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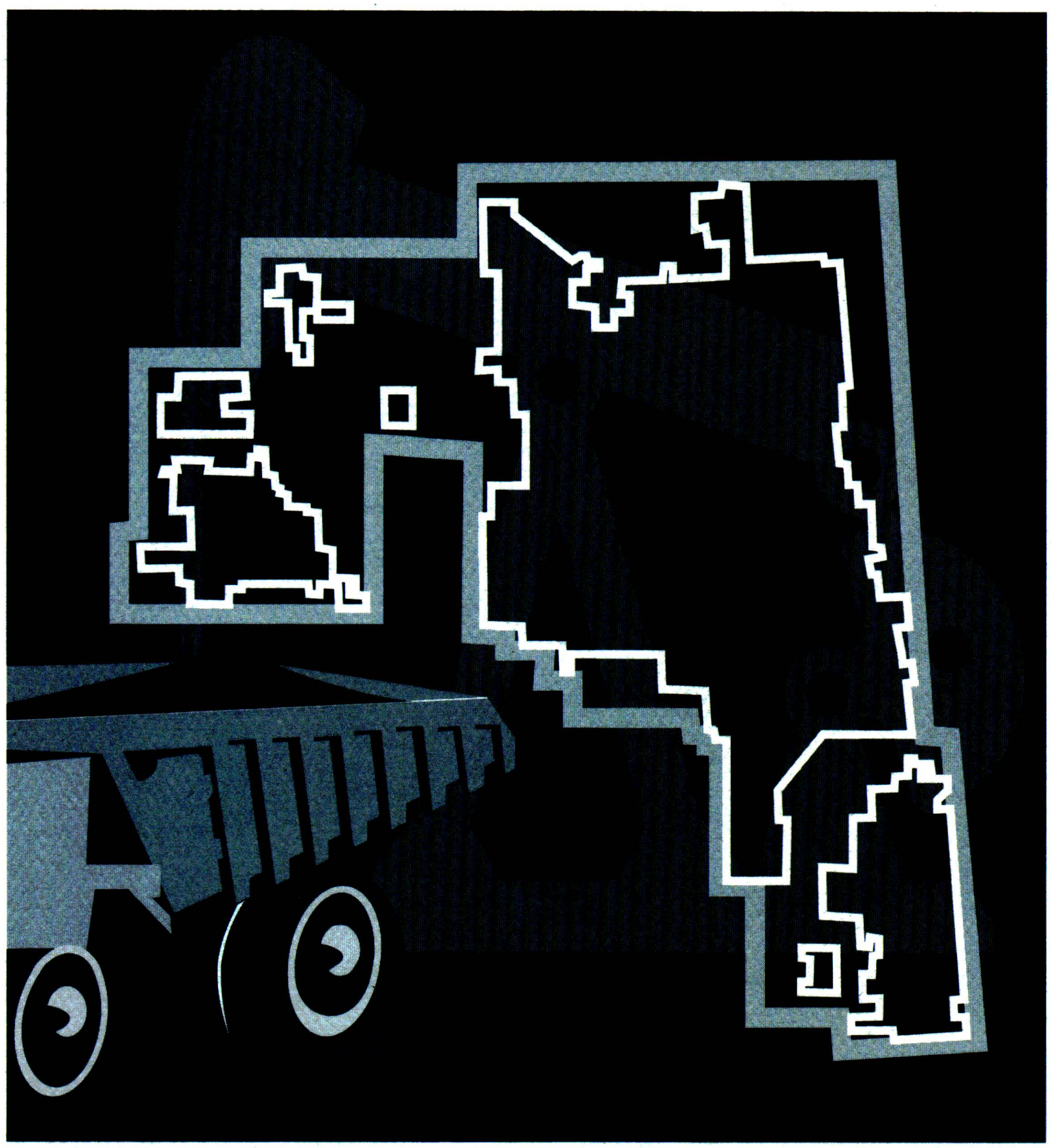
Crude Bitumen Reserves Atlas

May 1996



Alberta Energy and Utilities Board

Crude Bitumen Reserves Atlas

May 1996

CRUDE BITUMEN RESERVES ATLAS

Published by the Alberta Energy and Utilities Board
 Additional copies are available for $100.00 from: EUB Information Services
640-5 Avenue SW
Calgary Alberta T2P 3G4

Telephone (403)297-8190

CONTENTS

TABLES, MAPS AND FIGURES

Tables of Reserves of Crude Bitumen and Deposit Characteristics as at 31 December 1995 — Page

ATHABASCA OIL SANDS AREA MAPS

COLD LAKE OIL SANDS AREA MAPS

Upper Grand Rapids Deposit

TABLES, MAPS AND FIGURES

Cold Lake Oil Sands Area Maps (cont'd) — Page

TABLES, MAPS AND FIGURES

Cold Lake Oil Sands Area Maps (cont'd) Page

Clearwater Deposit

Wabiskaw-McMurray Deposit

Cold Lake Oil Sands Area Maps (cont'd) Page

PEACE RIVER OIL SANDS AREA MAPS

FIGURES

TABLES, MAPS AND FIGURES

Figures (cont'd) Page

PREFACE

The *Crude Bitumen Reserves Atlas* provides the estimated, initial in-place reserves for Alberta's oil sands deposits. These reserves were calculated by staff of the Alberta Energy and Utilities Board (EUB). Last published in 1990, this edition includes updated data on the deposits and additional detail of the bitumen distribution in the southern Cold Lake area.

The initial in-place volumes of crude bitumen within Alberta's designated oil sands deposits are determined by using either a building-block or geological mapping approach. Both methods of reserve calculation are discussed in Section 2. The reserves for most of the pools within the southern portion of the Cold Lake area have been determined from the isopach maps. These volumetric reserves are presented on a pool basis.

The maps in this atlas are not presented at a standard scale. This was done in order to best fit the map to the page and to provide as much detail as possible. It was necessary to split some maps over a number of pages, but with the exception of a few large pools, all pools are presented whole on at least one page. Future editions of the Atlas will contain index maps to assist the reader to better locate those pools on split sheets.

In its continued effort to better meet customers' needs the EUB welcomes comments and suggestions on improving this atlas. Please address suggestions to:

Crude Bitumen Reserves Atlas
Oil Sands Department, Resources Division
Alberta Energy and Utilities Board
640 - 5 Avenue SW
Calgary, Alberta, Canada
T2P 3G4

ACKNOWLEDGEMENTS

The editors of the *Crude Bitumen Reserves Atlas* thank the many people that have been involved in it's production. In particular we wish to acknowledge Brian Lucyk and Brenda Barkley who updated the reserves and prepared the new maps, Candace Maxwell for reviewing the maps, text and compiling the reserves, John Farnell for preparing the "Mining Area" portion, Loreen Froese, Todd Davidson, Grant King, Gabriela Eibenschutz and Gustavo Asensio for the graphical preparation of the atlas, and all the folks in the Printing Section for finally putting it together.

Edited by Joseph MacGillivray and Joan Brady

SECTION 1

CRUDE BITUMEN RESERVES

1 CRUDE BITUMEN RESERVES

Oil sands are defined as "sands and other rock materials containing crude bitumen" plus "the crude bitumen contained in those sands and other rock materials, and any other mineral substances, other than natural gas, in association with that crude bitumen or those sands and other rock materials"[1]. "In addition, an oil sands deposit may be designated by the Board by describing the surface area vertically above the oil sands deposit and by naming the geological formation, member, or zone in which the oil sands deposit occurs, or by any other method of description that the Board considers appropriate"[2].

The crude bitumen found in an oil sands deposit (OSD) is defined as "a naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that may contain sulphur compounds and that, in its naturally occurring viscous state, will not flow to a well"[3]. However, as some areas within OSDs are capable of primary production, a Board order designating Oil Sands Areas (OSAs) was issued in 1984[4], in which any hydrocarbon substance, with the exception of natural gas and coal found in certain geological zones within an OSD, is deemed to be bitumen.

The three designated Oil Sands Areas, Athabasca (OSA 1), Peace River (OSA 2) and Cold Lake (OSA 3), contain accumulations of oil sands which occur in sands and carbonates of Cretaceous, Permian, Mississippian, and Devonian age. The outlines of these OSAs are shown on Figure 1.1. OSDs within the three OSAs are described in Sections 3, 4, and 5.

Reserves are calculated on a deposit wide basis for the Athabasca and Peace River Oil Sands Areas. In the Cold Lake Oil Sands Area some of the deposits are further broken down into pools, which exist as discrete bitumen saturated sands within the deposit.

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1 Section 1(1)(n) of the Oil Sands Conservation Act.

2 Section 7(3) of the Oil Sands Conservation Act.

3 Section 1(1)(c) of the Oil Sands Conservation Act, c.0-5.5 SA 1983.

4 Informational Letter 84-7, *Declaration of Oil Sands Areas to Facilitate Orderly Leasing and Stable Regulation.*

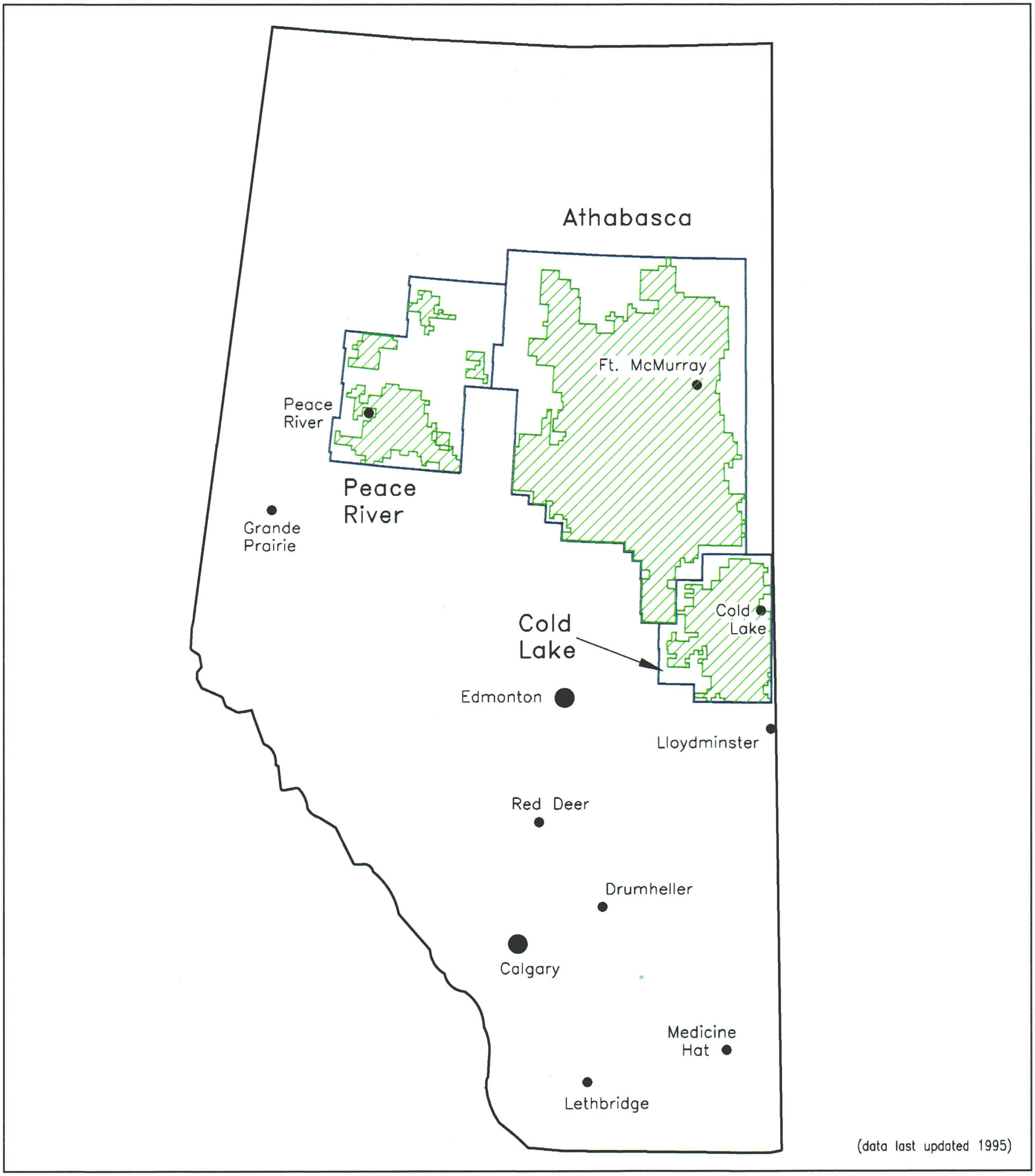

FIGURE 1.1 ALBERTA OIL SANDS

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Oil Sands Areas

Oil Sands Deposits

SECTION 2

INITIAL IN-PLACE VOLUMES OF CRUDE BITUMEN

2 INITIAL IN-PLACE VOLUMES OF CRUDE BITUMEN

Initial in-place volume is defined as the gross volume of crude bitumen calculated or interpreted to exist in an OSD before any of the bitumen is extracted. The 1994 in-place volumes of crude bitumen for all designated OSDs in Alberta are calculated by EUB staff using a building-block or volumetric method. Reserve numbers reflect data from wells within OSAs. The method used to determine reserves for each deposit is discussed in Sections 3, 4, and 5.

2.1 Building-block Reserve Calculation Method

The building-block method (Outtrim, C.P. and R.G. Evans, 1977) for reserve calculation is used for OSDs that are evaluated as a single unit but are composed of several zones. Non-bitumen bearing strata are removed using cut-offs.

Drillhole data are used to evaluate the net bitumen pay thickness, average porosity, and average mass (weight) per cent bitumen based on cut-offs of three weight per cent bitumen and a saturated zone thickness of 1.5 metres for clastic reservoirs, and 30 per cent pore volume bitumen and 5 per cent porosity for carbonates. This data is then converted to total bitumen metres, that is, the thickness of bitumen in metres after removing the rock matrix and non-bitumen filled porosity. Total bitumen metres terminology replaces "cumulative oil metres" used in the 1990 Atlas.

Equation 2.1 Total Bitumen Metres = (net pay x average mass % bitumen x bulk density at zone porosity)/100

Porosity values used in Equation 2.1 are calculated from density log data and standard log evaluation techniques using a matrix density of 2650 kg/m^3, a water density of 1000 kg/m^3, and bitumen density of 1000 kg/m^3.

Where more than one drillhole is present within a quarter-township, the data are summarized and averaged within the quarter-township block to arrive at its initial in-place volume. The total bitumen metres are multiplied by the area to estimate the volume of bitumen.

The initial in-place volumes determined from the drilled wells and the assigned areas are plotted on the map in the appropriate blocks. Quarter-township blocks containing no drilled wells are assigned inferred volumes based on the lowest volume from the adjacent blocks. Where the available drilling data indicate no pay in a block, zero reserve is inferred in all adjacent blocks where no drilling has occurred. Inferred volumes are assigned only adjacent to the known reserve accumulations. The total in-place volumes for each OSD are determined by adding the initial and inferred volumes from each block. This method of assuming in-place volumes for some undrilled blocks is fairly conservative.

The building-block method gives a good overall representation of gross reserves contained within a specific deposit, provided adequate well control is available. However, in areas of sparse well control, reserves cannot be adequately approximated by this method.

2.2 Volumetric Reserve Calculation Method

Initial in-place volumes are determined from pay isopach maps for deposits, or portions of deposits, if the building-block method does not accurately represent the initial in-place volumes of bitumen. Pay isopach maps for individual zones within deposits are also used in areas of primary, experimental or commercial in situ schemes, where specific zones within a deposit are being exploited. It is indicated on the building-block maps where a portion of a deposit's reserve is calculated based on the pay isopach maps.

The isopach maps in this atlas reflect either total bitumen metres (Equation 2.1), or net bitumen saturated sand thickness (net pay). Net pay maps are used primarily in areas where bitumen pay within zones is laterally restricted and variations in mass per cent bitumen are small.

SECTION 3

ATHABASCA OIL SANDS AREA

3 ATHABASCA OIL SANDS AREA (OSA 1)

Six deposits are designated in the Athabasca OSA, including, in descending stratigraphic order, Upper Grand Rapids, Middle Grand Rapids, Lower Grand Rapids, Wabiskaw-McMurray, Nisku and Grosmont. The reserve data in this atlas for the Athabasca area deposits have not been updated since 1984. Reserves for the Nisku and Grosmont Deposits are calculated volumetrically using total bitumen metres isopach maps. In this atlas the reserves are based on these maps, although reserve values are shown only for those quarter-township blocks containing wells. Reserves for all other Athabasca OSDs are shown in building-block form. Table 3-1 is a summary of initial in-place reserves for all Athabasca OSDs. Figures 3.1 and 3.2 are type logs of the deposits in the Athabasca OSA.

3.1 Grand Rapids - Maps 3.1 to 3.3

The initial in-place reserves for the Upper, Middle, and Lower Grand Rapids deposits (OSDs 5, 10 and 11) are calculated by the building-block method.

The Grand Rapids Formation is composed of fine-to medium-grained feldspathic sands, laminated sequences of silts and sands, and thin shales and coals. These were deposited in a high-energy, wave-dominated shoreline setting along a low-relief coastal plain and were cut locally by channels that are either sand or shale filled (Wightman *et al.*, 1989). The sequence is approximately 100 metres thick consisting of relatively thin regional sands and thick channel sands. The channel sands occur mainly in the Upper Grand Rapids.

3.2 Wabiskaw-McMurray - Maps 3.4a to 3.4d

The Wabiskaw-McMurray Deposit (OSD 1) contains the bulk of the reserves in the Athabasca OSA. In-place reserves for this deposit are calculated using the building-block method (Map 3.4a).

The McMurray Formation consists of fluvial and estuarine sands, deposited in a ridge and valley system developed on the underlying Devonian carbonates, in response to a rising sea level to the north (Strobl *et al.*, 1991, Keith *et al.*, 1988, Wightman and Pemberton, 1993). An erosional contact separates the McMurray Formation from the overlying marine sands of the Wabiskaw Member (Clearwater Formation), deposited during the transgression of the Boreal Sea (Wightman *et al.*, 1989). These two stratigraphic intervals are grouped together in the same deposit as they are separated in most places by only a thin shale.

The McMurray Formation ranges typically between 40 to 80 metres in thickness (MacGillivray *et al.*, 1988) and consists of uncemented, very fine to coarse-grained quartz sands (quartz arenites and sublitharenites) with minor amounts of shale, silt, and thin coals (Mossop *et al.*, 1981). In the channel deposits, the McMurray Formation sands are well sorted with little clay present. Individual sands are commonly not extensive, but due to the amalgamation of channel sands, through vertical stacking, thicknesses of up to 70 metres may occur (Keith *et al.*, 1990, MacGillivray *et al.*, 1992).

The Wabiskaw Member (Clearwater Formation) is marine in character and generally consists of lower to upper shoreface and offshore sands, silts, and shales. The uncemented quartz sands (quartz arenites to sublitharenites) are generally fine to very fine grained and form laterally extensive but relatively thin reservoirs (Keith *et al.*,1990, MacGillivray *et al.*, 1992).

The Athabasca Wabiskaw-McMurray is the only deposit being developed using surface mining methods. The surface-mineable area is shown on Maps 3.4b and 3.4d. Mineable area in-place reserves are calculated using a kriging-based computerized evaluation technique. The net bitumen pay for this area is presented in Map 3.4c.

The mineable areas are identified by economic stripping ratio criteria which are fully explained in Appendix III of EUB report 79-H *Alsands Fort McMurray Project*, December 1979. An isopach map of total discard (overburden plus top reject) for the surface-mineable area is shown on Map 3.4d.

3.3 Grosmont and Nisku - Maps 3.5 and 3.6

The Athabasca Grosmont (OSD 12) and Nisku (OSD 13) Deposits subcrop beneath the west-central portion of the Athabasca Wabiskaw-McMurray Deposit. Bitumen occurs along the eastern, updip edge of these formations.

The Devonian Grosmont Formation is a large, shallow-marine carbonate platform with reservoir horizons 25 to 50 metres in thickness. The EUB recognizes four units within the Grosmont, the Grosmont A, B, C, and D zones. The Grosmont is a well-lithified dolostone with a heterogeneous dual-porosity fabric of up to 20 per cent porosity. Vuggy porosity is common along the subcrop edge. Original depositional environments include relatively deep water (platform-slope to basin transition), through variable carbonate sand, mud, and patch reef accumulations within a platform interior, to restricted-marine shorelines and tidal flat settings. The Grosmont consists of a series of shallowing-upward depositional cycles with excellent lateral continuity, but having a highly-variable vertical reservoir pore fabric (Harrison, 1987, Wightman *et al.*, 1989)

The Nisku Formation is the smaller of the two carbonate deposits. It conformably overlies Ireton Formation shales and is conformably overlain by the Calmar Formation. The exception occurs along the Nisku subcrop edge where it is unconformably overlain by Cretaceous sands of the McMurray Formation. The Nisku Formation is composed of dolomitized, fossiliferous carbonates with an average thickness of 90 to 100 metres.

TABLE 3-1

OIL SANDS AREA OIL SANDS DEPOSIT OIL SANDS SECTOR, OIL SANDS POOL OVERBURDEN DEPTH (m) OR ZONE	1 INITIAL VOLUME IN PLACE $10^6 m^3$	2 AREA $10^3 ha$	3 AVERAGE PAY THICKNESS m	4 BITUMEN SATURATION mass frac	 pore vol frac	5 POROSITY frac	6 WATER SATN frac	7 REMARKS
ATHABASCA								
UPPER GRAND RAPIDS								
150 - 450+	5274.00	334.00	9.0	0.062	0.55	0.30	0.45	
SUBTOTAL	5274.00							
MIDDLE GRAND RAPIDS								
150 - 450+	2354.00	182.00	5.0	0.077	0.68	0.30	0.32	
SUBTOTAL	2354.00							
LOWER GRAND RAPIDS								
150 - 450+	1050.00	173.00	6.0	0.051	0.45	0.30	0.55	
SUBTOTAL	1050.00							
WABISKAW-MCMURRAY								
0 - 20	6874.00	88.00	39.0	0.091		0.27	0.25	WITHIN MINEABLE AREA
20 - 40	7378.00	98.00	39.0	0.087		0.27	0.27	WITHIN MINEABLE AREA
40 - 80	7341.00	97.00	41.0	0.085		0.27	0.29	WITHIN MINEABLE AREA
80 - 120	2551.00	26.00	51.0	0.088		0.26	0.24	WITHIN MINEABLE AREA
80 - 750+	119234.00	4329.00	19.0	0.079	0.62	0.28	0.38	BEYOND MINEABLE AREA
SUBTOTAL	143378.00							
NISKU								
200 - 800+	10330.00	499.00	8.0	0.057	0.63	0.21	0.37	
SUBTOTAL	10330.00							
GROSMONT								
D	19890.00	1063.00	16.0	0.058	0.67	0.20	0.33	
C	15390.00	1189.00	10.0	0.050	0.75	0.16	0.25	
B	5380.00	976.00	5.0	0.043	0.69	0.15	0.31	
A	9840.00	939.00	10.0	0.035	0.60	0.14	0.40	
SUBTOTAL	50500.00							
TOTAL	212886.00							

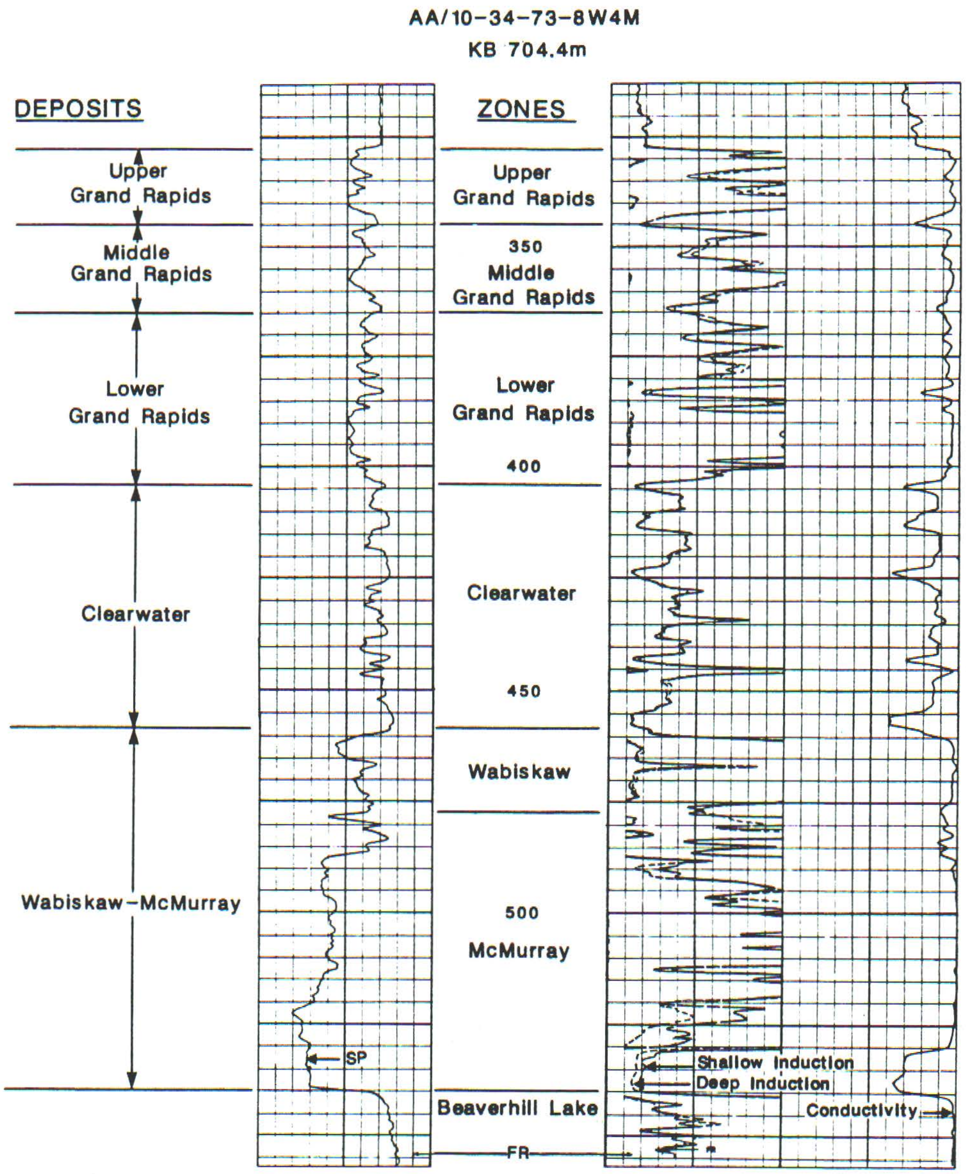

FIGURE 3.1 ATHABASCA OIL SANDS AREA REFERENCE WELL
CRETACEOUS SECTION
PEX KIRBY EX 10-34-73-08W4M

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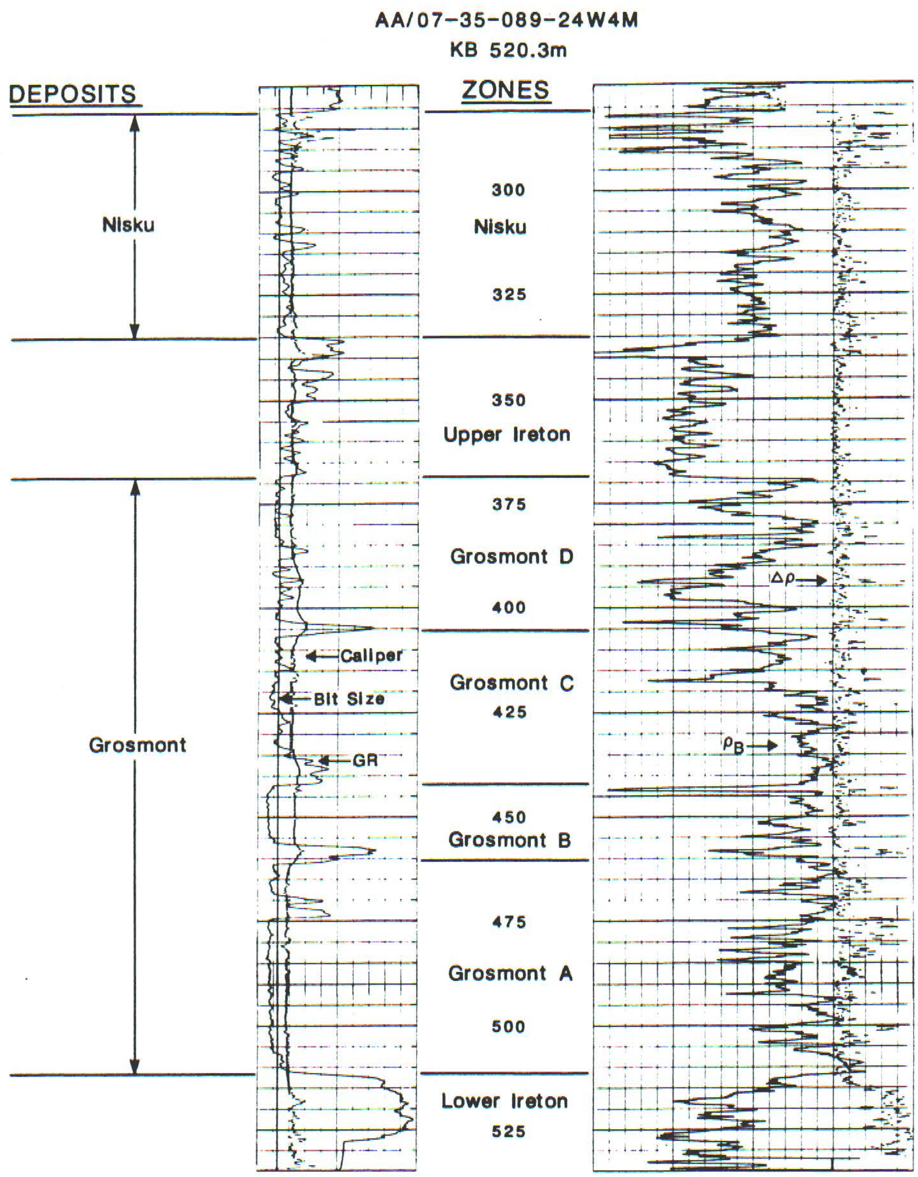
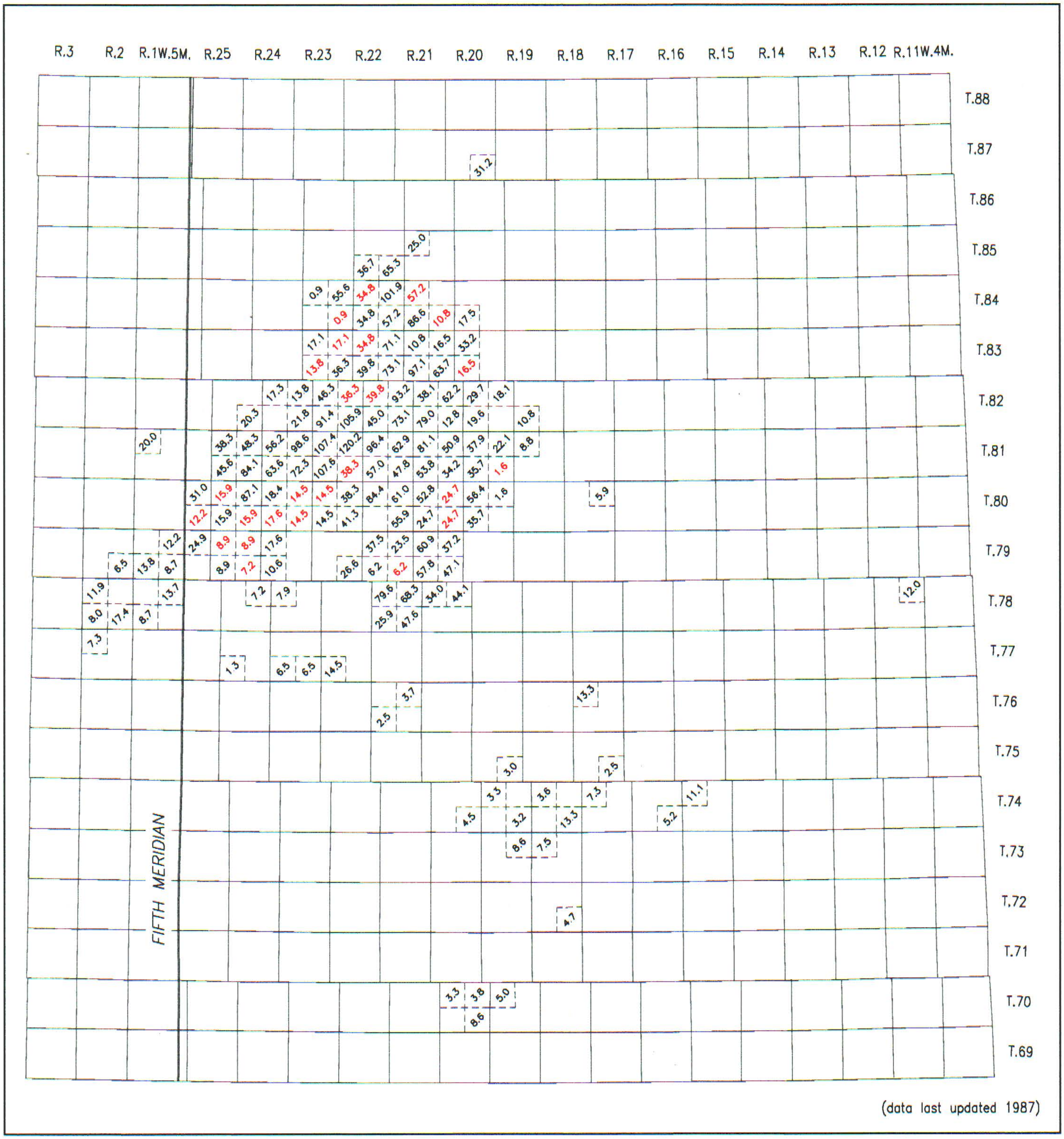


