ENHANCE ENERGY CLIVE MMV PLAN

APPENDICES E:

AITF: Characterization of the Wells that Penetrate the Leduc (D-3A) and Nisku (D-2) Oil Reservoirs in the Clive Oil Field in Alberta

July, 2019

APPENDIX E

Characterization of the Wells

that Penetrate the Leduc (D-3A) and Nisku (D-2)

Oil Reservoirs in the Clive Oil Field in Alberta

Confidential Client Report to Enhance Energy Inc.

by

Alberta Innovates – Technology Futures

December 2011

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Executive Summary

The Leduc (3-DA) and Nisku (D-2) oil reservoirs in the Clive oil filed are the target for CO_2 enhanced oil recovery using CO_2 captured in the Redwater area and brought by pipeline to the Clive oil field. All 252 wells that penetrate the Leduc D-3A and Nisku D-2 oil reservoirs were evaluated in terms of their potential to leak CO_2 using information publicly available in various data bases and methodology developed previously for similar studies in the Pembina and Zama oil fields. The well data were compiled and a series of charts were created depicting the characteristics of these wells, including the current status of all wells, primary cement type and casing grade utilized, year of abandonment of all abandoned wells and current age of all cased well abandonments, and abandonment plug types utilized for all cased well abandonments.

Following the electronic assignment of leakage potential scores, a manual process of validating and adjusting the scores was conducted with reference to GeoScout well data. A discussion of the rationale behind the assignment of shallow and deep leakage scores to the 252 wells that penetrate Leduc (3-DA) and Nisku (D-2) oil reservoirs in the Clive oil field is presented, followed by a listing of all wells classified as having high shallow, deep, and both shallow and deep leakage potential. Operating data from the ERCB relating to reported cases of surface casing vent flow (SCVF), gas migration (GM) and casing leaks or failures (CF) were incorporated into the overall assessment of leakage potential for all of these wells. While the leakage potential scores do not quantify absolute probability of leakage, they do suggest an ordinal ranking of wells that maybe more likely to be problematic based on experience with Alberta wells that have, in the past, demonstrated a higher likelihood of leaking. A series of maps illustrate the location of all the wells analyzed, of the wells assigned high leakage potential and of the wells with reported surface casing vent flow and casing failure.

All the wells assessed as having high shallow, deep, and shallow and deep leakage potential scores, and, in particular, the following six wells with high leakage potential scores in combination with reported surface casing vent flow and/or casing failure: 00/02-10-040-24W4, 00/04-08-041-24W4, 00/09-20-040-24W4, 00/10-02-040-24W4, 00/11-21-040-24W4 and 00/14-03-040-24W4, should be investigated further for vertical hydraulic integrity before implementation of CO_2-EOR in the Leduc (D-3A) and Nisku (D-2) reservoirs in the Clive oil field, regardless if they will be used as CO_2 injectors, oil producers or will just be abandoned.

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1. Introduction

1.1 Background

A major challenge in mitigating climate change effects is the reduction of anthropogenic CO_2 emissions through a broad portfolio of measures which includes increasing energy efficiency and conservation, switching from fossil-based energy production to other forms of energy such as nuclear, solar, wind and other renewables, and carbon capture, utilization and storage (CCUS) in geological media (IEA, 2010). The "utilization" in CCUS consists mainly in using CO_2 captured from large stationary sources for CO_2 enhanced oil recovery (CO_2-EOR). Currently there are more than a hundred CO_2-EOR operations in the world, the great majority of them being in the U.S. However, they predate CCUS and, with few exceptions, they are not considered as CO_2 storage operations. Geological storage of CO_2 is actively pursued at several locations around the globe, but all are storing CO_2 captured at gas plants after the separation of CO_2 from produced natural gas (e.g., Sleipner and Snohvit in Norway, and In Salah in Algeria).

CCUS is strongly supported by the International Energy Agency (IEA, 2010). The potential of this technology has been recognized by the G8, which consequently recommended the implementation of a series of large-scale demonstration projects to prove its potential, and also by individual governments in Australia, Canada, the European Union and USA. Aware of the potential of CCUS to reduce anthropogenic CO_2 emissions, the federal, Alberta and Saskatchewan governments have provided significant financial support for the implementation of large-scale CCUS demonstration projects in western Canada. Among the projects that have been initiated in western Canada is Enhance Energy's "Alberta Carbon Trunk Line" Project, known also as ACTL.

Enhance Energy Inc. will construct and operate the Alberta Carbon Trunk Line, which is a 240 km pipeline that will collect CO_2 from industrial emitters in and around Alberta's Industrial Heartland and transport it to aging oil reservoirs in central Alberta, more specifically the Clive oil field first and beyond as the project progresses, for secure storage in CO_2-EOR projects (Figure 1, reproduced from Enhance Energy Inc.'s fact sheet at http://www.enhanceenergy.com.). The Clive oil field is located east to northeast of Joffre and immediately north of the Red Deer River. At full capacity the ACTL route will provide access to oil reservoirs capable of producing an additional billion barrels of high-quality light-crude oil while storing 14.6 Mt CO_2.

All CCUS projects require the study of the fate and effects of the stored CO_2, and the development of an active monitoring program to ensure that there is no CO_2 leakage from the storage unit. In the case of CO_2-EOR operations, CO_2 is stored in the respective oil reservoir(s), and monitoring of the fate and effects of CO_2 in the reservoir(s) is part of the engineering practice.

Figure 1: Location of the Alberta Carbon Trunk Line (ACTL).

In the case of the Alberta Carbon Trunk Line project, Enhance Energy Inc. is taking care of studying, predicting and monitoring the effects of CO_2 injection into the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field, which are the oil reservoirs targeted for CO_2-EOR in the initial phase of the ACTL project. In regard to studying the effects of injecting CO_2 in the Leduc D-3A and Nisku D-2 reservoirs, Enhance Energy Inc. has retained Alberta Innovates – Technology Futures (AITF) to perform a series of studies in a staged approach that consists of several phases. In Phase 1 of the study, AITF in collaboration with University of Saskatchewan studied the geology, hydrogeology, rock mineralogy and geomechanical properties of the sedimentary succession from the top of the Leduc (D-3A) and Nisku (D-2) oil reservoirs to the ground surface (Bachu et al, 2011). The study area is defined as illustrated in Figure 2, covering 171 sections of land. A total 1715 wells were drilled within the study area, of which 660 wells reach the top of the Nisku Formation; most of those are located within the D-2 pools.

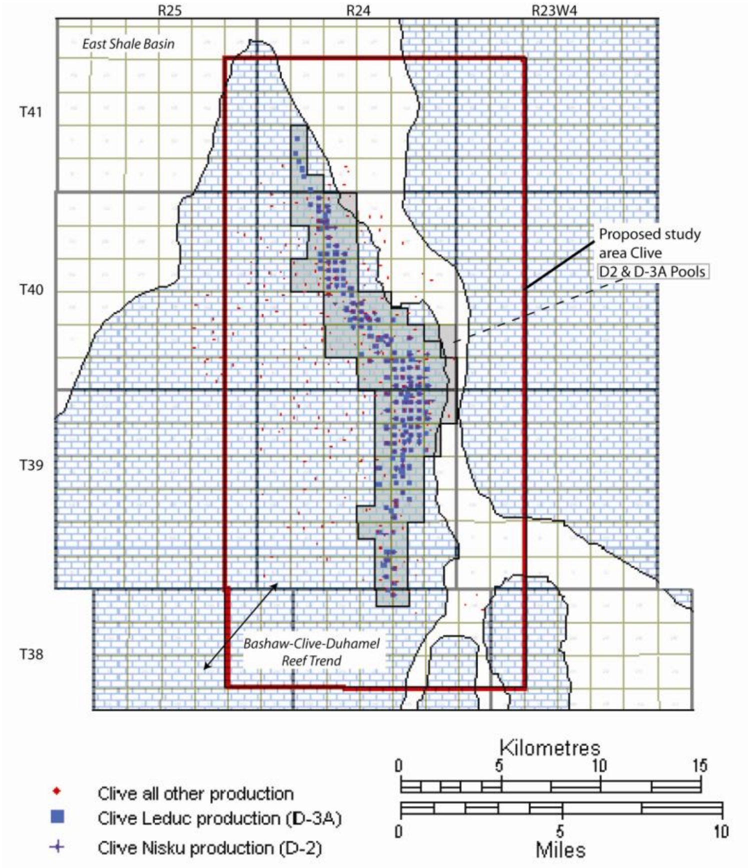


Figure 2: Study area, delineated by the red line, for the assessment of the effects of CO_2 injection in the Leduc (D -3A) and Nisku (D-2) oil reservoirs in the Clive oil field.

In Phase 2 of the project, the following areas of study were identified:

- Assessment of the potential for CO_2 leakage through wells that penetrate the Leduc D-3A and Nisku D-2 oil reservoirs in the Clive oil field;
- Evaluation of geomechanical effects of CO_2 injection on the reservoirs and caprock;
- Evaluation of geochemical effects of CO_2 injection on reservoir rocks and caprock;
- Evaluation of the effects of leaking CO_2 on intervening deep saline aquifers; and
- Preliminary evaluation of information available and/or required for the development of a monitoring program

This report presents the results of the evaluation of leakage potential of the wells that penetrate the Leduc D-3A and Nisku D-2 oil reservoirs in the Clive oil field.

