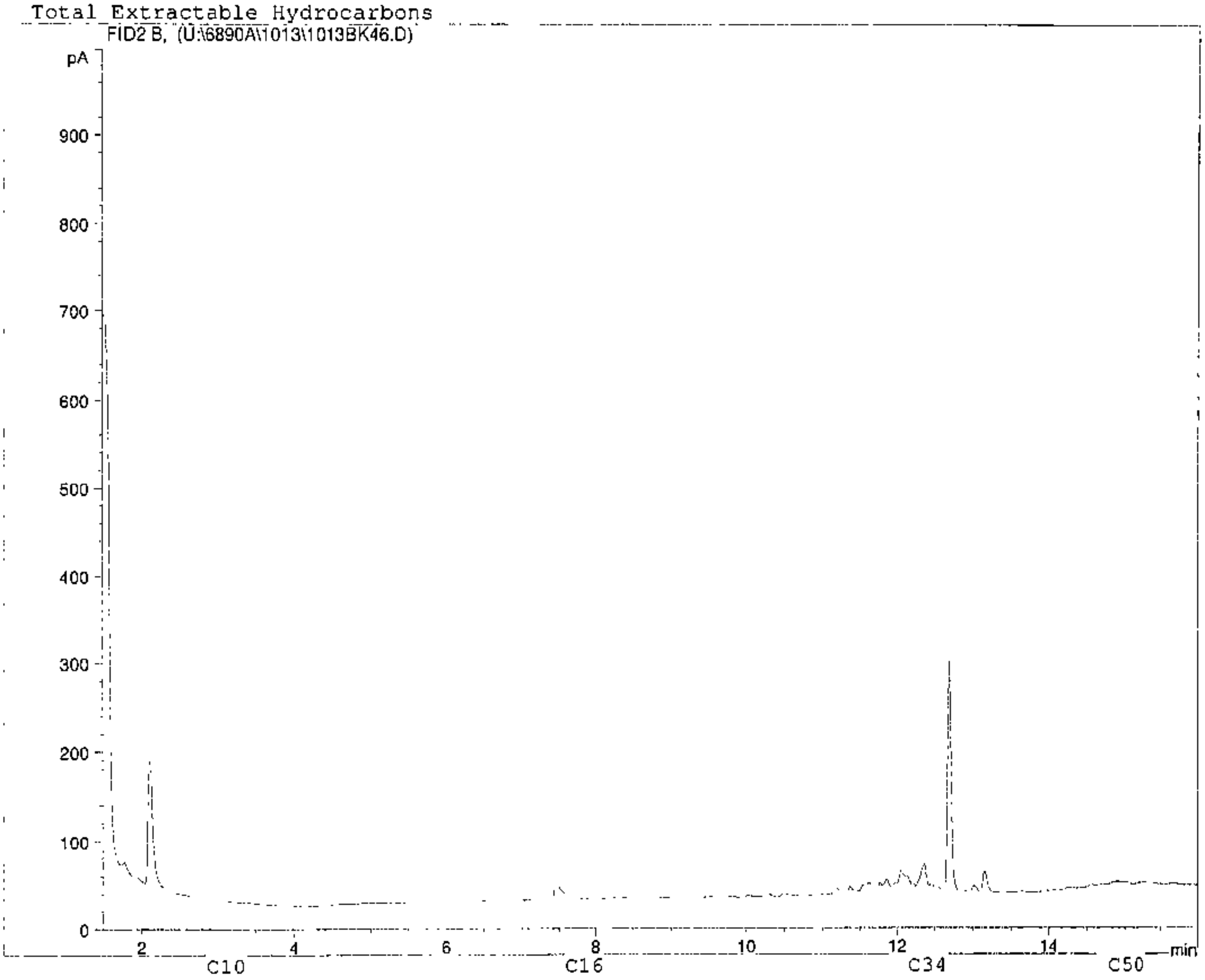


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 7-1

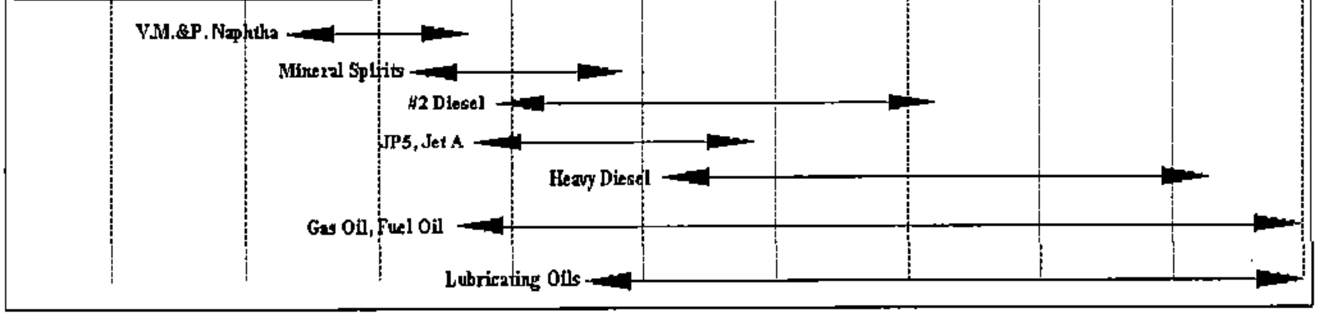
Sample ID: L437987-92 4
Injection Date: 10/14/2006 11:40:07 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

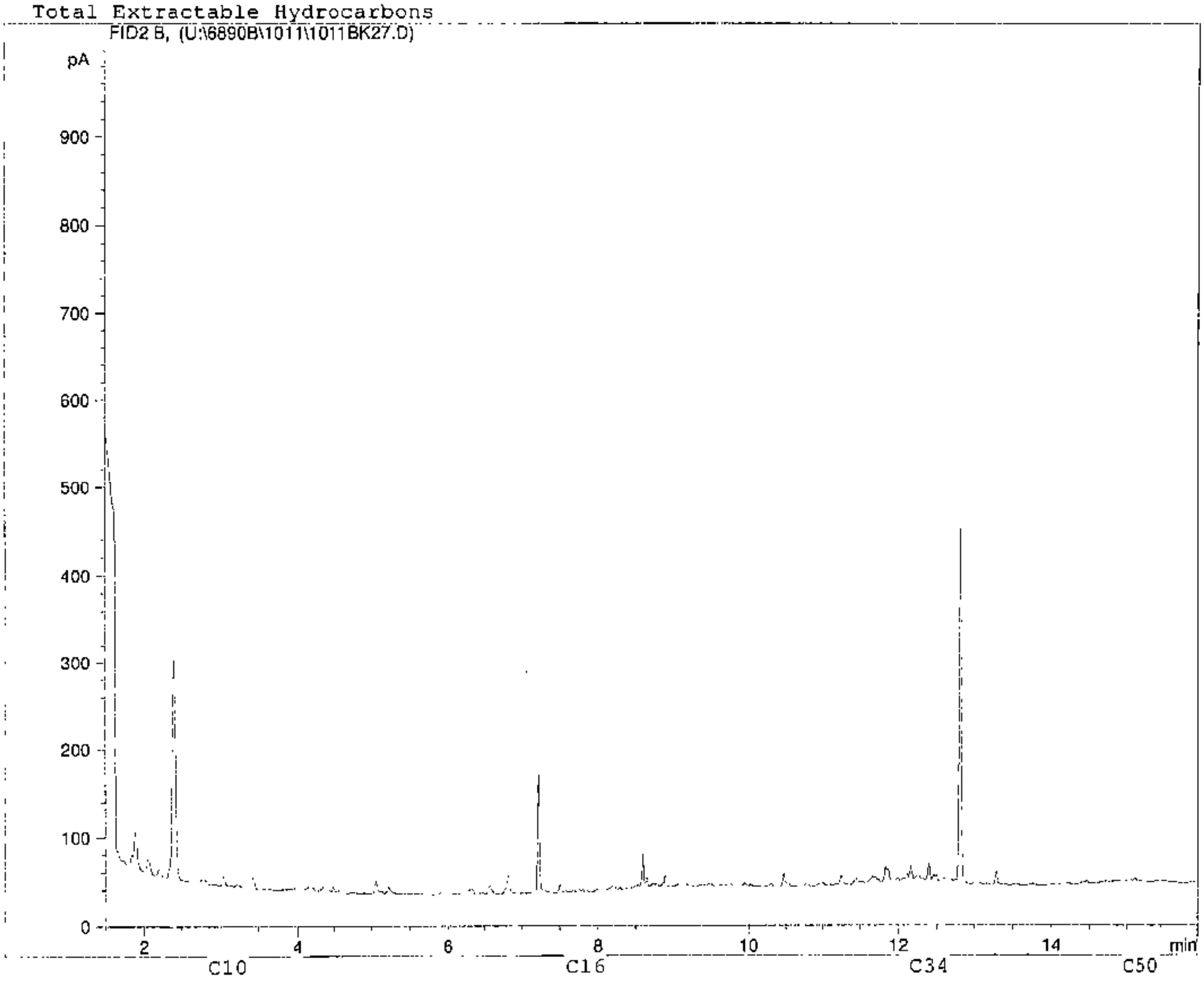


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 9-1

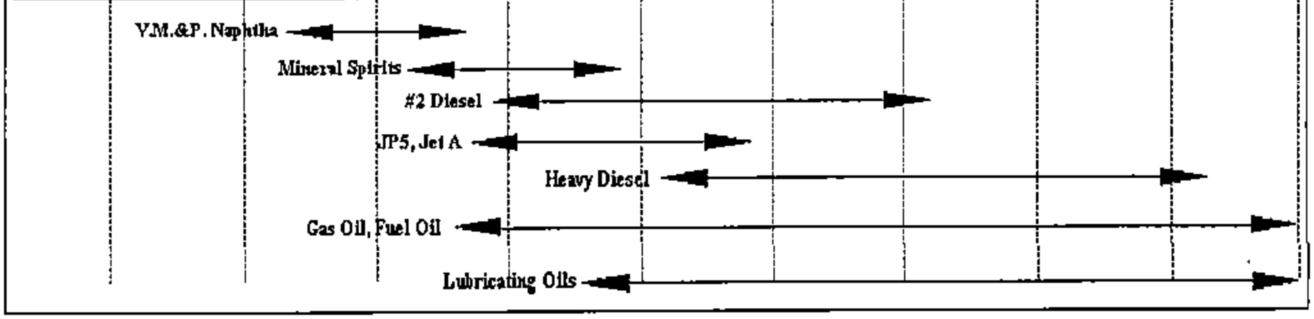
Sample ID: L437987-111 4
Injection Date: 10/12/06 3:23:05 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

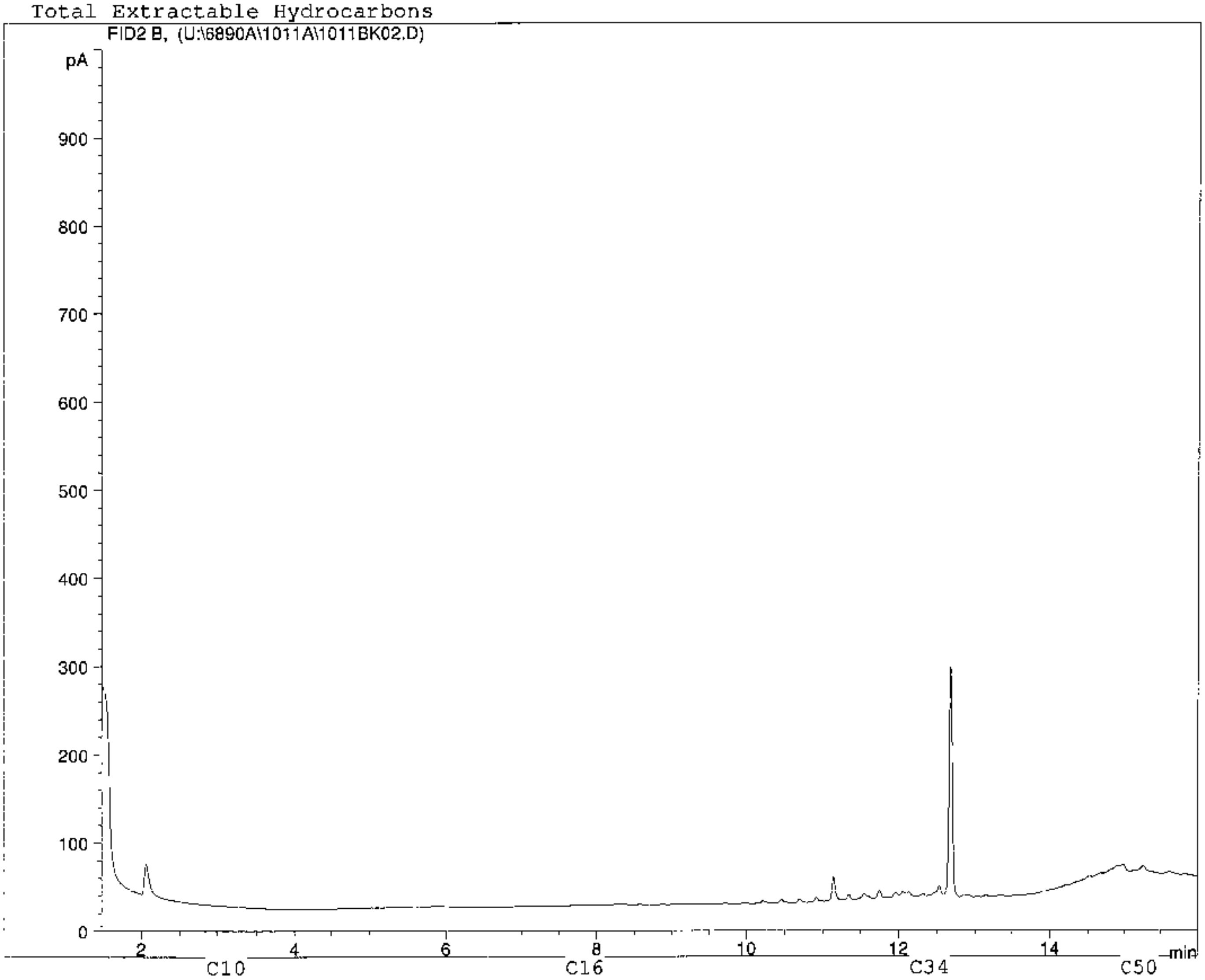


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 19-1

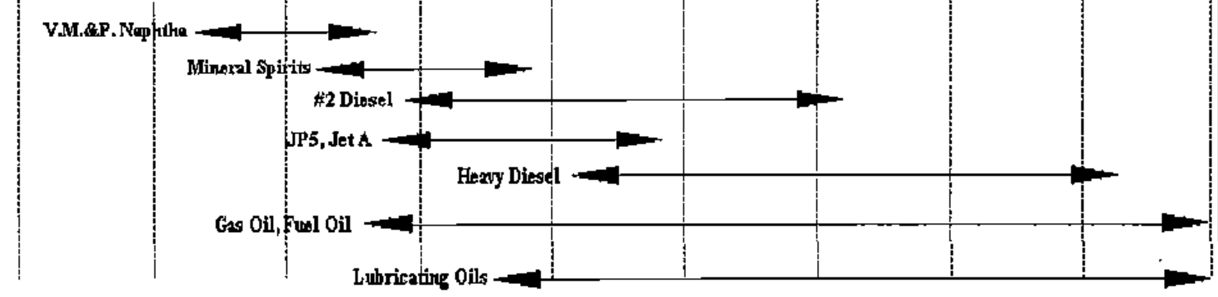
Sample ID: L439526-59 4
Injection Date: 10/12/2006 3:02:58 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

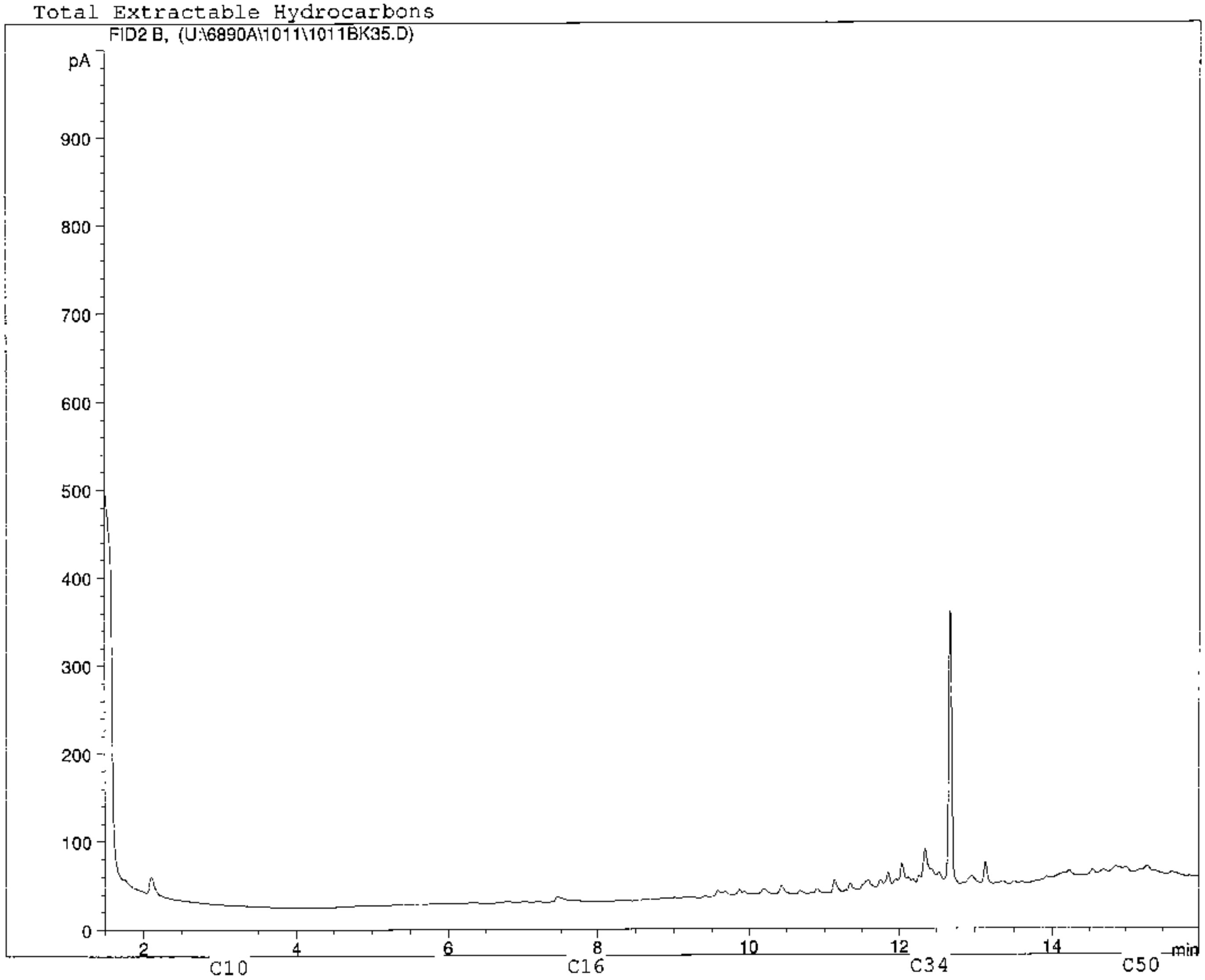


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 20-1

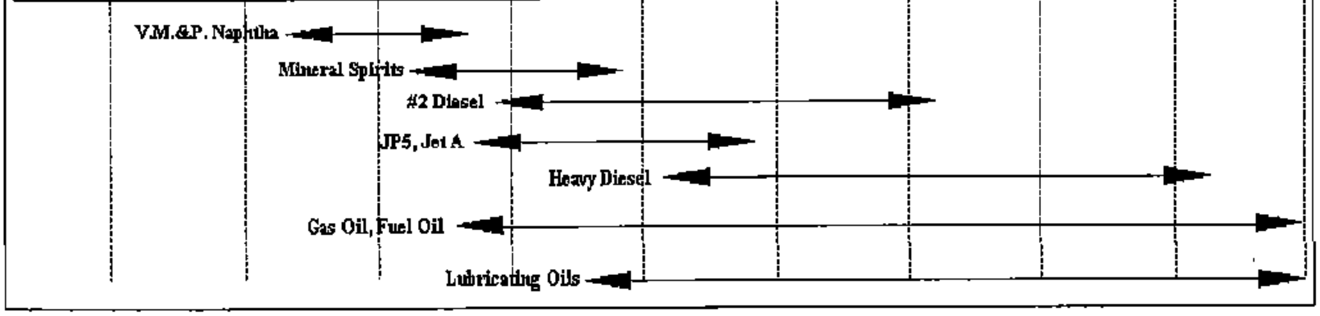
Sample ID: L439526-63 4
Injection Date: 10/12/2006 7:43:17 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

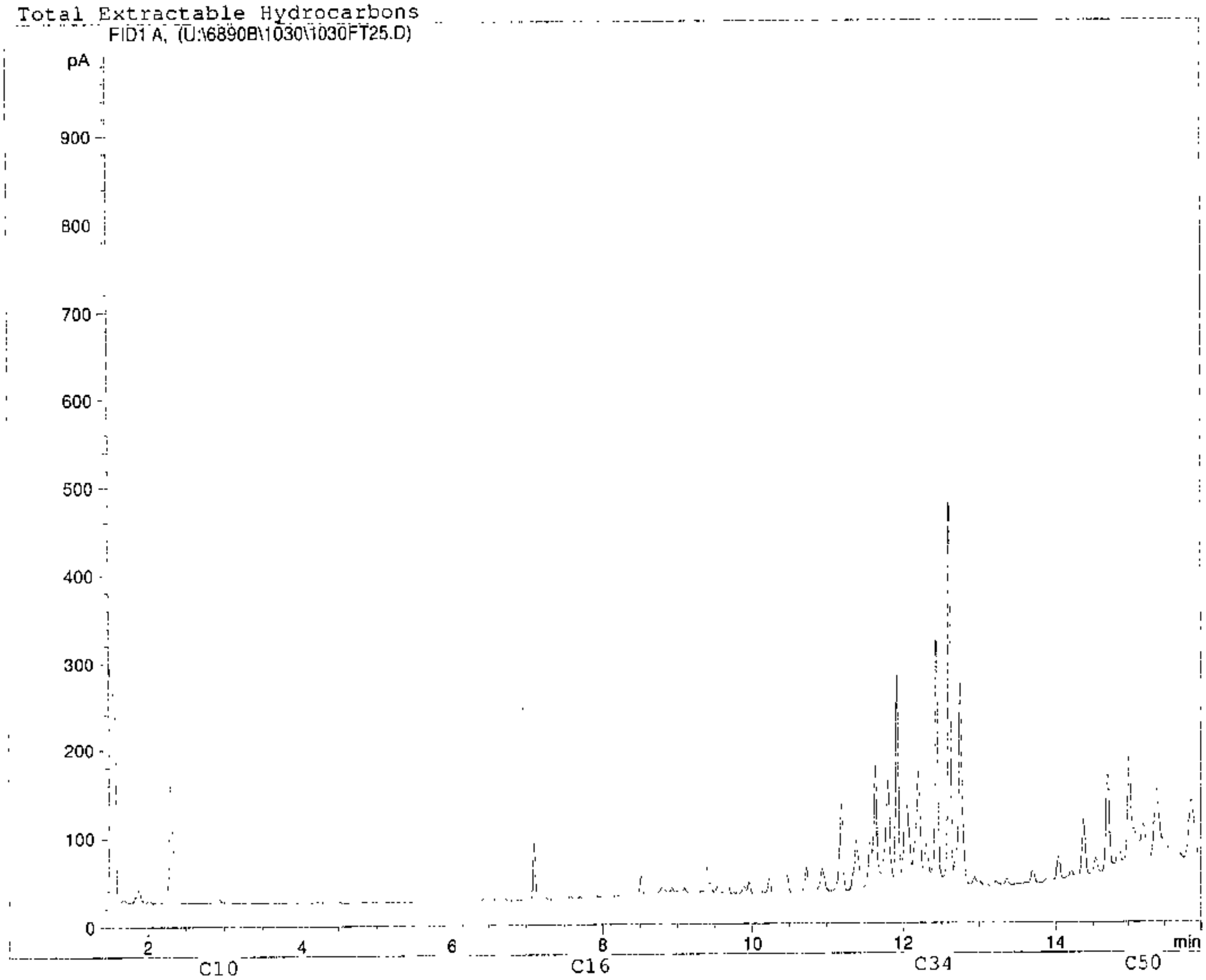


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 103-LFH

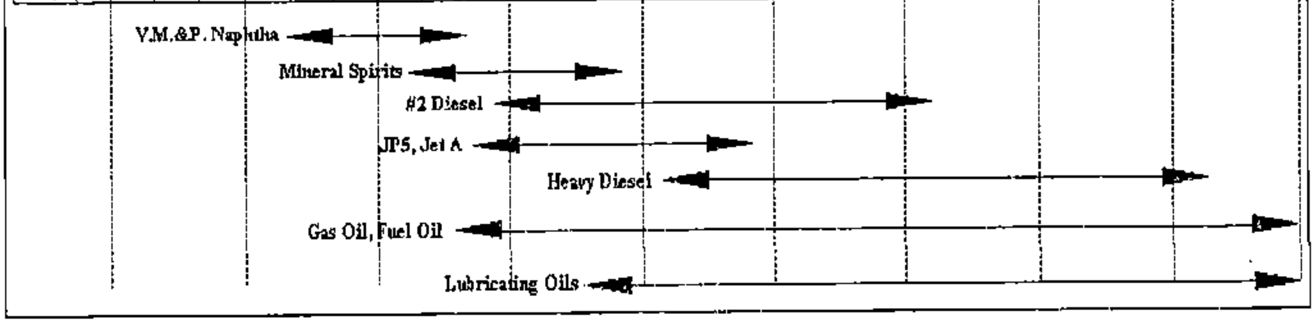
Sample ID: L437383-81 SGC 4
Injection Date: 10/31/06 5:02:43 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

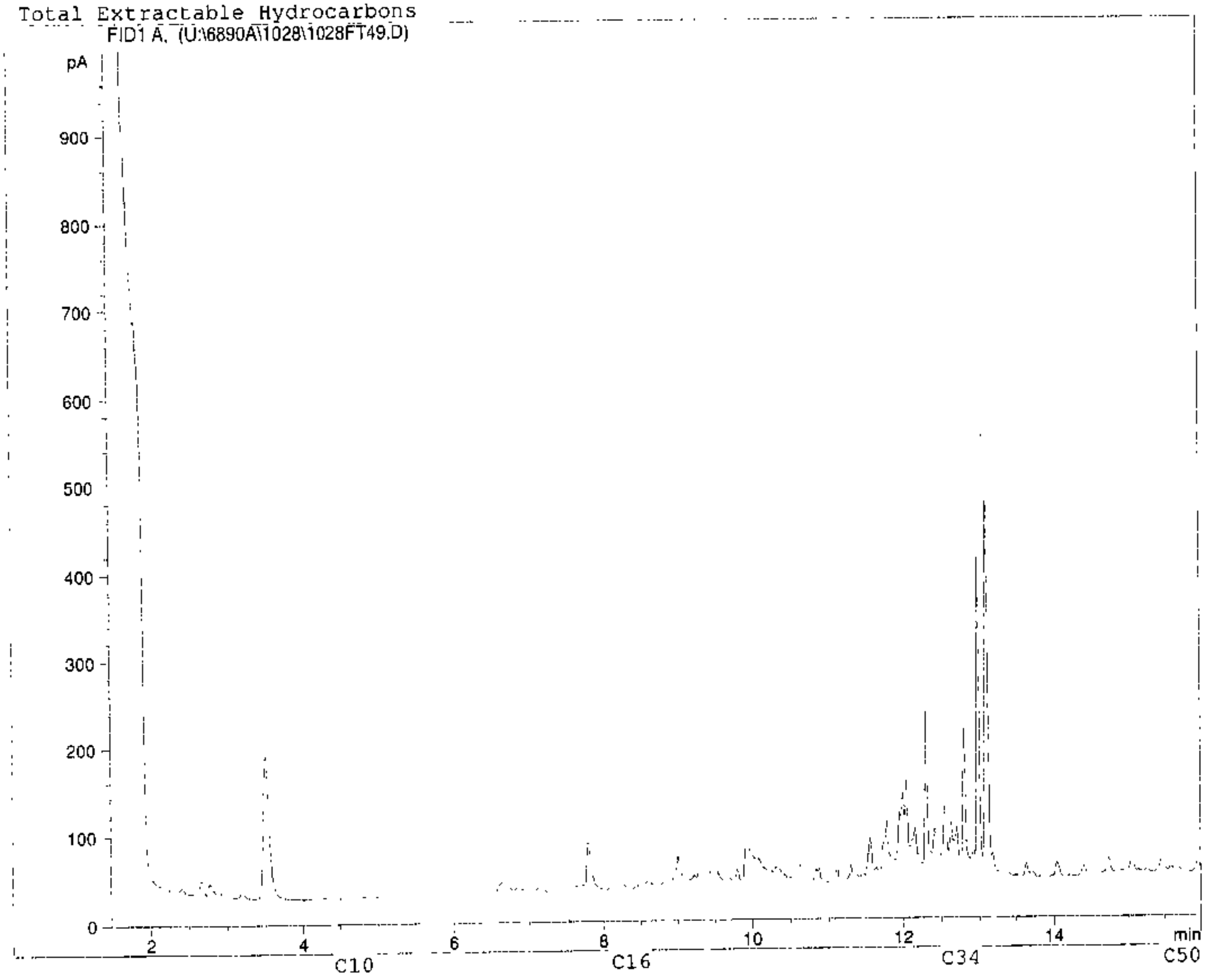


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 103-1

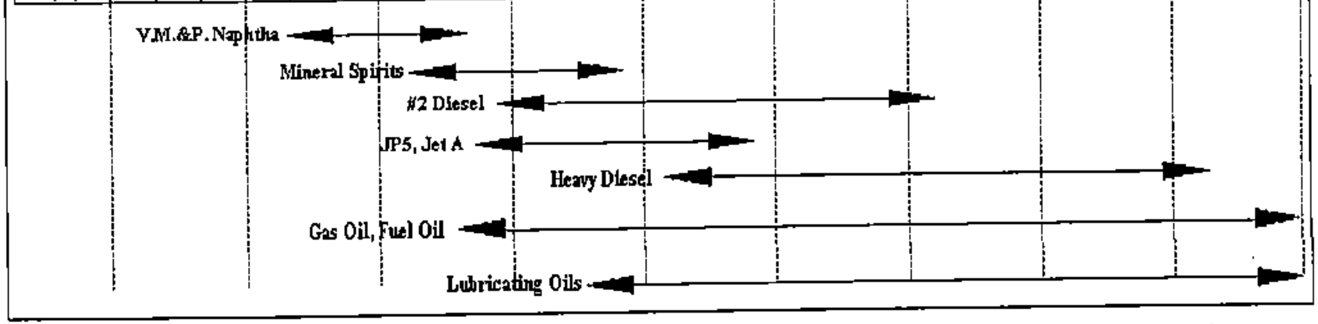
Sample ID: L437383-82 4
Injection Date: 10/29/2006 11:13:22 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

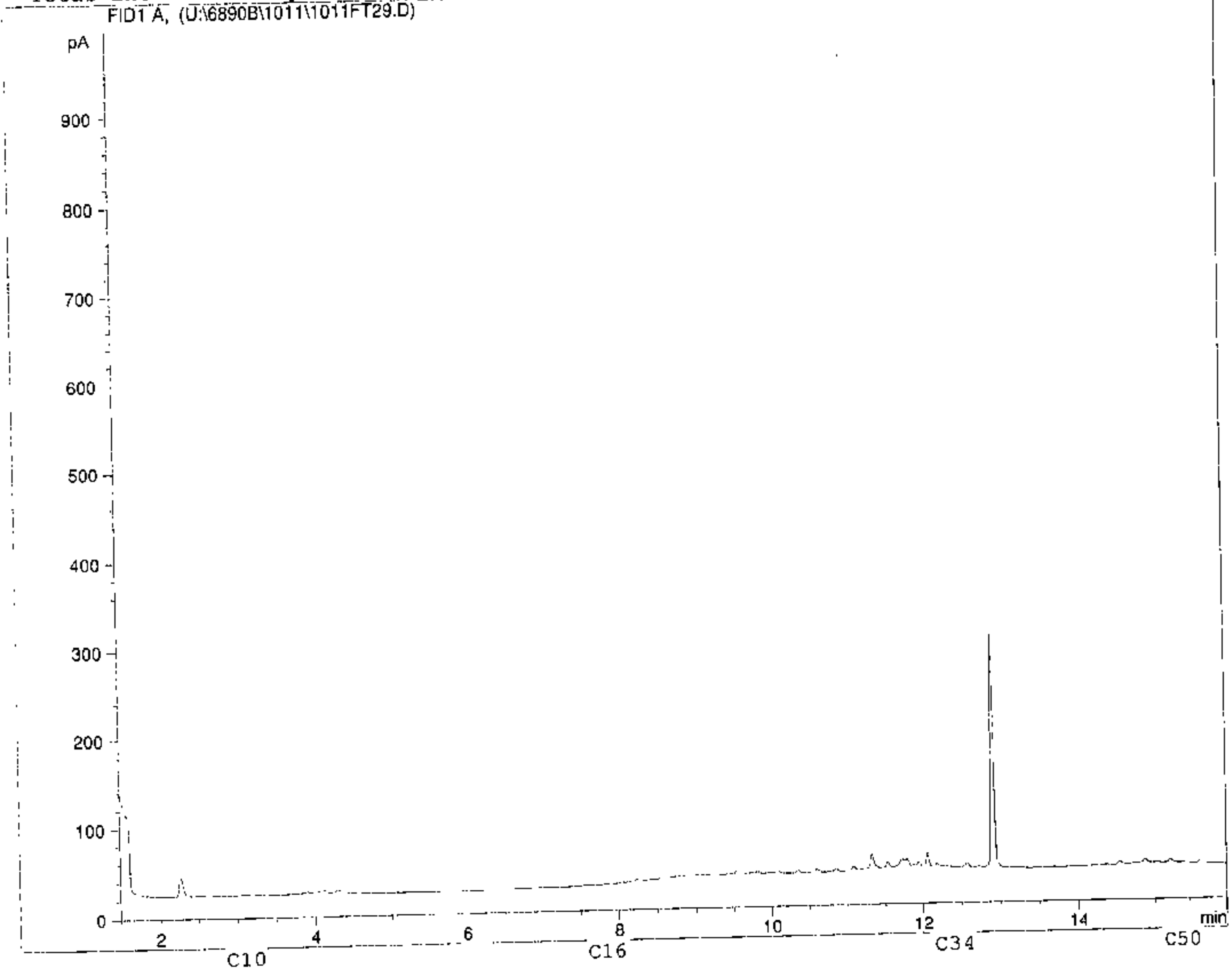
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



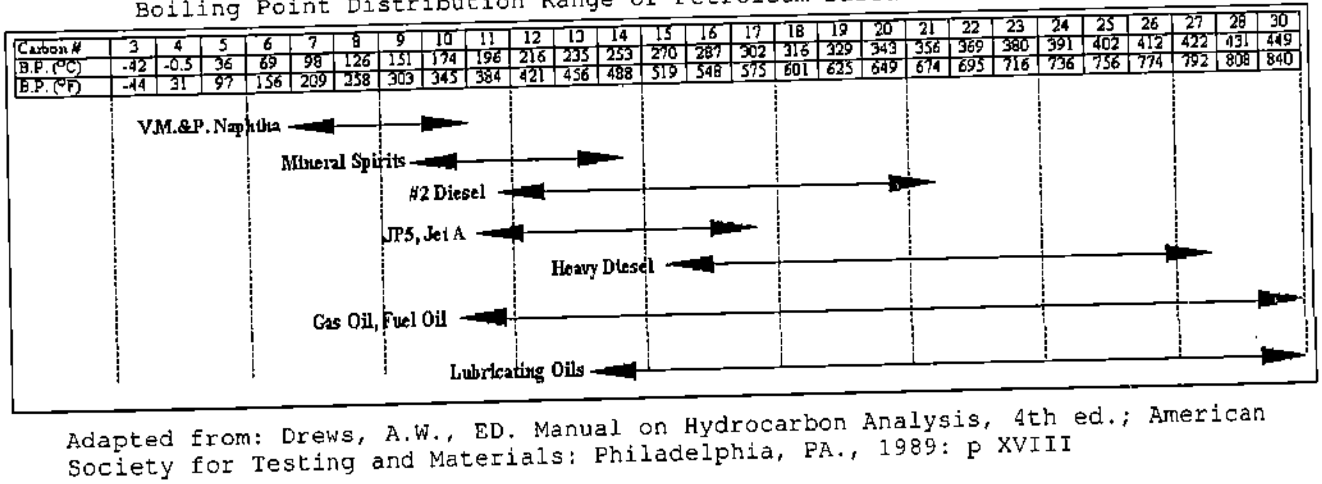
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID:	107-1
Sample ID:	L437987-63 4
Injection Date:	10/12/06 4:16:52 AM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



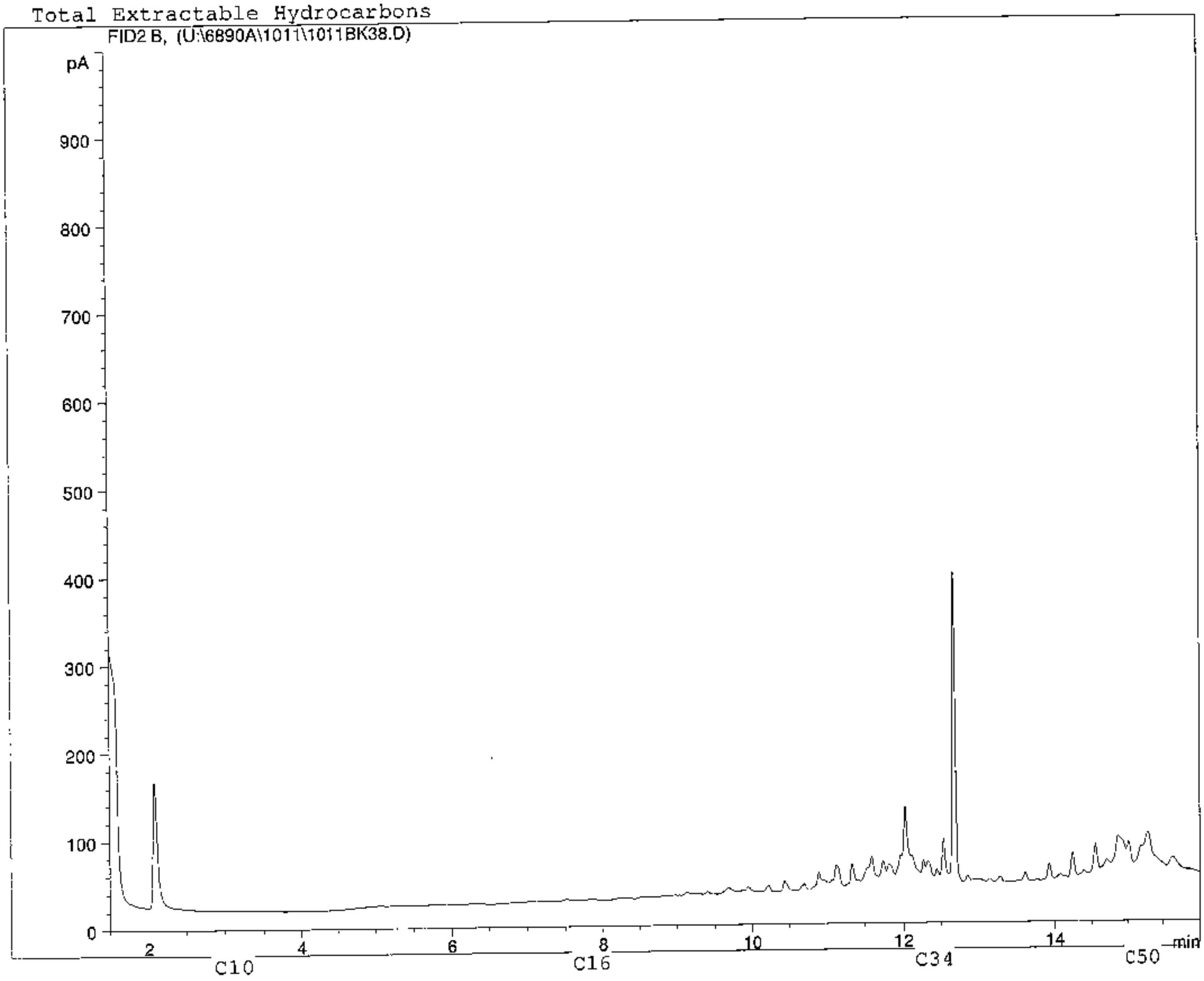
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 117-1

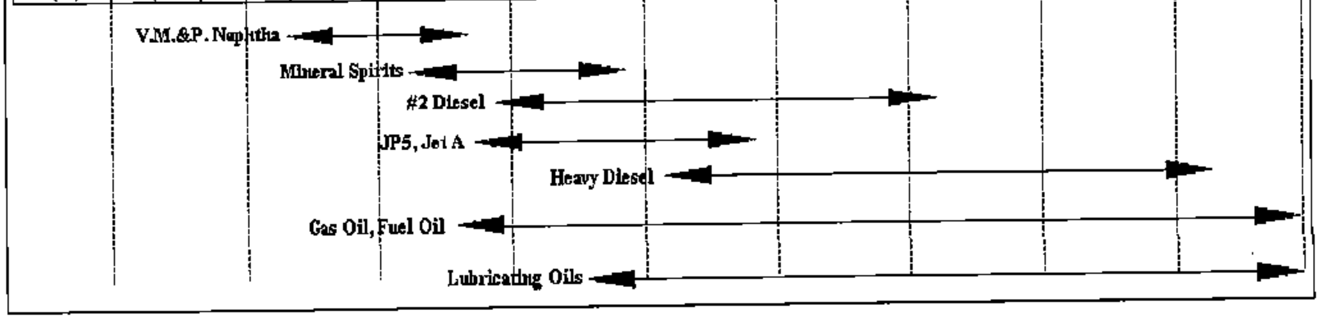
Sample ID: L439526-81 4
Injection Date: 10/12/2006 8:58:42 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

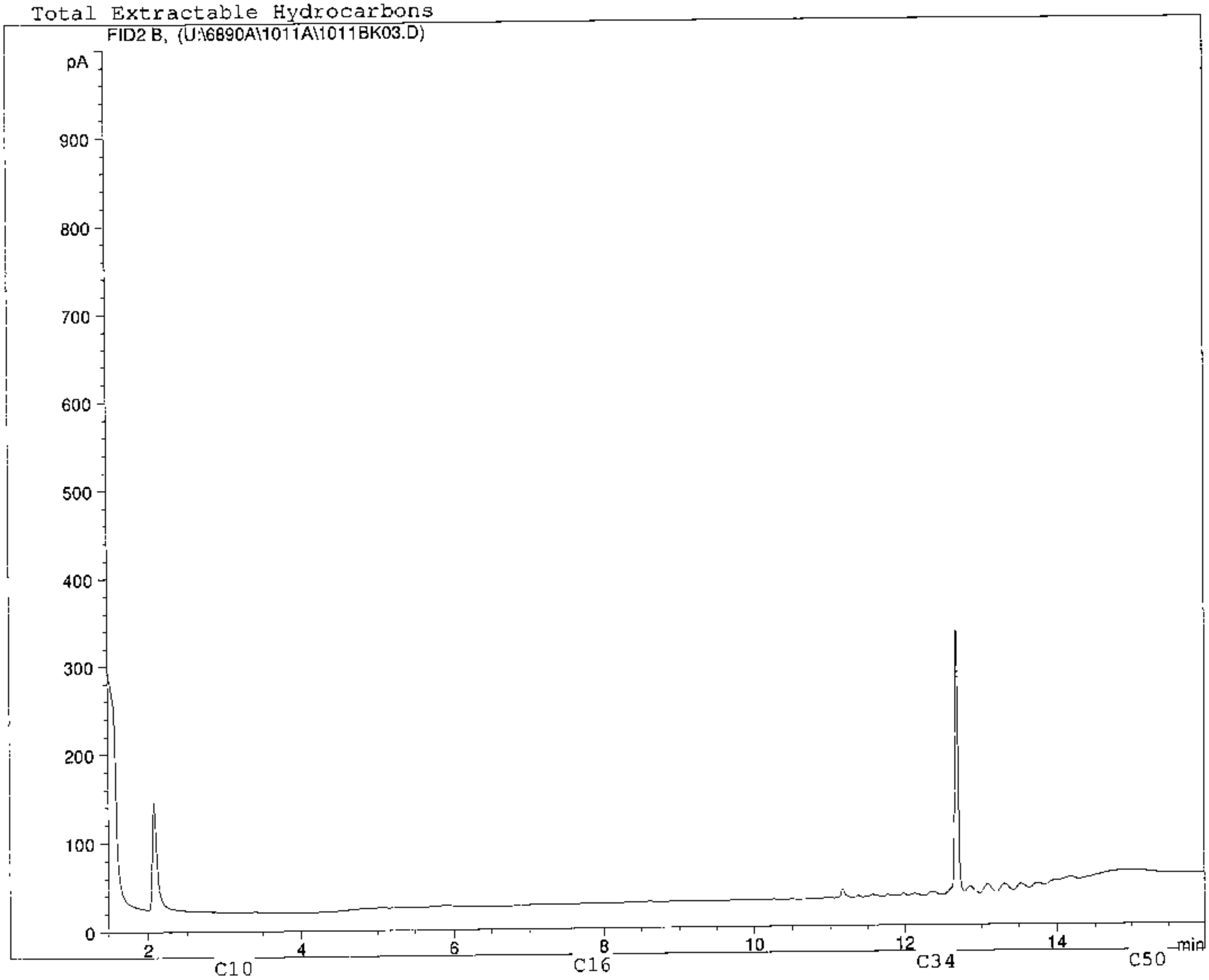


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 120-1

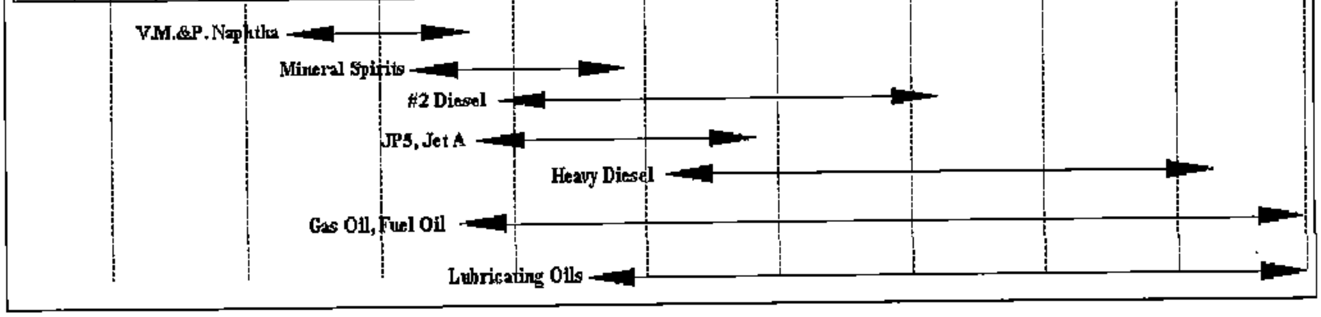
Sample ID: L439526-93 4
Injection Date: 10/12/2006 3:27:28 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

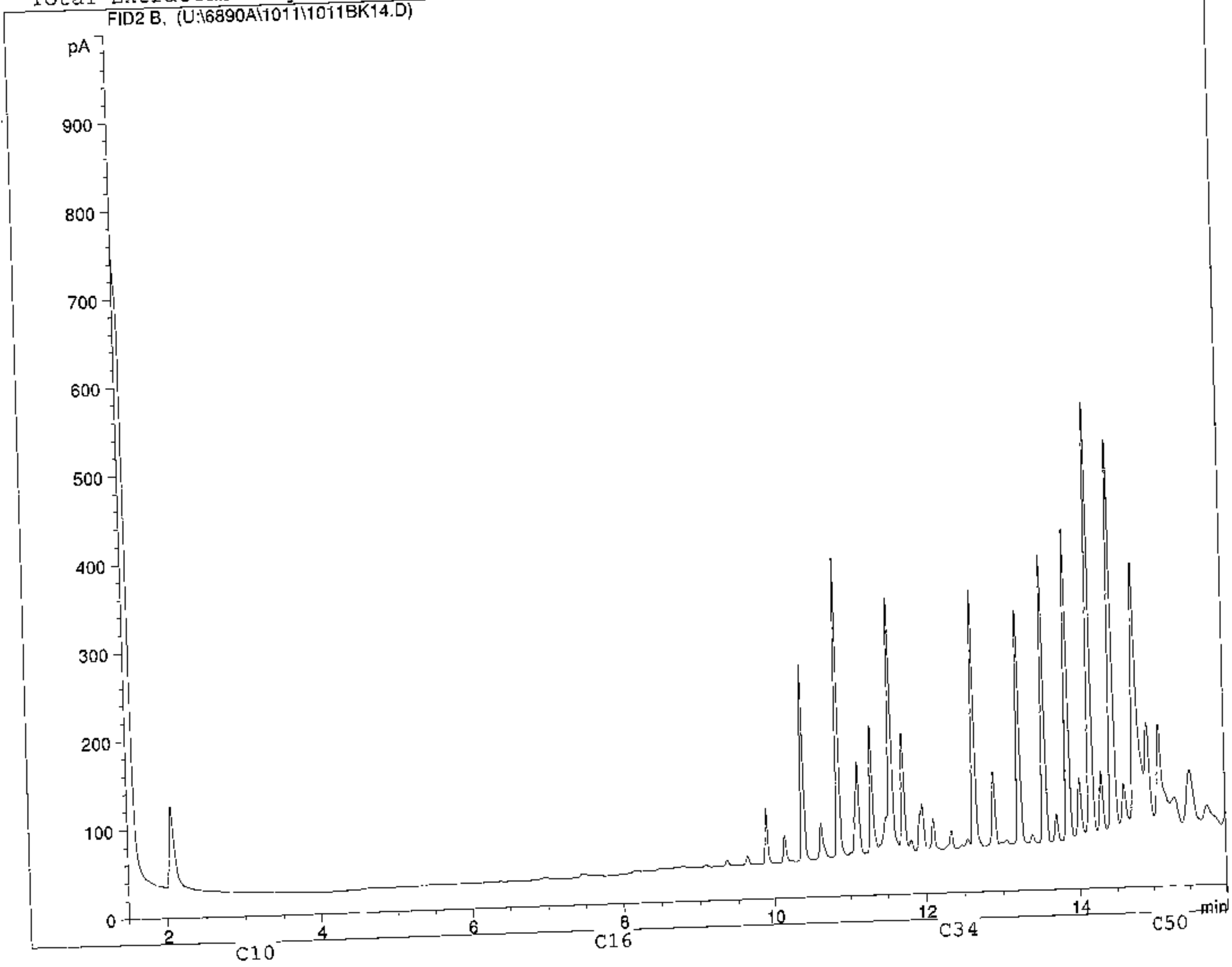


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 124-LFH

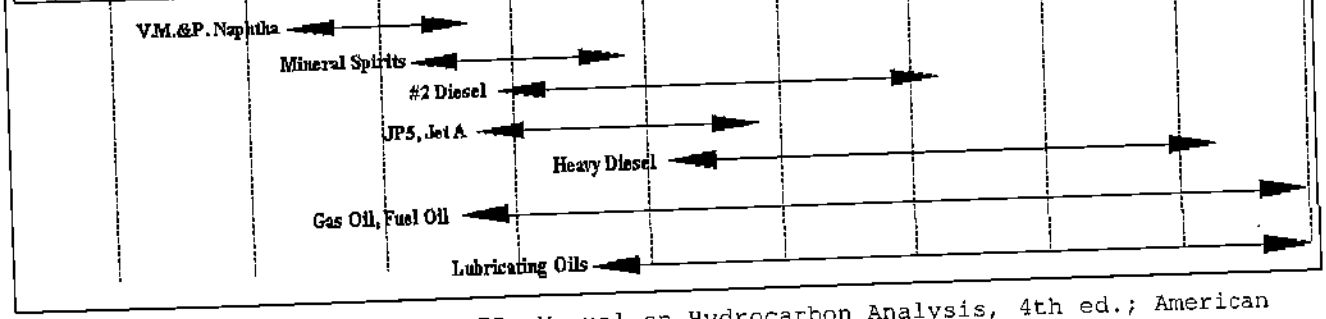
Sample ID: L438781-24 4 SG
Injection Date: 10/11/2006 10:55:27 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	486	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

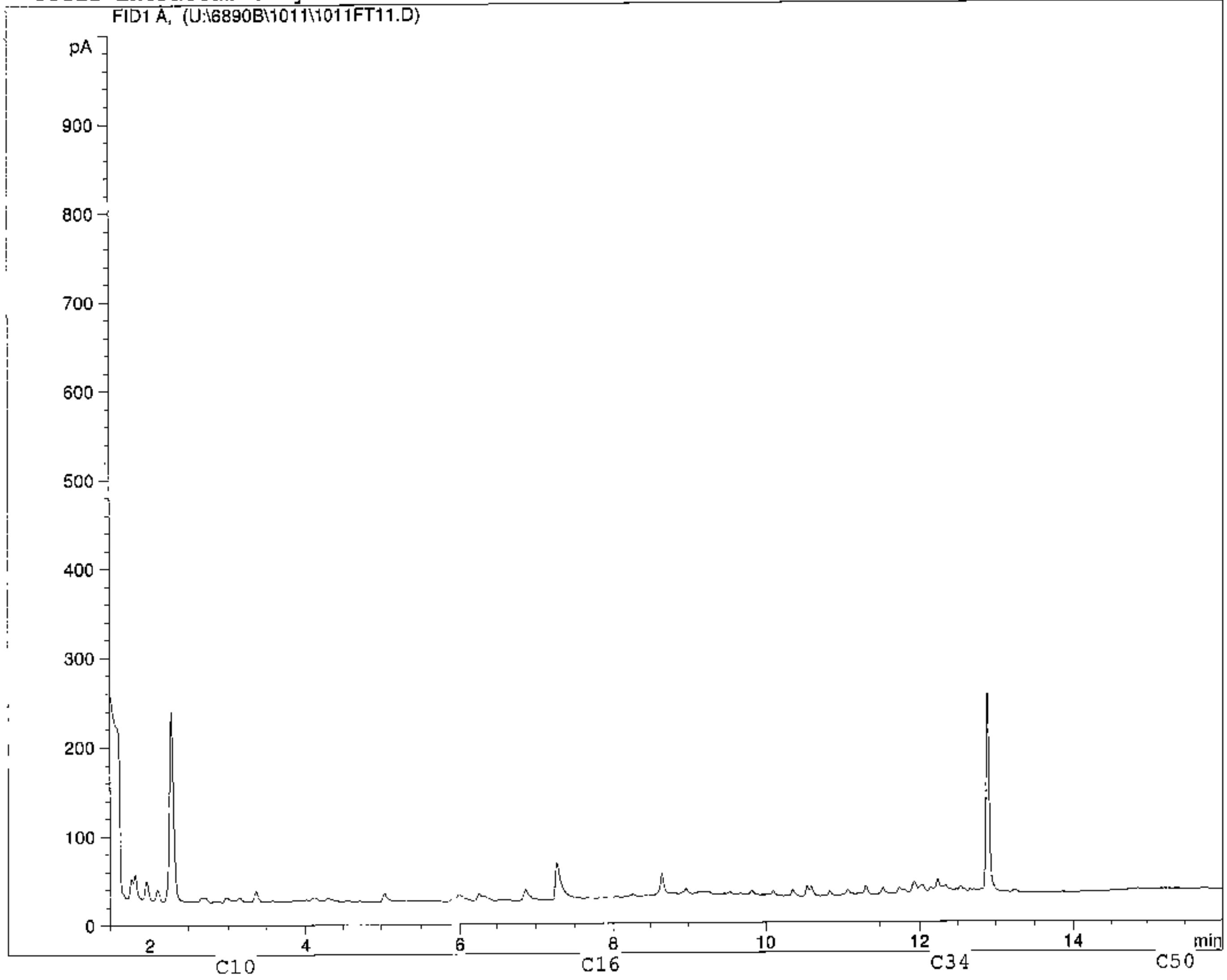


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 124-1

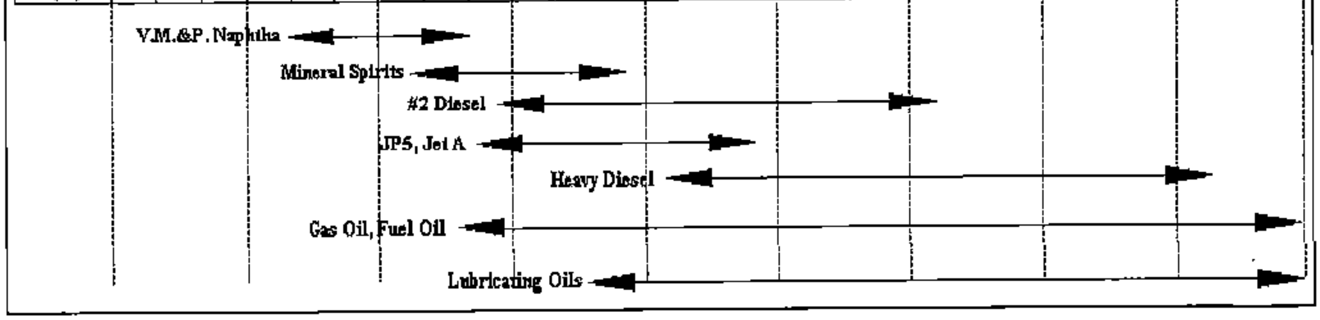
Sample ID: L438781-25 4
Injection Date: 10/11/06 8:11:10 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

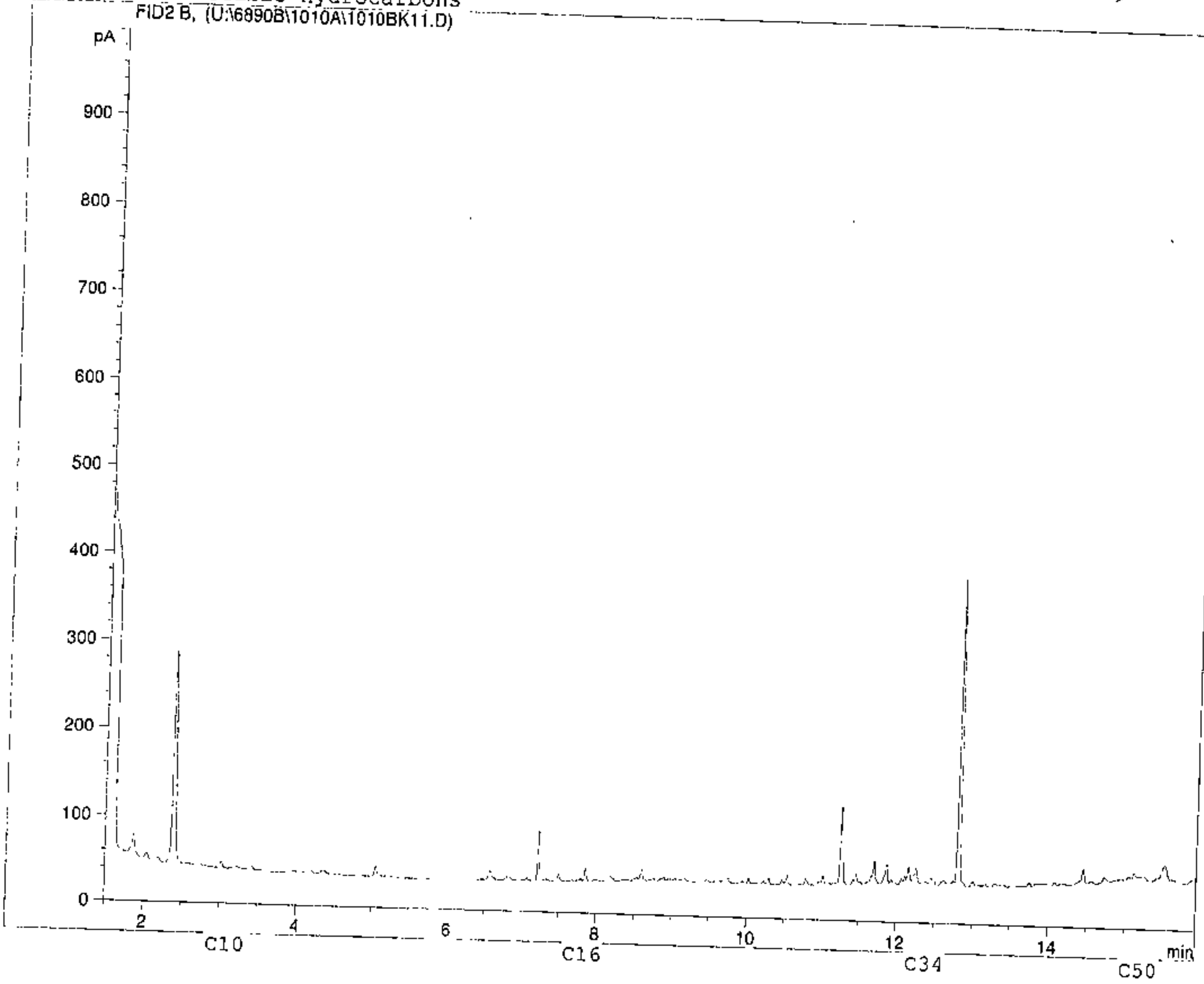


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 204-1

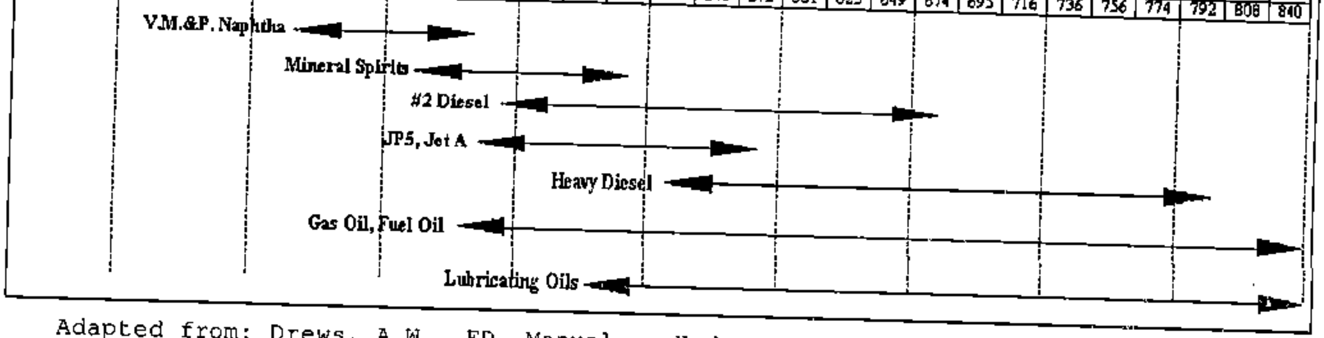
Sample ID: L437383-42 4
Injection Date: 10/10/06 10:50:11 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

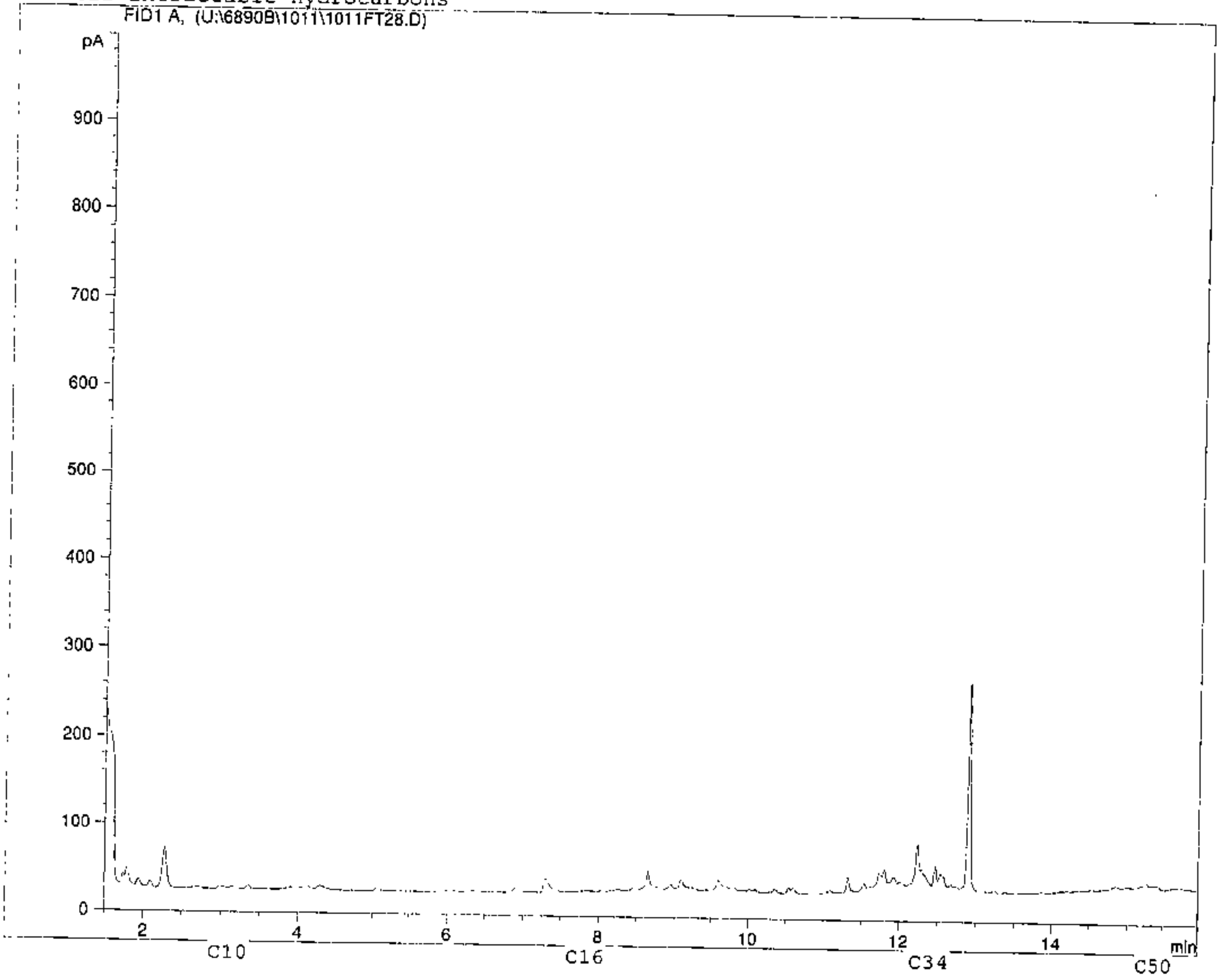
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

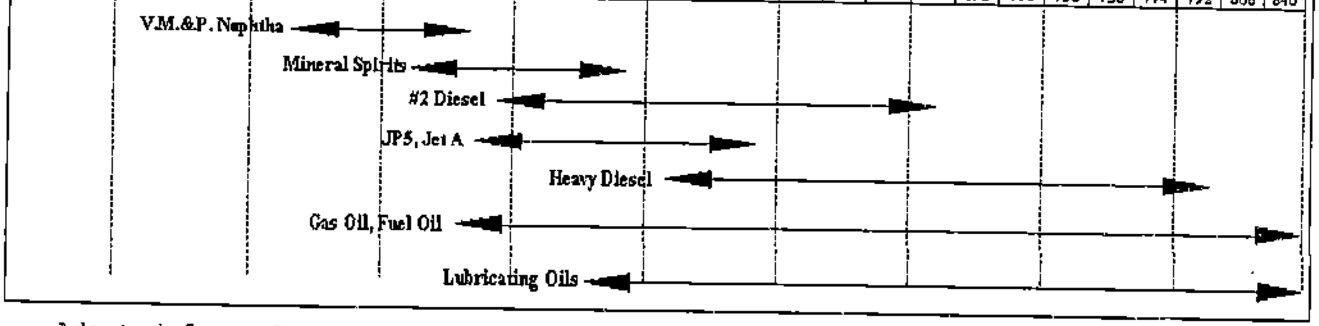
Client ID:	208-1
Sample ID:	L437987-48 4
Injection Date:	10/12/06 3:49:55 AM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

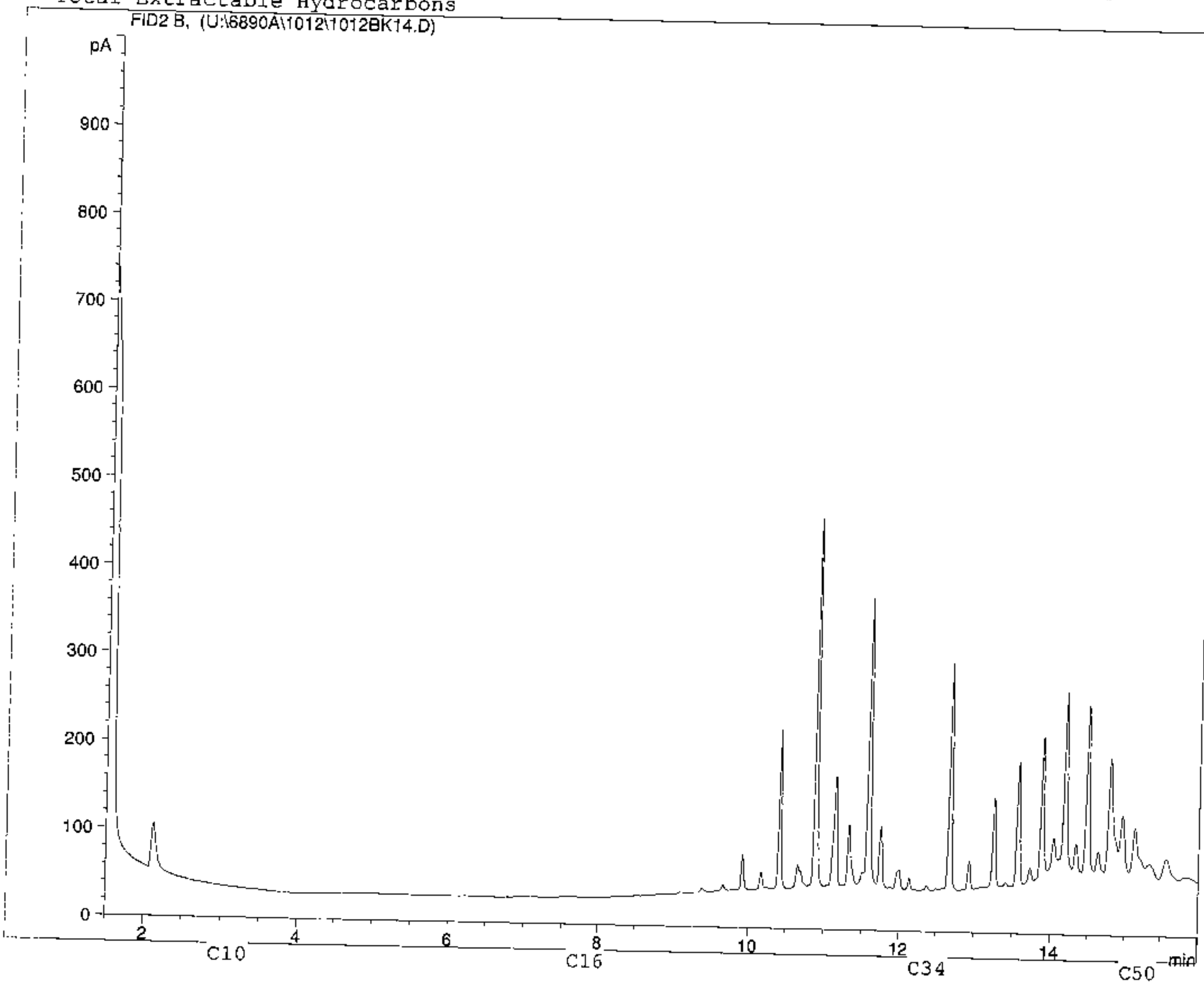


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 213-LFH

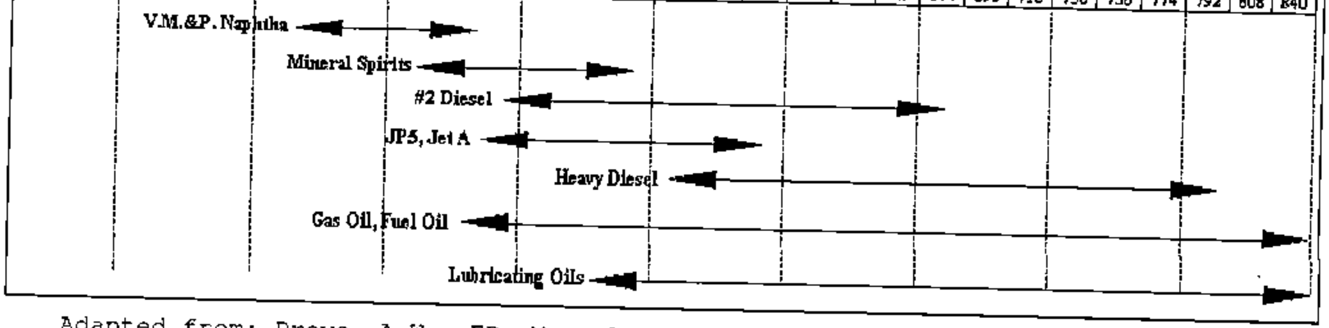
Sample ID: L439526-108 SG 4
Injection Date: 10/13/2006 12:24:57 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

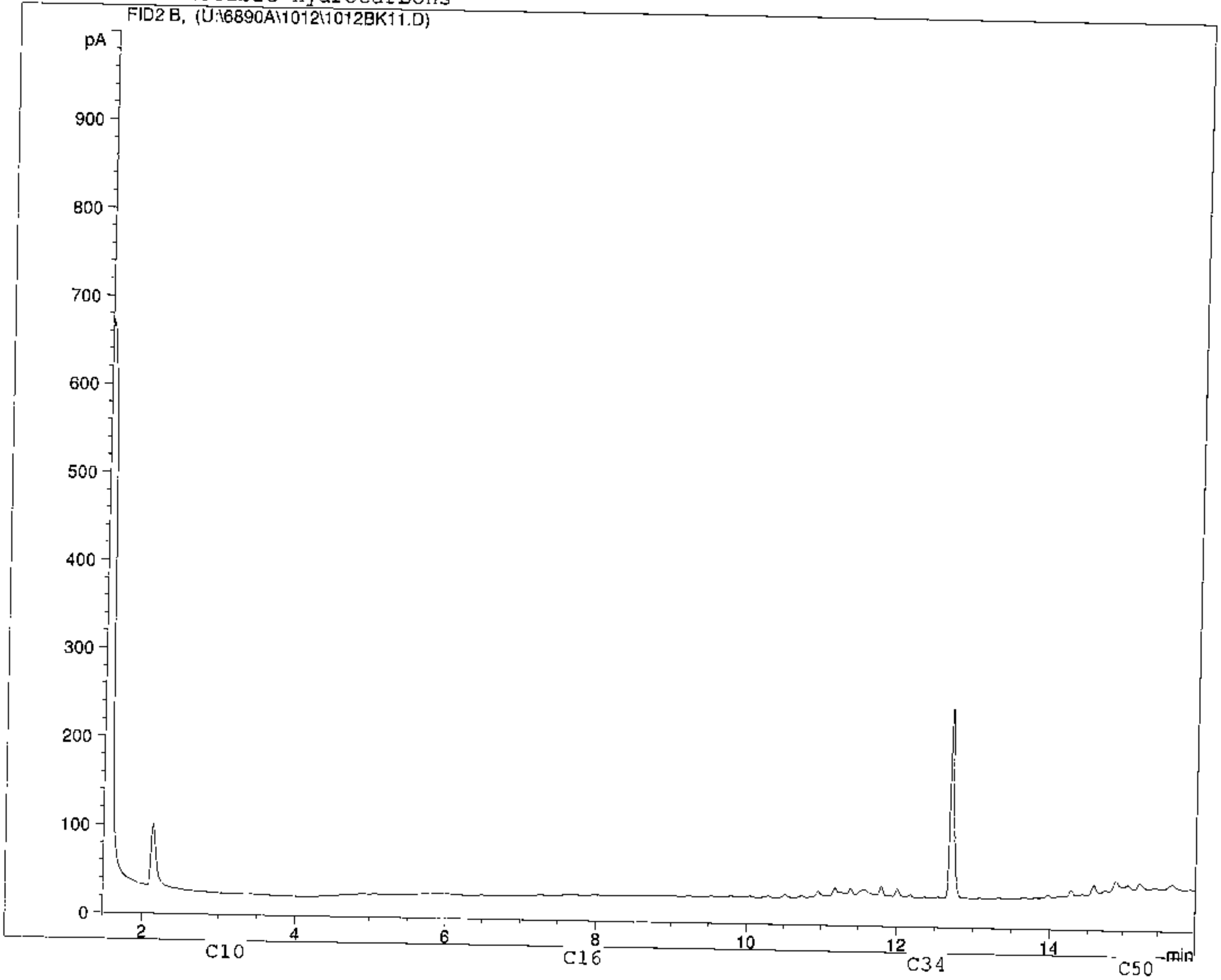


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 215-1

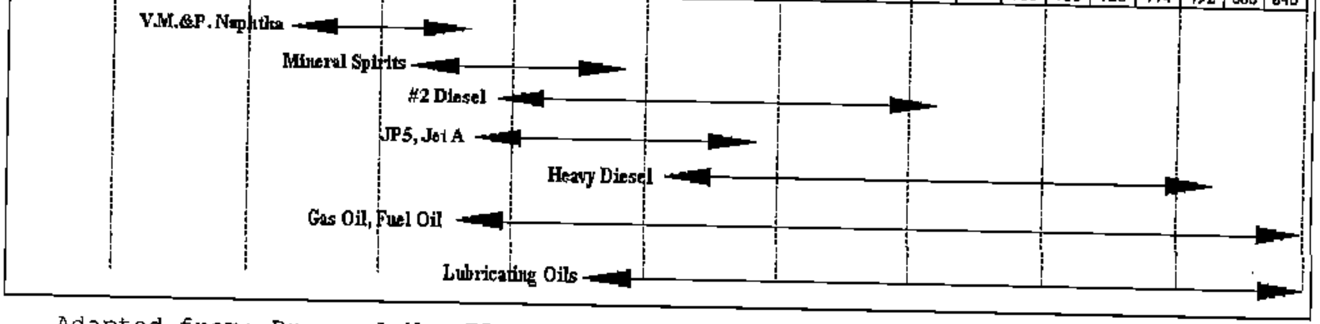
Sample ID: L439526-117 SG 4
Injection Date: 10/12/2006 11:09:20 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	423	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

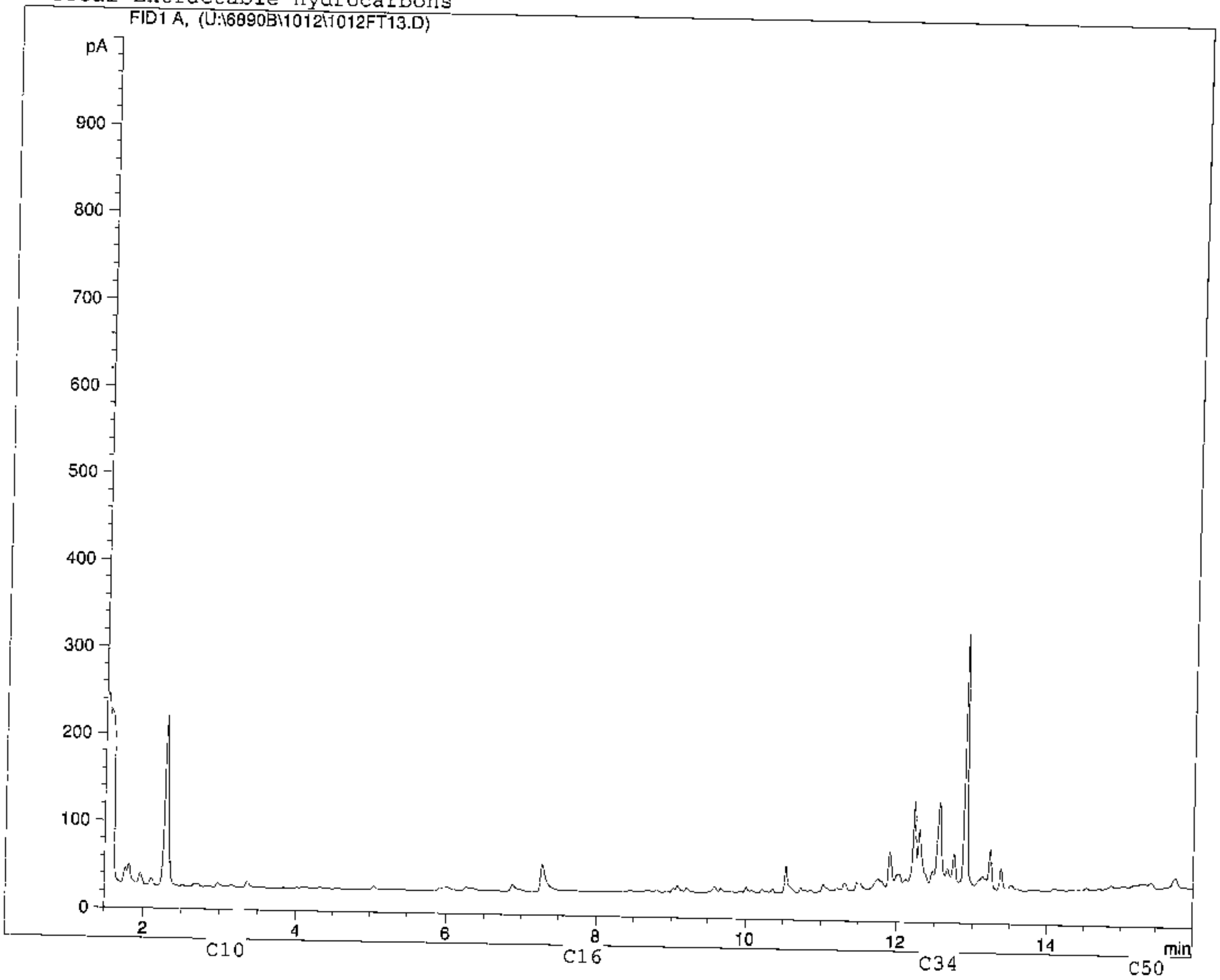


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 220-1

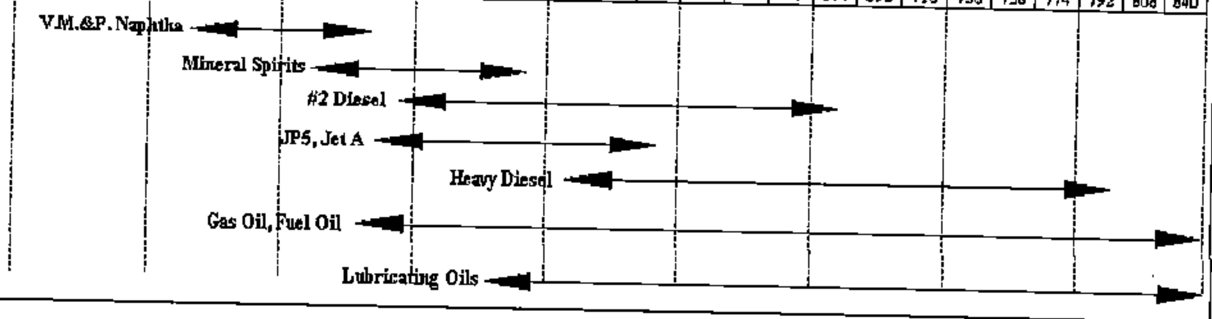
Sample ID: L439526-137 4
Injection Date: 10/12/06 9:36:13 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

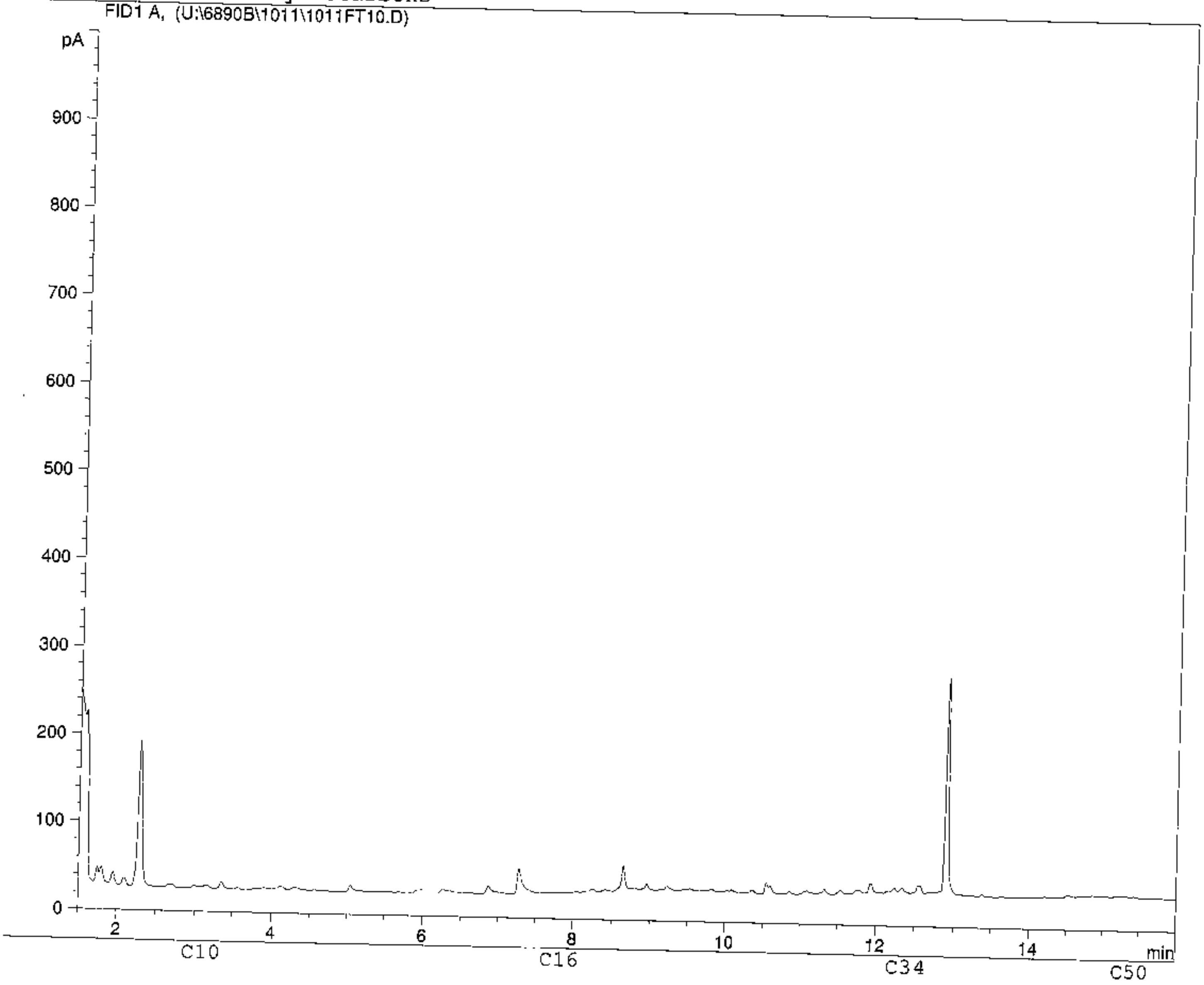


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 222-1

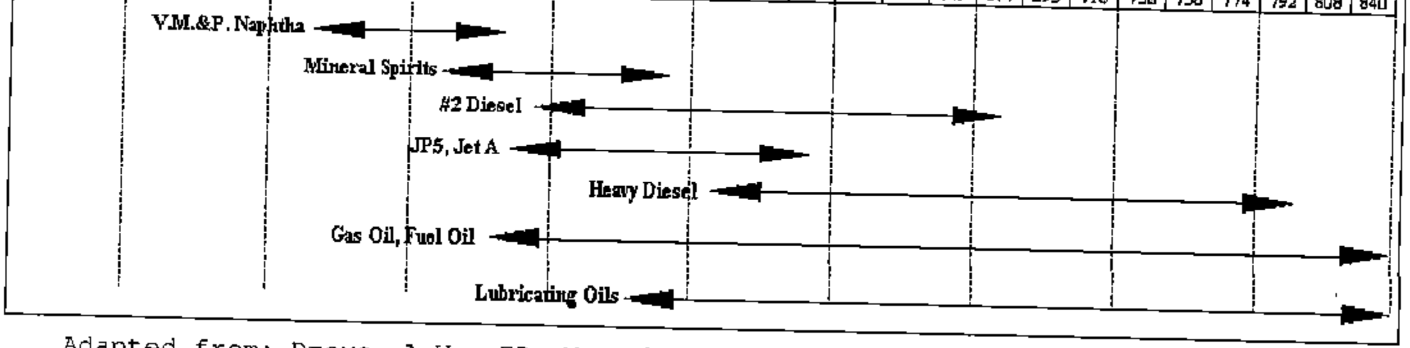
Sample ID: L438781-6 4
Injection Date: 10/11/06 7:44:12 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

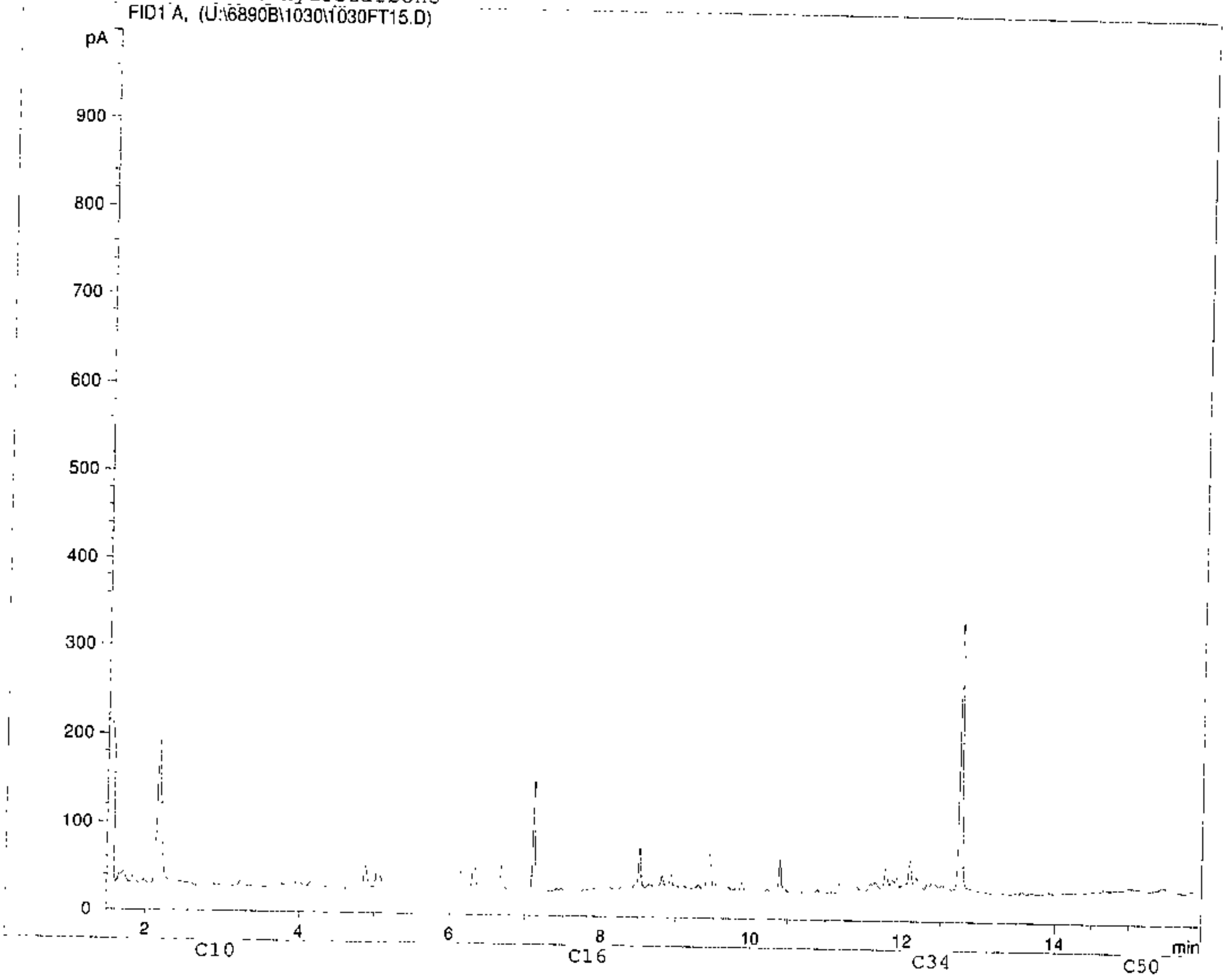


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 302-1

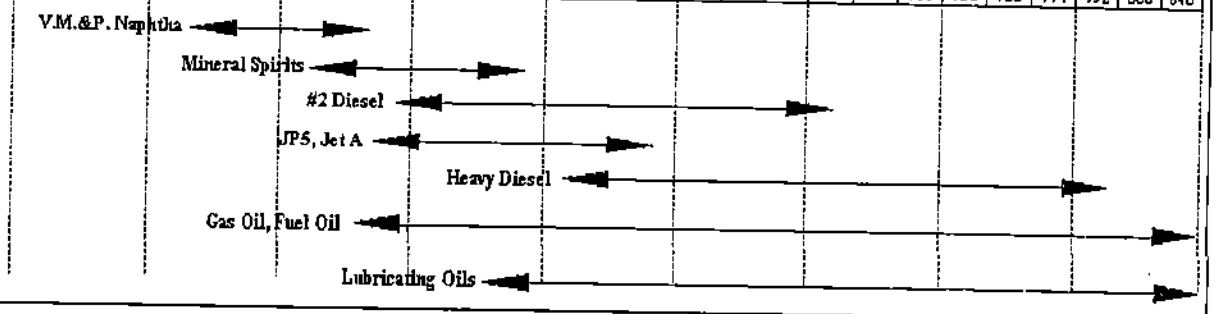
Sample ID: L437383-58 4
Injection Date: 10/30/06 12:31:43 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

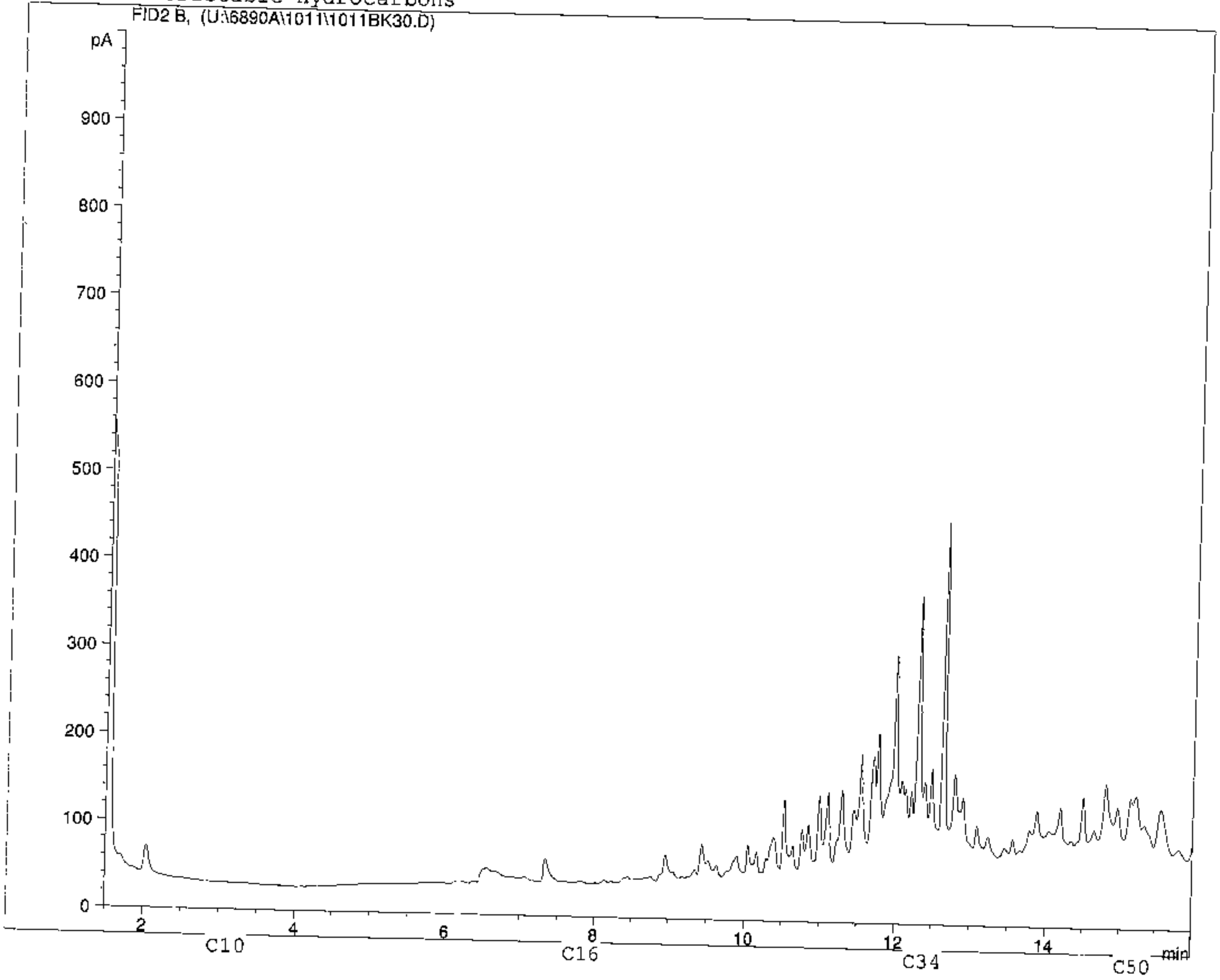


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

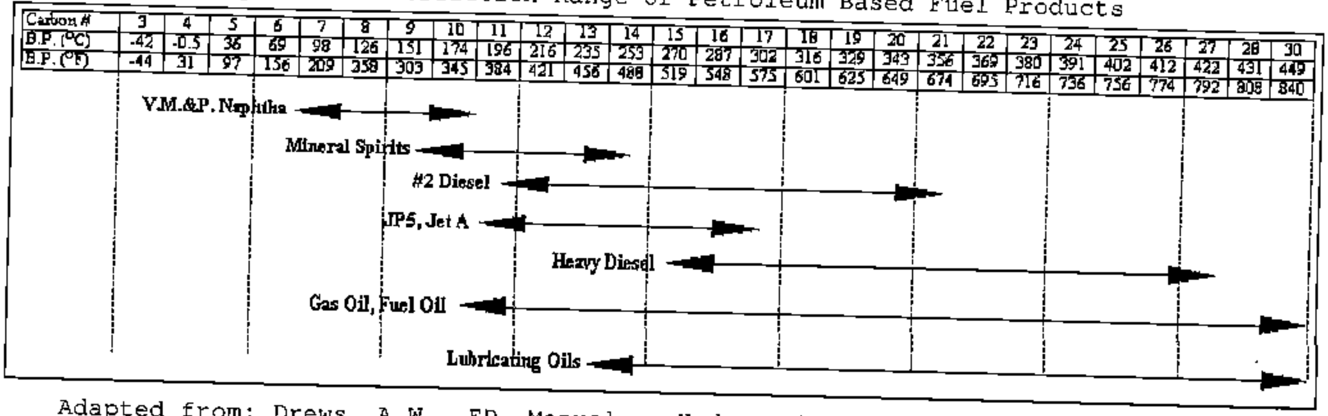
Client ID: 319-1

Sample ID: L439526-19 4
Injection Date: 10/12/2006 5:37:14 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

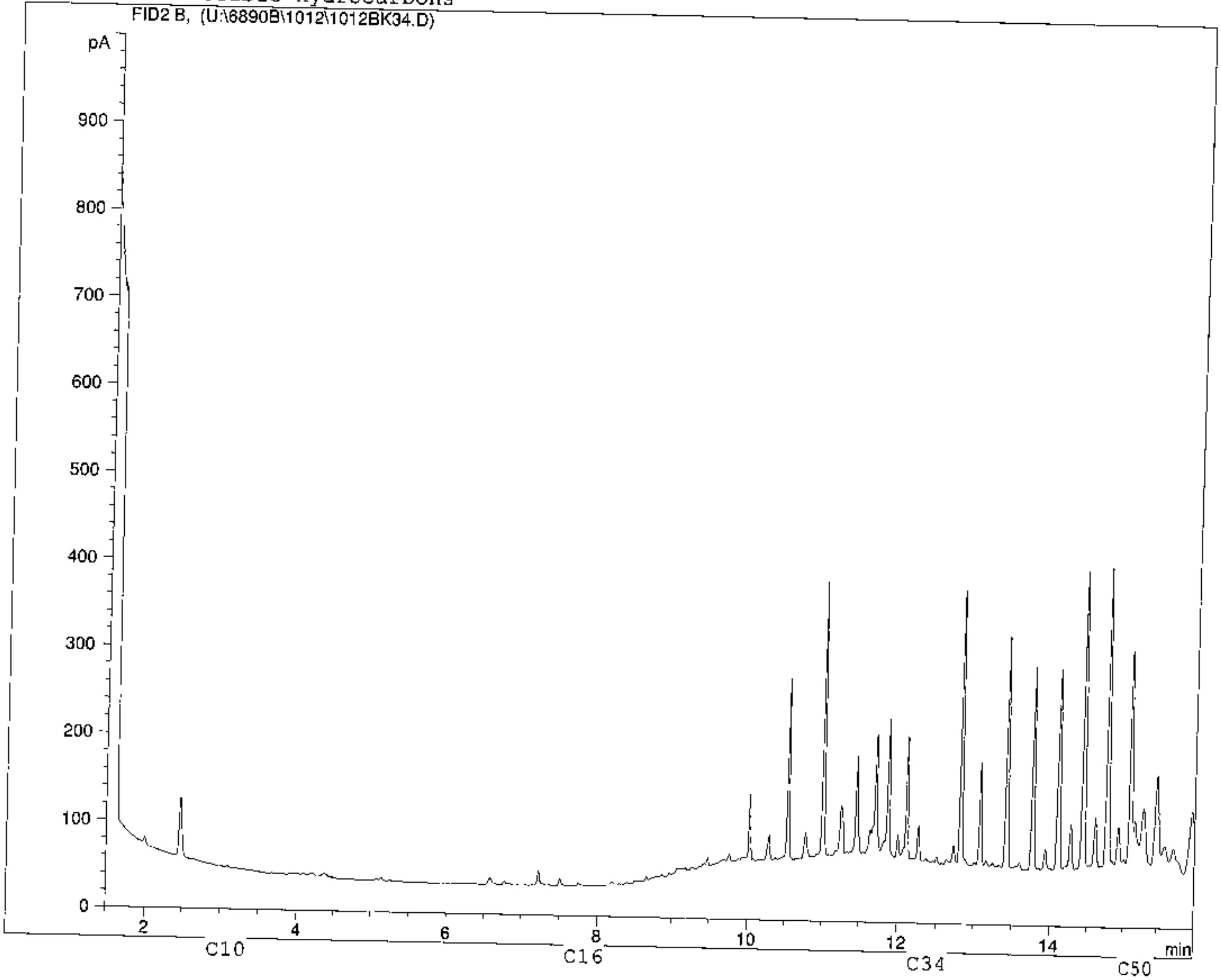


Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

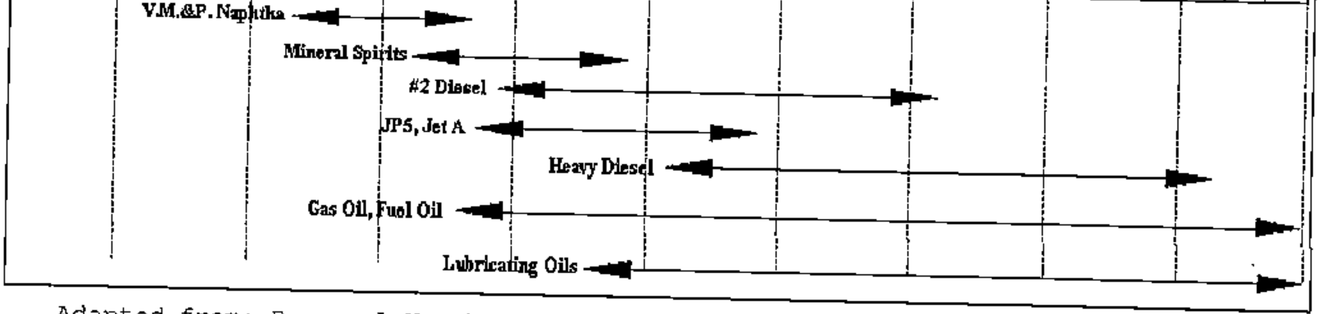
Client ID:	322-LFH
Sample ID:	L439526-30 4 SG
Injection Date:	10/13/06 7:07:40 AM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

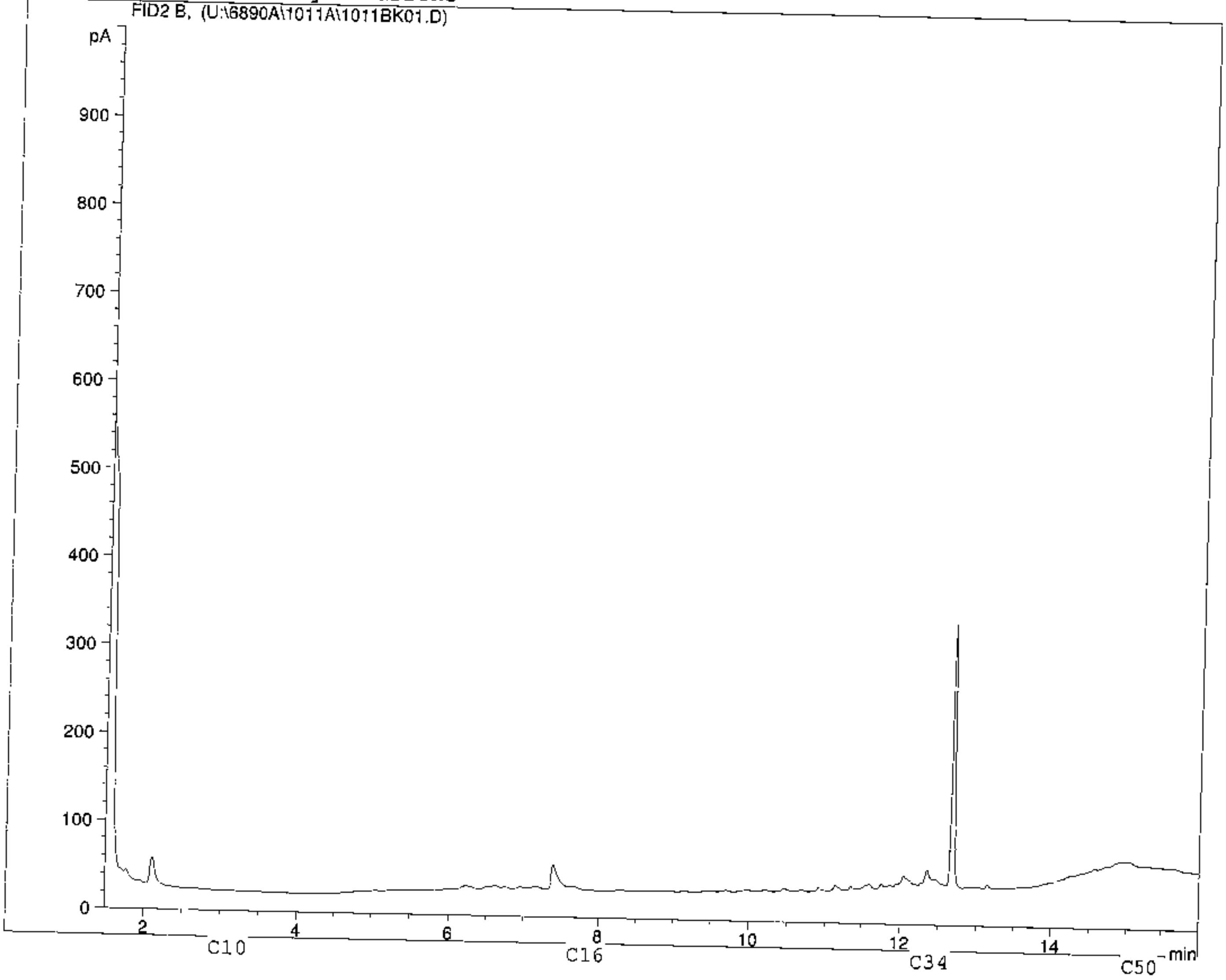


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 322-1

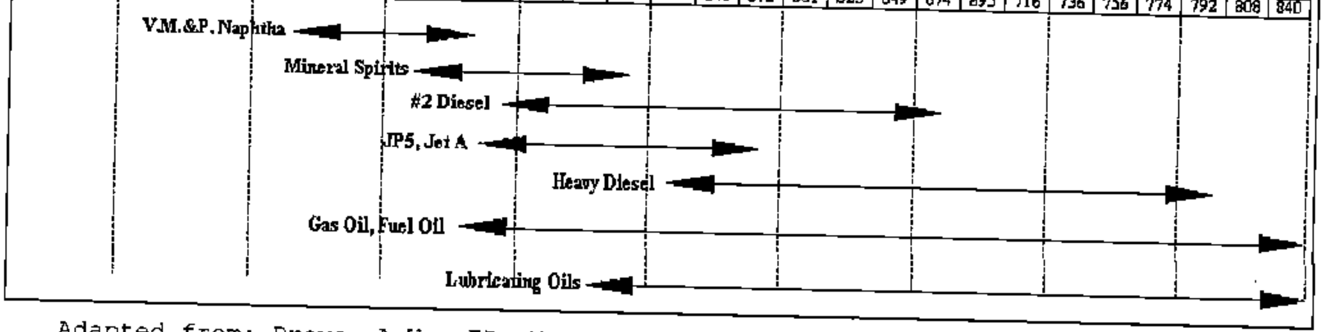
Sample ID: L439526-31 4
Injection Date: 10/12/2006 2:38:32 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

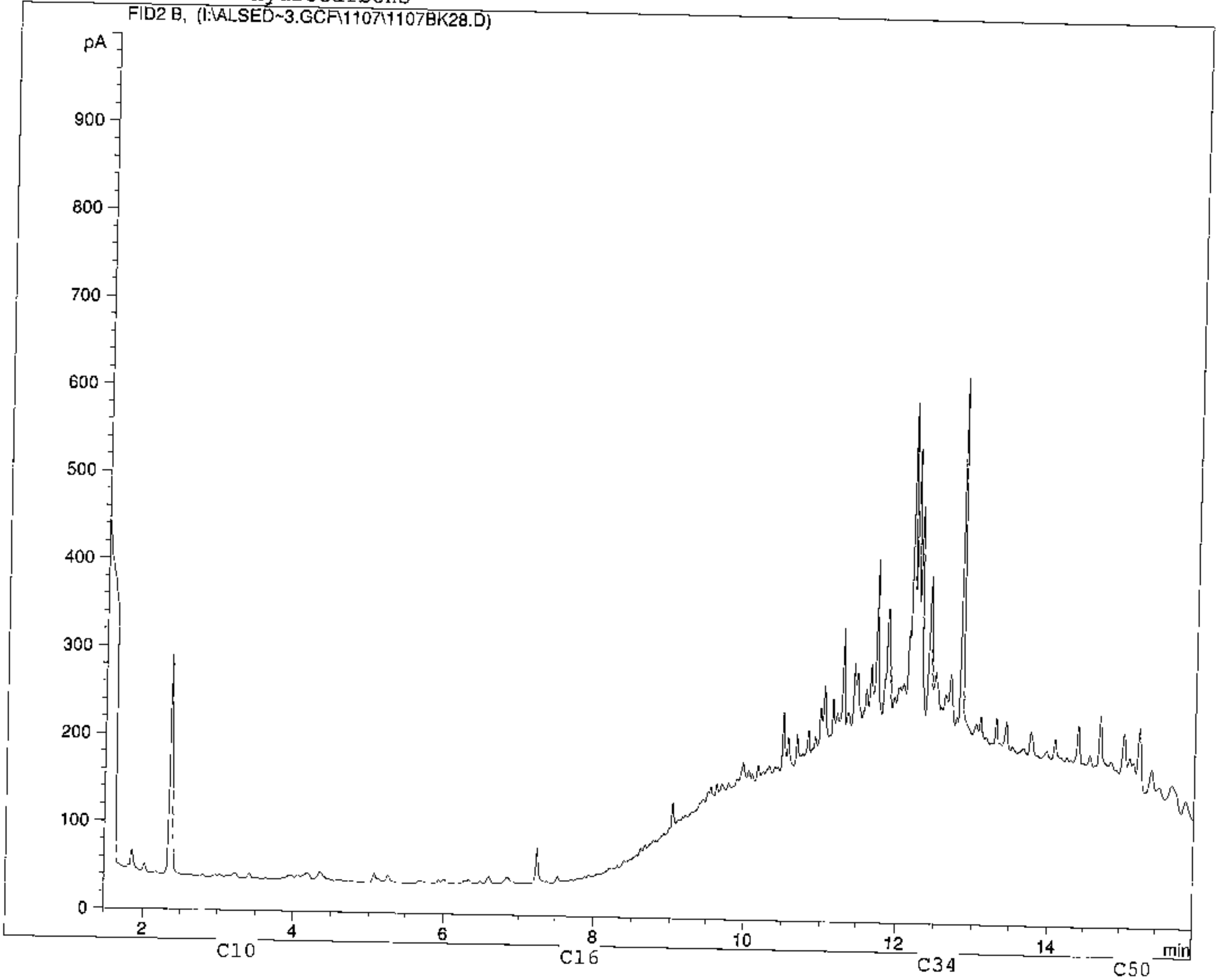


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 327-1

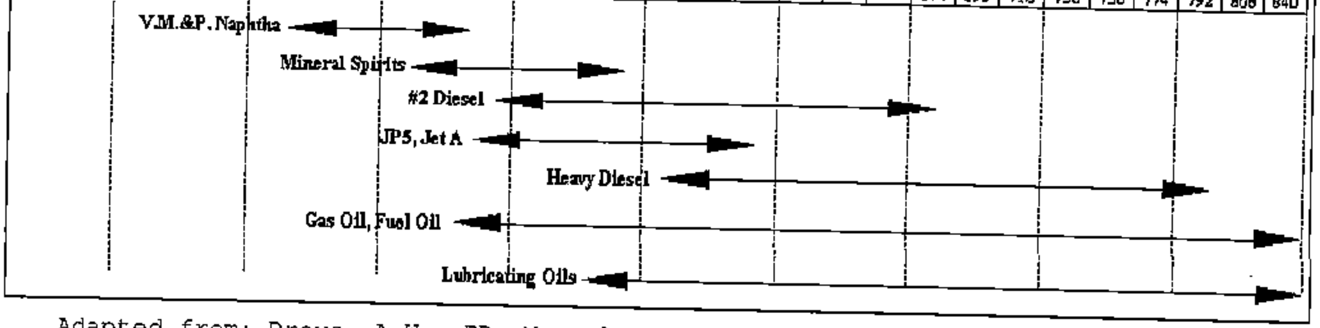
Sample ID: L438781-51 4
Injection Date: 11/8/06 3:41:23 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

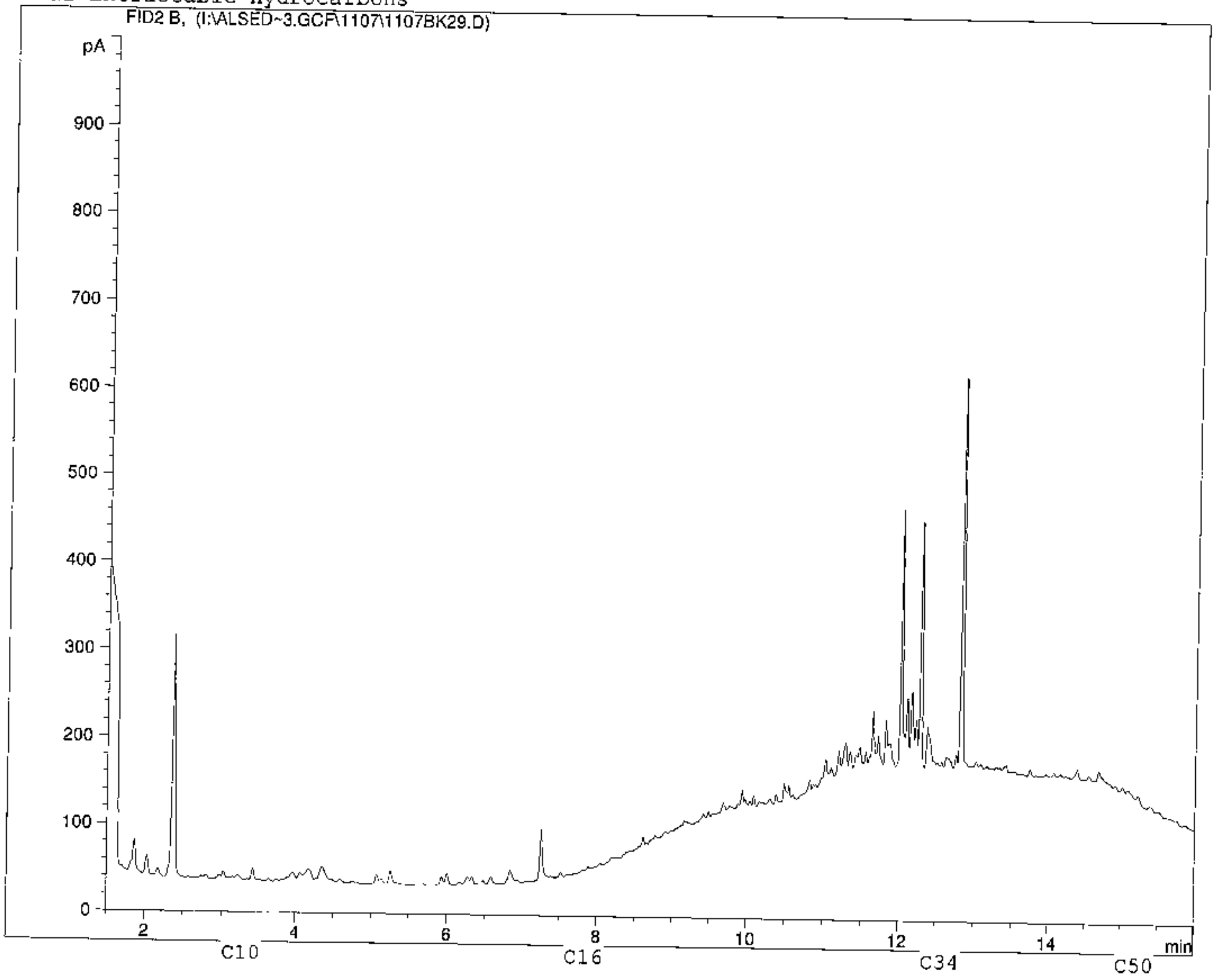


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 327-2

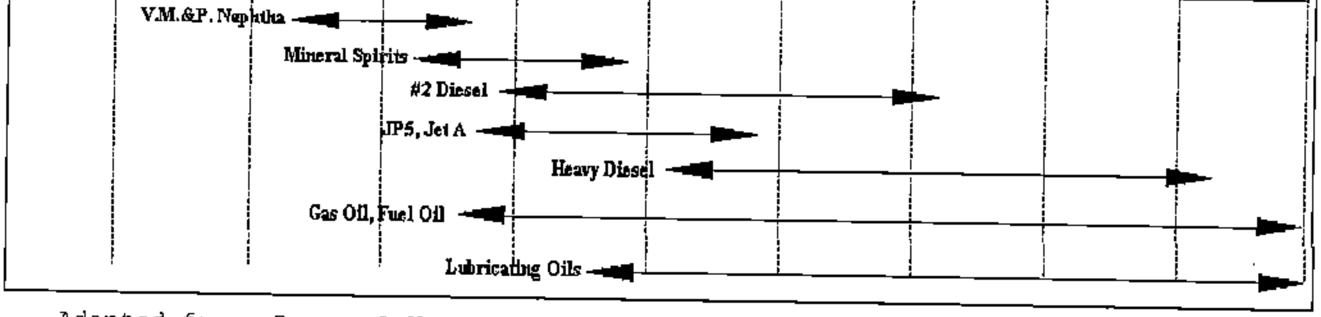
Sample ID: L438781-52 4
Injection Date: 11/8/06 4:08:39 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

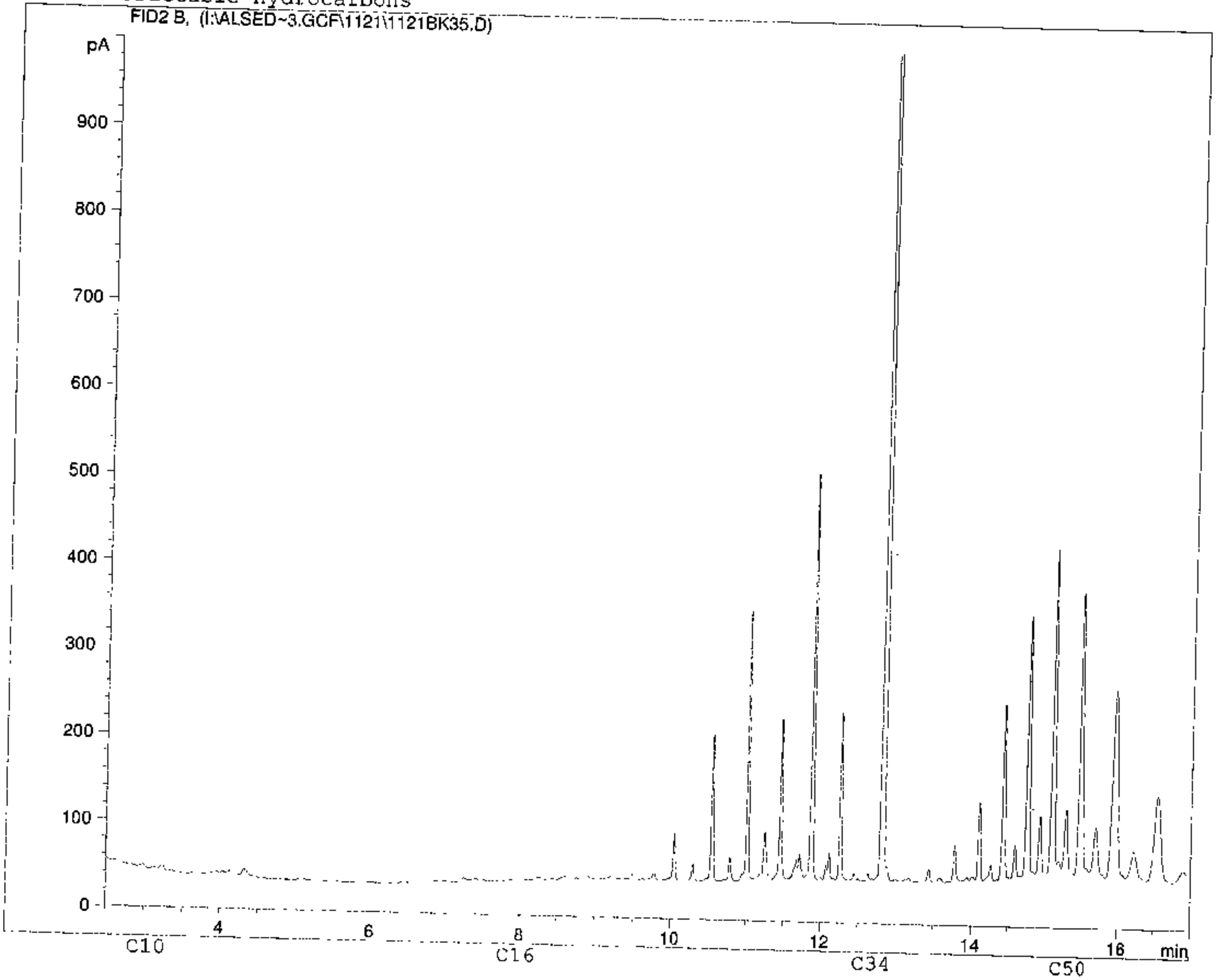


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW260-LFH

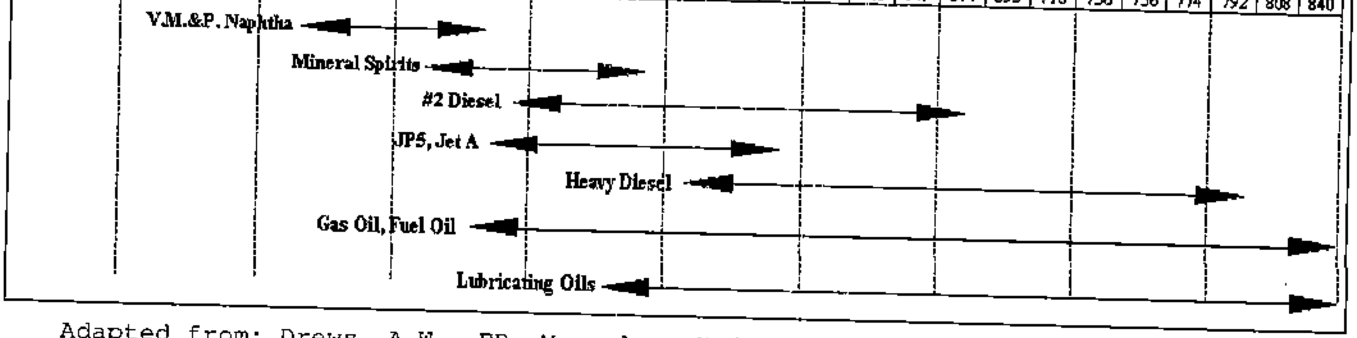
Sample ID: L450940-1 4 SGC
Injection Date: 11/22/06 7:09:44 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

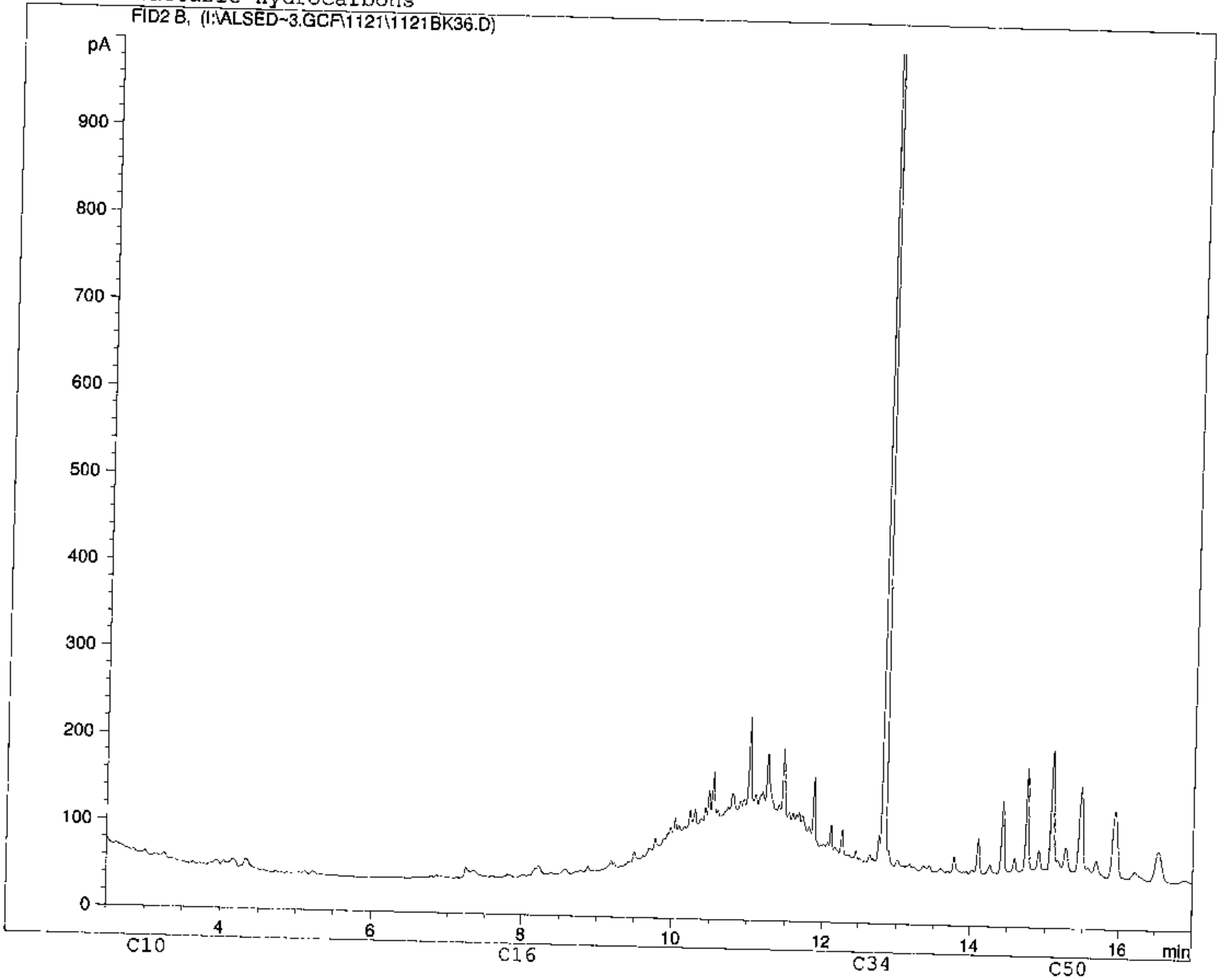


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW260-1

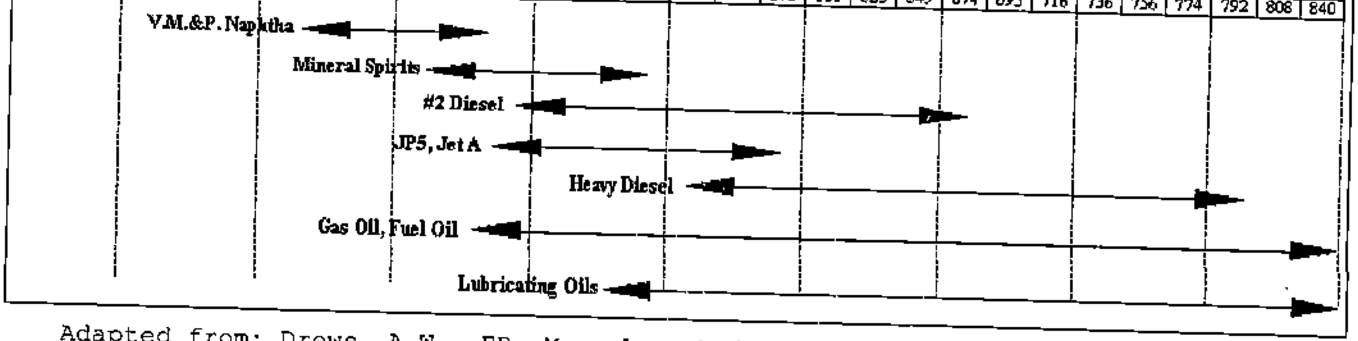
Sample ID: L450940-2 4 SGC
Injection Date: 11/22/06 7:36:32 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

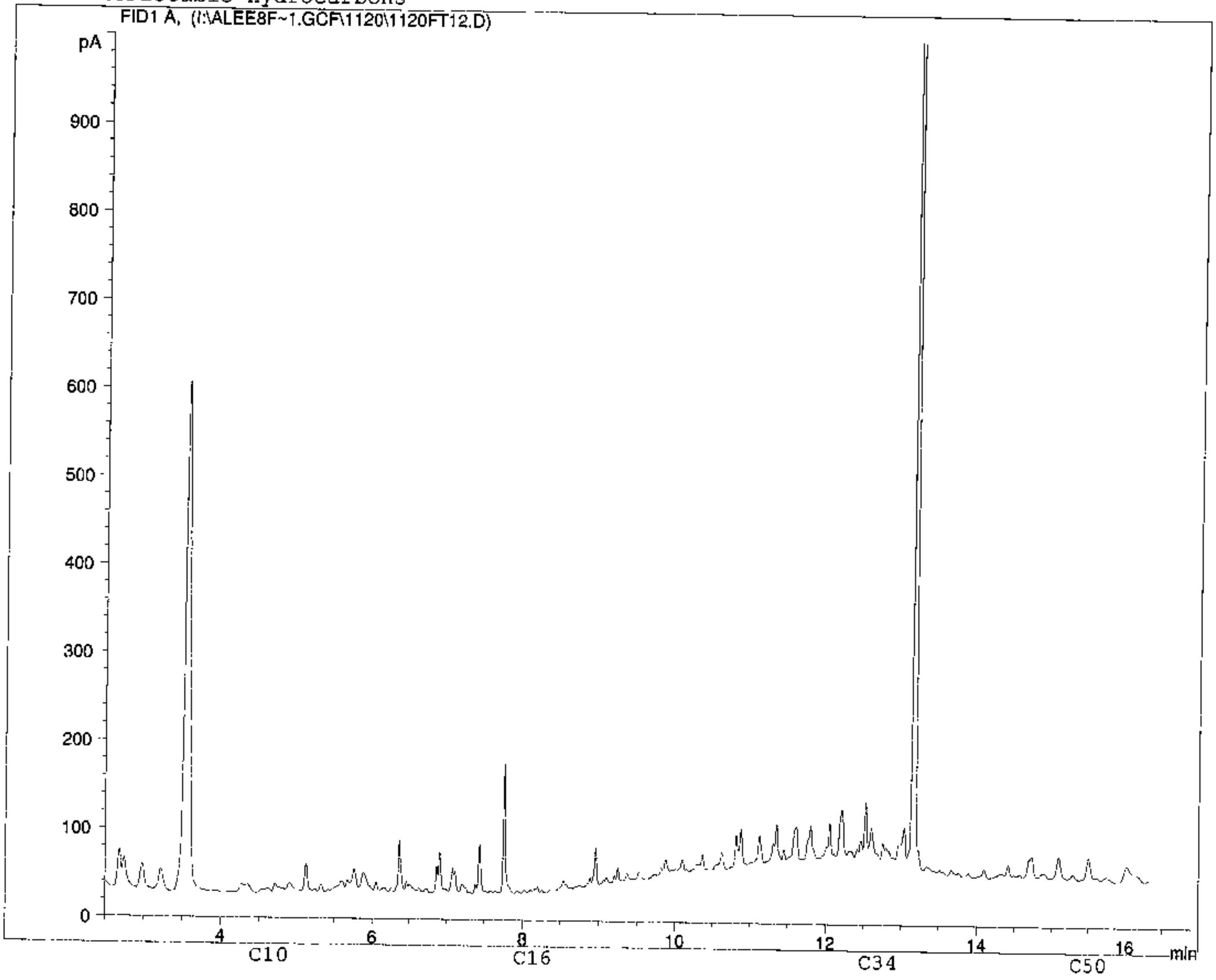


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW260-2

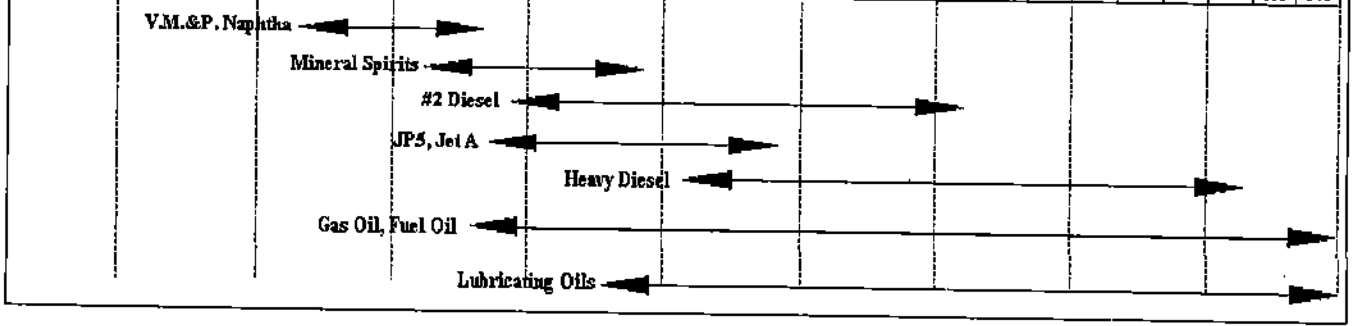
Sample ID: L450940-3 4
Injection Date: 11/20/2006 8:21:03 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

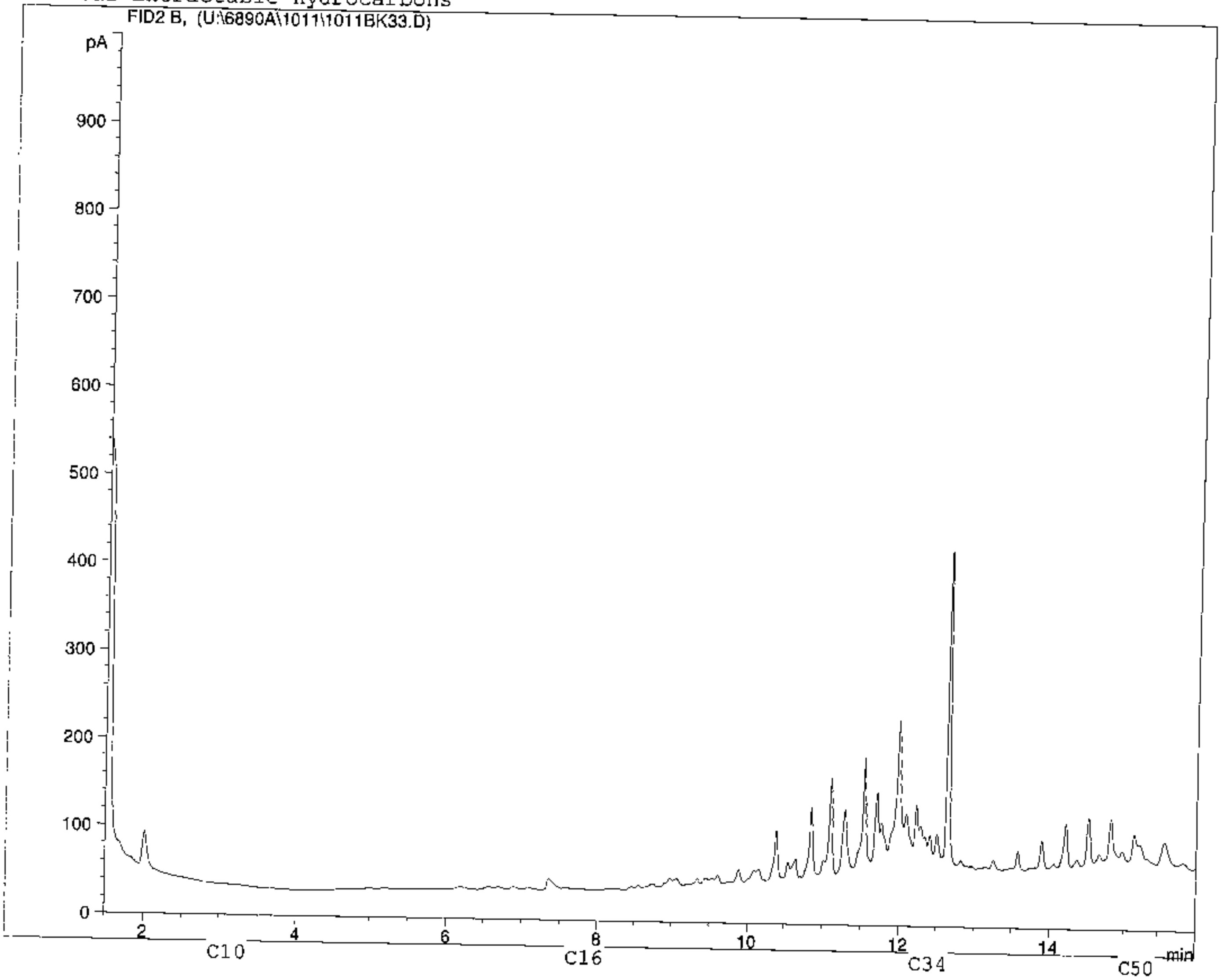


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 16-1

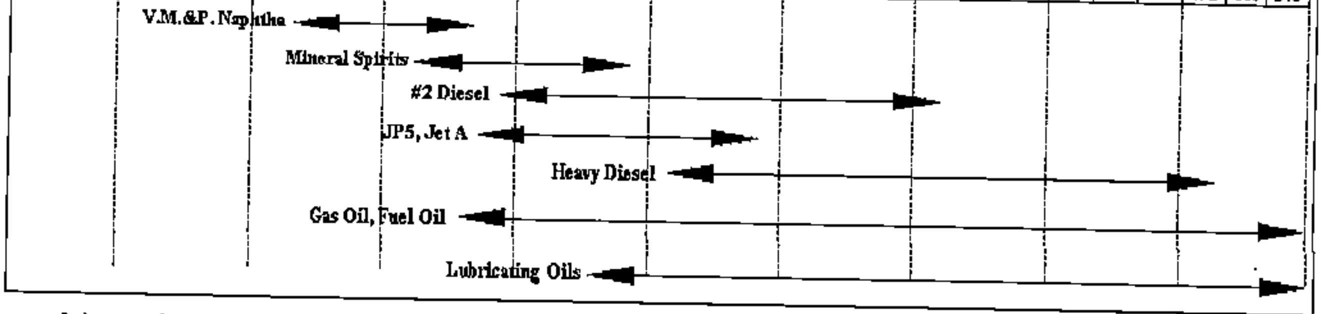
Sample ID: L439526-47 4
Injection Date: 10/12/2006 6:53:00 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

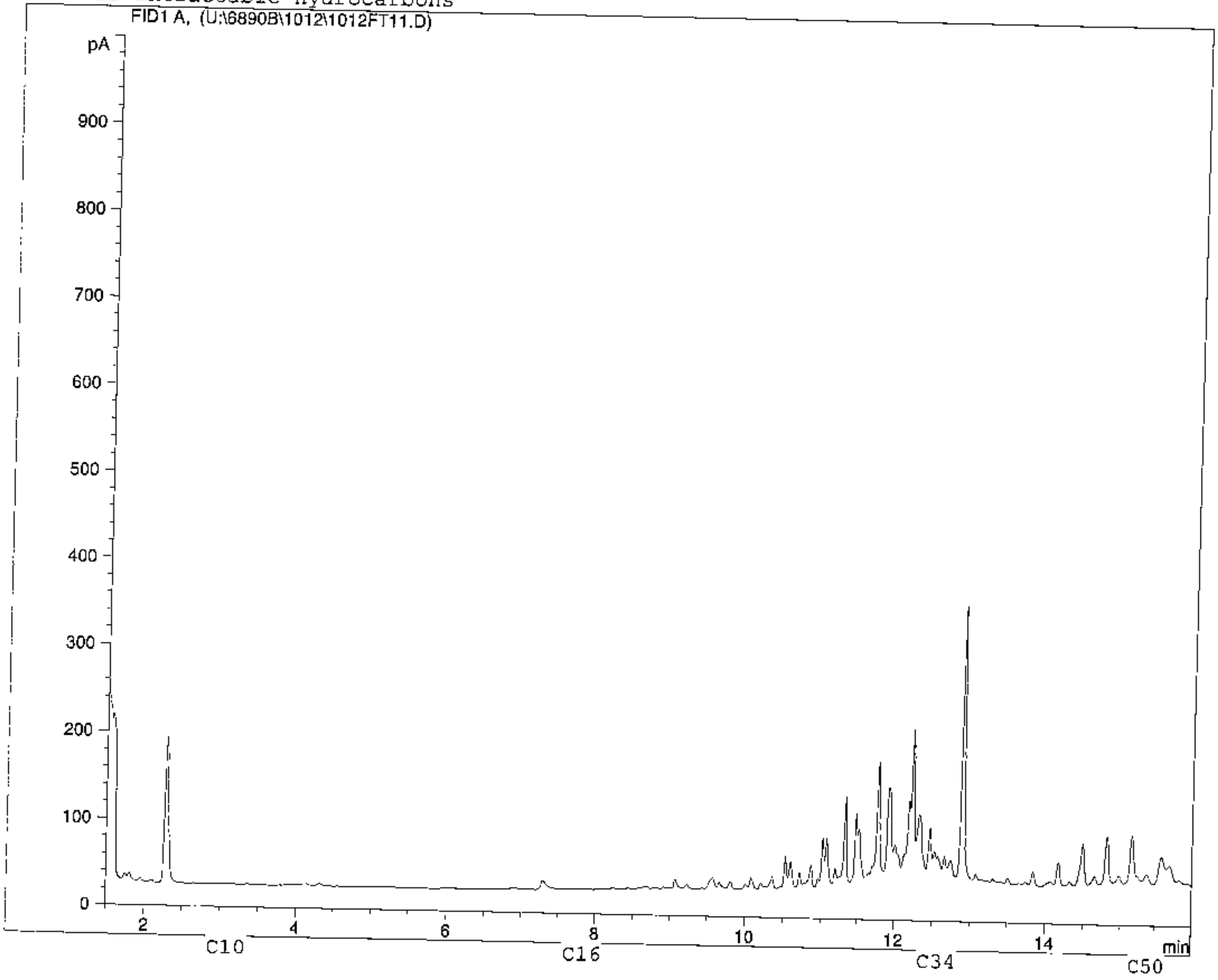


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 217-1

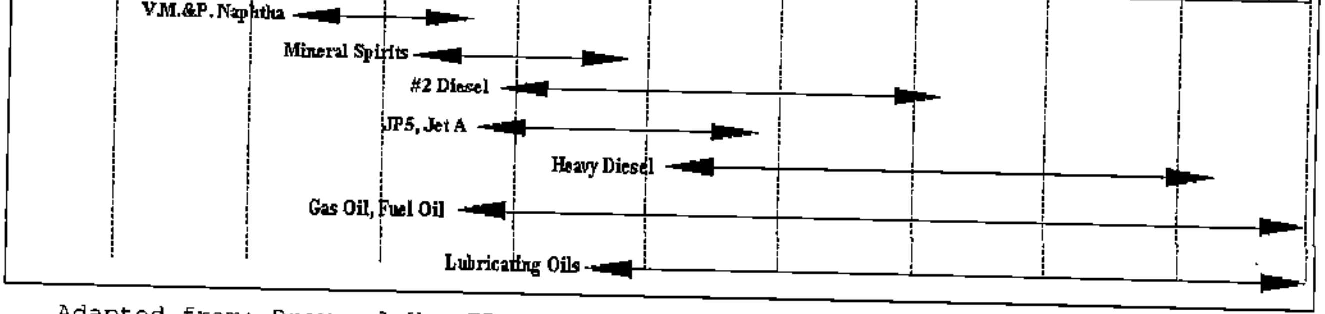
Sample ID: L439526-125 4
Injection Date: 10/12/06 8:42:17 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	486	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

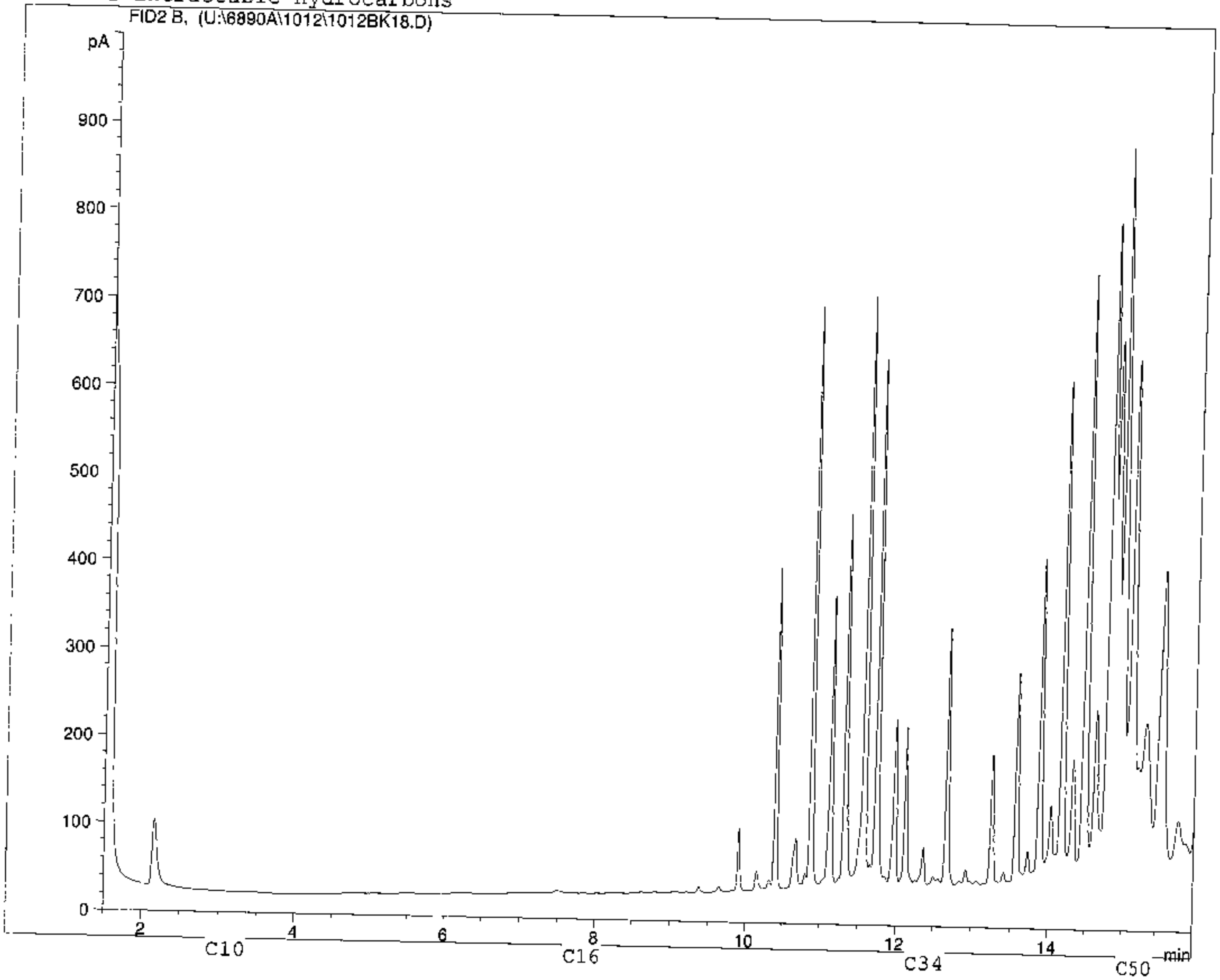


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 218-LFH

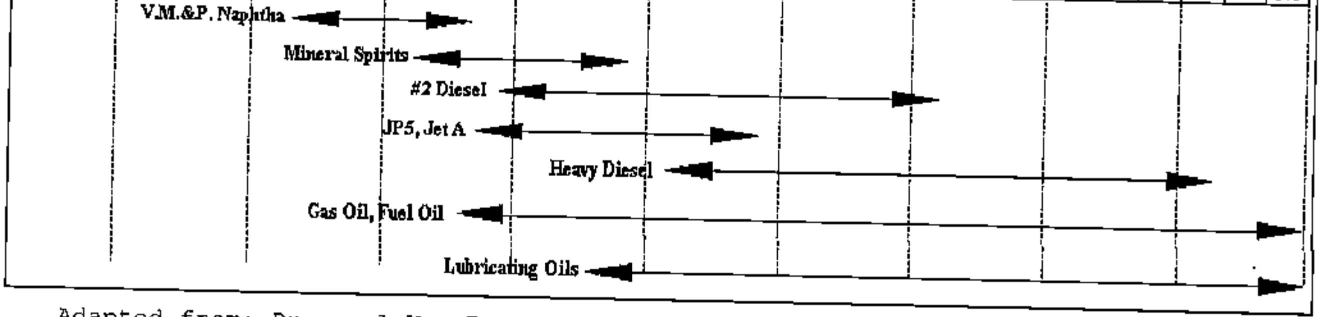
Sample ID: L439526-128 SG 4
Injection Date: 10/13/2006 2:05:57 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

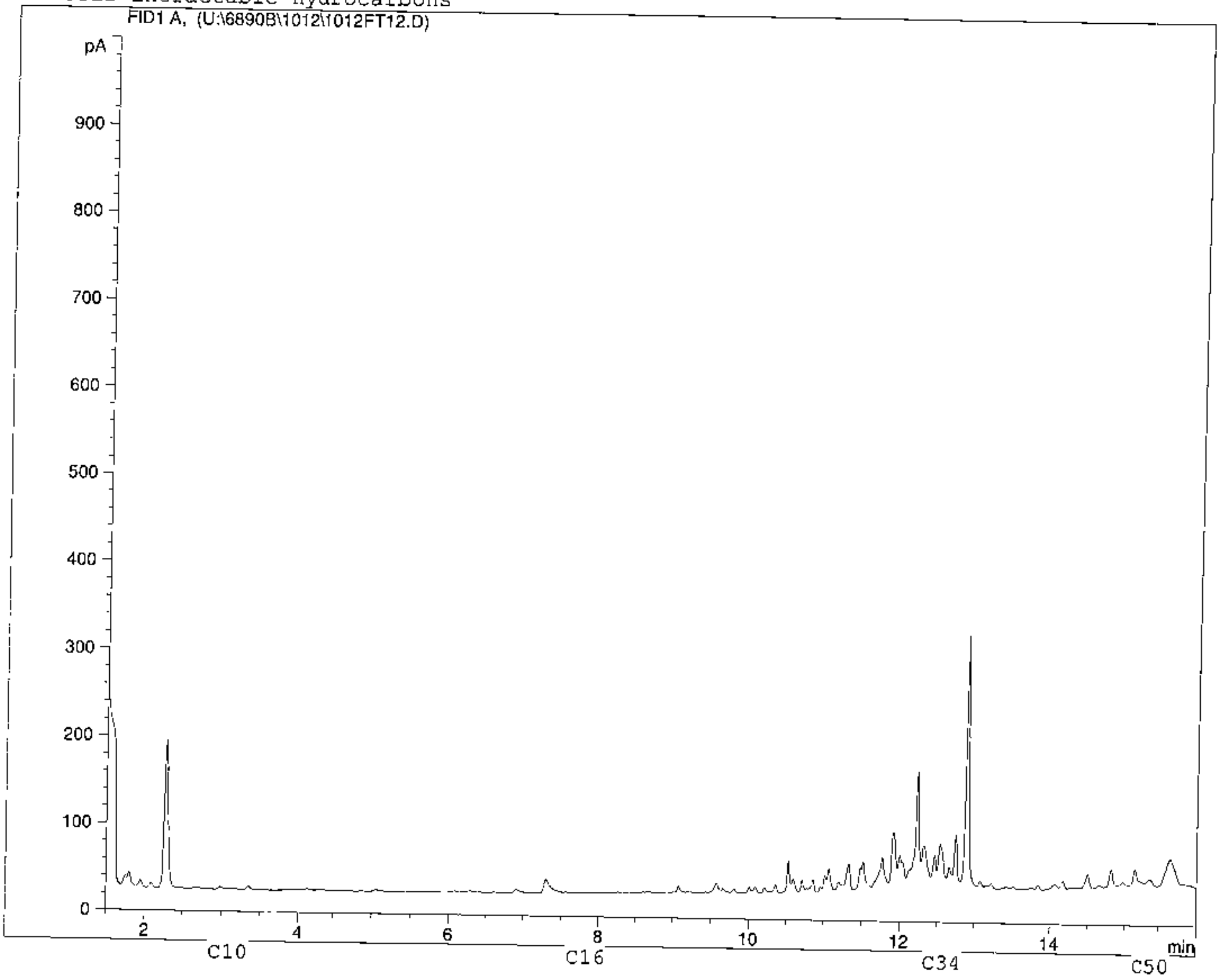


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 218-1

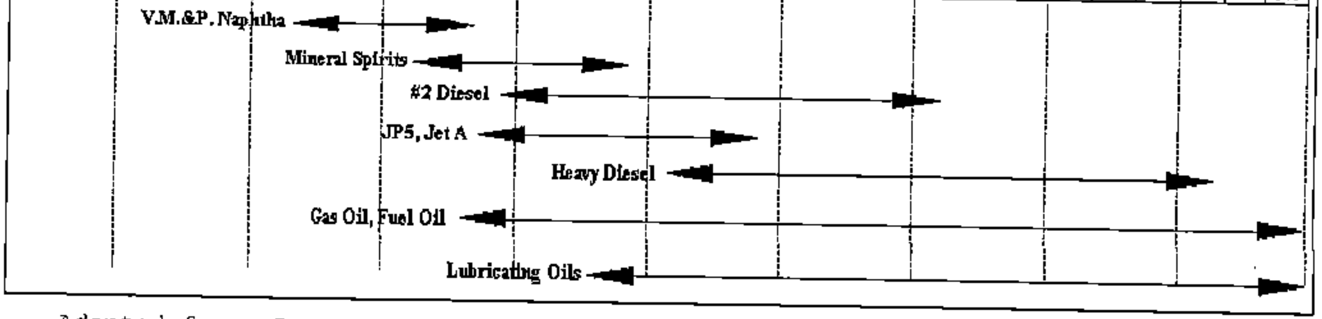
Sample ID: L439526-129 4
Injection Date: 10/12/06 9:09:25 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



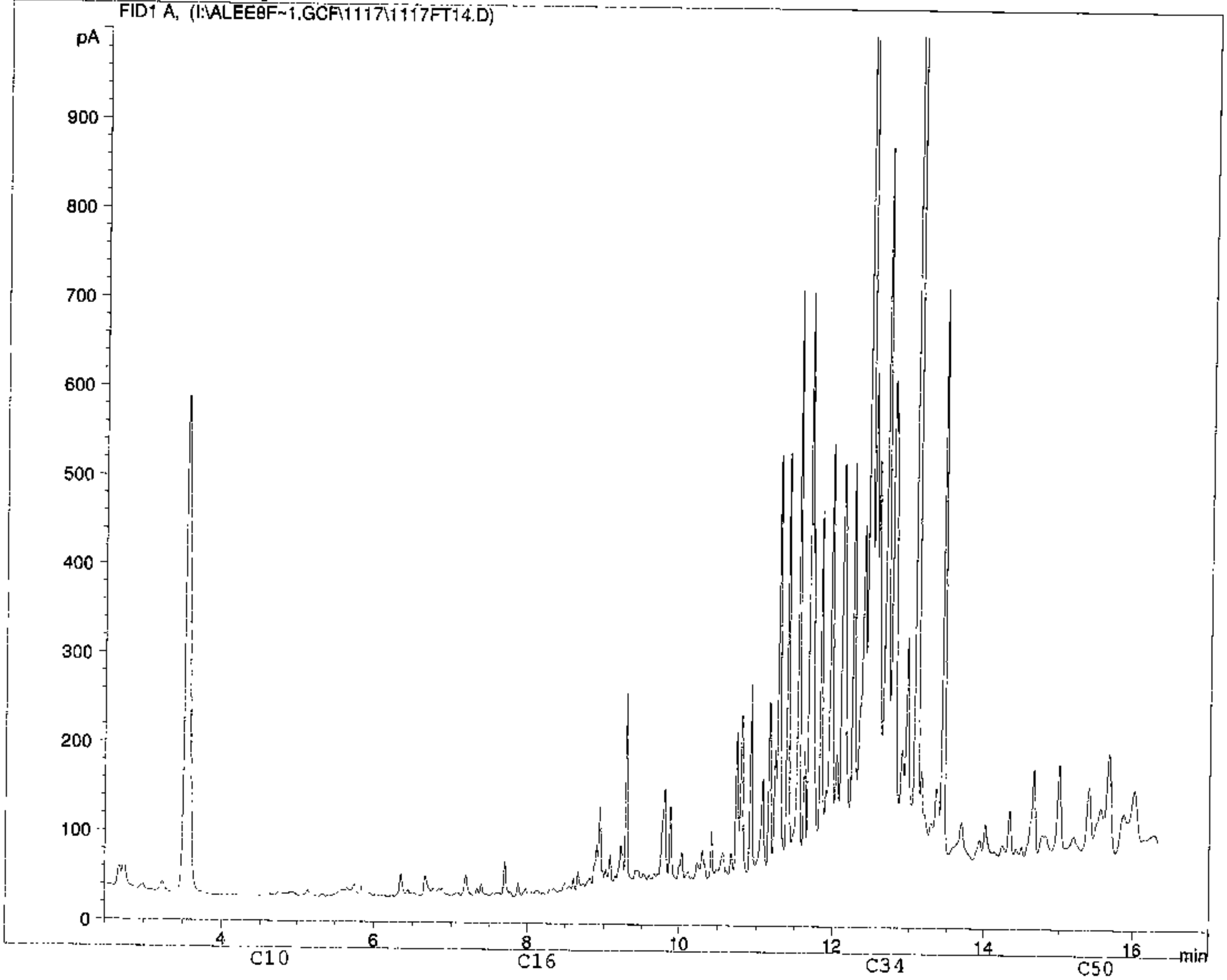
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

BACKGROUND SURFACE LITTER LAYER/SURFACE PEAT – GLEYSOL (MMW) & ORGANICS (MUS) CHROMATOGRAMS

Client ID: DGW261-LFH

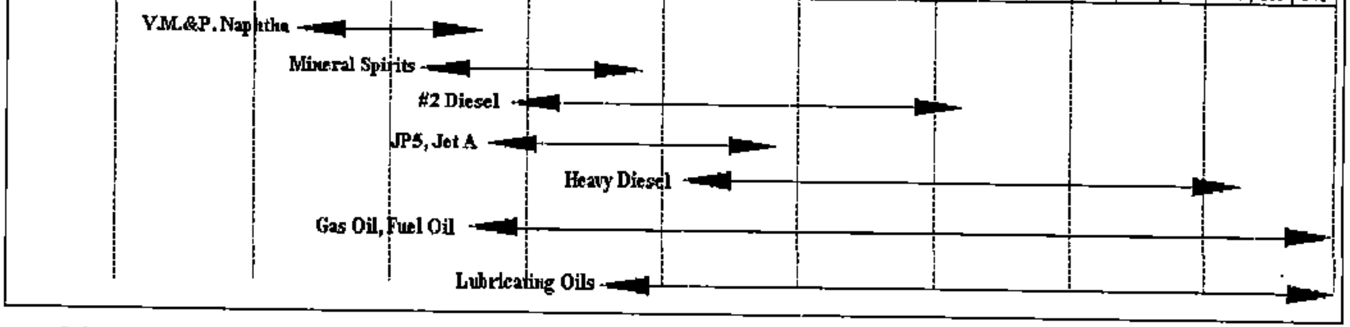
Sample ID: L450940-5 4
Injection Date: 11/17/2006 9:21:53 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	608	840

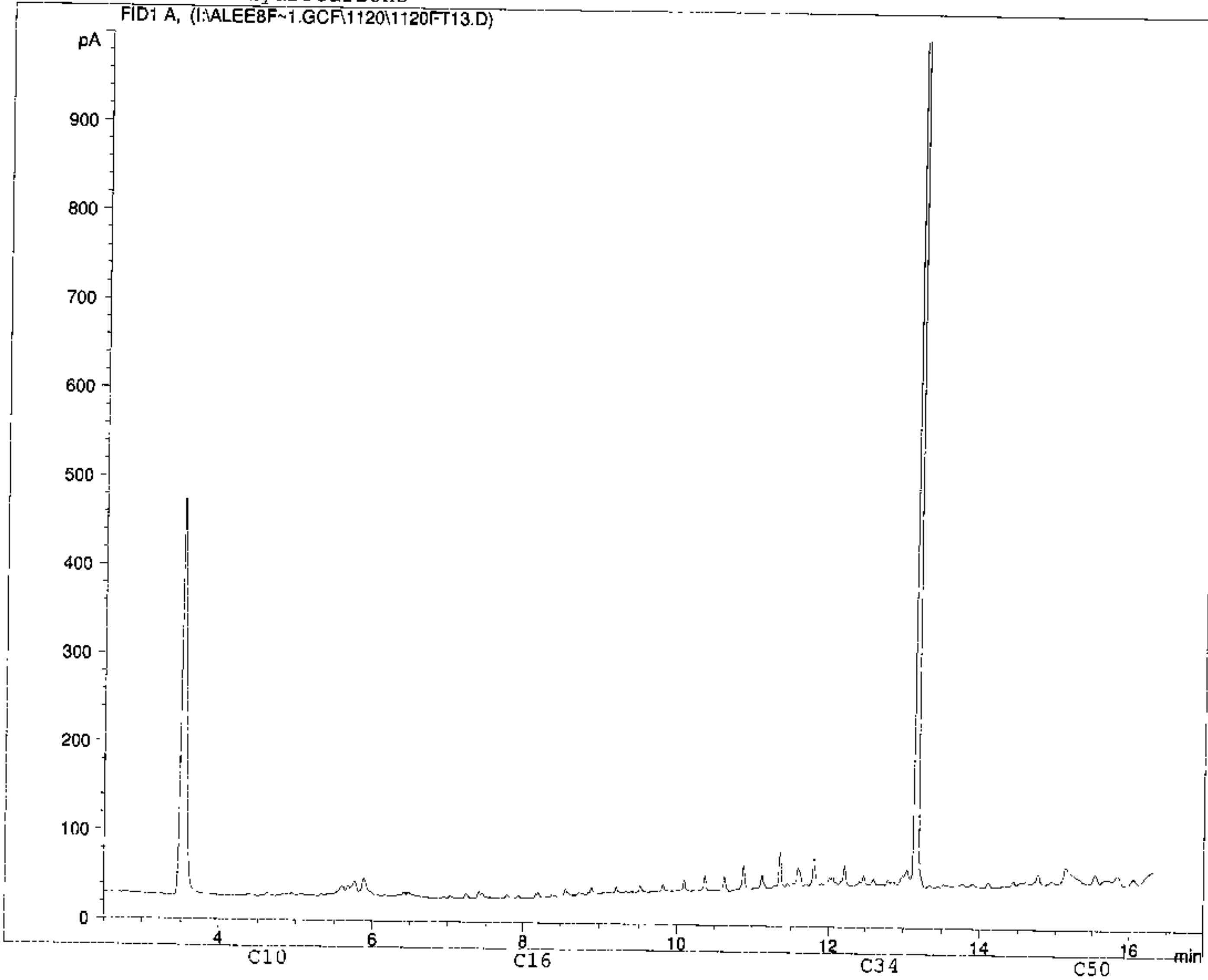


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW261-1

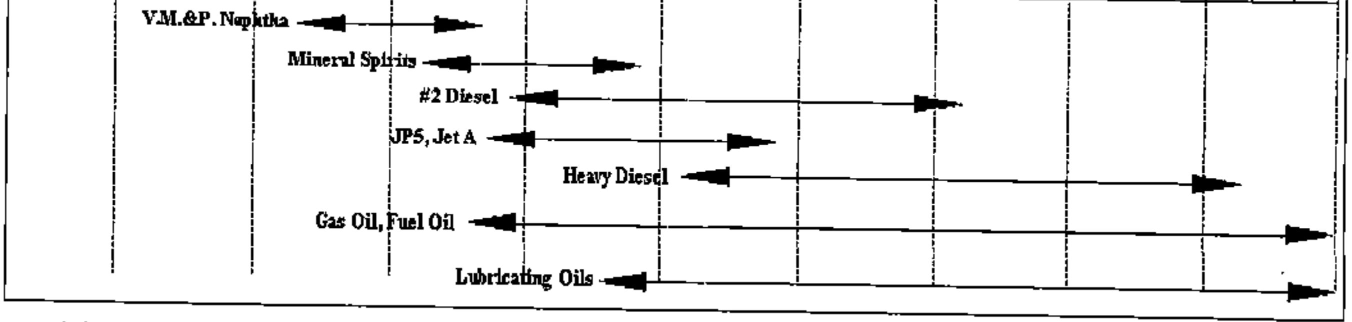
Sample ID: L450940-6 4
Injection Date: 11/20/2006 8:46:26 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