FIGURE 3.2 ATHABASCA OIL SANDS AREA REFERENCE WELL
NISKU/GROSMONT SECTION
CDN – SUP MINK OV 07-35-89-24W4M

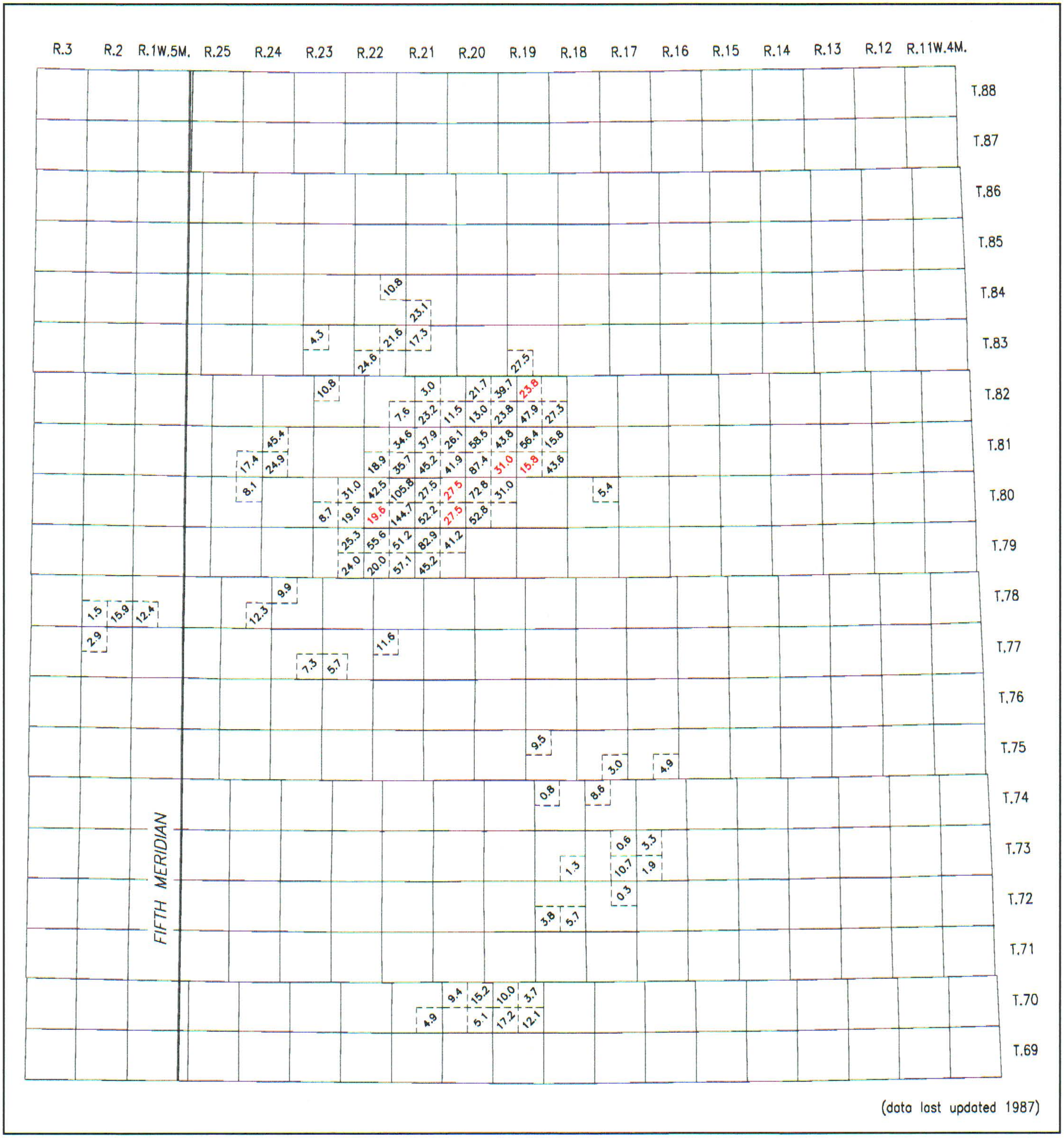
EUB



MAP 3.1 UPPER GRAND RAPIDS DEPOSIT
ATHABASCA OIL SANDS AREA
VOLUME IN-PLACE RESERVES 10^6 m^3

EUB

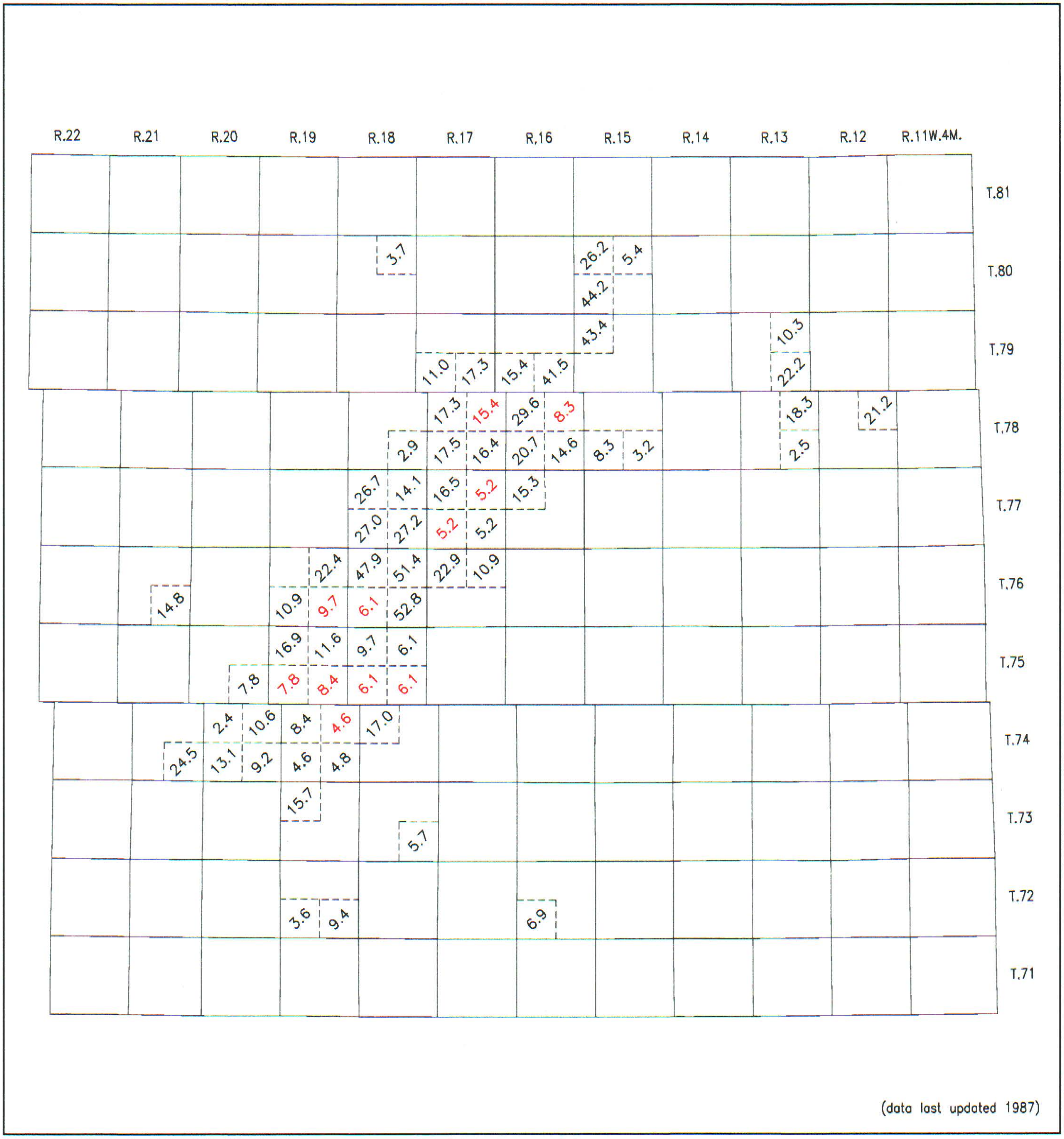
44.4 Initial
44.4 Inferred



MAP 3.2 MIDDLE GRAND RAPIDS DEPOSIT
ATHABASCA OIL SANDS AREA
VOLUME IN-PLACE RESERVES 10^6 m^3

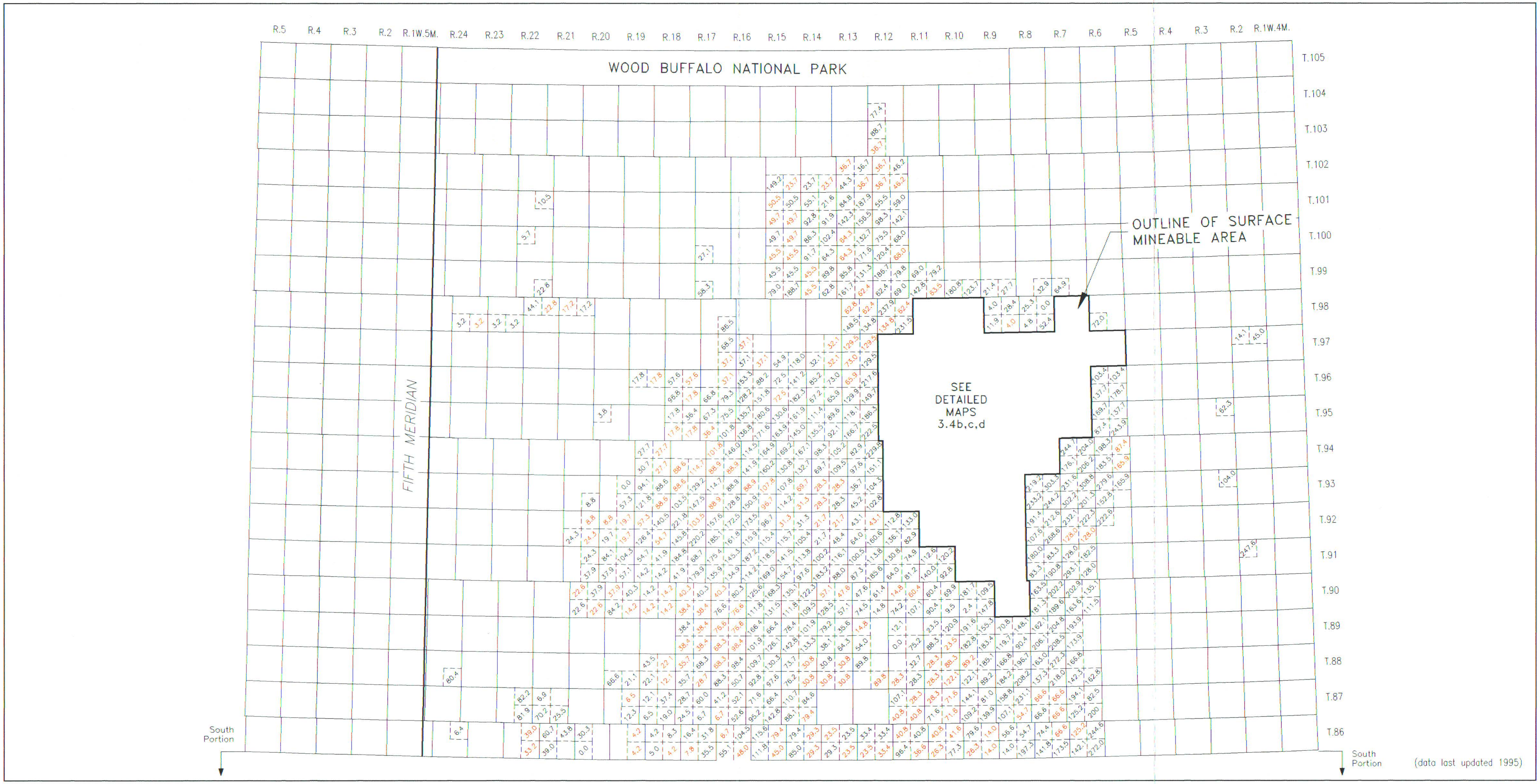
EUB

44.4 Initial
44.4 Inferred



MAP 3.3 LOWER GRAND RAPIDS DEPOSIT
ATHABASCA OIL SANDS AREA
VOLUME IN-PLACE RESERVES 10^6 m^3

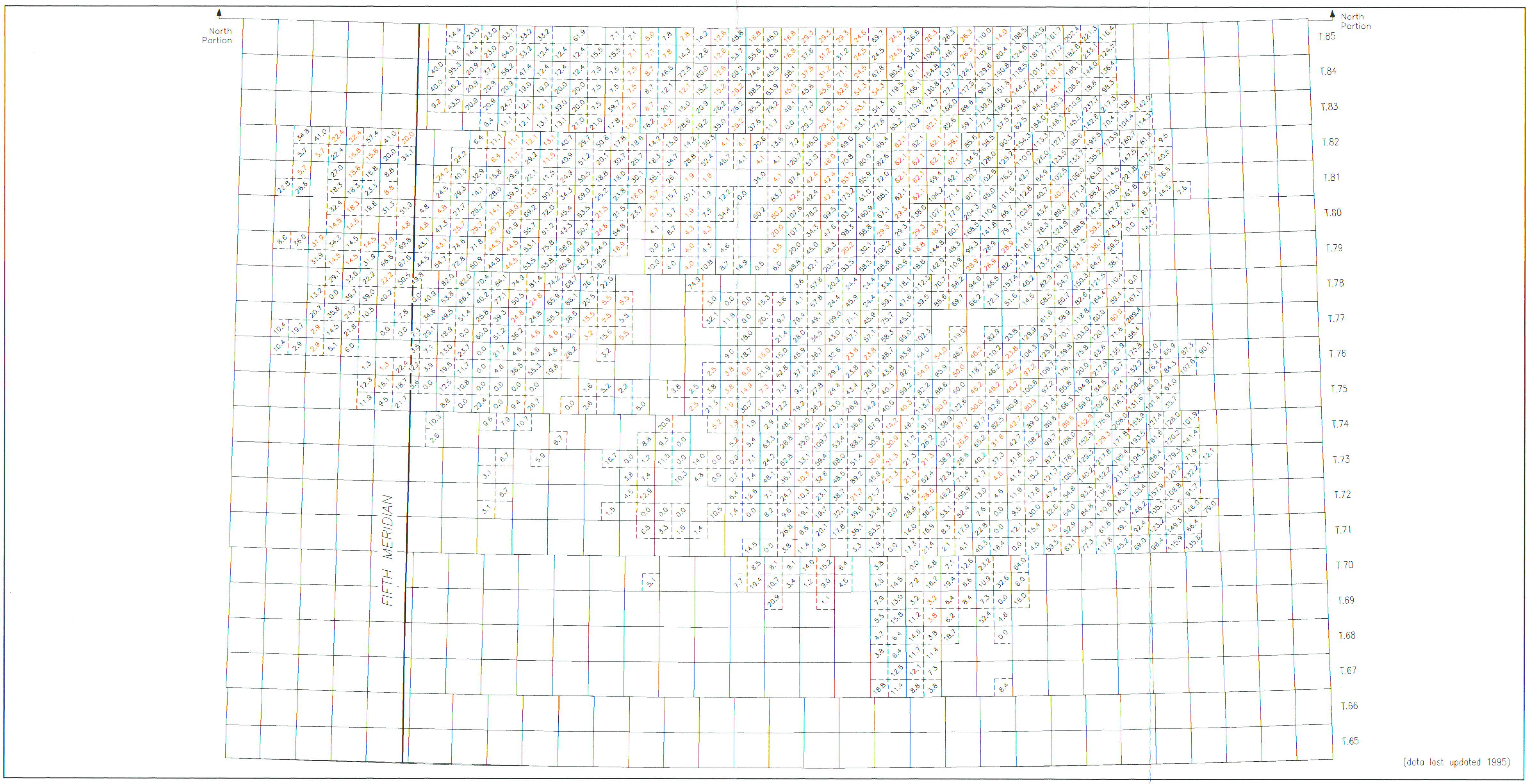
Initial
Inferred



MAP 3.4a WABISKAW–McMURRAY DEPOSIT (north portion)
ATHABASCA OIL SANDS AREA
VOLUME IN-PLACE RESERVES 10^6 m^3

EUB

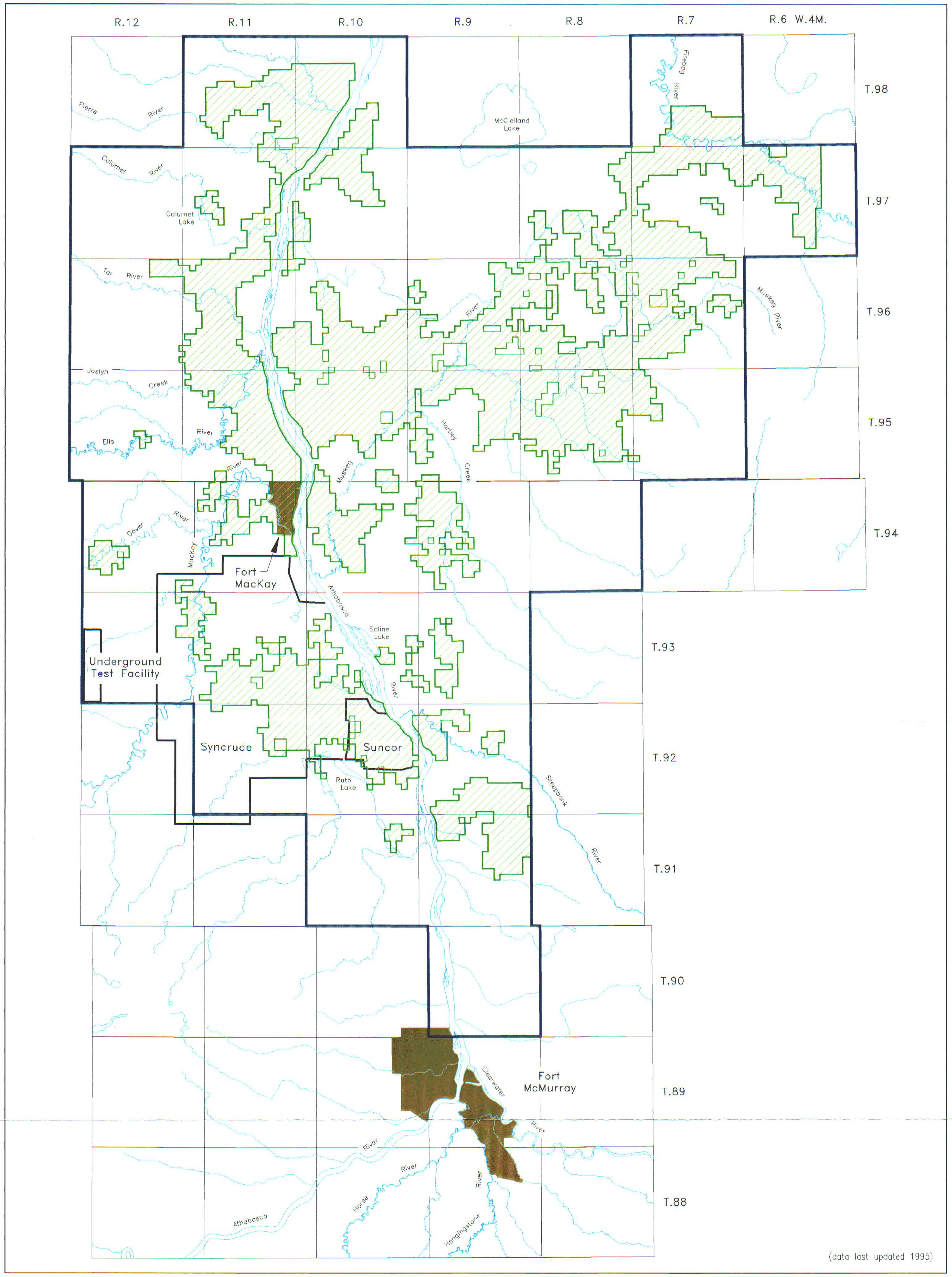
44.4 Initial
44.4 Inferred



MAP 3.4a WABISKAW–McMURRAY DEPOSIT (south portion)
ATHABASCA OIL SANDS AREA
VOLUME IN–PLACE RESERVES 10^6 m^3

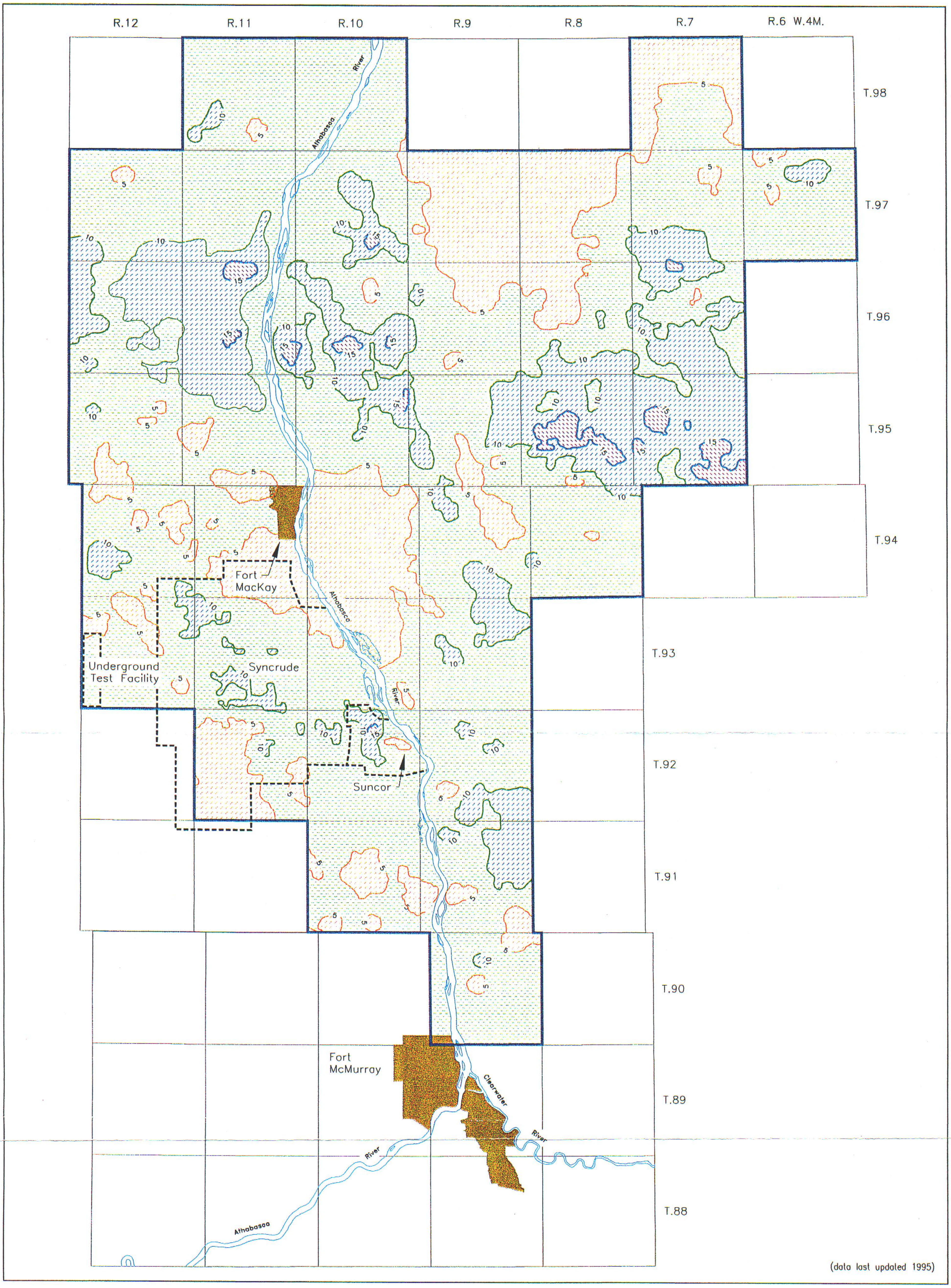
44.4 Initial
44.4 Inferred

EUB



MAP 3.4b SURFACE MINEABLE AREAS
WABISKAW–McMURRAY DEPOSIT
ATHABASCA OIL SANDS AREA

Surface Mineable Boundary
Approved Project Boundary
Surface Mineable Areas



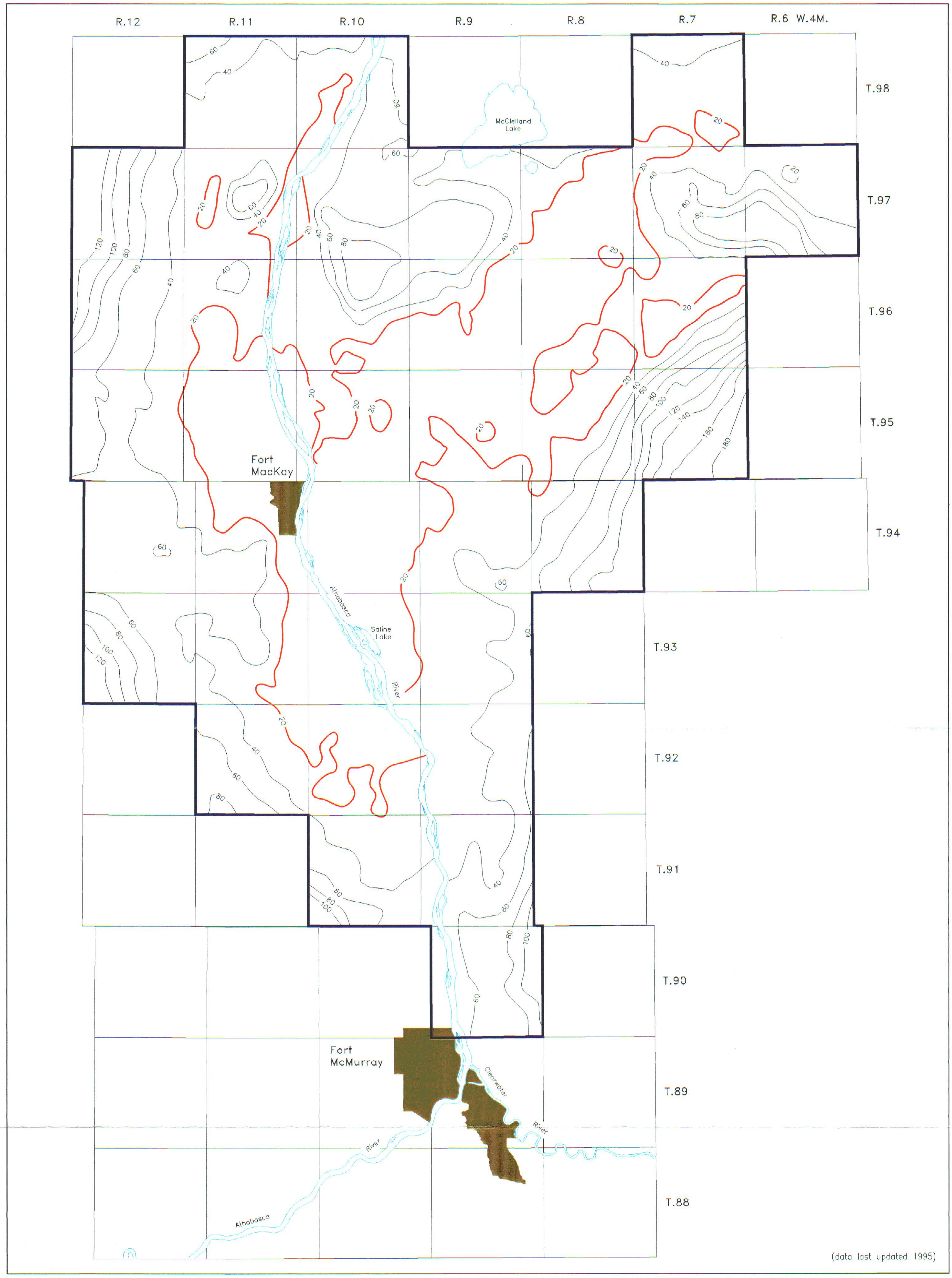
MAP 3.4c SURFACE MINEABLE AREA NET BITUMEN PAY
WABISKAW–McMURRAY DEPOSIT
ATHABASCA OIL SANDS AREA