A detailed survey of existing wells penetrating the Nisku D-2 and Leduc D-3A pools within the Clive oil field boundary was conducted in order to assess the potential for leakage of CO_2 from the these reservoirs through cap rock via existing wellbores to overlying permeable zones, shallow aquifers or the surface. For a leak to occur three elements must exist (Watson, 2004, Watson and Bachu, 2009): a leak source (CO_2

injected into the Leduc D3-A and Nisku D-2 reservoirs), a driving force (CO_2 buoyancy and injection pressure) and a leakage pathway. As this study involves CO_2 enhanced oil recovery, the first two conditions are met. The previous Phase 1 study has conclusively shown that no natural leakage pathways, such as faults and fractures, exist between these two oil reservoirs and the shallow potable groundwater, soils and atmosphere. . The only potentially weak geological barrier is the thin Ireton Fm. separating the Nisku D-2 and Leduc D-3A carbonate reservoirs (Hearn et al, 2010). Hearn et al. (2010) state that “Compared with off-reef Ireton aquitard, the Ireton Fm. over the reef complex has a much higher carbonate content, and significant secondary porosity. As a consequence, the off-reef Ireton Fm. is likely an effective seal to hydrocarbon migration, whereas the on-reef Ireton aquitard can potentially breach”. Also, given the relatively low thickness and high carbonate content of the Ireton aquitard and the multiple acid stimulations conducted on the Nisku D-2 and Leduc D-3A reservoirs, CO_2 containment between the two carbonate reservoirs may be problematic. However, this issue identified by Hearn et al. (2010) relates to the communication between the two oil reservoirs, Leduc D-3A and Nisku D-2, and not to potential leakage in and/or through the overlying strata.

Thus, the third condition for fluid leakage from the two reservoirs, the existence of a leakage pathway, may or may not exist depending on the condition of the existing wellbores that penetrate the Leduc D3-A and Nisku D-2 oil reservoirs. Common leak pathways in existing wellbores are often the result of poor primary cementing of the well casing/borehole annulus, casing leaks caused by corrosion, extensive operating history comprised of multiple pressure cycles from re-completions and stimulations, or improper design and execution of well abandonment programs. Data from 252 wells penetrating the Nisku D-2 and Leduc D3-A reservoirs in the Clive field study area were gathered from data warehouse vendors (GeoScout) and provincial government agencies for the purpose of assessing the potential for “shallow” and “deep” leakage. Deep leakage pertains to leakage from a higher pressure zone to adjacent permeable horizons above or below. Shallow leakage refers to compromised hydraulic well integrity higher up in the well closer to the surface where shallow gas may leak up the outside of the casing/wellbore annulus to shallow fresh water aquifers or through a casing leak and up the inside of the production casing to the surface. Surface leakage of methane gas out of the wellhead surface casing vent valve (always open) is referred to as “surface casing vent flow” (SCVF) and surface leakage of methane gas out of the ground around the wellhead is called “gas migration” (GM). Both SCVF and GM are obvious indications of high potential for leakage in the shallow portion of a well. In a worst case CO_2 leakage scenario, the combination of shallow leakage and deep leakage could result in CO_2 from a CO_2 injection reservoir re-entering a nearby abandoned wellbore, bypassing the deep abandonment plug, travelling up the inside of the wellbore production casing and around or through a shallow abandonment plug (if any), or out through a casing leak and up the outside/inside of the surface casing, and entering a shallow fresh water aquifer or venting to atmosphere. Even in this very unlikely scenario, the CO_2 leakage rate is highly unlikely to be large, given the long and low-permeability leakage pathway from deep in the well to surface

2. Characterization of the Wells within the Clive Study Area that Penetrate the Leduc D-3A and Nisku D-2 Oil Reservoirs

All the wells penetrating any of the Nisku/Leduc oil pools within the boundary of the Clive field study area, including some wells on the edge of the Chigwell and Alix fields, were included in the scope of this assessment. The well data set of 436 separate well events, as recorded by the Energy Resources Conservation Board (ERCB), meeting the above criterion, correspond to a set of 252 unique wellbores for the study. Well configuration, base of groundwater protection and operating history data for these 252 wells were retrieved from Alberta Environment, the Energy Resources Conservation Board (ERCB) and data warehouse vendor GeoScout. In addition, well leakage prediction software (TL Watson & Associates Inc.) was utilized to process the well data and assign a semi-quantitative leak potential score to each of the 252 wells in the Clive field study area that penetrate the Nisku and Leduc reservoirs. After electronic scores were assigned, a manual process of validating and adjusting the scores where necessary, was conducted with reference to the GeoScout well data set.

2.1 Well Characteristics

Shown in Figure 3 is the current status of all 252 distinct wellbores that penetrate the Clive oil field in the study area. In the “Drilled and abandoned” (D&A) category are wells that were unsuccessful at finding an original target reservoir and were subsequently abandoned before production casing was run into the well and cemented to total depth. Drilled and abandoned wells are generally less prone to leakage due to the absence of casing at the bottom of the well (Watson and Bachu, 2009). In a D&A well the absence of casing at the bottom permits cement abandonment plugs to be set directly against the irregular surface of the open hole, generally resulting in a better seal against the inside of the open borehole. The advantage of setting a plug in open-hole can be offset to a degree if the borehole is not circulated and conditioned properly to remove drilling mud filter cake adhering to the rock face before cementing the well. Also an issue is the fact that, historically, more stringent abandonment requirements existed for D&A wells relative to cased and abandoned wells. “Cased and abandoned” wells are abandoned after production casing has been run into the well and cemented to total depth. These wells are generally more prone to leakage as the presence of steel casing in the well precludes easy direct access to the casing/borehole annulus in the event that the operator has to fix a cement channel (void space resulting in poor annular cement seal). Proven methods exist to fix these annular cement channels, but they can be problematic and expensive. “Injectors” are wells that are injecting water for disposal or pressure maintenance. “Suspended” wells are producers or injectors that are temporarily inactive. They can usually be re-activated quickly and at low cost as needed. “Drilled and cased” wells are wells standing cased and cemented awaiting a completion decision.

"Producers" are wells currently producing oil or gas. "Abandoned zone" refers to wells where the original target zone is abandoned. Wells classified as "Abandoned and re-entered" are wells previously abandoned that were re-entered for a new purpose, and "Abandoned whipstocked" refers to whipstocked wells where the whipstocked wellbore was abandoned.

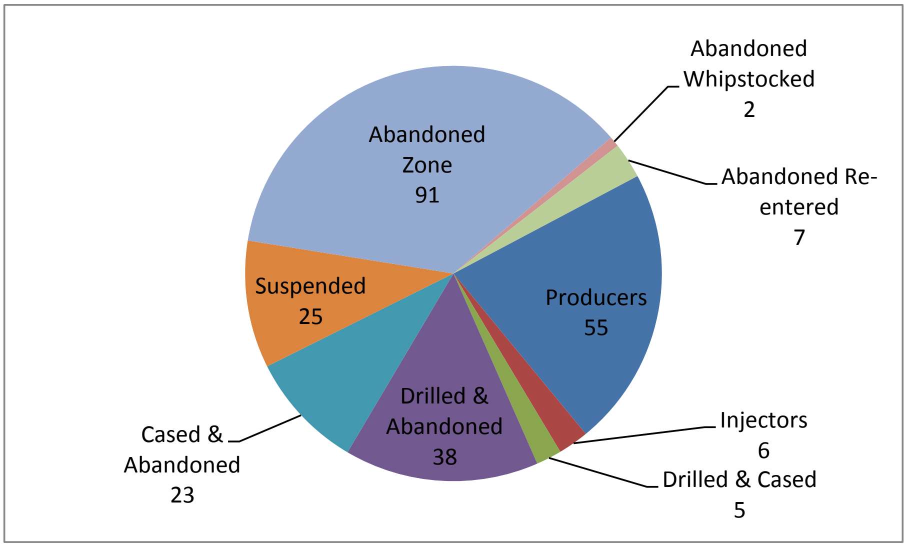
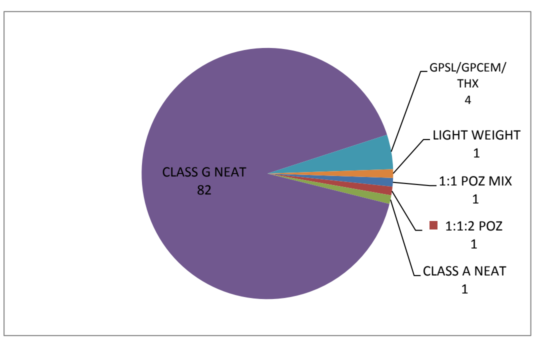
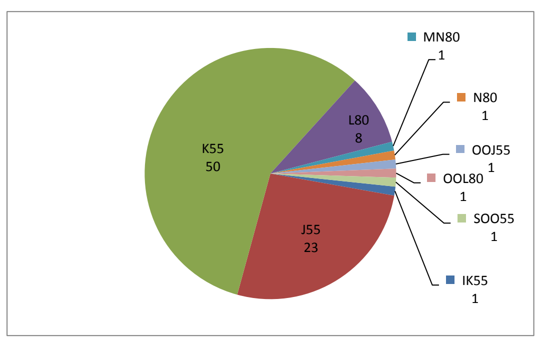


Figure 3: Status of the 252 wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs within the Clive oil field.

Figure 4 shows a breakdown of Clive D-2 and D-3 wells by primary cement type (a) and casing grade (b). Primary cement types consist of Class G Neat (no additives), Class A (no additives), Light Weight (gel additives to reduce density), POZ Mix (gel and fly ash) and GPSL/GPCEM/THX (gypsum & gel additives).





a) b)

Figure 4: Materials used in 214 cased wells that penetrate the Leduc (D-3A) and Nisku (D-2) reservoirs in the Clive oil field: a) cement type (data available for 90 wells); and b) casing grade (data available for 87 wells).

Figure 5 shows the geographic location of all 252 Clive D-2 and D-3 wells by current status: active, drilled & abandoned and drilled, cased & abandoned.