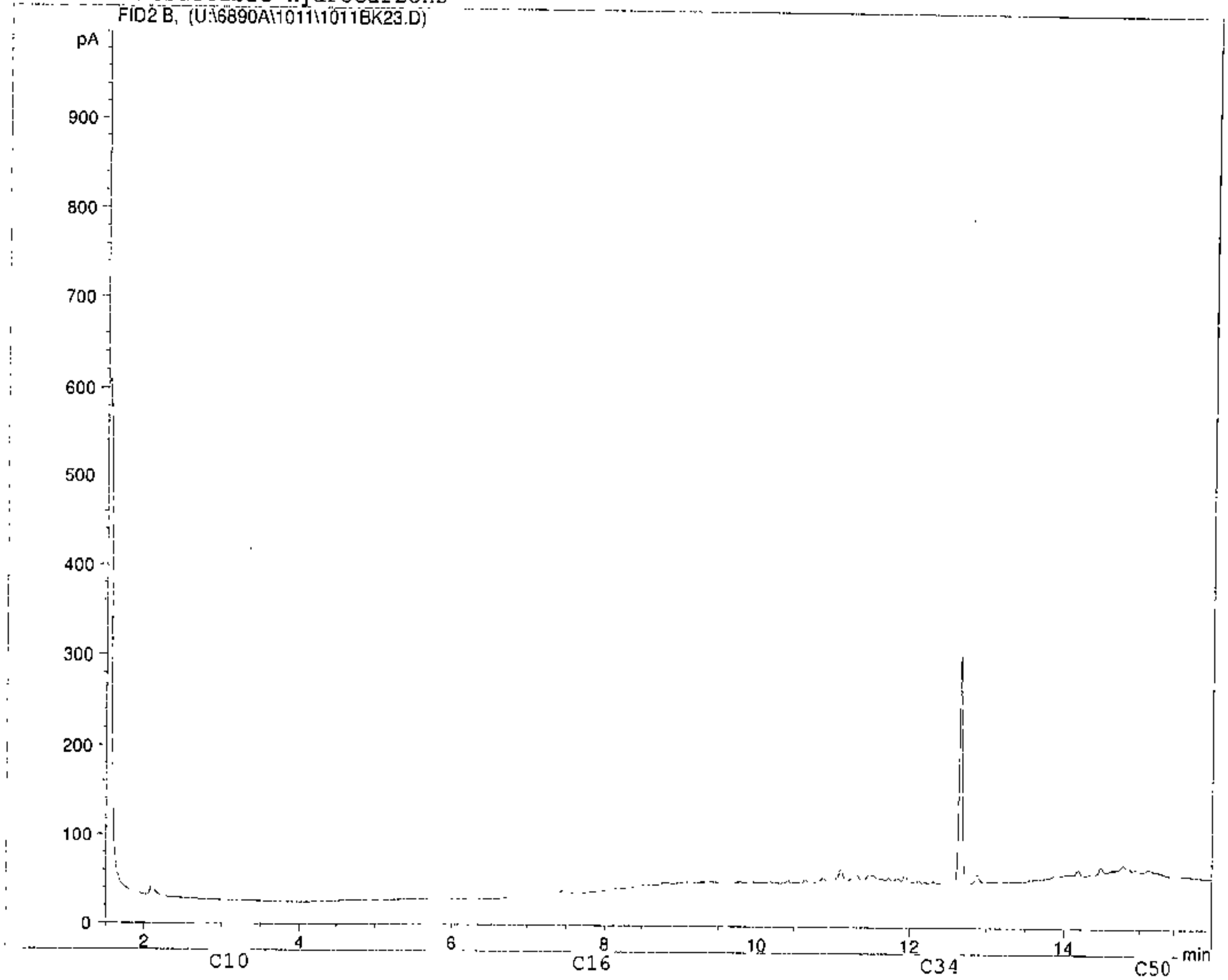


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 109-LFH

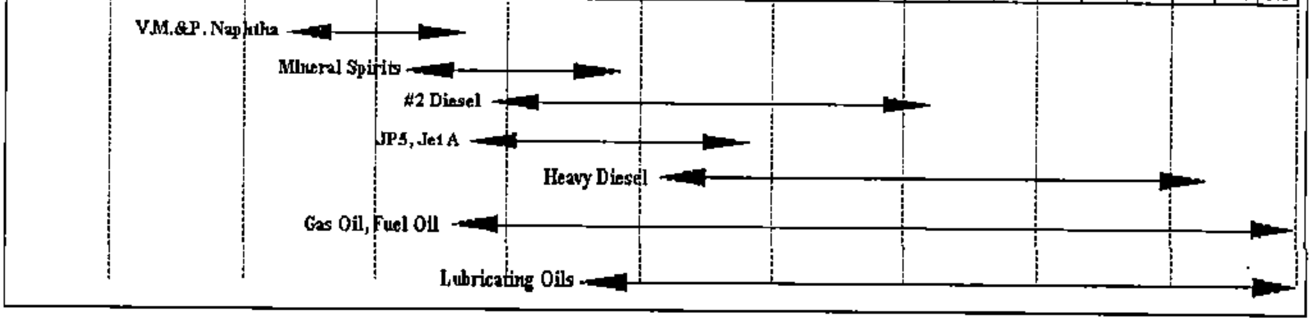
Sample ID: L437987-72 4 SG
Injection Date: 10/12/2006 2:41:26 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

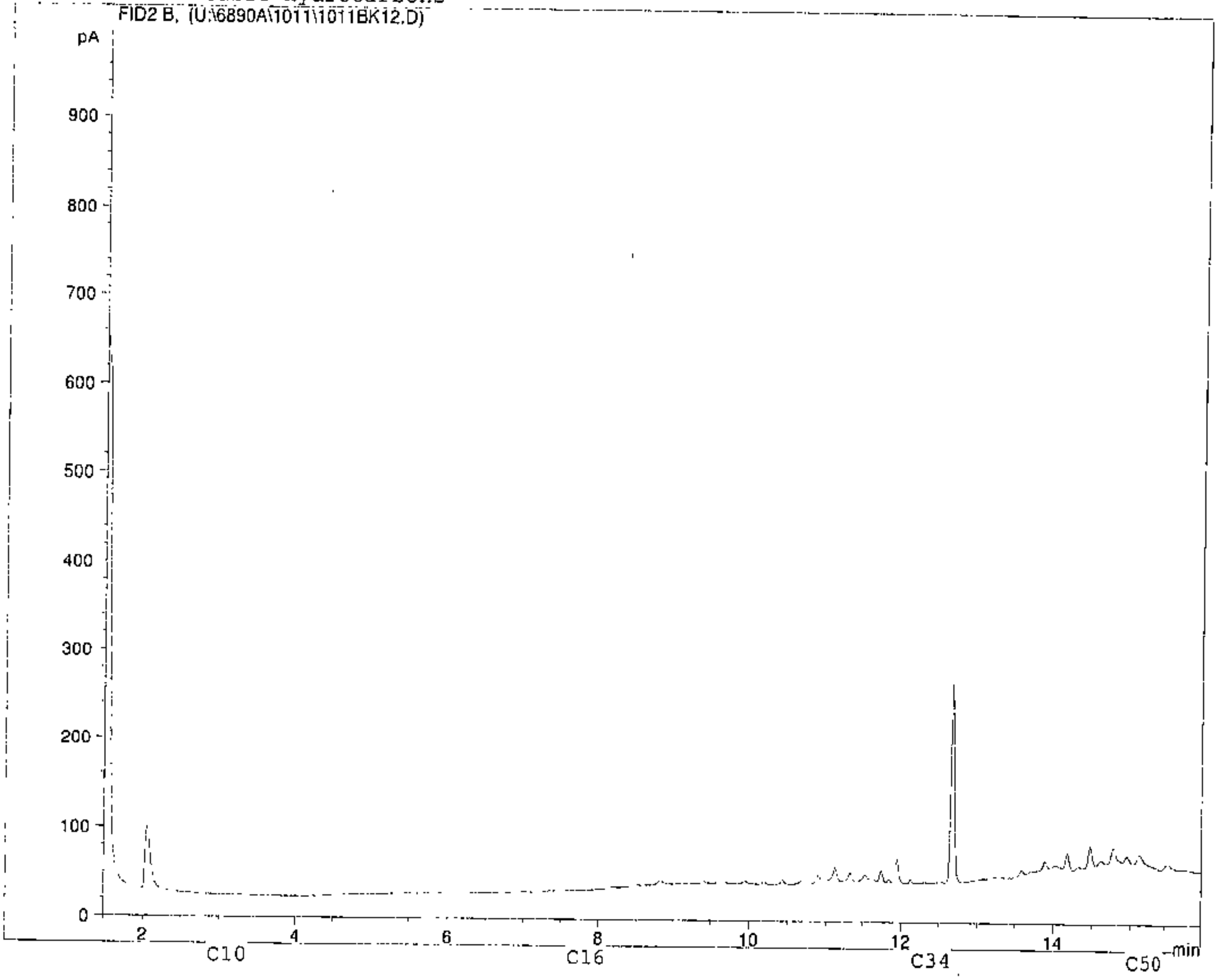
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

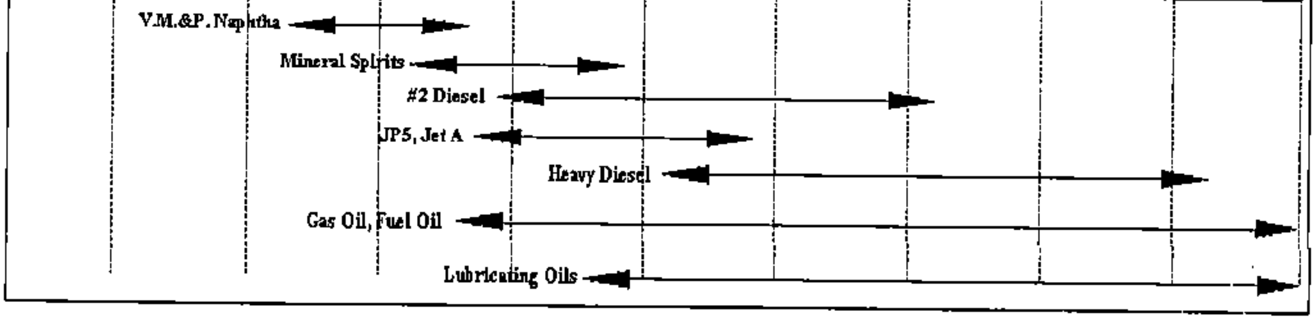
Client ID:	305 LFH
Sample ID:	L437383-72 4 SG
Injection Date:	10/11/2006 10:05:08 PM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



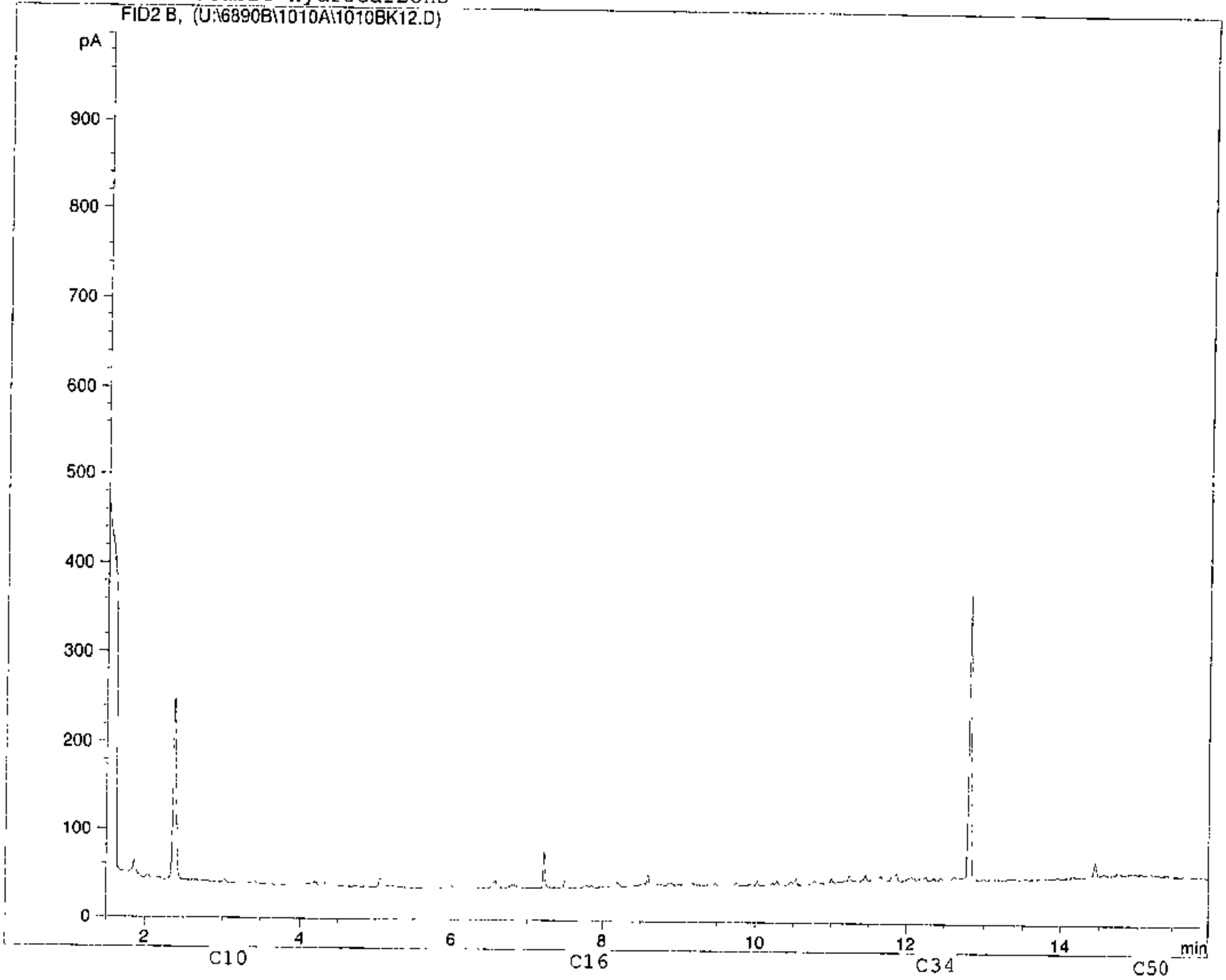
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Oct 24.06 c_L437383.PDF

Client ID: 305-1

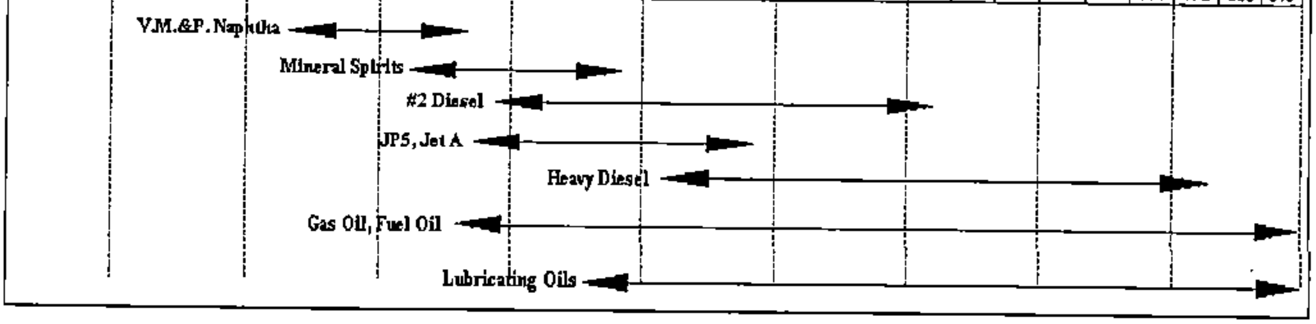
Sample ID: L437383-97 4
Injection Date: 10/10/06 11:17:09 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



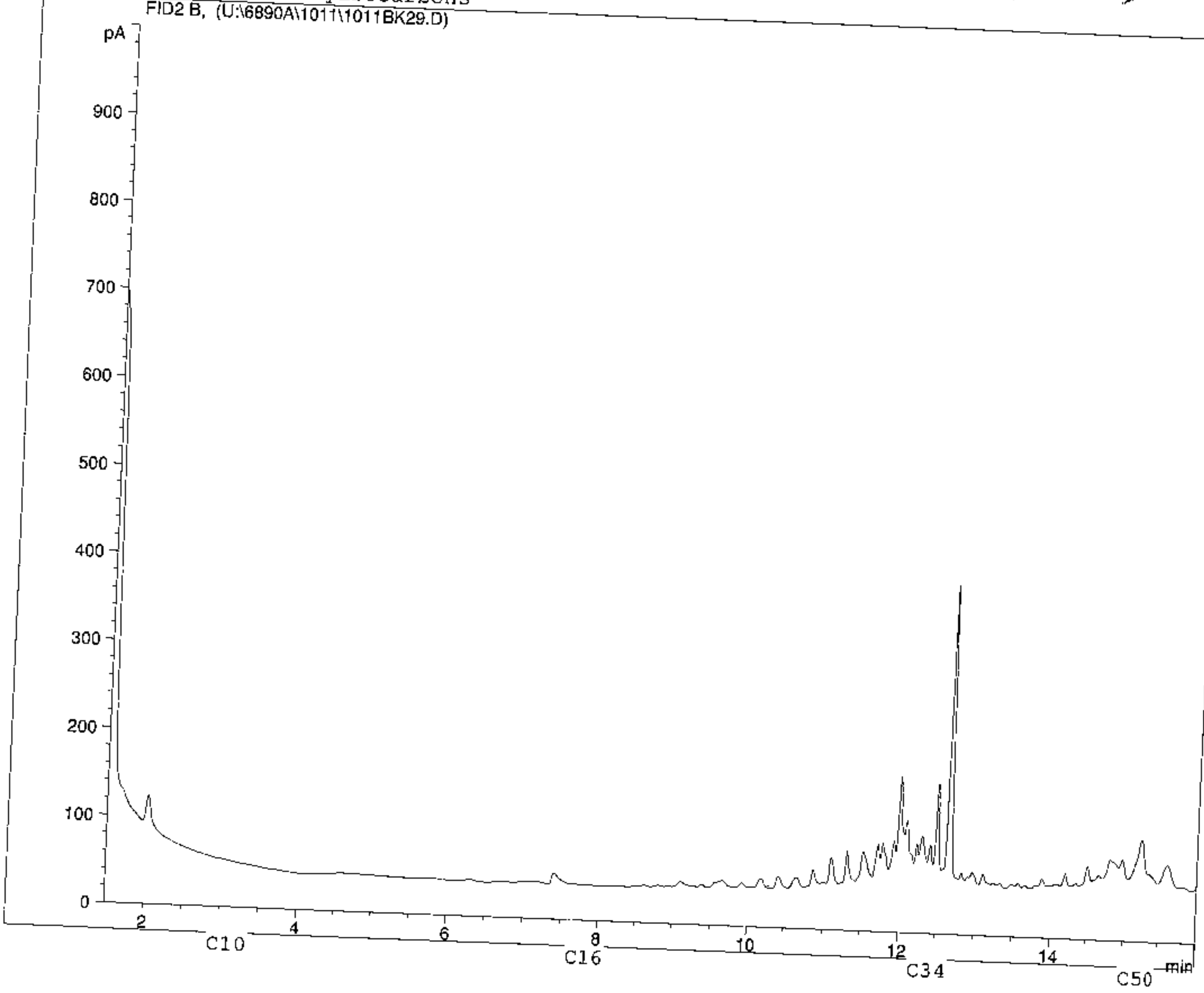
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Oct 24.06 c_L437383.PDF

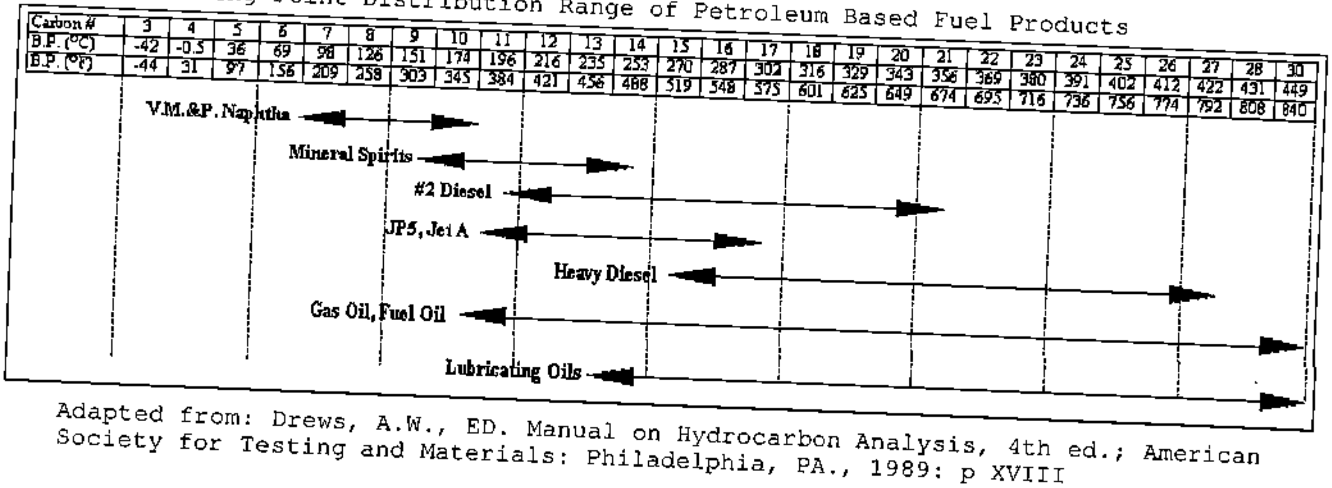
Client ID: 318-1

Sample ID: L439526-15 4
Injection Date: 10/12/2006 5:12:08 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



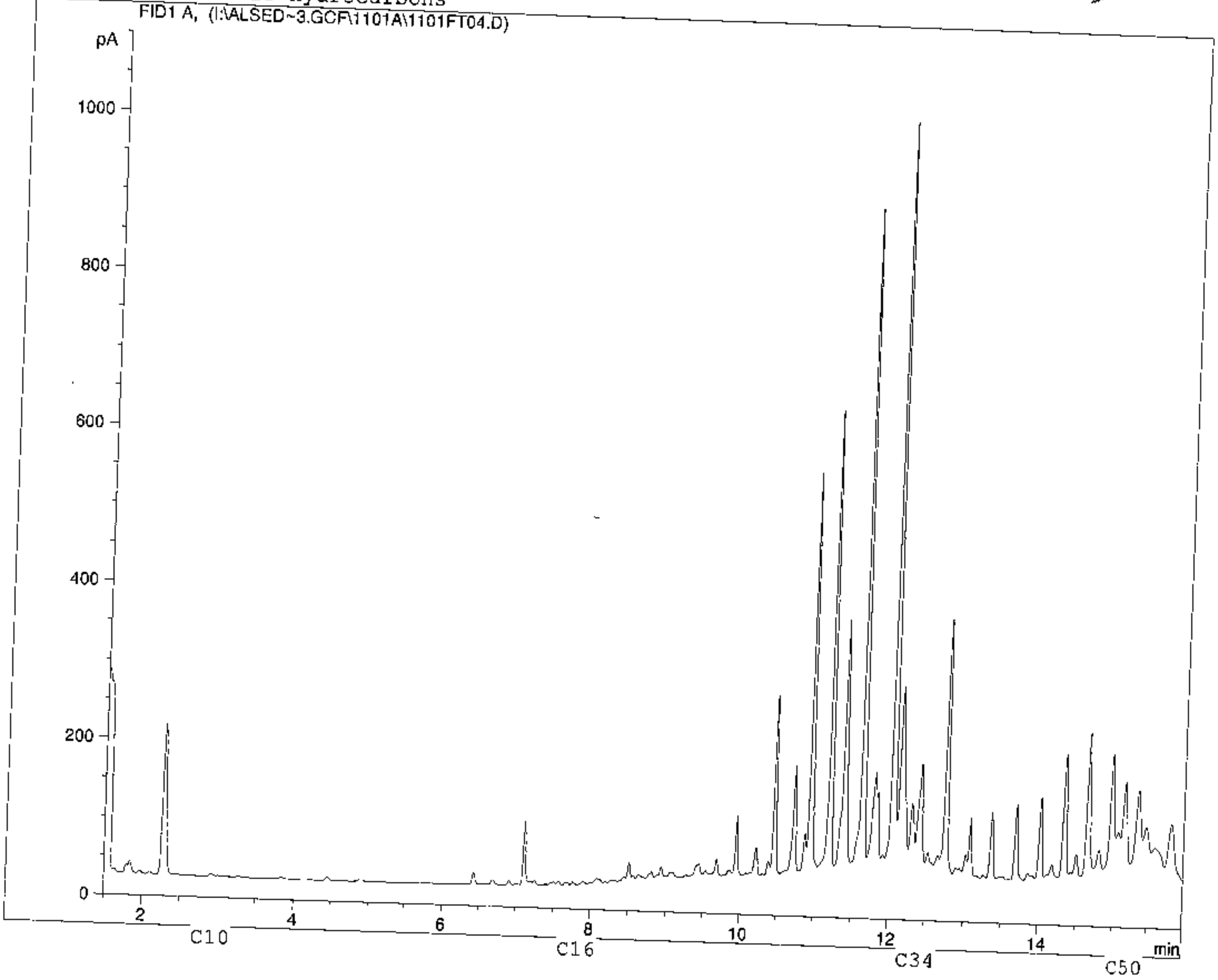
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

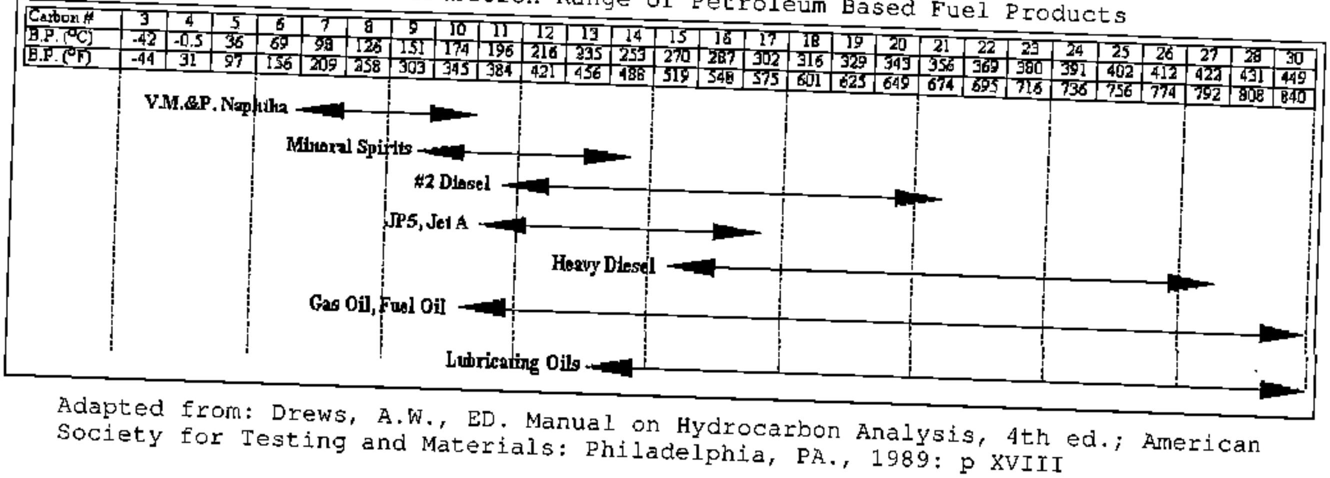
Client ID: 323-LFH

Sample ID: L438781-35 4 SG
Injection Date: 11/2/06 11:18:31 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



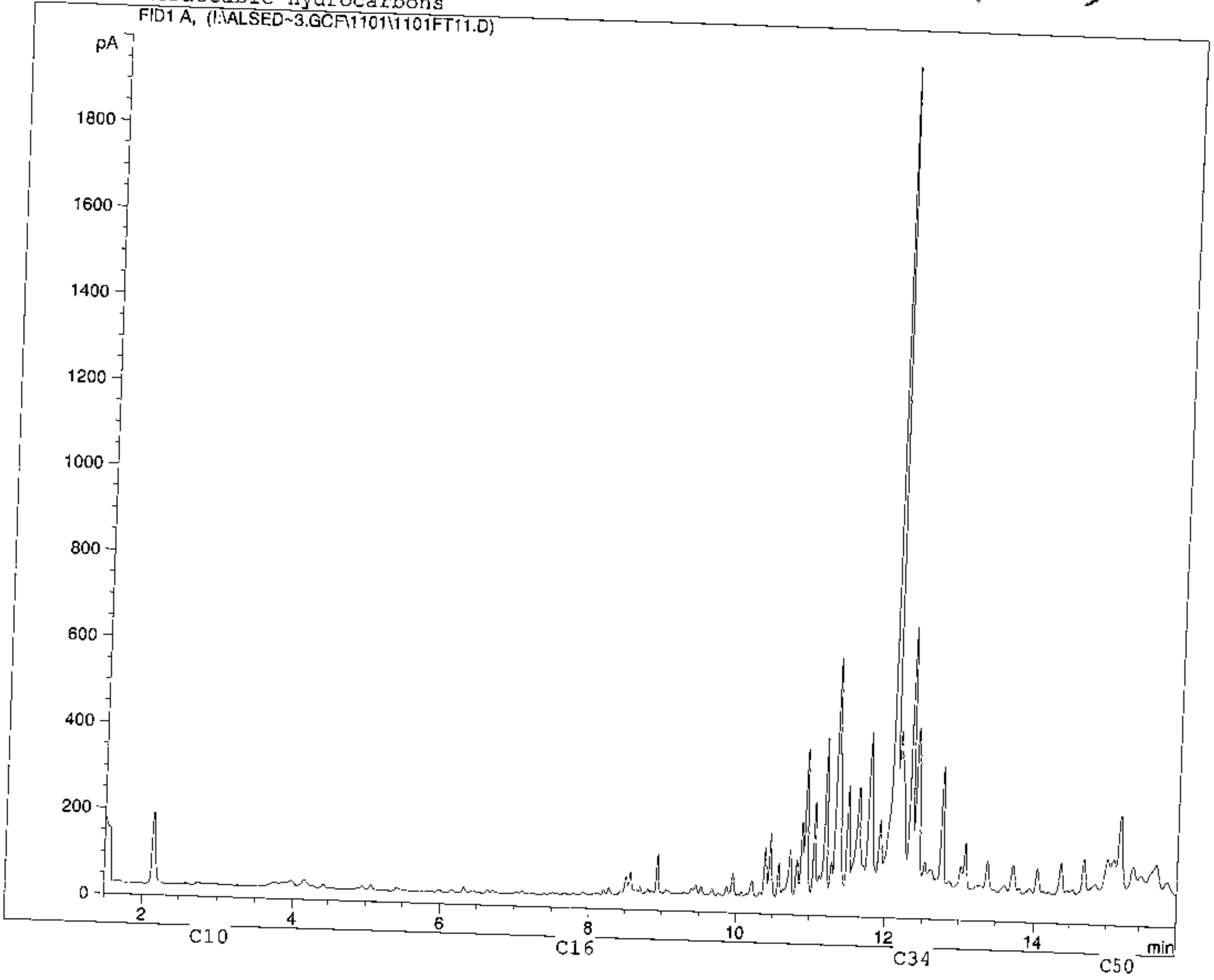
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

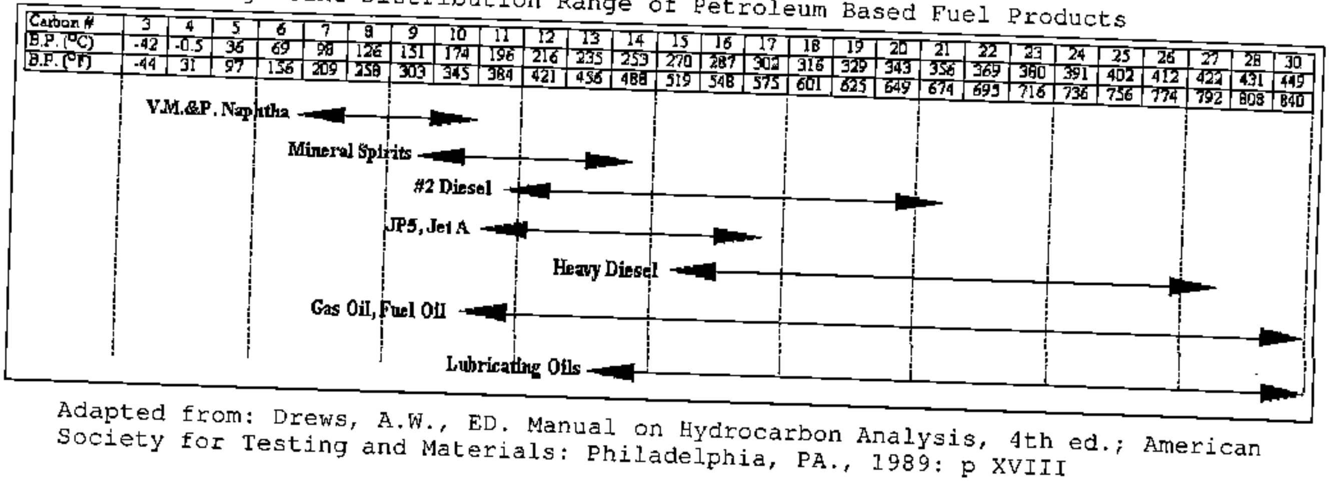
Client ID: 323-1

Sample ID: L438781-36 4
Injection Date: 11/1/06 9:35:33 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

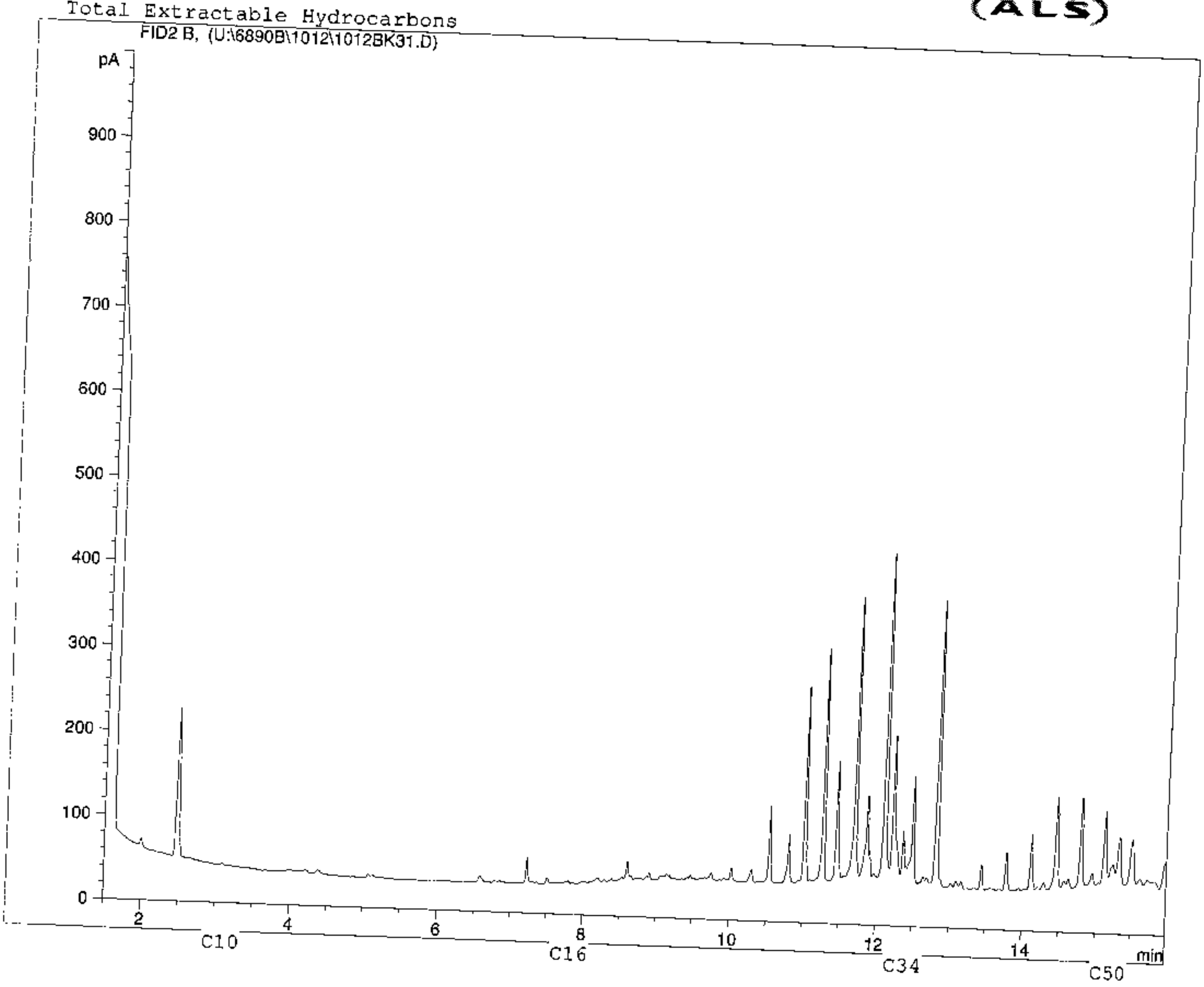


Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

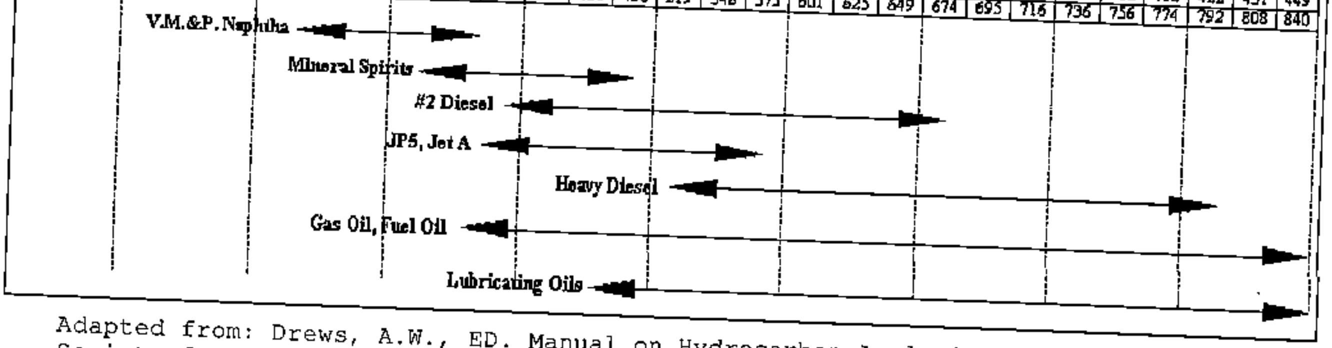
Client ID:	317-1
Sample ID:	L439526-11 4 SG
Injection Date:	10/13/06 5:45:55 AM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	486	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

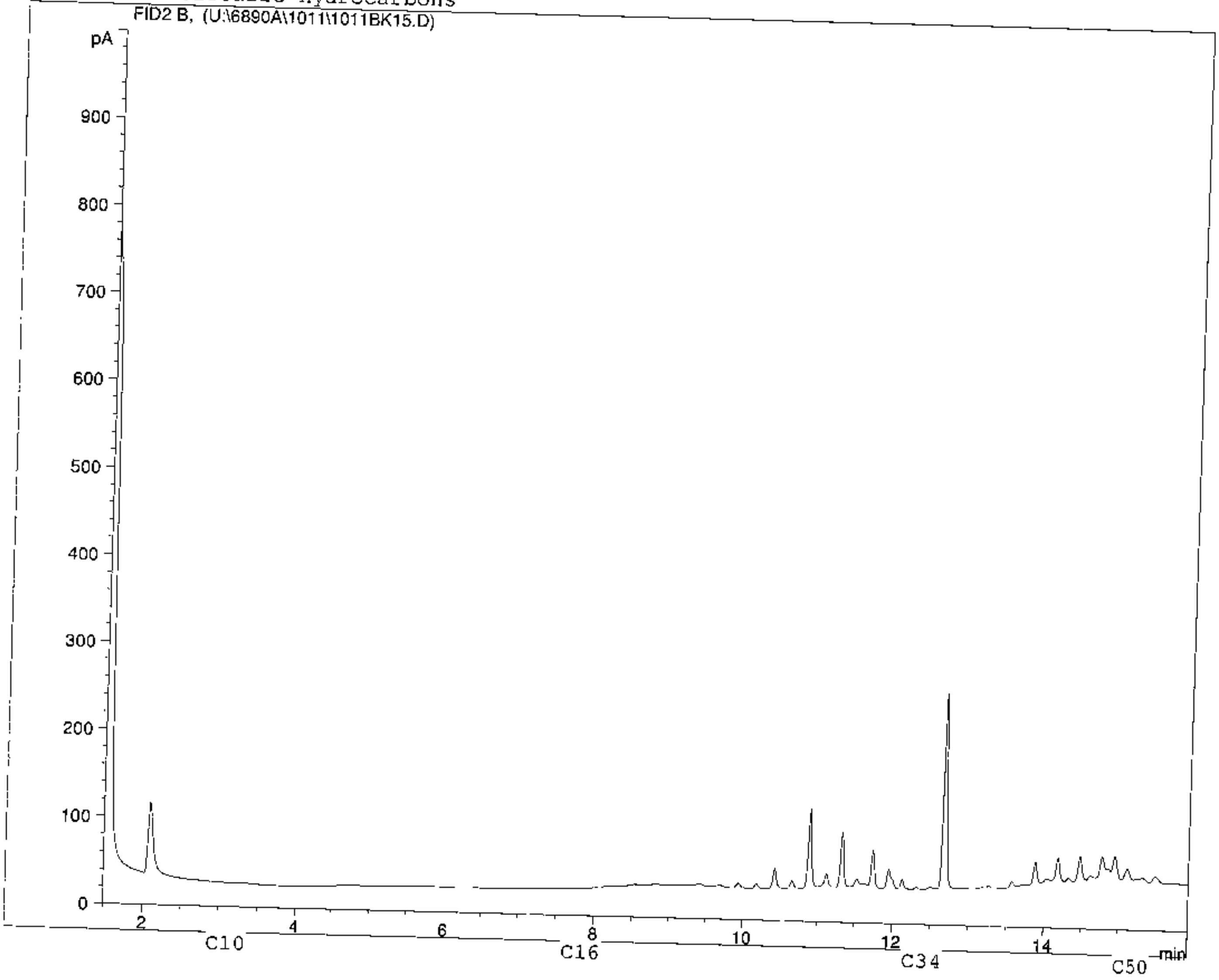


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 326-1

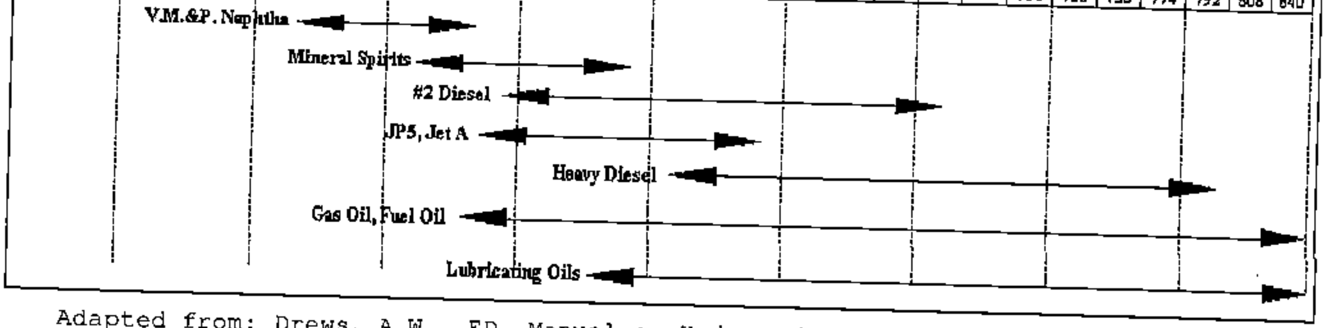
Sample ID: L438781-48 4 SG
Injection Date: 10/11/2006 11:20:31 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

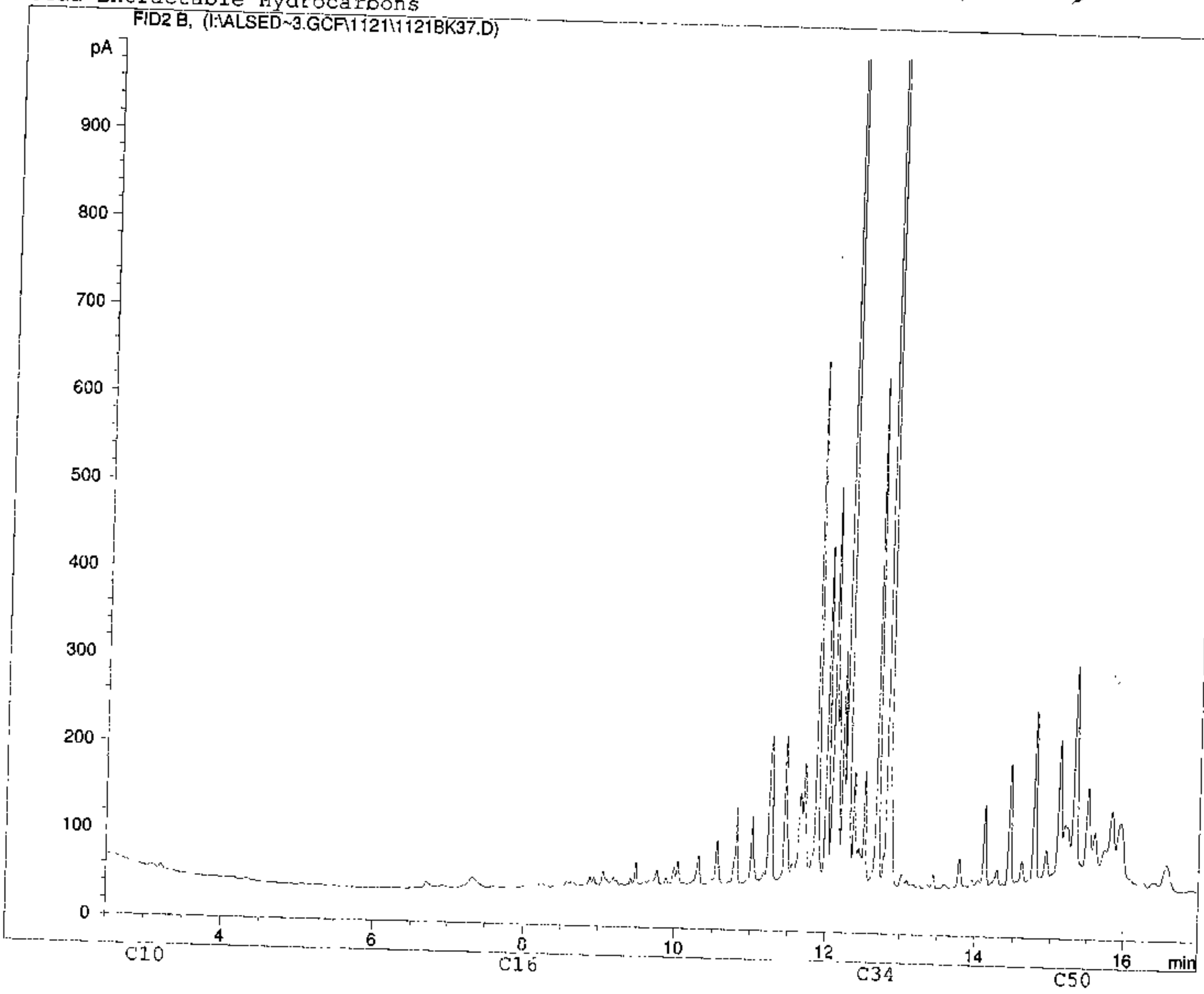


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW262-1

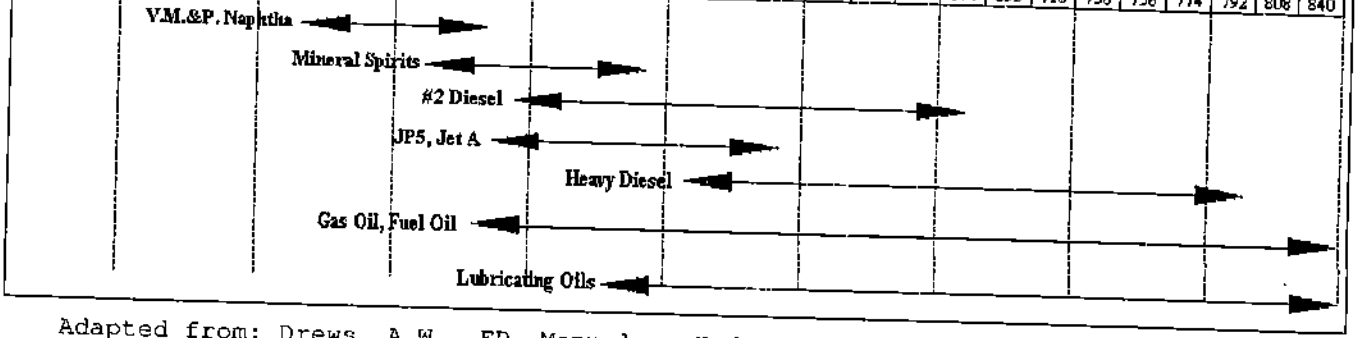
Sample ID: L450940-9 4 SGC
Injection Date: 11/22/06 8:03:33 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

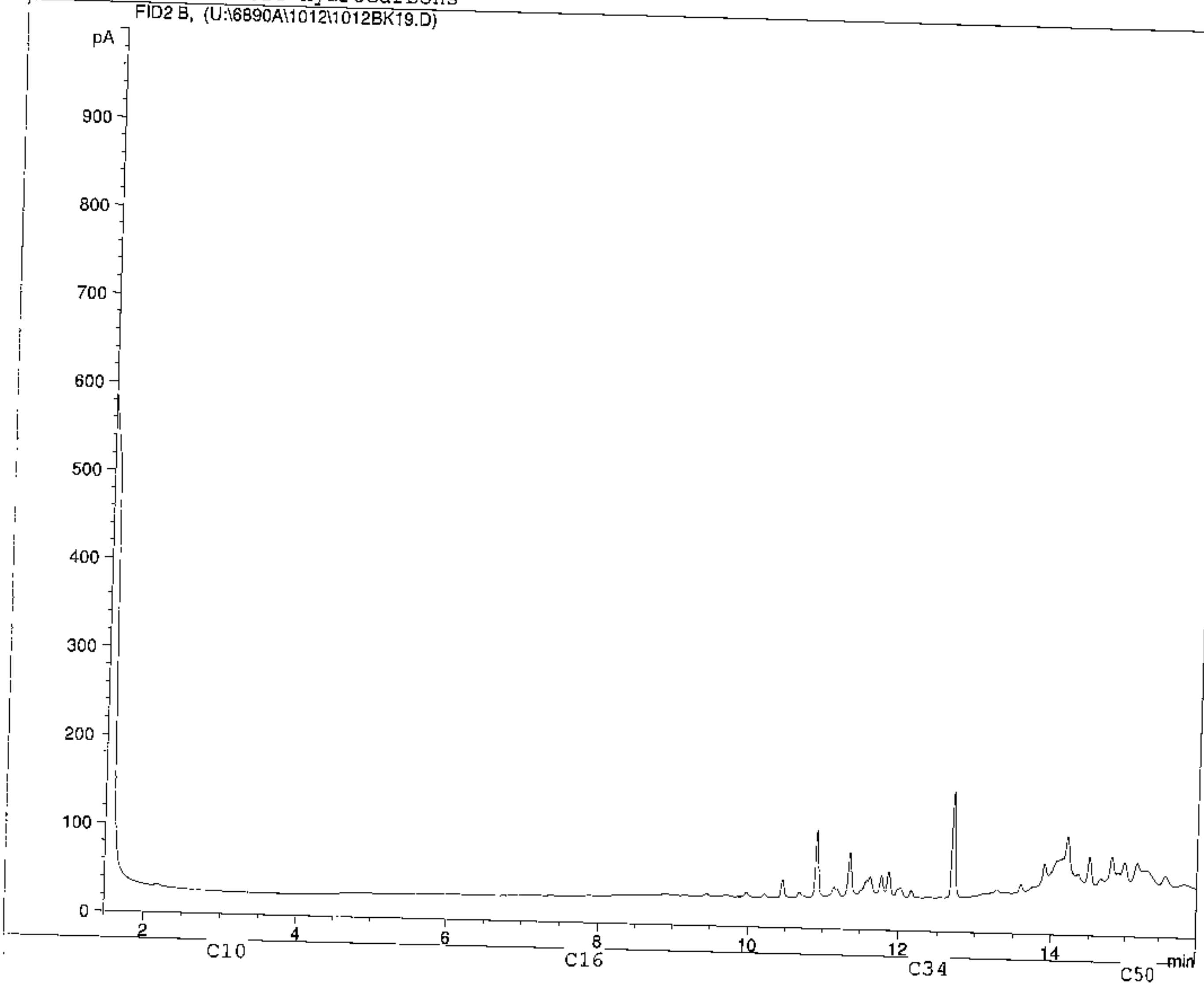


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 12-1

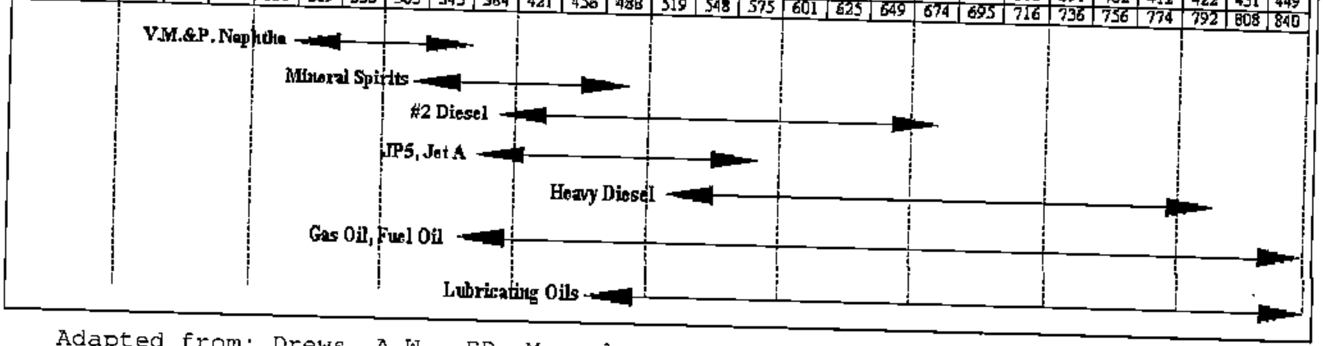
Sample ID: L437987-104 SG 4
Injection Date: 10/13/2006 2:31:19 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

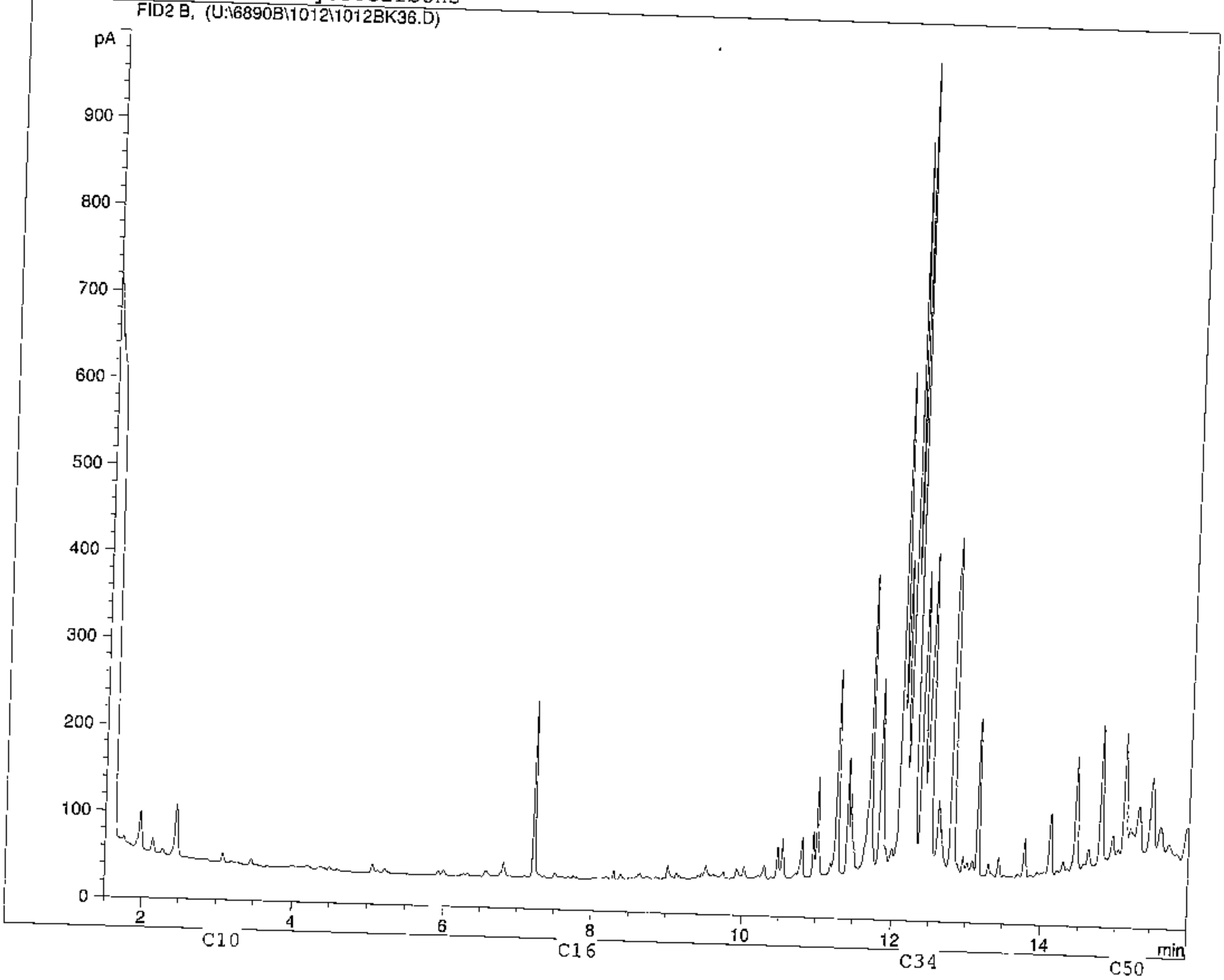


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

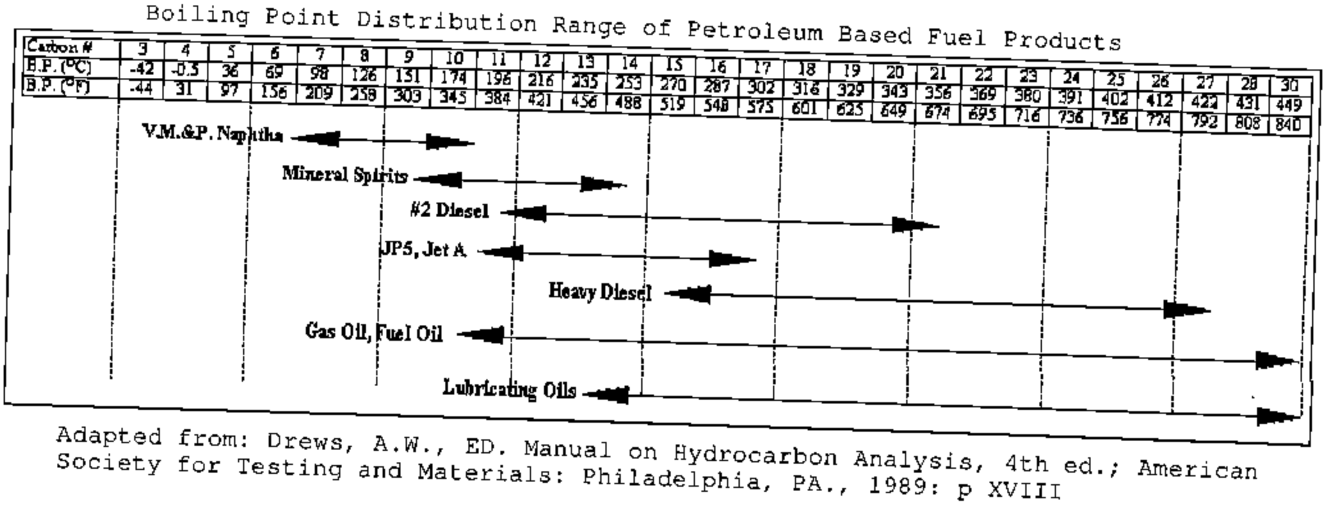
Client ID: 13-1

Sample ID: L439526-35 4 SG
Injection Date: 10/13/06 8:02:14 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



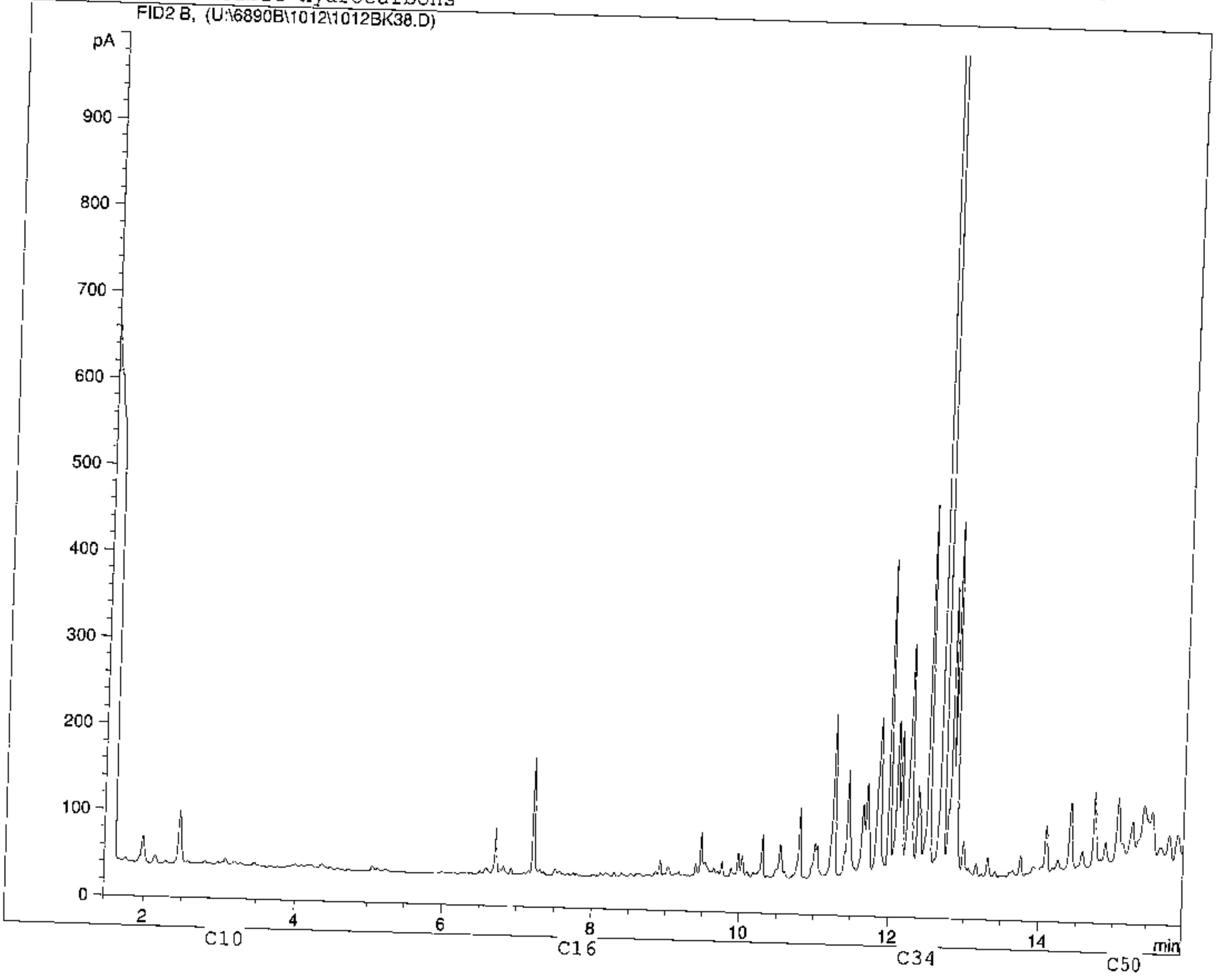
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 14-1

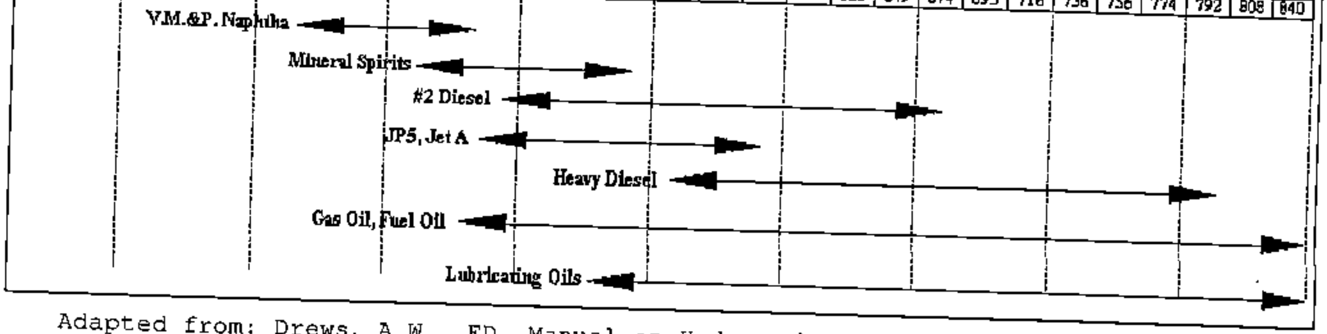
Sample ID: L439526-39 4 SG
Injection Date: 10/13/06 8:56:42 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

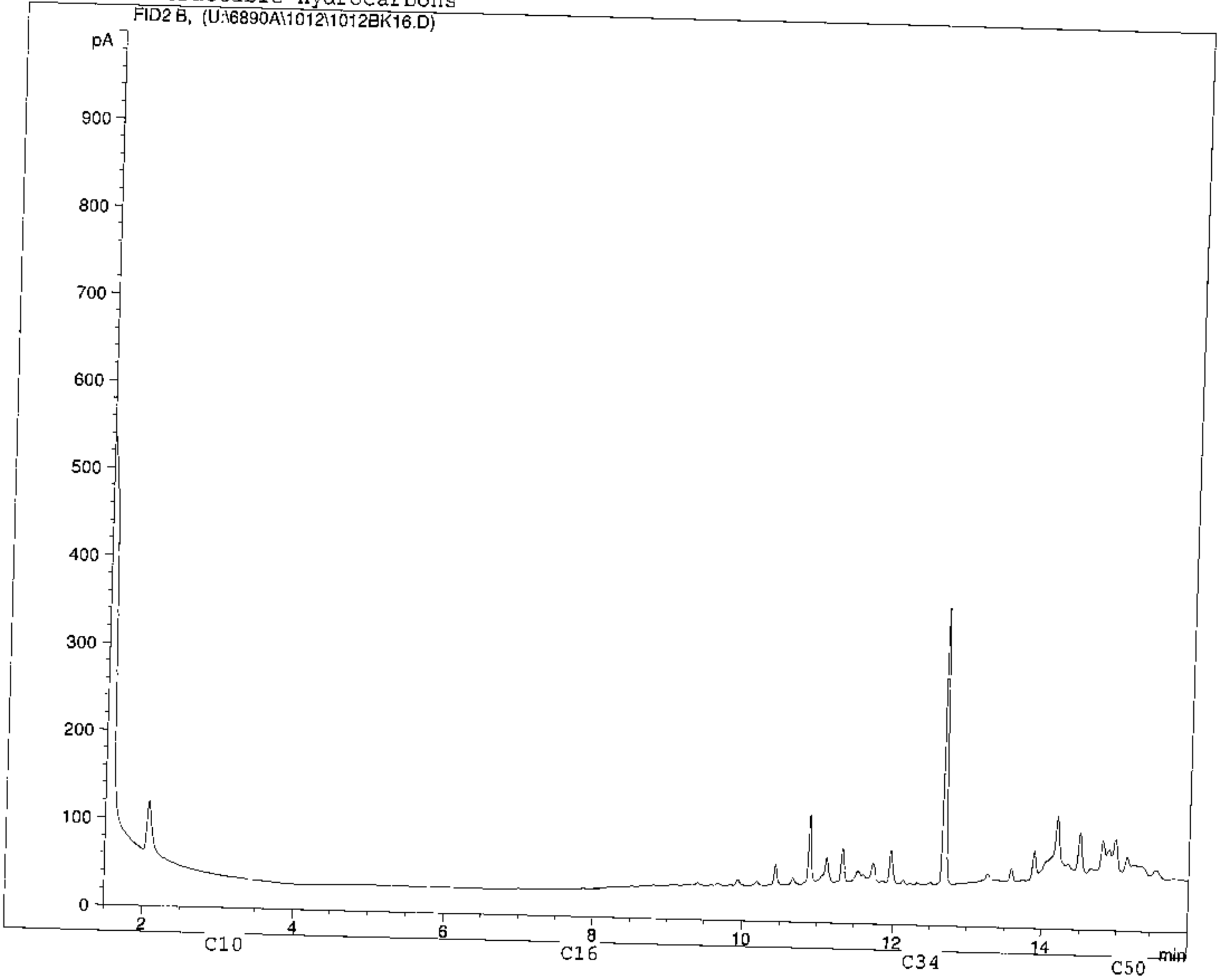
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID:	114-1
Sample ID:	L439526-71 SG 4
Injection Date:	10/13/2006 1:15:27 AM
Instrument:	6890

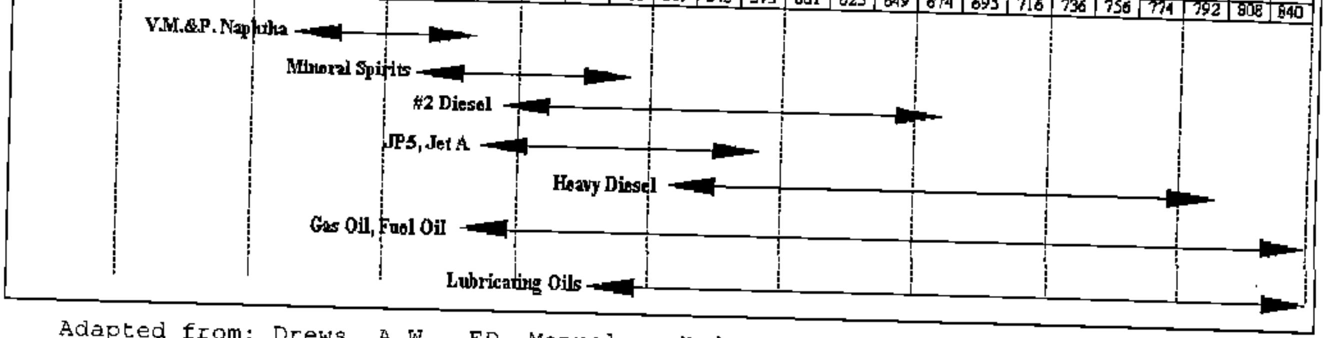
Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548

Carbon #	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	575	601	625	649	674	695	716	736	756	774	792	808	840

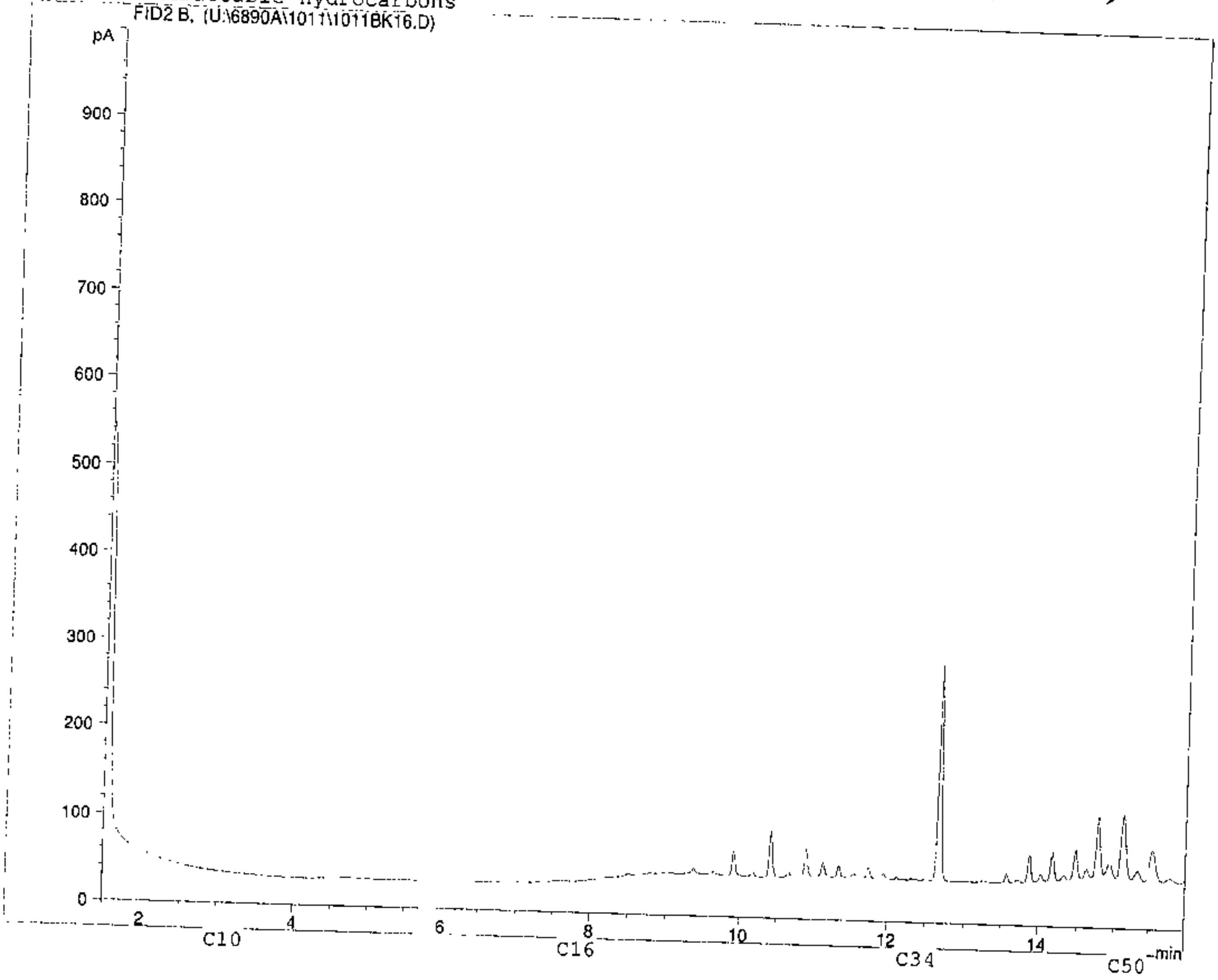


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 308-1

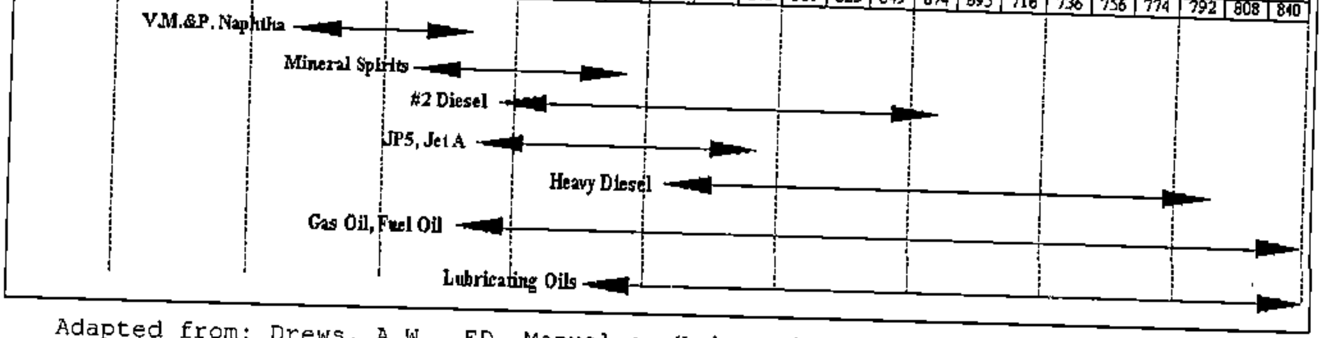
Sample ID: L438987-11
Injection Date: 10/11/2006 11:45:43 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

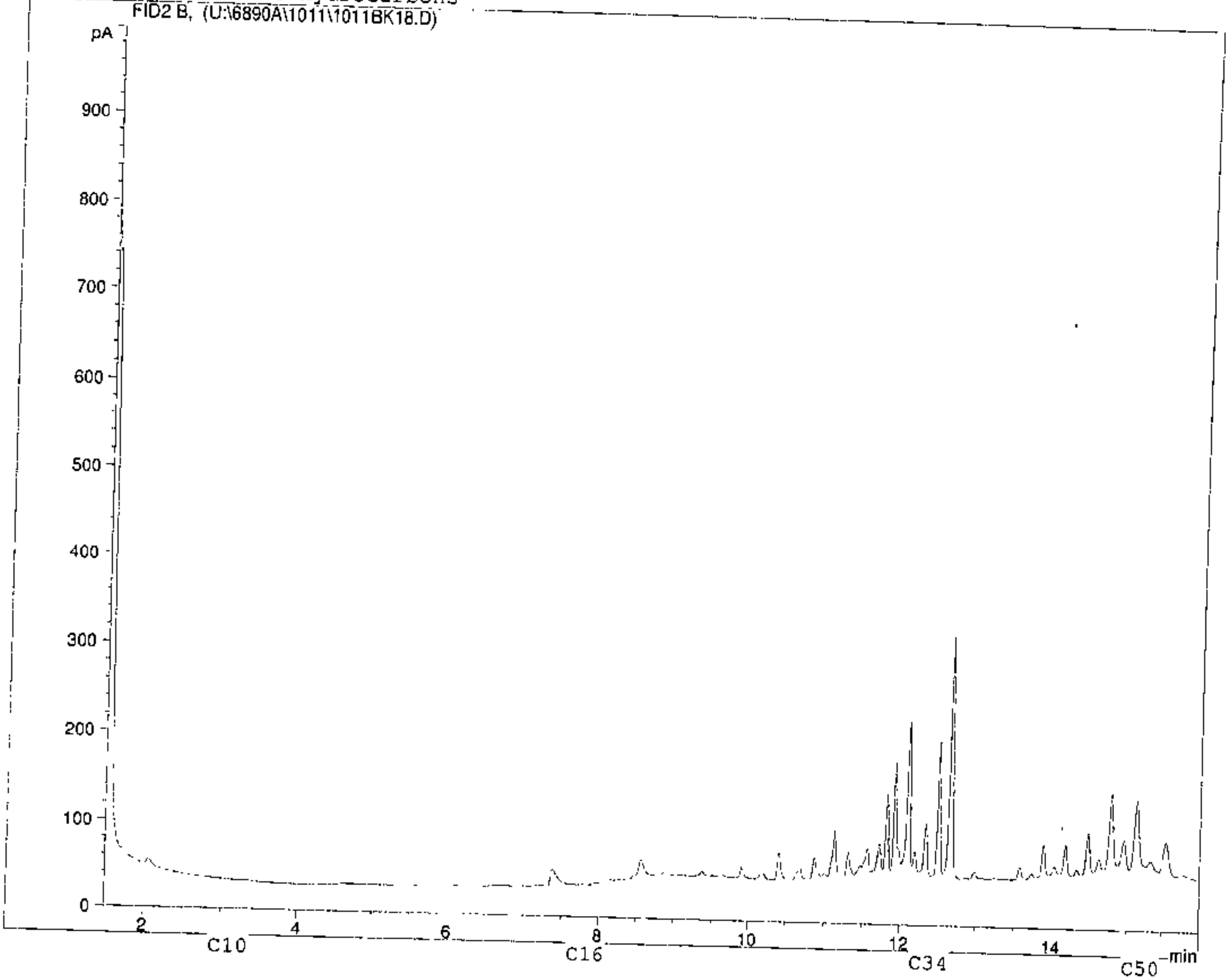


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 310-1

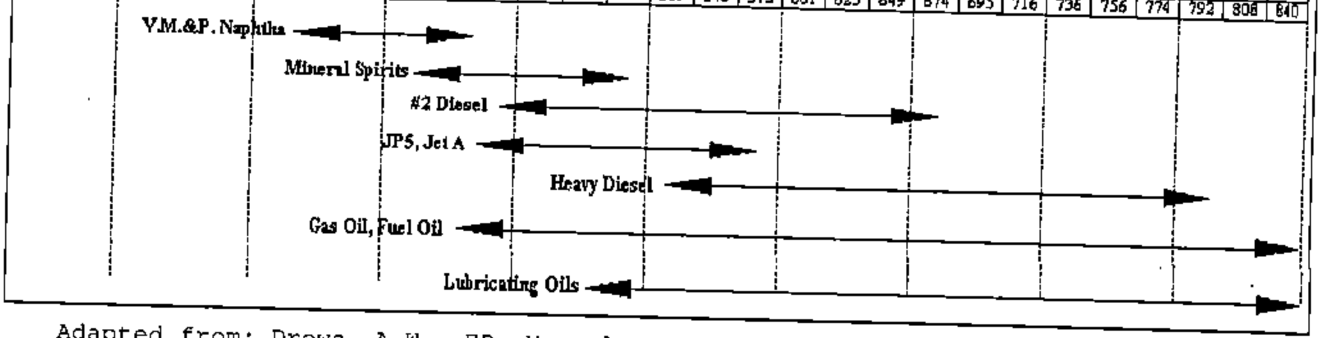
Sample ID: L437987-19 4 SG
Injection Date: 10/12/2006 12:35:50 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

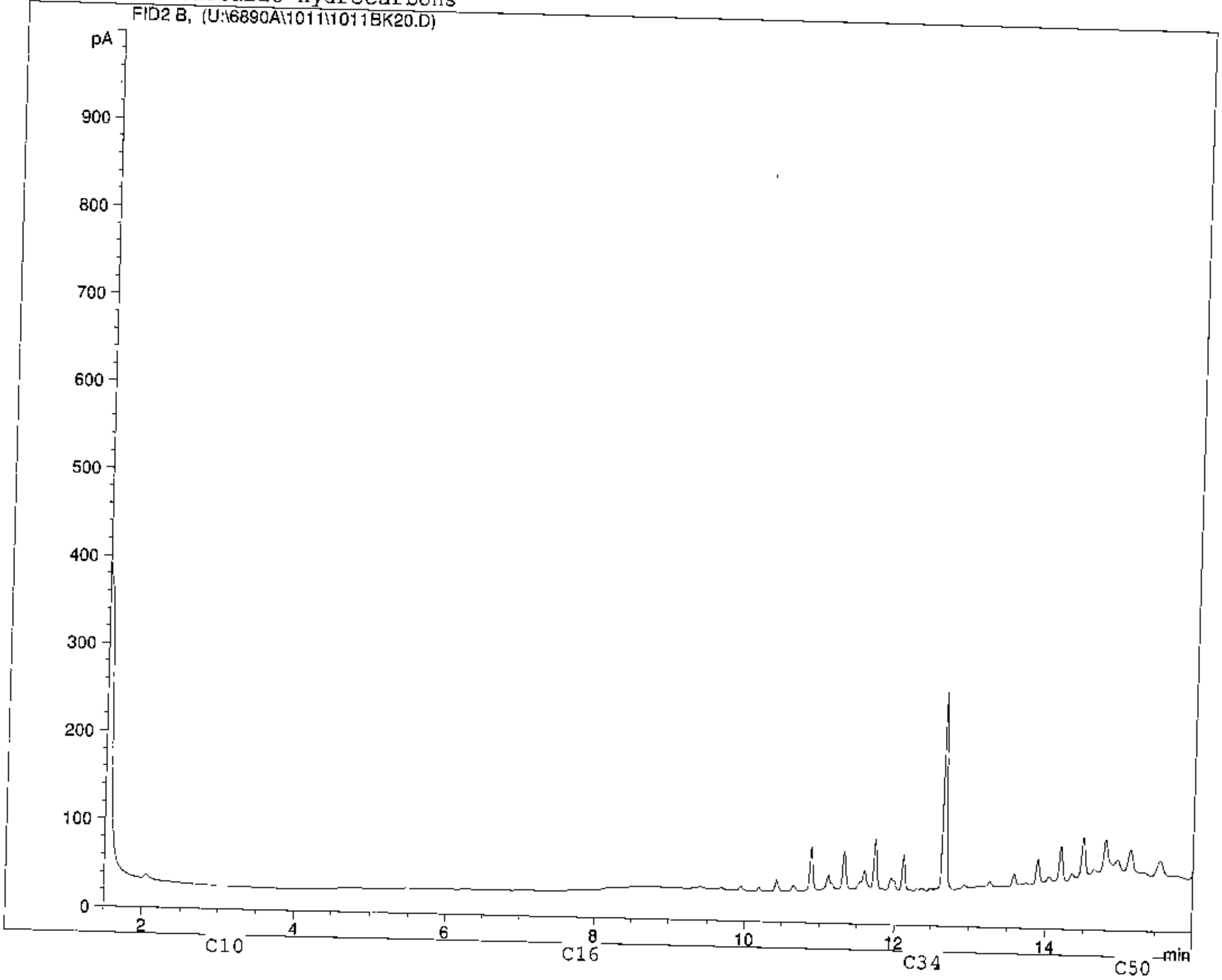


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 313-1

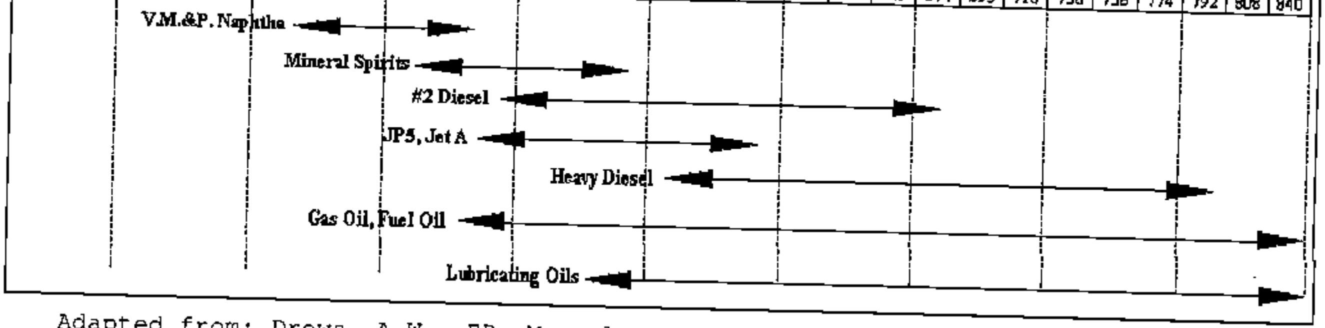
Sample ID: L437987-29 4 SG
Injection Date: 10/12/2006 1:26:14 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

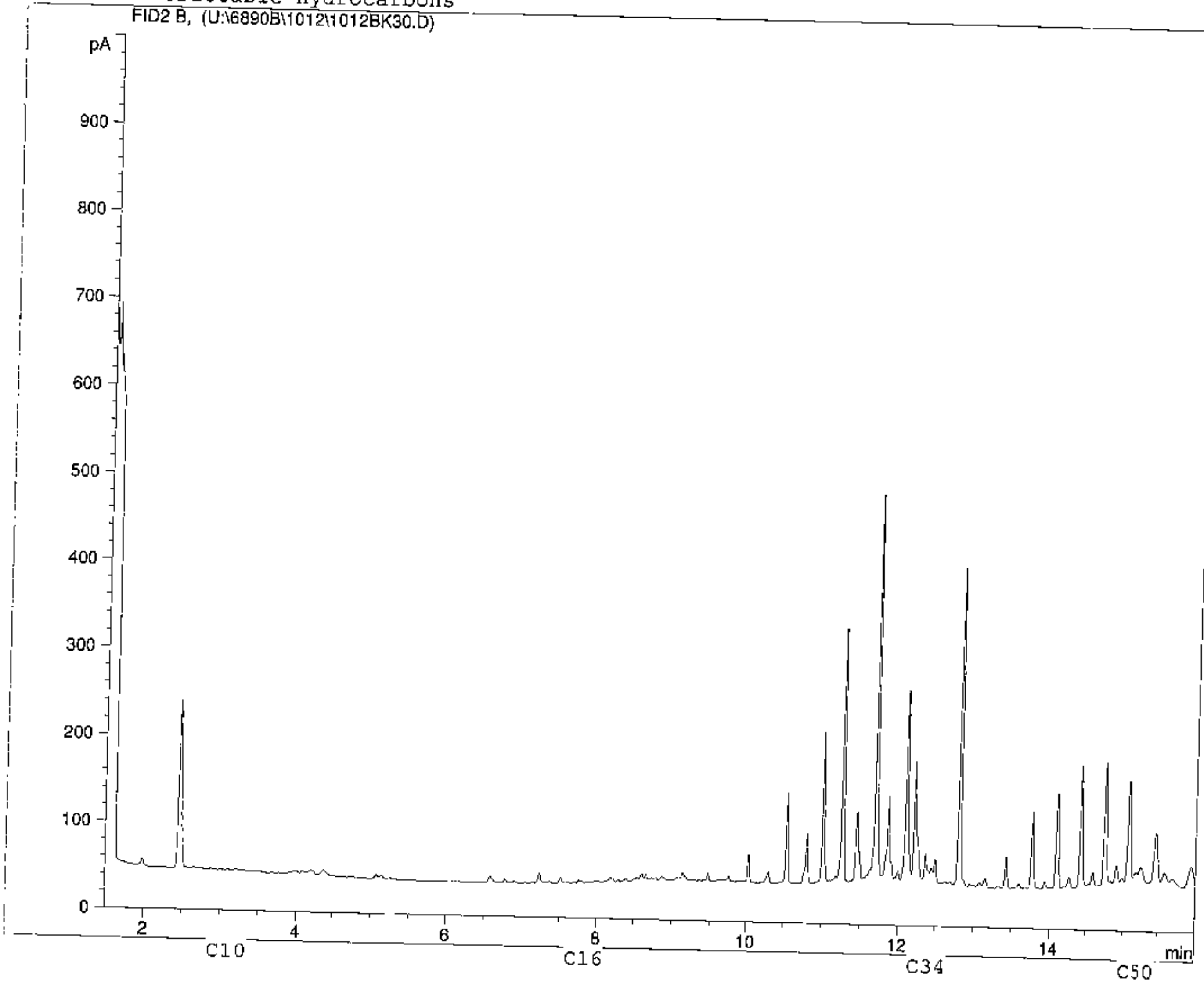
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

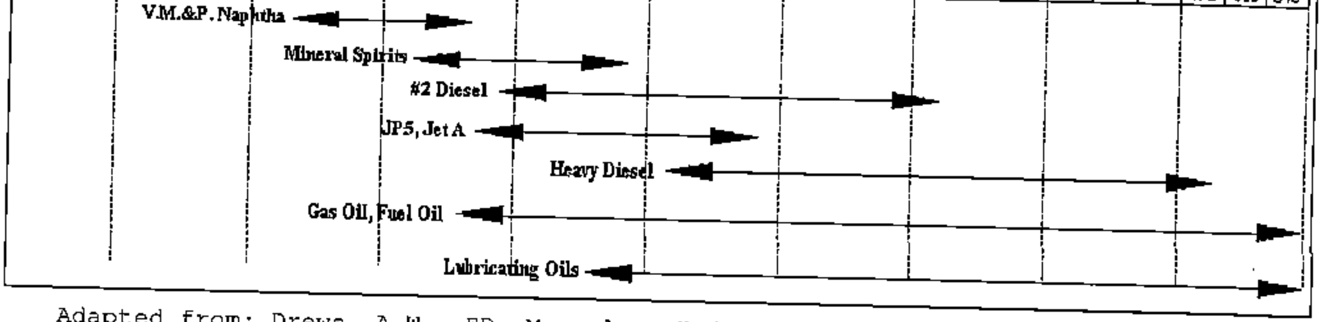
Client ID:	314-1
Sample ID:	L439526-2 4 SG
Injection Date:	10/13/06 5:18:33 AM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



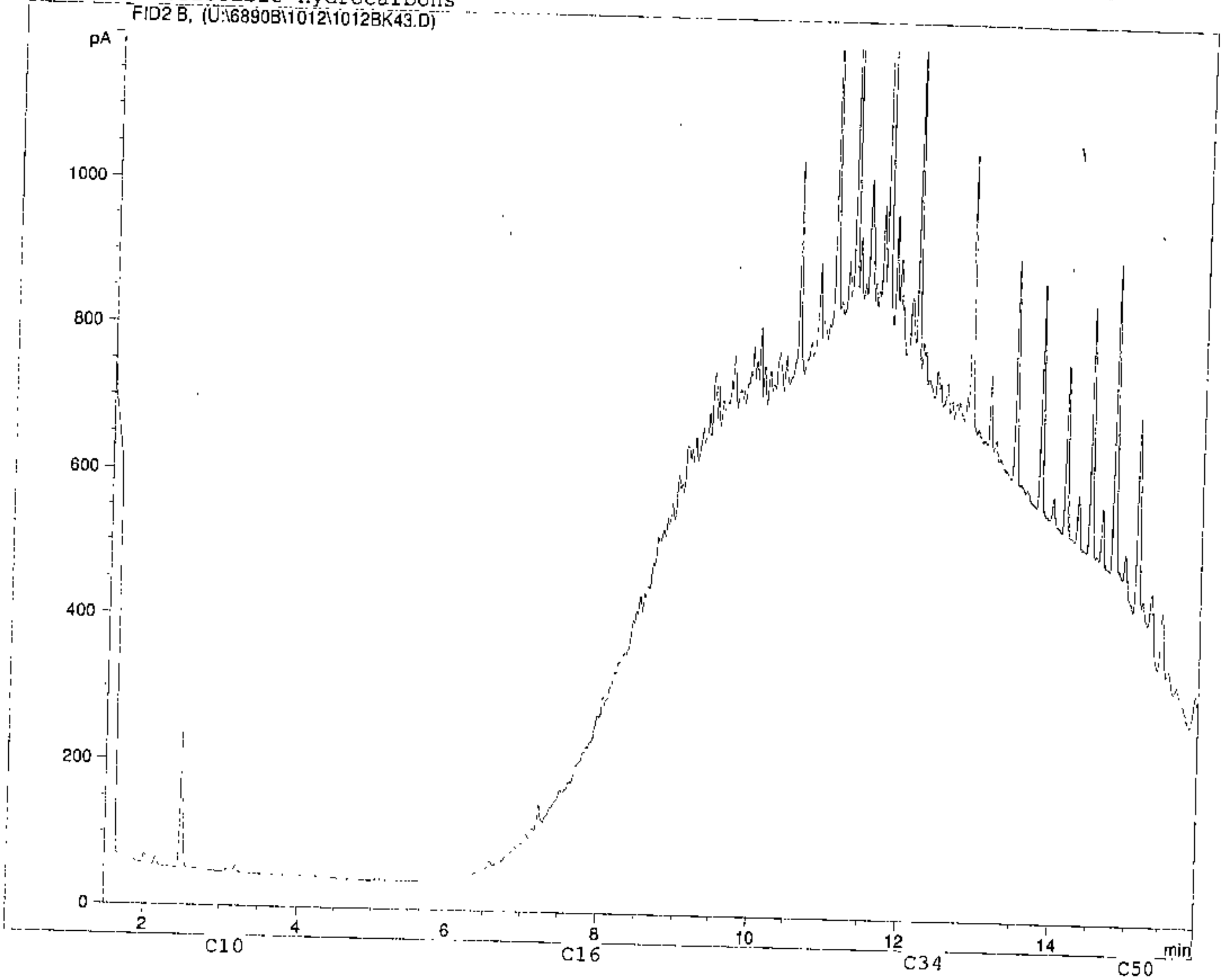
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

POTENTIALLY IMPACTED CHROMATOGRAM SIGNATURES

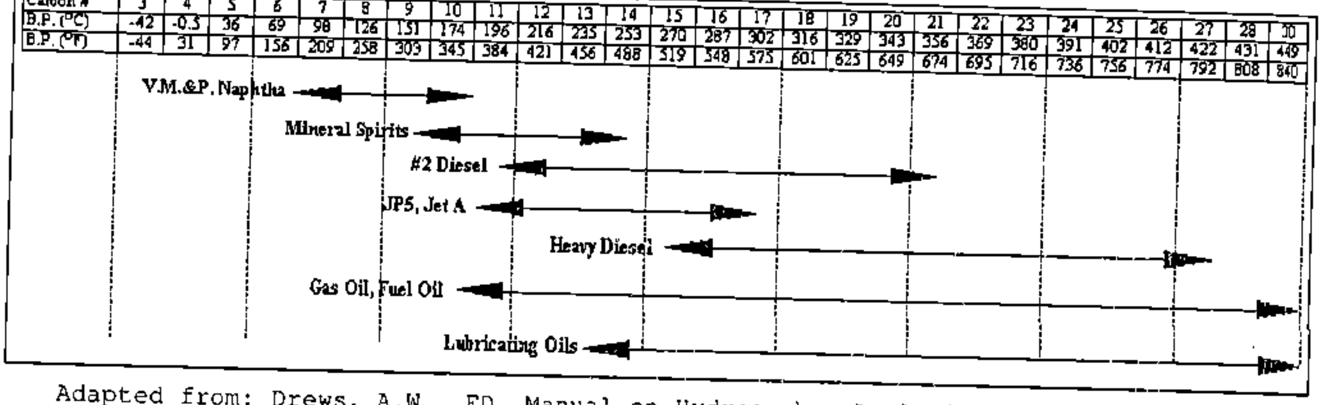
Client ID: 7-LFH

Sample ID: L437987-114 4 SG
Injection Date: 10/13/06 11:11:32 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

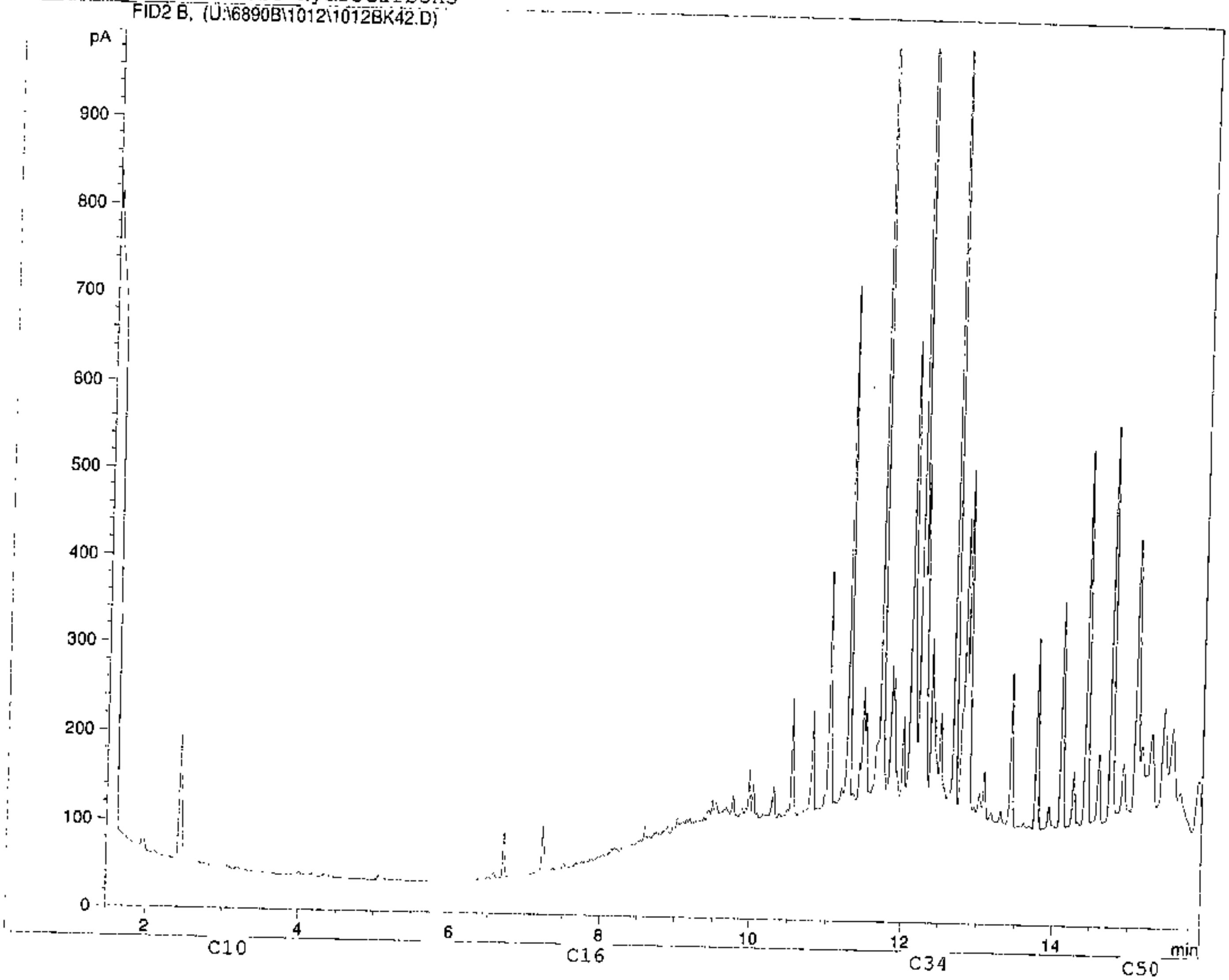


Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

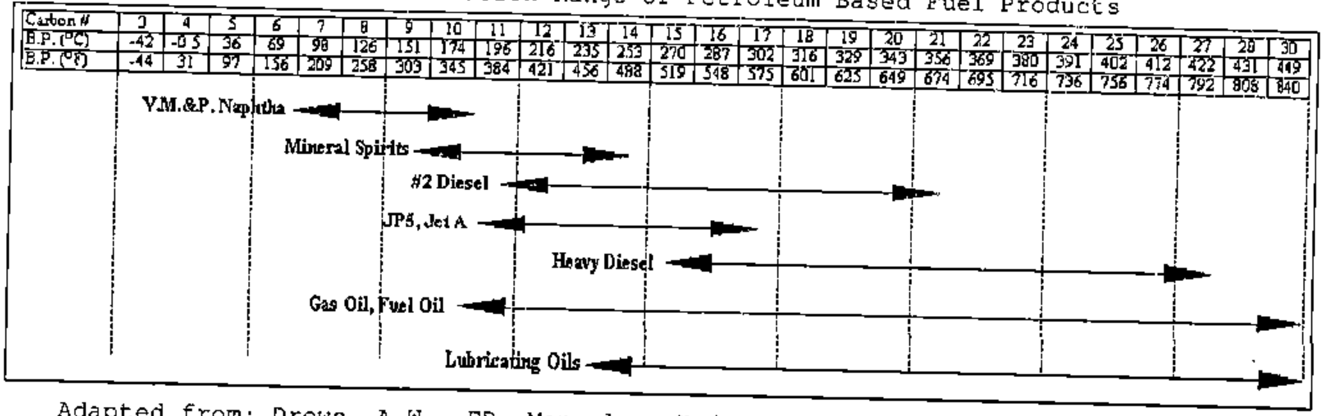
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID:	9-LFH
Sample ID:	L437987-110 4 SG
Injection Date:	10/13/06 10:44:43 AM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



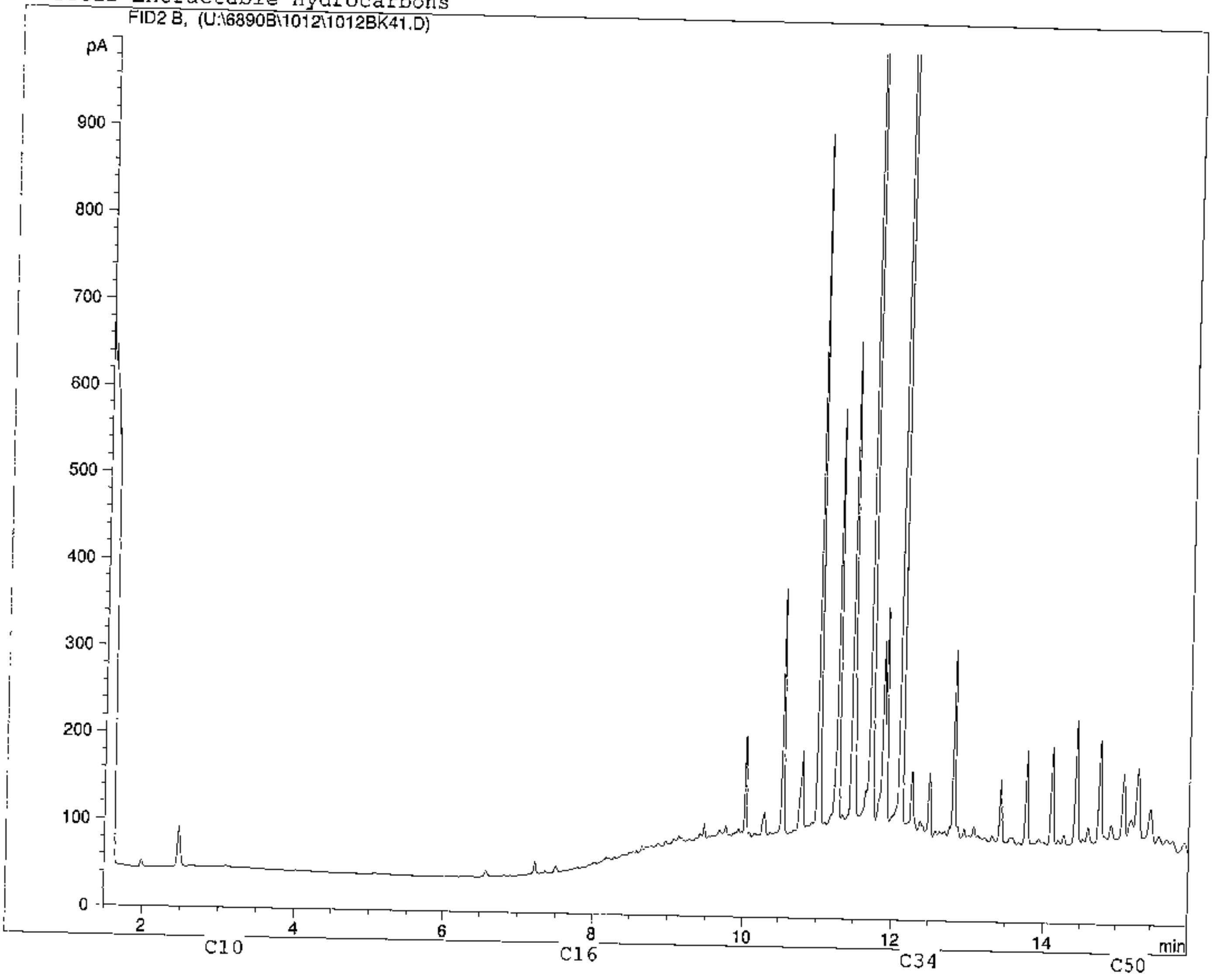
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 12-LFH

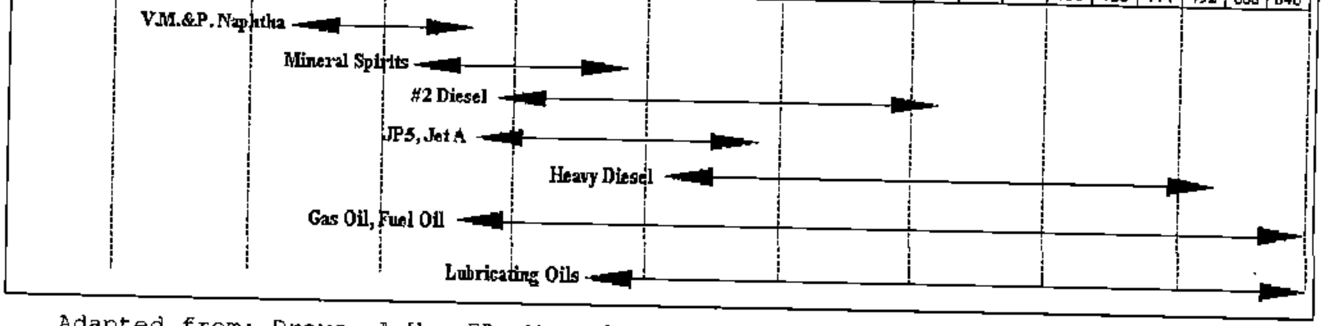
Sample ID: L437987-103 4 SG
Injection Date: 10/13/06 10:18:03 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	358	303	345	384	421	456	486	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

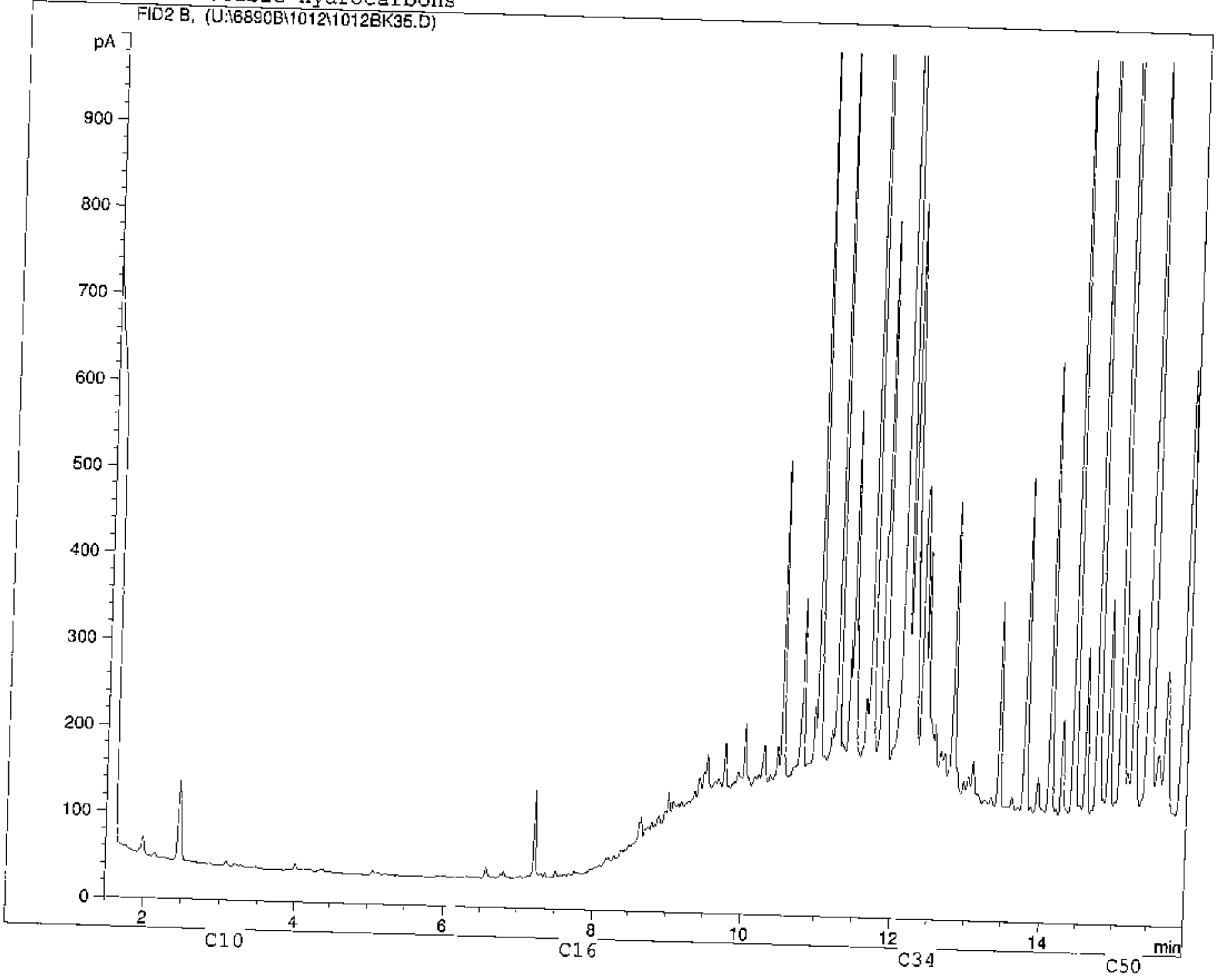


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 13-LFH

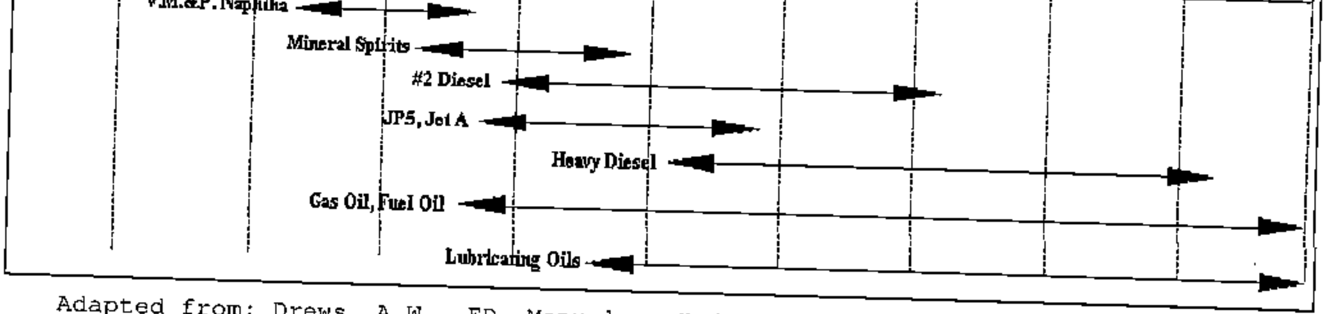
Sample ID: L439526-34 4 SG
Injection Date: 10/13/06 7:35:00 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

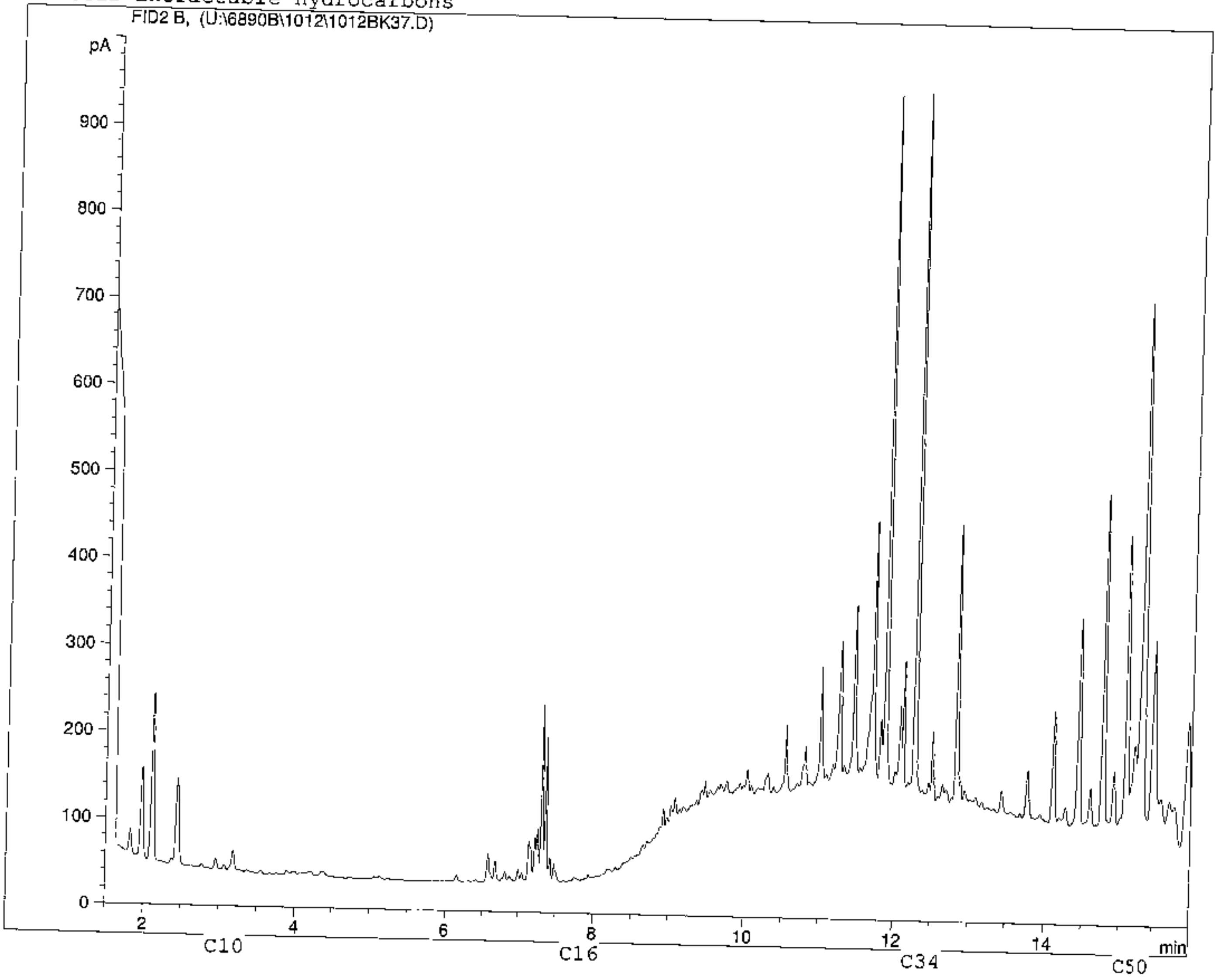


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 14-LFH

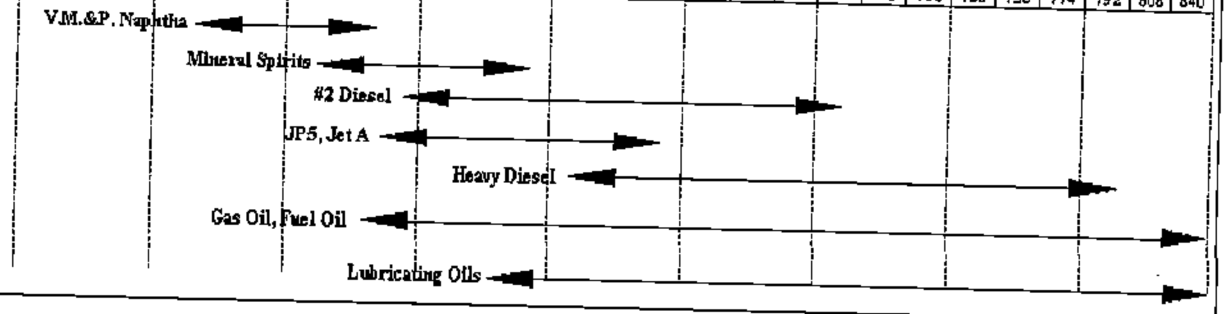
Sample ID: L439526-38 4 SG
Injection Date: 10/13/06 8:29:21 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

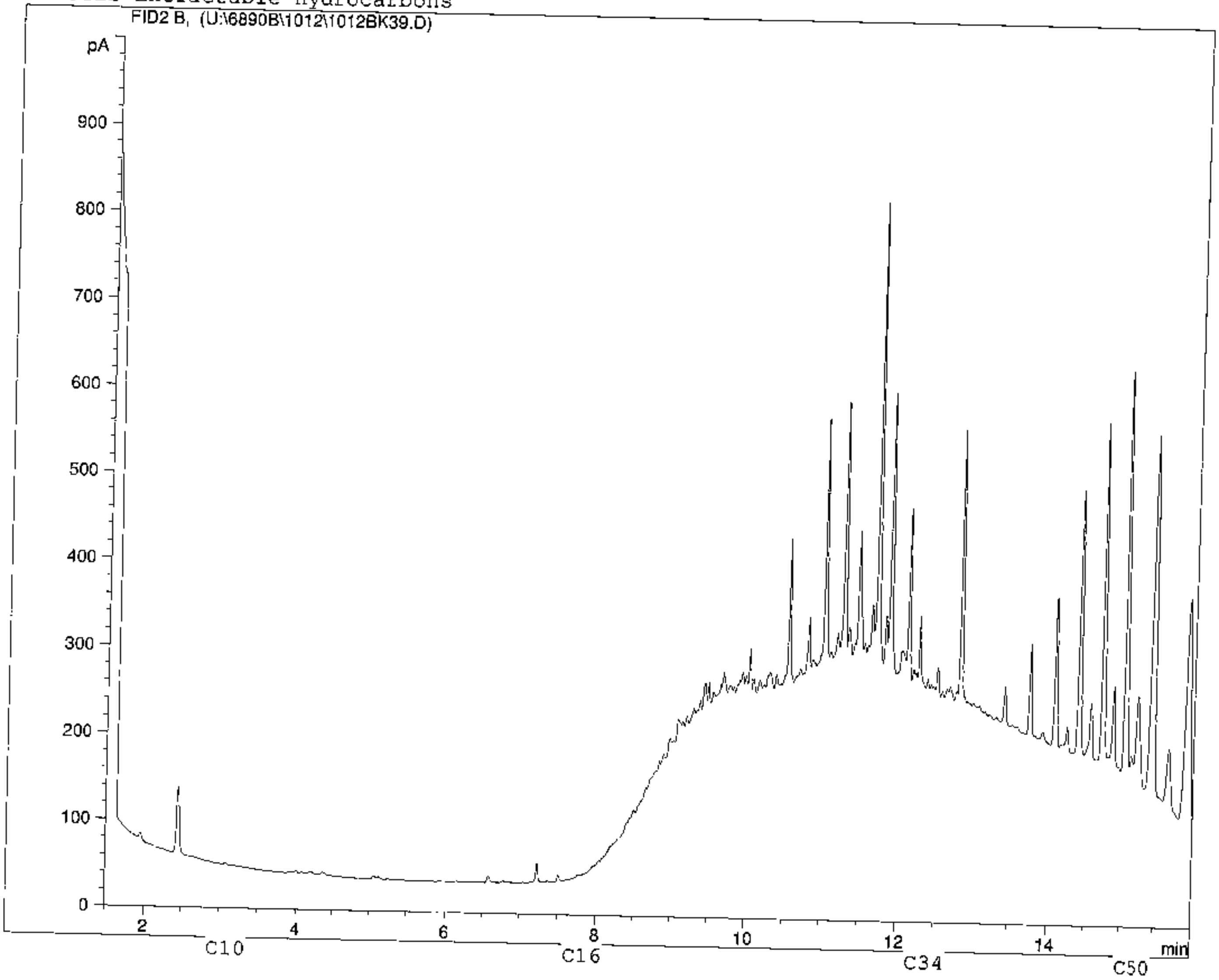


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 16-LFH

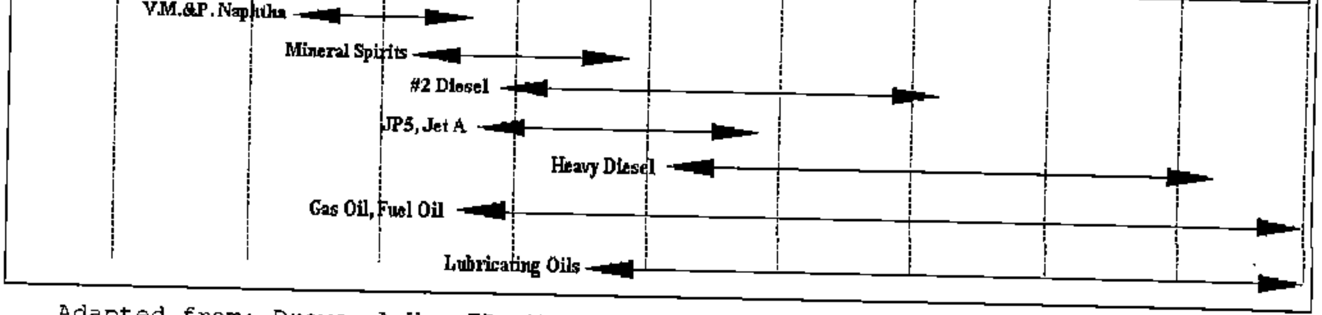
Sample ID: L439526-46 4 SG
Injection Date: 10/13/06 9:23:53 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

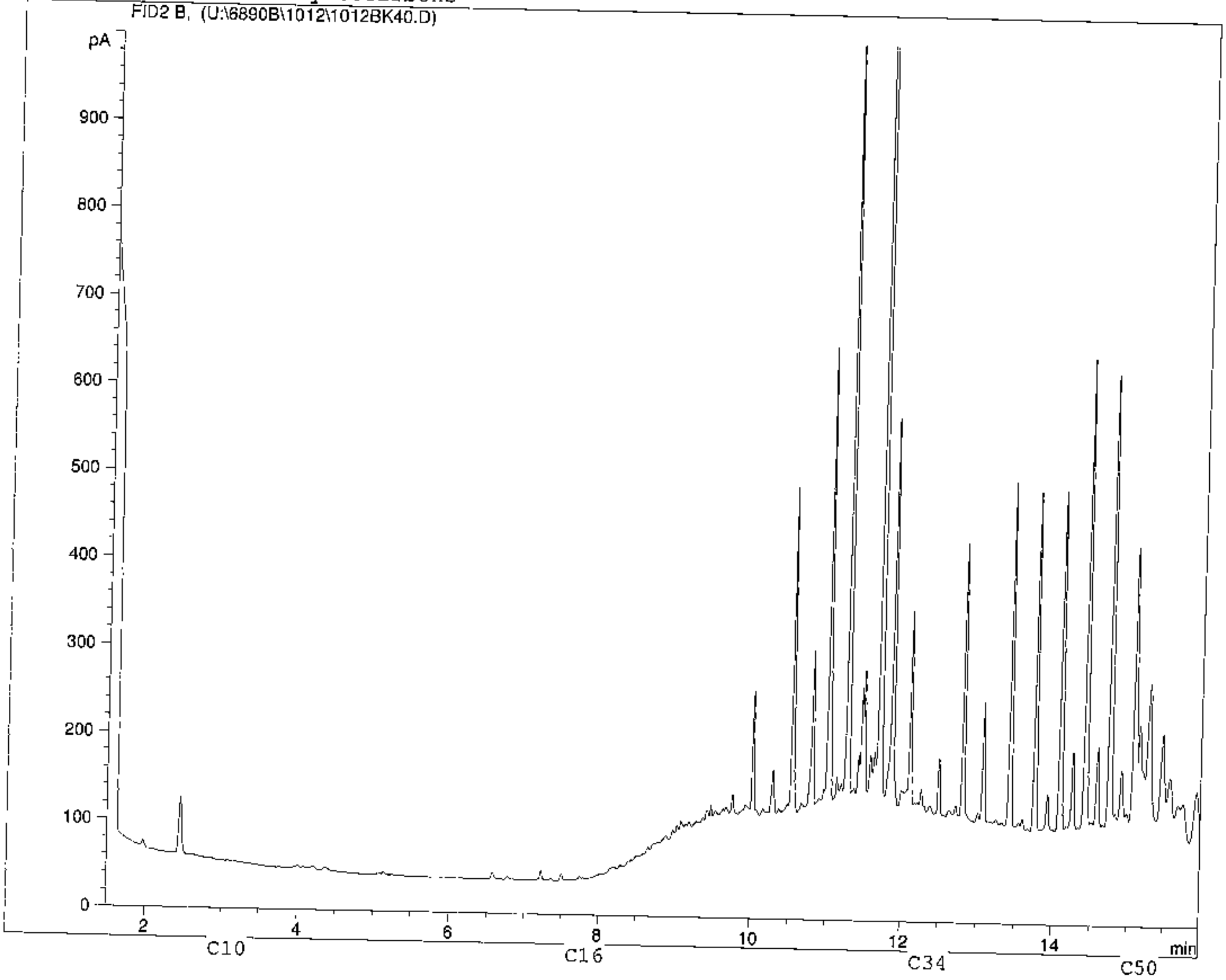


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 19-LFH

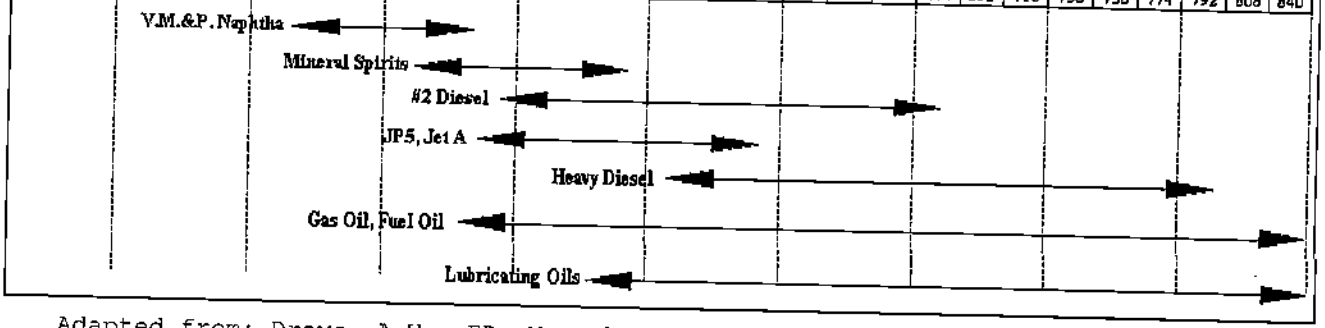
Sample ID: L439526-58 4 SG
Injection Date: 10/13/06 9:51:02 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

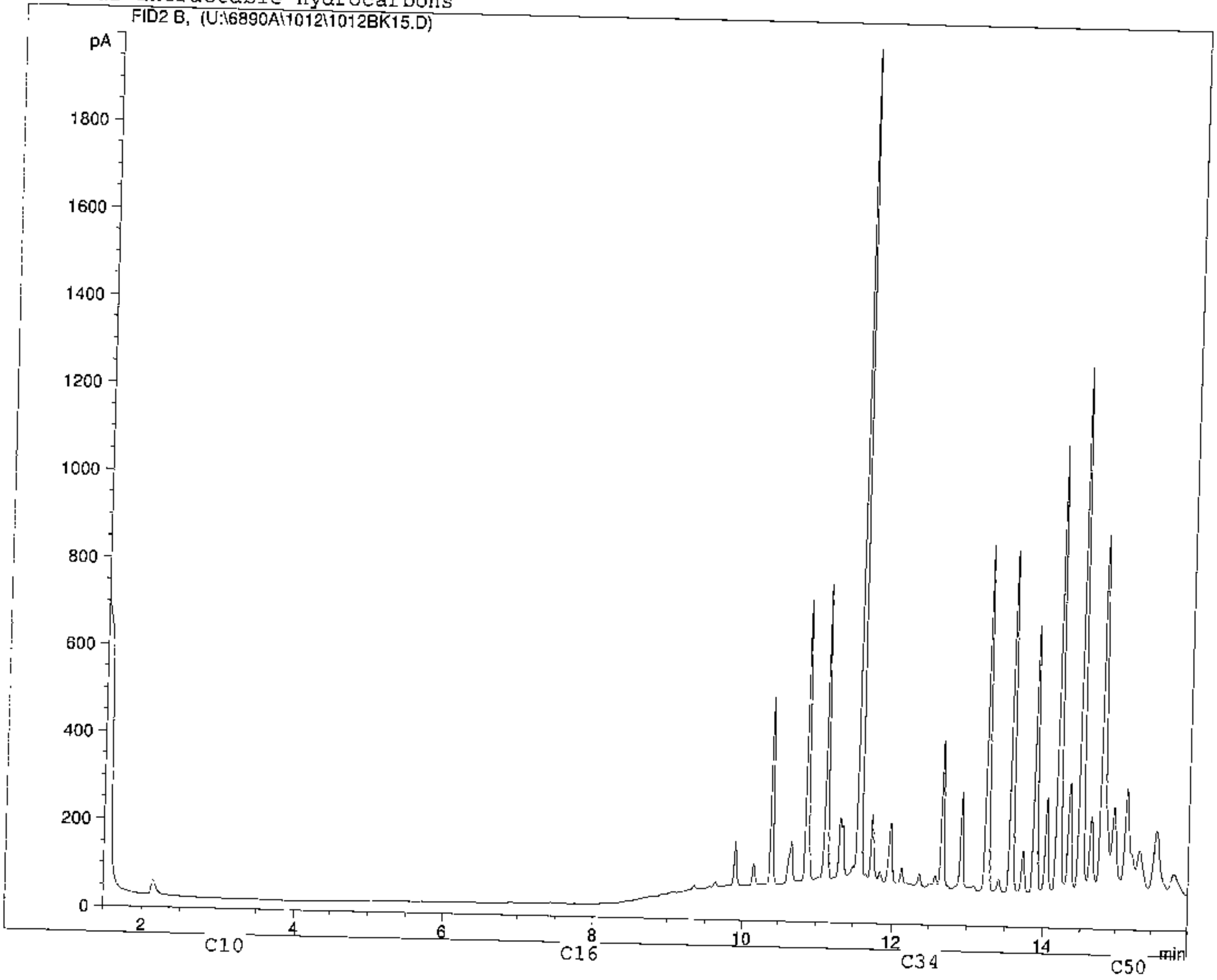


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 20-LFH

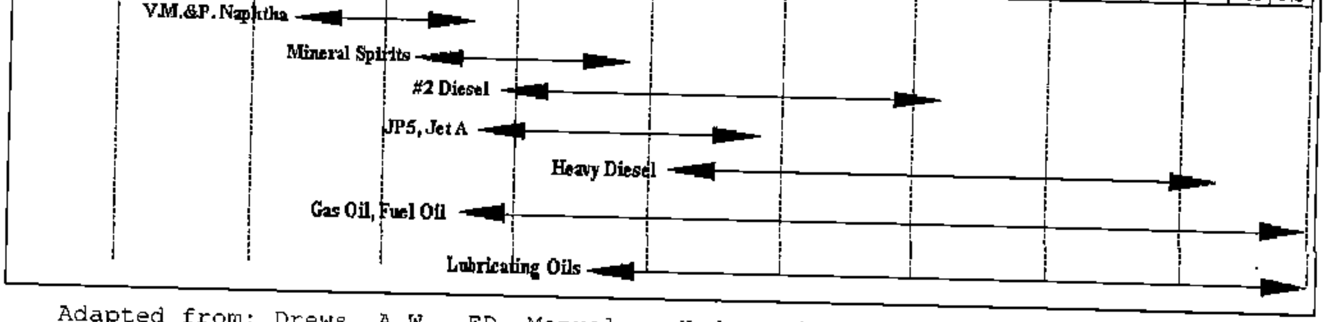
Sample ID: L439526-62 SG 4
Injection Date: 10/13/2006 12:50:10 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

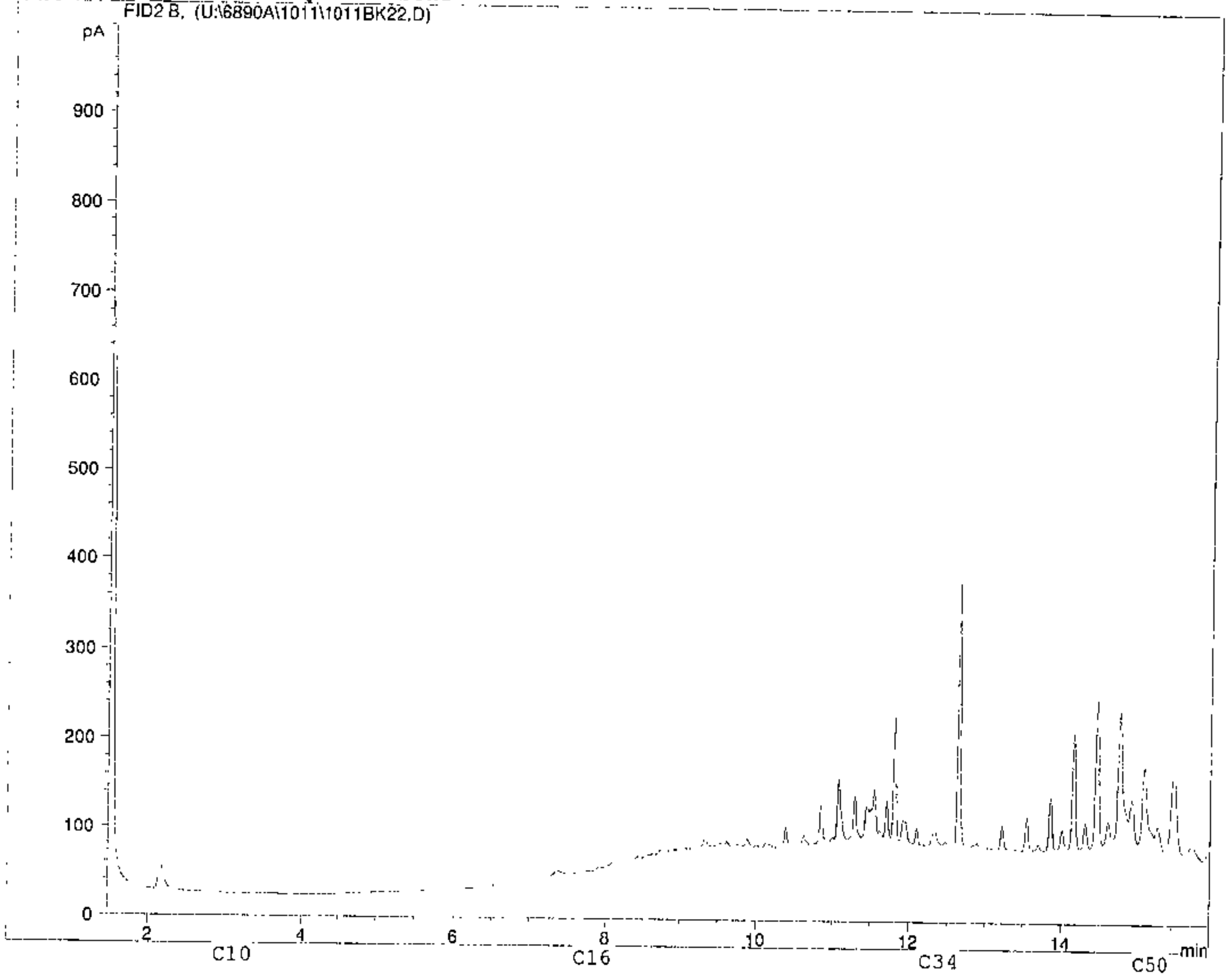


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 107-LFH

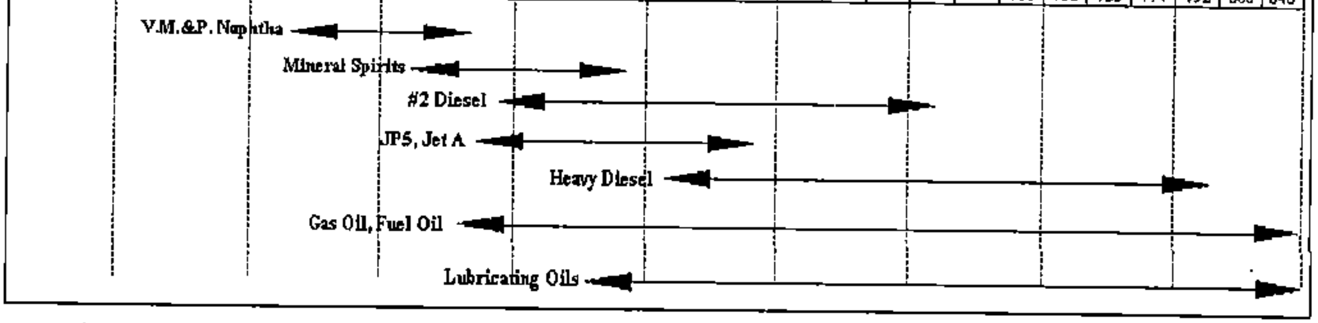
Sample ID: L437987-62 4 SG
Injection Date: 10/12/2006 2:16:28 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

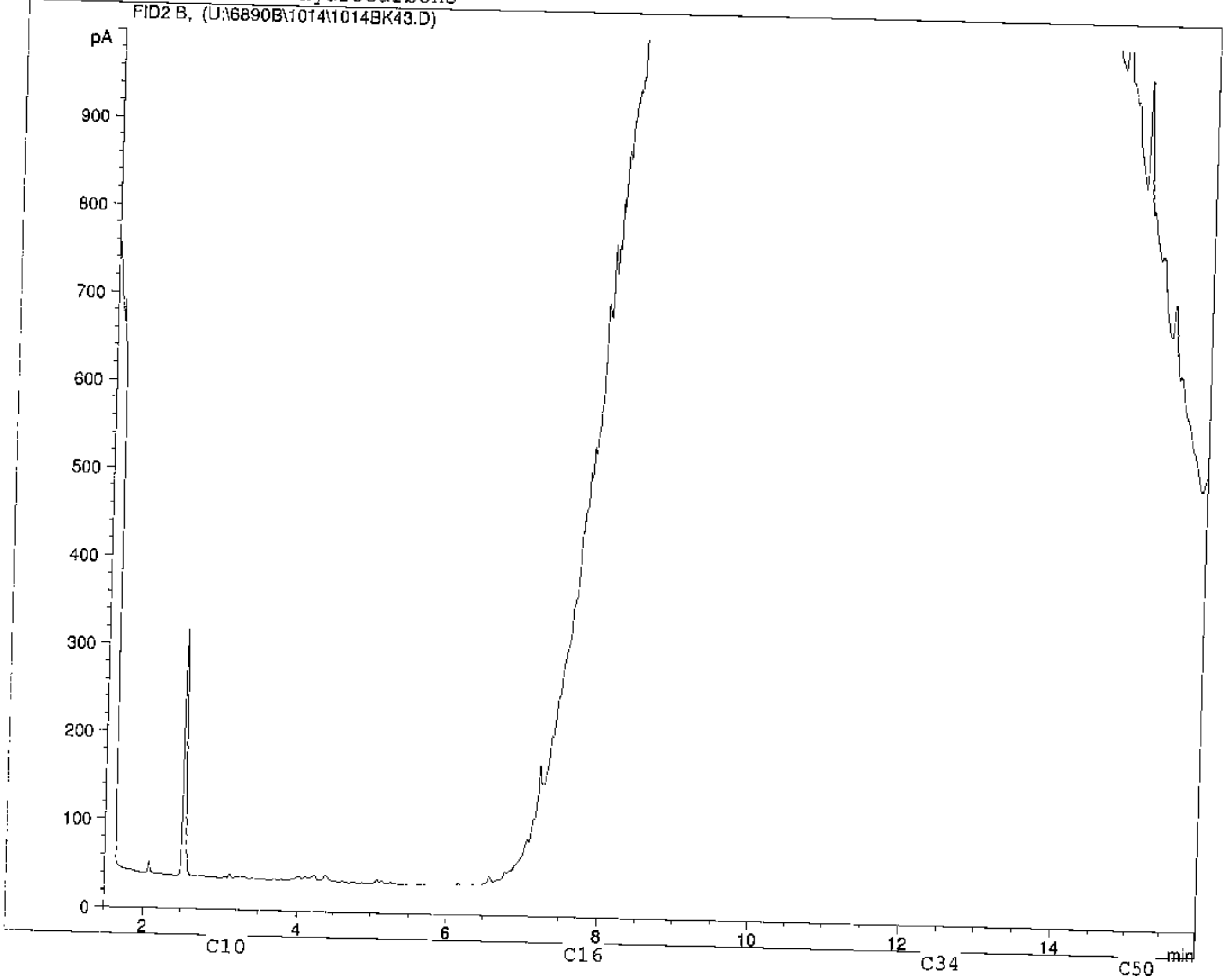


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 114-LFH

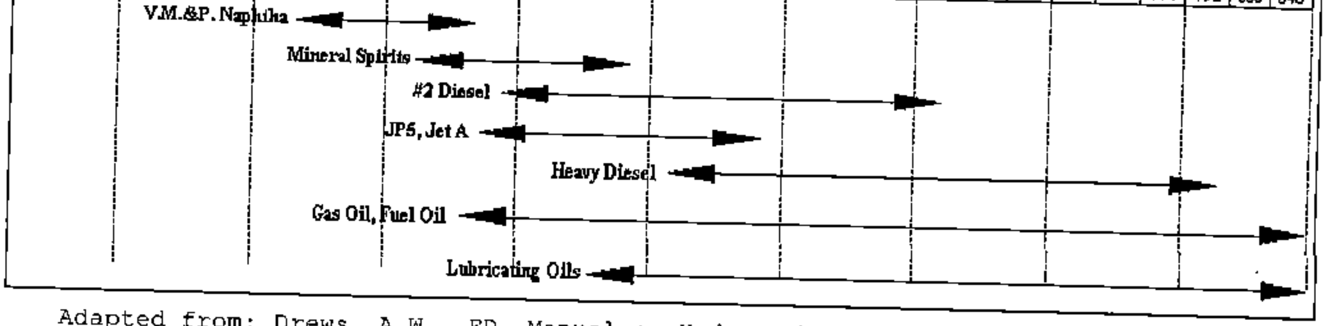
Sample ID: L439526-70 4
Injection Date: 10/15/06 10:56:14 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

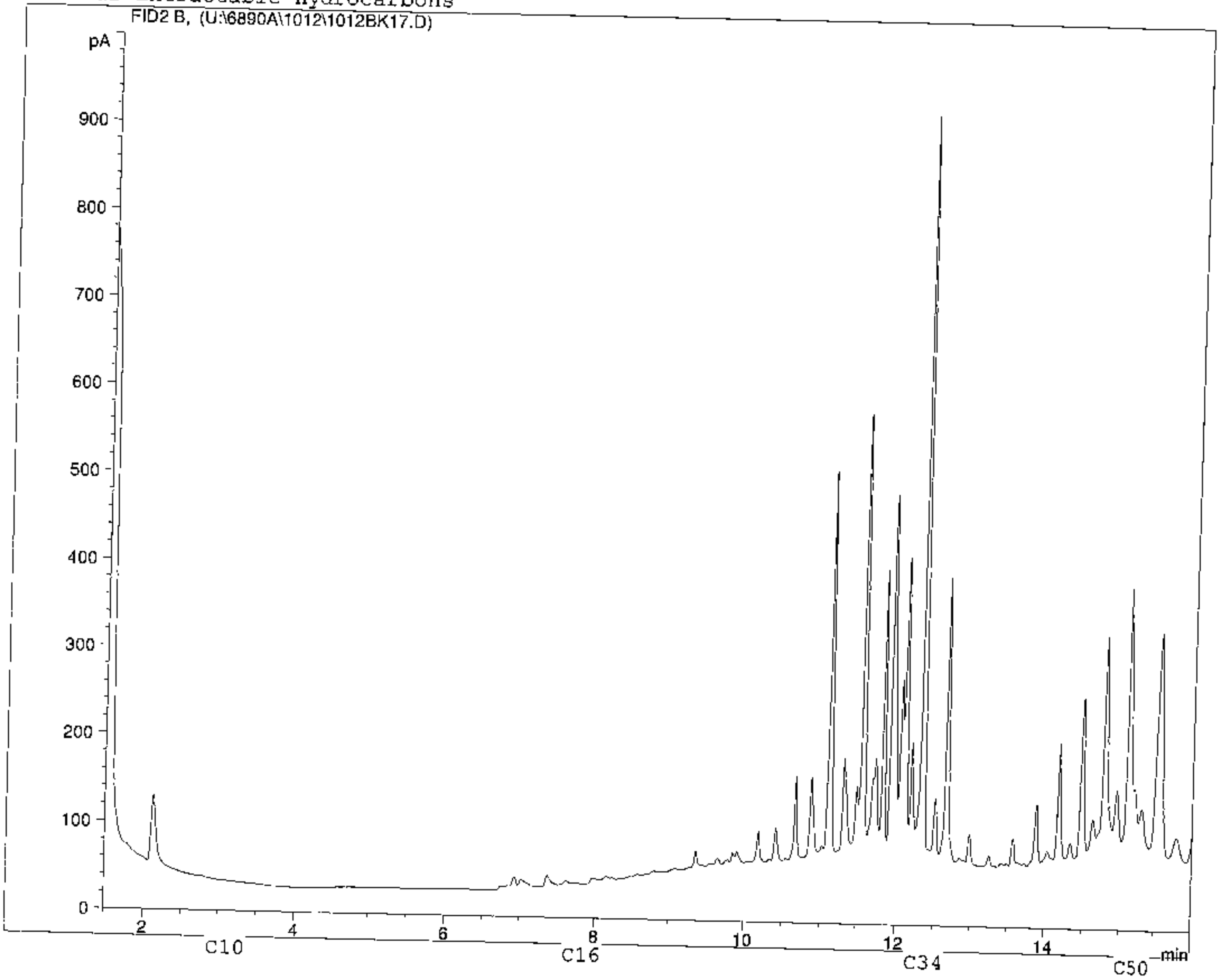
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

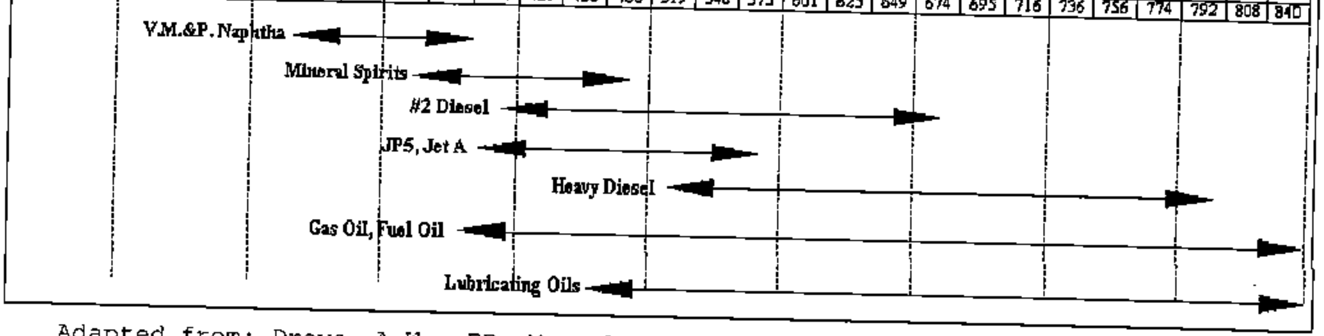
Client ID:	116-1
Sample ID:	L439526-77 SG 4
Injection Date:	10/13/2006 1:40:45 AM
Instrument:	6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

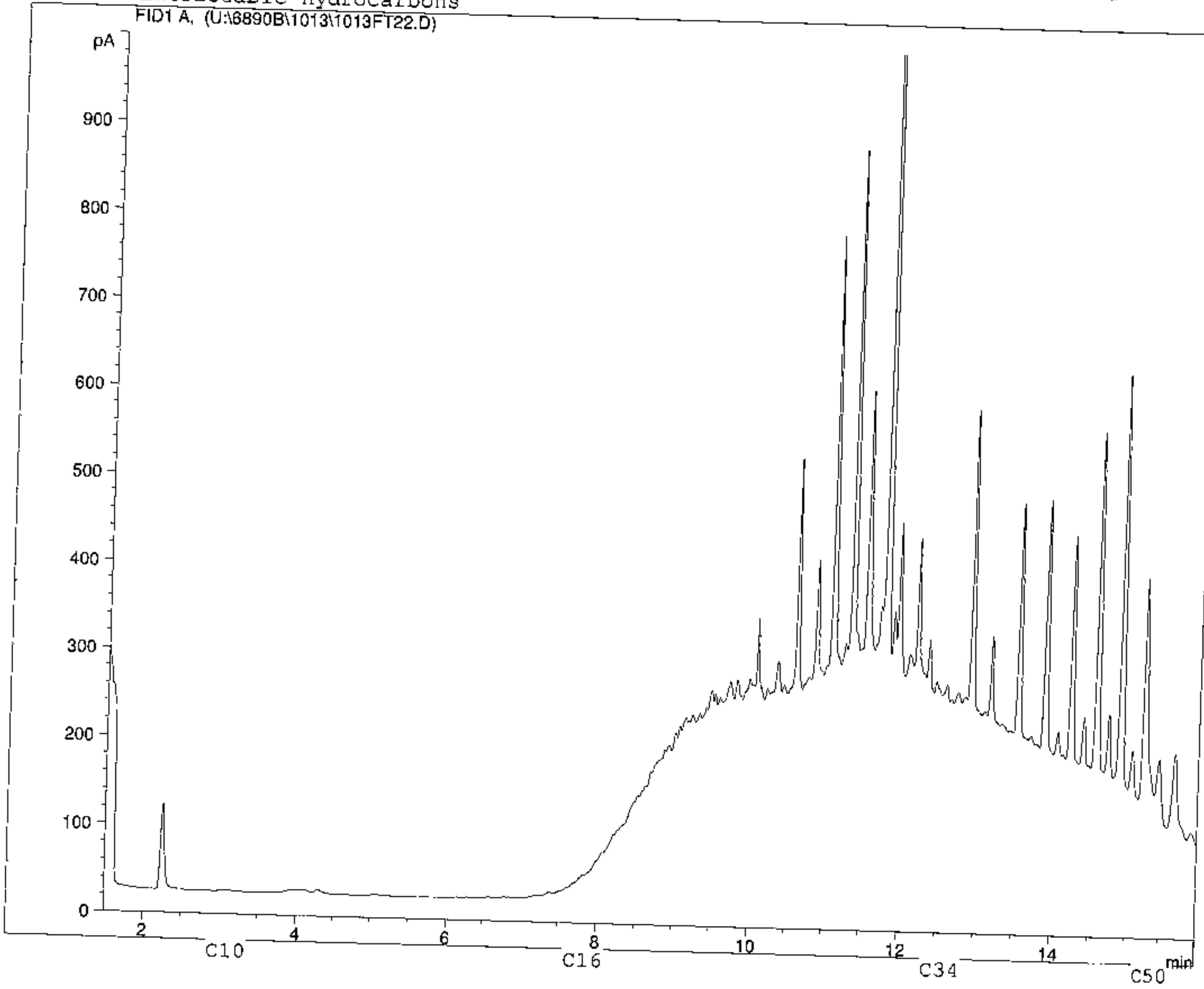


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 117-LFH

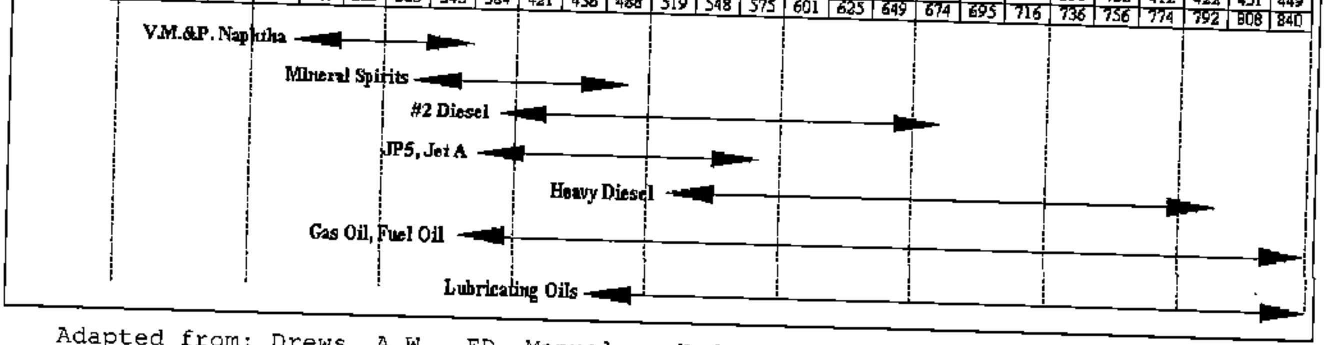
Sample ID: L439526-80 4
Injection Date: 10/14/06 1:13:06 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

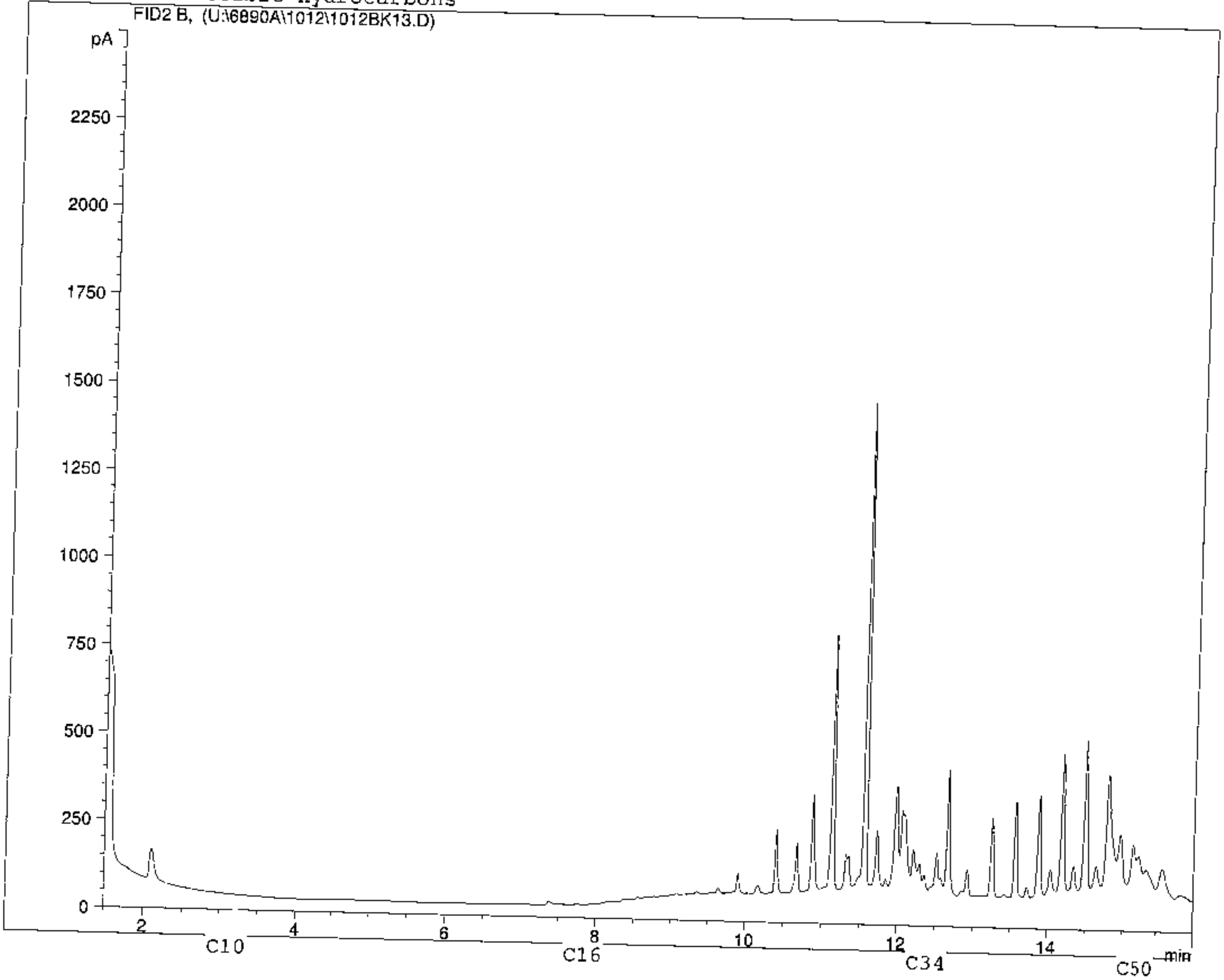


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 120-LFH

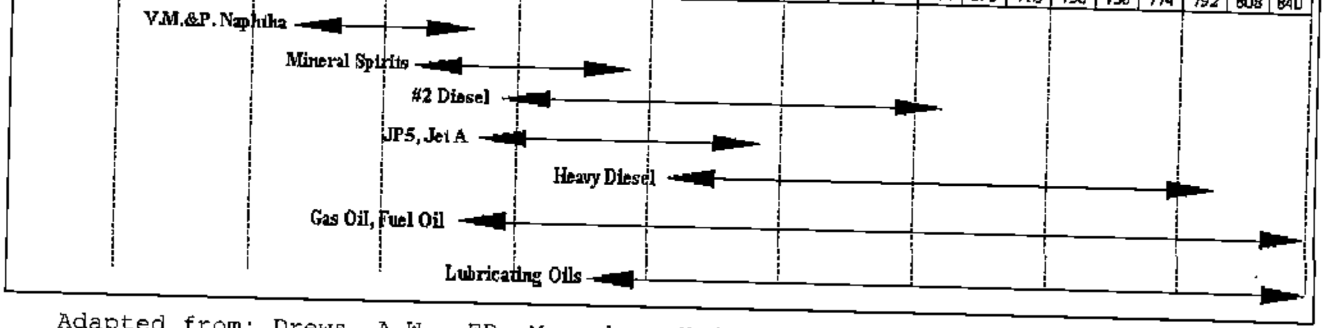
Sample ID: L439526-92 SG 4
Injection Date: 10/12/2006 11:59:39 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

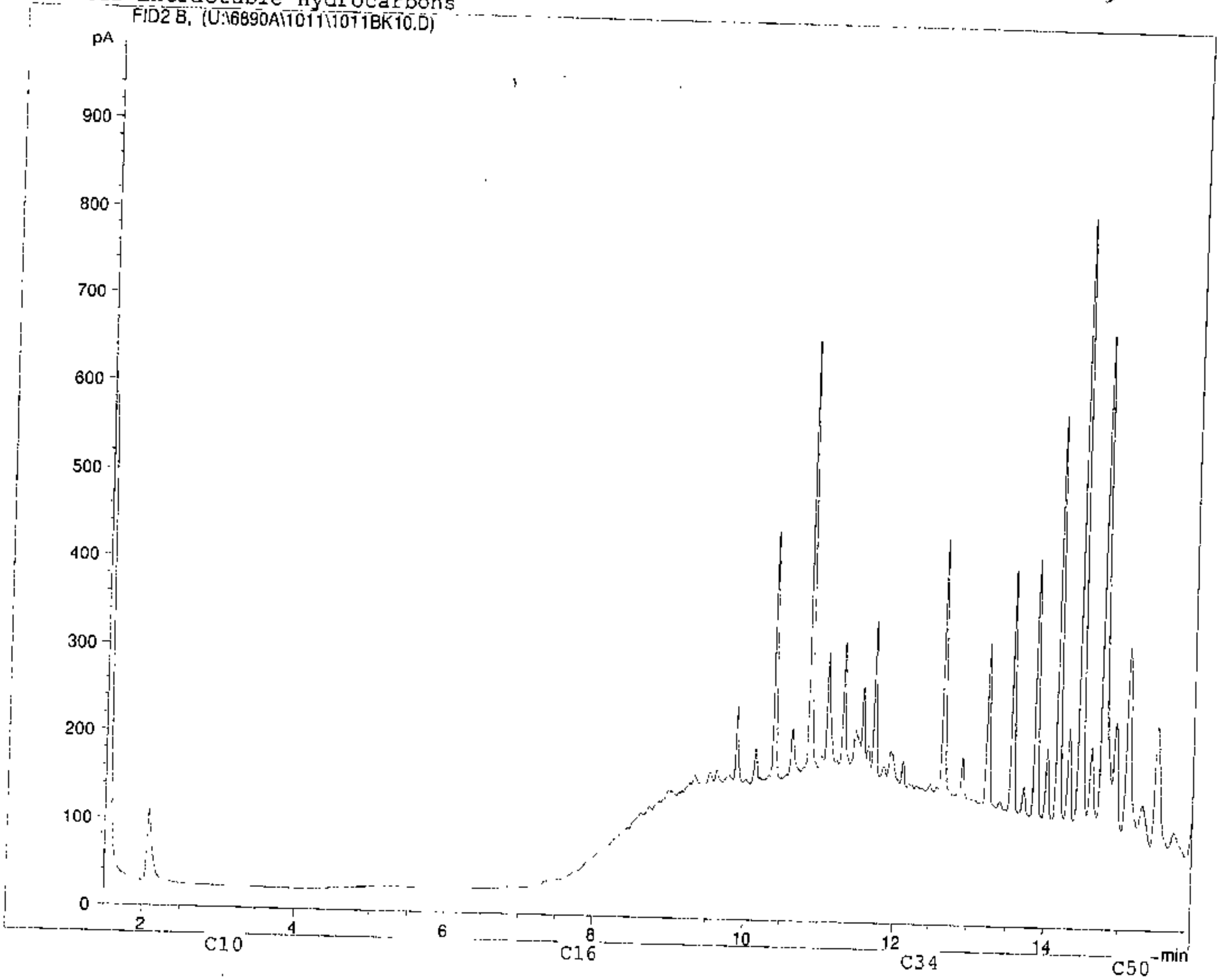


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID:	204-LFH
Sample ID:	L437383-41 4 SG
Injection Date:	10/11/2006 9:15:20 PM
Instrument:	6890

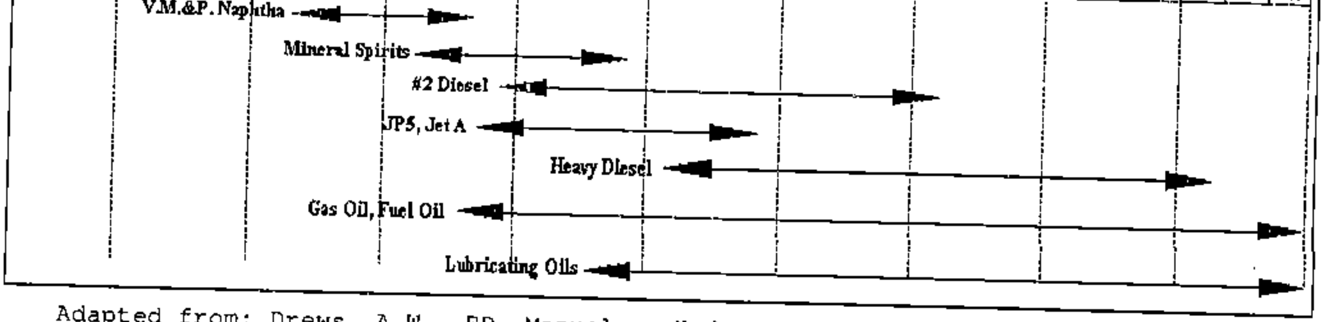
ALS

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



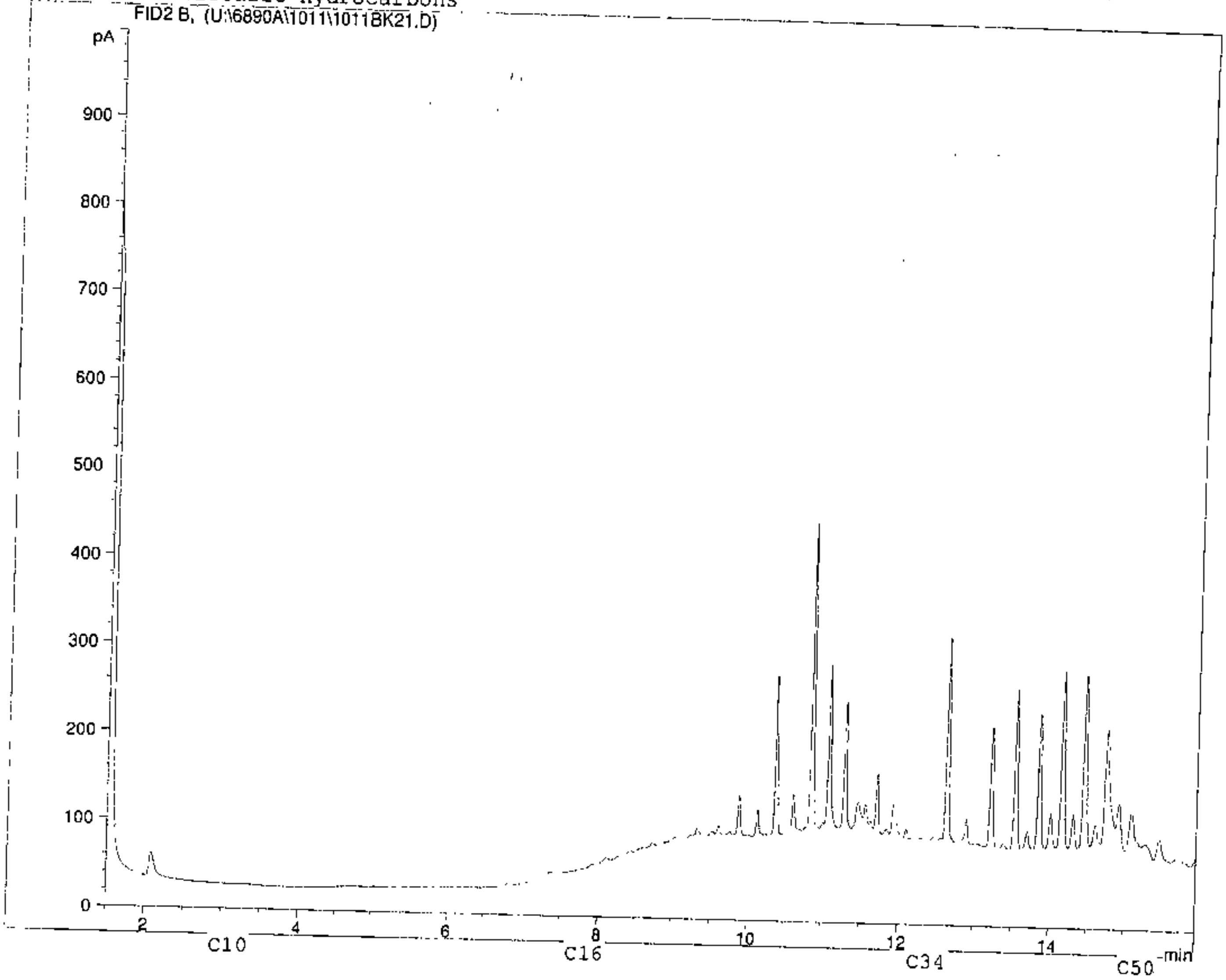
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Oct24.06 c_L437383.PDF