EUB

Surface Mineable Boundary
Approved Project Boundary

0–5 Meter Contour
5–10 Meter Contour
10–15 Meter Contour
15–20 Meter Contour

km 0 1 2 3 4 5 10 km
miles 0 1 2 3 4 5 6 miles



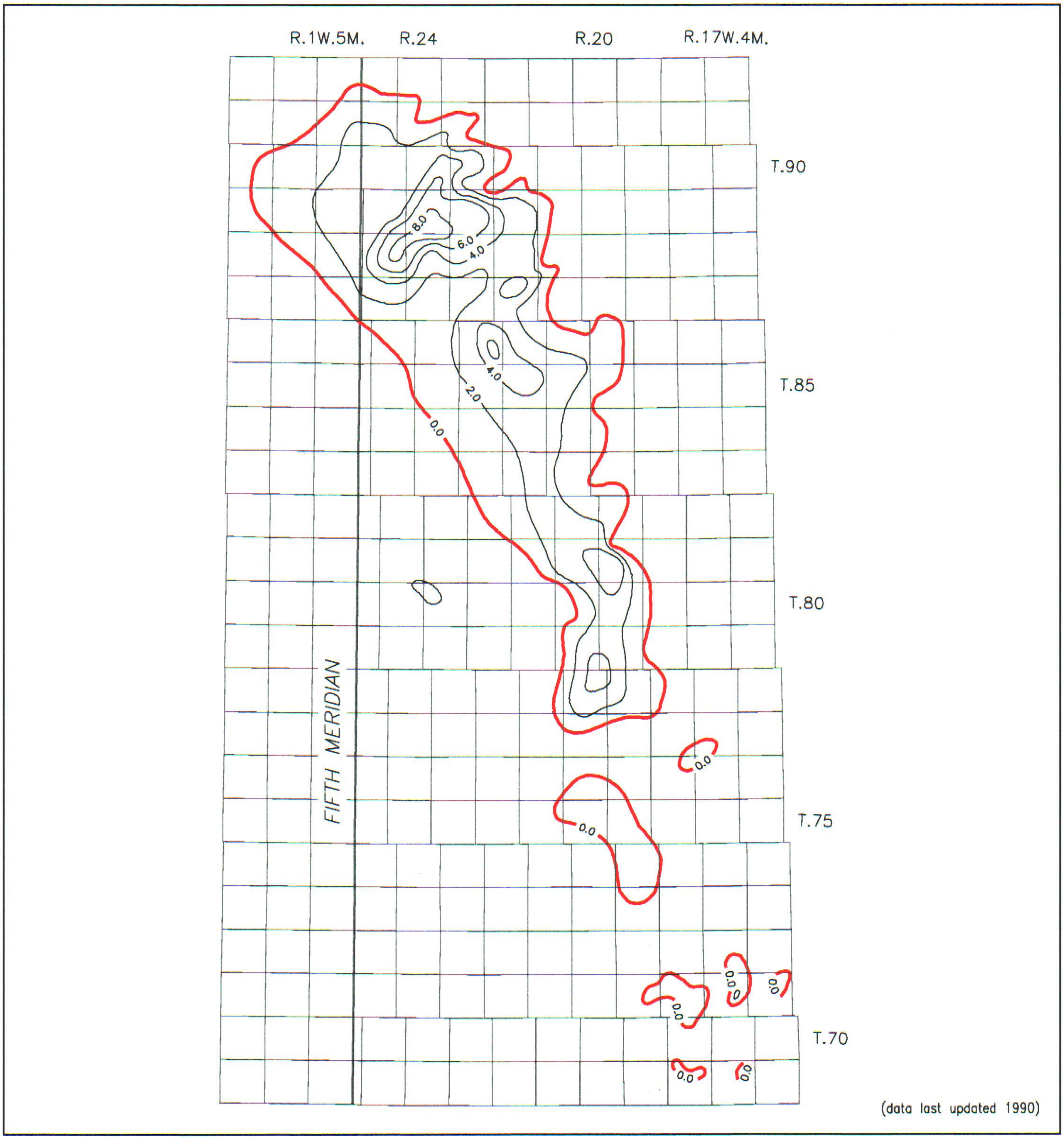
MAP 3.4d SURFACE MINEABLE AREAS OVERBURDEN THICKNESS
WABISKAW–McMURRAY DEPOSIT
ATHABASCA OIL SANDS AREA

EUB

Surface Mineable Boundary

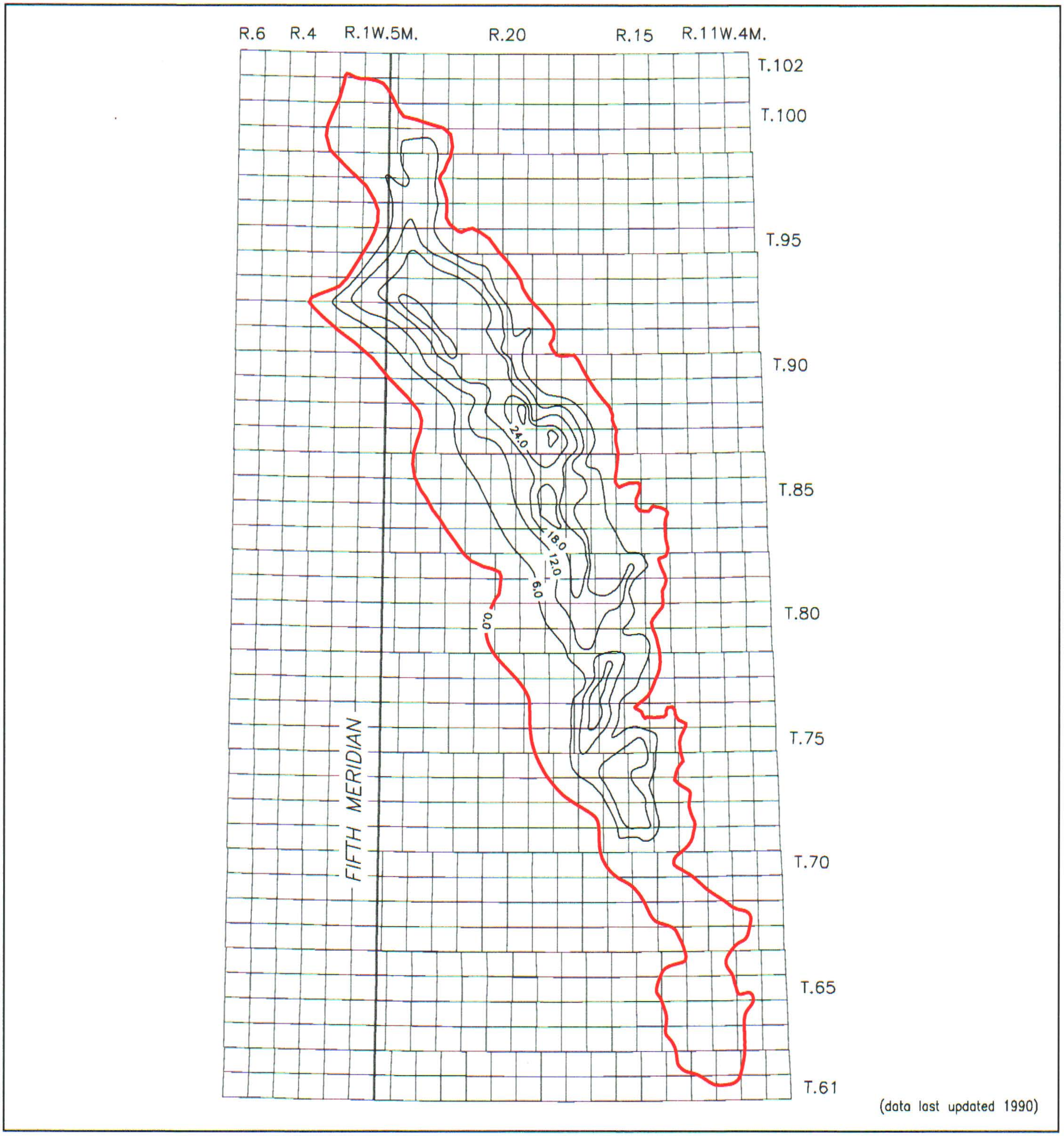
20 Contour Interval = 20 metres

km 0 1 2 3 4 5 10 km
miles 0 1 2 3 4 5 6 miles



MAP 3.5 NISKU DEPOSIT
ATHABASCA OIL SANDS AREA
>30% PORE VOLUME BITUMEN

0.0 Contour Interval = 2.0 metres



MAP 3.6 GROSMONT DEPOSIT
ATHABASCA OIL SANDS AREA
>30% PORE VOLUME BITUMEN

EUB

0.0 Contour Interval = 6.0 metres

SECTION 4

COLD LAKE OIL SANDS AREA

4 COLD LAKE OIL SANDS AREA (OSA 3)

The Cold Lake OSA is divided geographically into sectors, as shown in Figure 4.1. The Board designates four OSDs in the Cold Lake OSA. In descending stratigraphic order these are, Upper Grand Rapids, Lower Grand Rapids, Clearwater and Wabiskaw-McMurray Deposits. Building-block maps for the Cold Lake deposits have not been updated since the 1990 atlas. Cold Lake net bitumen pay maps are based on December 1995 data. Table 4-1 is a summary of the initial in-place reserves for all Cold Lake OSDs. Figures 4.2 and 4.3 are type logs of the deposits in the Cold Lake OSA.

4.1 Grand Rapids - Maps 4.1 to 4.2z

The Grand Rapids Formation is the uppermost formation within the Mannville Group and conformably overlies the Clearwater Formation and is disconformably overlain by the Joli Fou shales. The EUB subdivides the Grand Rapids into the Upper Grand Rapids and Lower Grand Rapids Deposits (Figure 4.2). Four distinct depositional environments have been recognized in the Grand Rapids Formation in the Cold Lake Area, marine shelf-shore deposits, delta front deposits, bay-fill/delta plain deposits, and distributary channel-fill deposits (Benyon and Pemberton, 1992). The sands vary from sublitharenites to feldspathic litharenites with kaolinite, illite, and smectite occurring as the dominant associated clay minerals.

The thickest deposits are associated with channel deposits, but the thinner marine sands form the most areally extensive continuous reservoirs (Wightman *et al.*, 1989). The trapping mechanism is a combination of structure, where the sands flex downwards over a scarp caused by the dissolution of underlying salt, and stratigraphic, where sands terminate due to a change in the depositional environments (Benyon and Pemberton, 1992). The combined thickness of the Upper and Lower Grand Rapids varies from roughly 50 metres in the north to 110 metres in the south.

In-place reserves are calculated for both the Upper (OSD 3) and Lower (OSD 9) Grand Rapids through a combination of building block and net bitumen pay maps. The Upper Grand Rapids net pay maps are separated into Colony, Upper Grand Rapids #2 and Waseca sands. The Lower Grand Rapids maps consist of Sparky, Lower Grand Rapids #2, #3, #4, #5 and Lloydminster sands.

4.2 Clearwater - Map 4.3

Due to the vertical and lateral continuity of the Clearwater sands, the Clearwater Deposit (OSD 4) is the major bitumen-bearing unit in the Cold Lake OSA. The Clearwater Formation unconformably overlies the McMurray Formation and is conformably overlain by the Grand Rapids Formation. The Clearwater sands are interpreted as a river-dominated deltaic deposit with laterally offset shoreface sands (Leyden, 1992). The Clearwater sands vary from litharenite to feldspathic litharenite in nature, and are associated with kaolinite, illite, smectite and various forms of authigenic chlorite (Wightman *et al.*, 1989). Bitumen trapping is partly stratigraphic, as the sands shale out to the north, and partially structural, as salt solution from the underlying Devonian evaporates, has caused a reversal in dip on the east side of the deposit (Wightman and Berezniuk, 1986).

In-place reserves for the Clearwater are calculated using the building-block method. Regional Clearwater reserves have not been updated since the 1990 atlas. In situ scheme areas, such as Imperial Cold Lake Production Project were updated, in 1994 using non-confidential wells.

4.3 Wabiskaw-McMurrray Maps 4.4a to 4.4f

The sands of the Cold Lake Wabiskaw-McMurray Deposit (OSD 8) are a southern extension of the Wabiskaw-McMurray sands in Athabasca (OSD 1). The McMurray Formation reflects initial infill of topographic lows on the sub-Cretaceous unconformity surface. Sediments are mainly quartzose in nature and were deposited in fluvial and lacustrine settings. The Wabiskaw Member represents the transitional deposits between the underlying continental McMurray Formation and the marine Clearwater Formation. The bitumen mainly occurs in the thinner sands at the top of the interval. The thick McMurray Formation channel deposits are usually water saturated (Wightman *et al.*, 1989).

In-place reserves for the Wabiskaw-McMurray are calculated through a combination of building-block and net bitumen pay maps. In this area, the Cummings sands are recognized as a local equivalent of the Wabiskaw and pay maps are broken down into Cummings #1, #2, and McMurray sands.

TABLE 4-1

OIL SANDS AREA OIL SANDS DEPOSIT OIL SANDS SECTOR, OIL SANDS POOL OVERBURDEN DEPTH (m) OR ZONE	1 INITIAL VOLUME IN PLACE $10^6 m^3$	2 AREA 10^3ha	3 AVERAGE PAY THICKNESS m	4 BITUMEN SATURATION mass frac	 pore vol frac	5 POROSITY frac	6 WATER SATN frac	7 REMARKS
COLD LAKE								
UPPER GRAND RAPIDS								
300 - 600								
BUILDING BLOCK	6433.40	816.00	6.0	0.081	0.58	0.30	0.42	
ISOPACH								
UPPER GRAND RAPIDS 2								
FROG LAKE/BEAVERDAM A	62.12	6.86	3.7	0.118	0.75	0.33	0.25	
BEAVERDAM/BONNYVILLE A	3.14	0.57	2.6	0.097	0.70	0.30	0.30	
BEAVERDAM A	4.23	0.67	2.7	0.112	0.74	0.32	0.26	
BEAVERDAM B	2.71	0.47	2.9	0.094	0.70	0.29	0.30	
BEAVERDAM C	8.16	1.05	3.1	0.119	0.79	0.32	0.21	
BEAVERDAM D	1.07	0.25	2.0	0.103	0.71	0.31	0.29	
BEAVERDAM E	0.20	0.10	0.8	0.111	0.71	0.33	0.29	
BEAVERDAM G	1.41	0.30	1.9	0.115	0.76	0.32	0.24	
BEAVERDAM H	3.31	0.63	2.6	0.091	0.68	0.29	0.32	
SUBTOTAL	86.35							
COLONY#1								
BEAVERDAM A	8.16	1.11	3.0	0.115	0.79	0.31	0.21	
BEAVERDAM B	4.69	0.52	3.5	0.122	0.84	0.31	0.16	
BEAVERDAM/BONNYVILLE A	13.16	1.97	2.7	0.116	0.80	0.31	0.20	
SUBTOTAL	26.01							
COLONY#2								
FROG LAKE A	2.58	0.50	2.2	0.109	0.75	0.31	0.25	
FROG LAKE B	0.11	0.04	1.2	0.093	0.67	0.30	0.33	
FROG LAKE C	0.34	0.12	1.3	0.103	0.74	0.30	0.26	
FROG LAKE D	0.28	0.10	1.3	0.099	0.71	0.30	0.29	
FROG LAKE E	0.43	0.14	1.4	0.106	0.79	0.29	0.21	
FROG LAKE F	0.36	0.14	1.4	0.087	0.68	0.28	0.32	
FROG LAKE M	0.61	0.14	2.0	0.100	0.72	0.30	0.28	
FROG LAKE N	0.85	0.23	1.7	0.099	0.71	0.30	0.29	
LINDBERGH A	0.45	0.12	1.9	0.091	0.68	0.29	0.32	
SUBTOTAL	6.01							
COLONY#3								
FROG LAKE G	0.33	0.09	1.6	0.112	0.77	0.31	0.23	
FROG LAKE H	0.02	0.77	0.2	0.079	0.62	0.28	0.38	
FROG LAKE I	1.70	0.23	3.1	0.110	0.79	0.30	0.21	
FROG LAKE J	0.75	0.19	2.2	0.112	0.74	0.32	0.26	
FROG LAKE L	8.28	0.38	8.0	0.130	0.86	0.32	0.14	
SUBTOTAL	11.08							
WASECA								
FROG LAKE A	1.30	0.38	2.1	0.076	0.57	0.29	0.43	
FROG LAKE B	60.48	2.60	10.0	0.109	0.75	0.31	0.25	
BEAVERDAM A	2.33	0.16	6.7	0.106	0.70	0.32	0.30	
FROG LAKE/LINDBERGH A	135.27	15.36	4.5	0.091	0.68	0.29	0.32	
SUBTOTAL	199.38							
LOWER GRAND RAPIDS								
300 - 600								
BUILDING BLOCK	8 780	729.00	6	0.106	0.60	0.31	0.27	
ISOPACH								
SPARKY								
FROG LAKE A	6.37	0.95	2.9	0.109	0.75	0.31	0.25	
FROG LAKE B	0.27	0.05	2.2	0.109	0.72	0.32	0.28	
FROG LAKE C	1.07	0.20	2.4	0.107	0.74	0.31	0.26	
FROG LAKE D	0.25	0.08	1.6	0.083	0.62	0.29	0.38	
FROG LAKE E	1.49	0.32	2.5	0.087	0.65	0.29	0.35	
LINDBERGH A	62.91	8.75	3.3	0.102	0.70	0.31	0.30	
LINDBERGH C	0.90	0.39	1.3	0.084	0.60	0.30	0.40	
LINDBERGH D	24.25	3.93	2.6	0.112	0.74	0.32	0.26	
LINDBERGH E	0.11	0.09	0.5	0.116	0.74	0.33	0.26	
LINDBERGH F	0.34	0.12	1.6	0.081	0.58	0.30	0.42	
LINDBERGH I	0.16	0.06	1.2	0.100	0.64	0.33	0.36	
LINDBERGH K	0.79	0.23	1.7	0.093	0.67	0.30	0.33	
BEAVERDAM A	4.98	0.35	5.7	0.119	0.73	0.34	0.27	
BEAVERDAM B	3.89	0.32	5.0	0.120	0.66	0.37	0.34	
BEAVERDAM C	5.22	0.60	3.2	0.132	0.81	0.34	0.19	
BEAVERDAM D	20.08	2.46	3.1	0.125	0.83	0.32	0.17	
BEAVERDAM E	25.07	3.45	2.7	0.127	0.81	0.33	0.19	

TABLE 4-1

OIL SANDS AREA OIL SANDS DEPOSIT OIL SANDS SECTOR, OIL SANDS POOL OVERBURDEN DEPTH (m) OR ZONE	1 INITIAL VOLUME IN PLACE 10^6 m³	2 AREA 10^3 ha	3 AVERAGE PAY THICKNESS m	4 BITUMEN SATURATION mass frac	 pore vol frac	5 POROSITY frac	6 WATER SATN frac	7 REMARKS
SPARKY (Continued)								
BEAVERDAM F	7.60	1.18	2.4	0.129	0.82	0.33	0.18	
SUBTOTAL	165.75							
LOWER GRAND RAPIDS 2								
LINDBERGH G	31.17	5.02	2.9	0.100	0.69	0.31	0.31	
LINDBERGH K	0.78	0.21	2.0	0.084	0.63	0.29	0.37	
LINDBERGH VV	0.37	0.12	1.5	0.095	0.68	0.30	0.32	
LINDBERGH WW	2.64	0.46	2.3	0.122	0.78	0.33	0.22	
BEAVERDAM A	4.57	1.69	1.8	0.069	0.62	0.25	0.38	
SUBTOTAL	39.53							
LOWER GRAND RAPIDS 3								
FROG LAKE C	5.49	0.51	4.6	0.109	0.75	0.31	0.25	
FROG LAKE D	9.33	1.10	3.4	0.119	0.79	0.32	0.21	
FROG LAKE E	3.87	0.72	2.5	0.103	0.71	0.31	0.29	
FROG LAKE F	0.38	0.09	2.0	0.098	0.73	0.29	0.27	
LINDBERGH F	29.24	2.80	4.2	0.118	0.78	0.32	0.22	
LINDBERGH L	1.60	0.23	3.0	0.108	0.69	0.33	0.31	
LINDBERGH M	9.05	1.46	2.9	0.099	0.68	0.31	0.32	
LINDBERGH O	12.39	1.60	3.9	0.093	0.67	0.30	0.33	
LINDBERGH P	2.04	0.25	3.5	0.110	0.76	0.31	0.24	
LINDBERGH Q	25.98	2.62	4.1	0.115	0.79	0.31	0.21	
LINDBERGH S	2.47	0.36	2.9	0.113	0.72	0.33	0.28	
LINDBERGH T	3.03	0.48	2.7	0.109	0.75	0.31	0.25	
LINDBERGH U	0.19	0.06	1.7	0.094	0.70	0.29	0.30	
LINDBERGH V	0.14	0.05	1.6	0.081	0.56	0.31	0.44	
LINDBERGH X	0.79	0.20	2.5	0.073	0.57	0.28	0.43	
LINDBERGH Y	1.67	0.33	2.8	0.086	0.59	0.31	0.41	
LINDBERGH Z	0.35	0.08	2.3	0.094	0.65	0.31	0.35	
LINDBERGH AA	3.19	0.47	3.2	0.099	0.71	0.30	0.29	
LINDBERGH BB	0.09	0.29	1.6	0.093	0.59	0.33	0.41	
LINDBERGH CC	1.52	0.23	2.8	0.110	0.76	0.31	0.24	
LINDBERGH OO	0.23	0.09	1.6	0.075	0.54	0.30	0.46	
LINDBERGH XX	0.33	0.08	2.2	0.086	0.62	0.30	0.38	
LINDBERGH YY	3.76	0.37	4.1	0.117	0.81	0.31	0.19	
FROG LAKE/LINDBERGH C	9.42	1.06	3.6	0.115	0.76	0.32	0.24	
FROG LAKE/BEAVERDAM A	3.78	0.55	2.8	0.119	0.73	0.34	0.27	
LINDBERGH/ST. PAUL A	9.14	0.77	4.6	0.121	0.80	0.32	0.20	
BEAVERDAM B	75.68	9.20	3.3	0.116	0.77	0.32	0.23	
BEAVERDAM G	1.42	0.25	2.3	0.115	0.76	0.32	0.24	
SUBTOTAL	216.57							
LOWER GRAND RAPIDS CHANNEL SAND								
BEAVERDAM F	27.04	0.87	10.3	0.145	0.83	0.36	0.17	
SUBTOTAL	27.04							
LOWER GRAND RAPIDS 4								
FROG LAKE G	9.13	0.98	3.6	0.124	0.79	0.33	0.21	
FROG LAKE I	15.99	1.57	4.0	0.121	0.80	0.32	0.20	
FROG LAKE J	2.50	0.31	3.3	0.116	0.77	0.32	0.23	
FROG LAKE K	0.68	0.06	3.6	0.146	0.93	0.33	0.07	
FROG LAKE L	0.88	0.17	2.1	0.112	0.77	0.31	0.23	
FROG LAKE M	1.13	0.22	2.2	0.109	0.72	0.32	0.28	
FROG LAKE N	1.49	0.22	2.8	0.114	0.73	0.33	0.27	
FROG LAKE P	1.75	0.19	3.2	0.135	0.86	0.33	0.14	
FROG LAKE Q	1.41	0.27	2.4	0.102	0.73	0.30	0.27	
FROG LAKE T	0.27	0.06	1.6	0.121	0.77	0.33	0.23	
LINDBERGH B	17.00	1.84	3.6	0.121	0.80	0.32	0.20	
LINDBERGH C	7.19	0.94	3.2	0.113	0.75	0.32	0.25	
LINDBERGH D	3.65	0.49	3.4	0.102	0.73	0.30	0.27	
LINDBERGH E	3.01	0.44	2.8	0.115	0.79	0.31	0.21	
LINDBERGH H	1.95	0.33	2.5	0.109	0.75	0.31	0.25	
LINDBERGH I	1.51	0.25	2.6	0.109	0.75	0.31	0.25	
LINDBERGH J	3.53	0.56	2.7	0.110	0.76	0.31	0.24	
LINDBERGH DD	0.29	0.07	2.1	0.092	0.61	0.32	0.39	
LINDBERGH EE	0.53	0.11	2.2	0.106	0.73	0.31	0.27	
LINDBERGH FF	0.81	0.13	2.5	0.115	0.76	0.32	0.24	
LINDBERGH GG	0.21	0.05	2.2	0.098	0.60	0.34	0.40	
LINDBERGH HH	0.78	0.16	2.5	0.090	0.62	0.31	0.38	
LINDBERGH II	0.18	0.04	2.5	0.089	0.59	0.32	0.41	
LINDBERGH JJ	6.00	0.70	3.4	0.119	0.79	0.32	0.21	
LINDBERGH KK	0.64	0.10	2.8	0.105	0.67	0.33	0.33	

TABLE 4-1

OIL SANDS AREA OIL SANDS DEPOSIT OIL SANDS SECTOR, OIL SANDS POOL OVERBURDEN DEPTH (m) OR ZONE	1 INITIAL VOLUME IN PLACE $10^6 m^3$	2 AREA 10^3ha	3 AVERAGE PAY THICKNESS m	4 BITUMEN SATURATION mass frac	 pore vol frac	5 POROSITY frac	6 WATER SATN frac	7 REMARKS
LOWER GRAND RAPIDS 4 (Continued)								
LINDBERGH MM	7.70	0.92	3.5	0.115	0.76	0.32	0.24	
LINDBERGH NN	2.71	0.37	2.9	0.119	0.76	0.33	0.24	
LINDBERGH PP	3.27	0.39	3.9	0.099	0.71	0.30	0.29	
LINDBERGH QQ	1.01	0.20	2.2	0.107	0.80	0.29	0.20	
LINDBERGH RR	0.06	0.02	1.5	0.089	0.64	0.30	0.36	
LINDBERGH SS	2.27	0.29	3.4	0.110	0.70	0.33	0.30	
LINDBERGH UU	0.52	0.10	2.2	0.109	0.75	0.31	0.25	
LINDBERGH ZZ	11.43	1.12	4.2	0.113	0.78	0.31	0.22	
BEAVERDAM C	24.14	2.70	3.5	0.119	0.79	0.32	0.21	
LINDBERGH/ST. PAUL B	10.30	1.22	3.6	0.110	0.73	0.32	0.27	
SUBTOTAL	145.92							
LOWER GRAND RAPIDS 5								
LINDBERGH AAA	3.12	0.55	2.8	0.094	0.70	0.29	0.30	
LINDBERGH BBB	0.33	0.09	2.0	0.083	0.62	0.29	0.38	
LINDBERGH CCC	0.12	0.04	1.8	0.080	0.60	0.29	0.40	
ST. PAUL A	2.02	0.32	3.3	0.089	0.64	0.30	0.36	
ST. PAUL B	0.23	0.06	2.2	0.084	0.63	0.29	0.37	
BEAVERDAM D	22.19	3.37	4.3	0.070	0.57	0.27	0.43	
SUBTOTAL	28.01							
LLOYDMINSTER								
FROG LAKE A	1.39	0.19	3.6	0.097	0.62	0.33	0.38	
FROG LAKE B	4.61	0.54	4.4	0.091	0.63	0.31	0.37	
FROG LAKE C	2.76	0.38	3.4	0.100	0.64	0.33	0.36	
LINDBERGH D	4.21	0.62	2.8	0.116	0.74	0.33	0.26	
LINDBERGH F	2.87	0.48	3.6	0.078	0.56	0.30	0.44	
LINDBERGH G	0.93	0.13	3.8	0.085	0.61	0.30	0.39	
LINDBERGH H	29.66	2.45	5.0	0.113	0.75	0.32	0.25	
LINDBERGH I	7.39	0.54	5.3	0.122	0.84	0.31	0.16	
LINDBERGH J	1.49	0.33	1.9	0.109	0.72	0.32	0.28	
BEAVERDAM A	125.76	6.47	8.6	0.107	0.71	0.32	0.29	
FROG LAKE/LINDBERGH A	4.88	0.63	4.0	0.091	0.63	0.31	0.37	
LINDBERGH/ST. PAUL B	61.15	2.45	8.9	0.133	0.85	0.33	0.15	
LINDBERGH/ST. PAUL C	3.54	0.36	4.2	0.110	0.73	0.32	0.27	
FROG LAKE/BEAVERDAM A	187.88	9.37	10.8	0.086	0.64	0.29	0.36	
LINDBERGH/BEAVERDAM A	44.50	3.18	5.4	0.120	0.83	0.31	0.17	
LINDBERGH/BEAVERDAM/BONNYVILLE A	521.25	19.95	9.0	0.138	0.85	0.34	0.15	
SUBTOTAL	1004.27							
CLEARWATER								
300 - 600	11051.00	589.00	15.0	0.089	0.64	0.30	0.36	
SUBTOTAL	11051.00							
WABISKAW-MCMURRAY								
300 - 600								
BUILDING BLOCK	2940.00	591.00	6.0	0.057	0.51	0.25	0.49	
ISOPACH								
CUMMINGS 1								
FROG LAKE/LINDBERGH A	38.80	3.70	4.0	0.122	0.84	0.31	0.16	
LINDBERGH/ST. PAUL A	339.78	29.43	4.4	0.109	0.78	0.30	0.22	
SUBTOTAL	378.58							
CUMMINGS 2								
ST. PAUL B	1.32	0.18	3.2	0.106	0.76	0.30	0.24	
LINDBERGH/ST. PAUL B	229.19	20.47	4.5	0.117	0.81	0.31	0.19	
SUBTOTAL	230.51							
MCMURRAY								
LINDBERGH A	89.65	5.38	6.2	0.127	0.84	0.32	0.16	
LINDBERGH B	0.09	0.02	2.4	0.083	0.68	0.27	0.32	
LINDBERGH C	38.82	5.28	3.1	0.112	0.77	0.31	0.23	
LINDBERGH D	0.52	0.11	1.8	0.125	0.86	0.31	0.14	
LINDBERGH E	0.05	0.05	0.5	0.088	0.69	0.28	0.31	
LINDBERGH F	8.18	0.56	6.7	0.103	0.71	0.31	0.29	
ST. PAUL A	0.04	0.02	1.1	0.090	0.62	0.31	0.38	
SUBTOTAL	137.35							
TOTAL	31906.66							