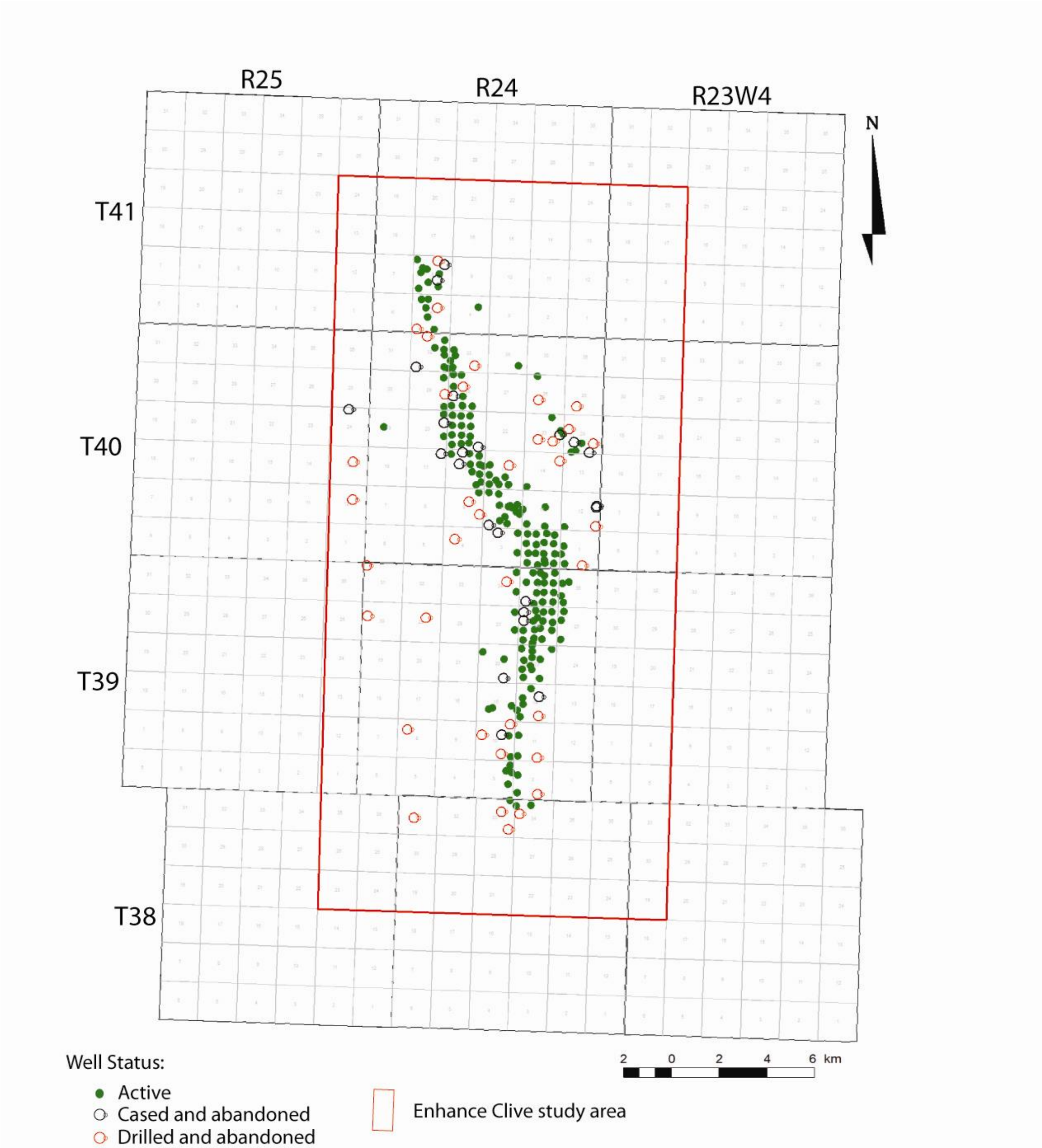


Figure 5: Location and current status of the 252 wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive field.

Many studies on CO_2/cement interaction, reviewed in Zhang and Bachu (2010), have been performed with somewhat different conclusions. Some studies based on bench tests of cement exposed to CO_2 and CO_2-saturated brine under strong flow conditions, concluded that CO_2 will react vigorously with cement, degrading its ability to maintain vertical hydraulic isolation in a casing/wellbore annulus (e.g., Duguid et al, 2005). Other studies, suggest that cement exposed to CO_2 or CO_2-saturated brine under flow conditions encountered in the subsurface will form a carbonated impermeable residue composed of Na-Al-Si (e.g., Carey et al., 2007; Kutchko et al, 2007, 2008). This carbonate residue seems to form a barrier to invasion of the cement by the $CO_{2,}$ thus limiting cement degradation. The difference between these divergent conclusions may stem from fundamental differences in the flow and reaction conditions present during each of the studies. During the primary cementing process, cement is pumped down the casing and up the casing/wellbore annulus. This process imposes a substantial hydrostatic pressure on the formation at the bottom of the casing string. Excessively high bottom-hole pressure can detrimentally fracture the rock formation. To avoid fracturing the formation during primary cementing, the cement can be mixed with light weight additives to reduce the density and hydrostatic pressure of the cement column.

It has also been suggested that the addition of some cement additives for purposes of density reduction, setting time extension, fluid loss reduction, and cost minimization may also result in an increase in cement porosity and water/cement ratio. High water/cement ratio, and thus cement porosity, has been linked to an increase the degradation rate of cement in CO_2-brine solutions (Benge, 2009). For the purpose of this study it is assumed that the addition of additives causing higher water/cement ratio to cement placed at the bottom of a well, constitutes one of the deep leakage risk factors.

Casing grades for Clive D-2 and D-3A wells, illustrated in Figure 4b, consist of standard API grades (Table 1) and five proprietary grades. Proprietary casing grades with minimum yield strength of 55,000 psi include OOJ55, SOO55, IK55 and proprietary grades with minimum yield strength of 80,000 psi consist of MN80 and OOL80.

Table 1: API standard casing grades.

Casing Grade	Minimum Yield Strength (psi)	Ultimate Tensile Strength (psi)
J-55	55,000	75,000
K-55	55,000	95,000
L-80	80,000	95,000
N-80	80,000	100,000
P-110	110,000	125,000

*API – American Petroleum Institute; 1 psi = 6.895 kPa

In general, well casing steel composition is the same for all grades but differs by heat treatment. Casing grades J-55, K-55, L-80, N-80 and P-110 are standard API grades. Grades OOJ55 and SOO55 (equivalent to J-55) are proprietary steel casing grades manufactured by Evras (Calgary) and Algoma (Sault Ste. Marie) and are often used for sour oil wells. Grade MN-80 (equivalent to N-80) is also a proprietary casing grade and is used for high stress thermal wells.

Figure 6 shows the year of abandonment for the 61 abandoned Clive D-2 and D-3 wells. In general the older the abandonment year, the less stringent were the regulatory abandonment requirements at the time of abandonment.

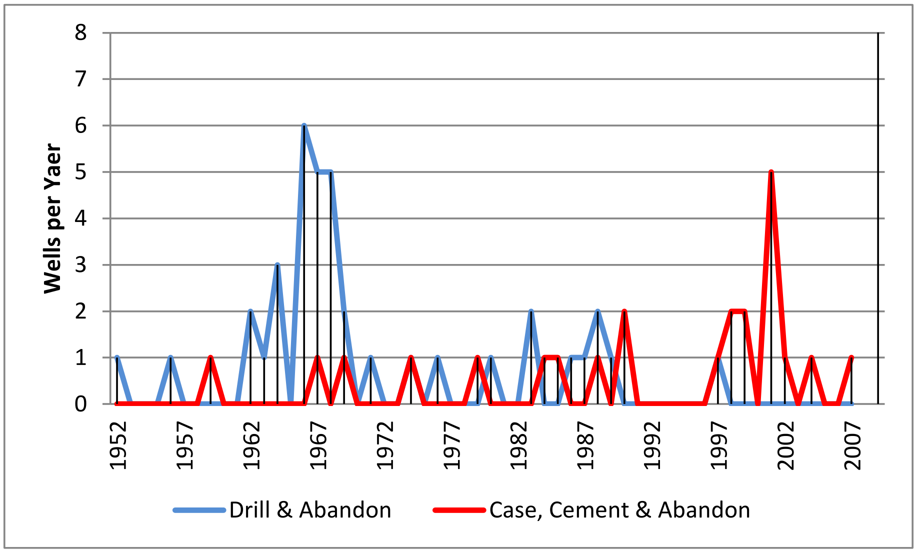


Figure 6: Year of abandonment of the 61 abandoned wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field.

Shown in Figure 7 is a histogram of the duration, or time span, from initial drilling to abandonment for all 23 of the cased and abandoned wells in the Clive oil field that penetrate the Nisku D-2 and Leduc D-3A reservoirs. Also shown is the average duration of the cased and abandoned wells.

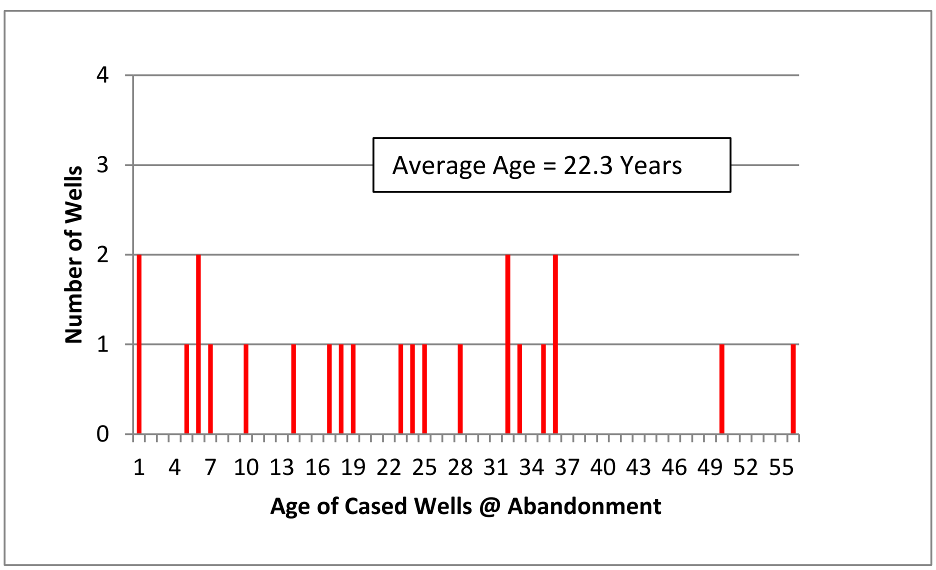


Figure 7: Duration (age) to abandonment of the 23 cased and abandoned wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field.