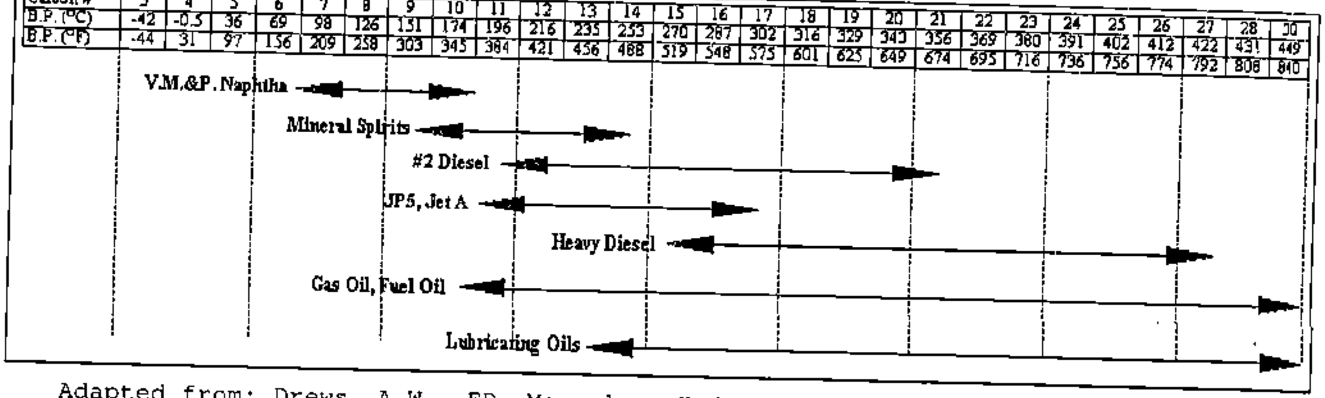
Client ID: 208-LFH

Sample ID: L437987-47 4 SG
Injection Date: 10/12/2006 1:51:19 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



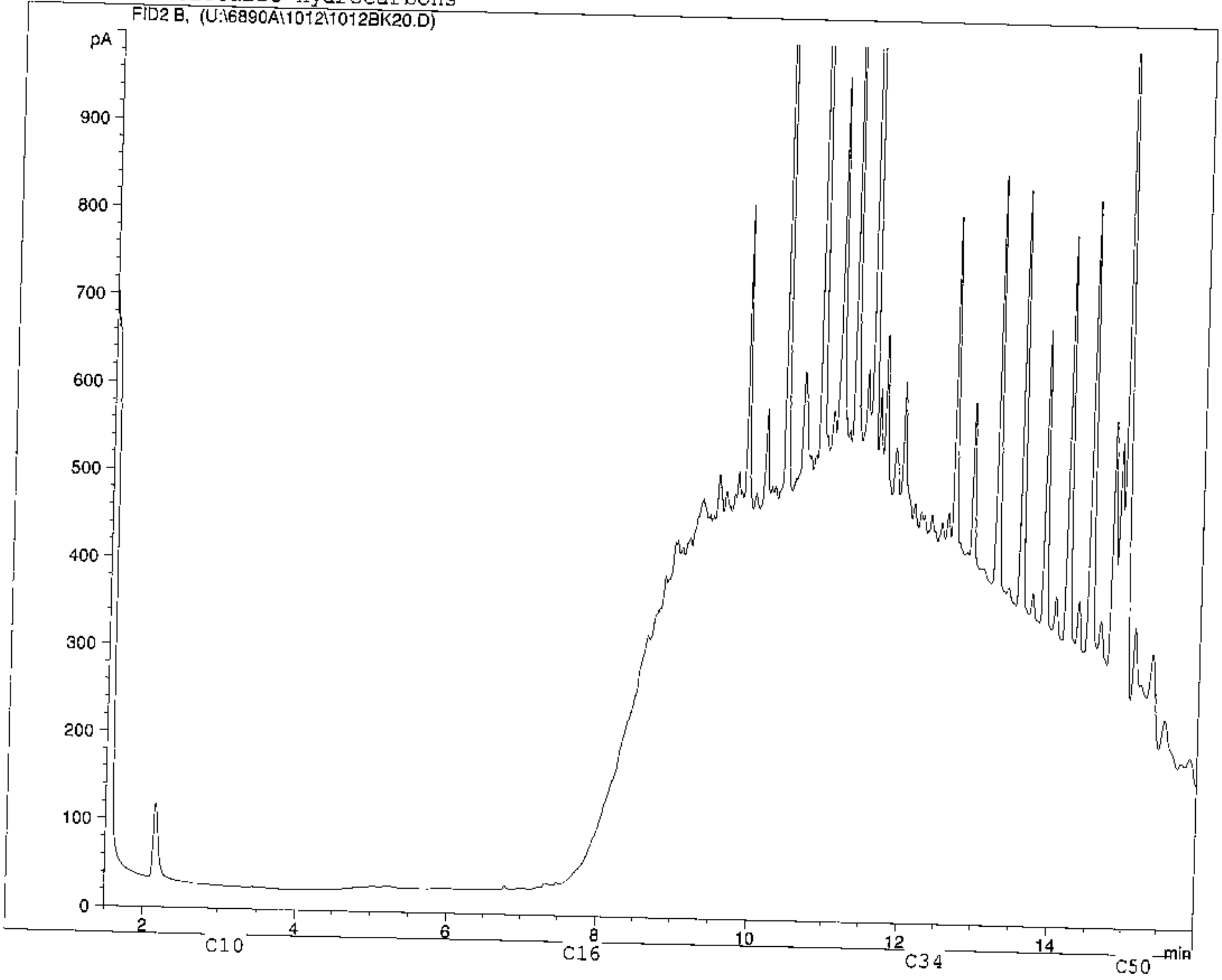
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 215-LFH

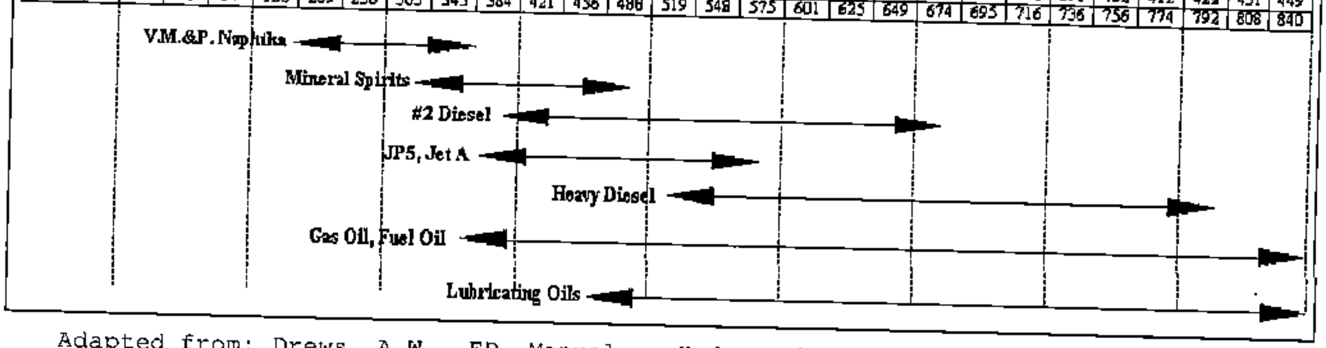
Sample ID: L439526-116 SG 4
Injection Date: 10/13/2006 2:56:37 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

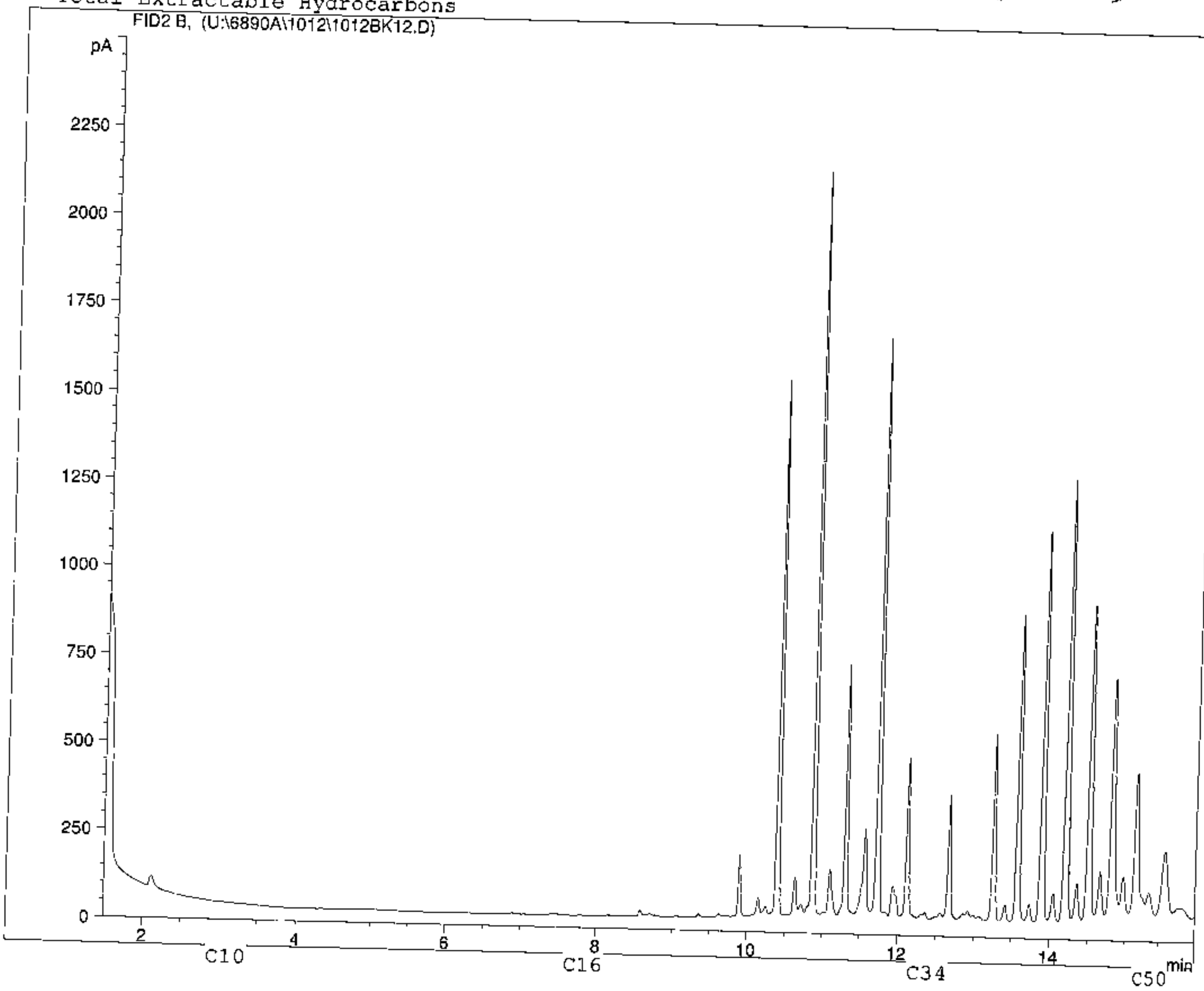


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 217-LFH

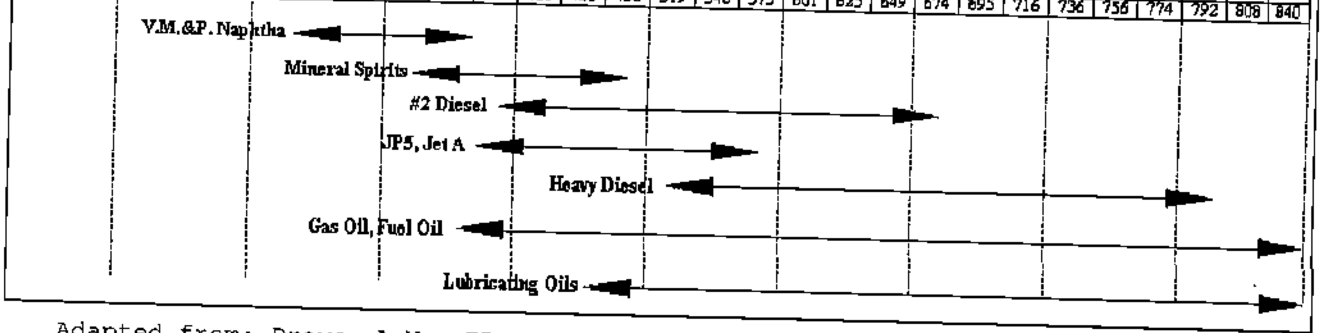
Sample ID: L439526-124 SG 4
Injection Date: 10/12/2006 11:34:24 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

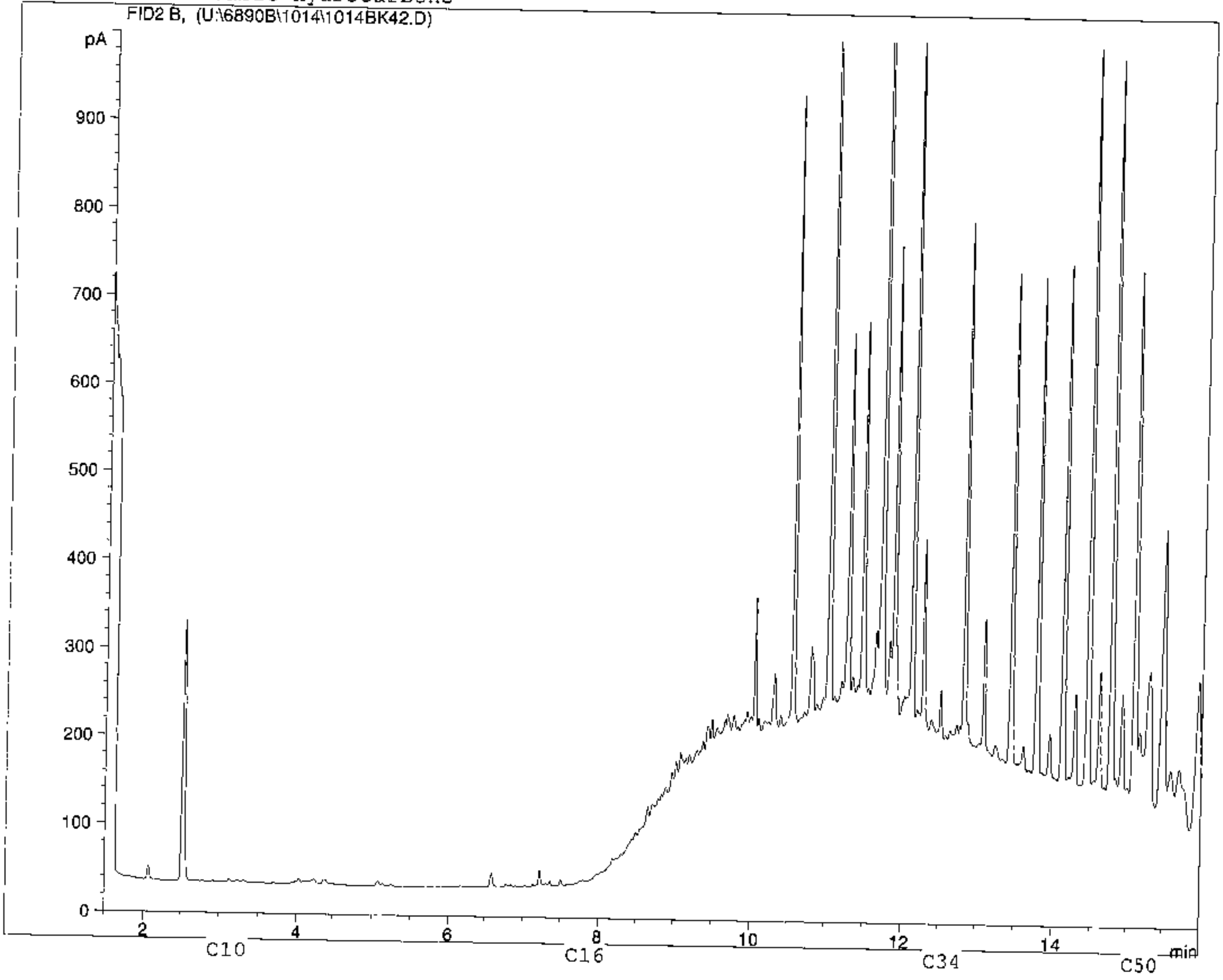


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 220-LFH

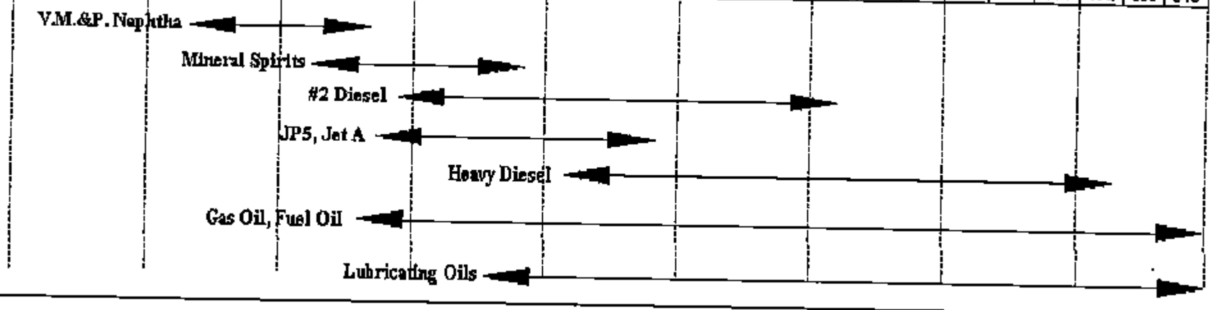
Sample ID: L439526-136 4
Injection Date: 10/15/06 10:29:34 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

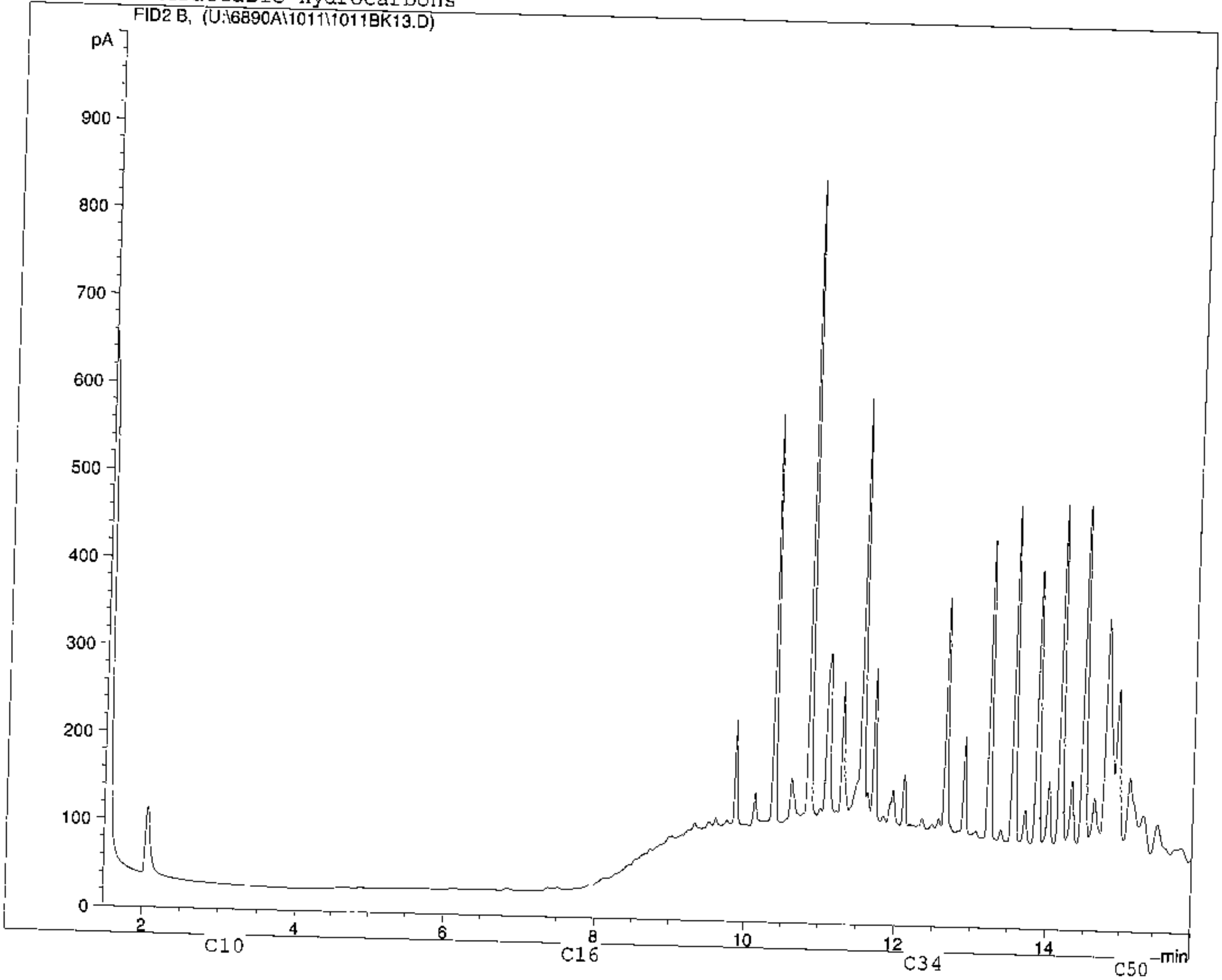


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 222-LFH

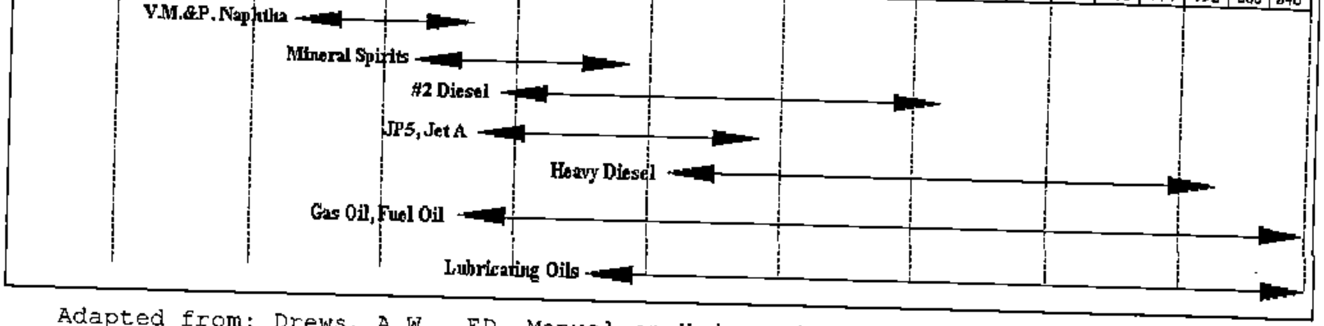
Sample ID: L438781-5 4 SG
Injection Date: 10/11/2006 10:30:19 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

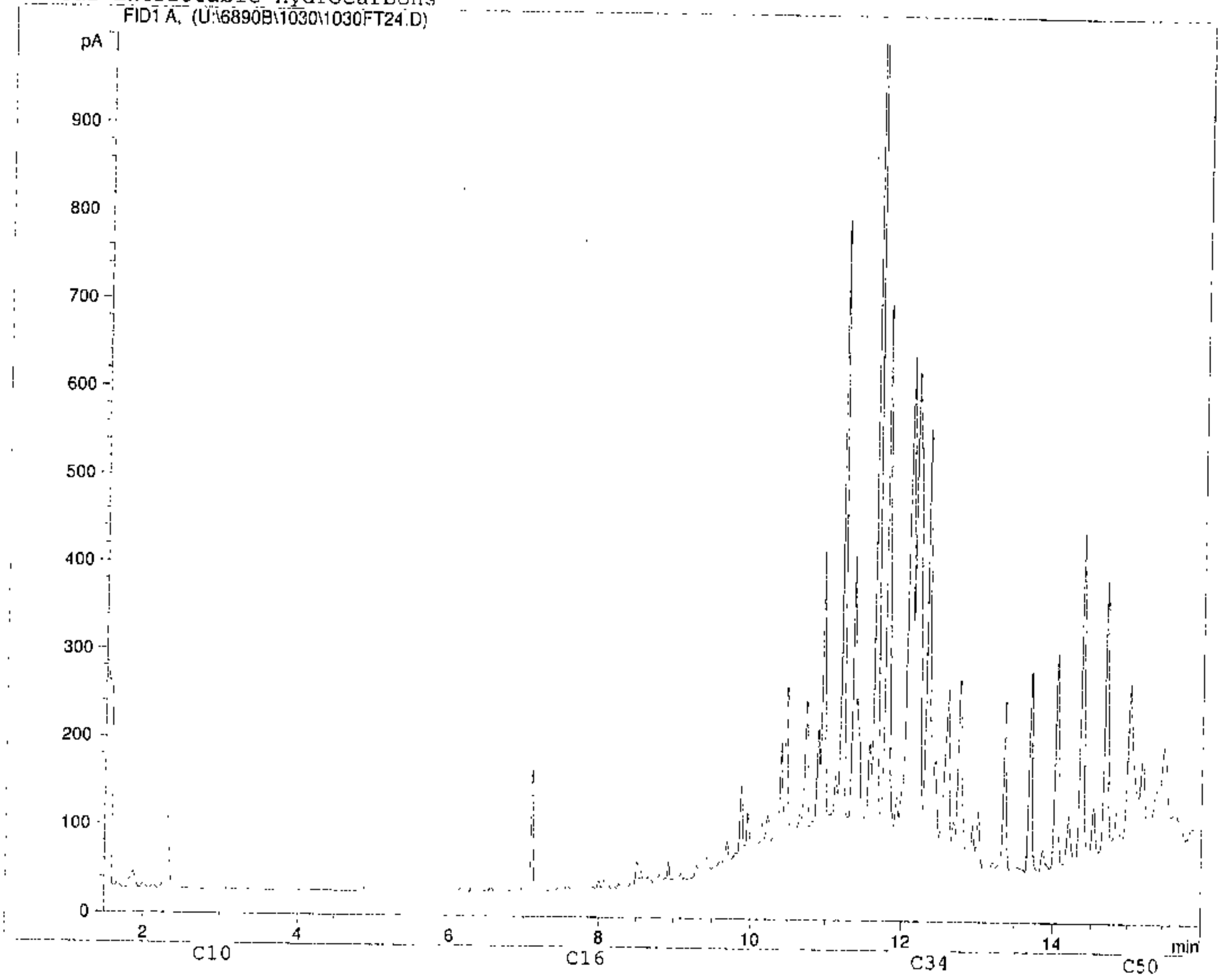


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 302-LFH

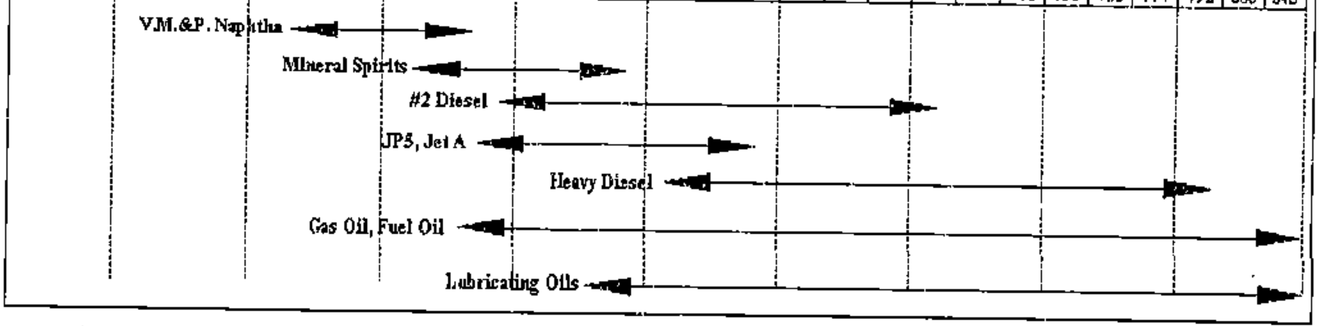
Sample ID: L437383-57 SGC 4
Injection Date: 10/31/06 4:35:33 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	358	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

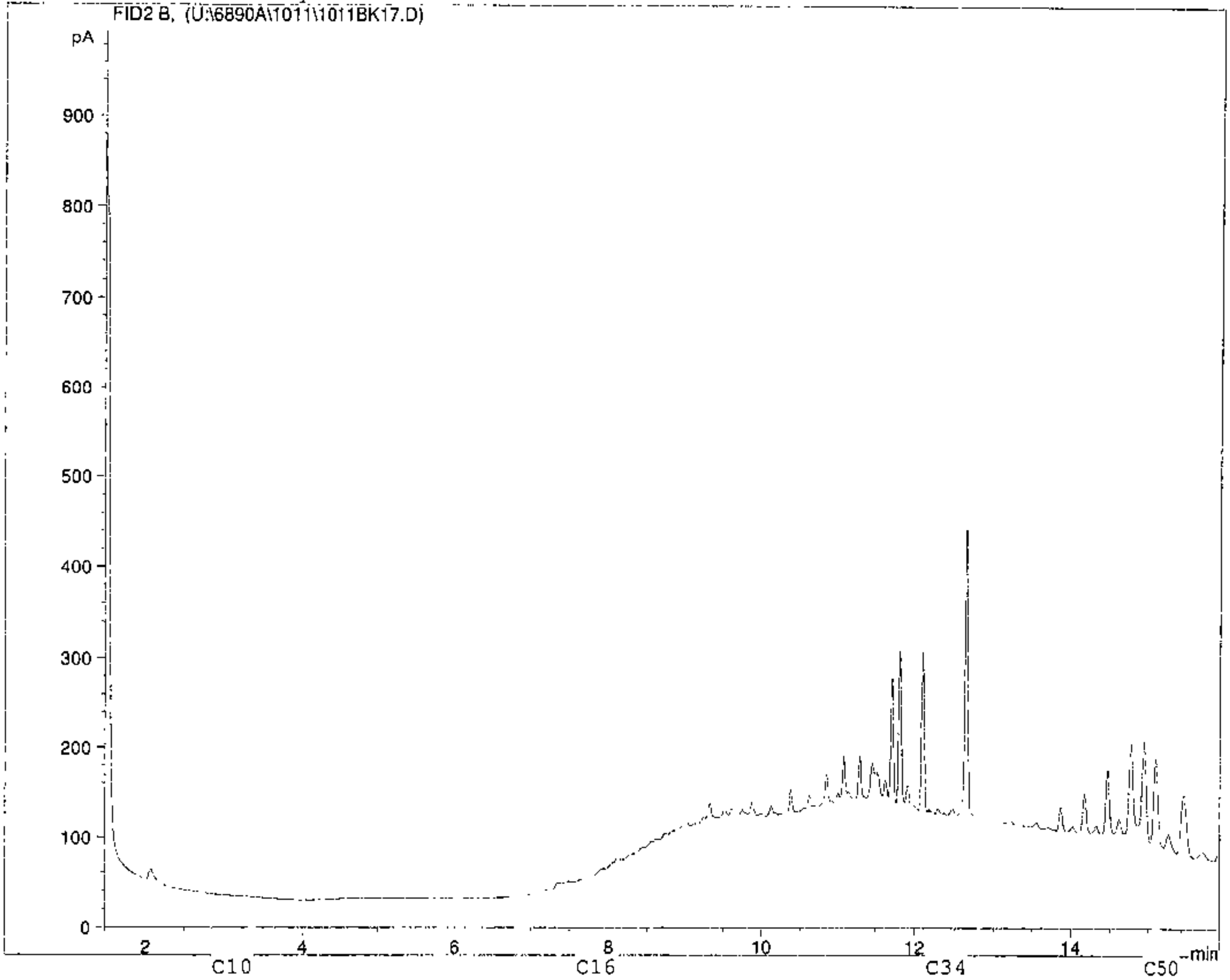


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 310-LFH

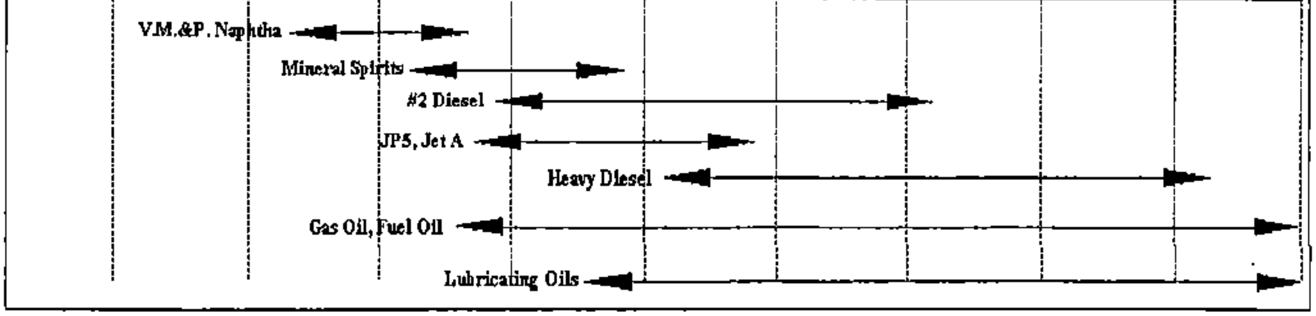
Sample ID: L437987-18 4 SG
Injection Date: 10/12/2006 12:10:39 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

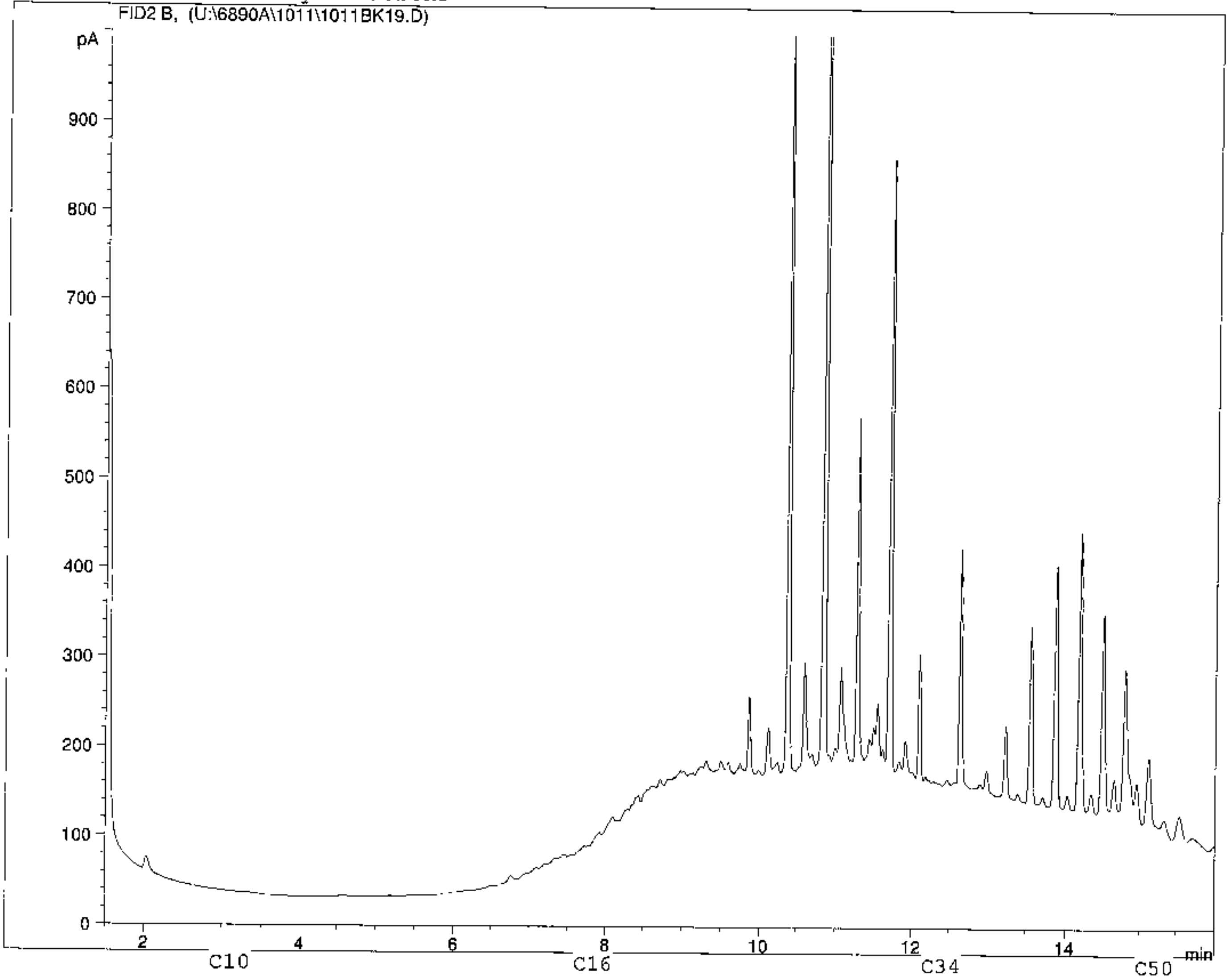


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 313-LFH

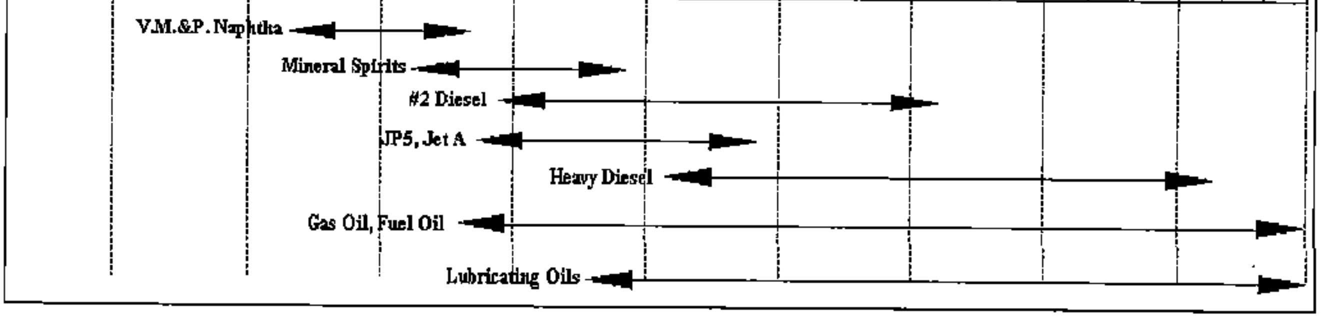
Sample ID: L437987-28 4 SG
Injection Date: 10/12/2006 1:01:05 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

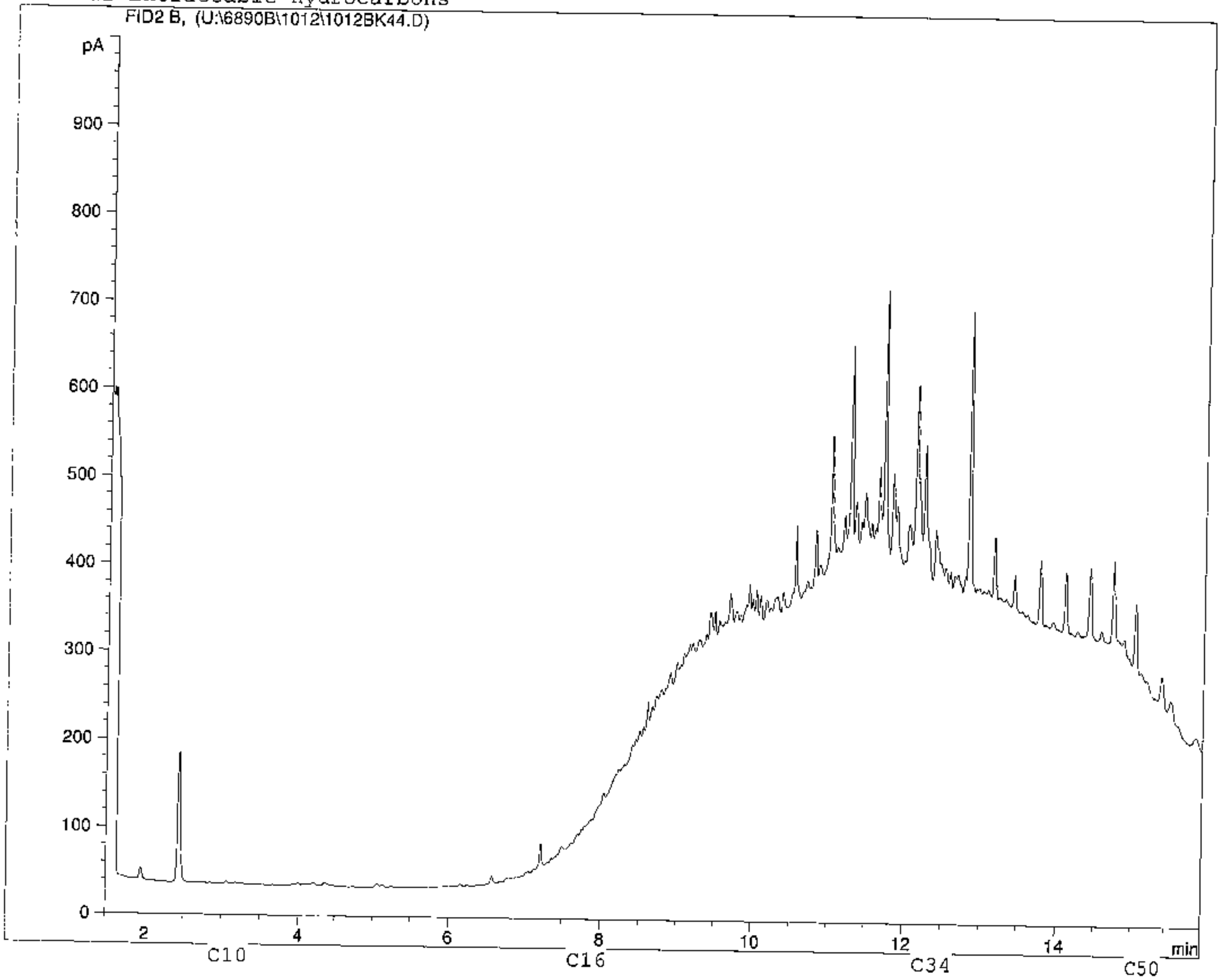


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 314-LFH

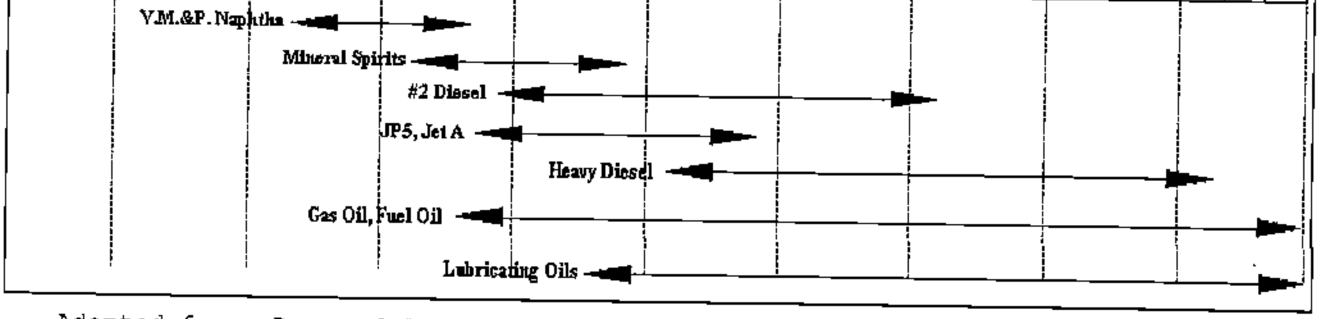
Sample ID: L439526-1 4 SG
Injection Date: 10/13/06 11:38:25 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

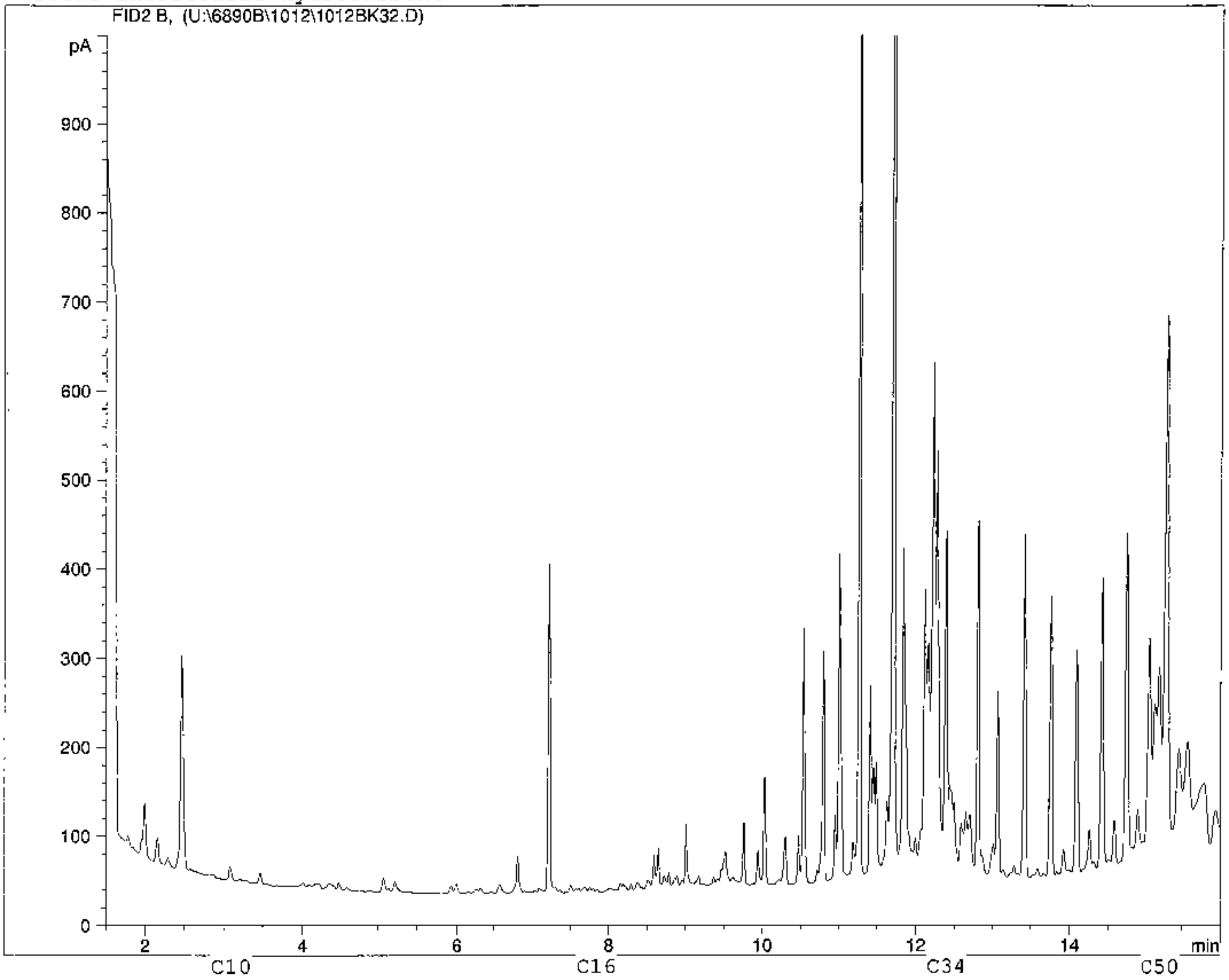


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 318-LFH

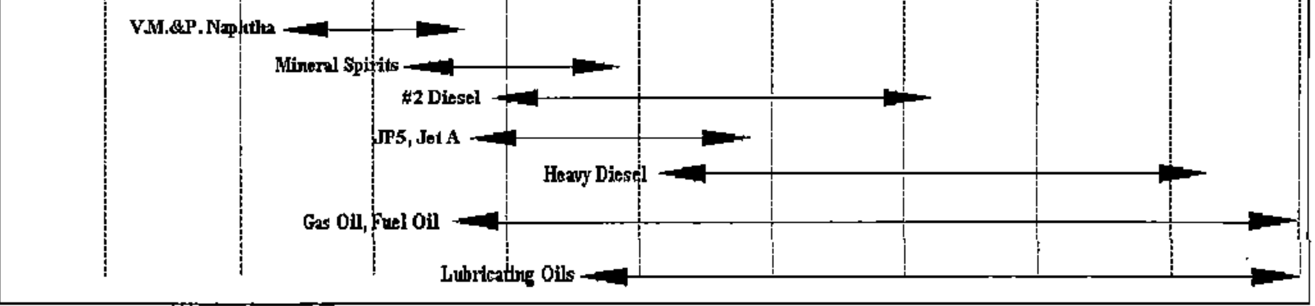
Sample ID: L439526-14 4 SG
Injection Date: 10/13/06 6:13:08 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

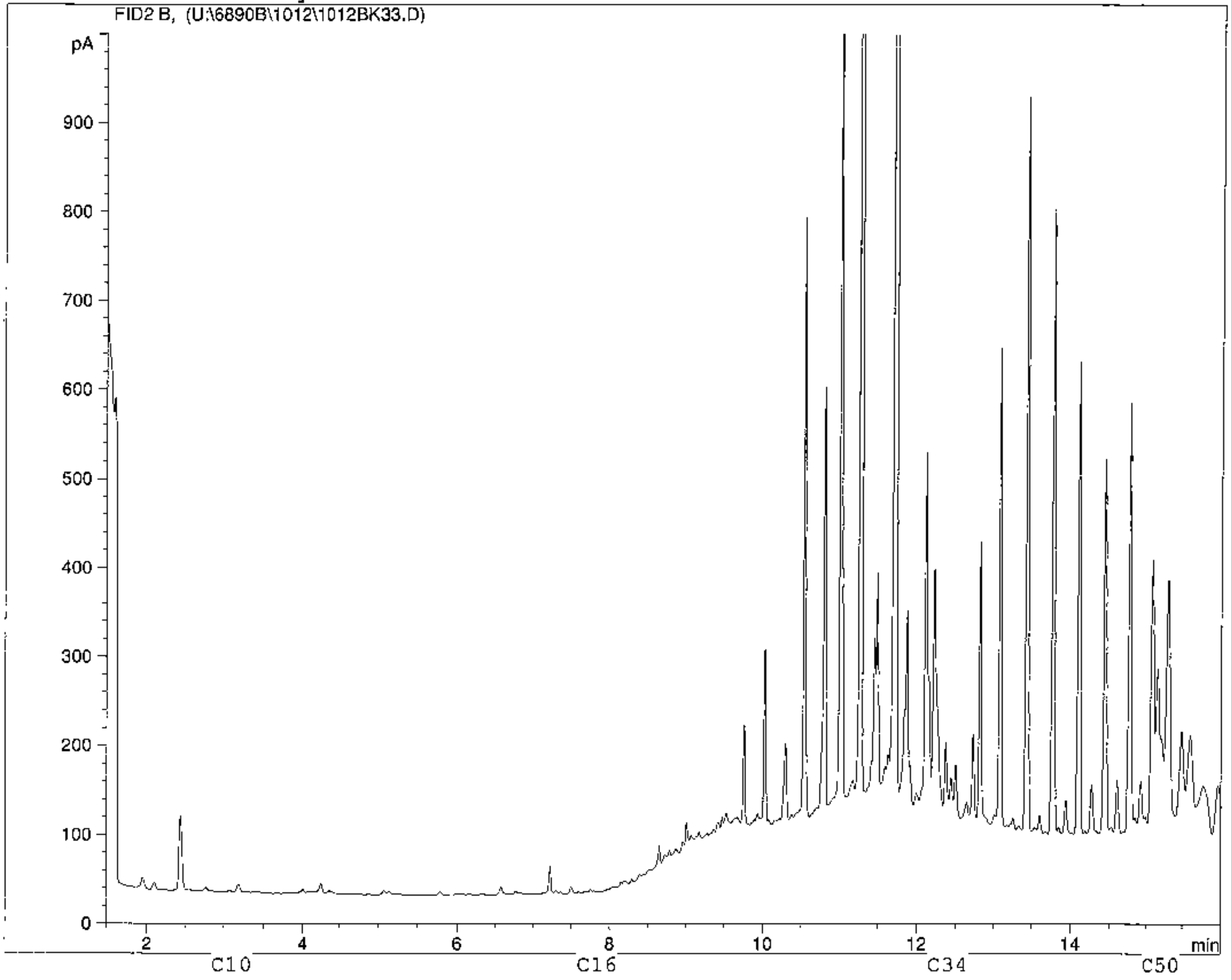


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 319-LFH

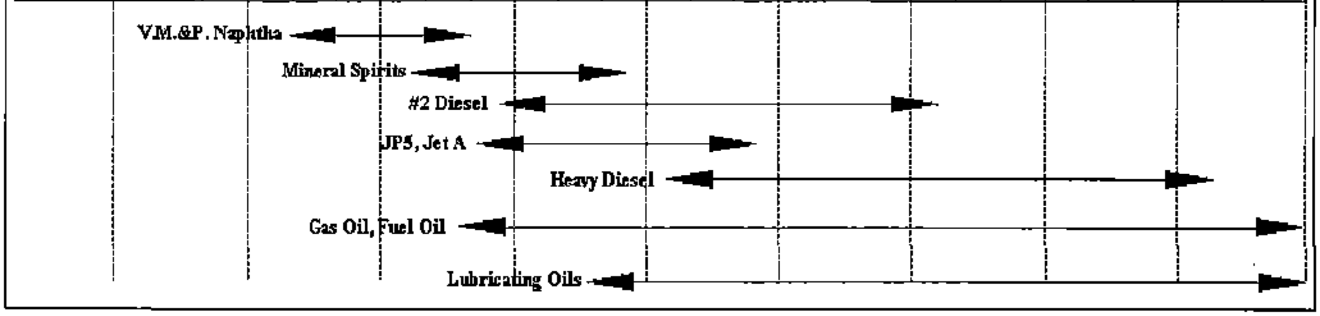
Sample ID: L439526-18 4 SG
Injection Date: 10/13/06 6:40:20 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

APPENDIX E: ORIGINAL LABORATORY DATA

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

PRELIMINARY RESULTS

MILLENNIUM
ATTN: RYAN MURI

208 4207 98 ST

EDMONTON AB T6E 5R7

Reported On: 07-DEC-06 03:21 PM
Revision: 2

Lab Work Order #: **L437383**
Date Received: **27-SEP-06**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 283301, 283328, 283329, 283330, 283331, 283332, 283333, 283335, 283500

Other Information:

Comments: ADDITIONAL 07-DEC-06 11:54 ADDITIONAL 01-DEC-06 10:24 ADDITIONAL 26-OCT-06 15:49 ADDITIONAL 26-OCT-06 14:18 A silica gel column clean up was done on TEH-CCME-ED F2-F4 samples L437383-41,72.

Silica gel column cleanup results reported for F2-F4 for fractions 57 and 81 for TEH-CCME-ED F2-F4. 31-Oct-06.

ROY JONES
General Manager, Edmonton

For any questions about this report please contact your Account Manager:

KAREN HUEBNER

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-13 4-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	92		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	80		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	29		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	31		2	mg/L		09-NOV-06	JWU	R463645
SAR	0.7		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	99		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	310		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.2		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.70		0.01	dS m-1		09-NOV-06	SZ	R463549
L437383-41 204-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	120		33-172	%	10-OCT-06	11-OCT-06	GRB	R452690
Surr: Hexatriacontane	237	SOL:MI	44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		12-OCT-06		
F1-BTEX	<5		5	mg/kg		12-OCT-06		
F2 (C10-C16)	65		5	mg/kg		12-OCT-06		
F3 (C16-C34)	2600		5	mg/kg		12-OCT-06		
F4 (C34-C50)	1700		5	mg/kg		12-OCT-06		
Total Hydrocarbons (C6-C50)	4400		5	mg/kg		12-OCT-06		
Chromatogram to baseline at nC50	NO					12-OCT-06		
% Moisture	68		0.1	%		06-OCT-06	SDL	R450962
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	99		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	62		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	25		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	10		2	mg/L		08-NOV-06	JWU	R463269
SAR	0.2		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	45		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	832		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	6.7		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.53		0.01	dS m-1		08-NOV-06	SR	R463184
L437383-42 204-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-42 204-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Toluene	<0.01		0.01	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	120		33-172	%	10-OCT-06	10-OCT-06	MKE	R452059
Surr: Hexatriacontane	111		44-173	%	10-OCT-06	10-OCT-06	MKE	R452059
Prep/Analysis Dates					10-OCT-06	10-OCT-06	MKE	R452059
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		11-OCT-06		
F1-BTEX	<5		5	mg/kg		11-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		11-OCT-06		
F3 (C16-C34)	12	RAMB	5	mg/kg		11-OCT-06		
F4 (C34-C50)	<5		5	mg/kg		11-OCT-06		
Total Hydrocarbons (C6-C50)	12		5	mg/kg		11-OCT-06		
Chromatogram to baseline at nC50	YES					11-OCT-06		
% Moisture	5.3		0.1	%		06-OCT-06	SDL	R450962
L437383-57 302-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Toluene	<0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Xylenes	0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	59		33-172	%	28-OCT-06	30-OCT-06	MKE	R460203
Surr: Hexatriacontane	147		44-173	%	28-OCT-06	30-OCT-06	MKE	R460203
Prep/Analysis Dates					28-OCT-06	30-OCT-06	MKE	R460203
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-NOV-06		
F1-BTEX	<5		5	mg/kg		14-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-NOV-06		
F3 (C16-C34)	2200		5	mg/kg		14-NOV-06		
F4 (C34-C50)	950		5	mg/kg		14-NOV-06		
Total Hydrocarbons (C6-C50)	3200		5	mg/kg		14-NOV-06		
Chromatogram to baseline at nC50	NO					14-NOV-06		
% Moisture	62		0.1	%		27-OCT-06	DJS	R459073
Detailed Salinity								
Chloride (Cl)	50		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	90		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	134		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	39		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	3		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	63		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	612		0.1	%		09-NOV-06	SZ	R463549

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-57 302-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
pH in Saturated Paste	5.8		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.78		0.01	dS m-1		09-NOV-06	SZ	R463549
L437383-58 302-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Toluene	<0.01	RAMB	0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.01		0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Xylenes	<0.01		0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	109		33-172	%	28-OCT-06	30-OCT-06	MKE	R460203
Surr: Hexatriacontane	114		44-173	%	28-OCT-06	30-OCT-06	MKE	R460203
Prep/Analysis Dates					28-OCT-06	30-OCT-06	MKE	R460203
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-NOV-06		
F1-BTEX	<5		5	mg/kg		14-NOV-06		
F2 (C10-C16)	5	RAMB	5	mg/kg		14-NOV-06		
F3 (C16-C34)	17	RAMB	5	mg/kg		14-NOV-06		
F4 (C34-C50)	<5		5	mg/kg		14-NOV-06		
Total Hydrocarbons (C6-C50)	22		5	mg/kg		14-NOV-06		
Chromatogram to baseline at nC50	YES					14-NOV-06		
% Moisture	7.0		0.1	%		27-OCT-06	DJS	R459073
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	22		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	5		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	10		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	7		2	mg/L		08-NOV-06	JWU	R463269
SAR	0.3		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	35		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	28.6		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	4.8		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.17		0.01	dS m-1		08-NOV-06	SR	R463184
L437383-70 305-DM1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Naphthenic Acids	1		1	mg/L		30-OCT-06	DBP	R459735
L437383-71 305-DM2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	0.021		0.005	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982
Toluene	0.02		0.01	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982
Ethylbenzene	<0.01		0.01	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-71 305-DM2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Xylenes	0.07		0.01	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					13-OCT-06	13-OCT-06	AAT	R453359
CCME Total Hydrocarbons								
F1 (C6-C10)	87	IPT	5	mg/kg		16-OCT-06		
F1-BTEX	87		5	mg/kg		16-OCT-06		
F2 (C10-C16)	1200		5	mg/kg		16-OCT-06		
F2-Naphth	1200		5	mg/kg		16-OCT-06		
F3 (C16-C34)	14000		5	mg/kg		16-OCT-06		
F3-PAH	14000		5	mg/kg		16-OCT-06		
F4 (C34-C50)	6800		5	mg/kg		16-OCT-06		
Total Hydrocarbons (C6-C50)	22000		5	mg/kg		16-OCT-06		
Chromatogram to baseline at nC50	NO					16-OCT-06		
% Moisture	16		0.1	%		12-OCT-06	JOM	R452862
CCME PAHs								
Naphthalene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Quinoline	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Phenanthrene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Pyrene	0.3		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Benzo(a)anthracene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Benzo(b)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Benzo(k)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Benzo(a)pyrene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Indeno(1,2,3-cd)pyrene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Dibenzo(a,h)anthracene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Surr: Nitrobenzene d5	0	SDO:RNA	18-135	%	13-OCT-06	15-OCT-06	JME	R453454
Surr: 2-Fluorobiphenyl	0	SDO:RNA	30-134	%	13-OCT-06	15-OCT-06	JME	R453454
Surr: p-Terphenyl d14	63		47-146	%	13-OCT-06	15-OCT-06	JME	R453454
Note: PAH detection limit raised due to matrix interference.								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	4.0		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	72		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	6		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	10.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	11		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	16		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	6		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.3		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	22		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Detailed Salinity								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-71 305-DM2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	50		20	mg/L		13-OCT-06	EOC	R453087
SAR								
Calcium (Ca)	62		5	mg/L		13-OCT-06	JWU	R452937
Potassium (K)	16		2	mg/L		13-OCT-06	JWU	R452937
Magnesium (Mg)	11		3	mg/L		13-OCT-06	JWU	R452937
Sodium (Na)	503		2	mg/L		13-OCT-06	JWU	R452937
SAR	15.4			SAR		13-OCT-06	JWU	R452937
Sulphate (SO4)	951		6	mg/L		13-OCT-06	JWU	R452937
pH and EC (Saturated Paste)								
% Saturation	53.6		0.1	%		13-OCT-06	SR	R452856
pH in Saturated Paste	7.6		0.1	pH		13-OCT-06	SR	R452856
Conductivity Sat. Paste	1.98		0.01	dS m-1		13-OCT-06	SR	R452856
L437383-72 305 LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Toluene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
Xylenes	<0.04	DLHM	0.04	mg/kg	06-OCT-06	08-OCT-06	DDU	R451712
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	109		33-172	%	10-OCT-06	11-OCT-06	GRB	R452690
Surr: Hexatriacontane	139		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		13-OCT-06		
F1-BTEX	<5		5	mg/kg		13-OCT-06		
F2 (C10-C16)	58		5	mg/kg		13-OCT-06		
F2-Naphth	58		5	mg/kg		13-OCT-06		
F3 (C16-C34)	420		5	mg/kg		13-OCT-06		
F3-PAH	420		5	mg/kg		13-OCT-06		
F4 (C34-C50)	400		5	mg/kg		13-OCT-06		
Total Hydrocarbons (C6-C50)	880		5	mg/kg		13-OCT-06		
Chromatogram to baseline at nC50	NO					13-OCT-06		
% Moisture	75		0.1	%		06-OCT-06	SDL	R450962
CCME PAHs								
Naphthalene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	73		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	89		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	96		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
Metals in Soil - CCME List								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-72 305 LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		12-OCT-06	JGP	R452666
Arsenic (As)	0.9		0.2	mg/kg		12-OCT-06	JGP	R452666
Barium (Ba)	87		5	mg/kg		12-OCT-06	JGP	R452666
Beryllium (Be)	<1		1	mg/kg		12-OCT-06	JGP	R452666
Cadmium (Cd)	<0.5		0.5	mg/kg		12-OCT-06	JGP	R452666
Cobalt (Co)	2		1	mg/kg		12-OCT-06	JGP	R452666
Chromium (Cr)	1.4		0.5	mg/kg		12-OCT-06	JGP	R452666
Copper (Cu)	7		2	mg/kg		12-OCT-06	JGP	R452666
Mercury (Hg)	<0.05		0.05	mg/kg		12-OCT-06	JGP	R452666
Molybdenum (Mo)	1		1	mg/kg		12-OCT-06	JGP	R452666
Nickel (Ni)	6		2	mg/kg		12-OCT-06	JGP	R452666
Lead (Pb)	<5		5	mg/kg		12-OCT-06	JGP	R452666
Antimony (Sb)	0.3		0.2	mg/kg		12-OCT-06	JGP	R452666
Selenium (Se)	1.3		0.2	mg/kg		12-OCT-06	JGP	R452666
Tin (Sn)	<5		5	mg/kg		12-OCT-06	JGP	R452666
Thallium (Tl)	<1		1	mg/kg		12-OCT-06	JGP	R452666
Uranium (U)	8		2	mg/kg		12-OCT-06	JGP	R452666
Vanadium (V)	7		1	mg/kg		12-OCT-06	JGP	R452666
Zinc (Zn)	20		10	mg/kg		12-OCT-06	JGP	R452666
Naphthenic Acids	500		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	50		20	mg/L		10-OCT-06	EOC	R451721
SAR								
Calcium (Ca)	106		5	mg/L		10-OCT-06	JWU	R451583
Potassium (K)	30		2	mg/L		10-OCT-06	JWU	R451583
Magnesium (Mg)	50		3	mg/L		10-OCT-06	JWU	R451583
Sodium (Na)	193		2	mg/L		10-OCT-06	JWU	R451583
SAR	3.9			SAR		10-OCT-06	JWU	R451583
Sulphate (SO4)	333		6	mg/L		10-OCT-06	JWU	R451583
pH and EC (Saturated Paste)								
% Saturation	403		0.1	%		10-OCT-06	SFC	R451435
pH in Saturated Paste	6.6		0.1	pH		10-OCT-06	SFC	R451435
Conductivity Sat. Paste	1.12		0.01	dS m-1		10-OCT-06	SFC	R451435
L437383-81 103-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Toluene	<0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Xylenes	<0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	66		33-172	%	28-OCT-06	30-OCT-06	MKE	R460203
Surr: Hexatriacontane	120		44-173	%	28-OCT-06	30-OCT-06	MKE	R460203
Prep/Analysis Dates					28-OCT-06	30-OCT-06	MKE	R460203
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-NOV-06		
F1-BTEX	<5		5	mg/kg		14-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-NOV-06		
F3 (C16-C34)	430		5	mg/kg		14-NOV-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-81 103-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F4 (C34-C50)	440		5	mg/kg		14-NOV-06		
Total Hydrocarbons (C6-C50)	870		5	mg/kg		14-NOV-06		
Chromatogram to baseline at nC50	NO					14-NOV-06		
% Moisture	64		0.1	%		27-OCT-06	DJS	R459073
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	39		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	83		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	11		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	2		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	34		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	634		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	4.9		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.35		0.01	dS m-1		09-NOV-06	SZ	R463549
L437383-82 103-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Toluene	0.02		0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.01		0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Xylenes	0.02		0.01	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	114		33-172	%	28-OCT-06	28-OCT-06	MKE	R459628
Surr: Hexatriacontane	174	SOL:MI	44-173	%	28-OCT-06	28-OCT-06	MKE	R459628
Prep/Analysis Dates					28-OCT-06	28-OCT-06	MKE	R459628
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-NOV-06		
F1-BTEX	<5		5	mg/kg		14-NOV-06		
F2 (C10-C16)	19	RAMB	5	mg/kg		14-NOV-06		
F3 (C16-C34)	120	RAMB	5	mg/kg		14-NOV-06		
F4 (C34-C50)	66		5	mg/kg		14-NOV-06		
Total Hydrocarbons (C6-C50)	210		5	mg/kg		14-NOV-06		
Chromatogram to baseline at nC50	NO					14-NOV-06		
% Moisture	19		0.1	%		27-OCT-06	DJS	R459073
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	17		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	7		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	5		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	4		2	mg/L		08-NOV-06	JWU	R463269
SAR	0.2		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	21		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	43.8		0.1	%		08-NOV-06	SR	R463184

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-82 103-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
pH in Saturated Paste	4.5		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.12		0.01	dS m-1		08-NOV-06	SR	R463184
L437383-97 305-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	104		33-172	%	10-OCT-06	10-OCT-06	MKE	R452059
Surr: Hexatriacontane	110		44-173	%	10-OCT-06	10-OCT-06	MKE	R452059
Prep/Analysis Dates					10-OCT-06	10-OCT-06	MKE	R452059
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		15-OCT-06		
F2-Naphth	<5		5	mg/kg		15-OCT-06		
F3 (C16-C34)	17	RAMB	5	mg/kg		15-OCT-06		
F3-PAH	17		5	mg/kg		15-OCT-06		
F4 (C34-C50)	23		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	40		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	17		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs								
Naphthalene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	93		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	96		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	106		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
MUST PSA % > 75um	57		1	%		07-NOV-06	NNK	R462870
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		12-OCT-06	JGP	R452666
Arsenic (As)	2.1		0.2	mg/kg		12-OCT-06	JGP	R452666
Barium (Ba)	71		5	mg/kg		12-OCT-06	JGP	R452666
Beryllium (Be)	<1		1	mg/kg		12-OCT-06	JGP	R452666
Cadmium (Cd)	<0.5		0.5	mg/kg		12-OCT-06	JGP	R452666
Cobalt (Co)	3		1	mg/kg		12-OCT-06	JGP	R452666
Chromium (Cr)	8.6		0.5	mg/kg		12-OCT-06	JGP	R452666
Copper (Cu)	3		2	mg/kg		12-OCT-06	JGP	R452666

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437383-97 305-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Metals in Soil - CCME List								
Mercury (Hg)	<0.05		0.05	mg/kg		12-OCT-06	JGP	R452666
Molybdenum (Mo)	<1		1	mg/kg		12-OCT-06	JGP	R452666
Nickel (Ni)	7		2	mg/kg		12-OCT-06	JGP	R452666
Lead (Pb)	<5		5	mg/kg		12-OCT-06	JGP	R452666
Antimony (Sb)	<0.2		0.2	mg/kg		12-OCT-06	JGP	R452666
Selenium (Se)	<0.2		0.2	mg/kg		12-OCT-06	JGP	R452666
Tin (Sn)	<5		5	mg/kg		12-OCT-06	JGP	R452666
Thallium (Tl)	<1		1	mg/kg		12-OCT-06	JGP	R452666
Uranium (U)	<2		2	mg/kg		12-OCT-06	JGP	R452666
Vanadium (V)	16		1	mg/kg		12-OCT-06	JGP	R452666
Zinc (Zn)	20		10	mg/kg		12-OCT-06	JGP	R452666
Naphthenic Acids	52		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		10-OCT-06	EOC	R451721
SAR								
Calcium (Ca)	69		5	mg/L		11-OCT-06	JWU	R451583
Potassium (K)	<2		2	mg/L		11-OCT-06	JWU	R451583
Magnesium (Mg)	21		3	mg/L		11-OCT-06	JWU	R451583
Sodium (Na)	49		2	mg/L		11-OCT-06	JWU	R451583
SAR	1.3			SAR		11-OCT-06	JWU	R451583
Sulphate (SO4)	112		6	mg/L		11-OCT-06	JWU	R451583
pH and EC (Saturated Paste)								
% Saturation	28.9		0.1	%		10-OCT-06	SFC	R451435
pH in Saturated Paste	7.1		0.1	pH		10-OCT-06	SFC	R451435
Conductivity Sat. Paste	0.40		0.01	dS m-1		10-OCT-06	SFC	R451435

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Number	Client ID	Qualifier	Description
L437383-57	302-LFH	IPC	TEH-CCME-ED F2-F4 - Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L437383-58	302-1	IPC	TEH-CCME-ED F2-F4 - Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L437383-81	103-LFH	IPC	TEH-CCME-ED F2-F4 - Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L437383-82	103-1	IPC	teh-ccme-ed f2-f4 - Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.

Sample Parameter Qualifier key listed:

Qualifier	Description
DLHM	Detection Limit Adjusted: Sample has High Moisture Content
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank
SDO:RNA	Surrogate diluted out:% recovery not available
SOL:MI	Surrogate recovery outside acceptable limits due to matrix interference

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
METAL-CCME-ED	Soil	Metals in Soil - CCME List	EPA 3050	SW 846 - 3051/6020-ICPMS
NAPHTHENIC-ACID-FM	Water	Naphthenic Acids by FTIR		Naphthenic Acids by FTIR,Syncrude,1994
NAPHTHENIC-ACID-FM	Soil	Naphthenic Acids by FTIR		Naphthenic Acids by FTIR,Syncrude,1994
PAH-CCME-ED	Soil	CCME PAHs	EPA 3540C	EPA 3540/8270-GC/MS
PREP-MOISTURE-ED	Soil	% Moisture		Oven dry 105C-Gravimetric
		MUST PSA D50 > 75um		ASTM D422-63-Hydrometer/Sieve

Reference Information

PSA-MUST-ED	Soil		
SAR-CALC-ED	Soil	SAR	CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)	CSSS 18.2, 16.2, 18.3
SO4-SAR-ED	Soil	Sulfate (SO4) in saturated paste	APHA 3120 B-ICP-OES

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

283301	283328	283329	283330	283331
283332	283333	283335	283500	

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA	FM	ALS LABORATORY GROUP - FORT MCMURRAY, ALBERTA, CANADA

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L437383

Lab ID Sample ID

L437383-13 4-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	310	0.70	77.2
Sulphate (SO4)	99	310	2.07	307.8
Calcium (Ca)	92	310	4.59	285.2
Potassium (K)	80	310	2.05	248.9
Magnesium (Mg	29	310	2.41	90.6
Sodium (Na)	31	310	1.34	95.4

L437383-57 302-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	50	612	1.45	314.7
Sulphate (SO4)	63	612	1.32	388.0
Calcium (Ca)	90	612	4.47	548.7
Potassium (K)	134	612	3.43	820.2
Magnesium (Mg	39	612	3.20	237.7
Sodium (Na)	3	612	0.15	21.4

L437383-71 305-DM2
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	50	53.6	1.55	29.4
Sulphate (SO4)	951	53.6	19.80	509.7
Calcium (Ca)	62	53.6	3.11	33.4
Potassium (K)	16	53.6	0.41	8.7
Magnesium (Mg	11	53.6	0.94	6.1
Sodium (Na)	503	53.6	21.86	269.4

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

Lab ID Sample ID

L437383-41 204-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	832	0.93	274.5
Sulphate (SO4)	45	832	0.93	371.8
Calcium (Ca)	99	832	4.94	823.7
Potassium (K)	62	832	1.58	514.1
Magnesium (Mg	25	832	2.03	205.5
Sodium (Na)	10	832	0.45	86.7

L437383-58 302-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	28.6	<0.56	<5.7
Sulphate (SO4)	35	28.6	0.74	10.1
Calcium (Ca)	22	28.6	1.09	6.2
Potassium (K)	5	28.6	0.13	1.4
Magnesium (Mg	10	28.6	0.82	2.8
Sodium (Na)	7	28.6	0.32	2.1

L437383-72 305 LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	50	403	1.49	213.2
Sulphate (SO4)	333	403	6.92	1340.3
Calcium (Ca)	106	403	5.28	426.7
Potassium (K)	30	403	0.77	121.7
Magnesium (Mg	50	403	4.13	202.4
Sodium (Na)	193	403	8.41	779.5

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L437383

Lab ID L437383-81 Sample ID 103-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	634	<0.56	<126.8
Sulphate (SO4)	34	634	0.72	217.9
Calcium (Ca)	39	634	1.93	244.9
Potassium (K)	83	634	2.13	528.7
Magnesium (Mg)	11	634	0.87	67.3
Sodium (Na)	2	634	0.09	12.9

Lab ID L437383-97 Sample ID 305-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	28.9	<0.56	<5.8
Sulphate (SO4)	112	28.9	2.34	32.4
Calcium (Ca)	69	28.9	3.45	20.0
Potassium (K)	<2	28.9	<0.05	<0.6
Magnesium (Mg)	21	28.9	1.73	6.1
Sodium (Na)	49	28.9	2.14	14.2

Lab ID L437383-82 Sample ID 103-1
Sample Date:
Matrix: SOIL

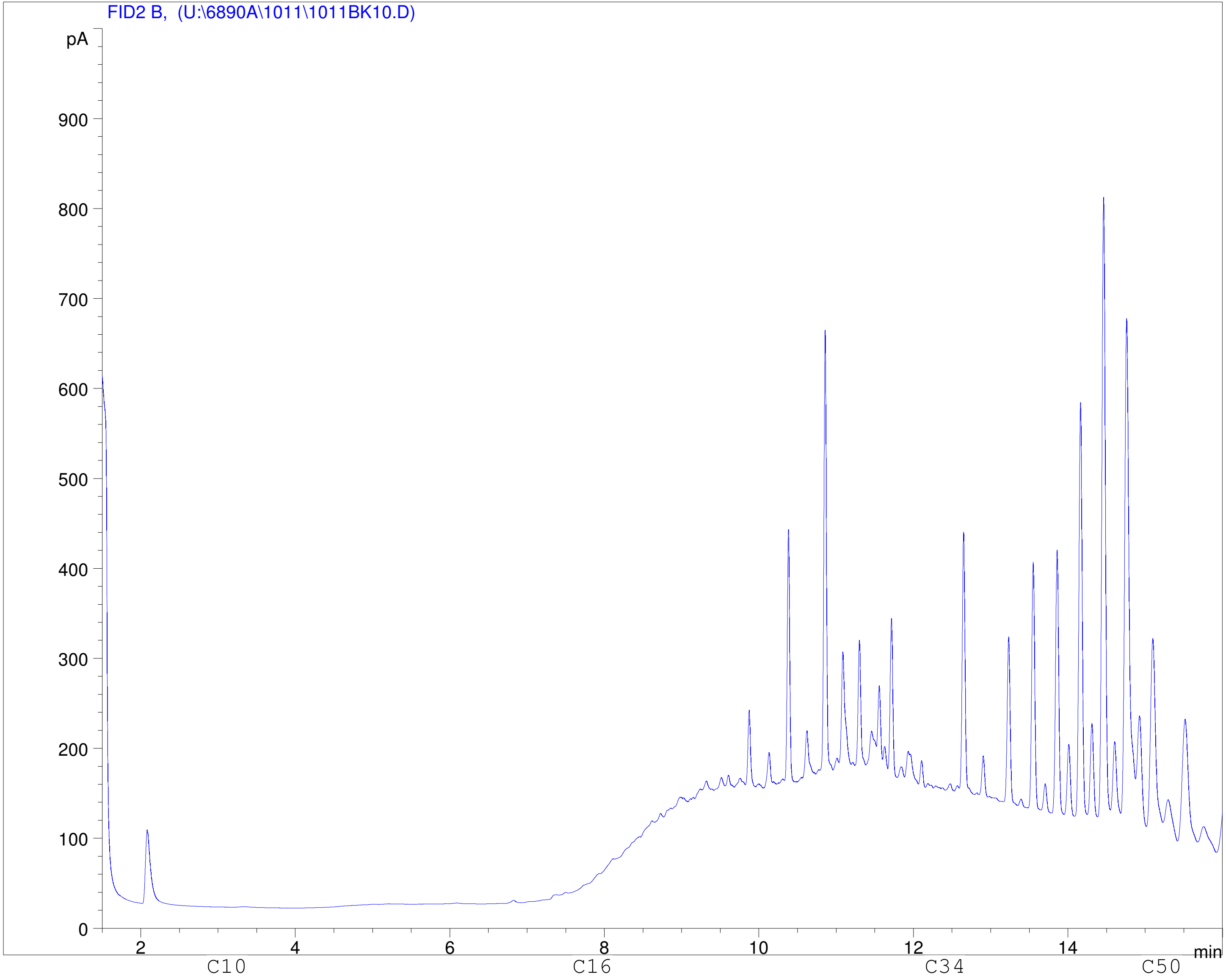
	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	43.8	<0.56	<8.8
Sulphate (SO4)	21	43.8	0.44	9.2
Calcium (Ca)	17	43.8	0.87	7.6
Potassium (K)	7	43.8	0.18	3.0
Magnesium (Mg)	5	43.8	0.38	2.0
Sodium (Na)	4	43.8	0.16	1.6

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

Client ID: 204-LFH

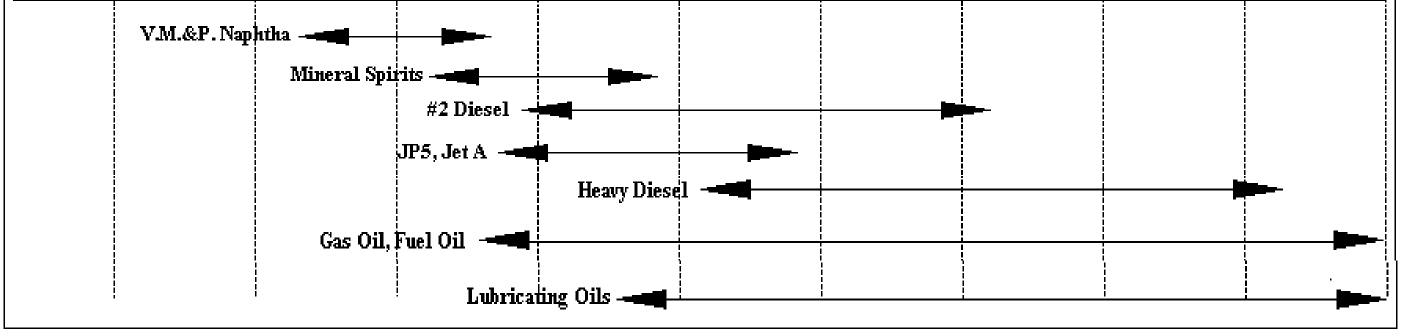
Sample ID: L437383-41 4 SG
Injection Date: 10/11/2006 9:15:20 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

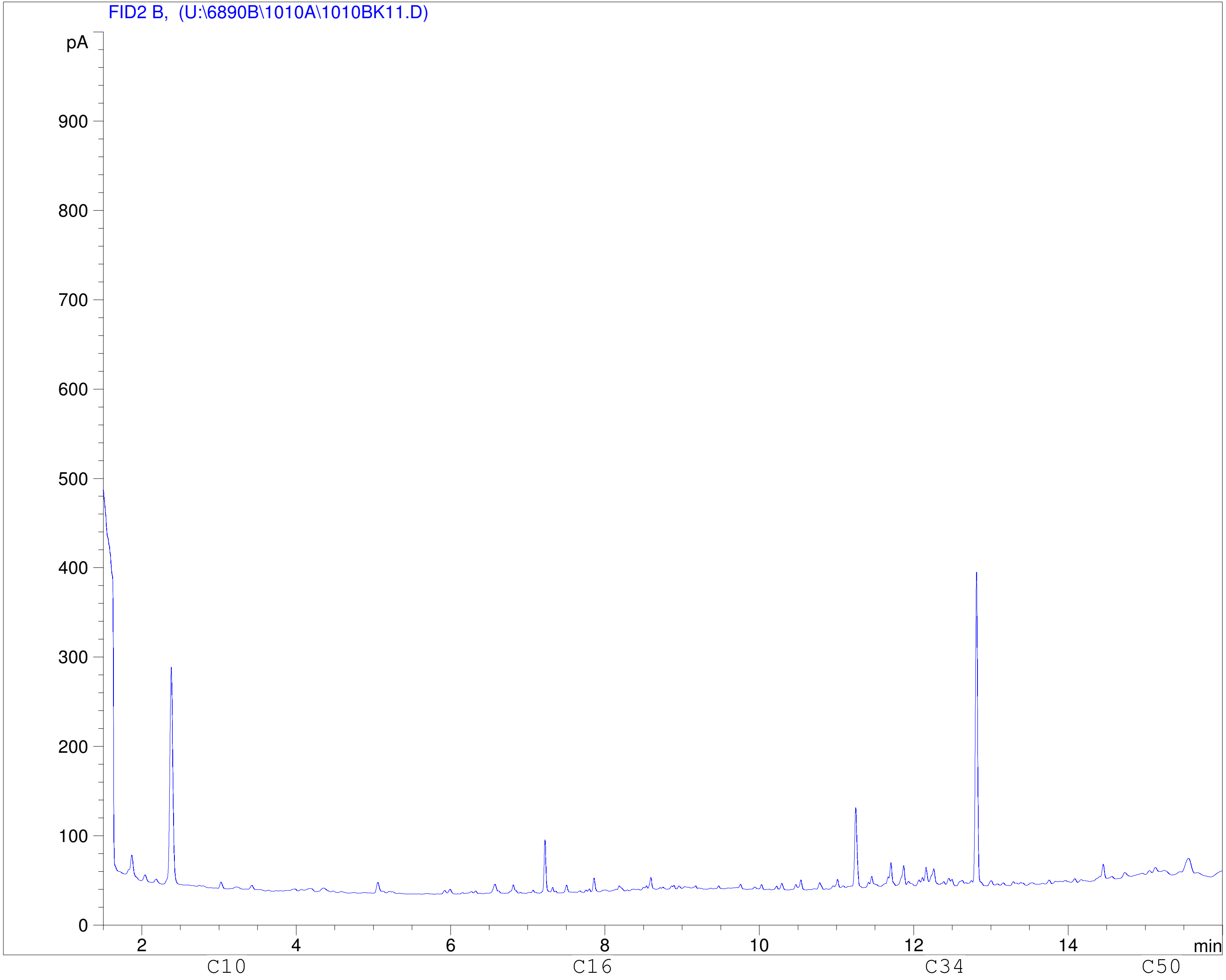


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 204-1

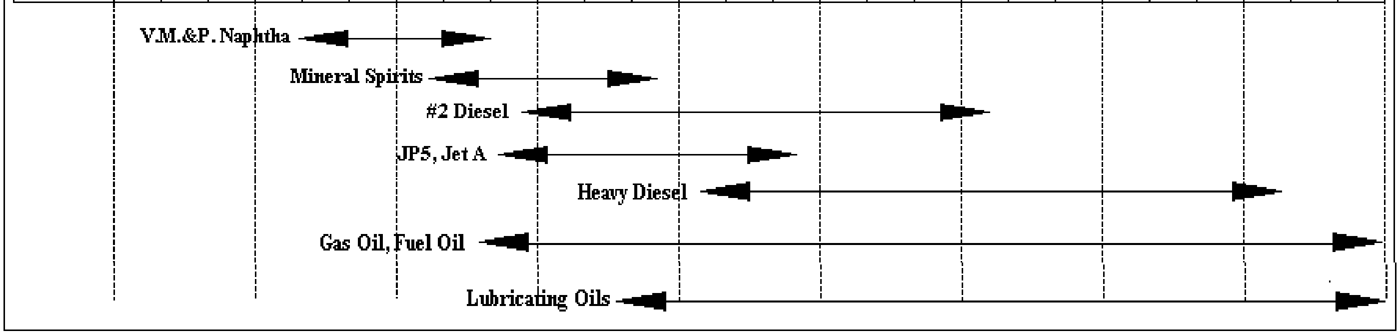
Sample ID: L437383-42 4
Injection Date: 10/10/06 10:50:11 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

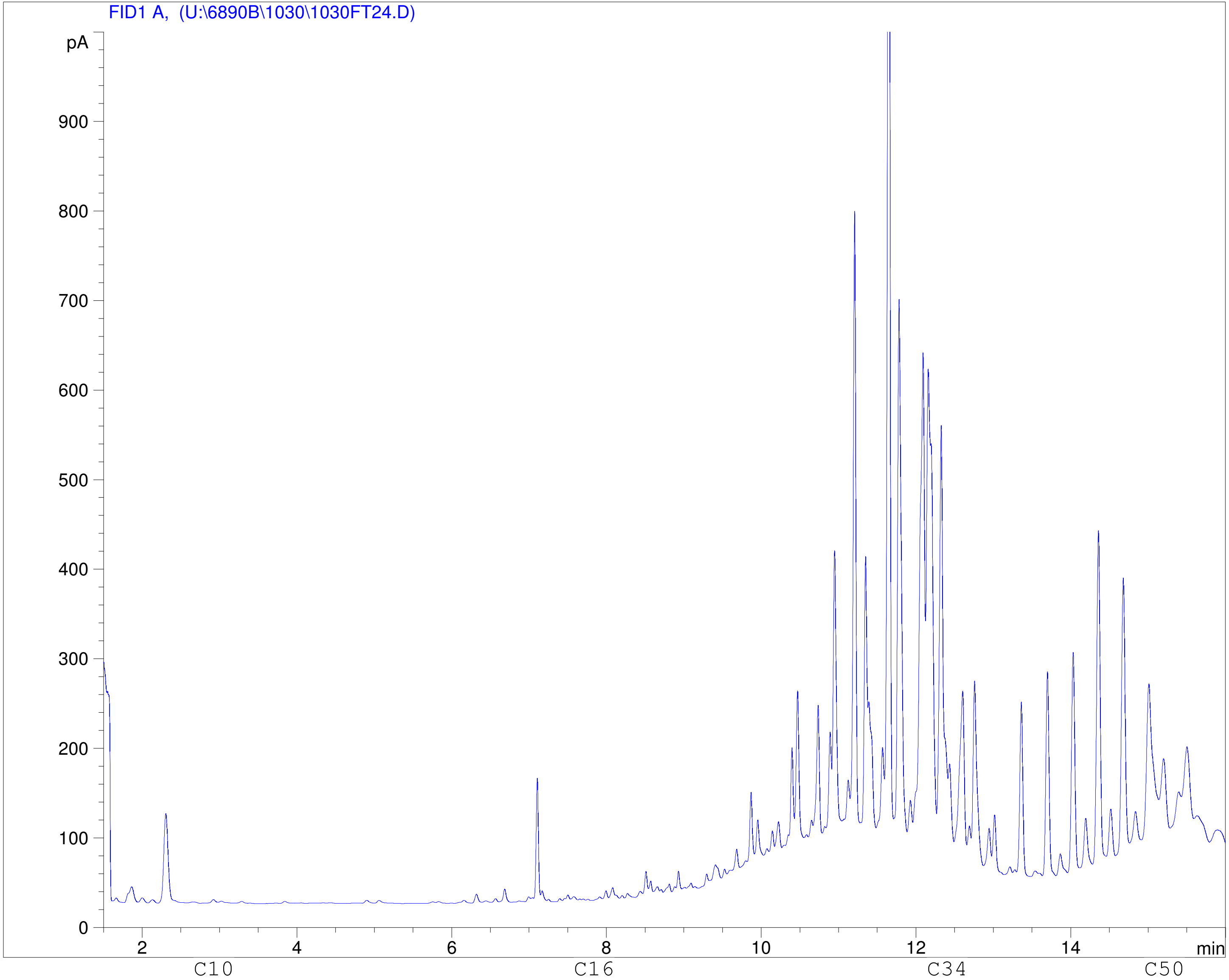


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 302-LFH

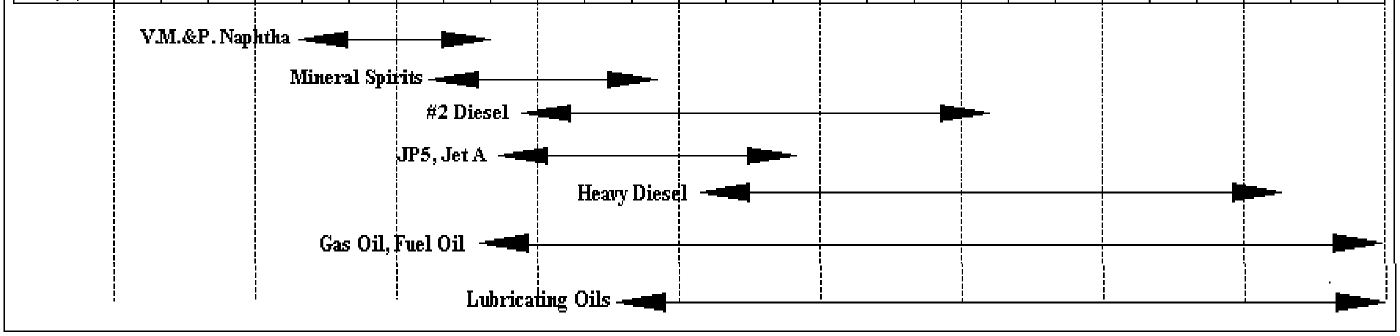
Sample ID: L437383-57 SGC 4
Injection Date: 10/31/06 4:35:33 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

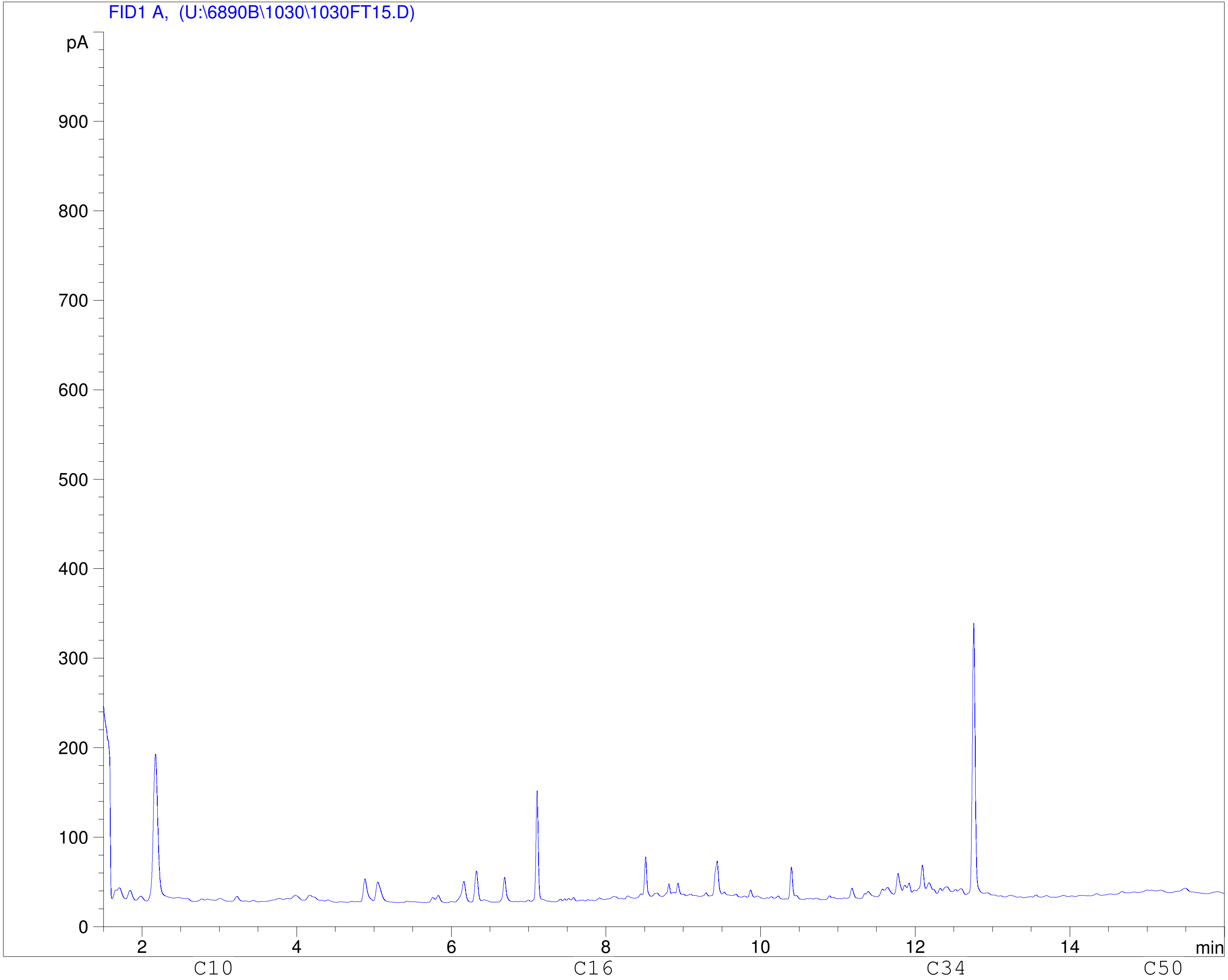


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 302-1

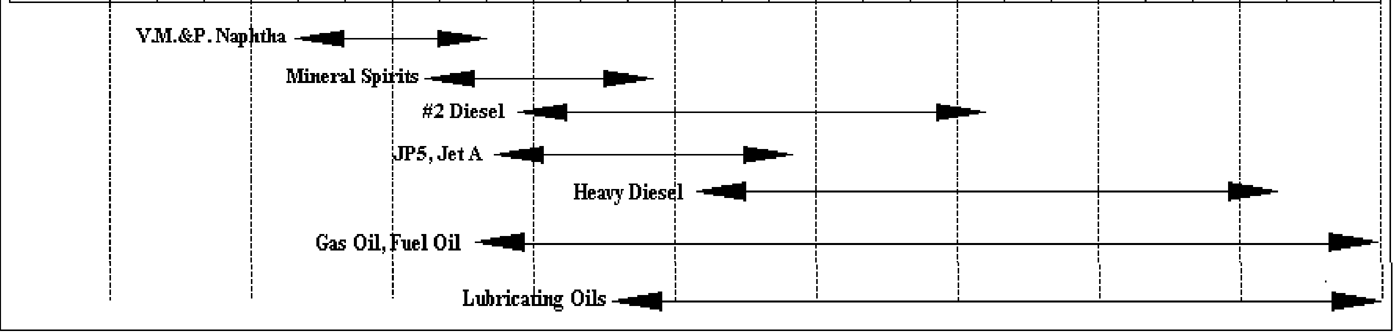
Sample ID: L437383-58 4
Injection Date: 10/30/06 12:31:43 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

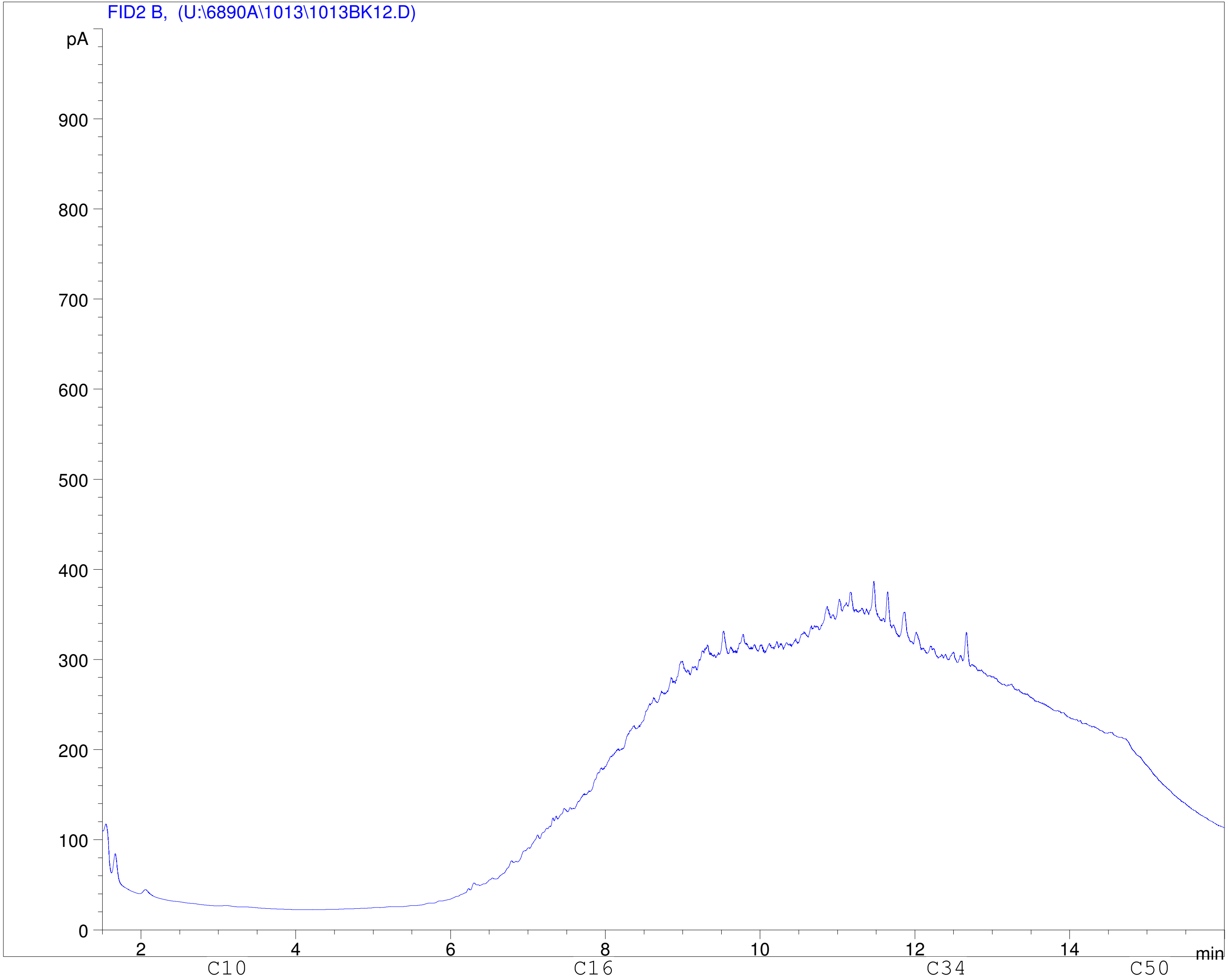


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 305-DM2

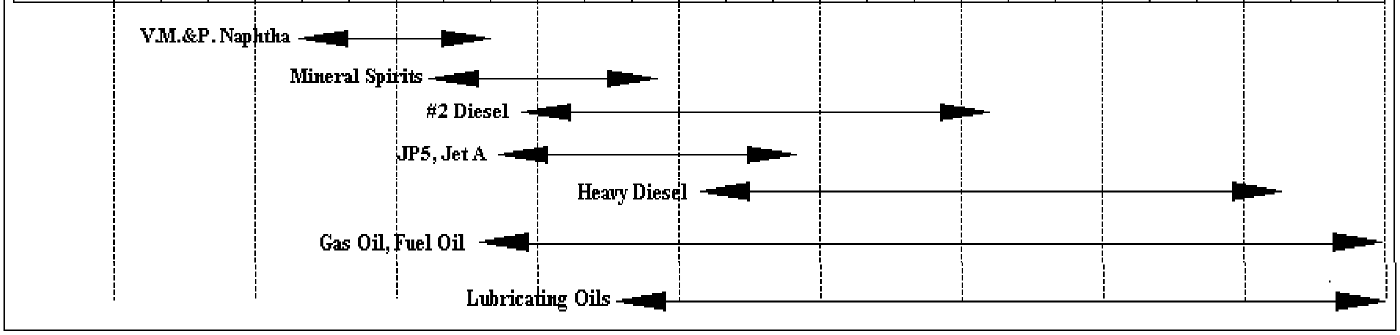
Sample ID: L437383-71 40
Injection Date: 10/13/2006 9:31:26 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

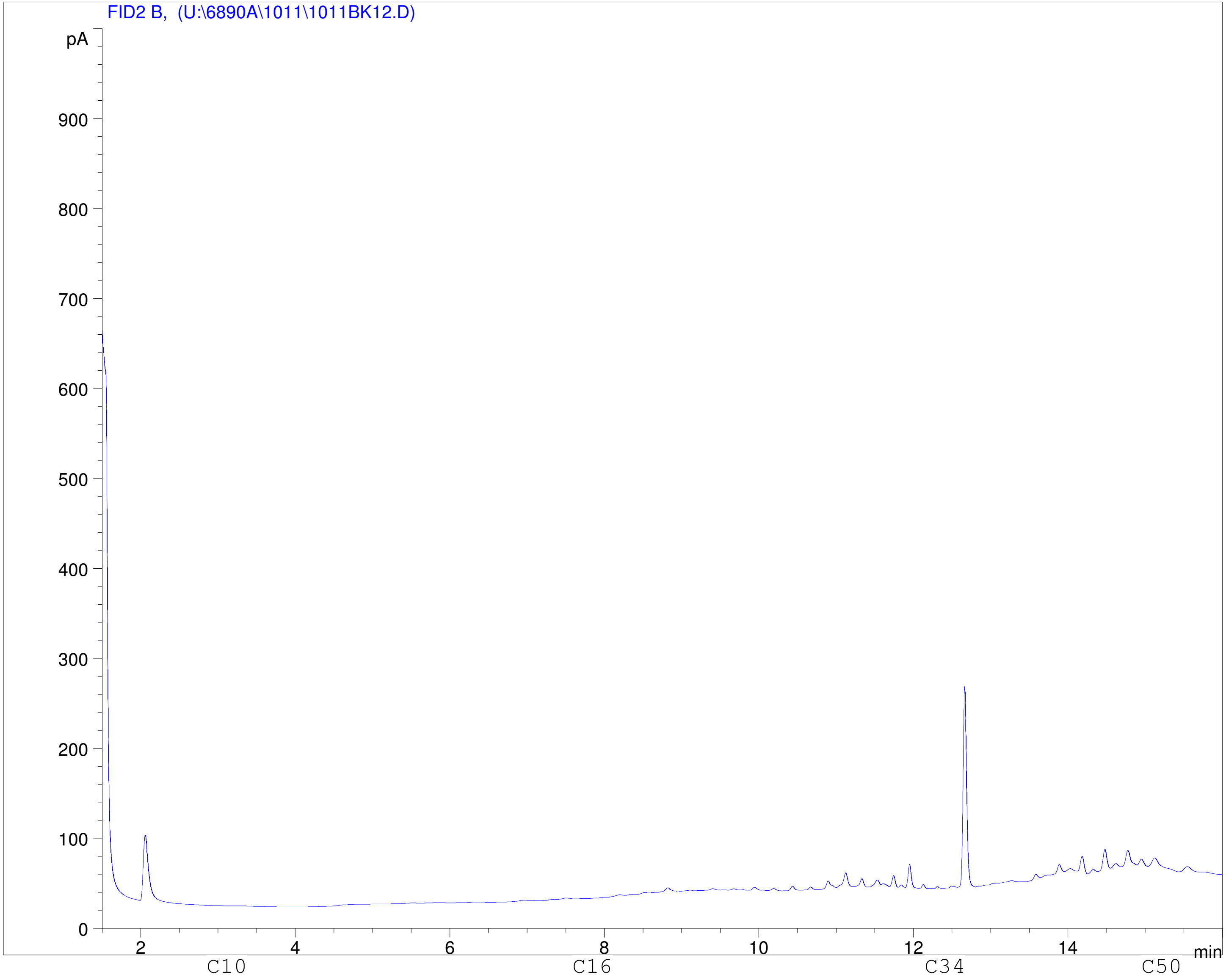


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 305 LFH

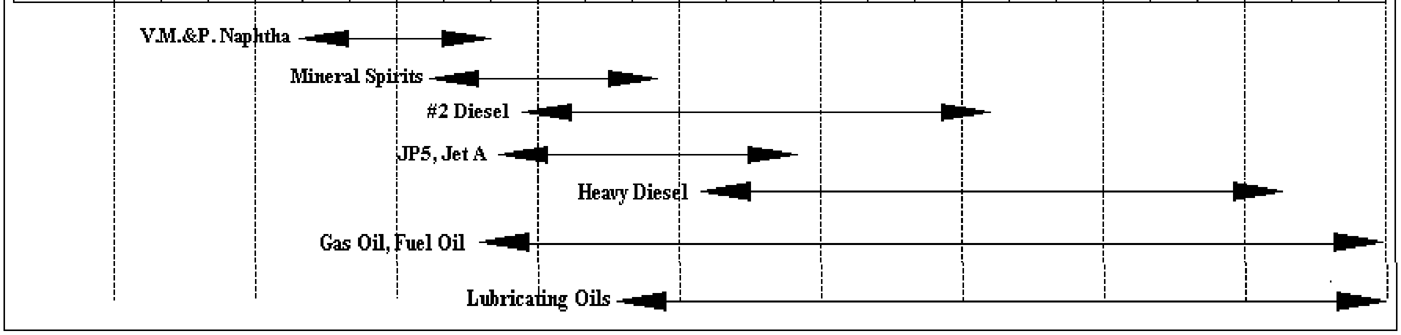
Sample ID: L437383-72 4 SG
Injection Date: 10/11/2006 10:05:08 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

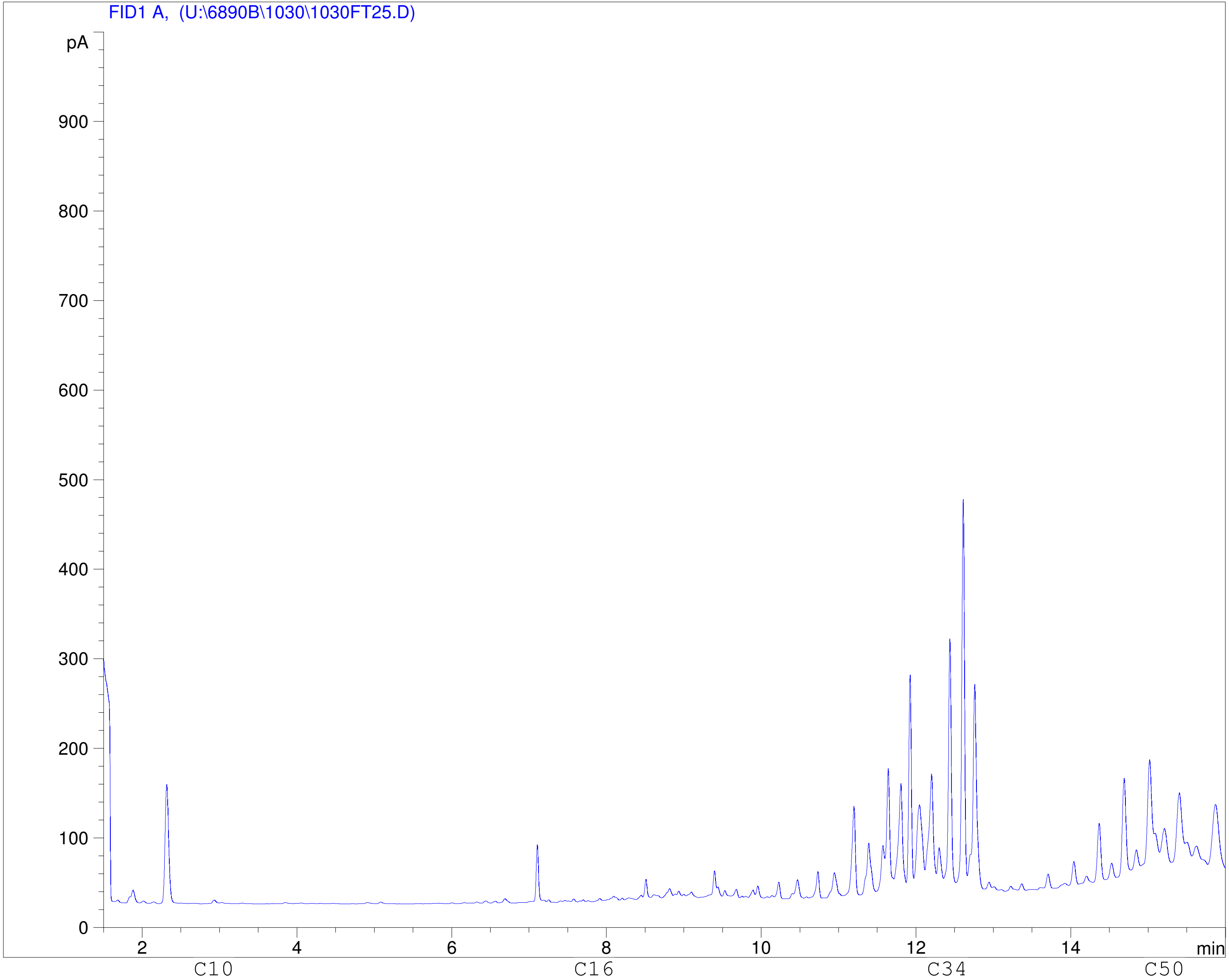


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 103-LFH

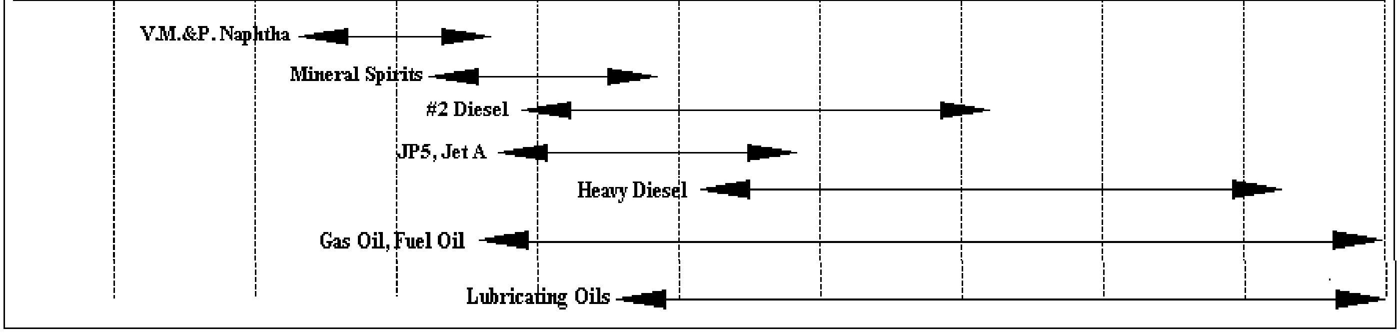
Sample ID: L437383-81 SGC 4
Injection Date: 10/31/06 5:02:43 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

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Client ID:              103-1

Sample ID:              L437383-82 4
Injection Date:         10/29/2006 11:13:22 AM
Instrument:             6890
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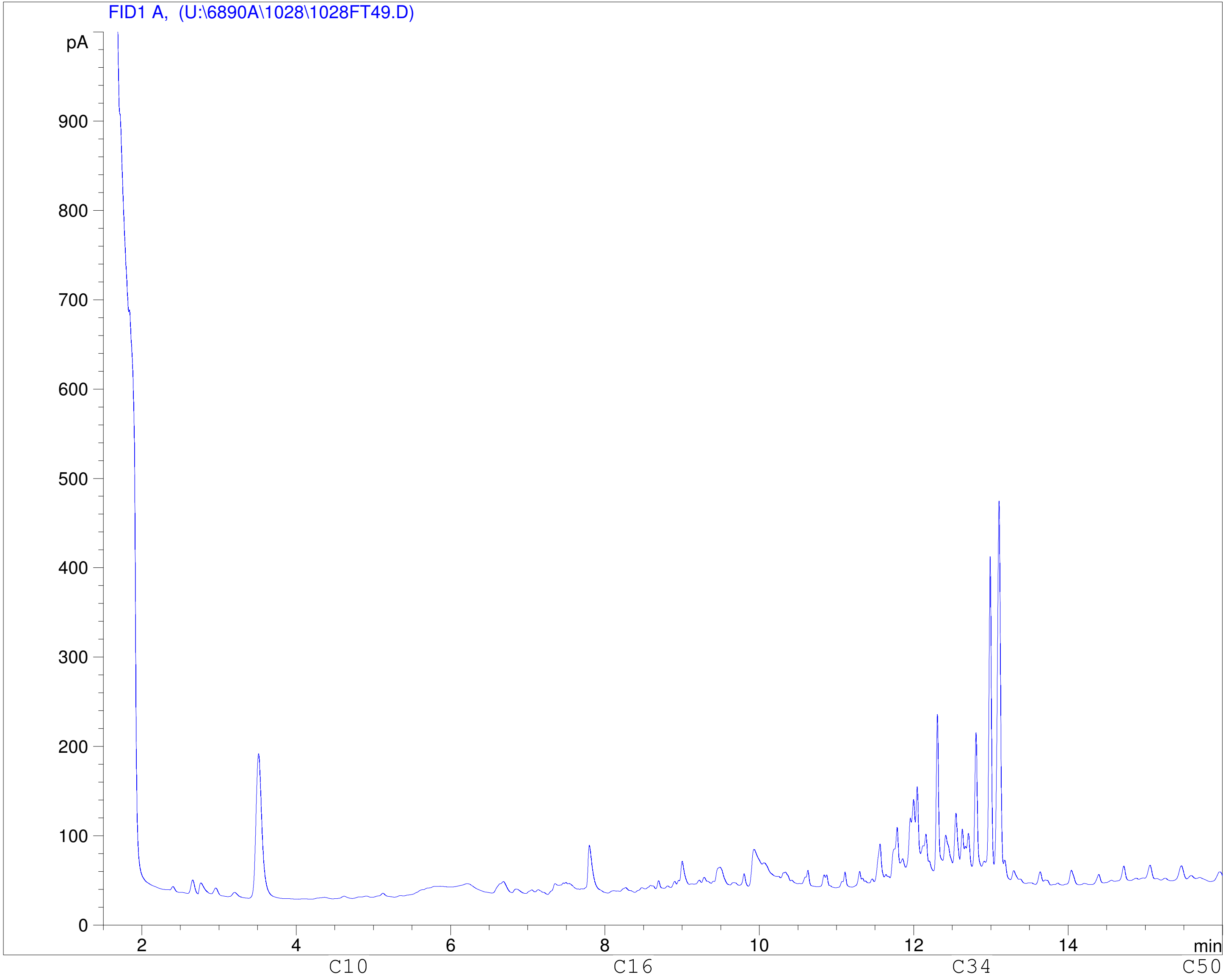
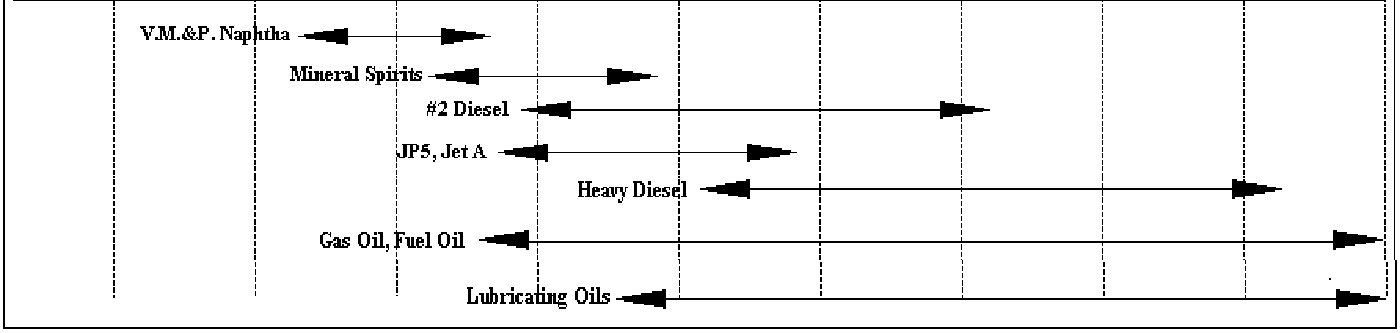
Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

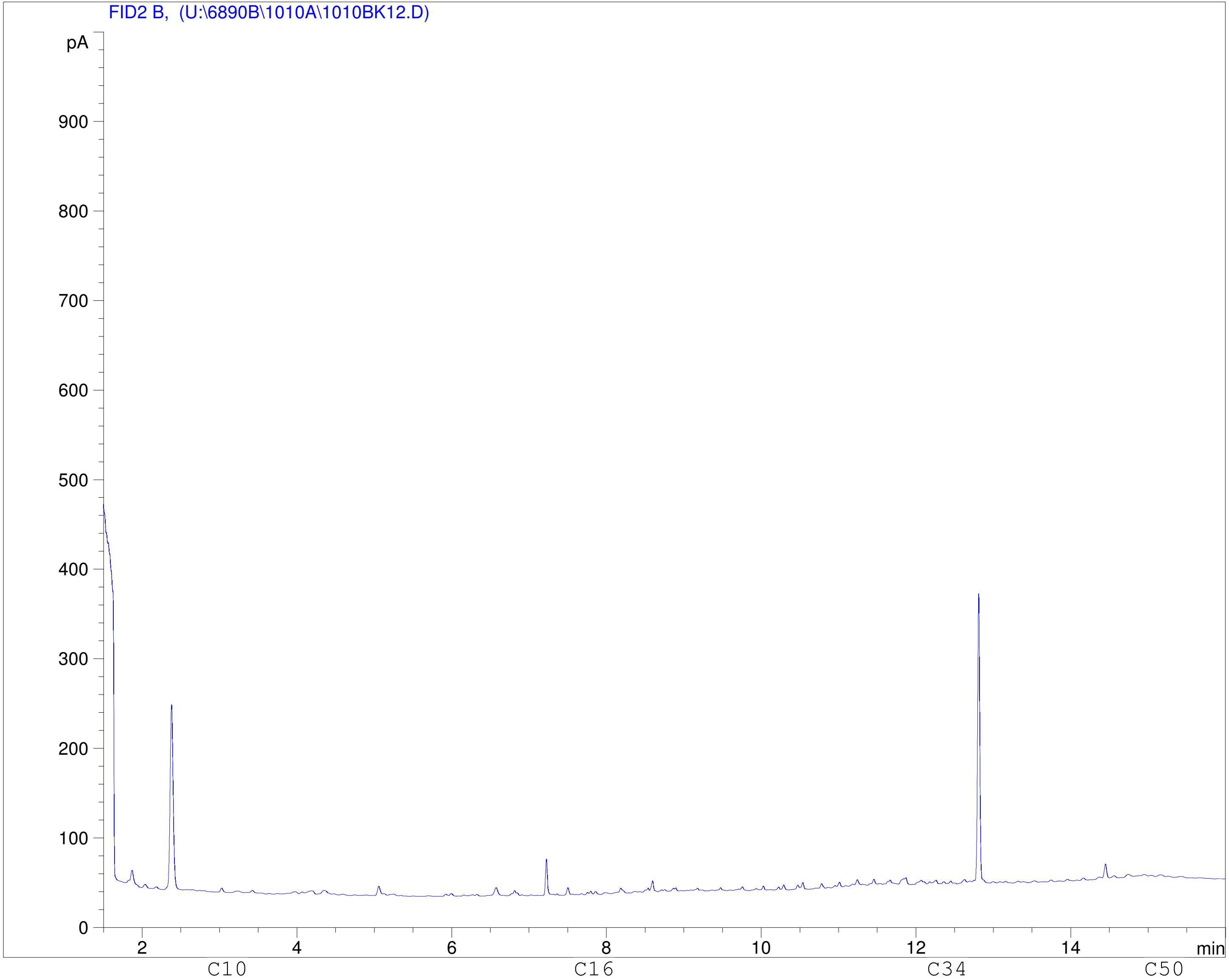


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 305-1

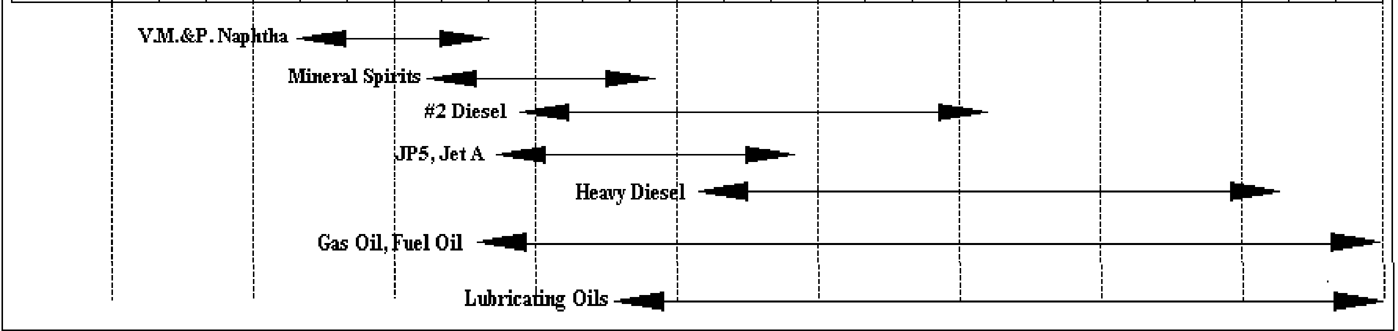
Sample ID: L437383-97 4
Injection Date: 10/10/06 11:17:09 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

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CONTACT: Ryan Muir
ADDRESS: #204 4207 98st Edmonton
T6E 5R7
PHONE: 496 9048 FAX: 496 9049
CELLPHONE:
INVOICE TO: SAME [✓ Y] / N
COMPANY:
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ADDRESS:
PHONE: FAX:

DATE: Sept 28
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1: rmuir@mems.ca.
EMAIL 2: gwoymarowich@mems.ca
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LAB WORK ORDER #: L437383

☒ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	HOLD										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
1-LFH					↓											3		
1-1																↓		
1-2																		
1-3																		
2-LFH																		
2-1																		
2-2																		
2-3																		
3-LFH																		
3-1																		
3-2																		
3-3																		

-Every Sample has two jars and 1 bag.

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L437383

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY · DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	HOLD										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
4-LEH																3		
4-1																		
4-2																		
4-3																		
5-LEH																		
5-1																		
5-2																		
5-3																		
6-LEH																		
6-1																		
6-2																		
6-3																		

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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CONTACT:	
ADDRESS:	
PHONE:	FAX:

DATE:

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PO/AFE:

LSD:

QUOTE #

LAB WORK ORDER # L437383

☒ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
200-LFH								
200-1								
200-2								
200-3								
201-LFH								
201-1								
201-2								
201-3								
202-LFH								
202-1								
202-2								
202-3								

HOLD.

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☐ AMBIENT

MEAN TEMPERATURE

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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EMAIL 1:
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JOB # D4-101
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L 437383

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
203-LFH								
203-1								
203-2								
203-3								
204-LFH								
204-1								
204-2								
204-3								
205-LFH								
205-1								
205-2								
205-3.								

HOLD

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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LAB WORK ORDER # L437383

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JOB # 04-101
PO/AFE:
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
300 LFH									
300-1									
300-2									
300-3									
301 LFH									
301-1									
301-2									
301-3									
302 LFH									
302-1									
302-2									
302-3									

HOLD all

☐ FROZEN
☐ COLD
☐ AMBIENT
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RELINQUISHED BY:
DATE & TIME
RECEIVED BY
DATE & TIME
RELINQUISHED BY:
DATE & TIME
RECEIVED BY
DATE & TIME
SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)

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JOB #
PO/AFE:
LSD.
QUOTE #

LAB WORK ORDER # L 437383

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
303 LFH																		
303-1																		
303-2																		
303-3																		
304 DM					HOLD													
304 LFH																		
304-1																		
304-2																		
304-3																		
305 DM1																		
305 DM2																		
305 LFH																		

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L 437383

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	Hold										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
101-LFH																3		
101-1																		
101-2																		
101-3																		
102-LFH																		
102-1																		
102-2																		
102-3																		
103-LFH																		
103-1																		
103-2																		
103-3																		

☐ FROZEN
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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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JOB # 04-101
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L 437383

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	Hold	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
104-DM							3		
-LFH									
-1									
-2									
-3									
105-DM									
-LFH									
-1									
-2									
-3									
106-DM									
-LFH									

☐ FROZEN
☐ COLD
☐ AMBIENT

MEAN TEMPERATURE

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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JOB # 04-101
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L437383.

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	Hold										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
305-1					✓											3		
106-1					✓											3		
106-2					✓											3		
106-3					✓											3		

☐ FROZEN
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MEAN TEMPERATURE

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY

GENF04 01

Norma Jestin

From: Karen Huebner
Sent: Friday, October 06, 2006 12:47 PM
To: Norma Jestin; Joanne Ringuette
Subject: Additionals for Millennium Files

Hello,

Please add the following

He needs TCLP NAP (will have to code as a water with a prep) Acids to all samples which had Nap Acid requested. As well client needs the DM samples for the corresponding IDs (ie 305,308,310,107,109) analysed for BTX F1-F4,detailed salinity, CCME metals, PAHs, Naphthenic acids and **TCLP Nap Acids** Original email is below. Additionals are in in **BOLD**

305-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437383-72 Add TCLP Nap Acids**
305-1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437383-97 Add TCLP Nap Acids**
305-DM2 BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437383-71

308-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-119 no jars - can't add TCLP Nap Acids**
308-1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-11 Add TCLP Nap Acids**
308-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-10

310-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's L437987-18 **TCLP Nap Acids L437987-18**
310 -1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **TCLP Nap Acids L437987-19**
310-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-18

107-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-62 TCLP Nap Acids**
107 -1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-63 TCLP Nap Acids**
107-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-61

109-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-72 TCLP Nap Acids**
109-1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-73 TCLP Nap Acids**
109-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-71

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Oct 10/06

www.alsenviro.com

Norma Jestin

From: Karen Huebner
Sent: Thursday, October 26, 2006 3:53 PM
To: Tanya Anthony; Dale Lucyk; Urszula Krzesinski
Cc: Patrick Corbiell; Lisa Schenk-Watt; Norma Jestin
Subject: L437383 Additonal TCLP Nap Acids
Importance: High

TCLP NAP Acids added to L437383-70 (sample was on HOLD) Priority TAT - Due Monday

Dale - There is a YELLOW DOT to leach the sample with water not the acetic acid as the acid didn't work. Patrick suggested using water to produce a rough TCLP result
**************YELLOW DOT****************
Sample to be leached with water not acetic acid as per the client
****

Thanks
Karen

Karen Huebner
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From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Thursday, October 26, 2006 3:32 PM
To: Karen Huebner
Subject: NAPTH acid 04-101

Karen,

I see that for sample number 305 I have a DM1 and a DM2, please run the leachable TCLP-NAPTH on which ever one is on hold, I believe that we analyzed one of the two. Priority TAT please.

Thanks.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
CELL:780-991-4616

through the ALS North America gateway.

Norma Jestin

From: Karen Huebner
Sent: Wednesday, October 25, 2006 4:33 PM
To: Norma Jestin; Joanne Ringuette
Subject: FW: 04-101

Please add BTX F1-F4 to the following samples. REg TAT

L437383-81,-82,-57,-58
L438781-35 and -36

Thanks
Karen

Karen Huebner
Senior Account Manager
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Oct 26/06

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Wednesday, October 25, 2006 10:58 AM
To: Karen Huebner
Subject: 04-101

Karen,

Can we please add the following samples to have BTEX F1-F4 analyzed;

D103-LFH;
D103-1;
302-LFH;
302-1;
323-LFH; and
323-1.

Regular TAT.

Thanks.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
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****

L439526 L437987
L438781 L437383

Additional Analysis Requests for Millennium EMS project No. 04-101, requested Nov 2, 2006
Samples submitted Sept 27, 28 & 29, 2006
For Questions, contact Callie Volf (780-496-9048 ext.259, cvolf@mems.ca)

Sample Name	SAL-Detail	PSA-MUST	BTX,TVH, TEH-CCME	
4-LFH	X			L437383-13
7-LFH	X			L437987-114
7-1	X			L437987-92
11-LFH	X			L437987-99
14-LFH	X			L439526-38
14-1	X			L439526-39
14-2	X			L439526-40
16-LFH	X			L439526-46
16-1	X	X		L439526-47
16-2		X		L439526-48
19-LFH	X			L439526-58
20-LFH	X			L439526-62
20-1	X			L439526-63
21-LFH	X			L439526-66
103-LFH	X			L437383-81
103-1	X			L437383-82
* 107-1		X		L437987-63
* 109-1		X		L437987-72
114-LFH	X			L439526-70
116-1	X			L439526-77
116-2	X			L439526-78
124-LFH	X			L438781-24
124-1	X			L438781-25
204-LFH	X			L437383-41
208-LFH	X			L437987-47
213-LFH	X			L439526-108
217-LFH	X			L439526-124
218-LFH	X			L439526-128
222-LFH	X			L438781-5
302-LFH	X			L437383-57
302-1	X			L437383-58
* 305-1		X		L437383-97
308-2	X			L437987-12
313-LFH	X			L437987-28
318-LFH	X			L439526-14
318-1	X	X		L439526-15
318-2		X		L439526-16
323-LFH	X			L438781-35
323-1		X		L438781-36
325-1	X			L438781-44
326-1	X			L438781-48
327-1	X		X	L438781-51
327-2	X		X	L438781-52

Nov3/06

Norma Jestin

From: Karen Huebner
Sent: Friday, December 01, 2006 9:42 AM
To: Norma Jestin; Joanne Ringuette; Aimee Thompson; Michelle Eckert; Ian Bullecer
Cc: Sean Johnston
Subject: Additional SGC

Please add TEH-SGC to the following. Reg TAT.

Aimee/Michelle/Ian - Please make sure the coverpage comments are added when results are completed.
Thanks

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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Dec 1/06

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Thursday, November 30, 2006 2:26 PM
To: Karen Huebner
Subject: FW: Silica Column vs silica gel clean up 04-101

Karen,

Please run the Silica column clean up on the following samples, on regular TAT:

4-LFH L437383-13
107-DM L437987-61
107-LFH L437987-62
109-DM L437987-71
109-LFH L437987-72
308-1 L437987-11
310-LFH L437987-18
310-1 L437987-19
7-LFH L437987-114
9-LFH L437987-110
204-LFH L437383-41
208-LFH L437987-47
12-LFH L437987-103
12-1 L437987-104
13-LFH L439526-34
13-1 L439526-35
14-LFH L439526-38
14-1 L439526-39
16-LFH L439526-46
114-LFH L439526-70

114-1 L439526- 71 ✓
116 -1 L439526-77 ✓
313-LFH L437987-28 ✓
313-1 L437987-29 ✓
213-LFH L439526-108 ✓
314-LFH L439526-1 ✓
314-1 L439526-2 ✓
318-LFH L439526-14 ✓
319-LFH L439526-18 ✓
117-LFH L439526-80 ✓
215-LFH L437526-116 ✓
217-LFH L439526-124 ✓
218-LFH L439526-128 ✓
20-LFH L439526-62 ✓
120-LFH L439526-92 ✓
220-LFH L439526-136 ✓
222-LFH L438781-5 ✓
323-LFH L438781-35 ✓
323-1 L438781-36 ✓
DGW260-LFH L450940-1 ✓
DGW261-LFH L450940-5 ✓
DGW262-1 L450940- 9 ✓
DGW262-2 L450940-10 ?
DGW263-LFH. L450940-12 ✓

Thanks Karen. Can you also send me MEMS price for these, I just need to do some budgeting changes.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
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-----Original Message-----
From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:48 PM
To: Ian Terry; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Hi Ian,

No, as per Cory's instructions we no longer run the F4G unless it's requested. His email is below (sent Aug 30th). I have the original email if you need it forwarded.

Thanks
Karen

****

Please remove the F4G. We will request it when required. Thanks Cory

> -----Original Message-----
> **From:** Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
> **Sent:** Thursday, August 24, 2006 8:46 AM
> **To:** Cory Sommer
> **Subject:** RE: L421098 addtional lab data requests

Hi Cory,

No problem, we don't have a BH06-24 @3.0M but we do have a BH06-24 @3.5M. I'll have the metals and salinity added to this sample instead.
Millennium is set up so that if the chrom does not return to baseline at C50 we automatically add the F4G. Technically you are obligated to report the F4G if the chrom does not return to baseline. If you Millennium no longer wants this then I can remove it but I need something in writing.

I found the following email from Ian, he never did get back to me on if the automatic F4G should be removed.
Thanks
Karen
****

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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From: Ian Terry [mailto:ITerry@mems.ca]
Sent: Thursday, November 30, 2006 1:39 PM
To: Karen Huebner; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Are you using the in-situ method then for samples that we submit?

Regards,

Ian

From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:00 PM
To: Ian Terry; Ryan Muri
Subject: Silica Column vs silica gel clean up

Please see below - this might clear things up a bit.

The CCME method makes silica gel cleanup mandatory for the F2-F4 fractions, but allows for two options: a simple in situ shake in which silica gel is added to a large solvent volume and shaken, or a column, in which a small volume of concentrated extract is passed through a glass column filled with packed silica gel. The column cleanup is much more intensive; in fact, it will remove some parts of petroleum hydrocarbons. The in situ cleanup. on the other hand, is less effective and will not remove high levels of naturally occurring hydrocarbons.

The F4G is a gravimetric measurement designed to account for hydrocarbons in and above the F4 range. Gas chromatograph response falls off dramatically above C50, so heavy hydrocarbons might not be accounted for in

the GC F2-F4 analysis. The CCME method allows F4G to be done on either a raw or a silica cleaned extract; we analyze only on a silica gel cleaned extract (F4G-SG), in order to be comparable to the F2-F4 results. The oven-dried gravimetric F4G result is highly variable, though, and can include significant portions of both the F4 and even the F3 hydrocarbons (the method requires the F4G to be dried at 110 degrees C, and the hydrocarbons in the F3 range typically have boiling points in the 250-300 degree C range or above). For this reason, the F4G can at times be surprisingly high.

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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PRELIMINARY RESULTS

MILLENNIUM
ATTN: RYAN MURI/GRANT WOYNAROWICH

208-4207 98 STREET

EDMONTON AB T6E 5R7

Reported On: 07-DEC-06 02:53 PM
Revision: 4

Lab Work Order #: **L437987**

Date Received: **28-SEP-06**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 283302, 283303, 283304, 283305, 283306, 283307, 283308, 283309, 283334, 283499

Other Information:

Comments: ADDITIONAL 07-DEC-06 09:15 ADDITIONAL 01-DEC-06 10:32 ADDITIONAL 03-NOV-06 13:52 A silica gel column clean up was done on TEH-CCME-ED F2-F4 samples L437987-11,18,19,28,29,47,62,72,103,104,110,114.

Silica gel column cleanup results reported for F2-F4 for fractions 61,71, 07-Dec-06.

ROY JONES
General Manager, Edmonton

For any questions about this report please contact your Account Manager:

KAREN HUEBNER

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-10	308-DM								
Sampled By:	NOT PROVIDED								
Matrix:	SOIL								
CCME BTEX, TVHs and TEHs									
CCME BTEX									
	Benzene	<0.005		0.005	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982
	Toluene	0.01		0.01	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982
	Ethylbenzene	<0.01		0.01	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982
	Xylenes	<0.01		0.01	mg/kg	12-OCT-06	15-OCT-06	CTL	R453982
CCME Total Extractable Hydrocarbons									
	Prep/Analysis Dates					13-OCT-06	13-OCT-06	AAT	R453359
CCME Total Hydrocarbons									
	F1 (C6-C10)	<5	IPT	5	mg/kg		16-OCT-06		
	F1-BTEX	<5		5	mg/kg		16-OCT-06		
	F2 (C10-C16)	1200		5	mg/kg		16-OCT-06		
	F2-Naphth	1200		5	mg/kg		16-OCT-06		
	F3 (C16-C34)	14000		5	mg/kg		16-OCT-06		
	F3-PAH	14000		5	mg/kg		16-OCT-06		
	F4 (C34-C50)	7800		5	mg/kg		16-OCT-06		
	Total Hydrocarbons (C6-C50)	23000		5	mg/kg		16-OCT-06		
	Chromatogram to baseline at nC50	NO					16-OCT-06		
	% Moisture	13		0.1	%		12-OCT-06	JOM	R452862
CCME PAHs									
	Naphthalene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Quinoline	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Phenanthrene	0.4		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Pyrene	0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Benzo(a)anthracene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Benzo(b)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Benzo(k)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Benzo(a)pyrene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Indeno(1,2,3-cd)pyrene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
	Dibenzo(a,h)anthracene	<0.2		0.2	mg/kg	13-OCT-06	15-OCT-06	JME	R453454
Surr:	Nitrobenzene d5	0	SDO:RNA	18-135	%	13-OCT-06	15-OCT-06	JME	R453454
Surr:	2-Fluorobiphenyl	0	SDO:RNA	30-134	%	13-OCT-06	15-OCT-06	JME	R453454
Surr:	p-Terphenyl d14	74		47-146	%	13-OCT-06	15-OCT-06	JME	R453454
Note: PAH detection limit raised due to matrix interference.									
Metals in Soil - CCME List									
	Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Arsenic (As)	4.4		0.2	mg/kg		13-OCT-06	JGP	R453215
	Barium (Ba)	245		5	mg/kg		13-OCT-06	JGP	R453215
	Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
	Cobalt (Co)	7		1	mg/kg		13-OCT-06	JGP	R453215
	Chromium (Cr)	22.4		0.5	mg/kg		13-OCT-06	JGP	R453215
	Copper (Cu)	12		2	mg/kg		13-OCT-06	JGP	R453215
	Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
	Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Nickel (Ni)	25		2	mg/kg		13-OCT-06	JGP	R453215
	Lead (Pb)	7		5	mg/kg		13-OCT-06	JGP	R453215
	Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
	Selenium (Se)	0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
	Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
	Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-10	308-DM								
Sampled By:	NOT PROVIDED								
Matrix:	SOIL								
Metals in Soil - CCME List									
	Vanadium (V)	23		1	mg/kg		13-OCT-06	JGP	R453215
	Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Detailed Salinity									
	Chloride (Cl)	60		20	mg/L		13-OCT-06	EOC	R453087
SAR									
	Calcium (Ca)	78		5	mg/L		13-OCT-06	JWU	R452937
	Potassium (K)	13		2	mg/L		13-OCT-06	JWU	R452937
	Magnesium (Mg)	17		3	mg/L		13-OCT-06	JWU	R452937
	Sodium (Na)	770		2	mg/L		13-OCT-06	JWU	R452937
	SAR	20.5			SAR		13-OCT-06	JWU	R452937
	Sulphate (SO4)	1600		6	mg/L		13-OCT-06	JWU	R452937
pH and EC (Saturated Paste)									
	% Saturation	50.8		0.1	%		13-OCT-06	SR	R452856
	pH in Saturated Paste	7.9		0.1	pH		13-OCT-06	SR	R452856
	Conductivity Sat. Paste	2.86		0.01	dS m-1		13-OCT-06	SR	R452856
L437987-11	308-1								
Sampled By:	NOT PROVIDED								
Matrix:	SOIL								
CCME BTEX, TVHs and TEHs									
CCME BTEX									
	Benzene	<0.1	DLHM	0.1	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
	Toluene	<0.2	DLHM	0.2	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
	Ethylbenzene	<0.2	DLHM	0.2	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
	Xylenes	<0.2	DLHM	0.2	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons									
Surr:	Hexatriacontane	143		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
	Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons									
	F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
	F1-BTEX	<5		5	mg/kg		15-OCT-06		
	F2 (C10-C16)	37		5	mg/kg		15-OCT-06		
	F2-Naphth	37		5	mg/kg		15-OCT-06		
	F3 (C16-C34)	1200		5	mg/kg		15-OCT-06		
	F3-PAH	1200		5	mg/kg		15-OCT-06		
	F4 (C34-C50)	830		5	mg/kg		15-OCT-06		
	Total Hydrocarbons (C6-C50)	2100		5	mg/kg		15-OCT-06		
	Chromatogram to baseline at nC50	NO					15-OCT-06		
	% Moisture	91		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs									
	Naphthalene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Quinoline	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Phenanthrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Pyrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Benzo(a)anthracene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Benzo(b)fluoranthene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Benzo(k)fluoranthene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Benzo(a)pyrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Indeno(1,2,3-cd)pyrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
	Dibenzo(a,h)anthracene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr:	Nitrobenzene d5	85		18-135	%	10-OCT-06	12-OCT-06	SH	R452437

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-11 308-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME PAHs								
Surr: 2-Fluorobiphenyl	99		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	105		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
Note: PAH detection limit raised due to high moisture content in sample.								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	0.8		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	27		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	1		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	2.7		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	3		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	5		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	5		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	20		10	mg/kg		13-OCT-06	JGP	R453215
Naphthenic Acids	600		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		11-OCT-06	EOC	R452092
SAR								
Calcium (Ca)	6		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	8		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	<3		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	137		2	mg/L		11-OCT-06	JWU	R452272
SAR	15.6	SAR:Q		SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	254		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	2070		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	5.8		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.57		0.01	dS m-1		11-OCT-06	SFC	R451857
L437987-12 308-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	9		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	4		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	4		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	56		2	mg/L		09-NOV-06	JWU	R463645
SAR	3.9		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	79		6	mg/L		09-NOV-06	JWU	R463645

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-12 308-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
% Saturation	2580		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.3		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.27		0.01	dS m-1		09-NOV-06	SZ	R463549
L437987-18 310-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.06	DLHM	0.06	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.06	DLHM	0.06	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.06	DLHM	0.06	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	209	SOL:MI	44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	88		5	mg/kg		15-OCT-06		
F2-Naphth	88		5	mg/kg		15-OCT-06		
F3 (C16-C34)	4300		5	mg/kg		15-OCT-06		
F3-PAH	4300		5	mg/kg		15-OCT-06		
F4 (C34-C50)	1900		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	6300		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	84		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs								
Naphthalene	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	0.07		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	0.04		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.03		0.03	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	102		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	99		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	105		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
Note: PAH detection limit raised due to high moisture content in sample.								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	3.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	67		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	4		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	7.0		0.5	mg/kg		13-OCT-06	JGP	R453215

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-18 310-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Metals in Soil - CCME List								
Copper (Cu)	10		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	11		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	6		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.3		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	17		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Naphthenic Acids	3900		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		11-OCT-06	EOC	R452092
SAR								
Calcium (Ca)	44		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	38		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	16		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	143		2	mg/L		11-OCT-06	JWU	R452272
SAR	4.7			SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	172		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	295		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	6.1		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.73		0.01	dS m-1		11-OCT-06	SFC	R451857
L437987-19 310-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.1	DLHM	0.1	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.1	DLHM	0.1	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.1	DLHM	0.1	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	140		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	24		5	mg/kg		15-OCT-06		
F2-Naphth	24		5	mg/kg		15-OCT-06		
F3 (C16-C34)	1300		5	mg/kg		15-OCT-06		
F3-PAH	1300		5	mg/kg		15-OCT-06		
F4 (C34-C50)	880		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	2200		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	91		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-19 310-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME PAHs								
Naphthalene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.04		0.04	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	104		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	104		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	108		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
Note: PAH detection limit raised due to high moisture content in sample.								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	1.5		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	35		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	2		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	7.7		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	4		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	7		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.3		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	9		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	30		10	mg/kg		13-OCT-06	JGP	R453215
Naphthenic Acids	410		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		11-OCT-06	EOC	R452092
SAR								
Calcium (Ca)	<5		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	7		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	<3		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	23		2	mg/L		11-OCT-06	JWU	R452272
SAR	Incalculable - Low Cations	SAR:INC		SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	32		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	1980		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	5.4		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.12		0.01	dS m-1		11-OCT-06	SFC	R451857

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-28 313-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.02	DLHM	0.02	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	184	SOL:MI	44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	97		5	mg/kg		15-OCT-06		
F3 (C16-C34)	2800		5	mg/kg		15-OCT-06		
F4 (C34-C50)	1200		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	4100		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	57		0.1	%		06-OCT-06	SDL	R450967
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	88		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	24		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	46		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	25		2	mg/L		09-NOV-06	JWU	R463645
SAR	0.5		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	240		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	317		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.1		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.67		0.01	dS m-1		09-NOV-06	SZ	R463549
L437987-29 313-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.1	DLHM	0.1	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.1	DLHM	0.1	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.1	DLHM	0.1	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	121		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	55		5	mg/kg		15-OCT-06		
F3 (C16-C34)	750		5	mg/kg		15-OCT-06		
F4 (C34-C50)	930		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	1700		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	91		0.1	%		06-OCT-06	SDL	R450967

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-29 313-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
L437987-47 208-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	38		33-172	%	10-OCT-06	11-OCT-06	GRB	R452690
Surr: Hexatriacontane	156		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	<5		5	mg/kg		17-OCT-06		
F2 (C10-C16)	63		5	mg/kg		17-OCT-06		
F3 (C16-C34)	1400		5	mg/kg		17-OCT-06		
F4 (C34-C50)	860		5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	2300		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	NO					17-OCT-06		
% Moisture	59		0.1	%		06-OCT-06	SDL	R450967
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	24		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	39		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	7		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	51		2	mg/L		08-NOV-06	JWU	R463269
SAR	2.4		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	49		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	712		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	5.7		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.35		0.01	dS m-1		08-NOV-06	SR	R463184
L437987-48 208-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.01	RAMB	0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	96		44-173	%	11-OCT-06	11-OCT-06	IJB	R452414
Prep/Analysis Dates					11-OCT-06	11-OCT-06	IJB	R452414
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		15-OCT-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-48 208-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F3 (C16-C34)	23	RAMB	5	mg/kg		15-OCT-06		
F4 (C34-C50)	7		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	30		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	4.9		0.1	%		06-OCT-06	SDL	R450967
L437987-61 107-DM								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
Toluene	0.01		0.01	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
Ethylbenzene	<0.01		0.01	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
Xylenes	<0.01		0.01	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	N/A	SDO:RNA		%	13-OCT-06	05-DEC-06	AAT	R473310
Surr: Hexatriacontane	N/A	SDO:RNA		%	13-OCT-06	05-DEC-06	AAT	R473310
Prep/Analysis Dates					13-OCT-06	05-DEC-06	AAT	R473310
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		07-DEC-06		
F1-BTEX	<5		5	mg/kg		07-DEC-06		
F2 (C10-C16)	720		5	mg/kg		07-DEC-06		
F2-Naphth	720		5	mg/kg		07-DEC-06		
F3 (C16-C34)	13000		5	mg/kg		07-DEC-06		
F3-PAH	13000		5	mg/kg		07-DEC-06		
F4 (C34-C50)	6500		5	mg/kg		07-DEC-06		
Total Hydrocarbons (C6-C50)	20000		5	mg/kg		07-DEC-06		
Chromatogram to baseline at nC50	NO					07-DEC-06		
% Moisture	15		0.1	%		12-OCT-06	JOM	R452862
CCME PAHs								
Naphthalene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Quinoline	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Phenanthrene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Pyrene	0.3		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Benzo(a)anthracene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Benzo(b)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Benzo(k)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Benzo(a)pyrene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Indeno(1,2,3-cd)pyrene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Dibenzo(a,h)anthracene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Surr: Nitrobenzene d5	0	SDO:RNA	18-135	%	13-OCT-06	16-OCT-06	JME	R453454
Surr: 2-Fluorobiphenyl	0	SDO:RNA	30-134	%	13-OCT-06	16-OCT-06	JME	R453454
Surr: p-Terphenyl d14	73		47-146	%	13-OCT-06	16-OCT-06	JME	R453454
Note: PAH detection limit raised due to matrix interference.								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	3.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	74		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-61 107-DM								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Metals in Soil - CCME List								
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	5		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	11.2		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	10		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	16		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	6		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.4		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	21		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		13-OCT-06	EOC	R453087
SAR								
Calcium (Ca)	28		5	mg/L		13-OCT-06	JWU	R452937
Potassium (K)	14		2	mg/L		13-OCT-06	JWU	R452937
Magnesium (Mg)	7		3	mg/L		13-OCT-06	JWU	R452937
Sodium (Na)	268		2	mg/L		13-OCT-06	JWU	R452937
SAR	11.9			SAR		13-OCT-06	JWU	R452937
Sulphate (SO4)	382		6	mg/L		13-OCT-06	JWU	R452937
pH and EC (Saturated Paste)								
% Saturation	45.9		0.1	%		13-OCT-06	SR	R452856
pH in Saturated Paste	7.8		0.1	pH		13-OCT-06	SR	R452856
Conductivity Sat. Paste	1.07		0.01	dS m-1		13-OCT-06	SR	R452856
L437987-62 107-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.04	DLHM	0.04	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	48		33-172	%	10-OCT-06	11-OCT-06	GRB	R452690
Surr: Hexatriacontane	184	SOL:MI	44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	19	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	19		5	mg/kg		17-OCT-06		
F2 (C10-C16)	170		5	mg/kg		17-OCT-06		
F2-Naphth	170		5	mg/kg		17-OCT-06		
F3 (C16-C34)	1500		5	mg/kg		17-OCT-06		
F3-PAH	1500		5	mg/kg		17-OCT-06		
F4 (C34-C50)	980		5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	2700		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	NO					17-OCT-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-62 107-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
% Moisture	68		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs								
Naphthalene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.1		0.1	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	107		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	95		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	103		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
Note: PAH detection limit raised due to matrix interference.								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	2.1		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	116		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	4		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	5.2		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	9		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	11		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	6		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.5		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	18		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Naphthenic Acids	2300		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		11-OCT-06	EOC	R452092
SAR								
Calcium (Ca)	55		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	60		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	12		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	180		2	mg/L		11-OCT-06	JWU	R452272
SAR	5.8			SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	220		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	576		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	5.8		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.84		0.01	dS m-1		11-OCT-06	SFC	R451857

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-63 107-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	0.03		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	83		33-172	%	11-OCT-06	11-OCT-06	IJB	R452414
Surr: Hexatriacontane	105		44-173	%	11-OCT-06	11-OCT-06	IJB	R452414
Prep/Analysis Dates					11-OCT-06	11-OCT-06	IJB	R452414
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	<5		5	mg/kg		17-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		17-OCT-06		
F2-Naphth	<5		5	mg/kg		17-OCT-06		
F3 (C16-C34)	27	RAMB	5	mg/kg		17-OCT-06		
F3-PAH	27		5	mg/kg		17-OCT-06		
F4 (C34-C50)	6		5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	33		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	NO					17-OCT-06		
% Moisture	11		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs								
Naphthalene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	102		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	101		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	106		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
MUST PSA % > 75um	28		1	%		07-NOV-06	NNK	R462870
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	3.4		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	65		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	4		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	9.2		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	3		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	5		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	7		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.3		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-63 107-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Metals in Soil - CCME List								
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	20		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	20		10	mg/kg		13-OCT-06	JGP	R453215
Naphthenic Acids	99		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		11-OCT-06	EOC	R452092
SAR								
Calcium (Ca)	34		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	4		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	8		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	41		2	mg/L		11-OCT-06	JWU	R452272
SAR	1.7			SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	129		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	25.9		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	5.1		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.32		0.01	dS m-1		11-OCT-06	SFC	R451857
L437987-71 109-DM								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
Toluene	0.02		0.01	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
Ethylbenzene	<0.01		0.01	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
Xylenes	2.0		0.01	mg/kg	12-OCT-06	16-OCT-06	DDU	R454336
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	68			%	13-OCT-06	05-DEC-06	AAT	R473310
Surr: Hexatriacontane	314	SOL:MI		%	13-OCT-06	05-DEC-06	AAT	R473310
Prep/Analysis Dates					13-OCT-06	05-DEC-06	AAT	R473310
CCME Total Hydrocarbons								
F1 (C6-C10)	110	IPT	5	mg/kg		07-DEC-06		
F1-BTEX	110		5	mg/kg		07-DEC-06		
F2 (C10-C16)	810		5	mg/kg		07-DEC-06		
F2-Naphth	810		5	mg/kg		07-DEC-06		
F3 (C16-C34)	11000		5	mg/kg		07-DEC-06		
F3-PAH	11000		5	mg/kg		07-DEC-06		
F4 (C34-C50)	4800		5	mg/kg		07-DEC-06		
Total Hydrocarbons (C6-C50)	17000		5	mg/kg		07-DEC-06		
Chromatogram to baseline at nC50	NO					07-DEC-06		
% Moisture	15		0.1	%		12-OCT-06	JOM	R452862
CCME PAHs								
Naphthalene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Quinoline	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Phenanthrene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Pyrene	0.3		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Benzo(a)anthracene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Benzo(b)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Benzo(k)fluoranthene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-71	109-DM								
Sampled By:	NOT PROVIDED								
Matrix:	SOIL								
CCME PAHs									
	Benzo(a)pyrene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
	Indeno(1,2,3-cd)pyrene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
	Dibenzo(a,h)anthracene	<0.2		0.2	mg/kg	13-OCT-06	16-OCT-06	JME	R453454
Surr:	Nitrobenzene d5	60		18-135	%	13-OCT-06	16-OCT-06	JME	R453454
Surr:	2-Fluorobiphenyl	63		30-134	%	13-OCT-06	16-OCT-06	JME	R453454
Surr:	p-Terphenyl d14	82		47-146	%	13-OCT-06	16-OCT-06	JME	R453454
Note: PAH detection limit raised due to matrix interference.									
Metals in Soil - CCME List									
	Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Arsenic (As)	3.6		0.2	mg/kg		13-OCT-06	JGP	R453215
	Barium (Ba)	664		5	mg/kg		13-OCT-06	JGP	R453215
	Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
	Cobalt (Co)	6		1	mg/kg		13-OCT-06	JGP	R453215
	Chromium (Cr)	10.6		0.5	mg/kg		13-OCT-06	JGP	R453215
	Copper (Cu)	12		2	mg/kg		13-OCT-06	JGP	R453215
	Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
	Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Nickel (Ni)	16		2	mg/kg		13-OCT-06	JGP	R453215
	Lead (Pb)	8		5	mg/kg		13-OCT-06	JGP	R453215
	Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
	Selenium (Se)	0.5		0.2	mg/kg		13-OCT-06	JGP	R453215
	Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
	Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
	Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
	Vanadium (V)	23		1	mg/kg		13-OCT-06	JGP	R453215
	Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Detailed Salinity									
	Chloride (Cl)	60		20	mg/L		13-OCT-06	EOC	R453087
SAR									
	Calcium (Ca)	75		5	mg/L		13-OCT-06	JWU	R452937
	Potassium (K)	10		2	mg/L		13-OCT-06	JWU	R452937
	Magnesium (Mg)	19		3	mg/L		13-OCT-06	JWU	R452937
	Sodium (Na)	292		2	mg/L		13-OCT-06	JWU	R452937
	SAR	7.8			SAR		13-OCT-06	JWU	R452937
	Sulphate (SO4)	429		6	mg/L		13-OCT-06	JWU	R452937
pH and EC (Saturated Paste)									
	% Saturation	48.8		0.1	%		13-OCT-06	SR	R452856
	pH in Saturated Paste	7.4		0.1	pH		13-OCT-06	SR	R452856
	Conductivity Sat. Paste	1.27		0.01	dS m-1		13-OCT-06	SR	R452856
L437987-72	109-LFH								
Sampled By:	NOT PROVIDED								
Matrix:	SOIL								
CCME BTEX, TVHs and TEHs									
CCME BTEX									
	Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
	Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
	Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
	Xylenes	0.41	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons									

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-72 109-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	143		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	18	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	18		5	mg/kg		17-OCT-06		
F2 (C10-C16)	46		5	mg/kg		17-OCT-06		
F2-Naphth	46		5	mg/kg		17-OCT-06		
F3 (C16-C34)	410		5	mg/kg		17-OCT-06		
F3-PAH	410		5	mg/kg		17-OCT-06		
F4 (C34-C50)	280		5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	750		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	NO					17-OCT-06		
% Moisture	69		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs								
Naphthalene	0.05		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	0.05		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	0.07		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	101		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	101		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	96		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	1.3		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	148		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	3		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	4.9		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	8		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	6		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	1.1		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	3		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	10		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Naphthenic Acids	2300		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		11-OCT-06	EOC	R452092

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-72 109-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
SAR								
Calcium (Ca)	68		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	12		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	31		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	105		2	mg/L		11-OCT-06	JWU	R452272
SAR	2.6			SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	194		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	375		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	6.4		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.69		0.01	dS m-1		11-OCT-06	SFC	R451857
L437987-73 109-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	100		44-173	%	11-OCT-06	11-OCT-06	IJB	R452414
Prep/Analysis Dates					11-OCT-06	11-OCT-06	IJB	R452414
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	<5		5	mg/kg		17-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		17-OCT-06		
F2-Naphth	<5		5	mg/kg		17-OCT-06		
F3 (C16-C34)	<5	RAMB	5	mg/kg		17-OCT-06		
F3-PAH	<5		5	mg/kg		17-OCT-06		
F4 (C34-C50)	<5		5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	<5		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	YES					17-OCT-06		
% Moisture	20		0.1	%		06-OCT-06	SDL	R450967
CCME PAHs								
Naphthalene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Quinoline	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Phenanthrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Benzo(a)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Indeno(1,2,3-cd)pyrene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Dibenzo(a,h)anthracene	<0.01		0.01	mg/kg	10-OCT-06	12-OCT-06	SH	R452437
Surr: Nitrobenzene d5	105		18-135	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: 2-Fluorobiphenyl	104		30-134	%	10-OCT-06	12-OCT-06	SH	R452437
Surr: p-Terphenyl d14	110		47-146	%	10-OCT-06	12-OCT-06	SH	R452437
MUST PSA % > 75um	19		1	%		09-NOV-06	NNK	R463714
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-73 109-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Metals in Soil - CCME List								
Arsenic (As)	6.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	143		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	7		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	22.0		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	6		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	13		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	10		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.4		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	40		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	40		10	mg/kg		13-OCT-06	JGP	R453215
Naphthenic Acids	56		5	mg/kg		13-OCT-06	DBP	R454659
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		11-OCT-06	EOC	R452092
SAR								
Calcium (Ca)	71		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	<2		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	25		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	55		2	mg/L		11-OCT-06	JWU	R452272
SAR	1.4			SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	185		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	38.7		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	7.4		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.53		0.01	dS m-1		11-OCT-06	SFC	R451857
L437987-92 7-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	12-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.01		0.01	mg/kg	12-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.01		0.01	mg/kg	12-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.01		0.01	mg/kg	12-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	104		33-172	%	13-OCT-06	13-OCT-06	AAT	R453359
Surr: Hexatriacontane	125		44-173	%	13-OCT-06	13-OCT-06	AAT	R453359
Prep/Analysis Dates					13-OCT-06	13-OCT-06	AAT	R453359
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		15-OCT-06		
F3 (C16-C34)	15		5	mg/kg		15-OCT-06		
F4 (C34-C50)	9		5	mg/kg		15-OCT-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-92 7-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
Total Hydrocarbons (C6-C50)	24		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	5.7		0.1	%		12-OCT-06	JOM	R452857
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	18		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	4		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	4		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	50		2	mg/L		08-NOV-06	JWU	R463269
SAR	2.7		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	99		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	26.4		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	4.9		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.29		0.01	dS m-1		08-NOV-06	SR	R463184
L437987-99 11-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	59		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	69		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	26		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	37		2	mg/L		09-NOV-06	JWU	R463645
SAR	1.0		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	95		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	905		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.0		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.60		0.01	dS m-1		09-NOV-06	SZ	R463549
L437987-103 12-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.01	DLHM	0.05	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.01	DLHM	0.05	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.01	DLHM	0.05	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	47		33-172	%	10-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	133		44-173	%	10-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					10-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	<5		5	mg/kg		17-OCT-06		
F2 (C10-C16)	57	IPC	5	mg/kg		17-OCT-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-103 12-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F3 (C16-C34)	2800	IPC	5	mg/kg		17-OCT-06		
F4 (C34-C50)	990	IPC	5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	3800		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	NO					17-OCT-06		
% Moisture	78		0.1	%		06-OCT-06	SDL	R450967
L437987-104 12-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.06	DLHM	0.06	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.06	DLHM	0.06	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.06	DLHM	0.06	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: Hexatriacontane	53		44-173	%	10-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					10-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	<5		5	mg/kg		17-OCT-06		
F2 (C10-C16)	40		5	mg/kg		17-OCT-06		
F3 (C16-C34)	260		5	mg/kg		17-OCT-06		
F4 (C34-C50)	360		5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	660		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	NO					17-OCT-06		
% Moisture	84		0.1	%		06-OCT-06	SDL	R450967
L437987-110 9-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
Toluene	0.03	DLHM	0.03	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
Xylenes	0.06	DLHM	0.03	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	120		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	228	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		16-OCT-06		
F1-BTEX	<5		5	mg/kg		16-OCT-06		
F2 (C10-C16)	59	IPC	5	mg/kg		16-OCT-06		
F3 (C16-C34)	1800	IPC	5	mg/kg		16-OCT-06		
F4 (C34-C50)	1200	IPC	5	mg/kg		16-OCT-06		
Total Hydrocarbons (C6-C50)	3100		5	mg/kg		16-OCT-06		
Chromatogram to baseline at nC50	NO					16-OCT-06		
% Moisture	46		0.1	%		06-OCT-06	SDL	R450967

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-111 9-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
Toluene	<0.01		0.01	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	15-OCT-06	DCD	R453984
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	117		33-172	%	11-OCT-06	11-OCT-06	MKE	R452564
Surr: Hexatriacontane	107		44-173	%	11-OCT-06	11-OCT-06	MKE	R452564
Prep/Analysis Dates					11-OCT-06	11-OCT-06	MKE	R452564
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		16-OCT-06		
F1-BTEX	<5		5	mg/kg		16-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		16-OCT-06		
F3 (C16-C34)	13	RAMB	5	mg/kg		16-OCT-06		
F4 (C34-C50)	<5		5	mg/kg		16-OCT-06		
Total Hydrocarbons (C6-C50)	13		5	mg/kg		16-OCT-06		
Chromatogram to baseline at nC50	YES					16-OCT-06		
% Moisture	4.2		0.1	%		06-OCT-06	SDL	R450967
L437987-114 7-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005	DLHM	0.02	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Toluene	<0.01	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Ethylbenzene	<0.01	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
Xylenes	<0.01	DLHM	0.03	mg/kg	06-OCT-06	14-OCT-06	IAU	R453466
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	157		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	778	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		17-OCT-06		
F1-BTEX	<5		5	mg/kg		17-OCT-06		
F2 (C10-C16)	360	IPC	5	mg/kg		17-OCT-06		
F3 (C16-C34)	10000	IPC	5	mg/kg		17-OCT-06		
F4 (C34-C50)	4800	IPC	5	mg/kg		17-OCT-06		
Total Hydrocarbons (C6-C50)	15000		5	mg/kg		17-OCT-06		
Chromatogram to baseline at nC50	NO					17-OCT-06		
% Moisture	47		0.1	%		06-OCT-06	SDL	R450967
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	59		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	65		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	15		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	136		2	mg/L		09-NOV-06	JWU	R463645
SAR	4.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	134		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	442		0.1	%		09-NOV-06	SZ	R463549

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L437987-114 7-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
pH in Saturated Paste	6.3		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.80		0.01	dS m-1		09-NOV-06	SZ	R463549
L437987-119 308-LF								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Arsenic (As)	1.5		0.2	mg/kg		13-OCT-06	JGP	R453215
Barium (Ba)	69		5	mg/kg		13-OCT-06	JGP	R453215
Beryllium (Be)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Cadmium (Cd)	<0.5		0.5	mg/kg		13-OCT-06	JGP	R453215
Cobalt (Co)	2		1	mg/kg		13-OCT-06	JGP	R453215
Chromium (Cr)	2.7		0.5	mg/kg		13-OCT-06	JGP	R453215
Copper (Cu)	5		2	mg/kg		13-OCT-06	JGP	R453215
Mercury (Hg)	<0.05		0.05	mg/kg		13-OCT-06	JGP	R453215
Molybdenum (Mo)	1		1	mg/kg		13-OCT-06	JGP	R453215
Nickel (Ni)	5		2	mg/kg		13-OCT-06	JGP	R453215
Lead (Pb)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Antimony (Sb)	<0.2		0.2	mg/kg		13-OCT-06	JGP	R453215
Selenium (Se)	0.4		0.2	mg/kg		13-OCT-06	JGP	R453215
Tin (Sn)	<5		5	mg/kg		13-OCT-06	JGP	R453215
Thallium (Tl)	<1		1	mg/kg		13-OCT-06	JGP	R453215
Uranium (U)	<2		2	mg/kg		13-OCT-06	JGP	R453215
Vanadium (V)	5		1	mg/kg		13-OCT-06	JGP	R453215
Zinc (Zn)	30		10	mg/kg		13-OCT-06	JGP	R453215
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		11-OCT-06	EOC	R452092
SAR								
Calcium (Ca)	31		5	mg/L		11-OCT-06	JWU	R452272
Potassium (K)	<2		2	mg/L		11-OCT-06	JWU	R452272
Magnesium (Mg)	11		3	mg/L		11-OCT-06	JWU	R452272
Sodium (Na)	20		2	mg/L		11-OCT-06	JWU	R452272
SAR	0.8			SAR		11-OCT-06	JWU	R452272
Sulphate (SO4)	51		6	mg/L		11-OCT-06	JWU	R452272
pH and EC (Saturated Paste)								
% Saturation	619		0.1	%		11-OCT-06	SFC	R451857
pH in Saturated Paste	5.9		0.1	pH		11-OCT-06	SFC	R451857
Conductivity Sat. Paste	0.19		0.01	dS m-1		11-OCT-06	SFC	R451857

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
DLHM	Detection Limit Adjusted: Sample has High Moisture Content
IPC	Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank
SAR:INC	SAR is incalculable due to Ca and Mg below detection limit.
SAR:Q	Qualified SAR value: actual SAR is lower but is incalculable due to Na, Ca or Mg below detection limit.
SDO:RNA	Surrogate diluted out:% recovery not available
SOL:MI	Surrogate recovery outside acceptable limits due to matrix interference

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
METAL-CCME-ED	Soil	Metals in Soil - CCME List	EPA 3050	EPA6020
NAPHTHENIC-ACID-FM	Soil	Naphthenic Acids by FTIR		Naphthenic Acids by FTIR,Syncrude,1994
PAH-CCME-ED	Soil	CCME PAHs	EPA 3540C	EPA 3540/8270-GC/MS
PREP-MOISTURE-ED	Soil	% Moisture		Oven dry 105C-Gravimetric
PSA-MUST-ED	Soil	MUST PSA D50 > 75um		ASTM D422-63-Hydrometer/Sieve
SAR-CALC-ED	Soil	SAR		CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)		CSSS 18.2, 16.2, 18.3
SO4-SAR-ED	Soil	Sulfate (SO4) in saturated paste		APHA 3120 B-ICP-OES

Reference Information

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

283302	283303	283304	283305	283306
283307	283308	283309	283334	283499

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA	FM	ALS LABORATORY GROUP - FORT MCMURRAY, ALBERTA, CANADA

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L437987

Lab ID Sample ID

L437987-10 308-DM
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	60	50.8	1.79	32.3
Sulphate (SO4)	1600	50.8	33.35	813.6
Calcium (Ca)	78	50.8	3.91	39.8
Potassium (K)	13	50.8	0.34	6.8
Magnesium (Mg	17	50.8	1.44	8.9
Sodium (Na)	770	50.8	33.51	391.3

L437987-11 308-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	2070	0.65	479.7
Sulphate (SO4)	254	2070	5.29	5255.2
Calcium (Ca)	6	2070	0.29	121.7
Potassium (K)	8	2070	0.19	156.8
Magnesium (Mg	<3	2070	<0.25	<62.1
Sodium (Na)	137	2070	5.98	2844.2

L437987-12 308-2
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	2580	0.66	606.9
Sulphate (SO4)	79	2580	1.65	2039.7
Calcium (Ca)	9	2580	0.47	241.7
Potassium (K)	4	2580	0.11	106.6
Magnesium (Mg	4	2580	0.33	103.1
Sodium (Na)	56	2580	2.45	1452.6