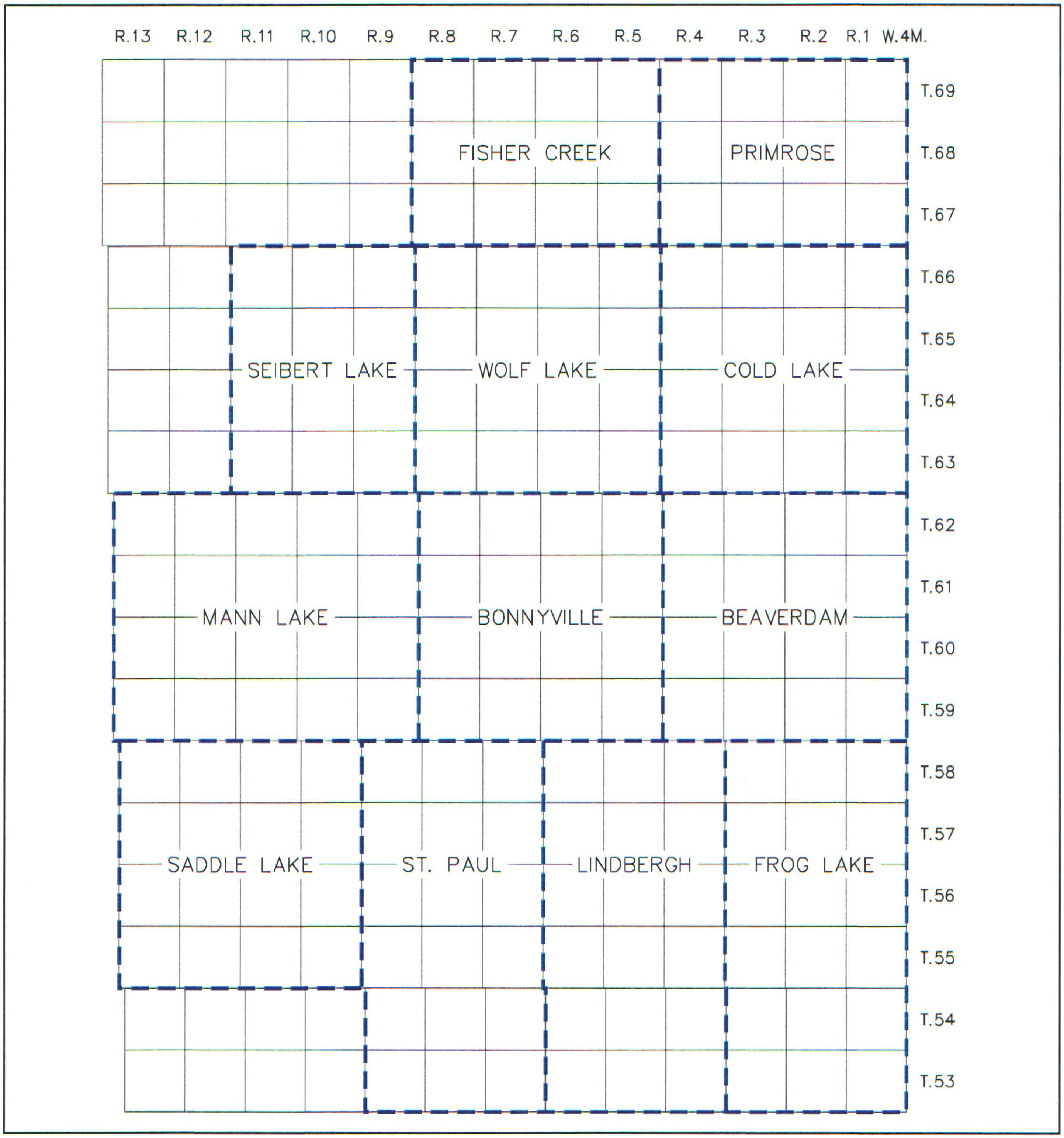


FIGURE 4.1 COLD LAKE OIL SANDS AREA – SECTORS

EUB

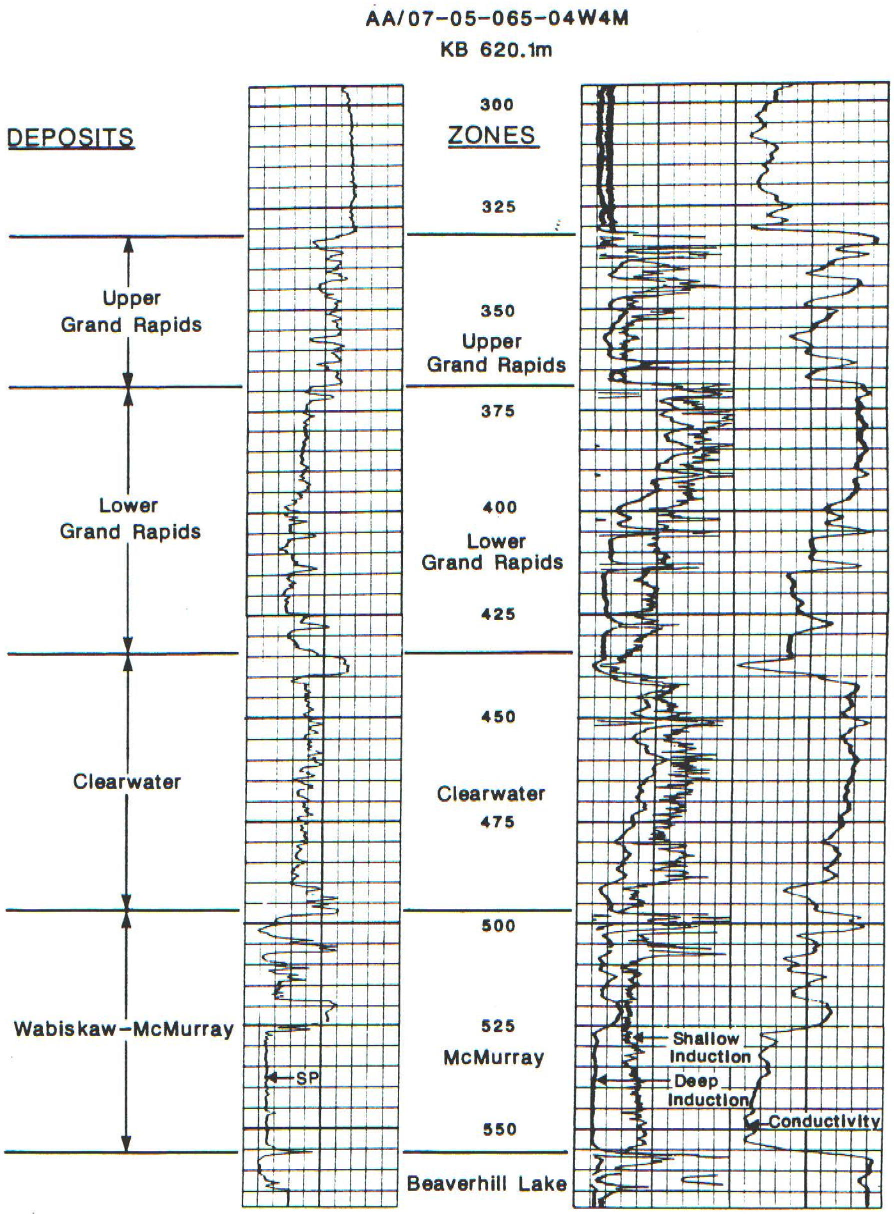


FIGURE 4.2 COLD LAKE OIL SANDS AREA REFERENCE WELL
ESSO COLD LAKE OV 7-5-65-4W4M

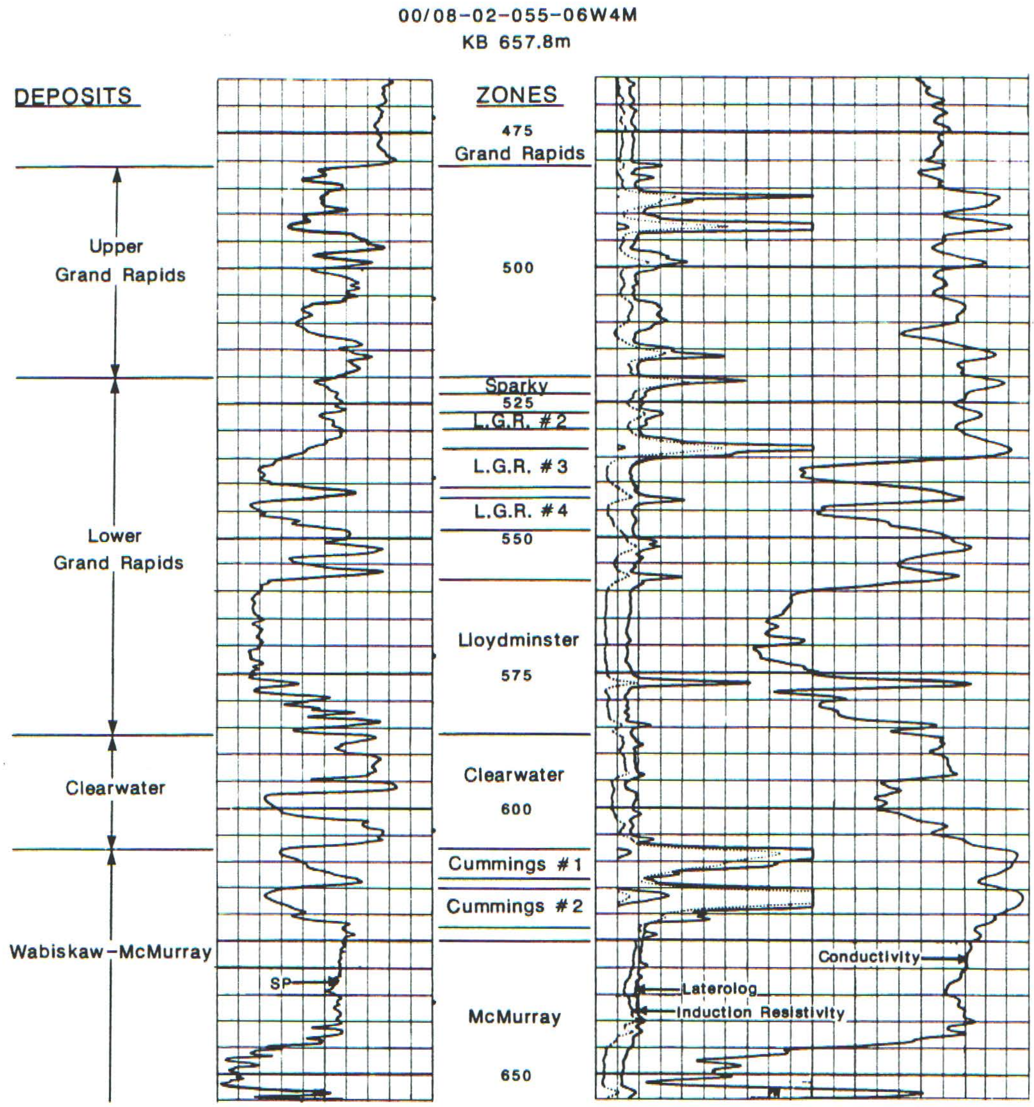
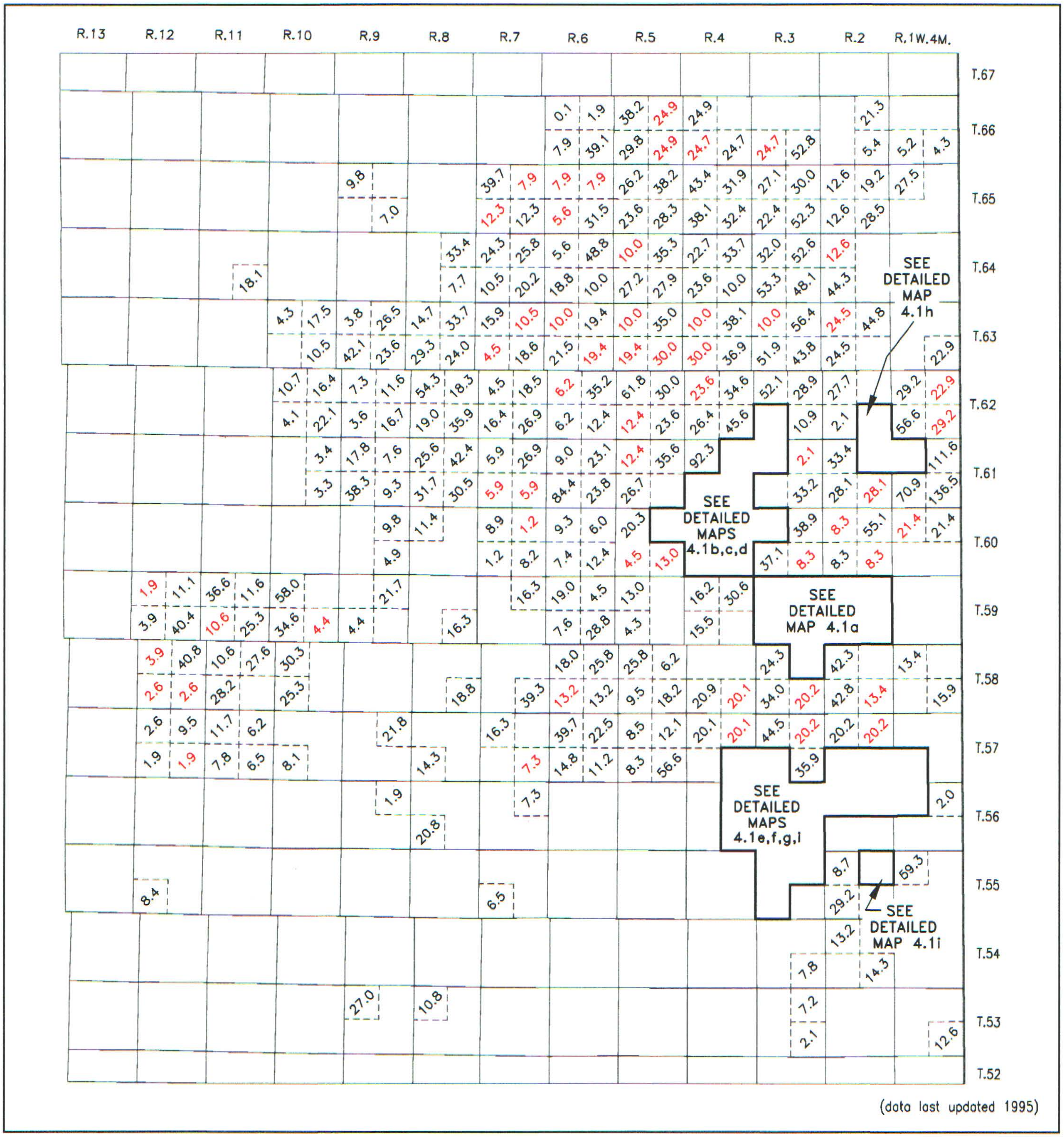


FIGURE 4.3 COLD LAKE OIL SANDS AREA REFERENCE WELL
LINDBERGH/ST. PAUL SECTORS
DOME ET AL LINDBERGH 8A-2-55-6W4M

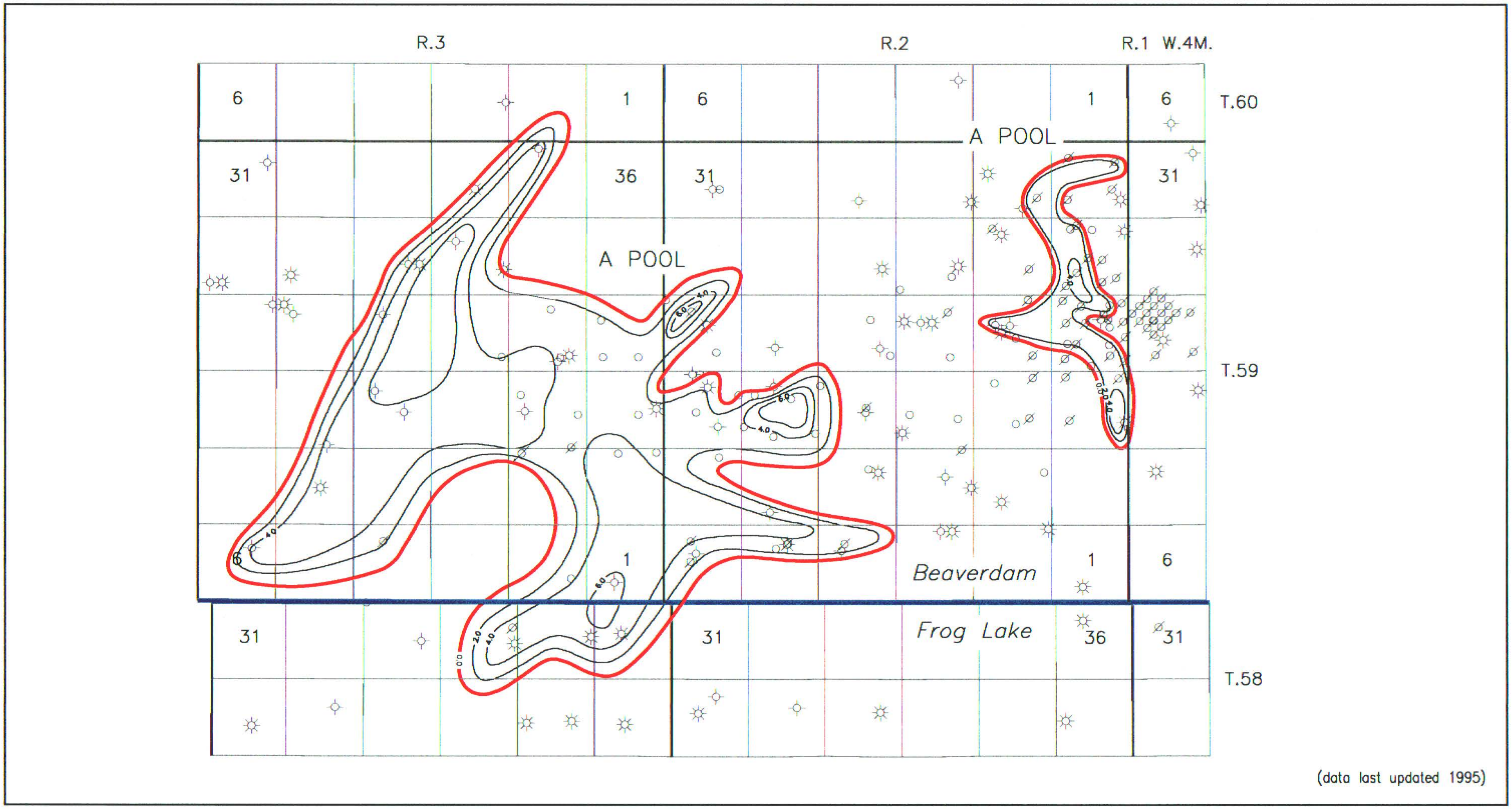
EUB



MAP 4.1 UPPER GRAND RAPIDS DEPOSIT
COLD LAKE OIL SANDS AREA
VOLUME IN-PLACE RESERVES 10^6 m^3

EUB

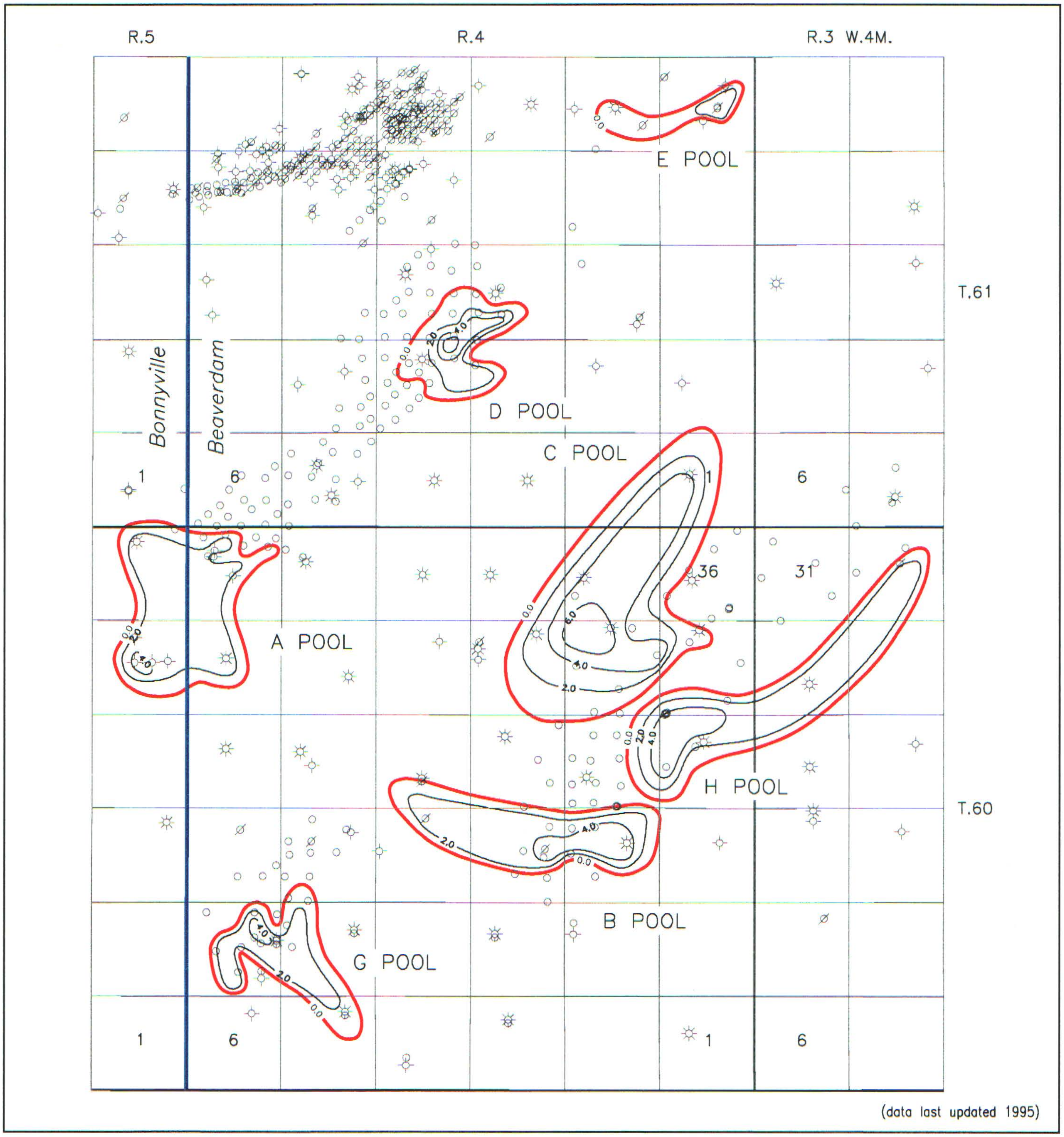
44.4 Initial
44.4 Inferred



MAP 4.1a UPPER GRAND RAPIDS #2 SAND
UPPER GRAND RAPIDS DEPOSIT
BEAVERDAM/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

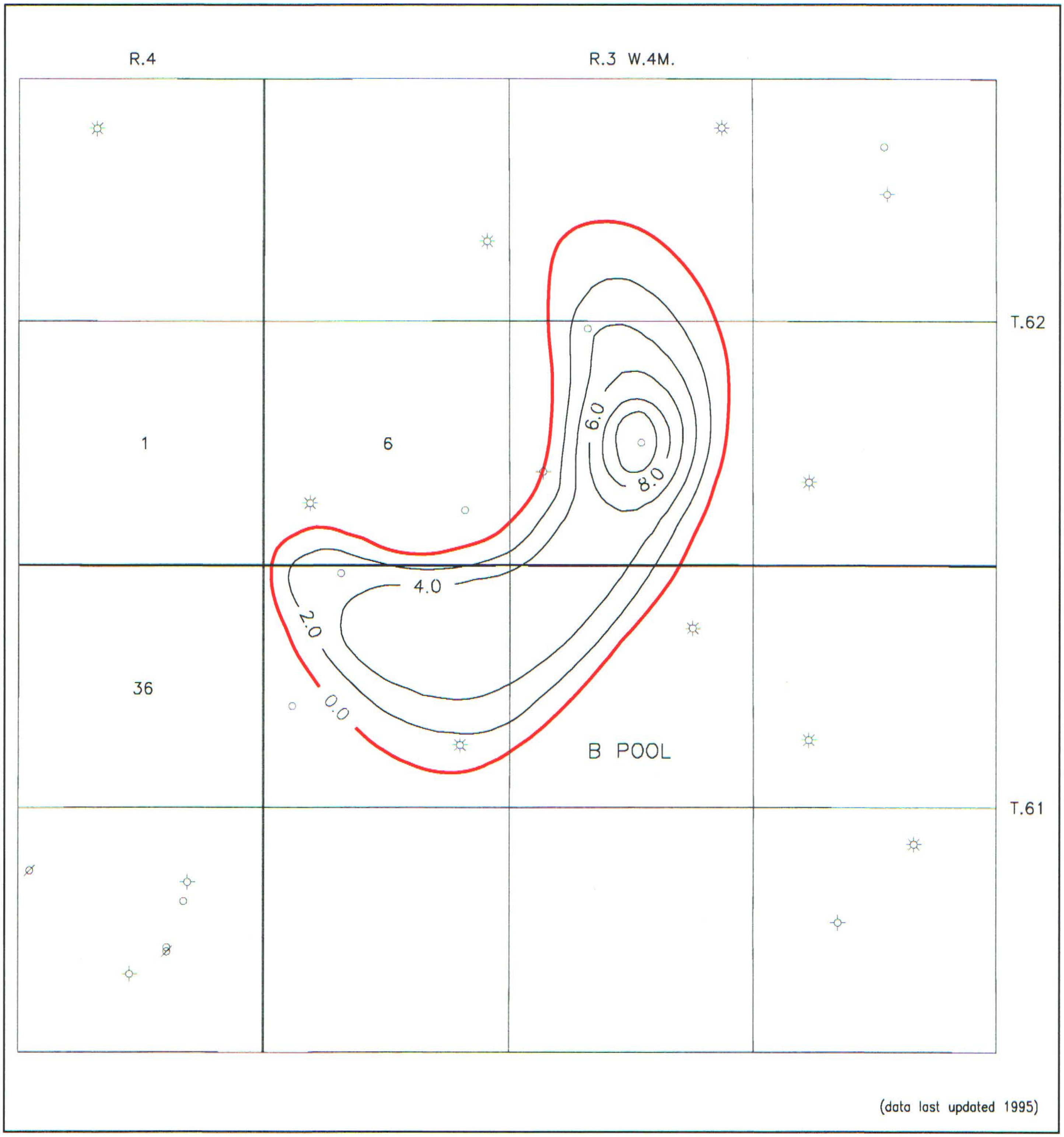
EUB



MAP 4.1b UPPER GRAND RAPIDS #2 SAND
UPPER GRAND RAPIDS DEPOSIT
BONNYVILLE/BEAVERDAM SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

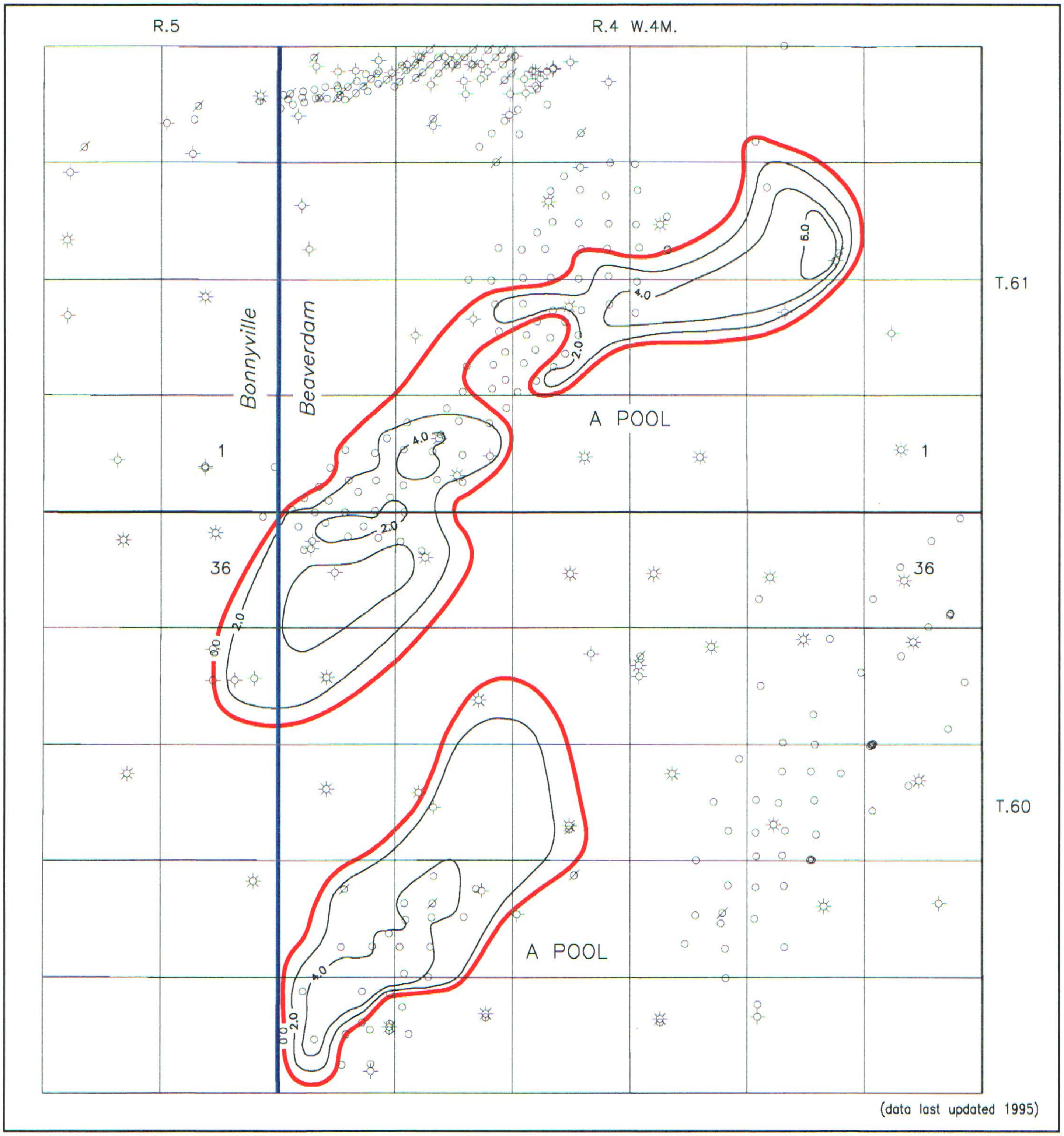


MAP 4.1c COLONY #1 SAND
UPPER GRAND RAPIDS DEPOSIT
BEAVERDAM SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

0.0 Contour Interval = 2.0 meters
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

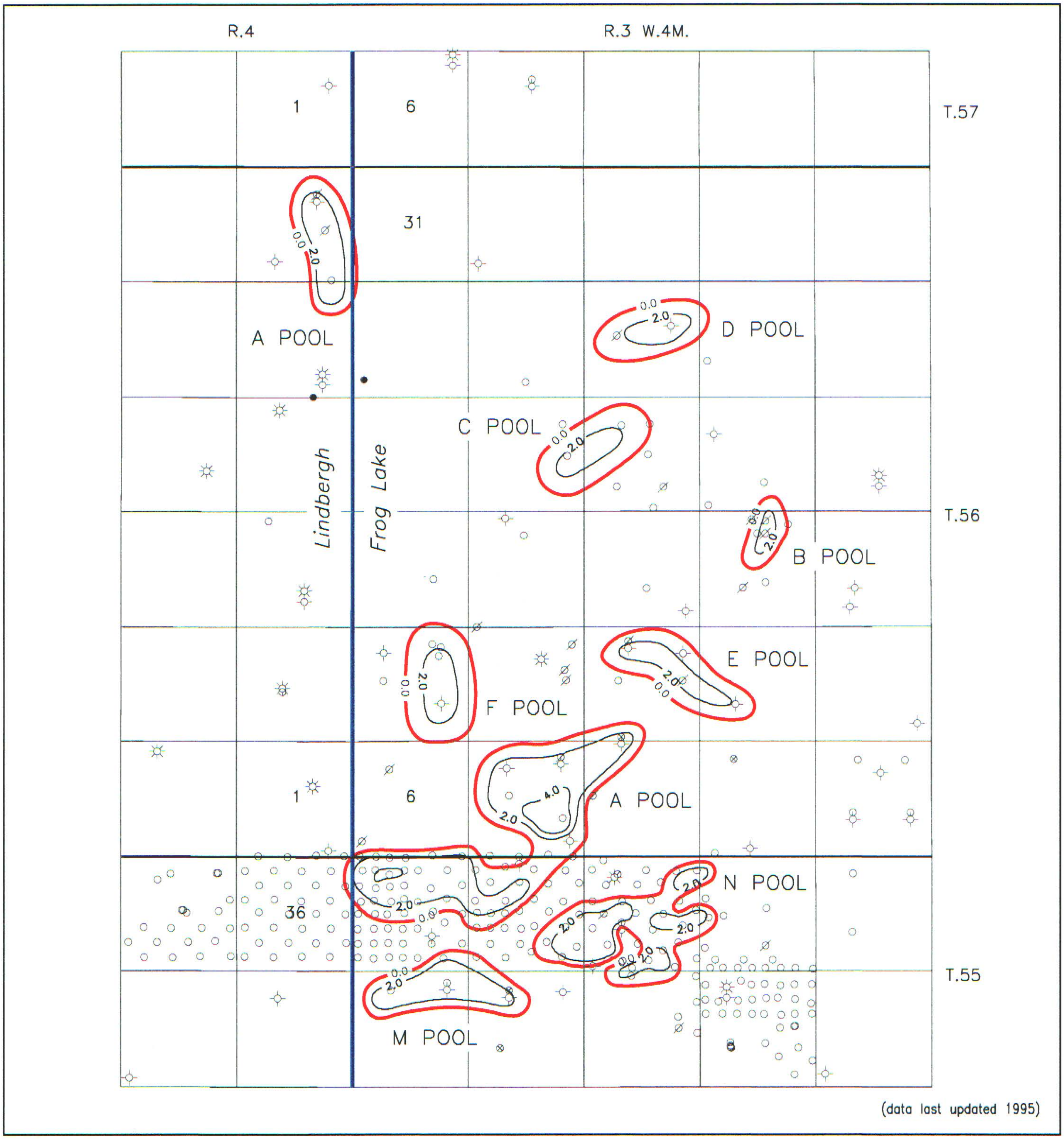


MAP 4.1d COLONY #1 SAND
UPPER GRAND RAPIDS DEPOSIT
BONNYVILLE/BEAVERDAM SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