Successful oil and gas wells are abandoned at the end of their productive life when the well production rate of oil and gas has declined to a level where revenue from the sale of oil or gas can no longer cover operating costs. If no well work-over option exists for restoring the well production rate to a profitable level, then abandonment is the logical next step for the well. Well abandonment procedures in Alberta are specified and enforced by the ERCB (ERCB Directive 020).

Unsuccessful wells (D&A's) with no casing in the hole are abandoned simply by placing cement plugs across all zones with significant porosity that may flow fluid or gas into the wellbore. The ERCB specifies which zones (in conjunction with porosity logs run by the operator) are to be isolated by placing a cement plug in the borehole adjacent to (and above) the subject zone. These plugs are generally very effective at sealing the well below the plug largely because the cement can come in close contact directly with the irregular surface of the rock face. These plugs are designed to completely shut off the porous zone adjacent to them. This prevents leakage to surface as well as down-hole cross flow from one higher pressure porous zone to another of lower pressure.

Cased well abandonments are more problematic due to the fact that the casing in the well precludes direct easy access to the borehole rock face for cement plug placement. The casing was initially cemented in place (after drilling) by circulating cement down the casing and up the annular space between the casing and the rock face. However, for a number of reasons this process is not error proof and voids (occupied by drilling mud) in the cement placed behind the casing exist to varying degrees. Micro-annuli, casing de-centralization, cement channels and gas or fluid influx during the cement setting period can also lead to cement sheath void spaces. These void spaces can provide fluid access to the casing where metal corrosion can occur, resulting in wellbore fluid leakage into the casing interior. In order to correct these "behind the casing" cement voids one must first find them. Even after void spaces are found, fixing them can be difficult to accomplish because the casing prevents direct easy access. In extreme cases the casing can be removed from the inside by milling out the casing and "under reaming" (drilling out with wide bit) the cement sheath and formation face thereby removing the suspect casing/cement void space, however this is expensive and generally not under-taken unless required by the ERCB Well Operations Group. A cement abandonment plug could then be placed at this depth in direct contact with the bare rock face sealing the well from below.

In cased wells where casing leaks or cement integrity problems are not suspected, routine cased well abandonments (CWA's) are performed. Three main types of CWA's are executed in Alberta: balanced cement plug placement, setting a bridge plug (BP) capped with cement, and a cement squeeze into the formation through casing perforations. These three methods are each designed to seal off the inside of the casing at pre-determined depths.

Balanced plug placement involves running production tubing to desired depth, circulating cement down the tubing with cement returns up the tubing/casing annulus. When sufficient cement has been placed, the tubing is pulled slowly leaving behind a cement plug blocking the inside of the casing. This method is the cheapest of the three routine cased well abandonment methods. It is the quickest method and requires only cement pumping equipment and relatively short service rig time. Problems, in addition to spotting the plug at the wrong depth, arise from pulling the tubing out of the cement too quickly, compromising the geometry of the plug, not waiting long enough to allow the cement to set properly or waiting too long and cementing the tubing in the hole.

The second routine abandonment method “BP w/cement cap” consist of running in the well with a bridge plug to the desired depth, setting the bridge plug thereby sealing the inside of the casing, followed by placement of cement on top of the set bridge plug. Problems with this method include not setting the BP properly or setting it in a bad section of casing, precluding establishment of an adequate seal, corrosion of the steel plug and degradation of the seal elastomers.

The third routine cased well abandonment method involves forcing (squeezing) cement into a perforated interval for the purpose of permanently sealing off the casing perforations. This method is often used in combination with the other two. This process involves setting a cement retainer on tubing above the perforations. A cement retainer is a down-hole tool that sets and seals off the tubing/casing annulus similar to a packer but with a valve that when opened, allows cement to be pumped through and below the retainer. The annular pack-off prevents cement returns from going up the annulus, thus forcing it to flow into the open perforations. When the cement is pumped into the perforations, the cement dehydrates, bridges off and the pressure climbs to maximum, forcing the cessation of pumping. This process is repeated several times until the pump discharge pressure reaches some threshold level and holds for a sufficient period of time indicating a reasonable seal. Following a successful pressure test, the tubing with stinger is pulled out of the retainer (retainer valve closes) and out of the well. Problems with this method include not achieving a sufficient initial feed rate (before maximum pressure) of squeeze cement into the perforations, resulting in a questionable perforation seal. Cement is pumped through the retainer but does little more than fill the casing below the retainer adjacent to, or below the perforations. Normally in this situation the operator will disconnect (sting out) from the retainer, pull the tubing and stinger out of the hole, and run the tubing back in and spot additional cement on top of the closed retainer. When this happens, the ERCB will often allow substitution of the cement retainer for a bridge plug and approve the abandonment. After the cement sets, the plug is pressure tested and tagged with tubing (or wireline) to confirm the actual plug depth. Problems with this method arise when, during the squeeze attempt, the retainer valve is cycled (opened) but does not close and reseat completely when disconnecting the stinger, resulting in a questionable pressure seal. The end result is effectively a bridge plug with a hole in it capped by a cement plug.

Over the history of the Alberta industry, abandonment methods have evolved largely as ERCB’s well-abandonment requirements developed. Initially, simple balanced cement plugs were common. More recently routine abandonments require all completed (perforated) zones to be squeeze-cemented to prevent down-hole cross flow, followed by the setting of a bridge plug capped with cement. Additional plugs may be required in cases where shallow aquifers are not properly protected (older wells). Illustrated in Figure 8 is a breakdown of the plug types used to abandon the 23 cased wells in the Clive oil field.

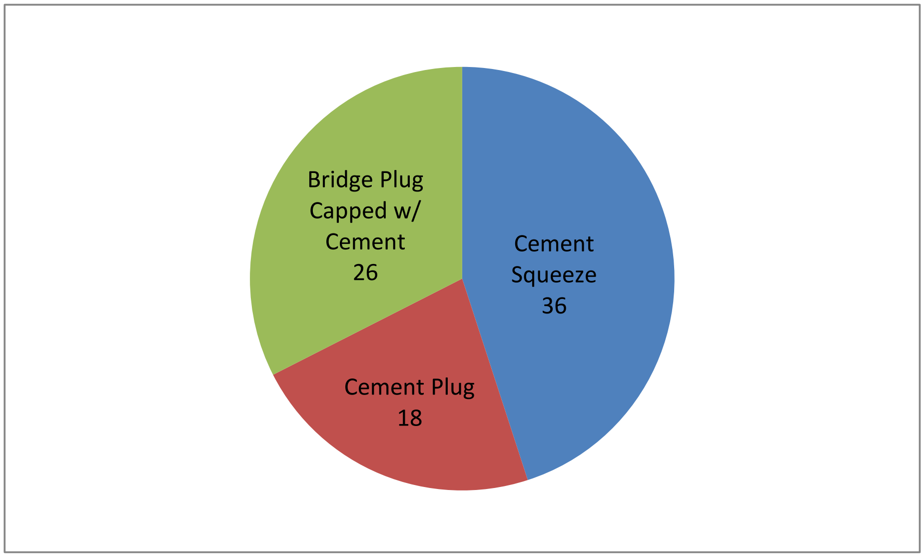


Figure 8: Method of abandonment for the 23 cased and abandoned wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oilfield (data available for 80 plugs set in 23 abandoned wells).

Unsuccessful well abandonments (generally older wells) are the result of improper plug placement or leakage through or around an internal plug, into the casing from outside through a casing leak or up the outside of the casing through a channel and past the cement top. The leaking gas can then migrate up the mud filled casing/borehole annulus or inside the casing to the welded plate at surface and accumulate, resulting in the build-up of pressure. At some point the gas will leak past the welded plate on top of the abandoned well casing and vent to atmosphere. In these cases where the leaking gas flow rate exceeds some threshold level, it is necessary to re-enter the abandoned wells, locate the leak, seal the zone (cement squeeze) and re-abandon the well. This process can be very difficult and expensive, especially if the well is located within a populated area (e.g., old Texaco wells in Calmar).

Shown in Figure 9 is a histogram illustrating the current age of all 191 active or non-abandoned wells in the Clive oil field. As with abandoned wells, in general the older the active well, the less stringent regulatory requirements were for drilling and primary cementing. In addition to age, some prior periods of very high drilling activity levels (induced by high oil prices during the period 1978-85) may have contributed to sub-standard drilling, cementing and stimulation practises (Watson and Bachu, 2009). In addition to the above, the older the well is, the longer is the time for casing corrosion to progress.

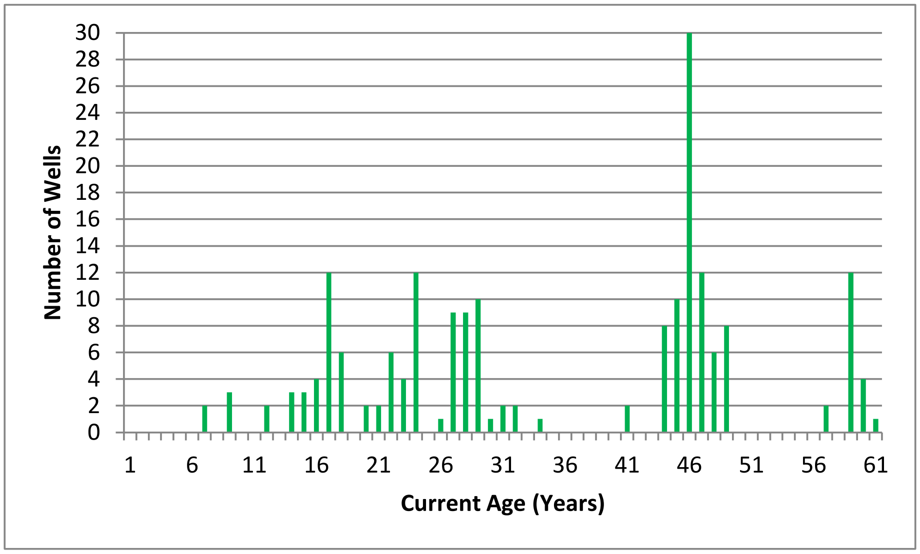


Figure 9: Age of the 191 non-abandoned wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field.