L437987-18 310-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	295	0.91	94.8
Sulphate (SO4)	172	295	3.58	506.7
Calcium (Ca)	44	295	2.20	130.0
Potassium (K)	38	295	0.98	112.7
Magnesium (Mg	16	295	1.30	46.7
Sodium (Na)	143	295	6.21	421.0

L437987-19 310-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	1980	<0.56	<396.0
Sulphate (SO4)	32	1980	0.66	627.1
Calcium (Ca)	<5	1980	<0.25	<99.0
Potassium (K)	7	1980	0.17	133.3
Magnesium (Mg	<3	1980	<0.25	<59.4
Sodium (Na)	23	1980	1.02	464.3

L437987-28 313-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	317	<0.56	<63.4
Sulphate (SO4)	240	317	4.99	759.3
Calcium (Ca)	88	317	4.38	278.1
Potassium (K)	24	317	0.60	74.8
Magnesium (Mg	46	317	3.80	146.5
Sodium (Na)	25	317	1.08	78.8

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L437987

Lab ID Sample ID

L437987-47 208-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	**% Sat**	**Meq/L**	**Dry Soil mg/kg**
Chloride (Cl)	30	712	0.74	187.0
Sulphate (SO4)	49	712	1.02	350.1
Calcium (Ca)	24	712	1.21	173.3
Potassium (K)	39	712	1.00	277.6
Magnesium (Mg	7	712	0.55	47.8
Sodium (Na)	51	712	2.21	362.1

Lab ID Sample ID

L437987-61 107-DM
Sample Date:
Matrix: SOIL

	Result mg/L	**% Sat**	**Meq/L**	**Dry Soil mg/kg**
Chloride (Cl)	30	45.9	0.79	12.9
Sulphate (SO4)	382	45.9	7.95	175.2
Calcium (Ca)	28	45.9	1.39	12.8
Potassium (K)	14	45.9	0.35	6.2
Magnesium (Mg	7	45.9	0.54	3.0
Sodium (Na)	268	45.9	11.66	123.0

L437987-62 107-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	**% Sat**	**Meq/L**	**Dry Soil mg/kg**
Chloride (Cl)	40	576	1.17	238.2
Sulphate (SO4)	220	576	4.58	1268.1
Calcium (Ca)	55	576	2.72	314.1
Potassium (K)	60	576	1.54	347.0
Magnesium (Mg	12	576	0.96	67.5
Sodium (Na)	180	576	7.84	1037.9

L437987-63 107-1
Sample Date:
Matrix: SOIL

	Result mg/L	**% Sat**	**Meq/L**	**Dry Soil mg/kg**
Chloride (Cl)	<20	25.9	<0.56	<5.2
Sulphate (SO4)	129	25.9	2.69	33.5
Calcium (Ca)	34	25.9	1.68	8.7
Potassium (K)	4	25.9	0.11	1.1
Magnesium (Mg	8	25.9	0.68	2.1
Sodium (Na)	41	25.9	1.80	10.7

L437987-71 109-DM
Sample Date:
Matrix: SOIL

	Result mg/L	**% Sat**	**Meq/L**	**Dry Soil mg/kg**
Chloride (Cl)	60	48.8	1.57	27.1
Sulphate (SO4)	429	48.8	8.94	209.5
Calcium (Ca)	75	48.8	3.72	36.4
Potassium (K)	10	48.8	0.26	5.0
Magnesium (Mg	19	48.8	1.56	9.3
Sodium (Na)	292	48.8	12.69	142.3

L437987-72 109-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	**% Sat**	**Meq/L**	**Dry Soil mg/kg**
Chloride (Cl)	30	375	0.88	116.6
Sulphate (SO4)	194	375	4.03	725.8
Calcium (Ca)	68	375	3.41	256.3
Potassium (K)	12	375	0.32	46.5
Magnesium (Mg	31	375	2.54	115.8
Sodium (Na)	105	375	4.55	392.6

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L437987

Lab ID Sample ID

L437987-73 109-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	38.7	<0.56	<7.7
Sulphate (SO4)	185	38.7	3.85	71.5
Calcium (Ca)	71	38.7	3.56	27.6
Potassium (K)	<2	38.7	<0.05	<0.8
Magnesium (Mg	25	38.7	2.07	9.7
Sodium (Na)	55	38.7	2.41	21.4

L437987-99 11-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	40	905	1.19	381.0
Sulphate (SO4)	95	905	1.99	863.0
Calcium (Ca)	59	905	2.94	532.5
Potassium (K)	69	905	1.77	627.6
Magnesium (Mg	26	905	2.11	231.9
Sodium (Na)	37	905	1.61	334.8

L437987-119 308-LF
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	619	<0.56	<123.8
Sulphate (SO4)	51	619	1.06	315.4
Calcium (Ca)	31	619	1.57	194.8
Potassium (K)	<2	619	<0.05	<12.4
Magnesium (Mg	11	619	0.90	68.0
Sodium (Na)	20	619	0.86	122.4

Lab ID Sample ID

L437987-92 7-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	26.4	0.57	5.3
Sulphate (SO4)	99	26.4	2.06	26.1
Calcium (Ca)	18	26.4	0.91	4.8
Potassium (K)	4	26.4	0.11	1.2
Magnesium (Mg	4	26.4	0.34	1.1
Sodium (Na)	50	26.4	2.16	13.1

L437987-114 7-LFH
Sample Date:
Matrix: SOIL

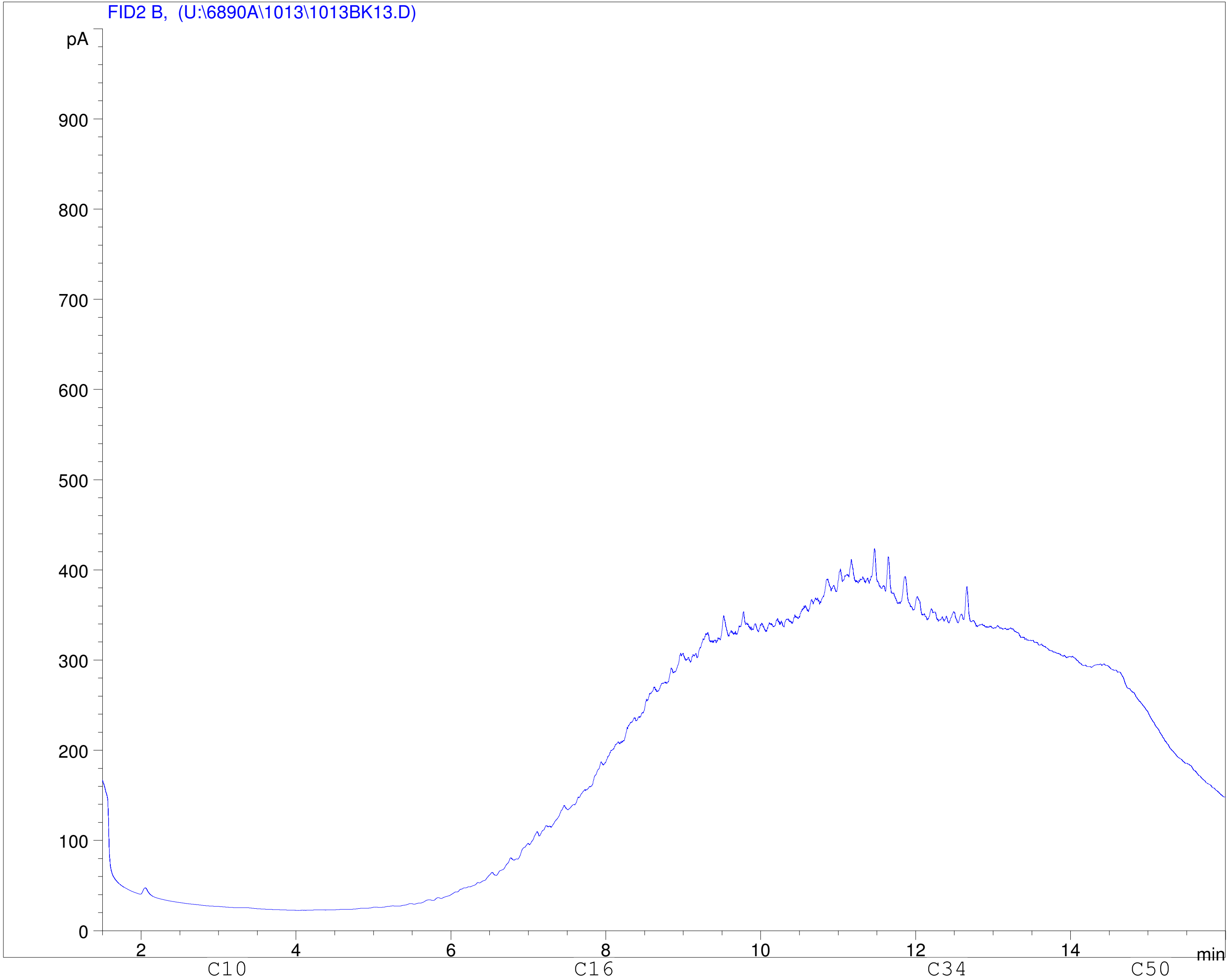
	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	40	442	1.16	181.3
Sulphate (SO4)	134	442	2.79	592.9
Calcium (Ca)	59	442	2.95	261.4
Potassium (K)	65	442	1.66	286.8
Magnesium (Mg	15	442	1.23	66.0
Sodium (Na)	136	442	5.92	601.5

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

Client ID: 308-DM

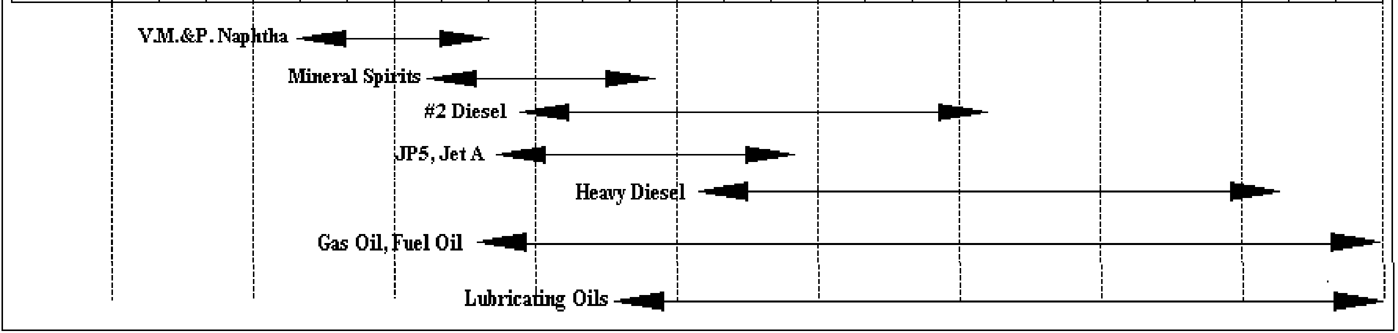
Sample ID: L437987-10 40
Injection Date: 10/13/2006 9:56:24 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

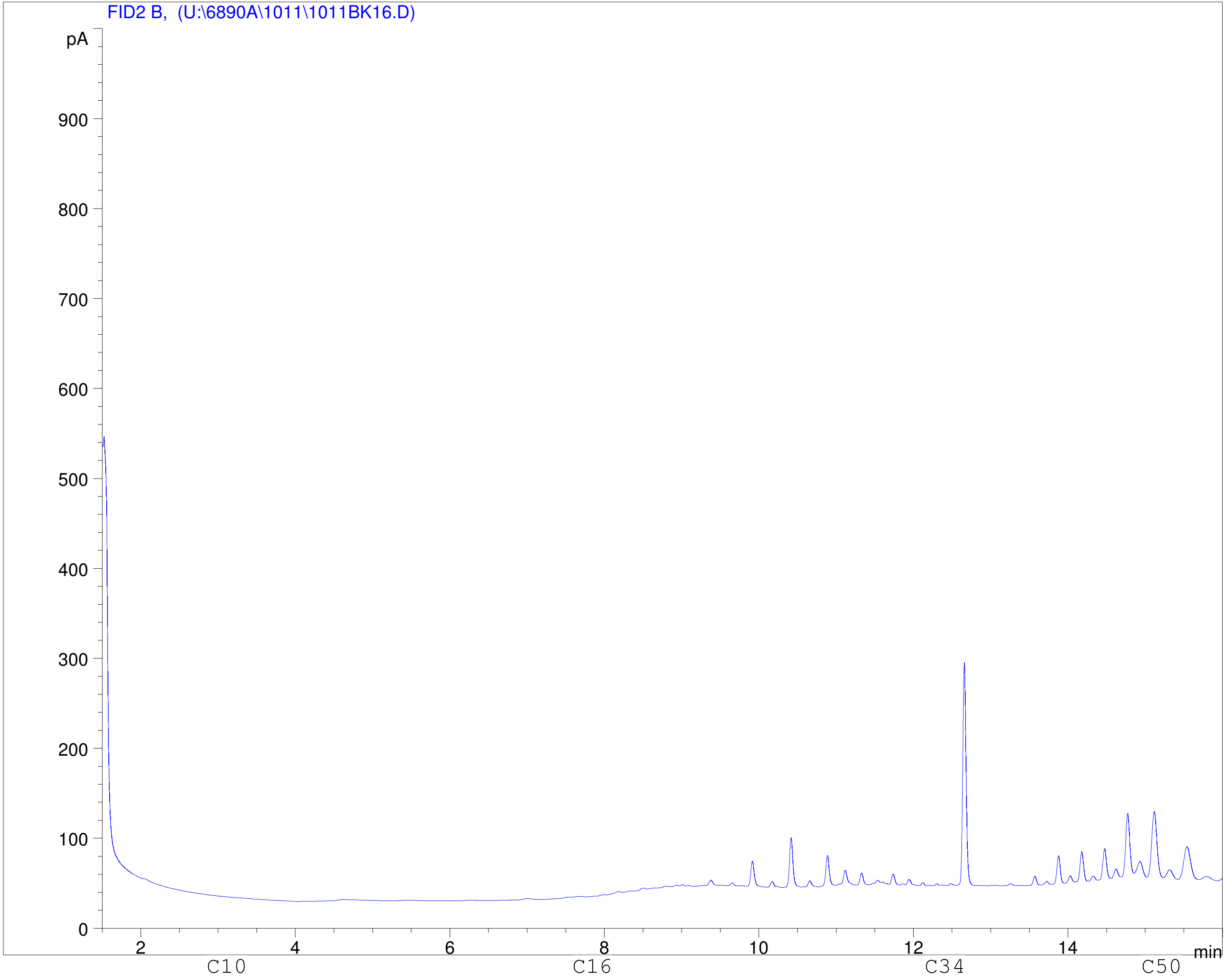


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 308-1

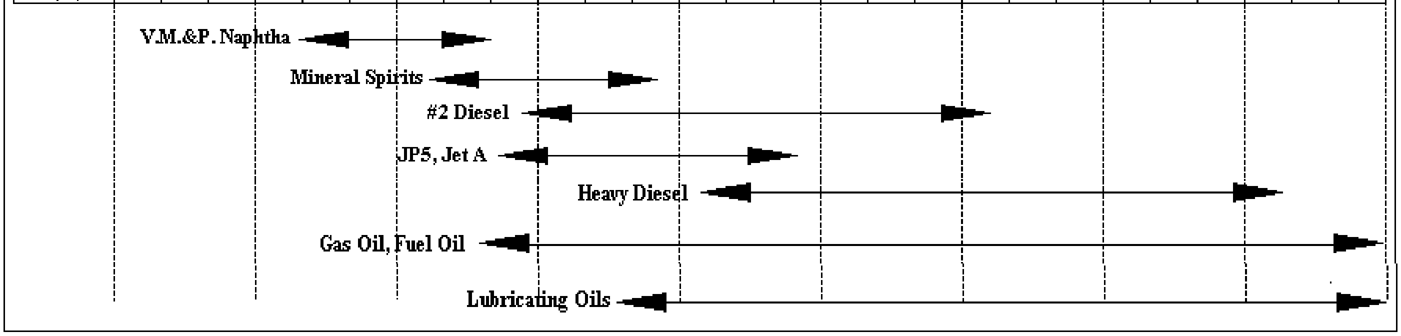
Sample ID: L438987-11
Injection Date: 10/11/2006 11:45:43 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

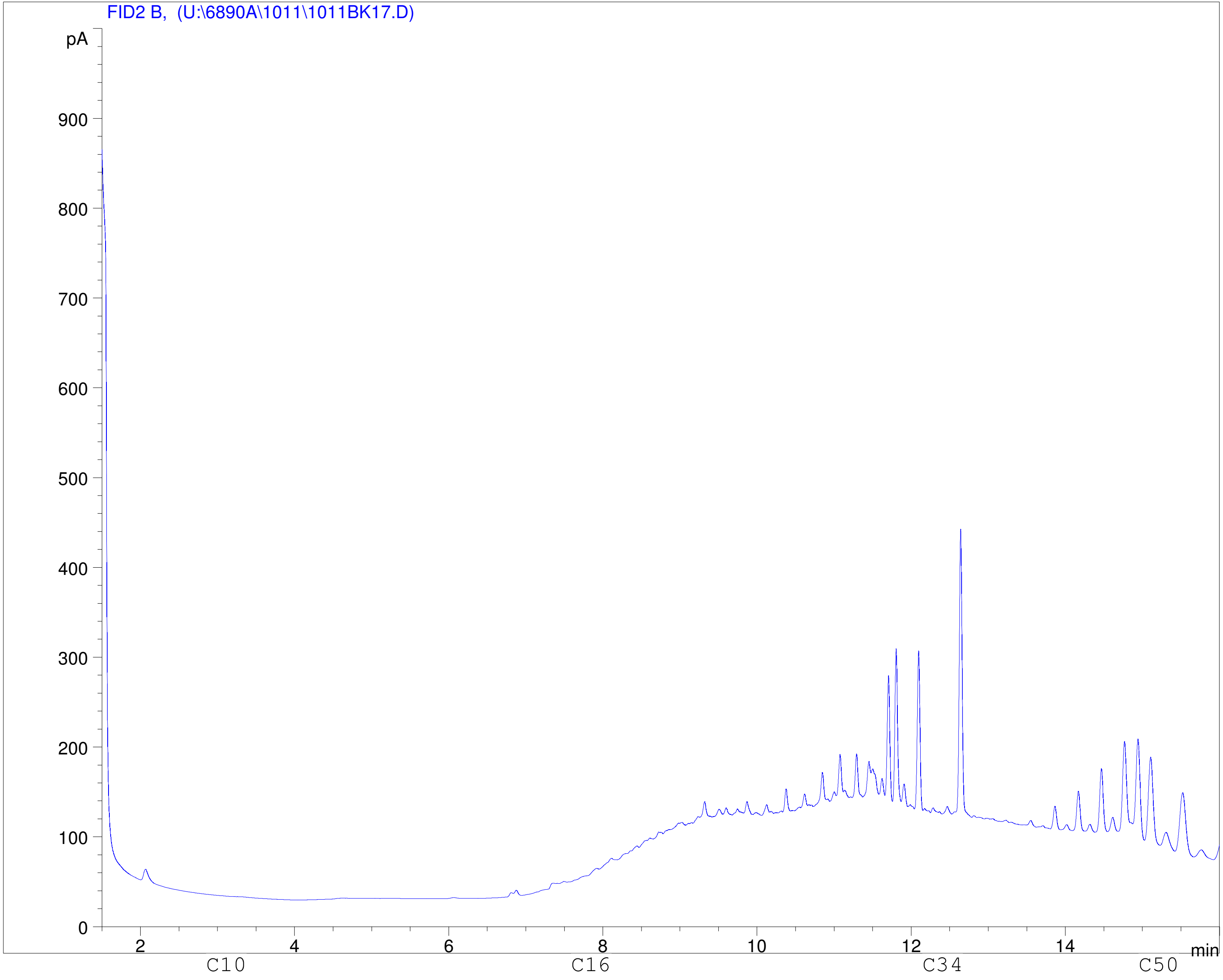


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

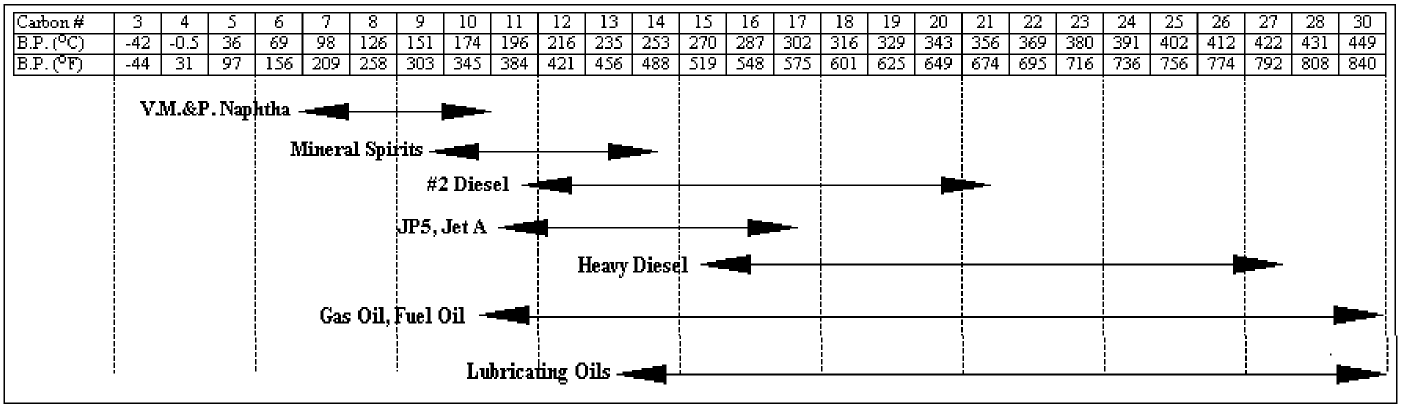
Client ID: 310-LFH

Sample ID: L437987-18 4 SG
Injection Date: 10/12/2006 12:10:39 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



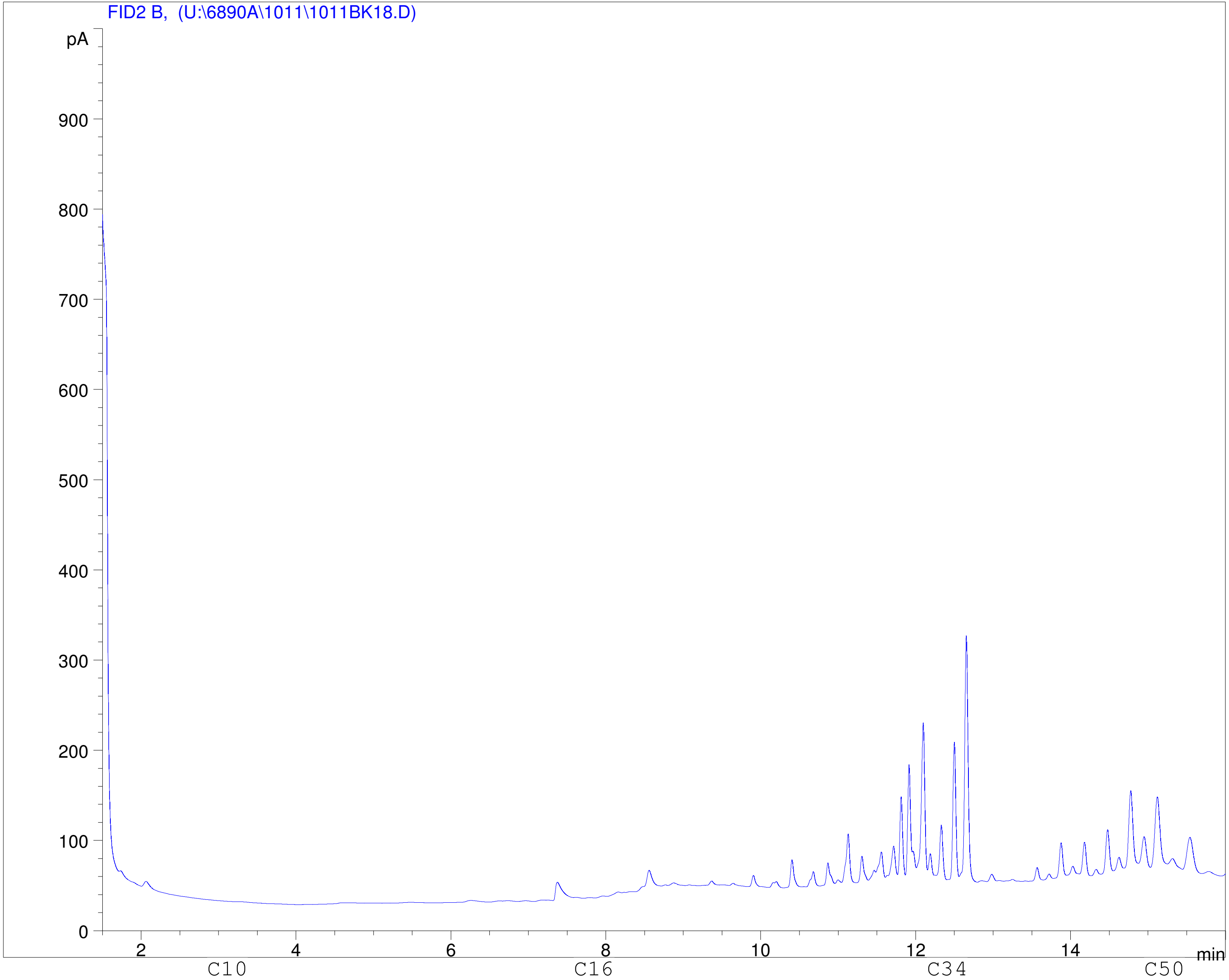
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

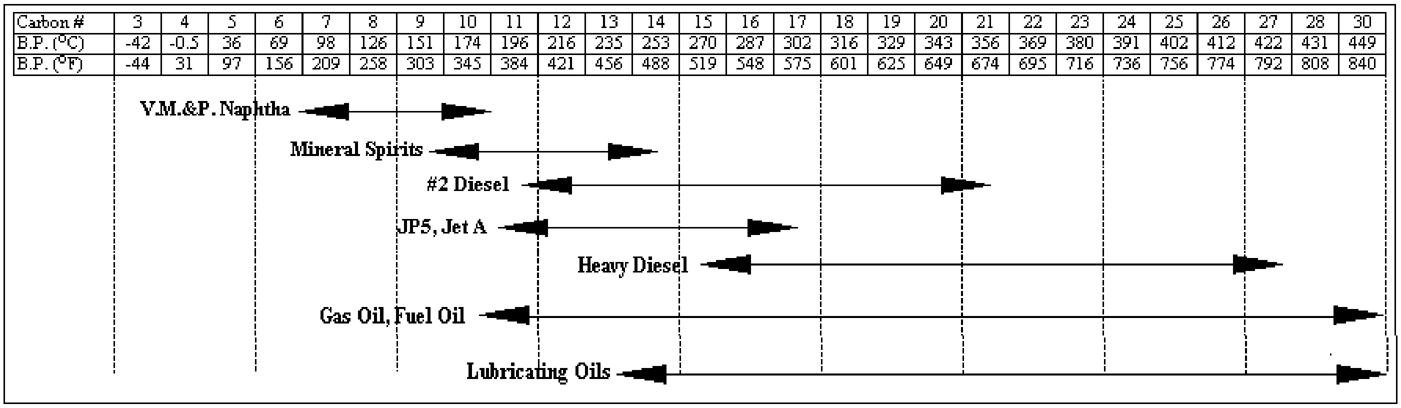
Client ID: 310-1

Sample ID: L437987-19 4 SG
Injection Date: 10/12/2006 12:35:50 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



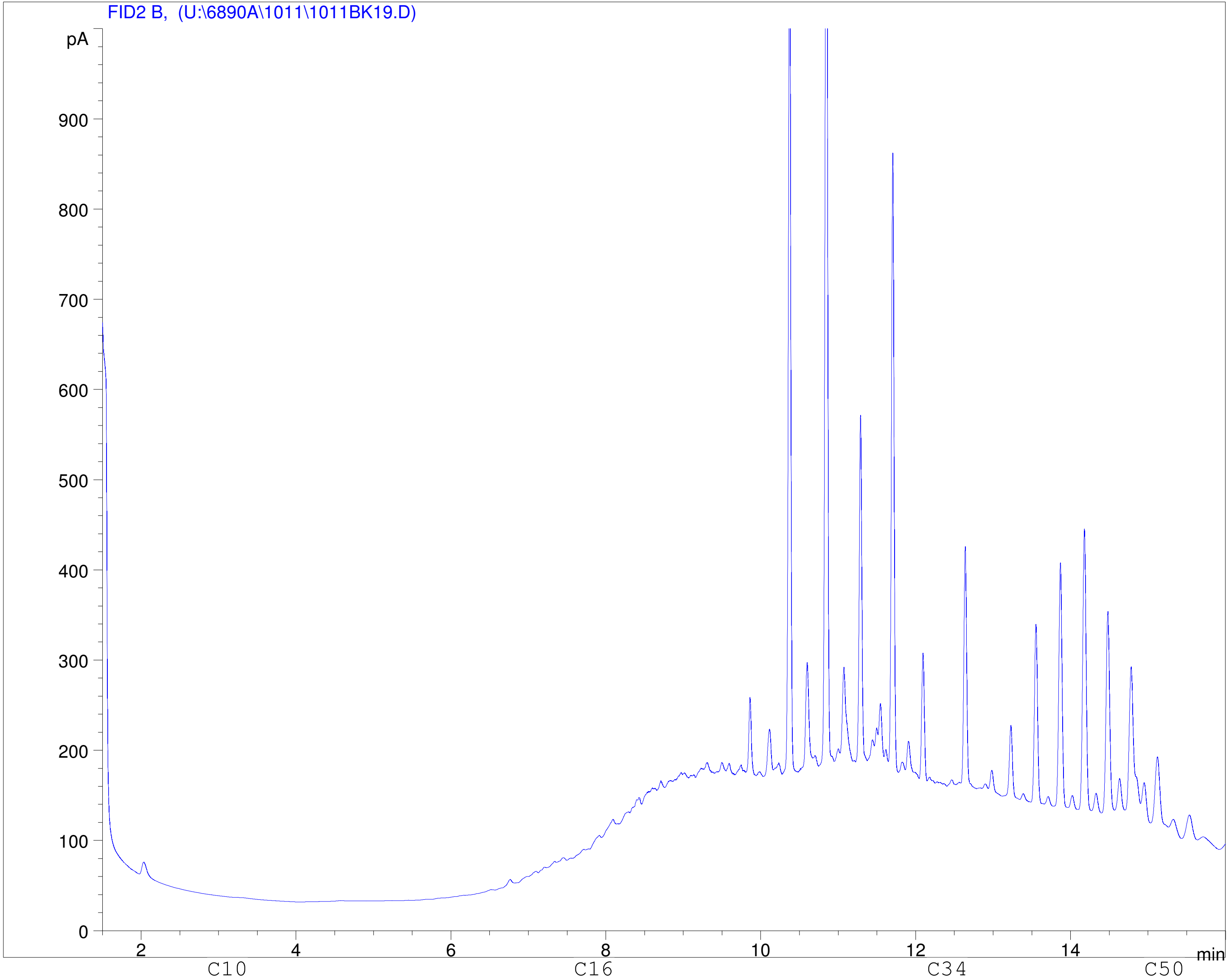
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 313-LFH

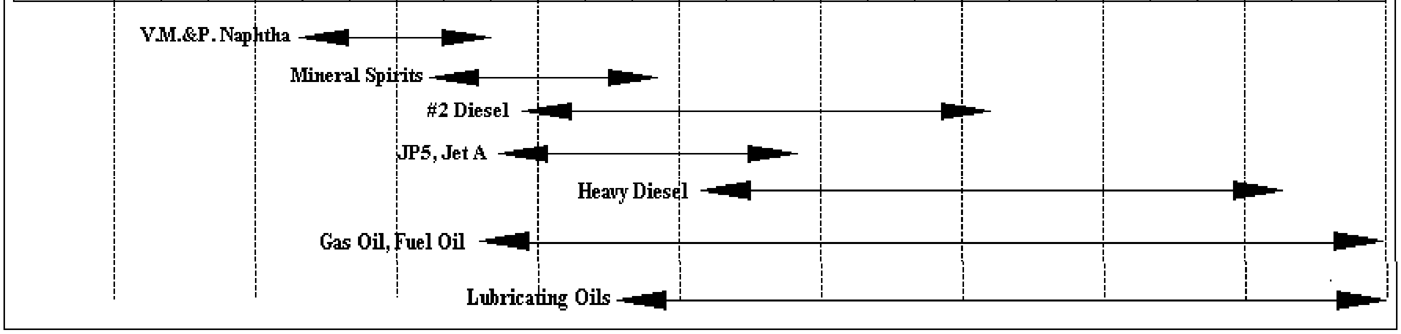
Sample ID: L437987-28 4 SG
Injection Date: 10/12/2006 1:01:05 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (^{o}C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (^{o}F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

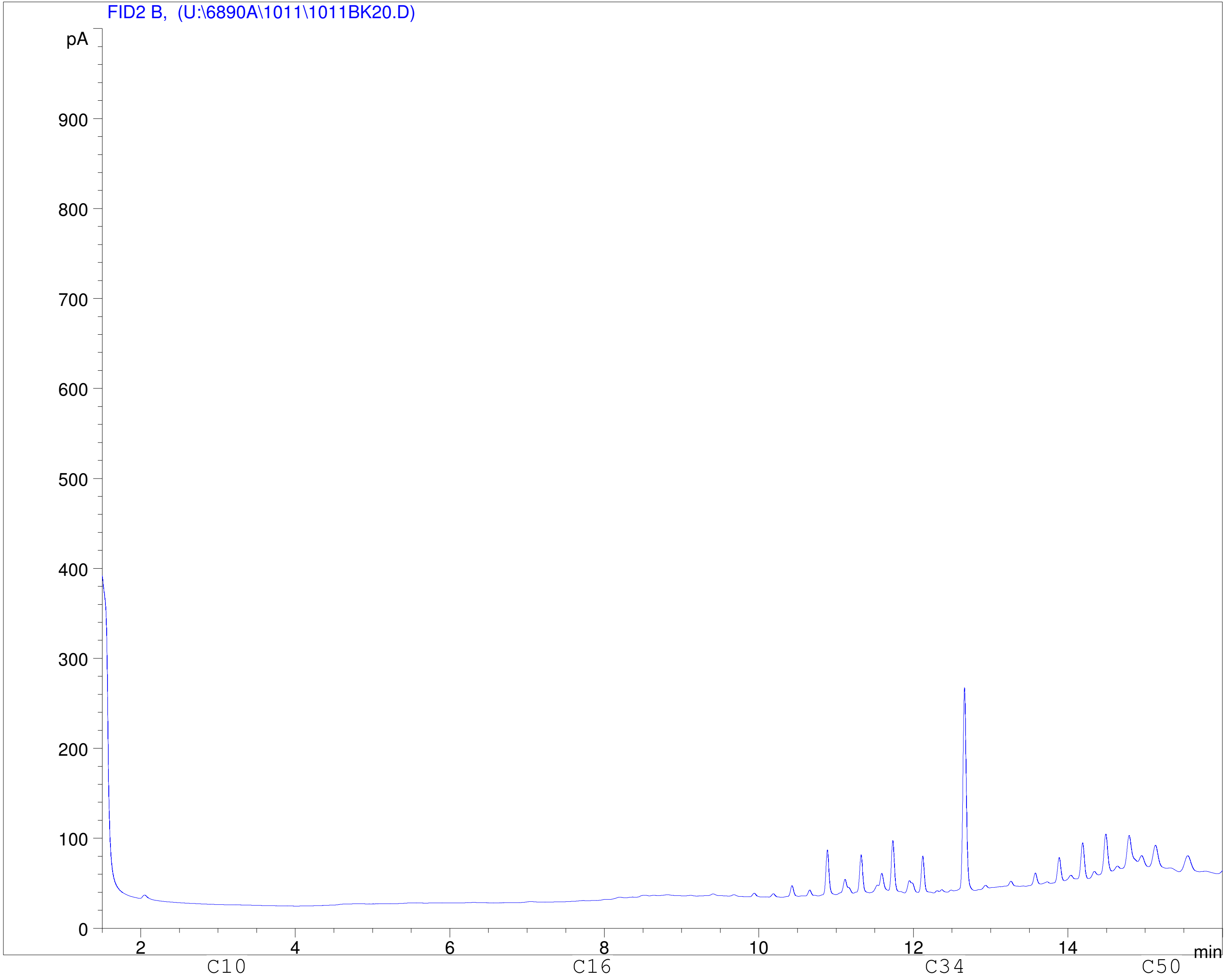


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 313-1

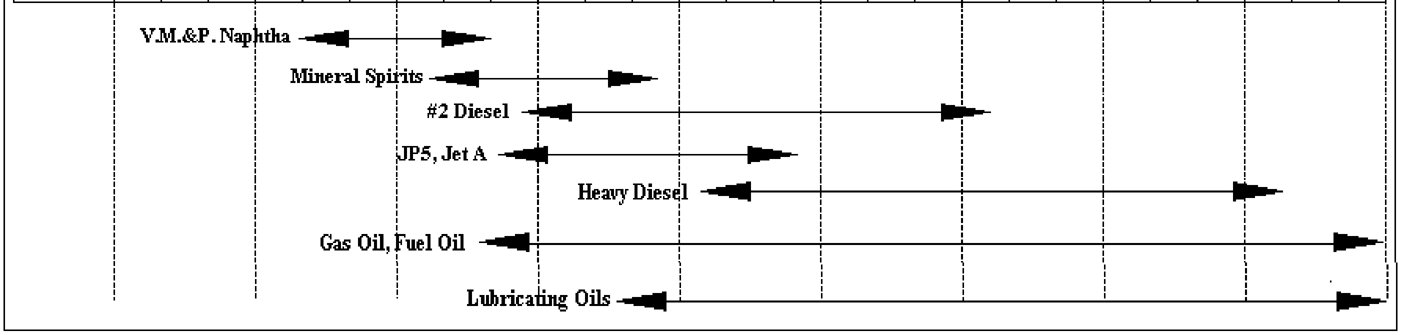
Sample ID: L437987-29 4 SG
Injection Date: 10/12/2006 1:26:14 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

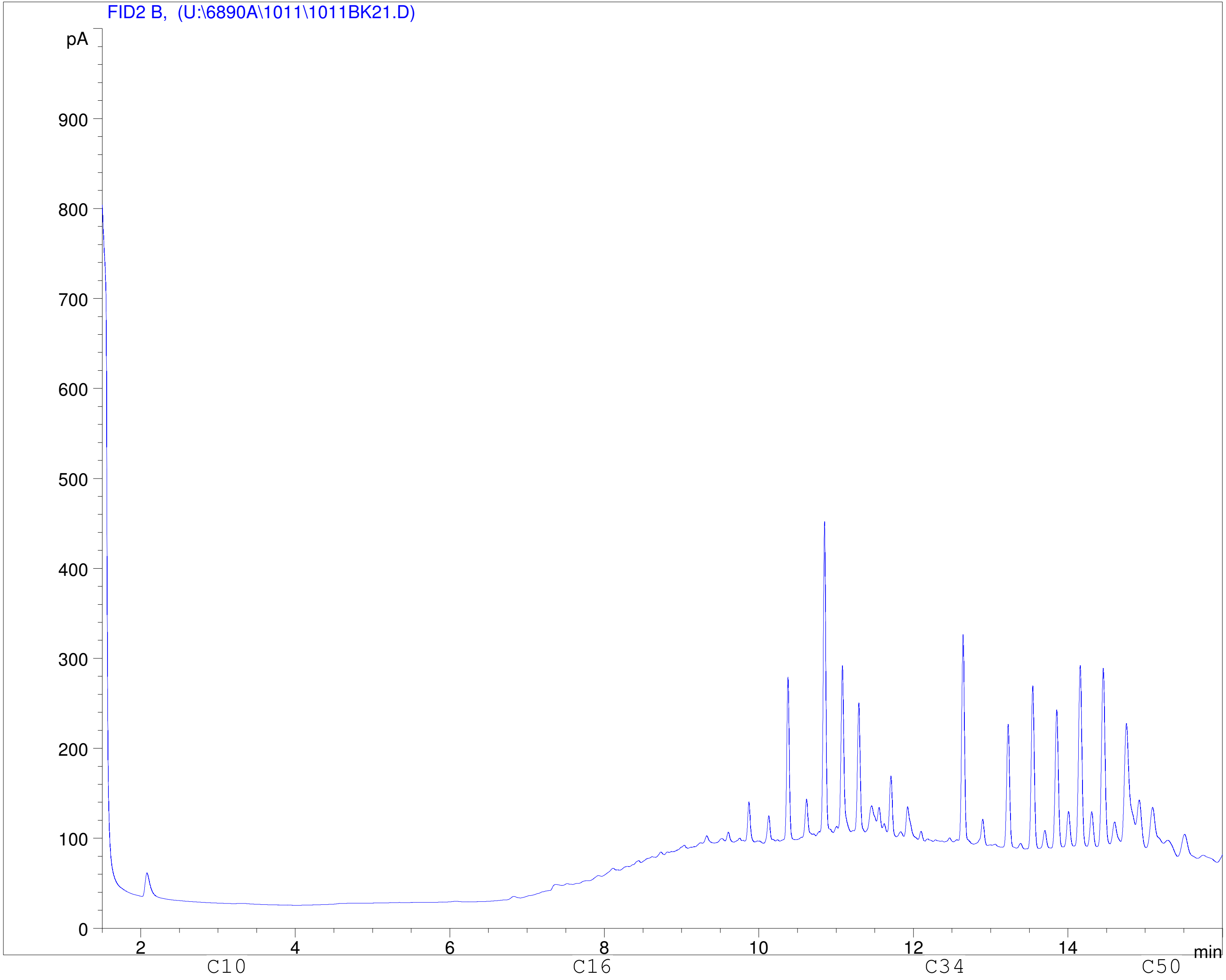


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 208-LFH

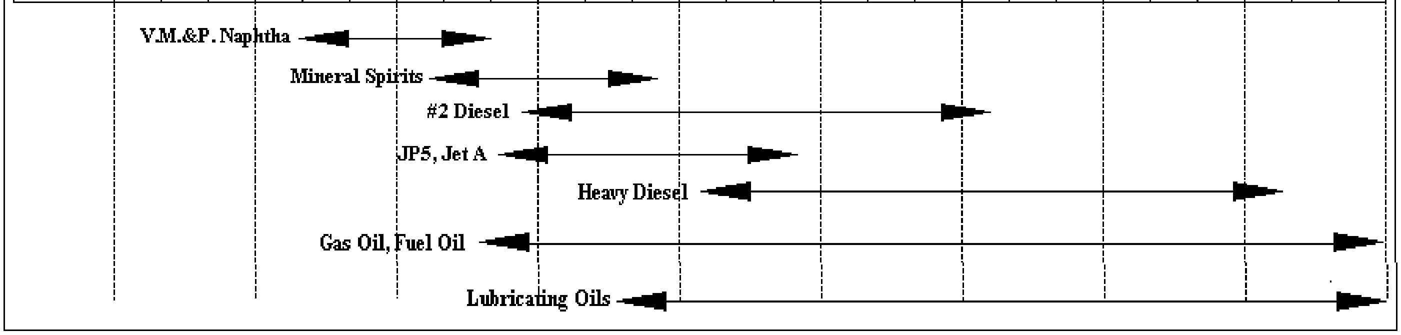
Sample ID: L437987-47 4 SG
Injection Date: 10/12/2006 1:51:19 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

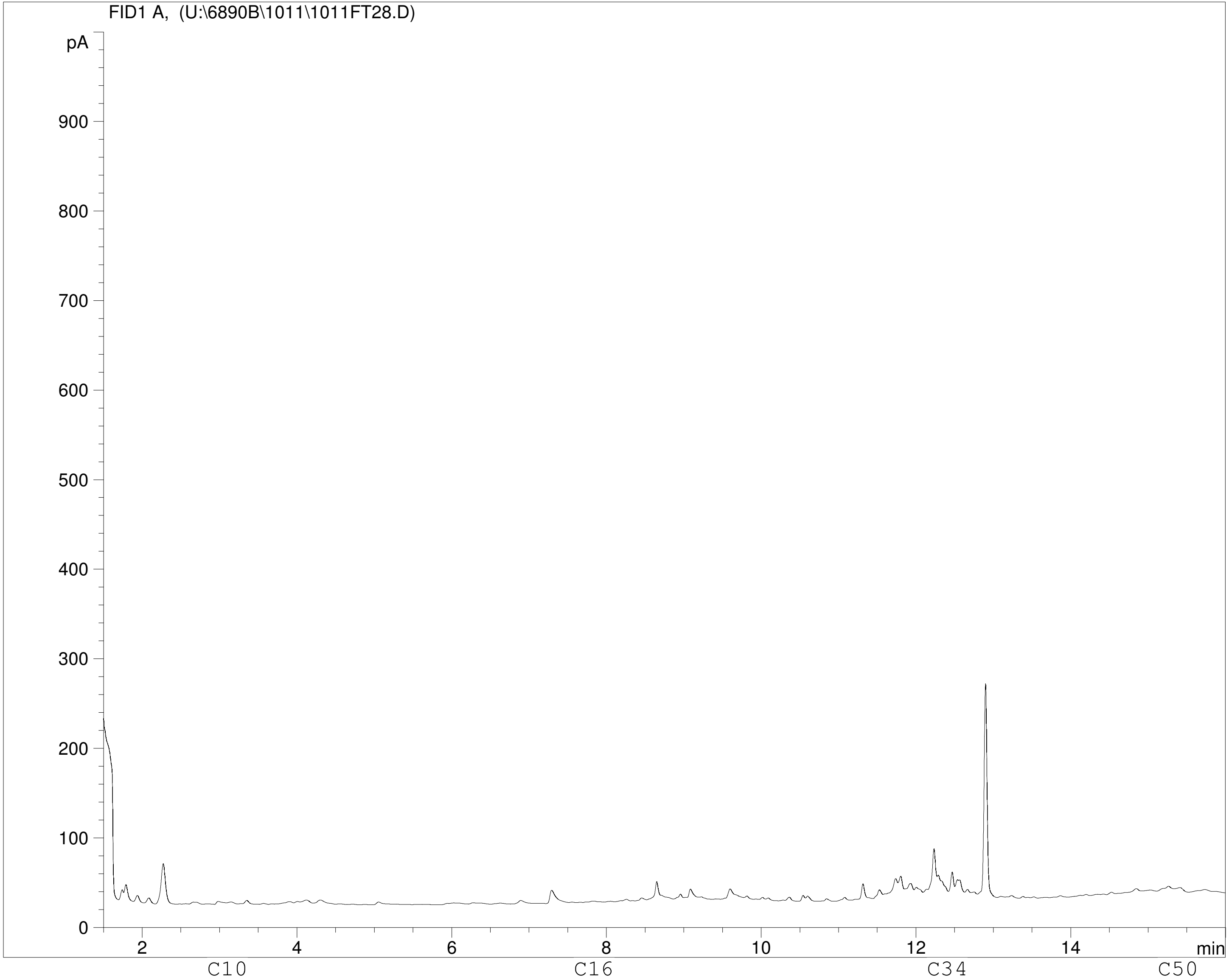


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 208-1

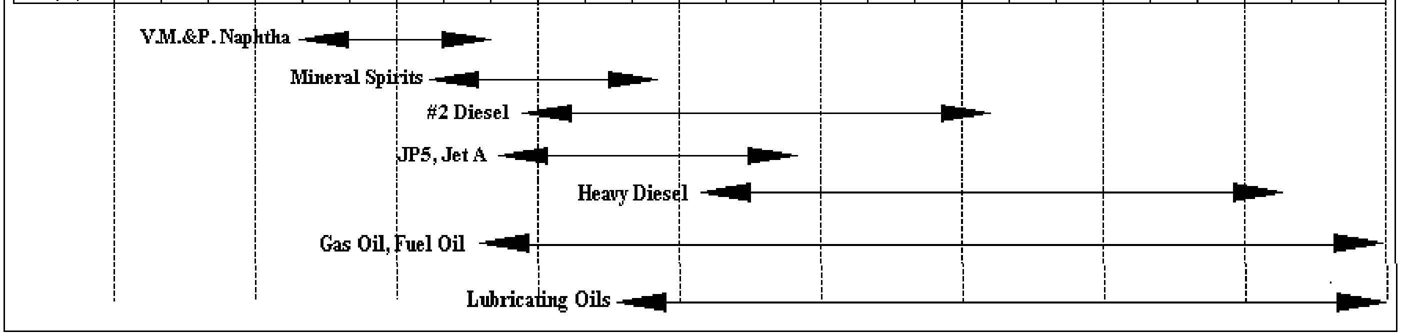
Sample ID: L437987-48 4
Injection Date: 10/12/06 3:49:55 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

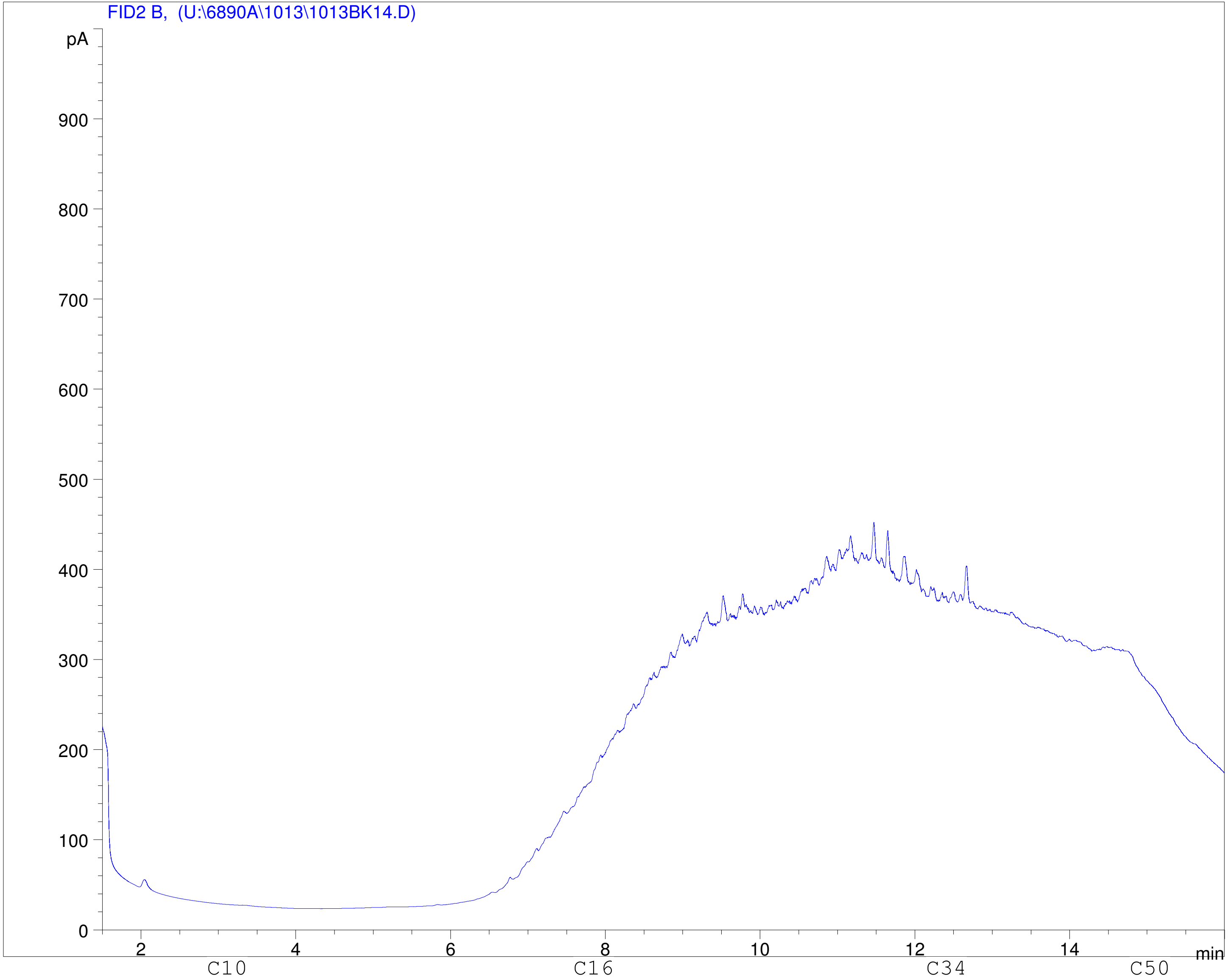


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 107-DM

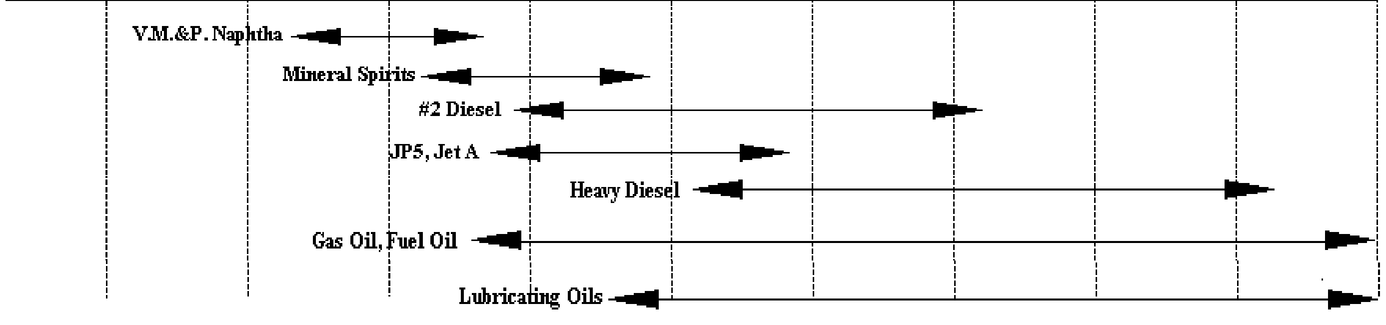
Sample ID: L437987-61 40
Injection Date: 10/13/2006 10:21:23 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

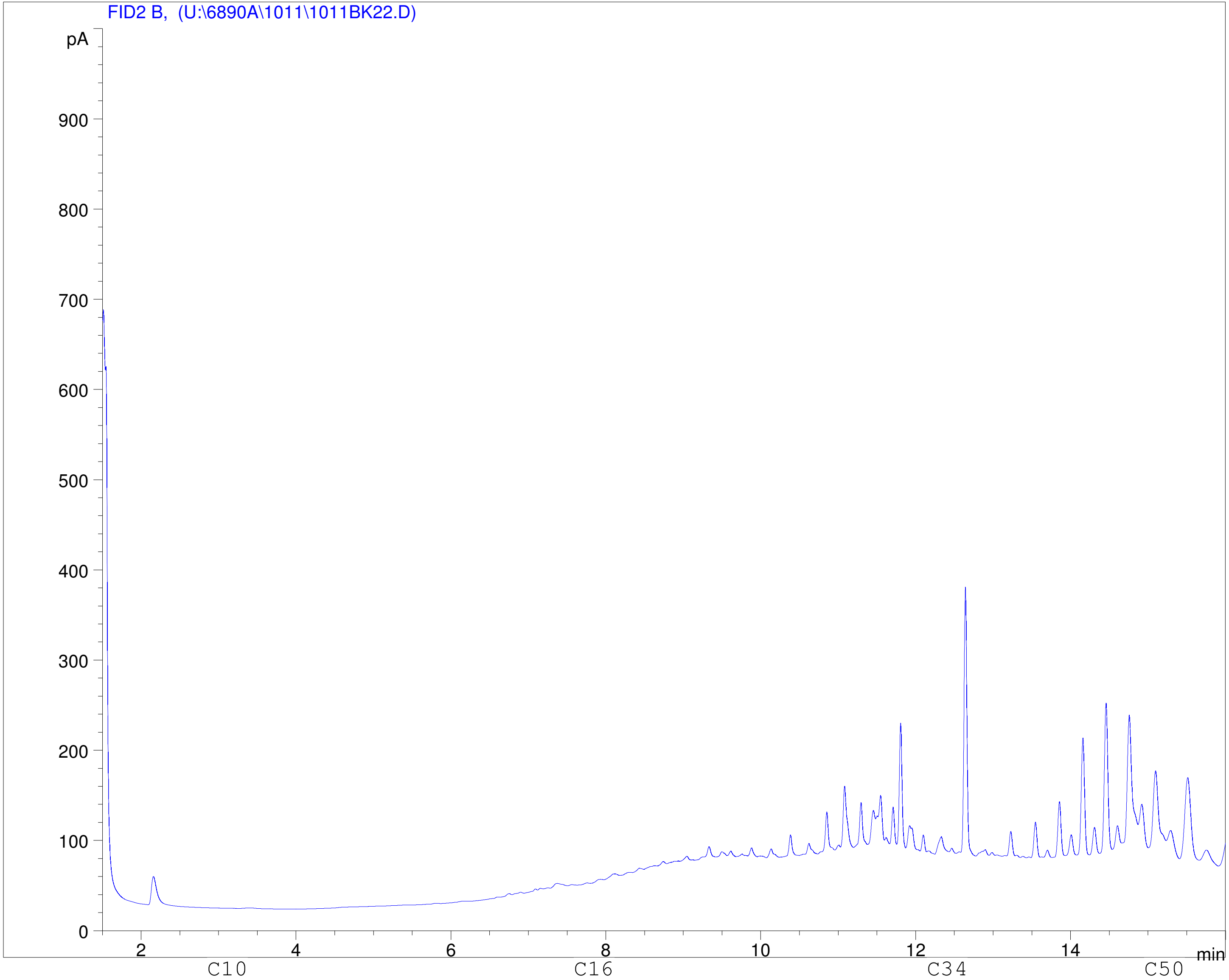


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 107-LFH

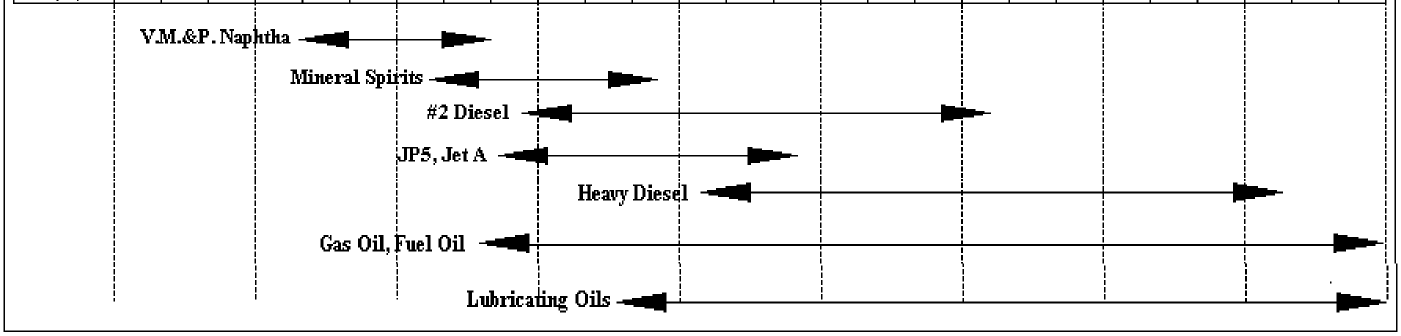
Sample ID: L437987-62 4 SG
Injection Date: 10/12/2006 2:16:28 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

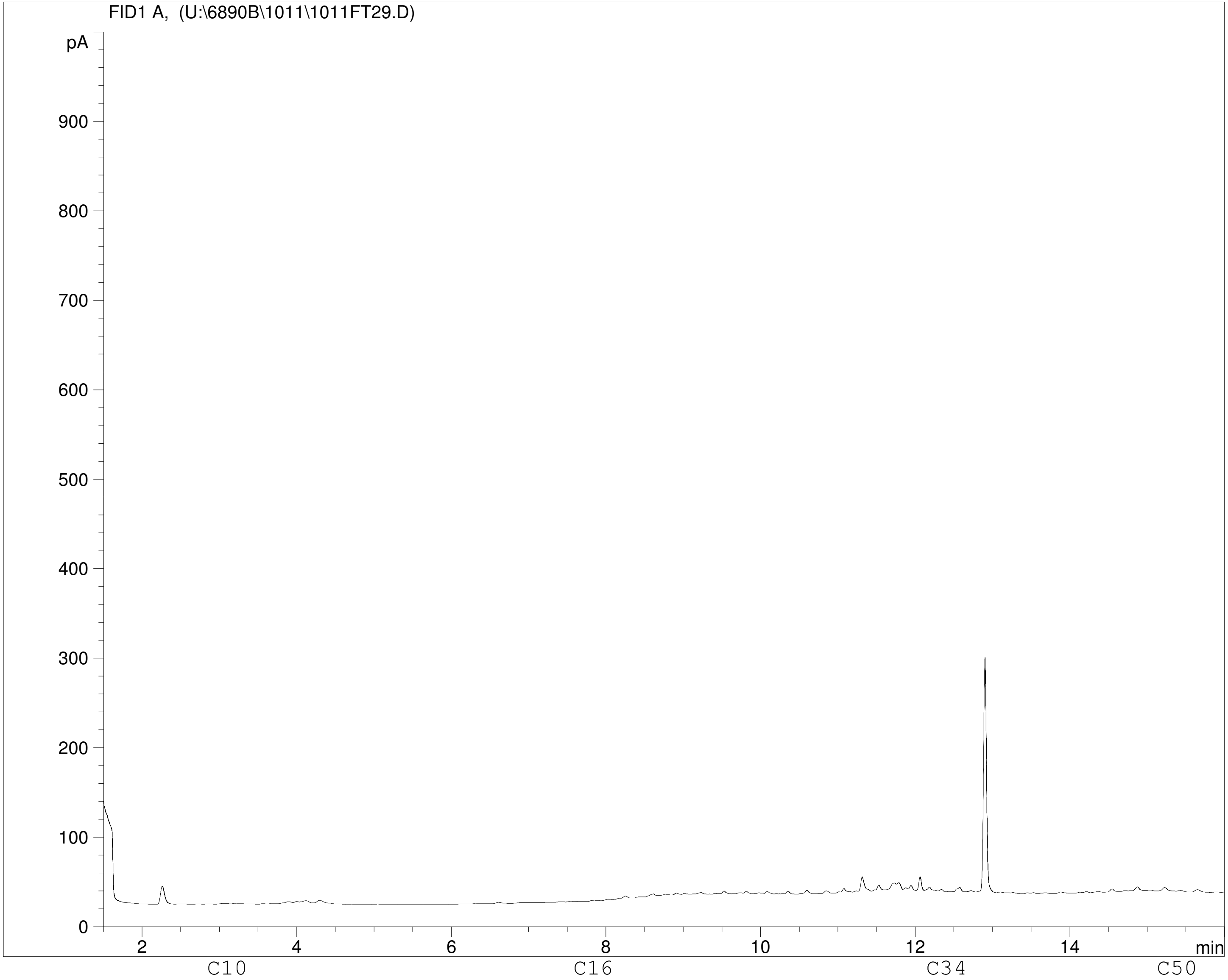


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 107-1

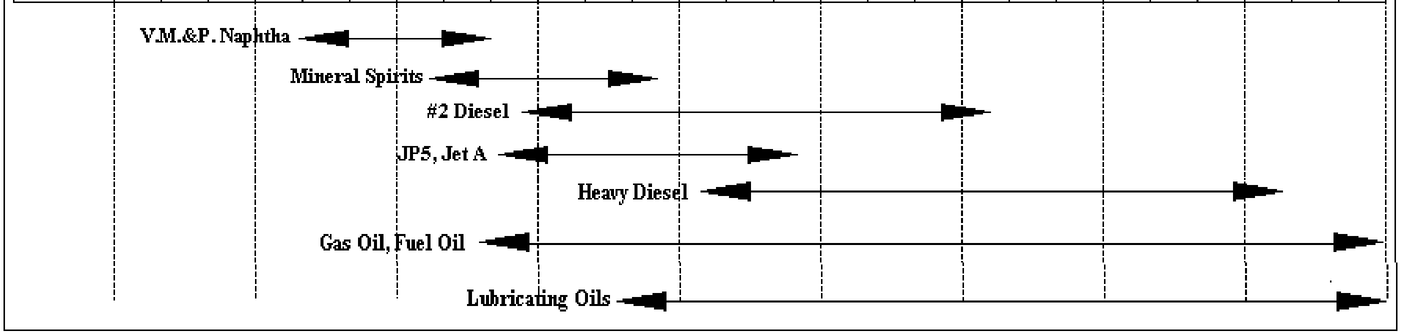
Sample ID: L437987-63 4
Injection Date: 10/12/06 4:16:52 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

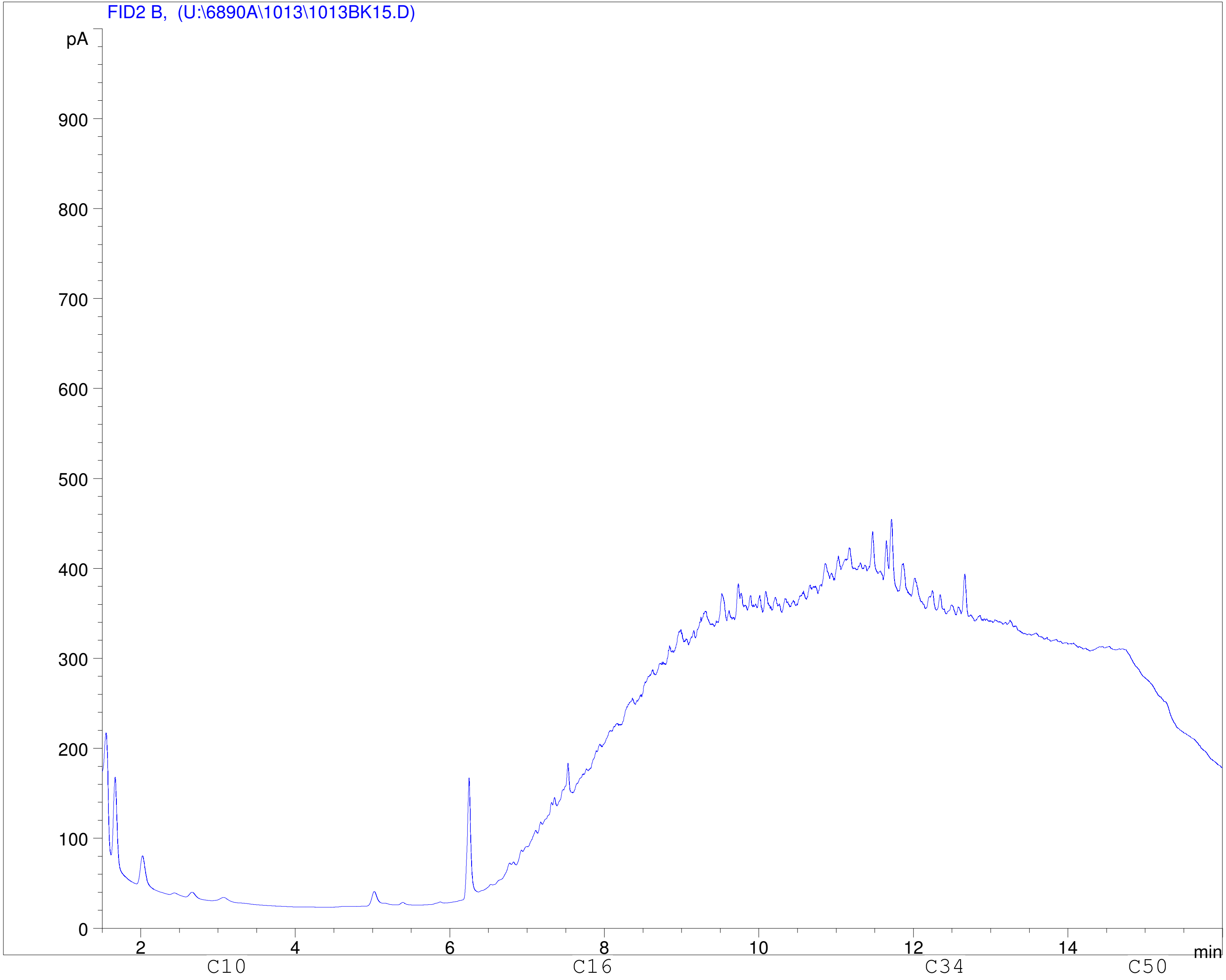


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 109-DM

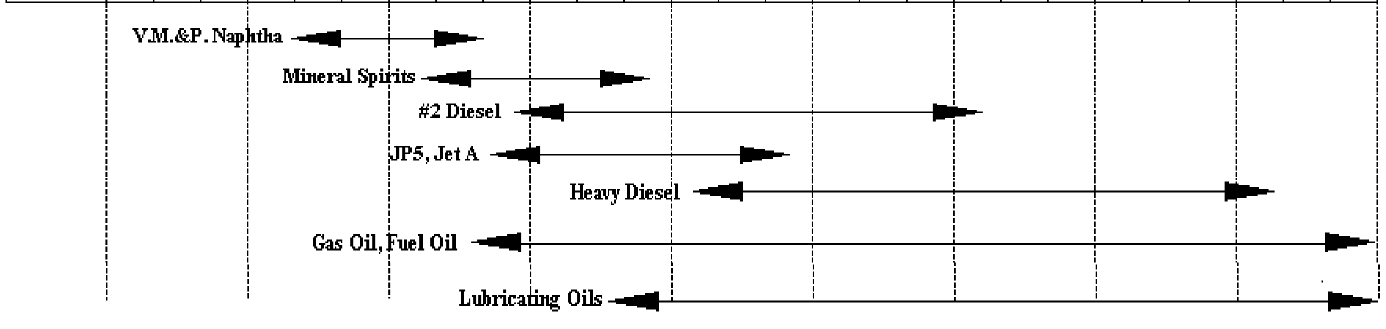
Sample ID: L437987-71 40
Injection Date: 10/13/2006 10:46:13 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

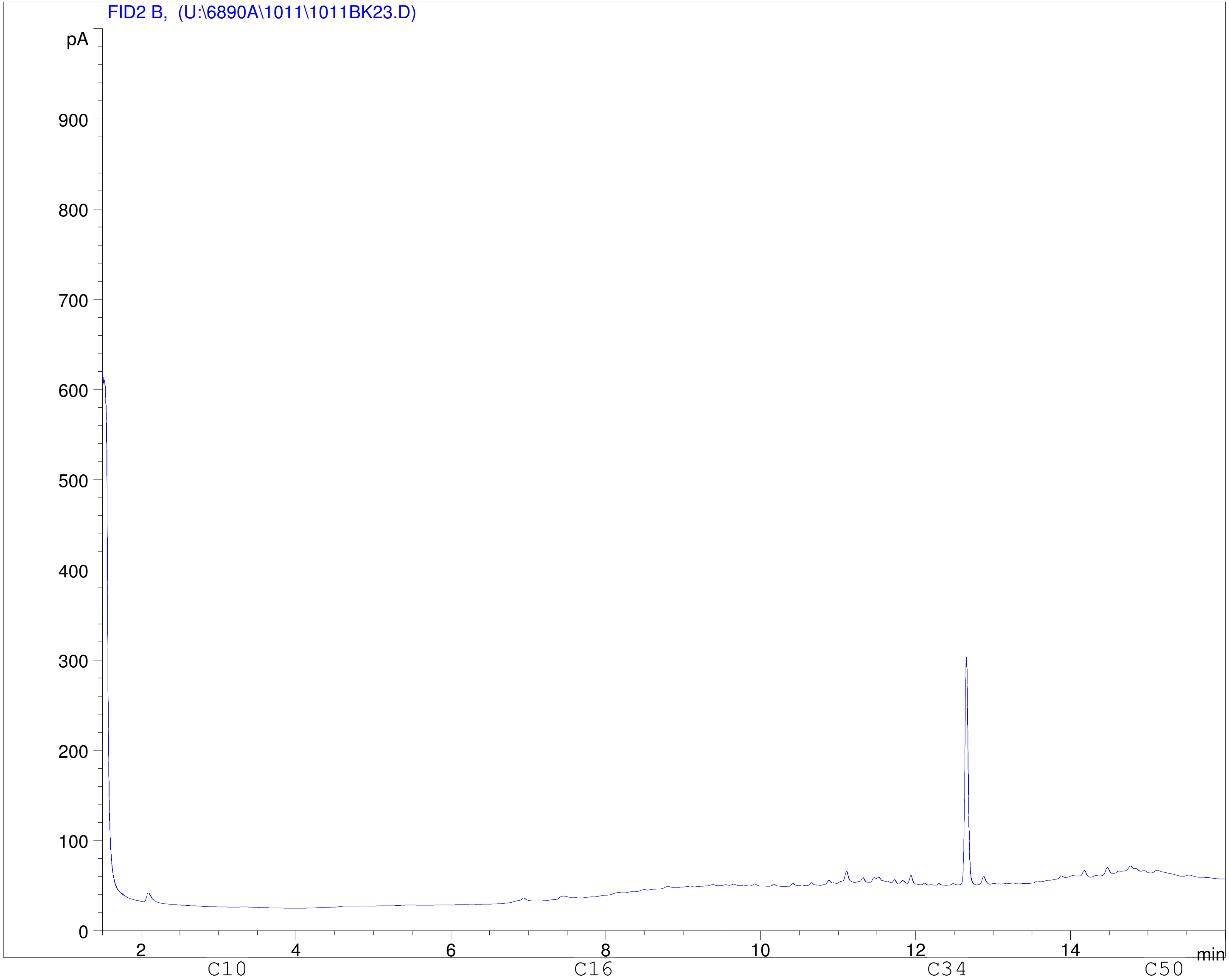


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 109-LFH

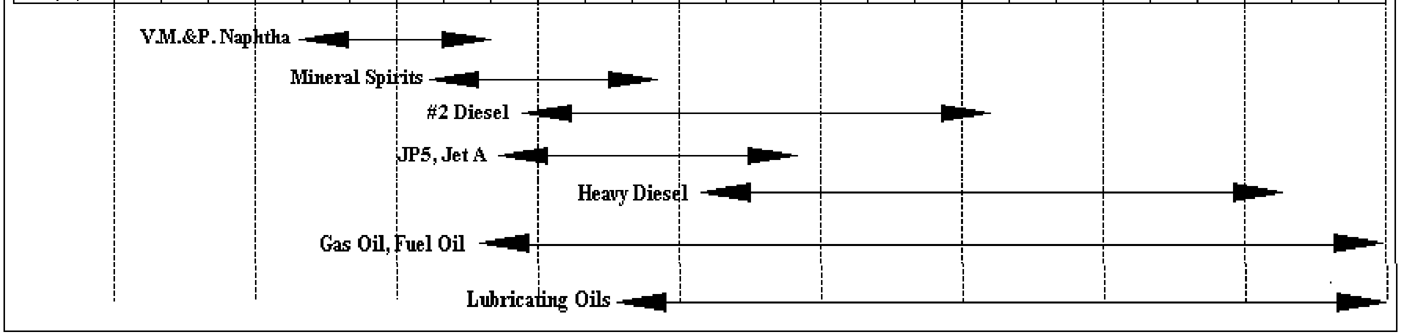
Sample ID: L437987-72 4 SG
Injection Date: 10/12/2006 2:41:26 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (^oC)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (^oF)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

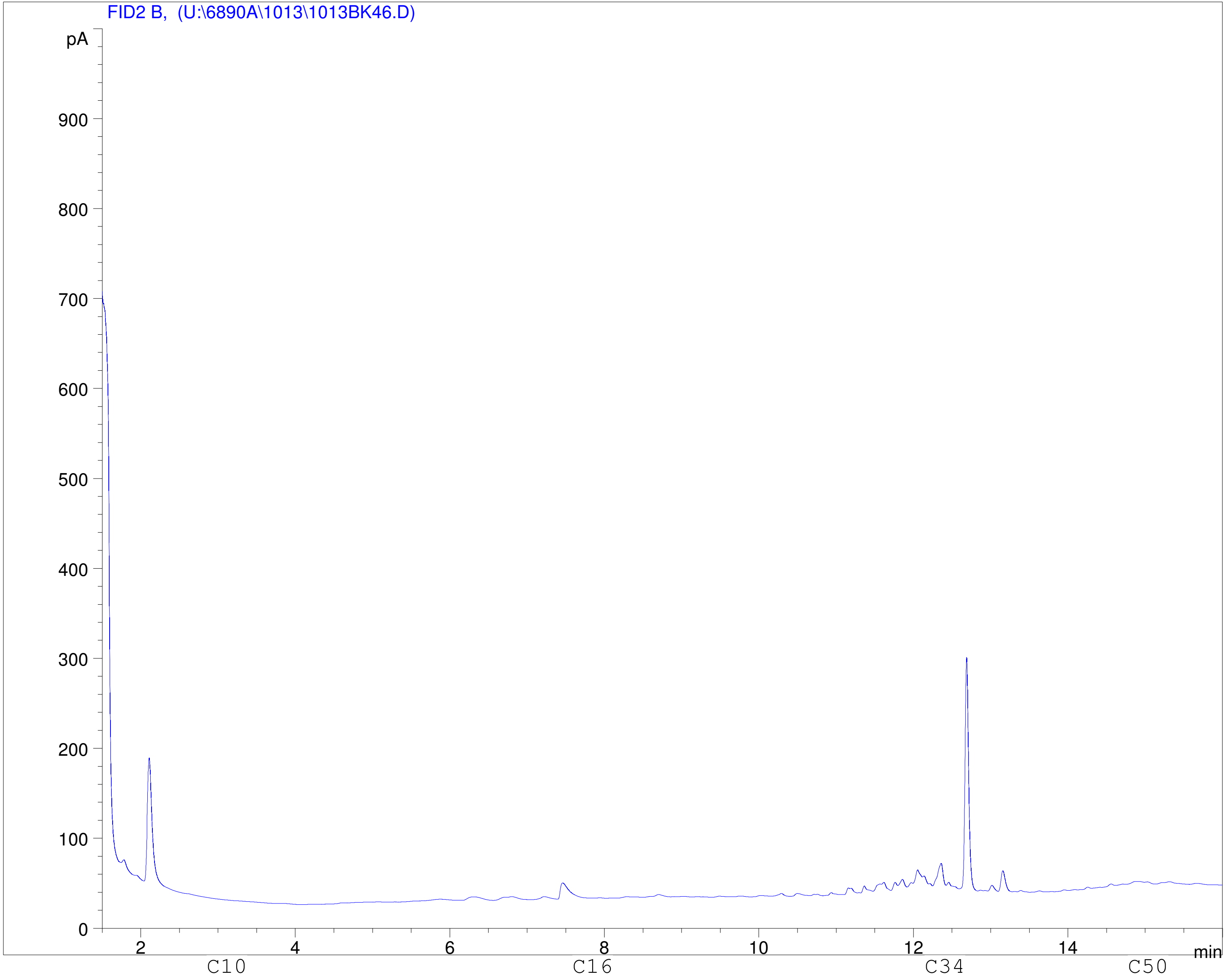


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 7-1

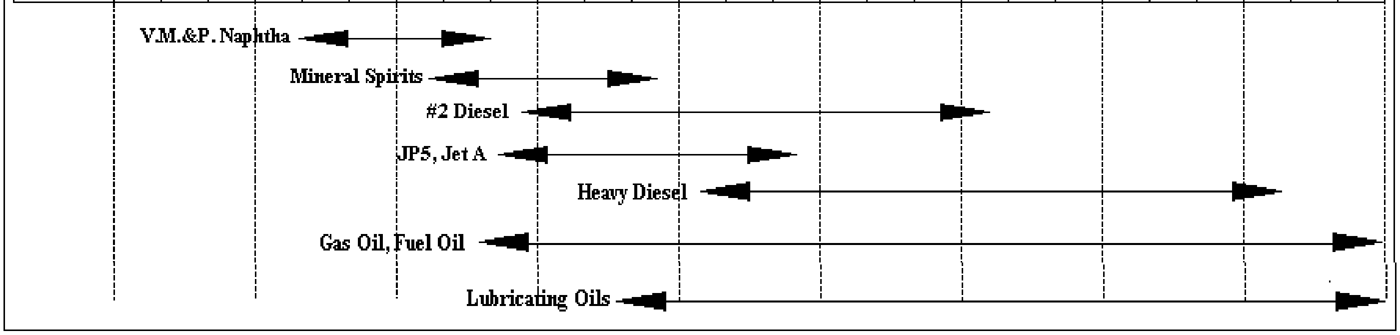
Sample ID: L437987-92 4
Injection Date: 10/14/2006 11:40:07 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

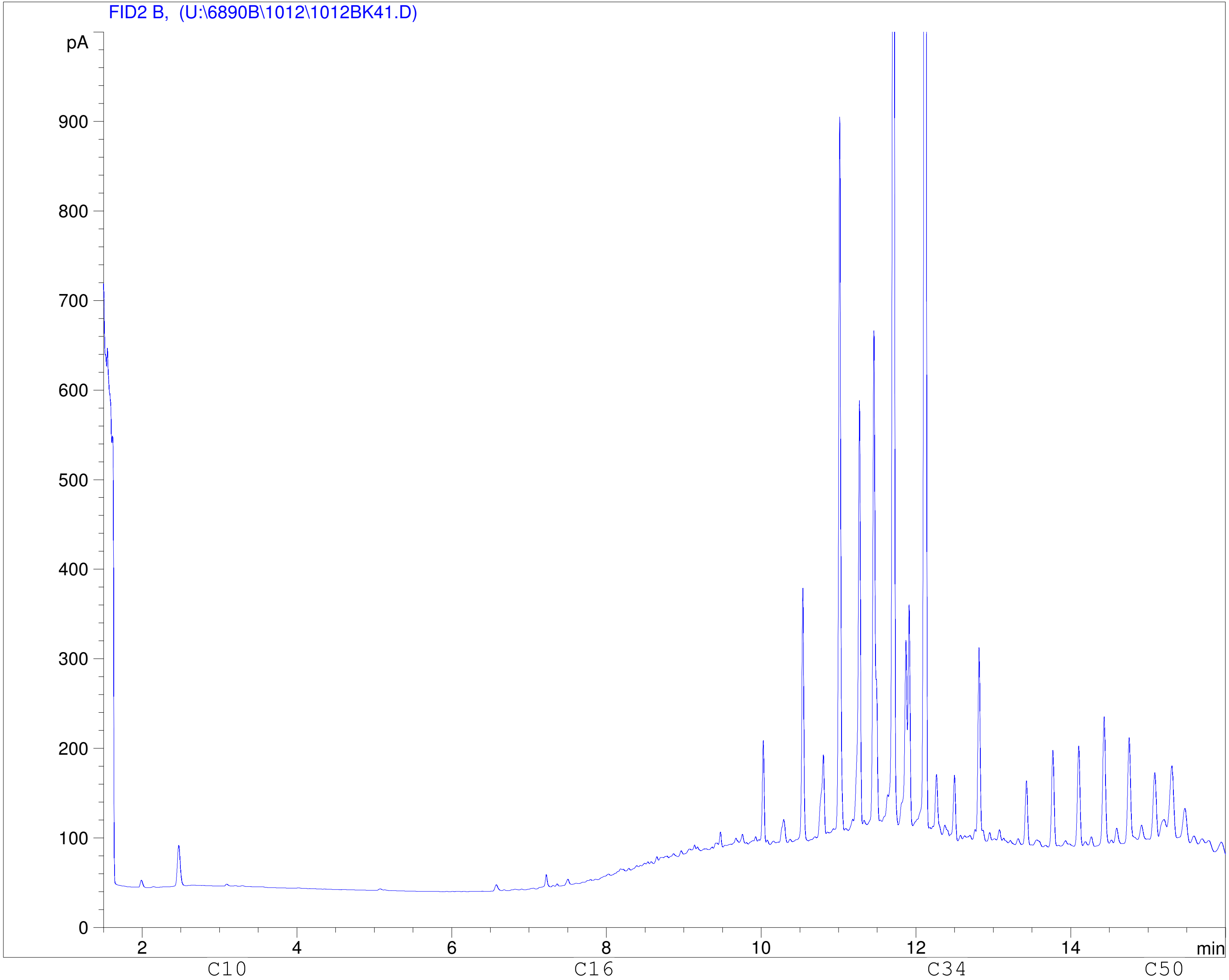


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 12-LFH

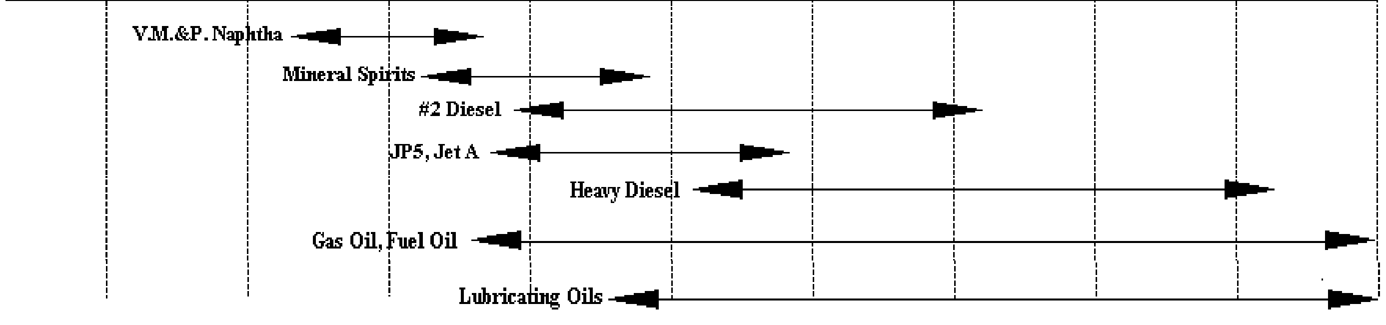
Sample ID: L437987-103 4 SG
Injection Date: 10/13/06 10:18:03 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



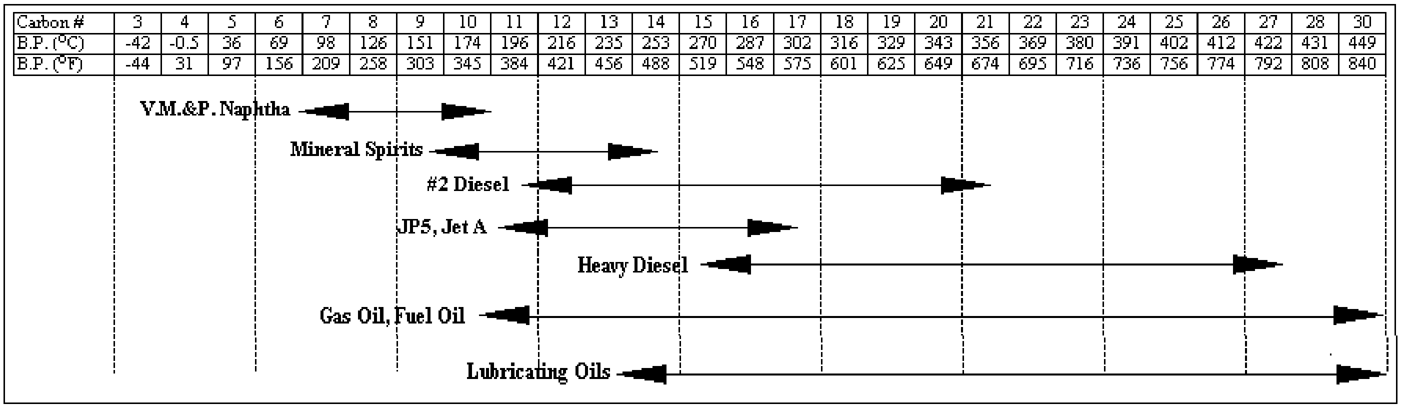
Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 12-1

Sample ID: L437987-104 SG 4
Injection Date: 10/13/2006 2:31:19 AM
Instrument: 6890

Total Extractable Hydrocarbons

Boiling Point Distribution Range of Petroleum Based Fuel Products



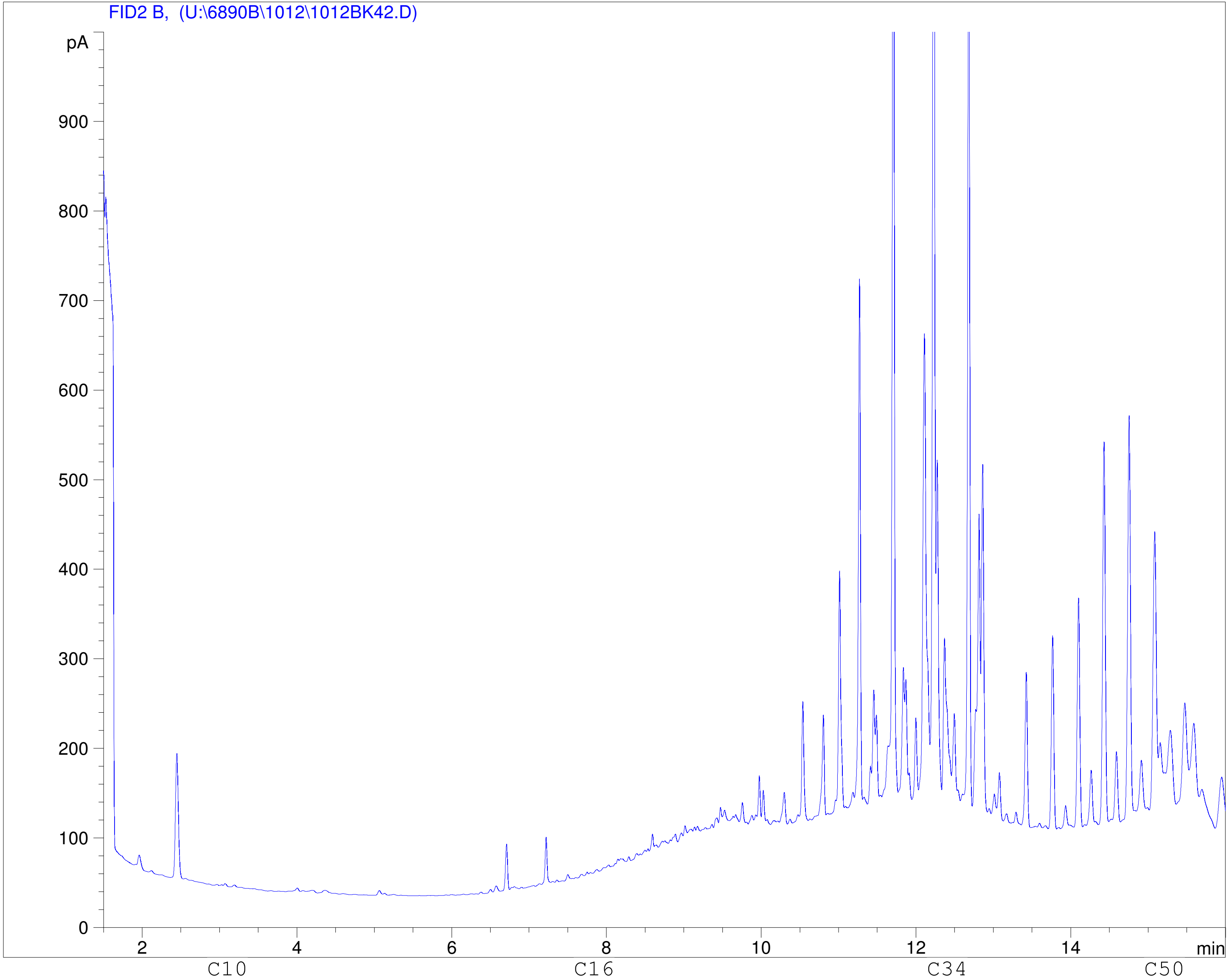
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

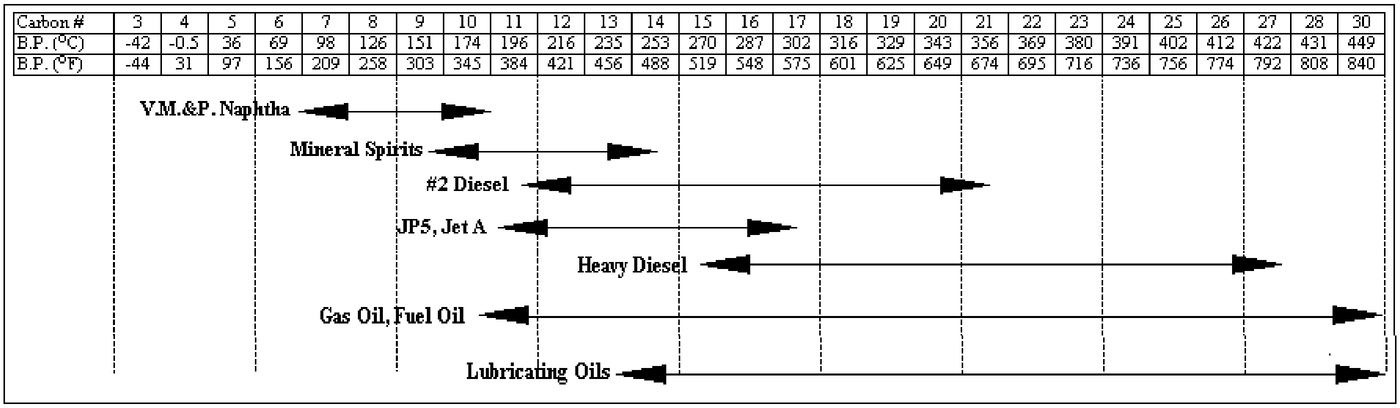
Client ID: 9-LFH

Sample ID: L437987-110 4 SG
Injection Date: 10/13/06 10:44:43 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



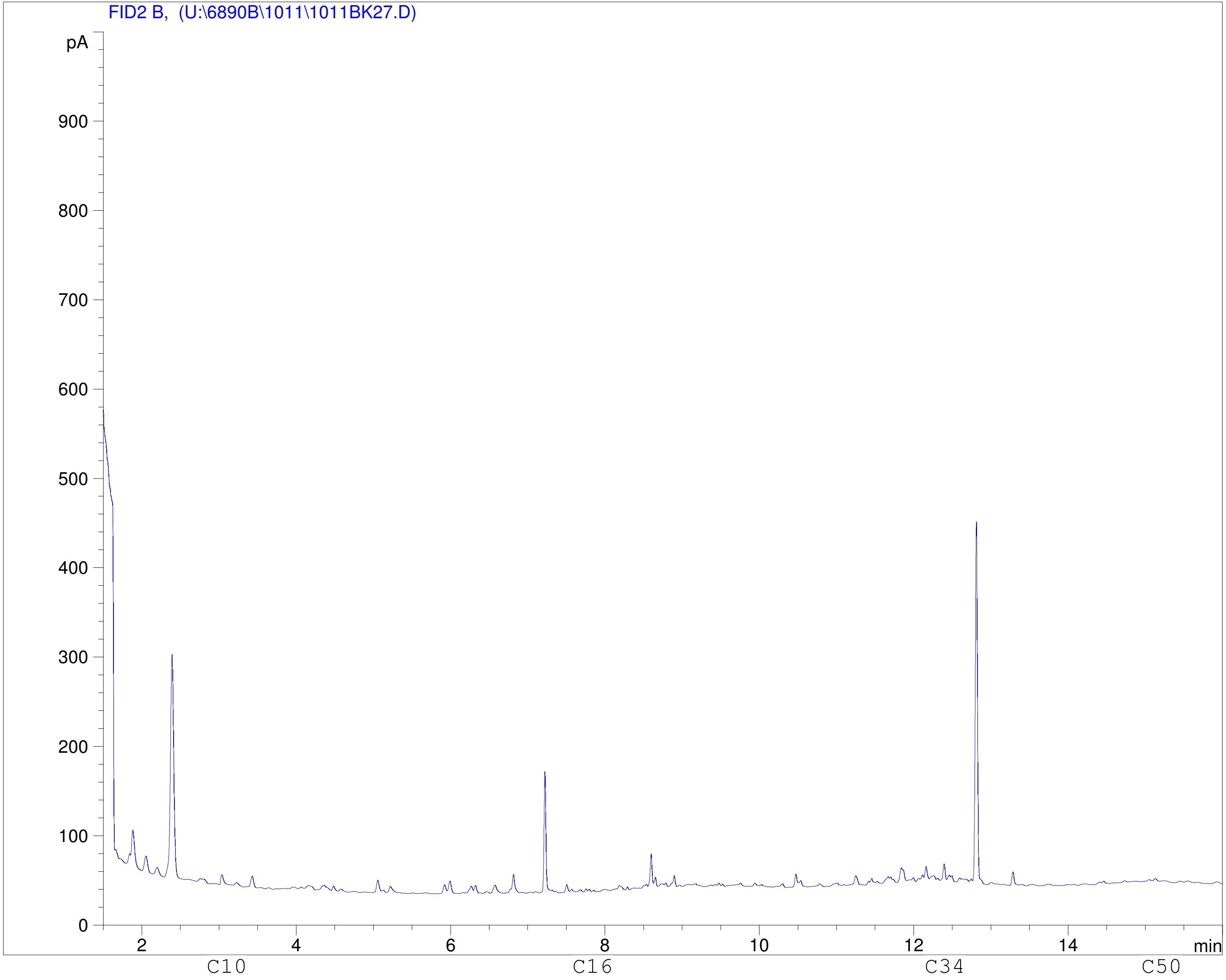
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 9-1

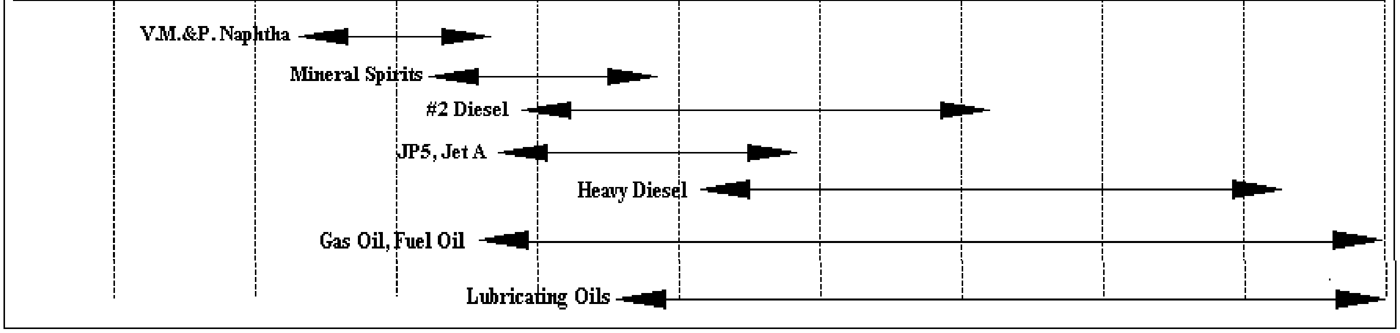
Sample ID: L437987-111 4
Injection Date: 10/12/06 3:23:05 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

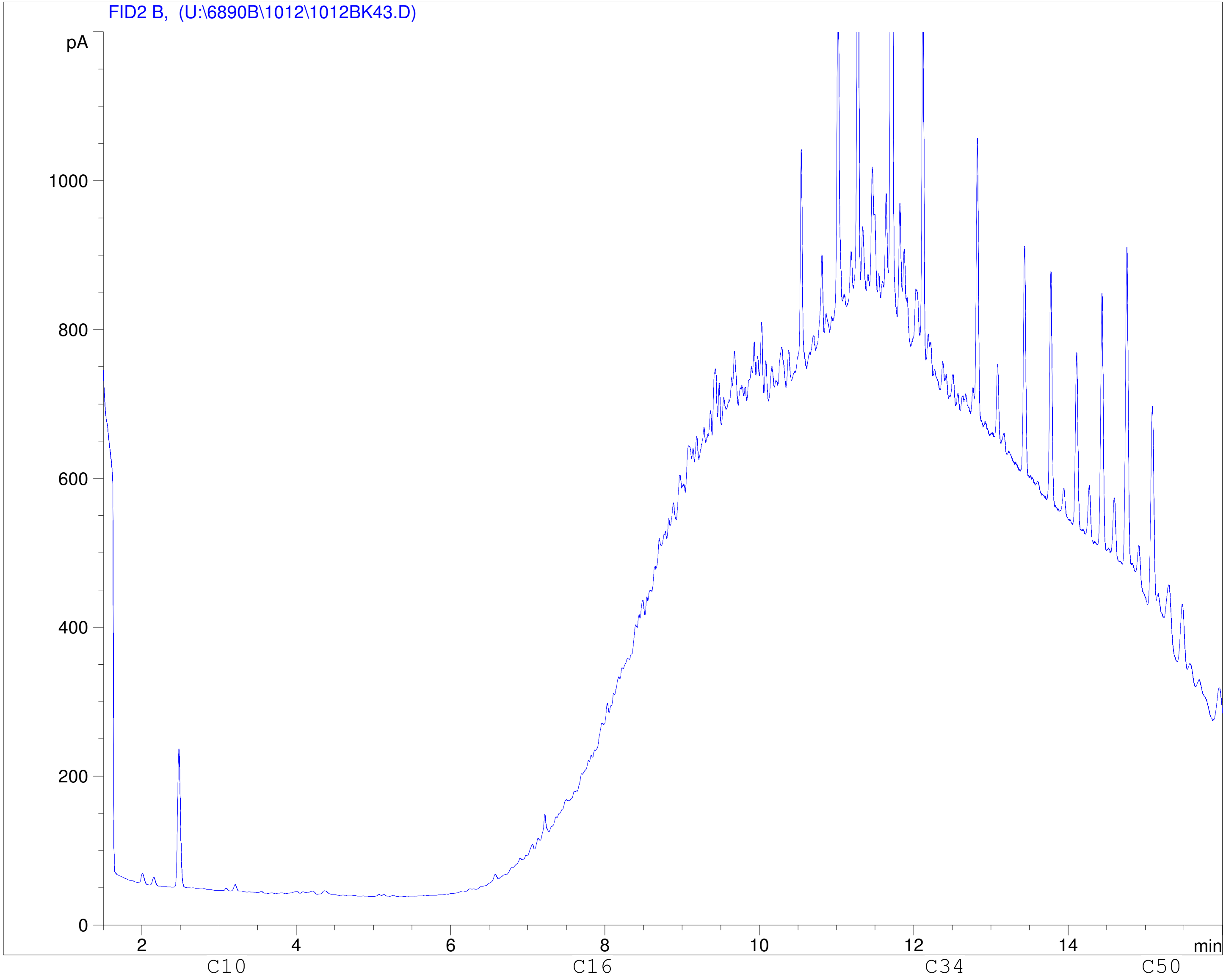


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 7-LFH

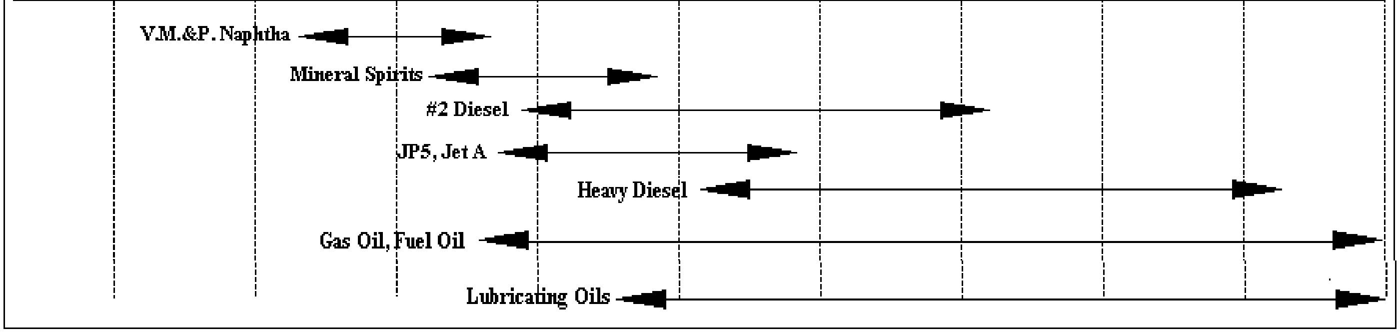
Sample ID: L437987-114 4 SG
Injection Date: 10/13/06 11:11:32 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

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COC # 283334

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Pg 1 of 10

DATE: Sept 27/06

LAB WORK ORDER# L437988

REPORT TO: Ryan Muri / Grant Woynarowich
COMPANY:
CONTACT: Millennium EMS
ADDRESS: #208, 4207 - 98 Street

PHONE: Ryan FAX: Grant
CELLPHONE: 780-991-4616 780-975-4335

INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL ___ FAX ___
EMAIL 1: gwoynarowich@mems.ca
EMAIL 2: rmuir@mems.ca
DIGITAL EMAIL: ___
SELECT: pdf___ digital___ [✓ both]
INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
JOB # 04-101
PO/AFE:
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
306 - DM							3		
306 - LFH							↓		
306 - 1					25ab + 1bag		↓		
306 - 2							↓		
[illegible]							↓		
307 DM							↓		
307 - [illegible] 1							↓		
307 - 2							↓		
307 - 3							↓		
308 - DM							↓		
308 - 1							↓		
308 - 2							↓		

Please hold all samples, requests for analytical will be submitted to Karen Hubner

FROZEN
✓ COLD
AMBIENT
MEAN TEMPERATURE

Failure to complete all portions of this form may delay analysis. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse of the white report copy.

RELINQUISHED BY: RM	DATE & TIME: Sept 27/06	RECEIVED BY:	DATE & TIME	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME: 7:05	RECEIVED BY:	DATE & TIME	

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250325-03003

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COC # 283302

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Pg 2 of

DATE: Sept 27/06	LAB WORK ORDER # L437989
REPORT TO:	REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
COMPANY:	EMAIL ___ FAX ___
CONTACT: See Pg #1	EMAIL 1:
ADDRESS:	EMAIL 2:
	DIGITAL EMAIL:
PHONE: FAX:	SELECT: pdf___ digital___ both___
CELLPHONE:	INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
INVOICE TO: SAME Y / N	JOB # 04-101
COMPANY:	
CONTACT:	PO/AFE:
ADDRESS:	
	LSD:
PHONE: FAX:	QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
309-3																3		
309-DY																		
309-1																		
309-2																		
309-3																		
310-LFH																		
310-1																		
310-2																		
310-3																		
311-LFH																		
311-1																		
311-2																		

☐ FROZEN
☐ COLD
☐ AMBIENT

MEAN TEMPERATURE

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RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY PINK - FILE COPY YELLOW - CLIENT COPY

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COC #283303

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Pg 3 of

DATE: Sept 27/06

LAB WORK ORDER # L437989

REPORT TO:
COMPANY:
CONTACT: See pg #1
ADDRESS:

PHONE: FAX:
CELLPHONE:

INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:

PHONE: FAX:

REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both___
INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
JOB # 04-101
PO/AFE
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
311-3																3		
312-LFH																		
312-1																		
313-LFH																		
313-1																		
313-2																		
313-3																		
211-DM																		
211-LFH																		
211-1																		
211-2																		
211-3																		

☐ FROZEN
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☐ AMBIENT

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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REPORT TO:
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CONTACT:
ADDRESS:
PHONE: FAX:

DATE: Sept 27/06
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
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JOB # 04-102
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L437989

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGH CONTAMINATED ?	LAB SAMPLE #
210 - LFH																3		
210 - 1																		
210 - 2																		
210 - 3																		
209 - OM																		
209 - 1																		
209 - 2																		
209 - 3																		
209 - LFH																		
208 - OM																		
208 - LFH																		
208 - 1																		

☐ FROZEN
☐ COLD
☐ AMBIENT

MEAN TEMPERATURE

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RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:	

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COC #283305

Pg 5 of

DATE: Sept 27/06

LAB WORK ORDER # L437987

REPORT TO:
COMPANY:
CONTACT: See Page 1
ADDRESS:

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INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:

PHONE: FAX:

REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
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EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
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JOB # 04-101
PO/AFE
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
208-2																3		
208-3																		
207-DM																		
207-LFH																		
207-1																		
207-2																		
207-3																		
206-DM																		
206-LFH																		
206-1																		
206-2																		
206-3.																		

☐ FROZEN
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☐ AMBIENT

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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COC #283499

Pg. 6 of

DATE:

LAB WORK ORDER # L437989

REPORT TO:
COMPANY:
CONTACT: See pg #1
ADDRESS:
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CELLPHONE
INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL ___ FAX ___
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both___
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JOB # 04-101
PO/AFE:
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
107-DM																3		
107-LFH																		
107-1																		
107-2																		
107-3																		
108-DM																		
108-LFH																		
108-1																		
108-2																		
108-3																		
109-DM																		
109-LFH																		

☐ FROZEN
☐ COLD
☐ AMBIENT

MEAN TEMPERATURE

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

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COC # 283306

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Pg 7 of

LAB WORK ORDER # L437987

REPORT TO:
COMPANY:
CONTACT: See pg #1
ADDRESS:
PHONE: FAX:
CELLPHONE:

INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

DATE:
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both___
INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
JOB # 09-101
PO/AFE:
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
109-1																3		
109-2																		
109-3																		
110-DM																		
110-1																		
110-2																		
110-3																		
~~1[illegible]~~ NO SAMPLE																		
111-1																		
111-2																		
111-3																		
112-LFH																		

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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RELINQUISHED BY: RM.
DATE & TIME: Sept 27/06
RECEIVED BY:
DATE & TIME:
SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)

RELINQUISHED BY:
DATE & TIME: 7:04 pm
RECEIVED BY:
DATE & TIME:

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COC #283307

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Pg. 8 of

LAB WORK ORDER# L437987

REPORT TO:
COMPANY:
CONTACT: Sergy
ADDRESS:
PHONE: FAX:
CELLPHONE:
INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

DATE:
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both___
INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
JOB # 04-101
PO/AFE:
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
112-1							3		
112-2									
112-3									
113-1									
113-2					HOLD.				
113-3									
7-DM									
7-1									
7-2									
7-3									
8-DM									
8-1									

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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LAB WORK ORDER # L437987

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LSD:
QUOTE #

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
10-2									HOLD							3		
10-3																		
11-LFH																		
11-1																		
11-2																		
11-3																		
12-LFH																		
12-1																		
12-2																		
12-3																		

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SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
8-2							3		
8-3									
9-DM									
9-LFH					HOLD				
9-1									
9-2									
9-3									
7-LFH									
8-LFH									
10-DM									
10-LFH									
10-1									

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RELINQUISHED BY: DATE & TIME: RECEIVED BY: DATE & TIME:

SAMPLE CONDITION ACCEPTABLE UPON RECEIPT (Y/N)

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Norma Jestin

From: Karen Huebner
Sent: Friday, October 06, 2006 12:47 PM
To: Norma Jestin; Joanne Ringuette
Subject: Additionals for Millennium Files

Hello,

Please add the following

He needs TCLP NAP (will have to code as a water with a prep) Acids to all samples which had Nap Acid requested. As well client needs the DM samples for the corresponding IDs (ie 305,308,310,107,109) analysed for BTX F1-F4,detailed salinity, CCME metals, PAHs, Naphthenic acids and **TCLP Nap Acids** Original email is below. Additionals are in in **BOLD**

305-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437383-72 Add TCLP Nap Acids**
305-1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437383-97 Add TCLP Nap Acids**
305-DM2 BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437383-71

308-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-119 no jars - can't add TCLP Nap Acids**
308-1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-11 Add TCLP Nap Acids**
308-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-10

310-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's L437987-18 **TCLP Nap Acids L437987-18**
310 -1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **TCLP Nap Acids L437987-19**
310-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-18

107-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-62 TCLP Nap Acids**
107 -1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-63 TCLP Nap Acids**
107-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-61

109-LFH: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-72 TCLP Nap Acids**
109-1: BTEX F1-F4, detailed salinity, CCME metals, Naphthenic acids, PAH's **L437987-73 TCLP Nap Acids**
109-DM BTX F1-F4 detailed salinity, CCME metals, Naphthenic acids, PAH's and TCLP Nap Acids L437987-71

Karen Huebner
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Fax: +1 780 437-2311

Oct 10/06

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L439526 L437987
L438781 L437383

Additional Analysis Requests for Millennium EMS project No. 04-101, requested Nov 2, 2006

Samples submitted Sept 27, 28 & 29, 2006

For Questions, contact Callie Volf (780-496-9048 ext.259, cvolf@mems.ca)

Sample Name	SAL-Detail	PSA-MUST	BTX,TVH, TEH-CCME	
4-LFH	X			L437383-13
7-LFH	X			L437987-114
7-1	X			L437987-92
11-LFH	X			L437987-99
14-LFH	X			L439526-38
14-1	X			L439526-39
14-2	X			L439526-40
16-LFH	X			L439526-46
16-1	X	X		L439526-47
16-2		X		L439526-48
19-LFH	X			L439526-58
20-LFH	X			L439526-62
20-1	X			L439526-63
21-LFH	X			L439526-66
103-LFH	X			L437383-81
103-1	X			L437383-82
* 107-1		X		L437987-63
* 109-1		X		L437987-72
114-LFH	X			L439526-70
116-1	X			L439526-77
116-2	X			L439526-78
124-LFH	X			L438781-24
124-1	X			L438781-25
204-LFH	X			L437383-41
208-LFH	X			L437987-47
213-LFH	X			L439526-108
217-LFH	X			L439526-124
218-LFH	X			L439526-128
222-LFH	X			L438781-5
302-LFH	X			L437383-57
302-1	X			L437383-58
* 305-1		X		L437383-97
308-2	X			L437987-12
313-LFH	X			L437987-28
318-LFH	X			L439526-14
318-1	X	X		L439526-15
318-2		X		L439526-16
323-LFH	X			L438781-35
323-1		X		L438781-36
325-1	X			L438781-44
326-1	X			L438781-48
327-1	X		X	L438781-51
327-2	X		X	L438781-52

Nov 3/06

Norma Jestin

From: Karen Huebner
Sent: Tuesday, November 07, 2006 8:30 AM
To: Norma Jestin
Subject: FW: L437987-73

Please add PSA-MUST to L437987-73 in place of L437987-72.

Thanks
Karen

Karen Huebner
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Nov 7/06

From: Callie Volf [mailto:cvolf@mems.ca]
Sent: Tuesday, November 07, 2006 7:56 AM
To: Karen Huebner; Ryan Muri
Subject: RE: L437987-72

Hi Karen,

I'm back in the office earlier than planned. That was supposed to be 109-1 for PSA-MUST. Apologies for the confusion.

Callie

> -----Original Message-----
> **From:** Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
> **Sent:** Monday, November 06, 2006 3:02 PM
> **To:** Ryan Muri
> **Cc:** Callie Volf
> **Subject:** L437987-72
>
> Hi Ryan,
>
> Callie ordered additionals on 04-101 last week and I think she's in the field this week. We aren't able to run the PSA-MUST on L437987-72 (109-LFH) as the sample is too organic. Sorry, the particle size has been canceled on this sample.
>
> Thanks
> Karen
>
> **Karen Huebner**
> Senior Account Manager

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Norma Jestin

From: Karen Huebner
Sent: Friday, December 01, 2006 9:42 AM
To: Norma Jestin; Joanne Ringuette; Aimee Thompson; Michelle Eckert; Ian Bullecer
Cc: Sean Johnston
Subject: Additional SGC

Please add TEH-SGC to the following. Reg TAT.

Aimee/Michelle/Ian - Please make sure the coverpage comments are added when results are completed.
Thanks

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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Dec 1/06

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Thursday, November 30, 2006 2:26 PM
To: Karen Huebner
Subject: FW: Silica Column vs silica gel clean up 04-101

Karen,

Please run the Silica column clean up on the following samples, on regular TAT:

4-LFH	L437383-13	
107-DM	L437987-61	✓
107-LFH	L437987-62	✓
109-DM	L437987-71	✓
109-LFH	L437987-72	✓
308-1	L437987-11	✓
310-LFH	L437987-18	✓
310-1	L437987-19	✓
7-LFH	L437987-114	✓
9-LFH	L437987-110	✓
204-LFH	L437383-41	✓
208-LFH	L437987-47	✓
12-LFH	L437987-103	✓
12-1	L437987-104	✓
13-LFH	L439526-34	✓
13-1	L439526-35	✓
14-LFH	L439526-38	✓
14-1	L439526-39	✓
16-LFH	L439526-46	✓
114-LFH	L439526-70	✓

114-1 L439526- 71 ✓
116 -1 L439526-77 ✓
313-LFH L437987-28 ✓
313-1 L437987-29 ✓
213-LFH L439526-108 ✓
314-LFH L439526-1 ✓
314-1 L439526-2 ✓
318-LFH L439526-14 ✓
319-LFH L439526-18 ✓
117-LFH L439526-80 ✓
215-LFH L437526-116 ✓
217-LFH L439526-124 ✓
218-LFH L439526-128 ✓
20-LFH L439526-62 ✓
120-LFH L439526-92 ✓
220-LFH L439526-136 ✓
222-LFH L438781-5 ✓
323-LFH L438781-35 ✓
323-1 L438781-36 ✓
DGW260-LFH L450940-1 ✓
DGW261-LFH L450940-5 ✓
DGW262-1 L450940- 9 ✓
DGW262-2 L450940-10 ?
DGW263-LFH. L450940-12 ✓

Thanks Karen. Can you also send me MEMS price for these, I just need to do some budgeting changes.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
CELL:780-991-4616

-----Original Message-----
From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:48 PM
To: Ian Terry; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Hi Ian,

No, as per Cory's instructions we no longer run the F4G unless it's requested. His email is below (sent Aug 30th). I have the original email if you need it forwarded.

Thanks
Karen

****

Please remove the F4G. We will request it when required. Thanks Cory

> -----Original Message-----
> **From:** Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
> **Sent:** Thursday, August 24, 2006 8:46 AM
> **To:** Cory Sommer
> **Subject:** RE: L421098 addtional lab data requests

Hi Cory,

No problem, we don't have a BH06-24 @3.0M but we do have a BH06-24 @3.5M. I'll have the metals and salinity added to this sample instead.
Millennium is set up so that if the chrom does not return to baseline at C50 we automatically add the F4G. Technically you are obligated to report the F4G if the chrom does not return to baseline. If you Millennium no longer wants this then I can remove it but I need something in writing.

I found the following email from Ian, he never did get back to me on if the automatic F4G should be removed.
Thanks
Karen
****

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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From: Ian Terry [mailto:ITerry@mems.ca]
Sent: Thursday, November 30, 2006 1:39 PM
To: Karen Huebner; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Are you using the in-situ method then for samples that we submit?

Regards,

Ian

From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:00 PM
To: Ian Terry; Ryan Muri
Subject: Silica Column vs silica gel clean up

Please see below - this might clear things up a bit.

The CCME method makes silica gel cleanup mandatory for the F2-F4 fractions, but allows for two options: a simple in situ shake in which silica gel is added to a large solvent volume and shaken, or a column, in which a small volume of concentrated extract is passed through a glass column filled with packed silica gel. The column cleanup is much more intensive; in fact, it will remove some parts of petroleum hydrocarbons. The in situ cleanup, on the other hand, is less effective and will not remove high levels of naturally occurring hydrocarbons.

The F4G is a gravimetric measurement designed to account for hydrocarbons in and above the F4 range. Gas chromatograph response falls off dramatically above C50, so heavy hydrocarbons might not be accounted for in

the GC F2-F4 analysis. The CCME method allows F4G to be done on either a raw or a silica cleaned extract; we analyze only on a silica gel cleaned extract (F4G-SG), in order to be comparable to the F2-F4 results. The oven-dried gravimetric F4G result is highly variable, though, and can include significant portions of both the F4 and even the F3 hydrocarbons (the method requires the F4G to be dried at 110 degrees C, and the hydrocarbons in the F3 range typically have boiling points in the 250-300 degree C range or above). For this reason, the F4G can at times be surprisingly high.

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PRELIMINARY RESULTS

MILLENNIUM
ATTN: GRANT WOYNAROWICH/RYAN MURI

208 4207 98 ST

EDMONTON AB T6E 5R7

Reported On: 07-DEC-06 03:13 PM
Revision: 2

Lab Work Order #: **L438781** **Date Received:** **29-SEP-06**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 283319, 283320, 283321, 283322, 283323

Other Information:

Comments: ADDITIONAL 01-DEC-06 10:42 ADDITIONAL 03-NOV-06 14:18 A silica gel column clean up was done on TEH-CCME-ED F2-F4 samples L438781-5,24,48.

Silica gel column cleanup results used for F2-F4 for fraction 35. 02-Nov-06.

Silica gel column cleanup results used for F2-F4 for fraction 36. 07-Dec-06.

ROY JONES
General Manager, Edmonton

For any questions about this report please contact your Account Manager:

KAREN HUEBNER

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L438781-5 222-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	104		33-172	%	10-OCT-06	11-OCT-06	GRB	R452690
Surr: Hexatriacontane	180	SOL:MI	44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		13-OCT-06		
F1-BTEX	<5		5	mg/kg		13-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		13-OCT-06		
F3 (C16-C34)	1900		5	mg/kg		13-OCT-06		
F4 (C34-C50)	1300		5	mg/kg		13-OCT-06		
Total Hydrocarbons (C6-C50)	3200		5	mg/kg		13-OCT-06		
Chromatogram to baseline at nC50	NO					13-OCT-06		
% Moisture	63		0.1	%		06-OCT-06	DJS	R450976
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	83		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	97		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	36		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	3		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	45		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	645		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.7		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.72		0.01	dS m-1		09-NOV-06	SZ	R463549
L438781-6 222-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Toluene	<0.01		0.01	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	104		33-172	%	10-OCT-06	11-OCT-06	IJB	R452413
Surr: Hexatriacontane	93		44-173	%	10-OCT-06	11-OCT-06	IJB	R452413
Prep/Analysis Dates					10-OCT-06	11-OCT-06	IJB	R452413
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		13-OCT-06		
F1-BTEX	<5		5	mg/kg		13-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		13-OCT-06		
F3 (C16-C34)	11	RAMB	5	mg/kg		13-OCT-06		
F4 (C34-C50)	<5		5	mg/kg		13-OCT-06		
Total Hydrocarbons (C6-C50)	11		5	mg/kg		13-OCT-06		
Chromatogram to baseline at nC50	YES					13-OCT-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L438781-6 222-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
% Moisture	7.2		0.1	%		06-OCT-06	DJS	R450976
L438781-24 124-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Xylenes	0.47	DLHM	0.03	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	134		33-172	%	10-OCT-06	11-OCT-06	GRB	R452690
Surr: Hexatriacontane	133		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	18	IPT	5	mg/kg		13-OCT-06		
F1-BTEX	18		5	mg/kg		13-OCT-06		
F2 (C10-C16)	29		5	mg/kg		13-OCT-06		
F3 (C16-C34)	660		5	mg/kg		13-OCT-06		
F4 (C34-C50)	1000		5	mg/kg		13-OCT-06		
Total Hydrocarbons (C6-C50)	1700		5	mg/kg		13-OCT-06		
Chromatogram to baseline at nC50	NO					13-OCT-06		
% Moisture	67		0.1	%		11-OCT-06	MPI	R452367
Detailed Salinity								
Chloride (Cl)	50		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	93		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	107		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	59		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	3		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	66		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	618		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	5.3		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.77		0.01	dS m-1		09-NOV-06	SZ	R463549
L438781-25 124-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	11-OCT-06	12-OCT-06	OOO	R453001
Toluene	<0.01		0.01	mg/kg	11-OCT-06	12-OCT-06	OOO	R453001
Ethylbenzene	<0.01		0.01	mg/kg	11-OCT-06	12-OCT-06	OOO	R453001
Xylenes	<0.01		0.01	mg/kg	11-OCT-06	12-OCT-06	OOO	R453001
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	131		33-172	%	10-OCT-06	11-OCT-06	IJB	R452413
Surr: Hexatriacontane	87		44-173	%	10-OCT-06	11-OCT-06	IJB	R452413
Prep/Analysis Dates					10-OCT-06	11-OCT-06	IJB	R452413
CCME Total Hydrocarbons								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L438781-25 124-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		13-OCT-06		
F1-BTEX	<5		5	mg/kg		13-OCT-06		
F2 (C10-C16)	7	RAMB	5	mg/kg		13-OCT-06		
F3 (C16-C34)	7	RAMB	5	mg/kg		13-OCT-06		
F4 (C34-C50)	<5		5	mg/kg		13-OCT-06		
Total Hydrocarbons (C6-C50)	14		5	mg/kg		13-OCT-06		
Chromatogram to baseline at nC50	YES					13-OCT-06		
% Moisture	7.3		0.1	%		11-OCT-06	MPI	R452367
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	35		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	3		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	27		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	7		2	mg/L		08-NOV-06	JWU	R463269
SAR	0.2		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	45		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	43.8		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	5.9		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.26		0.01	dS m-1		08-NOV-06	SR	R463184
L438781-35 323-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Toluene	<0.03	DLHM	0.03	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Xylenes	<0.03	DLHM	0.03	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	148		33-172	%	01-NOV-06	01-NOV-06	MKE	R461074
Surr: Hexatriacontane	131		44-173	%	01-NOV-06	01-NOV-06	MKE	R461074
Prep/Analysis Dates					01-NOV-06	01-NOV-06	MKE	R461074
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-NOV-06		
F1-BTEX	<5		5	mg/kg		14-NOV-06		
F2 (C10-C16)	39	IPC	5	mg/kg		14-NOV-06		
F3 (C16-C34)	1600	IPC	5	mg/kg		14-NOV-06		
F4 (C34-C50)	750	IPC	5	mg/kg		14-NOV-06		
Total Hydrocarbons (C6-C50)	2400		5	mg/kg		14-NOV-06		
Chromatogram to baseline at nC50	NO					14-NOV-06		
% Moisture	65		0.1	%		27-OCT-06	DJS	R459073
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	70		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	34		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	31		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	15		2	mg/L		09-NOV-06	JWU	R463645

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L438781-35 323-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
SAR								
SAR	0.4		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	51		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	419		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.3		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.52		0.01	dS m-1		09-NOV-06	SZ	R463549
L438781-36 323-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Toluene	<0.04	DLHM	0.04	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
Xylenes	<0.04	DLHM	0.04	mg/kg	27-OCT-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	101		33-172	%	01-NOV-06	05-DEC-06	AAT	R473310
Surr: Hexatriacontane	90		44-173	%	01-NOV-06	05-DEC-06	AAT	R473310
Prep/Analysis Dates					01-NOV-06	05-DEC-06	AAT	R473310
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		07-DEC-06		
F1-BTEX	<5		5	mg/kg		07-DEC-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		07-DEC-06		
F3 (C16-C34)	610		5	mg/kg		07-DEC-06		
F4 (C34-C50)	430		5	mg/kg		07-DEC-06		
Total Hydrocarbons (C6-C50)	1000		5	mg/kg		07-DEC-06		
Chromatogram to baseline at nC50	NO					07-DEC-06		
% Moisture	73		0.1	%		27-OCT-06	DJS	R459073
L438781-44 325-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	13		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	2		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	4		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	13		2	mg/L		08-NOV-06	JWU	R463269
SAR	0.8		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	30		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	30.7		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	4.7		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.14		0.01	dS m-1		08-NOV-06	SR	R463184
L438781-48 326-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L438781-48 326-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Toluene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Ethylbenzene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
Xylenes	<0.05	DLHM	0.05	mg/kg	06-OCT-06	12-OCT-06	OOO	R453001
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	118		33-172	%	10-OCT-06	11-OCT-06	GRB	R452690
Surr: Hexatriacontane	125		44-173	%	10-OCT-06	11-OCT-06	GRB	R452690
Prep/Analysis Dates					10-OCT-06	11-OCT-06	GRB	R452690
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		13-OCT-06		
F1-BTEX	<5		5	mg/kg		13-OCT-06		
F2 (C10-C16)	12		5	mg/kg		13-OCT-06		
F3 (C16-C34)	290		5	mg/kg		13-OCT-06		
F4 (C34-C50)	260		5	mg/kg		13-OCT-06		
Total Hydrocarbons (C6-C50)	560		5	mg/kg		13-OCT-06		
Chromatogram to baseline at nC50	NO					13-OCT-06		
% Moisture	79		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	48		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	29		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	26		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	18		2	mg/L		09-NOV-06	JWU	R463645
SAR	0.5		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	93		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	535		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	5.6		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.48		0.01	dS m-1		09-NOV-06	SZ	R463549
L438781-51 327-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
Toluene	<0.01		0.01	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.01		0.01	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
Xylenes	<0.01		0.01	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	128		33-172	%	06-NOV-06	07-NOV-06	MKE	R463347
Surr: Hexatriacontane	312	SOL:MI	44-173	%	06-NOV-06	07-NOV-06	MKE	R463347
Prep/Analysis Dates					06-NOV-06	07-NOV-06	MKE	R463347
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-NOV-06		
F1-BTEX	<5		5	mg/kg		14-NOV-06		
F2 (C10-C16)	14	IPC	5	mg/kg		14-NOV-06		
F3 (C16-C34)	750	IPC	5	mg/kg		14-NOV-06		
F4 (C34-C50)	500	IPC	5	mg/kg		14-NOV-06		
Total Hydrocarbons (C6-C50)	1300		5	mg/kg		14-NOV-06		
Chromatogram to baseline at nC50	NO					14-NOV-06		

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L438781-51 327-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
% Moisture	21		0.1	%		06-NOV-06	REK	R462361
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	318		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	15		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	90		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	93		2	mg/L		08-NOV-06	JWU	R463269
SAR	1.2		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	1040		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	53.4		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	7.2		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	1.70		0.01	dS m-1		08-NOV-06	SR	R463184
L438781-52 327-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
Toluene	<0.01		0.01	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
Ethylbenzene	<0.01		0.01	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
Xylenes	<0.01		0.01	mg/kg	06-NOV-06	13-NOV-06	OOO	R465133
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	141		33-172	%	06-NOV-06	07-NOV-06	MKE	R463347
Surr: Hexatriacontane	287	SOL:MI	44-173	%	06-NOV-06	07-NOV-06	MKE	R463347
Prep/Analysis Dates					06-NOV-06	07-NOV-06	MKE	R463347
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-NOV-06		
F1-BTEX	<5		5	mg/kg		14-NOV-06		
F2 (C10-C16)	24	IPC	5	mg/kg		14-NOV-06		
F3 (C16-C34)	530	IPC	5	mg/kg		14-NOV-06		
F4 (C34-C50)	380	IPC	5	mg/kg		14-NOV-06		
Total Hydrocarbons (C6-C50)	930		5	mg/kg		14-NOV-06		
Chromatogram to baseline at nC50	NO					14-NOV-06		
% Moisture	16		0.1	%		06-NOV-06	REK	R462361
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	317		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	9		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	131		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	91		2	mg/L		08-NOV-06	JWU	R463269
SAR	1.1		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	1260		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	55.6		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	7.5		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	1.83		0.01	dS m-1		08-NOV-06	SR	R463184

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
DLHM	Detection Limit Adjusted: Sample has High Moisture Content
IPC	Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank
SOL:MI	Surrogate recovery outside acceptable limits due to matrix interference

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
PREP-MOISTURE-ED	Soil	% Moisture		Oven dry 105C-Gravimetric
SAR-CALC-ED	Soil	SAR		CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)		CSSS 18.2, 16.2, 18.3
SO4-SAR-ED	Soil	Sulfate (SO4) in saturated paste		APHA 3120 B-ICP-OES

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

283319	283320	283321	283322	283323

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA		

Reference Information

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million.

mg/L (units) - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L438781

Lab ID Sample ID

L438781-5 222-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	645	0.94	216.0
Sulphate (SO4)	45	645	0.93	287.5
Calcium (Ca)	83	645	4.15	536.8
Potassium (K)	97	645	2.48	625.2
Magnesium (Mg	36	645	2.95	231.5
Sodium (Na)	3	645	0.14	21.1

L438781-25 124-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	43.8	<0.56	<8.8
Sulphate (SO4)	45	43.8	0.93	19.5
Calcium (Ca)	35	43.8	1.76	15.5
Potassium (K)	3	43.8	0.07	1.2
Magnesium (Mg	27	43.8	2.22	11.8
Sodium (Na)	7	43.8	0.29	2.9

L438781-44 325-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	30.7	<0.56	<6.1
Sulphate (SO4)	30	30.7	0.62	9.1
Calcium (Ca)	13	30.7	0.64	4.0
Potassium (K)	2	30.7	0.06	0.7
Magnesium (Mg	4	30.7	0.37	1.4
Sodium (Na)	13	30.7	0.59	4.1

Lab ID Sample ID

L438781-24 124-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	50	618	1.35	296.6
Sulphate (SO4)	66	618	1.37	407.8
Calcium (Ca)	93	618	4.65	575.8
Potassium (K)	107	618	2.73	658.5
Magnesium (Mg	59	618	4.87	365.8
Sodium (Na)	3	618	0.11	16.3

L438781-35 323-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	419	0.98	145.6
Sulphate (SO4)	51	419	1.06	213.6
Calcium (Ca)	70	419	3.47	291.4
Potassium (K)	34	419	0.86	141.4
Magnesium (Mg	31	419	2.58	131.3
Sodium (Na)	15	419	0.67	64.6

L438781-48 326-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	535	0.66	124.3
Sulphate (SO4)	93	535	1.94	498.6
Calcium (Ca)	48	535	2.37	254.3
Potassium (K)	29	535	0.73	153.6
Magnesium (Mg	26	535	2.13	138.3
Sodium (Na)	18	535	0.78	96.4

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L438781

Lab ID Sample ID

L438781-51 327-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	53.4	0.57	10.8
Sulphate (SO4)	1040	53.4	21.72	557.1
Calcium (Ca)	318	53.4	15.86	169.7
Potassium (K)	15	53.4	0.39	8.1
Magnesium (Mg)	90	53.4	7.44	48.3
Sodium (Na)	93	53.4	4.04	49.6

Lab ID Sample ID

L438781-52 327-2
Sample Date:
Matrix: SOIL

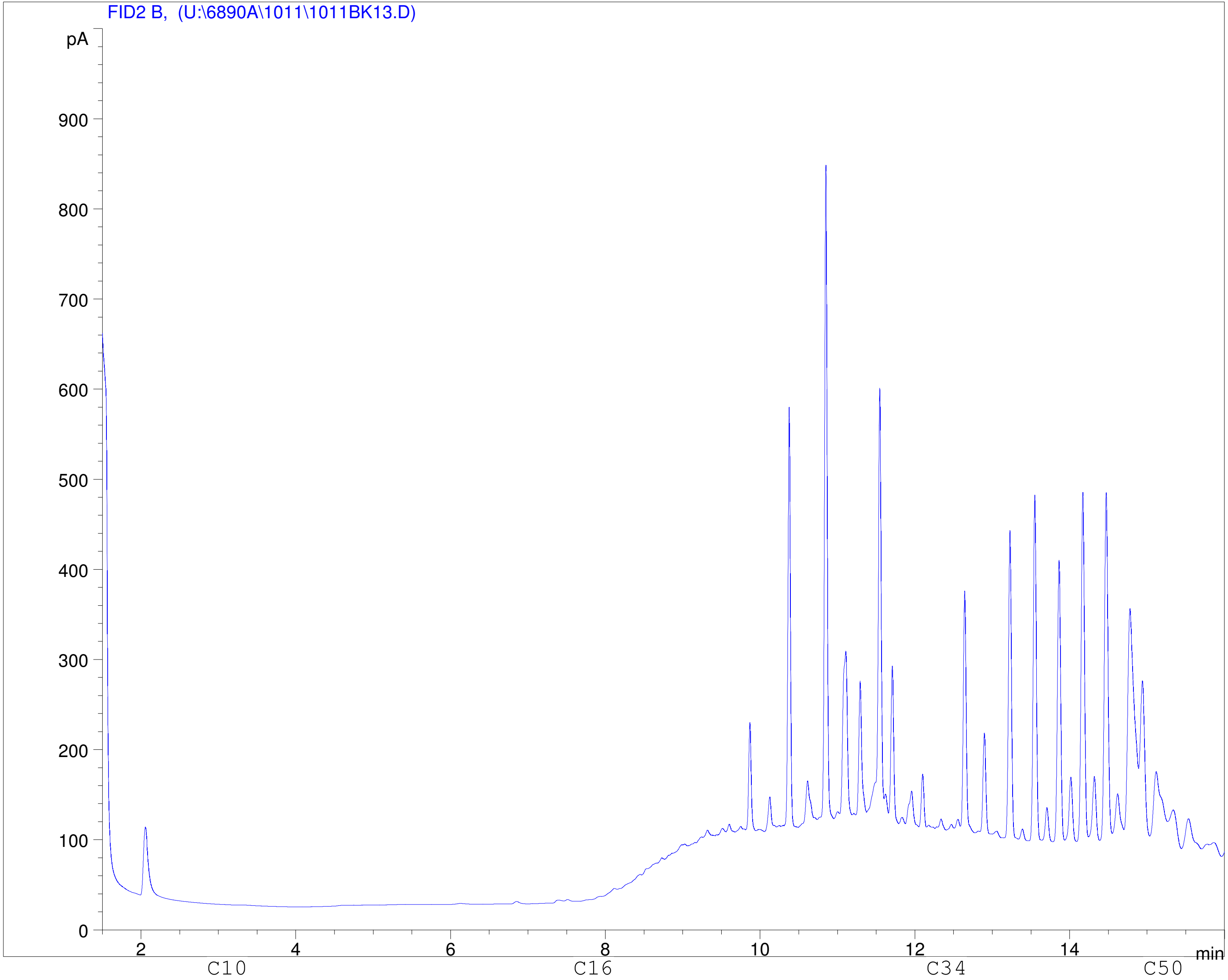
	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	55.6	0.60	11.9
Sulphate (SO4)	1260	55.6	26.19	699.3
Calcium (Ca)	317	55.6	15.84	176.5
Potassium (K)	9	55.6	0.22	4.7
Magnesium (Mg)	131	55.6	10.75	72.6
Sodium (Na)	91	55.6	3.97	50.7

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

Client ID: 222-LFH

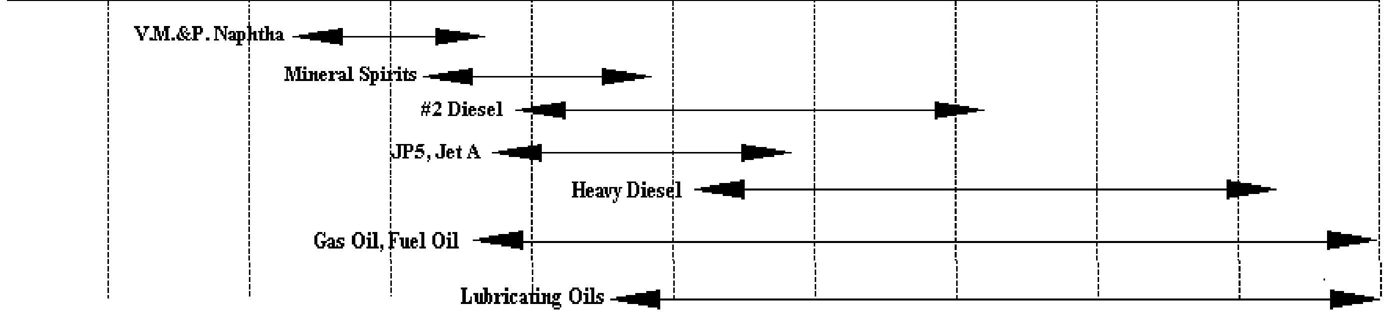
Sample ID: L438781-5 4 SG
Injection Date: 10/11/2006 10:30:19 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

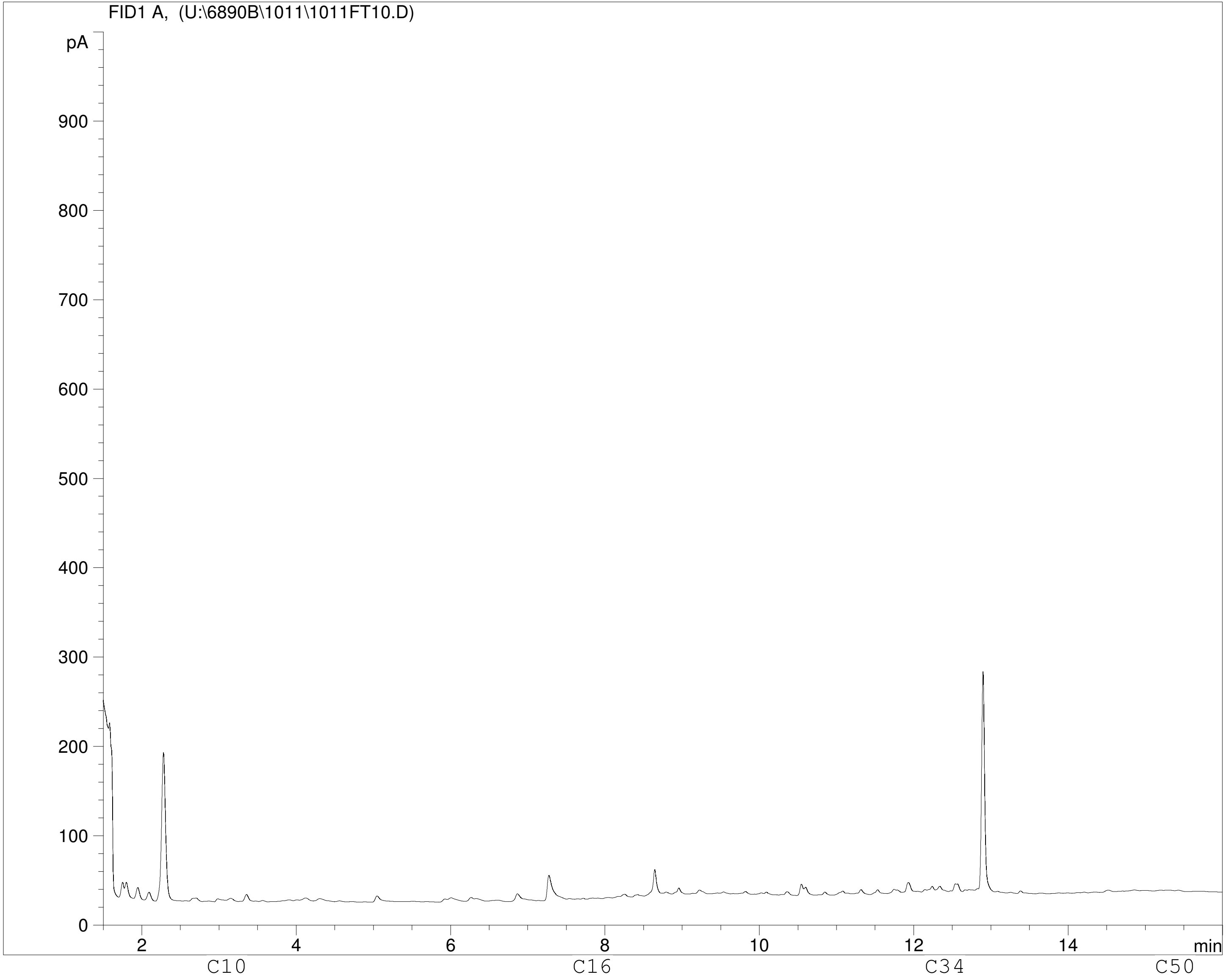


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 222-1

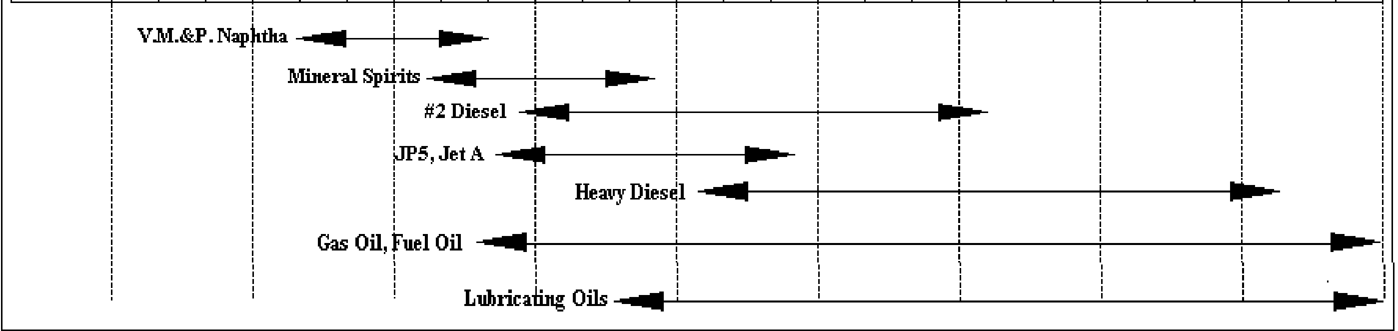
Sample ID: L438781-6 4
Injection Date: 10/11/06 7:44:12 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

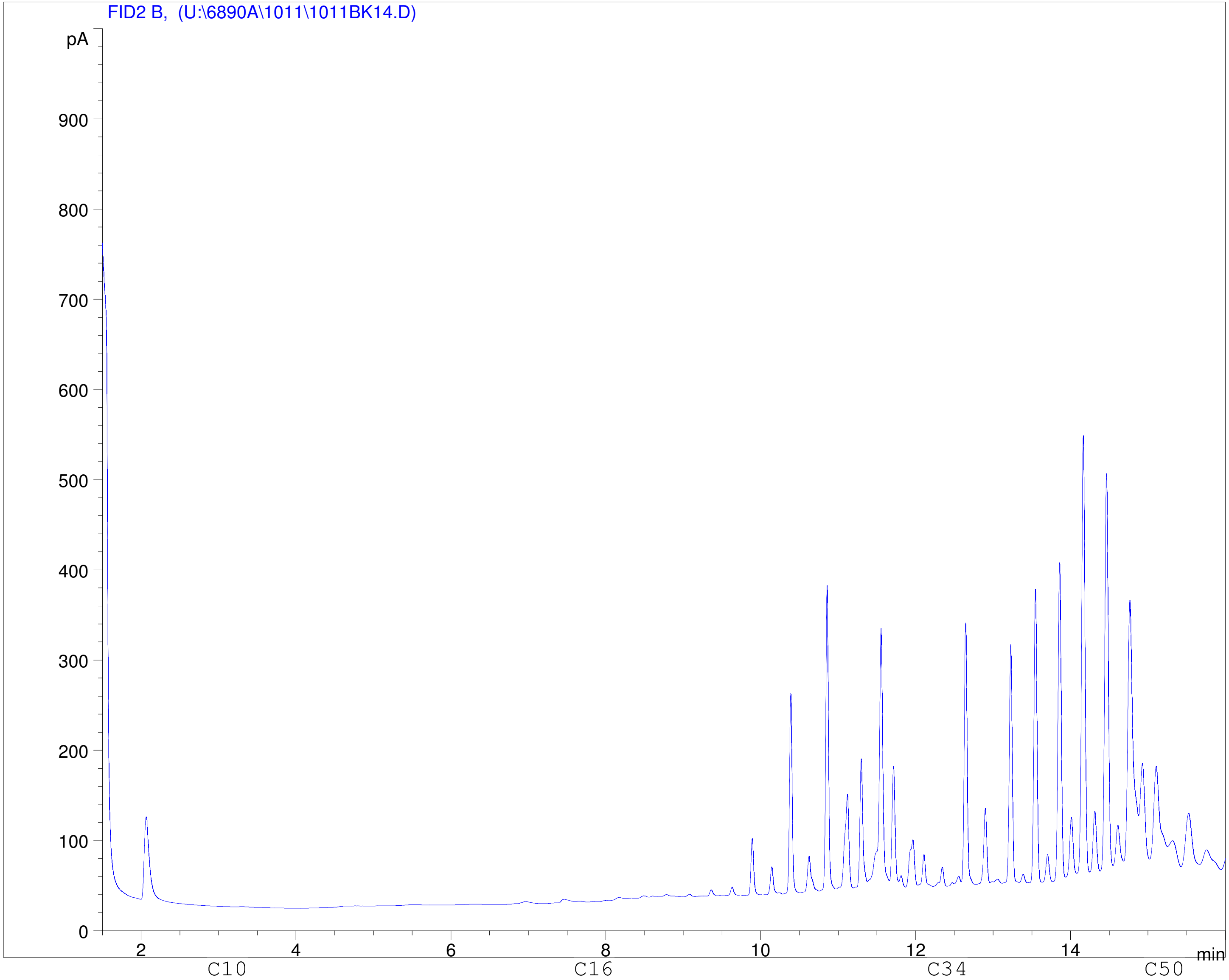


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

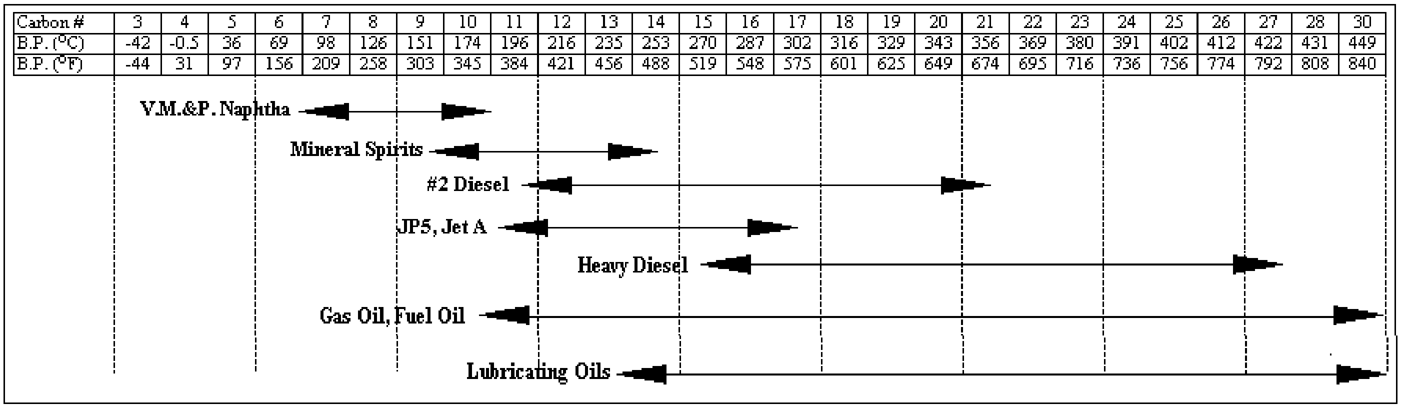
Client ID: 124-LFH

Sample ID: L438781-24 4 SG
Injection Date: 10/11/2006 10:55:27 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



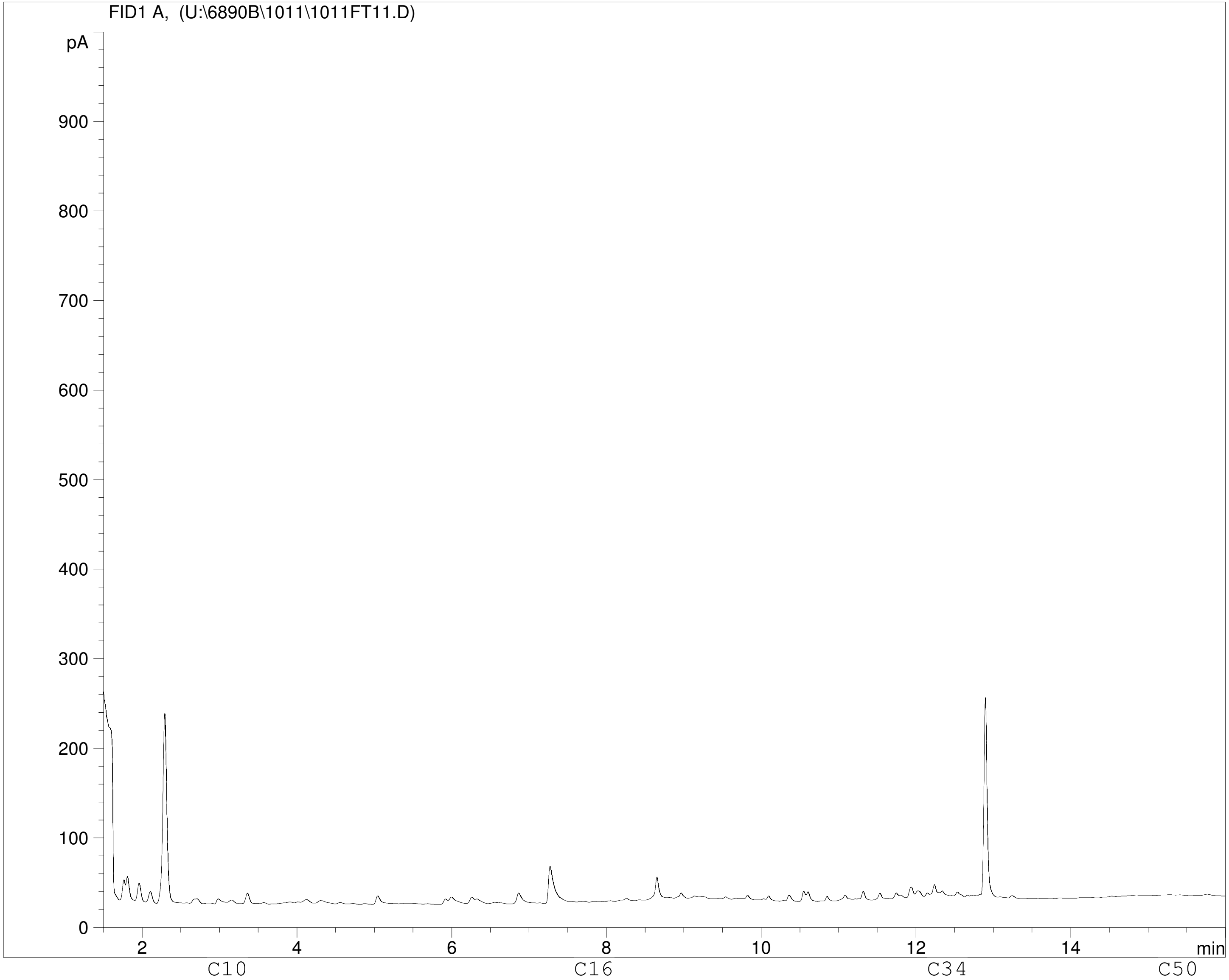
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 124-1

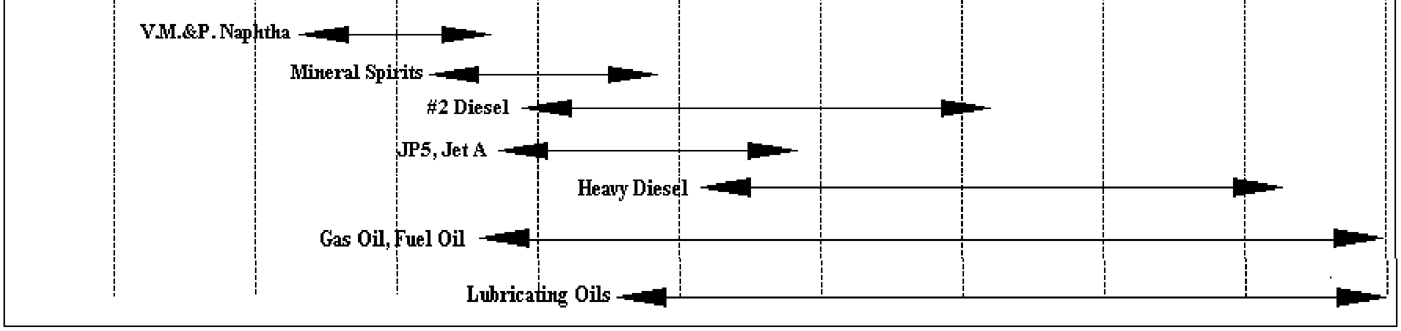
Sample ID: L438781-25 4
Injection Date: 10/11/06 8:11:10 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

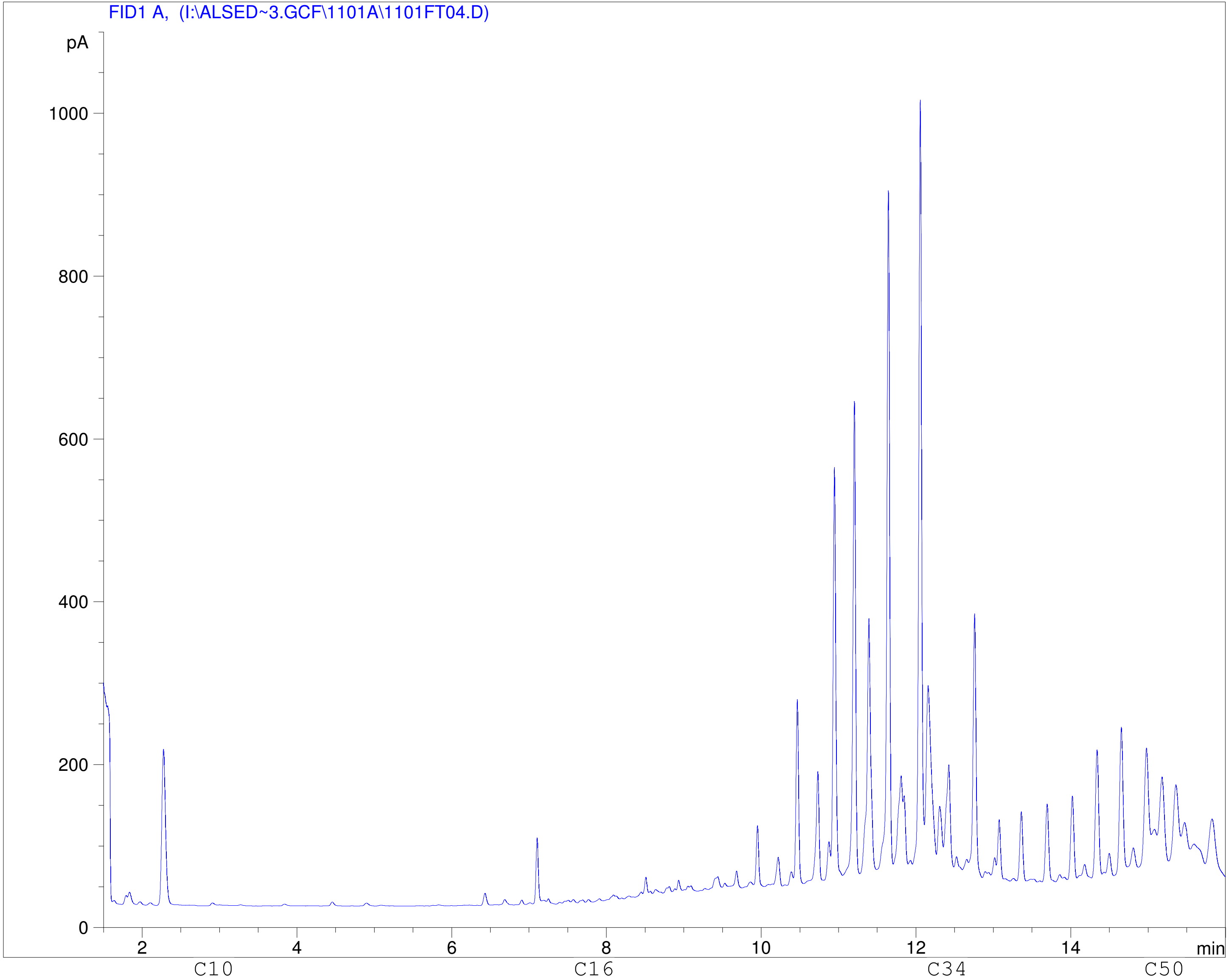


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

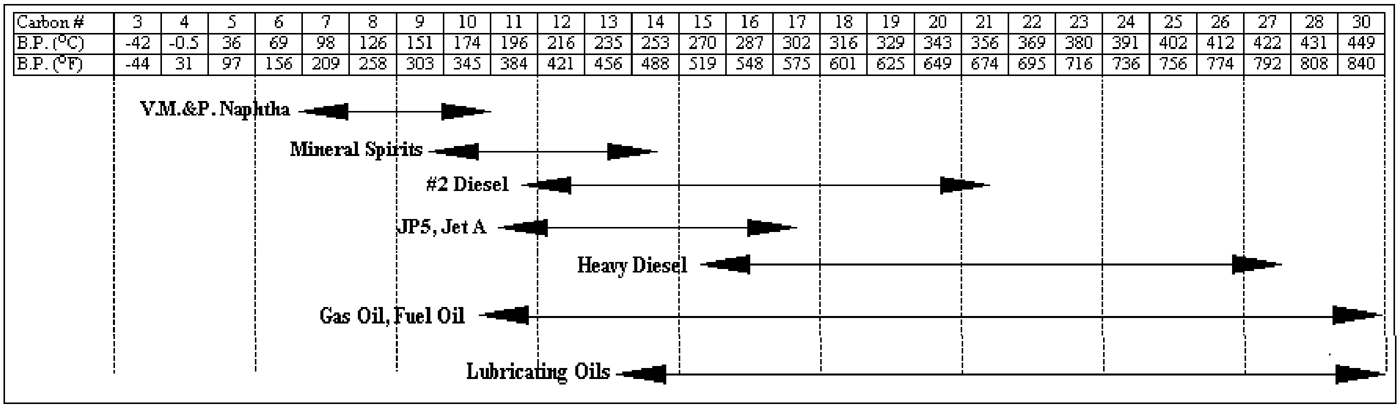
Client ID: 323-LFH

Sample ID: L438781-35 4 SG
Injection Date: 11/2/06 11:18:31 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



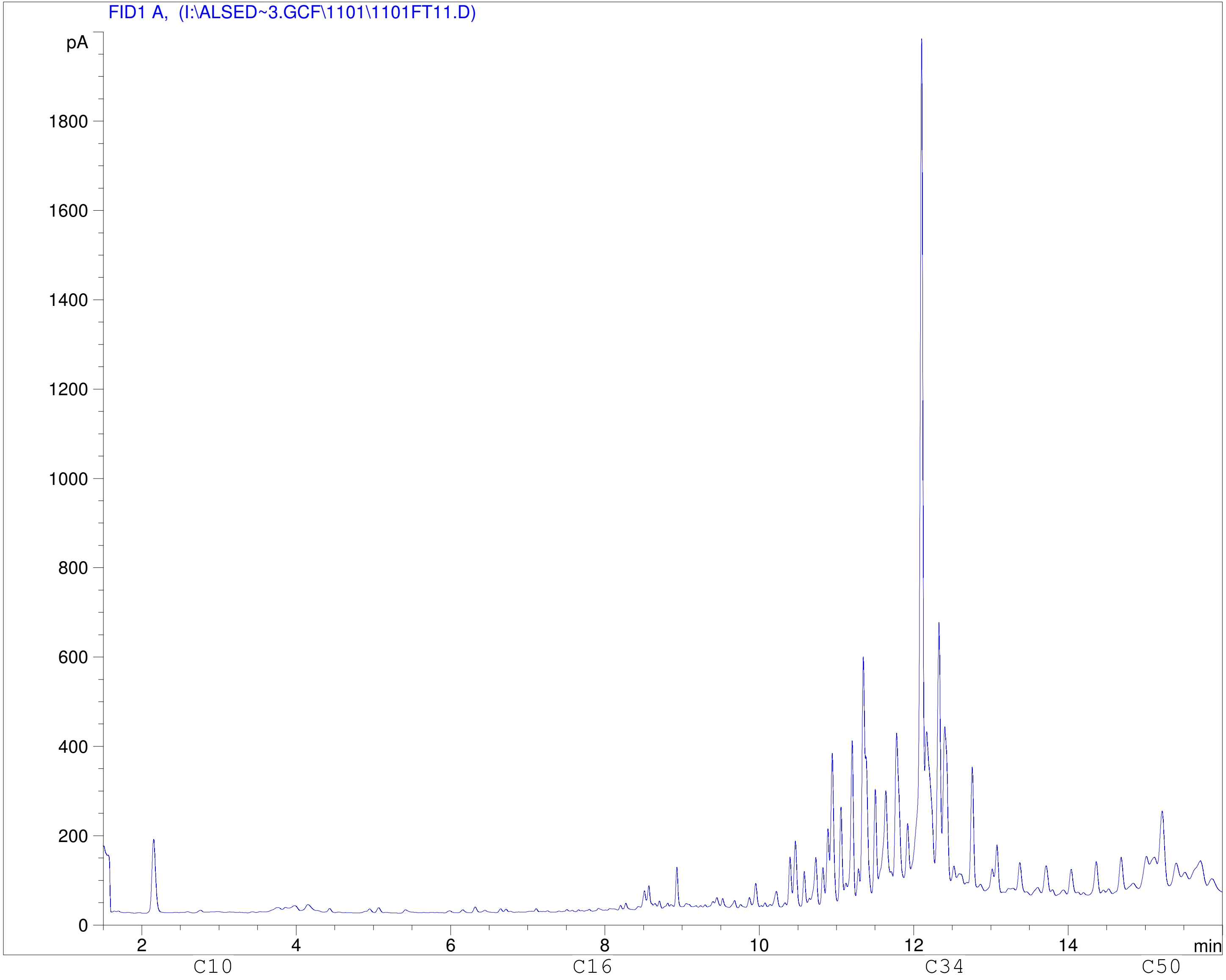
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 323-1

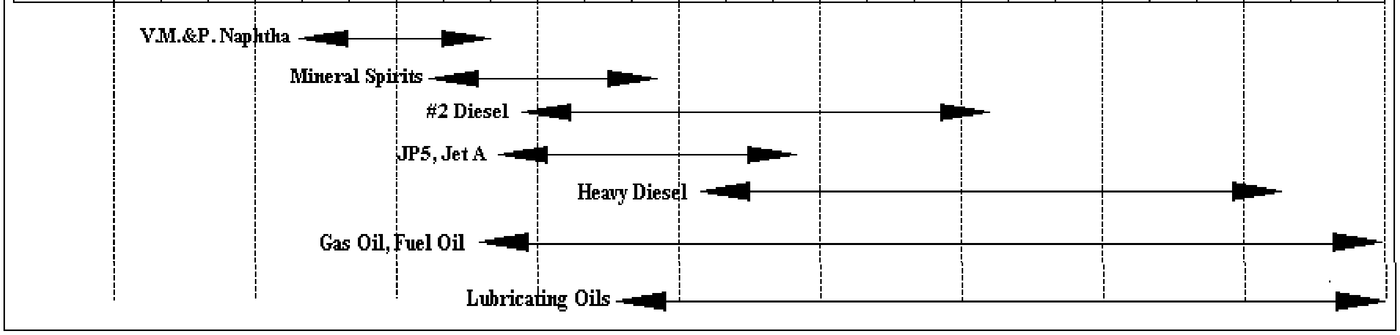
Sample ID: L438781-36 4
Injection Date: 11/1/06 9:35:33 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

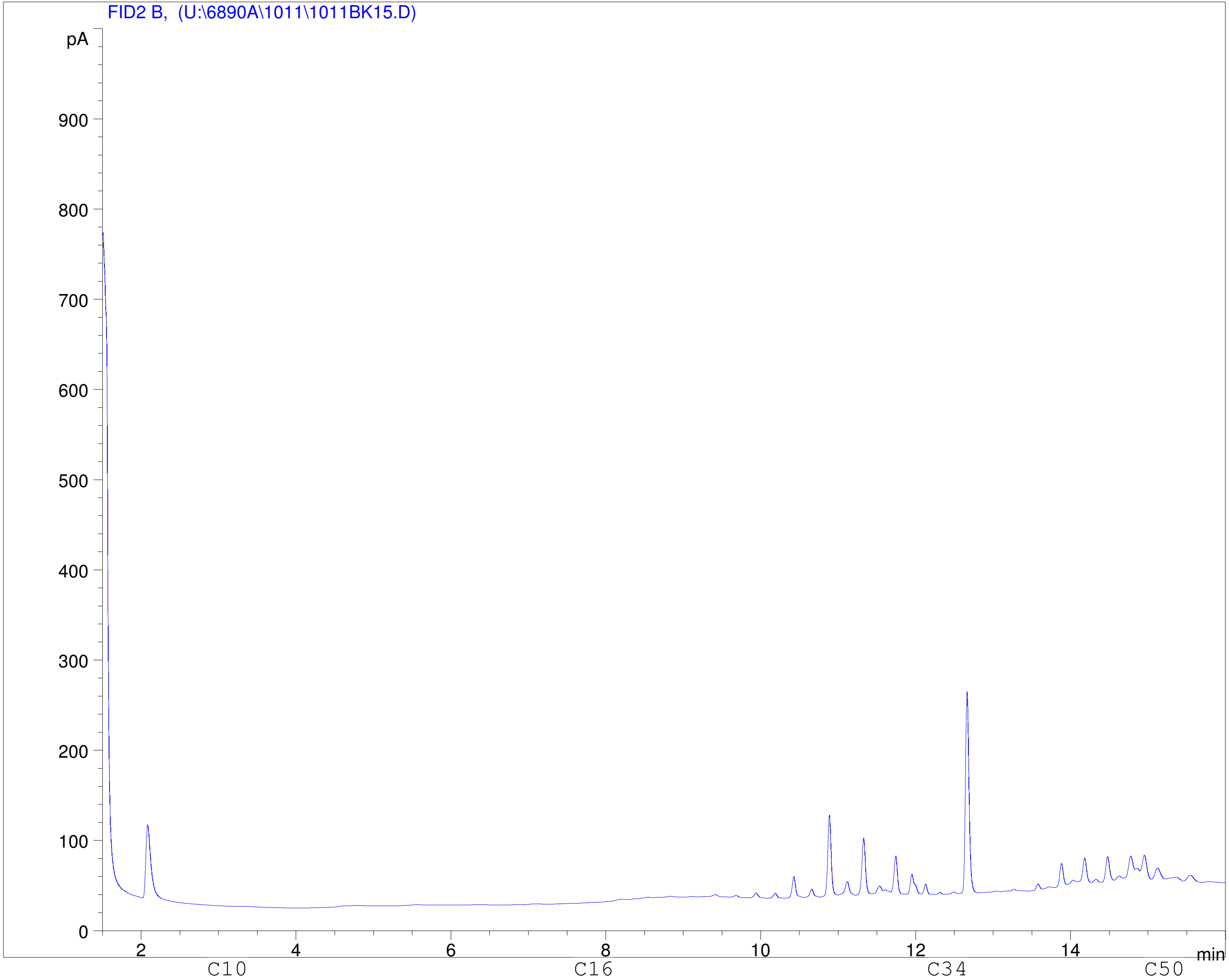


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 326-1

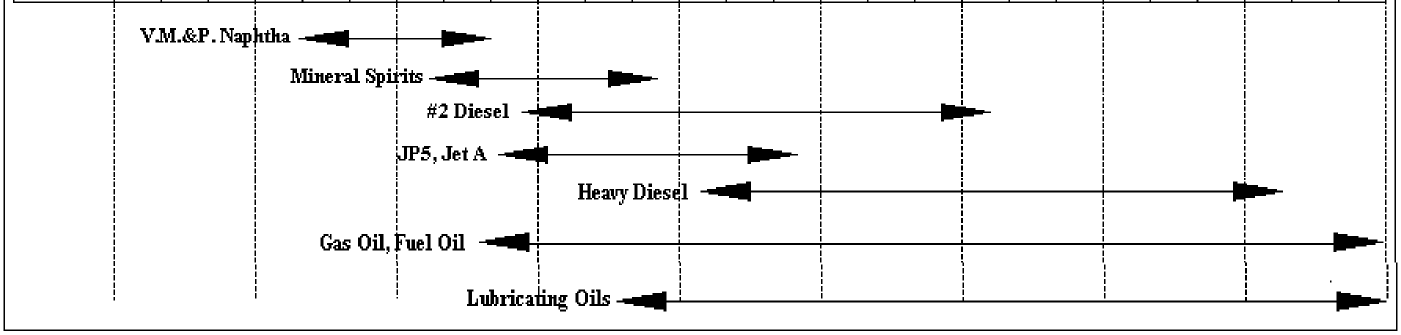
Sample ID: L438781-48 4 SG
Injection Date: 10/11/2006 11:20:31 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

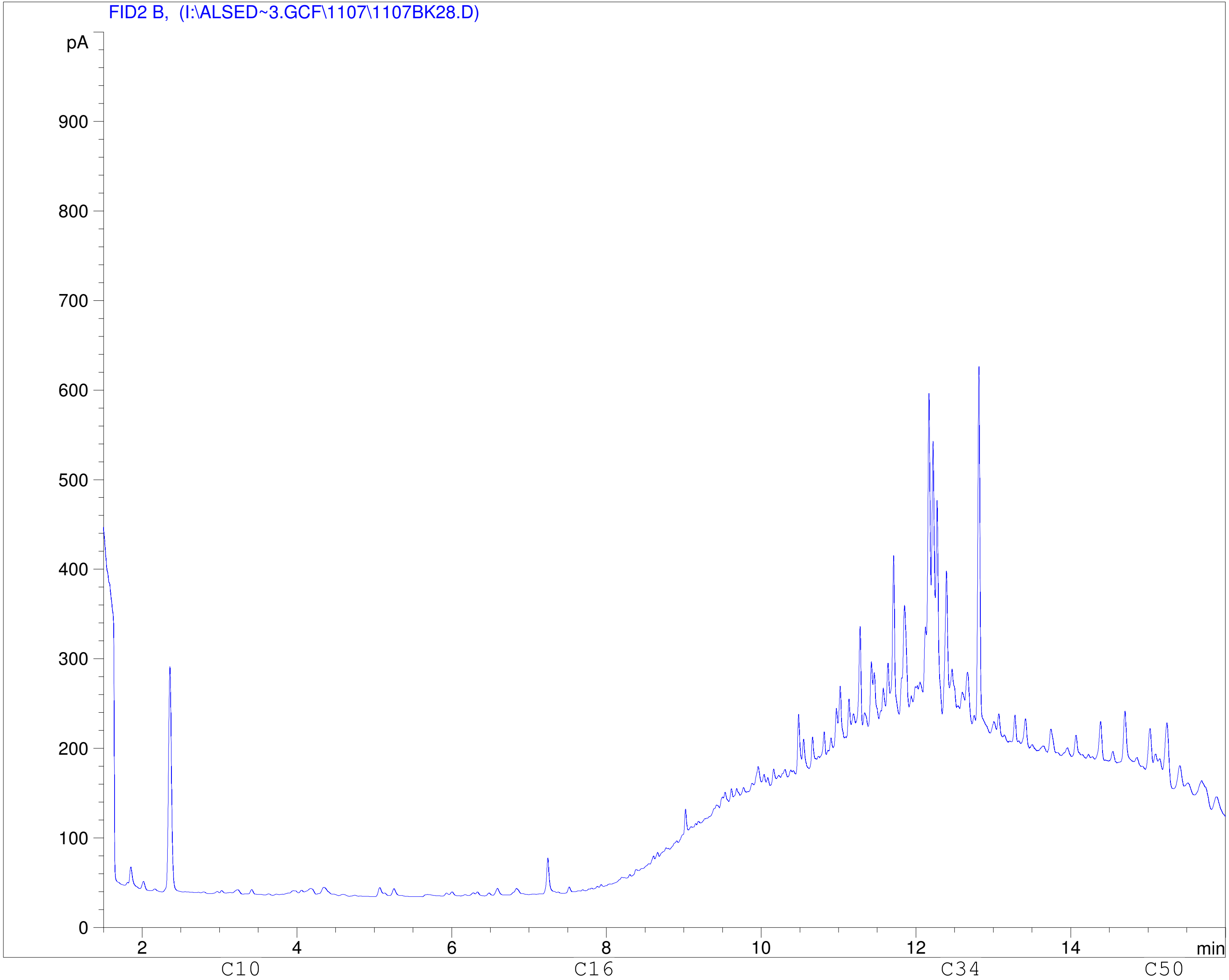


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 327-1

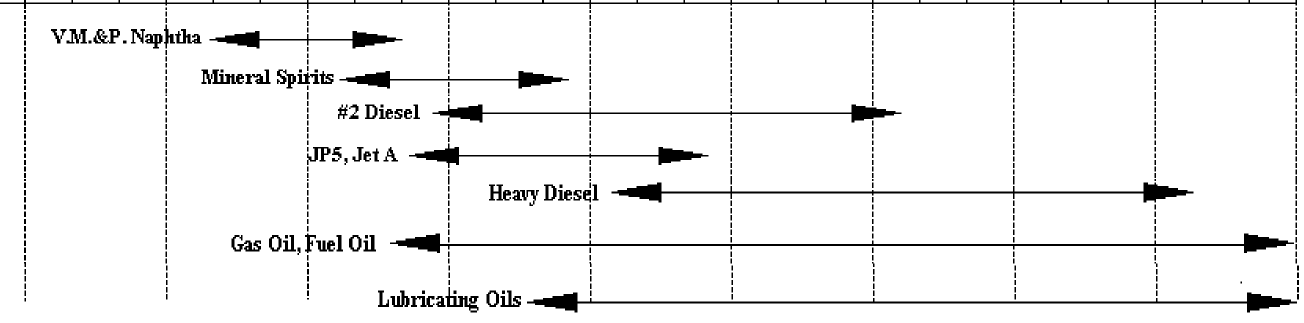
Sample ID: L438781-51 4
Injection Date: 11/8/06 3:41:23 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

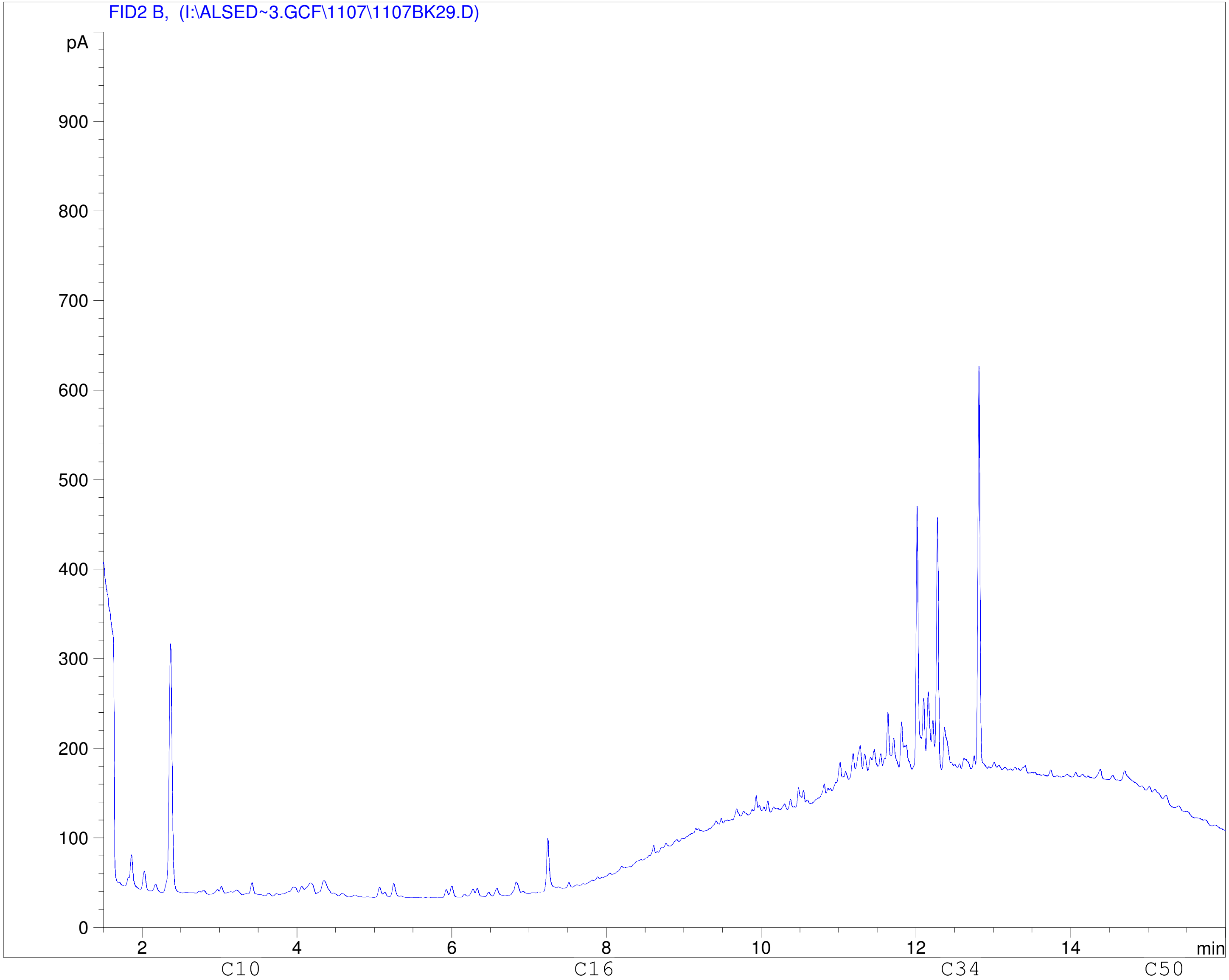


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: 327-2

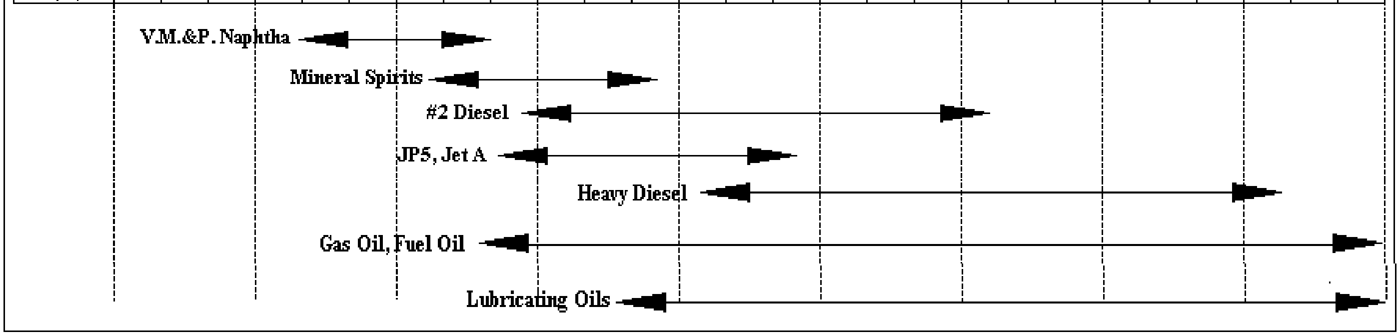
Sample ID: L438781-52 4
Injection Date: 11/8/06 4:08:39 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

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LABORATORIES

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

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COC # 283320

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Pg 1 of 5

REPORT TO: Grant Waynarowich / Ryan Muri
COMPANY: MEMS
CONTACT: Millennium EMS
ADDRESS: #208 4207 - 98 St.
PHONE: Ryan FAX: Grant
CELLPHONE: 780 991 4616 780 975 4335
INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

DATE: Sept 29/06
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1: gwaynarowich@mems.ca
EMAIL 2: rmuri@mems.ca
DIGITAL EMAIL:
SELECT: pdf x digital ___ both ___
INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
JOB #: 04-101
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER #: L438781

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
221 - LFH																		
221 - 1																		
221 - 2																		
221 - 3																		
222 - LFH					HOLD													
222 - 1																		
222 - 2																		
222 - 3																		
223 - LFH																		
223 - 1																		
223 - 2																		
223 - 3																		

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

Failure to complete all portions of this form may delay analysis. By the use of this form the **user acknowledges and agrees with the Terms and Conditions as specified on the reverse of the white report copy.**

RELINQUISHED BY:	DATE & TIME: Sept 29/06	RECEIVED BY: Hunes	DATE & TIME: Sep 29/06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME: 3:22	RECEIVED BY:	DATE & TIME:	

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CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

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Pg 2 of 5

REPORT TO:
COMPANY:
CONTACT:
ADDRESS: See Page 1
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INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

DATE: Sept 27/06
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
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JOB # 04-101
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L438781

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
224-LFH																		
224-1																		
224-2																		
224-3																		
225-0-5cm																		
225-5-15cm					HOLD													
225-15-30cm																		
123-LFH																		
123-1																		
123-2																		
123-3																		
124-LFH																		

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

Failure to complete all portions of this form may delay analysis. By the use of this form the **user acknowledges and agrees with the Terms and Conditions as specified on the reverse of the white report copy.**

RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME: Sep 29/06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY. PINK - FILE COPY. YELLOW - CLIENT COPY

GENF04.01

ETL EnviroTest LABORATORIES

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

CANADA TOLL FREE 1-800-668-9878

COC #283321

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Pg 3 of 5

REPORT TO:
COMPANY:
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ADDRESS: See Page 1
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INVOICE TO: SAME Y / N
COMPANY
CONTACT:
ADDRESS:
PHONE: FAX:

DATE: Sept 29/06
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both___
INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
JOB # 04-101
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L438781

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
124-1																		
124-2																		
124-3																		
125-LFH																		
125-1																		
125-2																		
125-3																		
126-0-5cm																		
126-5-15cm																		
126-15-30cm																		
323-LFH																		
323-1																		

HOLD

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME: Sep 29/06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY	DATE & TIME	RECEIVED BY	DATE & TIME	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY

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LABORATORIES

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM
CANADA TOLL FREE 1-800-668-9878

COC # 283322

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Pg 4 of 5

DATE: Sept 29/06

LAB WORK ORDER# L438781

REPORT TO:
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CONTACT:
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CELLPHONE:

INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both _
INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
JOB # 04-101
PO/AFE:
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
323-2																		
323-3																		
324-LFH																		
324-1																		
324-2																		
324-3					HOLD													
325-LFH																		
325-1																		
325-2																		
325-3																		
326-LFH																		
326-1																		

☐ FROZEN
☐ COLD
☐ AMBIENT

MEAN TEMPERATURE

Failure to complete all portions of this form may delay analysis. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse of the white report copy.