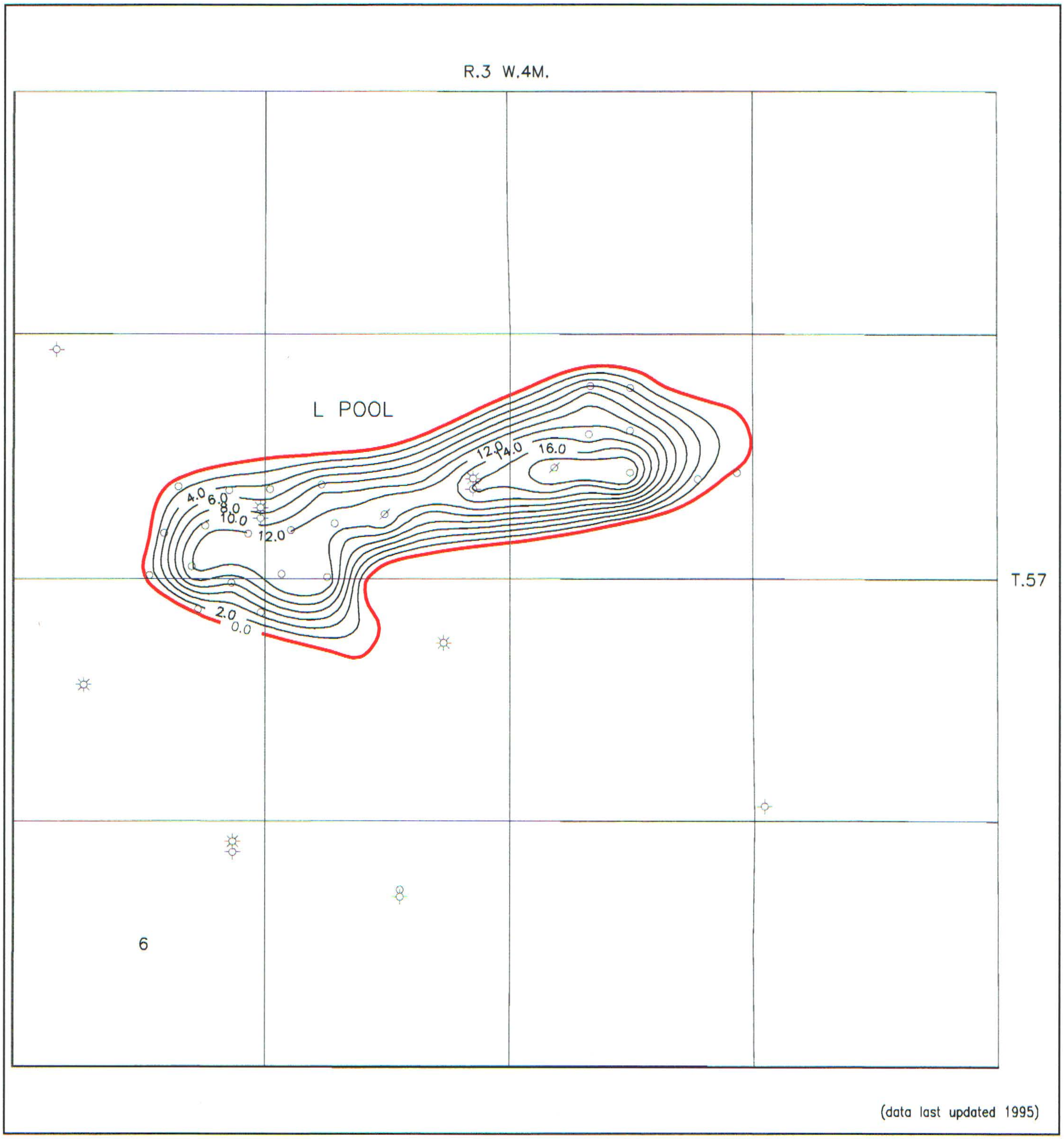


MAP 4.1e COLONY #2 SAND
UPPER GRAND RAPIDS DEPOSIT
LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

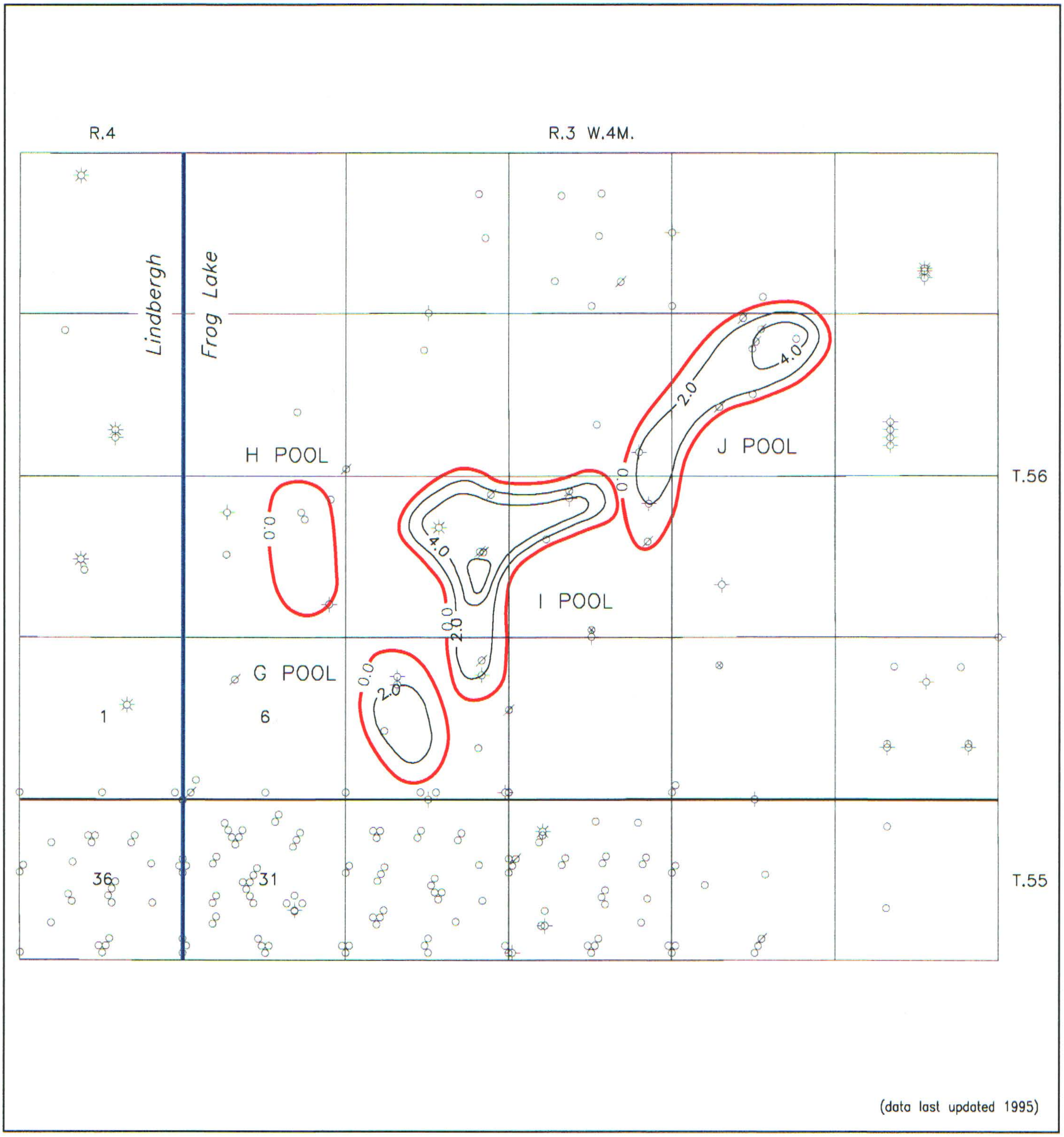
EUB



MAP 4.1f COLONY #3 SAND
UPPER GRAND RAPIDS DEPOSIT
FROG LAKE SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB

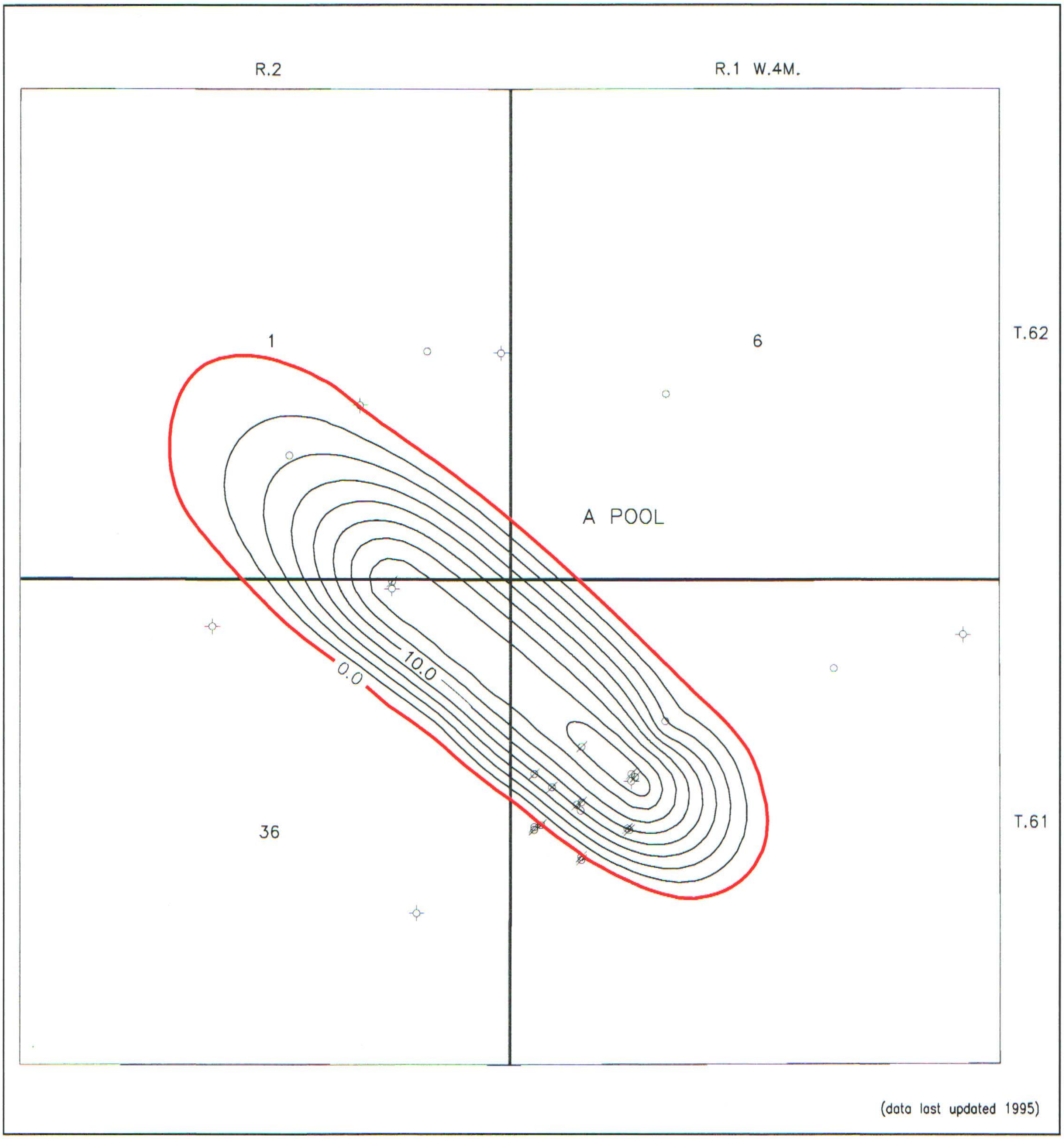


MAP 4.1g COLONY #3 SAND
UPPER GRAND RAPIDS DEPOSIT
LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

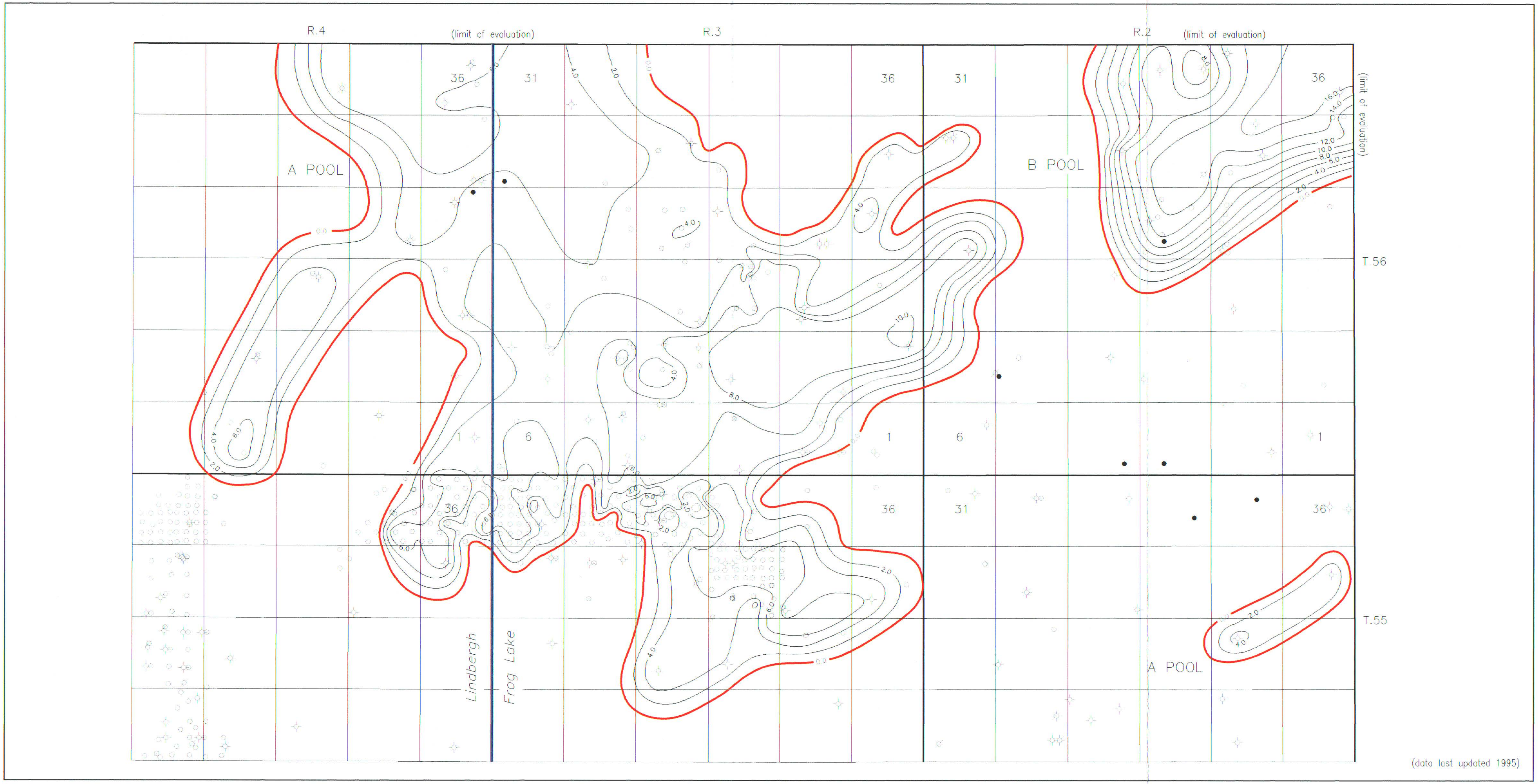


MAP 4.1h WASECA CHANNEL SAND
UPPER GRAND RAPIDS DEPOSIT
BEAVERDAM SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

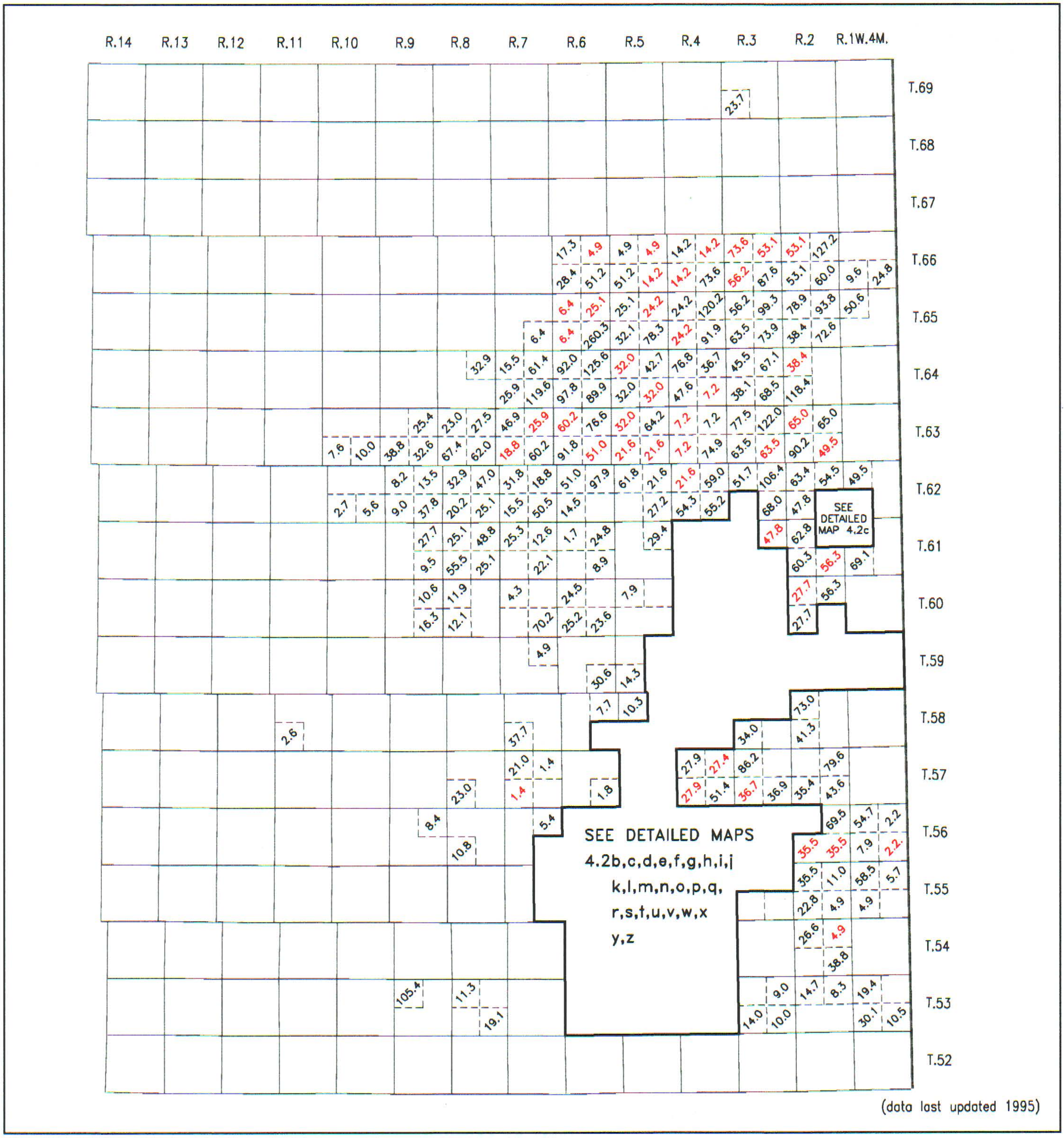
EUB



MAP 4.1i WASECA SAND
UPPER GRAND RAPIDS DEPOSIT
LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

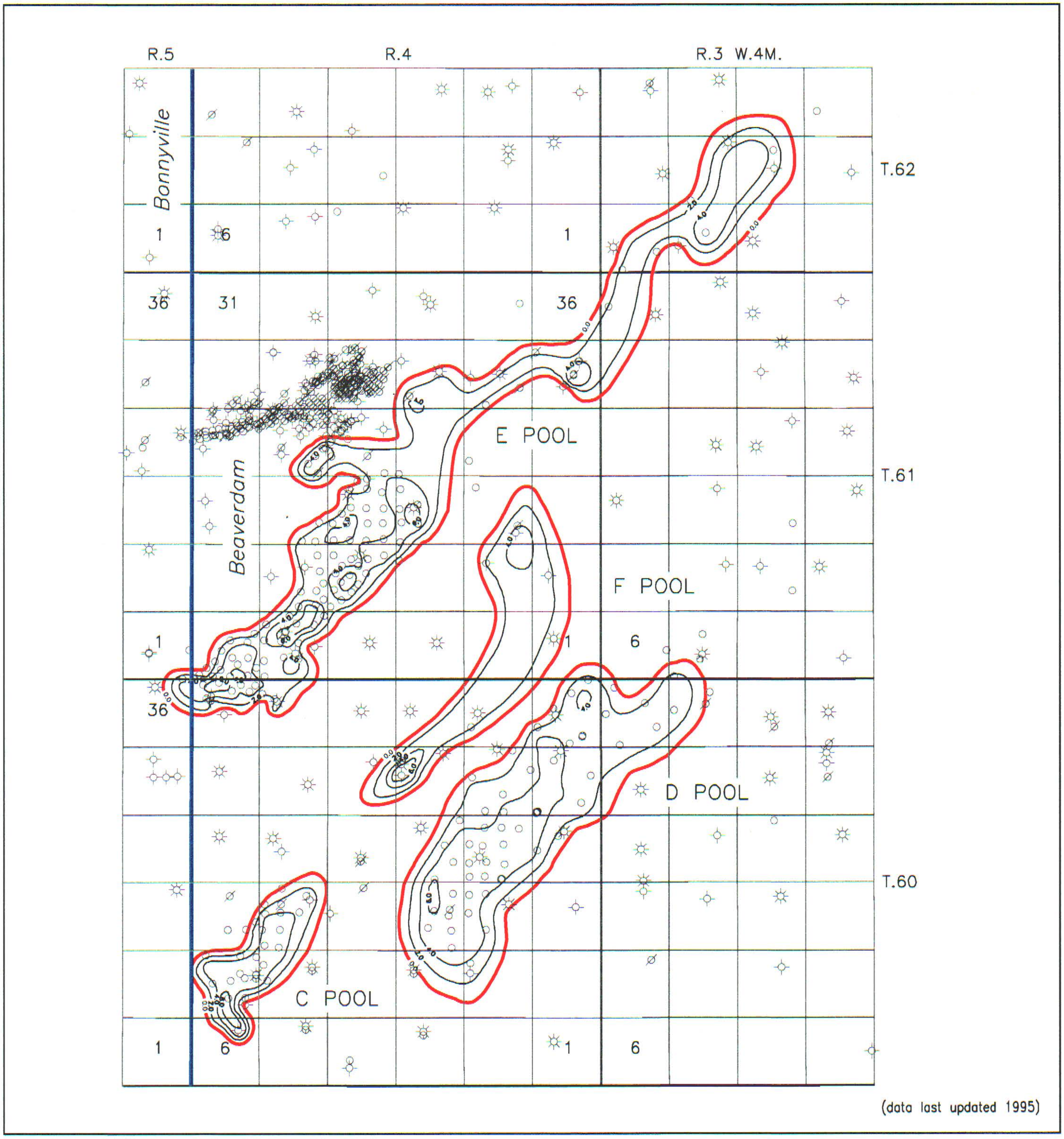
LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB



MAP 4.2a LOWER GRAND RAPIDS DEPOSIT
COLD LAKE OIL SANDS AREA
VOLUME IN-PLACE RESERVES 10^6 m^3

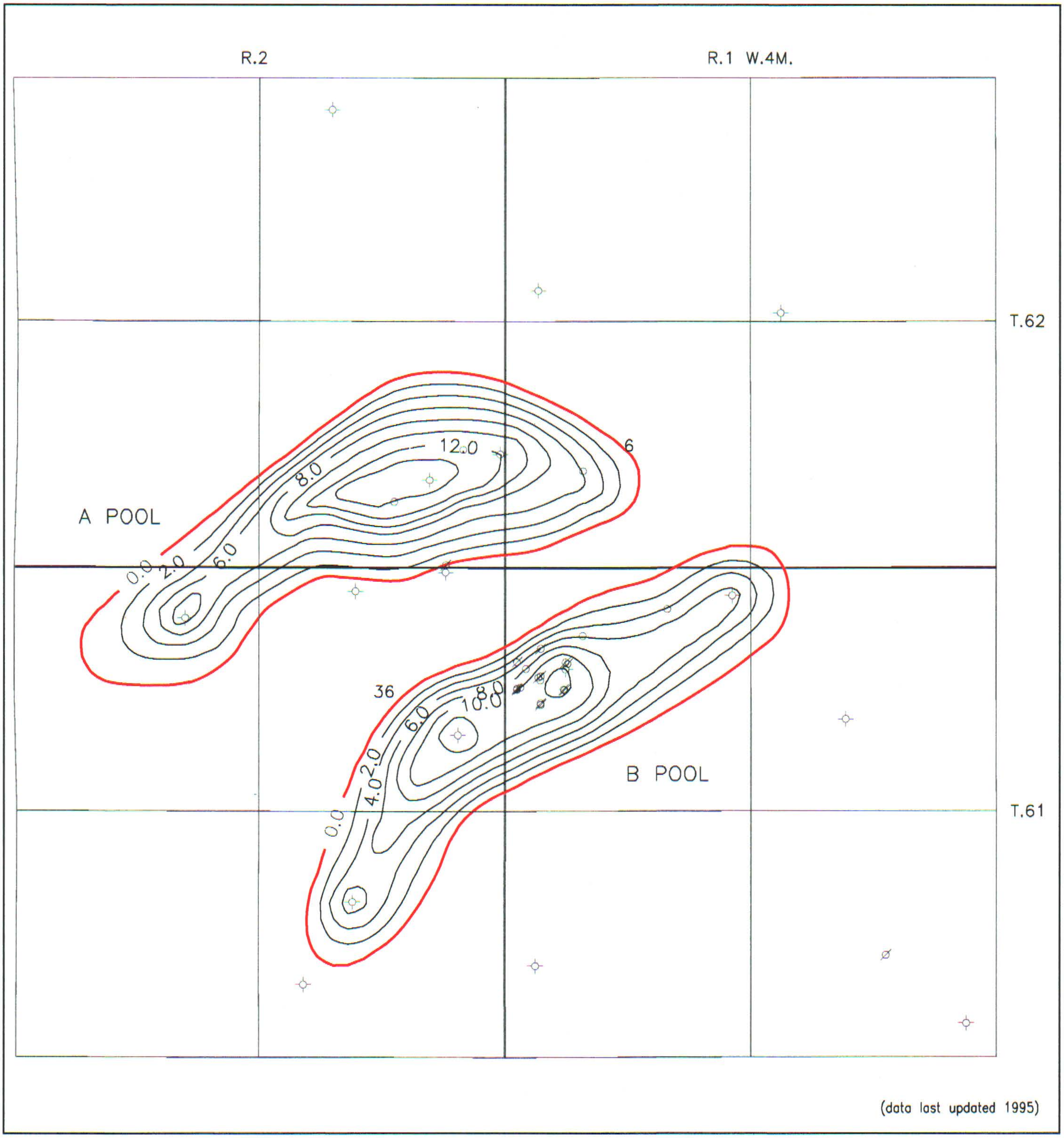
44.4 Initial
44.4 Inferred



MAP 4.2b SPARKY SAND
LOWER GRAND RAPIDS DEPOSIT
BEAVERDAM SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

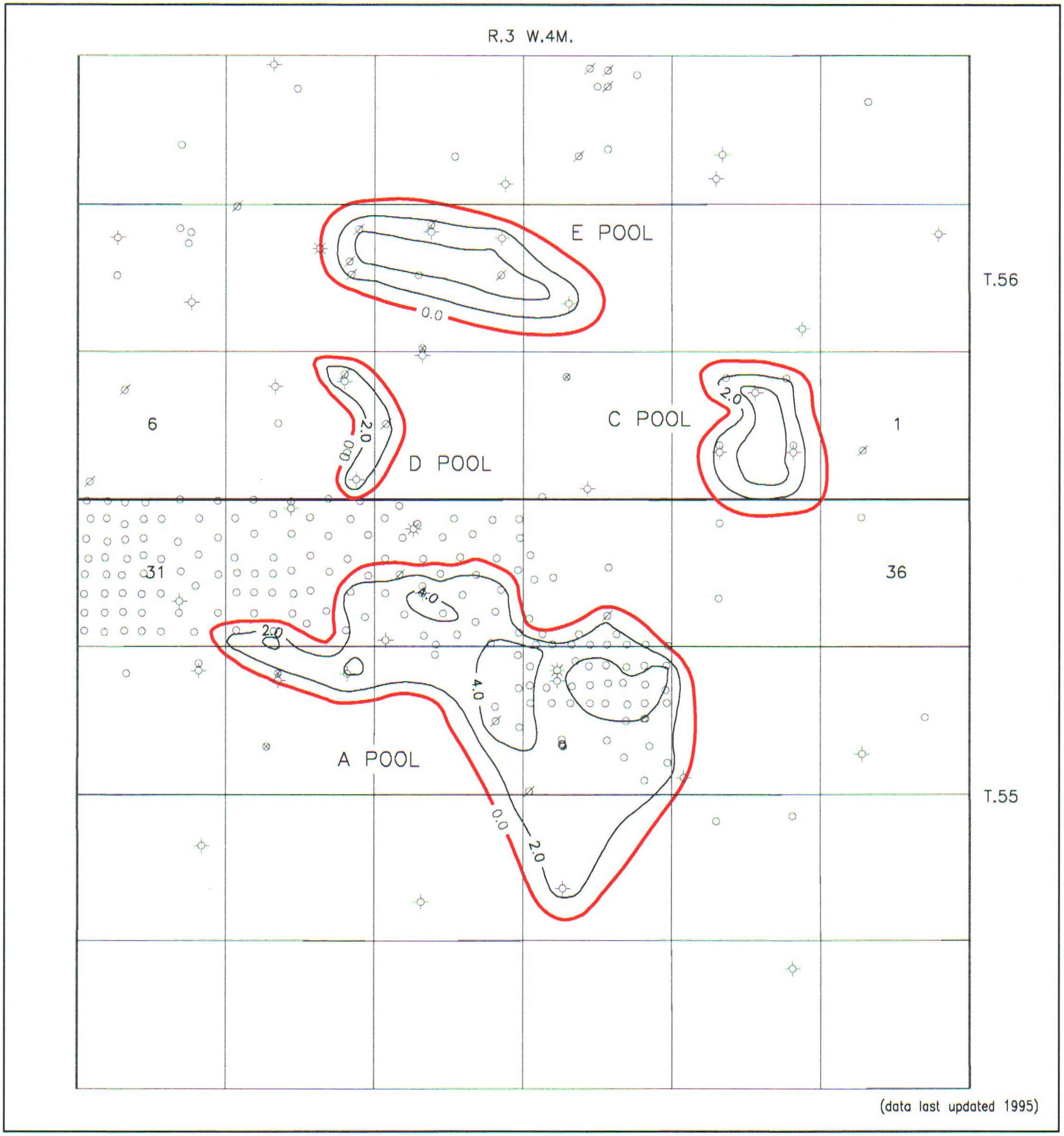
EUB



MAP 4.2c SPARKY SAND
LOWER GRAND RAPIDS DEPOSIT
BEAVERDAM SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
○ Standing/Other Well
Suspended Well
Abandoned Well
● Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