2.2 Assessment of the Leakage Potential through Wells

All wells in the Clive oil field penetrating the Nisku D-2 and Leduc D-3A reservoirs were investigated to assess their leakage potential by compiling electronic data from various sources. A proprietary database of well data comprising information from the ERCB, Alberta Environment and a commercial well database vendor was obtained and utilized by AITF for this study. The electronic data were first screened using leakage prediction software developed by TLWatson & Associates and made available to Alberta Innovates – Technology Futures, for the purpose of assigning semi-quantitative leak potential scores. Wells with high leak potential were then validated individually using information retrieved from GeoScout. Following this electronic screening process, the entire set of 252 wells penetrating the Nisku D-2 and Leduc D-3A reservoirs in the Clive oil field were surveyed manually with GeoScout to verify the leak potential scores and identify other relevant wellbore issues relevant to leakage potential.

2.2.1 Deep Leakage Criteria

Listed in Table 2 are five criteria that were used to assign leakage potential scores for deep leakage. Parameter values are multiplied together to arrive at the final score value. Deep leakage is defined as leakage (cross-flow) from a target production zone or CO_2 injection zone back into the wellbore (or outside the casing) up and into an adjacent permeable zone (productive zone or deep saline aquifer). "Fracture" and "acid" criteria refer to the number of fracture and acid stimulation treatments performed in the well. These treatments are executed at high pressure and are believed to contribute to degradation of local hydraulic isolation. The "Cement" criterion refers to primary cement type with additives. Some additives mixed with the base cement are believed to increase the cement porosity (higher water/cement ratio), resulting in a greater propensity to degenerate in the presence of CO_2. “Abandonment type” pertains to cased well abandonments utilizing steel bridge plugs which are prone to corrosion and seal failure in the presence of CO_2. “Number of completions” is a measure of how many separate zones were perforated in addition to the initial completion interval. Perforating a zone creates a communication pathway from inside the casing, through the casing wall and primary cement sheath and into the target formation. This is accomplished by firing explosive shaped charges (or hydro-jetting) which blow holes in the steel casing and shatters the cement sheath likely compromising local hydraulic integrity.

Table 2: Deep leakage criteria and values.

Factor	Criterion	Parameter Value	Default Value
Fracture	count = 1	1.5	1
Fracture	count > 1	2	1
Acid	count = 1	1.1	1
Acid	count = 2	1.2	1
Acid	count > 2	1.5	1
Cement	Known risk additive	3	1
Abandonment type	Bridge Plug	3	1
Abandonment type	Not abandoned	2	1
Number of Completions	count > 1	2	1

2.2.2 Shallow Leakage Criteria

Shallow leakage potential scores are a function of nine individual parameters as shown in Table 3. Shallow leakage is defined as the loss of hydraulic isolation in the upper part of the well. It is observed when gas from a shallow gas zone meanders up the outside of the casing through drilling mud occupying the annular space above a low cement top to the surface casing shoe. From there the gas will flow up inside the surface casing pressuring-up the surface casing annulus there-by inducing gas to flow out of the surface casing vent (surface casing vent flow, SCVF) at surface. It can also flow around the surface casing shoe (if the surface casing vent valve is closed) and up the outside of the surface casing and vent to atmosphere out of the ground at the surface (gas migration, GM).

In Table 3, “Spud date” is the date that the drilling of the well began. In Alberta, the 1965 to 1990 period tended to yield a disproportionately larger number of surface casing vent flows (SCVF) and gas migration (GM) cases possibly due to periods of historically higher drilling activity levels induced by high oil prices. “Abandonment date” refers to the date that the well was abandoned. Prior to 1995, abandonment regulatory requirements did not include testing for SCVF/GM or ground water protection. “Surface casing size” (large) has been observed to contribute to shallow leakage. “Well type” in this context, pertains to whether the well was cased or abandoned open-hole. Wells abandoned with casing in the hole to total depth have shown a significant increase in potential for leakage (Watson and Bachu, 2009). “Geographic location” refers to a region (Special Test Area) near Lloydminster where wells exhibit a greater frequency of SCVF/GM. Wells with a “Total Well Depth” greater than 2500 m tend to have a higher leak potential

(Watson and Bachu, 2008). “Well Deviation” appears to contribute to leakage probably due to poor primary cement sheath coverage as a result of decentralized casing at points of deviation (“dog-legs”). “Cement to Surface” is a measure of how high primary cement was circulated in the casing borehole annulus. Low cement tops are a major contributing factor to SCVF/GM. This is due to the fact that drilling mud occupies the casing borehole annulus above the cement top and serves as a poor barrier to gas leakage up the annulus. “Additional Plug” refers to the setting of an abandonment plug inside the well casing near surface to augment shallow well integrity. Since 1995 additional cement plugs were required to isolate shallow fresh water aquifers as well as for repair of SCVF/GM when detected. Further yet, since 2003 all wells that do not have primary cement covering (cement top above) all porous zones were required to set an additional plug inside the casing to provide further protection against leakage from below. As with Deep Leakage scores, shallow leakage parameters are multiplied together to arrive at the composite Shallow Leakage score. High scores suggest high potential for leakage.

Table 3: Shallow leakage criteria and values.

Factor	Criterion	Parameter Value	Default Value
Spud Date	1965 – 1990	3	1
Abandonment Date	<1995	5	1
Surface Casing Size	>=244.5	1.5	1
Well Type	Cased	8	1
Geographic Location	Special Test Area	4	1
Well Total Depth	>2500 m	1.5	1
Well Deviation	1.2 – 1.8	1.5	1
Cement to Surface	No	5	1
Cement to Surface	Unknown	3	1
Additional Plug	No	3	1
Additional Plug	Unknown	2	1
SCVF or GM	Yes	2	1
Casing Failure (leak)	Yes	2	1

2.2.3 Discussion of Leakage Scores

Figure 10 shows the number of wells that, based on the available data, have scored as having low and high leakage potential in the shallow and deep parts of the well.

Table 4 identifies the wells and shows the individual leakage scores for wells determined to have high shallow and/or deep leakage potential, and Figure 11 shows their location. Shallow leakage scores ≥ 400 and deep leakage scores ≥ to 10 are deemed to have high leakage potential in the respective zone of the well (Watson and Bachu, 2008, 2009).

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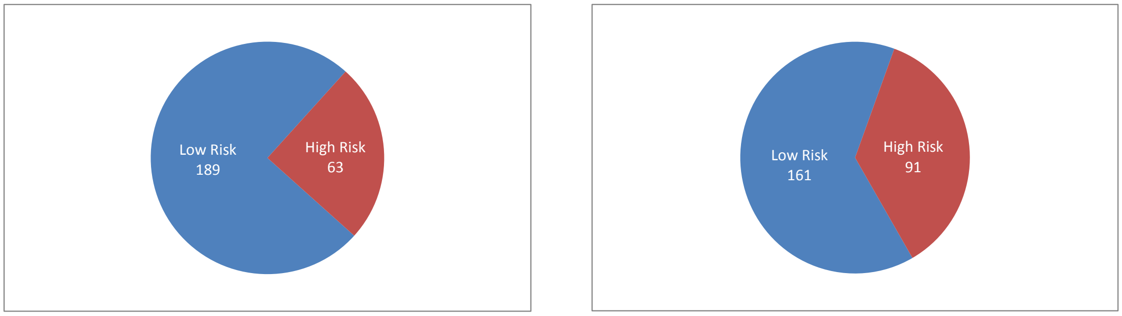

a) b)

Figure 10: Leakage potential of wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field: a) in the shallow part of the well; and b) in the deep part of the well.

Table 4: Wells with high shallow and deep leakage potential that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field.

Wells with High Shallow Leakage Potential	Shallow Score	Wells with High Deep Leakage Potential	Deep Score	Wells with High Shallow and Deep Leakage Potential	Shallow Score	Deep Score
00/01-02-040-24W4	540	00/01-16-040-24W4	12	00/02-10-040-24W4	432	12
00/01-10-039-24W4	540	00/01-21-040-24W4	12	00/06-02-040-24W4	540	12
00/01-35-039-24W4	540	00/01-34-040-24W4	12	00/06-26-039-24W4	540	12
00/02-22-039-24W4	540	00/02-02-040-24W4	12	00/06-35-039-24W4	540	12
00/03-02-040-24W4	540	00/02-05-041-24W4	12	00/10-02-040-24W4	432	12
00/03-26-039-24W4	540	00/02-11-040-24W4	12	00/11-21-040-24W4	720	12
00/03-35-039-24W4	540	00/02-15-040-24W4	18	00/12-02-039-24W4	540	12
00/04-02-039-24W4	540	00/02-21-040-24W4	12	00/12-26-039-24W4	540	18
00/04-08-041-24W4	720	00/02-26-039-24W4	12	00/13-28-040-24W4	540	18
00/04-10-040-24W4	540	00/02-28-040-24W4	12	00/14-03-040-24W4	720	13.2
00/04-12-040-24W4	540	00/03-15-040-24W4	12	00/14-23-039-24W4	540	12
00/05-14-039-24W4	540	00/03-21-040-24W4	12	00/14-35-039-24W4	540	12
00/05-23-039-24W4	540	00/03-28-040-24W4	12	00/16-26-039-24W4	540	12
00/05-26-039-24W4	540	00/04-01-040-24W4	12	02/16-29-040-24W4	720	18
00/05-28-040-24W4	600	00/04-02-040-24W4	12			
00/05-33-040-24W4	540	00/04-11-039-24W4	12			
00/05-36-039-24W4	540	00/04-11-040-24W4	12			
00/06-23-039-24W4	540	00/04-14-040-24W4	12			
00/07-02-040-24W4	540	00/04-15-040-24W4	12			
00/07-26-039-24W4	540	00/04-21-040-24W4	12			
00/07-35-039-24W4	540	00/04-23-039-24W4	12			
00/08-02-040-24W4	540	00/04-25-039-24W4	12			
00/08-23-040-24W4	1800	00/04-26-039-24W4	12			
00/08-26-039-24W4	540	00/04-28-040-24W4	12			
00/08-32-040-24W4	540	00/04-33-040-24W4	12			
00/09-02-040-24W4	540	00/04-35-039-24W4	18			
00/09-20-040-24W4	540	00/04-36-039-24W4	12			
00/09-26-039-24W4	540	00/05-15-040-24W4	12			
00/09-35-039-24W4	540	00/06-21-040-24W4	12			
00/10-10-039-24W4	1080	00/06-28-040-24W4	12			
00/11-02-040-24W4	540	00/07-08-041-24W4	10.8			
00/11-10-040-24W4	540	00/07-16-040-24W4	12			