RELINQUISHED BY:	DATE & TIME:	RECEIVED BY: L Huner	DATE & TIME: Sep 29/06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY PINK - FILE COPY YELLOW - CLIENT COPY

GENF04.01

WWW.ENVIROTEST.COM

Pg 5 of 5

ETL **Enviro·Test** LABORATORIES

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM
CANADA TOLL FREE 1-800-668-9878

COC #283323

LAB WORK ORDER# L438781

REPORT TO:
COMPANY:
CONTACT:
ADDRESS: See Page 1

PHONE: FAX:
CELLPHONE:

INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:

PHONE: FAX:

DATE: Sept 29/06
REPORT DISTRIBUTION ALL FINAL RESULTS WILL BE MAILED
EMAIL FAX
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both___
INDICATE BOTTLES, FILTERED/PRESERVED (F/P) ▶

JOB # 04-101
PO/AFE:
LSD:
QUOTE #

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
326-2					HOLD				
326-3									
327-1									
327-2									
327-3									

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

Failure to complete all portions of this form may delay analysis. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse of the white report copy.

RELINQUISHED BY:	DATE & TIME	RECEIVED BY: L Huier	DATE & TIME Sep 29/06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME	RECEIVED BY:	DATE & TIME	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY, PINK - FILE COPY YELLOW - CLIENT COPY

GENF04.01

Norma Jestin

From: Karen Huebner
Sent: Wednesday, October 25, 2006 4:33 PM
To: Norma Jestin; Joanne Ringuette
Subject: FW: 04-101

Please add BTX F1-F4 to the following samples. REg TAT

L437383-81,-82,-57,-58
L438781-35 and -36

Thanks
Karen

Karen Huebner
Senior Account Manager
ALS Laboratory Group
Environmental Division
Edmonton, Canada
Phone: +1 780 413-5220
Direct: +1 780 413-5984
Fax: +1 780 437-2311
www.alsenviro.com

Oct 26/06

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Wednesday, October 25, 2006 10:58 AM
To: Karen Huebner
Subject: 04-101

Karen,

Can we please add the following samples to have BTEX F1-F4 analyzed;

D103-LFH;
D103-1;
302-LFH;
302-1;
323-LFH; and
323-1.

Regular TAT.

Thanks.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
CELL:780-991-4616

****

L439526 L437987
L438781 L437383

Additional Analysis Requests for Millennium EMS project No. 04-101, requested Nov 2, 2006

Samples submitted Sept 27, 28 & 29, 2006

For Questions, contact Callie Volf (780-496-9048 ext.259, cvolf@mems.ca)

Sample Name	SAL-Detail	PSA-MUST	BTX,TVH, TEH-CCME	
4-LFH	X			L437383-13
7-LFH	X			L437987-114
7-1	X			L437987-92
11-LFH	X			L437987-99
14-LFH	X			L439526-38
14-1	X			L439526-39
14-2	X			L439526-40
16-LFH	X			L439526-46
16-1	X	X		L439526-47
16-2		X		L439526-48
19-LFH	X			L439526-58
20-LFH	X			L439526-62
20-1	X			L439526-63
21-LFH	X			L439526-66
103-LFH	X			L437383-81
103-1	X			L437383-82
*107-1		X		L437987-63
*109-1		X		L437987-72
114-LFH	X			L439526-70
116-1	X			L439526-77
116-2	X			L439526-78
124-LFH	X			L438781-24
124-1	X			L438781-25
204-LFH	X			L437383-41
208-LFH	X			L437987-47
213-LFH	X			L439526-108
217-LFH	X			L439526-124
218-LFH	X			L439526-128
222-LFH	X			L438781-5
302-LFH	X			L437383-57
302-1	X			L437383-58
*305-1		X		L437383-97
308-2	X			L437987-12
313-LFH	X			L437987-28
318-LFH	X			L439526-14
318-1	X	X		L439526-15
318-2		X		L439526-16
323-LFH	X			L438781-35
323-1		X		L438781-36
325-1	X			L438781-44
326-1	X			L438781-48
327-1	X		X	L438781-51
327-2	X		X	L438781-52

Nov3/06

Norma Jestin

From: Karen Huebner
Sent: Friday, December 01, 2006 9:42 AM
To: Norma Jestin; Joanne Ringuette; Aimee Thompson; Michelle Eckert; Ian Bullecer
Cc: Sean Johnston
Subject: Additional SGC

Please add TEH-SGC to the following. Reg TAT.

Aimee/Michelle/Ian - Please make sure the coverpage comments are added when results are completed.
Thanks

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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www.alsenviro.com

Dec 1/06

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Thursday, November 30, 2006 2:26 PM
To: Karen Huebner
Subject: FW: Silica Column vs silica gel clean up 04-101

Karen,

Please run the Silica column clean up on the following samples, on regular TAT:

4-LFH L437383-13
107-DM L437987-61
107-LFH L437987-62
109-DM L437987-71
109-LFH L437987-72
308-1 L437987-11
310-LFH L437987-18
310-1 L437987-19
7-LFH L437987-114
9-LFH L437987-110
204-LFH L437383-41
208-LFH L437987-47
12-LFH L437987-103
12-1 L437987-104
13-LFH L439526-34
13-1 L439526-35
14-LFH L439526-38
14-1 L439526-39
16-LFH L439526-46
114-LFH L439526-70

114-1 L439526- 71
116 -1 L439526-77
313-LFH L437987-28
313-1 L437987-29
213-LFH L439526-108
314-LFH L439526-1
314-1 L439526-2
318-LFH L439526-14
319-LFH L439526-18
117-LFH L439526-80
215-LFH L437526-116
217-LFH L439526-124
218-LFH L439526-124 8
20-LFH L439526-62
120-LFH L439526-92
220-LFH L439526-136
222-LFH L438781-5
323-LFH L438781-35
323-1 L438781-36
DGW260-LFH L450940-1
DGW261-LFH L450940-5
DGW262-1 L450940- 9
DGW262-2 L450940-10
DGW263-LFH. L450940-12

Thanks Karen. Can you also send me MEMS price for these, I just need to do some budgeting changes.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
CELL:780-991-4616

-----Original Message-----
From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:48 PM
To: Ian Terry; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Hi Ian,

No, as per Cory's instructions we no longer run the F4G unless it's requested. His email is below (sent Aug 30th). I have the original email if you need it forwarded.

Thanks
Karen

****

Please remove the F4G. We will request it when required. Thanks Cory

> -----Original Message-----
> **From:** Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
> **Sent:** Thursday, August 24, 2006 8:46 AM
> **To:** Cory Sommer
> **Subject:** RE: L421098 addtional lab data requests

Hi Cory,

No problem, we don't have a BH06-24 @3.0M but we do have a BH06-24 @3.5M. I'll have the metals and salinity added to this sample instead.
Millennium is set up so that if the chrom does not return to baseline at C50 we automatically add the F4G. Technically you are obligated to report the F4G if the chrom does not return to baseline. If you Millennium no longer wants this then I can remove it but I need something in writing.

I found the following email from Ian, he never did get back to me on if the automatic F4G should be removed.
Thanks
Karen
****

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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www.alsenviro.com

From: Ian Terry [mailto:ITerry@mems.ca]
Sent: Thursday, November 30, 2006 1:39 PM
To: Karen Huebner; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Are you using the in-situ method then for samples that we submit?

Regards,

Ian

From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:00 PM
To: Ian Terry; Ryan Muri
Subject: Silica Column vs silica gel clean up

Please see below - this might clear things up a bit.

The CCME method makes silica gel cleanup mandatory for the F2-F4 fractions, but allows for two options: a simple in situ shake in which silica gel is added to a large solvent volume and shaken, or a column, in which a small volume of concentrated extract is passed through a glass column filled with packed silica gel. The column cleanup is much more intensive; in fact, it will remove some parts of petroleum hydrocarbons. The in situ cleanup. on the other hand, is less effective and will not remove high levels of naturally occurring hydrocarbons.

The F4G is a gravimetric measurement designed to account for hydrocarbons in and above the F4 range. Gas chromatograph response falls off dramatically above C50, so heavy hydrocarbons might not be accounted for in

the GC F2-F4 analysis. The CCME method allows F4G to be done on either a raw or a silica cleaned extract; we analyze only on a silica gel cleaned extract (F4G-SG), in order to be comparable to the F2-F4 results. The oven-dried gravimetric F4G result is highly variable, though, and can include significant portions of both the F4 and even the F3 hydrocarbons (the method requires the F4G to be dried at 110 degrees C, and the hydrocarbons in the F3 range typically have boiling points in the 250-300 degree C range or above). For this reason, the F4G can at times be surprisingly high.

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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PRELIMINARY RESULTS

MILLENNIUM
ATTN: GRANT WOYNAROWICH/R.MURI

208 4207 98 ST

EDMONTON AB T6E 5R7

Reported On: 07-DEC-06 03:15 PM
Revision: 1

Lab Work Order #: L439526 **Date Received:** 03-OCT-06

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 247147, 283310, 283311, 283312, 283313, 283314, 283315, 283316, 283317, 283318

Other Information:

Comments: ADDITIONAL 01-DEC-06 10:40 ADDITIONAL 03-NOV-06 14:09 Silica gel column cleanup results used for F2-F4 for fractions 1,2,11,14,18,30,34,35,38,39,46,58,62,71,77,92,108,116,117,124,128,80,136,70.

ROY JONES
General Manager, Edmonton

For any questions about this report please contact your Account Manager:

KAREN HUEBNER

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-1 314-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	130		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	492	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	220	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	8000	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	4500	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	13000		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	69		0.1	%		06-OCT-06	MPI	R450966
L439526-2 314-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.07	DLHM	0.07	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.07	DLHM	0.07	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.07	DLHM	0.07	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	164		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	142		44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	60	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	1200	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	640	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	1900		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	84		0.1	%		06-OCT-06	MPI	R450966
L439526-11 317-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-11 317-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	148		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	144		44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	34	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	1000	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	510	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	1500		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	77		0.1	%		06-OCT-06	MPI	R450966
L439526-14 318-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	209	SOL:MI	33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	160		44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	130	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	2000	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	1200	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	3300		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	75		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	79		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	86		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	20		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	3		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	49		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	565		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.1		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.53		0.01	dS m-1		09-NOV-06	SZ	R463549

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-15 318-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	68		33-172	%	11-OCT-06	11-OCT-06	GRB	R452693
Surr: Hexatriacontane	147		44-173	%	11-OCT-06	11-OCT-06	GRB	R452693
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452693
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-OCT-06		
F3 (C16-C34)	75		5	mg/kg		14-OCT-06		
F4 (C34-C50)	99		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	170		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	27		0.1	%		06-OCT-06	MPI	R450966
MUST PSA % > 75um	3		1	%		08-NOV-06	NNK	R463349
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	21		5	mg/L		09-NOV-06	JWU	R463269
Potassium (K)	13		2	mg/L		09-NOV-06	JWU	R463269
Magnesium (Mg)	5		3	mg/L		09-NOV-06	JWU	R463269
Sodium (Na)	19		2	mg/L		09-NOV-06	JWU	R463269
SAR	1.0		0.1	SAR		09-NOV-06	JWU	R463269
Sulphate (SO4)	35		6	mg/L		09-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	66.8		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	5.3		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.21		0.01	dS m-1		08-NOV-06	SR	R463184
L439526-16 318-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
MUST PSA % > 75um	2		1	%		08-NOV-06	NNK	R463349
L439526-18 319-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	75		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	117		44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-18 319-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	29	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	3600	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	1900	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	5500		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	67		0.1	%		06-OCT-06	MPI	R450966
L439526-19 319-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	66		33-172	%	11-OCT-06	11-OCT-06	GRB	R452693
Surr: Hexatriacontane	194	SOL:MI	44-173	%	11-OCT-06	11-OCT-06	GRB	R452693
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452693
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	8	RAMB	5	mg/kg		14-OCT-06		
F3 (C16-C34)	290		5	mg/kg		14-OCT-06		
F4 (C34-C50)	220		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	520		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	22		0.1	%		06-OCT-06	MPI	R450966
L439526-30 322-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	57		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	139		44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	17	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	890	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	850	IPC	5	mg/kg		14-OCT-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-30 322-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
Total Hydrocarbons (C6-C50)	1800		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	63		0.1	%		06-OCT-06	MPI	R450966
L439526-31 322-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	66		33-172	%	11-OCT-06	11-OCT-06	GRB	R452693
Surr: Hexatriacontane	132		44-173	%	11-OCT-06	11-OCT-06	GRB	R452693
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452693
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-OCT-06		
F3 (C16-C34)	41		5	mg/kg		14-OCT-06		
F4 (C34-C50)	53		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	94		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	6.7		0.1	%		06-OCT-06	MPI	R450966
L439526-34 13-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	82		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	265	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	43	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	4200	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	2500	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	6700		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	64		0.1	%		06-OCT-06	MPI	R450966

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-35 13-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	56		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	120		44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	87	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	1600	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	1000	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	2700		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	75		0.1	%		06-OCT-06	MPI	R450966
L439526-38 14-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	0.54	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	2.5	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	94		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	190	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	560	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	560		5	mg/kg		14-OCT-06		
F2 (C10-C16)	160	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	3100	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	1800	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	5600		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	69		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	51		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	100		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	35		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	16		2	mg/L		09-NOV-06	JWU	R463645
SAR	0.4		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	63		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	577		0.1	%		09-NOV-06	SZ	R463549

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-38 14-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
pH in Saturated Paste	3.9		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.59		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-39 14-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	0.17	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	58		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	139		44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	130	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	1100	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	2400	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	3600		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	82		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	<5	RRV	5	mg/L		10-NOV-06	JWU	R464091
Potassium (K)	12		2	mg/L		10-NOV-06	JWU	R464091
Magnesium (Mg)	<3		3	mg/L		10-NOV-06	JWU	R464091
Sodium (Na)	4		2	mg/L		10-NOV-06	JWU	R464091
SAR	Incalculable	SAR:INC	0.1	SAR		10-NOV-06	JWU	R464091
Sulphate (SO4)	16		6	mg/L		10-NOV-06	JWU	R464091
pH and EC (Saturated Paste)								
% Saturation	1820		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	3.5		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.15		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-40 14-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	14		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	8		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	5		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	4		2	mg/L		09-NOV-06	JWU	R463645
SAR	0.2		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	35		6	mg/L		09-NOV-06	JWU	R463645

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-40 14-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
% Saturation	2120		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	3.6		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.16		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-46 16-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	68		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	323	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	18	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	4700	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	2600	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	7300		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	65		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	73		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	72		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	24		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	5		2	mg/L		09-NOV-06	JWU	R463645
SAR	0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	40		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	316		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.7		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.60		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-47 16-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	80		33-172	%	11-OCT-06	11-OCT-06	GRB	R452693
Surr: Hexatriacontane	167		44-173	%	11-OCT-06	11-OCT-06	GRB	R452693

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-47 16-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452693
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	150		5	mg/kg		14-OCT-06		
F4 (C34-C50)	120		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	270		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	21		0.1	%		06-OCT-06	MPI	R450966
MUST PSA % > 75um	34		1	%		08-NOV-06	NNK	R463349
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	20		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	17		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	4		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	8		2	mg/L		08-NOV-06	JWU	R463269
SAR	0.4		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	49		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	65.0		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	4.9		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.21		0.01	dS m-1		08-NOV-06	SR	R463184
L439526-48 16-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
MUST PSA % > 75um	54		1	%		08-NOV-06	NNK	R463349
L439526-58 19-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	56		33-172	%	11-OCT-06	12-OCT-06	MKE	R453047
Surr: Hexatriacontane	185	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	MKE	R453047
Prep/Analysis Dates					11-OCT-06	12-OCT-06	MKE	R453047
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	14	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	2300	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	1400	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	3700		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-58 19-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
% Moisture	58		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	139		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	102		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	51		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	5		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	64		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	376		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.3		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.90		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-59 19-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	80		33-172	%	11-OCT-06	11-OCT-06	GRB	R452693
Surr: Hexatriacontane	105		44-173	%	11-OCT-06	11-OCT-06	GRB	R452693
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452693
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	<5	RAMB	5	mg/kg		14-OCT-06		
F4 (C34-C50)	22		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	22		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	5.5		0.1	%		06-OCT-06	MPI	R450966
L439526-62 20-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	55		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	137		44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-62 20-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	52		5	mg/kg		14-OCT-06		
F3 (C16-C34)	2300		5	mg/kg		14-OCT-06		
F4 (C34-C50)	2600		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	5000		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	69		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	60		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	200		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	203		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	87		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	3		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	64		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	670		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	5.6		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	1.47		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-63 20-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01	RAMB	0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	43		33-172	%	11-OCT-06	11-OCT-06	GRB	R452693
Surr: Hexatriacontane	138		44-173	%	11-OCT-06	11-OCT-06	GRB	R452693
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452693
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	31		5	mg/kg		14-OCT-06		
F4 (C34-C50)	47		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	78		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	8.6		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		08-NOV-06	EOC	R463391
SAR								
Calcium (Ca)	25		5	mg/L		08-NOV-06	JWU	R463269
Potassium (K)	7		2	mg/L		08-NOV-06	JWU	R463269
Magnesium (Mg)	8		3	mg/L		08-NOV-06	JWU	R463269
Sodium (Na)	8		2	mg/L		08-NOV-06	JWU	R463269

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-63 20-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
SAR								
SAR	0.3		0.1	SAR		08-NOV-06	JWU	R463269
Sulphate (SO4)	35		6	mg/L		08-NOV-06	JWU	R463269
pH and EC (Saturated Paste)								
% Saturation	37.2		0.1	%		08-NOV-06	SR	R463184
pH in Saturated Paste	5.1		0.1	pH		08-NOV-06	SR	R463184
Conductivity Sat. Paste	0.20		0.01	dS m-1		08-NOV-06	SR	R463184
L439526-66 21-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	65		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	80		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	26		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	2		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	44		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	454		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	5.2		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.49		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-70 114-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	97		33-172	%	11-OCT-06	14-OCT-06	AAT	R453504
Surr: Hexatriacontane	907	SOL:MI	44-173	%	11-OCT-06	14-OCT-06	AAT	R453504
Prep/Analysis Dates					11-OCT-06	14-OCT-06	AAT	R453504
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	440	IPC	5	mg/kg		15-OCT-06		
F3 (C16-C34)	18000	IPC	5	mg/kg		15-OCT-06		
F4 (C34-C50)	8000	IPC	5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	26000		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	60		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	118		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	57		2	mg/L		09-NOV-06	JWU	R463645

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-70 114-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
SAR								
Magnesium (Mg)	48		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	62		2	mg/L		09-NOV-06	JWU	R463645
SAR	1.2		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	190		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	187		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.7		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.86		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-71 114-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.05	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	96		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	94		44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	200		5	mg/kg		14-OCT-06		
F4 (C34-C50)	310		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	510		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	78		0.1	%		06-OCT-06	MPI	R450966
L439526-77 116-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.05	DLM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.1	DLM	0.1	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.1	DLM	0.1	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	4.5	DLM	0.1	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	118		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	120		44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	39		5	mg/kg		15-OCT-06		
F1-BTEX	35		5	mg/kg		15-OCT-06		
F2 (C10-C16)	25		5	mg/kg		15-OCT-06		
F3 (C16-C34)	1300		5	mg/kg		15-OCT-06		
F4 (C34-C50)	830		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	2200		5	mg/kg		15-OCT-06		

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-77 116-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	61		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	49		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	37		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	29		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	37		2	mg/L		09-NOV-06	JWU	R463645
SAR	1.0		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	93		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	470		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	5.1		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.43		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-78 116-2								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	33		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	4		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	15		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	19		2	mg/L		09-NOV-06	JWU	R463645
SAR	0.7		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	61		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	472		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	5.6		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.22		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-80 117-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.02	DLHM	0.02	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.02	DLHM	0.02	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	100		33-172	%	12-OCT-06	13-OCT-06	AAT	R453324
Surr: Hexatriacontane	420	SOL:MI	44-173	%	12-OCT-06	13-OCT-06	AAT	R453324
Prep/Analysis Dates					12-OCT-06	13-OCT-06	AAT	R453324
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	29	IPC	5	mg/kg		15-OCT-06		
F3 (C16-C34)	2700	IPC	5	mg/kg		15-OCT-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-80 117-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F4 (C34-C50)	1400	IPC	5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	4100		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	49		0.1	%		12-OCT-06	JOM	R452848
L439526-81 117-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	0.03		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	87		33-172	%	11-OCT-06	11-OCT-06	GRB	R452694
Surr: Hexatriacontane	147		44-173	%	11-OCT-06	11-OCT-06	GRB	R452694
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452694
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-OCT-06		
F3 (C16-C34)	110		5	mg/kg		14-OCT-06		
F4 (C34-C50)	89		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	200		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	24		0.1	%		06-OCT-06	MPI	R450966
L439526-92 120-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	131		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	132		44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	1600		5	mg/kg		14-OCT-06		
F4 (C34-C50)	1200		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	2800		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	68		0.1	%		06-OCT-06	MPI	R450966

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-93 120-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	76		33-172	%	11-OCT-06	11-OCT-06	GRB	R452694
Surr: Hexatriacontane	114		44-173	%	11-OCT-06	11-OCT-06	GRB	R452694
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452694
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-OCT-06		
F3 (C16-C34)	30		5	mg/kg		14-OCT-06		
F4 (C34-C50)	47		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	77		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	5.0		0.1	%		06-OCT-06	MPI	R450966
L439526-108 213-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.05	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	0.15	DLHM	0.05	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	79		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	72		44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	590		5	mg/kg		14-OCT-06		
F4 (C34-C50)	680		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	1300		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	75		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	60		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	200		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	204		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	65		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	6		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1		0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	66		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	525		0.1	%		09-NOV-06	SZ	R463549

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-108 213-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
pH in Saturated Paste	6.1		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	1.28		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-109 213-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	0.03		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	76		33-172	%	11-OCT-06	11-OCT-06	GRB	R452694
Surr: Hexatriacontane	105		44-173	%	11-OCT-06	11-OCT-06	GRB	R452694
Prep/Analysis Dates					11-OCT-06	11-OCT-06	GRB	R452694
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	<5		5	mg/kg		14-OCT-06		
F4 (C34-C50)	<5		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	<5		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	YES					14-OCT-06		
% Moisture	6.5		0.1	%		06-OCT-06	MPI	R450966
L439526-116 215-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.02	DLHM	0.02	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.02	DLHM	0.02	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	134		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	396	SOL:MI	44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	26		5	mg/kg		15-OCT-06		
F3 (C16-C34)	4500		5	mg/kg		15-OCT-06		
F4 (C34-C50)	2200		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	6700		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	50		0.1	%		06-OCT-06	MPI	R450966
L439526-117 215-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-117 215-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
Xylenes	0.01		0.01	mg/kg	12-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	115		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	91		44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	<5		5	mg/kg		15-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		15-OCT-06		
F3 (C16-C34)	18	RAMB	5	mg/kg		15-OCT-06		
F4 (C34-C50)	20		5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	38		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	27		0.1	%		06-OCT-06	MPI	R450966
L439526-124 217-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.04	DLHM	0.04	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	47		33-172	%	11-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	103		44-173	%	11-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					11-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5		5	mg/kg		14-OCT-06		
F3 (C16-C34)	1300		5	mg/kg		14-OCT-06		
F4 (C34-C50)	1300		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	2600		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	73		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		09-NOV-06	BOC	R463791
SAR								
Calcium (Ca)	102		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	142		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	43		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	<2		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1	SAR:DL	0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	32		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	781		0.1	%		09-NOV-06	SZ	R463549

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-124 217-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
pH in Saturated Paste	6.4		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	1.02		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-125 217-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	110		33-172	%	12-OCT-06	12-OCT-06	MKE	R453092
Surr: Hexatriacontane	141		44-173	%	12-OCT-06	12-OCT-06	MKE	R453092
Prep/Analysis Dates					12-OCT-06	12-OCT-06	MKE	R453092
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-OCT-06		
F3 (C16-C34)	150		5	mg/kg		14-OCT-06		
F4 (C34-C50)	91		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	240		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	19		0.1	%		06-OCT-06	MPI	R450966
L439526-128 218-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	124		33-172	%	12-OCT-06	12-OCT-06	GRB	R453198
Surr: Hexatriacontane	99		44-173	%	12-OCT-06	12-OCT-06	GRB	R453198
Prep/Analysis Dates					12-OCT-06	12-OCT-06	GRB	R453198
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	18		5	mg/kg		14-OCT-06		
F3 (C16-C34)	500		5	mg/kg		14-OCT-06		
F4 (C34-C50)	680		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	1200		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	60		0.1	%		06-OCT-06	MPI	R450966
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		09-NOV-06	BOC	R463791
SAR								

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-128 218-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
Detailed Salinity								
SAR								
Calcium (Ca)	104		5	mg/L		09-NOV-06	JWU	R463645
Potassium (K)	131		2	mg/L		09-NOV-06	JWU	R463645
Magnesium (Mg)	27		3	mg/L		09-NOV-06	JWU	R463645
Sodium (Na)	<2		2	mg/L		09-NOV-06	JWU	R463645
SAR	<0.1	SAR:DL	0.1	SAR		09-NOV-06	JWU	R463645
Sulphate (SO4)	34		6	mg/L		09-NOV-06	JWU	R463645
pH and EC (Saturated Paste)								
% Saturation	491		0.1	%		09-NOV-06	SZ	R463549
pH in Saturated Paste	6.7		0.1	pH		09-NOV-06	SZ	R463549
Conductivity Sat. Paste	0.79		0.01	dS m-1		09-NOV-06	SZ	R463549
L439526-129 218-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	114		33-172	%	12-OCT-06	12-OCT-06	MKE	R453092
Surr: Hexatriacontane	138		44-173	%	12-OCT-06	12-OCT-06	MKE	R453092
Prep/Analysis Dates					12-OCT-06	12-OCT-06	MKE	R453092
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		14-OCT-06		
F3 (C16-C34)	86		5	mg/kg		14-OCT-06		
F4 (C34-C50)	67		5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	150		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	27		0.1	%		06-OCT-06	MPI	R450966
L439526-136 220-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	0.04	DLHM	0.03	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	103		33-172	%	12-OCT-06	14-OCT-06	AAT	R453504
Surr: Hexatriacontane	262	SOL:MI	44-173	%	12-OCT-06	14-OCT-06	AAT	R453504
Prep/Analysis Dates					12-OCT-06	14-OCT-06	AAT	R453504
CCME Total Hydrocarbons								
F1 (C6-C10)	11	IPT	5	mg/kg		15-OCT-06		
F1-BTEX	11		5	mg/kg		15-OCT-06		
F2 (C10-C16)	56	IPC	5	mg/kg		15-OCT-06		
F3 (C16-C34)	5400	IPC	5	mg/kg		15-OCT-06		

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L439526-136 220-LFH								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F4 (C34-C50)	3200	IPC	5	mg/kg		15-OCT-06		
Total Hydrocarbons (C6-C50)	8700		5	mg/kg		15-OCT-06		
Chromatogram to baseline at nC50	NO					15-OCT-06		
% Moisture	68		0.1	%		06-OCT-06	MPI	R450966
L439526-137 220-1								
Sampled By: NOT PROVIDED								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Toluene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Ethylbenzene	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
Xylenes	<0.01		0.01	mg/kg	06-OCT-06	13-OCT-06	IAU	R453302
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	130		33-172	%	12-OCT-06	12-OCT-06	MKE	R453092
Surr: Hexatriacontane	131		44-173	%	12-OCT-06	12-OCT-06	MKE	R453092
Prep/Analysis Dates					12-OCT-06	12-OCT-06	MKE	R453092
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		14-OCT-06		
F1-BTEX	<5		5	mg/kg		14-OCT-06		
F2 (C10-C16)	9	IPC	5	mg/kg		14-OCT-06		
F3 (C16-C34)	47	IPC	5	mg/kg		14-OCT-06		
F4 (C34-C50)	50	IPC	5	mg/kg		14-OCT-06		
Total Hydrocarbons (C6-C50)	110		5	mg/kg		14-OCT-06		
Chromatogram to baseline at nC50	NO					14-OCT-06		
% Moisture	7.3		0.1	%		06-OCT-06	MPI	R450966

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Number	Client ID	Qualifier	Description
L439526-125	217-1	IPC	teh-ccme-ed f2-f4 - Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L439526-129	218-1	IPC	teh-ccme-ed f2-f4 - Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.

Sample Parameter Qualifier key listed:

Qualifier	Description
DLHM	Detection Limit Adjusted: Sample has High Moisture Content
DLM	Detection Limit Adjustment For Sample Matrix Effects
IPC	Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank
RRV	Reported Result Verified By Repeat Analysis
SAR:DL	SAR cannot be calculated due to undetectable Na. Detection Limit represents the maximum possible value.
SAR:INC	SAR is incalculable due to Ca and Mg below detection limit.
SOL:MI	Surrogate recovery outside acceptable limits due to matrix interference

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
PREP-MOISTURE-ED	Soil	% Moisture		Oven dry 105C-Gravimetric
PSA-MUST-ED	Soil	MUST PSA D50 > 75um		ASTM D422-63-Hydrometer/Sieve
SAR-CALC-ED	Soil	SAR		CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)		CSSS 18.2, 16.2, 18.3
		Sulfate (SO4) in saturated paste		APHA 3120 B-ICP-OES

Reference Information

SO4-SAR-ED	Soil

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

247147	283310	283311	283312	283313
283314	283315	283316	283317	283318

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L439526

Lab ID Sample ID

L439526-14 318-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	565	0.85	171.1
Sulphate (SO4)	49	565	1.01	275.0
Calcium (Ca)	79	565	3.95	446.8
Potassium (K)	86	565	2.19	483.1
Magnesium (Mg	20	565	1.63	112.0
Sodium (Na)	3	565	0.12	15.6

L439526-15 318-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	66.8	0.60	14.2
Sulphate (SO4)	35	66.8	0.74	23.6
Calcium (Ca)	21	66.8	1.02	13.7
Potassium (K)	13	66.8	0.33	8.6
Magnesium (Mg	5	66.8	0.44	3.6
Sodium (Na)	19	66.8	0.82	12.6

L439526-38 14-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	40	577	1.08	221.1
Sulphate (SO4)	63	577	1.32	365.6
Calcium (Ca)	51	577	2.56	295.7
Potassium (K)	100	577	2.57	579.9
Magnesium (Mg	35	577	2.88	201.8
Sodium (Na)	16	577	0.72	94.9

L439526-39 14-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	1820	<0.56	<364.0
Sulphate (SO4)	16	1820	0.32	282.3
Calcium (Ca)	<5	1820	<0.25	<91.0
Potassium (K)	12	1820	0.30	214.8
Magnesium (Mg	<3	1820	<0.25	<54.6
Sodium (Na)	4	1820	0.19	80.3

L439526-40 14-2
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	2120	<0.56	<424.0
Sulphate (SO4)	35	2120	0.73	740.1
Calcium (Ca)	14	2120	0.70	296.3
Potassium (K)	8	2120	0.20	164.9
Magnesium (Mg	5	2120	0.39	100.7
Sodium (Na)	4	2120	0.17	80.6

L439526-46 16-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	316	0.74	82.7
Sulphate (SO4)	40	316	0.83	125.5
Calcium (Ca)	73	316	3.66	231.6
Potassium (K)	72	316	1.85	228.9
Magnesium (Mg	24	316	1.93	74.3
Sodium (Na)	5	316	0.22	15.9

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L439526

Lab ID Sample ID

L439526-47 16-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	65	0.79	18.2
Sulphate (SO4)	49	65	1.02	31.8
Calcium (Ca)	20	65	1.01	13.2
Potassium (K)	17	65	0.43	11.0
Magnesium (Mg	4	65	0.36	2.8
Sodium (Na)	8	65	0.36	5.3

L439526-62 20-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	60	670	1.58	375.0
Sulphate (SO4)	64	670	1.33	429.5
Calcium (Ca)	200	670	9.98	1339.9
Potassium (K)	203	670	5.18	1358.0
Magnesium (Mg	87	670	7.16	583.2
Sodium (Na)	3	670	0.13	20.5

L439526-66 21-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	40	454	1.04	168.0
Sulphate (SO4)	44	454	0.92	200.6
Calcium (Ca)	65	454	3.23	293.5
Potassium (K)	80	454	2.04	361.7
Magnesium (Mg	26	454	2.15	118.6
Sodium (Na)	2	454	0.10	10.0

"Calculations are as per:
Methods of Analysis for Soils, Plants and Waters
Homer D. Chapman and Parker F. Pratt
University of California, Riverside, Cl.
August, 1961."

Lab ID Sample ID

L439526-58 19-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	40	376	1.18	157.6
Sulphate (SO4)	64	376	1.34	242.0
Calcium (Ca)	139	376	6.91	521.0
Potassium (K)	102	376	2.61	383.9
Magnesium (Mg	51	376	4.21	192.4
Sodium (Na)	5	376	0.21	17.8

L439526-63 20-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	37.2	0.79	10.4
Sulphate (SO4)	35	37.2	0.73	13.0
Calcium (Ca)	25	37.2	1.25	9.3
Potassium (K)	7	37.2	0.18	2.6
Magnesium (Mg	8	37.2	0.65	2.9
Sodium (Na)	8	37.2	0.33	2.8

L439526-70 114-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	40	187	1.21	79.9
Sulphate (SO4)	190	187	3.95	354.6
Calcium (Ca)	118	187	5.87	220.2
Potassium (K)	57	187	1.47	107.5
Magnesium (Mg	48	187	3.95	89.7
Sodium (Na)	62	187	2.69	115.5

ALS LABORATORY GROUP SOIL SALINITY CONVERSION

L439526

Lab ID L439526-77 Sample ID 116-1
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	20	470	0.68	112.8
Sulphate (SO4)	93	470	1.94	437.2
Calcium (Ca)	49	470	2.47	232.5
Potassium (K)	37	470	0.95	174.7
Magnesium (Mg	29	470	2.39	136.7
Sodium (Na)	37	470	1.59	172.1

Lab ID L439526-78 Sample ID 116-2
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	<20	472	<0.56	<94.4
Sulphate (SO4)	61	472	1.27	288.9
Calcium (Ca)	33	472	1.63	153.9
Potassium (K)	4	472	0.10	19.1
Magnesium (Mg	15	472	1.27	72.9
Sodium (Na)	19	472	0.81	88.4

L439526-108 213-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	60	525	1.81	337.6
Sulphate (SO4)	66	525	1.38	347.3
Calcium (Ca)	200	525	9.96	1047.9
Potassium (K)	204	525	5.22	1072.4
Magnesium (Mg	65	525	5.36	341.6
Sodium (Na)	6	525	0.24	29.0

L439526-124 217-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	30	781	0.85	235.1
Sulphate (SO4)	32	781	0.67	252.3
Calcium (Ca)	102	781	5.11	800.5
Potassium (K)	142	781	3.63	1108.1
Magnesium (Mg	43	781	3.53	334.9
Sodium (Na)	<2	781	<0.09	<15.6

L439526-128 218-LFH
Sample Date:
Matrix: SOIL

	Result mg/L	% Sat	Meq/L	Dry Soil mg/kg
Chloride (Cl)	40	491	1.10	191.4
Sulphate (SO4)	34	491	0.71	168.0
Calcium (Ca)	104	491	5.18	509.5
Potassium (K)	131	491	3.34	640.9
Magnesium (Mg	27	491	2.20	131.4
Sodium (Na)	<2	491	<0.09	<9.8

"Calculations are as per:
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August, 1961."

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LAB WORK ORDER # L439524

SERVICE REQUESTED
☑ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	BTX, F1-F4										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
314-LF/t					✓											3		1
314.1					✓											3		2
314-2																2		3
314-3																2		4
315-1																3		5
315-2																2		6
315-3																2		7
316-1																3		8
316-2																3		9
316-3																2		10
317-1					✓											3		11
317-2																2		12

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL
Hold all samples analytical requests will be faxed to Karen Huber

SAMPLE CONDITION
☐ FROZEN
☑ COLD
☐ AMBIENT
MEAN TEMPERATURE

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QUOTE #

LAB WORK ORDER# L439526

SERVICE REQUESTED
☑ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	BTH, F1-F4										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
317-3																2		13
318-LF/L					✓											3		14
318-1					✓											3		15
318-2																3		16
318-3																2		17
319-LFH					✓											3		18
319-1					✓											3		19
319-2																2		20
319-3																2		21
320-LF/L																3		22
320-1																3		23
320-2																2		24

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION
☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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LAB WORK ORDER # L439526

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SERVICE REQUESTED
☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	BTX, F1-F4										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
320-3																2		25
321-LFH																3		26
321-1																3		27
321-2																2		28
321-3																2		29
322-LFH					✓											3		30
322-1					✓											3		31
322-2																2		32
322-3																2		33
13-LFH					✓											3		34
13-1					✓											3		35
13-2																2		36

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL__

SAMPLE CONDITION
☐ FROZEN
☐ COLD
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PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L439526

SERVICE REQUESTED
☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	BTX, F1-F4										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
13-3																2		37
14-LFH					✓											3		38
14-1					✓											3		39
14-2																2		40
14-3																2		41
15-LFH																3		42
15-1																3		43
15-2																2		44
15-3.																2		45
16-LFH					✓											3		46
16-1					✓											3		47
16-2																2		48
16-3																2		49

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION
☐ FROZEN
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LSD:
QUOTE #

LAB WORK ORDER# L439526

SERVICE REQUESTED
☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	BTX,F1,F4										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
17-LFH																3		50
17-1																3		51
17-2																2		52
17-3																2		53
18-LFH																3		54
18-1																3		55
18-2																2		56
18-3																2		57
19-LFH																3		58
19-1					✓											3		59
19-2					✓											2		60
19-3.																2		61

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION
☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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JOB #
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L439526

SERVICE REQUESTED
☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	BTX,F1-F4										HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
20-LFH					✓											3		62
20-1					✓											3		63
20-2																2		64
20-3																2		65
21-LFH																3		66
21-1																3		67
21-2																2		68
21-3																2		69
114-LFH					✓											3		70
114-1					✓											3		71
114-2																2		72
114-3																2		73

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION
☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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JOB #
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L439526

SERVICE REQUESTED
☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
115-1																3		74
115-2																2		75
115-3																2		76
116-1																3		77
116-2					✓											2		78
116-3																2		79
117-LFH																3		80
117-1					✓											3		81
117-2					✓											2		82
117-3																2		83
118-LFH																3		84

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION
☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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COMPANY:	
CONTACT:	PO/AFE:
ADDRESS:	
	LSD:
PHONE: FAX:	QUOTE #

LAB WORK ORDER# L439526

SERVICE REQUESTED

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
118-1																3		85
118-2																2		86
118-3																2		87
119-LFH																3		88
119-1																3		89
119-2																2		90
119-3																2		91
120-LFH					✓											3		92
120-1					✓											3		93
120-2																2		94
120-3																2		95
121-LFH																3		96

GUIDELINES / REGULATIONS	SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL	SAMPLE CONDITION
		☐ FROZEN ☐ COLD ☐ AMBIENT MEAN TEMPERATURE

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JOB #
PO/AFE:
LSD:
QUOTE #

LAB WORK ORDER # L439526

SERVICE REQUESTED
☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
121-1																3		97
121-2																2		98
121-3																2		99
122-LFH																3		100
122-1																3		101
122-2																2		102
122-3																2		103
212-LFH																3		104
212-1																3		105
212-2																2		106
212-3																2		107
213-LFH					✓											3		108

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION
☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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DATE:

LAB WORK ORDER# L439526

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SERVICE REQUESTED
☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

INVOICE TO: SAME Y / N
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

JOB # 04-101
PO/AFE:
LSD:
QUOTE #

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
213-1					✓											3		109
213-2																2		110
213-3																2		111
214-LFH																3		112
214-1																3		113
214-2																2		114
214-3																2		115
215-LFH					✓											3		116
215-1					✓											3		117
215-2																2		118
215-3																2		119
216-LFH																3		120

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION
☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

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JOB #
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LSD:
QUOTE #

LAB WORK ORDER #

SERVICE REQUESTED

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
216-1																3		121
216-2																2		122
216-3																2		123
217-LFH					✓											3		124
217-1					✓											3		125
217-2																2		126
217-3																2		127
218-LFH					✓											3		128
218-1					✓											3		129
218-2																2		130
218-3																2		131
219-LFH																3		132

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL

SAMPLE CONDITION

☐ FROZEN
☐ COLD
☐ AMBIENT

MEAN TEMPERATURE

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COMPANY:	
CONTACT:	PO/AFE:
ADDRESS:	
	LSD:
PHONE: FAX:	QUOTE #

LAB WORK ORDER #

SERVICE REQUESTED

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
219-1																3		133
219-2																2		134
219-3																2		135
220-LFH					✓											3		136
220-1					✓											3		137
220-2																2		138
220-3																2		139
221-LFH																		140
221-1							not rec'd											14
221-2																		142
221-3																		143

GUIDELINES / REGULATIONS	SPECIAL INSTRUCTIONS / NATURE OF HAZARDOUS MATERIAL	SAMPLE CONDITION
		☐ FROZEN ☐ COLD ☐ AMBIENT MEAN TEMPERATURE

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L439526 L437987
L438781 L437383

Additional Analysis Requests for Millennium EMS project No. 04-101, requested Nov 2, 2006
Samples submitted Sept 27, 28 & 29, 2006
For Questions, contact Callie Volf (780-496-9048 ext.259, cvolf@mems.ca)

Sample Name	SAL-Detail	PSA-MUST	BTX,TVH, TEH-CCME	
4-LFH	X			L437383-13
7-LFH	X			L437987-114
7-1	X			L437987-92
11-LFH	X			L437987-99
14-LFH	X			L439526-38
14-1	X			L439526-39
14-2	X			L439526-40
16-LFH	X			L439526-46
16-1	X	X		L439526-47
16-2		X		L439526-48
19-LFH	X			L439526-58
20-LFH	X			L439526-62
20-1	X			L439526-63
21-LFH	X			L439526-66
103-LFH	X			L437383-81
103-1	X			L437383-82
* 107-1		X		L437987-63
* 109-1		X		L437987-72
114-LFH	X			L439526-70
116-1	X			L439526-77
116-2	X			L439526-78
124-LFH	X			L438781-24
124-1	X			L438781-25
204-LFH	X			L437383-41
208-LFH	X			L437987-47
213-LFH	X			L439526-108
217-LFH	X			L439526-124
218-LFH	X			L439526-128
222-LFH	X			L438781-5
302-LFH	X			L437383-57
302-1	X			L437383-58
* 305-1		X		L437383-97
308-2	X			L437987-12
313-LFH	X			L437987-28
318-LFH	X			L439526-14
318-1	X	X		L439526-15
318-2		X		L439526-16
323-LFH	X			L438781-35
323-1		X		L438781-36
325-1	X			L438781-44
326-1	X			L438781-48
327-1	X		X	L438781-51
327-2	X		X	L438781-52

Nov3/06

Norma Jestin

From: Karen Huebner
Sent: Friday, December 01, 2006 9:42 AM
To: Norma Jestin; Joanne Ringuette; Aimee Thompson; Michelle Eckert; Ian Bullecer
Cc: Sean Johnston
Subject: Additional SGC

Please add TEH-SGC to the following. Reg TAT.

Aimee/Michelle/Ian - Please make sure the coverpage comments are added when results are completed.
Thanks

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
Senior Account Manager
ALS Laboratory Group
Environmental Division
Edmonton, Canada
Phone: +1 780 413-5220
Direct: +1 780 413-5984
Fax: +1 780 437-2311
www.alsenviro.com

Dec 1/06

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Thursday, November 30, 2006 2:26 PM
To: Karen Huebner
Subject: FW: Silica Column vs silica gel clean up 04-101

Karen,

Please run the Silica column clean up on the following samples, on regular TAT:

4-LFH L437383-13
107-DM L437987-61
107-LFH L437987-62
109-DM L437987-71
109-LFH L437987-72
308-1 L437987-11
310-LFH L437987-18
310-1 L437987-19
7-LFH L437987-114
9-LFH L437987-110
204-LFH L437383-41
208-LFH L437987-47
12-LFH L437987-103
12-1 L437987-104
13-LFH L439526-34
13-1 L439526-35
14-LFH L439526-38
14-1 L439526-39
16-LFH L439526-46
114-LFH L439526-70

114-1 L439526- 71
116 -1 L439526-77
313-LFH L437987-28
313-1 L437987-29
213-LFH L439526-108
314-LFH L439526-1
314-1 L439526-2
318-LFH L439526-14
319-LFH L439526-18
117-LFH L439526-80
215-LFH L437526-116
217-LFH L439526-124
218-LFH L439526-128
20-LFH L439526-62
120-LFH L439526-92
220-LFH L439526-136
222-LFH L438781-5
323-LFH L438781-35
323-1 L438781-36
DGW260-LFH L450940-1
DGW261-LFH L450940-5
DGW262-1 L450940- 9
DGW262-2 L450940-10 ?
DGW263-LFH. L450940-12

Thanks Karen. Can you also send me MEMS price for these, I just need to do some budgeting changes.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
CELL:780-991-4616

-----Original Message-----
From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:48 PM
To: Ian Terry; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Hi Ian,

No, as per Cory's instructions we no longer run the F4G unless it's requested. His email is below (sent Aug 30th). I have the original email if you need it forwarded.

Thanks
Karen

****

Please remove the F4G. We will request it when required. Thanks Cory

> -----Original Message-----
> **From:** Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
> **Sent:** Thursday, August 24, 2006 8:46 AM
> **To:** Cory Sommer
> **Subject:** RE: L421098 addtional lab data requests

Hi Cory,

No problem, we don't have a BH06-24 @3.0M but we do have a BH06-24 @3.5M. I'll have the metals and salinity added to this sample instead.
Millennium is set up so that if the chrom does not return to baseline at C50 we automatically add the F4G. Technically you are obligated to report the F4G if the chrom does not return to baseline. If you Millennium no longer wants this then I can remove it but I need something in writing.

I found the following email from Ian, he never did get back to me on if the automatic F4G should be removed.
Thanks
Karen
****

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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From: Ian Terry [mailto:ITerry@mems.ca]
Sent: Thursday, November 30, 2006 1:39 PM
To: Karen Huebner; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Are you using the in-situ method then for samples that we submit?

Regards,

Ian

From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:00 PM
To: Ian Terry; Ryan Muri
Subject: Silica Column vs silica gel clean up

Please see below - this might clear things up a bit.

The CCME method makes silica gel cleanup mandatory for the F2-F4 fractions, but allows for two options: a simple in situ shake in which silica gel is added to a large solvent volume and shaken, or a column, in which a small volume of concentrated extract is passed through a glass column filled with packed silica gel. The column cleanup is much more intensive; in fact, it will remove some parts of petroleum hydrocarbons. The in situ cleanup. on the other hand, is less effective and will not remove high levels of naturally occurring hydrocarbons.

The F4G is a gravimetric measurement designed to account for hydrocarbons in and above the F4 range. Gas chromatograph response falls off dramatically above C50, so heavy hydrocarbons might not be accounted for in

the GC F2-F4 analysis. The CCME method allows F4G to be done on either a raw or a silica cleaned extract; we analyze only on a silica gel cleaned extract (F4G-SG), in order to be comparable to the F2-F4 results. The oven-dried gravimetric F4G result is highly variable, though, and can include significant portions of both the F4 and even the F3 hydrocarbons (the method requires the F4G to be dried at 110 degrees C, and the hydrocarbons in the F3 range typically have boiling points in the 250-300 degree C range or above). For this reason, the F4G can at times be surprisingly high.

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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PRELIMINARY RESULTS

MILLENNIUM
ATTN: GRANT WOYNAROWICH

208 4207 98 ST

EDMONTON AB T6E 5R7

Reported On: 07-DEC-06 02:54 PM
Revision: 4

Lab Work Order #: **L450940**
Date Received: **03-NOV-06**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 226625, 230150

Other Information:

Comments: ADDITIONAL 30-NOV-06 11:14

Sililca gel column cleanup was done for F2-F4 on fractions 1,5,9,12. Results did not change. Original results used. 07-Dec-06.

ROY JONES
General Manager, Edmonton

For any questions about this report please contact your Account Manager:

KAREN HUEBNER

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450940-1 DGW260-LFH								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.01	DLHM	0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Toluene	<0.02	DLHM	0.02	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Ethylbenzene	<0.02	DLHM	0.02	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Xylenes	<0.02	DLHM	0.02	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	105		33-172	%	16-NOV-06	21-NOV-06	MKE	R468086
Surr: Hexatriacontane	103		44-173	%	16-NOV-06	21-NOV-06	MKE	R468086
Prep/Analysis Dates					16-NOV-06	21-NOV-06	MKE	R468086
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-NOV-06		
F1-BTEX	<5		5	mg/kg		24-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-NOV-06		
F3 (C16-C34)	230		5	mg/kg		24-NOV-06		
F4 (C34-C50)	230		5	mg/kg		24-NOV-06		
Total Hydrocarbons (C6-C50)	460		5	mg/kg		24-NOV-06		
Chromatogram to baseline at nC50	NO					24-NOV-06		
% Moisture	62		0.1	%		10-NOV-06	COB	R464473
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	72		5	mg/L		14-NOV-06	MLH	R465135
Potassium (K)	80		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	26		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	5		2	mg/L		14-NOV-06	MLH	R465135
SAR	0.1		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	105		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	328		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	6.1		0.1	pH		15-NOV-06	CDU	R465106
Conductivity Sat. Paste	0.52		0.01	dS m-1		15-NOV-06	CDU	R465106
L450940-2 DGW260-1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Toluene	<0.01		0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Ethylbenzene	<0.01		0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Xylenes	<0.01		0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	115		33-172	%	16-NOV-06	21-NOV-06	MKE	R468086
Surr: Hexatriacontane	102		44-173	%	16-NOV-06	21-NOV-06	MKE	R468086
Prep/Analysis Dates					16-NOV-06	21-NOV-06	MKE	R468086
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-NOV-06		
F1-BTEX	<5		5	mg/kg		24-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-NOV-06		
F3 (C16-C34)	260		5	mg/kg		24-NOV-06		
F4 (C34-C50)	93		5	mg/kg		24-NOV-06		
Total Hydrocarbons (C6-C50)	350		5	mg/kg		24-NOV-06		
Chromatogram to baseline at nC50	NO					24-NOV-06		

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450940-2 DGW260-1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
% Moisture	27		0.1	%		10-NOV-06	COB	R464473
MUST PSA % > 75um	25		1	%		14-NOV-06	NNK	R465124
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	28		5	mg/L		14-NOV-06	MLH	R465135
Potassium (K)	9		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	6		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	3		2	mg/L		14-NOV-06	MLH	R465135
SAR	0.1		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	30		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	74.8		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	5.0		0.1	pH		15-NOV-06	CDU	R465106
Conductivity Sat. Paste	0.14		0.01	dS m-1		15-NOV-06	CDU	R465106
L450940-3 DGW260-2								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Toluene	<0.01		0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Ethylbenzene	<0.01		0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Xylenes	<0.01		0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	94		33-172	%	16-NOV-06	20-NOV-06	GRB	R467646
Surr: Hexatriacontane	118		44-173	%	16-NOV-06	20-NOV-06	GRB	R467646
Prep/Analysis Dates					16-NOV-06	20-NOV-06	GRB	R467646
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-NOV-06		
F1-BTEX	<5		5	mg/kg		24-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-NOV-06		
F3 (C16-C34)	140	RAMB	5	mg/kg		24-NOV-06		
F4 (C34-C50)	66	RAMB	5	mg/kg		24-NOV-06		
Total Hydrocarbons (C6-C50)	210		5	mg/kg		24-NOV-06		
Chromatogram to baseline at nC50	NO					24-NOV-06		
% Moisture	18		0.1	%		10-NOV-06	COB	R464473
MUST PSA % > 75um	34		1	%		14-NOV-06	NNK	R465124
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	22		5	mg/L		14-NOV-06	MLH	R465135
Potassium (K)	4		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	6		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	5		2	mg/L		14-NOV-06	MLH	R465135
SAR	0.2		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	38		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	50.6		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	4.6		0.1	pH		15-NOV-06	CDU	R465106

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450940-3 DGW260-2								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
Detailed Salinity								
pH and EC (Saturated Paste)								
Conductivity Sat. Paste	0.13		0.01	dS m-1		15-NOV-06	CDU	R465106
L450940-5 DGW261-LFH								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Toluene	<0.04	DLHM	0.04	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Ethylbenzene	<0.04	DLHM	0.04	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Xylenes	<0.04	DLHM	0.04	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	91		33-172	%	16-NOV-06	17-NOV-06	GRB	R467242
Surr: Hexatriacontane	103		44-173	%	16-NOV-06	17-NOV-06	GRB	R467242
Prep/Analysis Dates					16-NOV-06	17-NOV-06	GRB	R467242
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-NOV-06		
F1-BTEX	<5		5	mg/kg		24-NOV-06		
F2 (C10-C16)	6	RAMB	5	mg/kg		24-NOV-06		
F3 (C16-C34)	770		5	mg/kg		24-NOV-06		
F4 (C34-C50)	340		5	mg/kg		24-NOV-06		
Total Hydrocarbons (C6-C50)	1100		5	mg/kg		24-NOV-06		
Chromatogram to baseline at nC50	NO					24-NOV-06		
% Moisture	77		0.1	%		10-NOV-06	COB	R464473
Detailed Salinity								
Chloride (Cl)	30		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	41		5	mg/L		14-NOV-06	MLH	R465135
Potassium (K)	42		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	19		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	20		2	mg/L		14-NOV-06	MLH	R465135
SAR	0.6		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	84		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	663		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	5.8		0.1	pH		15-NOV-06	CDU	R465106
Conductivity Sat. Paste	0.37		0.01	dS m-1		15-NOV-06	CDU	R465106
L450940-6 DGW261-1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	24-NOV-06	24-NOV-06	DCD	R469300
Toluene	<0.01		0.01	mg/kg	24-NOV-06	24-NOV-06	DCD	R469300
Ethylbenzene	<0.01		0.01	mg/kg	24-NOV-06	24-NOV-06	DCD	R469300
Xylenes	0.04		0.01	mg/kg	24-NOV-06	24-NOV-06	DCD	R469300
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	71		33-172	%	16-NOV-06	20-NOV-06	GRB	R467646
Surr: Hexatriacontane	111		44-173	%	16-NOV-06	20-NOV-06	GRB	R467646
Prep/Analysis Dates					16-NOV-06	20-NOV-06	GRB	R467646
CCME Total Hydrocarbons								

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450940-6 DGW261-1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		25-NOV-06		
F1-BTEX	<5		5	mg/kg		25-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		25-NOV-06		
F3 (C16-C34)	39	RAMB	5	mg/kg		25-NOV-06		
F4 (C34-C50)	34	RAMB	5	mg/kg		25-NOV-06		
Total Hydrocarbons (C6-C50)	73		5	mg/kg		25-NOV-06		
Chromatogram to baseline at nC50	NO					25-NOV-06		
% Moisture	18		0.1	%		10-NOV-06	COB	R464473
MUST PSA % > 75um	12		1	%		14-NOV-06	NNK	R465124
Detailed Salinity								
Chloride (Cl)	40		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	90		5	mg/L		14-NOV-06	MLH	R465135
Potassium (K)	6		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	40		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	59		2	mg/L		14-NOV-06	MLH	R465135
SAR	1.3		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	283		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	62.7		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	6.0		0.1	pH		15-NOV-06	CDU	R465106
Conductivity Sat. Paste	0.68		0.01	dS m-1		15-NOV-06	CDU	R465106
L450940-9 DGW262-1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.04	DLHM	0.04	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Toluene	<0.08	DLHM	0.08	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Ethylbenzene	<0.08	DLHM	0.08	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Xylenes	<0.08	DLHM	0.08	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	100		33-172	%	16-NOV-06	21-NOV-06	MKE	R468086
Surr: Hexatriacontane	83		44-173	%	16-NOV-06	21-NOV-06	MKE	R468086
Prep/Analysis Dates					16-NOV-06	21-NOV-06	MKE	R468086
CCME Total Hydrocarbons								
F1 (C6-C10)	71	IPT	5	mg/kg		24-NOV-06		
F1-BTEX	71		5	mg/kg		24-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-NOV-06		
F3 (C16-C34)	2000		5	mg/kg		24-NOV-06		
F4 (C34-C50)	980		5	mg/kg		24-NOV-06		
Total Hydrocarbons (C6-C50)	3100		5	mg/kg		24-NOV-06		
Chromatogram to baseline at nC50	NO					24-NOV-06		
% Moisture	87		0.1	%		10-NOV-06	COB	R464473
Naphthenic Acids	4400		5	mg/kg		21-NOV-06	CLK	R467793
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	12		5	mg/L		14-NOV-06	MLH	R465135

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450940-9 DGW262-1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
Detailed Salinity								
SAR								
Potassium (K)	29		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	4		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	4		2	mg/L		14-NOV-06	MLH	R465135
SAR	0.2		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	26		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	767		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	3.6		0.1	pH		15-NOV-06	CDU	R465106
Conductivity Sat. Paste	0.18		0.01	dS m-1		15-NOV-06	CDU	R465106
L450940-12 DGW263 LFH								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.02	DLHM	0.02	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Toluene	<0.03	DLHM	0.03	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Ethylbenzene	<0.03	DLHM	0.03	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Xylenes	<0.03	DLHM	0.03	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	72		33-172	%	16-NOV-06	21-NOV-06	MKE	R468086
Surr: Hexatriacontane	83		44-173	%	16-NOV-06	21-NOV-06	MKE	R468086
Prep/Analysis Dates					16-NOV-06	21-NOV-06	MKE	R468086
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-NOV-06		
F1-BTEX	<5		5	mg/kg		24-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-NOV-06		
F3 (C16-C34)	580		5	mg/kg		24-NOV-06		
F4 (C34-C50)	360		5	mg/kg		24-NOV-06		
Total Hydrocarbons (C6-C50)	940		5	mg/kg		24-NOV-06		
Chromatogram to baseline at nC50	NO					24-NOV-06		
% Moisture	64		0.1	%		10-NOV-06	COB	R464473
Detailed Salinity								
Chloride (Cl)	50		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	88		5	mg/L		14-NOV-06	MLH	R465135
Potassium (K)	73		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	31		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	5		2	mg/L		14-NOV-06	MLH	R465135
SAR	0.1		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	79		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	401		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	5.3		0.1	pH		15-NOV-06	CDU	R465106
Conductivity Sat. Paste	0.52		0.01	dS m-1		15-NOV-06	CDU	R465106
L450940-13 DGW263 1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450940-13 DGW263 1								
Sampled By: GW on 03-NOV-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME BTEX								
Toluene	<0.01	RAMB	0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Ethylbenzene	<0.01	RAMB	0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
Xylenes	0.03		0.01	mg/kg	10-NOV-06	23-NOV-06	DDU	R468910
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	90		33-172	%	16-NOV-06	20-NOV-06	GRB	R467646
Surr: Hexatriacontane	129		44-173	%	16-NOV-06	20-NOV-06	GRB	R467646
Prep/Analysis Dates					16-NOV-06	20-NOV-06	GRB	R467646
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		24-NOV-06		
F1-BTEX	<5		5	mg/kg		24-NOV-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		24-NOV-06		
F3 (C16-C34)	45	RAMB	5	mg/kg		24-NOV-06		
F4 (C34-C50)	35	RAMB	5	mg/kg		24-NOV-06		
Total Hydrocarbons (C6-C50)	80		5	mg/kg		24-NOV-06		
Chromatogram to baseline at nC50	NO					24-NOV-06		
% Moisture	4.7		0.1	%		10-NOV-06	COB	R464473
MUST PSA % > 75um	12		1	%		14-NOV-06	NNK	R465124
Detailed Salinity								
Chloride (Cl)	<20		20	mg/L		14-NOV-06	CLT	R465190
SAR								
Calcium (Ca)	21		5	mg/L		14-NOV-06	MLH	R465135
Potassium (K)	8		2	mg/L		14-NOV-06	MLH	R465135
Magnesium (Mg)	8		3	mg/L		14-NOV-06	MLH	R465135
Sodium (Na)	5		2	mg/L		14-NOV-06	MLH	R465135
SAR	0.2		0.1	SAR		14-NOV-06	MLH	R465135
Sulphate (SO4)	28		6	mg/L		14-NOV-06	MLH	R465135
pH and EC (Saturated Paste)								
% Saturation	30.0		0.1	%		15-NOV-06	CDU	R465106
pH in Saturated Paste	4.7		0.1	pH		15-NOV-06	CDU	R465106
Conductivity Sat. Paste	0.14		0.01	dS m-1		15-NOV-06	CDU	R465106

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Numbe	Client ID	Qualifier	Description
L450940-1	DGW260-LFH	IPC	Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L450940-12	DGW263 LFH	IPC	Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L450940-2	DGW260-1	IPC	Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L450940-5	DGW261-LFH	IPC	TEH-CCME-ED F2-F4 - Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.
L450940-9	DGW262-1	IPC	Instrument performance not showing the C50 response factor within 30% of the average of C10, C16 & C34 response factors.

Sample Parameter Qualifier key listed:

Qualifier	Description
DLHM	Detection Limit Adjusted: Sample has High Moisture Content
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
NAPHTHENIC-ACID-FM	Soil	Naphthenic Acids by FTIR		Naphthenic Acids by FTIR,Syncrude,1994
PREP-MOISTURE-ED	Soil	% Moisture		Oven dry 105C-Gravimetric
PSA-MUST-ED	Soil	MUST PSA D50 > 75um		ASTM D422-63-Hydrometer/Sieve
SAR-CALC-ED	Soil	SAR		CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)		CSSS 18.2, 16.2, 18.3
SO4-SAR-ED	Soil	Sulfate (SO4) in saturated paste		APHA 3120 B-ICP-OES

Reference Information

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

226625 230150

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

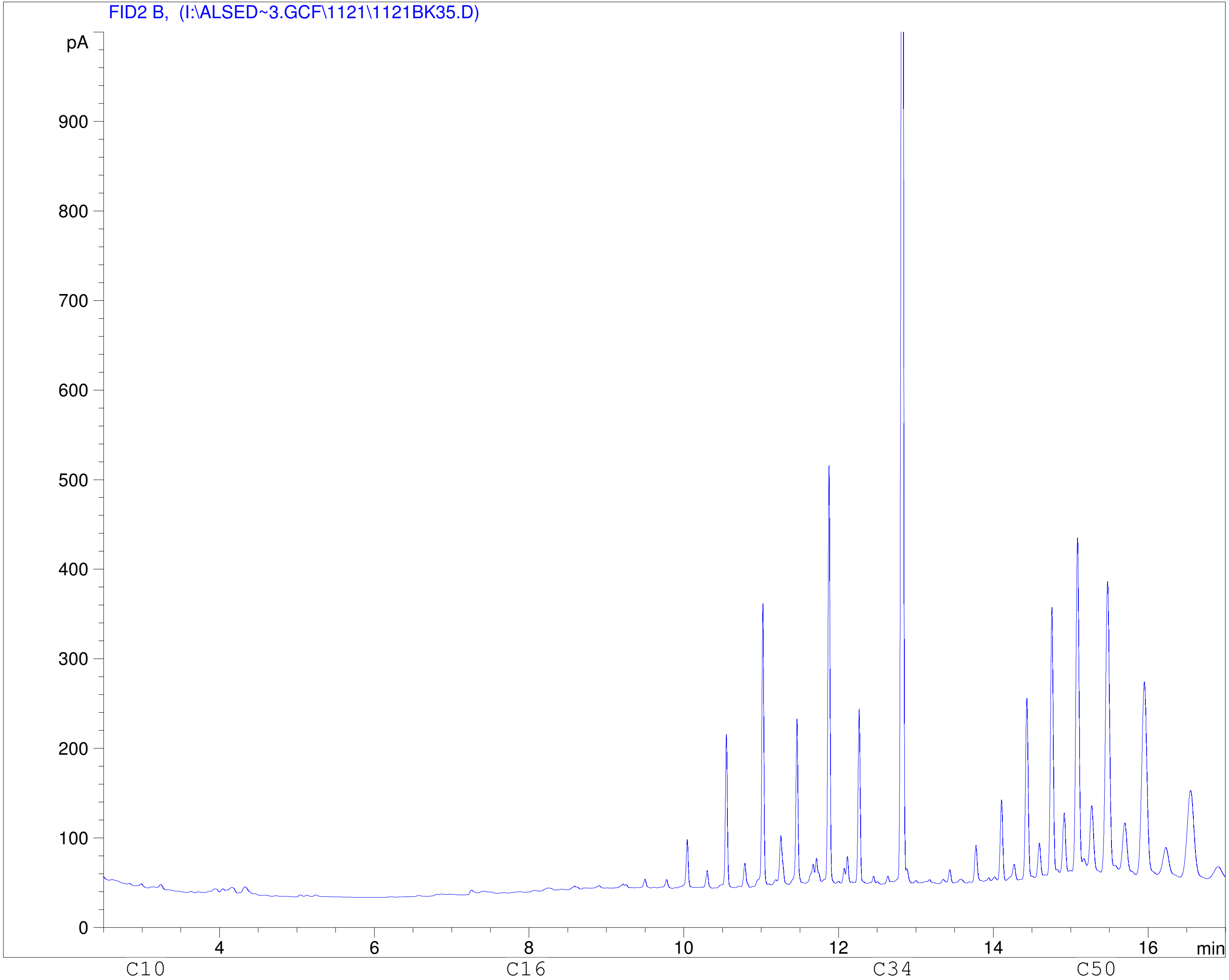
Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA	FM	ALS LABORATORY GROUP - FORT MCMURRAY, ALBERTA, CANADA

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

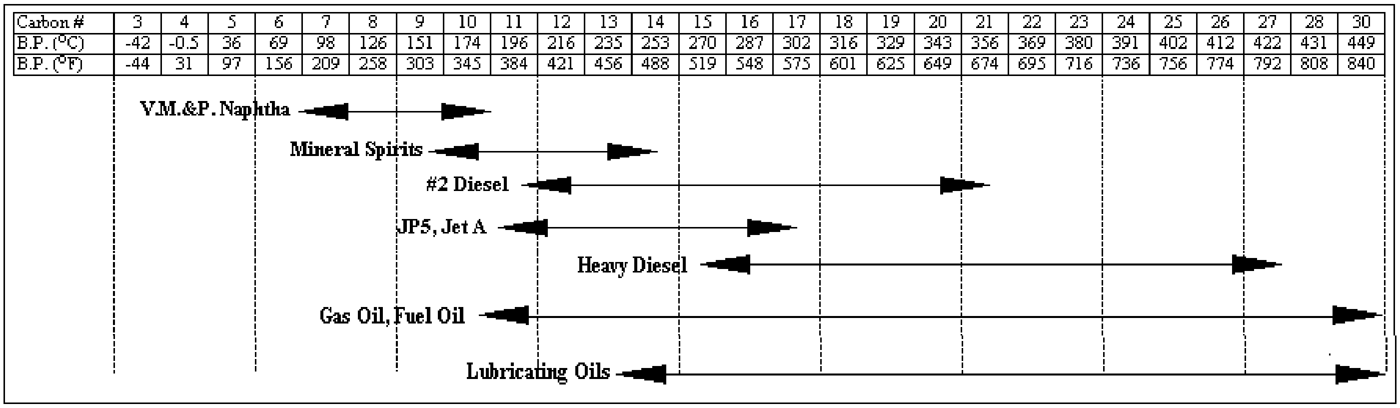
Client ID: DGW260-LFH

Sample ID: L450940-1 4 SGC
Injection Date: 11/22/06 7:09:44 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

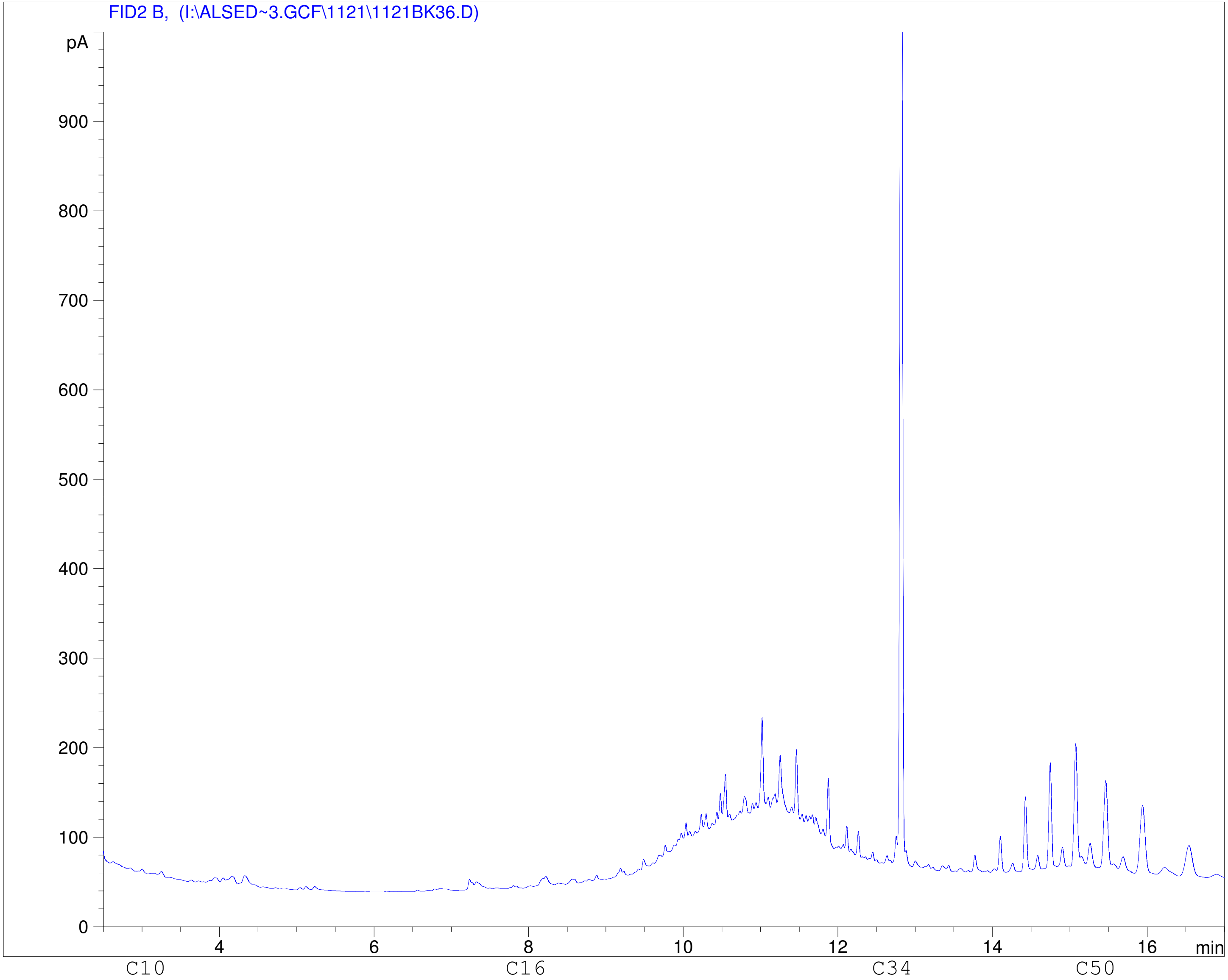


Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

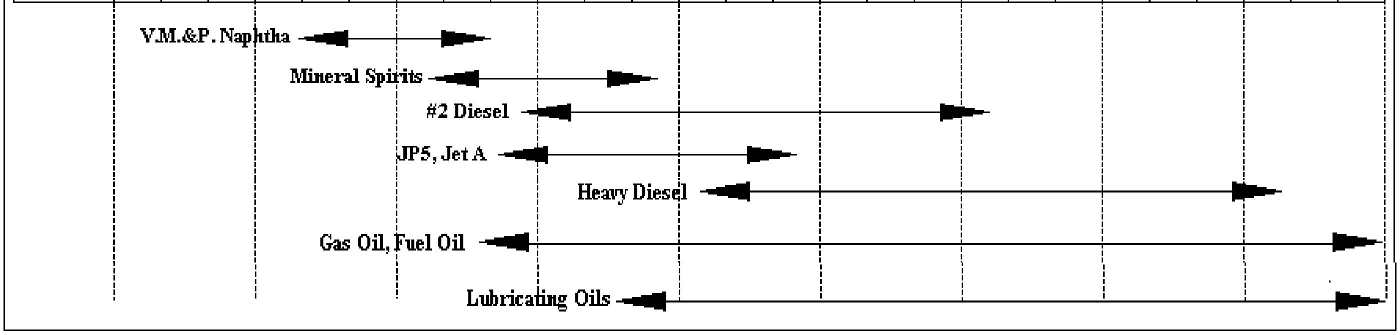
```
Client ID:              DGW260-1

Sample ID:              L450940-2 4 SGC
Injection Date:         11/22/06 7:36:32 AM
Instrument:             6890
```

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

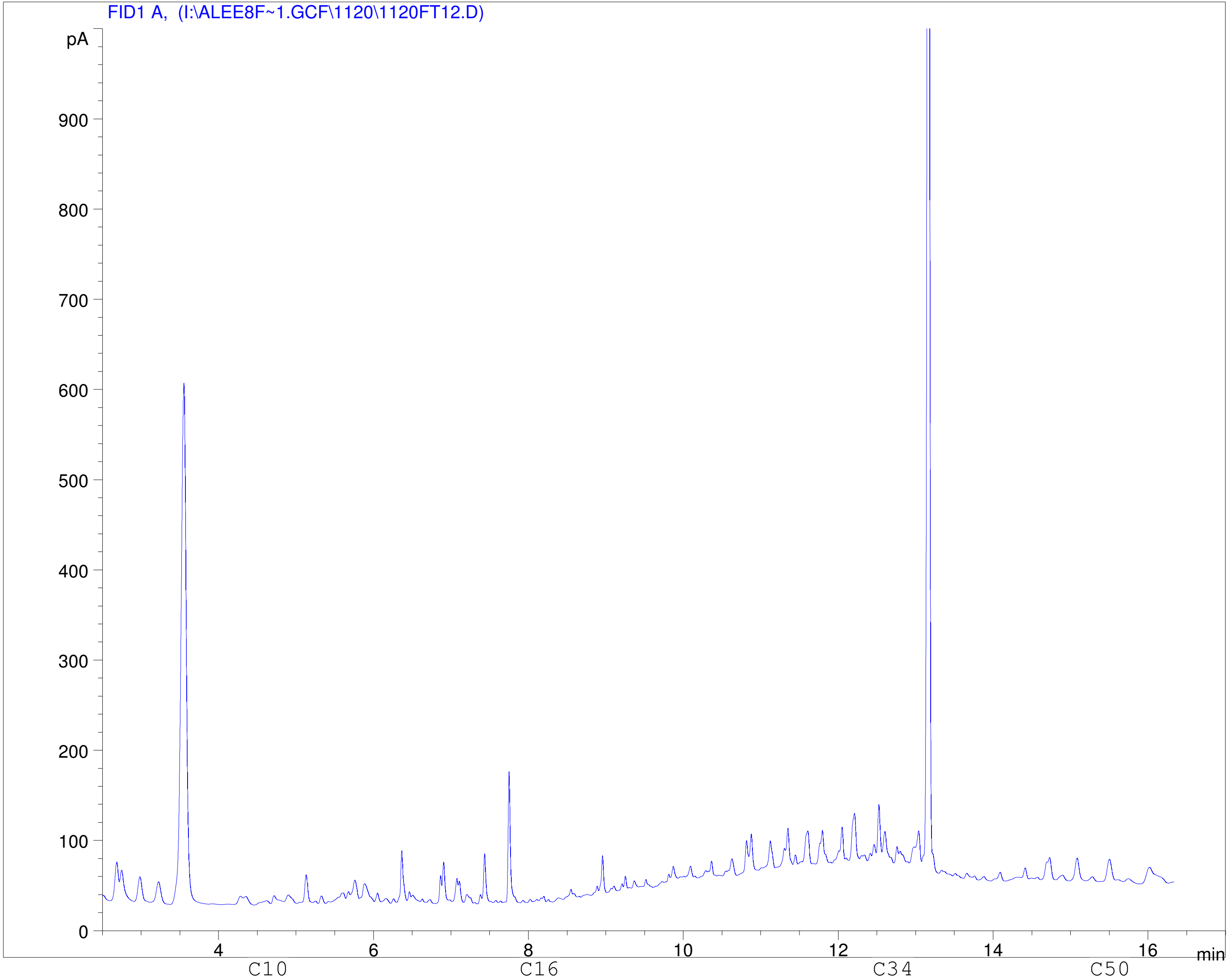


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW260-2

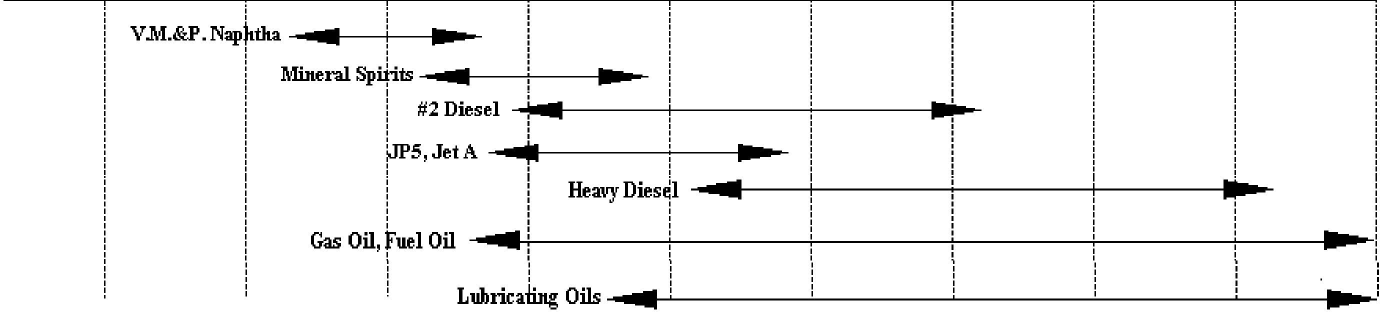
Sample ID: L450940-3 4
Injection Date: 11/20/2006 8:21:03 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

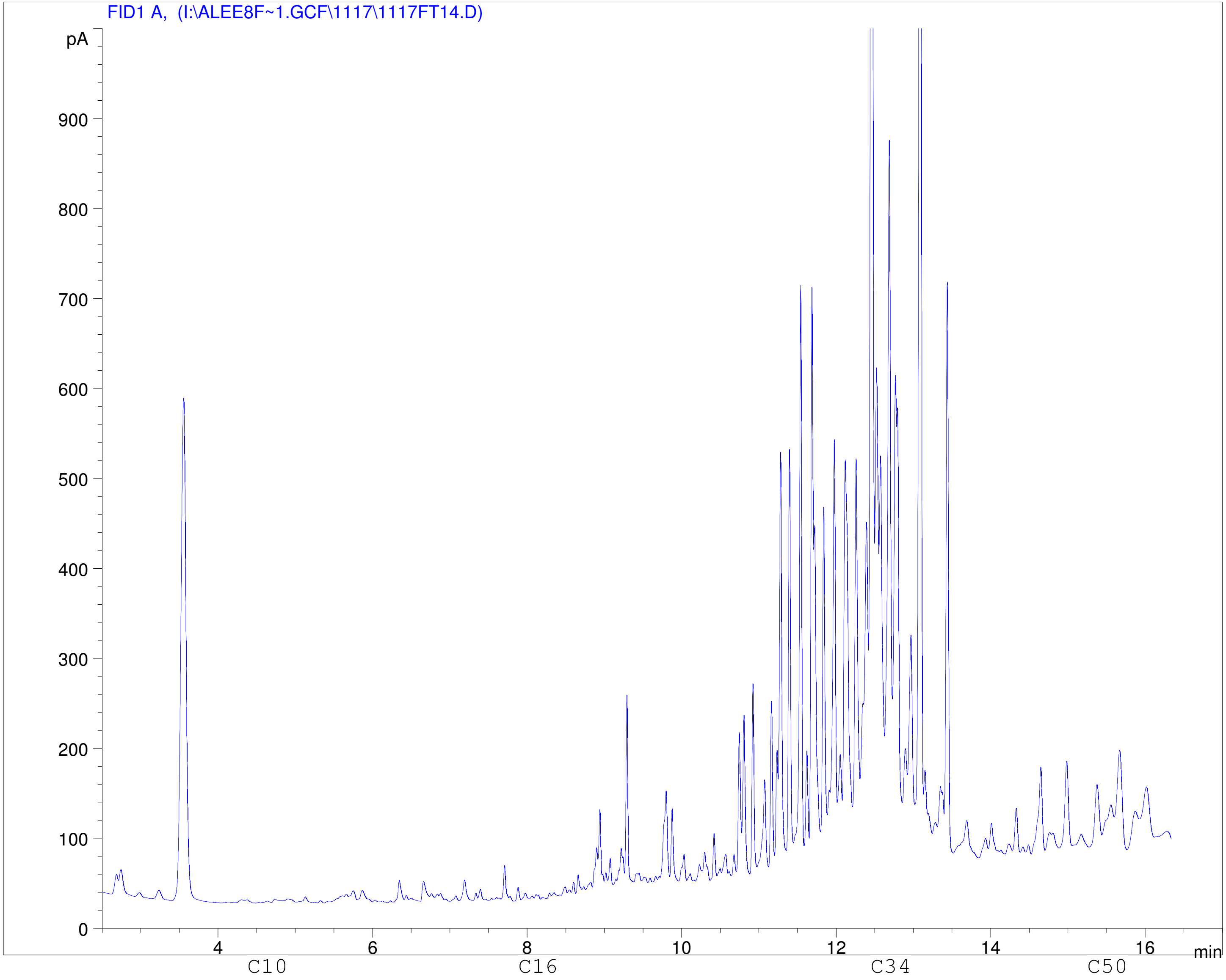


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW261-LFH

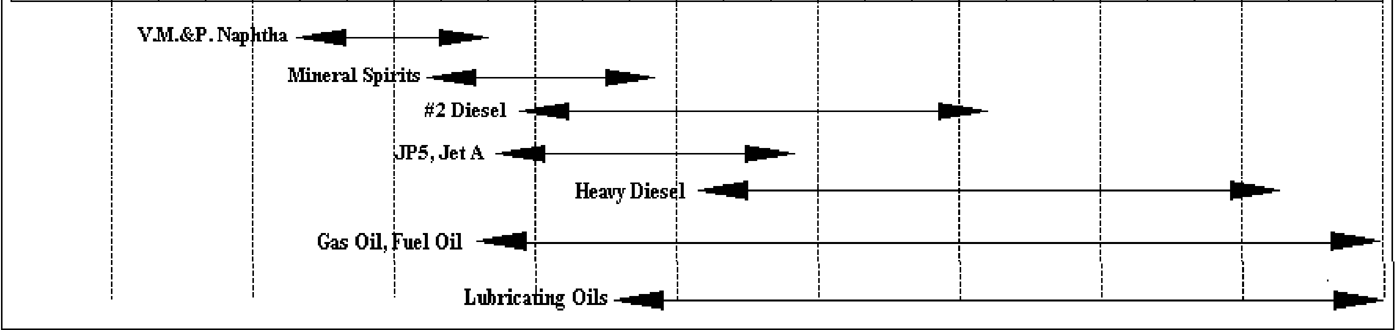
Sample ID: L450940-5 4
Injection Date: 11/17/2006 9:21:53 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

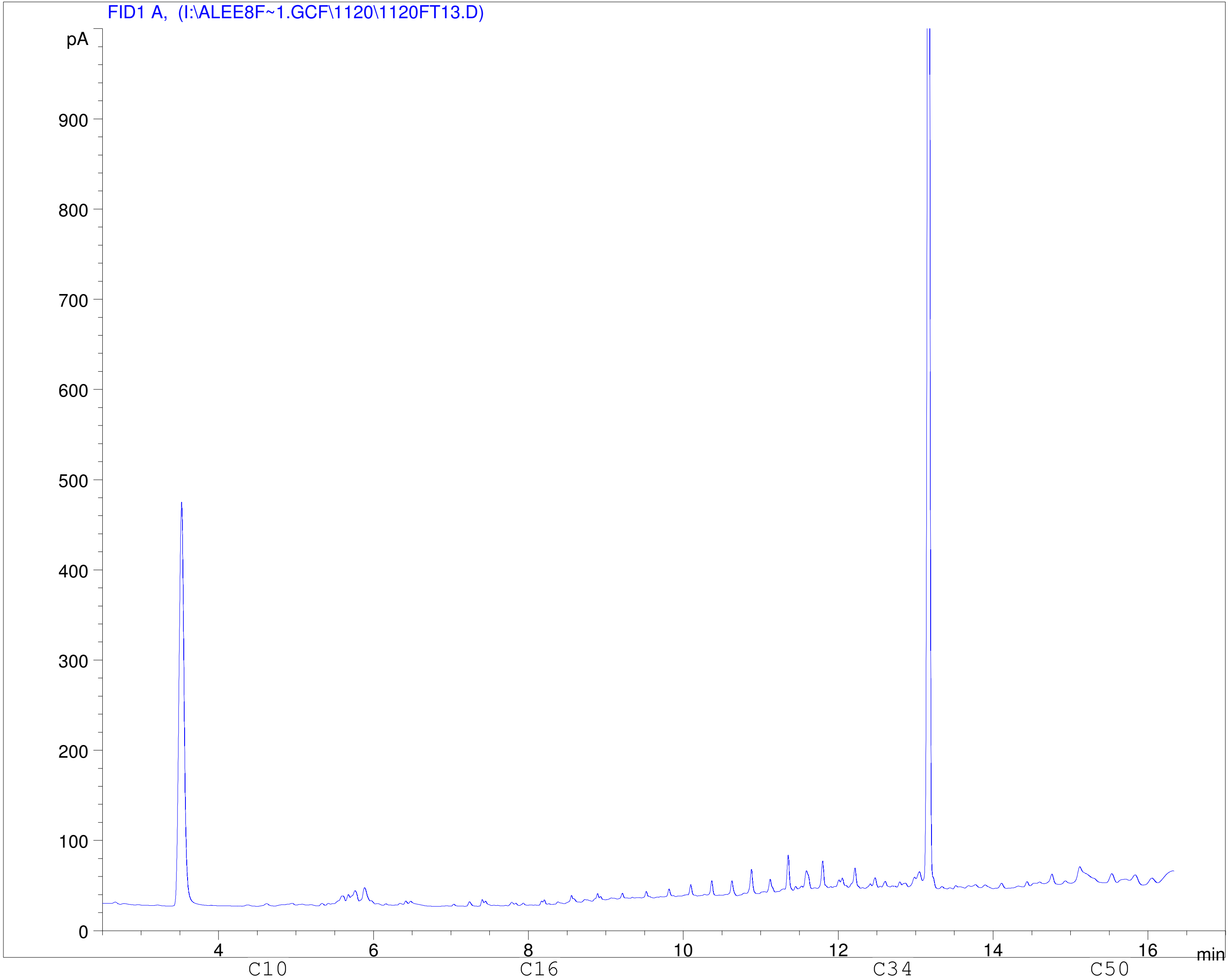


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW261-1

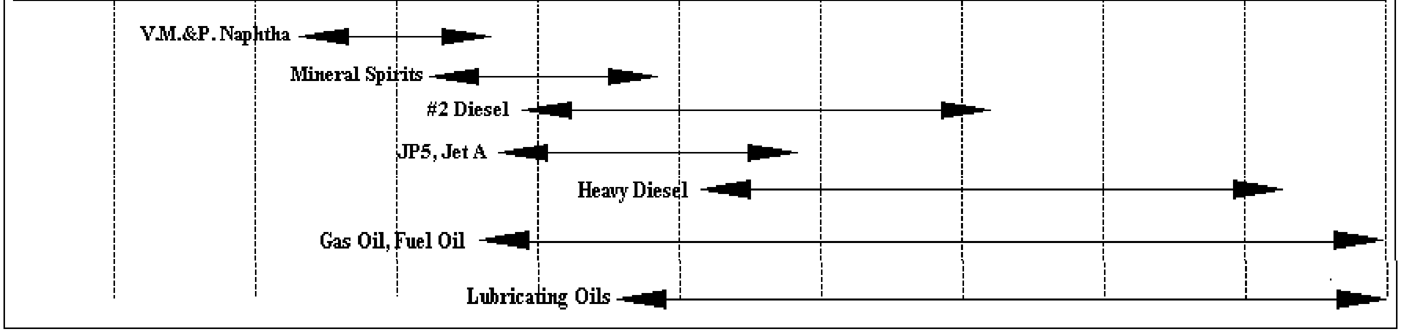
Sample ID: L450940-6 4
Injection Date: 11/20/2006 8:46:26 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

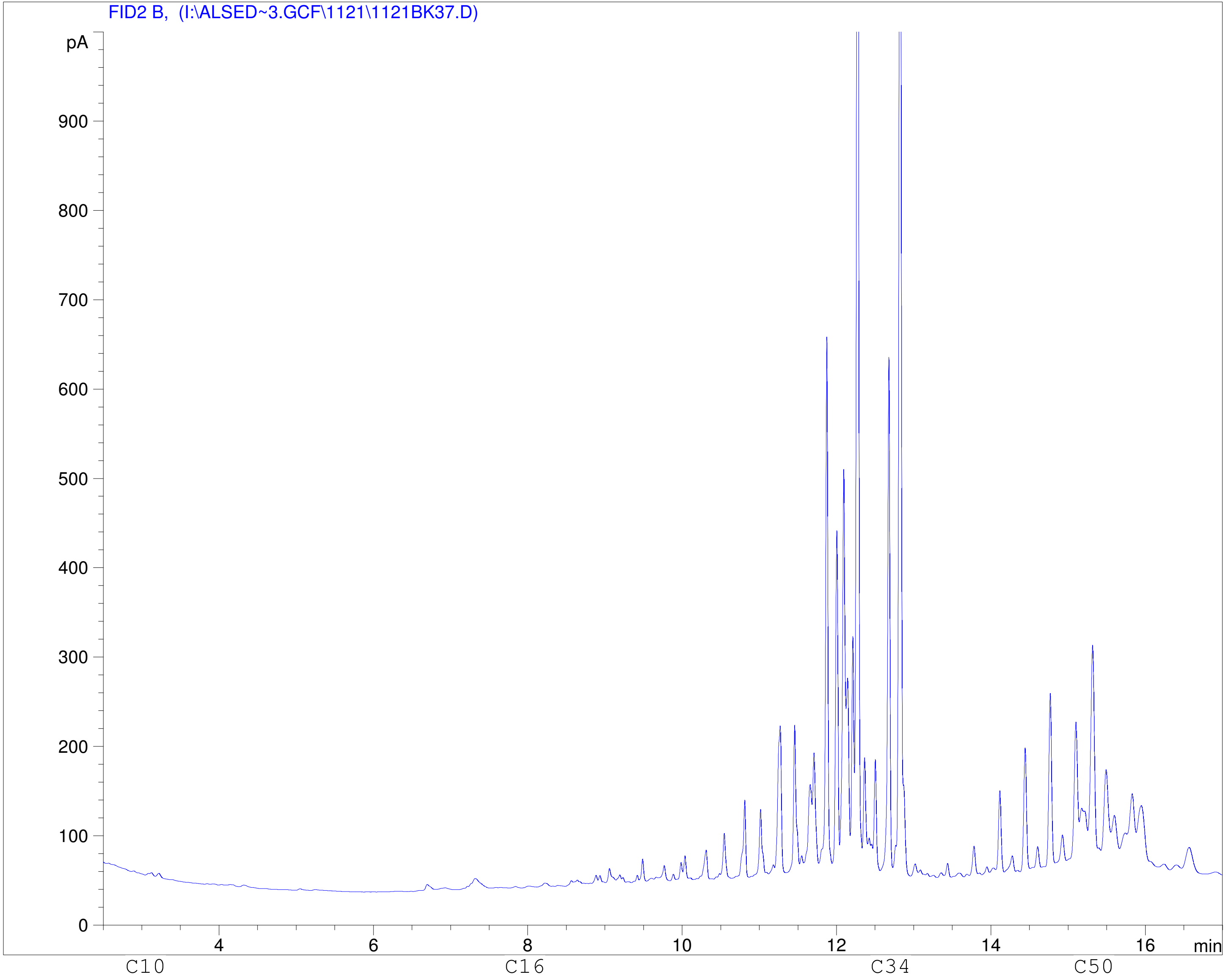


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

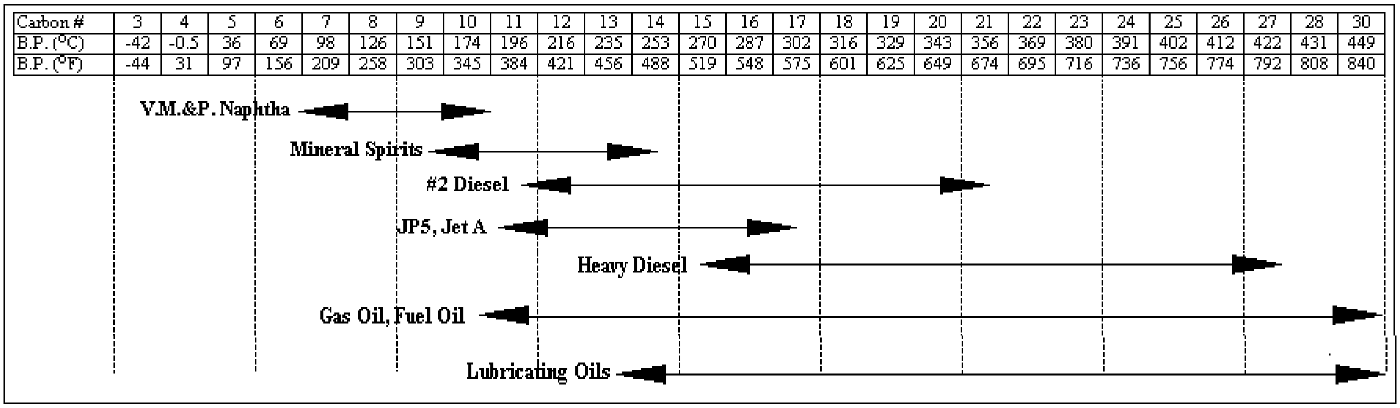
Client ID: DGW262-1

Sample ID: L450940-9 4 SGC
Injection Date: 11/22/06 8:03:33 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products



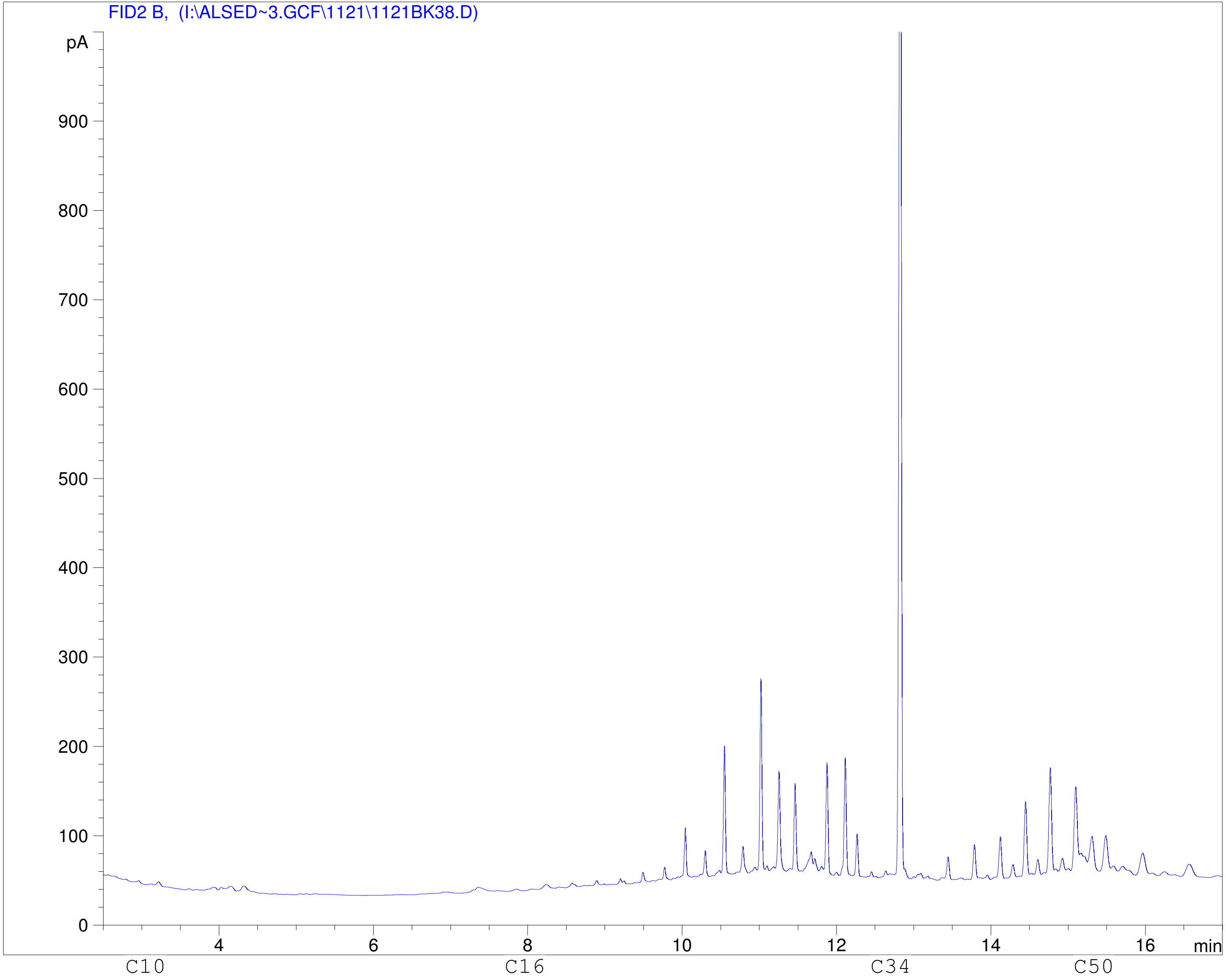
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW263 LFH

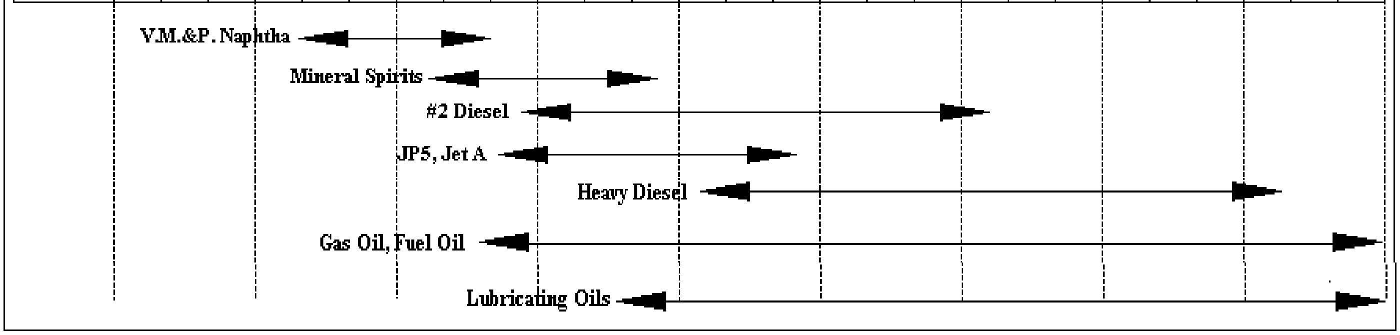
Sample ID: L450940-12 4 SGC
Injection Date: 11/22/06 8:30:19 AM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

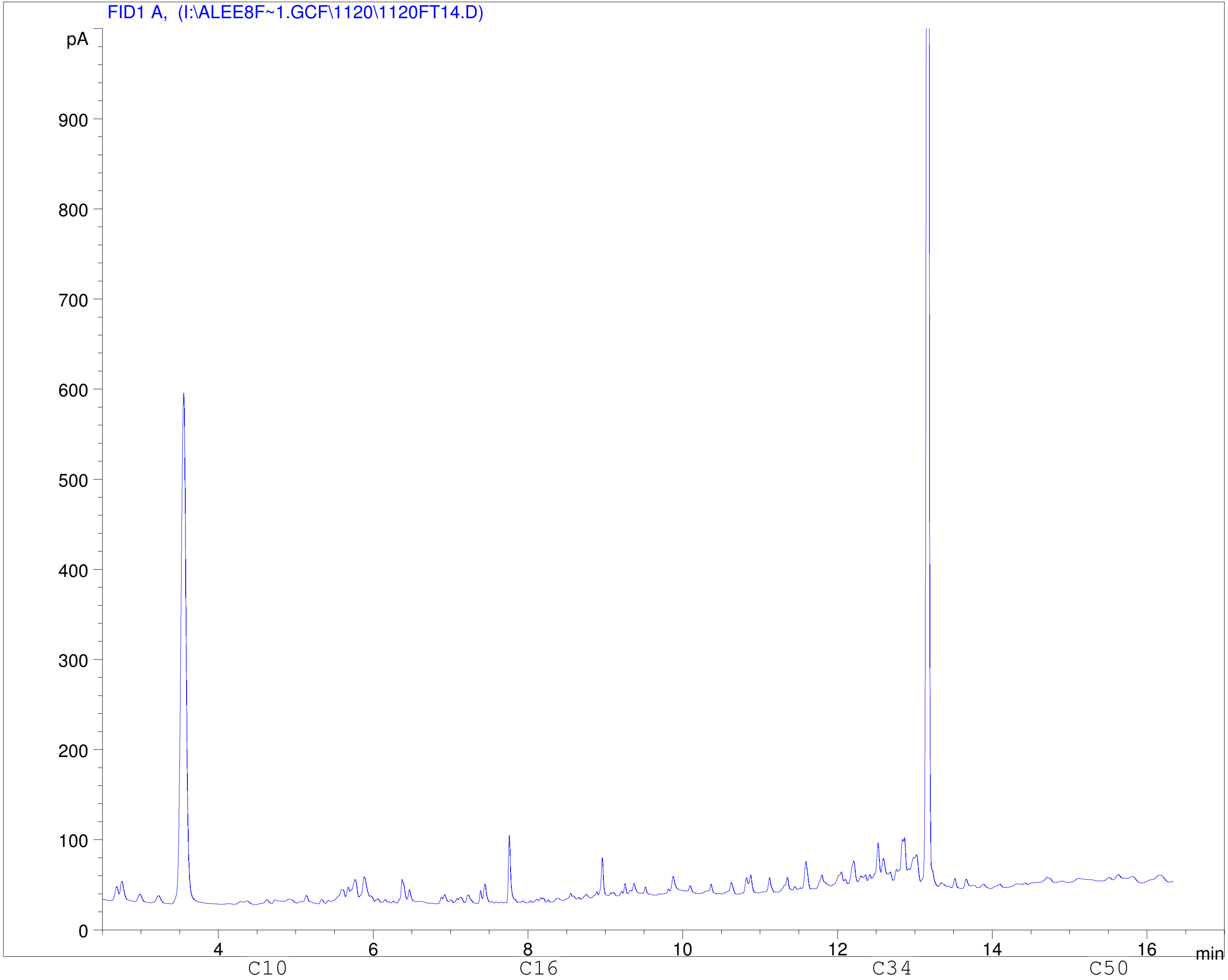


Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Client ID: DGW263 1

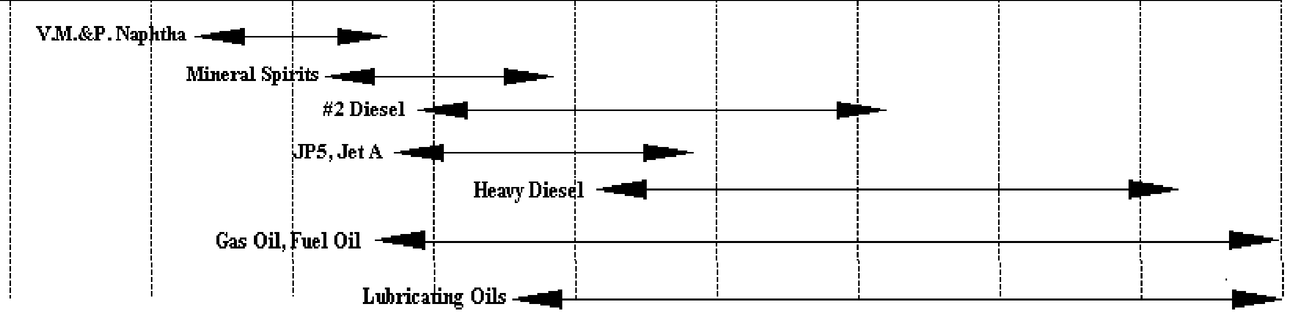
Sample ID: L450940-13 4
Injection Date: 11/20/2006 9:11:35 PM
Instrument: 6890

Total Extractable Hydrocarbons



Boiling Point Distribution Range of Petroleum Based Fuel Products

Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840



Adapted from: Drews, A.W., ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII

Enviro·Test LABORATORIES

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

CANADA TOLL FREE 1-800-668-9878

COC # 226625

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Pg. 1 of 2

REPORT TO:	**DATE:**
COMPANY: Millennium	**REPORT DISTRIBUTION** ALL FINAL RESULTS WILL BE MAILED
CONTACT: Grant	EMAIL___ FAX___
ADDRESS:	EMAIL 1: rmuri@mems.ca
	EMAIL 2:
	DIGITAL EMAIL:
PHONE: FAX:	SELECT: pdf___ digital___ both___
CELLPHONE: 975-4335	INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶
INVOICE TO: SAME Y / N	JOB # 04-101
COMPANY:	
CONTACT:	PO/AFE:
ADDRESS:	
	LSD:
PHONE: FAX:	QUOTE #

LAB WORK ORDER # L450940

☒ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	ANALYSIS REQUEST	HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
DGW260-LFH		GW / Nov 3/06					4		
~~R~~ 1							4		
2							2		
3							2		
DGW261-LFH					HOLD		4		
-1							4		
-2							2		
-3							2		
DGW262-1							4		
-2							4		
-3							2		

☐ FROZEN
☐ COLD
☐ AMBIENT

MEAN TEMPERATURE

Failure to complete all portions of this form may delay analysis. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse of the white report copy.

RELINQUISHED BY:	DATE & TIME: Nov 3/06 5:00 pm	RECEIVED BY: Julie OBrien	DATE & TIME: 3-NOV-06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME: 17:10	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY GENF04.01

EnviroTest
LABORATORIES

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM
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COC # 230150

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Pg. 2 of 2

LAB WORK ORDER # L450940

REPORT TO:
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:
CELLPHONE:

DATE:
REPORT DISTRIBUTION **ALL FINAL RESULTS WILL BE MAILED**
EMAIL___ FAX___
EMAIL 1:
EMAIL 2:
DIGITAL EMAIL:
SELECT: pdf___ digital___ both___

☐ REGULAR SERVICE (DEFAULT)
☐ PRIORITY SERVICE (50% SURCHARGE)
☐ EMERGENCY SERVICE (100% SURCHARGE)

INVOICE TO: **SAME Y / N**
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

JOB # 04-101
PO/AFE:
LSD:
QUOTE #

INDICATE BOTTLES: FILTERED/PRESERVED (F/P) ▶

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE											HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
DGW 2L3 LF#		GW Nov3/06														4		
" 1		↓														4		
" 2					HOLD.											2		
" 3																2		

☐ FROZEN
☐ COLD
☐ AMBIENT
MEAN TEMPERATURE

Failure to complete all portions of this form may delay analysis. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse of the white report copy.

RELINQUISHED BY:	DATE & TIME: Nov 3/06 5:00 pm.	RECEIVED BY: Julie OBrien	DATE & TIME: 3-NO-06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME: 17:10.	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY

GENF04.01

32502325-03003

Norma Jestin

From: Karen Huebner
Sent: Thursday, November 09, 2006 11:25 AM
To: Norma Jestin; Joanne Ringuette
Subject: FW: Analysis Request

Please add the additionals listed below. Reg TAT

Karen Huebner
Senior Account Manager
ALS Laboratory Group
Environmental Division
Edmonton, Canada
Phone: +1 780 413-5220
Direct: +1 780 413-5984
Fax: +1 780 437-2311
www.alsenviro.com

From: Callie Volf [mailto:cvolf@mems.ca]
Sent: Tuesday, November 07, 2006 11:51 AM
To: Karen Huebner; Ryan Muri
Cc: Callie Volf
Subject: Analysis Request

Hi Karen,

Can you run the following analysis for our job number 04-101 (new set of samples this time).

COC# 226625 & 226631, received by ALS Nov 3/06.

Sample ID	Analysis Requested
DGW260-LFH	SAL-detail, BTX,TVH,TEH-CCME L450940-1
DGW260-1	SAL-detail, PSA-MUST, BTX,TVH,TEH-CCME -2
DGW260-2	SAL-detail, PSA-MUST, BTX,TVH,TEH-CCME -3
DGW261-LFH	SAL-detail, BTX,TVH,TEH-CCME -5
DGW261-1	SAL-detail, PSA-MUST, BTX,TVH,TE H-CCME -6
DGW262-1	SAL-detail, BTX,TVH,TEH-CCME, Naphthenic Acids -9
DGW263-LFH	SAL-detail, BTX,TVH,TEH-CCME -12
DGW263-1	SAL-detail, PSA-MUST, BTX,TVH,TEH-CCME -13

Nov 9/06

Thanks,

Callie

DISCLAIMER:

Norma Jestin

From: Karen Huebner
Sent: Wednesday, November 29, 2006 4:33 PM
To: Norma Jestin; Joanne Ringuette
Subject: FW: 450940

Please add Nap Acids to L450940-5,-6,-7,-12,-13 reg TAT as per email below

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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Fax: +1 780 437-2311
www.alsenviro.com

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Wednesday, November 29, 2006 3:07 PM
To: Karen Huebner
Subject: RE: 450940

Nov 30/06

Karen,

Can we please run NAP-acids on the following samples:

DGW261-LFH
DGW261-1
DGW261-2
DGW263-LFH
DGW263-1

On regular TAT, thanks.

Ryan

From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Tue 11/28/2006 10:09 AM
To: Ryan Muri
Cc: Callie Volf
Subject: RE: L438781

Hi Ryan,

No problem. Were you expecting the sample to be clean? The BTX results are all ND but there are hits on the F2-F4, just wondering which part of the analysis you thought may be wrong as we run the package in two different labs.

Thanks

Karen

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Tuesday, November 28, 2006 9:33 AM
To: Karen Huebner
Cc: Callie Volf
Subject: L438781

Karen,

Can you double check the BTEX F1-F4 results for sample 323-1? Thanks.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
CELL:780-991-4616

Norma Jestin

From: Karen Huebner
Sent: Friday, December 01, 2006 9:42 AM
To: Norma Jestin; Joanne Ringuette; Aimee Thompson; Michelle Eckert; Ian Bullecer
Cc: Sean Johnston
Subject: Additional SGC

Please add TEH-SGC to the following. Reg TAT.

Aimee/Michelle/Ian - Please make sure the coverpage comments are added when results are completed.
Thanks

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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Dec 1/06

From: Ryan Muri [mailto:RMuri@mems.ca]
Sent: Thursday, November 30, 2006 2:26 PM
To: Karen Huebner
Subject: FW: Silica Column vs silica gel clean up 04-101

Karen,

Please run the Silica column clean up on the following samples, on regular TAT:

4-LFH L437383-13
107-DM L437987-61
107-LFH L437987-62
109-DM L437987-71
109-LFH L437987-72
308-1 L437987-11
310-LFH L437987-18
310-1 L437987-19
7-LFH L437987-114
9-LFH L437987-110
204-LFH L437383-41
208-LFH L437987-47
12-LFH L437987-103
12-1 L437987-104
13-LFH L439526-34
13-1 L439526-35
14-LFH L439526-38
14-1 L439526-39
16-LFH L439526-46
114-LFH L439526-70

114-1 L439526- 71
116 -1 L439526-77
313-LFH L437987-28
313-1 L437987-29
213-LFH L439526-108
314-LFH L439526-1
314-1 L439526-2
318-LFH L439526-14
319-LFH L439526-18
117-LFH L439526-80
215-LFH L437526-116
217-LFH L439526-124
218-LFH L439526-128
20-LFH L439526-62
120-LFH L439526-92
220-LFH L439526-136
222-LFH L438781-5
323-LFH L438781-35
323-1 L438781-36
DGW260-LFH L450940-1
DGW261-LFH L450940-5
DGW262-1 L450940- 9
DGW262-2 L450940-10
DGW263-LFH. L450940-12

Thanks Karen. Can you also send me MEMS price for these, I just need to do some budgeting changes.

Ryan Muri, B.Sc., P.Ag.
Millennium EMS Solutions Ltd.
#208, 4207-98 Street
Edmonton AB T6E 5R7
780-496-9048
FAX: 780-496-9049
CELL:780-991-4616

-----Original Message-----
From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:48 PM
To: Ian Terry; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Hi Ian,

No, as per Cory's instructions we no longer run the F4G unless it's requested. His email is below (sent Aug 30th). I have the original email if you need it forwarded.

Thanks
Karen

****

Please remove the F4G. We will request it when required. Thanks Cory

> -----Original Message-----
> **From:** Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
> **Sent:** Thursday, August 24, 2006 8:46 AM
> **To:** Cory Sommer
> **Subject:** RE: L421098 addtional lab data requests

Hi Cory,

No problem, we don't have a BH06-24 @3.0M but we do have a BH06-24 @3.5M. I'll have the metals and salinity added to this sample instead.
Millennium is set up so that if the chrom does not return to baseline at C50 we automatically add the F4G. Technically you are obligated to report the F4G if the chrom does not return to baseline. If you Millennium no longer wants this then I can remove it but I need something in writing.

I found the following email from Ian, he never did get back to me on if the automatic F4G should be removed.
Thanks
Karen
****

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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From: Ian Terry [mailto:ITerry@mems.ca]
Sent: Thursday, November 30, 2006 1:39 PM
To: Karen Huebner; Ryan Muri
Subject: RE: Silica Column vs silica gel clean up

Are you using the in-situ method then for samples that we submit?

Regards,

Ian

From: Karen Huebner [mailto:Karen.Huebner@ALSEnviro.com]
Sent: Thursday, November 30, 2006 1:00 PM
To: Ian Terry; Ryan Muri
Subject: Silica Column vs silica gel clean up

Please see below - this might clear things up a bit.

The CCME method makes silica gel cleanup mandatory for the F2-F4 fractions, but allows for two options: a simple in situ shake in which silica gel is added to a large solvent volume and shaken, or a column, in which a small volume of concentrated extract is passed through a glass column filled with packed silica gel. The column cleanup is much more intensive; in fact, it will remove some parts of petroleum hydrocarbons. The in situ cleanup. on the other hand, is less effective and will not remove high levels of naturally occurring hydrocarbons.

The F4G is a gravimetric measurement designed to account for hydrocarbons in and above the F4 range. Gas chromatograph response falls off dramatically above C50, so heavy hydrocarbons might not be accounted for in

the GC F2-F4 analysis. The CCME method allows F4G to be done on either a raw or a silica cleaned extract; we analyze only on a silica gel cleaned extract (F4G-SG), in order to be comparable to the F2-F4 results. The oven-dried gravimetric F4G result is highly variable, though, and can include significant portions of both the F4 and even the F3 hydrocarbons (the method requires the F4G to be dried at 110 degrees C, and the hydrocarbons in the F3 range typically have boiling points in the 250-300 degree C range or above). For this reason, the F4G can at times be surprisingly high.

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

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Norma Jestin

From: Karen Huebner
Sent: Tuesday, December 05, 2006 9:00 AM
To: Tanya Anthony; Norma Jestin
Subject: RE: L450940

Yep no problem

Norma - Please change the due dates for Nap Acids to Friday

-5,6,7,12,13

Thanks
Karen

Karen Huebner
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Dec 5/06

From: Tanya Anthony
Sent: Tuesday, December 05, 2006 8:56 AM
To: Karen Huebner
Subject: RE: L450940

Hey Karen

We received the Nap Acids late yesterday afternoon. We won't have them completed by tomorrow's due date so would it be a problem if I changed the due date to Friday?

Tanya

Tanya Anthony
Laboratory Coordinator
ALS Laboratory Group
Environmental Division
Fort McMurray, Canada
ph. 1-780-791-1524
cell. 1-780-714-8482
fax. 1-780-791-1586
tanya.anthony@alsenviro.com

From: Karen Huebner
Sent: Monday, December 04, 2006 9:19 AM
To: Tanya Anthony; Norma Jestin

Subject: RE: L450940

Hey Norma,

Can you please check if the additional Nap acids on this file have been sent. Please move the due date to Friday.

Thanks
Karen

Please note that on Friday, December 1st the Edmonton location will be closed after 2:00pm.

Karen Huebner
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ALS Laboratory Group
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Edmonton, Canada
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www.alsenviro.com

From: Tanya Anthony
Sent: Monday, December 04, 2006 9:02 AM
To: Karen Huebner
Subject: L450940

Good Morning Karen

I was wondering if you knew when we should be expecting the five nap acids in soil for this file? They are due on Wednesday and its going to take us a couple of days to do them.

Thanks
Tanya

Tanya Anthony
Laboratory Coordinator
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Deer Creek Energy Limited
Steam Release Incident
LSD 09-33-095-12-W4M

Volume III - Surface Water Monitoring Program: Summary Report

DRAFT

Prepared for:
Deer Creek Energy Limited

Prepared by:
Millennium EMS Solutions Ltd.
#208, 4207 – 98 St
Edmonton, Alberta
T6E 5R7

December 2006
File #04-101

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1.0 INTRODUCTION

Millennium EMS Solutions Ltd. (MEMS) has been retained by Deer Creek Energy Limited (DCEL) to assist in the assessment, delineation and subsequent remediation of the lands potentially impacted by the Joslyn North Mine Project steam release event. The Joslyn Project is located approximately 60 km North of Fort McMurray, west of the Athabasca River. This phase of the steam assisted gravity drain (SAGD) facility started injecting steam into the production reservoir on April 15, 2006. The plant circulated steam for approximately one month and then began producing bitumen.

On May 18, 2006 at 5:15 am, a steam release was discovered adjacent to Well Pair 204-P1 (Appendix A, Figure 1). The Energy and Utilities Board (EUB) in Bonnyville and Alberta Environment (AENV) were notified immediately after the release was controlled. On May 25, 2006, DCEL, a subsidiary of Total E&P Canada Ltd. (TEPC) submitted a preliminary assessment of the incident to the EUB for review. The preliminary assessment of the incident included initial soil and surface water sampling in proximity to and down gradient of the release point. An additional summary and work plan was submitted to AENV in September 2006. The following report outlines the methods and findings of the surface water monitoring program including the initial assessment and a subsequent sampling event proposed in the September 2006 work plan.

1.1 Background Information

Initial Assessment of Potentially Impacted Area – Soil & Surface Water (May 2006)

The September 2006 report prepared by MEMS documented the findings of the initial assessment and presented a work plan for further soil, groundwater and surface water investigation and monitoring. During the initial assessment, samples of the displaced material were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), leachable BTEX, F1-F4 petroleum hydrocarbon fractions, total extractable hydrocarbons, detailed salinity, and trace metals. The displaced material was considered to be the subsurface material deposited on the ground surface as a result of the steam release event. Analytical results of the displaced material consistently exceeded the Alberta soil quality guidelines for F2-F4 hydrocarbon fractions (AENV 2001a) and the Alberta salt contamination guidelines for sodium adsorption ratio (SAR) (AENV 2001b). All other parameters measured were below the applicable guidelines. The approximate area of visible displaced material at the time of the initial assessment is outlined in Appendix A, Figure 1.

Surface water samples were collected from Joslyn creek on May 20, 2006, up and down stream of the portion of the creek located in the zone of displaced material. Additional water samples were collected May 21, 22 and 23, 2006, at the point immediately down stream of the deposition zone. No measurable changes in water quality were observed between these monitoring events. The results of the May monitoring events are discussed in further detail in Section 4.0 of this report.

Detailed Assessment of Potentially Impacted Area – Soil (September 2006)

As outlined in the September 2006 work plan, a detailed assessment of the steam release area was conducted to further characterize the displaced material and delineate the extent of the impacted area. Details of this soil assessment program have been documented in Volume 2 of the *draft* MEMS report, dated *December 2006*. In addition to the F2-F4 hydrocarbon fractions and SAR values initially reported to exceed the current guidelines, electrical conductivity (EC), pyrene and phenanthrene values measured from select samples of displaced material also exceeded applicable guidelines. Concentrations of sodium and sulphate were also notably elevated above background concentrations.

Alberta Environment Letter of Response – October 5, 2006

Comments and questions pertaining to the surface water monitoring program were identified in a letter response from AENV, dated October 5, 2006 (Appendix C). These comments and questions have been addressed in subsequent section of this report.

1.2 Objectives and Scope of Work

The objective of the surface water monitoring program was to identify and characterize potential impacts of the May 18th steam release event to the water quality of Joslyn Creek and any other surface water bodies located down gradient of the release point, immediately after and six months after the steam release event occurred.

The scope of work for the surface water monitoring program is detailed as follows:

- Complete a review of all initial environmental assessment work conducted in the vicinity of the steam release location.
- Identify any surface water bodies in addition to Joslyn Creek that may have been impacted by displaced material from the steam release.
- Conduct a surface water sampling event six months after the steam release event at three locations along Joslyn Creek representing areas upstream, within and downstream of the deposition area.
- If necessary, collect additional water samples from other surface water bodies that may have been impacted by displaced material from the steam release.

- Analyze water samples for routine potability, BTEX, F1-F2 hydrocarbon fractions, polycyclic aromatic hydrocarbons (PAHs), naphthenic acids, and trace metals.

- Prepare a report outlining the analytical findings with comparisons to applicable guidelines and available background data.

- Provide recommendations for further monitoring, remediation, or a risk based management plan, if necessary, based of the findings of the work completed.

2.0 PHYSIOGRAPHIC SETTING

2.1 Topography

The landscape within the SAGD area varies from flat to gently rolling, and much of it is of low relief. Greatest relief, usually in the order of three to five metres, is found along drainage courses and around small lakes. A majority of the area up and down gradient of the steam release location is upland. The release location and other small pockets of lowland soils are found throughout the area predominantly in proximity to drain ways. The relief from the steam release point to Joslyn Creek is approximately 3 – 5 m over a distance of approximately 350 m.

2.2 Soils

The soils in proximity to the steam release area consist of Luvisols, Gleysols, Regosols and Organics. Orthic Gray Luvisols dominate all upland areas in proximity to and down gradient of the release location. Lower slope and drainage swales are occupied by either Orthic or Humic Gleysols, often with a significant surface peat layer. Regosolic soils and various Rego complexes are confined to the Joslyn creek flood plain and a narrow band along the banks of the flood plain. Various depressional pockets, including the steam release location are dominated by relatively shallow Organic soils containing bog peat.

2.3 Surface Water

The DCEL lease is transected by two major streams – the Ells River and Joslyn Creek, a major tributary of the Ells. The SAGD Phase III operations are entirely within the Joslyn Creek Watershed.

DCEL has conducted sampling of the Joslyn Creek during baseline data collection for a number of regulatory applications. Water in Joslyn Creek is slightly alkaline, with total alkalinity, conductivity, and concentrations of total dissolved solids generally highest in winter. Organic parameters such as hydrocarbons, naphthenic acids, and phenols tend to be low in Joslyn Creek. Historical concentrations of oil and grease, measured over the period from 1976 to 1979, ranged from <0.1 mg/L to 1.5 mg/L. Since baseline data collection began the recoverable hydrocarbon concentrations have been below the detection limit.

2.4 Geologic Setting

Within the project area, the total overburden thickness is approximately 40 to 60 m with 20 to 30 m being the shales of the Clearwater Formation while the remaining sediments are Pleistocene tills. The Clearwater Formation is fully marine in nature. It consists predominantly of marine shales which do not contain bitumen and are considered a barrier to fluid flow. The Wabiskaw Member of the Clearwater Formation directly overlies the McMurray formation and is comprised of shales, silts and very fine grained sands. These sands can contain low grades of bitumen. Reservoir quality and thickness within the Wabiskaw member are poor and do not contribute to the in-situ recovery of bitumen.

The McMurray Formation is present from approximately 40 to 60 m below ground level to a depth of 115 m. The McMurray Formation is comprised of stacked fluvial-estuarine sands and off-channel silts and shales. The sands of the McMurray Formation are 90 to 95% quartz. The McMurray has three informal members including the Lower, Middle and Upper McMurray. These informal divisions correspond to changes in the depositional environments within the McMurray from fluvial at the base (Lower Member) to estuarine in the middle (Middle Member) to marginal marine at the top (Upper Member). The depth of the prospective Middle McMurray SAGD zone is approximately 65 to 110 m. The non-pay McMurray sediments that overlie the intended steam chamber consist of 20 to 25 m of interbedded sands and shales of largely estuarine origin.

3.0 METHODOLOGY

3.1 Sample Locations

For the initial surface water sampling event, conducted by MEMS personnel on May 20, 2006, four sample locations were selected (Appendix A, Figure 1). One sample was located in the immediate area of the steam release, 25 m southwest of the well head located on-site. This sample was collected from a small amount of ponded water that had seeped into a low spot from the surrounding bog area after the ground disturbance of the steam release occurred. A second sample was located upstream, approximately 50 m west of the estimated deposition zone, intended to provide comparable background water quality results. A third sample was collected immediately downstream, approximately 200 m east of the estimated deposition zone. This sample was intended to capture any displaced material that may have been transported downstream during the two days between the steam release event and the initial sampling event. A fourth sample, further downstream, was located approximately 1.2 km southeast of the estimated deposition zone. Three subsequent surface water sampling events were conducted by DCEL operations personnel on May 21, 23 and 23, 2006, at the immediate downstream sampling location.

An additional surface water sampling event was conducted by MEMS personnel on November 3, 2006, consisting of three samples collected from Joslyn Creek (Appendix A, Figure 1). Access to the creek was limited due to frozen conditions. Locations were chosen where open water was safely accessible or where ice was thick enough to bear the sampler's weight. One sample point was located approximately 150 m upstream of the deposition zone. The second sample point was located in the deposition zone. The third sample point was located approximately 120 m east of the deposition zone. The small area of ponded water in the immediate vicinity of the steam release sampled on May 20, 2006 was not re-sampled in November 2006 as the ponded water no longer existed at that time. No additional water bodies were identified in the deposition zone.

3.2 Sample Collection and Analysis

Surface water samples were collected from the mid to upper zone of flowing water. Seven bottles were filled from each sample location, including three 500 mL plastic bottles, one with preservative and two without, one 1 L amber coloured glass bottle, and three 25 mL amber coloured glass vials with preservative, filled with no headspace remaining. All samples were transported in a cooler with ice to the ALS Environmental laboratory in Edmonton for analysis.

Samples collected in May 2006 were analysed for BTEX, F1-F2 hydrocarbon fractions, total metals and routine water analysis. Samples collected in November 2006 were analysed for BTEX, F1-F2 hydrocarbon fractions, PAHs, naphthenic acids, dissolved metals and routine water analysis.

4.0 RESULTS

Analytical results of the surface water samples collected are presented in Appendix B, Table 1 and the original laboratory reports are available in Appendix D. These results were compared to the Alberta surface water quality guidelines for the protection of freshwater aquatic life (AENV 1999), the Canadian water quality guidelines for the protection of aquatic life (CCME 2006), the Canadian drinking water quality guidelines (Health Canada 2006), and the background water quality data collected for the Joslyn North Creek Mine Project application (Hatfield Consultants Ltd. 2006). Comparisons were also made between the upstream samples and the samples collected within the deposition zone and down stream.

For the ten samples collected, F1-F2 hydrocarbon concentrations were below the laboratory detection limit. The BTEX concentrations in all samples were below or marginally greater than the laboratory detection limit but remained less than the Canadian water quality guidelines for protection of aquatic life and the drinking water guidelines. Concentrations of the individual PAHs as well as naphthenic acids, measured from the three samples collected in November 2006, were all below the laboratory detection limit.

Results of the routine water analysis were below the available guidelines for total dissolved solids (TDS), chloride, nitrate-N and nitrite-N, sodium and sulphate and within the acceptable ranges for pH. Applicable guidelines did not exist for the other routine parameters. Baseline measurements of pH, total alkalinity, TDS, chloride, nitrate+nitrite-N, potassium, sodium and sulphate were available for comparison. Concentrations of these parameters measured from the ten samples collected for this assessment were within the ranges of the baseline concentrations, with one exception. The low pH value of the sample collected at the steam release site (Sample Name “25 M SW W/C” collected May 20, 2006). This sample was collected from bog water, which is naturally acidic, that had seeped into a low spot created by the steam release incident. The baseline data did not include samples collected from comparable bog sources.

Concentrations of metals in the samples collected for analysis tended to be below the applicable guidelines, where guidelines were available for comparison. The four exceptions were aluminum, iron, manganese and zinc. Concentrations of these four parameters measured from samples collected in May 2006 exceeded the applicable CCME and/or drinking water quality guidelines. However, these concentrations were all within the ranges observed for the baseline water quality results. Samples collected in November 2006 were analysed for dissolved metals due to a miscommunication with the laboratory and, thus, cannot be directly compared to the May 2006 results, or the baseline data. Because the detailed soil sampling program did not identify metal concerns in the displaced material or any of the down gradient soils, concentrations of metals in Joslyn Creek are not expected to be influenced by the steam release.

No notable differences in any of the parameters measured were observed between the samples collected upstream of the deposition zone and the samples collected within and downstream of the deposition zone. Nor were differences observed over time in the samples collected immediately downstream of the deposition zone.

5.0 DISCUSSION OF RESULTS

Surface water samples were collected at intervals the week following the steam release and six months later. All samples were analysed for BTEX, F1-F2 hydrocarbon fractions, routine water analysis and metals. The samples collected six months after the steam release event were also analysed for PAHs and naphthenic acids. Parameters of concern identified in the concurrent soil assessment program were F2-F4 hydrocarbons, SAR, sodium, sulphate, EC, pyrene and phenanthrene.

Analytical results of the surface water samples collected for this assessment were compared to the current provincial and federal guidelines and background data collected for the Joslyn North Mine Project. Aluminum, iron, manganese and zinc concentrations in some samples exceeded the applicable guidelines but were within the ranges of baseline concentrations measured. All other parameters were at, below or within the acceptable ranges of the applicable guidelines and were also within the ranges of baseline concentrations measured. No water quality impacts to Joslyn Creek from the steam release event were identified in the week following the event or six months after.

6.0 CLOSURE

If you have any questions concerning this report please contact the undersigned at (780) 496-9048.

Yours truly,

Millennium EMS Solutions Ltd.

Reviewed by:

Callie Volf, M.Sc., P.Ag.
Environmental Scientist

Ian Terry, P.Eng.
Principal

7.0 REFERENCES

AENV (Alberta Environment). 2001a. Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities. Volumes 1-3. Science and Standards Division, Alberta Environment. Edmonton, Alberta. 103 pp.

AENV (Alberta Environment). 2001b. Salt Contamination Assessment and Remediation Guidelines. Environment Sciences Division, Alberta Environment. Edmonton, Alberta. 88 pp.

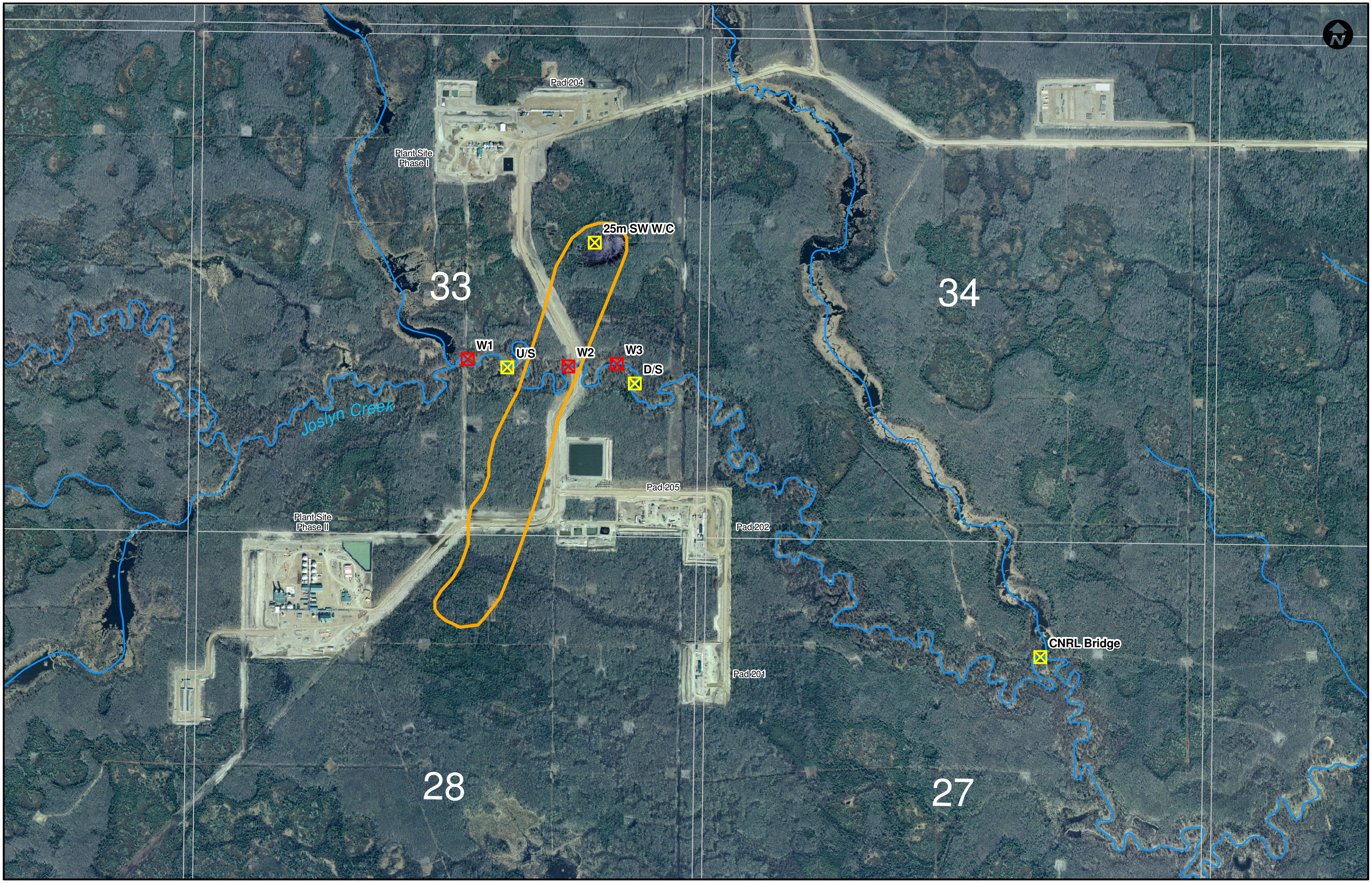
AENV (Alberta Environment). 1999. Surface Water Quality Guidelines for Use in Alberta. Environmental Assurance Division, Science and Standards Branch, Publication No.T/483, November 1999.

CCME (Canadian Council of Ministers of the Environment). 2006. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table. Updated July, 2006. In: Canadian Environmental Quality Guidelines, Publication No. 1299, 1999, CCME, Winnipeg.

Hatfield Consultants Ltd. 2006. Deer Creek Energy Ltd. Joslyn North Mine Project Aquatic Resources Environmental Impact Assessment: Surface Water Quality, Sediment Quality, and Benthic Invertebrate Communities. In: Joslyn North Mine Project Alberta Energy and Utilities Board Alberta Environment Integrated Application, Volume Five: Consultants Reports. February 2006.

Health Canada. 2006. Guidelines for Canadian Drinking Water Quality Summary Table. Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment, March 2006.

APPENDIX A: FIGURES



Map Document: (C:\Documents and Settings\Peter\My Documents\Meridian\DeerCreek\Spill\Fig 1 Surface Water Sampling Loc.mxd) 12/19/2006 -- 10:04:39 AM

DEER CREEK Energy Limited
A wholly-owned subsidiary of TOTAL E&P CANADA LTD

PROJECT
DCEL Steam Release Incident

TITLE
Surface Water Sampling Locations near the Steam Release

LEGEND

Surface Water Sample Location

- ☒ May2006
- ☒ Nov2006
- ▭ May 2006, Estimated Area of Deposition

DRAWN	CHECKED	DATE
PS	CV	14Dec06

SCALE
0 100 200 400
Metres

PROJECTION:
UTM12 NAD83

FILE No.
04-101

FIGURE
1

APPENDIX B: TABLES

Table 1. Analytical Results of Surface Water near the Steam Release.

				Baseline Measurements[b,c]	--- Upstream Locations ---		------ Deposition Zone ------		--- Downstream Locations ---					
					-------- Joslyn Creek --------		Bog Water	Joslyn Creek	--- Joslyn Creek ---					
	Detection			*median (5th-95th*	U/S[c]	W1[c]	25M SW W/C[c]	W2[c]	--- D/S[c] ---				W3[c]	CNRL Bridge[c]
Analytical Parameters	**Limit**	**Units**	**Guidelines[a]**	*precentile)*	**20-May-06**	**3-Nov-06**	**20-May-06**	**3-Nov-06**	**20-May-06**	**21-May-06**	**22-May-06**	**23-May-06**	**3-Nov-06**	**20-May-06**
Hyrdrocarbons														
Benzene	0.0005	mg/L	0.37[d]/ 0.005[e]	na	0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
EthylBenzene	0.0005	mg/L	0.09[d]/ 0.0024[e]	na	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toluene	0.0005	mg/L	0.002[d] / 0.024[e]	na	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Xylenes	0.0005	mg/L	0.3 [e]	na	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
F1(C6-C10)	0.1	mg/L	nc	na	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
F1-BTEX	0.1	mg/L	nc	na	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
F2 (>C10-C16)	0.05	mg/L	nc	na	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Polycyclic Aromatic Hydrocarbons														
Acenaphthene	0.00001	mg/L	0.0058 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Acridine	0.00001	mg/L	0.0044 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Anthracene	0.00001	mg/L	0.000012 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Benzo(a)anthracene	0.00001	mg/L	0.000018 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Benzo(a)pyrene	0.00001	mg/L	0.000015[d] / 0.00001[e]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Benzo(b)fluoranthene	0.00001	mg/L	nc	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Benzo(k)fluoranthene	0.00001	mg/L	nc	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Chrysene	0.00001	mg/L	nc	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Dibenzo(a,h)anthracene	0.00001	mg/L	nc	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Fluoranthene	0.00001	mg/L	0.00004 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Fluorene	0.00001	mg/L	0.003 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Indeno(1,2,3-cd)pyrene	0.00001	mg/L	nc	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Naphthalene	0.00001	mg/L	0.0011 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Naphthenic Acids	1	mg/L	nc	1.0 (1-2)	na	<1	na	<1	na	na	na	na	<1	na
Phenanthrene	0.00001	mg/L	0.0004 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Pyrene	0.00001	mg/L	0.000025 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Quinoline	0.00001	mg/L	0.0034 [d]	na	na	<0.00001	na	<0.00001	na	na	na	na	<0.00001	na
Routine Water Analysis														
pH	0.1	pH	6.5 to 8.5[e,f]/to 9.0[d]	8.1 (7.6-8.4)	8.1	8.1	7.4	8.1	8.1	8.1	8.1	8.1	8.1	8.2
Conductivity (EC)	0.2	uS/cm	nc	na	445	616	560	618	457	455	470	485	617	459
SAR		SAR	nc	na	1.1	na	na	na	1.0	1.2	1.2	1.2	na	1.0
Alkalinity, Total (as CaCO3)	5	mg/L	nc	166 (59-398)	139	253	202	254	141	143	148	153	254	145
Hardness (as CaCO3)		mg/L	nc	na	174	266	223	265	167	159	167	159	266	163
Ion Balance		%	nc	na	106	105	109	103	102	104	104	98.5	105	97.3
TDS (Calculated)		mg/L	500 [e]	305.0 (87.0-623.5)	272	411	329	415	265	264	273	271	411	261
Bicarbonate (HCO3)	5	mg/L	nc	na	170	309	246	310	172	175	181	187	310	177
Calcium (Ca)	0.5	mg/L	nc	na	48.2	71.4	48.8	71.1	46.2	44.1	45.8	43.7	71.6	45.0
Carbonate (CO3)	5	mg/L	nc	na	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloride (Cl)	1	mg/L	250 [e]	2.0 (1.0-22.8)	4	4	na	4	4	3	4	4	4	4
Hydroxide (OH)	5	mg/L	nc	na	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Magnesium (Mg)	0.1	mg/L	nc	na	13.1	21.3	24.6	21.2	12.6	11.9	12.7	12.1	21.2	12.2
Nitrate+Nitrite-N	0.1	mg/L	nc	0.1 (0.05-0.3)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate-N	0.1	mg/L	2.9[d] / 10[e]	na	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite-N	0.05	mg/L	0.06 [d]	na	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Potassium (K)	0.5	mg/L	nc	2.65 (1.10-9.16)	2.8	2.8	3.9	2.9	2.6	3.8	3.8	3.5	2.8	2.5
Sodium (Na)	1	mg/L	200 [e]	32.5 (6.7-75.6)	33	54	43	54	31	35	36	35	54	29
Sulfate (SO4)	0.5	mg/L	500 [e]	19.6 (6.7-125.1)	87.3	106	81.0	109	83.7	80.5	82.1	80.9	105	81.1

Analytical Parameters	Detection Limit	Units	Guidelines[a]	Baseline Measurements[b,c] *median (5th-95th precentile)*	--- Upstream Locations ---		------ Deposition Zone ------		--- Downstream Locations ---					
					-------- Joslyn Creek --------		Bog Water	Joslyn Creek	--- Joslyn Creek ---					
					U/S[c]	**W1[c]**	**25M SW W/C[c]**	**W2[c]**	--- **D/S[c]** ---				**W3[c]**	**CNRL Bridge[c]**
					20-May-06	**3-Nov-06**	**20-May-06**	**3-Nov-06**	**20-May-06**	**21-May-06**	**22-May-06**	**23-May-06**	**3-Nov-06**	**20-May-06**
Metals[g]														
Aluminum (Al)	0.01	mg/L	0.1[d,e]	0.15 (0.02-14.8)	**1.32**	<0.01	**2.33**	<0.01	**1.56**	**1.79**	**1.53**	**1.89**	<0.01	**1.03**
Antimony (Sb)	0.0004	mg/L	0.006 [e]	0.00028 (0.00003-0.00130)	0.0006	0.0005	0.0008	0.0004	0.0005	0.0005	0.0006	0.0006	0.0005	0.0005
Arsenic (As)	0.0004	mg/L	0.005[d,e]	0.0014 (0.0004-0.0061)	0.0034	0.0008	0.0014	0.0009	0.0032	0.0036	0.0035	0.0038	0.0008	0.0028
Barium (Ba)	0.003	mg/L	1 [e]	0.043 (0.018-0.108)	0.049	0.019	0.061	0.02	0.046	0.054	0.050	0.055	0.019	0.041
Beryllium (Be)	0.001	mg/L	nc	0.00008 (0.000004-0.001)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron (B)	0.05	mg/L	nc	0.113 (0.033-0.35)	0.21	0.27	0.25	0.27	0.21	0.20	0.21	0.22	0.27	0.22
Cadmium (Cd)	0.0002	mg/L	0.000017[d]/ 0.005[e]	0.00004 (0.000003-0.0002)	<0.0002	<0.0001	<0.0002	<0.0001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0001	<0.0002
Calcium (Ca)	0.5	mg/L	nc	na	50.0	na	54.2	na	46.3	45.4	47.2	47.8	na	47.1
Chromium (Cr)	0.005	mg/L	0.05 [e]	0.0009 (0.0002-0.0068)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cobalt (Co)	0.002	mg/L	nc	na	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Copper (Cu)	0.001	mg/L	0.007[f,h,i]/ 0.002-0.004[d,j]/1[e]	0.0015 (0.0003-0.0089)	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.004	0.003	0.003
Iron (Fe)	0.005	mg/L	0.3[d,e]	1.220 (0.095-11.42)	**4.03**	0.133	**1.26**	0.093	**3.98**	**4.70**	**4.51**	**4.82**	0.075	**3.21**
Lead (Pb)	0.0001	mg/L	0.01[e,j]	0.0004 (0.0001-0.0027)	0.0012	0.0002	0.0007	0.0002	0.0010	0.0013	0.0011	0.0013	<0.0001	0.0008
Lithium (Li)	0.01	mg/L	nc	na	0.04	0.059	0.05	0.058	0.04	0.04	0.04	0.05	0.057	0.04
Magnesium (Mg)	0.1	mg/L	nc	na	13.5		27.4		12.5	12.4	12.8	12.9	na	12.6
Manganese (Mn)	0.001	mg/L	0.05[e]	0.05 (0.01-0.57)	**0.094**	0.04	**0.056**	0.037	**0.085**	**0.112**	**0.107**	**0.115**	0.036	**0.058**
Mercury (Hg)	0.0002	mg/L	0.013[f,k]/0.005[f,h]/ 0.026[d]/1[e] μg/L	na	<0.0002	<0.0001	<0.0002	<0.0001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0001	<0.0002
Molybdenum (Mo)	0.005	mg/L	0.073[d]	0.0008 (0.00005-0.0054)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (Ni)	0.002	mg/L	0.025-0.150[d,j]	0.0022 (0.0002-0.0119)	0.006	0.006	0.002	0.007	0.006	0.006	0.006	0.006	0.006	0.005
Potassium (K)	0.1	mg/L	nc	na	3.3		3.7		3.1	3.3	3.2	3.2		3.0
Selenium (Se)	0.0004	mg/L	0.001[d]/0.01[e]	0.0004 (0.0001-0.0015)	0.0006	0.0007	0.0013	0.0009	0.0006	0.0005	0.0007	0.0005	0.0008	0.0005
Silver (Ag)	0.0004	mg/L	0.0001[d]	0.000021 (0.000001-0.0004)	<0.0004	<0.0001	<0.0004	<0.0001	<0.0004	<0.0004	<0.0004	<0.0004	<0.0001	<0.0004
Sodium (Na)	1	mg/L	nc	na	34	na	46	na	31	31	33	34	na	31
Thallium (Tl)	0.0001	mg/L	0.0008[d]	na	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Tin (Sn)	0.05	mg/L	nc	na	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Titanium (Ti)	0.001	mg/L	nc	na	0.053	<0.001	0.071	<0.001	0.050	0.062	0.050	0.064	<0.001	0.034
Uranium (U)	0.0001	mg/L	0.02[e]	na	0.0025	0.0022	0.0047	0.0022	0.0023	0.0024	0.0027	0.0027	0.0022	0.0024
Vanadium (V)	0.001	mg/L	nc	0.0012 (0.0002-0.0122)	0.006	<0.001	0.007	<0.001	0.007	0.008	0.007	0.008	<0.001	0.005
Zinc (Zn)	0.004	mg/L	0.03[d]/5[e]	0.008 (0.002-0.058)	0.007	0.006	**0.036**	**0.04**	<0.004	0.007	0.006	0.007	0.004	<0.004

Notes:

a) nc = no criteria

b) Hatfield Consultants Limited. 2006. Deer Creek Energy Limited Joslyn North Mine Project, Aquatic Resources Environmental Assessment: Surface Water Quality, Sediment Quality and Benthic Invertebrate Communities. In: Joslyn North Mine Project, Alberta Energy and Utilities Board/Alberta Environment Integrated Application, Volume 5 - Consultants Reports. February 2006.

c) na = not analyzed, **bold** = exceeds most stringent guideline.

d) Canadian Council of Ministers of the Environment (CCME). 2006. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table. Updated July 2006. In: Canadian Environmental Quality Guidelines, 1999, Publication No. 1299, CCME, Winnipeg.

e) Health Canada. 2006. Guidelines for Canadian Drinking Water Quality: Summary Table. Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment, March 2006.

f) Alberta Environment. 1999. Surface Water Quality Guidelines for Use in Alberta. Publication No. T/483. Environmental Assurance Division, Science and Standards Branch, November 1999.

g) Results for May 2006 samples are total metals, results for November 2006 samples are dissolved metals.

h) Guideline is for chronic exposure.

i) Applicable guidelines for copper (acute exposure) based on hardness are as follows (AENV 1999):

Hardness	Copper
-------------- (mg/L)	--------------
150	0.024
175	0.028
200	0.032
225	0.035
250	0.039
275	0.043

j) CCME (2006) guidelines for the following metals based on hardness are as follows:

Hardness	Copper	Lead	Nickel
---- mg/L ----	------------	μg/L	------------
0-60	2	1	25
60-120	2	2	65
120-180	3	4	110
>180	4	7	150

k) Guideline is for acute exposure.

APPENDIX C: ALBERTA ENVIRONMENT LETTER OF RESPONSE

Alberta
Environment

Regional Services
111 Twin Atria Building
4999-98 Avenue
Edmonton, Alberta T6B 2X3

Telephone: (780) 427-7617
Fax: (780) 427-7824
Web: www.environment.gov.ab.ca

October 5, 2006

Mr. Stan McBride
Senior Environmental Advisor
Total E&P Canada Ltd.
Suite 1900, 333-7th Avenue S.W.
Calgary, AB T2P 2Z1

Dear Mr. McBride:

RE: Site Characterization Proposal- Joslyn Project Steam Release Report

Thank you for the Joslyn Project Steam Release report. Our staff has reviewed the report and our comments/questions are provided below in sections:

Groundwater:

The environmental site characterization program should confirm the following:

- the Wabasca Sand is not present in the close vicinity of the release
- the aeolin sands present in the NE portion of the lease do not extend to the immediate area of deposition.

The Groundwater Assessment Program should first establish the groundwater flow regime in the immediate vicinity of the release, and subsequently, the scope of groundwater assessment should be established.

Analytical parameters for groundwater sampling should also include phenols and dissolved metals including arsenic.

Surface Water:

- Figure 4.1 and Table B.2: It does not appear that any water samples were analysed within the area of the displaced soil plume in Joslyn creek (Figure 4.1). Is this correct? If so, please explain this exclusion.

- Figure 4.1 and Table B.2: It appears that a water sample was taken next to soil sampling location #1. Describe what type of waterbody is in that location. Additionally, is the analytical data for this location presented in Table B.2? Will this location be sampled as part of the upcoming surface water sampling program? If not, please explain its exclusion.

- P.10, Section 5.3: How many surface water samples will be taken and analysed from Joslyn creek within the displaced soil plume?

- Figure 4.1 and Table B.2: It appears that two surface water sampling locations are located downstream of the displaced soil plume in Joslyn creek. Please detail which of these locations is called "Joslyn creek downstream" as referenced in Table B.2. Also, indicate where the "25M SW W/C location" is located.

Soil:

Deer Creek Energy Limited (DCEL) did not describe the methods used for preliminary soil monitoring. These details can be important in interpretation of the analytical results. For example:

- How was the area of deposition indicated on Fig. 4.1 determined?
- What stratum of the soil profile or overlying material is represented by the analyses reported in Table B.1?
- Given the variation in naturally occurring soils in the area, how was the single control sample location (#5) selected?

Fig. 4.1 and Table B.1 indicated that the soil samples #1-4 were located at increasing distances (up to approximately 200 m) from the point of steam release. DCEL reported that 'the thickness of displaced soil > 2 cm is mostly limited to the area within a 50 m radius of the steam release point' (p. 8). Yet, some of the analyses are remarkably similar among all four samples, and do not reflect their position relative to the point of steam release. For example, the standard deviation of measurements of F3, F4 and total hydrocarbon contents, chloride and sodium contents, and pH ranged from 2 to 11% of the mean. DCEL stated on p. 8 that soil analytical results indicated that 'the potential contaminants of concern associated with the release are not highly mobile in the subsurface nor are they prone to leaching into surface water systems.' This is not strictly correct for contaminants such as chloride, although the actual mass present may constrain its distribution in the environment.

The proposed soil sampling strategy on pp. 8-9 also raised questions concerning methodology. For example, DCEL indicated on p. 8 that the 'extent of the distribution of the displaced soil' has been determined. The term 'displaced soil' is confusing. Soil is a naturally occurring body of mineral and organic material at the earth's surface. Was soil in fact displaced by the steam release? Or, does the term 'displaced soil' refer to sediments released from further below the surface. In the absence of description of the methods employed, can the reader be assured that the 'extent of the distribution' has been determined?

DCEL indicated that 'control sample locations' will be included in the soil-sampling program. It would be useful to consult baseline soil information, and describe the soils at all sampling locations based on the Canadian System of Soil Classification, to ensure that the control locations are indeed representative of all other sampling locations. Use of a coring device is appropriate for investigations where the mass of the contaminants or the volume of affected soil need to be determined. In this instance, shallow soil pits may be effective. The proposed strategy wherein the soil profile is sampled by 'discrete soil horizons' from a shallow pit can provide vertical delineation. Are the 'discrete soil horizons' collected to represent a vertical continuum? How will the bulk density measurements mentioned on p. 9 be used or interpreted?

Finally, Table 5.1 indicated that analyses will be 'representative.' For clarity, is a sample intended to be a combination of sampling position and depth-increment? And, will all samples be analyzed, or will a protocol be employed to analyze sufficient samples for vertical delineation of all contaminants at each sampling location within the target depth (to 60 cm)? Is the aliquot of soil analyzed intended to represent the entire mass of each sample—i.e., the 'discrete soil horizon' or depth-increment?

Risk Assessment Proposal:

The risk assessment proposal and methodology is acceptable and it appears to follow an appropriate step-wise approach for conducting risk assessments.