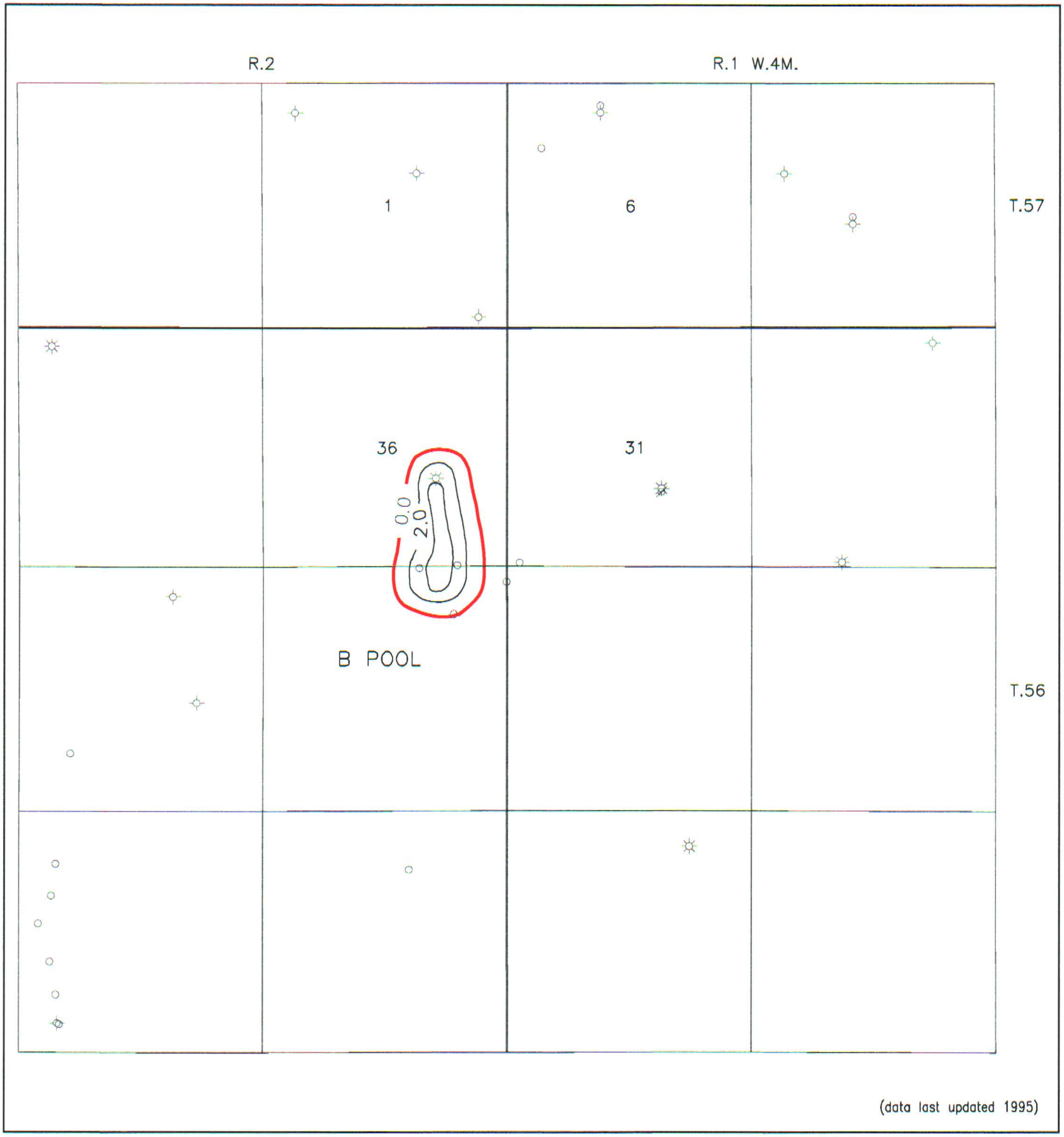
EUB



MAP 4.2d SPARKY SAND
LOWER GRAND RAPIDS DEPOSIT
FROG LAKE SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

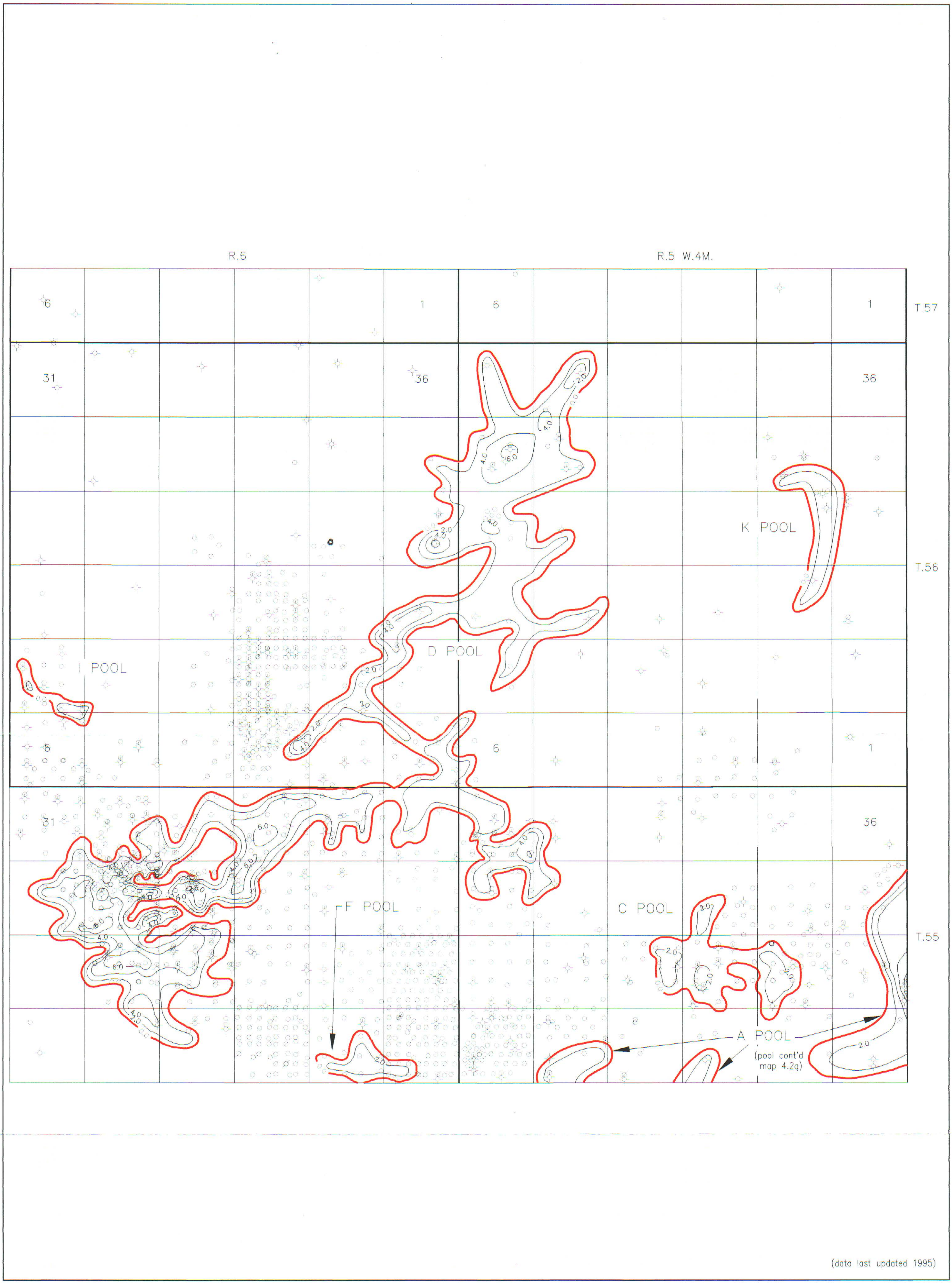
EUB



MAP 4.2e SPARKY SAND
LOWER GRAND RAPIDS DEPOSIT
FROG LAKE SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

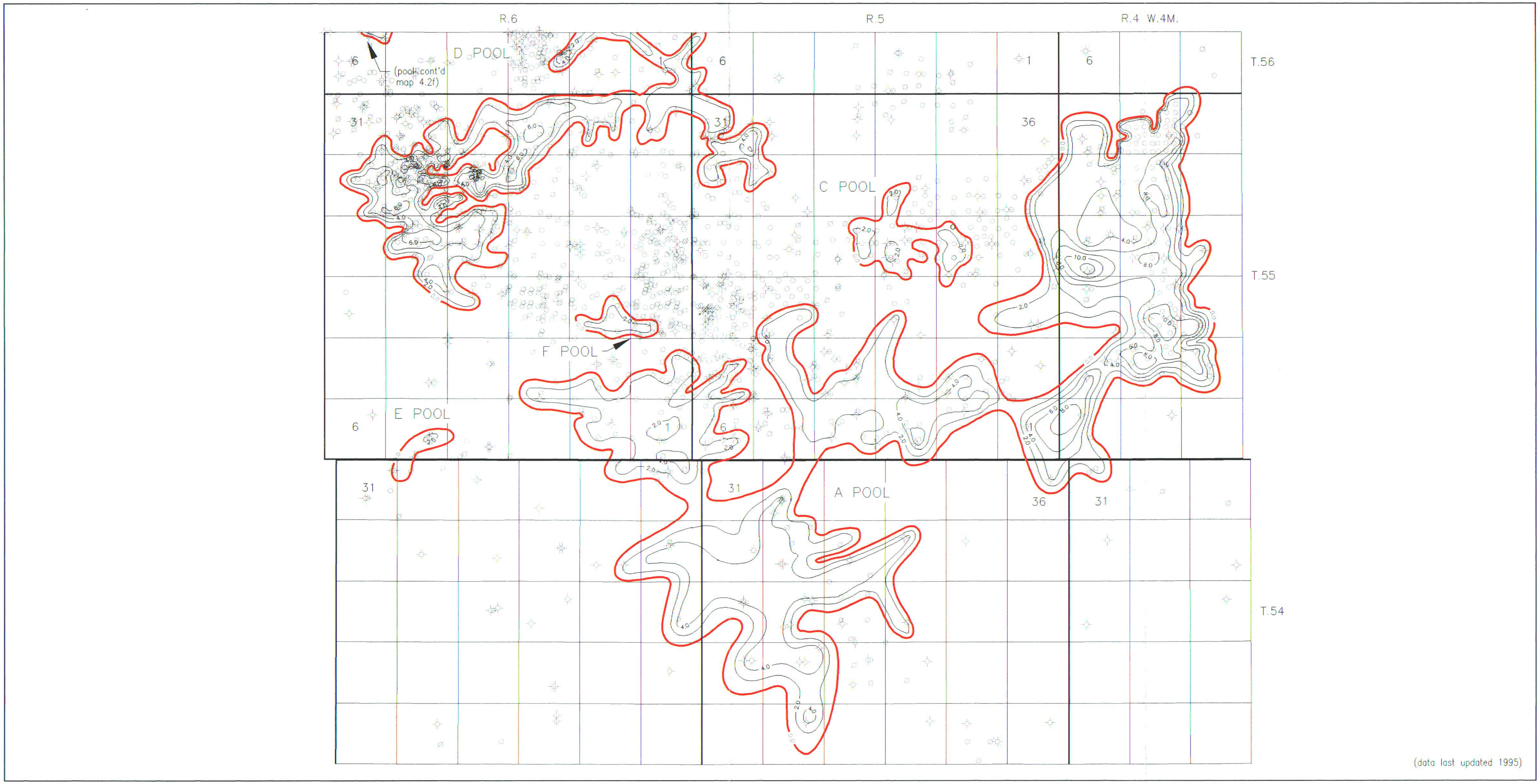
LEGEND
0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB



MAP 4.2f SPARKY SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

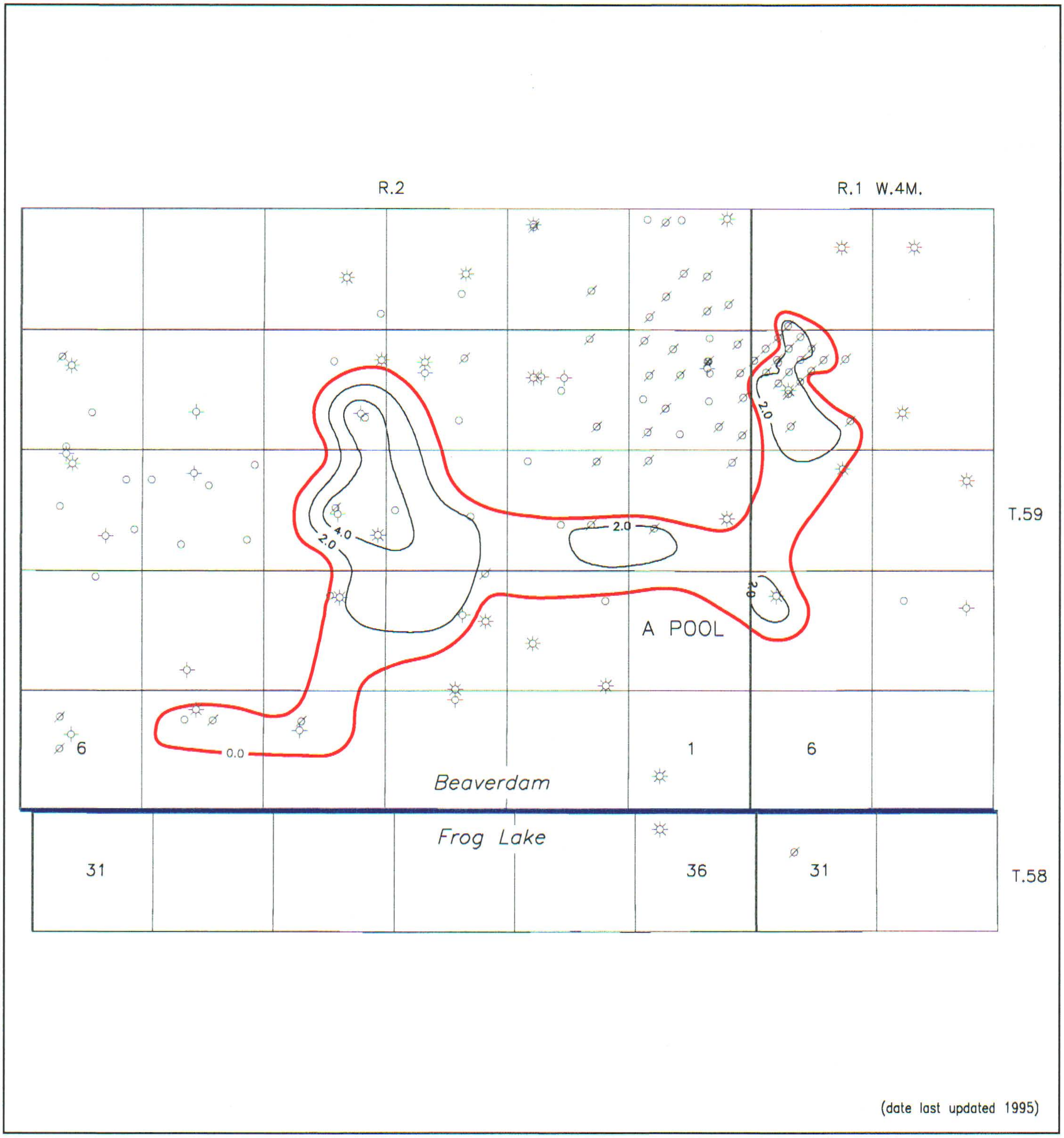


MAP 4.2g SPARKY SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

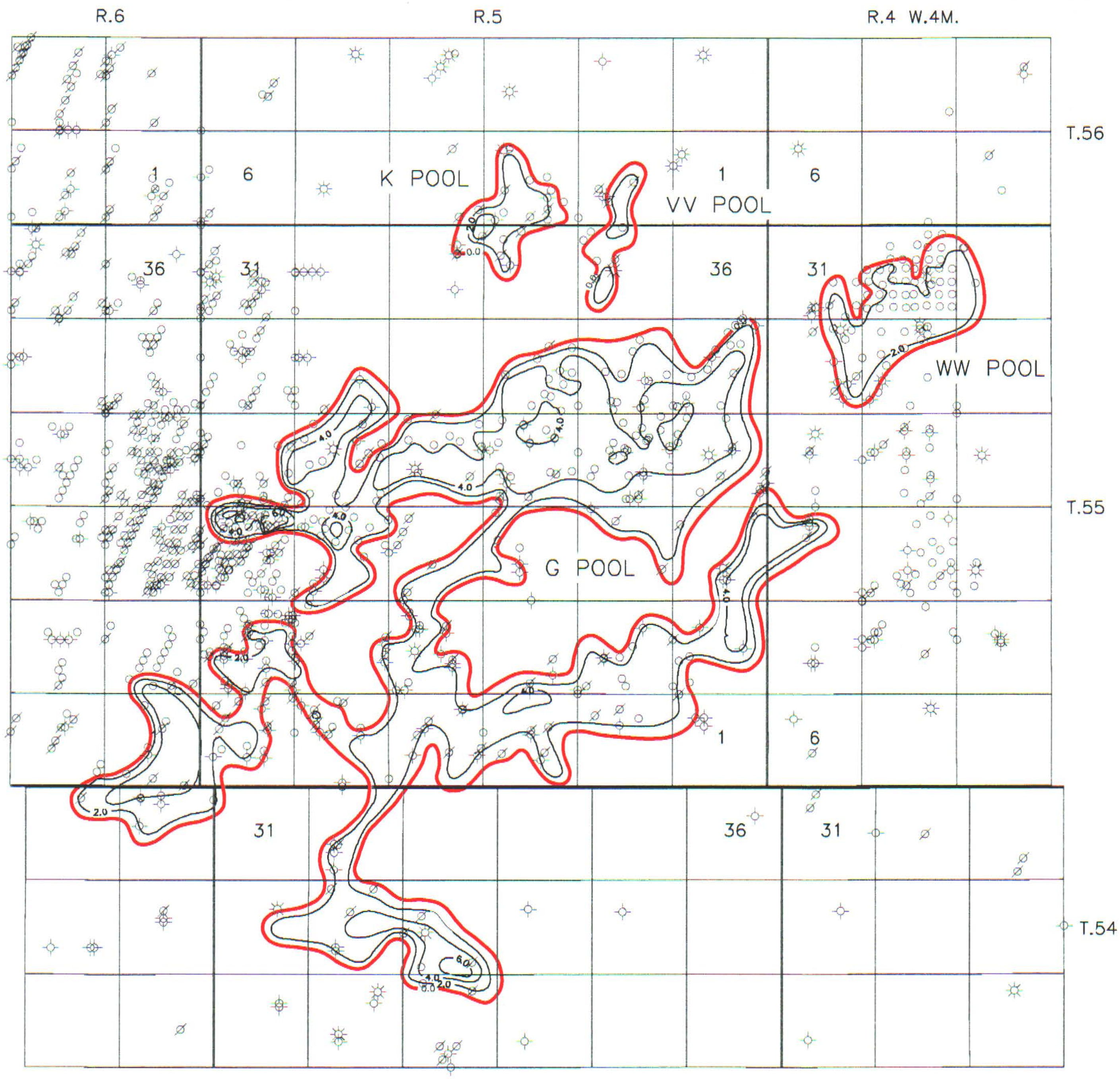
EUB



MAP 4.2h LOWER GRAND RAPIDS #2 SAND
LOWER GRAND RAPIDS DEPOSIT
BEAVERDAM/FROG LAKE SECTORS
COLD LAKE OIL SANDS
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB



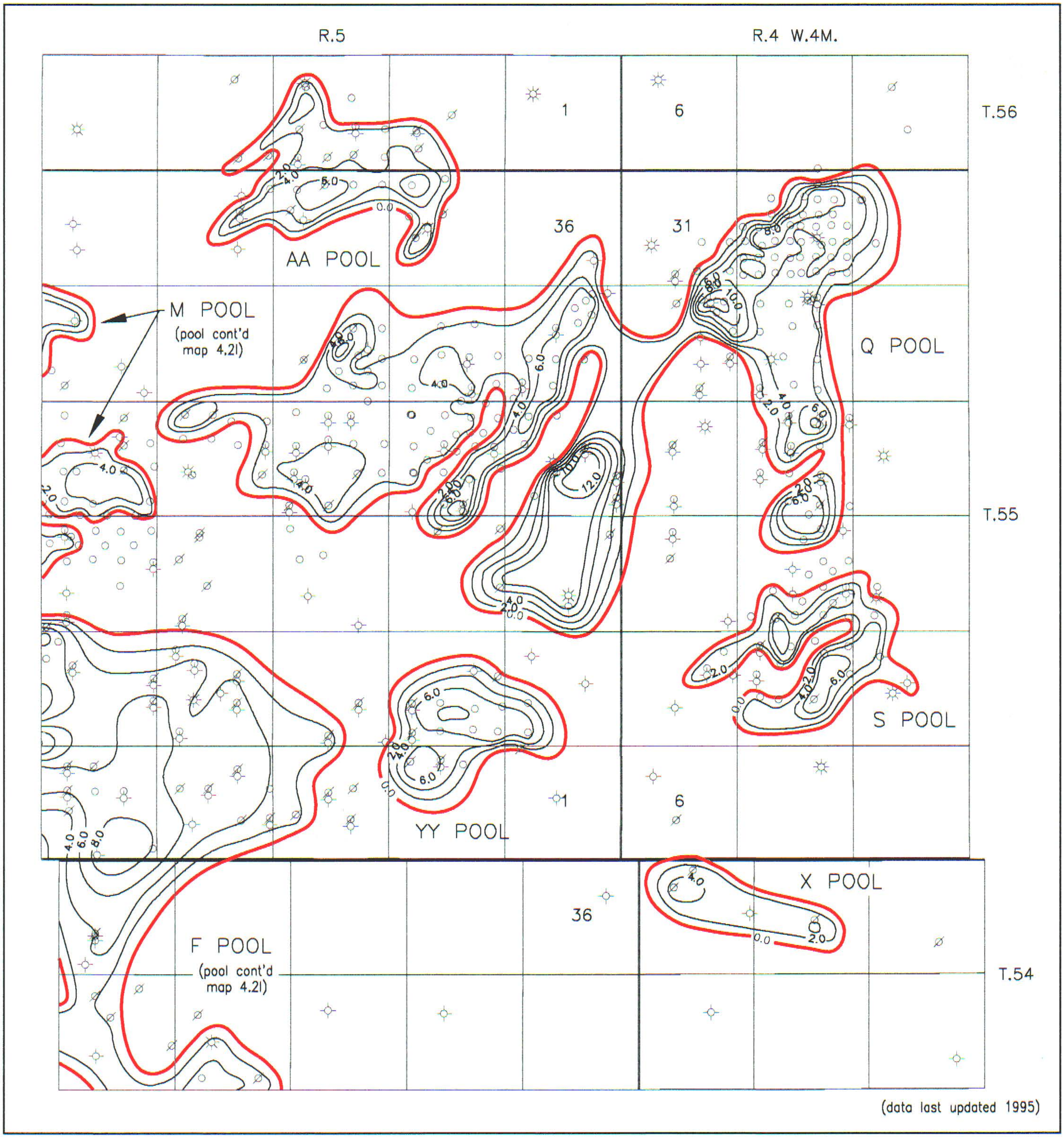
(date last updated 1995)

MAP 4.2i LOWER GRAND RAPIDS #2 SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB

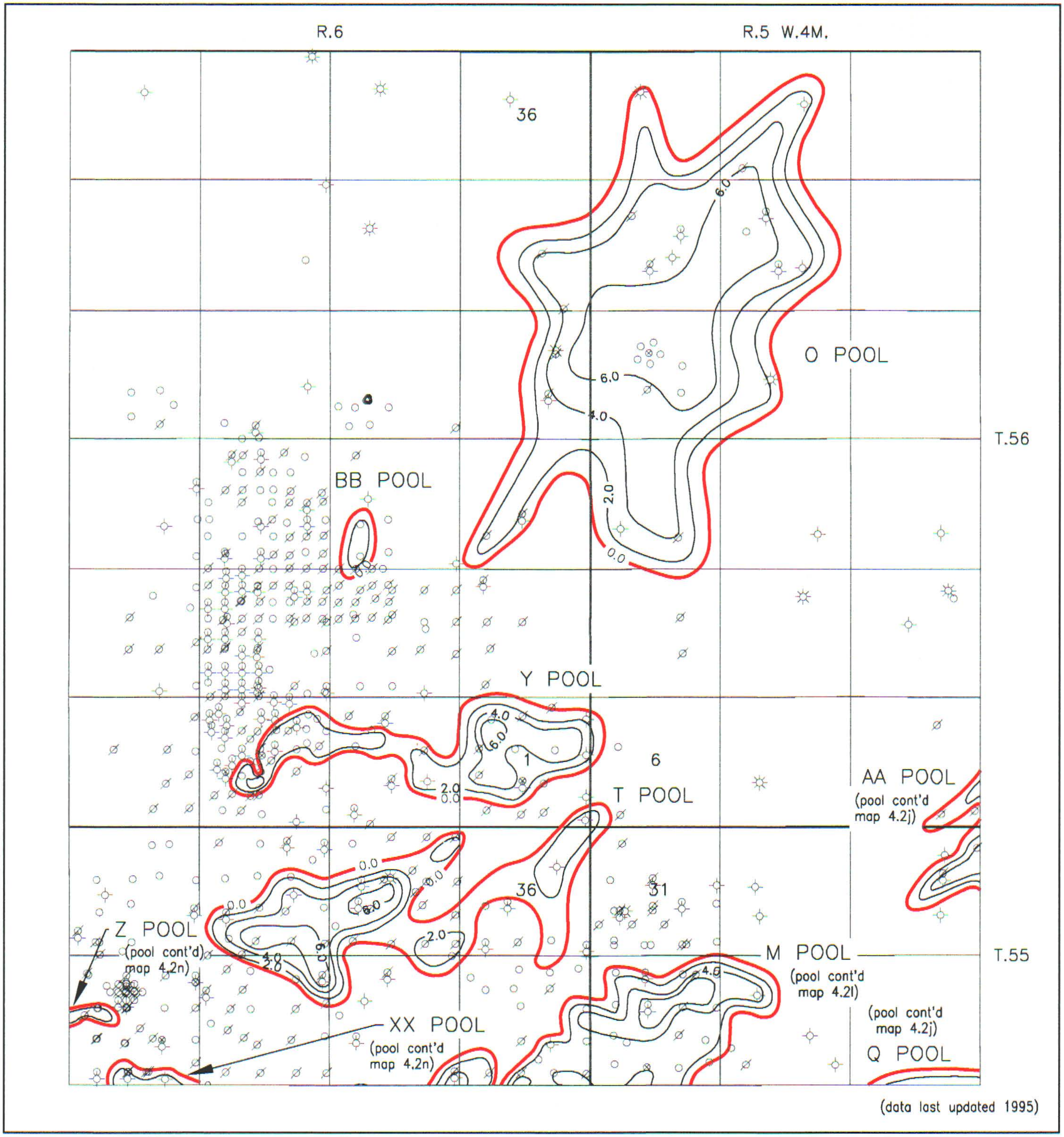


MAP 4.2j LOWER GRAND RAPIDS #3 SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB

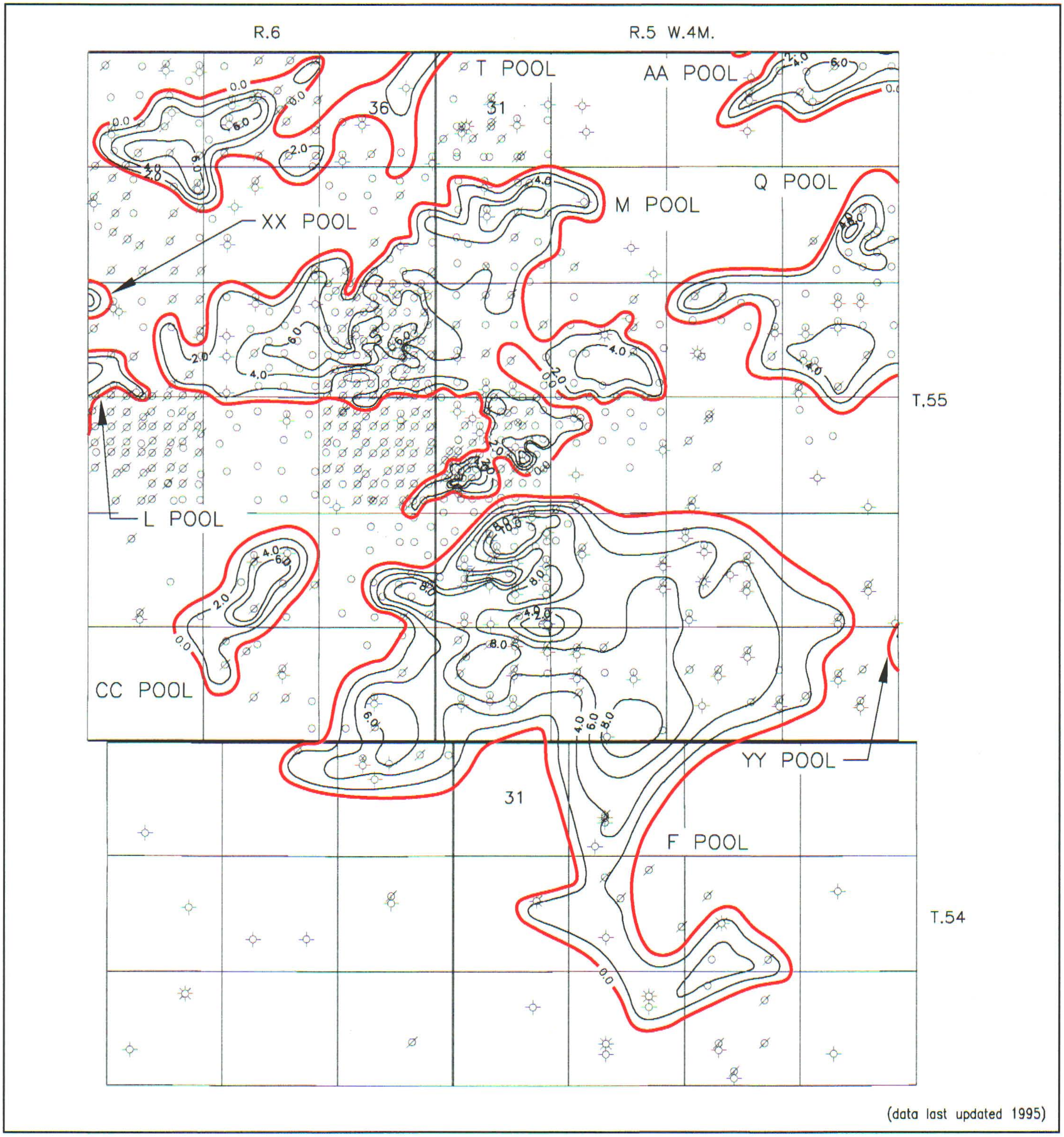


MAP 4.2k LOWER GRAND RAPIDS #3 SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- ○ Standing/Other Well
- Suspended Well
- Abandoned Well
- ● Oil Well
- Gas Well
- Injection Well
- Observation Well
- ⊗ Disposal Well