00/11-23-039-24W4	540	00/07-21-040-24W4	18			
00/11-26-039-24W4	540	00/08-03-039-24W4	12			
00/11-35-039-24W4	540	00/08-03-040-24W4	12			
00/11-36-039-24W4	405	00/08-15-039-24W4	18			
00/13-23-039-24W4	540	00/08-16-040-24W4	12			
00/13-26-039-24W4	540	00/08-27-039-24W4	18			
00/14-02-040-24W4	540	00/08-34-039-24W4	12			
00/14-14-039-24W4	540	00/09-10-040-24W4	12			
00/14-24-040-25W4	2700	00/09-16-040-24W4	12			
00/14-26-039-24W4	540	00/10-11-040-24W4	12			
00/14-26-040-24W4	1080	00/10-21-040-24W4	12			
00/14-28-040-24W4	540	00/10-22-039-24W4	12			
00/15-26-039-24W4	540	00/10-23-039-24W4	12			
00/15-35-039-24W4	540	00/10-26-039-24W4	12			
00/16-02-040-24W4	540	00/10-35-039-24W4	12			
00/16-32-040-24W4	540	00/11-05-041-24W4	12			
00/16-35-039-24W4	540	00/12-01-040-24W4	12			
		00/12-02-040-24W4	12			
		00/12-11-040-24W4	12			
		00/12-14-039-24W4	12			
		00/12-15-040-24W4	12			
		00/12-21-040-24W4	12			
		00/12-23-039-24W4	12			
		00/12-25-039-24W4	12			
		00/12-28-040-24W4	12			
		00/12-33-040-24W4	12			
		00/12-35-039-24W4	12			
		00/12-36-039-24W4	12			
		00/13-10-040-24W4	12			
		00/13-16-040-24W4	14.4			
		00/13-21-040-24W4	12			
		00/13-34-038-24W4	12			
		00/14-21-040-24W4	12			
		00/15-16-040-24W4	12			
		00/15-21-040-24W4	12			
		00/16-03-039-24W4	12			
		00/16-03-040-24W4	12			
		00/16-09-040-24W4	12			
		00/16-16-040-24W4	12			
		00/16-20-040-24W4	12			
		00/16-23-039-24W4	18			
		00/16-27-039-24W4	12			
		00/16-34-039-24W4	12			
		02/02-35-039-24W4	12			
		02/12-08-041-24W4	27			

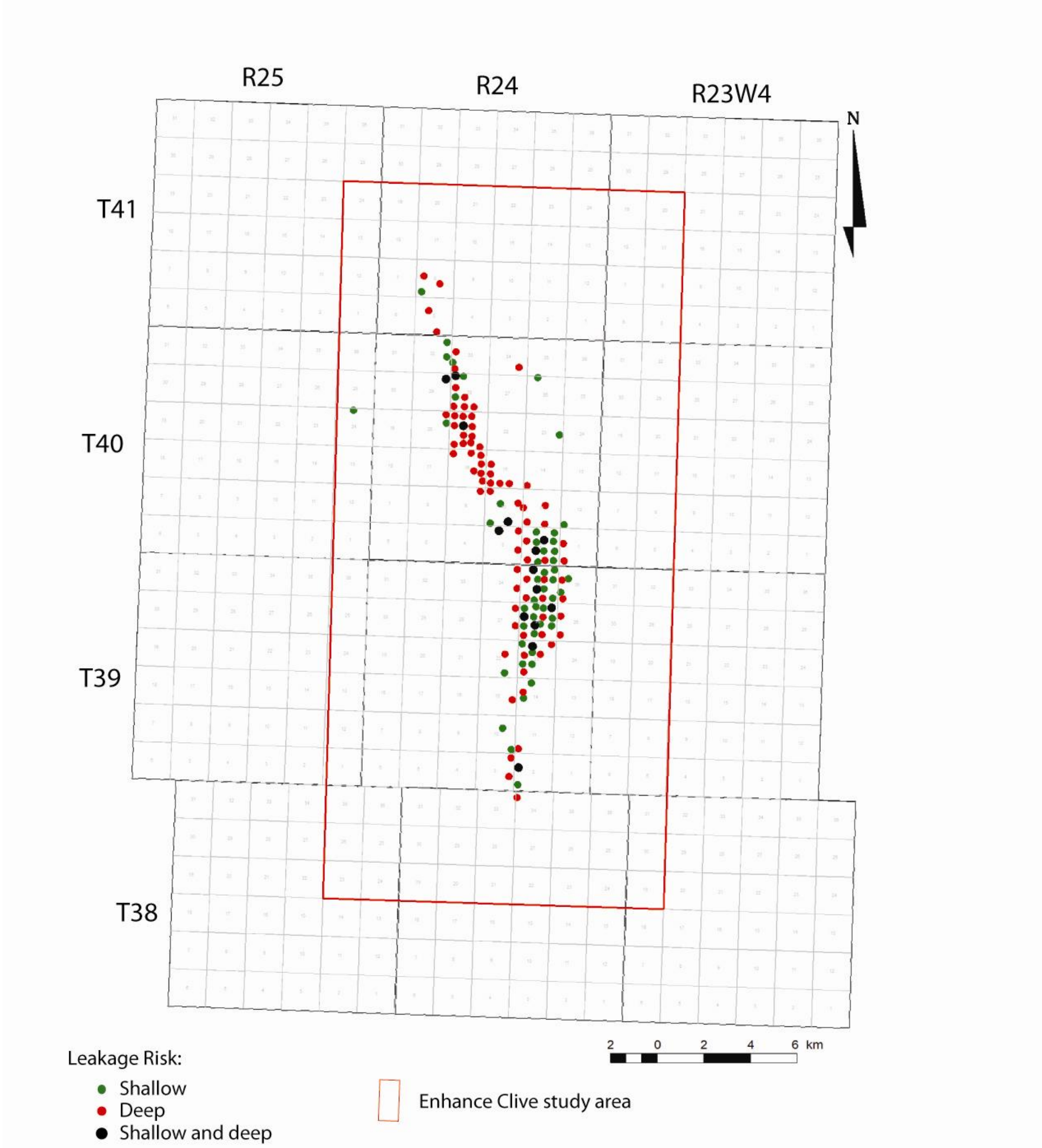

Figure 11: Location of wells with high potential for leakage that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oilfield: in the shallow part of the well (green dot), in the deep part of the well (red dot), and in both the shallow and deep part of the well (black dot).

Leakage potential scores, as described in the sub-section “Leakage Potential”, are semi-quantitative numeric estimates of the likelihood of leakage based on research conducted by T.L. Watson and Associates Inc. (Watson and Bachu, 2008, 2009). The individual leakage potential factors were established based on field experience and in-depth study of correlations between well leakage and logical causes; though no direct causal linkage could be verified statistically. As the individual leak factor scores are multiplied together to arrive at composite shallow and deep leakage scores, any individual factor greater than one indicates a leakage issue that will impact the composite score. A composite leakage score of 1.0 suggests that a well has none of the higher risk attributes identified by T.L. Watson and Associates Inc.

After review of the wells that penetrate the Nisku D-2 and Leduc D3-A reservoirs in the Clive field study area with reference to the ERCB database and GeoScout, it is clear that a relatively high proportion of the wells exhibit high leakage potential scores relative to a similar sized random selection of Alberta wells (Bachu and Watson, 2006). This is not surprising given that the subject wells are located within a mature light oilfield composed of multiple stacked hydrocarbon target reservoirs. The primary target zones, the Nisku D-2 and Leduc D-3A carbonate reservoirs, were perforated, tested, acid stimulated and squeeze cemented multiple times at different depth intervals to maximize production rates over their history. This is not uncommon in mature Alberta oilfields given the significant time period involved and the rapid evolution in reservoir evaluation technology. Common shallow leakage risk factors found to exist in many of the wells in the study area consisted of “spud date” during a relatively high activity period (1965 to 1990), “large surface casing size” (>244.5 mm / 9 5/8 “), “production casing” in the hole and “low cement top”. Common deep leakage factors observed in the wells in the study area included “number of completions” due to multiple target zones including shallow gas, multiple “acid squeeze stimulations” and cement squeezes in the carbonate Nisku D-2 and Leduc D-3A reservoirs, and in a few cases “fracture stimulations” in the up-hole gas zones. This relatively active history resulting from numerous pressure and temperature cycling well work-overs can increase the risk of development of micro-annuli at boundaries between the production casing, primary cement and formation face across the subject intervals. Micro-annuli can be difficult to mitigate given the small clearance and thus low permeability resulting in low squeeze cement feed rates. This could be an issue when CO_2 injection is contemplated, given its low viscosity

2.2.4 Surface Casing Vent Flows and Casing Failures

In addition to assigning leakage potential scores to flag wells with high risk based on available data in electronic form, other relevant issues that may lead to containment issues in regard to the CO_2 injected in the Nisku D-2 and/or Leduc D-3A reservoirs in the Clive study area were investigated. These issues relate to wells that have reported cases of surface casing vent flows or gas migration (SCVF/GM) and confirmed casing leaks or failures (CF). Wells with SCVF/GM constitute obvious shallow leakage risk as they have been observed directly to be leaking. These wells are often problematic to seal due to difficulty in precisely identifying the depth and mechanism of the low-rate leaking gas source. Even when the leak source depth is pin-pointed, sealing of the leak source zone by perforating the production casing and squeezing in cement can be difficult when the source gas zone is “tight” or has low permeability to gas, let alone cement. Cement squeeze work-over operations of this type historically have an average success rate of less than 50% and can cost several hundred thousand dollars. Casing leaks also constitute shallow (or deep) leakage risk as they allow uncontrolled hydraulic communication through the casing wall and inside the casing. This is an obvious breakdown in well integrity and is usually the result of external corrosion of the production casing above the annular cement top where no cement is present to protect the steel casing. Table 5 lists the wells that penetrate the Nisku D-2 and Leduc D-3A reservoirs in the Clive oil field where cases of SCVF/GM or casing leak (failure) have been reported to the ERCB, and Figure 12 shows the location of these wells.