Sincerely

N Morin

Nicole Morin, M.Sc., P.Biol.
Risk Assessment and Management Specialist
Northern Region

cc: Margaret Klebek, AENV
David Bergstrom, AENV
Nicole Morin, AENV

APPENDIX D: LABORATORY REPORT

PRELIMINARY RESULTS

MILLENNIUM
ATTN: DANE MCCOY
208 4207 98 ST
EDMONTON AB T6E 5R7

Report On: 25-MAY-06 09:52 PM

Lab Work Order #: **L390729**

Date Received: **23-MAY-06**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 230126

Comments:

DOUG JOHNSON
Director of Operations, Edmonton

KAREN HUEBNER
Account Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-1 JOSLYN CREEK U/S								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	105		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	80		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	0.0010		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	0.0006		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	1.32		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0034		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.21		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.049		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.004		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.006		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0012		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.053		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0025		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.006		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	0.007		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	50.0		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.3		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	13.5		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	34		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	4.03		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.094		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.1			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-1 JOSLYN CREEK U/S								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
Routine Water Analysis								
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	445		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	170		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	139		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	106			%		23-MAY-06		
TDS (Calculated)	272			mg/L		23-MAY-06		
Hardness (as CaCO3)	174			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	48.2		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.8		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	13.1		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	33		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	87.3		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-2 JOSLYN CREEK D/S								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	100		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	114		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	1.56		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0032		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.21		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.046		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.006		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0010		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0006		0.0004	mg/L		22-MAY-06	QLI	R401078

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-2 JOSLYN CREEK D/S								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
Total Metals - CCME								
Total Trace Metals								
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.050		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0023		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.007		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	<0.004		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	46.3		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.1		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	12.5		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	31		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	3.98		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.085		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.0			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	457		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	172		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	141		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	102			%		23-MAY-06		
TDS (Calculated)	265			mg/L		23-MAY-06		
Hardness (as CaCO3)	167			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	46.2		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.6		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	12.6		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	31		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	83.7		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	98		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	84		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	1.03		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0028		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.22		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.041		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.04		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.005		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0008		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0005		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.034		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0024		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.005		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	<0.004		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	47.1		0.5	mg/L		23-MAY-06	SYF	R401153
Potassium (K)	3.0		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	12.6		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	31		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	3.21		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.058		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.0			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	8.2		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	459		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	177		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	145		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	97.3			%		23-MAY-06		

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-3 JOSLYN CREEK CNRL BRIDGE								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
Routine Water Analysis								
Ion Balance Calculation								
TDS (Calculated)	261			mg/L		23-MAY-06		
Hardness (as CaCO3)	163			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	45.0		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	2.5		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	12.2		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	29		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	81.1		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-4 25 M SW W/C								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	23-MAY-06	23-MAY-06	MKE	R401353
Surr: 2-Bromobenzotrifluoride	99		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
Surr: Hexatriacontane	87		55-145	%	23-MAY-06	23-MAY-06	MKE	R401353
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	IAU	R400955
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		22-MAY-06	QLI	R401078
Aluminum (Al)	2.33		0.01	mg/L		22-MAY-06	QLI	R401078
Arsenic (As)	0.0014		0.0004	mg/L		22-MAY-06	QLI	R401078
Boron (B)	0.25		0.05	mg/L		22-MAY-06	QLI	R401078
Barium (Ba)	0.061		0.003	mg/L		22-MAY-06	QLI	R401078
Beryllium (Be)	<0.001		0.001	mg/L		22-MAY-06	QLI	R401078
Cadmium (Cd)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Cobalt (Co)	<0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Chromium (Cr)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Copper (Cu)	0.003		0.001	mg/L		22-MAY-06	QLI	R401078
Mercury (Hg)	<0.0002		0.0002	mg/L		22-MAY-06	QLI	R401078
Lithium (Li)	0.05		0.01	mg/L		22-MAY-06	QLI	R401078
Molybdenum (Mo)	<0.005		0.005	mg/L		22-MAY-06	QLI	R401078
Nickel (Ni)	0.002		0.002	mg/L		22-MAY-06	QLI	R401078
Lead (Pb)	0.0007		0.0001	mg/L		22-MAY-06	QLI	R401078
Antimony (Sb)	0.0008		0.0004	mg/L		22-MAY-06	QLI	R401078
Selenium (Se)	0.0013		0.0004	mg/L		22-MAY-06	QLI	R401078
Tin (Sn)	<0.05		0.05	mg/L		22-MAY-06	QLI	R401078
Titanium (Ti)	0.071		0.001	mg/L		22-MAY-06	QLI	R401078
Thallium (Tl)	<0.0001		0.0001	mg/L		22-MAY-06	QLI	R401078
Uranium (U)	0.0047		0.0001	mg/L		22-MAY-06	QLI	R401078
Vanadium (V)	0.007		0.001	mg/L		22-MAY-06	QLI	R401078
Zinc (Zn)	0.036		0.004	mg/L		22-MAY-06	QLI	R401078
Total Major Metals								
Calcium (Ca)	54.2		0.5	mg/L		23-MAY-06	SYF	R401153

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-4 25 M SW W/C								
Sample By: CW on 20-MAY-06								
Matrix: WATER								
Total Metals - CCME								
Total Major Metals								
Potassium (K)	3.7		0.1	mg/L		23-MAY-06	SYF	R401153
Magnesium (Mg)	27.4		0.1	mg/L		23-MAY-06	SYF	R401153
Sodium (Na)	46		1	mg/L		23-MAY-06	SYF	R401153
Iron (Fe)	1.26		0.005	mg/L		23-MAY-06	SYF	R401153
Manganese (Mn)	0.056		0.001	mg/L		23-MAY-06	SYF	R401153
SAR	1.3			SAR		23-MAY-06		
Routine Water Analysis								
Chloride (Cl)	6		1	mg/L		22-MAY-06	BYU	R401046
Nitrate+Nitrite-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrate-N	<0.1		0.1	mg/L		22-MAY-06	SHC	R401058
Nitrite-N	<0.05		0.05	mg/L		22-MAY-06	SHC	R401058
pH, Conductivity and Total Alkalinity								
pH	7.4		0.1	pH		22-MAY-06	PTT	R401032
Conductivity (EC)	560		0.2	uS/cm		22-MAY-06	PTT	R401032
Bicarbonate (HCO3)	246		5	mg/L		22-MAY-06	PTT	R401032
Carbonate (CO3)	<5		5	mg/L		22-MAY-06	PTT	R401032
Hydroxide (OH)	<5		5	mg/L		22-MAY-06	PTT	R401032
Alkalinity, Total (as CaCO3)	202		5	mg/L		22-MAY-06	PTT	R401032
Ion Balance Calculation								
Ion Balance	109			%		23-MAY-06		
TDS (Calculated)	329			mg/L		23-MAY-06		
Hardness (as CaCO3)	223			mg/L		23-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	48.8		0.5	mg/L		22-MAY-06	JWU	R401039
Potassium (K)	3.9		0.5	mg/L		22-MAY-06	JWU	R401039
Magnesium (Mg)	24.6		0.1	mg/L		22-MAY-06	JWU	R401039
Sodium (Na)	43		1	mg/L		22-MAY-06	JWU	R401039
Sulfate (SO4)	81.0		0.5	mg/L		22-MAY-06	JWU	R401039
L390729-5 25 M SW W/C								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		25-MAY-06		
F1-BTEX	<5		5	mg/kg		25-MAY-06		
F2 (C10-C16)	1400		5	mg/kg		25-MAY-06		
F3 (C16-C34)	18000		5	mg/kg		25-MAY-06		
F4 (C34-C50)	9000		5	mg/kg		25-MAY-06		
F4G-SG (GHH-Silica)	9800		100	mg/kg		25-MAY-06		
Total Hydrocarbons (C6-C50)	28000		5	mg/kg		25-MAY-06		
Chromatogram to baseline at nC50	NO					25-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-5 25 M SW W/C								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
% Moisture	2.6		0.1	%		23-MAY-06	DDU	R401577
Prep/Analysis Dates					25-MAY-06	25-MAY-06	AAT	R402447
MUST PSA % > 75um	60		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.1		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	62		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	10.7		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	12		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	16		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	6		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.6		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	26		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	230		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	352		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	42.3		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.6		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.52		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	7		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	396		2	mg/L		23-MAY-06	JWU	R401341
SAR	40.7	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-6 SW W/C ~ 100 M								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		25-MAY-06		
F1-BTEX	<5		5	mg/kg		25-MAY-06		
F2 (C10-C16)	1800		5	mg/kg		25-MAY-06		
F3 (C16-C34)	19000		5	mg/kg		25-MAY-06		

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-6 SW W/C ~ 100 M								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F4 (C34-C50)	9400		5	mg/kg		25-MAY-06		
F4G-SG (GHH-Silica)	11000		100	mg/kg		25-MAY-06		
Total Hydrocarbons (C6-C50)	30000		5	mg/kg		25-MAY-06		
Chromatogram to baseline at nC50	NO					25-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	6.2		0.1	%		23-MAY-06	DDU	R401577
Prep/Analysis Dates					25-MAY-06	25-MAY-06	AAT	R402447
MUST PSA % > 75um	57		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	5.3		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	71		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	8		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	12.6		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	15		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	25		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	8		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.7		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	28		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	270		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	333		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	40.6		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.5		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.68		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	13		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-6 SW W/C ~ 100 M								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
Detailed Salinity								
SAR								
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	471		2	mg/L		23-MAY-06	JWU	R401341
SAR	35.4	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-7 SW W/C ~ 200 M								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		25-MAY-06		
F1-BTEX	<5		5	mg/kg		25-MAY-06		
F2 (C10-C16)	1800		5	mg/kg		25-MAY-06		
F3 (C16-C34)	18000		5	mg/kg		25-MAY-06		
F4 (C34-C50)	8900		5	mg/kg		25-MAY-06		
F4G-SG (GHH-Silica)	11000		100	mg/kg		25-MAY-06		
Total Hydrocarbons (C6-C50)	29000		5	mg/kg		25-MAY-06		
Chromatogram to baseline at nC50	NO					25-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	2.5		0.1	%		24-MAY-06	REK	R401573
Prep/Analysis Dates					25-MAY-06	25-MAY-06	AAT	R402447
MUST PSA % > 75um	52		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	60		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	10.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	13		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	17		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	7		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.6		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-7 SW W/C ~ 200 M								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
Metals in Soil - CCME List								
Vanadium (V)	24		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	300		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	215		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	51.9		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.4		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.69		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	17		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	7		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	4		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	507		2	mg/L		23-MAY-06	JWU	R401341
SAR	28.5			SAR		23-MAY-06	JWU	R401341
L390729-8 PIPE SAMPLE								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		25-MAY-06		
F1-BTEX	<5		5	mg/kg		25-MAY-06		
F2 (C10-C16)	410		5	mg/kg		25-MAY-06		
F3 (C16-C34)	20000		5	mg/kg		25-MAY-06		
F4 (C34-C50)	10000		5	mg/kg		25-MAY-06		
F4G-SG (GHH-Silica)	11000		100	mg/kg		25-MAY-06		
Total Hydrocarbons (C6-C50)	30000		5	mg/kg		25-MAY-06		
Chromatogram to baseline at nC50	NO					25-MAY-06		
CCME Total Extractable Hydrocarbons								
Prep/Analysis Dates					23-MAY-06	24-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01	RAMB	0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
% Moisture	0.8		0.1	%		23-MAY-06	DDU	R401577
Prep/Analysis Dates					25-MAY-06	25-MAY-06	AAT	R402447
MUST PSA % > 75um	58		1	%		23-MAY-06	SR	R401413
TCLP Leachable BTEX								
Benzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.005		0.005	mg/L	23-MAY-06	23-MAY-06	DCD	R401876
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	4.9		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	58		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-8 PIPE SAMPLE								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
Metals in Soil - CCME List								
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	9.3		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	11		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	15		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	6		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.5		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	24		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	30		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	290		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	325		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	53.6		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	8.2		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	1.67		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	9		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	6		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	<3		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	484		2	mg/L		23-MAY-06	JWU	R401341
SAR	43.8	SAR:Q		SAR		23-MAY-06	JWU	R401341
L390729-9 CONTROL								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
CCME BTEX, TVHs and TEHs								
CCME Total Hydrocarbons								
F1 (C6-C10)	<5	IPT	5	mg/kg		25-MAY-06		
F1-BTEX	<5		5	mg/kg		25-MAY-06		
F2 (C10-C16)	<5	RAMB	5	mg/kg		25-MAY-06		
F3 (C16-C34)	340		5	mg/kg		25-MAY-06		
F4 (C34-C50)	310		5	mg/kg		25-MAY-06		
F4G-SG (GHH-Silica)	500	RAMB	100	mg/kg		25-MAY-06		
Total Hydrocarbons (C6-C50)	650		5	mg/kg		25-MAY-06		
Chromatogram to baseline at nC50	NO					25-MAY-06		
CCME Total Extractable Hydrocarbons								
Surr: 2-Bromobenzotrifluoride	181	G	55-145	%	23-MAY-06	23-MAY-06	AAT	R401937
Surr: Hexatriacontane	111		55-145	%	23-MAY-06	23-MAY-06	AAT	R401937
Prep/Analysis Dates					23-MAY-06	23-MAY-06	AAT	R401937
CCME BTEX								
Benzene	<0.005		0.005	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Toluene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Ethylbenzene	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876
Xylenes	<0.01		0.01	mg/kg	23-MAY-06	23-MAY-06	DCD	R401876

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-9 CONTROL								
Sample By: CW on 20-MAY-06								
Matrix: SOIL								
% Moisture	3.4		0.1	%		23-MAY-06	DDU	R401577
Prep/Analysis Dates					25-MAY-06	25-MAY-06	AAT	R402447
Metals in Soil - CCME List								
Silver (Ag)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Arsenic (As)	5.8		0.2	mg/kg		23-MAY-06	QLI	R401079
Barium (Ba)	99		5	mg/kg		23-MAY-06	QLI	R401079
Beryllium (Be)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Cadmium (Cd)	<0.5		0.5	mg/kg		23-MAY-06	QLI	R401079
Cobalt (Co)	6		1	mg/kg		23-MAY-06	QLI	R401079
Chromium (Cr)	18.9		0.5	mg/kg		23-MAY-06	QLI	R401079
Copper (Cu)	13		2	mg/kg		23-MAY-06	QLI	R401079
Mercury (Hg)	<0.05		0.05	mg/kg		23-MAY-06	QLI	R401079
Molybdenum (Mo)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Nickel (Ni)	18		2	mg/kg		23-MAY-06	QLI	R401079
Lead (Pb)	9		5	mg/kg		23-MAY-06	QLI	R401079
Antimony (Sb)	<0.2		0.2	mg/kg		23-MAY-06	QLI	R401079
Selenium (Se)	0.5		0.2	mg/kg		23-MAY-06	QLI	R401079
Tin (Sn)	<5		5	mg/kg		23-MAY-06	QLI	R401079
Thallium (Tl)	<1		1	mg/kg		23-MAY-06	QLI	R401079
Uranium (U)	<40		40	mg/kg		23-MAY-06	QLI	R401079
Vanadium (V)	31		1	mg/kg		23-MAY-06	QLI	R401079
Zinc (Zn)	40		10	mg/kg		23-MAY-06	QLI	R401079
Detailed Salinity								
Chloride (Cl)	60		20	mg/L		23-MAY-06	BYU	R401388
Sulphate (SO4)	1470		6	mg/L		23-MAY-06	JWU	R401341
pH and EC (Saturated Paste)								
% Saturation	41.5		0.1	%		23-MAY-06	SR	R401167
pH in Saturated Paste	7.4		0.1	pH		23-MAY-06	SR	R401167
Conductivity Sat. Paste	2.12		0.01	dS m-1		23-MAY-06	SR	R401167
SAR								
Calcium (Ca)	377		5	mg/L		23-MAY-06	JWU	R401341
Potassium (K)	4		2	mg/L		23-MAY-06	JWU	R401341
Magnesium (Mg)	149		3	mg/L		23-MAY-06	JWU	R401341
Sodium (Na)	118		2	mg/L		23-MAY-06	JWU	R401341
SAR	1.3			SAR		23-MAY-06	JWU	R401341
L390729-10 JOSLYN CREEK D/S MAY 21								
Sample By: NOT PROVIDED on 21-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	24-MAY-06	24-MAY-06	IJB	R402238
Surr: 2-Bromobenzotrifluoride	109		55-145	%	24-MAY-06	24-MAY-06	IJB	R402238
Surr: Hexatriacontane	119		55-145	%	24-MAY-06	24-MAY-06	IJB	R402238
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005	RAMB	0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-10 JOSLYN CREEK D/S MAY 21								
Sample By: NOT PROVIDED on 21-MAY-06								
Matrix: WATER								
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		24-MAY-06	QLI	R401978
Aluminum (Al)	1.79		0.01	mg/L		24-MAY-06	QLI	R401978
Arsenic (As)	0.0036		0.0004	mg/L		24-MAY-06	QLI	R401978
Boron (B)	0.20		0.05	mg/L		24-MAY-06	QLI	R401978
Barium (Ba)	0.054		0.003	mg/L		24-MAY-06	QLI	R401978
Beryllium (Be)	<0.001		0.001	mg/L		24-MAY-06	QLI	R401978
Cadmium (Cd)	<0.0002		0.0002	mg/L		24-MAY-06	QLI	R401978
Cobalt (Co)	<0.002		0.002	mg/L		24-MAY-06	QLI	R401978
Chromium (Cr)	<0.005		0.005	mg/L		24-MAY-06	QLI	R401978
Copper (Cu)	0.004		0.001	mg/L		24-MAY-06	QLI	R401978
Mercury (Hg)	<0.0002		0.0002	mg/L		24-MAY-06	QLI	R401978
Lithium (Li)	0.04		0.01	mg/L		24-MAY-06	QLI	R401978
Molybdenum (Mo)	<0.005		0.005	mg/L		24-MAY-06	QLI	R401978
Nickel (Ni)	0.006		0.002	mg/L		24-MAY-06	QLI	R401978
Lead (Pb)	0.0013		0.0001	mg/L		24-MAY-06	QLI	R401978
Antimony (Sb)	0.0005		0.0004	mg/L		24-MAY-06	QLI	R401978
Selenium (Se)	0.0005		0.0004	mg/L		24-MAY-06	QLI	R401978
Tin (Sn)	<0.05		0.05	mg/L		24-MAY-06	QLI	R401978
Titanium (Ti)	0.062		0.001	mg/L		24-MAY-06	QLI	R401978
Thallium (Tl)	<0.0001		0.0001	mg/L		24-MAY-06	QLI	R401978
Uranium (U)	0.0024		0.0001	mg/L		24-MAY-06	QLI	R401978
Vanadium (V)	0.008		0.001	mg/L		24-MAY-06	QLI	R401978
Zinc (Zn)	0.007		0.004	mg/L		24-MAY-06	QLI	R401978
Total Major Metals								
Calcium (Ca)	45.4		0.5	mg/L		24-MAY-06	HAS	R401970
Potassium (K)	3.3		0.1	mg/L		24-MAY-06	HAS	R401970
Magnesium (Mg)	12.4		0.1	mg/L		24-MAY-06	HAS	R401970
Sodium (Na)	31		1	mg/L		24-MAY-06	HAS	R401970
Iron (Fe)	4.70		0.005	mg/L		24-MAY-06	HAS	R401970
Manganese (Mn)	0.112		0.001	mg/L		24-MAY-06	HAS	R401970
SAR	1.2			SAR		25-MAY-06		
Routine Water Analysis								
Chloride (Cl)	3		1	mg/L		24-MAY-06	BYU	R401916
Nitrate+Nitrite-N	<0.1		0.1	mg/L		24-MAY-06	SEL	R401832
Nitrate-N	<0.1		0.1	mg/L		24-MAY-06	SEL	R401832
Nitrite-N	<0.05		0.05	mg/L		24-MAY-06	SEL	R401832
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		24-MAY-06	PTT	R401754
Conductivity (EC)	455		0.2	uS/cm		24-MAY-06	PTT	R401754
Bicarbonate (HCO3)	175		5	mg/L		24-MAY-06	PTT	R401754
Carbonate (CO3)	<5		5	mg/L		24-MAY-06	PTT	R401754
Hydroxide (OH)	<5		5	mg/L		24-MAY-06	PTT	R401754
Alkalinity, Total (as CaCO3)	143		5	mg/L		24-MAY-06	PTT	R401754
Ion Balance Calculation								
Ion Balance	104			%		25-MAY-06		
TDS (Calculated)	264			mg/L		25-MAY-06		
Hardness (as CaCO3)	159			mg/L		25-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	44.1		0.5	mg/L		24-MAY-06	EOC	R401845

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-10 JOSLYN CREEK D/S MAY 21								
Sample By: NOT PROVIDED on 21-MAY-06								
Matrix: WATER								
Routine Water Analysis								
ICP metals and SO4 for routine water								
Potassium (K)	3.8		0.5	mg/L		24-MAY-06	EOC	R401845
Magnesium (Mg)	11.9		0.1	mg/L		24-MAY-06	EOC	R401845
Sodium (Na)	35		1	mg/L		24-MAY-06	EOC	R401845
Sulfate (SO4)	80.5		0.5	mg/L		24-MAY-06	EOC	R401845
L390729-11 JOSLYN CREEK D/S MAY 22								
Sample By: NOT PROVIDED on 22-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	24-MAY-06	24-MAY-06	IJB	R402238
Surr: 2-Bromobenzotrifluoride	115		55-145	%	24-MAY-06	24-MAY-06	IJB	R402238
Surr: Hexatriacontane	123		55-145	%	24-MAY-06	24-MAY-06	IJB	R402238
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		24-MAY-06	QLI	R401978
Aluminum (Al)	1.53		0.01	mg/L		24-MAY-06	QLI	R401978
Arsenic (As)	0.0035		0.0004	mg/L		24-MAY-06	QLI	R401978
Boron (B)	0.21		0.05	mg/L		24-MAY-06	QLI	R401978
Barium (Ba)	0.050		0.003	mg/L		24-MAY-06	QLI	R401978
Beryllium (Be)	<0.001		0.001	mg/L		24-MAY-06	QLI	R401978
Cadmium (Cd)	<0.0002		0.0002	mg/L		24-MAY-06	QLI	R401978
Cobalt (Co)	<0.002		0.002	mg/L		24-MAY-06	QLI	R401978
Chromium (Cr)	<0.005		0.005	mg/L		24-MAY-06	QLI	R401978
Copper (Cu)	0.003		0.001	mg/L		24-MAY-06	QLI	R401978
Mercury (Hg)	<0.0002		0.0002	mg/L		24-MAY-06	QLI	R401978
Lithium (Li)	0.04		0.01	mg/L		24-MAY-06	QLI	R401978
Molybdenum (Mo)	<0.005		0.005	mg/L		24-MAY-06	QLI	R401978
Nickel (Ni)	0.006		0.002	mg/L		24-MAY-06	QLI	R401978
Lead (Pb)	0.0011		0.0001	mg/L		24-MAY-06	QLI	R401978
Antimony (Sb)	0.0006		0.0004	mg/L		24-MAY-06	QLI	R401978
Selenium (Se)	0.0007		0.0004	mg/L		24-MAY-06	QLI	R401978
Tin (Sn)	<0.05		0.05	mg/L		24-MAY-06	QLI	R401978
Titanium (Ti)	0.050		0.001	mg/L		24-MAY-06	QLI	R401978
Thallium (Tl)	<0.0001		0.0001	mg/L		24-MAY-06	QLI	R401978
Uranium (U)	0.0027		0.0001	mg/L		24-MAY-06	QLI	R401978
Vanadium (V)	0.007		0.001	mg/L		24-MAY-06	QLI	R401978
Zinc (Zn)	0.006		0.004	mg/L		24-MAY-06	QLI	R401978
Total Major Metals								
Calcium (Ca)	47.2		0.5	mg/L		24-MAY-06	HAS	R401970
Potassium (K)	3.2		0.1	mg/L		24-MAY-06	HAS	R401970
Magnesium (Mg)	12.8		0.1	mg/L		24-MAY-06	HAS	R401970
Sodium (Na)	33		1	mg/L		24-MAY-06	HAS	R401970
Iron (Fe)	4.51		0.005	mg/L		24-MAY-06	HAS	R401970

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-11 JOSLYN CREEK D/S MAY 22								
Sample By: NOT PROVIDED on 22-MAY-06								
Matrix: WATER								
Total Metals - CCME								
Total Major Metals								
Manganese (Mn)	0.107		0.001	mg/L		24-MAY-06	HAS	R401970
SAR	1.2			SAR		25-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		24-MAY-06	BYU	R401916
Nitrate+Nitrite-N	<0.1		0.1	mg/L		24-MAY-06	SEL	R401832
Nitrate-N	<0.1		0.1	mg/L		24-MAY-06	SEL	R401832
Nitrite-N	<0.05		0.05	mg/L		24-MAY-06	SEL	R401832
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		24-MAY-06	PTT	R401754
Conductivity (EC)	470		0.2	uS/cm		24-MAY-06	PTT	R401754
Bicarbonate (HCO3)	181		5	mg/L		24-MAY-06	PTT	R401754
Carbonate (CO3)	<5		5	mg/L		24-MAY-06	PTT	R401754
Hydroxide (OH)	<5		5	mg/L		24-MAY-06	PTT	R401754
Alkalinity, Total (as CaCO3)	148		5	mg/L		24-MAY-06	PTT	R401754
Ion Balance Calculation								
Ion Balance	104			%		25-MAY-06		
TDS (Calculated)	273			mg/L		25-MAY-06		
Hardness (as CaCO3)	167			mg/L		25-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	45.8		0.5	mg/L		24-MAY-06	EOC	R401845
Potassium (K)	3.8		0.5	mg/L		24-MAY-06	EOC	R401845
Magnesium (Mg)	12.7		0.1	mg/L		24-MAY-06	EOC	R401845
Sodium (Na)	36		1	mg/L		24-MAY-06	EOC	R401845
Sulfate (SO4)	82.1		0.5	mg/L		24-MAY-06	EOC	R401845
L390729-12 JOSLYN CREEK D/S MAY 23								
Sample By: NOT PROVIDED on 23-MAY-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	24-MAY-06	24-MAY-06	IJB	R402238
Surr: 2-Bromobenzotrifluoride	104		55-145	%	24-MAY-06	24-MAY-06	IJB	R402238
Surr: Hexatriacontane	114		55-145	%	24-MAY-06	24-MAY-06	IJB	R402238
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Toluene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
EthylBenzene	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Xylenes	<0.0005		0.0005	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1(C6-C10)	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
F1-BTEX	<0.1		0.1	mg/L	23-MAY-06	23-MAY-06	DCD	R401926
Total Metals - CCME								
Total Trace Metals								
Silver (Ag)	<0.0004		0.0004	mg/L		24-MAY-06	QLI	R401978
Aluminum (Al)	1.89		0.01	mg/L		24-MAY-06	QLI	R401978
Arsenic (As)	0.0038		0.0004	mg/L		24-MAY-06	QLI	R401978
Boron (B)	0.22		0.05	mg/L		24-MAY-06	QLI	R401978
Barium (Ba)	0.055		0.003	mg/L		24-MAY-06	QLI	R401978
Beryllium (Be)	<0.001		0.001	mg/L		24-MAY-06	QLI	R401978
Cadmium (Cd)	<0.0002		0.0002	mg/L		24-MAY-06	QLI	R401978
Cobalt (Co)	<0.002		0.002	mg/L		24-MAY-06	QLI	R401978

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L390729-12 JOSLYN CREEK D/S MAY 23								
Sample By: NOT PROVIDED on 23-MAY-06								
Matrix: WATER								
Total Metals - CCME								
Total Trace Metals								
Chromium (Cr)	<0.005		0.005	mg/L		24-MAY-06	QLI	R401978
Copper (Cu)	0.004		0.001	mg/L		24-MAY-06	QLI	R401978
Mercury (Hg)	<0.0002		0.0002	mg/L		24-MAY-06	QLI	R401978
Lithium (Li)	0.05		0.01	mg/L		24-MAY-06	QLI	R401978
Molybdenum (Mo)	<0.005		0.005	mg/L		24-MAY-06	QLI	R401978
Nickel (Ni)	0.006		0.002	mg/L		24-MAY-06	QLI	R401978
Lead (Pb)	0.0013		0.0001	mg/L		24-MAY-06	QLI	R401978
Antimony (Sb)	0.0006		0.0004	mg/L		24-MAY-06	QLI	R401978
Selenium (Se)	0.0005		0.0004	mg/L		24-MAY-06	QLI	R401978
Tin (Sn)	<0.05		0.05	mg/L		24-MAY-06	QLI	R401978
Titanium (Ti)	0.064		0.001	mg/L		24-MAY-06	QLI	R401978
Thallium (Tl)	<0.0001		0.0001	mg/L		24-MAY-06	QLI	R401978
Uranium (U)	0.0027		0.0001	mg/L		24-MAY-06	QLI	R401978
Vanadium (V)	0.008		0.001	mg/L		24-MAY-06	QLI	R401978
Zinc (Zn)	0.007		0.004	mg/L		24-MAY-06	QLI	R401978
Total Major Metals								
Calcium (Ca)	47.8		0.5	mg/L		24-MAY-06	HAS	R401970
Potassium (K)	3.2		0.1	mg/L		24-MAY-06	HAS	R401970
Magnesium (Mg)	12.9		0.1	mg/L		24-MAY-06	HAS	R401970
Sodium (Na)	34		1	mg/L		24-MAY-06	HAS	R401970
Iron (Fe)	4.82		0.005	mg/L		24-MAY-06	HAS	R401970
Manganese (Mn)	0.115		0.001	mg/L		24-MAY-06	HAS	R401970
SAR	1.2			SAR		25-MAY-06		
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		24-MAY-06	BYU	R401916
Nitrate+Nitrite-N	<0.1		0.1	mg/L		24-MAY-06	SEL	R401832
Nitrate-N	<0.1		0.1	mg/L		24-MAY-06	SEL	R401832
Nitrite-N	<0.05		0.05	mg/L		24-MAY-06	SEL	R401832
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		24-MAY-06	PTT	R401754
Conductivity (EC)	485		0.2	uS/cm		24-MAY-06	PTT	R401754
Bicarbonate (HCO3)	187		5	mg/L		24-MAY-06	PTT	R401754
Carbonate (CO3)	<5		5	mg/L		24-MAY-06	PTT	R401754
Hydroxide (OH)	<5		5	mg/L		24-MAY-06	PTT	R401754
Alkalinity, Total (as CaCO3)	153		5	mg/L		24-MAY-06	PTT	R401754
Ion Balance Calculation								
Ion Balance	98.5			%		25-MAY-06		
TDS (Calculated)	271			mg/L		25-MAY-06		
Hardness (as CaCO3)	159			mg/L		25-MAY-06		
ICP metals and SO4 for routine water								
Calcium (Ca)	43.7		0.5	mg/L		24-MAY-06	EOC	R401845
Potassium (K)	3.5		0.5	mg/L		24-MAY-06	EOC	R401845
Magnesium (Mg)	12.1		0.1	mg/L		24-MAY-06	EOC	R401845
Sodium (Na)	35		1	mg/L		24-MAY-06	EOC	R401845
Sulfate (SO4)	80.9		0.5	mg/L		24-MAY-06	EOC	R401845

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
G	Outlier - No assignable cause for nonconformity has been determined.
IPT	Instrument performance showing response factors for C6 and C10 not within 30% of the response factor for toluene.
RAMB	Result Adjusted For Method Blank
SAR:Q	Qualified SAR value: actual SAR is lower but is incalculable due to Na, Ca or Mg below detection limit.
SDO:RNA	Surrogate diluted out:% recovery not available

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BTX,F1-ED	Water	BTEX and F1 (C6-C10)	EPA 5030	EPA 5030/8015&8260-P&T GC-MS & FID
BTX-TCLP-ED	Waste	TCLP Leachable BTEX	EPA 5030	EPA 5030/8015& 8260-P&T GC-MS/FID
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
CL-SAR-ED	Soil	Chloride (Cl) (Saturated Paste)		APHA 4500 Cl E-Colorimetry
ETL-BTX,TVH-CCME-ED	Soil	CCME BTEX	EPA 5030	CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-OGG-CCME-ED	Soil	CCME Gravimetric Heavy Hydrocarbons (SG)		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
ETL-SAR-ROU-ED	Water	SAR with Routine Analysis		CSSS 18.4-Calculation
ETL-TEH-CCME-ED	Soil	CCME Total Extractable Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
ETL-TVH,TEH-CCME-ED	Soil	CCME Total Hydrocarbons		CCME CWS-PHC Dec-2000 - Pub# 1310
F2-ED	Water	F2 (>C10-C16)		EPA 3510/8000-GC-FID
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MET1-TOT-CCME-ED	Water	Total Trace Metals	EPA3015	EPA 6020
MET2-TOT-LOW-ED	Water	Total Major Metals	EPA3015	EPA 200.7
METAL-CCME-ED	Soil	Metals in Soil - CCME List	EPA 3050	EPA 6020
N2N3-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3H-Colorimetry

Analytical methods used for analysis of CCME Petroleum Hydrocarbons have been validated and comply with the Reference Method for the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

In cases where results for both F4 and F4G are reported, the greater of the two results must be used in any application of the CWS PHC guidelines and the gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
In samples where BTEX and F1 were analyzed , F1-BTEX represents a value where the sum of Benzene, Toluene, Ethylbenzene and total Xylenes has been subtracted from F1.

In samples where PAHs, F2 and F3 were analyzed, F2-Naphth represents the result where Naphthalene has been subtracted from F2. F3-PAH represents a result where the sum of Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene has been subtracted from F3.

Unless otherwise qualified, the following quality control criteria have been met for the F1 hydrocarbon range:
1. All extraction and analysis holding times were met.
2. Instrument performance showing response factors for C6 and C10 within 30% of the response factor for toluene.
3. Linearity of gasoline response within 15% throughout the calibration range.

Unless otherwise qualified, the following quality control criteria have been met for the F2-F4 hydrocarbon ranges:
1. All extraction and analysis holding times were met.
2. Instrument performance showing C10, C16 and C34 response factors within 10% of their average.
3. Instrument performance showing the C50 response factor within 30% of the average of the C10, C16 and C34 response factors.
4. Linearity of diesel or motor oil response within 15% throughout the calibration range.

Reference Information

NO2-ED	Water	Nitrite-N	APHA 4500 NO2B-Colorimetry
NO3-ED	Water	Nitrate-N	APHA 4500 NO3H-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity	APHA 4500-H, 2510, 2320
PREP-MOISTURE-ED	Soil	% Moisture	Oven dry 105C-Gravimetric
PSA-MUST-ED	Soil	MUST PSA D50 > 75um	ASTM D422-63-Hydrometer/Sieve
SAR-CALC-ED	Soil	SAR	CSSS 18.4-Calculation
SAT/PH/EC-ED	Soil	pH and EC (Saturated Paste)	CSSS 18.2, 16.2, 18.3
SO4-SAR-ED	Soil	Sulfate (SO4) in saturated paste	APHA 3120 B-ICP-OES

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

230126

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
< - Less than
D.L. - Detection Limit
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

PRELIMINARY RESULTS

MILLENNIUM
ATTN: GRANT WOYNAROWICH
208 4207 98 ST
EDMONTON AB T6E 5R7

Reported On: 14-NOV-06 05:54 PM

Lab Work Order #: **L450939**

Date Received: **06-NOV-06**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc:
CofC Numbers: 226631

Other Information:

Comments:

PATRICK CORBIELL
General Manager, Fort McMurray

For any questions about this report please contact your Account Manager:

PATRICK CORBIELL

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450939-1 W1 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
Toluene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
EthylBenzene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
Xylenes	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F1(C6-C10)	<0.1		0.1	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F1-BTEX	<0.1		0.1	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	07-NOV-06	07-NOV-06	AAT	R463230
Surr: 2-Bromobenzotrifluoride	100		60-148	%	07-NOV-06	07-NOV-06	AAT	R463230
Surr: Hexatriacontane	99		57-147	%	07-NOV-06	07-NOV-06	AAT	R463230
Dissolved Metals - CCME								
Dissolved Trace Metals								
Silver (Ag)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Aluminum (Al)	<0.01		0.01	mg/L		09-NOV-06	MCHU	R463944
Arsenic (As)	0.0008		0.0004	mg/L		09-NOV-06	MCHU	R463944
Boron (B)	0.27		0.05	mg/L		09-NOV-06	MCHU	R463944
Barium (Ba)	0.019		0.003	mg/L		09-NOV-06	MCHU	R463944
Beryllium (Be)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Cadmium (Cd)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Cobalt (Co)	<0.002		0.002	mg/L		09-NOV-06	MCHU	R463944
Chromium (Cr)	<0.005		0.005	mg/L		09-NOV-06	MCHU	R463944
Copper (Cu)	0.003		0.001	mg/L		09-NOV-06	MCHU	R463944
Mercury (Hg)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Lithium (Li)	0.059		0.003	mg/L		09-NOV-06	MCHU	R463944
Molybdenum (Mo)	<0.005		0.005	mg/L		09-NOV-06	MCHU	R463944
Nickel (Ni)	0.006		0.002	mg/L		09-NOV-06	MCHU	R463944
Lead (Pb)	0.0002		0.0001	mg/L		09-NOV-06	MCHU	R463944
Antimony (Sb)	0.0005		0.0004	mg/L		09-NOV-06	MCHU	R463944
Selenium (Se)	0.0007		0.0004	mg/L		09-NOV-06	MCHU	R463944
Tin (Sn)	<0.05		0.05	mg/L		09-NOV-06	MCHU	R463944
Titanium (Ti)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Thallium (Tl)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Uranium (U)	0.0022		0.0001	mg/L		09-NOV-06	MCHU	R463944
Vanadium (V)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Zinc (Zn)	0.006		0.002	mg/L		09-NOV-06	MCHU	R463944
Iron (Fe)-Dissolved	0.133		0.005	mg/L		08-NOV-06	HAS	R462570
Manganese (Mn)-Dissolved	0.040		0.001	mg/L		08-NOV-06	HAS	R462570
CCME PAHs								
Naphthalene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Quinoline	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Acenaphthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Fluorene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Phenanthrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Acridine	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(a)anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Chrysene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450939-1 W1 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
CCME PAHs								
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(a)pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Indeno(1,2,3-cd)pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Dibenzo(a,h)anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Surr: Nitrobenzene d5	61		32-119	%	08-NOV-06	09-NOV-06	JME	R463557
Surr: 2-Fluorobiphenyl	61		34-116	%	08-NOV-06	09-NOV-06	JME	R463557
Surr: p-Terphenyl d14	83		45-144	%	08-NOV-06	09-NOV-06	JME	R463557
Naphthenic Acids	<1		1	mg/L		10-NOV-06	DBP	R464110
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		08-NOV-06	EOC	R463391
ICP metals and SO4 for routine water								
Calcium (Ca)	71.4		0.5	mg/L		07-NOV-06	EOC	R462809
Potassium (K)	2.8		0.5	mg/L		07-NOV-06	EOC	R462809
Magnesium (Mg)	21.3		0.1	mg/L		07-NOV-06	EOC	R462809
Sodium (Na)	54		1	mg/L		07-NOV-06	EOC	R462809
Sulfate (SO4)	106		0.5	mg/L		07-NOV-06	EOC	R462809
Ion Balance Calculation								
Ion Balance	105			%		08-NOV-06		
TDS (Calculated)	411			mg/L		08-NOV-06		
Hardness (as CaCO3)	266			mg/L		08-NOV-06		
Nitrate+Nitrite-N	<0.1		0.1	mg/L		07-NOV-06	MCH	R463152
Nitrate-N	<0.1		0.1	mg/L		07-NOV-06	MCH	R463152
Nitrite-N	<0.05		0.05	mg/L		07-NOV-06	MCH	R463152
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		07-NOV-06	UM	R463163
Conductivity (EC)	616		0.2	uS/cm		07-NOV-06	UM	R463163
Bicarbonate (HCO3)	309		5	mg/L		07-NOV-06	UM	R463163
Carbonate (CO3)	<5		5	mg/L		07-NOV-06	UM	R463163
Hydroxide (OH)	<5		5	mg/L		07-NOV-06	UM	R463163
Alkalinity, Total (as CaCO3)	253		5	mg/L		07-NOV-06	UM	R463163
L450939-2 W2 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
Toluene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
EthylBenzene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
Xylenes	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F1(C6-C10)	<0.1		0.1	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F1-BTEX	<0.1		0.1	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	07-NOV-06	07-NOV-06	AAT	R463230
Surr: 2-Bromobenzotrifluoride	99		60-148	%	07-NOV-06	07-NOV-06	AAT	R463230
Surr: Hexatriacontane	100		57-147	%	07-NOV-06	07-NOV-06	AAT	R463230
Dissolved Metals - CCME								
Dissolved Trace Metals								
Silver (Ag)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Aluminum (Al)	<0.01		0.01	mg/L		09-NOV-06	MCHU	R463944
Arsenic (As)	0.0009		0.0004	mg/L		09-NOV-06	MCHU	R463944

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450939-2 W2 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
Dissolved Metals - CCME								
Dissolved Trace Metals								
Boron (B)	0.27		0.05	mg/L		09-NOV-06	MCHU	R463944
Barium (Ba)	0.020		0.003	mg/L		09-NOV-06	MCHU	R463944
Beryllium (Be)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Cadmium (Cd)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Cobalt (Co)	<0.002		0.002	mg/L		09-NOV-06	MCHU	R463944
Chromium (Cr)	<0.005		0.005	mg/L		09-NOV-06	MCHU	R463944
Copper (Cu)	0.003		0.001	mg/L		09-NOV-06	MCHU	R463944
Mercury (Hg)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Lithium (Li)	0.058		0.003	mg/L		09-NOV-06	MCHU	R463944
Molybdenum (Mo)	<0.005		0.005	mg/L		09-NOV-06	MCHU	R463944
Nickel (Ni)	0.007		0.002	mg/L		09-NOV-06	MCHU	R463944
Lead (Pb)	0.0002		0.0001	mg/L		09-NOV-06	MCHU	R463944
Antimony (Sb)	0.0004		0.0004	mg/L		09-NOV-06	MCHU	R463944
Selenium (Se)	0.0009		0.0004	mg/L		09-NOV-06	MCHU	R463944
Tin (Sn)	<0.05		0.05	mg/L		09-NOV-06	MCHU	R463944
Titanium (Ti)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Thallium (Tl)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Uranium (U)	0.0022		0.0001	mg/L		09-NOV-06	MCHU	R463944
Vanadium (V)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Zinc (Zn)	0.040		0.002	mg/L		09-NOV-06	MCHU	R463944
Iron (Fe)-Dissolved	0.093		0.005	mg/L		08-NOV-06	HAS	R462570
Manganese (Mn)-Dissolved	0.037		0.001	mg/L		08-NOV-06	HAS	R462570
CCME PAHs								
Naphthalene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Quinoline	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Acenaphthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Fluorene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Phenanthrene	<0.00001	RAMB	0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Acridine	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(a)anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Chrysene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(a)pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Indeno(1,2,3-cd)pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Dibenzo(a,h)anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Surr: Nitrobenzene d5	66		32-119	%	08-NOV-06	09-NOV-06	JME	R463557
Surr: 2-Fluorobiphenyl	69		34-116	%	08-NOV-06	09-NOV-06	JME	R463557
Surr: p-Terphenyl d14	83		45-144	%	08-NOV-06	09-NOV-06	JME	R463557
Naphthenic Acids	<1		1	mg/L		10-NOV-06	DBP	R464110
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		08-NOV-06	EOC	R463391
ICP metals and SO4 for routine water								
Calcium (Ca)	71.1		0.5	mg/L		07-NOV-06	EOC	R462809
Potassium (K)	2.9		0.5	mg/L		07-NOV-06	EOC	R462809
Magnesium (Mg)	21.2		0.1	mg/L		07-NOV-06	EOC	R462809

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450939-2 W2 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
Routine Water Analysis								
ICP metals and SO4 for routine water								
Sodium (Na)	54		1	mg/L		07-NOV-06	EOC	R462809
Sulfate (SO4)	109		0.5	mg/L		07-NOV-06	EOC	R462809
Ion Balance Calculation								
Ion Balance	103			%		08-NOV-06		
TDS (Calculated)	415			mg/L		08-NOV-06		
Hardness (as CaCO3)	265			mg/L		08-NOV-06		
Nitrate+Nitrite-N	<0.1		0.1	mg/L		07-NOV-06	MCH	R463152
Nitrate-N	<0.1		0.1	mg/L		07-NOV-06	MCH	R463152
Nitrite-N	<0.05		0.05	mg/L		07-NOV-06	MCH	R463152
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		07-NOV-06	UM	R463163
Conductivity (EC)	618		0.2	uS/cm		07-NOV-06	UM	R463163
Bicarbonate (HCO3)	310		5	mg/L		07-NOV-06	UM	R463163
Carbonate (CO3)	<5		5	mg/L		07-NOV-06	UM	R463163
Hydroxide (OH)	<5		5	mg/L		07-NOV-06	UM	R463163
Alkalinity, Total (as CaCO3)	254		5	mg/L		07-NOV-06	UM	R463163
L450939-3 W3 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
Toluene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
EthylBenzene	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
Xylenes	<0.0005		0.0005	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F1(C6-C10)	<0.1		0.1	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F1-BTEX	<0.1		0.1	mg/L	12-NOV-06	12-NOV-06	DDU	R465111
F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	07-NOV-06	07-NOV-06	AAT	R463230
Surr: 2-Bromobenzotrifluoride	102		60-148	%	07-NOV-06	07-NOV-06	AAT	R463230
Surr: Hexatriacontane	102		57-147	%	07-NOV-06	07-NOV-06	AAT	R463230
Dissolved Metals - CCME								
Dissolved Trace Metals								
Silver (Ag)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Aluminum (Al)	<0.01		0.01	mg/L		09-NOV-06	MCHU	R463944
Arsenic (As)	0.0008		0.0004	mg/L		09-NOV-06	MCHU	R463944
Boron (B)	0.27		0.05	mg/L		09-NOV-06	MCHU	R463944
Barium (Ba)	0.019		0.003	mg/L		09-NOV-06	MCHU	R463944
Beryllium (Be)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Cadmium (Cd)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Cobalt (Co)	<0.002		0.002	mg/L		09-NOV-06	MCHU	R463944
Chromium (Cr)	<0.005		0.005	mg/L		09-NOV-06	MCHU	R463944
Copper (Cu)	0.003		0.001	mg/L		09-NOV-06	MCHU	R463944
Mercury (Hg)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Lithium (Li)	0.057		0.003	mg/L		09-NOV-06	MCHU	R463944
Molybdenum (Mo)	<0.005		0.005	mg/L		09-NOV-06	MCHU	R463944
Nickel (Ni)	0.006		0.002	mg/L		09-NOV-06	MCHU	R463944
Lead (Pb)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Antimony (Sb)	0.0005		0.0004	mg/L		09-NOV-06	MCHU	R463944
Selenium (Se)	0.0008		0.0004	mg/L		09-NOV-06	MCHU	R463944

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450939-3 W3 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
Dissolved Metals - CCME								
Dissolved Trace Metals								
Tin (Sn)	<0.05		0.05	mg/L		09-NOV-06	MCHU	R463944
Titanium (Ti)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Thallium (Tl)	<0.0001		0.0001	mg/L		09-NOV-06	MCHU	R463944
Uranium (U)	0.0022		0.0001	mg/L		09-NOV-06	MCHU	R463944
Vanadium (V)	<0.001		0.001	mg/L		09-NOV-06	MCHU	R463944
Zinc (Zn)	0.004		0.002	mg/L		09-NOV-06	MCHU	R463944
Iron (Fe)-Dissolved	0.075		0.005	mg/L		08-NOV-06	HAS	R462570
Manganese (Mn)-Dissolved	0.036		0.001	mg/L		08-NOV-06	HAS	R462570
CCME PAHs								
Naphthalene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Quinoline	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Acenaphthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Fluorene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Phenanthrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Acridine	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(a)anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Chrysene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Benzo(a)pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Indeno(1,2,3-cd)pyrene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Dibenzo(a,h)anthracene	<0.00001		0.00001	mg/L	08-NOV-06	09-NOV-06	JME	R463557
Surr: Nitrobenzene d5	57		32-119	%	08-NOV-06	09-NOV-06	JME	R463557
Surr: 2-Fluorobiphenyl	58		34-116	%	08-NOV-06	09-NOV-06	JME	R463557
Surr: p-Terphenyl d14	86		45-144	%	08-NOV-06	09-NOV-06	JME	R463557
Naphthenic Acids	<1		1	mg/L		10-NOV-06	DBP	R464110
Routine Water Analysis								
Chloride (Cl)	4		1	mg/L		08-NOV-06	EOC	R463391
ICP metals and SO4 for routine water								
Calcium (Ca)	71.6		0.5	mg/L		07-NOV-06	EOC	R462809
Potassium (K)	2.8		0.5	mg/L		07-NOV-06	EOC	R462809
Magnesium (Mg)	21.2		0.1	mg/L		07-NOV-06	EOC	R462809
Sodium (Na)	54		1	mg/L		07-NOV-06	EOC	R462809
Sulfate (SO4)	105		0.5	mg/L		07-NOV-06	EOC	R462809
Ion Balance Calculation								
Ion Balance	105			%		08-NOV-06		
TDS (Calculated)	411			mg/L		08-NOV-06		
Hardness (as CaCO3)	266			mg/L		08-NOV-06		
Nitrate+Nitrite-N	<0.1		0.1	mg/L		07-NOV-06	MCH	R463152
Nitrate-N	<0.1		0.1	mg/L		07-NOV-06	MCH	R463152
Nitrite-N	<0.05		0.05	mg/L		07-NOV-06	MCH	R463152
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		07-NOV-06	UM	R463163
Conductivity (EC)	617		0.2	uS/cm		07-NOV-06	UM	R463163
Bicarbonate (HCO3)	310		5	mg/L		07-NOV-06	UM	R463163
Carbonate (CO3)	<5		5	mg/L		07-NOV-06	UM	R463163

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L450939-3 W3 JOSLYN								
Sampled By: GW on 03-NOV-06								
Matrix: WATER								
Routine Water Analysis								
pH, Conductivity and Total Alkalinity								
Hydroxide (OH)	<5		5	mg/L		07-NOV-06	UM	R463163
Alkalinity, Total (as CaCO3)	254		5	mg/L		07-NOV-06	UM	R463163

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
RAMB	Result Adjusted For Method Blank

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BTX,F1-ED	Water	BTEX and F1 (C6-C10)	EPA 5030	EPA 5030/8015&8260-P&T GC-MS & FID
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
F2-ED	Water	F2 (>C10-C16)		EPA 3510/8000-GC-FID
FE-DIS-ED	Water	Iron (Fe)-Dissolved		EPA 200.7
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MET1-DIS-CCME-ED	Water	Dissolved Trace Metals		EPA 6020
MN-DIS-ED	Water	Manganese (Mn)-Dissolved		EPA 200.7
N2N3-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3H-Colorimetry
NAPHTHENIC-ACID-FM	Water	Naphthenic Acids by FTIR		Naphthenic Acids by FTIR,Syncrude,1994
NO2-ED	Water	Nitrite-N		APHA 4500 NO2B-Colorimetry
NO3-ED	Water	Nitrate-N		APHA 4500 NO3H-Colorimetry
PAH-CCME-ED	Water	CCME PAHs	EPA 3510	EPA 3510/8270-GC/MS
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity		APHA 4500-H, 2510, 2320

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

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The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

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ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA	FM	ALS LABORATORY GROUP - FORT MCMURRAY, ALBERTA, CANADA

Reference Information

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

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CONTACT: Grant Woynarowich

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INVOICE TO: SAME Y / N

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LSD:

QUOTE #

ANALYSIS REQUEST

SAMPLE ID	SAMPLING LOCATION	SAMPLED BY / DATE / TIME	SAMPLING METHOD	SAMPLE TYPE	CCME-NET	BTEX-F1F2	PAH.	Napthenic acids	Routine						HAZARDOUS ?	NUMBER OF CONTAINERS	HIGHLY CONTAMINATED ?	LAB SAMPLE #
					F/P	P												
W1	Joslyn.	GW/Nov3/06		watr	X	X	X	X	X									
W2	↓				X	X	X	X	X									
W3		↓		↓	X	X	X	X	X									

☐ FROZEN

☐ COLD

☐ AMBIENT

MEAN TEMPERATURE

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RELINQUISHED BY:	DATE & TIME: Nov 3/06 5:00 pm	RECEIVED BY: Julie OBrien	DATE & TIME: 03-NOV-06	SAMPLE CONDITION ACCEPTABLE UPON RECEIPT ? (Y/N)
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME: 17:10	

REFER TO BACK PAGE FOR SAMPLING INFORMATION & REGIONAL LOCATIONS WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY

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Millennium
EMS Solutions Ltd.

Deer Creek Energy Limited
Steam Release Incident
LSD 09-33-095-12-W4M

Volume IV - Groundwater Monitoring Program: Summary Report

DRAFT

Prepared for:
Deer Creek Energy Limited

Prepared by:
Millennium EMS Solutions Ltd.
#208, 4207 – 98 St
Edmonton, Alberta
T6E 5R7

April 2007
File #04-101

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1.0 INTRODUCTION

Millennium EMS Solutions Ltd. (MEMS) has been retained by Deer Creek Energy Limited (DCEL) to assist in the assessment, delineation and subsequent remediation of the lands potentially impacted by the Joslyn North Mine Project steam release event. The Joslyn Project is located approximately 60 km North of Fort McMurray, west of the Athabasca River. This phase of the steam assisted gravity drain (SAGD) facility started injecting steam into the production reservoir on April 15, 2006. The plant circulated steam for approximately one month and then began producing bitumen.

On May 18, 2006 at 5:15 am, a steam release was discovered adjacent to Well Pair 204-P1 (Appendix A, Figure 1). The Energy and Utilities Board (EUB) in Bonnyville and Alberta Environment (AENV) were notified immediately after the release was controlled. On May 25, 2006, DCEL, a subsidiary of Total E&P Canada Ltd. (TEPC) submitted a preliminary assessment of the incident to the EUB for review. The preliminary assessment of the incident included initial soil and surface water sampling in proximity to and down gradient of the release point. An additional summary and work plan was submitted to AENV in September 2006. The following report outlines the methods and findings of the groundwater monitoring program including the initial assessment and a subsequent sampling event proposed in the September 2006 work plan.

1.1 Background Information

Initial Assessment of Potentially Impacted Area – Soil & Surface Water (May 2006)

The September 2006 report prepared by MEMS documented the findings of the initial assessment and presented a work plan for further soil, groundwater and surface water investigation and monitoring. During the initial assessment, samples of the displaced material were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), leachable BTEX, F1-F4 petroleum hydrocarbon fractions, total extractable hydrocarbons, detailed salinity, and trace metals. The displaced material was considered to be the subsurface material deposited on the ground surface as a result of the steam release event. Analytical results of the displaced material consistently exceeded the Alberta soil quality guidelines for F2-F4 hydrocarbon fractions (AENV 2001a) and the Alberta salt contamination guidelines for sodium adsorption ratio (SAR) (AENV 2001b). All other parameters measured were below the applicable guidelines. The approximate area of visible displaced material at the time of the initial assessment is outlined in Appendix A, Figure 1.

Surface water samples were collected from Joslyn creek on May 20, 2006, up and down stream of the portion of the creek located in the zone of displaced material. Additional water samples were collected May 21, 22 and 23, 2006, at the point immediately down stream of the deposition zone. No measurable changes in water quality were observed between these monitoring events.

Detailed Assessment of Potentially Impacted Area – Soil (September 2006)

As outlined in the September 2006 work plan, a detailed assessment of the steam release area was conducted to further characterize the displaced material and delineate the extent of the impacted area. Details of this soil assessment program have been documented in Volume 2 of the *draft* MEMS report, dated *December 2006*. In addition to the F2-F4 hydrocarbon fractions and SAR values initially reported to exceed the current guidelines, electrical conductivity (EC), pyrene and phenanthrene values measured from select samples of displaced material also exceeded applicable guidelines. Concentrations of sodium and sulphate were also notably elevated above background concentrations.

Alberta Environment Letter of Response – October 5, 2006

Comments pertaining to the groundwater monitoring program were identified in a letter from AENV, dated October 5, 2006 (Appendix C). These comments are summarized below:

> *"The environmental site characterization program should confirm the following:*
>
> - *The Wabasca sand is not present in the close vicinity of the release*
> - *The aeolin sands present in the NE portion of the lease do not extend to the immediate area of deposition.*
>
> *The Groundwater Assessment Program should first establish the groundwater flow regime in the immediate vicinity of the release, and subsequently, the scope of groundwater assessment should be established.*
>
> *Analytical parameters for groundwater sampling should also include phenols and dissolved metals including arsenic."*

1.2 Objectives

The groundwater monitoring program was designed to:

- determine existing groundwater quality;
- allow for the prediction of the groundwater flow system towards Joslyn Creek; and
- provide sufficient information to allow for the risk assessment of groundwater quality to potential receptors in the area,

thereby identifying and characterizing potential impacts of the May 18th steam release event on the groundwater quality in the immediate vicinity of the steam release area and on the water quality of Joslyn Creek.

1.3 Scope of Work

The scope of work for the groundwater monitoring program is detailed as follows:

- Complete ground disturbance protocols;
- Install a series of seven monitor wells along a transect between the steam release point and Joslyn Creek;
- Conduct a groundwater sampling event upon installation of the monitor wells and equilibration of groundwater levels, including:
    - Measurement of the groundwater table at each monitor well;
    - Development of the monitor wells;
    - Collect groundwater samples from each monitor well; and
    - Analyze samples for benzene, toluene, ethylbenzene, xylenes (BTEX) and F1(C6-C10) and F2(>C10-C16) hydrocarbons, routine (salinity) parameters, polycyclic aromatic hydrocarbons (PAHs), and naphthenic acid.
- Prepare a report outlining the analytical findings with comparisons to applicable guidelines and available background data.
- Provide recommendations for further monitoring, remediation, or a risk based management plan, if necessary, based of the findings of the work completed.

2.0 PHYSIOGRAPHIC SETTING

2.1 Topography

The landscape within the SAGD area varies from flat to gently rolling, and much of it is of low relief. Greatest relief, usually in the order of three to five metres, is found along drainage courses and around small lakes. A majority of the area up and down gradient of the steam release location is upland. The release location and other small pockets of lowland soils are found throughout the area predominantly in proximity to drain ways. The relief from the steam release point to Joslyn Creek is approximately 3 – 5 m over a distance of approximately 350 m.

2.2 Soils

The soils in proximity to the steam release area consist of Luvisols, Gleysols, Regosols and Organics. Orthic Gray Luvisols dominate all upland areas in proximity to and down gradient of the release location. Lower slope and drainage swales are occupied by either Orthic or Humic Gleysols, often with a significant surface peat layer. Regosolic soils and various Rego complexes are confined to the Joslyn creek flood plain and a narrow band along the banks of the flood plain. Various depressional pockets, including the steam release location are dominated by relatively shallow Organic soils containing bog peat.

2.3 Surface Water

The DCEL lease is transected by two major streams – the Ells River and Joslyn Creek, a major tributary of the Ells. The SAGD Phase III operations are entirely within the Joslyn Creek Watershed.

DCEL has conducted sampling of the Joslyn Creek during baseline data collection for a number of regulatory applications. Water in Joslyn Creek is slightly alkaline, with total alkalinity, conductivity, and concentrations of total dissolved solids generally highest in winter. Organic parameters such as hydrocarbons, naphthenic acids, and phenols tend to be low in Joslyn Creek. Historical concentrations of oil and grease, measured over the period from 1976 to 1979, ranged from <0.1 mg/L to 1.5 mg/L. Since baseline data collection began the recoverable hydrocarbon concentrations have been below the detection limit.

2.4 Geologic Setting

Within the project area, the total overburden thickness is approximately 40 to 60 m with 20 to 30 m being the shales of the Clearwater Formation while the remaining sediments are Pleistocene tills. The Clearwater Formation is fully marine in nature. It consists predominantly of marine shales which do not contain bitumen and are considered a barrier to fluid flow. The Wabiskaw Member of the Clearwater Formation directly overlies the McMurray formation and is comprised of shales, silts and very fine grained sands. These sands can contain low grades of bitumen. Reservoir quality and thickness within the Wabiskaw member are poor and do not contribute to the in-situ recovery of bitumen.

The McMurray Formation is present from approximately 40 to 60 m below ground level to a depth of 115 m. The McMurray Formation is comprised of stacked fluvial-estuarine sands and off-channel silts and shales. The sands of the McMurray Formation are 90 to 95% quartz. The McMurray has three informal members including the Lower, Middle and Upper McMurray. These informal divisions correspond to changes in the depositional environments within the McMurray from fluvial at the base (Lower Member) to estuarine in the middle (Middle Member) to marginal marine at the top (Upper Member). The depth of the prospective Middle McMurray SAGD zone is approximately 65 to 110 m. The non-pay

McMurray sediments that overlie the intended steam chamber consist of 20 to 25 m of interbedded sands and shales of largely estuarine origin.

3.0 METHODOLOGY

A series of seven groundwater monitor wells (MW1 – MW7) were installed along a transect between the steam release point and Joslyn Creek (primarily within the soil deposition zone). MW1 is situated just upstream of the point of release. MW2, MW3 and MW4 are located just around the perimeter of the release area, and MW 5, MW6 and MW7 are located along the depositional path downstream of the release approaching Joslyn Creek in approximately 100 m intervals. The location of these wells is shown in Figure 1 (Appendix A).

The boreholes were advanced using a truck-mounted solid stem auger rig on February 1 – 2, 2007. The holes were drilled to depths corresponding to bedrock surface or auger refusal (6.9 – 10.7 m below ground surface). Each borehole was logged with respect to general soil description, including texture, color, moisture, and cohesiveness throughout the entire depth of investigation. Borehole logs are included in Appendix B.

Groundwater monitor wells were installed into the boreholes. The boreholes were first backfilled with bentonite chips to a depth of 2 m below the elevation where the clay soils become saturated, followed by 0.15 m of frac sand on the chips. The monitor wells were constructed of factory cleaned and wrapped Schedule 40 threaded 50 mm PVC pipe with the screened interval being a 3.0 m long 10 slot PVC screen. The screened interval was packed with frac sand (to 0.5 m above the top of the screened interval) and the borehole annulus was sealed above the sand with bentonite chips to surface. Construction details are presented in Appendix B.

Groundwater sampling and water level measurements were conducted on February 12, 2007. A water interface probe was used to measure the depth of the water table below the top of well casing (TOC). The wells were then developed by purging prior to collecting samples. Proper development of the wells prior to sampling is required such that the samples collected are representative of actual groundwater conditions and are not impacted from the drilling or the well installation processes. Water samples were then collected and placed in a cooler and transported to ALS for analysis. All groundwater samples were analyzed for BTEX, F1-F2 hydrocarbons, routine (salinity) parameters, PAHs, and naphthenic acids.

4.0 CRITERIA SELECTION

4.1 Hydrocarbon Criteria

The Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities (2001) have been applied as the primary criteria. The human drinking water criteria were applied as the most stringent applicable guidelines.

4.2 Salinity Criteria

The Canadian Environmental Quality Guidelines for drinking water (community use) (CCME 2006) have been applied as the most stringent applicable guidelines for salinity parameters. Additionally, the Action Limits from DCEL's Phase I plant site (accepted by AENV) and background levels are provided as representative concentrations typical of the area for comparison.

4.3 PAH Criteria

The Canadian Environmental Quality Guidelines for the protection of freshwater aquatic life (CCME 2006) have been applied as the most stringent applicable guidelines for PAHs.

4.4 Naphthenic Acids Criteria

As there are no guidelines available for naphthenic acids in groundwater, the Action Limits from DCEL's Phase I plant site (accepted by AENV) and background levels are provided for comparison.

5.0 SUMMARY OF RESULTS

5.1 Stratigraphy

All seven boreholes had similar stratigraphy with only minor lithological variations. The stratigraphic sequence, in descending order, is comprised of moist, firm, brown clay with some silt and/or fine sand (occasionally overlain by moist-wet, brown peat), transitioning to softer, grey clay with some silt, sand and small stones. Occasional thin (~0.01 – 0.10 m thick) sand seams/pockets were observed in this grey clay. Bedrock (fine-grained, grey sandstone and grey shale) were encountered beneath the clay. Detailed borehole logs are presented in Appendix B.

5.2 Groundwater Investigation

The measured depths to groundwater and approximate relative groundwater elevations are provided in Table 5.1. The relative groundwater elevation at each of the monitor wells is shown in Figure 1 (Appendix A). The depth to groundwater ranged from 1.73 to 4.72 m below ground surface on February 12th, 2007. Groundwater levels can be affected by subsurface anthropogenic services, backfill areas, lenses of permeable material, etc. and groundwater levels and flow directions may fluctuate seasonally. Groundwater flow cannot accurately be inferred from the measured levels in this series of monitor wells. The linear arrangement of the monitor wells is not conducive to the determination of gradient and flow direction. It is expected however, that the regional groundwater flow direction from the steam release point is generally south, towards Joslyn Creek.

Table 5.1 Relative groundwater elevations.

Well ID	Elevations		Groundwater Levels	
	Ground (mASL)	Top of Casing (mASL)	mBTOC	mASL
MW1	337.111	338.0	4.72	333.2
MW2	337.371	338.3	DRY	<330.8
MW3	335.278	336.1	1.73	334.4
MW4	335.205	336.3	4.33	331.9
MW5	335.172	336.1	2.03 (Frozen)	334.0
MW6	331.476	332.3	1.99	330.3
MW7	338.584	339.4	DRY	<330.8

Groundwater samples were analyzed for hydrocarbons (BTEX, F1-F2), routine parameters, PAHs, and naphthenic acids. The analytical results are summarized in Tables 5.2 – 5.5, respectively, with a comparison to the applicable criteria. Complete analytical results are provided in Appendix C.

Table 5.2 Hydrocarbon results.

PARAMETER	UNITS	CRITERIA	PHASE I PLANT SITE		MW1	MW3	MW4	MW6
			Action Limits	*Background Levels*				
Benzene	mg/L	0.005	0.37	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toluene	mg/L	0.024	0.002	<0.0005 - 0.001	0.0006	<0.0005	0.0007	<0.0005
EthylBenzene	mg/L	0.0024	0.09	<0.0005 - 0.001	<0.0005	<0.0005	<0.0005	<0.0005
Xylenes	mg/L	0.3	0.0009	<0.0005 - 0.003	0.0016	0.0005	0.0019	0.0010
F1 (C6-C10)	mg/L	4.6	0.6	<0.1 - <0.5	<0.1	<0.1	<0.1	<0.1
F2 (>C10-C16)	mg/L	2.1	0.1	<0.05 - 0.1	0.12	1.8	0.16	0.11

The measured hydrocarbon concentrations in the groundwater samples were generally below the laboratory detection limit, and those fractions that were detectable (toluene, xylenes and F2) in some or all of the monitor wells, were only present at levels below the applicable guidelines. Xylenes and F2 hydrocarbons were occasionally present at levels exceeding the background levels observed at DCEL's Phase I plant site. This was not of particular concern however, as the measured concentrations were still below the drinking water guidelines.

Table 5.3 Routine parameters results.

PARAMETER	UNITS	CRITERIA	PHASE I PLANT SITE		MW1	MW3	MW4	MW6
			Action Limits	***Background Levels***				
pH	pH	6.5 - 8.5*	6.5 - 9.0	8.1 - 8.3	8.0	7.5	8.0	7.9
Conductivity (EC)	µS/cm				2,560	616	1,680	1,020
Alkalinity, Total (as $CaCO_3$)	mg/L				790	309	455	538
Hardness (as $CaCO_3$)	mg/L				289	219	222	94
Ion Balance	%				94.0	100	93.7	97.9
TDS (Calculated)	mg/L	500*	5,400	650 - 5,400	1,690	364	1,090	612
Bicarbonate (HCO_3)	mg/L		1,400	650 - 1,400	964	377	555	657
Calcium (Ca)	mg/L		260	70 - 260	76.0	72.5	62.8	24.6
Carbonate (CO_3)	mg/L		15		<5	<5	<5	<5
Chloride (Cl)	mg/L	250*	320	25 - 320	58	11	46	26
Hydroxide (OH)	mg/L				<5	<5	<5	<5
Magnesium (Mg)	mg/L		110	20 - 110	24.2	9.2	15.9	7.8
Nitrate+Nitrite-N	mg/L				1.3	0.3	8.3	0.2
Nitrate-N	mg/L	10	1		1.3	0.3	8.1	<0.1
Nitrite-N	mg/L	3.2	0		0.07	<0.05	0.19	0.16
Potassium (K)	mg/L		20	8 - 20	8.8	6.6	7.0	5.2
Sodium (Na)	mg/L	200*	1,400	200 - 1,400	491	56	291	217
Sulfate (SO_4)	mg/L	500*	3,200	38 - 3,200	556	22.3	358	8.0

** These values represent Aesthetic Objectives*

The routine water parameters were all within the range of background levels observed at DCEL's Phase I plant site and below the accepted action limits. The concentrations of sodium, sulphate and total dissolved solids (TDS) were all in exceedance of the aesthetic objectives in the drinking water guidelines. The values observed were still within the lower end of the range of background levels observed at the Phase I plant site.

Table 5.4 PAH results.

PARAMETER	UNITS	CRITERIA	MW1	MW3	MW4	MW6
Naphthalene	mg/L	1.1	0.00010	<0.0001	0.00016	0.0002
Quinoline	mg/L	3.4	<0.00001	<0.0001	<0.00001	<0.0001
Acenaphthene	mg/L	5.8	<0.00001	<0.0001	<0.00001	<0.0001
Fluorene	mg/L	3.0	<0.00001	<0.0001	<0.00001	<0.0001
Phenanthrene	mg/L	0.4	<0.00001	<0.0001	<0.00001	<0.0001
Anthracene	mg/L	0.012	<0.00001	<0.0001	<0.00001	<0.0001
Acridine	mg/L	4.4	<0.00001	<0.0001	<0.00001	<0.0001
Fluoranthene	mg/L	0.04	<0.00001	<0.0001	0.00003	<0.0001
Pyrene	mg/L	0.025	<0.00001	0.0002	0.00013	0.0001
Benzo(a)anthracene	mg/L	0.018	<0.00001	<0.0001	<0.00001	<0.0001
Chrysene	mg/L		<0.00001	<0.0001	0.00012	0.0001
Benzo(b)fluoranthene	mg/L		<0.00001	<0.0001	<0.00001	0.0001
Benzo(k)fluoranthene	mg/L		<0.00001	<0.0001	<0.00001	<0.0001
Indeno(1,2,3-cd)pyrene	mg/L		<0.00001	<0.0001	<0.00001	<0.0001
Dibenzo(a,h)anthracene	mg/L		<0.00001	<0.0001	<0.00001	<0.0001

The measured PAH concentrations in the groundwater samples were generally below the laboratory detection limit, and those parameters that were detectable (naphthalene, fluoranthene, pyrene, chrysene, and benzo(b)fluoranthene) in some or all of the monitor wells, were only present at levels well below the applicable guidelines.

Table 5.5 Naphthenic acids results.

PARAMETER	UNITS	PHASE I PLANT SITE		MW1	MW3	MW4	MW6
		Action Limits	*Background Levels*				
Naphthenic Acids	mg/L	4	3 - 4	2	<1	2	1

As there are no applicable guidelines for naphthenic acids, the measured concentrations were compared with the background levels and action limits for DCEL's Phase I plant site. The measured values were well below the background and action limit levels.

6.0 CONCLUSIONS

The following conclusions can be drawn from the results of the groundwater monitoring program:

- BTEX and F1 – F2 concentrations were all below the applicable guidelines;
- Routine parameters were all at concentrations within the background levels and accepted action limits observed at the Phase I plant site;
- PAH concentrations were all below the applicable guidelines. Many were not present at detectable levels; and,
- Naphthenic acids were present at concentrations within background levels and accepted action limits observed at the Phase I plant site.

The concentrations of the measured parameters are all within the acceptable guidelines and/or background levels and accepted action limits observed at the Phase I plant site. It does not appear, therefore, that the steam release event has had a noticeable effect on groundwater quality.

Analysis of dissolved metals and phenols was left out by an oversight during this sampling event. The low background metals levels observed during the soil sampling following the steam release suggest that elevated dissolved metals concentrations in the groundwater are not of particular concern. The parameters that were analyzed are adequate for initial analysis of the impact of the steam release on groundwater quality and to begin discussions with Alberta Environment.

7.0 CLOSURE

If you have any questions concerning this report please contact the undersigned at (780) 496-9048.

Yours truly,

Millennium EMS Solutions Ltd.

Reviewed by:

Kris Krahn, M.Sc.
Environmental Scientist

Ian Terry, P.Eng.
Principal

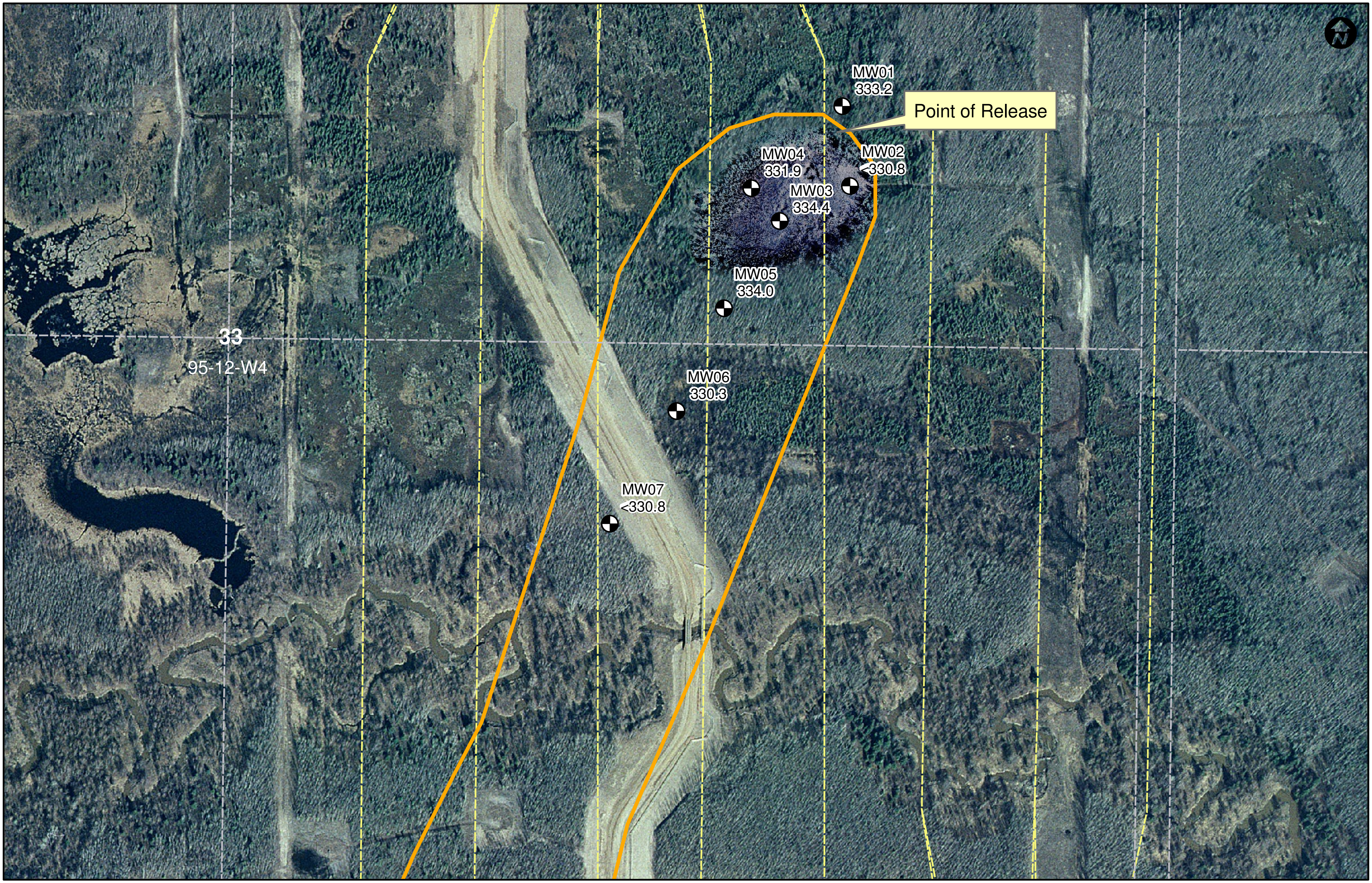
8.0 REFERENCES

AENV (Alberta Environment). 2001a. Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities. Volumes 1-3. Science and Standards Division, Alberta Environment. Edmonton, Alberta. 103 pp.

AENV (Alberta Environment). 1999. Surface Water Quality Guidelines for Use in Alberta. Environmental Assurance Division, Science and Standards Branch, Publication No.T/483, November 1999.

CCME (Canadian Council of Ministers of the Environment). 2006. Canadian Water Quality Guidelines: Summary Table. Updated July, 2006. In: Canadian Environmental Quality Guidelines, Publication No. 1299, 1999, CCME, Winnipeg.

APPENDIX A: FIGURES AND DRAWINGS



Deer Creek Energy Limited
A wholly-owned subsidiary of TOTAL E&P CANADA LTD

PROJECT

Deer Creek Energy Limited

TITLE

Proposed Monitoring Wells

LEGEND

- ◐ Proposed Monitoring Wells
- ▭ Area of Deposition
- - - - SAGD Well Pair

DRAWN	CHECKED	DATE
PS	KK	10Apr07

SCALE
0 30 60 120
Metres

PROJECTION:
UTM12 NAD83

FILE No.
04-101

FIGURE
1

APPENDIX B: BOREHOLE LOGS

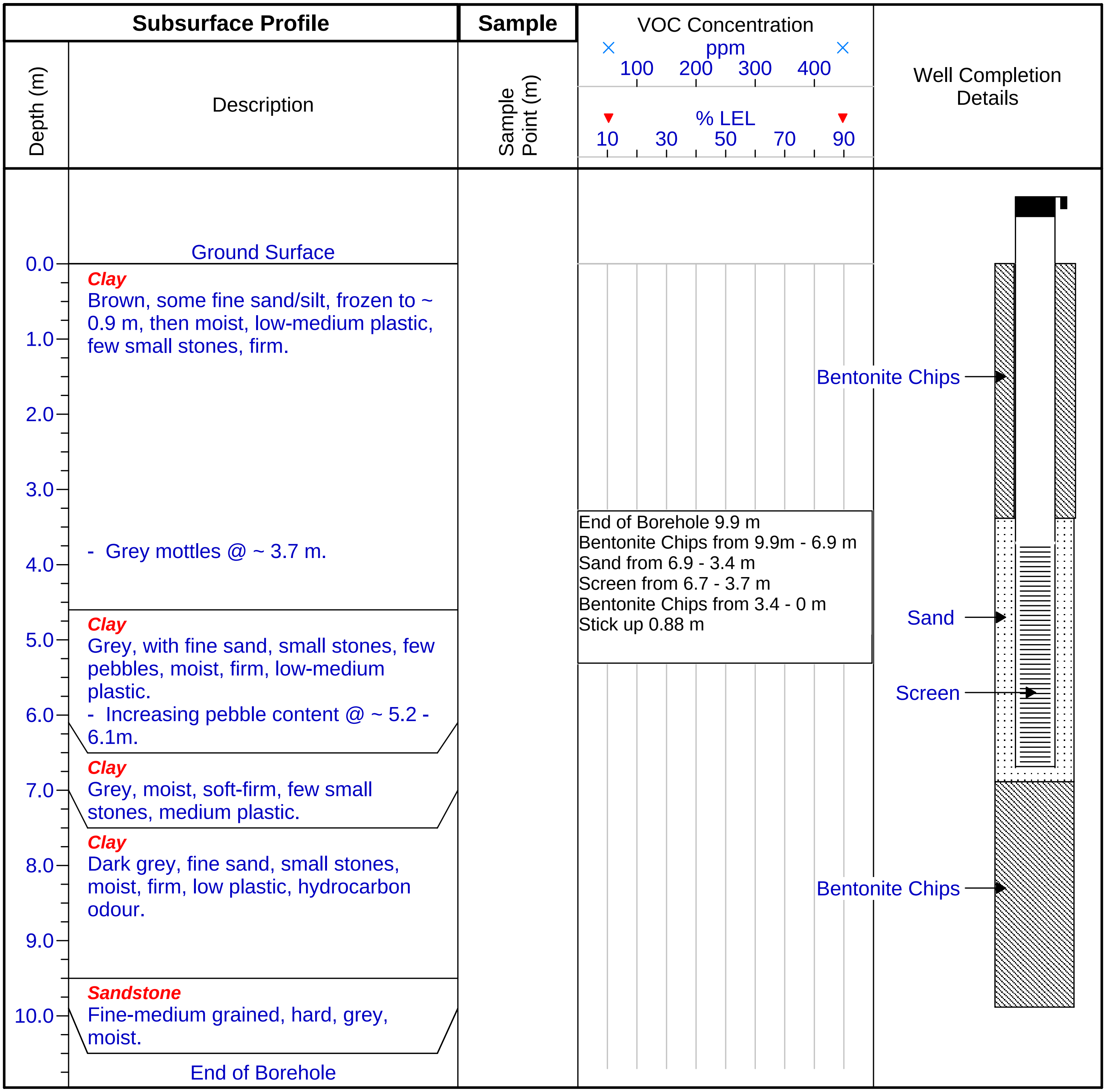
Project No: 04-101

Borehole No: MW1

Drill Method: Solid Stem Auger

Client: DCEL

Location: 108



Subsurface Profile

Sample

VOC Concentration

Well Completion Details

Ground Surface

Clay
Brown, some fine sand/silt, frozen to ~ 0.9 m, then moist, low-medium plastic, few small stones, firm.

- Grey mottles @ ~ 3.7 m.

Clay
Grey, with fine sand, small stones, few pebbles, moist, firm, low-medium plastic.

- Increasing pebble content @ ~ 5.2 - 6.1m.

Clay
Grey, moist, soft-firm, few small stones, medium plastic.

Clay
Dark grey, fine sand, small stones, moist, firm, low plastic, hydrocarbon odour.

Sandstone
Fine-medium grained, hard, grey, moist.

End of Borehole

End of Borehole 9.9 m
Bentonite Chips from 9.9m - 6.9 m
Sand from 6.9 - 3.4 m
Screen from 6.7 - 3.7 m
Bentonite Chips from 3.4 - 0 m
Stick up 0.88 m

Logged By: KK

Entered By: CN

Drill Date: February 1, 2007

Millennium EMS Solutions Ltd.
#208, 4207- 98 Street
Edmonton, AB T6E 5R7

Project No: 04-101

Borehole No: MW2

Drill Method: Solid Stem Auger

Client: DCEL

Location: 109

Millennium EMS Solutions Ltd.

Subsurface Profile | **Sample** | VOC Concentration | Well Completion Details

Depth (m) | Description | Sample Point (m)

VOC Concentration ppm: 100 200 300 400

% LEL: 10 30 50 70 90

Depth (m): 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

Ground Surface

Clay
Brown, sandy, few grey mottles, frozen to ~ 1.5 m, pink mottles, firm, moist, stiff, low plastic

- Pebbles @ ~ 1.5 m - 3.1 m.

- Dark grey mottles @ ~ 2.1 m.
- Increasing greyness with depth.

Sandy Clay
Dark grey, fine, oxides, firm, moist, low plastic, occassional stones, decreasing sand content with depth.

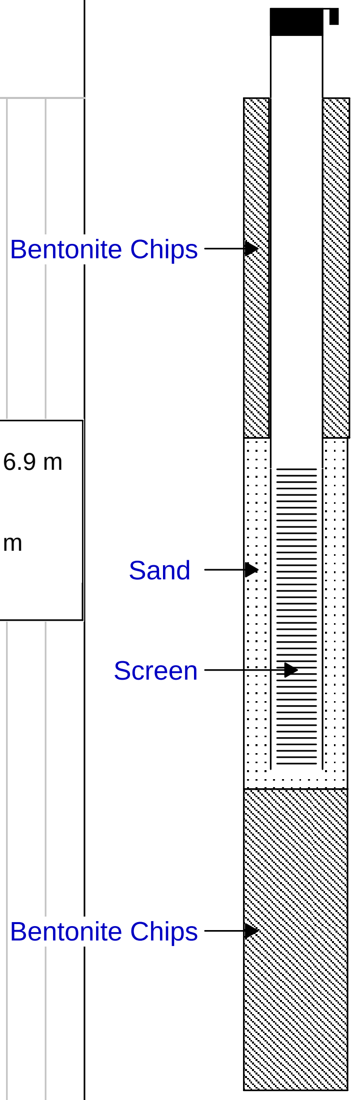
- Hydrocarbon odour ~ 5.2 m - 6.1 m.

Clay
Grey, pink mottling to ~ 6.7 m, moist, soft-firm, plastic, faint hydrocarbon odour.

Sandstone
Hard, fine grained.

End of Borehole

End of Borehole 9.9 m
Bentonite Chips from 9.9m - 6.9 m
Sand from 6.9 - 3.4 m
Screen from 6.7 - 3.4 m
Bentonite Chips from 3.4 - 0 m
Stick up 0.97 m



Logged By: KK

Entered By: CN

Drill Date: February 1, 2007

Millennium EMS Solutions Ltd.
#208, 4207- 98 Street
Edmonton, AB T6E 5R7

Project No: 04-101

Borehole No: MW3

Drill Method: Solid Stem Auger

Client: DCEL

Location: 104 (~ 15 m south of surveyed location)

Millennium
EMS Solutions Ltd.

Subsurface Profile		Sample	VOC Concentration	Well Completion Details
Depth (m)	Description	Sample Point (m)	ppm: × 100 200 300 400 × % LEL: ▼ 10 30 50 70 90 ▼	

Depth (m): 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

Ground Surface

Peat
Brown, frozen to ~ 0.8 m, moist-wet, loose, soft.

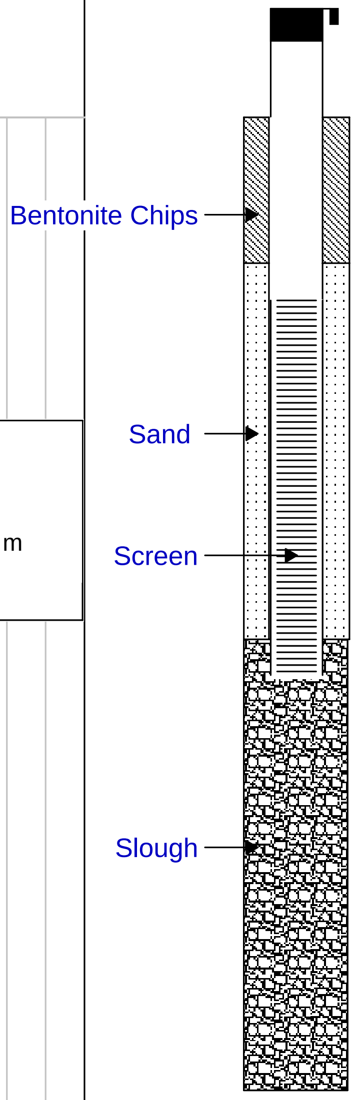
Clay
Dark grey with light light grey streaks, some silt to ~ 3.1 m, moist, soft-firm, low-medium plastic.

- With small stones beginning @ ~ 3.7 m, some fine grained sand.

Sandstone
Fine grained, grey, hard.
Auger Refusal @ 7.9 m.

End of Borehole

End of Borehole 8.0 m
Slough from 8.0 m - 4.3 m
Screen from 4.6 - 1.5 m
Sand from 4.3 - 1.2 m
Bentonite Chips from 1.2 - 0 m
Stick up 0.99 m



Logged By: KK

Entered By: CN

Drill Date: February 2, 2007

Millennium EMS Solutions Ltd.
#208, 4207- 98 Street
Edmonton, AB T6E 5R7

Project No: 04-101

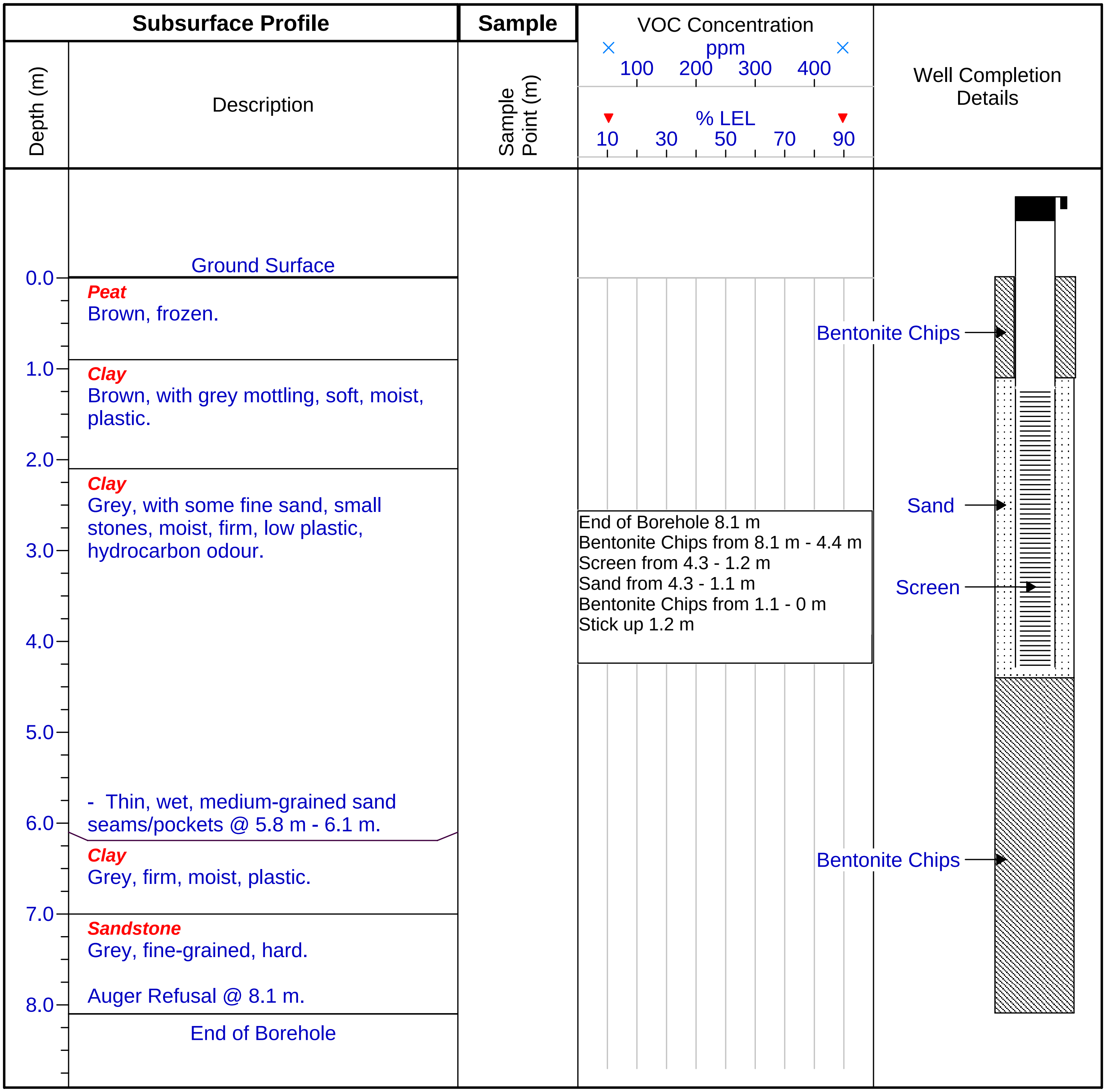
Borehole No: MW4

Drill Method: Solid Stem Auger

Client: DCEL

Location: 103

Millennium
EMS Solutions Ltd.



Ground Surface

Peat
Brown, frozen.

Clay
Brown, with grey mottling, soft, moist, plastic.

Clay
Grey, with some fine sand, small stones, moist, firm, low plastic, hydrocarbon odour.

- Thin, wet, medium-grained sand seams/pockets @ 5.8 m - 6.1 m.

Clay
Grey, firm, moist, plastic.

Sandstone
Grey, fine-grained, hard.

Auger Refusal @ 8.1 m.

End of Borehole

End of Borehole 8.1 m
Bentonite Chips from 8.1 m - 4.4 m
Screen from 4.3 - 1.2 m
Sand from 4.3 - 1.1 m
Bentonite Chips from 1.1 - 0 m
Stick up 1.2 m

Logged By: KK

Entered By: CN

Drill Date: February 2, 2007

Millennium EMS Solutions Ltd.
#208, 4207- 98 Street
Edmonton, AB T6E 5R7

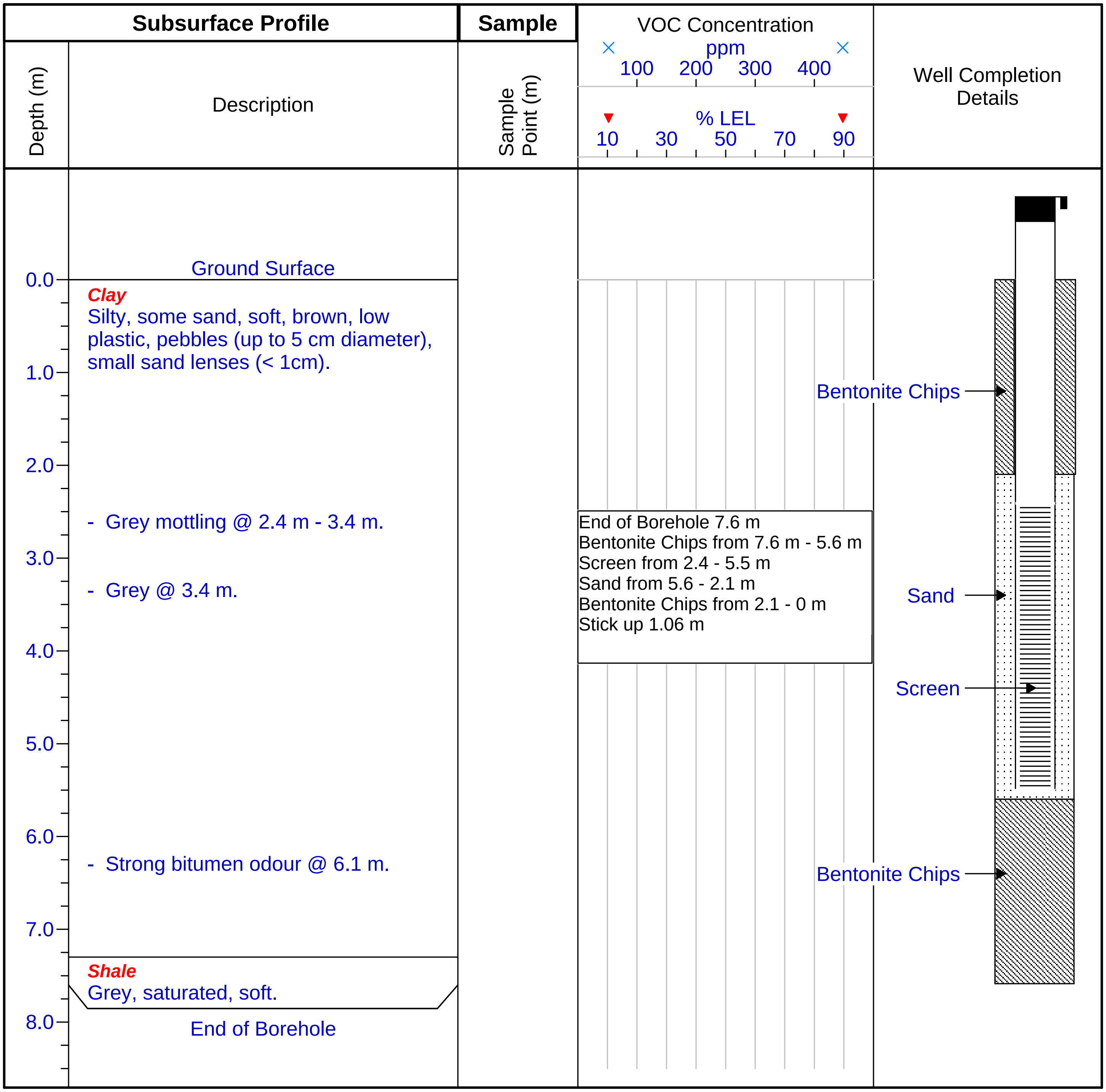
Project No: 04-101

Borehole No: MW5

Drill Method: Solid Stem Auger

Client: DCEL

Location: 105



Clay
Silty, some sand, soft, brown, low plastic, pebbles (up to 5 cm diameter), small sand lenses (< 1cm).

- Grey mottling @ 2.4 m - 3.4 m.
- Grey @ 3.4 m.
- Strong bitumen odour @ 6.1 m.

Shale
Grey, saturated, soft.

End of Borehole 7.6 m
Bentonite Chips from 7.6 m - 5.6 m
Screen from 2.4 - 5.5 m
Sand from 5.6 - 2.1 m
Bentonite Chips from 2.1 - 0 m
Stick up 1.06 m

Logged By: KK

Entered By: CN

Drill Date: February 2, 2007

Millennium EMS Solutions Ltd.
#208, 4207- 98 Street
Edmonton, AB T6E 5R7

Project No: 04-101

Borehole No: MW6

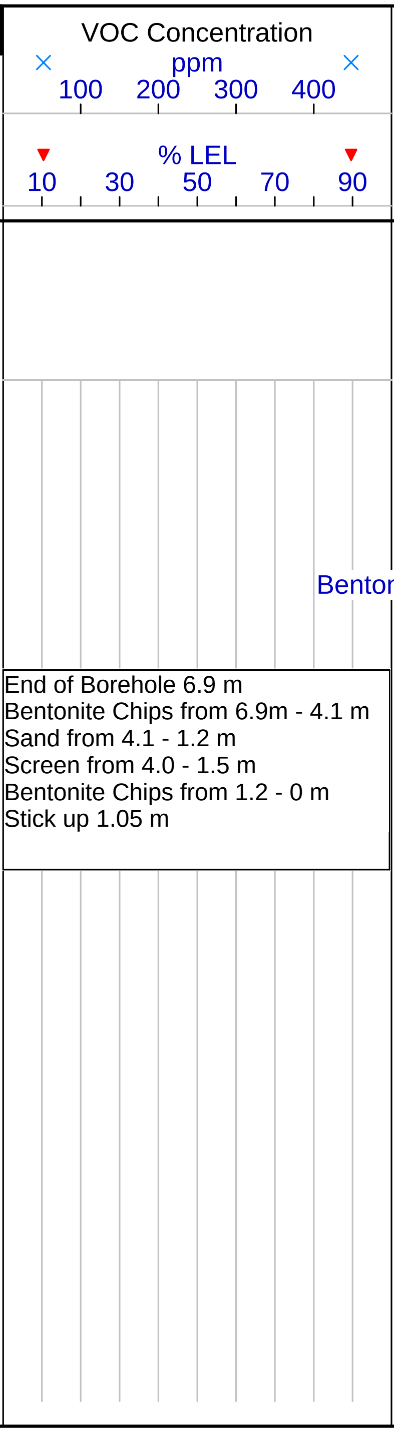
Drill Method: Solid Stem Auger

Client: Deer Creek

Location: 106

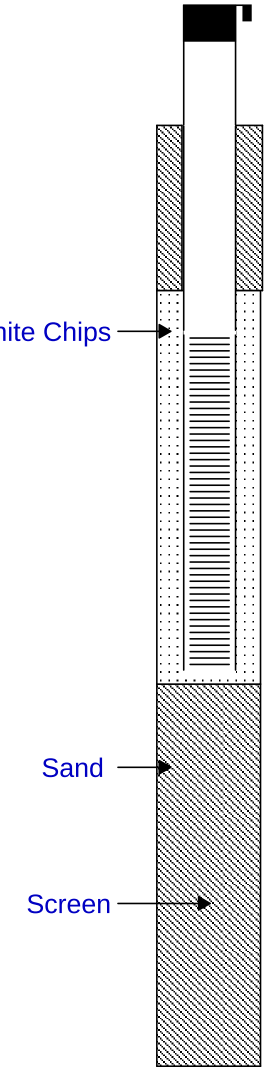
Millennium
EMS Solutions Ltd.

Subsurface Profile		**Sample**
Depth (m)	Description	Sample Point (m)
	Ground Surface	
0.0	***Peat*** Brown, frozen.	
1.0	***Interbedded Clay/Peat*** Mottled, grey/brown, moist, soft.	
2.0	***Clay*** Grey, soft-firm, moist, plastic.	
	Sandy Clay Grey, with pebbles, wet, loose.	
3.0		
4.0	***Clay*** Grey, stiff, moist, low plastic.	
5.0	***Shale*** Grey, hard, stiff, moist.	
6.0		
7.0	End of Borehole	



End of Borehole 6.9 m
Bentonite Chips from 6.9m - 4.1 m
Sand from 4.1 - 1.2 m
Screen from 4.0 - 1.5 m
Bentonite Chips from 1.2 - 0 m
Stick up 1.05 m

Well Completion Details



Logged By: KK

Entered By: CN

Drill Date: February 2, 2007

Millennium EMS Solutions Ltd.
#208, 4207- 98 Street
Edmonton, AB T6E 5R7

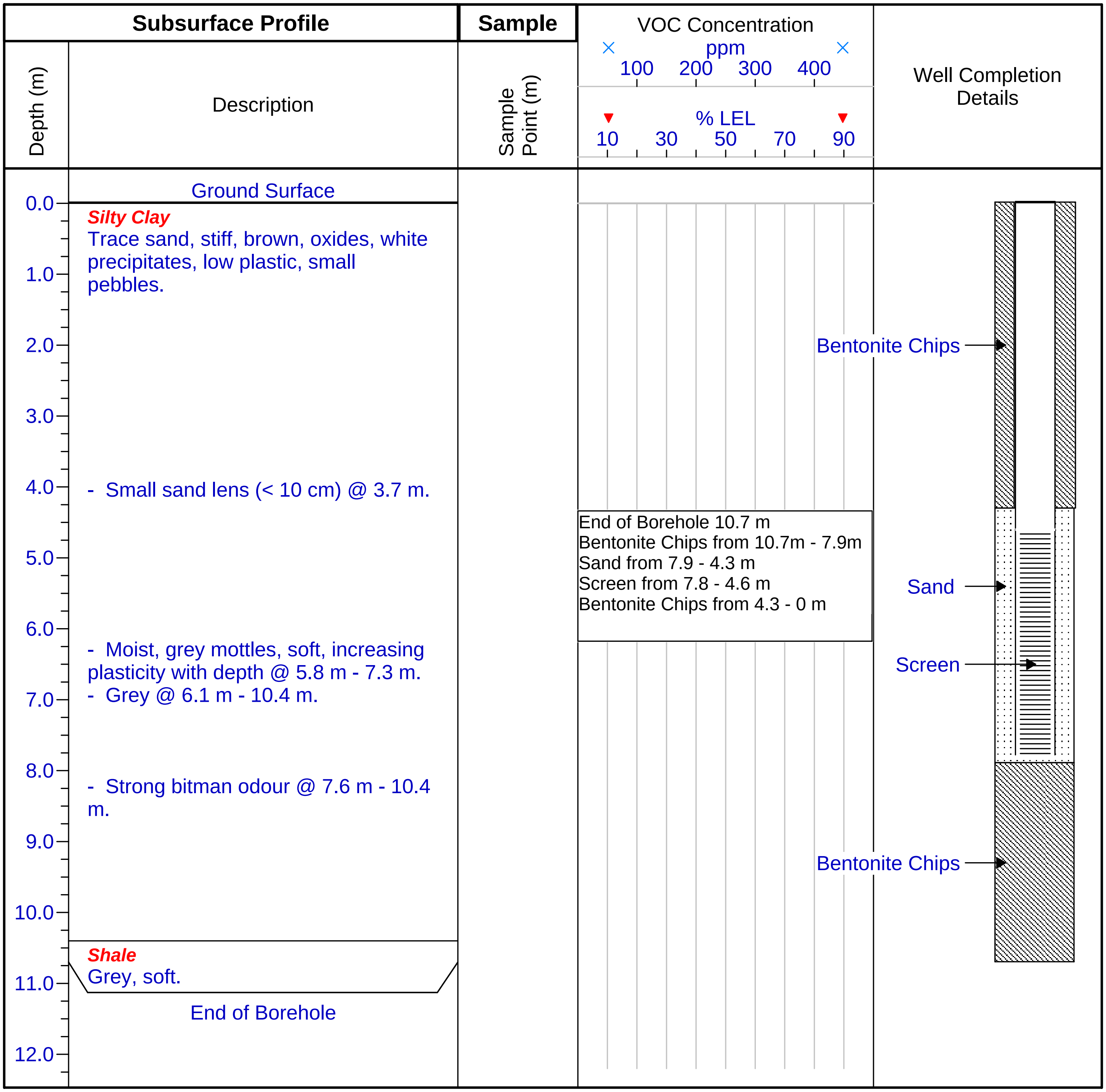
Project No: 04-101

Borehole No: MW7

Drill Method: Solid Stem Auger

Client: DCEL

Location: 107



Ground Surface

Silty Clay
Trace sand, stiff, brown, oxides, white precipitates, low plastic, small pebbles.

- Small sand lens (< 10 cm) @ 3.7 m.

- Moist, grey mottles, soft, increasing plasticity with depth @ 5.8 m - 7.3 m.
- Grey @ 6.1 m - 10.4 m.

- Strong bitman odour @ 7.6 m - 10.4 m.

Shale
Grey, soft.

End of Borehole

End of Borehole 10.7 m
Bentonite Chips from 10.7m - 7.9m
Sand from 7.9 - 4.3 m
Screen from 7.8 - 4.6 m
Bentonite Chips from 4.3 - 0 m

Logged By: KK

Entered By: CN

Drill Date: February 2, 2007

Millennium EMS Solutions Ltd.
#208, 4207- 98 Street
Edmonton, AB T6E 5R7

APPENDIX C: ALBERTA ENVIRONMENT LETTER OF RESPONSE

Alberta
Environment

Regional Services
111 Twin Atria Building
4999-98 Avenue
Edmonton, Alberta T6B 2X3

Telephone: (780) 427-7617
Fax: (780) 427-7824
Web: www.environment.gov.ab.ca

October 5, 2006

Mr. Stan McBride
Senior Environmental Advisor
Total E&P Canada Ltd.
Suite 1900, 333-7th Avenue S.W.
Calgary, AB T2P 2Z1

Dear Mr. McBride:

RE: Site Characterization Proposal- Joslyn Project Steam Release Report

Thank you for the Joslyn Project Steam Release report. Our staff has reviewed the report and our comments/questions are provided below in sections:

Groundwater:

The environmental site characterization program should confirm the following:

- the Wabasca Sand is not present in the close vicinity of the release
- the aeolin sands present in the NE portion of the lease do not extend to the immediate area of deposition.

The Groundwater Assessment Program should first establish the groundwater flow regime in the immediate vicinity of the release, and subsequently, the scope of groundwater assessment should be established.

Analytical parameters for groundwater sampling should also include phenols and dissolved metals including arsenic.

Surface Water:

- Figure 4.1 and Table B.2: It does not appear that any water samples were analysed within the area of the displaced soil plume in Joslyn creek (Figure 4.1). Is this correct? If so, please explain this exclusion.

- Figure 4.1 and Table B.2: It appears that a water sample was taken next to soil sampling location #1. Describe what type of waterbody is in that location. Additionally, is the analytical data for this location presented in Table B.2? Will this location be sampled as part of the upcoming surface water sampling program? If not, please explain its exclusion.

- P.10, Section 5.3: How many surface water samples will be taken and analysed from Joslyn creek within the displaced soil plume?

- Figure 4.1 and Table B.2: It appears that two surface water sampling locations are located downstream of the displaced soil plume in Joslyn creek. Please detail which of these locations is called "Joslyn creek downstream" as referenced in Table B.2. Also, indicate where the "25M SW W/C location" is located.

Soil:

Deer Creek Energy Limited (DCEL) did not describe the methods used for preliminary soil monitoring. These details can be important in interpretation of the analytical results. For example:

- How was the area of deposition indicated on Fig. 4.1 determined?
- What stratum of the soil profile or overlying material is represented by the analyses reported in Table B.1?
- Given the variation in naturally occurring soils in the area, how was the single control sample location (#5) selected?

Fig. 4.1 and Table B.1 indicated that the soil samples #1-4 were located at increasing distances (up to approximately 200 m) from the point of steam release. DCEL reported that 'the thickness of displaced soil > 2 cm is mostly limited to the area within a 50 m radius of the steam release point' (p. 8). Yet, some of the analyses are remarkably similar among all four samples, and do not reflect their position relative to the point of steam release. For example, the standard deviation of measurements of F3, F4 and total hydrocarbon contents, chloride and sodium contents, and pH ranged from 2 to 11% of the mean. DCEL stated on p. 8 that soil analytical results indicated that 'the potential contaminants of concern associated with the release are not highly mobile in the subsurface nor are they prone to leaching into surface water systems.' This is not strictly correct for contaminants such as chloride, although the actual mass present may constrain its distribution in the environment.

The proposed soil sampling strategy on pp. 8-9 also raised questions concerning methodology. For example, DCEL indicated on p. 8 that the 'extent of the distribution of the displaced soil' has been determined. The term 'displaced soil' is confusing. Soil is a naturally occurring body of mineral and organic material at the earth's surface. Was soil in fact displaced by the steam release? Or, does the term 'displaced soil' refer to sediments released from further below the surface. In the absence of description of the methods employed, can the reader be assured that the 'extent of the distribution' has been determined?

DCEL indicated that 'control sample locations' will be included in the soil-sampling program. It would be useful to consult baseline soil information, and describe the soils at all sampling locations based on the Canadian System of Soil Classification, to ensure that the control locations are indeed representative of all other sampling locations. Use of a coring device is appropriate for investigations where the mass of the contaminants or the volume of affected soil need to be determined. In this instance, shallow soil pits may be effective. The proposed strategy wherein the soil profile is sampled by 'discrete soil horizons' from a shallow pit can provide vertical delineation. Are the 'discrete soil horizons' collected to represent a vertical continuum? How will the bulk density measurements mentioned on p. 9 be used or interpreted?

Finally, Table 5.1 indicated that analyses will be 'representative.' For clarity, is a sample intended to be a combination of sampling position and depth-increment? And, will all samples be analyzed, or will a protocol be employed to analyze sufficient samples for vertical delineation of all contaminants at each sampling location within the target depth (to 60 cm)? Is the aliquot of soil analyzed intended to represent the entire mass of each sample—i.e., the 'discrete soil horizon' or depth-increment?

Risk Assessment Proposal:

The risk assessment proposal and methodology is acceptable and it appears to follow an appropriate step-wise approach for conducting risk assessments.

Sincerely

N Morin

Nicole Morin, M.Sc., P.Biol.
Risk Assessment and Management Specialist
Northern Region

cc: Margaret Klebek, AENV
David Bergstrom, AENV
Nicole Morin, AENV

APPENDIX D: ALS LABORATORY REPORT

ANALYTICAL REPORT

MILLENNIUM
ATTN: MARILIN SCHMIDT
208 4207 98 ST

EDMONTON AB T6E 5R7

Reported On: 02-APR-07 12:32 PM
Revision: 1

Lab Work Order #: **L477689**
Date Received: **12-FEB-07**

Project P.O. #:
Job Reference: 04-101
Legal Site Desc: DEAR CREEK BLOWOUT
CofC Numbers: 01279

Other Information:

Comments:

Cheryle Kearley

CHERYLE KEARLEY
General Manager, Fort McMurray

For any questions about this report please contact your Account Manager:

CHERYLE KEARLEY

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L477689-1 MW1								
Sampled By: M.S. on 12-FEB-07 @ 12:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
Toluene	0.0006		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
EthylBenzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
Xylenes	0.0016		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
F1(C6-C10)	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
F1-BTEX	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
F2 (>C10-C16)	0.12		0.05	mg/L	15-FEB-07	17-FEB-07	JEA	R494271
CCME PAHs								
Naphthalene	0.00010		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Quinoline	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Acenaphthene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Fluorene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Phenanthrene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Anthracene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Acridine	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Fluoranthene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Pyrene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Chrysene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Indeno(1,2,3-cd)pyrene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Dibenzo(a,h)anthracene	<0.00001		0.00001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Surr: Nitrobenzene d5	60		24-132	%	15-FEB-07	15-FEB-07	JME	R494010
Surr: 2-Fluorobiphenyl	53		37-123	%	15-FEB-07	15-FEB-07	JME	R494010
Surr: p-Terphenyl d14	83		50-142	%	15-FEB-07	15-FEB-07	JME	R494010
Naphthenic Acids	2		1	mg/L		14-FEB-07	JOB	R493488
Routine Water Analysis								
Chloride (Cl)	58		1	mg/L		14-FEB-07	CLT	R493262
ICP metals and SO4 for routine water								
Calcium (Ca)	76.0		0.5	mg/L		14-FEB-07	EOC	R493361
Potassium (K)	8.8		0.5	mg/L		14-FEB-07	EOC	R493361
Magnesium (Mg)	24.2		0.1	mg/L		14-FEB-07	EOC	R493361
Sodium (Na)	491		1	mg/L		14-FEB-07	EOC	R493361
Sulfate (SO4)	556		0.5	mg/L		14-FEB-07	EOC	R493361
Ion Balance Calculation								
Ion Balance	94.0			%		15-FEB-07		
TDS (Calculated)	1690			mg/L		15-FEB-07		
Hardness (as CaCO3)	289			mg/L		15-FEB-07		
Nitrate+Nitrite-N	1.3		0.1	mg/L		14-FEB-07	MCH	R493422
Nitrate-N	1.3		0.1	mg/L		14-FEB-07	MCH	R493422
Nitrite-N	0.07		0.05	mg/L		14-FEB-07	MCH	R493422
pH, Conductivity and Total Alkalinity								
pH	8.0		0.1	pH		14-FEB-07	UM	R493634
Conductivity (EC)	2560		0.2	uS/cm		14-FEB-07	UM	R493634
Bicarbonate (HCO3)	964		5	mg/L		14-FEB-07	UM	R493634
Carbonate (CO3)	<5		5	mg/L		14-FEB-07	UM	R493634
Hydroxide (OH)	<5		5	mg/L		14-FEB-07	UM	R493634
Alkalinity, Total (as CaCO3)	790		5	mg/L		14-FEB-07	UM	R493634

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L477689-1 MW1								
Sampled By: M.S. on 12-FEB-07 @ 12:00								
Matrix: WATER								
Routine Water Analysis								
L477689-2 MW3								
Sampled By: M.S. on 12-FEB-07 @ 12:00								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
Toluene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
EthylBenzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
Xylenes	0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
F1(C6-C10)	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
F1-BTEX	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
F2 (>C10-C16)	1.8		0.05	mg/L	15-FEB-07	17-FEB-07	JEA	R494271
CCME PAHs								
Naphthalene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Quinoline	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Acenaphthene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Fluorene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Phenanthrene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Anthracene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Acridine	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Fluoranthene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Pyrene	0.0002		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(a)anthracene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Chrysene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(b)fluoranthene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(k)fluoranthene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Benzo(a)pyrene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Indeno(1,2,3-cd)pyrene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Dibenzo(a,h)anthracene	<0.0001		0.0001	mg/L	15-FEB-07	15-FEB-07	JME	R494010
Surr: Nitrobenzene d5	0	SOL:MI	24-132	%	15-FEB-07	15-FEB-07	JME	R494010
Surr: 2-Fluorobiphenyl	0	SOL:MI	37-123	%	15-FEB-07	15-FEB-07	JME	R494010
Surr: p-Terphenyl d14	0	SOL:MI	50-142	%	15-FEB-07	15-FEB-07	JME	R494010
Note: PAH detection limit raised due to matrix interference.								
Naphthenic Acids	<1		1	mg/L		14-FEB-07	JOB	R493488
Routine Water Analysis								
Chloride (Cl)	11		1	mg/L		14-FEB-07	CLT	R493262
ICP metals and SO4 for routine water								
Calcium (Ca)	72.5		0.5	mg/L		14-FEB-07	EOC	R493361
Potassium (K)	6.6		0.5	mg/L		14-FEB-07	EOC	R493361
Magnesium (Mg)	9.2		0.1	mg/L		14-FEB-07	EOC	R493361
Sodium (Na)	56		1	mg/L		14-FEB-07	EOC	R493361
Sulfate (SO4)	22.3		0.5	mg/L		14-FEB-07	EOC	R493361
Ion Balance Calculation								
Ion Balance	100			%		15-FEB-07		
TDS (Calculated)	364			mg/L		15-FEB-07		
Hardness (as CaCO3)	219			mg/L		15-FEB-07		
Nitrate+Nitrite-N	0.3		0.1	mg/L		14-FEB-07	MCH	R493422
Nitrate-N	0.3		0.1	mg/L		14-FEB-07	MCH	R493422
Nitrite-N	<0.05		0.05	mg/L		14-FEB-07	MCH	R493422
pH, Conductivity and Total Alkalinity								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L477689-2	MW3								
Sampled By:	M.S. on 12-FEB-07 @ 12:00								
Matrix:	WATER								
Routine Water Analysis									
pH, Conductivity and Total Alkalinity									
	pH	7.5		0.1	pH		14-FEB-07	UM	R493634
	Conductivity (EC)	616		0.2	uS/cm		14-FEB-07	UM	R493634
	Bicarbonate (HCO3)	377		5	mg/L		14-FEB-07	UM	R493634
	Carbonate (CO3)	<5		5	mg/L		14-FEB-07	UM	R493634
	Hydroxide (OH)	<5		5	mg/L		14-FEB-07	UM	R493634
	Alkalinity, Total (as CaCO3)	309		5	mg/L		14-FEB-07	UM	R493634
L477689-3	MW4								
Sampled By:	M.S. on 12-FEB-07 @ 12:00								
Matrix:	WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)									
BTEX and F1 (C6-C10)									
	Benzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	Toluene	0.0007		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	EthylBenzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	Xylenes	0.0019		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	F1(C6-C10)	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	F1-BTEX	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	F2 (>C10-C16)	0.16		0.05	mg/L	15-FEB-07	17-FEB-07	JEA	R494271
CCME PAHs									
	Naphthalene	0.00016		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Quinoline	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Acenaphthene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Fluorene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Phenanthrene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Anthracene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Acridine	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Fluoranthene	0.00003		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Pyrene	0.00013		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Chrysene	0.00012		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Indeno(1,2,3-cd)pyrene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Dibenzo(a,h)anthracene	<0.00001		0.00001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
Surr:	Nitrobenzene d5	53		24-132	%	15-FEB-07	16-FEB-07	JME	R494010
Surr:	2-Fluorobiphenyl	60		37-123	%	15-FEB-07	16-FEB-07	JME	R494010
Surr:	p-Terphenyl d14	82		50-142	%	15-FEB-07	16-FEB-07	JME	R494010
	Naphthenic Acids	2		1	mg/L		14-FEB-07	JOB	R493488
Routine Water Analysis									
	Chloride (Cl)	46		1	mg/L		14-FEB-07	CLT	R493262
ICP metals and SO4 for routine water									
	Calcium (Ca)	62.8		0.5	mg/L		14-FEB-07	EOC	R493361
	Potassium (K)	7.0		0.5	mg/L		14-FEB-07	EOC	R493361
	Magnesium (Mg)	15.9		0.1	mg/L		14-FEB-07	EOC	R493361
	Sodium (Na)	291		1	mg/L		14-FEB-07	EOC	R493361
	Sulfate (SO4)	358		0.5	mg/L		14-FEB-07	EOC	R493361
Ion Balance Calculation									
	Ion Balance	93.7			%		15-FEB-07		
	TDS (Calculated)	1090			mg/L		15-FEB-07		

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L477689-3	MW4								
Sampled By:	M.S. on 12-FEB-07 @ 12:00								
Matrix:	WATER								
Routine Water Analysis									
Ion Balance Calculation									
	Hardness (as CaCO3)	222			mg/L		15-FEB-07		
	Nitrate+Nitrite-N	8.3		0.1	mg/L		14-FEB-07	MCH	R493422
	Nitrate-N	8.1		0.1	mg/L		14-FEB-07	MCH	R493422
	Nitrite-N	0.19		0.05	mg/L		14-FEB-07	MCH	R493422
pH, Conductivity and Total Alkalinity									
	pH	8.0		0.1	pH		14-FEB-07	UM	R493634
	Conductivity (EC)	1680		0.2	uS/cm		14-FEB-07	UM	R493634
	Bicarbonate (HCO3)	555		5	mg/L		14-FEB-07	UM	R493634
	Carbonate (CO3)	<5		5	mg/L		14-FEB-07	UM	R493634
	Hydroxide (OH)	<5		5	mg/L		14-FEB-07	UM	R493634
	Alkalinity, Total (as CaCO3)	455		5	mg/L		14-FEB-07	UM	R493634
L477689-4	MW6								
Sampled By:	M.S. on 12-FEB-07 @ 12:00								
Matrix:	WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)									
BTEX and F1 (C6-C10)									
	Benzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	Toluene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	EthylBenzene	<0.0005		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	Xylenes	0.0010		0.0005	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	F1(C6-C10)	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	F1-BTEX	<0.1		0.1	mg/L	15-FEB-07	16-FEB-07	PGM	R494190
	F2 (>C10-C16)	0.11		0.05	mg/L	15-FEB-07	17-FEB-07	JEA	R494271
CCME PAHs									
	Naphthalene	0.0002		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Quinoline	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Acenaphthene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Fluorene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Phenanthrene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Anthracene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Acridine	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Fluoranthene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Pyrene	0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(a)anthracene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Chrysene	0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(b)fluoranthene	0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(k)fluoranthene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Benzo(a)pyrene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Indeno(1,2,3-cd)pyrene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
	Dibenzo(a,h)anthracene	<0.0001		0.0001	mg/L	15-FEB-07	16-FEB-07	JME	R494010
Surr:	Nitrobenzene d5	0	SDO:RNA	24-132	%	15-FEB-07	16-FEB-07	JME	R494010
Surr:	2-Fluorobiphenyl	0	SDO:RNA	37-123	%	15-FEB-07	16-FEB-07	JME	R494010
Surr:	p-Terphenyl d14	0	SDO:RNA	50-142	%	15-FEB-07	16-FEB-07	JME	R494010
Note: PAH detection limit raised due to matrix interference.									
	Naphthenic Acids	1		1	mg/L		14-FEB-07	JOB	R493488
Routine Water Analysis									
	Chloride (Cl)	26		1	mg/L		14-FEB-07	CLT	R493262
ICP metals and SO4 for routine water									
	Calcium (Ca)	24.6		0.5	mg/L		14-FEB-07	EOC	R493361

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L477689-4 MW6								
Sampled By: M.S. on 12-FEB-07 @ 12:00								
Matrix: WATER								
Routine Water Analysis								
ICP metals and SO4 for routine water								
Potassium (K)	5.2		0.5	mg/L		14-FEB-07	EOC	R493361
Magnesium (Mg)	7.8		0.1	mg/L		14-FEB-07	EOC	R493361
Sodium (Na)	217		1	mg/L		14-FEB-07	EOC	R493361
Sulfate (SO4)	8.0		0.5	mg/L		14-FEB-07	EOC	R493361
Ion Balance Calculation								
Ion Balance	97.9			%		15-FEB-07		
TDS (Calculated)	612			mg/L		15-FEB-07		
Hardness (as CaCO3)	94			mg/L		15-FEB-07		
Nitrate+Nitrite-N	0.2		0.1	mg/L		14-FEB-07	MCH	R493422
Nitrate-N	<0.1		0.1	mg/L		14-FEB-07	MCH	R493422
Nitrite-N	0.16		0.05	mg/L		14-FEB-07	MCH	R493422
pH, Conductivity and Total Alkalinity								
pH	7.9		0.1	pH		14-FEB-07	UM	R493634
Conductivity (EC)	1020		0.2	uS/cm		14-FEB-07	UM	R493634
Bicarbonate (HCO3)	657		5	mg/L		14-FEB-07	UM	R493634
Carbonate (CO3)	<5		5	mg/L		14-FEB-07	UM	R493634
Hydroxide (OH)	<5		5	mg/L		14-FEB-07	UM	R493634
Alkalinity, Total (as CaCO3)	538		5	mg/L		14-FEB-07	UM	R493634

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
EHT	Routine - Exceeds Recommended Holding Time Prior To Analysis

Sample Parameter Qualifier key listed:

Qualifier	Description
SDO:RNA	Surrogate diluted out:% recovery not available
SOL:MI	Surrogate recovery outside acceptable limits due to matrix interference

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BTX,F1-CL	Water	BTEX and F1 (C6-C10)	EPA 5030B	EPA 5030/8015& 8260-P&T GC-MS/FID
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
F2-CL	Water	F2	EPA 3550B	EPA 3510/8000-GC-FID
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
N2N3-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3H-Colorimetry
NAPHTHENIC-ACID-FM	Water	Naphthenic Acids by FTIR		Naphthenic Acids by FTIR,Syncrude,1994
NO2-ED	Water	Nitrite-N		APHA 4500 NO2B-Colorimetry
NO3-ED	Water	Nitrate-N		APHA 4500 NO3H-Colorimetry
PAH-CCME-ED	Water	CCME PAHs	EPA 3510	EPA 3510/8270-GC/MS
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity		APHA 4500-H, 2510, 2320

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

01279

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
CL	ALS LABORATORY GROUP - CALGARY, ALBERTA, CANADA	ED	ALS LABORATORY GROUP - EDMONTON, ALBERTA, CANADA
FM	ALS LABORATORY GROUP - FORT MCMURRAY, ALBERTA, CANADA		

Reference Information

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million.

mg/L (units) - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

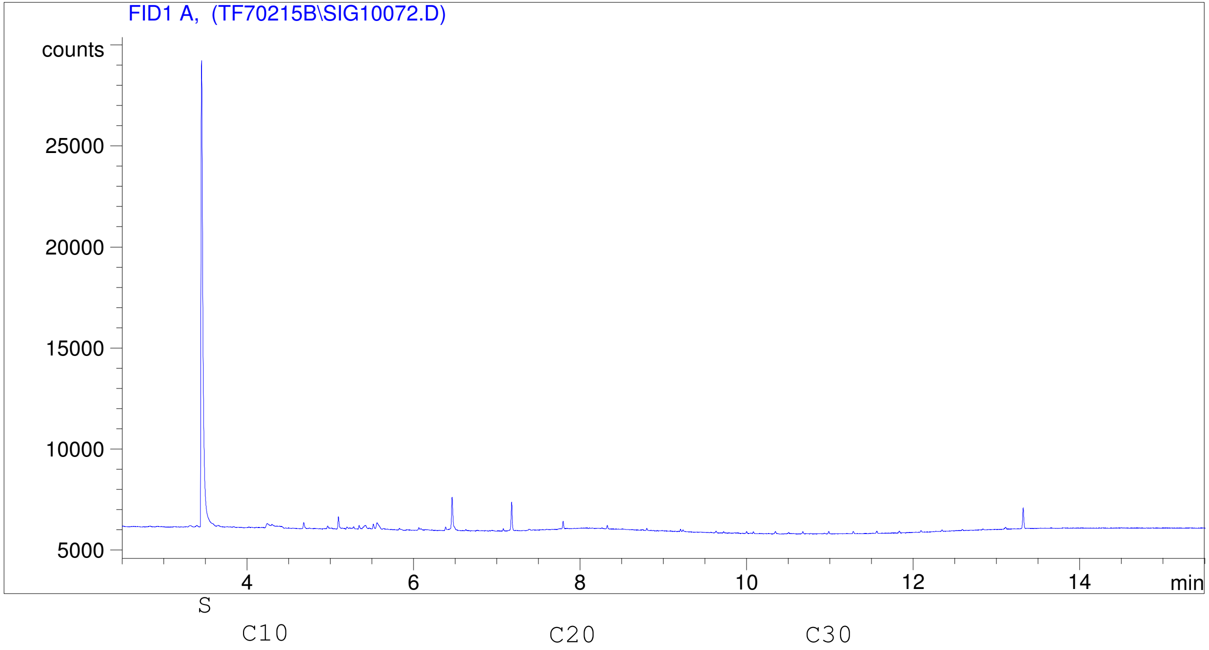
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

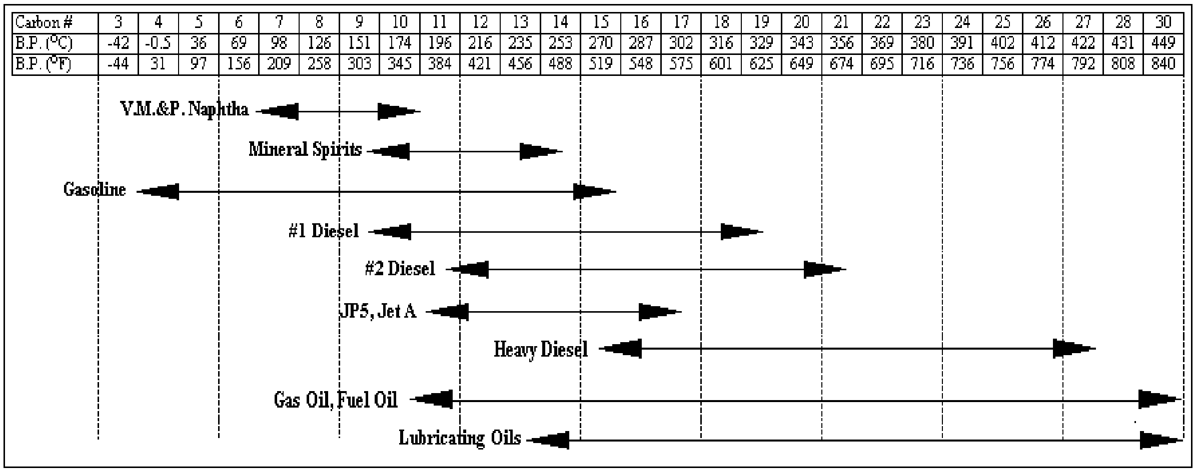
```
Client ID:         MW1

Sample ID:         L477689-1 V4F2
Injection Date:    2/17/2007
Injection Time:    12:12:14 AM
Instrument ID:     Instrument 1
```

Total Extractable Hydrocarbons



S = Surrogate

Boiling Point Distribution Range for Petroleum Based Fuel Products



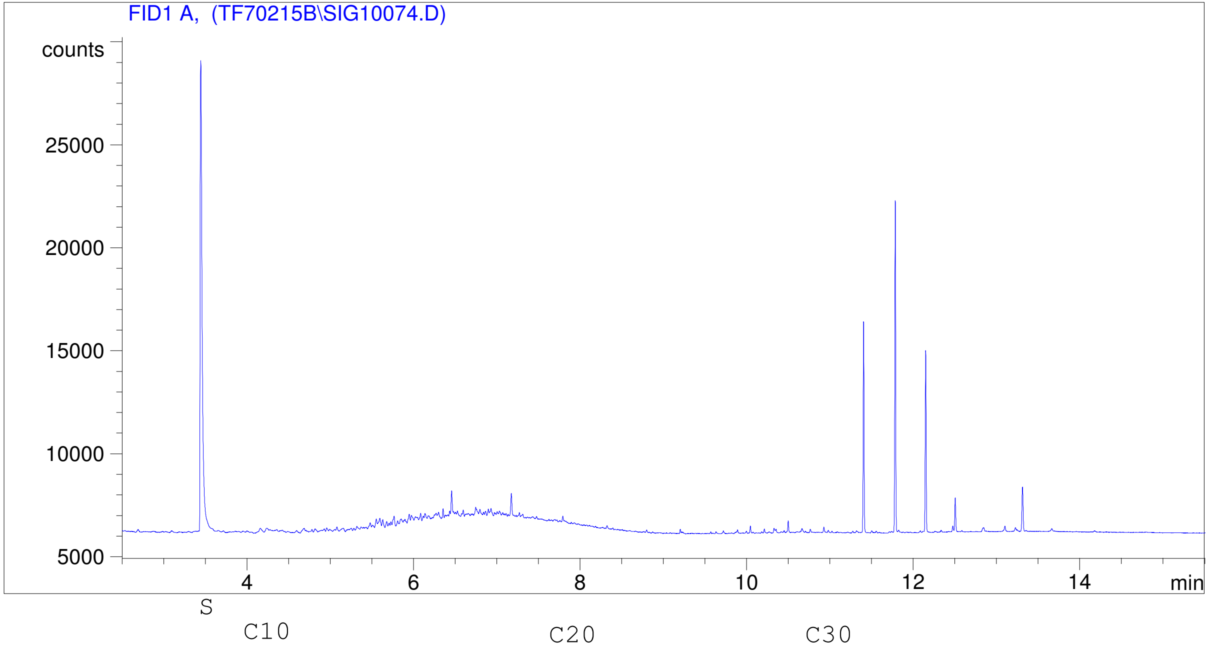
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W.,ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII.

Client ID: MW1

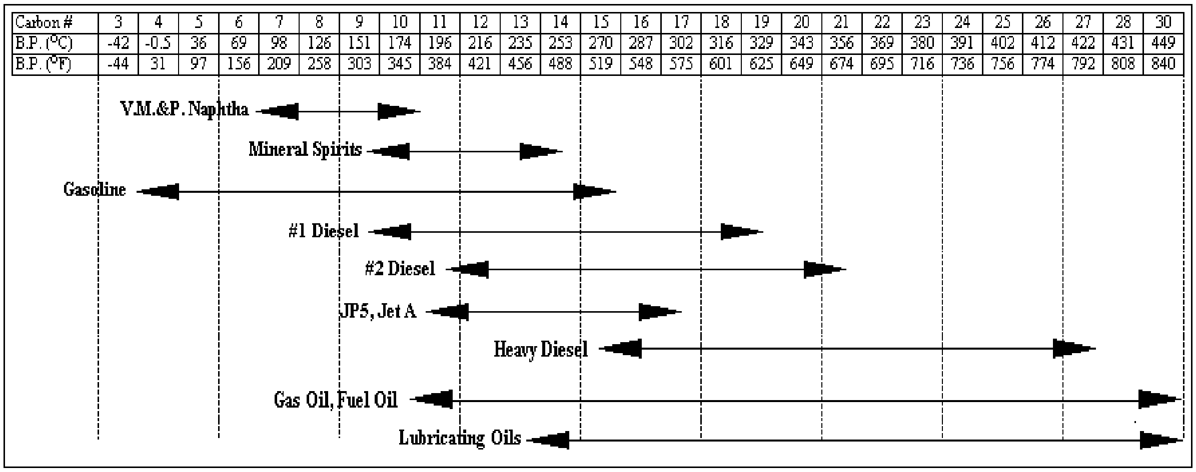
Sample ID: L477689-2 V4F2
Injection Date: 2/17/2007
Injection Time: 1:01:36 AM
Instrument ID: Instrument 1

Total Extractable Hydrocarbons



S = Surrogate

Boiling Point Distribution Range for Petroleum Based Fuel Products



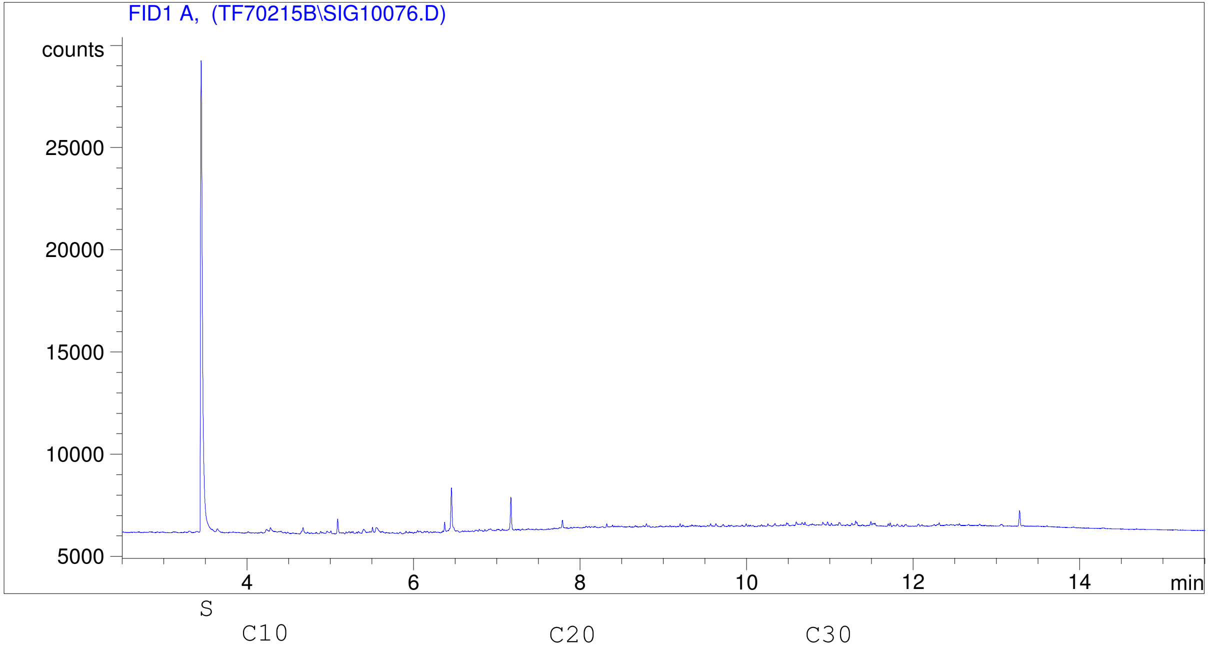
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W.,ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII.

Client ID: MW1

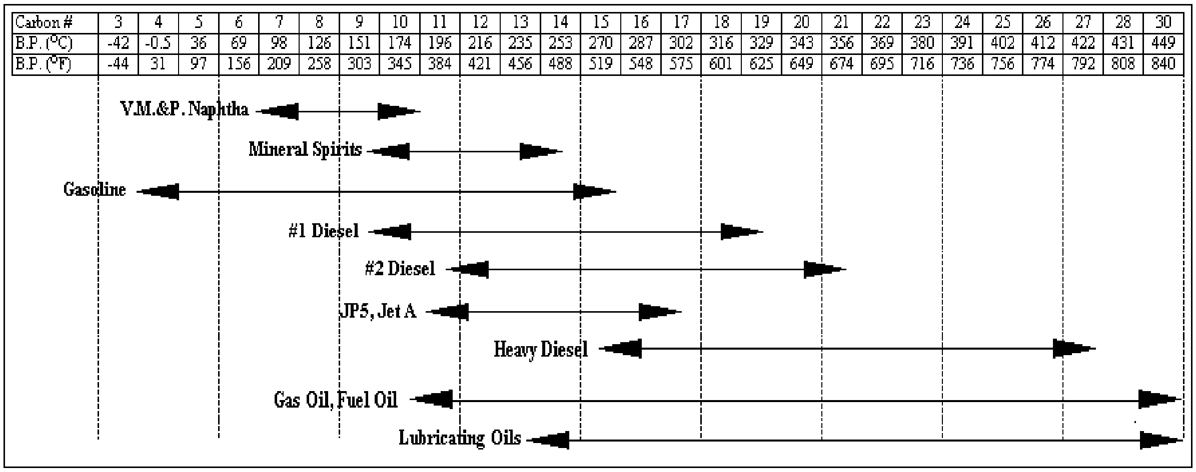
Sample ID: L477689-3 V4F2
Injection Date: 2/17/2007
Injection Time: 1:51:02 AM
Instrument ID: Instrument 1

Total Extractable Hydrocarbons



S = Surrogate

Boiling Point Distribution Range for Petroleum Based Fuel Products



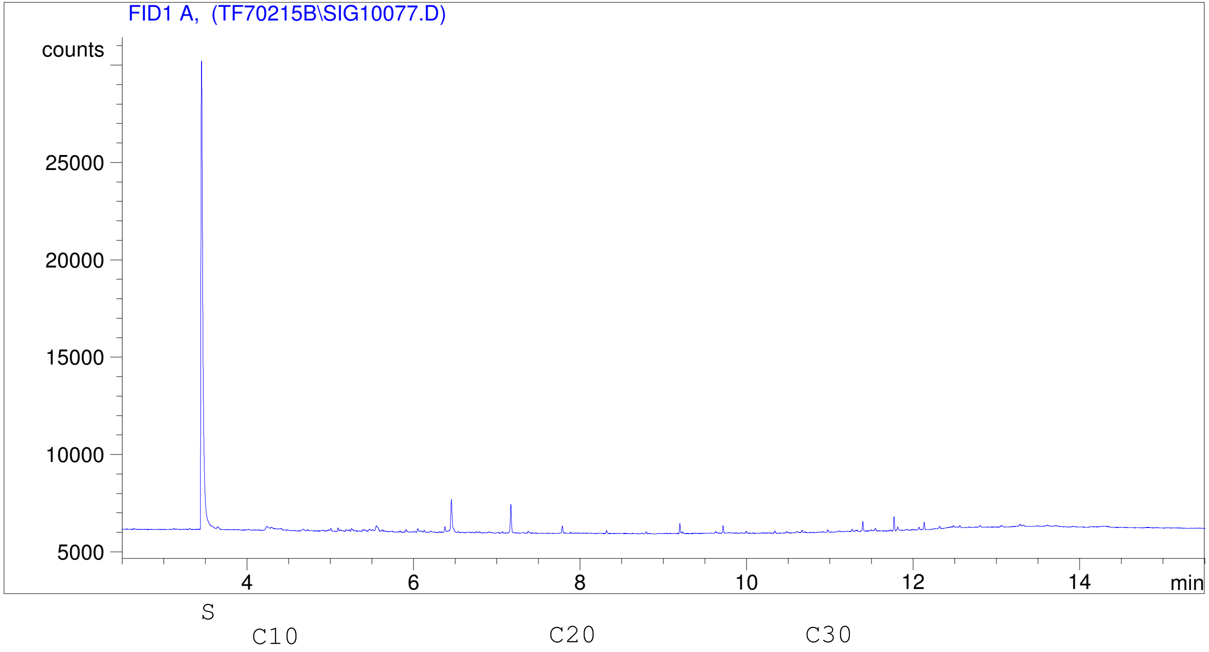
Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W.,ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII.

Client ID: MW1

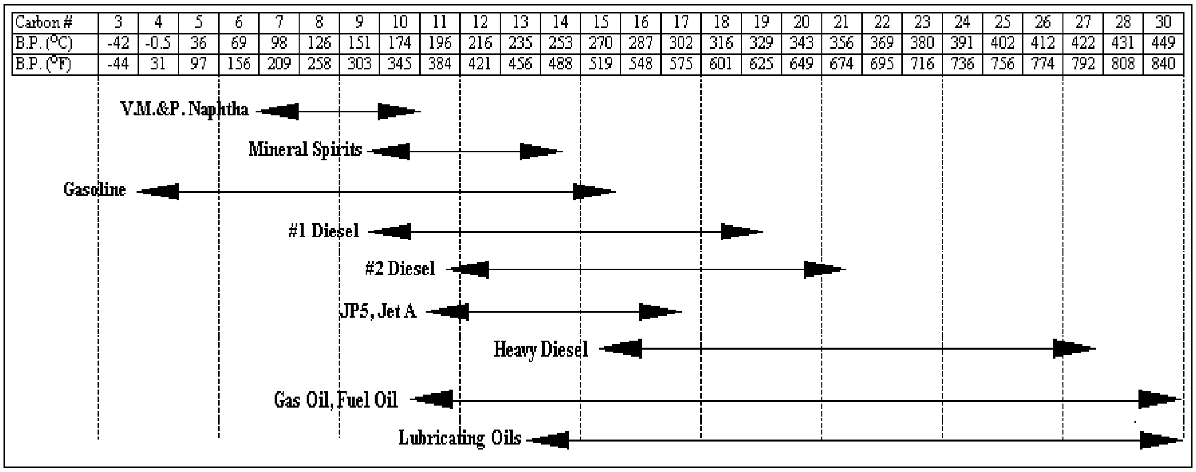
Sample ID: L477689-4 V4F2
Injection Date: 2/17/2007
Injection Time: 2:15:42 AM
Instrument ID: Instrument 1

Total Extractable Hydrocarbons



S = Surrogate

Boiling Point Distribution Range for Petroleum Based Fuel Products



Carbon #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
B.P. (°C)	-42	-0.5	36	69	98	126	151	174	196	216	235	253	270	287	302	316	329	343	356	369	380	391	402	412	422	431	449
B.P. (°F)	-44	31	97	156	209	258	303	345	384	421	456	488	519	548	575	601	625	649	674	695	716	736	756	774	792	808	840

Adapted from: Drews, A.W.,ED. Manual on Hydrocarbon Analysis, 4th ed.; American Society for Testing and Materials: Philadelphia, PA., 1989: p XVIII.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

CHAIN OF COUSTODY / ANALYTICAL REQUEST FORM

CANADA TOLL FREE 1-800-668-9878
www.alsenviro.com

COC # 01279

Page 1 of 1

REPORT TO:
COMPANY: Millennium EMS Solutions
CONTACT: Marlin Schmidt
ADDRESS: #208, 4207-98 Street
Edmonton, AB
PHONE: 780-496-9048 FAX: 780-496-9049

REPORT FORMAT / DISTRIBUTION
[✓ STANDARD] OTHER
[✓ PDF] EXCEL CUSTOM FAX
EMAIL 1: mschmidt@mems.ca
EMAIL 2:

SERVICE REQUESTED
REGULAR SERVICE (DEFAULT) ✓
RUSH SERVICE (2-3 DAYS)
PRIORITY SERVICE (1 DAY or ASAP)
EMERGENCY SERVICE (<1 DAY / WEEKEND) - CONTACT ALS

INVOICE TO: SAME AS REPORT ? [✓ YES] / NO
COMPANY:
CONTACT:
ADDRESS:
PHONE: FAX:

INDICATE BOTTLES: FILTERED / PRESERVED (F/P) ➤➤

CLIENT / PROJECT INFORMATION:
JOB #: 04-101
PO/AFE:
Legal Site Description: Deer Creek Blowout
QUOTE #:

Lab Work Order # (lab use only) L477689

SAMPLER (Initials): M.S.

ANALYSIS REQUEST

Sample #	SAMPLE IDENTIFICATION (This description will appear on the report)	DATE	TIME	SAMPLE TYPE	BTEX F1, F2	Napthenic Acid	Detailed Salinity	PAHs	HAZARDOUS?	HIGHLY CONTAMINATED?	NUMBER OF CONTAINERS
	MW1	12 Feb. 07	12:00 p.m.	Water	✓	✓	✓	✓			
	MW3										
	MW4										
	MW6										

GUIDELINES / REGULATIONS

SPECIAL INSTRUCTIONS / HAZARDOUS DETAILS

Failure to complete all portions of this form may delay analysis. Please fill in this from *LEGIBLY*.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse page of the white report copy.

RELINQUISHED BY:	DATE & TIME: 12 Feb. 2007 1:00 pm	RECEIVED BY:	DATE & TIME: 12-Feb-07
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME: 14:30

SAMPLE CONDITION (lab use only)
TEMPERATURE
SAMPLES RECEIVED IN GOOD CONDITION? YES / NO
(If no provide details)

REFER TO BACK PAGE FOR REGIONAL LOCATIONS AND SAMPLING INFORMATION

WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY

GENF14.00

Deer Creek Energy Limited
Steam Release Incident
LSD 09-33-095-12-W4M

Volume V – Human Health and Ecological Risk Assessment

Project Prepared for:
Millennium EMS Solutions Ltd
#208, 4207 – 98 Street
Edmonton, Alberta
T6E 5R7

On Behalf of:
Deer Creek Energy Limited

Prepared by:

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August 1, 2007

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1. INTRODUCTION

Millennium EMS Solutions Ltd. (MEMS) retained Axiom Environmental Inc. (Axiom) to conduct a human health and ecological health risk assessment for displaced oilsand material (“displaced material”) on lands impacted by the Joslyn Project steam release at the Deer Creek Energy Limited (DCEL) site at 09-33-095-12-W4M (the Site). The Site is located approximately 60 km north of Fort McMurray, on the west side of the Athabasca River.

1.1 Objectives and Scope of Work

The objectives of this risk assessment were:

1. to determine whether displaced material at various locations within the Site presented a risk to the health of humans or the environment; and,
2. make recommendations for appropriate management of displaced material at the Site based on the results of the risk assessment.

The scope of work for this risk assessment includes the following tasks:

- Review the environmental site assessment reports listed in Section 2.1 of this report, and briefly summarize the Site history, Site setting, and nature and extent of contamination at the Site.
- Conduct a risk assessment problem formulation for the Site.
- Develop site-specific guidelines for chemicals of potential concern as appropriate using current Alberta Environment guideline development protocols (AENV, 2007a).
- Based on the results of the risk assessment, make risk management recommendations for the appropriate management of displaced material at the Site.
- Generate draft and final reports.

1.2 Definitions of Deposit Areas

displaced material was released from the steam release location, and was transported south by southwest (downwind) across Joslyn Creek forming a deposit that covered an area of approximately 1 km in length by 100 m in width. Three distinct zones of the deposit are defined for ease of reference in this report.

- ***The “Unstable Area***” is defined as the area closest to the release location and cannot currently be entered due to geotechnical instability / personnel safety considerations. The exact extent of the Unstable Area will need to be defined by an appropriately qualified safety professional.

- ***The "Near Deposit"*** includes that part of the deposit with sufficient thickness to be identified and sampled as a distinct layer of displaced material. Based on field observations and practical sampling considerations (MEMS, 2006a), the Near Deposit was defined as the area with a thickness of displaced material greater than 2 cm. The Near Deposit is mostly located within 200 m south southwest of the steam release point (Figure 4).
- ***The "Trace Deposit"*** extends out to approximately 1 km from the steam release point, and comprises that part of the deposit with less than 2 cm of displaced material (Figure 4).

2. BACKGROUND

2.1 Site History

The Joslyn Phase II Project is a Steam Assisted Gravity Drainage (SAGD) operation. The current phase of the project started injecting steam into the reservoir on April 15, 2006. Steam was circulated for approximately 1 month, and then bitumen production commenced. After three days of production, on May 18th, 2006, a steam release was discovered. Prior to the release being controlled, the released steam displaced oilsand material from the Fort McMurray oilsands reservoir to the surface, and distributed it in a plume downwind in a south by southwest direction. The steam release location and the general extent of the plume are indicated on Figure 1.

2.2 Environmental Investigations

Environmental site assessments that were made available as source information for this risk assessment are summarized in Table 1.

Table 1. Available Environmental Investigation Reports

Report Date	Program	Reference
December, 2006	DCEL Steam Release Incident, Volume II - Soil Delineation Program: Summary Report	MEMS (2006a)
December, 2006	DCEL Steam Release Incident, Volume III - Surface Water Monitoring Program: Summary Report	MEMS (2006b)
April, 2007	DCEL Steam Release Incident, Volume IV - Groundwater Monitoring Program: Summary Report	MEMS (2007b)

2.3 Site Setting

The Site is located in northeastern Alberta, approximately 60 km north of Fort McMurray, and lies within the Boreal Plains Ecozone.

2.3.1 Topography, Drainage and Surface Water

The release area is characterized by subdued topography. The greatest relief, of the order of three to five meters is found along drainage courses. The nearest surface water body to the steam release point is Joslyn Creek, which lies approximately 350 m to the south of the release point. The relief from the steam release point to Joslyn Creek is approximately 3 – 5 m.

2.3.2 Geology

The Joslyn Project targets the oilsands of the Cretaceous McMurray Formation, which consists of bitumen-containing stacked fluvial-estuarine sands and off-channel silts and sands. In the project area, the McMurray Formation in present from approximately 40-60 m below ground level to a depth of approximately 115 m. The McMurray Formation is overlain by 20-30 m of the Cretaceous Clearwater Formation, which consists predominantly of marine shales, and do not contain bitumen. Pleistocene tills overlie the Clearwater Formation.

2.3.3 Soils

Several different soil types are present at the Site, depending primarily on topographic location (upland, intermediate, lowland, creek floodplain). Soils at the Site were classified into one of the following four series (MEMS, 2006a; Figures 3a and 3b):

- DOV – An Orthic Grey Luvisol of the Dover (DOV) series is the predominant soil in the area, and is found in upland areas.
- MMW – An Orthic Rego Gleysol of the Mamwai (MMW) series is present along the edges of drainways.
- MMY – An Orthic Humic Regosol of the McMurray (MMY) soils complex is found in the floodplain of Joslyn Creek.
- MUS – An organic soil, mapped as a Muskeg (MUS) series organic is present in low lying depressional areas.

Based on seven borehole logs presented in MEMS (2007b), Site soils are underlain by approximately 4.5 to 10.5 m of unconsolidated sediments overlying sandstone or shale bedrock. The unconsolidated sediments are described predominantly as brown or grey clay, with some observations of silty or sandy clay, and occasional small (< 10 cm) sand lenses .

2.3.4 Hydrogeology

MEMS (2007b) describes a groundwater monitoring program that consisted of the installation and sampling of seven monitoring wells in and around the areas of displaced material. Two of the wells were dry, and the remainder indicated groundwater depths between approximately 1.7 and 4.7 m below ground level. The measured groundwater elevations did not lend themselves to the determination of a groundwater flow pattern, and suggested that discontinuous or perched groundwater is present in shallow sediments at the Site.

Hydraulic conductivity values were not reported in MEMS (2007b). However, information provided by MEMS (Doug Hackbarth, *pers. com.*) from monitoring wells in adjacent projects indicated a range of hydraulic conductivity from 4 x 10^{-8} m/s to 3 x 10^{-9} m/s (7 monitoring wells) with one, apparently anomalous monitoring well yielding 1 x 10^{-6} m/s.

2.4 Applicable Guidelines

For screening purposes chemical concentrations in soil were compared to the latest Alberta Tier 1 (AENV, 2007a) soil quality guidelines. Guidelines were available for petroleum hydrocarbons, salinity parameters, and metals. No guidelines were available for naphthenic acids, which were screened against background conditions.

Alberta Tier 1 Guidelines for selected parameters for fine soil and natural area land use are provided in Table 2 below.

Table 2. Applicable Alberta Tier 1 Soil Quality Guidelines

Parameter	Guideline (mg/kg)
F2	150
F3	1,300
F4	5,600
SAR	4

Notes:
Guideline values for fine soil and natural area land use.
F2, F3, and F4 are petroleum hydrocarbon fractions
SAR is sodium adsorption ratio

3. NATURE AND EXTENT OF CONTAMINATION

An assessment of the nature and extent of contamination at the Site is relatively straightforward in the sense that the only anthropogenic event of concern at the Site is the steam release incident noted in Section 2.1. MEMS (2006a,b, 2007b) conducted environmental site investigations focusing on soil, surface water and groundwater, respectively. The results of these programs salient to this risk assessment are summarized in the following three sections.

3.1 Soil

MEMS (2006a) reports the results of analysis at 101 locations (Figures 2a and 2b), including 90 delineation locations, 8 area-specific controls (just outside the area estimated to be impacted), and 3 perimeter controls (well away from the impacted area, as a check on the area-specific controls).

3.1.1 Displaced Material

Samples from the Near Deposit are essentially samples of displaced material. Samples of displaced material from this area are characterized by high levels of F2, F3, and F4 hydrocarbons, with average F2, F3, and F4 concentrations of approximately 1,200 mg/kg, 16,000 mg/kg, and 8,000 mg/kg, respectively. In addition, the sodium adsorption ratio is high, with an average of approximately 26. Pyrene is also above guideline values in the displaced material, however, for petroleum hydrocarbon mixtures, non-carcinogenic PAHs are managed via management of the hydrocarbon fractions and no specific attention to pyrene will be required at this Site. Naphthenic acids were analyzed in one sample of displaced material, and a concentration of 44 mg/kg was determined. Concentrations of other parameters, including benzene, toluene, ethylbenzene, and xylenes (BTEX), hydrocarbon fraction F1, salts, and trace metals were generally within guideline values.

3.1.2 Surface Litter

Mineral soils in the Site area are typically overlain by a surface litter layer of decomposing organic material referred to as the LFH layer. In the Trace Deposit, it was not possible to sample the displaced material directly, since it had typically sifted into the LFH layer. The shallowest samples from the Trace Deposit were therefore typically composite samples of the LFH layer together with any displaced material. Assessment of contaminants in the LFH layer was confounded by two factors:

1. The LFH layer contains humic substances which are detected as F2, F3, and F4 hydrocarbons by the analytic method used.
2. The soil quality guideline for F2, F3 and F4 (and a range of other parameters) are based on toxicity tests conducted in soil. The LFH layer will have a significantly higher organic carbon content than the test soils, and accordingly the availability and toxicity of the hydrocarbons to plants and invertebrates will be different (very likely lower) than in the tests. Thus generic hydrocarbon soil quality guidelines are not relevant for assessing contaminant levels in the LFH layer.

Point one above was addressed in MEMS (2006a) by determining mean background concentrations for F2, F3, and F4 in control samples for each soil type, and making a background correction. F2, F3, and F4 were present in the LFH layer above all four soil types at concentrations above background.

The majority of SAR analyses in the LFH layer yielded values below the guideline value of 4. However, one sample of the LFH layer in a DOV-series soil yielded an SAR of 5.8, and one sample of the LFH layer in a MUS-series soil yielded an SAR of 15.6.

Naphthenic acids were measured in a limited number of LFH layer samples, yielding relatively high concentrations (1,500-3,900 mg/kg). However, since the naphthenic acid measured in the displaced material was much lower (44 mg/kg), it was assumed that the naphthenic acids measured in the LFH layer were naturally occurring.

3.1.3 Mineral Soil

Samples of mineral soil were analyzed from surficial layers immediately beneath the LFH layer in DOV, MMW, and MMY soils. Samples were analyzed for hydrocarbons (BTEX, F1 to F4, and, in some cases naphthenic acids and/or PAHs), major ions and salinity parameters. All parameters were either consistent with background values and/or were within applicable guideline values except for naphthenic acids. Naphthenic acids were measured in a limited number of mineral soil samples, yielding concentrations in the range 52-99 mg/kg. However, since the naphthenic acid measured in the displaced material was lower (44 mg/kg), it was assumed that the naphthenic acids measured in the mineral soil were naturally occurring.

3.2 Surface Water

MEMS (2006b) conducted a surface water monitoring program. Samples were collected from two locations on Joslyn Creek upstream of the deposition zone, one location within the deposition zone and three locations downstream of the deposition zone. One of the downstream locations was sampled on four consecutive days shortly after the steam release. Samples were analyzed for hydrocarbons including BTEX, F1, F2, and PAHs, major ions salinity parameters, and trace metals. Downstream samples did not show any parameters significantly elevated over the corresponding upstream values, and accordingly there appear to be no concerns with surface water quality in Joslyn Creek.

3.3 Groundwater

MEMS (2007b) installed and sampled seven monitoring wells to identify possible groundwater contamination at the Site. All the wells were installed in the surficial sediments at the Site. Groundwater samples were analyzed for hydrocarbons including BTEX, F1, F2, PAHs, and naphthenic acids, and major ions and salinity parameters. BTEX, F1, F2, and PAHs were either not detected, or in a few cases were detected but were well below guideline levels. Naphthenic acids, major ions and salinity parameters were all within the expected range of background conditions. Overall, there are currently no concerns with groundwater quality at the Site.

4. RISK ASSESSMENT PROBLEM FORMULATION

Problem formulation is the first step in a human health or environmental health risk assessment. This step assesses land use, identifies chemicals of potential concern, provides an exposure pathway assessment, and identifies receptors of potential concern, and is used to focus the risk assessment on the situations or conditions most likely to be important at the Site.

Principles used in developing this risk assessment problem formulation are based on the latest Alberta Environment guidance in AENV (2007a,b), and also on currently–accepted practices in risk assessment (CCME, 1996, 2005; Health Canada 2004; US EPA 1989, 1997).

4.1 Land Use

Land use is important in the problem formulation stage of a risk assessment because it defines the sorts of activities that would be expected to occur at a site, and has implications for societal expectations as to the receptors and exposure pathways that need to be protected.

The Site is located approximately 60 km north of Fort McMurray, west of the Athabasca River. Land use at the Site is consistent with the definition of “natural area” land use provided in AENV (2007a). Natural areas are defined as being away from human habitation and activities, where the primary concern is the protection of ecological receptors. Accordingly, human exposure pathways are not assessed directly, with the exception of the protection of groundwater for drinking water pathway which, based on the definition of a Domestic Use Aquifer (DUA), applies in all land uses.

Intermittent human presence is assumed to occur in natural areas, however, it is assumed that ecological receptors, having much closer contact with contaminants than humans, will be more exposed, and thus protecting ecological receptors will also protect humans who may use the Site occasionally.

4.2 Chemicals of Potential Concern

As noted in Section 3, the source of contamination at the Site is displaced oilsand material “displaced material”. The chemical properties of this material are relatively uniform, and it is characterized by petroleum hydrocarbon fractions F2, F3, and F4, and sodium adsorption ratio (SAR) that are above generic guidelines (MEMS, 2007b). Naphthenic acids can be of concern in contaminant situations related to oilsands deposits, however, as indicated in Section 3, the displaced material includes only low concentrations of naphthenic acids, and most of the naphthenic acids measured in organic or mineral soils appear to be naturally occurring.

MEMS (2006a, b, 2007b) investigated the distribution of contaminants in soil, surface water (Joslyn Creek), and groundwater, respectively. All chemical parameters in surface water and groundwater were consistent with background conditions (Section 3), and therefore there are no chemicals of potential concern in surface water or groundwater.

Based on data in MEMS (2006a) and Section 3, the following are identified (Table 3) as chemicals of potential concern in each of the areas defined in Section 1.2. Note that the LFH layer and the underlying soil in the Trace Deposit are considered separately.

Table 3. Chemicals of Potential Concern

	Chemical of Potential Concern?			
Chemical	**Displaced Material in Unstable Area**	**Displaced Material in Near Deposit**	**LFH Layer in Trace Deposit**	**Underlying Mineral Soil in Trace Deposit**
F2	Yes	Yes	Yes	No
F3	Yes	Yes	Yes	No
F4	Yes	Yes	Yes	No
SAR	Yes	Yes	Yes	No
Naphthenic acids	No	No	No	No

Hydrocarbon fractions F2, F3, F4, and sodium adsorption ratio are chemicals of potential concern in the LFH layer based on these parameters exceeding generic guidelines in that layer. Naphthenic acids measured in the LFH layer appear to be naturally occurring, and therefore are not considered a chemical of potential concern. There are no chemicals of potential concern in the underlying mineral soil, since all chemicals were below generic background concentrations or were consistent with background conditions.

4.3 Exposure Pathway Analysis

Exposure pathway analysis is the process in which all the potential exposure pathways through which chemicals of potential concern could reach receptors of potential concern are considered. Those exposure pathways which could not realistically result in a receptor of concern being exposed to chemicals of potential concern at the Site are considered “incomplete” and are not considered further. Complete exposure pathways are retained for further consideration and analysis in the Exposure Assessment (Sections 6 and 7). Thus the exposure pathway analysis is a useful tool to focus risk assessment efforts on the exposure pathways most likely to be of significance at a Site. Separate exposure pathway analyses are provided for i) the Unstable Area, and ii) the Near Deposit and Trace Deposit together as described below.

The exposure pathway analysis for the Unstable Area is summarized in Table 4, and reflects what is understood to be DCEL's preferred remediation strategy for this area, which is to cap the Unstable Area with at least 3 m of soil, and allow the weight of the cap to help compact the geotechnically Unstable Area. This would result in the direct exposure pathways becoming incomplete for the displaced material in the Unstable Area.

Table 4. Exposure Pathway Analysis – Unstable Area

Exposure Pathway	Complete?	Rationale
Human Exposure Pathways		
Human direct contact (soil ingestion, dermal contact, particulate inhalation)	No	Not complete, since there will be no direct contact with the displaced material.
Human indoor vapour inhalation	No	Not complete since no permanent residents are expected at the Site and this exposure pathway is not considered (AENV, 2007a) under natural area land use.
Human ingestion of potable groundwater	No	Based on information in MEMS (2007a), the site is underlain by approximately 40m of low permeability sediments, a sandstone with high TDS water, and then oilsand deposits. MEMS (2007a) concludes that the Site is not underlain by a domestic use aquifer, and this risk assessment concurs with the MEMS (2007a) conclusion.
Ecological Exposure Pathways		
Direct contact with plants and soil invertebrates	No	Not complete, since there will be no direct contact with the displaced material.
Wildlife soil ingestion	No	Not complete, since there will be no direct contact with the displaced material.
Groundwater transport of contaminants to aquatic life or wildlife in Joslyn Creek	Yes	The potential for contaminants to be transported in groundwater to Joslyn Creek must be considered.

Note:
This exposure pathway analysis assumes that the displaced material in the Unstable Area will have a cap of at least 3m of soil placed on it.

As indicated in Table 4, only one exposure pathway is considered complete at the Site for the Unstable Area. This pathway is addressed in Section 6 of this report.

The exposure pathway analysis for the Near Deposit and Trace Deposit is summarized in Table 5, and reflects the exposure pathways relevant to a surficial deposit of displaced material.

Table 5. Exposure Pathway Analysis – Near Deposit and Trace Deposit

Exposure Pathway	Complete?	Rationale
Human Exposure Pathways		
Human direct contact (soil ingestion, dermal contact, particulate inhalation)	No	Not complete since no permanent residents are expected at the Site and this exposure pathway is not considered (AENV, 2007a) under natural area land use.
Human indoor vapour inhalation	No	Not complete since no permanent residents are expected at the Site and this exposure pathway is not considered (AENV, 2007a) under natural area land use.
Human ingestion of potable groundwater	No	Based on information in MEMS (2007a), the site is underlain by approximately 40m of low permeability sediments, a sandstone with high TDS water, and then oilsand deposits. MEMS (2007a) concludes that the Site is not underlain by a domestic use aquifer, and this risk assessment concurs with the MEMS (2007a) conclusion.
Ecological Exposure Pathways		
Direct contact with plants and soil invertebrates	Yes	Plant roots and invertebrates could come into contact with contaminants in and on the surface soil and overlying organic matter (LFH layer)
Wildlife soil ingestion	Yes	Wildlife species present at the Site may ingest displaced material directly, or may ingest contaminated soil, and/or fodder.
Groundwater transport of contaminants to aquatic life or wildlife in Joslyn Creek	Yes	The potential for contaminants to be transported in groundwater to Joslyn Creek must be considered.

As indicated in Table 5, three exposure pathways are considered complete at the Site for the Near and Trace Deposits. Each of these exposure pathways is analyzed in detail in Section 7 of this risk assessment.

4.4 Receptors of Potential Concern

Human receptors of potential concern for the Site are hypothetical people who might make use of a Domestic Use Aquifer at the Site, now or in the future.

Ecological receptors of concern include all elements of the local ecosystem. However, experience has shown that certain key ecosystem elements (species, or groups of organisms) are maximally affected in particular contaminant situations, and that by identifying and ensuring the protection of these maximally affected elements, the whole ecosystem can be protected. The key ecosystem elements identified for this risk assessment, and the rationale for selecting each are summarized in Table 6.

Table 6. Key Ecosystem Elements

Ecosystem Element	Species Selected	Rationale
Plants	Generic Plant	Plants may come into direct contact with contaminant chemicals in soil.
Soil Invertebrates	Generic Invertebrate	Soil invertebrates may come into direct contact with contaminant chemicals in soil.
Wildlife Species	Meadow Vole (*Microtus pennsylvanicus*)	Small species are typically maximally exposed to contaminants in soil and food, due to a high ingestion rate to body weight ratio, and a small range area. The meadow vole was selected to represent all wildlife species based on its small size, ubiquitous presence in a wide range of habitats, and range that includes the Site. In addition, it is the species used by AENV (2007a) to develop Tier 1 guidelines.

5. RISK ASSESSMENT APPROACH

As noted in Section 1.2, three distinct zones of the deposit are defined. Each of these zones requires a different risk assessment approach, as noted below.

5.1 Unstable Area

As noted in Section 1.2, the Unstable Area is defined as the area closest to the steam release point, where the release has affected the geotechnical stability of the ground, and there are safety concerns restricting the options for remediation in this area.

Geotechnical and safety concerns are outside the scope of this risk assessment, and it is recommended that the site be inspected by an appropriately qualified safety professional to determine the extent of the Unstable Area, and what restrictions need to be placed on access to ensure worker and public safety.

It is understood that DCEL's preferred remediation strategy for the Unstable Area is to add a cap of at least 3 m of soil to the Unstable Area, and allow the weight of the cap to help compact the geotechnically Unstable Area. This approach would effectively exclude any of the direct contact exposure pathways for the displaced material in the Unstable Area as indicated in Table 4.

This strategy would fall under the "Exposure Control" scenario of AENV (2007a,b). The exposure assessment for the Unstable Area is provided in Section 6.

5.2 Near Deposit

As noted in Section 1.2, the Near Deposit includes that part of the deposit with sufficient thickness to be identified and sampled as a distinct layer of displaced material. MEMS (2006a) reports the results of the analysis of eight samples of displaced material. Mean concentrations for chemicals that exceed AENV (2007a) guideline values are summarized in Table 7.

PHC fractions F2, F3, and F4, and sodium adsorption ratio exceed AENV (2007a) guideline values. PHC F3 exceeds the guideline by over an order of magnitude.

The displaced material in the Near Deposit is an identifiable layer with similar properties to a mineral soil and concentrations of F3 that exceed applicable guidelines by an order of magnitude for some parameters. Accordingly, the displaced material in the Near Deposit will require removal, remediation or other management, and is not considered further in this risk assessment.

Table 7. Displaced Material Chemical Concentrations in Near Deposit

Parameter	Guideline Value [a] (mg/kg)	Average Value in DM (mg/kg)
PHC F2	150	1,168
PHC F3	1,300	15,875
PHC F4	5,600	7,900
SAR	<4	25.5

Notes:
Source: MEMS (2006a)
Only chemicals that exceed screening criteria are included
PHC = petroleum hydrocarbon
DM = displaced material
SAR = sodium adsorption ratio
Guideline values from AENV (2007a)
Average values are from 8 samples of displaced material in the Near Deposit.