EUB

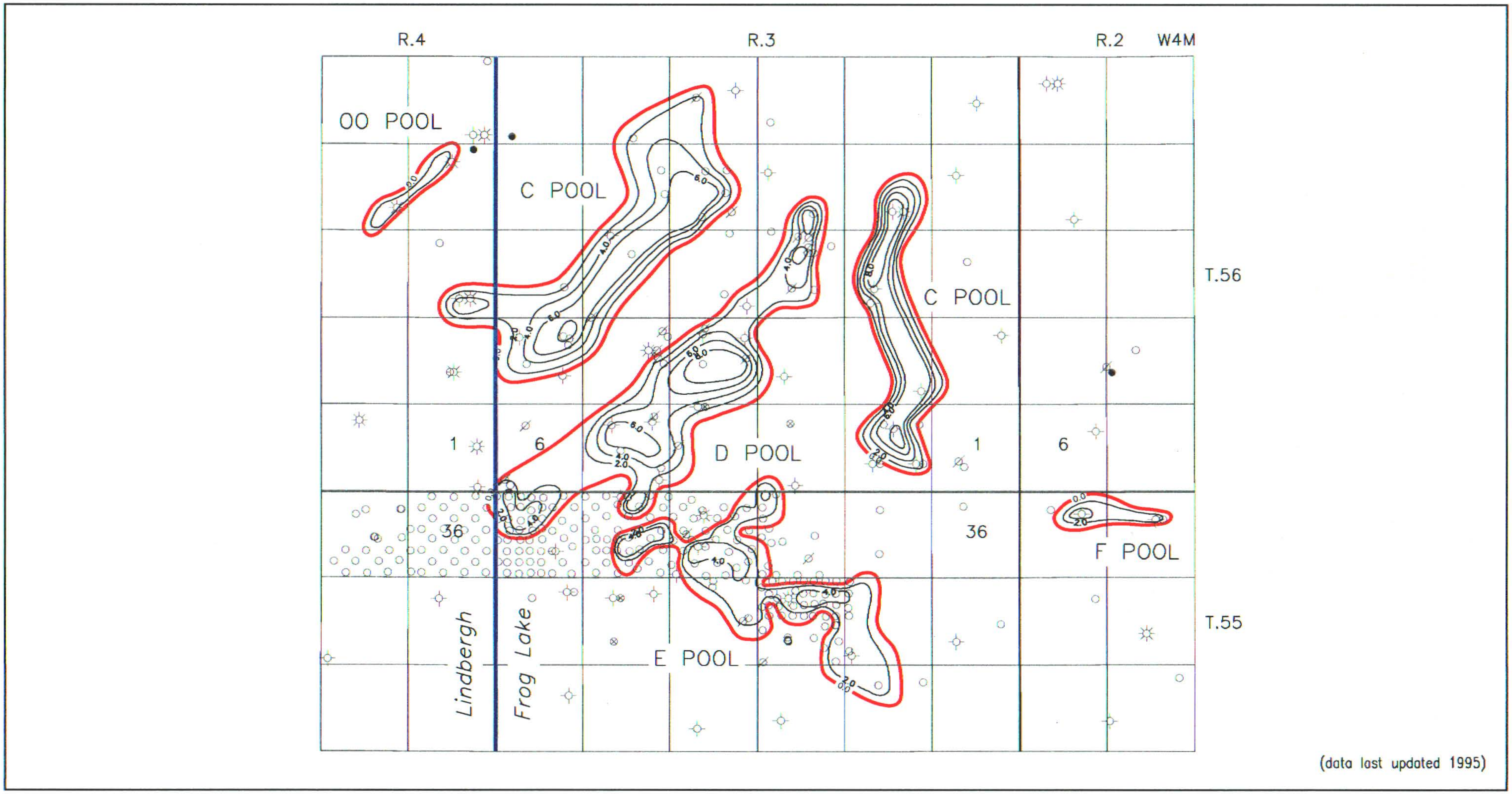


MAP 4.21 LOWER GRAND RAPIDS #3 SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

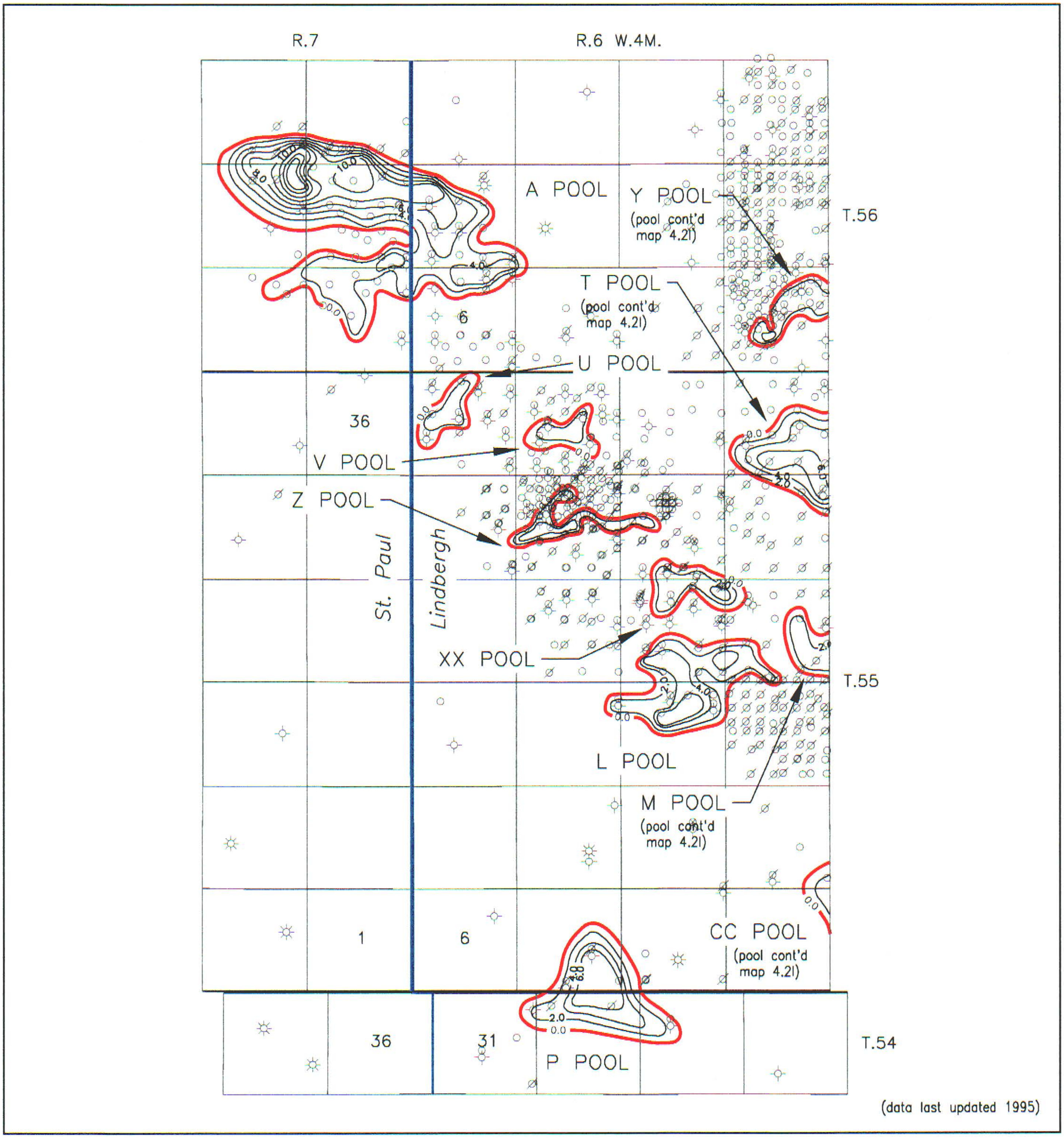


MAP 4.2m LOWER GRAND RAPIDS #3 SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

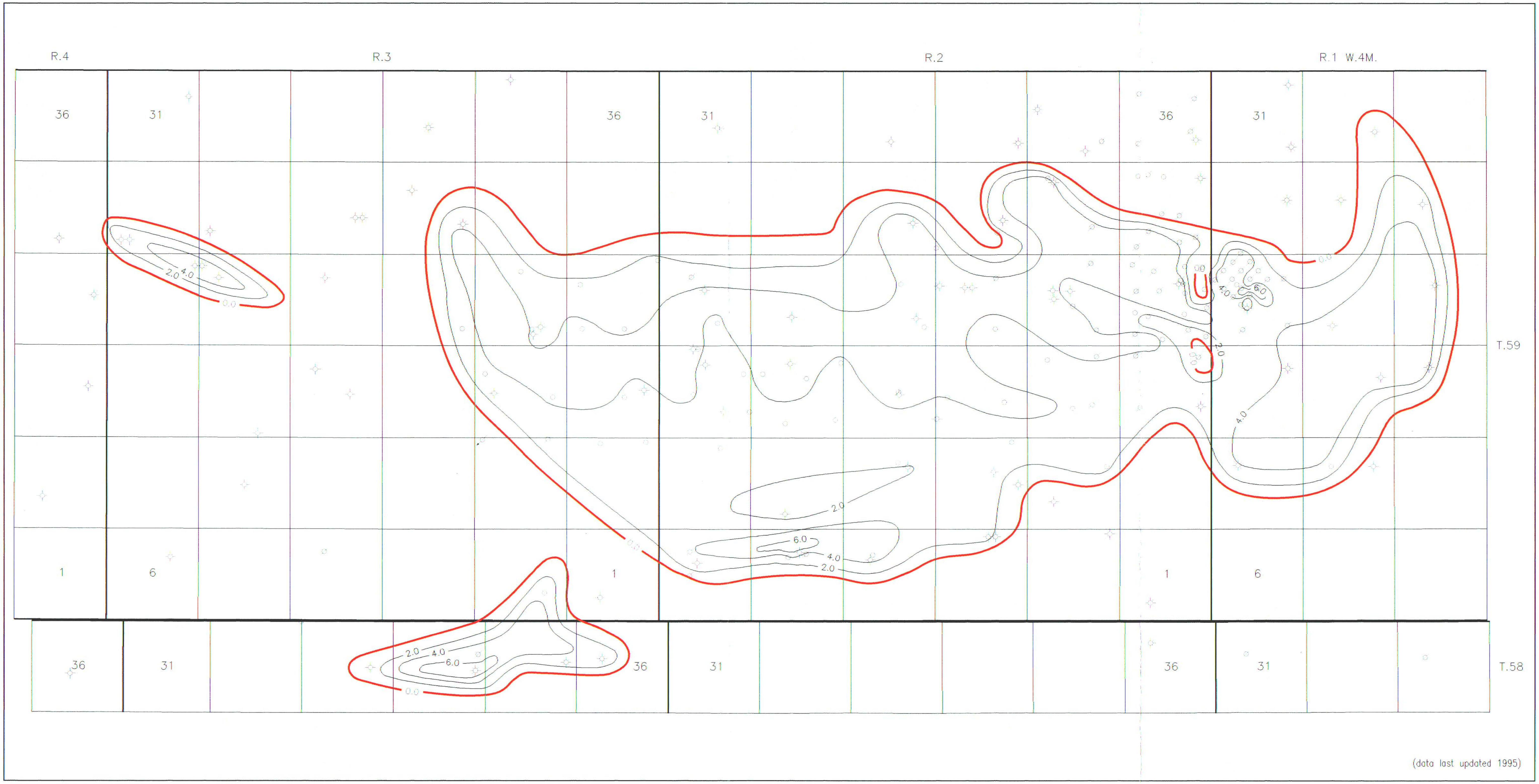
EUB



MAP 4.2n LOWER GRAND RAPIDS #3 SAND
LOWER GRAND RAPIDS DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

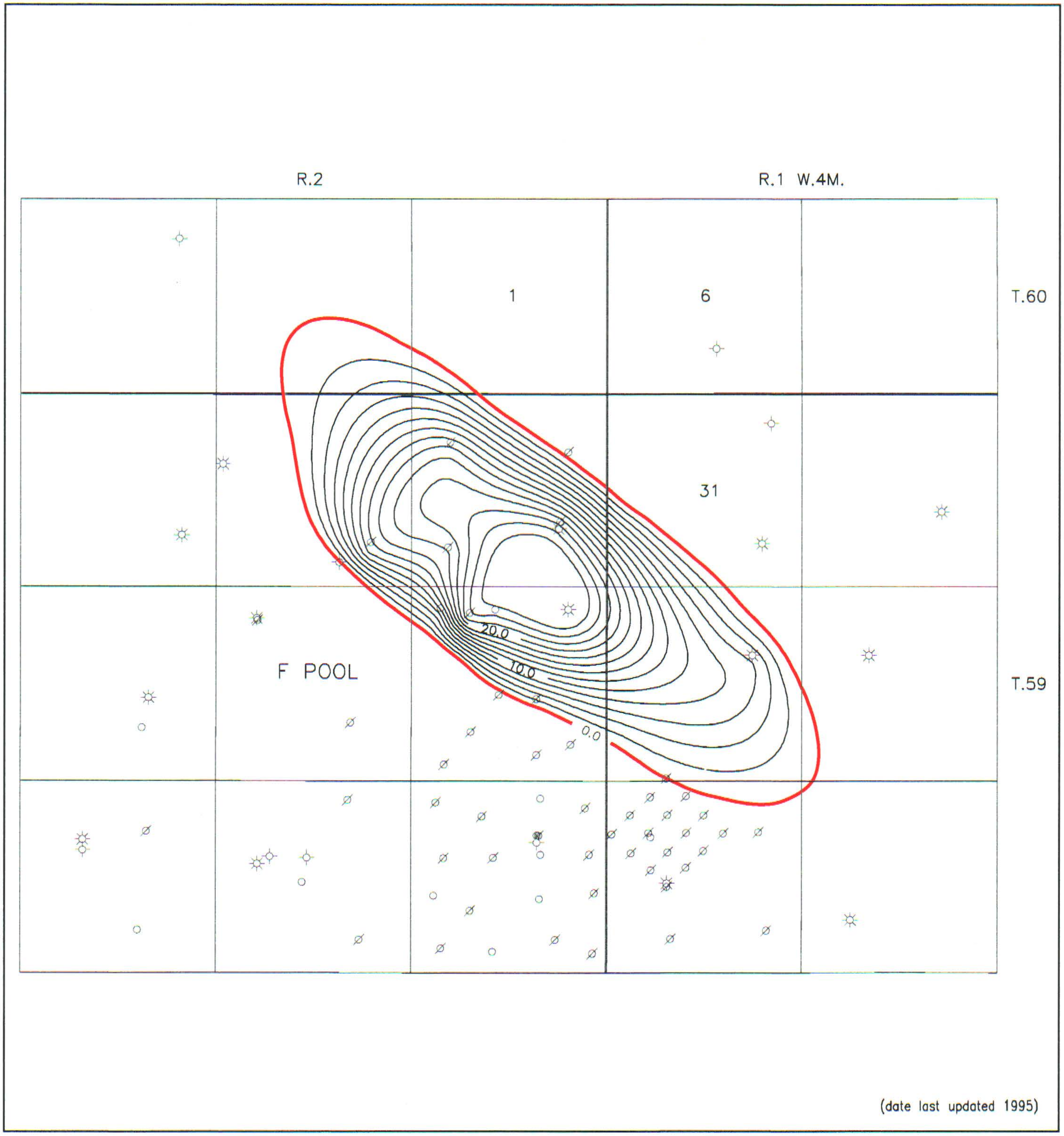


MAP 4.2o LOWER GRAND RAPIDS #3 SAND
LOWER GRAND RAPIDS DEPOSIT
FROG LAKE/BEAVERDAM SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

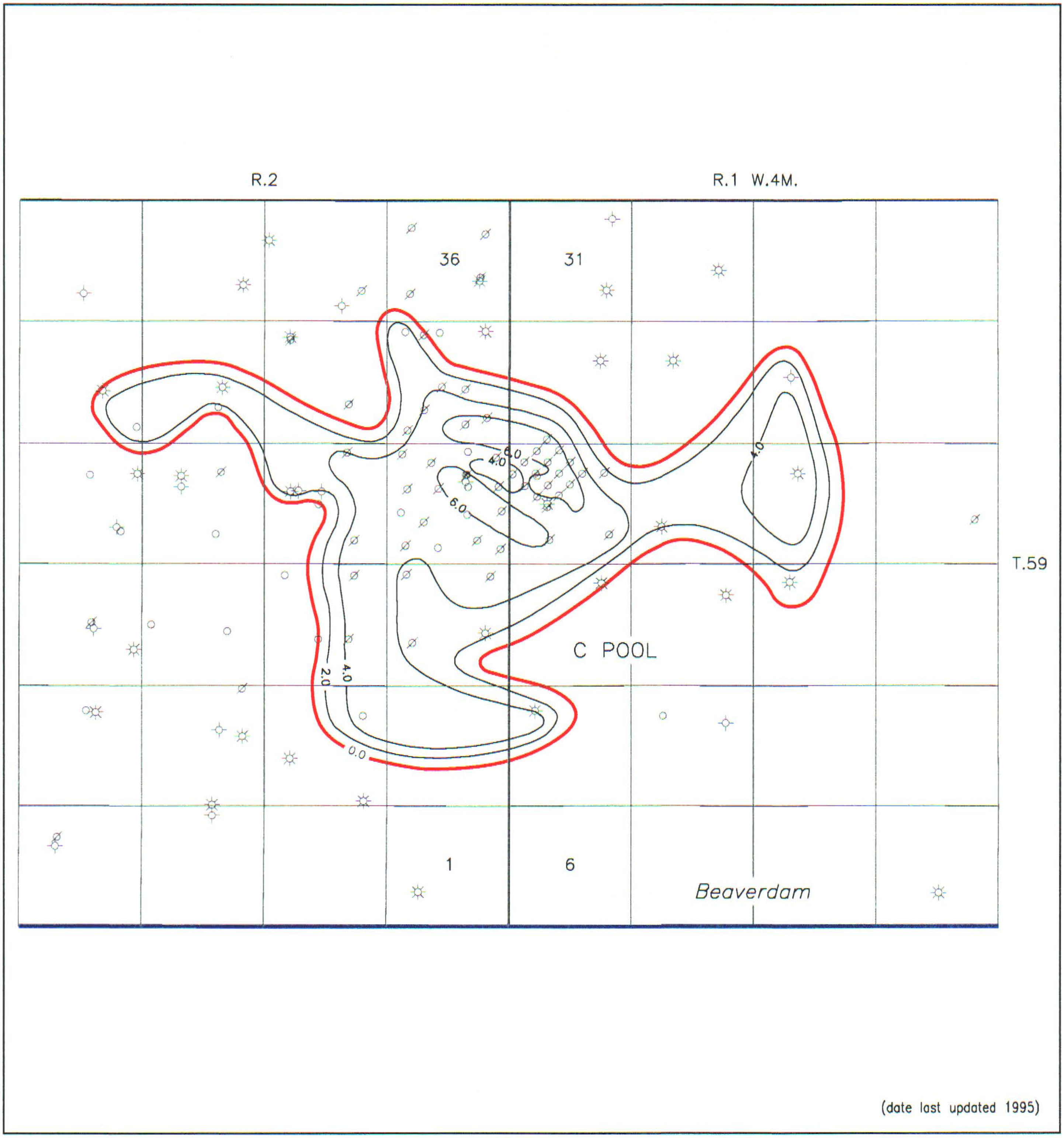


MAP 4.2p LOWER GRAND RAPIDS CHANNEL SAND
LOWER GRAND RAPIDS DEPOSIT
BEAVERDAM SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

EUB

LEGEND

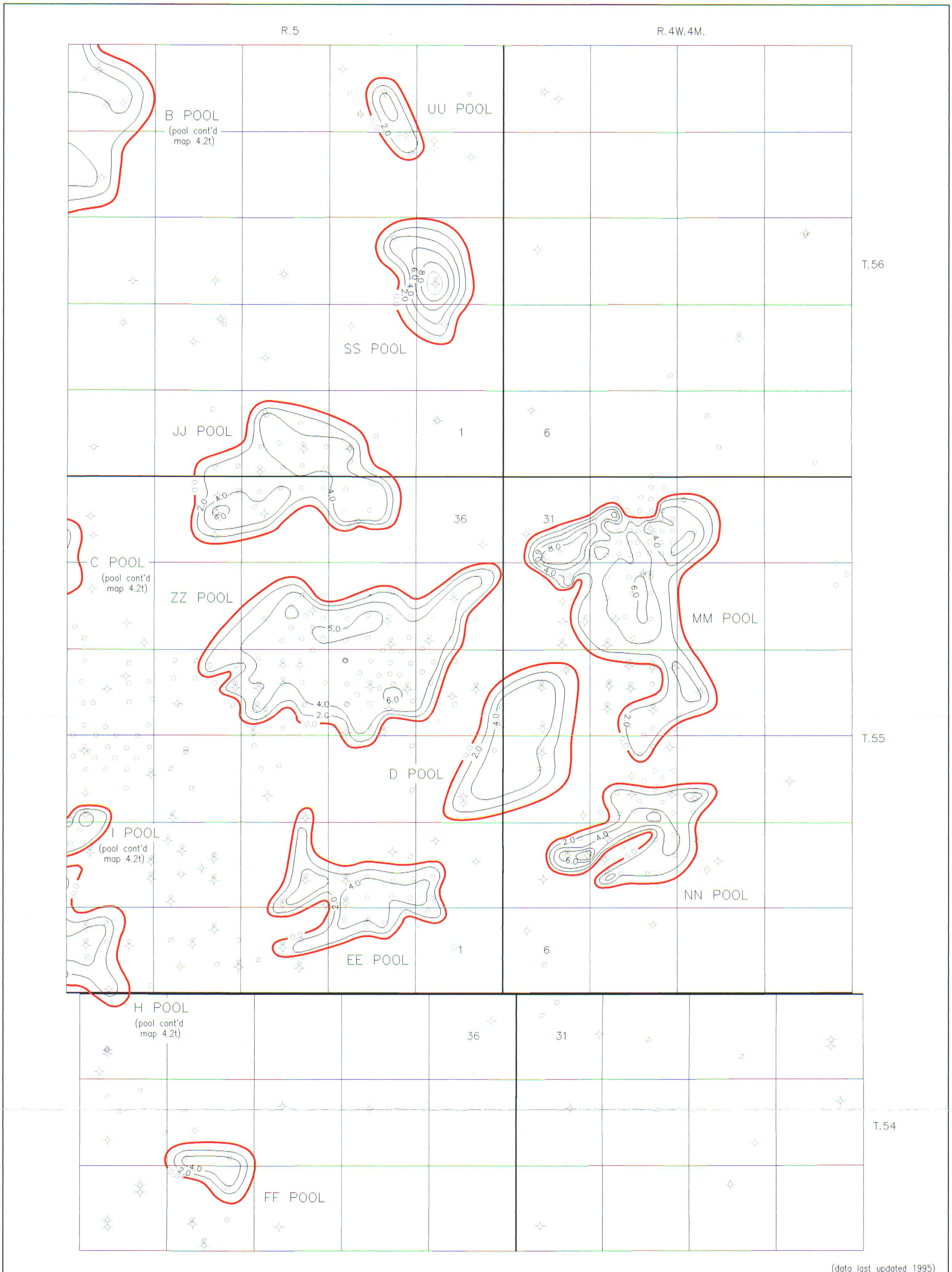
0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well



MAP 4.2q LOWER GRAND RAPIDS #4 SAND
LOWER GRAND RAPIDS DEPOSIT
BEAVERDAM SECTOR
COLD LAKE OIL SANDS
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

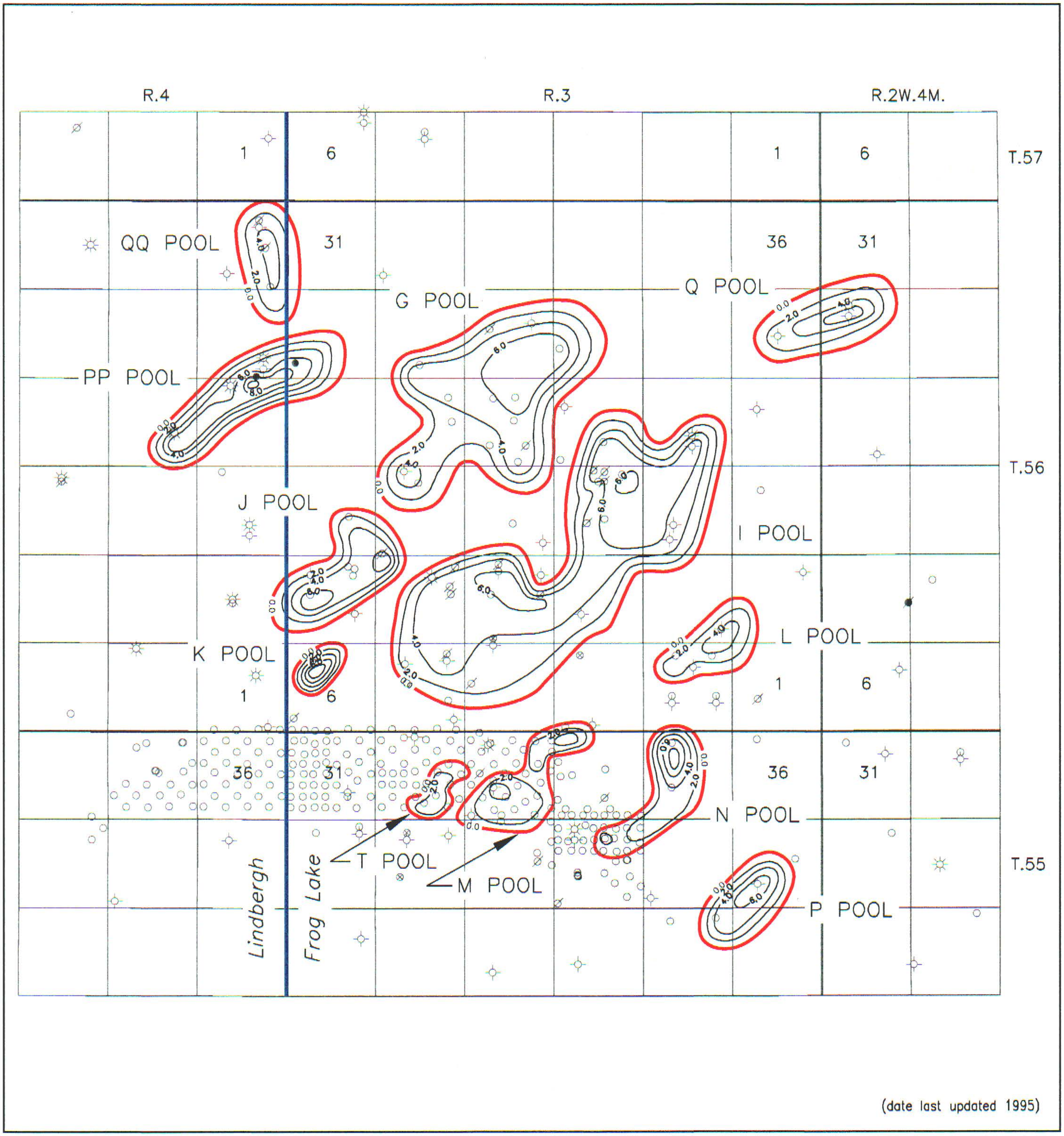
EUB



MAP 4.2r LOWER GRAND RAPIDS #4 SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

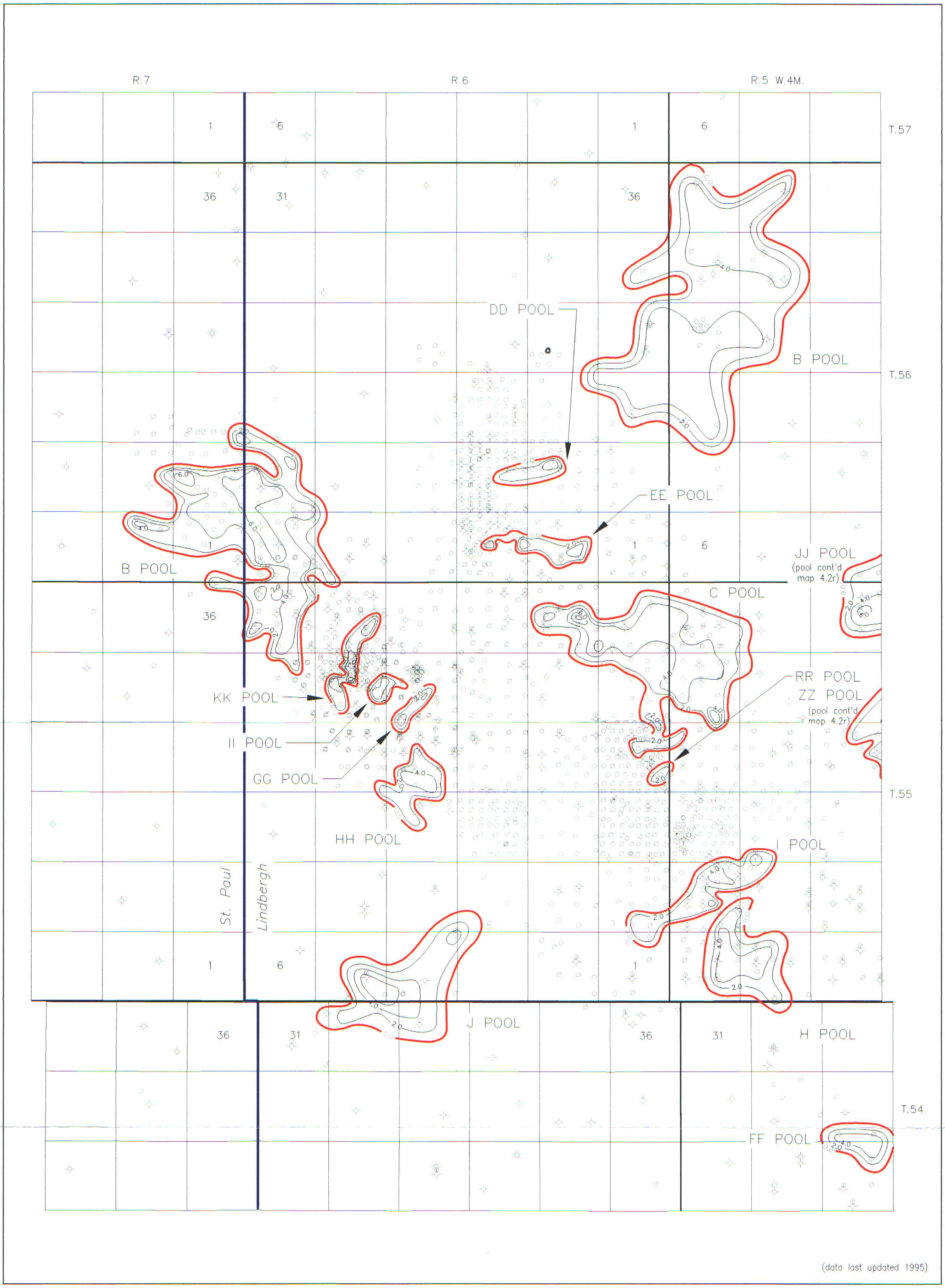
EUB



MAP 4.2s LOWER GRAND RAPIDS #4 SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