Table 5: Wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field with reported Surface Casing Vent Flow (SCVF), Gas Migration (GM) or Casing Failure (CF). The columns of the right indicate the leakage potential assigned to these wells based on the analysis of other types of data (see Section 2.2.3 on wells leakage potential).

Clive D-2/D-3A Well	Leak Type	Shallow Leakage Potential	Deep Leakage Potential
00/02-10-040-24W4	Casing Failure	High	High
00/04-08-041-24W4	Casing Failure	High	Low
00/04-21-040-24W4	Casing Failure	Low	High
00/04-28-040-24W4	Casing Failure	Low	High
00/06-28-040-24W4	Casing Failure	Low	High
00/07-16-040-24W4	Casing Failure	Low	High
00/09-10-039-24W4	Casing Failure & SCVF	Low	Low
00/09-20-040-24W4	Casing Failure	High	Low
00/10-02-040-24W4	Casing Failure	High	High
00/10-10-040-24W4	SCVF	Low	Low
00/10-11-040-24W4	Casing Failure	Low	Low
00/10-16-040-24W4	Casing Failure	Low	Low
00/11-16-040-24W4	Casing Failure	Low	Low
00/11-21-040-24W4	Casing Failure	High	High
00/12-28-040-24W4	Casing Failure	Low	High
00/13-10-040-24W4	Casing Failure	Low	High
00/14-03-040-24W4	Casing Failure	High	High
00/15-16-040-24W4	Casing Failure & SCVF	Low	High
00/15-21-040-24W4	Casing Failure	Low	High

It should be noted that two wells, 15-16-040-24W4 and 09-10-039-24W4, that are designated in Figure 12 (below) as having low leakage potential - casing failure (green square) also have reported surface casing vent flow (black circle, masked by the green square).

In addition, six wells indicated above in Table 5 with reported cases of casing failure also have been assessed as having high shallow leakage potential, with four of them also assessed as having deep leakage potential (Section 2.2.3). All of these six wells should be investigated further to confirm casing and cement integrity prior to the start of CO_2-EOR operations. The wells with high leak potential scores in combination with casing failure are: 00/02-10-040-24W4, 00/04-08-041-24W4, 00/09-20-040-24W4, 00/10-02-040-24W4, 00/11-21-040-24W4 and 00/14-03-040-24W4.

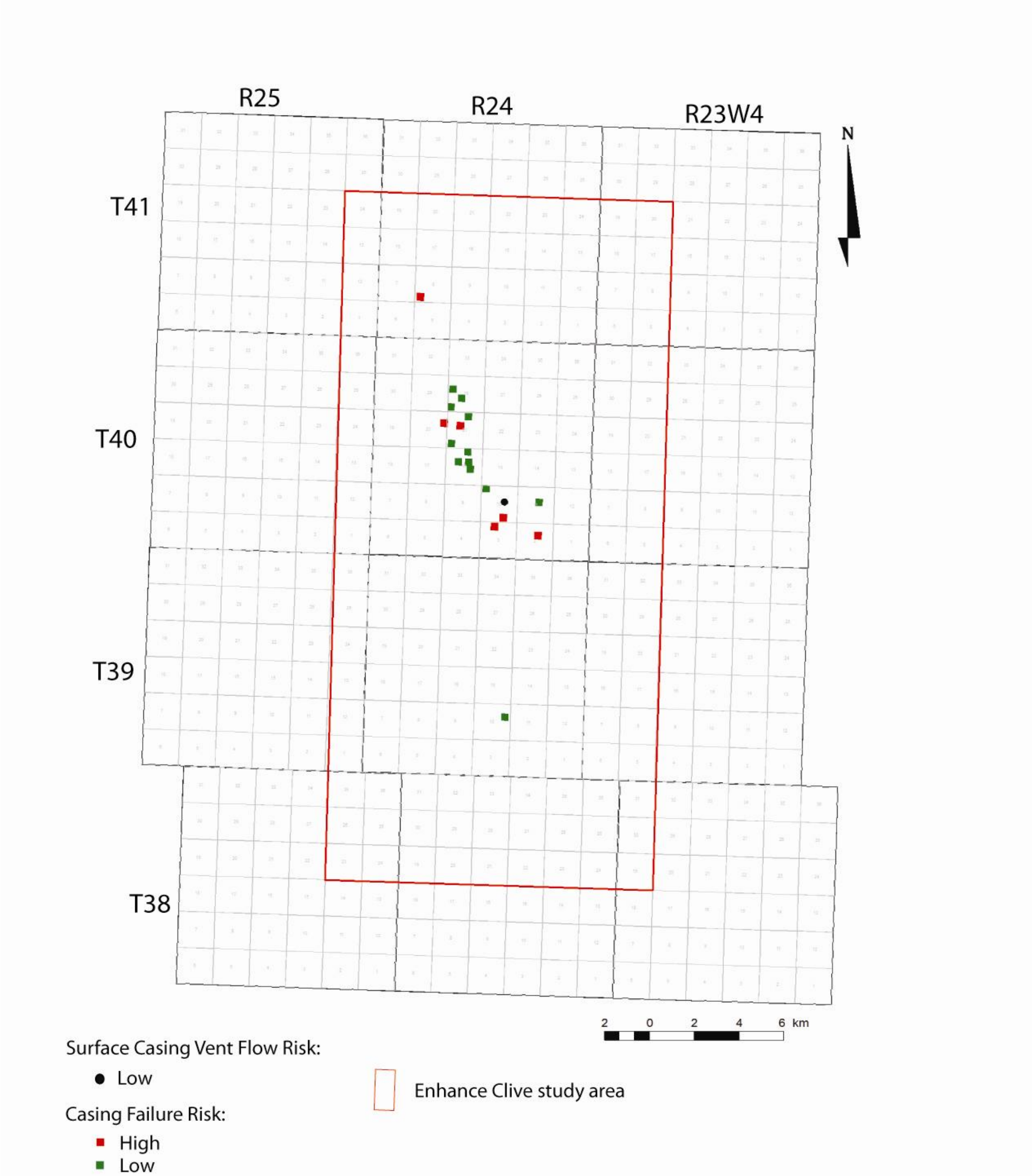

Figure 12: Location of wells that penetrate the Leduc (D-3A) and Nisku (D-2) oil reservoirs in the Clive oil field that have recorded surface casing vent flow (SCVF) and/or gas migration (GM) (circle symbol), and/or casing failure (CF) (square symbol). The high risk designation (red square) relates to casing failure in combination with a high shallow leakage potential factor.

3. Summary

The objective of this report was to evaluate all 252 wells within the Clive oil field boundary that penetrate the Leduc D-3A and Nisku D-2 oil reservoirs that are the target for CO_2 enhanced oil recovery, for the potential of CO_2 leakage into adjacent permeable reservoirs, shallow aquifers and to surface. Well data were compiled from data warehouse vendor GeoScout, the ERCB and Alberta Environment and used in the evaluation. Leakage potential software was also used to process the data and assign semi-quantitative leakage potential scores. Following the electronic assignment of leakage potential scores, a manual process of validating and adjusting the scores was conducted with reference to GeoScout well data. In addition, the data were compiled and a series of charts were created depicting the characteristics of wells in the Clive oil field that penetrate the two reservoirs of interest, including the current status of all wells, primary cement type and casing grade utilized, year of abandonment of all abandoned wells and current age of all cased well abandonments. Well abandonment practices common in Alberta were then discussed in conjunction with a chart showing abandonment plug types utilized for all cased well abandonments in the Clive oil field. In addition, a series of maps were prepared illustrating the location of all the wells analyzed, of the wells assigned high leakage potential and of the wells with reported surface casing vent flow and casing failure.

A discussion of the rationale behind the assignment of shallow and deep leakage scores to the wells in the Clive field was presented, followed by a listing of all wells classified as having high shallow, deep, and both shallow and deep leakage potential. Operating data from the ERCB relating to reported cases of surface casing vent flow (SCVF), gas migration (GM) and casing leaks or failures (CF) were then retrieved and incorporated into the overall assessment of leakage potential for all of the Clive wells. While the leakage potential scores do not quantify absolute probability of leakage, they do suggest an ordinal ranking of wells that maybe more likely to be problematic based on experience with Alberta wells that have, in the past, demonstrated a higher likelihood of leaking.

All wells assessed as having high shallow, deep, or shallow and deep leakage potential scores, and, in particular, wells with high leakage potential scores in combination with reported SCVF and/or CF should be investigated further for vertical hydraulic integrity before implementation of CO_2-EOR in the Leduc (D-3A) and Nisku (D-2) reservoirs in the Clive oil field, regardless if they will be used as CO_2 injectors, oil producers or will just be abandoned. The wells with high leak potential scores in combination with casing failure are: 00/02-10-040-24W4, 00/04-08-041-24W4, 00/09-20-040-24W4, 00/10-02-040-24W4, 00/11-21-040-24W4 and 00/14-03-040-24W4.

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5. APPENDIX – List of the Wells that Penetrate the Leduc D-3A and Nisku D-2 Oil Reservoirs in the Clive Oil Field

The following list includes all 252 wells in the Clive oilfield that penetrate the Nisku D-2 and Leduc D-3A carbonate reservoirs. The left column identifies the well by Unique Well Identifier (UWID). The middle column indicates the shallow leakage risk potential with scores over 400 (high risk) in red. The right column lists the deep leakage risk potential with scores equal to or greater than 10 (high risk) in blue. Wells with high deep and shallow risk potential are flagged with UWID high-lighted in red.