5.3 Trace Deposit

The Trace Deposit is a somewhat unusual contaminant situation, in the following respects:

- the contaminant is only present in the LFH layer;
- generic soil quality guidelines are developed using mineral soils, and have little relevance to organic layers; and,
- removing the contaminant from the Trace Deposit would involve removing the entire LFH layer over the extent of the Trace Deposit; the LFH layer is an important part of the ecosystem.

Considering the points above, the approach taken in this risk assessment was to use or adapt protocols from AENV (2007a,b), but also to try to balance the risk in leaving the contaminant in place in the Trace Deposit against the damage to the ecosystem involved in removing the entire LFH layer, along with understory vegetation and trees. This approach is elaborated further in relevant parts of Section 5.

The exposure assessments for SAR and hydrocarbons in the Trace Deposit are provided in Section 7.

6. EXPOSURE ASSESSMENT FOR UNSTABLE AREA

It is understood that DCEL’s preferred remediation strategy for this area is to cap the Unstable Area with at least 3 m of soil, and allow the weight of the cap to help compact the geotechnically Unstable Area. This would be considered an Exposure Control approach. The exposure pathway analysis provided in Table 4 is based on this strategy, and identifies the only complete pathways as being the protection of aquatic life in, or wildlife drinking from, nearby creeks fed by groundwater from the Site.

This exposure pathway applies to F2, but not to F3 or F4, based on limited solubility. The Alberta Environment Tier 1 guideline for this exposure pathway for F2 in fine soil is 20,000 mg/kg for freshwater aquatic life, and no guideline is required (NGR) for wildlife drinking creek water. No samples of displaced material were collected from the Unstable Area due to safety concerns. However, the displaced material in the Unstable Area is expected to be similar in composition to the displaced material in the Near Deposit. The mean F2 concentration in the DM in the Near Deposit is 1,168 mg/kg (Table 7), which complies with the Tier 1 guideline, and accordingly no on-site or off-site risk is anticipated for the Unstable Area under this exposure control scenario.

7. EXPOSURE ASSESSMENT FOR TRACE DEPOSIT

7.1 Exposure Assessment for SAR

SAR is elevated in the displaced material (25.5, average of eight samples, MEMS, 2006a). This reflects a higher concentration of sodium relative to calcium and magnesium, however, the overall ion concentrations are not particularly high (1.7 dS/m, average of eight samples, MEMS, 2006a).

Sodium absorption ratio (SAR) was included as a chemical of potential concern in the LFH layer because it exceeded the Alberta Tier 1 guideline value of 4.0 in three out of twenty seven samples. The “-1” samples in the Muskeg (MUS) units also represent organic soils. If these are included, then four out of thirty one samples exceed the guideline value (Table 8).

The reason that a guideline value exists for SAR is due to the potential detrimental effect of higher values of SAR on the structures of clays in mineral soil. All the samples with elevated SAR are in organic, rather than mineral soils. Since organic soils do not rely on clay minerals for their soil structure, the SAR guideline value of 4.0 is not relevant to these samples.

Over time, it is likely that salts will leach out of the –LFH and MUS soils, and be transported into underlying mineral soils. However, given that:

1. leaching into underlying mineral soils will provide an opportunity for the salts to disperse from the slight hot spots;
2. leaching into underlying mineral soils will provide the opportunity for sodium from the LFH layer to be balanced by calcium and magnesium in the mineral soils;
3. the salt concentrations in the –LFH and MUS soils are low (average EC 0.65 dS/m, Table 8); and,
4. the average SAR value (1.6, Table 8) is well below the guideline value of 4.0.

It seams likely that any possible minor effect on the structure of underlying mineral soils would be less significant for the overall ecosystem than the removal of the LFH layer, and accordingly, no remedial action is recommended based on the measured SAR values.

Table 8. EC and SAR in LFH and Organic Samples

Location	Soil Series	EC (dS/m)	SAR
263-LFH	DOV	0.52	0.1
4-LFH	DOV	0.70	0.7
107-LFH	DOV	0.84	**5.8**
7-LFH	DOV	0.80	**4.1**
204-LFH	DOV	0.53	0.2
208-LFH	DOV	0.35	2.4
213-LFH	DOV	1.28	<0.1
19-LFH	DOV	0.9	<0.1
20-LFH	DOV	1.47	<0.1
21-LFH	DOV	0.49	<0.1
124-LFH	DOV	0.77	<0.1
222-LFH	DOV	0.72	<0.1
103-LFH	DOV	0.35	<0.1
302-LFH	DOV	0.78	<0.1
11-LFH	MMW	0.60	1.0
109-LFH	MMW	0.69	2.6
305-LFH	MMW	1.12	3.9
318-LFH	MMW	0.53	<0.1
323-LFH	MMW	0.52	0.4
16-LFH	MMY	0.6	0.1
217-LFH	MMY	1.02	<0.1
218-LFH	MMY	0.52	0.1
308-LFH	MUS	0.19	0.8
308-1 [a]	MUS	0.57	**15.6**
310-LFH	MUS	0.73	**4.7**
310-1 [a]	MUS	0.12	NA
14-LFH	MUS	0.59	NA
14-1 [a]	MUS	0.15	NA
116-1 [a]	MUS	0.4	1.0
313-LFH	MUS	0.67	0.5
Average [b]		**0.65**	**1.6**

Notes:

a. The “-1” samples from the muskeg (MUS) unit are organic (peat) soils and included with the LFH samples in this table.

b. Average computed by assuming that non-detected parameters are present at half the detection limit

Values in red exceed the SAR guideline value of 4.0

7.2 Exposure Assessment for Hydrocarbons

Hydrocarbon fractions F2, F3, and F4 are chemicals of potential concern in the LFH layer (but not the mineral soils underneath). Concentrations of F2, F3, and F4 measured in LFH samples in the Trace Deposit and controls are summarized in Table 9. (Displaced material samples from the Near Deposit are not included in this Table). Concentrations have been corrected for background based on the area specific background corrections in MEMS (2006a).

Table 9. PHC Fractions F2, F3, and F4 in LFH Samples

Location	Soil Series	F2[a] (mg/kg)	F3[a] (mg/kg)	F4[a] (mg/kg)
Samples from the Trace Deposit				
107-LFH	DOV	156	857	237
7-LFH	DOV	346	9,357	4,057
9-LFH	DOV	45	1,157	457
204-LFH	DOV	51	1,957	957
208-LFH	DOV	49	757	117
319-LFH	DOV	15	2,957	1,157
117-LFH	DOV	15	2,057	657
215-LFH	DOV	12	3,857	1,457
20-LFH	DOV	38	1,657	1,857
120-LFH	DOV	BB	957	457
220-LFH	DOV	42	4,757	2,457
302-LFH	DOV	BB	1,557	207
261-LFH	MMW	BB	BB	BB
109-LFH	MMW	20	BB	BB
305-LFH	MMW	32	BB	BB
318-LFH	MMW	104	1,055	695
16-LFH	MMY	6	4,335	2,145
217-LFH	MMY	BB	935	845
310-LFH	MUS	62	3,355	1,395
12-LFH	MUS	31	1,855	485
13-LFH	MUS	17	3,255	1,995
14-LFH	MUS	134	2,155	1,295
114-LFH	MUS	414	17,055	7,495
313-LFH	MUS	71	1,855	695
314-LFH	MUS	194	7,055	3,995
Average of Trace Deposit Samples[b]		88	2,942	1,385
Control Samples				
263-LFH	DOV	<5	580	360
103-LFH	DOV	<5	430	440
124-LFH	DOV	29	660	1,000
213-LFH	DOV	<5	590	680
322-LFH	DOV	17	890	850
323-LFH	MMW	39	1,600	750
218-LFH	MMY	18	500	680
260-LFH	MMY	<5	230	230
Average of Control Samples[b]		14	685	624

Notes:

a. *Values have been corrected for background using the following area-specific control values for F2, F3, and F4, respectively, from MEMS (2006a):*
  - *DOV Series: 14 mg/kg, 643 mg/kg, 743 mg/kg.*
  - *MMW Series: 26 mg/kg, 945 mg/kg, 505 mg/kg.*
  - *MMY Series: 12 mg/kg, 365 mg/kg, 455 mg/kg.*
  - *MUS Series: 26 mg/kg, 945 mg/kg, 505 mg/kg.*

b. *Average computed by assuming that non-detected parameters are present at half the detection limit*

c. *BB = below background*

7.2.1 Plants and Soil Invertebrates

Background corrected F2, F3, and F4 concentrations in the LFH layer of the Trace Deposit are summarized in Table 9. Many of the F3 values, and a few of the F2 and F4 values are above the Alberta Tier 1 fine grained natural area soil ecological contact guidelines ("The Tier 1 Eco-Contact Guidelines") for these hydrocarbons (150 mg/kg, 1,300 mg/kg, and 5,600 mg/kg, respectively). However, the generic guideline values have little relevance to these samples for the following reasons:

1. The Tier 1 Eco-Contact Guidelines for these compounds are based on toxicity tests conducted in mineral soils with approximately 10% organic matter. The LFH samples are likely to be close to 100% organic matter. Hydrocarbons have an affinity for organic matter, and become less available to soil biota in highly organic soils. Thus the generic guidelines are likely over-conservative for the LFH layer.
2. The Tier 1 Eco-Contact Guidelines for these compounds are based on toxicity tests conducted using agricultural and grassland plants (northern wheatgrass, barley, alfalfa). The relevance to boreal plants is not known.
3. The Tier 1 Eco-Contact Guidelines for these hydrocarbons are influenced strongly by the toxicity of earthworms (*Eisenia andrei*), since this species was one of the most sensitive to these compounds. Earthworms of the genus *Eisenia* are not native to boreal LFH layer soils, and accordingly the generic guidelines may be over-conservative for the LFH layer.

Considering the three points above, there is significant uncertainty in the relevance of The Tier 1 Eco-Contact Guidelines to LFH layer soils at the Site, and indications that these guidelines maybe unnecessarily conservative for this situation.

Another extremely important consideration at this Site is that a decision to remediate LFH layer soils in the Trace Deposit would involve removing the entire LFH layer over approximately 10 ha of forest. This would be a difficult task in itself due to the presence of trees, and would undoubtedly involve significant damage, and possibly complete removal of the understory, including shrubs, small trees, forbs, and grasses over this area, and possibly also the removal of trees. The vast majority of soil invertebrates in boreal soils are present in the LFH layer, and thus removing this layer would remove the invertebrates and their habitat. Removing the understory vegetation and perhaps the trees form the Near Deposit would remove the habitat in this area for a wide range of ecosystem components.

Due to the significant ecosystem damage involved in remediating hydrocarbons in the Trace Deposit, and significant uncertainty concerning the relevance of the Alberta Tier 1 Eco-Contact guidelines to LFH soils at this Site, it is strongly recommended that no attempt at remediation be made for hydrocarbons in the Trace Deposit.

However, it is recommended that a qualified field biologist assess the vegetation in the Trace Deposit during the growing season 1 year after the release (i.e., 2007) to assess any impact on the vegetation in that area and confirm that leaving the Trace Deposit in place is causing less damage to the ecosystem than removing the entire LFH layer and much of the understory vegetation and trees in the area of the Trace Deposit.

7.2.2 Wildlife Ingestion of Soil

The wildlife ingestion of soil exposure pathway is complete at this Site, since wildlife species will pass through the Trace Deposit, and may feed there and be subject to incidental ingestion of contaminant hydrocarbons.

The maximum (background corrected) concentrations of F2, F3, and F4 measured in the Trace Deposit are compared to Alberta Environment Tier 1 Guidelines for wildlife soil and food ingestion in Table 10.

Table 10. Maximum Site F2, F3, and F4 Compared to Tier 1 Wildlife Ingestion Guidelines

	F2 [a] (mg/kg)	F3 [a] (mg/kg)	F4 [a] (mg/kg)
Maximum Measured Value in Trace Deposit	414	17,055	7,495
Alberta Tier 1 Wildlife Soil and Food Ingestion Guideline	9,800	16,000	8,400

As can be seen from Table 10, the maximum measured concentrations of F2 and F4 are below the Tier 1 guideline for this exposure pathway. The highest measured F3 concentration slightly exceeds the guideline value. Since the exceedance is less than 10%, and greater than 95% of the samples collected (i.e., all the other 24 samples) comply with this guideline, no further action is recommended based on this exposure pathway.

7.2.3 Groundwater Transport of Contaminants to Joslyn Creek

This exposure pathway ensures that groundwater transport of contaminants to Joslyn Creek doesn’t result in surface water quality in the Creek that would adversely affect the health of freshwater aquatic life in the creek, or of wildlife that might drink from the Creek.

This exposure pathway applies to F2, but not to F3 or F4, based on limited solubility. The Alberta Environment Tier 1 guideline for this exposure pathway for F2 in fine soil is 20,000 mg/kg for freshwater aquatic life, and no guideline is required (NGR) for wildlife drinking creek water. Since the highest measured concentration of F2 in the Trace Deposit (414 mg/kg, Table 10) compiles with both these guidelines, no further action is required for this exposure pathway.

This recommendation is supported by the results of the surface water monitoring program which indicated that water quality in Joslyn Creek was very similar both upstream and downstream of the deposit of displaced material.

8. RISK MANAGEMENT RECOMMENDATIONS

As identified in Sections 1.2 and 5, three distinct areas of displaced material are identified at this site. Risk management recommendations based on the conclusions of the risk assessment are provided for each area below.

8.1 Unstable Area

The Unstable Area is the area closest to the steam release location where safety concerns related to geotechnical stability currently preclude access. The exact limits of the Unstable Area are not currently defined. It is understood that DCEL's preferred remediation strategy for the Unstable Area is to manage the potential worker and public safety issues in this area by adding a cap of at least 3 m of soil to the Unstable Area, and allow the weight of the cap to help compact the geotechnically Unstable Area. This strategy would fall under the "Exposure Control" option in AENV (2007a,b). The following risk management recommendations are made for the Unstable Area:

1. The Unstable Area should be inspected by an appropriately qualified safety professional to determine the limits of the Unstable Area and the restrictions necessary to ensure worker and public safety.
2. If a cap of 3 or more metres of soil is placed on the Unstable Area, then based on the analysis in this risk assessment, no on-site or off-site risk is anticipated for the Unstable Area under this Exposure Control scenario, and no further action is required in this area. Note, however, that no form of regulatory closure is available under the Exposure Control option.
3. The placed cap would require revegetation, either natural vegetation or through planned reclamation.

8.2 Near Deposit

The Near Deposit includes that part of the deposit which forms an identifiable layer corresponding to a thickness of approximately 2 cm or greater. The Near Deposit is mostly located within 200 m south southwest of the steam release point. The Near Deposit has similar properties to a mineral soil and concentrations of F3 that exceed applicable guidelines by an order of magnitude for some parameters. Based on the analysis in this risk assessment, the following risk management recommendation is made for the Near Deposit:

1. The displaced material in the Near Deposit will require removal, remediation or other management.

8.3 Trace Deposit

The Trace Deposit extends out to approximately 1 km from the steam release point, and comprises that part of the deposit with less than 2 cm of displaced material. The Trace Deposit is a somewhat unusual contaminant situation, in the following respects: i) the contaminant is only present in the surficial organic LFH layer; ii) generic soil quality guidelines for petroleum hydrocarbons were developed using mineral soils, and have little relevance to organic layers; and, iii) removing the contaminant from the Trace Deposit would involve removing the entire LFH layer, and likely also the understory vegetation and trees over the extent of the Trace Deposit; which would effectively remove the entire ecosystem in this area.

Considering the relative ecosystem damage likely to be caused by leaving the Trace Deposit in place or removing it, the following risk management recommendations are made for the Trace Deposit:

1. Due to the significant ecosystem damage involved in remediating hydrocarbons in the Trace Deposit, and significant uncertainty concerning the relevance of the Alberta Tier 1 Eco-Contact guidelines to LFH soils at this Site, it is strongly recommended that no attempt at remediation be made for hydrocarbons in the Trace Deposit.
2. However, it is recommended that a qualified field biologist assess the vegetation in the Trace Deposit during the growing season in 2008 and 2010 to assess any impact on the vegetation in that area and confirm that leaving the Trace Deposit in place is causing less damage to the ecosystem than removing the entire LFH layer and much of the understory vegetation and trees in the area of the Trace Deposit.

9. CLOSURE

The information presented in this report was compiled and interpreted exclusively for the purposes stated in Section 1.1 of the document. Axiom Environmental Inc. (Axiom) provided this report for Millennium EMS Solutions Ltd. and Deer Creek Energy Limited solely for the purpose noted above.

Axiom has exercised reasonable skill, care and diligence to assess the information acquired during the preparation of this report, but makes no guarantees or warranties as to the accuracy or completeness of this information. The information contained in this report is based upon, and limited by, the circumstances and conditions acknowledged herein, and upon information available at the time of its preparation. The information provided by others is believed to be accurate but cannot be guaranteed. Risk assessment calculations and Tier 2 guidelines developed in this report are based on current protocols used by regulatory agencies including Alberta Environment and the Canadian Council of Ministers of the Environment (CCME).

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Any questions concerning the information in this report or its interpretation should be directed to Miles Tindal at (403) 678 4790, or mtindal@axiomenvironmental.ca.

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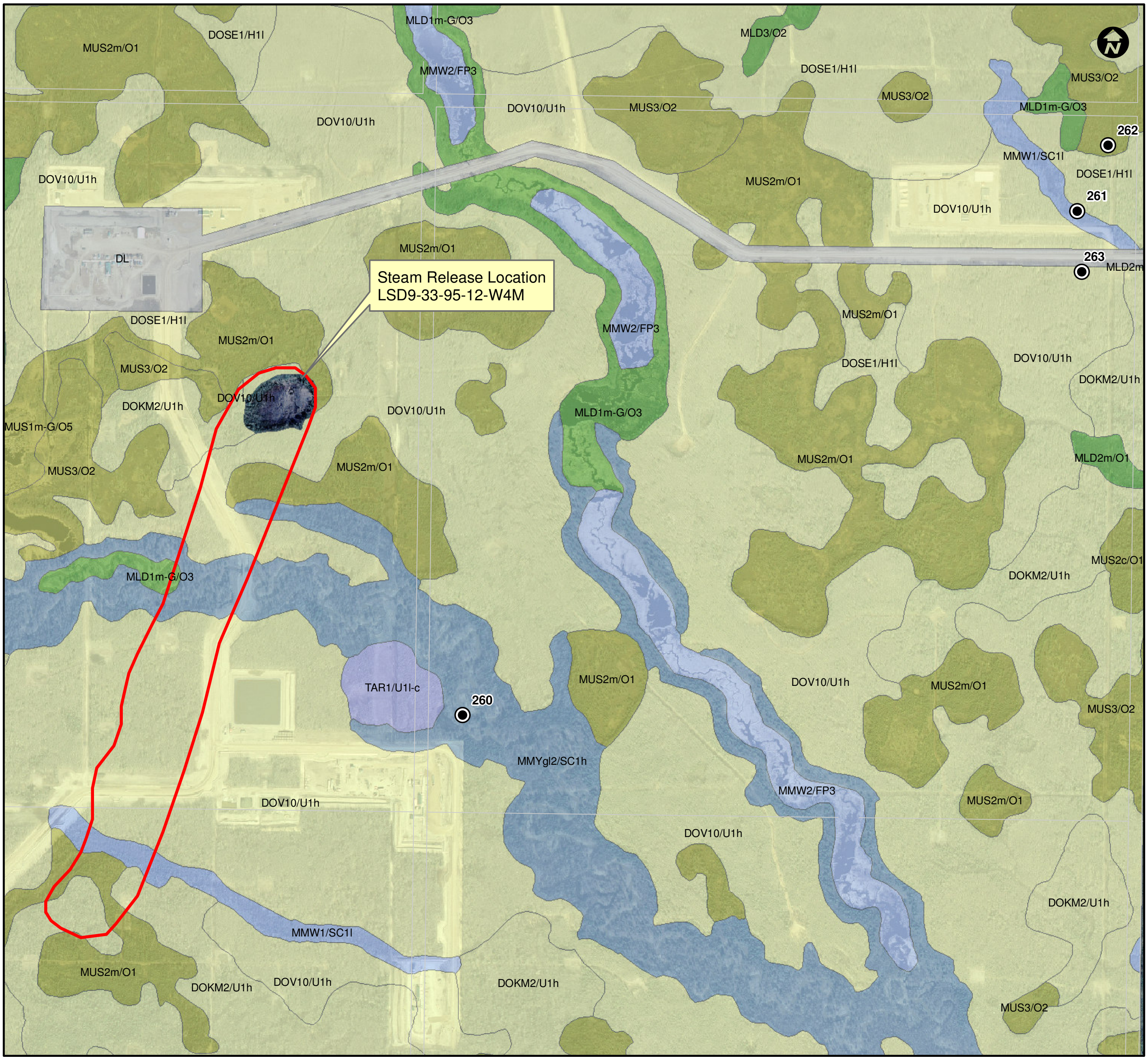
FIGURES



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
Prepared by BeauTerre Soil Soilscapes and Millennium EMS Solutions Ltd (February 2005)

Legend

◉ Perimeter Control Location

🟥 Initial estimated aerial extent of displaced material based on visual indicators

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Millennium EMS Solutions Ltd.

PROJECT
DCEL Steam Release Incident

TITLE
General Location of Steam Release

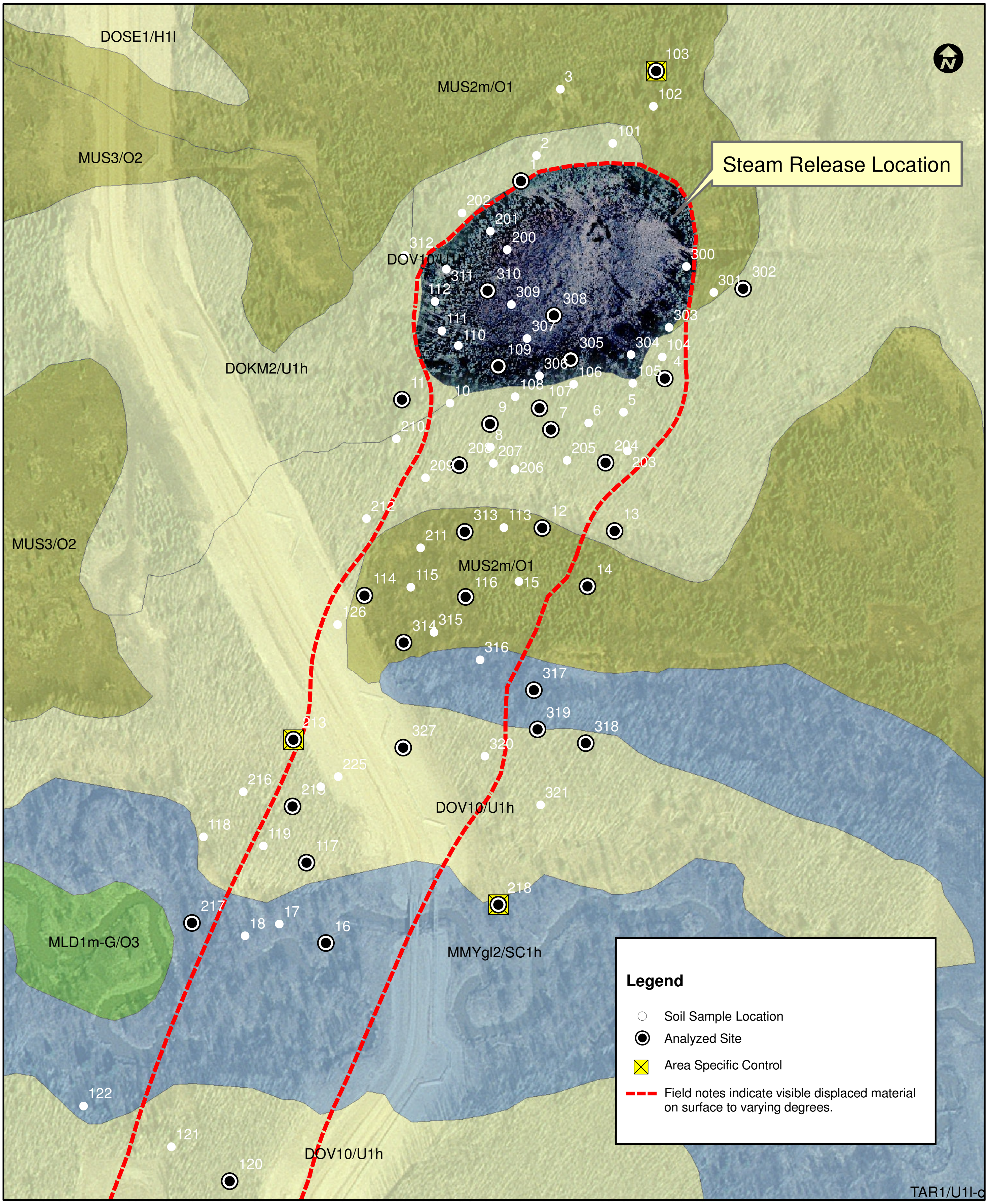
DRAWN	CHECKED	DATE
PS	RM	08Dec06

PROJECTION: UTM12 NAD83

FILE No. 04-101

SCALE
0 80 160 320
Meters

FIGURE
1



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
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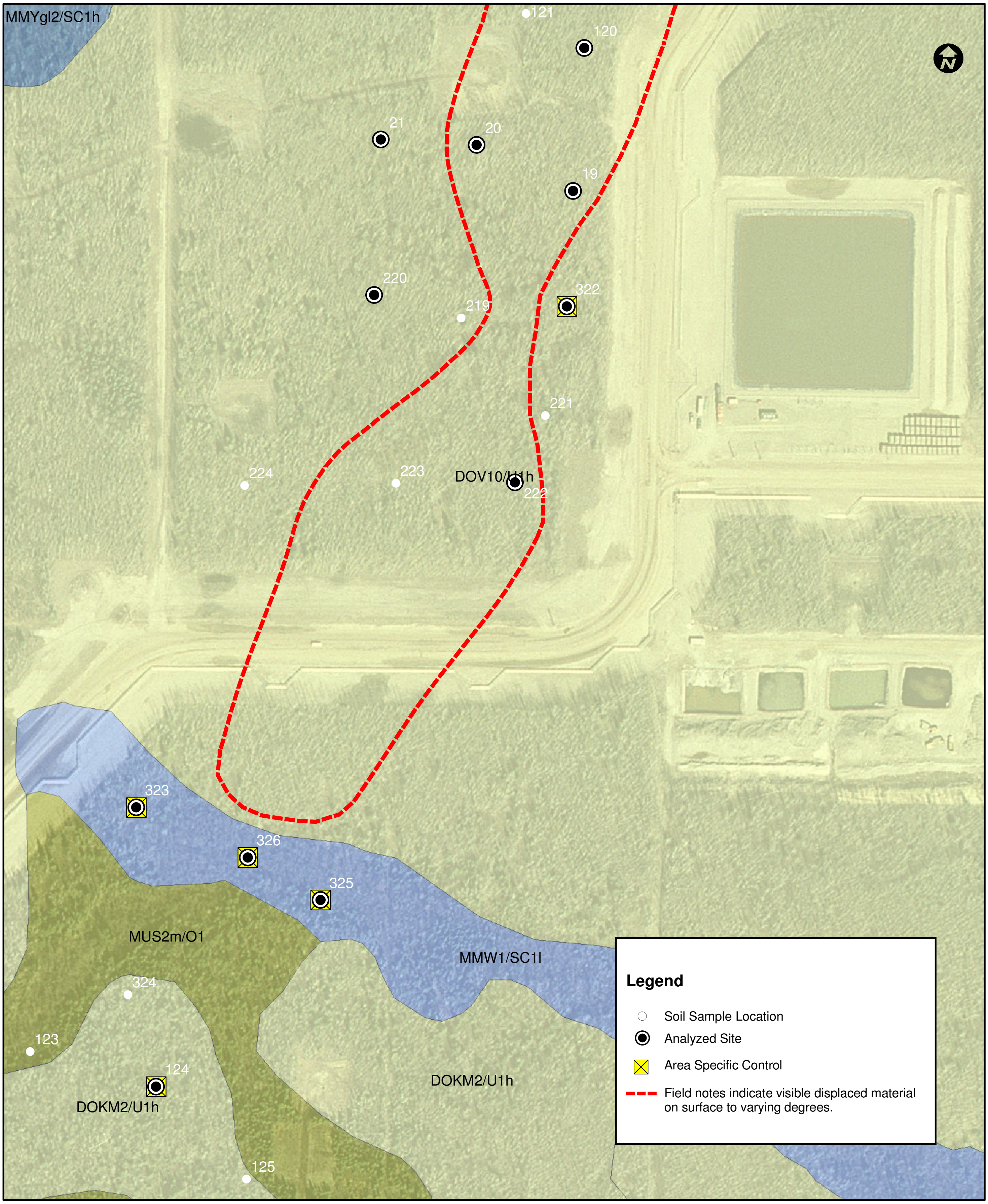
DEER CREEK Energy Limited A wholly-owned subsidiary of TOTAL E&P CANADA LTD	PROJECT **DCEL Steam Release Incident**	DRAWN PS	CHECKED RM	DATE 08Dec06	PROJECTION: UTM12 NAD83 FILE No. 04-101
Millennium EMS Solutions Ltd.	TITLE **Soil Sampling Locations**	SCALE 0 20 40 80 Metres			FIGURE **2a**



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PROJECT
DCEL Steam Release Incident

TITLE
Soil Sampling Locations

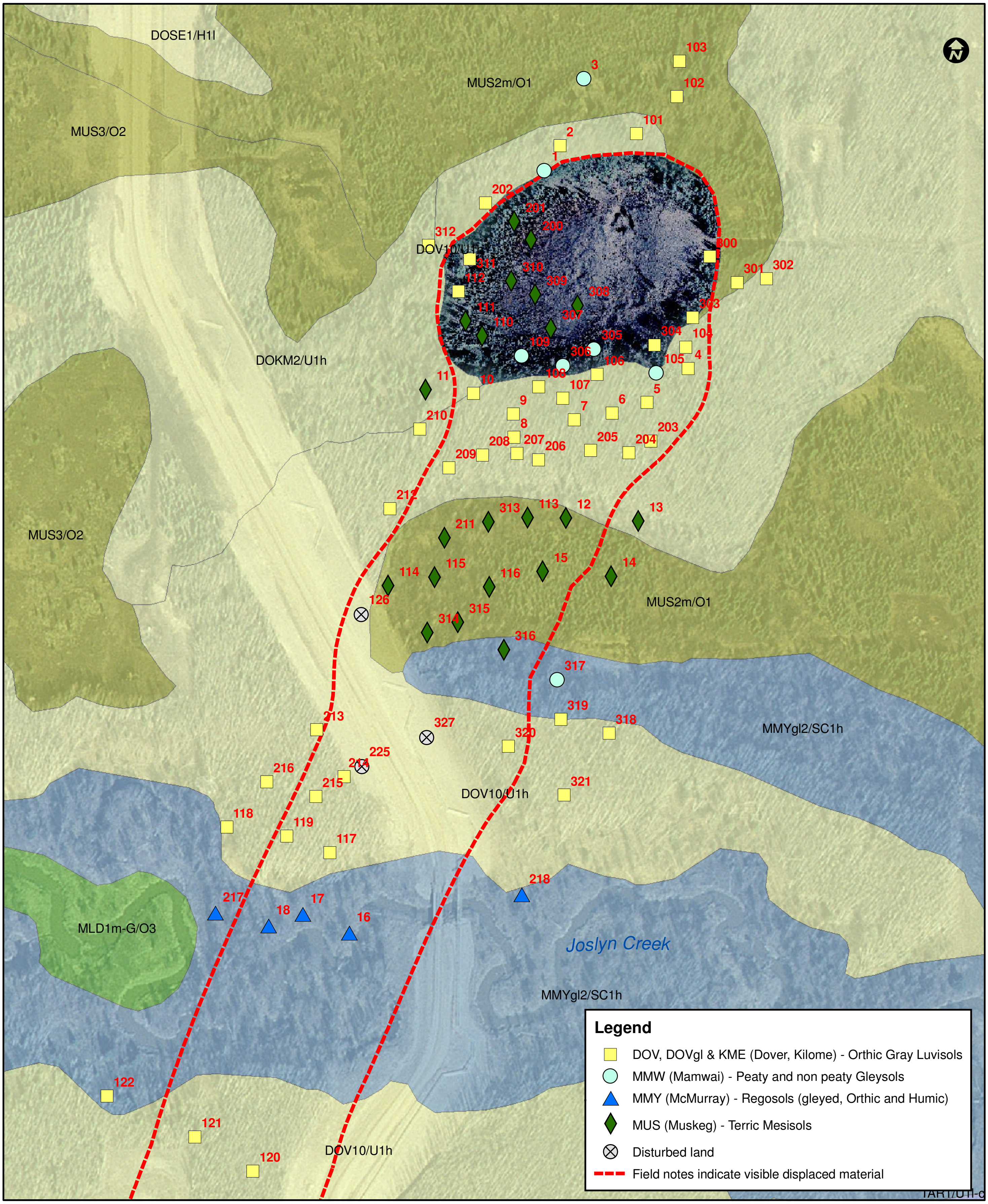
DRAWN	CHECKED	DATE
PS	RM	08Dec06

PROJECTION: UTM12 NAD83

FILE No. 04-101

SCALE
0 20 40 80
Metres

FIGURE
2b



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
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PROJECT
DCEL Steam Release Incident

TITLE
Soil Classification of Sample Points

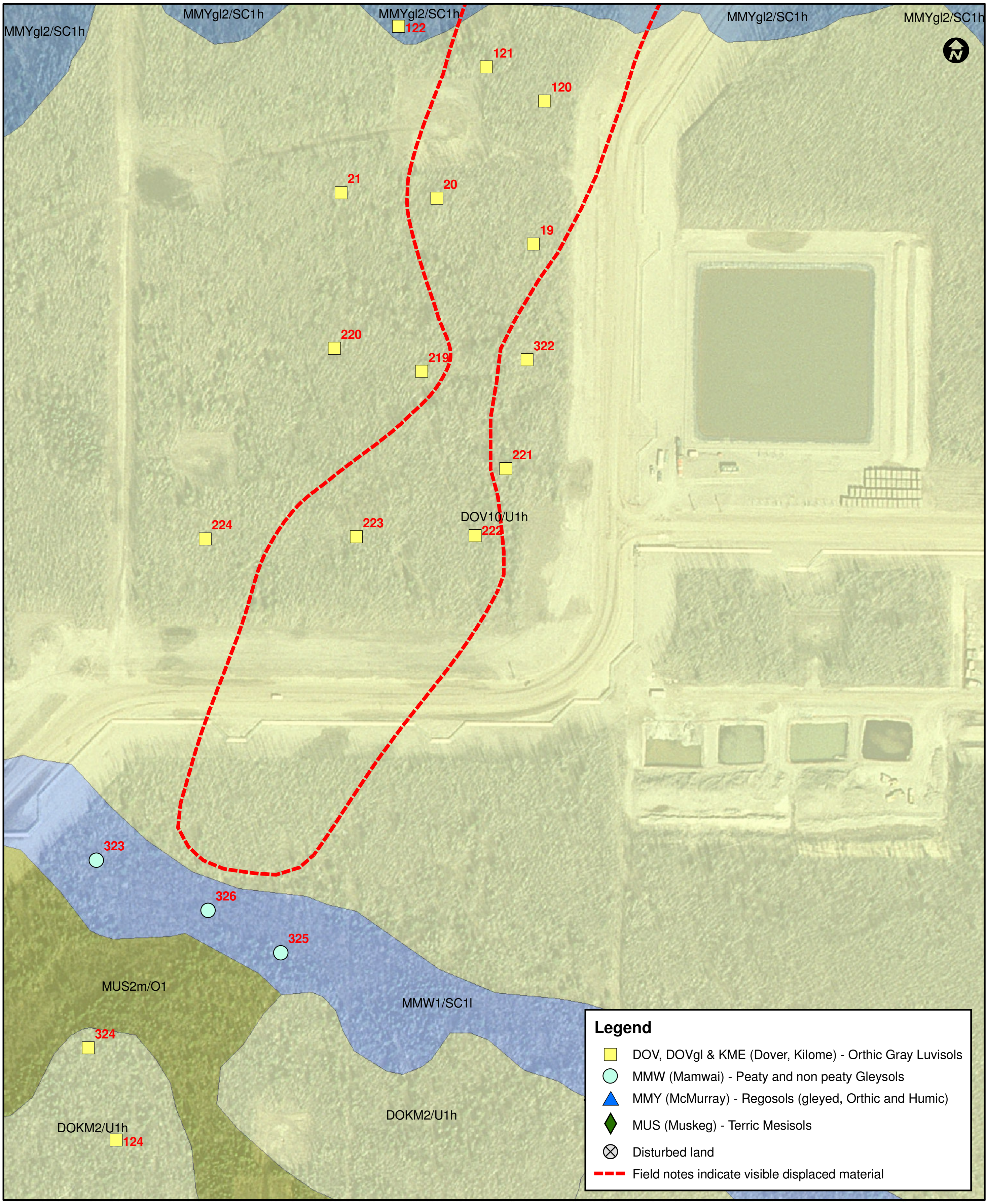
DRAWN	CHECKED	DATE
PS	RM	08Dec06

SCALE 0 20 40 80 Metres

PROJECTION: UTM12 NAD83

FILE No. 04-101

FIGURE **3a**



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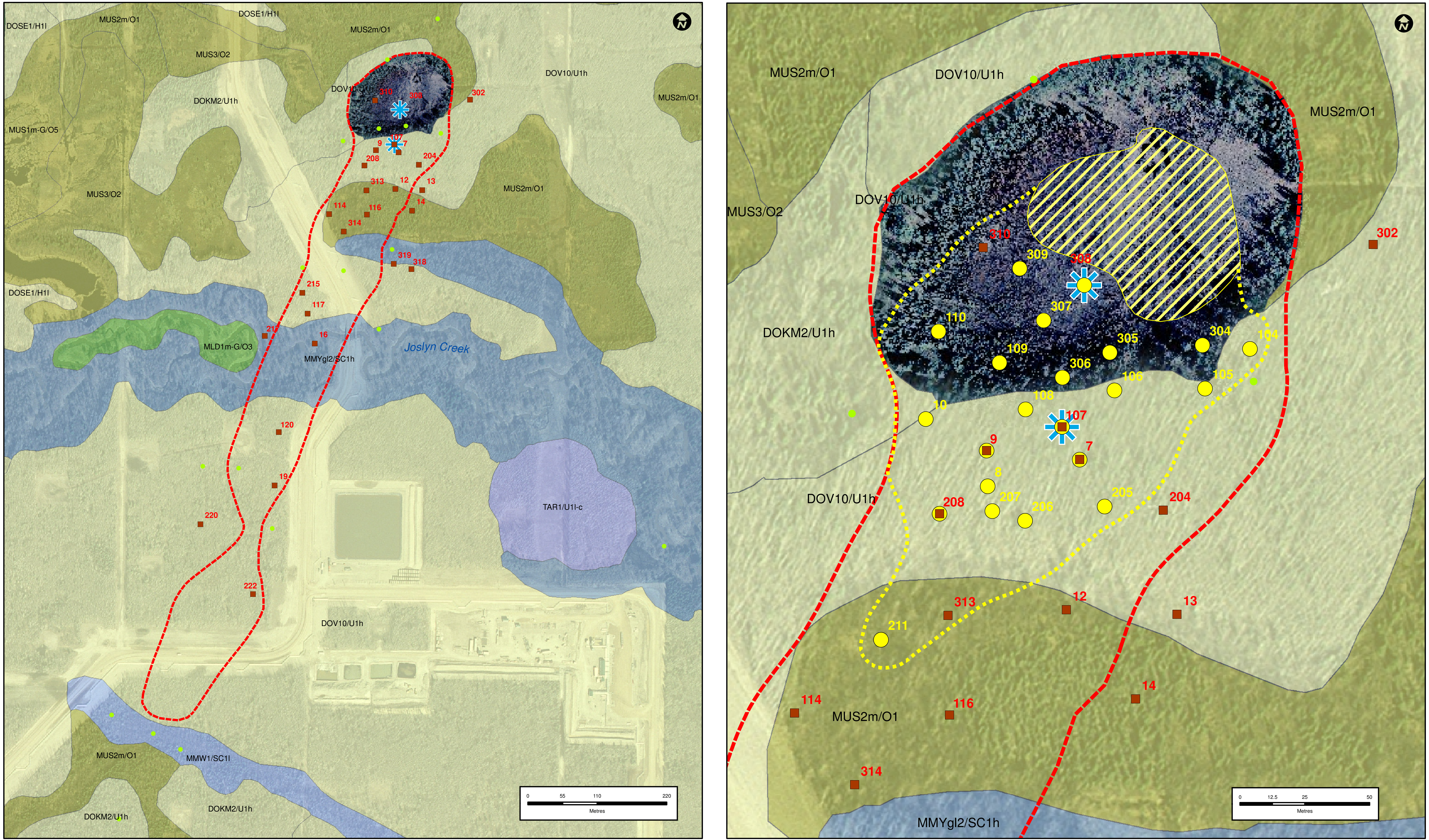
PROJECT
DCEL Steam Release Incident

TITLE
Soil Classification of Sample Points

DRAWN	CHECKED	DATE	PROJECTION: UTM12 NAD83
PS	RM	08Dec06	FILE No. 04-101

SCALE
0 20 40 80
Metres

FIGURE
3b



Soils baseline map adapted from: Deer Creek Energy Limited (DCEL) Joslyn SAGD Phase IIIA, Soil Survey Report with Impact Assessment.
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Millennium
EMS Solutions Ltd.

PROJECT
DCEL Steam Release Incident

TITLE
Hydrocarbon and SAR Exceedences

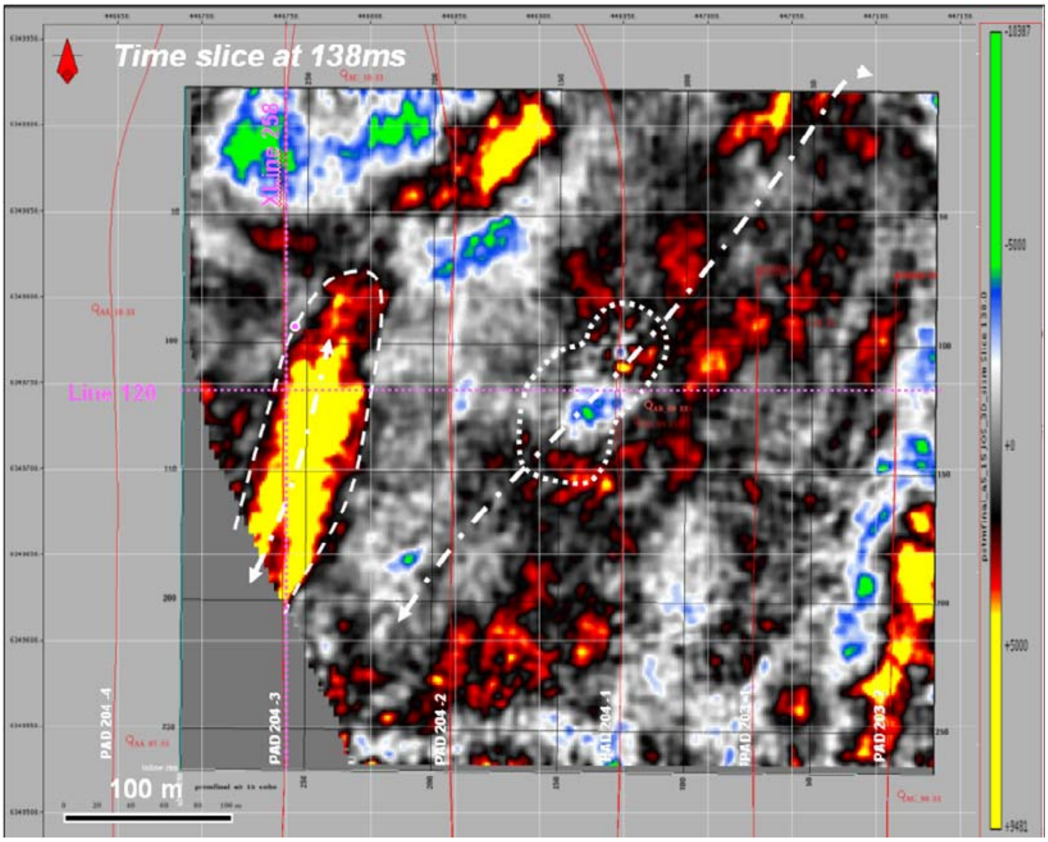
LEGEND

■	Elevated Hydrocarbon values (F2-F4)	▨	Area of Instability*
✳	Elevated SAR values	○	Displaced Material > 2cm
●	Sites Meet Criteria	·····	Field notes indicate >2cm of displaced material at surface
----	Field notes indicate visible displaced material		

* Area roped off, contains a visible layer of displaced material at surface

DRAWN	CHECKED	DATE	PROJECTION: UTM12 NAD83
PS	RM	08Dec06	FILE No. 04-101
SCALE			FIGURE 4

TOTAL E&P CANADA LTD.



Resuming 204-I3P3 Operations Information File

TEPC/GSR/2008.002 April 08

Total E&P Canada Ltd. Dome Tower, Suite 1900, 333 – 7th Avenue SW, Calgary, AB T2P 2Z1, Phone: (403) 571-7599, Fax: (403) 571-7595

Identification page

Title : Resuming 204-I3P3 Operations – Information File
Author(s) : P. Bergey, G. Chalier, A. Delafargue, D. Druesne, E. Warren
Entity : TOTAL E&P CANADA
Location - Date : April 08 Validated by: A. de Leebeeck / JM Feroul

- Chronological reference : TEPC/GSR/2008.002
- RFS :
- Number of Volumes : 1

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Storage Location on the Entity Server:[1]

Keywords (10 max.- other than title):
204-I3P3, SAGD, HSE, Steam Relase, Confinement, 3D Seismic, Risk Analysis

Geographical references: (Country, Region, License, Field, Well(s))
Canada, Alberta, Deer Creek, Joslyn Creek, Township 12W4, Range 095, Well 104-10-33-095-12W4

ABSTRACT – About 10 lines explicit

Objectives (Aim, Purpose, Target) - **Strong points - Recommendation(s) and/or conclusion(s)**

The objective of the present file is to present the main elements justifying the resumption from December 20th 2007 of production operations on well pair 204-I3P3 and to illustrate how customized monitoring ensured, ensures and will continue to ensure the safety of such production activities. Geological, geophysical, reservoir and monitoring aspects of 204-I3P3 past, present and future operations are detailed.

Based upon the work detailed in the present report, it can be concluded that:

1. TOTAL diligently executed the actions required to safely operate 204-I3P3 SAGD pair while fully complying with all relevant AEUB/ERCB directives.
2. The AEUB/ERCB has been and is being kept informed by TOTAL, on a voluntarily basis, of key findings related to the safety of Joslyn operations.
3. Whether or not Monitoring is taken into consideration the risk related to Steam Confinement Loss is estimated to reach level 4 within ERCB Risk assessment framework. Would a non compliance to a directive be directly related to the steam confinement loss issue, such non compliance should be treated as Low Risk as per ERCB directive 19.
4. Following the drilling and logging of well 104_10-33-095-12W4 and the installation of piezometers in such well, the risks related to 204-I3P3 operations are deemed extremely low probability provided proper monitoring is achieved especially monitoring the pressure readings from well 104_10-33-095-12W4.
5. Such status should be reviewed in light of any significant change in the matter including 204-I3P3 behaviour as monitored by surface metering and instrumentation, piezometers pressure reading or surface heave (INSAR and tiltmeters) – such list is not extensive

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Reference 2 Geological Insights in the Joslyn May 18th Steam Release – November 2007 – E. Visser / P. Bergey TEPC/GSR/2007.005.

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Reference 4 Reservoir Insights in the Joslyn May 18th Steam Release – November 2007 – A. Delafargue TEPC/GSR/2007.004.

Reference 5 Geo-mechanical Insights in the Joslyn May 18th Steam Release – November 2007 – A. Onaisi TEPC/GSR/2007.003.

Reference 6 Cement Bond Evaluation Insights in the Joslyn May 18th Steam Release – November 2007 – G. Chalier TEPC/GSR/2007.007

Reference 7 Steam Release Incident LSD 09-33-095-12-W4M Volume I Executive Summary prepared by Millennium Solutions Ltd. September 2007 File #04-101

Reference 8 Summary of investigations in Joslyn May 18th Steam Release. P. Bergey. TEPC/GSR/2007.006 August 2007

Reference 9 JOSLYN STEAM RELEASE - INVESTIGATION REPORT - Report of Taskforce TDO/GSR - TDO/CA-06-251 August 2006

Reference 10 Cap Rock Competence of wells DCEL 0B3C JOSLYN 2-33-95-12 and DCEL 0B1A JOSLYN 11-33-95-12 Determined From Electrical Borehole Image Data – Richard Y. Shang Ph. D, P. Geol. Schlumberger Canada Ltd. May 2003. PROVIDED AS APPENDIX 1.

1 Introduction

1.1 Objective

The objective of the present file is to present the main elements justifying the resumption from December 20th 2007 of production operations on well pair 204-I3P3 and to illustrate how customized monitoring ensured, ensures and will continue to ensure the safety of such production activities. Geological, geophysical, reservoir and monitoring aspects of 204-I3P3 past, present and future operations are detailed.

1.2 History Key Points

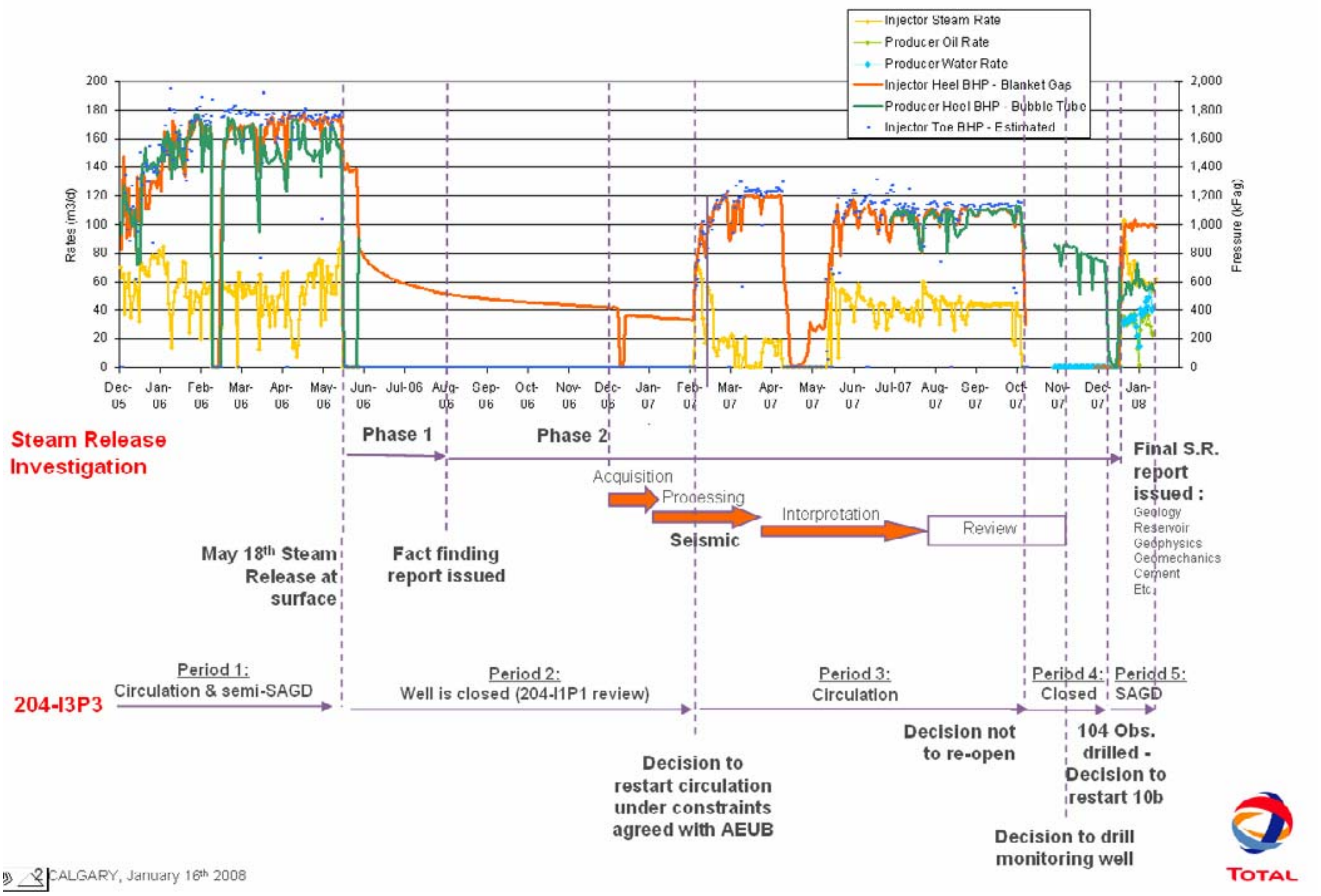


Figure 1 History key points

Key dates:

- 18 May 2006: steam release happens, EUB, AENV, etc. informed of events. Production stops.
- 30 June 2006: presentation to EUB of the results of the Steam Release Investigation Task Force
- 14 July 2006: request sent to EUB to start steam injection in Pad 202
- 1 August 2006: notice sent to EUB to inform them about start of steam injection in Pad 201
- 8 – 15 August 2006: production re-starts at pads 201 and 202.

- August 2006: Final Steam Release TF Report (Reference 9) issued to EUB; start of 2nd phase dedicated to root cause analysis.
- 5 September 2006: Board approval letter to start steam injection in Pad 202
- 25 October 2006: Wells start up sequence sent to the EUB
- 6 December 2006: update meeting with EUB on Steam Release and current operations
- December 2006 – January 2007: 3D HR Seismic acquisition in Steam release area
- 12 April 2007: update meeting with EUB on Steam Release and current operations
- April 2007 First tiltmeter readings; start of tiltmeter data validation process
- April First INSAR surveys; start of INSAR data validation process
- 2 October 2007: brief update on Steam Release during annual EUB progress presentation.
- Early October: decision is taken not to re-open well 204-I3P3 well pair after shut down
- End October: decision is taken to drill well target 3804 (later drilled as well 104-10-33-095-12W4)
- 9 December 2007: well 104-10-33-095-12W4 drilled and logged. Based upon the 104-10-33-095-12W4 results, the decision is taken to restart 204-I3P3 as soon as close monitoring of 104-10-33-095-12W4 pressure is in place.
- December 2007: wells 112-02-33-095-12W4, 113-02-33-095-12W4, 114-02-33-095-12W4drilled, logged and completed.
- 19 December 2007: 204-I3P3 Work over (installation of Metal – Metal PCP 550MET750)
- 20 December 2007: 204-I3 start of continuous injection / 204-P3 start of continuous SAGD production. Start of hourly recordings of 104-10-33-095-12W4 pressure (3 piezometers).
- 21 December 2007: Steam Investigation Report sent to EUB (Reference 1 to Reference 8). Questions & Answers Meeting planned.
- January 16th 2008: ERCB Meeting – Status of 204-I3P3 production. A document summarizing elements supporting the resumption of 204-I3P3 is requested by ERCB (formerly known as EUB).
- January 23rd 2008: 204-I3P3 Operations Resume File dispatched to ERCB.

No observations were ever made on well production data, surface heave or observation wells that would suggest in any way that increased risk exists in relation with 204-I3P3 production.

The above timeline can be commented as follows:

- The initial inquiry into the Steam release event was performed very quickly. A first report summarizing the main facts and root cause leads was issued 3 months after the first relevant observation (i.e. the May 18th 2006 steam release).
- A large array of complex and costly long term actions necessary to progress beyond the initial inquiry was launched as soon as physically possible (3D seismic survey, geo-mechanical modelling, etc.). These actions were instrumental in the final root cause analysis.
- The Joslyn monitoring network was significantly upgraded following the Steam release (tiltmeters, INSAR corner reflectors, pressure observation wells, etc.)[2].
- Upon noticing a cause for concern in the 3D HR seismic survey, TOTAL reacted promptly to ensure both short term safety (decision not to re-start circulation on 204-I3P3) and long term safety (decision to drill, log / core the 3804 well location and equip the corresponding well with piezometers).

---

[2] Further upgrades are under consideration as presented in the present report.

- TOTAL informed EUB of 204-I3P3 safety issue on a voluntarily basis in the Joslyn May 18th Steam Release Investigation Report issued on December 21st 2007.

2 Geology

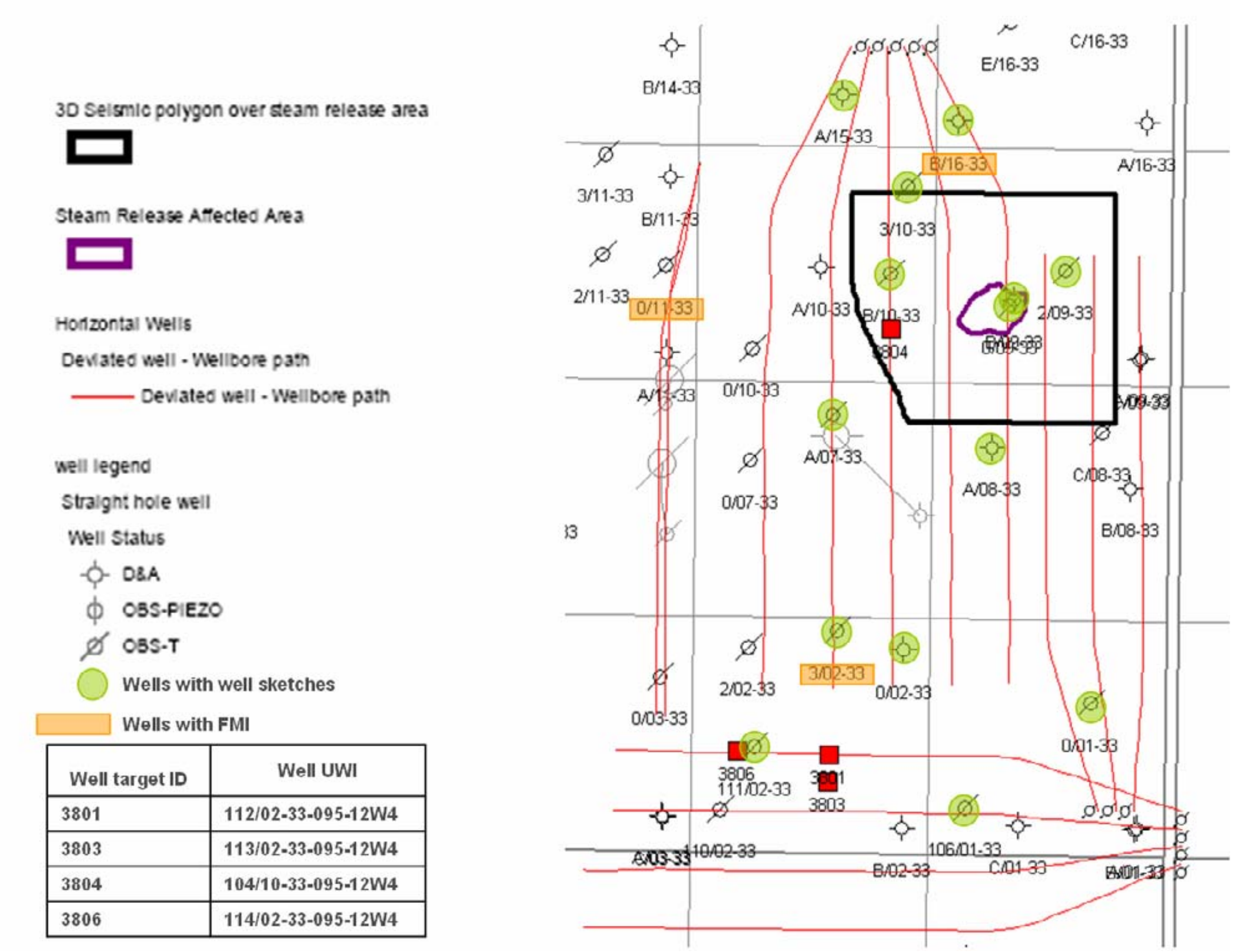
The geology of the area in the vicinity of 204-I3P3 well pair is not substantially different from the geology of the Joslyn May 18th 2006 Steam release. The key item of notice is the shallow reservoir depth (and related limited thickness of the overburden); no local aspect of the geology clearly stands out as a parameter for locally increased risk of steam confinement loss. See Reference 2 and especially figures 3 to 18 of such report, for a general description of the geology in this area.

The following paragraph will only present details or specific observations relative to the geology in the vicinity of 204-I3P3:

- Figure 8 to Figure 21 present well sketches for wells in the vicinity of well pair 204-I3P3 as illustrated on the well location map (Figure 2). Figure 3 presents a X-section in the Joslyn reservoir model along 204-I3P3 trajectory. It should be noted that the Gamma Ray plotted on these figure are acquired during the reservoir logging run. GR response behind casing for shallow intervals could be mistaken for a sand indication. Casing points vary greatly from well to well (typically 12 to 27 m MD).
- Three pre-2007 wells in the vicinity of pad 204 have FMI logs. These wells are highlighted on the location map (Figure 1). Corresponding FMI data was reviewed for fracture detection. A single fracture was observed on FMI in the Devonian interval on well 103_02-33-095-12W4. It is illustrated on Figure 4. As expressed in reference 10 and in relation with the general interpretation outline in paragraph 3.2 of reference2, it is not deemed to characterize any fracture related risk in reservoir or shallower levels.
- Well 104_10-33-095-12W4 (drilled in December 2007) was specifically reviewed for observations related to the possible effects 204-I3P3 steam circulation on the reservoir:
    - Fluid column: the log analysis suggests the following fluid column at 104-10-33-095-12W4
        - 36.55 – 38.6 m MD (302.86 - 300.81 m SS) [Kcw 3 unit]: water & bitumen bearing sand,
        - 44.5 - 54 m MD (294.91 – 284.5 m SS) [Upper and Middle McMurray]: gas & bitumen bearing sand shale alternation.
        - 54 - TD m MD (284.5 – TD m SS) [Middle McMurray]: bitumen bearing sand shale alternation. The logs do not suggest the presence of condensed water bearing sands close to the top reservoir.
    - Fracture detection on FMI: no fractures were identified on the FMI from 104_10-33-095-12W4. Two dip events can be singled out due to their higher than usual dip (Figure 5 and Figure 6). These events are found at the base of highly resistive, sandy intervals and are not likely intervals for fracture development. The dips measured are also relatively low to be attributed to fractures. After a careful review these dip events were deemed to be related to sedimentology:
        - The dip event in Figure 4 is 21 degrees; it has been interpreted as a basal scour surface of a sandy tidal channel.
        - The dip event in Figure 5 is 23 degrees; it is most likely a dipping crossbed of a prograding current ripple.
- Wabiskaw cores. The Wabiskaw was cored during December 2007 in wells 104_10-33-095-12W4, 112_02-33-095-12W4, 113_02-33-095-12W4, and 114_02-33-095-12W4. The objective was to gather more petrophysical data related to this particular formation for which only a limited dataset is currently available (Figure 7):
    - Kcw 3 reservoir properties: porosity, rock compressibility, permeability, saturation, effective permeability, etc.
    - Kcw 2 seal properties: permeability, Poisson's ratio, Young's Modulus, friction angle, dilation angle, etc.

  These analyses are yet to be launched. They should (along with the results of the planned Wabiskaw Kcw 3 water injection test) provide essential insights for qualifying the ability of the Kcw 3 to act as a drain (hence be used for pressure monitoring) and the ability of Kcw 2 to act as a seal (and thus ensuring a second level of steam confinement beyond the McMurray).

Overall, no geological observation (but the shallow reservoir depth) points towards risks specific to the particular location of 204-I3P3.



Well target ID	Well UWI
3801	112/02-33-095-12W4
3803	113/02-33-095-12W4
3804	104/10-33-095-12W4
3806	114/02-33-095-12W4

Figure 2 Well Location Map

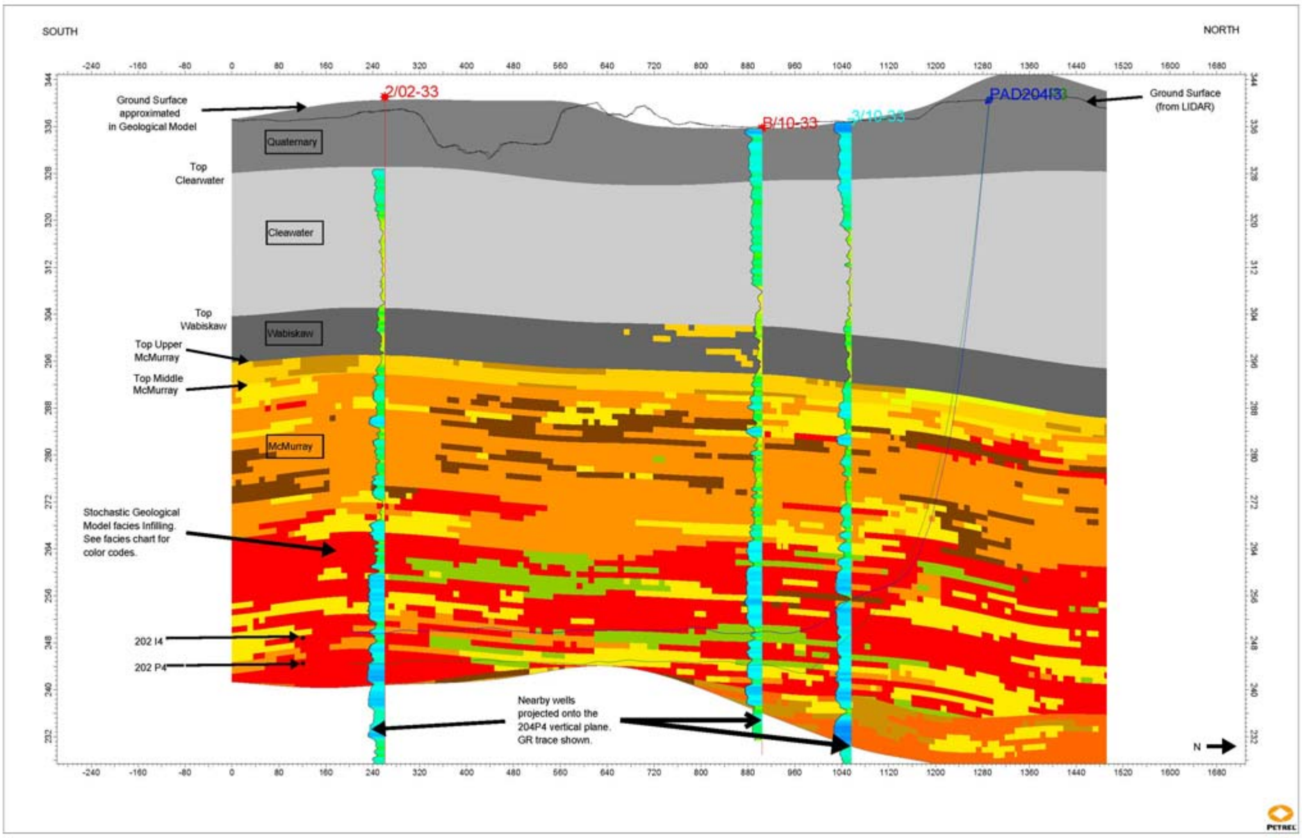


Figure 3 204-I3P3 Reservoir Model X Section

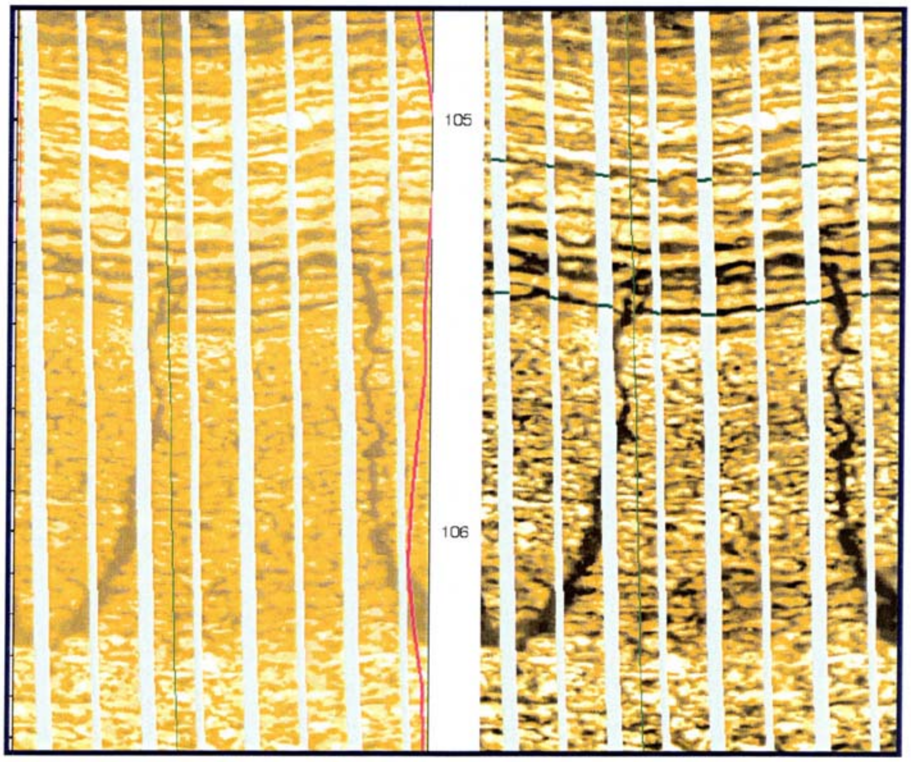


Figure 4 Fracture at 106 m (Devonian) on well 111_02-33-095-12W4

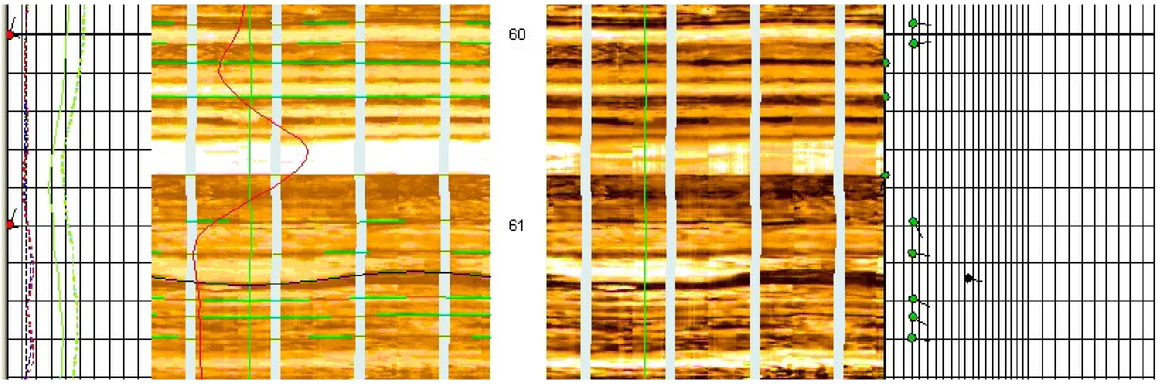


Figure 5 : Dip feature at 61.2 m

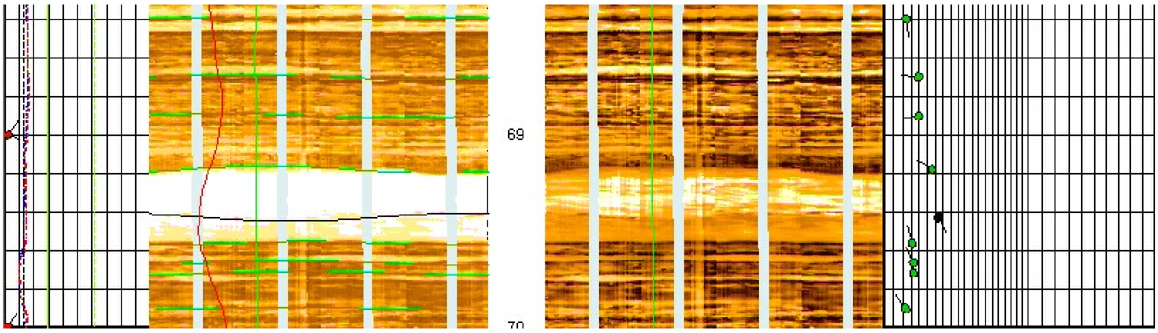
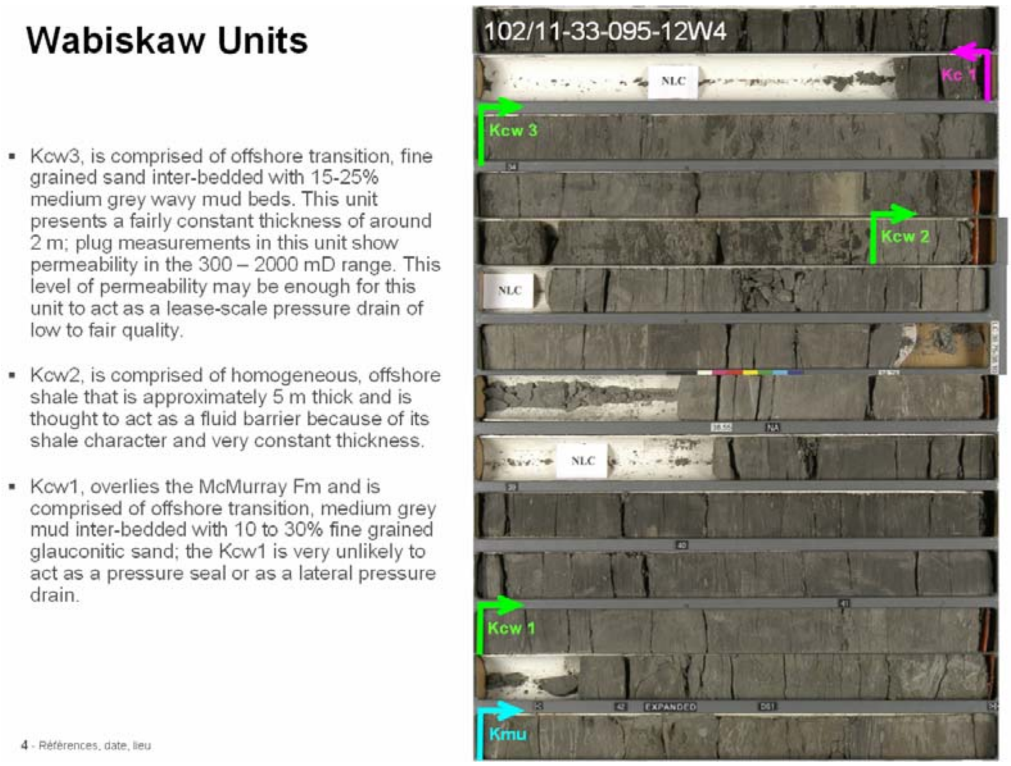


Figure 6 : Dip feature at 69.4 m



Wabiskaw Units

- Kcw3, is comprised of offshore transition, fine grained sand inter-bedded with 15-25% medium grey wavy mud beds. This unit presents a fairly constant thickness of around 2 m; plug measurements in this unit show permeability in the 300 – 2000 mD range. This level of permeability may be enough for this unit to act as a lease-scale pressure drain of low to fair quality.
- Kcw2, is comprised of homogeneous, offshore shale that is approximately 5 m thick and is thought to act as a fluid barrier because of its shale character and very constant thickness.
- Kcw1, overlies the McMurray Fm and is comprised of offshore transition, medium grey mud inter-bedded with 10 to 30% fine grained glauconitic sand; the Kcw1 is very unlikely to act as a pressure seal or as a lateral pressure drain.

4 - Références, date, lieu

Figure 7 Wabiskaw Core Pictures at 102/11-33-095-12W4

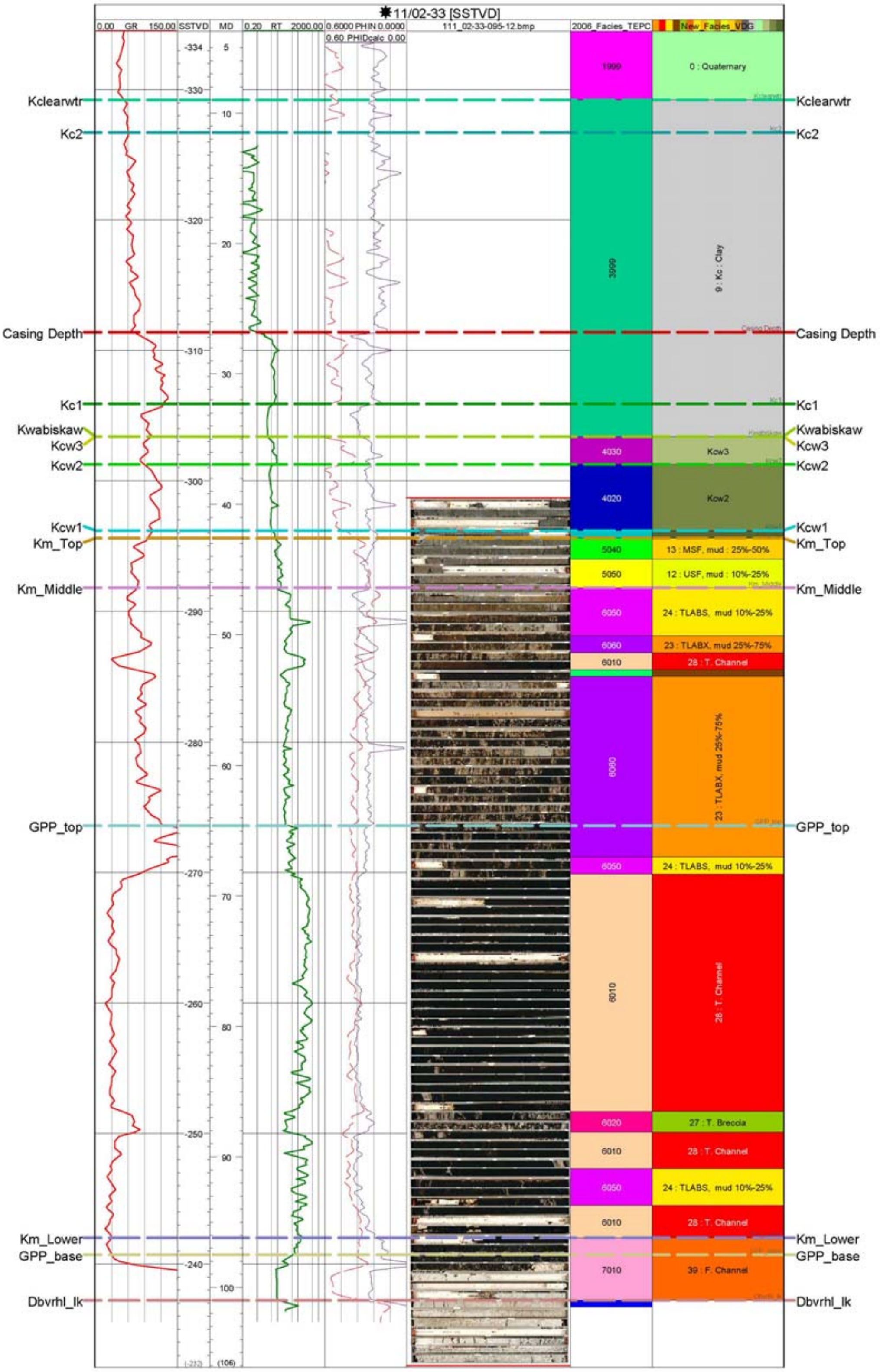


Figure 8 111_02-33-095-12W4 Well Sketch

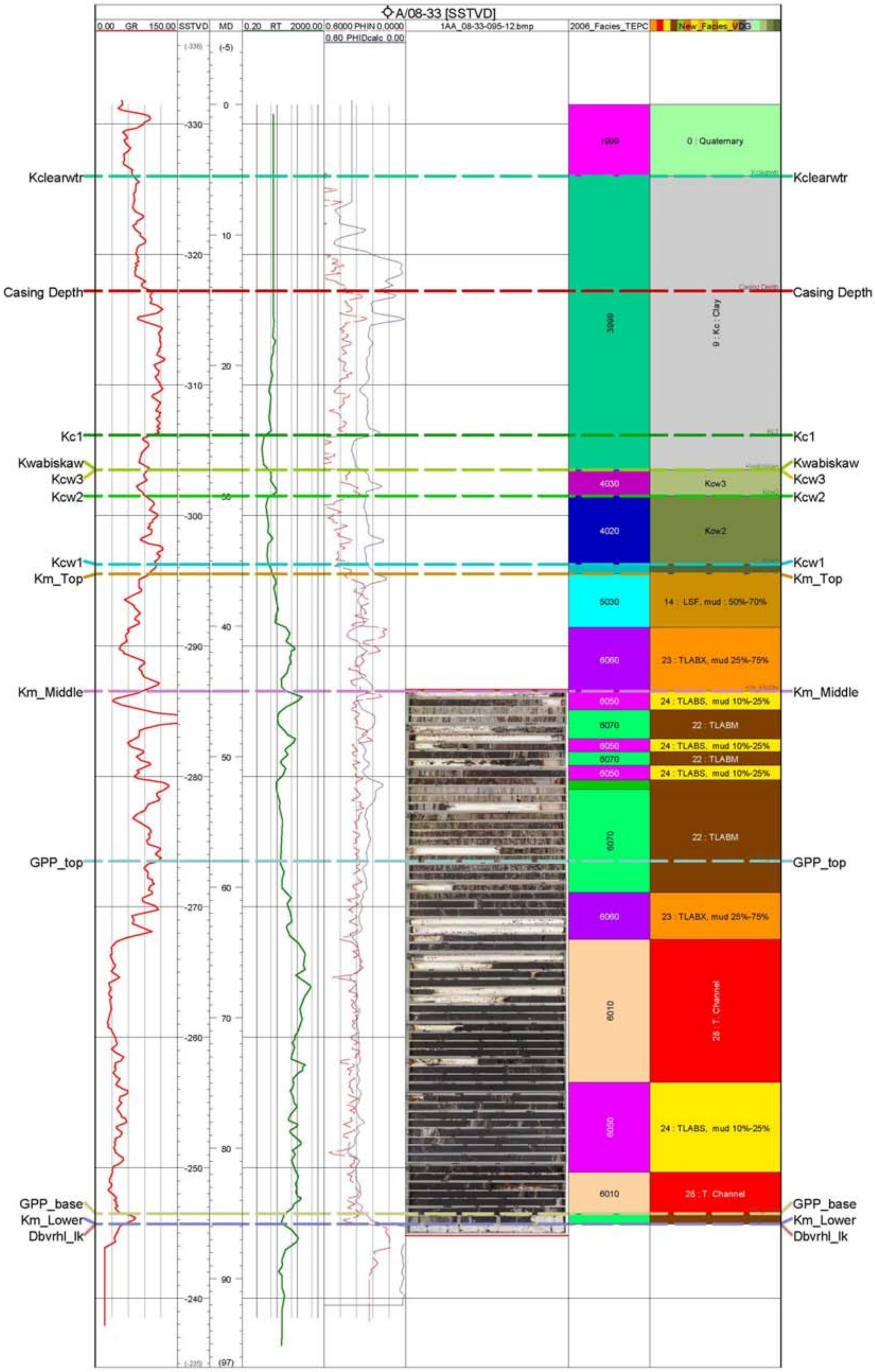


Figure 9 1AA 08-33-095-12 Well Sketch

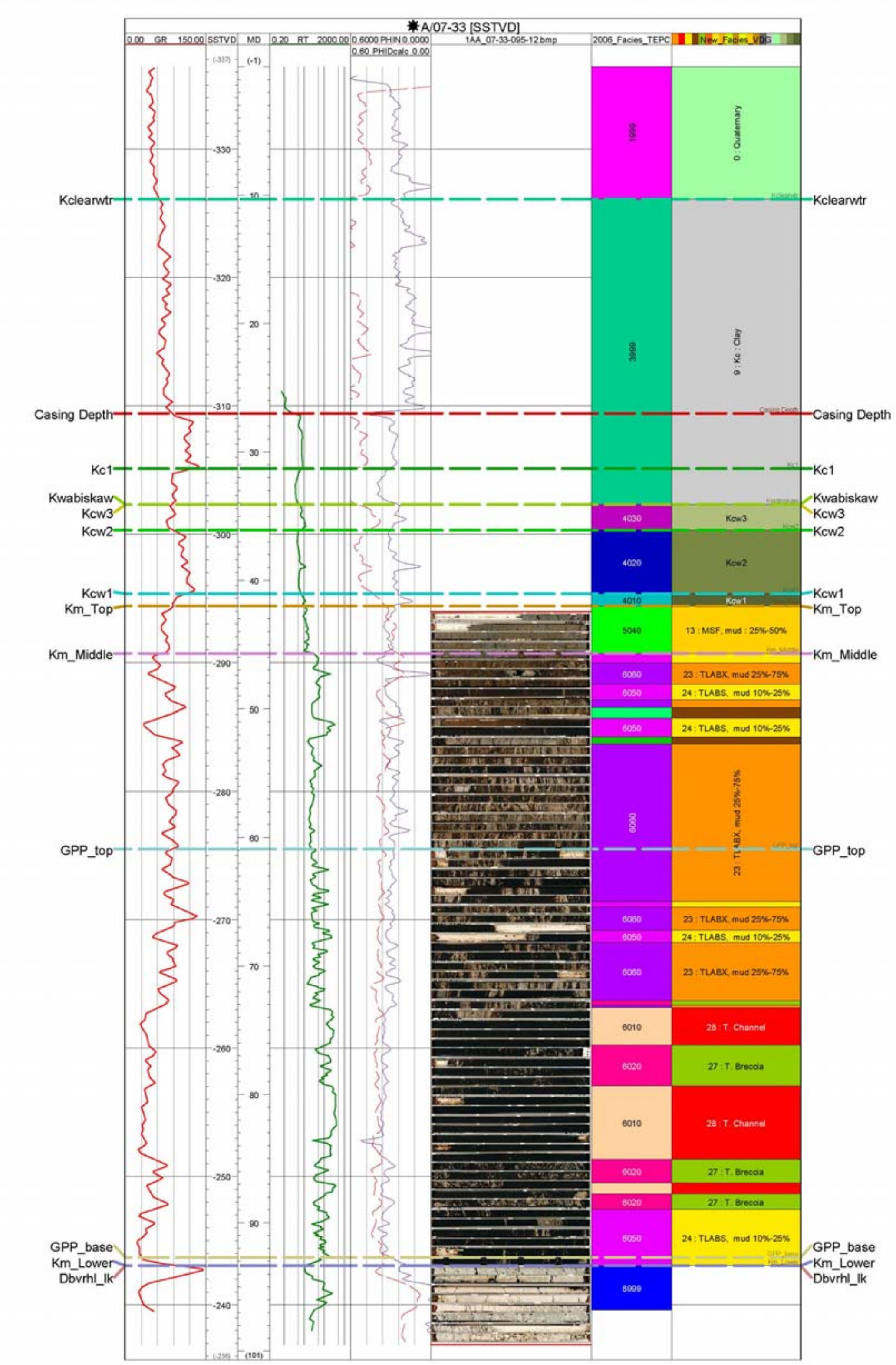


Figure 10 1AA_07-33-095-12W4 Well Sketch

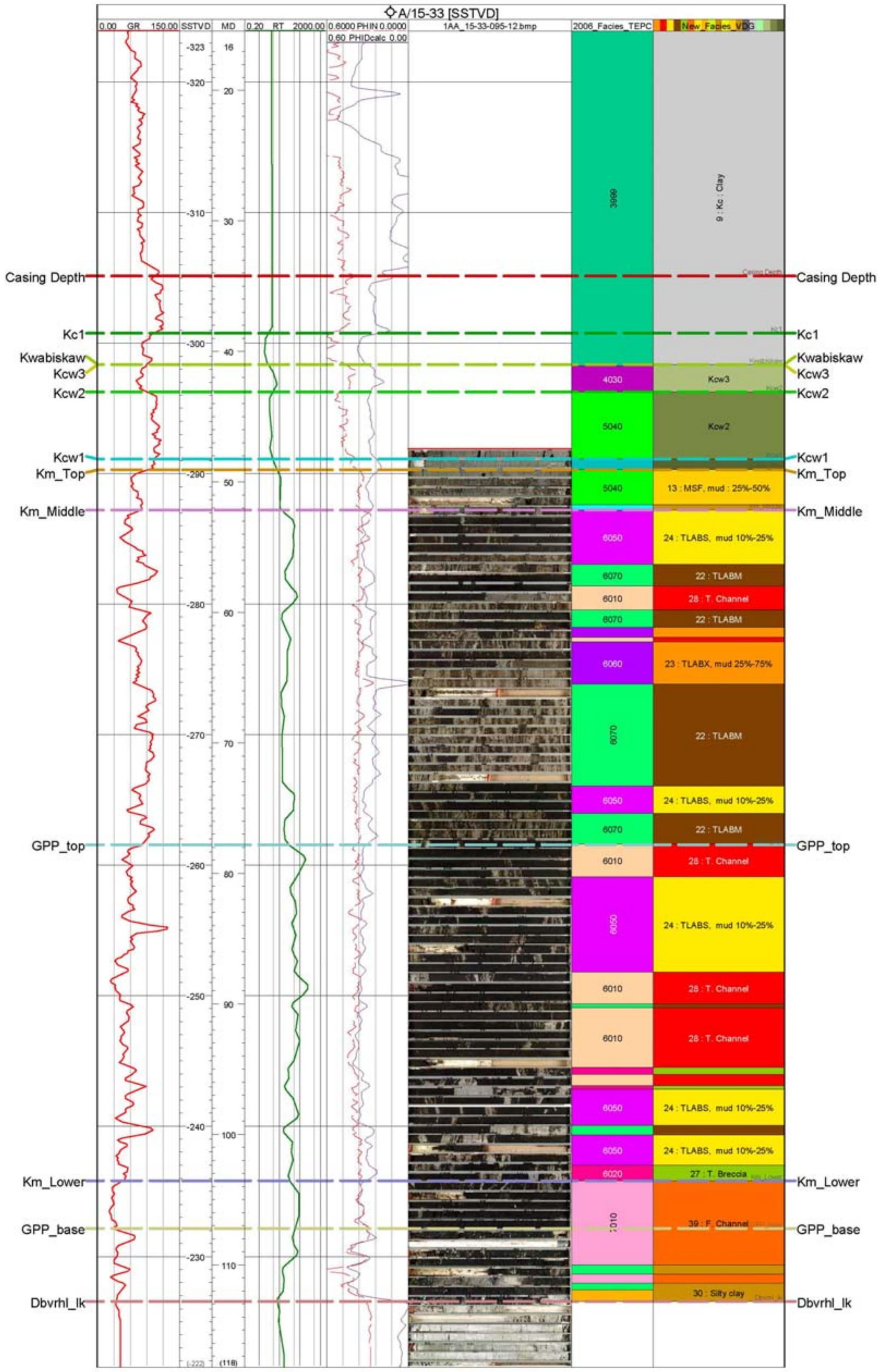


Figure 11 1AA_15-33-095-12W4 Well Sketch

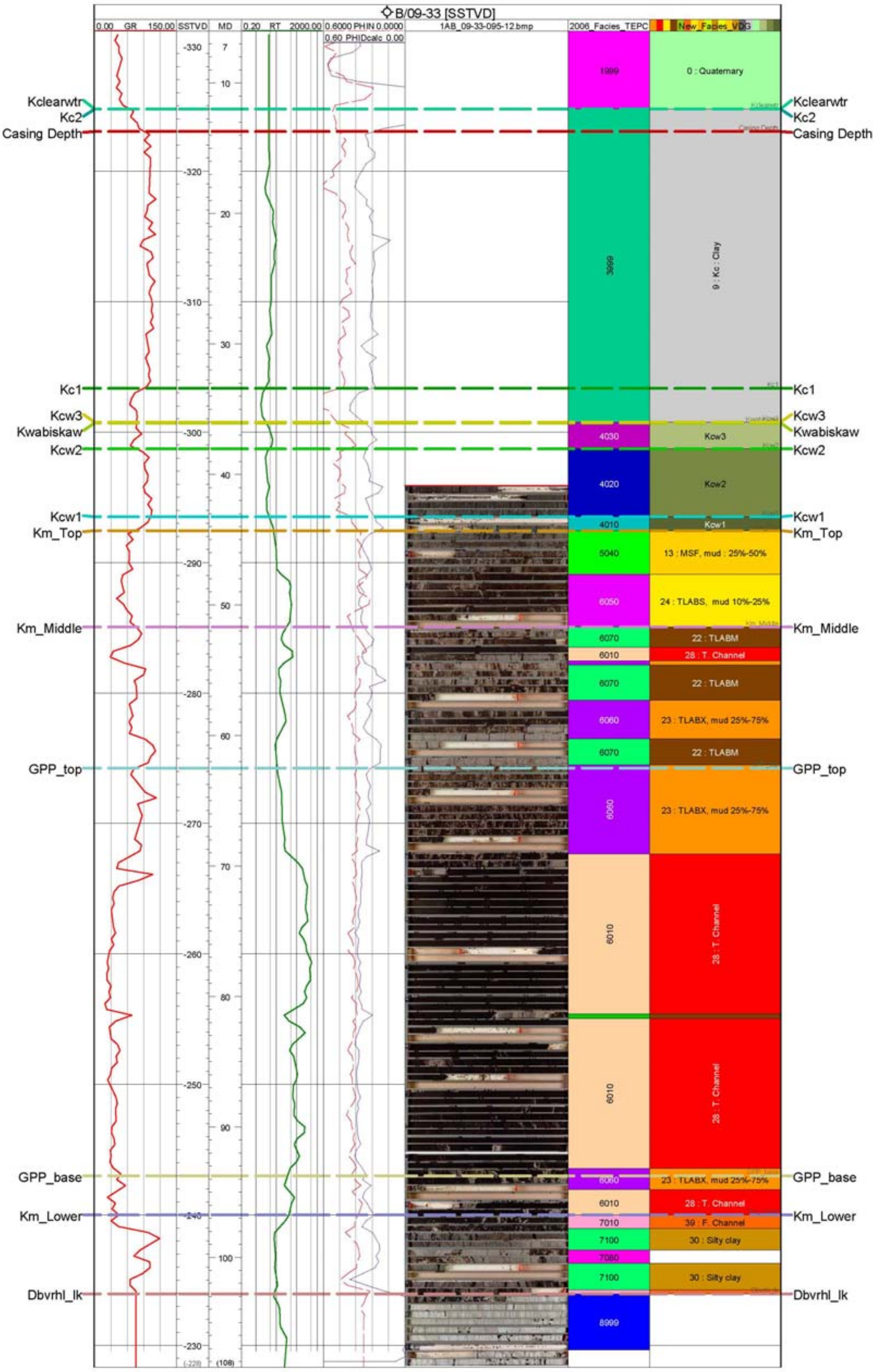


Figure 12 1AB 09-33-095-12 Well Sketch

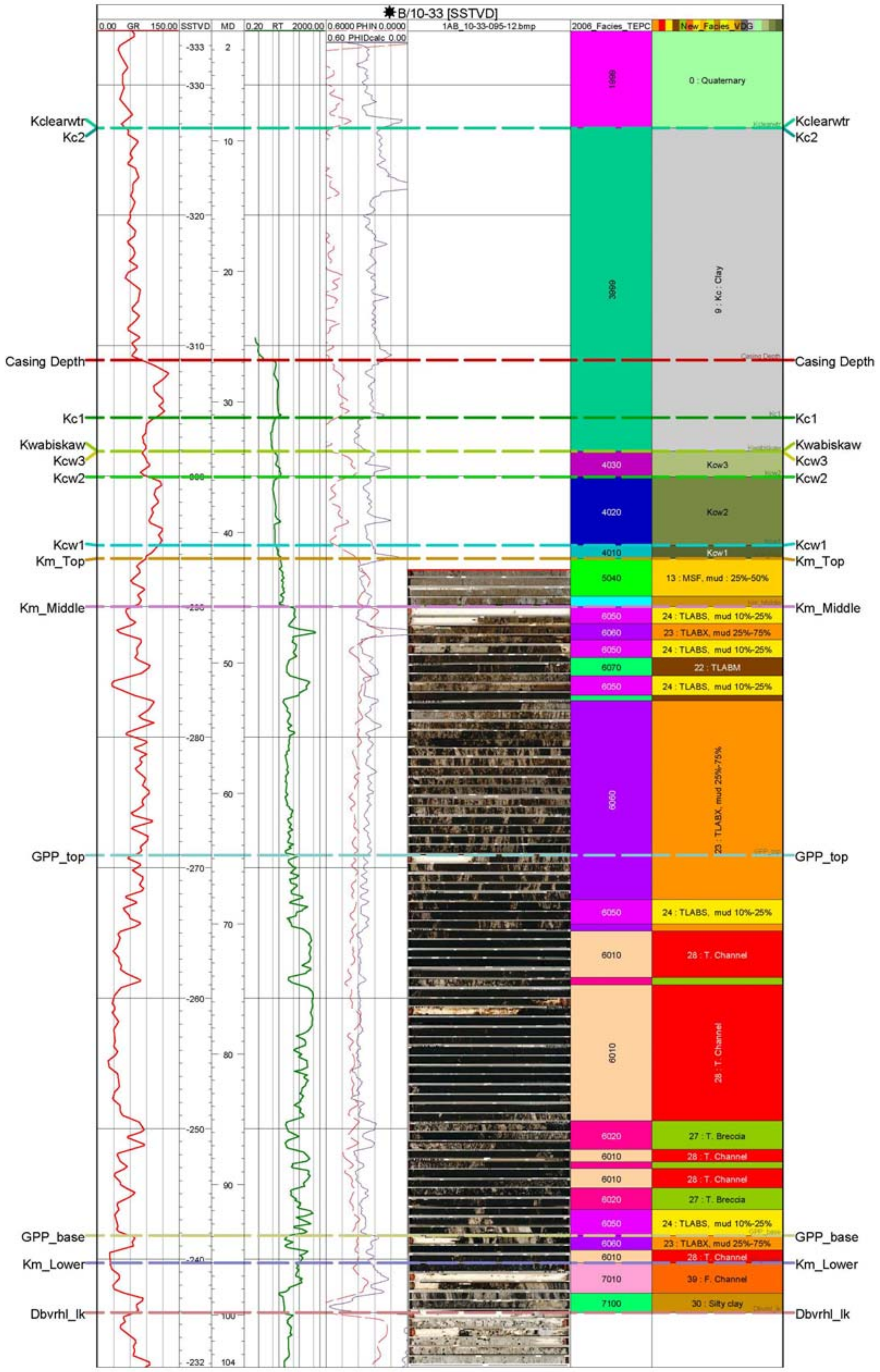


Figure 13 1AB 10-33-095-12 Well Sketch

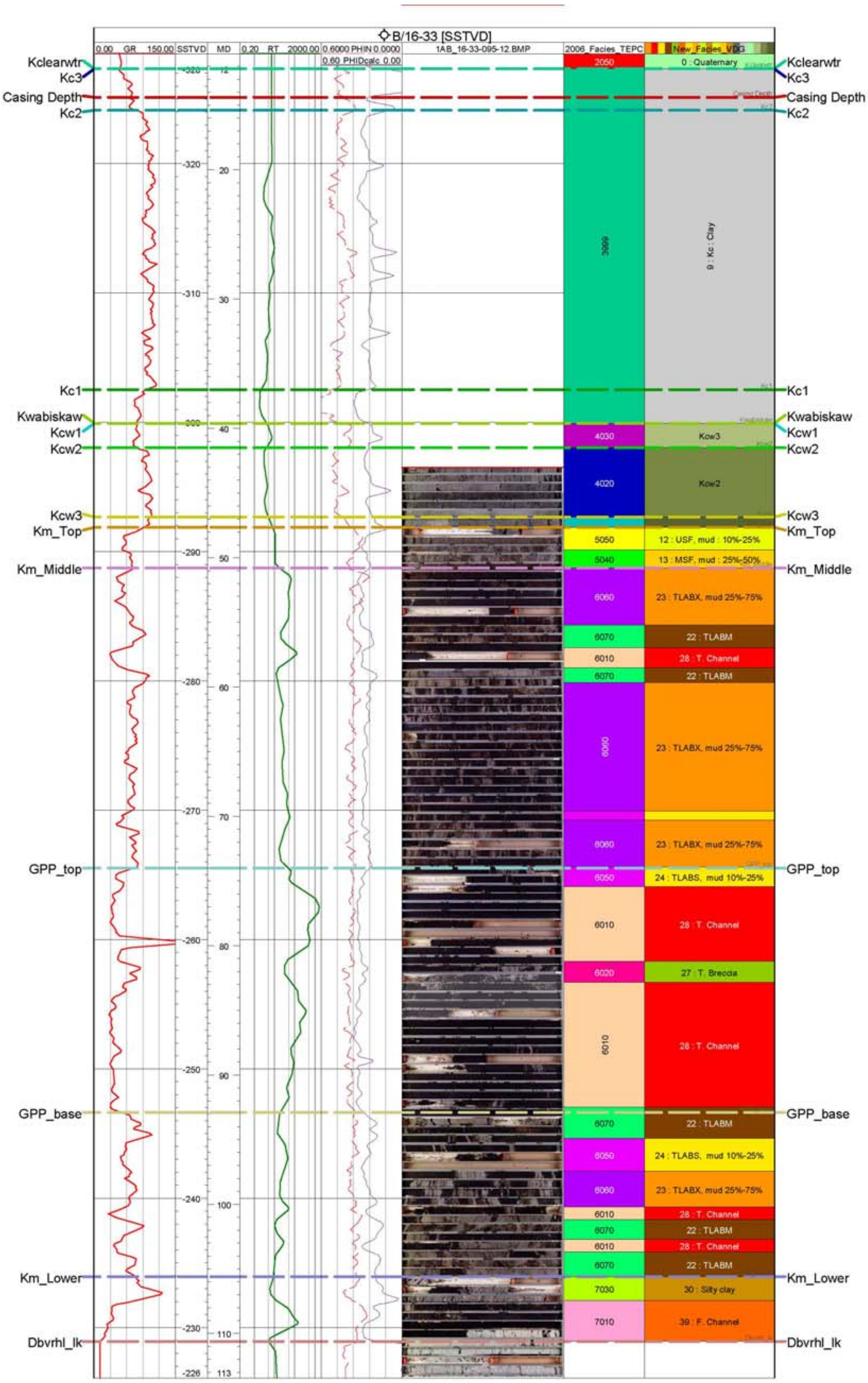


Figure 14 1AB_16-33-095-12W4 Well Sketch

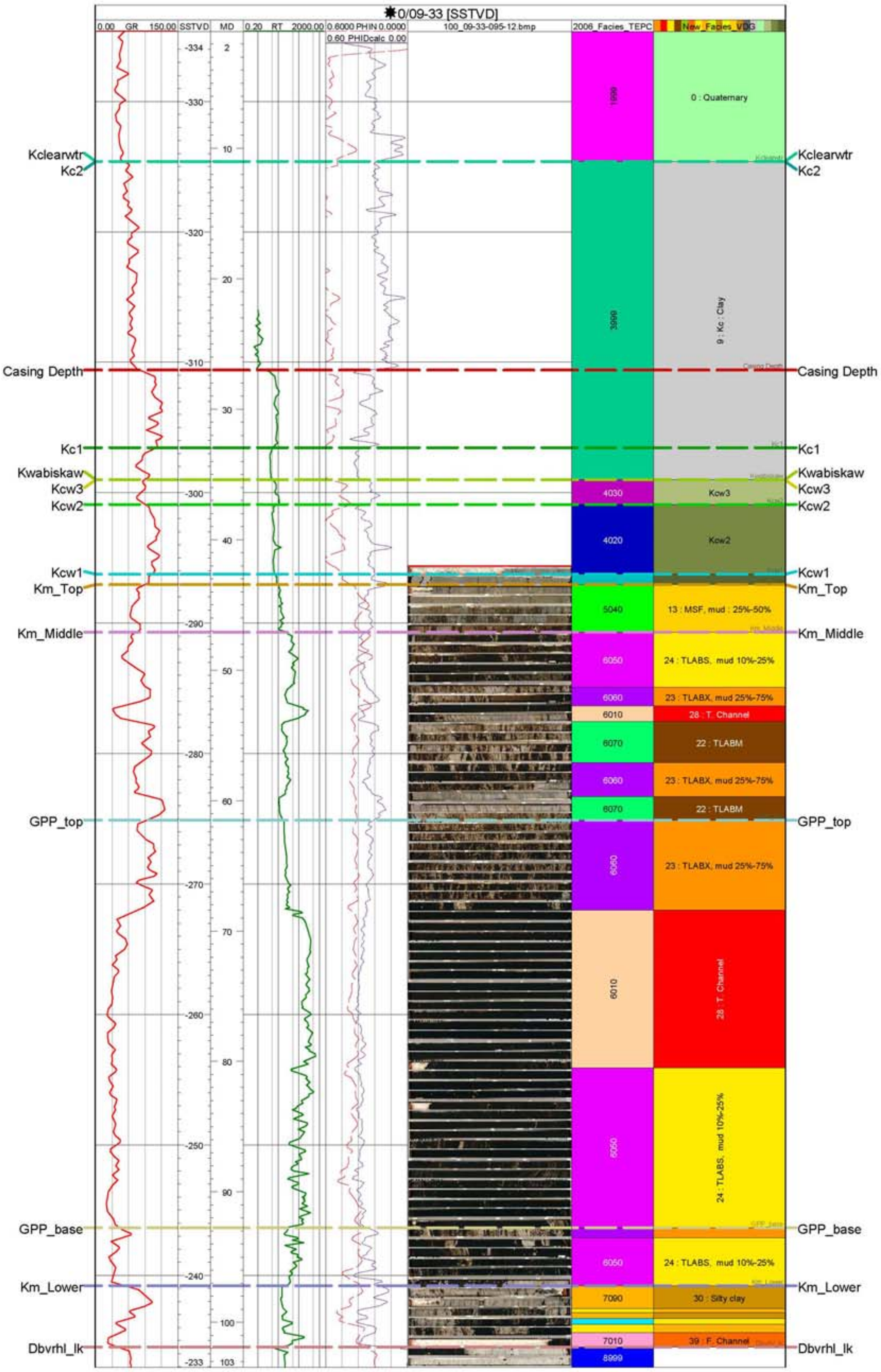


Figure 15 100 09-33-095-12 Well Sketch

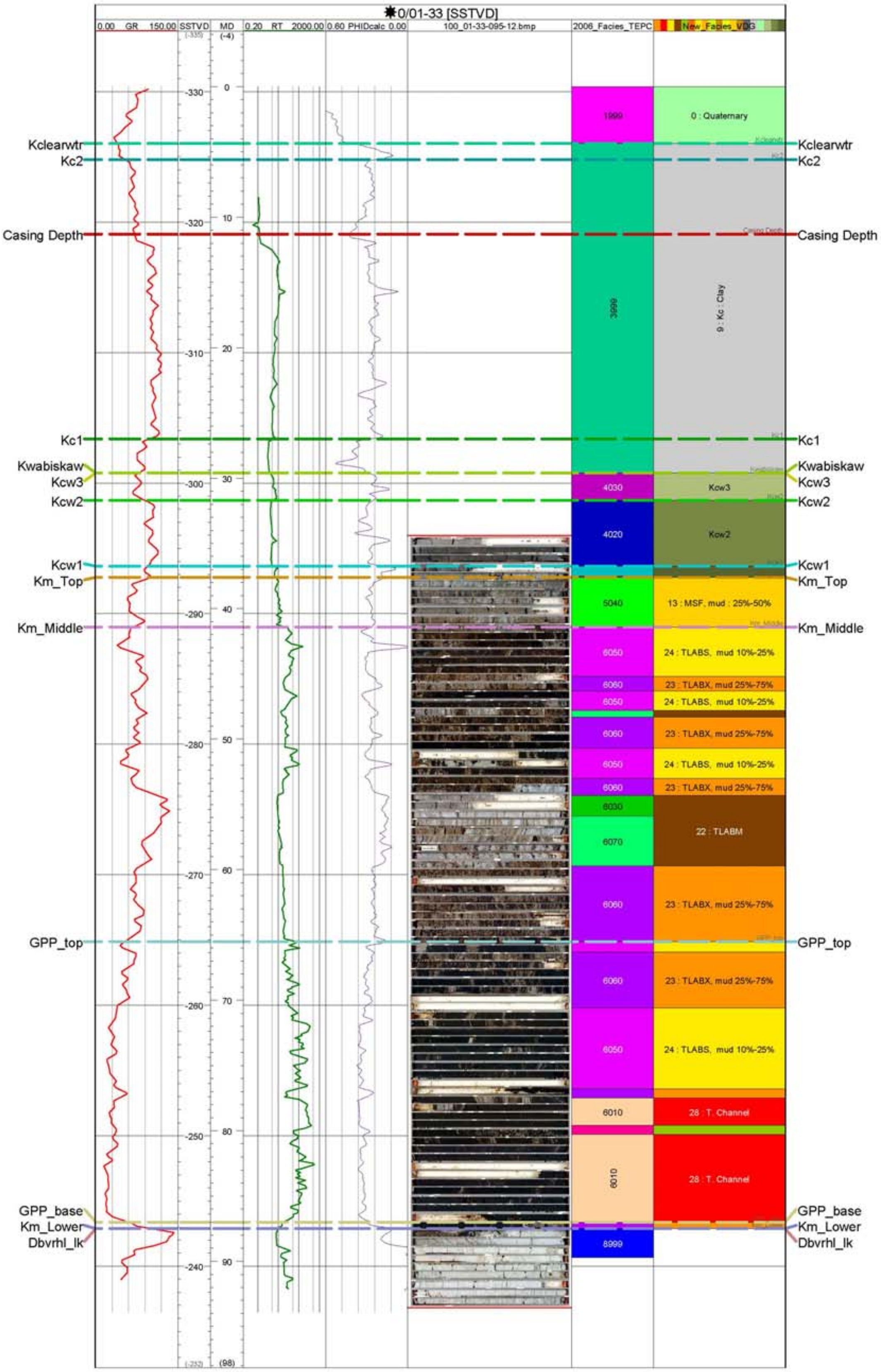


Figure 16 100_01-33-095-12W4 Well Sketch

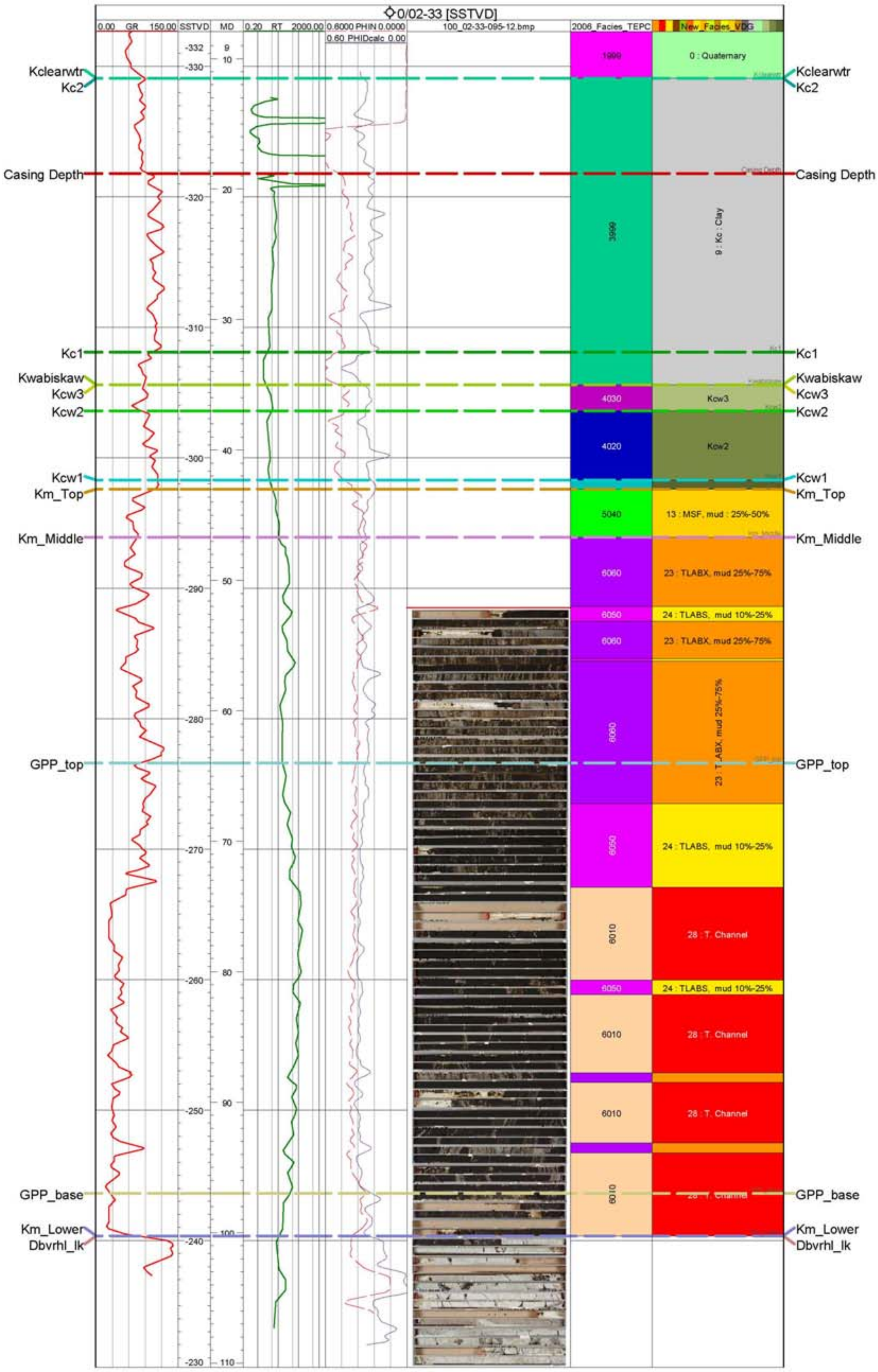


Figure 17 100_02-33-095-12W4 Well Sketch

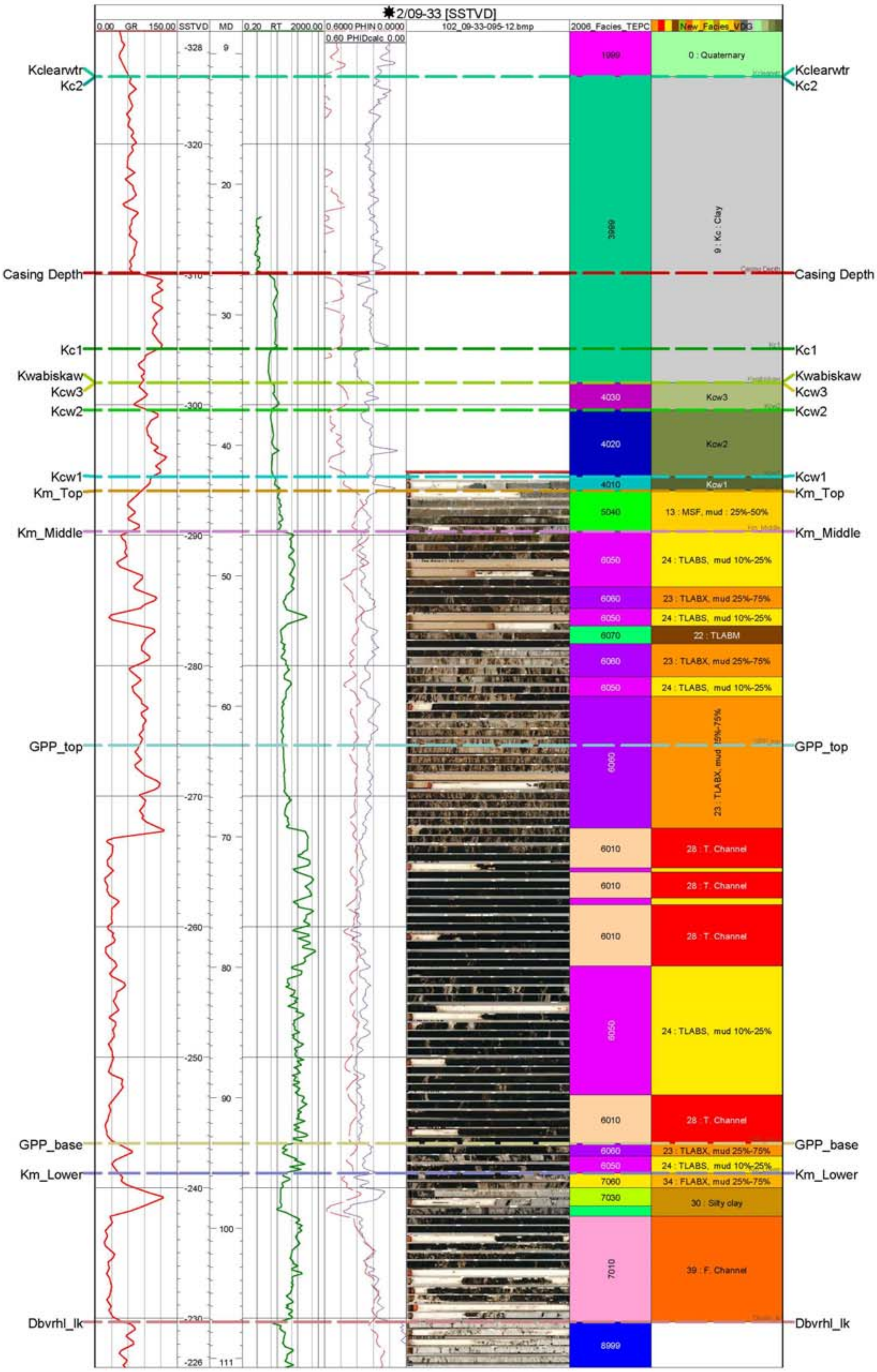


Figure 18 102 09-33-095-12 Well Sketch

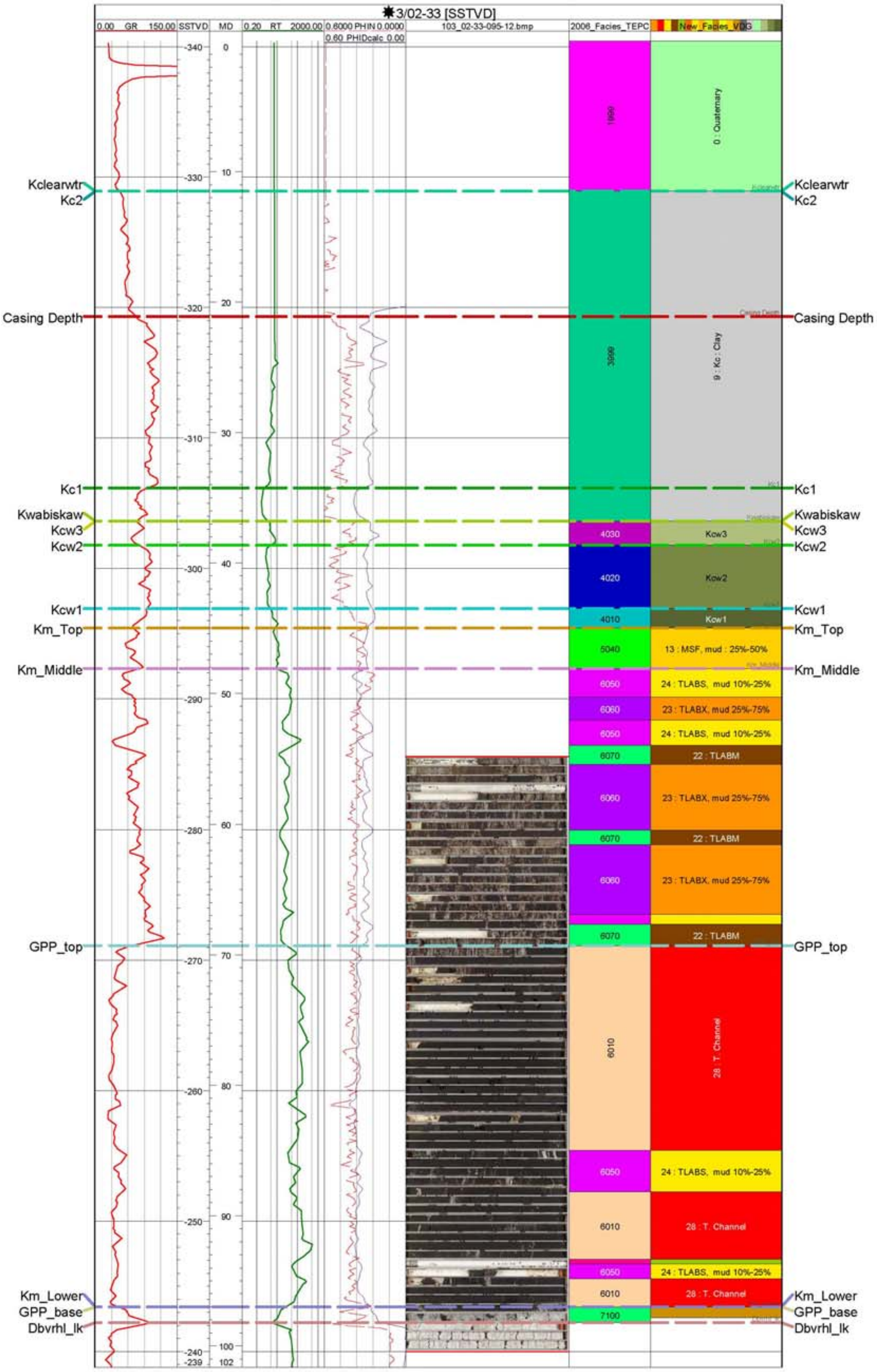


Figure 19 103_02-33-095-12W4 Well Sketch

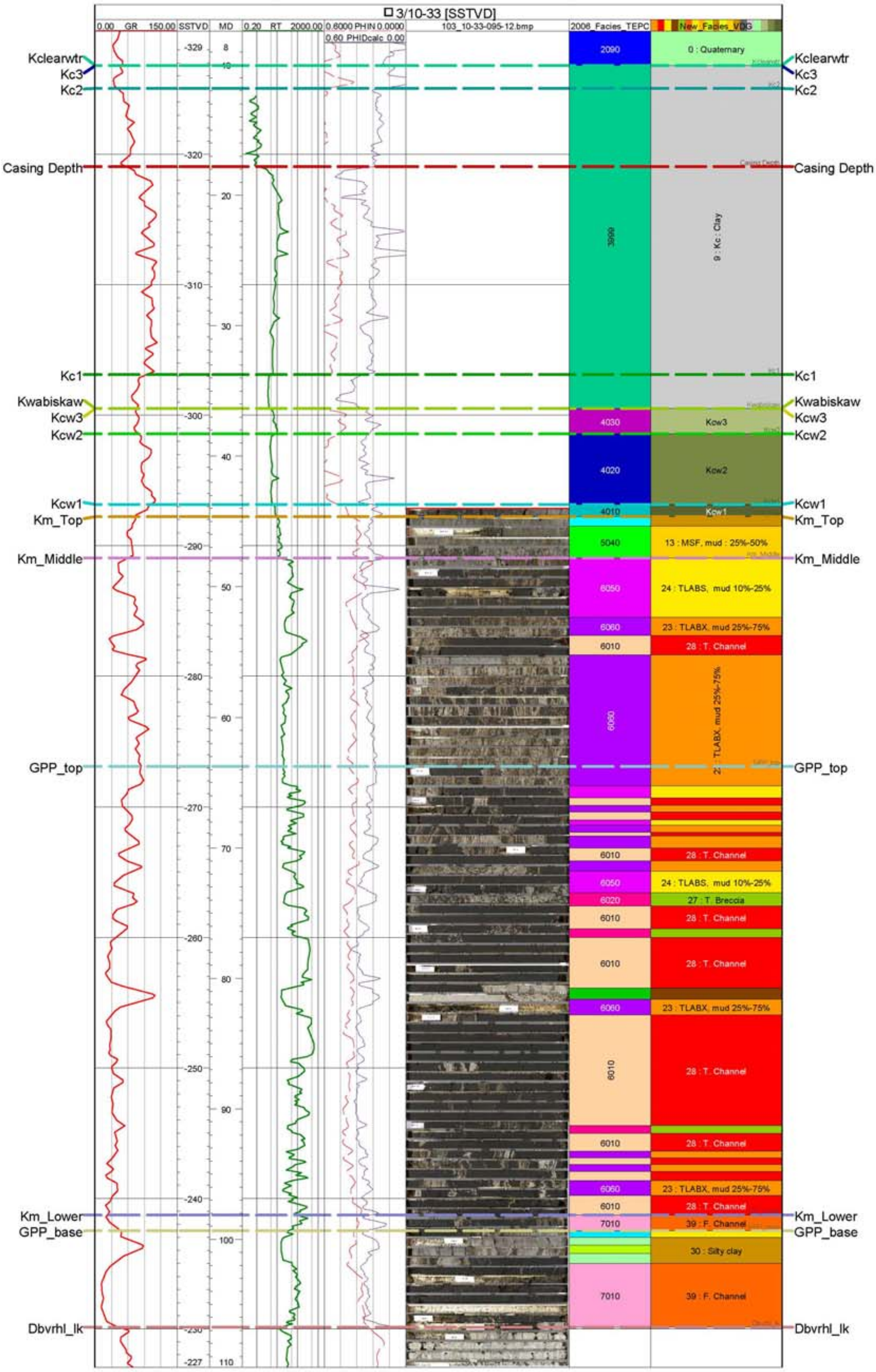


Figure 20 103_10-33-095-12W4 Well Sketch

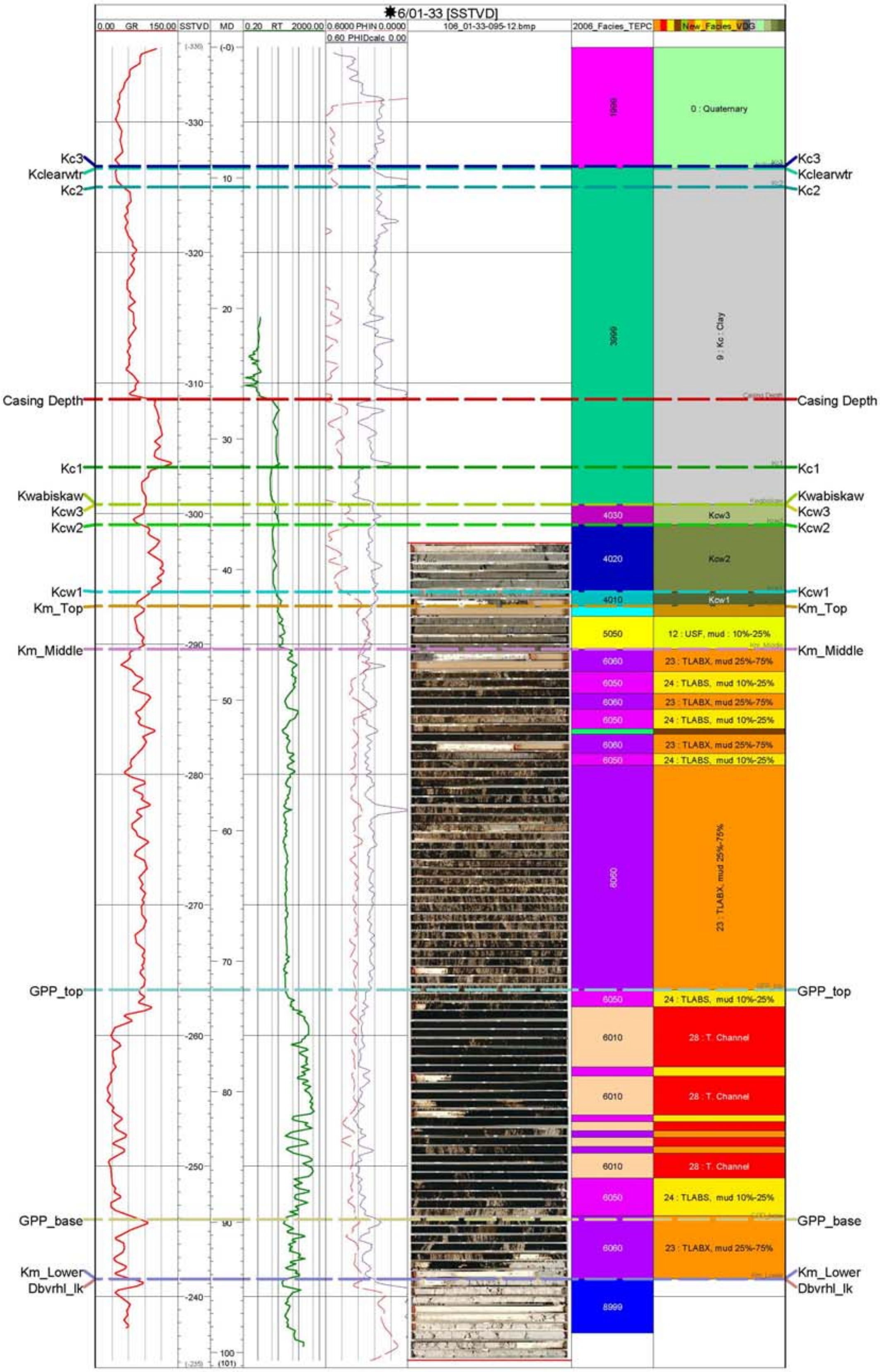


Figure 21 106_01-33-095-12W4 Well Sketch

3 Geophysics

As documented in **Reference 3**, the interpretation of the 3D HR seismic survey shot within the framework of the Joslyn May 18th steam release investigation has evidenced seismic observations close to 204-I3P3 well pair that may be seen, depending upon their interpretation, as cause of concern for the safety of 204-I3P3 production operations. These seismic observations are sometimes referred to as the 204-I3P3 "seismic anomaly".

Please see **Reference 3** for general information related to the 3D seismic survey acquisition, processing and interpretation. The following paragraphs will focus solely on possible interpretations of the 204-I3P3 seismic observations considering or not the information brought by well 104-10-33-095-12W4 on the matter (possible interpretation before and after the drilling and logging of the aforementioned delineation / monitoring well).

As an addition to the reference report, the status of the wells covered by the seismic survey at the time it was shot is summarized in Table 1. Well pair 204WP3 had been shut for 8 months and was cold (see Figure 29) at the time the survey was shot. It is clear that no steam, had there be any steam in any location, could have remained near the wells or higher up in the formation since the steam release or before.

Well pair ID	Well pair Status	Wellbore Dowhole pressure	Well bore down hole max temperature	History	Max Pressure Regime applied
203P1	Shut		10ºC	Never started	
204P1	Shut	200-400kPag ?	10ºC	3.5months circulation + 1.5month semi-SAGD + steam release	1800kPag
204P2	Shut	200-400kPag ?	20ºC	3months circulation	1775kPag
204P3	**Shut**	**350kPag**	**40ºC**	**3.5months circulation + 1.5month semiSAGD**	**1800kPag**
204P4	SAGD mode	1100kPag	190ºC	6months circulation + 3months SAGD	1775kPag

Table 1. Well status at the time of the Seismic Survey (Jan2007).

3.1 Summary of 204-I3P3 observations

The key observations made in the 204-I3P3 area can be summarized as follows. They are discussed in details hereafter:

- High amplitude reflections below the McMurray 5 level, whose extension coincide with a local anti-form.
- A small flexure at the Top McMurray/Wabiskaw level above and oriented parallel to the axis of the high amplitude area and corresponding anti-form.
- Flat reflections in the upper part of the Middle McMurray interval above the aforementioned high amplitude,

3.2 Seismic interpretation without well 104-10-33-095-12W4 data

The rationale for interpreting the 204-I3P3 observations are detailed hereafter. **Diverging interpretations can be formulated to explain those observations as detailed below**:

- The high amplitude reflections evidenced above the injector 204-I3 along line 120

  The Figure 22 on the EW line 120 shows the evidence of the high amplitude close to 204-I3P3 and the apparent similarity between these amplitude observations and those made above pair 204-I1 where the steam release occurred. These two sets of amplitude reflections appear to be at the same level below the McMurray 5 seismic horizon. Based on the nearest available wells they are both located below the top Middle McMurray pay zone

  This kind of observations can be related to fluid contact (gas water or gas bitumen) or strong lithology variation (such as carbonate presence). Pressurized water and sand dilation could also be envisaged by comparison with the observations above pair 204-1.

  The pick of density observed in the 104/10-33-095-12W4 well is quite specific and different compared with the 4 other available wells in the 3D (102/10-33-095-12W4, 100/09-33-095-12W4, 1AB/09-33-095-12W4 and102/09-33-095-12W4) as illustrated on Plate 4 Possible carbonate answer of available wells over the 3D seismic acreage.

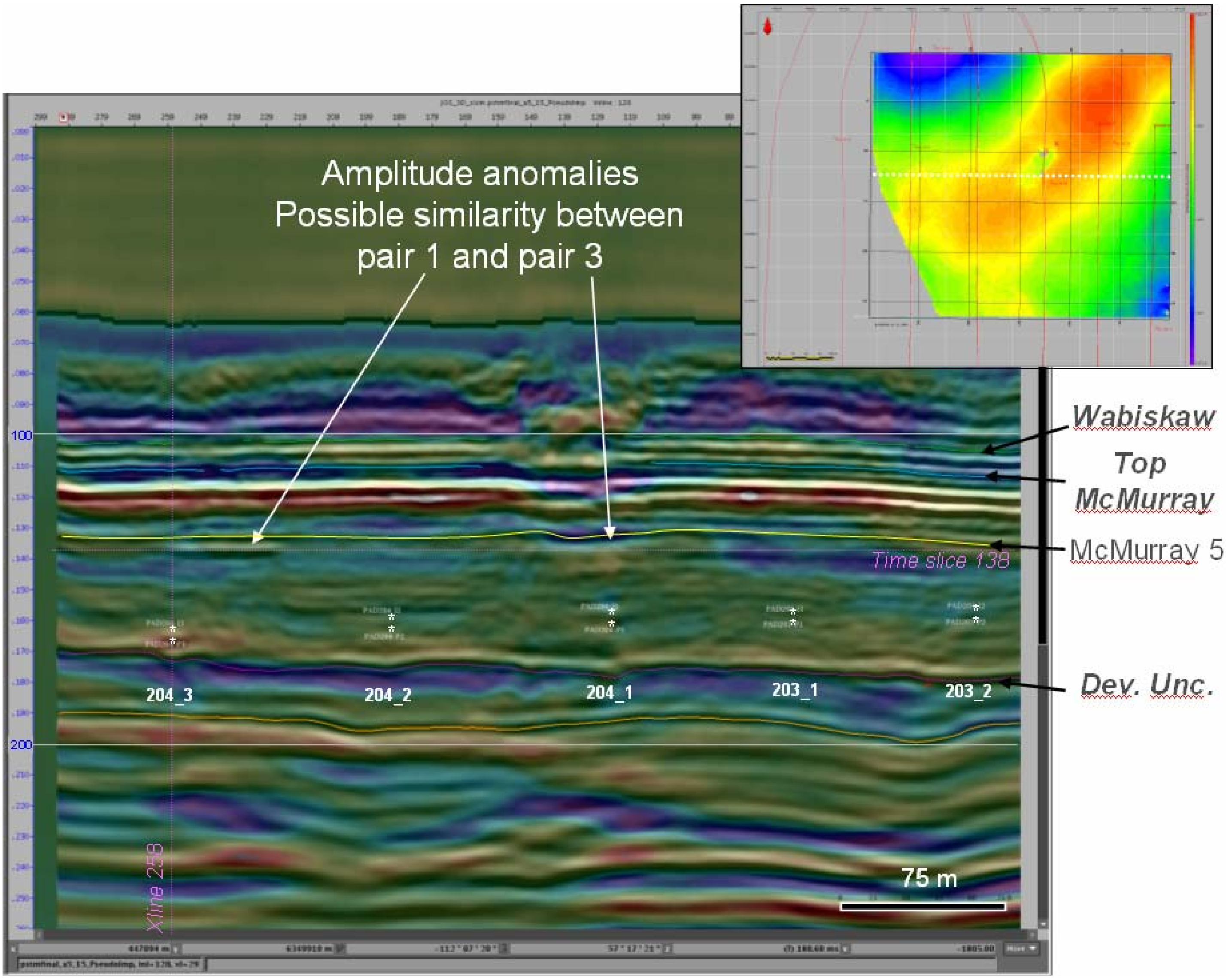


Figure 22: Seismic anomaly on line 120

The amplitude configuration along the well pair 204-3 (Xline 158 - Figure 23)

This orientation the high amplitude reflections is clearly flat and is not conformable to the other horizons above. This configuration is suggesting that the high amplitude reflection could be related

- To a fluid effect (‘flat spot’ effect). This kind of effect is generally related to a gas water contact. It could also be related to lithology contrast if the Lithology variation is in relation with diagenetic (post depositional) effect along a fluid contact.
- Or to seismic artefact origin but no clear evidence has been found on a check of gather data.

The absence of clear seismic event or degradation between the well pairs and the high amplitude reflections is suggesting that **there is no link between the injector and the anomaly**.

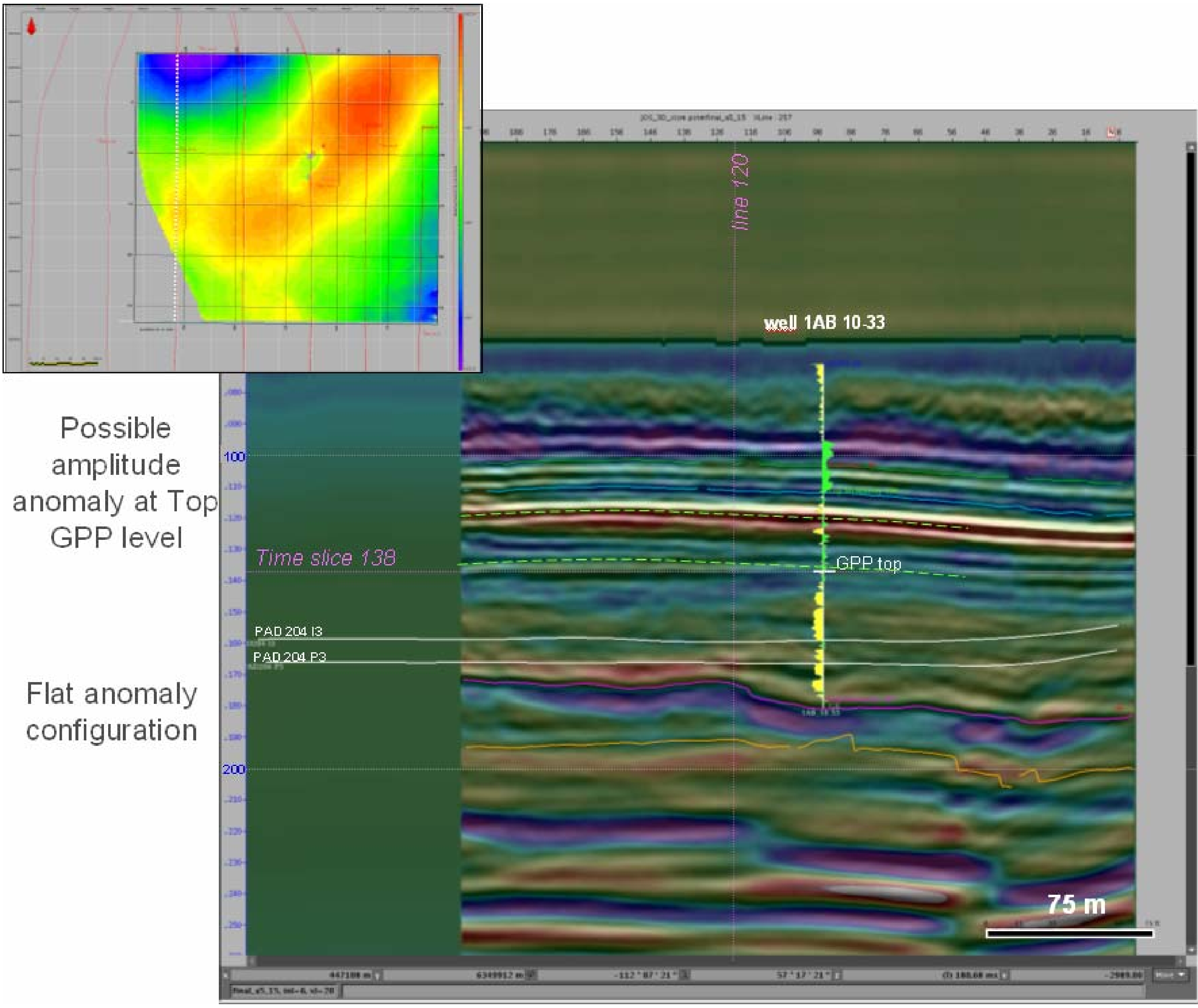


Figure 23: Seismic anomaly on Xline 158

Well 1AB 1033 is just on the border of the high amplitude reflections and cannot be used to characterize the anomaly. Nevertheless this well is suggesting that the lithology at the high amplitude reflections level correspond to a poor reservoir quality level at the top of the middle McMurray pay zone.

The location and the lateral extension of the anomaly

Figure 24 is showing the map of the high amplitude reflections component of the anomaly (amplitude map at time 138 ms) and the time map of the neighboring picked horizon. The main point to be noticed is the local small (120m x 60m) anticline deformation affecting the McMurray 3 above the amplitude anomaly and the apparent conformance between the high amplitude reflections and the small anticline deformation. This last point is suggesting that a possible relation could exist between the high amplitude reflections and the small structural deformation.

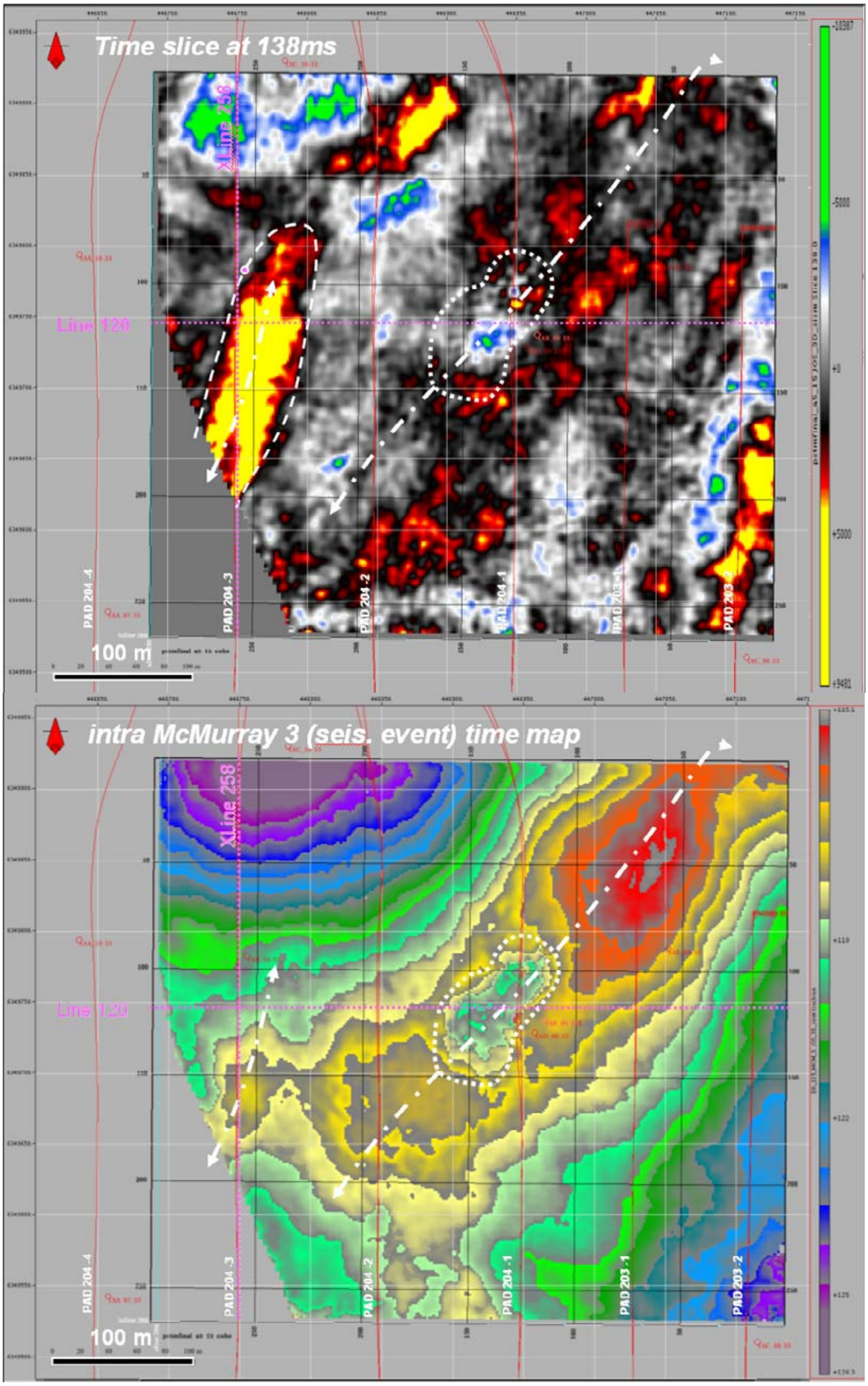


Figure 24 Amplitude map at 138ms and McMurray3 time map

Two main points are suggesting that natural gas is not likely to be responsible of the anomaly;

- No neighboring well is showing gas at the level of this anomaly
- The reservoir quality at the level of the anomaly is poor in most of the cases. So a geological gas accumulation is not probable or too small to be seen on seismic

Overall, based upon this review and without including results from well 104-10-33-095-12W4 no definitive interpretation could be provided for the anomaly.

Before drilling the observation, two main explanations appeared more probable than others:

- A steam injection related event. In such hypothesis, the high amplitude close to the top of the reservoir, the Upper McMurray / Wabiskaw flexure and the small structural deformation observed in the same area could be the result of a steam injection induced horizontal sand failure. Such hypothesis would constitute a cause for strong concern about 204-I3P3 operational safety.
- A complex lithology-related local seismic signature not involving any man-induced effect and not cause for safety concern.

Upon reaching such conclusion, the decision was taken to:

1. Not to resume operations on 204-I3P3 (the well was already shut in for the plant turn around, at the time the conclusion was reached).
2. Drill one observation well in the apex of the anomaly in order to
    a. Gather data that would allow to further discriminate between the various hypothesis
    b. And, in any case, to be in a position to monitor the risks of steam confinement loss over the area in the future.

3.3 Seismic interpretation with 104-10-33-095-12W4 well data

Well 104-10-33-095 has been drilled in December 2007 in the center of the anomaly at the apex of the NNE-SSW small anticline deformation above well pair 204-I3P3

The well has been TD at 71.4m in the middle McMurray 27m below the Top McMurray (last Stratigraphical reference).

Lithology at the base of the well (65 to 71.4m) is characterized by a succession of decimetric to metric sand and shale layers clearly imaged on the FMI, the GR and the resistivity logs. Fluid in the sandy layers is bitumen. No gas has been identified in them – if gas were present the logging suite used should have picked it up.

The FMI image interpretation did not conclude to the presence of any fractures. Identified true dip poles mainly correspond to bed boundary with a dip les than 10°. Two occurrences of scour surfaces with a maximum dip of 20° have also been identified.

The well has been calibrated on seismic using sonic and density curves. Without the Devonian Unconformity as a reference level, the well calibration remains very uncertain.

Two calibrations can be proposed:

1. The first case gives us a fair correlation between the synthetic and the seismic trace (Figure 25). This calibration is in agreement with the picking initially done and presented in the interpretation report. Based

upon this calibration the well TD is just at the base of the anomaly and as the sonic was not acquired in the lowermost part of the well, it has not been possible to characterize the observed anomaly. The main conclusions with this calibration are:

- The absence of gas at the level of the high amplitude reflections
- The lithology at the base of the well does not support the hypothesis of the anomaly being linked to lithological effects.

2. The second case calibration (Figure 26) is not in agreement with the initial picking presented in the interpretation report and is 9ms lower than the previous one. This calibration allows an explanation for the anomaly as the sonic trace actually covers the anomaly interval. Velocity intervals used for this calibration are relatively low and raise the question of static correction applied on the seismic data. With this calibration:

    - The gas levels are lower on the section and can be correlated with the flat event above the anomaly itself.
    - A pick of density (most likely a carbonate streak) can be correlated with the amplitude anomaly at the base of the well.

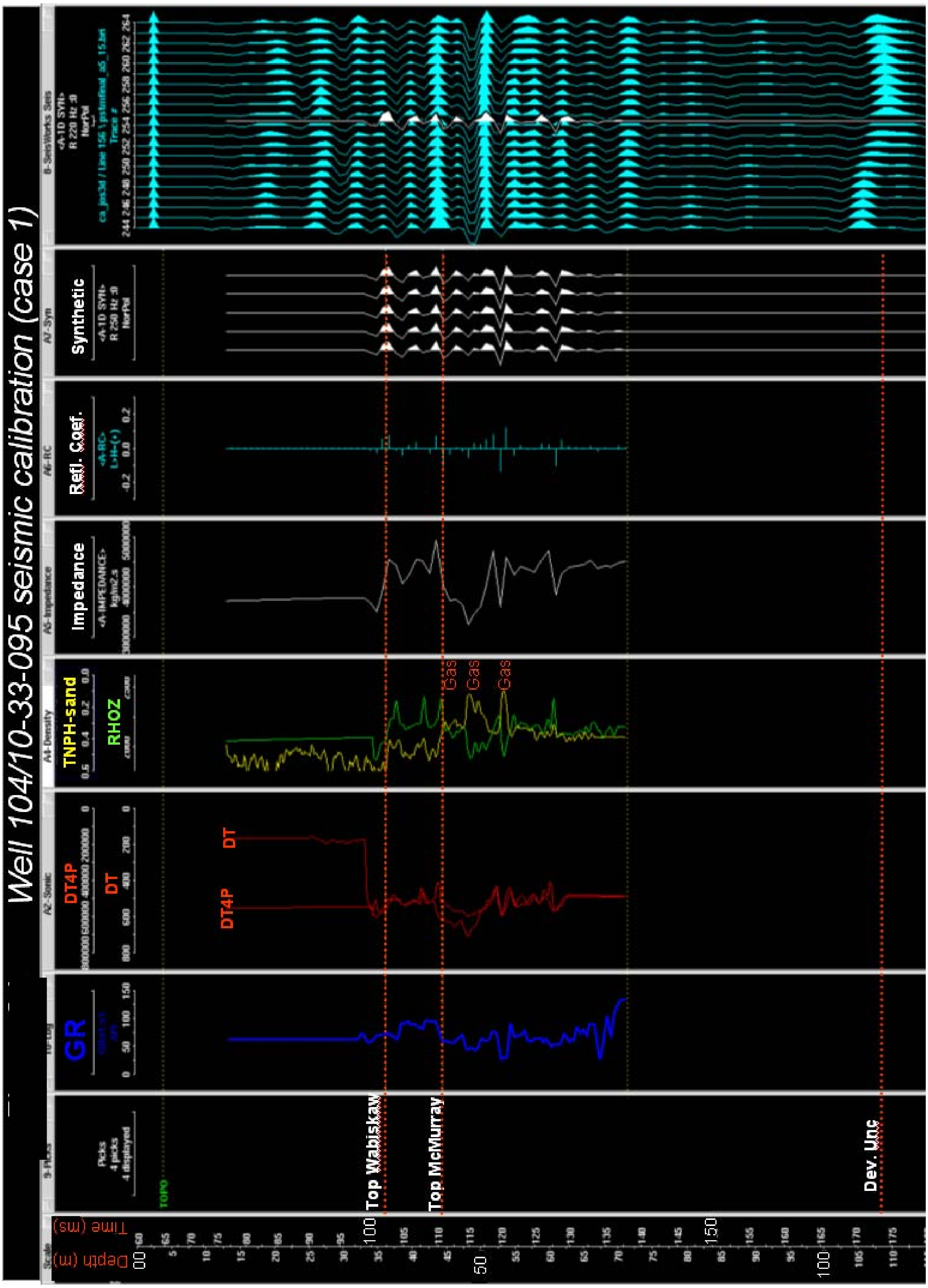


Figure 25: Well 104-10-33-095-12W4 calibration plate – Case 1

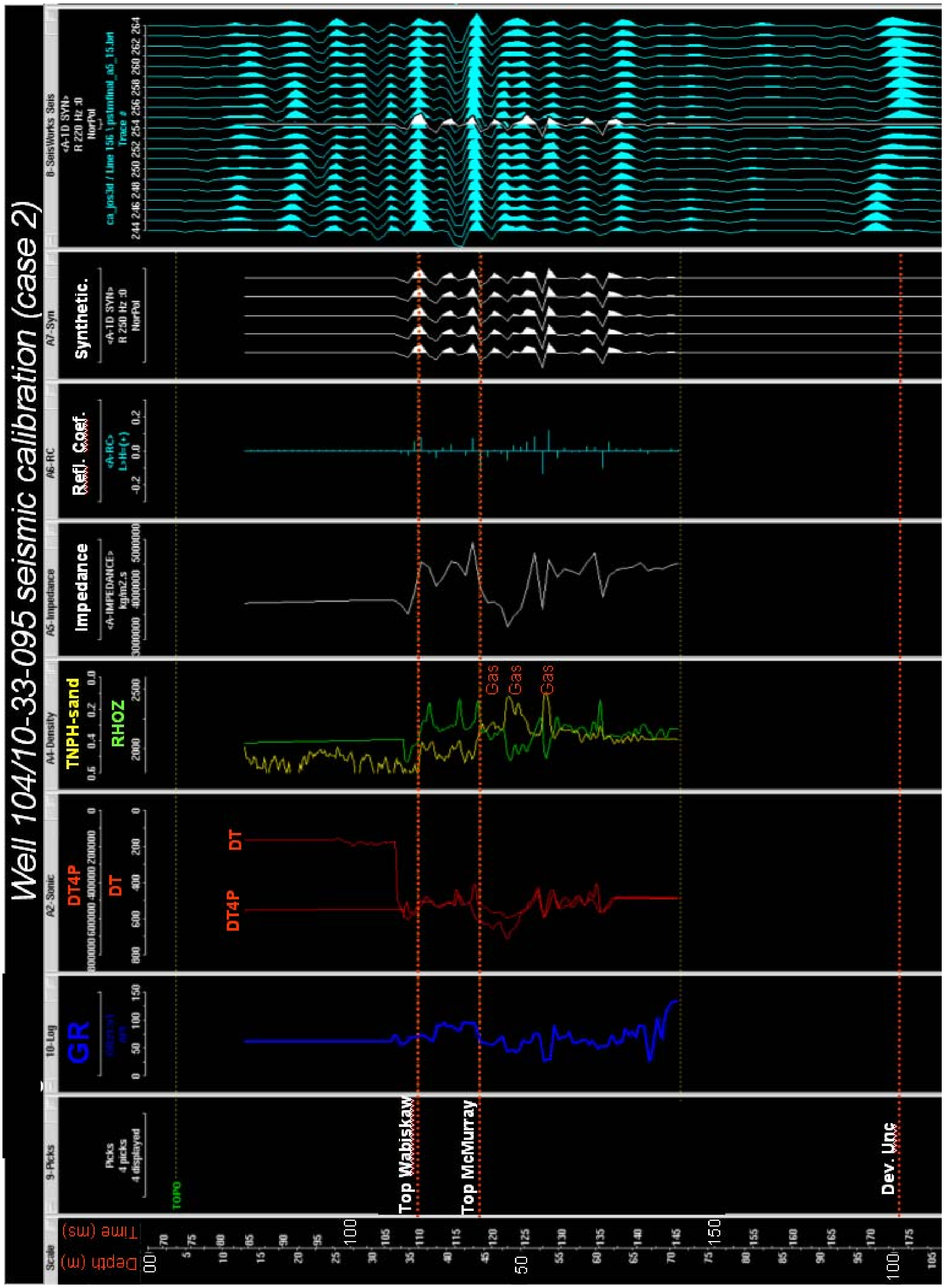


Figure 26 Well 104-10-33-095-12W4 calibration plate – Case 2

At the present stage, and with the 104-10-33-095-12W4 well information, no single interpration can unfortunately be drawn from the seismic. Depending upon the seismic calibration, the anomaly may be related to, :

- A steam injection related event. Such hypothesis would constitute a cause for concern about 204-I3P3 operational safety.

- A lithology and fluid-related local seismic signature not involving any man-induced effect and not a cause for safety concern.

Work is still on going relative to this interpretation and some additional data may gathering may be considered.

Acquiring a VSP on the well 104-10-33-095-12W4 and a new sonic on well 1AE/09-33-095-12W4 was considered to improve the calibration and globally reduce the uncertainty of the interpretation. Unfortunately, it as not been possible yet to find a tool compatible with these wells' ID (internal diameter 62 mm). Such acquisition is on hold pending further investigation of extremely slim sonic tools.

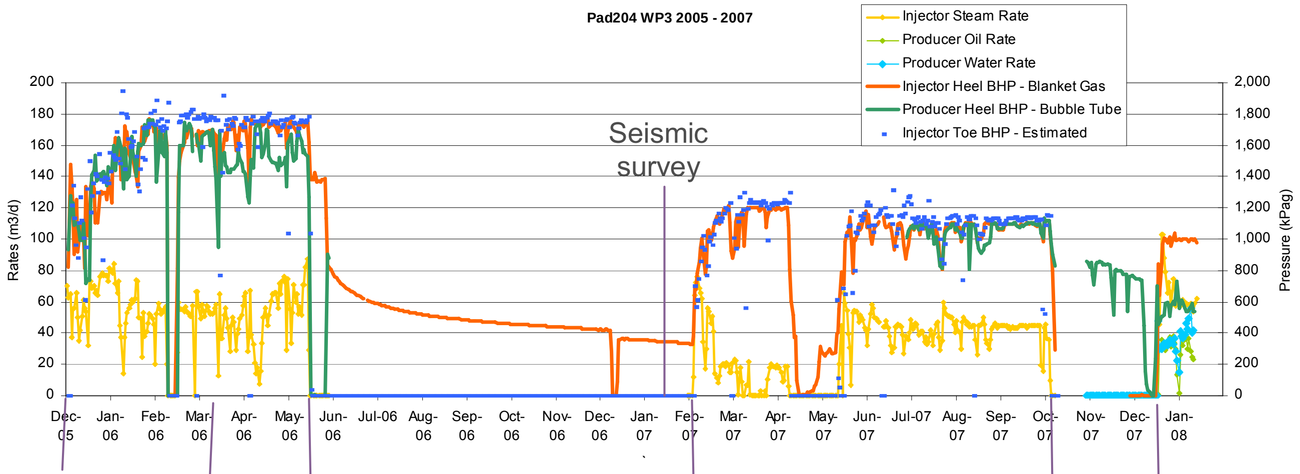
4 Reservoir, Production and Monitoring

Please see Reference 4 for generalities related to the definition key characteristics of circulation, semi-SAGD and SAGD phases on Joslyn.

4.1 204-I3P3 Production history

The key elements of 204WP3 history are shown on Figure 27. The well pair had the same high pressure history as 204WP1 before the steam release then it was shut for 9 months. Steam circulation at 1200kPag was resumed in Feb 2007. The SAGD conversion work-over was performed in Dec 2007 and the well pair has operated in SAGD mode at 1,000kPag since.

A careful review of all 204WP3 injection and production data did not reveal any indication of steam confinement loss at any time since the startup of operations on that pair.



Phase	Circulation	Semi SAGD	Shutin	Circulation	Shutin	SAGD
Start date	12/4/2005	3/24/2006	5/18/2006	2/5/2007	10/7/2007	12/20/2007
Duration (days)	110	56	263	244	75	29
Injector Heel BHP max (kPag)	1825	1813		1218		1035
Cumulated steam volume injector (m³)	9,600	12,450	12,450	19,800	19,800	21,500
Cumulated oil volume (m³)	~300	~500	~500	~1,000	~1,000	~1,700

Figure 27. 204WP3 History Overview.

The seismic survey was shut in Jan 2007. At this time the well pairs and reservoir had cooled down (See **Error! Reference source not found.**).

4.1.1 204WP3 High Pressure, Pre-Steam Release- History

The pressure and rates history before May 18th 2006 is shown on Figure 28.

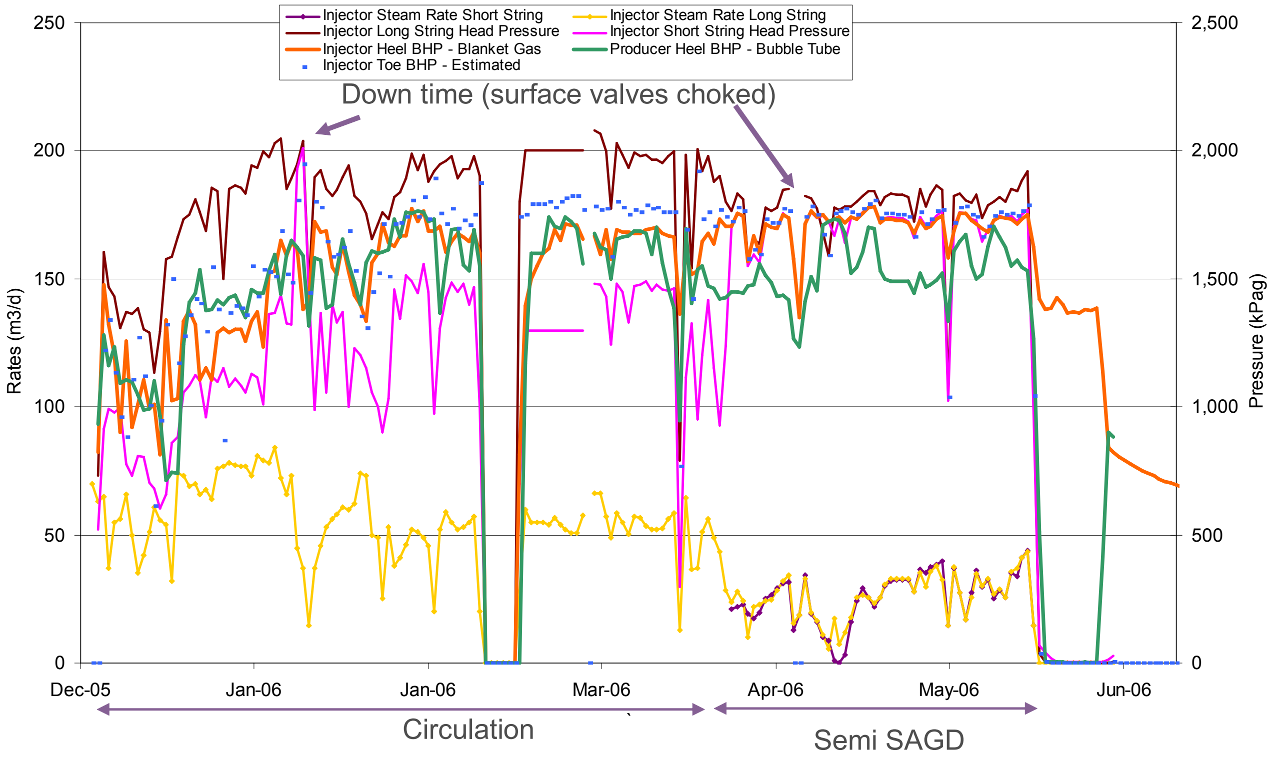


Figure 28. 204WP3 High Pressure History.

During this period, the formation temperature profile in the observation well 1AB/10-33-095-12W4 did not show abnormal heating above the injector level up to 59 m depth (Figure 29), where temperature remained at 45ºC. The temperature increase at the injector level was linked to possible sand dilation (cf. **Reference 4**). Mobile water in the breccia facies found at this level may have played a role also.

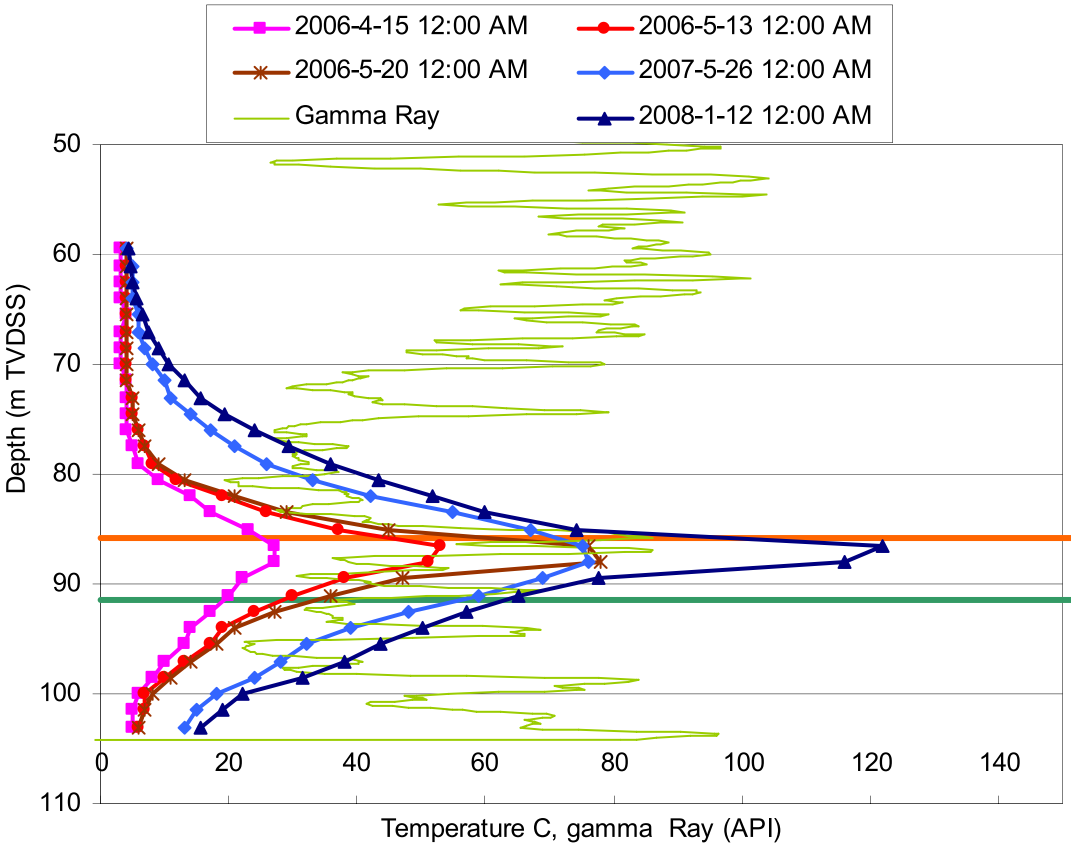


Figure 29. 204 P3 Heel Observation Well Temperature Profiles: Apr 15th, May 13th and May 20st 2006 during the high pressure circulation phase, May 26th 2006 during the 1,200kPa circulation phase, and Jan 12th 2008 in SAGD phase. The well is located ~6m away from the pair.

The producer temperature profile during shut-ins showed quite standard features, including hot spots at the heel and mid drain, where the chamber currently seems to develop (Figure 30, April 2006 fall off profile).

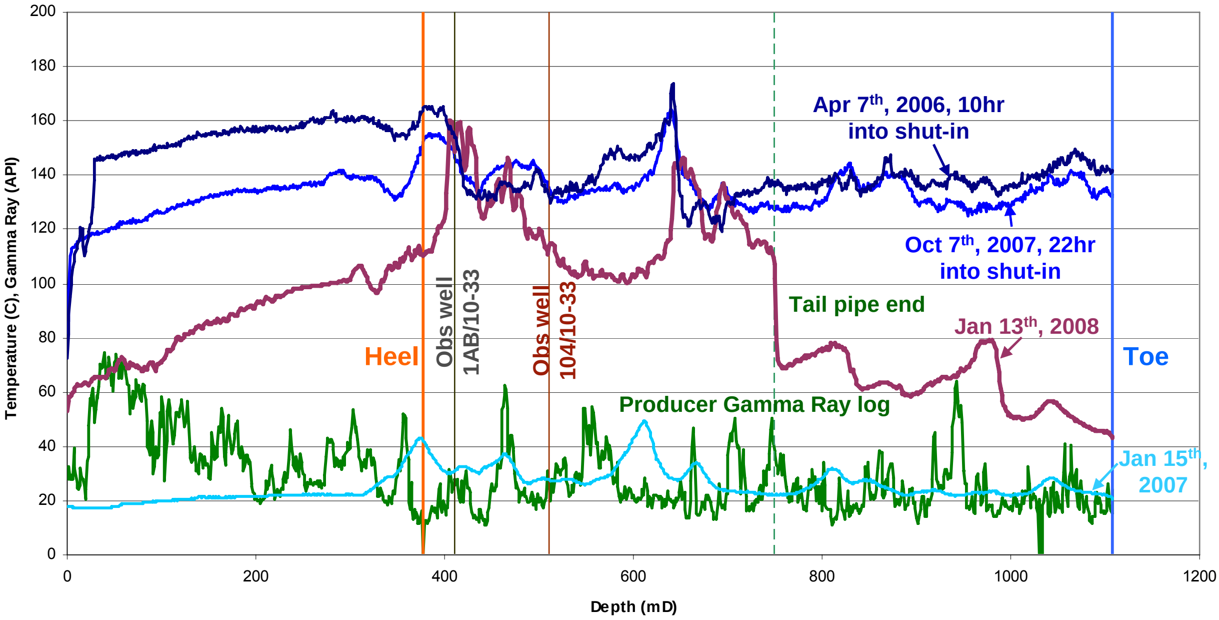


Figure 30. 204WP3 Producer Temperature Profile (from Fiber Optics). April 7th 2006 fall off, Jan2007 at the time of the 3D seismic survey, Oct 2007 pre-SAGD fall-off, and Jan 13th 2008 SAGD profile.