UWID	Shallow	Deep
00/01-02-040-24W4	540	6
00/01-10-039-24W4	540	8.8
00/01-12-040-24W4	30	2
00/01-16-040-24W4	48	12
00/01-21-040-24W4	240	12
00/01-29-040-24W4	120	9.6
00/01-32-040-24W4	72	4.8
00/01-33-038-24W4	90	2
00/01-34-040-24W4	360	12
00/01-35-039-24W4	540	6
00/02-01-040-24W4	337.5	2
00/02-02-039-24W4	225	2
00/02-02-040-24W4	144	12
00/02-05-041-24W4	360	12
00/02-08-041-24W4	180	2.4
00/02-10-039-24W4	337.5	2

00/02-10-040-24W4	432	12
00/02-11-039-24W4	135	2
00/02-11-040-24W4	216	12
00/02-14-039-24W4	135	2
00/02-15-040-24W4	216	18
00/02-21-040-24W4	72	12
00/02-22-039-24W4	540	6
00/02-23-039-24W4	216	8.8
00/02-24-040-24W4	360	3
00/02-26-039-24W4	216	12
00/02-28-040-24W4	144	12
00/02-33-040-24W4	90	2
00/02-35-039-24W4	144	8.8
00/03-02-040-24W4	540	6
00/03-10-040-24W4	120	2
00/03-15-040-24W4	144	12
00/03-21-040-24W4	72	12
00/03-24-040-24W4	48	2.4
00/03-25-040-24W4	225	2
00/03-26-039-24W4	540	9
00/03-28-040-24W4	120	12
00/03-35-039-24W4	540	6
00/04-01-040-24W4	144	12
00/04-02-039-24W4	540	9.6
00/04-02-040-24W4	216	12

00/04-05-041-24W4	90	2
00/04-08-041-24W4	720	9.6
00/04-10-040-24W4	540	6
00/04-11-039-24W4	144	12
00/04-11-040-24W4	144	12
00/04-12-040-24W4	540	6
00/04-14-039-24W4	216	8.8
00/04-14-040-24W4	144	12
00/04-15-040-24W4	72	12
00/04-21-040-24W4	144	12
00/04-23-039-24W4	216	12
00/04-24-040-24W4	360	4
00/04-25-039-24W4	360	12
00/04-26-039-24W4	216	12
00/04-28-040-24W4	240	12
00/04-32-040-24W4	240	6.6
00/04-33-040-24W4	360	12
00/04-35-039-24W4	144	18
00/04-36-039-24W4	144	12
00/05-01-040-24W4	72	2
00/05-02-040-24W4	72	6
00/05-14-039-24W4	540	6
00/05-15-040-24W4	72	12
00/05-21-040-24W4	72	9.6
00/05-23-039-24W4	540	2.2

00/05-26-039-24W4	540	6
00/05-28-040-24W4	600	9
00/05-33-040-24W4	540	2.2
00/05-36-039-24W4	540	4
00/06-02-040-24W4	540	12
00/06-05-041-24W4	360	4.4
00/06-08-041-24W4	180	3
00/06-15-039-24W4	360	6.6
00/06-21-040-24W4	72	12
00/06-23-039-24W4	540	6
00/06-23-040-24W4	90	2
00/06-24-040-24W4	144	9
00/06-26-039-24W4	540	12
00/06-26-040-24W4	225	2
00/06-28-040-24W4	96	12
00/06-31-038-24W4	225	1
00/06-35-039-24W4	540	12
00/07-02-040-24W4	540	4.8
00/07-08-041-24W4	240	10.8
00/07-10-040-24W4	180	9
00/07-15-040-24W4	72	8.8
00/07-16-040-24W4	240	12
00/07-21-040-24W4	72	18
00/07-23-040-24W4	225	2
00/07-26-039-24W4	540	6

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00/07-35-039-24W4	540	6
00/08-02-040-24W4	540	6
00/08-03-039-24W4	360	12
00/08-03-040-24W4	360	12
00/08-09-040-24W4	225	2
00/08-10-040-24W4	324	9
00/08-15-039-24W4	216	18
00/08-16-040-24W4	72	12
00/08-20-040-24W4	9	4
00/08-23-040-24W4	1800	9.9
00/08-24-040-24W4	225	1
00/08-26-039-24W4	540	6
00/08-27-039-24W4	360	18
00/08-29-040-24W4	75	2
00/08-32-040-24W4	540	9.6
00/08-34-039-24W4	144	12
00/08-35-039-24W4	67.5	3
00/09-02-040-24W4	540	6
00/09-03-039-24W4	72	2.4
00/09-10-039-24W4	288	2.4
00/09-10-040-24W4	48	12
00/09-12-040-24W4	240	9
00/09-16-040-24W4	72	12
00/09-20-040-24W4	480	6.6
00/09-23-040-24W4	48	6

00/09-26-039-24W4	540	6
00/09-32-040-24W4	216	4.4
00/09-35-039-24W4	540	6
00/10-02-040-24W4	432	12
00/10-04-041-24W4	180	4
00/10-05-041-24W4	225	2
00/10-08-041-24W4	180	2.4
00/10-09-040-24W4	135	2
00/10-10-039-24W4	1080	6
00/10-10-040-24W4	324	2
00/10-11-040-24W4	288	12
00/10-12-040-25W4	30	2
00/10-13-040-25W4	45	2
00/10-14-039-24W4	216	7.2
00/10-15-040-24W4	90	2
00/10-16-040-24W4	240	7.2
00/10-21-040-24W4	144	12
00/10-22-039-24W4	216	12
00/10-23-039-24W4	216	12
00/10-26-039-24W4	216	12
00/10-29-039-24W4	75	2
00/10-32-040-24W4	144	6
00/10-33-038-24W4	225	2
00/10-34-039-24W4	90	2
00/10-35-039-24W4	144	12

00/11-02-040-24W4	540	6
00/11-04-040-24W4	337.5	1
00/11-05-041-24W4	144	12
00/11-08-041-24W4	6	4.5
00/11-10-040-24W4	540	6
00/11-16-040-24W4	144	7.2
00/11-19-040-24W4	120	3
00/11-21-040-24W4	720	12
00/11-23-039-24W4	540	6
00/11-26-039-24W4	540	6
00/11-28-040-24W4	30	2
00/11-35-039-24W4	540	6
00/11-36-039-24W4	405	2
00/12-01-040-24W4	144	12
00/12-02-039-24W4	540	12
00/12-02-040-24W4	216	12
00/12-08-039-24W4	225	1
00/12-08-041-24W4	240	2.2
00/12-10-039-24W4	225	2
00/12-11-039-24W4	144	8.8
00/12-11-040-24W4	216	12
00/12-11-040-25W4	337.5	2
00/12-14-039-24W4	216	12
00/12-15-040-24W4	72	12
00/12-21-040-24W4	120	12

00/12-23-039-24W4	216	12
00/12-24-040-24W4	45	2
00/12-25-039-24W4	144	12
00/12-26-039-24W4	540	18
00/12-28-040-24W4	240	12
00/12-30-039-24W4	225	2
00/12-33-040-24W4	360	12
00/12-34-038-24W4	135	2
00/12-35-039-24W4	144	12
00/12-36-039-24W4	144	12
00/13-02-040-24W4	48	6.6
00/13-05-041-24W4	162	2
00/13-08-041-24W4	72	3
00/13-10-040-24W4	288	12
00/13-16-040-24W4	72	14.4
00/13-21-040-24W4	72	12
00/13-22-039-24W4	180	4.4
00/13-23-039-24W4	540	2.4
00/13-25-039-24W4	48	4.4
00/13-26-039-24W4	540	3.6
00/13-28-040-24W4	540	18
00/13-31-039-24W4	6	1
00/13-34-038-24W4	216	12
00/14-02-040-24W4	540	6
00/14-03-040-24W4	720	13.2

00/14-05-041-24W4	180	4.4
00/14-10-040-24W4	72	8
00/14-14-039-24W4	540	6
00/14-16-040-24W4	360	7.2
00/14-21-040-24W4	72	12
00/14-23-039-24W4	540	12
00/14-24-040-25W4	2700	3
00/14-26-039-24W4	540	6
00/14-26-040-24W4	1080	6
00/14-28-040-24W4	540	3
00/14-32-040-24W4	225	2
00/14-34-038-24W4	72	8
00/14-35-039-24W4	540	12
00/15-02-040-24W4	72	4.8
00/15-08-041-24W4	45	2
00/15-16-040-24W4	288	12
00/15-21-040-24W4	96	12
00/15-23-040-24W4	48	2.2
00/15-26-039-24W4	540	6
00/15-35-039-24W4	540	6
00/16-02-040-24W4	540	3
00/16-03-039-24W4	360	12
00/16-03-040-24W4	144	12
00/16-08-041-24W4	120	3.3
00/16-09-040-24W4	144	12

00/16-10-039-24W4	337.5	1
00/16-14-040-24W4	225	2
00/16-16-040-24W4	72	12
00/16-17-040-24W4	72	6.6
00/16-20-040-24W4	120	12
00/16-23-039-24W4	120	18
00/16-26-039-24W4	540	12
00/16-27-039-24W4	360	12
00/16-32-040-24W4	540	6
00/16-33-038-24W4	216	8
00/16-34-039-24W4	360	12
00/16-35-039-24W4	540	6
02/01-16-040-24W4	162	2.2
02/01-32-040-24W4	324	2
02/02-02-040-24W4	48	6
02/02-35-039-24W4	216	12
02/03-15-040-24W4	72	6
02/03-26-039-24W4	216	4
02/03-28-040-24W4	48	4.4
02/05-14-039-24W4	216	2.2
02/05-33-040-24W4	72	6
02/06-15-039-24W4	72	6
02/06-23-039-24W4	216	2
02/06-24-040-24W4	360	2.2
02/08-10-040-24W4	216	6

02/08-23-040-24W4	48	4.4
02/09-03-039-24W4	216	4
02/09-10-040-24W4	162	2
02/09-12-040-24W4	360	6
02/09-16-040-24W4	72	2
02/10-10-040-24W4	72	6.6
02/11-26-039-24W4	216	6
02/12-08-041-24W4	48	27
02/15-35-039-24W4	108	2
02/16-29-040-24W4	720	18
S0/03-26-039-24W4	216	2.2