4.1.2 204WP3 Low Pressure, Post-Steam release, Circulation History

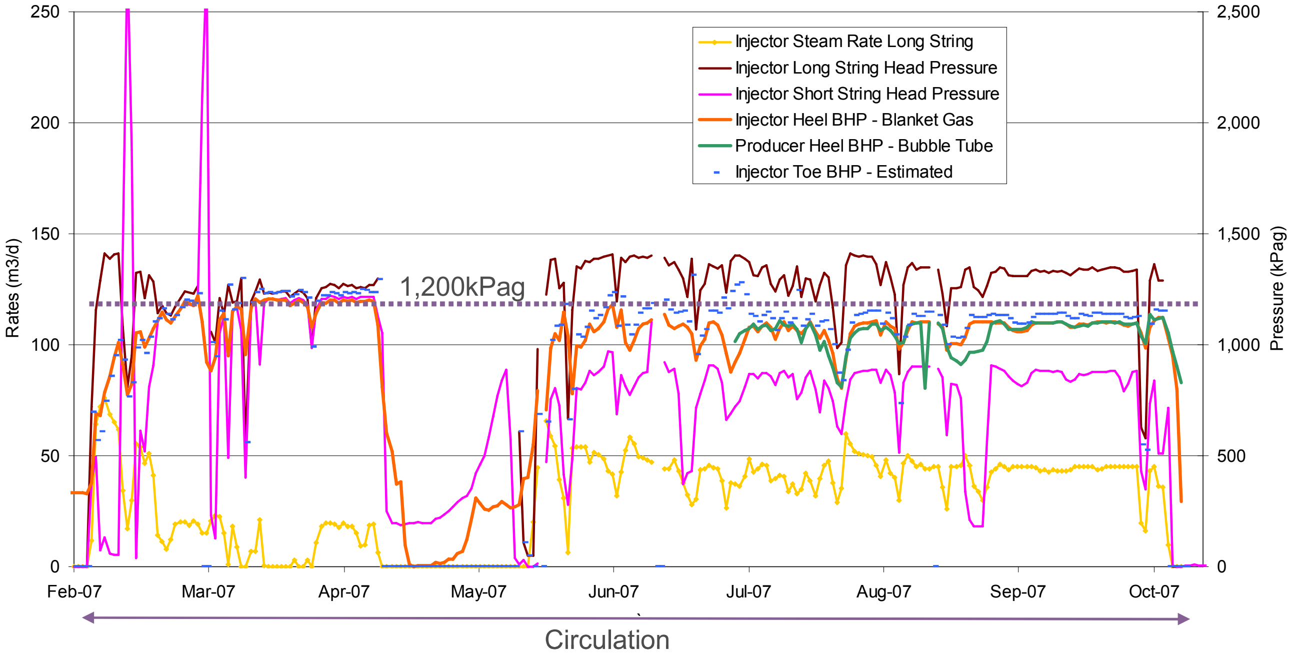


Figure 31. 204WP3 Low Pressure Circulation History.

This circulation period was interrupted by two major shut-ins, one in April-May 2007 (lack of condenser) and one in Oct 2007 (plant turnaround). For various reasons related to steam condensers, the well pair was operated in semi-SAGD between Feb 19th and April 10th 2007. During this period, the injector steam rate did not exceed 40m^3/d (20m^3/d in short string, 20m^3/d in long string), a sign of good pressure containment of the reservoir around the well pair. After restarting the well pair in circulation mode in May 2007, the injection BHP has been maintained at or below 1,100kPag, with stable steam rates below 50m^3/d.

Following the observation and interpretation of a seismic anomaly above 204WP3 between August and October 2007, the decision was taken, early October - during the plant turnaround - not to resume operations on that well after the end of the turnaround. Immediately afterwards, the decision was taken to drill a delineation well into the seismic anomaly. Operations on 204WP3 were suspended pending the drilling, logging and completion with piezometers of an observation well in the area of the seismic anomaly.

4.1.3 204WP3 SAGD History

Immediately after the results of well 104/10-33-095-12W4 were analyzed, well 204-P3 was worked over (December 19th 2007)and the 204WP3 well pair operations resumed on December 20th 2007. Figure 32 shows the main well pair parameters since the start up of the pump on Dec 20th 2007. Pressure has been maintained below 1,000kPag, and steam rates stabilized around 60 m3/d. The 1,000 kPa pressure target was chosen to check the stabilization of steam rates at reasonable levels and the quality of the formation pressure monitoring in well 104/10-33-095-12W4. All other well parameters follow expected trends (producer temperature on Figure 30).

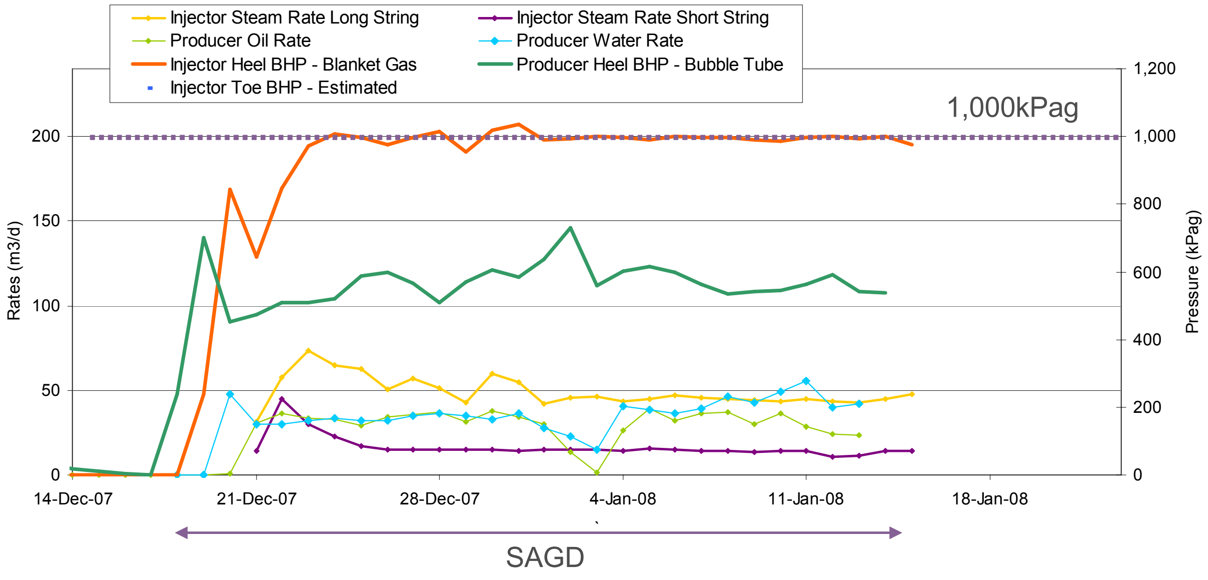


Figure 32. 204WP3 SAGD History

The current reservoir temperature profile (January 2008) along the 204WP3 heel observation well 1AB/10-33-095-12W4 is shown on Figure 29. While -as expected- temperature has increased at the injector level, the profile is indicative of rather pure heat conduction above the injector level. Temperature is still 4°C at 59m depth.

Temperature and pressure data obtained from the new observation well at the heel of 204WP3 (104/10-33-095-12W4) is given on Figure 33. The data is still being checked as some of the measurements appear noisier than expected, possibly in relation with sub-optimal piezometers data queries or data transmission glitches. Temperatures are cold as expected at this level of the reservoir. Initial pressure values seem consistent with a hydrostatic gradient and large scale lateral drainage into the Upper McMurray top gas and/or Wabiskaw Kcw3 layers. The pressure at the top reservoir level (seismic anomaly level) appears very noisy, but is definitely far below steam pressure (1,000kPag), even transmitted through liquid water from the injector level (800kPag).

The pressure in the Wabiskaw is higher than in the gas interval in the McMurray, clearly indicating that there is no communication whatsoever between these two intervals.

Pressure in the Upper McMurray gas layer has been quite stable, while pressure in the Wabiskaw has shown an increase punctuated by a 20kPa jump on Jan 8th 2008. Whether this jump is real or not is being investigated, but it cannot be related to changes of operating conditions on 204WP3 or other wells in the area. Wabiskaw pressure measurements since January 8th 2008 do not suggest any steam confinement loss in the area.

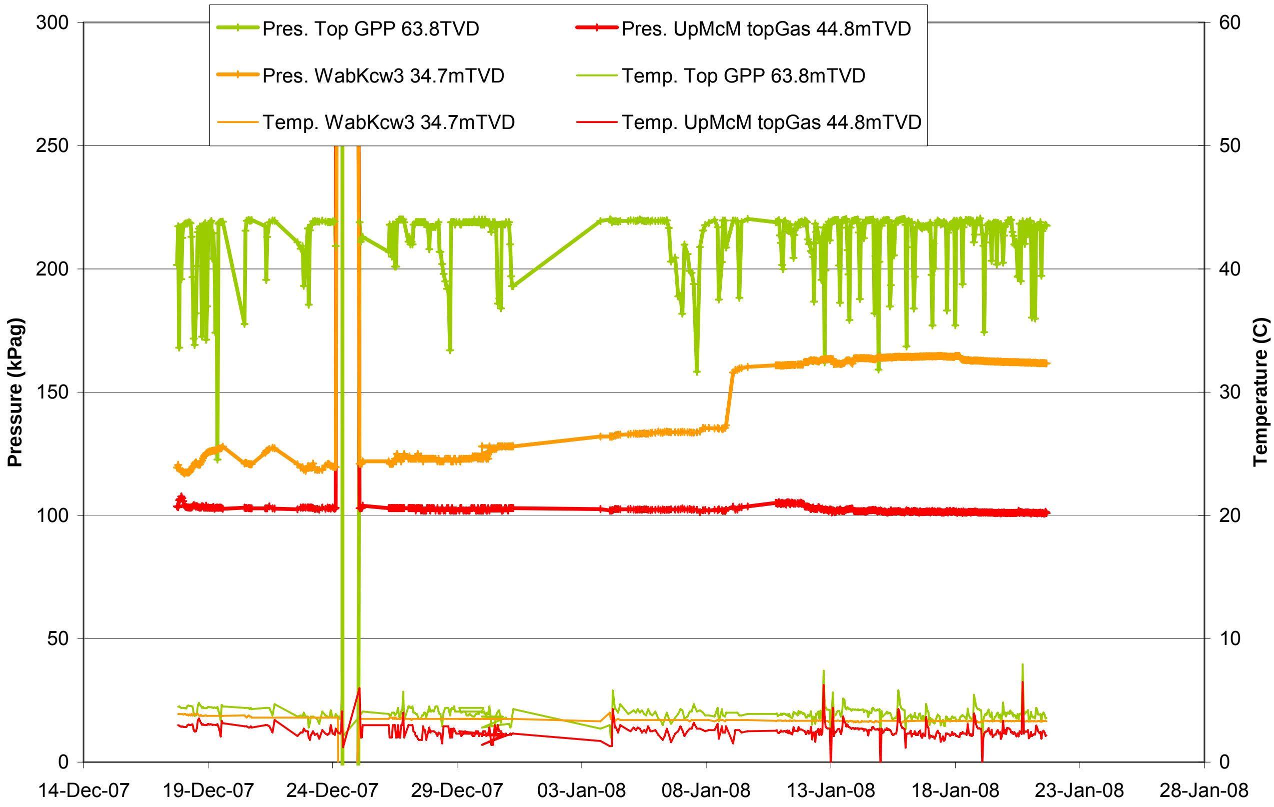


Figure 33. Temperature and Pressure data from 204 WP3 Heel-Mid Observation well (104/10-33-095-12W4). Temperature is given by thermistors, pressure measured by vibrating wire piezometers set and cemented outside of the casing. This well is located approximately 8m aside from the well pair trajectory.

Finally, no significant ground heave movement could be inferred around 204WP3 from the various heave monitoring techniques implemented in the area (Section 4.3.3 with Figure 41, Figure 42 and Figure 43).

204WP3 is currently (January 2008) producing under a 1,000 kPag maximum steam bottom hole injection pressure policy.

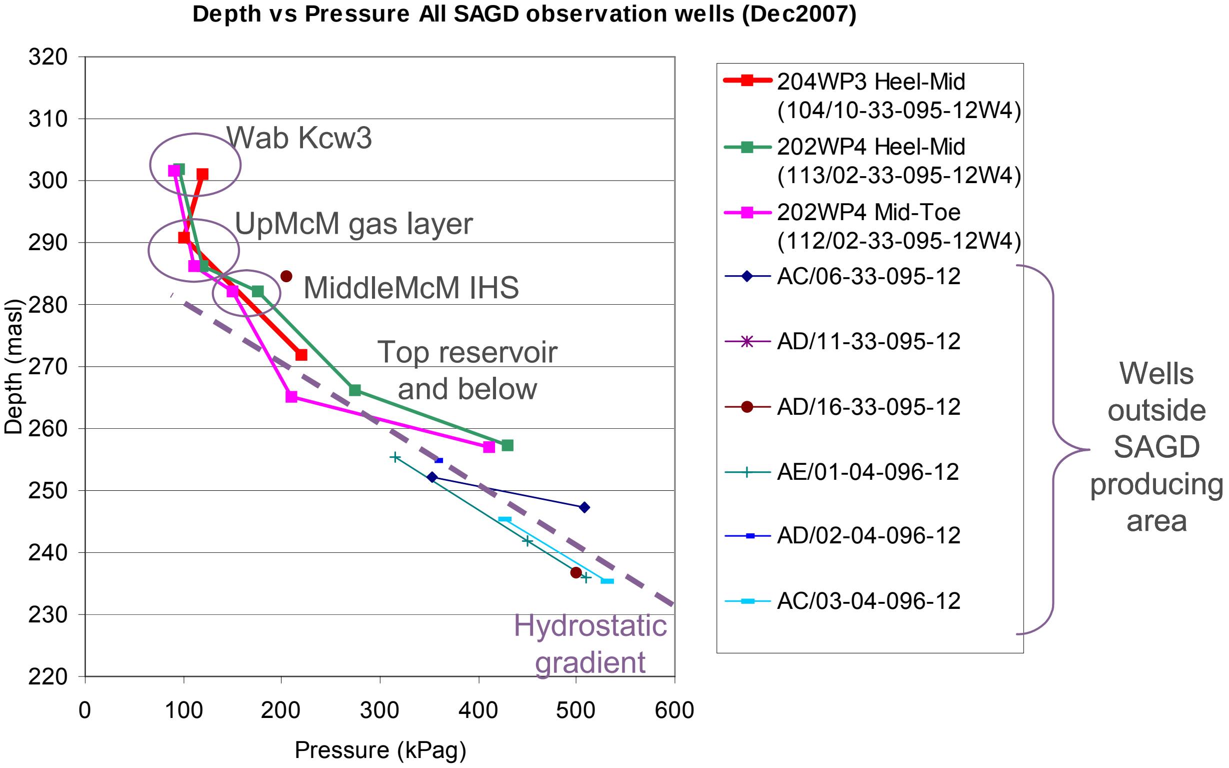
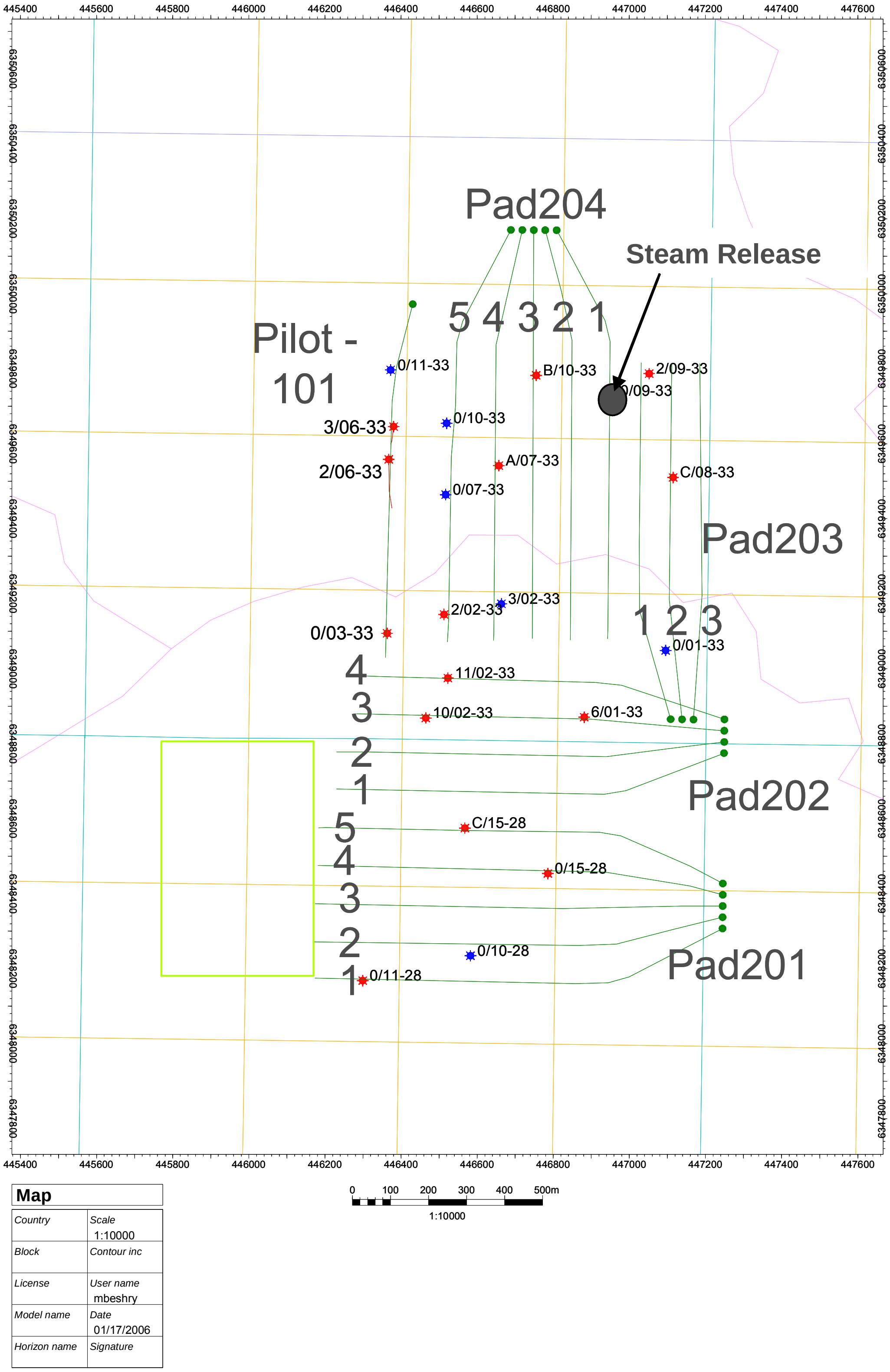


Figure 34. Depth vs. Formation Pressure in the Joslyn phase 2 area. Pressure data from wells outside the production area are given for reference. Reservoir pressures seem to follow a hydrostatic gradient (added on the graph for reference) up to the upper McMurray gas layer or Wabiskaw, which could have acted as large scale lateral drains.

4.2 Comparison 204WP3 history with other well pairs' histories

Figure 35, Figure 36 and Table 2 show the well location, status and main elements of each production phase for the phase 2 wells where production operations were started at the time of the steam release.

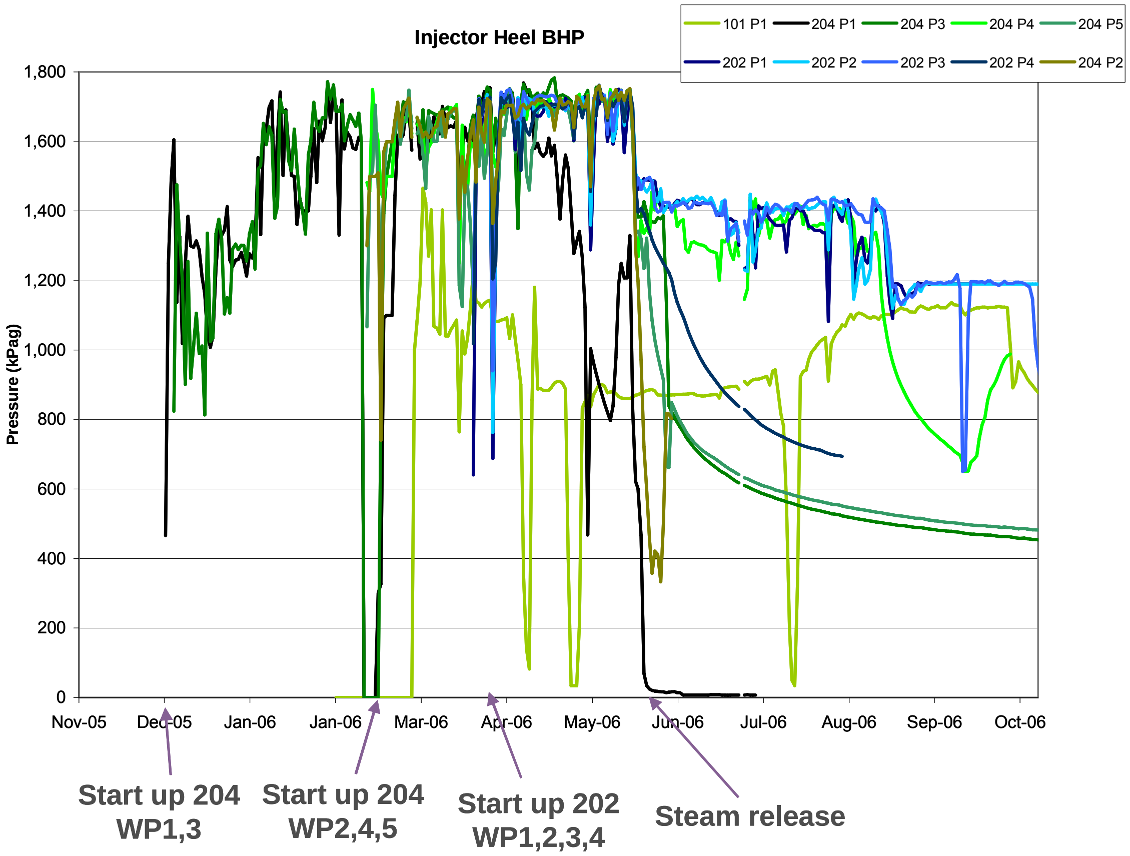


Map	
Country	Scale 1:10000
Block	Contour inc
License	User name mbeshry
Model name	Date 01/17/2006
Horizon name	Signature

Figure 35. Joslyn SAGD Project pad lay out with well pair IDs.

	Start Date	End Date	Duration (days)	Injector - BH Pressure Heel (kPa)	Producer - BH Pressure Heel (kPa)	Injector - Steam Flow Short String (m3/d)	Injector - Steam Flow Long String (m3/d)
202-WP4							
Circulation	3/22/2006			1799	1756		65
202-WP3							
Circulation	3/22/2006			1763	1742		63
202-WP2							
Circulation	3/22/2006			1782	1760		70
202-WP1							
Circulation	3/22/2006			1739	1747		65
204-WP5							
Circulation	2/12/2006	4/1/2006	48	1729	1610		60
Semi SAGD	4/11/2006	5/18/2006	37	1800	1800	45	45
204-WP4							
Circulation	2/12/2006	4/23/2006	70	1815	1853		64
Semi SAGD	4/28/2006	5/21/2006	23	1814	1800	41	37
Circultaion	5/24/2006	8/14/2006	82	1449	1480		46
204-WP3							
Circulation	12/1/2005	3/24/2006	113	1825	1840		46
Semi SAGD	3/24/2006	5/18/2006	55	1813	1830	44	44
204-WP2							
Circulation	2/12/2006	4/27/2006	74	1745	1763		58
Semi SAGD	4/27/2006	5/18/2006	21	1774	1679	27	28
204-WP1							
Circulation	2/12/2006	3/26/2006	42				
Semi SAGD	3/26/2006	5/2/2006	37				
Workover	5/2/2006	5/11/2006	9	NA	NA	0	0
SAGD	5/11/2006	5/18/2006	7	1400	1400	80	60

Table 2 Production operations history for pair other well pairs



Start up 204 WP1,3

Start up 204 WP2,4,5

Start up 202 WP1,2,3,4

Steam release

Figure 36. Joslyn 2006 Daily Injection Pressure History. 3 Types of pressure histories are highlighted: 204PWP1&3, 204WP2&4&5 and 202 well pairs with respectively 4,3 and 2 months at high injection pressure (injector BHP higher than 1600kPag).

It can be noted that all phase 2 well pairs started before May 18th 2006 (date of the Joslyn surface steam release) experienced circulation at a pressure between 1750 and 1850 kPa. Overall, 204WP1, and 204WP3 experienced 4 months of high pressure circulation, 204WP2,204WP4 and 204WP5, 3 months, and all pad202 well pairs, about 2 months.

But unlike 204WP1, the other well pairs did not show anomalous signs of steam leakage during the circulation or semi-SAGD phases. The pilot well pair history is not shown in the figures above, as it has never been operated above 1500kPag down hole pressure. All pad 201 and 203 well pairs have been operated at or below 1200kPag down hole pressure.

It is clear from this analysis that 204WP1 stands out as the most likely location where past operations before the May 18th 2006 steam release may have had a detrimental effect upon reservoir and seal integrity. Other well pairs production histories, including 204WP3, show no indications that past activities damaged the seal or reservoir.

4.3 Monitoring in 204-I3P3 vicinity

In addition to a conservative injection pressure policy (1,000 Kpag current target injection pressure), real time monitoring is considered as the other key to ensure the safety of SAGD operations at JOSLYN. As detailed in the steam release report and shown on Figure 37, steam release prevention monitoring covers specific well pair parameters, reservoir temperatures and pressures and surface movements. In that regard, 204WP3 is one of the well pairs with the most complete monitoring coverage of Joslyn field.

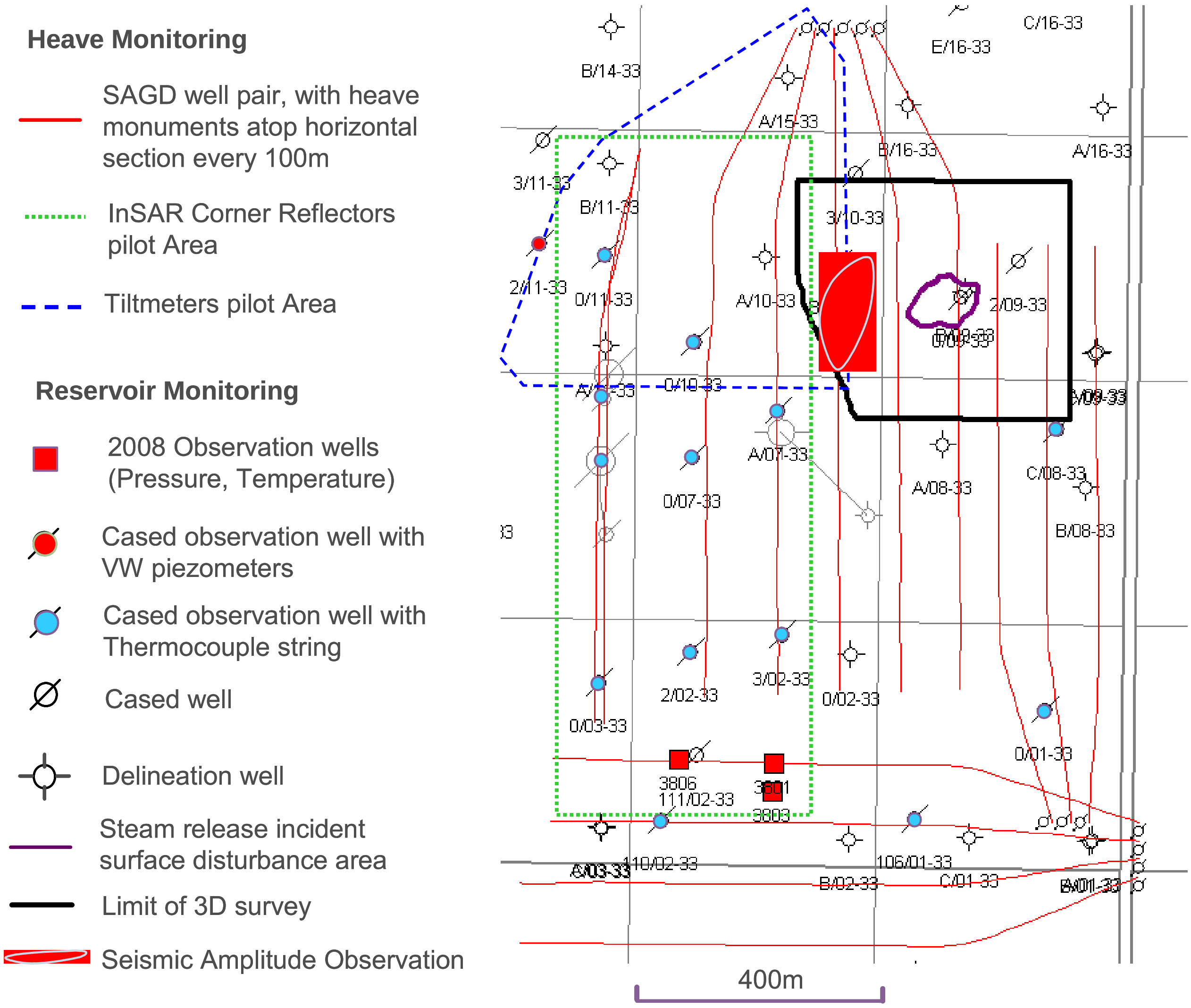


Figure 37. Overview map of the Key means for JOSLYN Safety Monitoring.

4.3.1 Production Monitoring

Well pair performance indicators are currently the most reliable warning for steam leakage in the overburden. As for other well pairs, steam rates and injection pressures are monitored in real time. Production is tested regularly on pad 204 test separator. A relatively sudden steam leak of over 30m^3/d would readily be noticed. A slowly increasing leak would be definitively detected once reaching the 75m^3/d. By comparison, the steam leak on 204WP1 was probably around 120m^3/d a month before the steam release.

4.3.2 Temperature and Pressure Monitoring [subsurface observation wells]

There are two observation wells near 204WP3: 1AB/10-33-095-12W4 and 104/10-33-095-12W4, respectively 30m and 130m south from the heel along the well pair trajectory.

1AB/10-33-095-12W4 is equipped with a thermocouple string down to the Devonian surface and will help asses the vertical development of the steam chamber in the heel area of the well pair. Examples of temperature profiles are shown on Figure 29.

104/10-33-095-12W4 is equipped with 3 vibrating wire piezometers and 3 thermistors for P&T monitoring at three locations down to the top reservoir (Lay out on Figure 40, data on Figure 33): at the level of the seismic anomaly near the reservoir top, in a gas streak in the upper McMurray, and in the Wabiskaw kcw3 layer.

The monitoring of reservoir temperature is mostly related to reservoir performance assessment as opposed to ensuring safety and will not be discussed in the present report.

The monitoring of reservoir formation pressure for ensuring safety present two aspects:

1. Detect fluid entries in shallow layers with high permeability. Such fluid entries if they happen will generate a pressure build-up that will be detected by pressure sensors depending mostly upon entry rate, distance between the entry and the sensor and reservoir permeability and compressibility (**Figure 38**).

2. Improve the models calibration for pressure propagation in and above the reservoir and fine tune the operating pressure strategy in relation with pressure related changes in economic recovery. This part is not addressed in the present report.

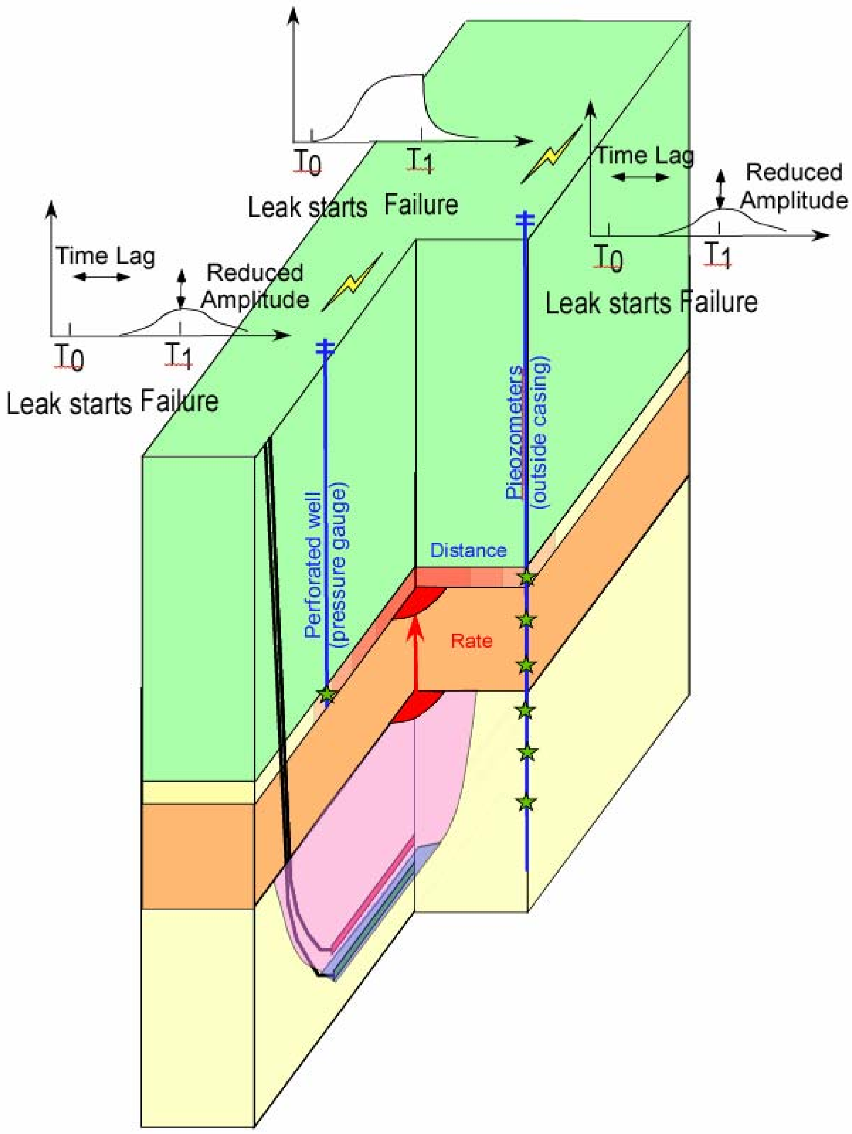


Figure 38 Wabiskaw Pressure Monitoring Principle

Well 104/10-33-095-12W4 allows monitoring the following:

- **Top reservoir Pressure**: Assuming the seismic anomaly was related to some kind of mechanical damage of the formation filled by water, pressure would quickly propagate in it should this area be contacted by the chamber pressure.
- **Upper McMurray Gas Layer:** The large extent of this sandy/silty gas bearing layer can be seen on the seismic survey. A steam leak anywhere in this interval would be seen as a uniform pressure increase once filling a noticeable portion of the layer. This layer may be a poor candidate for detecting small leaks given the high gas compressibility, but a suitable one to buffer any anomalous upward pressure propagation in the reservoir and delay a potential steam release.
- **Wabiskaw kcw3:** This continuous silty layer of mixed water/bitumen saturation may be a good candidate for pressure interference monitoring, to detect breaches of the seals below from a distance to be determined. The principle is displayed on **Figure 38**. This technique is currently being investigated at JOSLYN. 2 other observation wells equipped with piezometers in the same Wabiskaw layer have been drilled atop 202 pad (as shown on Figure 37), and a third well nearby will be perforated for an injectivity/interference test in Kcw3.

Water injection interference test(s) and/or core measurements should be performed to characterize with certainty the ability of targeted stratigraphic intervals to be used in such pressure monitoring scheme. Such a test is planned on Joslyn, well 113-02-33-095-12W4 being used as an emitter (water injection well) and wells 112-02-33-095-12W4, 114-02-33-095-12W4 and possibly 104- being used as receivers. It is tentatively scheduled for early February 2008.

It is expected that such test demonstrate the ability of the Kcw3 interval to be used for pressure monitoring with a possible usable detection range of 100 to 500 m. Well 104/10-33-095-12W4 is located at the centre of the seismic anomaly in an ideal position for detecting any seal confinement loss related to the seismic anomaly (Figure 39).

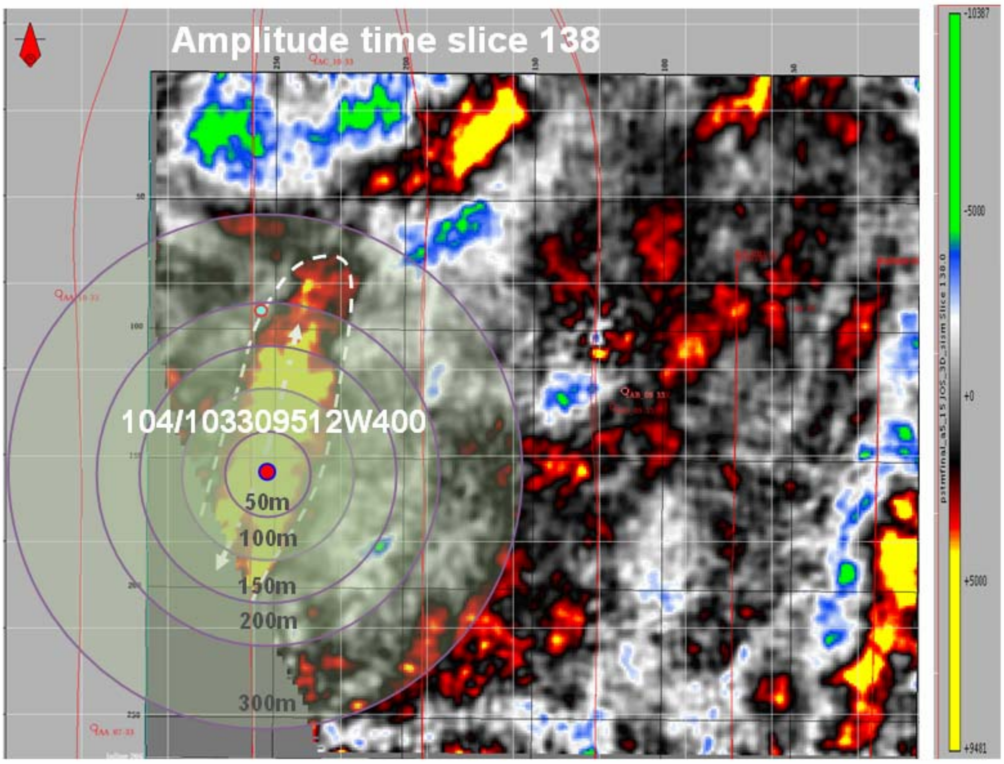


Figure 39 Well 104/10-33-095-12W4 detection range vs. 204-I3P3 seismic anomaly

Adding more piezometers over the Joslyn field acreage is under consideration. Several ways to do could be considered including punching holes in existing observation wells (with the disadvantage of perturbing thermocouple data), drilling wells down to the Wabiskaw or further down to the McMurray seal. These different options have different technical and costs advantages and disadvantage that should be analyzed further prior to take a decision.

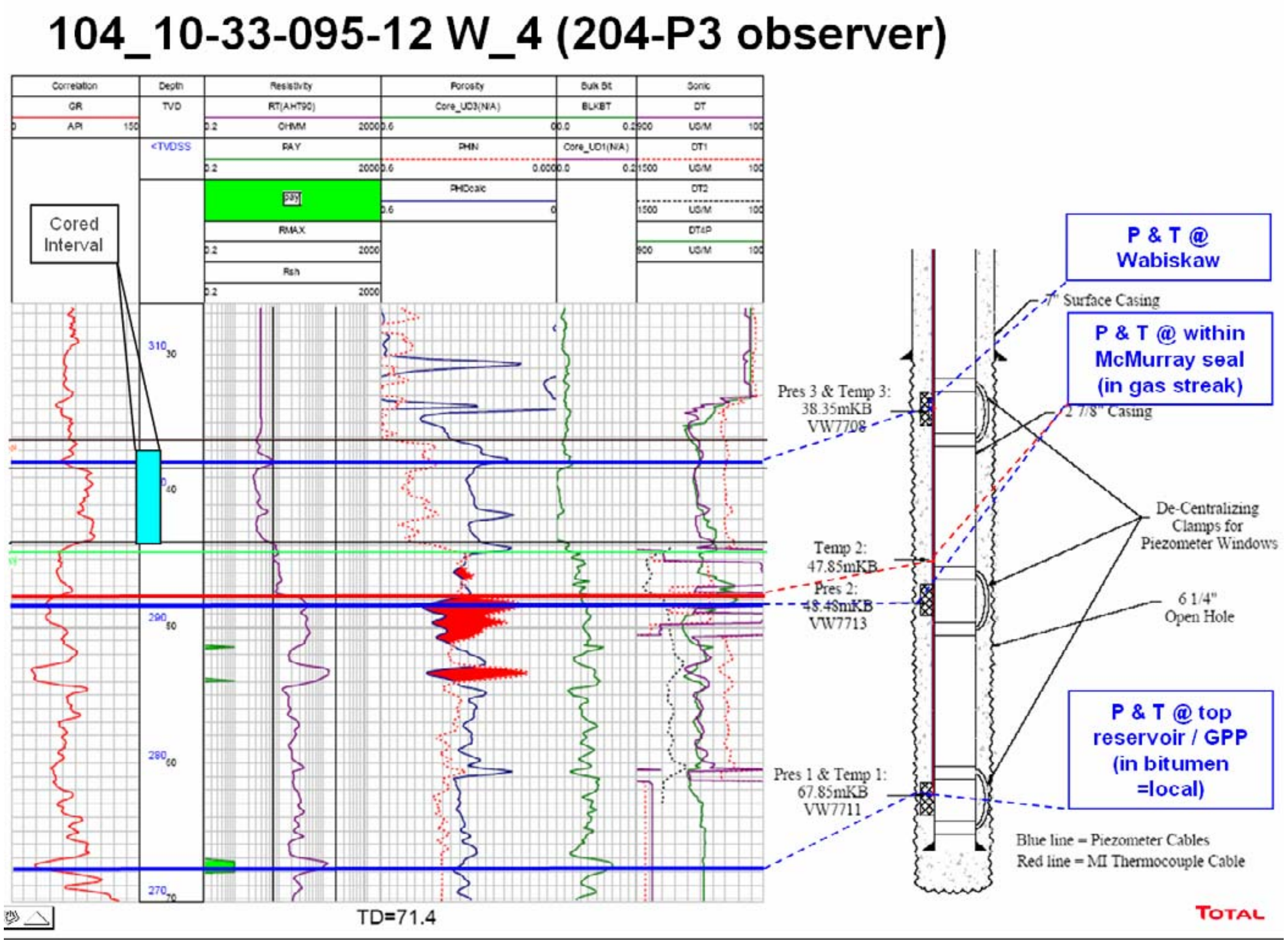


Figure 40. 204WP3 Heel Pressure Observation Well log and Piezometer layout.

4.3.3 Heave Monitoring

The heave monitoring lay out is detailed in the steam release report. As shown on Figure 37, in addition to the heave monuments spaced by 100m atop the well trajectory, 204WP3 build section and heel area are partly covered by the tiltmeter network. The array of InSAR corner reflectors extends near 204WP3 but does not overlay 204WP3 trajectory. The frequency of surveys is typically 15 days for the heave monuments, 8 days for the InSAR and daily for the tiltmeters. Based on sensor characteristics and burial design, tiltmeters should give the most accurate vertical heave measurement (heave monuments giving the least accurate data).

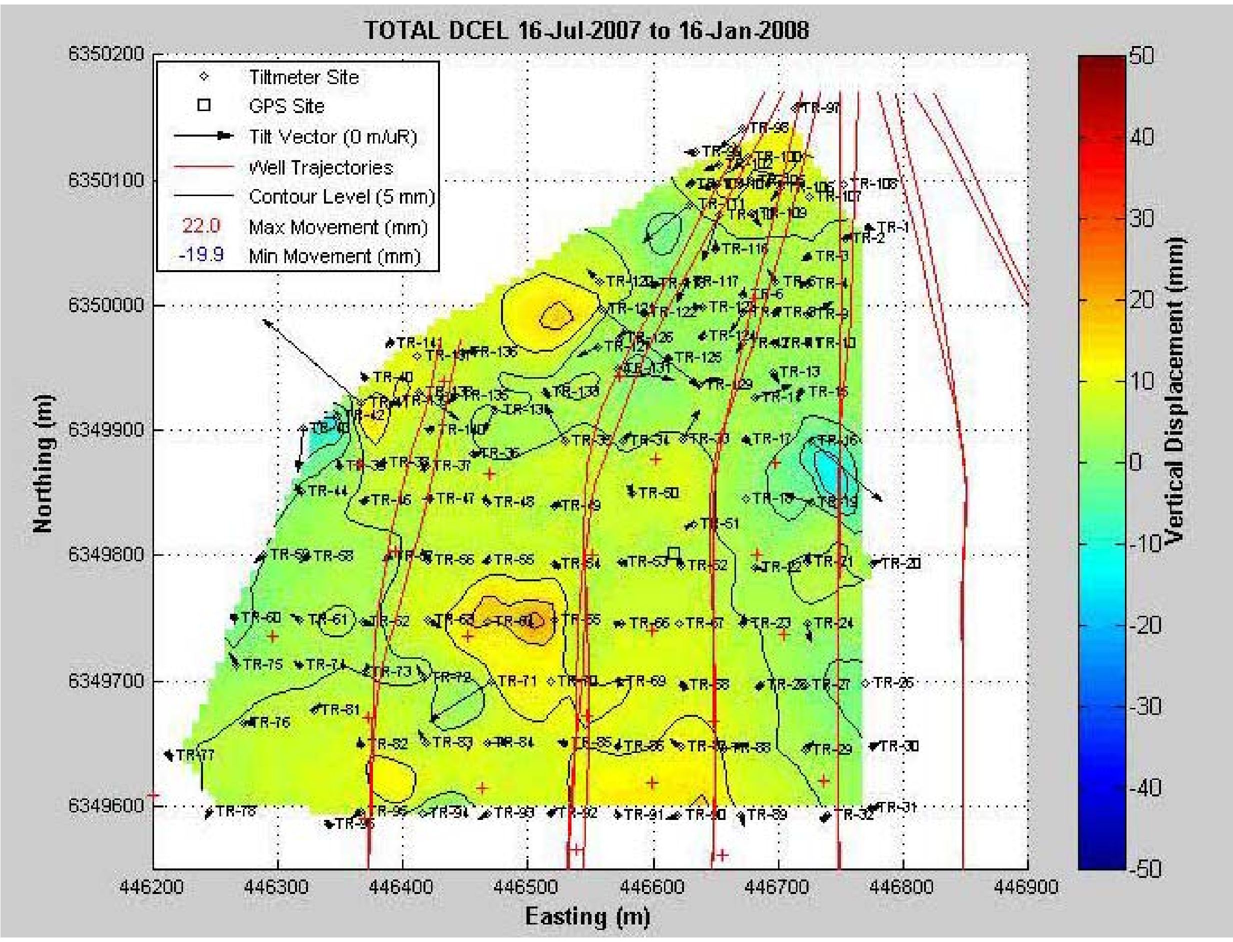


Figure 41. Cumulative vertical shift based on tiltmeters inclinations (arrows) over the period July 16th to Jan 16th 2007.

The heave monitoring data are displayed on Figure 41, Figure 42 and Figure 43 from the tiltmeters, InSAR corner reflectors and heave monuments respectively. The data quality from all sources is still being checked, as diverging signals have regularly been observed for a given location, even in areas with no SAGD activity. This is the case of the two InSAR corner reflectors close the road and 204WP3 build section showing important heave but with no parallel trend on the tiltmeters array. So far, no significant ground heave could be inferred around 204WP3 by at least two monitoring data sources.

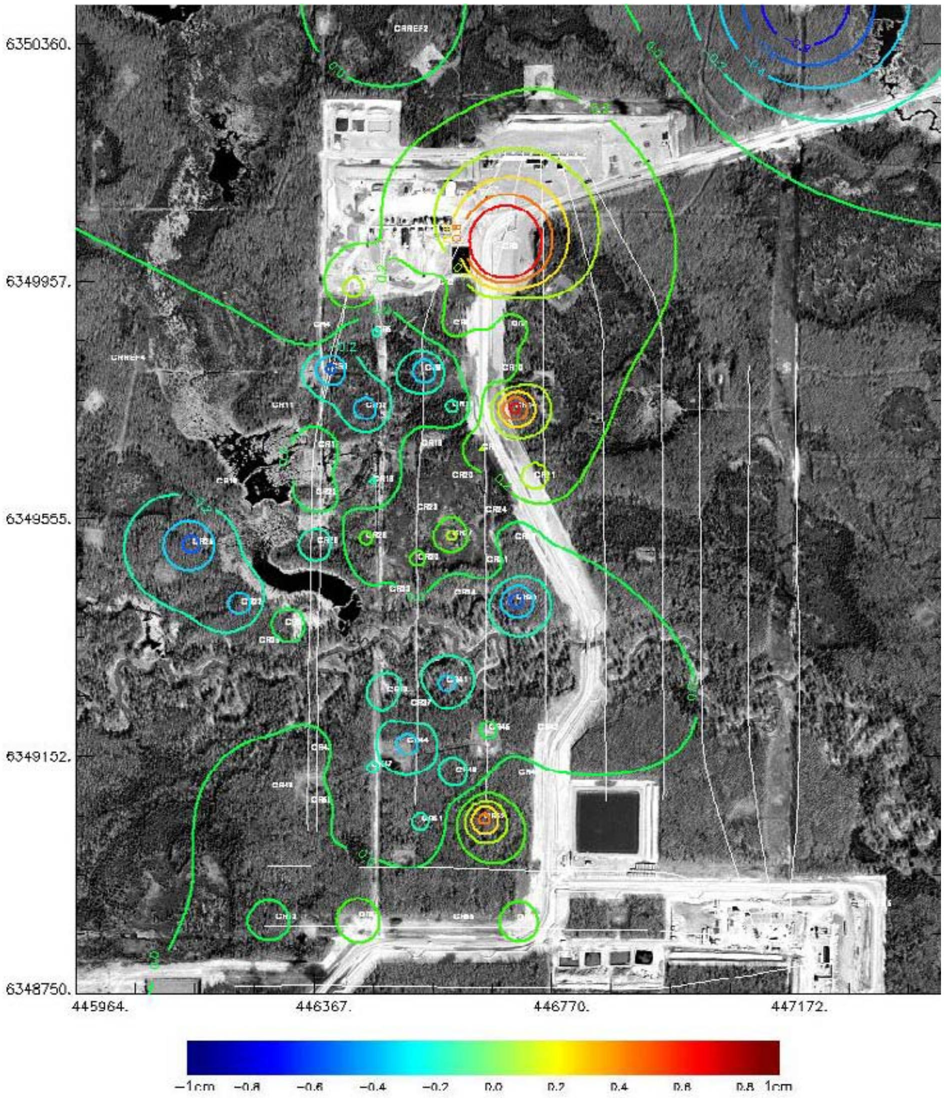


Figure 42. Cumulative vertical shift of InSAR corner reflectors over the period July 2007- Dec 12th 2007 (Interpolated map).

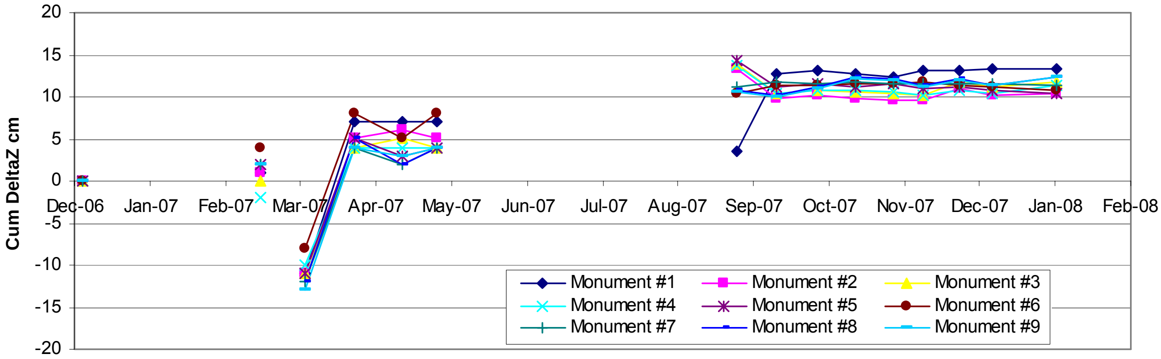


Figure 43. Cumulative vertical shift of heave monuments along well pair 3 since Dec 6th 2006. Monuments are located every 100m above the well pair trajectory from heel (#1) to toe (#9).

5 Compliance, Risk Analysis, and Conclusion

5.1 Compliance with ERCB requirements

To the best of our knowledge, no ERCB directive, draft directive, or other regulation governs, today, the use of seismic surveys for assessing the safety of SAGD operations. The observations made by TOTAL in the late stage of the Joslyn HR Survey interpretation do not relate to a specific ERCB requirement. Such observations were voluntarily and fully shared with ERCB. They should not constitute ground for a non compliance notice from ERCB.

5.2 Risk Analysis (as per ERCB Risks Analysis Framework)

Notwithstanding the above considerations related to compliance with ERCB regulations, the Risk Assessment Matrix defined by ERCB within its Compliance Assurance framework (cf. ERCB Directive 19) can be used to qualify the risks related to 204-I3P3 operations as perceived today (Appendix 1).

Potential consequences of a loss of steam confinement on 204-I3P3 or any other Joslyn SAGD well could include:

- Widespread reduction in stakeholder confidence,
- Permanent damage to the reservoir,
- Localized, medium term adverse effect on the environment. Reclemation lasts < 3 years.
- Multiple serious injuries or one fatality,

Hence, the potential consequences of a steam release on Joslyn fully qualify for C level in ERCB Risk Assesment classification.

Without taking into account any mitigation actions (monitoring and corrective actions, such as, for example, an emergency blow down from SAGD wells following an abnormal heave observation), available analysis suggest a very low probability for a steam confinement loss if the Bottom Hole Pressure is maintained at or below 1200 Kpag (as agreed between ERCB and TOTAL). Such analysis would justify a qualification as “unlikely” in ERCB Risk Assesment Matrix.

If mitigation actions (monitoring and corrective actions, i.e. emergency blow down) are taken into actions, available analysis suggest an extremely low probability for a steam confinement loss if the Bottom Hole Steam Injection Pressure is maintained at or below 1200 Kpag (as agreed to ERCB). Such analysis would also justify a qualification as “unlikely” in ERCB Risk Assesment Matrix.

Whether or not Monitoring is taken into consideration the risk of Steam Confinement Loss is estimated to reach level 4 (severe consequences / minimal probability). Would a non compliance to an ERCB directive be directly related to steam confinement loss, such non compliance should be treated as Low Risk as per ERCB directive 19.

TOTAL is fully aware of the importance of the issue at hand. TOTAL is committed to fully abide by all ERCB directives and beyond that to take all necessary measures to ensure safe operations at Joslyn in cooperation with all Stakeholders (in accordance with ERCB general HSE philosophy).

5.3 Risk management

Figure 44 summarizes the main steam release scenarios that can be envisioned on any Joslyn well:

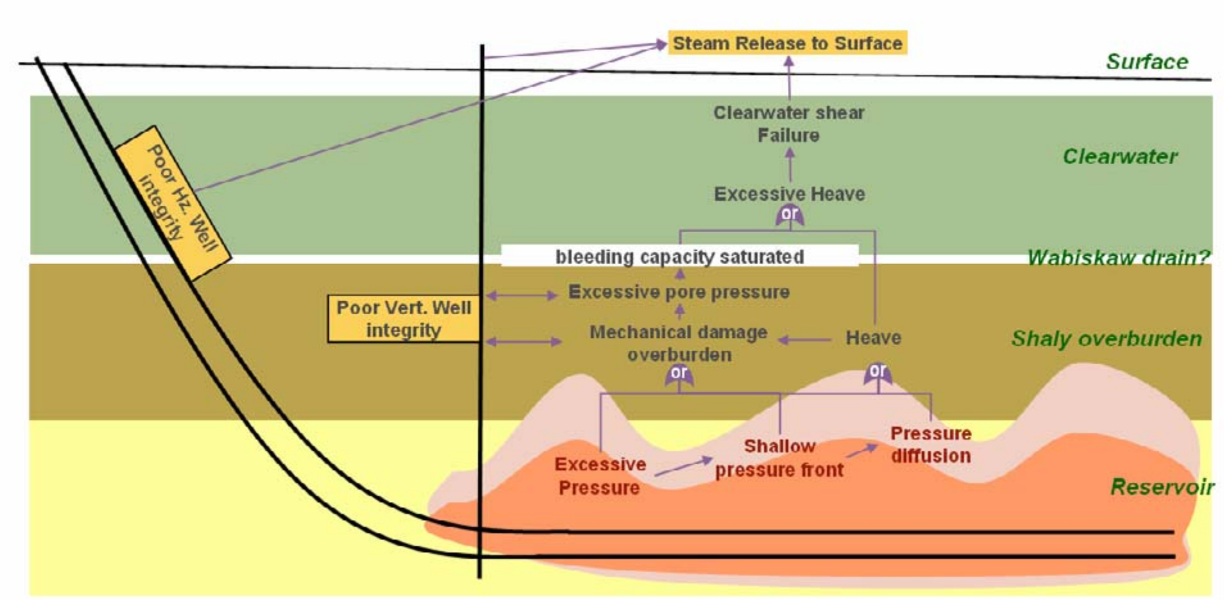


Figure 44 Steam Release Scenarios Rationale

For a steam release to occur without warning multiples factors are required to be involved simultaneously:

- A steam chamber pressure such that the mechanical resistance of the seal is exceeded,
- No detection of surface heave,
- No detection of water balance loss,
- No detection of Wabiskaw pressure buildup,
- No detection of temperature increase on observation wells,
- Etc.

Based upon the available data, the main conclusion of the 3D seismic interpretation is that we may have created a dilation zone or a fracture at / around the top reservoir depth. Such conclusion constitutes a legitimate cause for concern as creating a dilation zone or facture at the top of the reservoir was the second step of the scenario brought forward to explain the May 18th 2006 steam release. It does not however necessarily mean that we damage the seal in any way. The pressure profile observed between the middle and top pressure piezometers on well 104_10-33-095-12W4 clearly indicates that there is no communication between the gas intervals within the seal and the Wabiskaw Kcw2 sand. Such observation is an indication pointing supporting the hypothesis that even if the seismic observation are steam injection related we may not have reduced the seal mechanical resistance.

A well has been positioned in an ideal location to detect any pressure build-up within and above the seal in the seismic anomaly area, the 204-I3P3 well production data is closely monitored and has not shown any indication of steam loss, the area surface heave is monitored and did not show any abnormal heave. The scarce temperature readings in the area also did not show any problem.

The seismic observations constitute only a factor that may impact, not necessarily significantly, one out of the multiples factors required for a steam release to happen. 204-I3P3 is on the other hand much more closely monitored than any other wells (with the possible exception of 202-P4 that has not started yet[3]). **As a consequence, global risks on 204-I3P3 are not deemed higher than on any other Joslyn well.**

5.4 204-I3P3 Safety Status Conclusion

Based upon the work detailed in the present report, it can be concluded that:

1. TOTAL diligently executed the actions required to safely operate 204-I3P3 SAGD pair while fully complying with all relevant AEUB (now ERCB) directives.
2. The ERCB has been and is being kept informed by TOTAL, on a voluntarily basis, of key findings related to the safety of Joslyn operations.
3. Whether or not Monitoring is taken into consideration the risk related to Steam Confinement Loss is estimated to reach level 4. Would a non compliance to a directive be directly related to the steam confinement loss issue, such non compliance should be treated as Low Risk as per ERCB directive 19.
4. Following the drilling and logging of well 104_10-33-095-12W4 and the installation of piezometers in such well, the risks related to 204-I3P3 operations are deemed extremely low probability provided proper monitoring is achieved especially monitoring the pressure readings from well 104_10-33-095-12W4.
5. Such status should be reviewed in light of any significant change in the matter including 204-I3P3 behaviour as monitored by surface metering and instrumentation, piezometers pressure reading or surface heave (INSAR and tiltmeters) – such list is not extensive.

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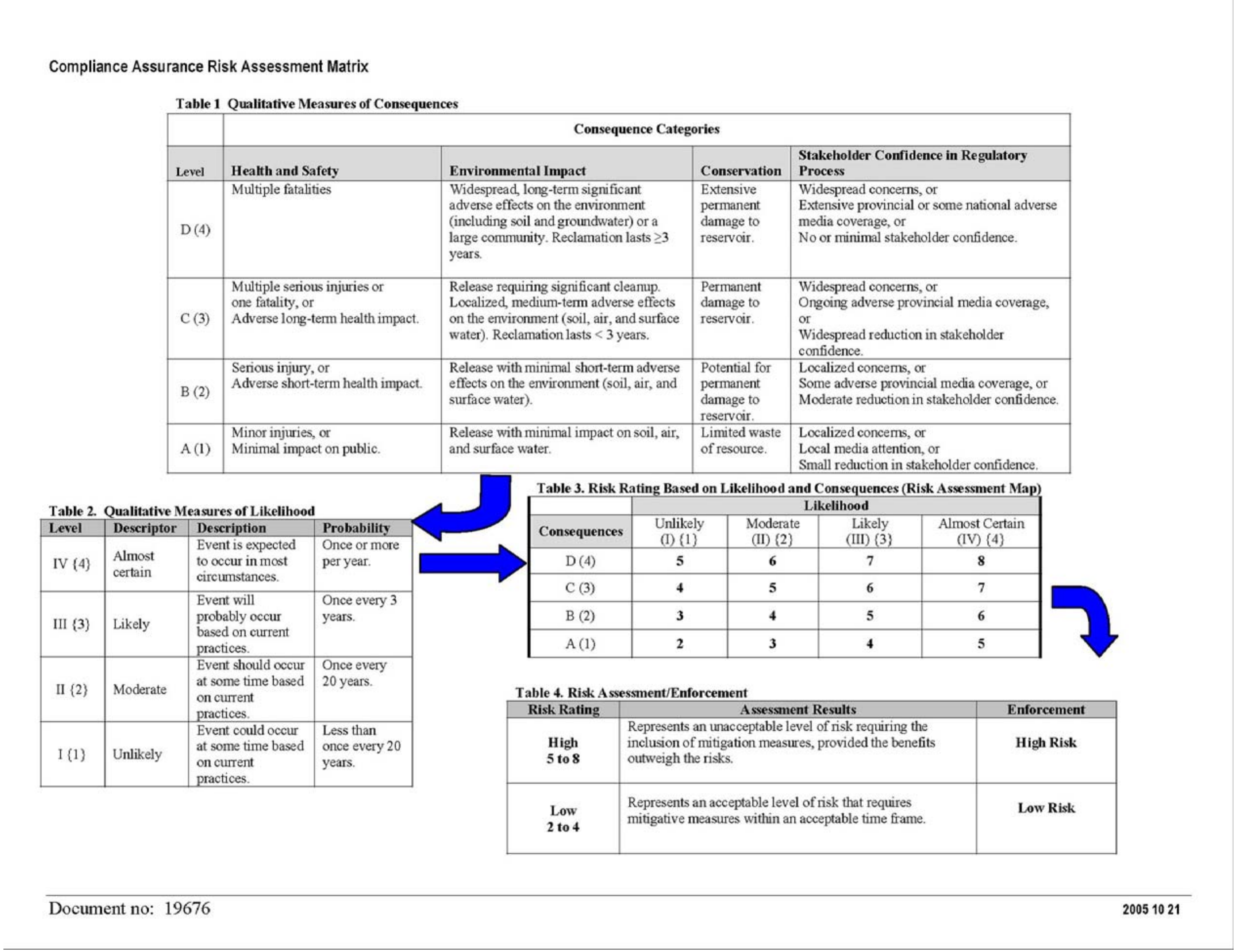
[3] , Such ranking depends upon what relative confidence is brought to pressure vs. heave monitoring. Surface heave coverage is loose while pressure monitoring coverage is tight in the vicinity of well pair 202-I4P4.

Appendix 1

ERCB Compliance Assurance Risk Assessment Matrix



Compliance Assurance Risk Assessment Matrix

Table 1 Qualitative Measures of Consequences

	Consequence Categories			
Level	**Health and Safety**	**Environmental Impact**	**Conservation**	**Stakeholder Confidence in Regulatory Process**
D (4)	Multiple fatalities	Widespread, long-term significant adverse effects on the environment (including soil and groundwater) or a large community. Reclamation lasts ≥3 years.	Extensive permanent damage to reservoir.	Widespread concerns, or Extensive provincial or some national adverse media coverage, or No or minimal stakeholder confidence.
C (3)	Multiple serious injuries or one fatality, or Adverse long-term health impact.	Release requiring significant cleanup. Localized, medium-term adverse effects on the environment (soil, air, and surface water). Reclamation lasts < 3 years.	Permanent damage to reservoir.	Widespread concerns, or Ongoing adverse provincial media coverage, or Widespread reduction in stakeholder confidence.
B (2)	Serious injury, or Adverse short-term health impact.	Release with minimal short-term adverse effects on the environment (soil, air, and surface water).	Potential for permanent damage to reservoir.	Localized concerns, or Some adverse provincial media coverage, or Moderate reduction in stakeholder confidence.
A (1)	Minor injuries, or Minimal impact on public.	Release with minimal impact on soil, air, and surface water.	Limited waste of resource.	Localized concerns, or Local media attention, or Small reduction in stakeholder confidence.

Table 2. Qualitative Measures of Likelihood

Level	Descriptor	Description	Probability
IV {4}	Almost certain	Event is expected to occur in most circumstances.	Once or more per year.
III {3}	Likely	Event will probably occur based on current practices.	Once every 3 years.
II {2}	Moderate	Event should occur at some time based on current practices.	Once every 20 years.
I {1}	Unlikely	Event could occur at some time based on current practices.	Less than once every 20 years.

Table 3. Risk Rating Based on Likelihood and Consequences (Risk Assessment Map)

	Likelihood			
Consequences	Unlikely (I) {1}	Moderate (II) {2}	Likely (III) {3}	Almost Certain (IV) {4}
D (4)	**5**	**6**	**7**	**8**
C (3)	**4**	**5**	**6**	**7**
B (2)	**3**	**4**	**5**	**6**
A (1)	**2**	**3**	**4**	**5**

Table 4. Risk Assessment/Enforcement

Risk Rating	Assessment Results	Enforcement
High **5 to 8**	Represents an unacceptable level of risk requiring the inclusion of mitigation measures, provided the benefits outweigh the risks.	**High Risk**
Low **2 to 4**	Represents an acceptable level of risk that requires mitigative measures within an acceptable time frame.	**Low Risk**

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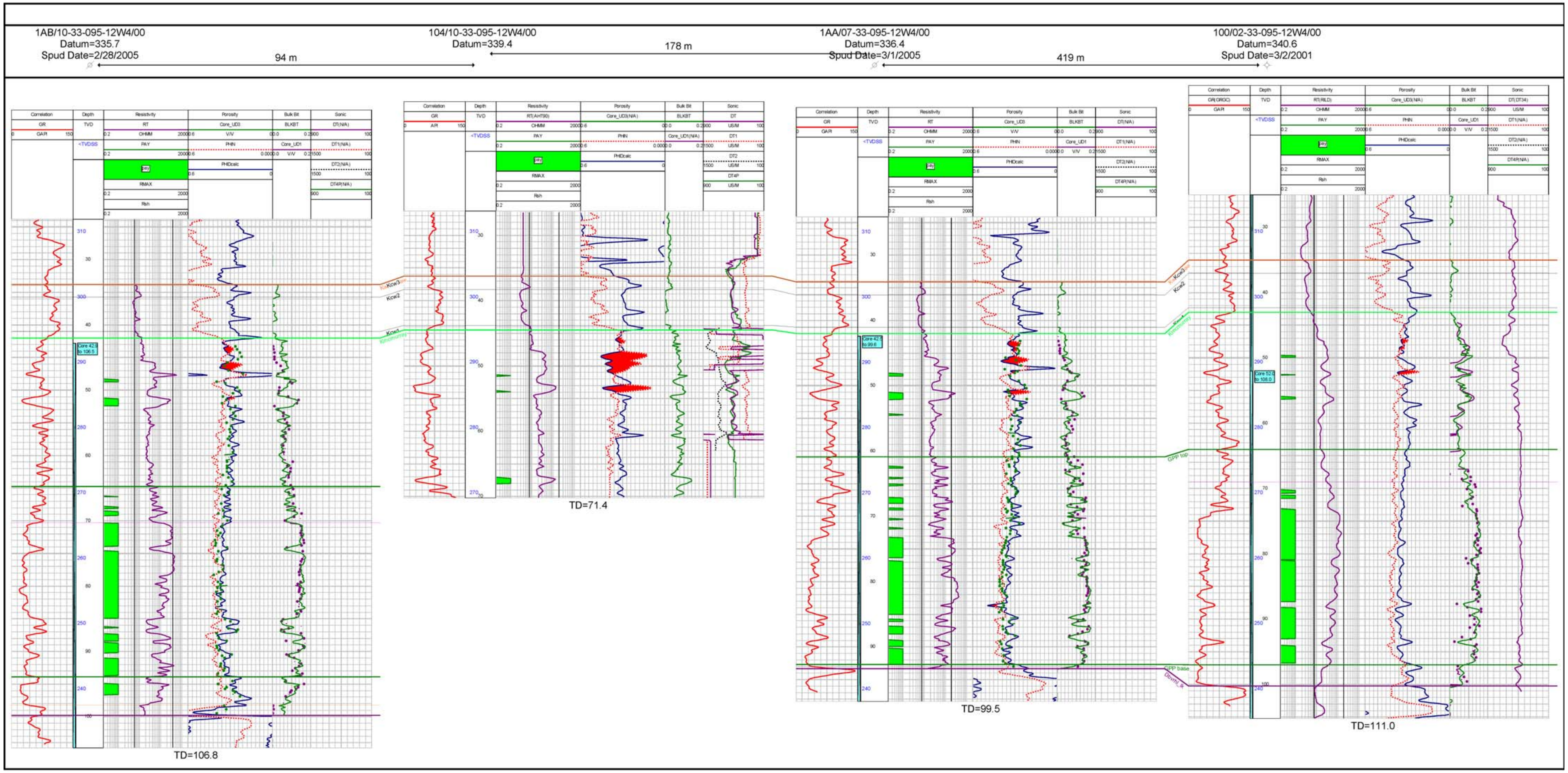


Plate 1 North – South X section through wells in the vicinity of 204-I3P3

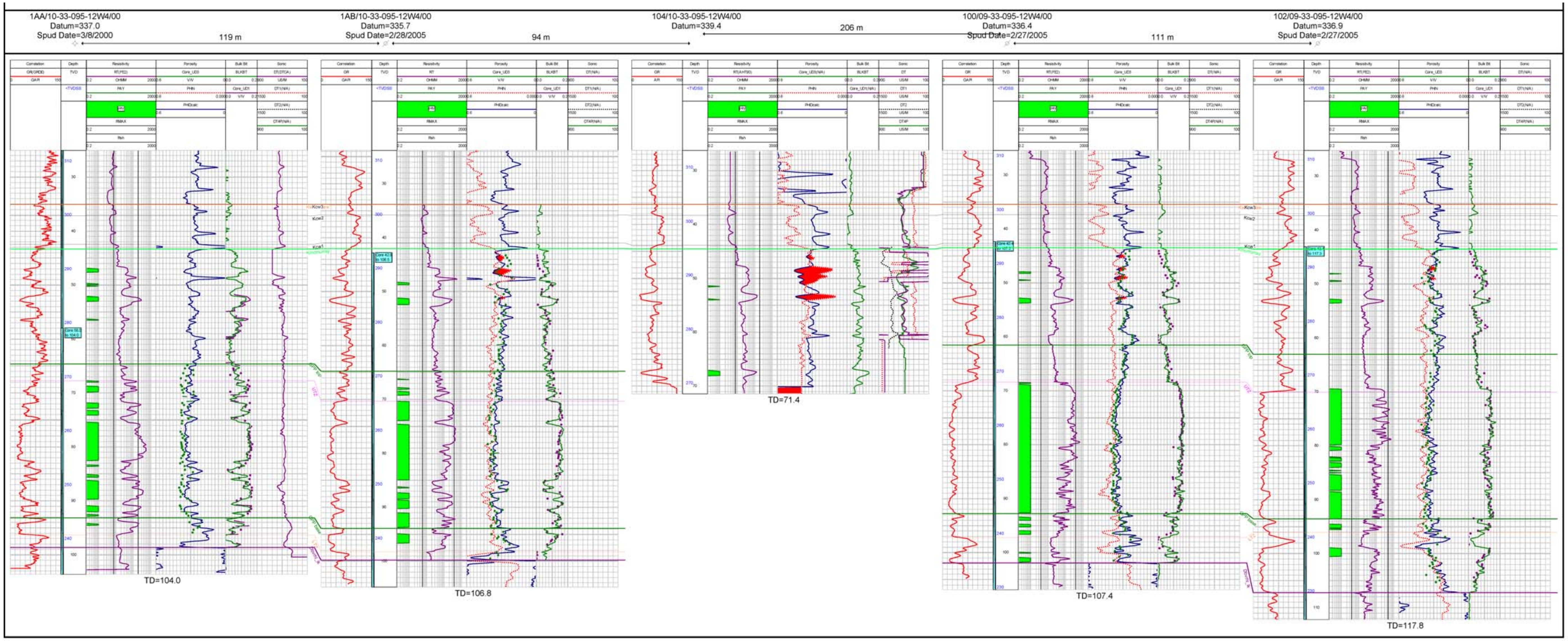
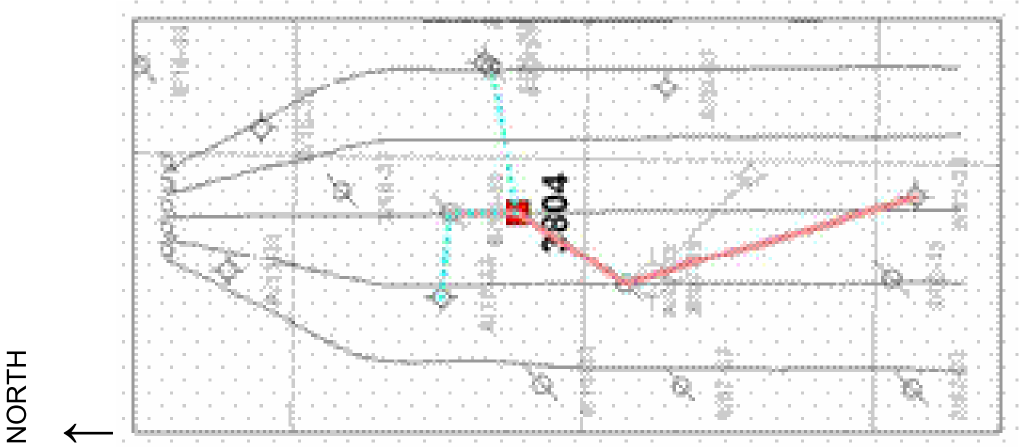


Plate 2 East- West X-section through wells in the vicinity of 204-I3P3



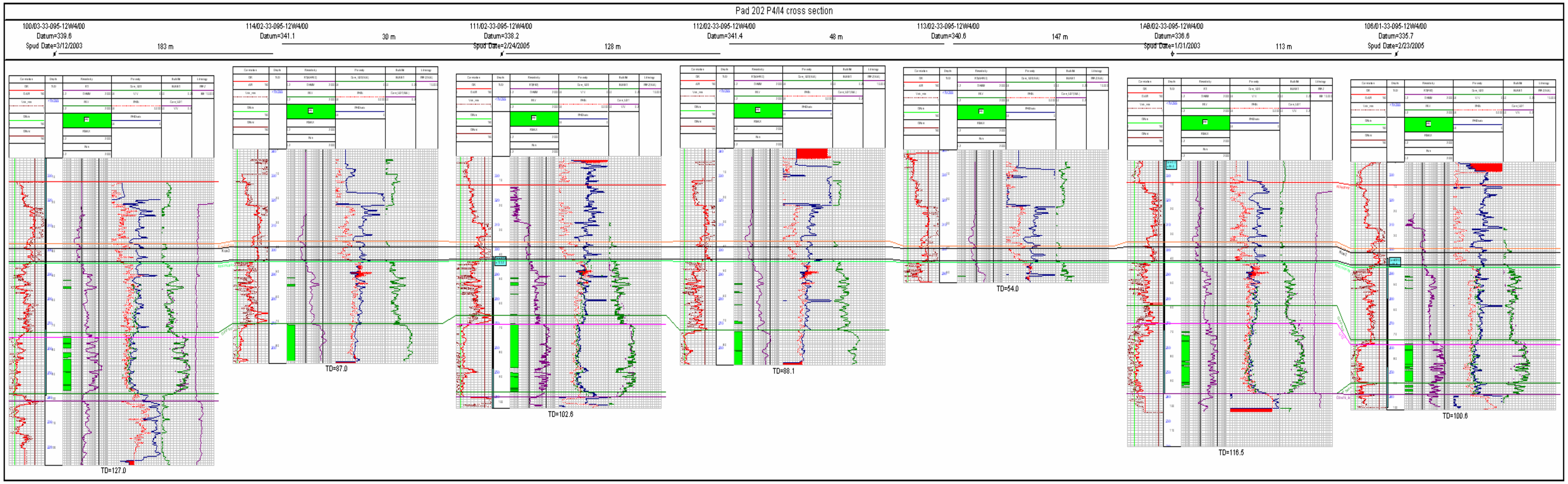
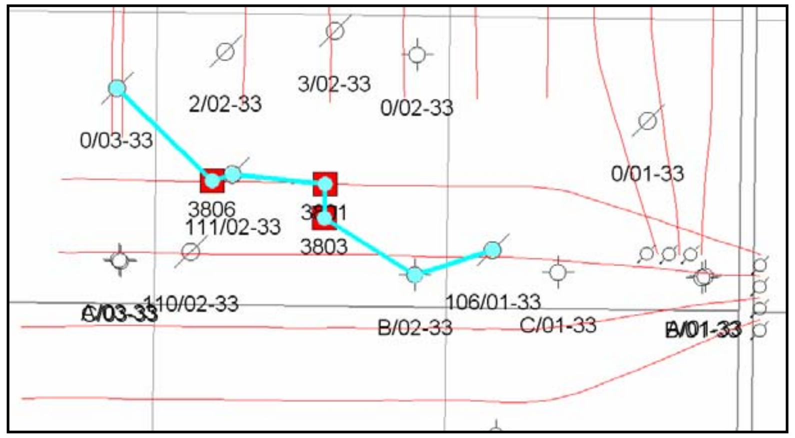


Plate 3 East- West X-section through wells in the vicinity of 202-I4P4



North
↑

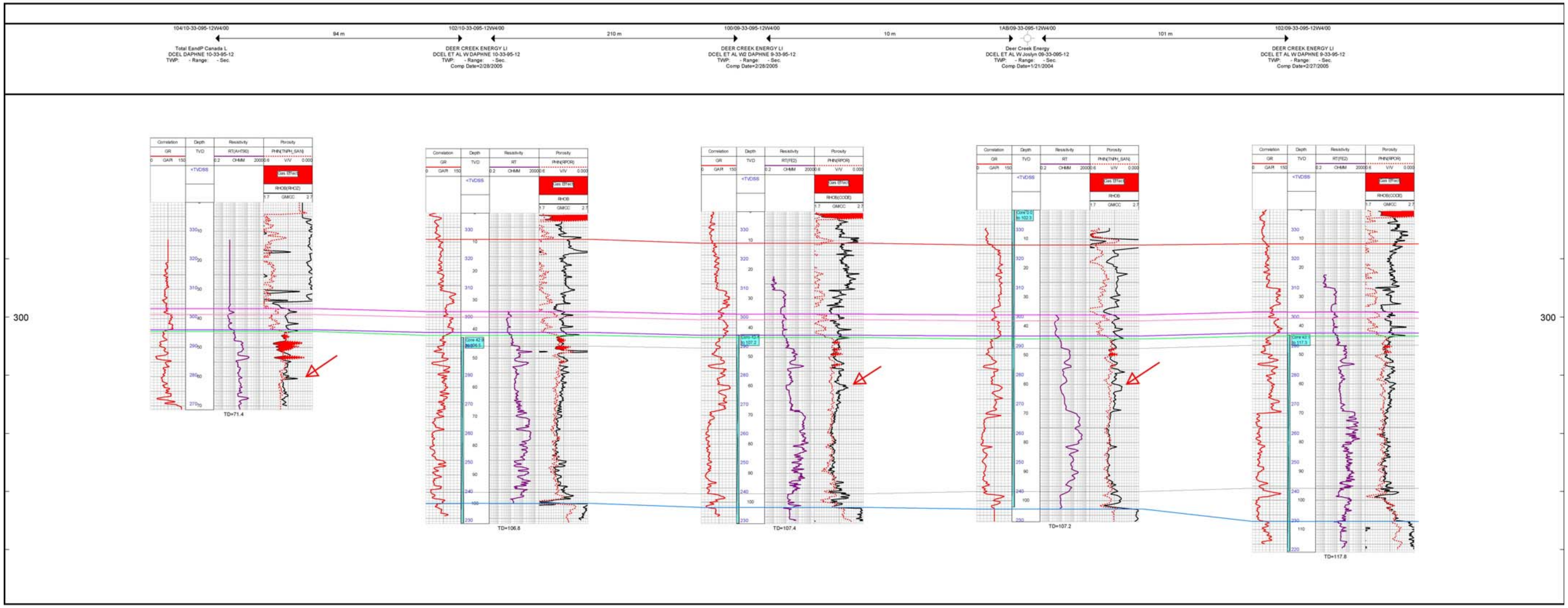


Plate 4 Possible carbonate answer of available wells over the 3D seismic acreage

Appendix 1

Cap Rock Competence of wells DCEL 0B3C JOSLYN 2-33-95-12 and DCEL 0B1A JOSLYN 11-33-95-12 Determined From Electrical Borehole Image Data – Richard Y. Shang Ph. D, P. Geol. Schlumberger Canada Ltd. May 2003.

Schlumberger Canada Limited

Report to Deer Creek Energy Limited

Cap Rock Competence of Wells: DCEL 0B3C JOSYN 2-33-95-12 and DCEL 0B1A JOSYN 11-33-95-12 Determined From Electrical Borehole Image Data

By

Richard Y. Shang, Ph.D, P.Geol.

525 – 3rd Avenue S.W.
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May 12, 2003

Cap Rock Competence of Wells: DCEL 0B3C JOSYN 2-33-95-12 and DCEL 0B1A JOSYN 11-33-95-12 Determined From Electrical Borehole Image Data

Introduction

Electrical imaging tools consist of a set of arms equipped with pads, which are pressed against the borehole wall while logging. An array of small electrodes (diameter approx. 4 mm) is located on each pad. These electrodes are kept at a constant potential with respect to a return electrode further up in the borehole. The electrical current emitted by the passively focused electrodes is a measure for the shallow electrical resistivity in front of the electrode.

The images recorded by these tools depict fine features like bedding planes and natural fractures. High-resolution (~ 2.5 mm) and nearly complete borehole coverage can greatly increase the detail and precision of geological interpretation. As images are displayed as color-coded maps of the resistivity at the borehole wall with the depth and the borehole circumference, natural fractures appear as sinusoidal traces, which make it possible to determine the dip and the dip direction of these features.

Electrical images in boreholes are becoming increasingly important in interpreting the rock record in past decade. In addition to identifying bedding planes and natural fractures, borehole imaging tools are used for a variety of other applications, such as horizontal drilling; stress-orientation measurement studies; sequence stratigraphy; sand counting; and paleocurrent, facies, and sandbody geometry analyses.

FMI images were logged for the wells: DCEL 0B3C JOSYN 2-33-95-12 and DCEL 0B1A JOSYN 11-33-95-12. Main purpose is to determine the competence/integrity of cap rock above potential SGAD intervals.

Image Quality

FMI image logs were logged for the intervals: 24 - 123 m of DCEL 0B1A JOSYN 11-33-95-12 and 26 – 126 m of DCEL 0B3C JOSYN 2-33-95-12. Borehole conditions were very good for both wells as indicated by nearly constant caliper logs with some minor enlargements. In both wells pad 1 azimuth is continuously rotating, indicating that the hole is in-gauge. As results image quality is excellent after smooth speed and accelerometer correction (Figures 1a and 1b).

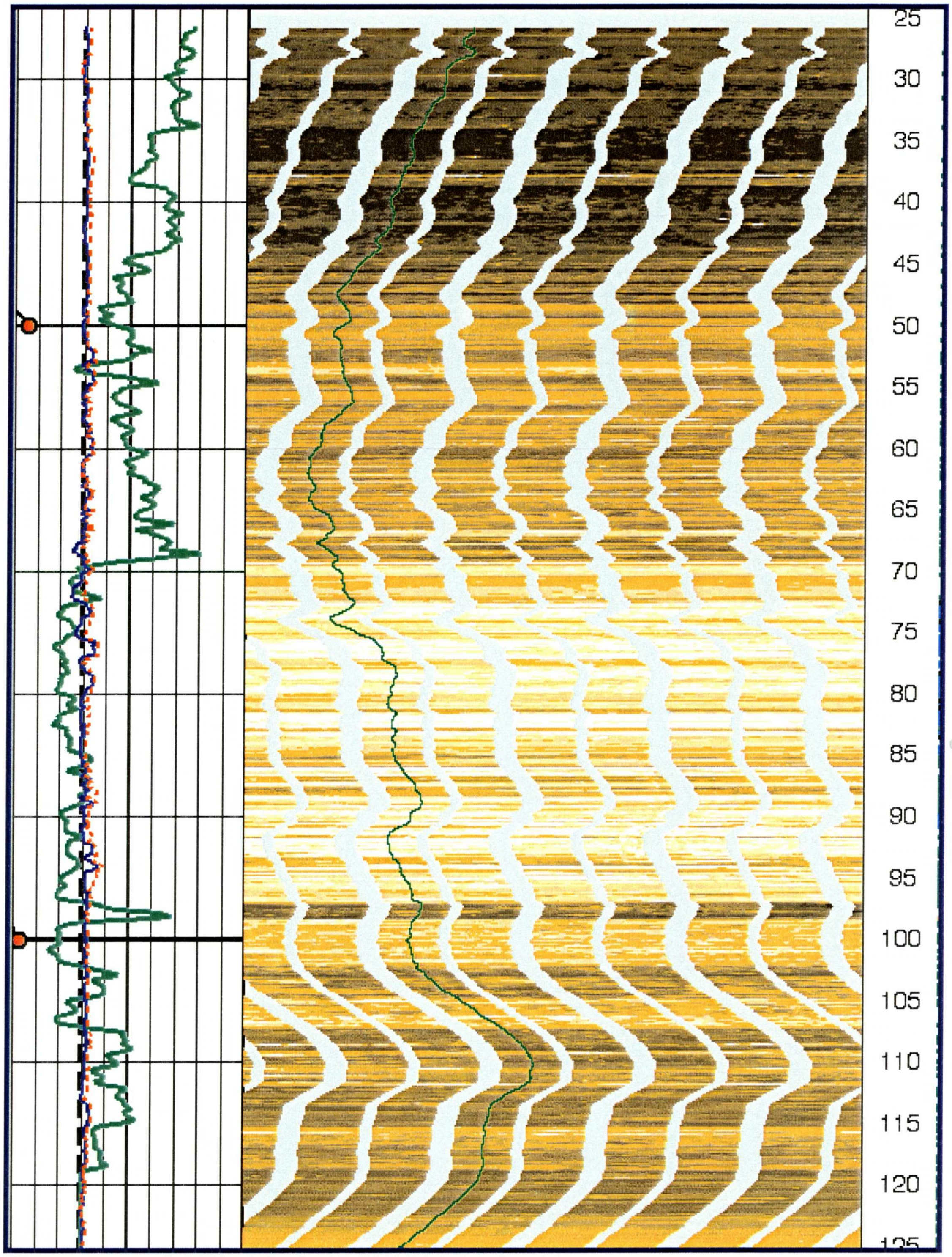

Figure 1a   DCEL 0B1A JOSYN 11-33-95-12

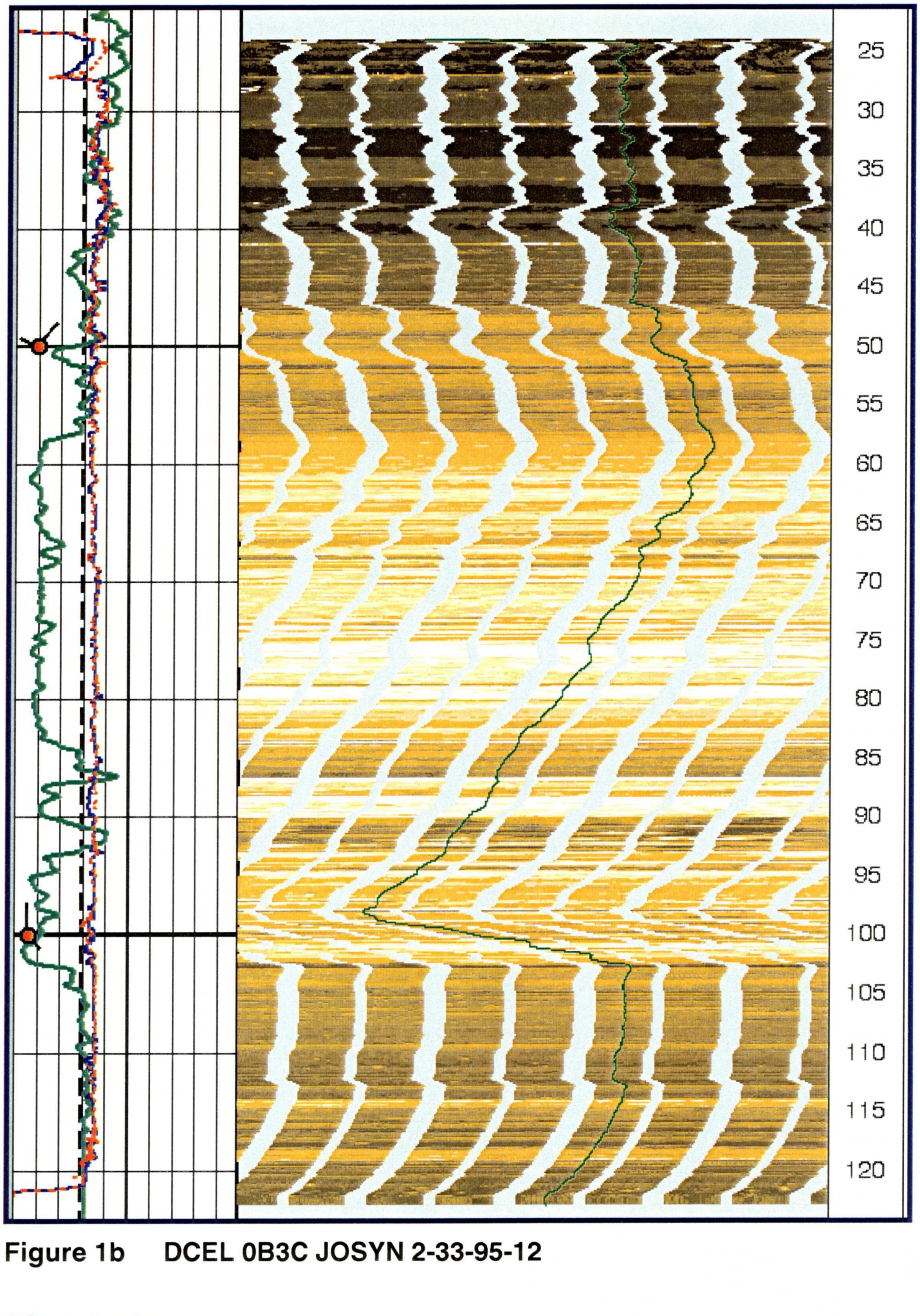

Figure 1b DCEL 0B3C JOSYN 2-33-95-12

Dipmeter Log

Dip logs of bed boundary have been created by manually correlating similarity of feature surfaces in FMI images under workstation. In general, dip logs from both wells indicate a very gentle dip (less than 5 degrees) in cap rock intervals, higher dips with various azimuth changes over sand zones (most of these dips are current flows), and relative constant dips in Paleozoic section (Figures 2a and 2b).

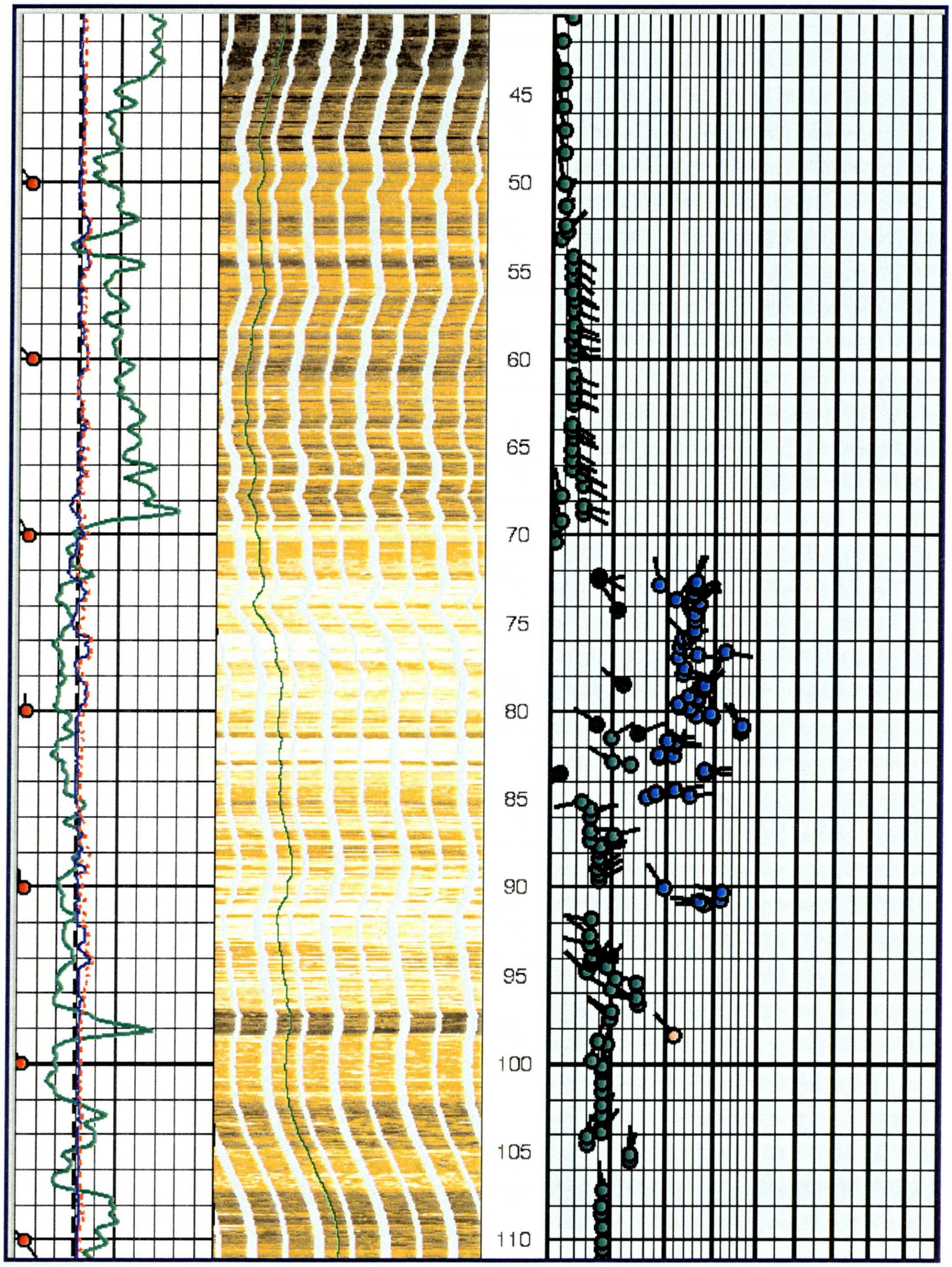

Figure 2a DCEL 0B1A JOSYN 11-33-95-12

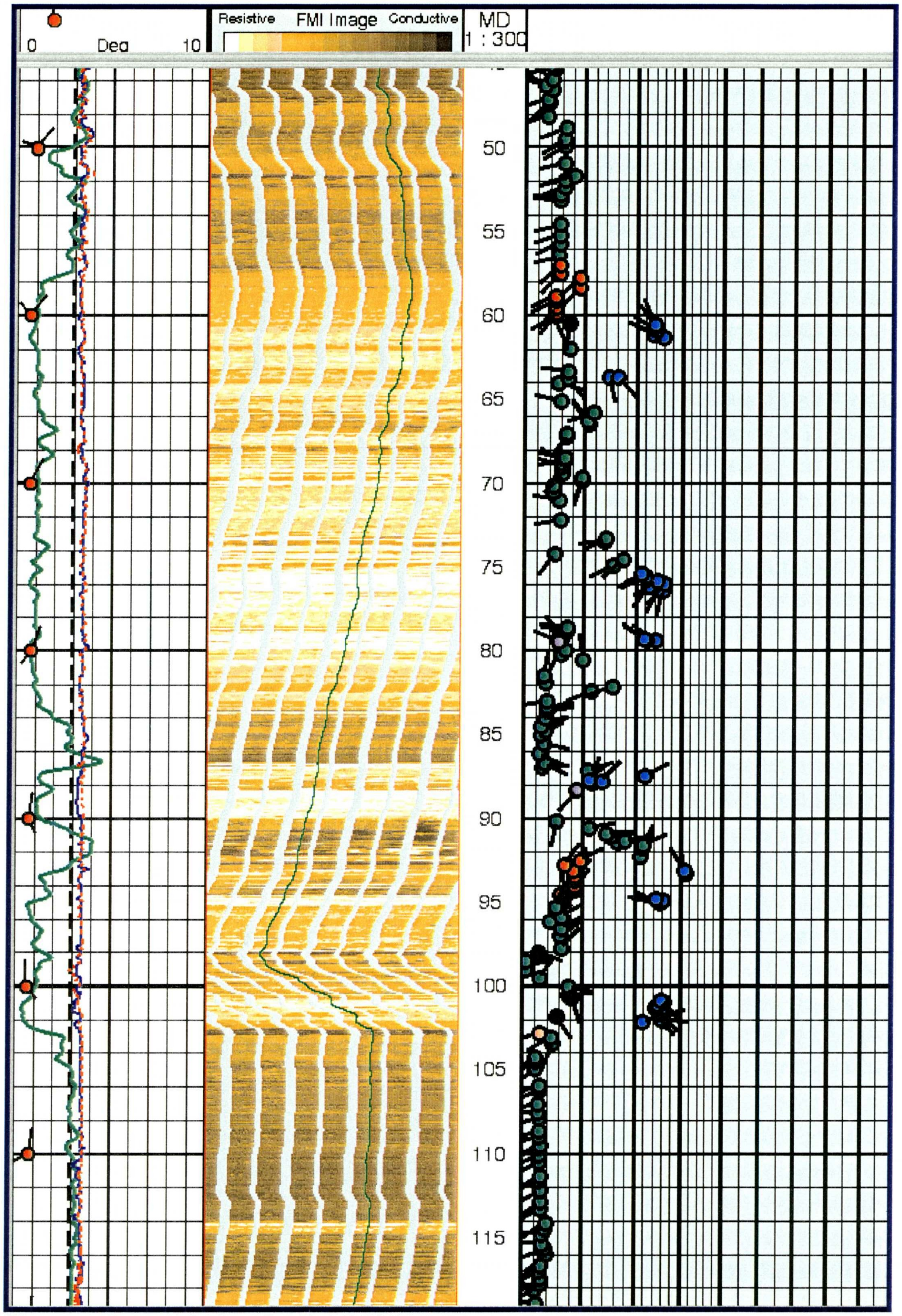

Figure 2b DCEL 0B3C JOSYN 2-33-95-12

Fracture/Rock Competence

Containment of the injected steam is essential for SAGD project from both an economic and environmental perspective, as is the structural integrity of the casing within the vicinity of the cap rock. Natural fractures in FMI images normally display as conductive anomalies (dark and elongated events) with strong contrast and wide aperture visible from image. Fortunately, only one fracture has been identified from FMI image data. This fracture occurs at depth of 106 m in the well: DCEL 0B3C JOSYN 2-33-95-12 (Figure 3a). The general conclusion to be made from FMI data is that cap rocks of both wells are very competent and there is no natural fracture/physical discontinuity throughout the cap rock intervals (Figure 3b).

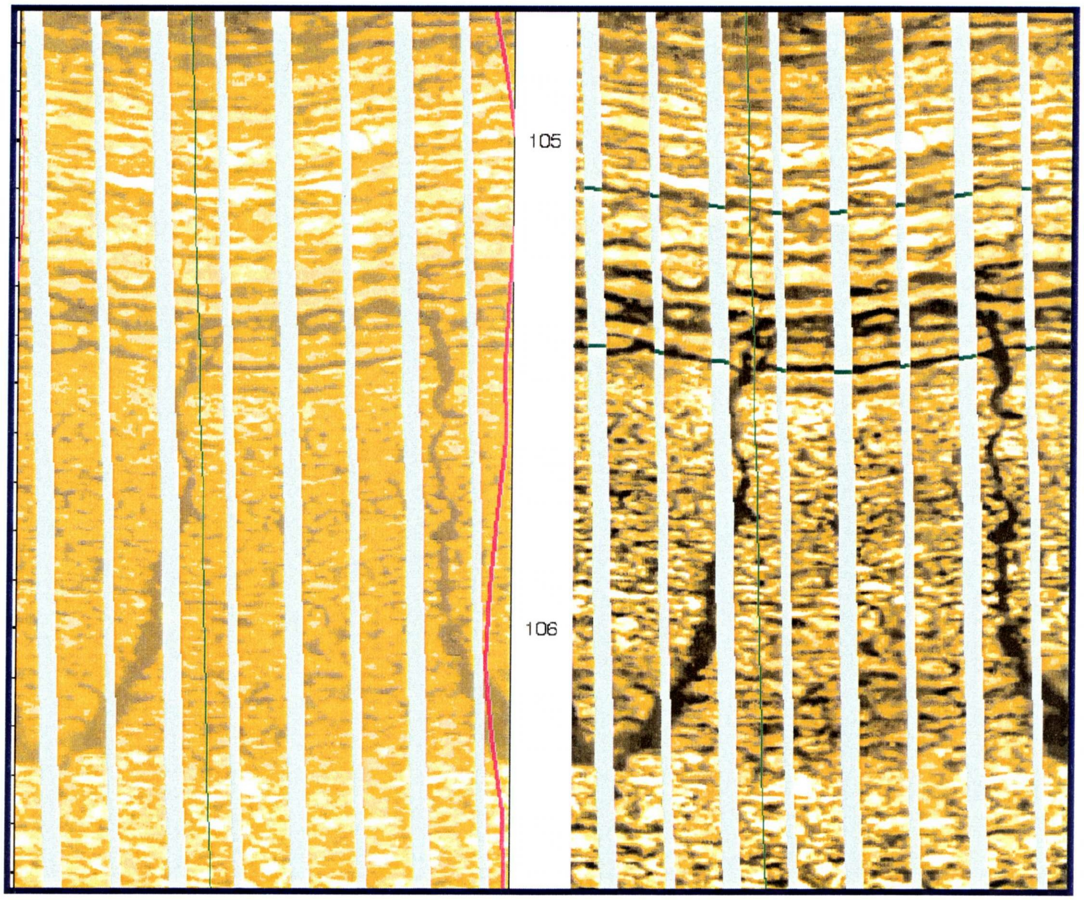

Figure 3a **Fracture at depth of 106 m in the well: DCEL 0B3C JOSYN 2-33-95-12**

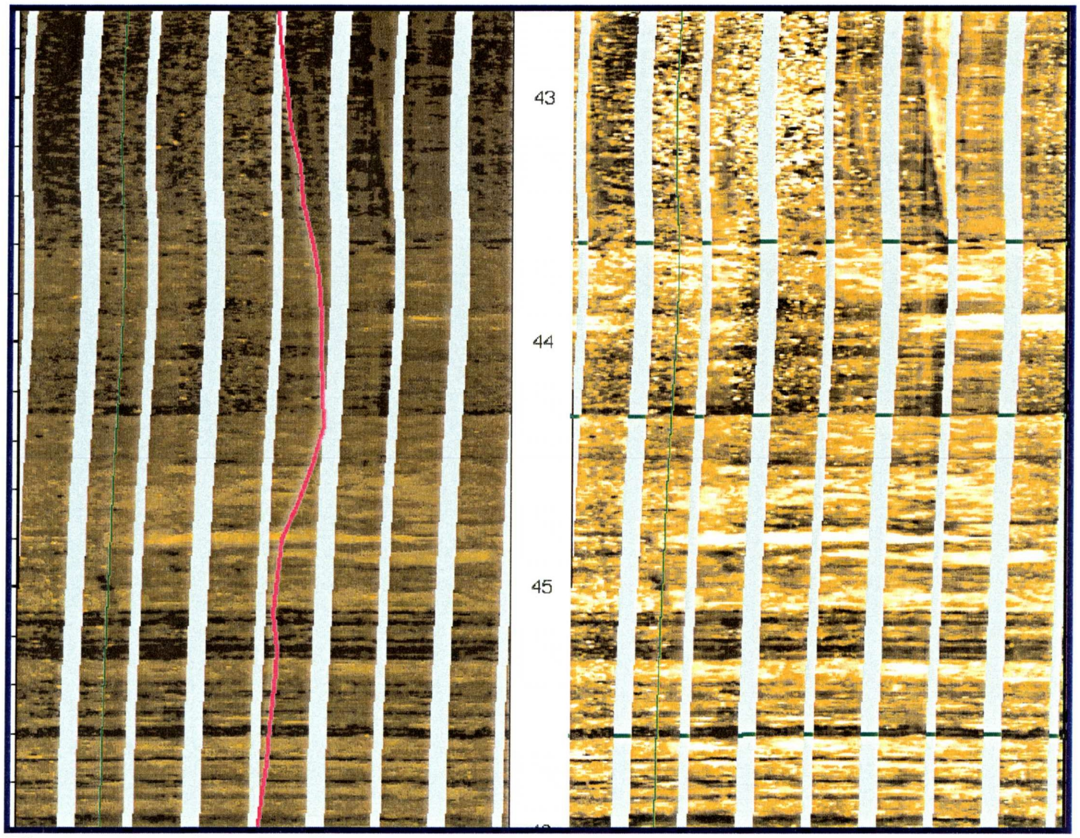

Figure 3b Cap Rock

TOTAL E&P JOSLYN LTD.

April 24, 2008

Alberta Energy and Utilities Board
Application Branch
Resources Applications
640 – 5th Avenue SW
Calgary, Alberta
T2P 3G4

RECEIVED
APR 24 2007

Attention: Tom Keenan

Subject: Steam Release

Dear Tom,

Please find enclosed a CD containing a revised edition of the final report related to the technical investigation of Joslyn SAGD Project May 18th 2006 Steam release.

The report was edited to answer as fully as possible to the remarks and questions raised by ERCB's technical staff in the three written communications received to date.

Copies of these communications are included on the CD-ROM for convenience. They were related respectively to geology aspects of the whole report, geology and geophysical aspects of the 204-13P3 status sub-report, and reservoir and well engineering aspects of the whole report. Questions and remarks were clarified during two meetings held in ERCB offices in Calgary on February 4th and 27th 2008.

In accordance with ERCB staff's recommendations, answers to these questions and remarks were directly embedded in the revised report whenever possible. In addition, you will find attached to the present letter a memo summarizing the answers to each specific question or remark or pointing to the most relevant section of the edited report.

As in its initial edition, the report consists in one summary report and ancillary technical reports dedicated to various disciplines or sub-issues; the 204-13P3 status information file has been joined to the Steam Release Investigation bundle of reports.

The report was also edited to provide, whenever possible, TOTAL's vision of best SAGD practices to answer ERCB's calls on the matter. Answering such calls within the framework of a report focusing on the investigation of a specific event that occurred on a specific location is challenging. Nonetheless, TOTAL is fully willing to further discuss its vision on such HSE-critical matters as steam confinement practices in any ERCB sponsored forum.

We are available to answer any remark or question pertaining to this revised edition of the report.

Sincerely yours,

Andre De Leebeeck, P.Eng.
V.P. – Thermal Operations

TOTAL

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Modification Summary

This document lists all ERCB questions and remarks received to date. Three separate lists of questions / remarks were received relative to

- Geology questions (Steam Release report),
- Geology and Seismic Questions 204 I3P3 Well Pair,
- Engineering and Content Issue/Questions.

As per ERCB request, answers were provided as modifications / complements to the reports whenever that was possible (as opposed to completely separate answers).

Depending upon the nature of the question / remark, the answers below fully answer the question, summarizes TOTAL's position on the matter or point to the relevant section of the updated reports.

1 Geology questions (Steam Release report)

1.1 *Item 1*

The ERCB Geology staff have reviewed the lithological character of the T21 (Total Wabiskaw Top) and the Devonian in the immediate area of the site and surrounding sections. A total of 33 cores were reviewed in the area. There is limited core coverage of the T21 marker in the area. We consider the lithology of the T21 to be a sandy siltstone dominated by the presence of glauconite. There is a distinct absence of continuous fissile shale within stratigraphic interval of the area reviewed. ERCB geologists and other industry operators believe the presence of continuous fissile shales is required to confine steam chambers. Further it was noted that an in-situ fracture exists in the well AA/04-31-095-12W4 just below the top of the core.

It is with interest, page 37 of Totals Geological Insights report the description of the Kcw3 as:

> **Offshore transition, fine grained (often glauconitic) sand inter-bedded with 15-25% medium grey wavy mud beds. Moderate to common burrows, typically diplocraterion and asterosoma.**

The Kcw2 as:

> **Offshore medium grey mud with moderate silt lenses and rare glauconitic sand. Rare to moderate burrows, typically chondrites.**

The Kcw1 as:

> **Offshore transition, medium grey mud interbedded with 10-30% fine grained glauconitic sand. Moderate to common burrows, typically diplocraterion.**

In light of the ERCB staff review and Total's description of the same interval, please comment and explain giving consideration to the presence of sand and burrows, how this interval could seal a steam chamber?

In addition, the ERCB staff review of the log readings above these intervals indicate readings of greater sand content than that noted in the studied interval. Does Total consider this interval to be a seal? If so, what information is this interpretation based on?

Answer: the Clearwater – Wabiskaw member description has been completed to describe in more details which intervals are characterized as static pressure seals (and likely seals in SAGD conditions), which intervals are known to stop steam chamber vertical movement and which intervals do not present seal characteristics (or may even constitute potential thief zones and thus target for pressure monitoring). See section 2.3 of the updated report for details.

Overall, TOTAL conclusions on the matter are that:

- There are continuous fissile shales in the Kcw2 and Clearwater intervals. Kcw2 constitutes a static seal as evidenced by the contrast in between the Upper McMurray gas content and the Wabiskaw water content and the difference in pressure between these intervals (as detailed in reference 7 of the updated report).
- There are numerous occurrences of (fissile) shale in the Upper and Middle McMurray. These fissile shale layers are responsible for stopping the vertical movement of steam at observation wells and with a near certainty everywhere else (such limitation is a major issue for the economic character of SAGD production on Joslyn). However, residual uncertainties remain on the lateral continuity of these shale intervals; as a consequence it is not certain whether or not such shale layers can stop the pressure from building up toward shallow interval (through water and possibly gas movement).
- Several instances exist of gas or water bearing sands exist in the McMurray and Wabiskaw overburden. The existence of such levels presents advantages and disadvantages in term of sealing ability and seal monitoring:
  - Advantages: these levels can act as buffer intervals in case of underlying shale layer breakage or slow pressure diffusion through such shale layers. The can be targeted for installation of pressure monitoring gauges that would provide early warning in case of loss of steam confinement.
  - Disadvantages: in case of localized seal shale failure at any weak point on a stratigraphic interval, these levels may allow lateral connections to overlying weak points at different stratigraphic intervals. It is especially true of gas intervals.
- No evidence of fracture has been identified in the overburden in the vicinity of JOSLYN Phases 1 and 2 although the well density is not such that the presence of fracture can fully be excluded. Similarly, the vertical permeability of Kcw2 shale is known from analogs to be extremely low but the thickness required to be fully certain to contain all pressure diffusion over decades is not fully ascertained. Permeability measurements are being launched to address this specific issue.

1.2 Item 2

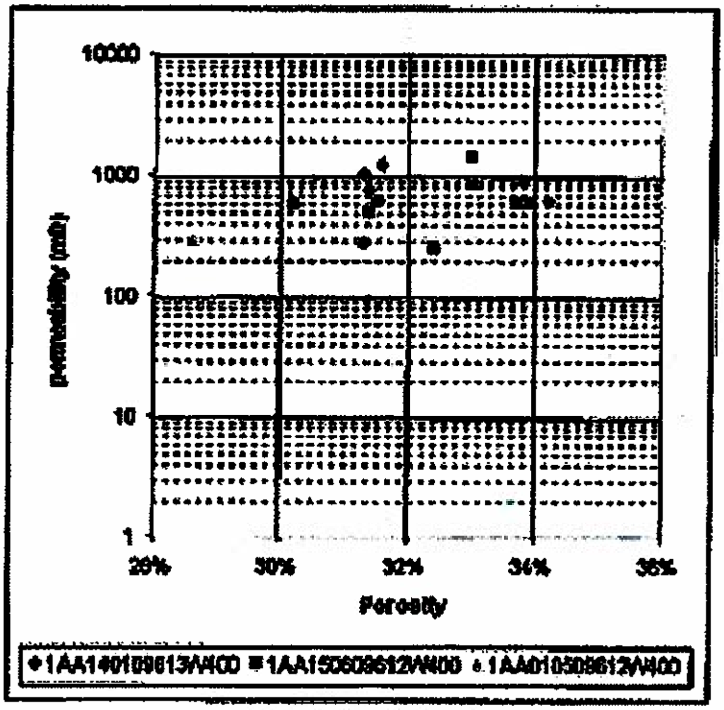

Figure 18 Wabiskaw plug permeability

Page 30 of the Geological Insights report presents this graph denoting the porosity and permeability of the Wabiskaw. It is noted that all permeability measurements exceed 200 md and porosity exceeds 30 percent. Please explain how sediment with these characteristics is behaving as a seal?

Answer: the label for this figure was modified into "Wabiskaw sand / silts plug permeability" in the updated report. As described in details in the completed section 2.3 of the updated report the Wabiskaw is made of three units well correlated at field scale. Most data on this plot is taken from Kcw3 that is certainly not a seal and may be a drain / thief zone while the underlying Kcw 2 is proven, by pressure and fluid column data, to be a static pressure seal.

1.3 Item 3

Page 5 of the Geological Insights report notes under the Devonian title:

> "Lower elevations are a result of collapse due to salt dissolution of the underlying Prairie Evaporite Formation (Figure 4). They may be associated with small scale fractures in this particular interval."

In the ERCB review, the presence of an in-situ fracture within the T21 interval was previously noted, as well as the occurrence of clay-filled fractures and mineralized faults in the limestone (AA/16-33, 13-33, AB/08-33-95-12W4) and), karst brecciation and dissolution (AA/15-33, 05-33, AB/03-33, and AB/08-33-095-12W4). A similar paleokarst interpretation was previously presented by Deer Creek Energy Ltd. in 2001 their application #1277348 to the Board. Based on the statement presented on page 5, further supported by ERCB staff core observations, it appears that Total acknowledges the presence of karst topography of the Devonian. Is this correct? Does Total, believe that there is a potential of the incident being initiated at the Devonian level? What is the evidence supporting the interpretation?

Answer: as detailed (and complemented) in the section 2.5 of the updated report and the seismic insights report Any collapse structure and associated fracturing has been interpreted to have occurred pre-Cretaceous. As a consequence the Devonian fractures are not deemed likely to have been a factor in the steam release. However the hypothesis that fracture may have played a role in the steam release cannot be completely overruled considering the scarce observations in the region of fracture over the whole stratigraphic column.

1.4 Item 4

In the ERCB review of the Seismic Insights document, there were 3 examples noted that illustrated disruption of the Devonian reflector. Copies defining the interval in question are attached.

Please provide an explanation for the disruption of the Devonian reflector and a map denoting its areal extent. In addition, please provide additional interpreted E-W seismic sections perpendicular to the SAGD pairs.

Answer: the Devonian reflector corresponds to an erosion surface hence it is a disturbed surface. Seismic imaging of disturbed surface is not always easy; discontinuity in the reflector picking can occur as seen on plate 12 and 23.

Seismic artifacts can also be responsible of some deformations. It is known that heated bitumen is creating below steam-injected wells a low velocity anomaly and a pull down effect below the injector at the Devonian unconformity level. The disruption of the Devonian unconformity below Pad 204-1 observed on plate 8 is a good example of this effect.

The plate below is showing the Devonian Unconformity time structure map.

Blue lineaments are "natural" lineaments related to erosion like canyon (blue dot lines) or Cuesta (discontinuous blue line). White dot lines are showing seismic artifacts (pull down effect) below steamed Pad 204 injector wells. There is no similar anomaly below Pad 203 because steam injection was not started on these wells at the time of the seismic acquisition (January 2007).

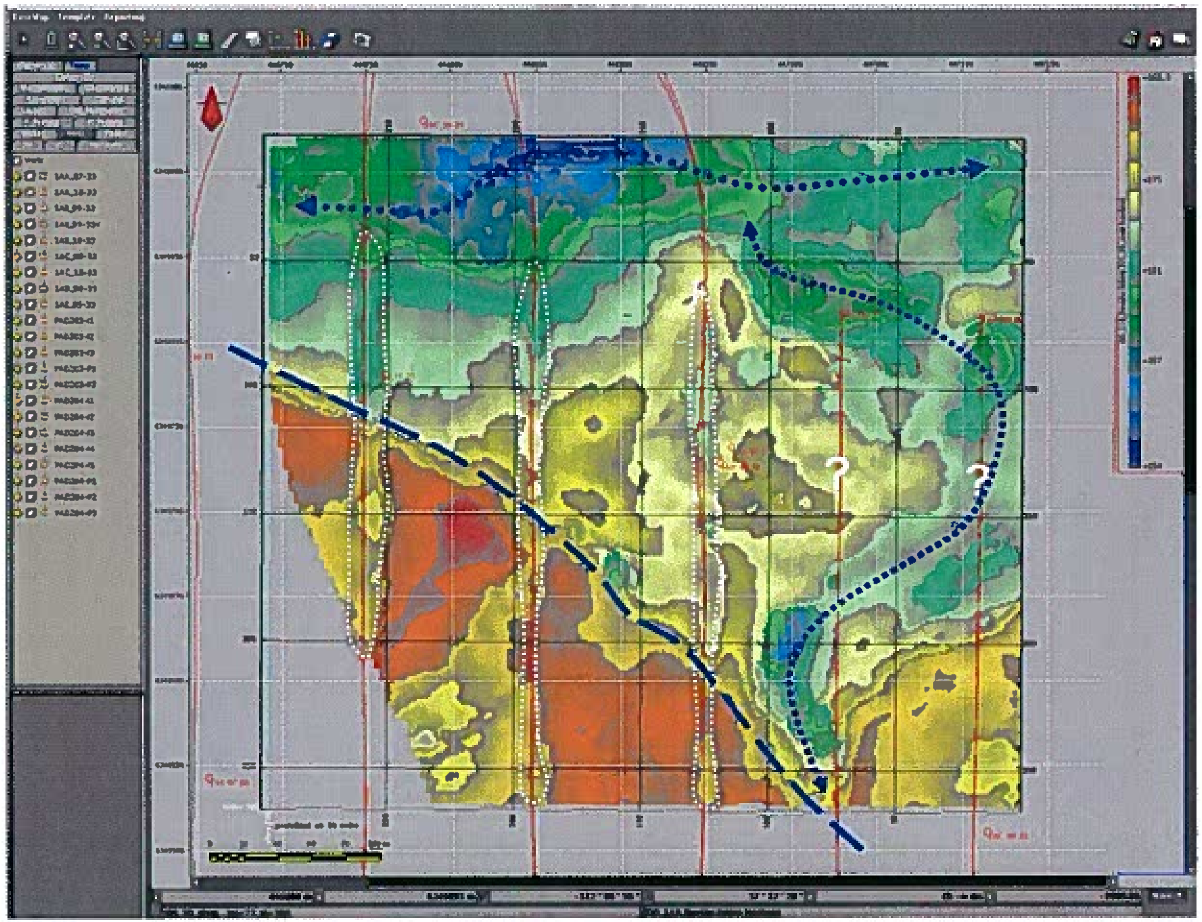

Figure 26: Devonian Unconformity Time structure map showing the main disturb areas (blue: natural related to erosion White: seismic artifact related to bitumen heating effect)

This answer was reflected in paragraph 5.5.2 of the updated report. The above figure was inserted as figure 26.

1.5 *Item 5*

In appendix B of the Millennium EMS Solutions groundwater report the auger hole information reports the presence of hydrocarbon odor in several wells at the 7 to 10 metre interval. The wells containing the odor are denoted on the attached map. The presence of this odor, particularly at the most distal hole from the event MW07 suggests to ERCB staff that sediment above the scheme is permitting the migration of petroleum into the shallow horizons. Please comment on this potential.

Answer: there are seven mentions in Millennium report on groundwater of hydrocarbon odor at various wells in the 7-10m depth range. At this depth the odor is originating from the Pleistocene glacial till deposit. It is known that the glacial reworking of the McMurray formation, can account for hydrocarbon shows in the till by incorporating bituminous material during glacial advance and retreat. This till has been described as "Firebag Till". We believe that such is the cause of the hydrocarbon odors described in the report and that such observations do not relate in any manner to migration of hydrocarbon from the McMurray.

1.6 *Item 6*

Reference is made to the presence of seismic anomalies at operating well pair 204-I3P3 similar to those observed at the incident well pair 204-I1P1 on page 8 and 15 within the Summary document. Page 8 states:

> In addition, a seismic anomaly is observed above well pair 204 – I3P3. Following this observation operations were suspended on this well pair and an observation / monitoring well was drilled within the anomaly for characterization purposes and to ensure the safety of future operations. No steam related events were observed in the well. The well was completed as an observation well on December 10 for both pressure and temperature. The interpretation results are not presented in this report. Continued operations are closely monitored.

The presence of a similar anomaly strongly suggests there is a significant risk associated with this additional well pair. The ERCB received Totals report on the 204-I3P3 well pair January 25, 2008. The ERCB believes information on the anomaly is an integral part of the incident review and is currently reviewing the information filed. As a result, the ERCB does not accept that the final report on the incident is complete until its review of the 204-I3P3 report is completed. Questions on this recently filed report will be forwarded to Total as a separate document.

Answer: the follow-up information submitted on 204 - I3P3 seismic anomaly in January 2008 is integrated as an appendix to the steam release investigation report. Several modifications related to 204-I3P3 are made in the steam release investigation report including a specific reference to the new appendix made in the executive summary.

1.7 *Item 7*

Text:

It is also noted within the Cement Bond Insights Report that there is concern expressed regarding the quality of the cement bond in the 204-I1P1 well pair after investigation. Additionally it is noted that lack of a cement bond log for the proximal 100/09-33-95-12W4 observation well. The ERCB believes that reliable cement bond logs on cased wells would provide meaningful information in occurrences such as this failure. Is Total in agreement with this statement? Does Total believe the ERCB should require cement bond logging of all injection, production and observation wells prior to the implementation of injection at SAGD schemes?

Answer: TOTAL agrees that reliable cement bond logs would provide meaningful information. Unfortunately such data is not available everywhere leaving room for doubt in our particular case. A comment was inserted in the summary of the cement bond review (paragraph 3.6 of the revised report) to clarify our position on the subject: "Overall, the cement bond review did not brought to light conclusive evidence related to the role that may or may not have played steam channeling at wells in the steam release."

In addition paragraph 4.6, related to well integrity insights, was added in answer to this and other related request for insights.

1.8 Item 8

Text:

To conclude, existing reports and geological data at the site suggest that the sediment at the top of the exploited interval is not behaving as a seal.

This opinion is based on the ERCB independent review of the T21 interval, which notes

- **the absence of continuous fissile shale,**
- **burrowed sandy siltstone,**
- **log information indicating the increasing presence of sand above the Wabiskaw,**

and the Total reports noting the,

- **petrophysical characteristics of the Wabiskaw presented on page 30 of the Geological Insights Report,**
- **Kcw1, Kcw2 and Kcw3 core descriptions noted on page 37 of the Geological Insights Report,**
- **hydrocarbon odor encountered in the shallow auger holes, Millennium EMS Solutions Ltd. Report,**
- **seismic anomalies present at the Devonian level Seismic Insight Document and,**
- **Totals acknowledgement of the presence of karst topography presented on page 5 and figure 4 of the Geological Insights Report.**

Please have consideration for this conclusion in your responses to the ERCB questions.

Answer: ERCB remarks were taken into account in the revision of the report especially paragraph 2.3 of the Geological Insights report.

2 Geology and Seismic Questions 204 I3P3 Well Pair

2.1 Item 1

Text:

Total states:

"A pick of density (most likely a carbonate streak) can be correlated with the amplitude anomaly at the base of the well." [page 32, point 2., bullet 2].

Given that the core did not intersect this depth, this explanation is therefore based upon Total's interpretation of a correlation between the wire-line log response (interpreted as the carbonate streak) and the occurrence of the base of the seismic anomaly. ERCB geologists in their review of this area have found that such deflections on the density wire-line logs are quite common, and similarly interpret them to be siderite cemented zones, usually in the McMurray as sideritization of either mudstone intraclasts or siderite cement of thin intervals.

The same density deflection (red arrow on attached logs) is found in the following wells near the Steam Release Incident area [wells AA/02-5-96-12W4; AA/05-33-95-12W4; AA/12-34-095-12W4; AA/13-33-095-12W4; AA/15-28-095-12W4). Assuming that Total's hypothesis is correct regarding the "carbonate streak" effect, please submit all seismic lines that are nearby to these other wells to demonstrate that carbonate streaks in other wells of the immediate area similarly result in seismic anomalies. If these carbonate streaks in other nearby wells do not correlate with seismic anomalies, please explain how this is a viable explanation for the occurrence in the 104/10-33-095-12W4 well.

Answer: this interpretation remains one of the 2 proposed hypotheses. The pick of density observed in the 104/10-33-095-12W4 well is quite specific and different compared with the 4 other available wells in the 3D (102/10-33-095-12W4, 100/09-33-095-12W4, 1AB/09-33-095-12W4 and102/09-33-095-12W4) as illustrated by red arrows on plate 4 of the updated 204-I3P3 information file report.

2.2 Item 2

Text:

Total has given a facies interpretation on its annotated well sketches that indicates a clay facies interpretation for the Clearwater that lies between the top of the Wabiskaw and the base of the Quaternary successions [black arrow on right side of Figures 7 to 20, attached]. ERCB geologists note that there is a sandy gamma-ray response over some of the interval that has been mapped as "clay" by Total geologists [red arrows on right side of Figures 7 to 20, attached]. Please explain how a sandy gamma ray response occurs over these intervals on each well attached for which Total has designated a clay facies for the Clearwater.

Would this discrepancy in lithologic interpretation have any relevance to Total's interpretation of the sealing capacity of the caprock in this area? Please comment.

Answer: the observation of low Gamma Ray in the upper section of the well related to the fact that GR was acquired behind casing for this section. The following clarification comment was added in paragraph 2: "It should be noted that the Gamma Ray plotted on these figure are acquired during the reservoir logging run. GR response behind casing for shallow intervals could be mistaken for a sand indication. Casing points vary greatly from well to well (typically 12 to 27 m MD)." In addition figures 7 to 20 were updated to clearly indicate the casing depth.

2.3 Item 3

Text:

Total states:

"A single fracture was observed on FMI in the Devonian interval on well 103/02-33-095-12W4. It is illustrated on Figure 3. It is not deemed to characterize any fracture related risk in reservoir or shallower levels." [page 10, paragraph 2, bullet 2].

Explain the reason for this opinion and give any supporting evidence.

Answer:
Supporting evidence for the opinion that 103/02-33-095-12W4 fracture observation in the Devonian does not characterize fracture related risk in the reservoir or shallower level is twofold:

- The observations made at the particular wells as discussed in report: Cap Rock Competence of wells DCEL 0B3C JOSLYN 2-33-95-12 and DCEL 0B1A JOSLYN 11-33-95-12 Determined From Electrical Borehole Image Data – Richard Y. Shang Ph. D, P. Geol. Schlumberger Canada Ltd. May 2003. This report is provided in appendix to the 204-I3P3 information file report.
- The general interpretation of the geology in the area especially the top McMurray depth map and NPP thickness maps as discussed in section 3.2 of the report entitled "Geological Insights in the Joslyn May 18th 2006 Steam Release".

Explicit references to both reports were inserted in the updated report.

This interpretation should not be seen as more than the collective opinion of in house and external geologists that worked on the matter.

2.4 Item 4

Text:

Total states:

"Fracture detection on FMI: no fractures were identified on the FMI from 104/10-33-095-12W4. Two dip events can be singled out due to their higher than usual dip (Figure 4 and Figure 5). After a careful review these dip events were deemed to be related to sedimentology." [page 10, paragraph 2, bullet 8].

What is the dip angle on these dip events in the FMI logs? What is the basis for your opinion that these features relate to sedimentology? What type of sedimentological feature is it? Give evidence supports this view.

Answer: the dip events in Figures 4 and 5 are dipping, respectively, 21 and 13 degrees. The dip event in Figure 4 has been interpreted as a basal scour surface of a sandy tidal channel. The dip event in Figure 5 is most likely a dipping crossbed of a prograding current ripple. These events are found at the base of highly resistive, sandy intervals and are not likely intervals for fracture development. The dips measured are also relatively low to be attributed to fractures. Paragraph 2 was amended to reflect this answer.

2.5 Item 5

Text:

Total states

"Overall, no geological observation (but the shallow reservoir depth) points towards risks specific to the particular location of 204-I3P3."

Refer to Figure 39 in Total report (attached). Just below the cored interval (from about 45 m to 55 m depth) are indicated three gas cross-over zones on the density logs (shaded in red on Total's figure). Would Total agree that upper gas zones are potential thief zones that may be a risk to successful containment of a SAGD chamber?

Refer to Figure 39 in Total report (attached). Just above the cored interval (from about 27 m to about 38 m depth) is there not a sandy response on the gamma ray logs? Would Total agree that upper sandy water zones are potential thief zones that may be a risk to successful containment of a SAGD chamber?

Please justify your above statement in light of these observations.

Answer: a very similar question has been answered previously. Key points are nevertheless repeated here:

- Gas streaks. TOTAL does not expect steam to reach the gas layers found in the topmost fraction of the Middle and Upper McMurray and illustrated on figure 39 of the original report. This expectation is based upon the review of Athabasca SAGD pilot areas (especially Joslyn phase 1 and UTF) and the comparison of **what blocked vertical steam progression on these pilots to the extensive core data** in Joslyn. Considering the uncertain lateral continuity and permeability of the underlying shale barriers we cannot be absolutely certain that steam will never reach these levels. If it the case, one can expect pressure to progressively build up in these layers which represent both a risk (as it may allow steam to migrate laterally to any weak point of the overlying Kcw2 seal) and a monitoring opportunity (as these layers can be used to position a pressure monitoring system). An accurate permeability assessment (test) of these layers would be necessary for further assessment of the risks and monitoring opportunities brought by such layers. Such testing is under consideration.

- Clearwater properties. The core observations of the many wells available in the area leave no doubt that the base of the Clearwater (Kc1) is made of continuous black, fissile, low-density clay with rare to moderate silt laminae/lenses. It constitutes a static seal. This interval, down to 36 m in figure 39, is also sometimes referred to as T21.

2.6 Item 6

Text:

> Re Figure 2. Please explain how the Top of the Upper McMurray on your Reservoir Model occurs between the Top of the Wabiskaw and the Top of the Middle Wabiskaw? [Highlighted boxes on attached figure].

Answer: The top MiddleMcMurray was incorrectly labeled as Top Middle Wabiskaw on the figure. The figure was corrected in the updated report.

2.7 Item 7

Text:

> Re: Figure 6. The caption for Kcw3, Total states:
> "Kcw2 is comprised of homogeneous, offshore shale that is approximately 5 m thick and is thought to act as a fluid barrier because of its shale character and very constant thickness."
>
> Please submit the supporting evidence for this statement, including an isopach of the Kcw2 and cross sections showing its lateral continuity.

Answer: the largely complemented section 2.3 (and particularly newly introduced sub section 2.3.2) of the Reference 2 Geological Insights in the Joslyn May 18th Steam Release – November 2007 – E. Visser / P. Bergey / J. Clarke TEPC/GSR/2007.005 details the evidence demonstrating that Kcw2 is a static seal and likely to act as a seal under SAGD conditions.

2.8 Item 8

Text:

Total states

"The well has been calibrated on seismic using sonic and density curves. Without the Devonian unconformity as a reference level, the well calibration remains very uncertain." [page 31, 5 and 6th last lines]

Explain why Total did not run the wire line logs and the core to TD below the Devonian unconformity so that proper calibrations could be done, and why sonic was not acquired in the lowermost part of the well (as indicated at the top of page 32).

Figures 21 to 23 of the report are not very legible. Please provide legible vertical and horizontal scales on the seismic lines and denote the location of the well pairs where appropriate. Please label the location of the seismic lines and well pairs on the associated amplitude maps. Please clarify the interval presented on the amplitude maps; for example are the maps representing the strength of a specific reflector?

Answer: the well program was to drill the upper part of the reservoir without encountering the steamed zone for drilling safety reasons linked with the extremely limited overburden. Such decision was taken in after discussing the issue with EUB drilling engineers. So in this case it was not possible to go trough the lower part of the McMurray and the Devonian Unconformity.

The prognosis final depth of the well was 5 meters below the GP level. This last level has not been clearly identified during the drilling and the final well TD as been as per the initial prognosis without any adjustment. This TD was in fact to shallow to get a sonic log recording at the level of the anomaly.

The figures 21 to 23 were upgraded in the updated report as per the reference requests.

2.9 *Item 9*

Reference first point page 29: It is noted that Total makes reference to the McMurray 5 horizon in the text. Please label the interval on the seismic line presented in figure 21. Please denote west and east on the cross-section.

The figure 21 was upgraded in the updated report as per the reference request.

2.10 *Item 10*

Reference: second point page 29: ERCB staff do not understand the interpretation presented with this point. Please clarify.

Answer: the reference paragraph was modified as follows (modifications underlined):

"The amplitude configuration along the well pair 204-3 (Xline 158 - **Error! Reference source not found.**)

On this orientation the high amplitude reflections is clearly flat and is not conformable to the other horizons above. This configuration is suggesting that the high amplitude reflection could be related:

- To a fluid effect ('flat spot' effect). This kind of effect is generally related to a gas water contact. It could also be related to lithology contrast if the Lithology variation is in relation with diagenetic (post depositional) effect along a fluid contact.
- Or to seismic artefact origin but no clear evidence has been found on a check of gather data."

2.11 Item 11

Text:

Reference: Figures 24 and 25. Please provide these figures with a different background color to improve legibility.

Answer: figures 24 and 25 were upgraded to improve legibility. The software used unfortunately did not allow modifying the background color.

2.12 Item 12

Text:

Reference: Page 33. Total states:

"Work is still on going relative to this interpretation and some additional data may gathering is being considered."

What additional data is being considered? How will this additional data assist with interpretation?

attachments

Answer: acquiring a VSP on the well 104-10-33-095-12W4 and a new sonic on well 1AE/09-33-095-12W4 was considered to improve the calibration and globally reduce the uncertainty of the interpretation.

Unfortunately, it as not been possible yet to find a tool compatible with these wells' ID (internal diameter 62 mm). Such acquisition is on hold pending further investigation of extremely slim sonic tools.

3 Engineering and Content Issue/Questions:

3.1 Item 1

Text: "Total must fully address how the findings from the steam release investigation will apply to the ongoing and potential future operations at Joslyn including 204 I3P3. This is meant to be Total's current view of the best practices associated with these issues. The ERCB recognizes that these specific recommendations may be subject to change pending further assessment by Total. This must include but not be limited to the following:

- Start-up steaming strategy
- Fluid measurement to and from wells
- Pressure monitoring at wells and within reservoir – number of Wabiskaw monitoring wells would be needed for adequate coverage
- Operating pressure over life of well pair/scheme
- Further geomechanical studies
- Discuss use of heave monitoring, tiltmeters, passive seismic
- Improvements to cement bond logging, and detail provided in daily drilling reports and cementing company reports."

Answer: Section 4 of the Steam Release Investigation report has been largely complemented in relation with the above request. Please refer in particular to the added paragraphs:

- 4.2 Operating Practices: Description and Key Insights
- 4.5 Further Geo-mechanical Studies
- 4.6 Well integrity Improvements

Smaller amendments were also made to other parts of the report notably in the Executive Summary section.

TOTAL is fully willing to share its views on best practices on all fields with ERCB and other operators. We tried our best to spell out key insights but it should be noted that framing recommendation in generic terms was outside of the scope of the studies performed.

3.2 Item 2

Text: "The follow-up information submitted on 204 - I3P3 seismic anomaly in January 2008 must be fully integrated into final report (possibly as an appendix)."

Answer: the follow-up information submitted on 204 - I3P3 seismic anomaly in January 2008 is integrated as an appendix to the steam release investigation report. Several modifications related to 204-I3P3 are made in the steam release investigation report including a specific reference to the new appendix made in the executive summary.

3.3 *Item 3*

Text: "The mini-frac report prepared by Patrick Collins referenced must to be part of the final release (possibly as an appendix)."

Answer: the mini-frac report prepared by Patrick Collins is provided as an appendix to the updated Geo-mechanical findings report.

3.4 *Item 4*

Text: Provide a full picture of facilities setup including specific details of injection and production fluid measurement to and from all pads and wells.

- Was Pad 204 production measured separately from Pilot well?
- Was there higher than expected bitumen as this could help support vertical steam chamber hypothesis?

Answer: the Phase 1 well was connected to pad 204 at the time of the Steam Release and afterwards as illustrated on newly introduced figure 4. The metering setup is further detailed in section 4.2 entitled "Operating practices: Description and key Insights" of the updated report.

The volume of fluid produced from a finger small while oil was not metered on a well by well basis during circulation; while a small increase in pilot production was observed during 204-P1 startup; overall it is impossible to give a conclusive answer to that question.

3.5 *Item 5*

Text: "Update date on all reports to December 2007."

Answer: the issue date was reset at December 2007 for all reports except :

- The 204-I3P3 information file dated January 2008 as this report contain data that was available only in January 2008.
- The report Site Reconnaissance - Joslyn SAGD - Aug 2006 report by P. McLellan as it is report from an external consultant that was effectively published in 2006.

3.6 *Item 6*

Text: Security settings must be removed from all PDF files.

Answer: security settings were removed from all PDF files.

3.7 *Item 7*

Text: "On pages 2&8 of "Summary of Investigations" report the reference to Dec 10 must include the year (2007) for clarity."

Answer: the date was explicitly stated as December 10th 2007 on the referenced pages.

3.8 Item 8

Text: "In the first bullet page 9, section 2.1 of "Summary of Investigations" report, there is an error in well common names (I4&P4 instead of I1&P1)."

Answer: the well pair labels were corrected on page 9, section 2.1 of "Summary of Investigations" report. A similar error was found in Pat McLellan report and was corrected.

3.9 Item 9

Text:"Much of the Millenium report appears to be repeated in this PDF document. (Report to AEUB - Steam Release Incident LSD 09-35-095-12-W4M)."

Answer: section 5 of the Steam Release Investigation Report is a summary of the "Steam Release Incident LSD 09-35-095-12-W4M" report by Millenium.

3.10Item 10

Text: "Provide summary of the project (location, size, etc), map of project clearly indicating well locations/surface facilities/release site and a summary of the key operational events (i.e. a non-technical discussion) leading up to and following the release. While, this has been provided in other areas of the report for clarity this information should be given in the executive summary on to provide reader with full context (may require no more than cutting and pasting from other sections)."

Answer: section 2.2 Project description was introduced in the report in answer to the request.

3.11Item 11

Text: "Section 1.2 (Main Conclusions) first point – expand this point to provide more clarity on what implications this statement has on the steam release mechanism (or provide this in the conclusions that follow)."

Answer: The paragraph in reference was complemented by adding the following sentences: "Such observation indicates that the steam release was not caused by the opening of a fracture originating from the well depth immediately before the steam release.

Steam vents are observed at surface more than 30 m away from any surface well locations. Such observation supports the hypothesis that the steam release is not related to channeling around wells."

3.12 Item 12

Text: "Section 1.2 (Main Conclusions) second point – the term disconnected is vague. State more clearly that Total concludes, based on the 3-D seismic mapping of the disturbed zone, that the steam release did not involve nearby observation, evaluation or development wells (or as an alternative, put such a statement in your conclusions that follow)."

Answer:
The paragraph was modified as follows:

- "The seismic survey shot in December 2006 – January 2007 over the steam release area allowed a volume of formation affected by the steam release to be mapped. The affected volume is fully disconnected from nearby delineation, monitoring or development wells below the Top McMurray interval. Such observation supports the hypothesis that the steam release is not related to channeling around wells.
- Steam vents are observed at surface more than 30 m away from any surface well locations. Such observation supports the hypothesis that the steam release is not related to channeling around wells."

3.13 Item 13

Text: "Provide an XML data file for ERCB use only of the following from 204 I1&P1:

- Steam injection rates and pressures (bottom hole and wellhead) for each string in injector and producer
- Calculated "Injectivity"
- All data should be on an hourly basis"

Answer: the production and injection data extracted from the Joslyn CPF historian software is provided on an hourly basis in XML format within the file labeled "Joslyn_204WP1_HourlyData.xml". The data covers the period from February 10th 2006 to May 30th 2006.

3.14 Item 14

Text: "Provide further clarity to justify using injectivity (Inj. Rate/ΔP inj-prod) as an indicator of fracture events. While this is addressed in Reservoir Insights Report the ERCB is still not clear on the importance of the differential going to zero or negative. For example why did events 1 and 2a only see a change in the producer pressure (i.e. no drop in injector pressure) and why did it spike above injector pressure?"

Answer:

- The paragraph in introduction of section 3 was renamed as a section 3.1 "Injectivity Concept" and modified to more clearly state why and how the concept of injectivity is used, and the caveats with the interpretation of events of infinite injectivity (effect of natural leak off, transient periods of high injectivity).
- Section 3.2 (formerly 3.1) Periods of Infinite injectivity has been modified to differentiate among all events of infinite injectivity, those probably related to actual fracturing events from those triggered by operator moves (producer pressure spikes), showing that fracturing has already occurred.

3.15 Item 15

Text: "Total's steam fingering hypothesis requires a number of assumptions to be made, such as:

- The process had to occur over a long period of time, likely initiating shortly after steam circulation commenced in December 2005.
- The location near the heel had to have some anomalous geological (good quality reservoir, high water saturation) or completion characteristics (high point in well trajectory) for it to be the initiation point for the small SAGD finger to form. Total chose the "good quality reservoir" as the most likely anomaly.
- The movement of the finger had to remain fairly vertical for the finger to reach the top of pay in just a few months of circulation. Total developed a gravity driven dilation/sand-shear theory to explain this odd movement.
- In order to model the finger development Total had to explicitly input a 50 Darcy "chimney" at the heel location. This represents the effects of the dilation/sand-shear method of vertical SAGD fingering.

The following questions concern the above assumptions:

a. Justify assessment of very good quality reservoir only at the heel of the well (Reservoir Insights Page 26 third paragraph). There appears to be little geological evidence that this is localized to the heel, and could apply to the entire length of the wellpair. Is the evaluation-well drilling density sufficient to make this statement.
b. If the process for initiating a vertical movement of steam is dilation/shear mechanism, why wouldn't steam fingering initiate near the toe since:
   - injection occurred only at toe from Dec 1 2005- March 26 2006, prior to any heel injection, and
   - during toe injection the toe pressure and steam temperature should be consistently higher than pressure and temperature at the heel, due to friction and heat loss as steam flows from the toe to heel?
c. The initial injection rate and pressure anomaly (marker 3 on Fig 13, p20) occurred only 18 days after high pressure injection started at the heel (Semi-SAGD). The anomalous drop in pressure at the injector was in response to a step increase in steam rate from 40 m3/d to 80 m3/d, and a resulting spike in pressure. Does this dispute Total's SAGD finger theory? (i.e., The event could be interpreted as a fracture initiation at or near the well-pair in response to

recent injection at the heel (perhaps coupled with continued injection at the producer heel)and not to the arrival of the SAGD finger at the top of the Gross Process Pay and subsequent shear failure of the first shale barrier.)

d. Confirm that it is Total's hypothesis that the needed 50D permeability zone in its numerical simulation model is accomplished by the dilation/shearing process occurring over the first four months of steam circulation?

e. Given that a SAGD steam chamber "chimney" requires bitumen production in order to develop, what does Total's numerical simulator results show the total produced bitumen volume would be over four months of steaming for such a chamber to reach the top of GPP?

"

Answer:

a. Only comparatively two soft arguments support the hypothesis that the reservoir is of especially good quality at the heel of 204-I1P1 well pair:

- Logs from the two vertical wells and the gamma ray log of the 204P1 and I1. Logs from the two vertical wells stands out as the best in the phase 2 area. They are close to 204-I1P1 heel. The gamma ray logs of the horizontal wells (Figure 16) showing slightly higher shaliness further to the toe. This argument is rather statistical, and is essentially used as a clue for selecting the best explanation for the pressure upward propagation. The statement has been reformulated in section 5 introduction.
- The 3D HR seismic survey. The survey shows an SW-NE antiform that may be related to a channeling direction, the Steam release area being located close to the center of the channel stacking. This argument is soft as the seismic does not allow tracking detailed sedimentological features.

b. During the circulation phase, injecting steam through the toe tubing only does not mean that the heel reservoir area is preserved: steam quality in the liner and heat losses are actually typically higher at the heel than at the toe, and the pressure losses from the toe back to the heel in the liner should be very small (<30kPa according to Qflow simulations). This is clarified in Section 5.3.1.

Of course, with a shallower thickness a slightly higher down hole circulation pressure at the toe, one would expect more likeliness for any of the preliminary phenomena (dilation, fracturing in the reservoir) to occur at the toe than at the heel. Notwithstanding the steam release occurred at the heel…

Hence, other factors pointing to the heel have to be invoked for the exercise of matching the steam release event. Our most likely scenario relies upon better reservoir quality at the heel, but it could be the presence of wells, of the well pair slant section, of natural fracture with high permeability etc. This has been detailed in the introduction of section 5 and 5.3.1.

c. As explained above, injection at the heel started in December 2005. It is difficult to say whether the increase of rates from 40 to 80m3/d (40 through the short string, 40 through the long string) has played a particular role in triggering the fracturing. Perhaps the semi SAGD phase has accelerated the drainage of the heated bitumen out of the dilated zone by changing the direction of flow in the heel area. This comment was added in section 3.2

d. The initial sand permeability has been proved too low to permit the required chamber growth rate, so the 50D permeability figure used is directly related to mechanical dilation. In the simulations several techniques were used. Permeability was either set via a higher initial permeability figure, or by using the Stars dilation module, or both. An increase of absolute permeability to 50D would not be necessary if accompanied with an important increase of the relative permeability to water (not modeled in Stars). This has been added in Sections 5.1.2. and 5.1.3. The 50 D is provided only as an illustration of the order of magnitude of the type of permeability improvement required to transmit pressure to the top of reservoir in the given timeframe.

e. Simulated bitumen production figures have been added in section 5.1.2. The estimated produced bitumen volume is consistent with the measured production figures, even though there are limitations with the both metering and the way drainage is modeled in the simulation.

3.16 Item 16

Text: "Identify specific modeling program used and provide basic input parameters used (porosity, permeability, etc.)."

Answer: as discussed orally with ERCB we propose to provide the CMG Stars data file to answer this request. Reference to Stars was added in Section 5.1.2.

3.17 Item 17

Question: "Has this study provided Total with new understandings of the fracture pressure at Joslyn. What are the fracture pressures at higher elevations? Which elevation will Total be basing future maximum injection pressures on?"

Answer: for unconsolidated rock materials, the main mechanism of inelastic deformation is shear and not tensile fracturing which is accompanied by dilation. In oil saturated sands, the most important effect of dilation would be the increase of permeability to steam. When the steam reaches the top of the oil, the rate of pressure penetration into the cap rock will depend on the permeability and the temperature evolution in this cap rock. Pressure and temperature transmission to cap rock will induce some dilation and increase of permeability there.

As long as the steam is confined in the oil zone, our model predicts that a steam pressure of 12 bars is safe. Once the steam reaches the top of the oil and steam chambers start to expand laterally, the safety will depend on how the pressure and the temperature will affect the permeability of the cap rock. A study is ongoing to assess the long term safety of the cap rock using a coupled stress-pressure simulator which allows calculating the dilation and the resulting in change of permeability both in the reservoir and in the cap rock. We anticipate that the results of the calculation will be sensitive to many parameters, in particular the mechanical and petrophysical properties of rocks and initial in situ stresses. This is why some work will be done with P. Collins to define uncertainty ranges on those parameters and to re-visit his interpretation of the minifracs that were done on some Joslyn wells.

3.18 Item 18

Text: "Discuss other possible explanations for the vertical movement of steam as is depicted in the 3D seismic shot over the incident area, such as:

- A natural fracture system brought about by Karsting, that is not detectable by seismic or logs, nor present in the cores taken in the area.
- A horizontal fracture that initiated some distance away from the steam release point and moved upwards (with or without the assistance of natural fractures in the formation). Such a fracture would not be detectable on seismic except that portion very close to the Wabiskaw zone where the Clearwater failure occurred. (i.e., it was a pipeline that closed up once the pressure was released.)"

Answer: as an answer the following text was added to end of the paragraph entitled 3.9.3 Key variations around the base case scenario:

"Numerous other steam release scenario variations could be envisioned. Some may include factors such as natural or induced fracture at the depth of the SAGD wells or above. Providing a complete list of such scenario is not practically feasible.

Such scenarios are not deemed likely based, for example, upon the lack of observed natural fracture at the relevant stratigraphic levels in the vicinity of Phase 2 for scenarios involving natural fractures, mini frac data incompatible with tensile fracture at the SAGD well depth for deep fracture scenarios, etc. but it should be clear that such alternate cannot be excluded with absolute certainty on such basis (and/or similar arguments). For example the lack of observation of fracture is not an absolute proof that they don't exist (it is only proof that they are extremely rare or do not exist).

There remain and will probably always remain residual doubts about the process by which the steam release occur. In any case, what is very certain is that the high pressure used during the early stage of 204-I1P1 startup played a major role in the steam release."

3.19 Item 19

Provide details of calculation of 1000-2600 m3 volume of steam released.

Answer: details are provided with the production data of this period (appendix 1) and paragraph 3.1 and 3.2 of the updated report.

3.20 Item 20

Provide a conclusion as the role, if any, that a poor cement bond could have played in the steam release.

Answer: TOTAL considers as unlikely the hypothesis that cement bond played a role in the steam release.

To better reflect and justify this opinion, the reports were amended as follows:

- A comment was inserted in the summary of the cement bond review (paragraph 3.6 of the revised report) to clarify our position on the subject: "Overall, the cement bond review did not brought to light conclusive evidence related to the role that may or may not have played steam channeling at wells in the steam release."
- Comments were added in paragraph 2.1 related stating that two specific observations support the hypothesis that the steam release is not related to nearby wells:
    - The surface steam vents locations are comparatively far away from any surface well locations.
    - The steam disturbed area as seen on seismic is fairly far from those wells from the reservoir up to the base Clearwater.

3.21 Item 21

First bullet under "Item 1" p18: For clarity this statement should be corrected to indicate that the steam release occurred during steam injection under SAGD operations rather than under circulation.

Answer: the paragraph in reference was completed as follows (additions underlined): "The catastrophic steam release at surface occurred during SAGD production at a time when a comparatively low pressure (~ 1400 kPag) was used to circulate injection steam in wells (NB: higher pressures were exerted during earlier circulation and semi-SAGD stages)."

3.22 Item 22

Second bullet under "Items 2-4" p19: Would it be unusual for natural fractures not to show up on seismic or core, given the limited resolution of the seismic and the very small sample size represented by core?

Answer: yes, if there are only a few (especially nearly vertical) fractures, they may be extremely difficult to detect with seismic and wells. Even rare fractures could be very detrimental to the seal ability of the overburden. The following comment was added to the paragraph in reference in the updated report: "It should be noted that vertical fractures would be unlikely to be encountered at wells if not present in large number and that the seismic may not be able to catch signs of fractures despite an extremely high resolution."

3.23 Item 23

Text: "Third bullet under "Item 5" p19: The stated reason for the very high fracture initiation pressures in the minifrac tests performed on well 8-29-95-12W4, was "…the need before initiating the fracture to dilate the rock sufficiently to allow for the pumped fluid to penetrated into the rock." (p20 of Geomechanical Insights Report). Comment on the different conditions that existed during the minifrac test compared to the conditions that existed just prior to the first anomalous pressure drop and rate increase on April 12 at I1P1. Specifically:

- the injection of unheated water vs. steam
- the minifrac test on a cold reservoir vs. the anomalous pressure and rate drop occurring after 4 months of heating the reservoir around the wellbore.

This question is partly answered under item (3.17 item 17). It is important to notice that in our approach, we are not using breakdown pressures measured during minifracs as maximum injection pressure around steaming wells. Minifracs however are thought to provide a threshold of dilation beyond which one might expect a significant increase of permeability to the injected fluid. The dilation around injection wells is then calculated as a function of time, i.e. pressure and temperature, using a mechanical model. This dilation can then be linked to a change of permeability to steam. In the ongoing study, we intend to implement such relationship between relative permeability and dilation in order to better predict the dynamics of pressure and heat transmission first within the reservoir and then into the overburden. By doing that, we will be able to better predict the kinetics of steam, pressure and temperature fronts.

3.24 Item 24

Text: "Based upon Total's understanding of the geology and the mechanism which led to the pressure build-up in the porous and permeable Wabiskaw prior to the steam release, what are the risks of the Wabiskaw acting as a thief zone and connecting surrounding wells on steam to rupture/incident area?"

Answer: The Wabiskaw Kcw3 layer may be connected to the crater area. But this layer is far above the top GPP level in the Middle McMurray (where steam usually stops its upward movement) and above the continuous shale layer Kcw2 that is proven to constitute a static seal. As a consequence it is certainly not likely to act as a thief zone under normal SAGD operations.

If its effective water permeability is sufficient, it may act as a temporary pressure buffer in case of seal loss over the top GPP – top Kcw2 interval or be used for pressure monitoring above the Kcw2 seal [positive aspects]. It may also allow the steam to migrate laterally from a ruptured weak point at the Kcw2 level to another laterally positioned overlying weak point in the Clearwater [negative aspect].

3.25 Item 25

Text: "First paragraph p23: Total has described the Wabiskaw zone just under the Clearwater shale as a high mobility reservoir that has the capacity to take a fairly high volume of steam with only a slow pressure buildup. Total does not consider the McMurray above the top of GPP to be commercial pay in that it is a series of shales/mudstones with bitumen saturated sands scattered throughout it, and the possibility of some thin gas pockets. Given this description, comment on the following alternate sequence of events to Total's "most likely scenario":

- The significant rate increase seen on April 12 and April 13 coupled with the drop in injection pressure indicates that not only did fracture occur but that the fracture acted as a conduit to a reservoir capable of taking large volumes of steam/water. Normal fracture leak-off would be small outside of the heated zone in the McMurray. The only reservoir fitting this description appears to be the Wabiskaw zone, unless small gas pockets in the upper McMurray are sufficiently large. The location of these gas pockets is not known.
- After the initial steam rate increase the steam rate remains fairly steady at more than twice what it was at prior to April 12th. During this time the steam/water pooled under the Clearwater "shale". However, the Clearwater is composed of sandy shales rather than a true fissile shale.
- The overburden stress gradient of 21 kPa/m at 35 m depth (just under Clearwater caprock) gives a minimum horizontal fracture initiation pressure of 735 kPa. The pressure of the steam/water at this depth during the last half of April ranged between 900 and 1100 kPa based upon a hydraulic head of about 50 m between the injector and the base of the Clearwater, and higher if a steam chamber existed in the Wabiskaw. The high pressure and temperature resulting in the movement of steam/water both horizontally through the Wabiskaw and perhaps vertically as it found weaknesses in the Clearwater. This movement accounts for the anomalous events 2a-d, where there was very little change in the injection rates. Then the well-pair was shut in to install the pump.
- When the well was started up in SAGD mode, the pressure was brought up to about 1400 kPa at the injector over a one-week period and then the steam release occurred. Two scenarios are:
    - The additional injection was sufficient to allow Total's shear failure of the Clearwater to surface to occur, or
    - The high pressure steam/water had worked its way through the Clearwater during the last half of April Semi-SAGD and the first week of SAGD operations, and communicated with the Quaternary which was at a pressure equal to the hydrostatic head. The sudden drop in pressure was communicated to the water pooled in the Wabiskaw, causing it to flash to steam with catastrophic results."

Answer: This alternative scenario is in fact very close to the one proposed in the report. The main difference lies in the fact that the fracturing starts from the depth of the SAGD wells, not from the top of the good quality reservoir, without having to involve the steam finger explanation. This possibility was discarded after it was found that a fracture was unlikely to occur at such depth.

The other difference relates to the proposed upward propagation of fracture and pressure into the Clearwater propagation. This was not brought forward in Total's most likely scenario, since the operating pressure at the time of the release was considered sufficient to trigger the failure of the whole Clearwater body.

TOTAL proposed a scenario for the steam release based upon an extensive multi-disciplinary review. We believe it is the most likely but it should be clear that many variations around the proposed scenario (such as the one suggested by ERCB) or even significantly different scenarios could be considered without conclusive proof to demonstrate that they are actually what occurred or could not have occurred. We cannot practically discuss in detail many of those.

It is TOTAL opinion that the root cause of the steam release would remain, in nearly all the cases, the excessive pressure that was applied during circulation on 204-I1P1.

3.26 Item 26

Text:

26 Was Total able to model the large increase in injection rate seen at markers 3 and 1?

Answer: a quantitative interpretation of the increase of injectivity would require a geo-mechanically realistic coupling between dilation and permeability, which is the aim of the ongoing study. This was not attempted in the study detailed in the reference report; this study provides only qualitative interpretation based on our understanding of the way the steam channeled through the cap rock up to the Wabiskaw.

3.27 Item 27

Text:"Figure 13, p26: Provide the criteria used to mark the pressure boundaries between "sand dilation - no heave", "sand dilation - heave", and "fracture domain"."

Answer: the current definition of the various areas is still notional. The drawing was provided for illustration purposes only. On going geo-mechanical studies aim precisely at mapping as much as possible the different geo-mechanical domains. Ideally the results should be formulated in such a simple format whose meaning can be understood by non geo-mechanical specialized people; based upon some early discussions on the subject we may have, at least, to add a third axis with the width of the pressurized area.

This notional mapping was proposed based upon the following (probably very simplistic) assumptions:

- The domain boundaries are strongly related to depth,
- Dilation should start occurring before significant heave,
- Heave should occur before failure,
- The failure domain was defined in relation with 204-I1P1 conditions.

Using, as we did, straight lines converging at surface may not be the best choice (the seal present enough stiffness to keep some mechanical properties for zero overburden). It was selected for simplicity sake.

3.28 Item 27

Text: "Given the shallow depth would it be more correct to represent the orientation of fracture in Figure 5 (page 13 of Geo-Mechanical Insights Report) as horizontal? If so then is it Total's view that the vertical movement of the steam chamber upwards is through a succession of small horizontal fractures."

Answer: the mentioned figure is a schematic of a fracture that can be either horizontal or vertical. The figure just illustrates the fact that the effective normal stress at the fracture wall is null, which is true regardless of the fracture orientation.

3.29 Item 28

Text: "There is no evidence of horizontal fracturing on the seismic. Given the depth and injection pressure shouldn't a horizontal fracture be expected, and if initiated why wouldn't it continue to propagate given the McMurray is saturated with immobile bitumen?"

Answer: the seismic report does mention some horizontal features in the steam disturbed area (at / close to the top GPP, within the Non reservoir McMurray and at the top Upper McMurray / Wabiskaw level).

Those horizontal affected zones are not necessarily fractures but could be dilated zones or non geomechanically related. If such zones were related to dilation the lateral extension of such zone would be controlled by the relative permeability to steam which is not infinite. If those features were related to fracture, their extension would be related to fracture permeability which is also not infinite.

3.30 Item 29

Were injection volumes too low in the dilation/steam fingering period to propagate a horizontal fracture?

Answer: injection volumes were probably too low for a horizontal fracture of decent size. Considering the typical leak off into the reservoir in circulation phases, being able to propagate a horizontal fracture –assuming the mechanical conditions allow it- would require loosing much more fluids into the reservoir from the fracture planes (analogy with well stimulation by hydraulic fracturing). The volume of the fracture itself would probably require much less injection rate than the leak off.

3.31 Item 30

Text: "Sec 4.3.1 p20: In discussion fracture mechanics in a minifrac test, Total refers to the need for a very high fracture initiation pressure due to the inability of the water to penetrate the rock in order to initiate the fracture. To clarify, would Total agree that:

- in the case of the McMurray the "rock" is unconsolidated sand that has the characteristics of an aquitard due to the high saturation of immobile bitumen,
- once the bitumen saturation has been heated it will mobilize and communicate high injection pressures, and
- the injection pressure required to initiated a horizontal fracture in a mini-frac conducted on heated McMurray sand at Joslyn would likely be close to the pressure calculated from the vertical stress gradient, once the bitumen is mobile and water can penetrate the sand."

Answer: see answers for items 3.17 and 3.23.

3.32 Item 31

Figures 17, 18, 19 (Geo-mechanical Insights Report page 30-32) Provide plots of model at different intervals of steam/water build-up radius.

Answer: such additional plots were not available. Additional plots describing modeling results related to the impact coalescing steam chamber (variable width of pressurized area) were introduced in the new section 5.3 of the geo-mechanical insights reports.

3.33 Item 32

Text: "Sec 2.2.1, page 9: If injection at the toe was not measured and the pressure loss calculations were only recently performed on the Q-flow simulator, is it true that the toe injection was only tracked by the wellhead pressure? Was this also true of toe injection at other wells in Joslyn Creek? At present, does total use the Q-flow simulator to track the estimated toe bottom hole injection pressure at all of its wells?"

Answer: at the time of the steam release, the toe BHP was not estimated, for any of the wells. At present, we use a formula that fits Qflow results and is compatible with historical Heel BHP and steam chamber pressure data. However, the calculated difference Heel-Toe BHP is often higher and more variable than the very little value obtained from Qflow (<30kPa), and not well correlated with the heel/toe injection rate splits. So we think the calculation useful to spot anomaly (blockage in the liner, scaling inside the long tubing) but not very precise.

3.34 Item 33

Text: "Figure 27 (Page 53 of Seismic Insights) appears to show modeled steam growth down to producer – Why, as this was not seen on fiber optic data from well as hot spots in Figure 15 (Page 22 Reservoir Insights)?"

Answer: figure 27 of the Seismic Insights report presents an interpretation that was built without cross checking fiber optics data. From a pure seismic analysis point of view the extension of the disturbed character of the seismic down to the producer level is highly uncertain (the seismic signal is affected by the above lying disturbed area).

3.35 Item 34

Figure 16 on page 22 of Reservoir Insights Report requires more discussion. In the second to last paragraph on page 21 Figure 16 is alluded to in the first sentence but the rest of the paragraph appears to discuss Figure 15. There does not appear to ever be a discussion of Figure 16.

Answer: Figure 16 was essentially used to introduce the times of the fall offs, and the difficulties associated with failing fiber. The order between Figures 15 and 16 has been changed, and the text been clarified.

3.36 Item 35

Text: "Given the hypothesis presented for steam fingering and evidence of some channel sand between injector and producer on Figure 19 (Page 27 of Reservoir Insights Report) why wouldn't there be a connection there between injector and producer? Provide an expandable and legible version of Figure 19 with actual evaluation well locations denoted."

Answer: This has been clarified in Section 3.1 (formerly section 3 introductory part). Communication with the producer may have occurred, but not to the extent to explain the level of injectivity observed. Figure 19 has been modified.

3.37 Item 36

Text: "Figure 20 (Page 27 of Reservoir Insights Report) seems to show a connection between the injector and producer further along the length of the wellbore from the incident area."

Answer: Both Figures 19 and 20 show a connection between the injector and producer wells that indeed does not match the interpretation of the producer temperature fall offs of Figures 15 and 16. Such connections are highly dependent on the fine scale characteristics of the model used, and are very difficult to reproduce with accuracy. The goal of this particular simulation was limited to testing the feasibility of a fast growing chamber. The steam and oil rates associated with these communications were compatible with what was observed before April 12th. The oil of the steam finger was actually produced through the producer well (producing it from the injector location was not possible). This answer has been added to the section 5.1.2.

From: Andre.DE-LEEBEECK@total.com
Sent: Friday, September 05, 2008 1:38 PM
To: Andrew MacPherson
Cc: Pierre.BERGEY@total.com; John.FOULKES@total.com; jean-marc.feroul@total.com; Geoff.CHOW@total.com; Natalie.SANDERS@total.com; Tom Keelan; Ken Schuldhaus
Subject: FINAL Follow-ups on Joslyn Steam Release Report

Andrew,

Further to your questions sent July 25 please find following TEPC's response.
We have answered as best we can with regard to our understanding of the question and, in the case of the first question, our access to comparative information.
Should you have any additional questions please do not hesitate to contact either John Foulkes (403 538 4597) or Pierre Bergey (403 538 6375).
I would answer myself but I am moving on from Total.

I hope that with these answers you have what you need for your internal reporting.

Regards,

With regards to caprock the response states that it has similar character to other schemes. Please provide supporting evidence and examples.

The May 2006 Joslyn SAGD steam release investigation involved an in-depth review of the local geology. It relied primarily upon local data as the efficiency of the seal to contain steam is highly dependent of the very specific geological aspects of the area considered. Not having analyzed in such details other SAGD projects, TEPC is not in a position to build an extensive cap rock sealing efficiency comparison between Athabasca SAGD projects (beyond the obvious observations – e.g. Joslyn shallow depth is a significant risk indicator). Such a review would require access to minute data related to such projects and as such cannot be performed by TEPC. We can however highlight key aspects that should be investigated in a cap rock sealing ability assessment:

- SAGD operating conditions,
- Stress and fluid pressure regime in the cap rock and reservoir,
- Shale lateral continuity in the reservoir and cap rock,
- Water mobility in the reservoir and cap rock,

Well cementation procedures and cementation logging.

Comment: We did not find the reference in our text to "similar character to other schemes".

Collins report appended to geomechanical insights but not referenced in table of contents/glossary.
P. Collins's report is listed in the list of appendices page 5 of the "Geo-mechanical insights in the May 18th 2006 Joslyn Steam Release" report.

Engineering question 13 missing producer steam injection rates: was it measured?
As mentioned in paragraph 2.2.3 of report entitled "Reservoir Insights into the May 18th 2006 Joslyn Steam release", the steam injection rates into the producers were not measured during the circulation phase. Measuring steam injection rates on all wells during circulation is an identified safety improvement for future Joslyn wells.

Numerous ongoing studies where cited in the responses, please provide some general timelines for these studies.

Ensuring the safety of our Joslyn SAGD operation is a primary goal for TEPC that determines constant efforts. Key studies identified to date are detailed hereafter. Detailed scope of work and planning may change as a function of the study results themselves, workload constraints, and technological development (part of these activity are Research & Development). Expected dates for first additional results are indicated hereafter. TEPC will update the ERCB of key findings as part of the regular project reviews:

1. INSAR heave monitoring network extension - design and implementation. Design to be finalized by end October 2008. Implementation during winter 2008 – 2009 field operations campaign. Qualification spring 2009.
2. Additional pressure observation wells – design and drilling. Design finalized by end October 2008. Drilling during winter 2008 -2009 field operations campaign. Qualification spring 2009.
3. Geo-mechanical modelling – failure risk criteria refinement, heave inversion. Results expected by end 2008.
4. Reservoir modelling – pressure diffusion characterization. Additional modelling planned mid-2009 (pending further data gathering).

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**"Andrew MacPherson"
<Andrew.MacPherson@ercb.ca>**

25/07/2008 02:58 PM

To "Andre DE-LEEBEECK" <Andre.DE-LEEBEECK@total.com>
cc
Subject FINAL Follow-ups on Joslyn Steam Release Report

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Andre

Our apologies for the delay on this but below are the follow-ups to the
April update to the final report submitted by Total:

-With regards to caprock the response states that it has similar
character to other schemes.  Please provide supporting evidence and
examples.
- Collins report appended to geomechanical insights but not referenced
in table of contents/glossary
- Engineering question 13 missing producer steam injection rates: was it
measured?
- Numerous ongoing studies where cited in the responses, please provide
some general timelines for these studies

These are intended to be the FINAL questions/follow-ups for Total.  ERCB
staff are now working on a final internal report to be presented to our
management

Thanks,

Andrew MacPherson, P.Eng.
Resources Applications
ERCB
297-5613
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