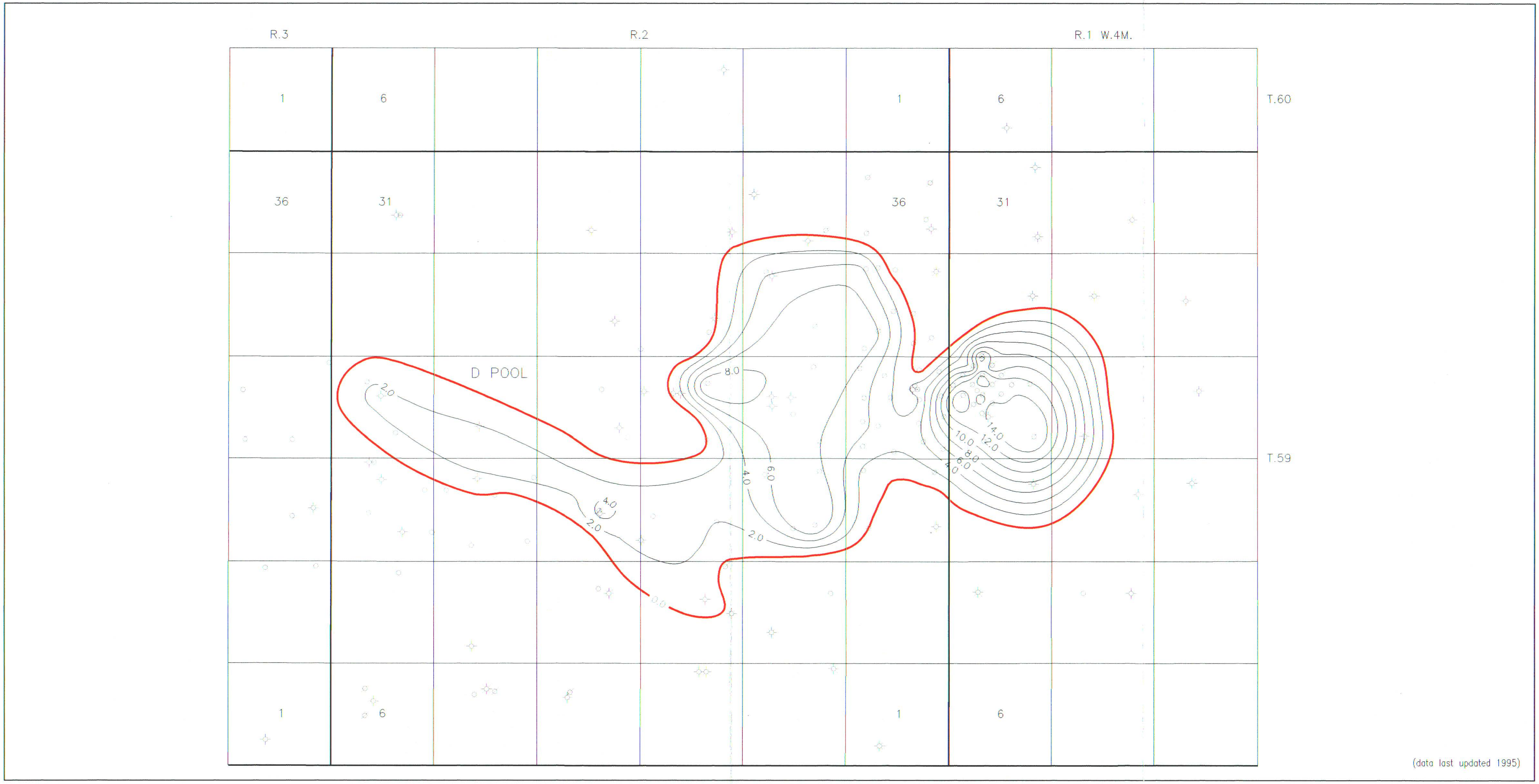
EUB



MAP 4.2t LOWER GRAND RAPIDS #4 SAND
LOWER GRAND RAPIDS DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
- Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

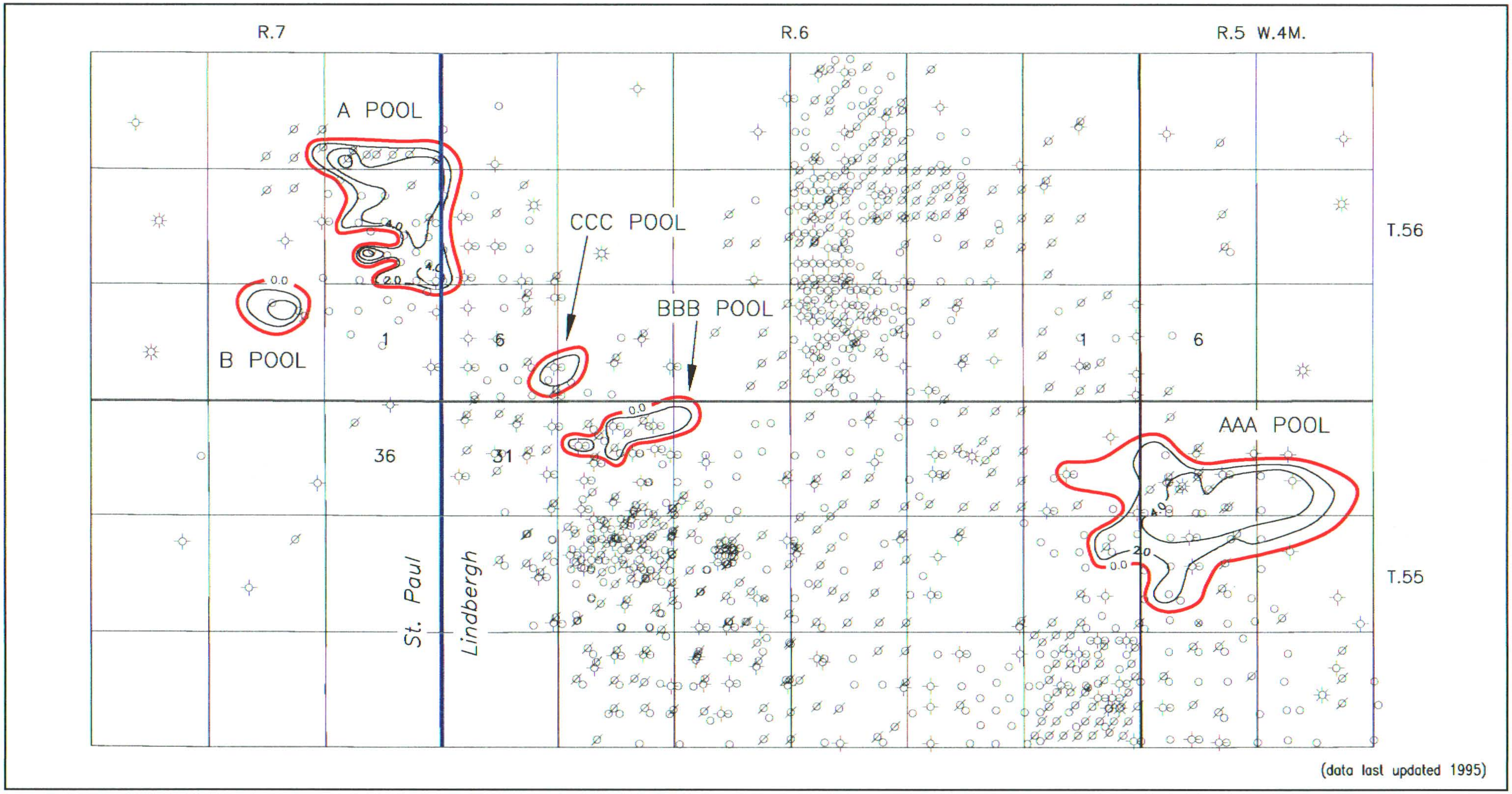
EUB



MAP 4.2u LOWER GRAND RAPIDS #5 SAND
LOWER GRAND RAPIDS DEPOSIT
BEAVERDAM SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
- 0.0 Contour Interval = 2.0 meters
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

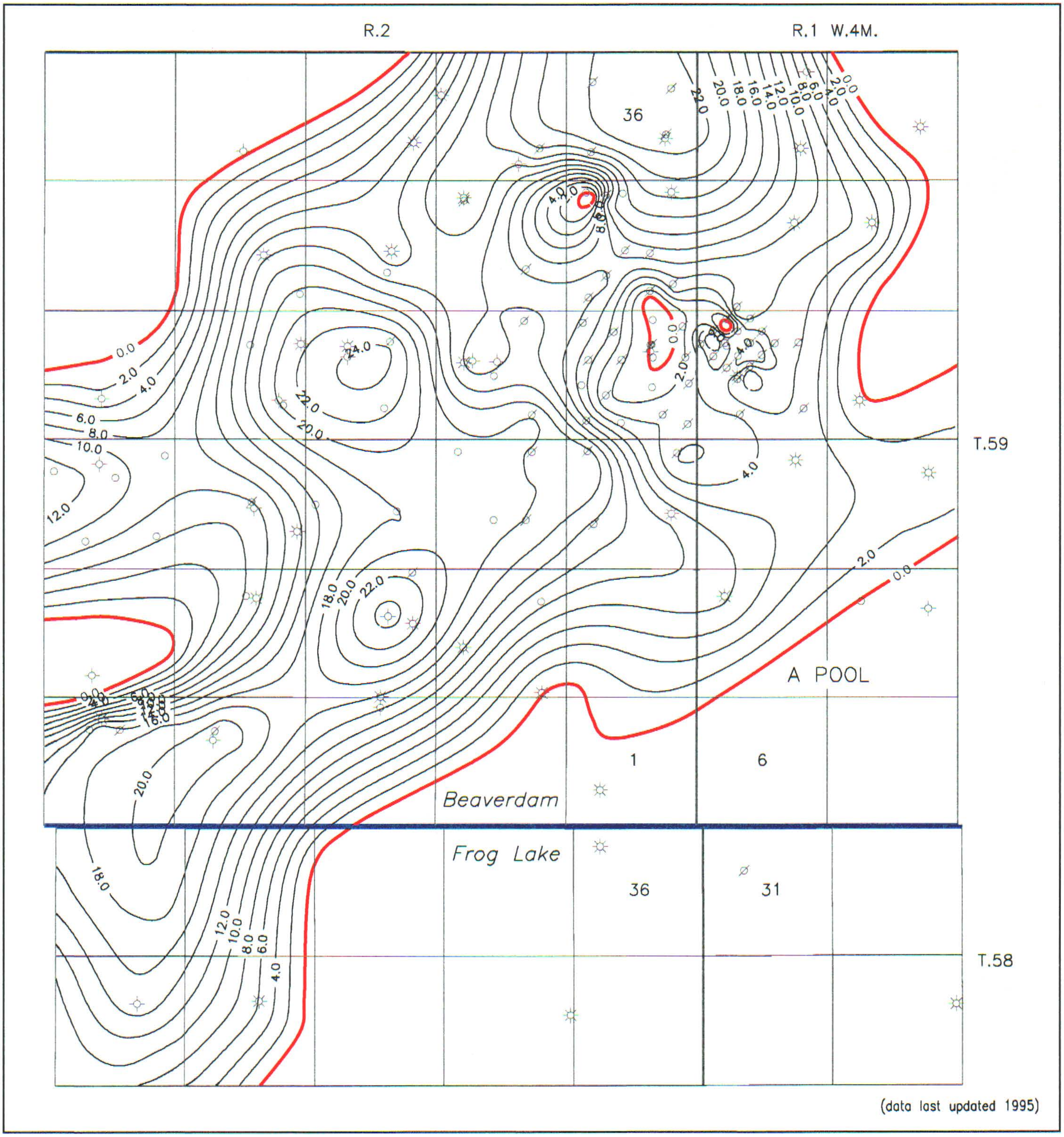


MAP 4.2v LOWER GRAND RAPIDS #5 SAND
LOWER GRAND RAPIDS DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

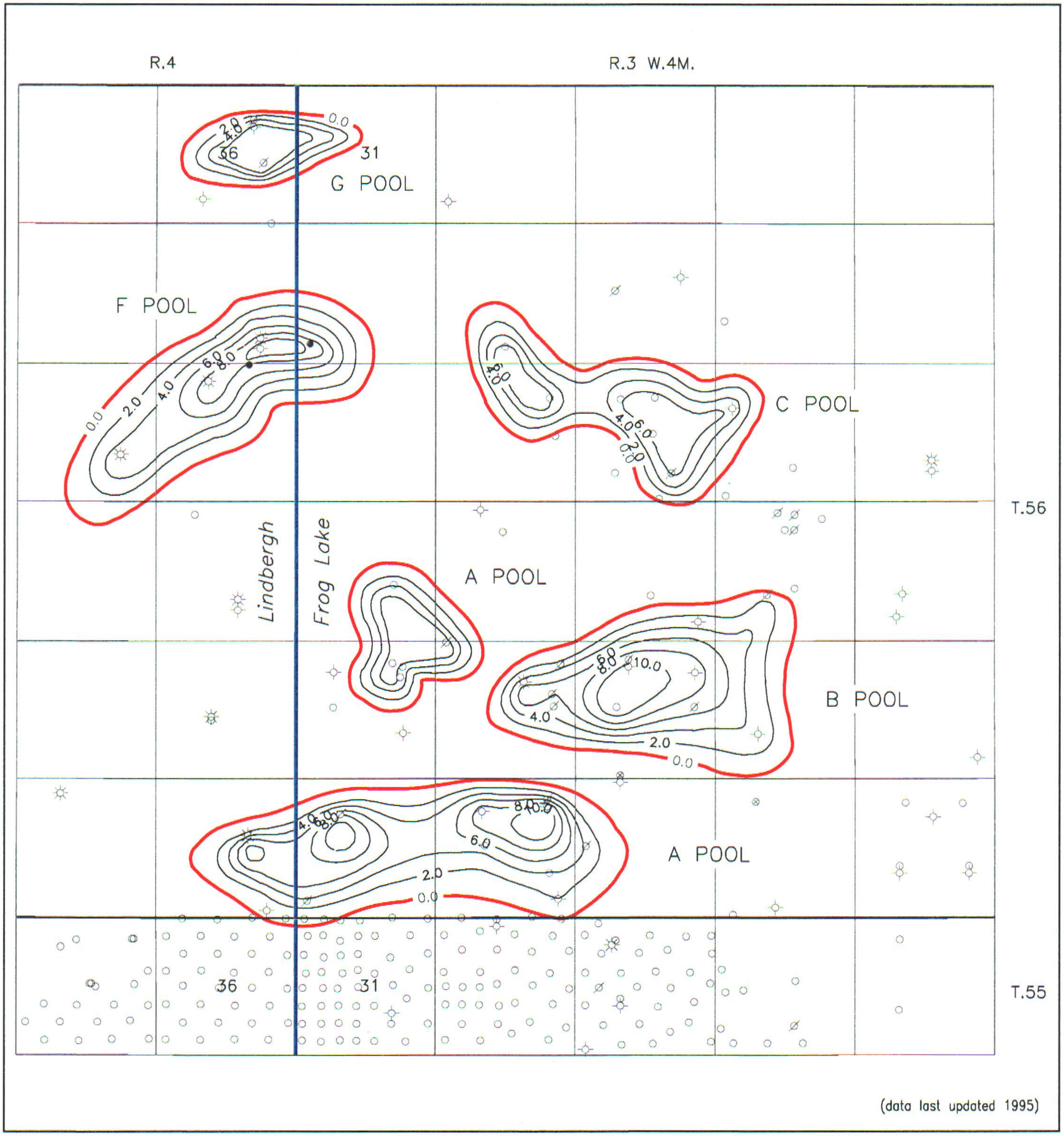
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB



MAP 4.2w LLOYDMINSTER SAND
LOWER GRAND RAPIDS DEPOSIT
FROG LAKE/BEAVERDAM SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

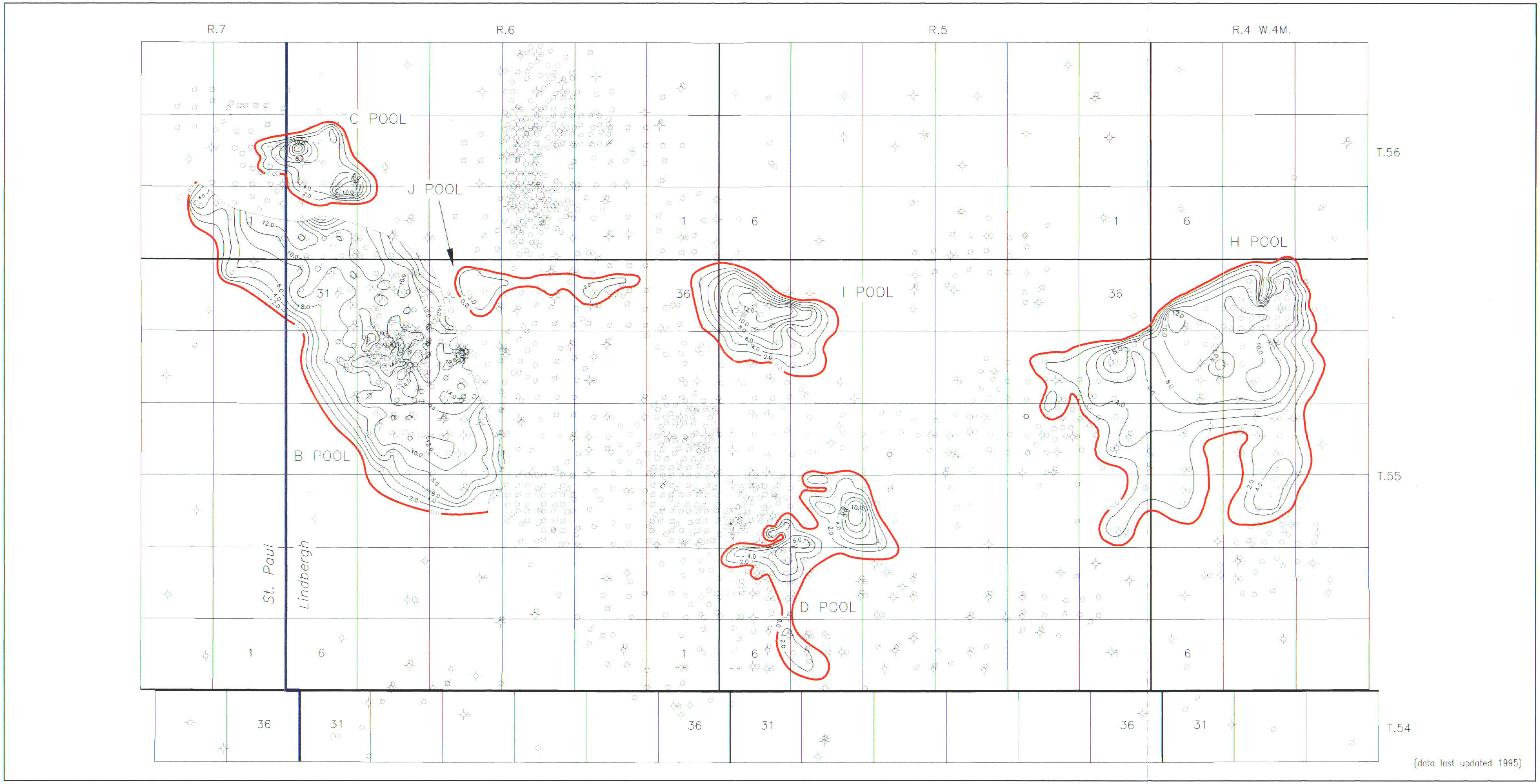


MAP 4.2x LLOYDMINSTER SAND
LOWER GRAND RAPIDS DEPOSIT
LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

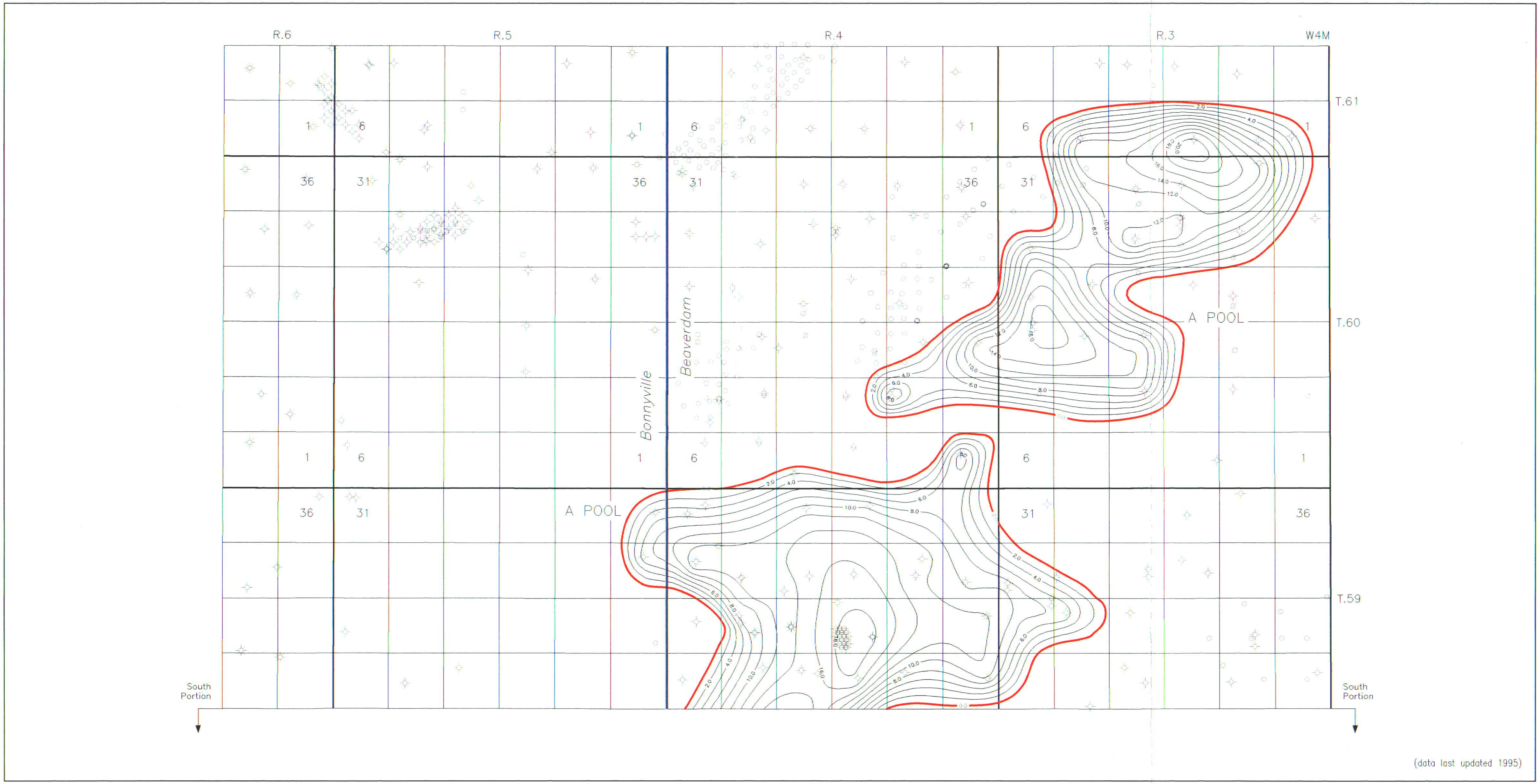
EUB



MAP 4.2y LLOYDMINSTER SAND
LOWER GRAND RAPIDS DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
- Contour Interval = 2.0 meters
- Sector Line
- Erosional Edge
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

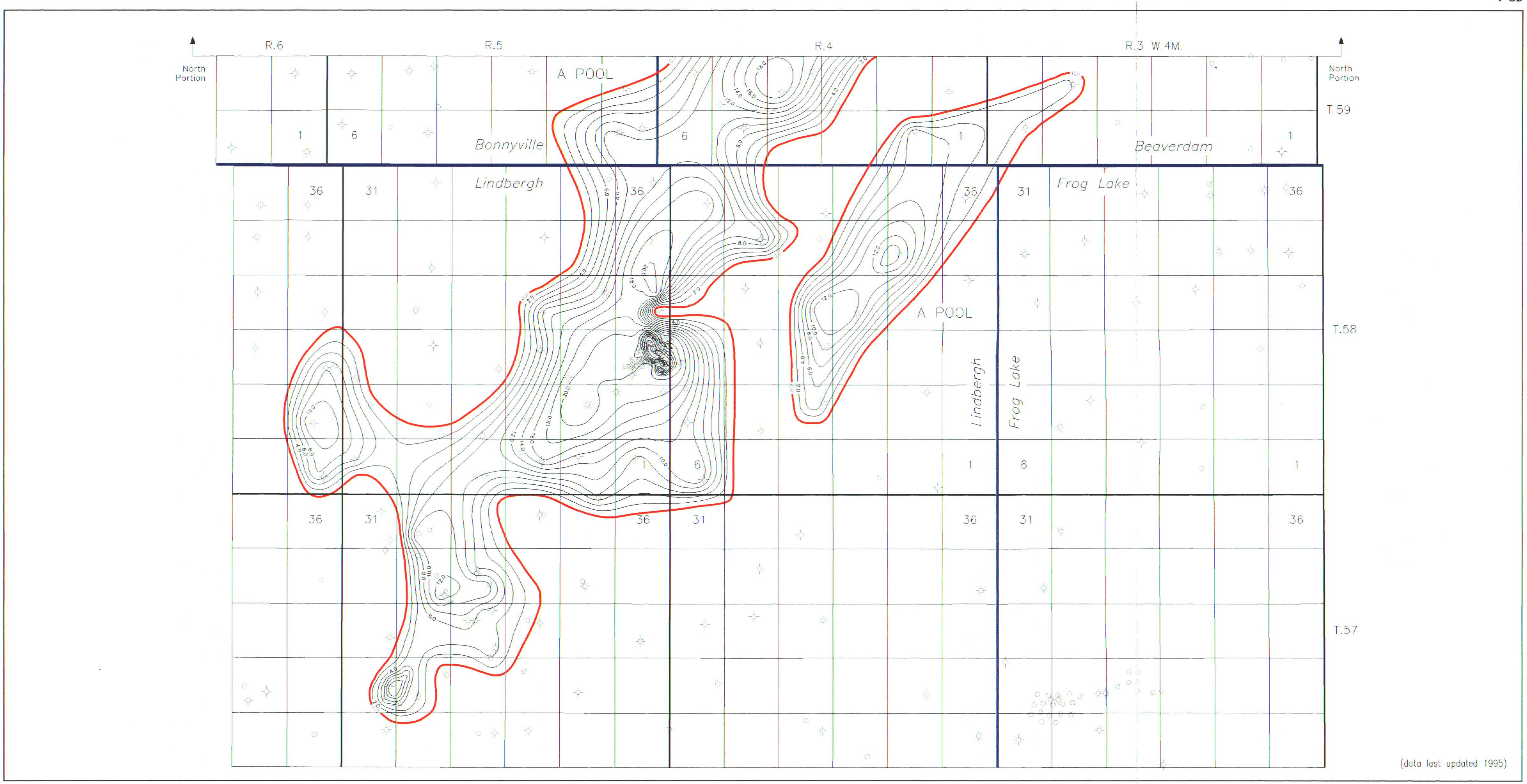
EUB



MAP 4.2z LLOYDMINSTER SAND (north portion)
LOWER GRAND RAPIDS DEPOSIT
BONNYVILLE/BEAVERDAM SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

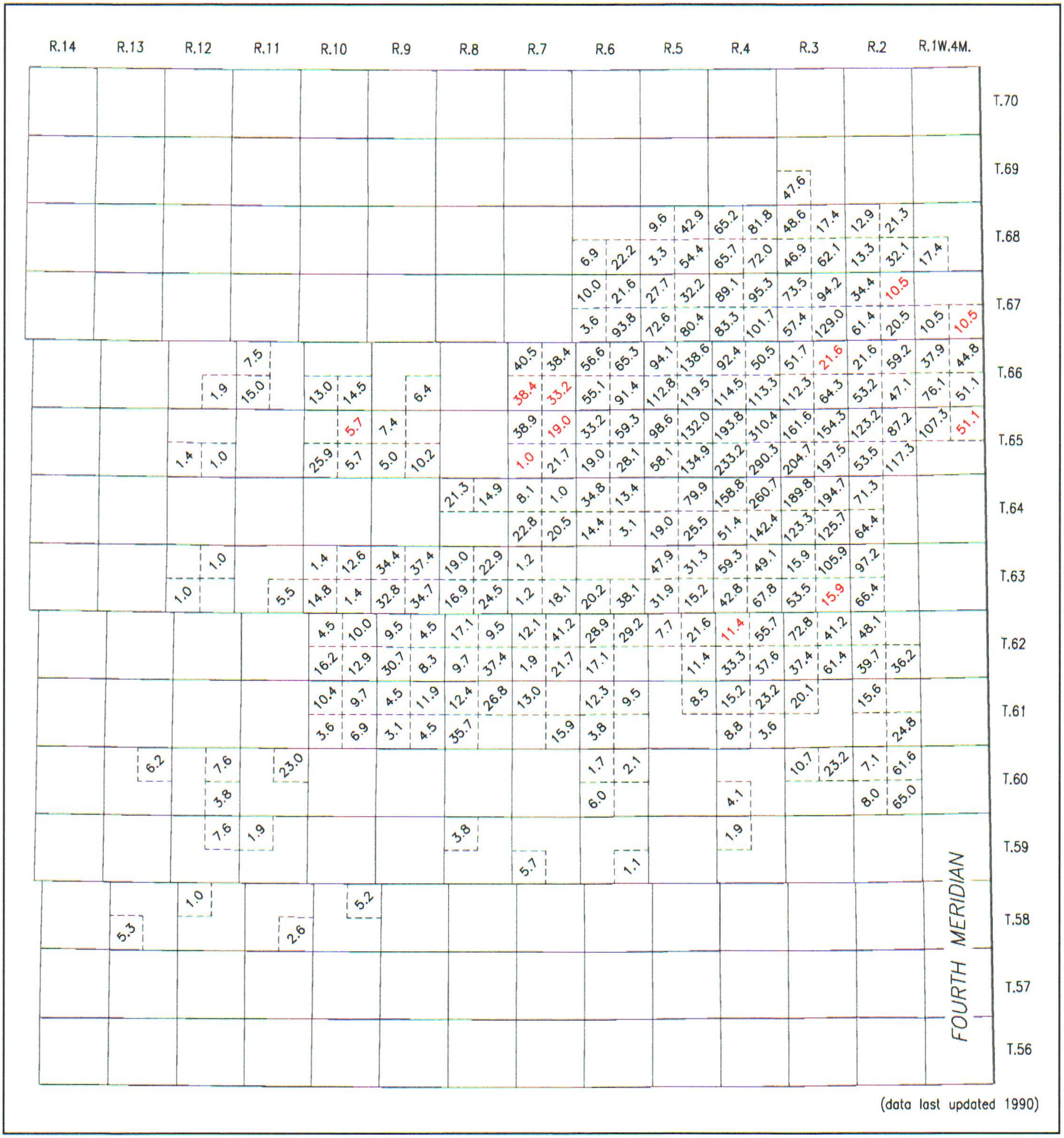
EUB



MAP 4.2z LLOYDMINSTER SAND (south portion)
LOWER GRAND RAPIDS DEPOSIT
BONNYVILLE/BEAVERDAM/LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

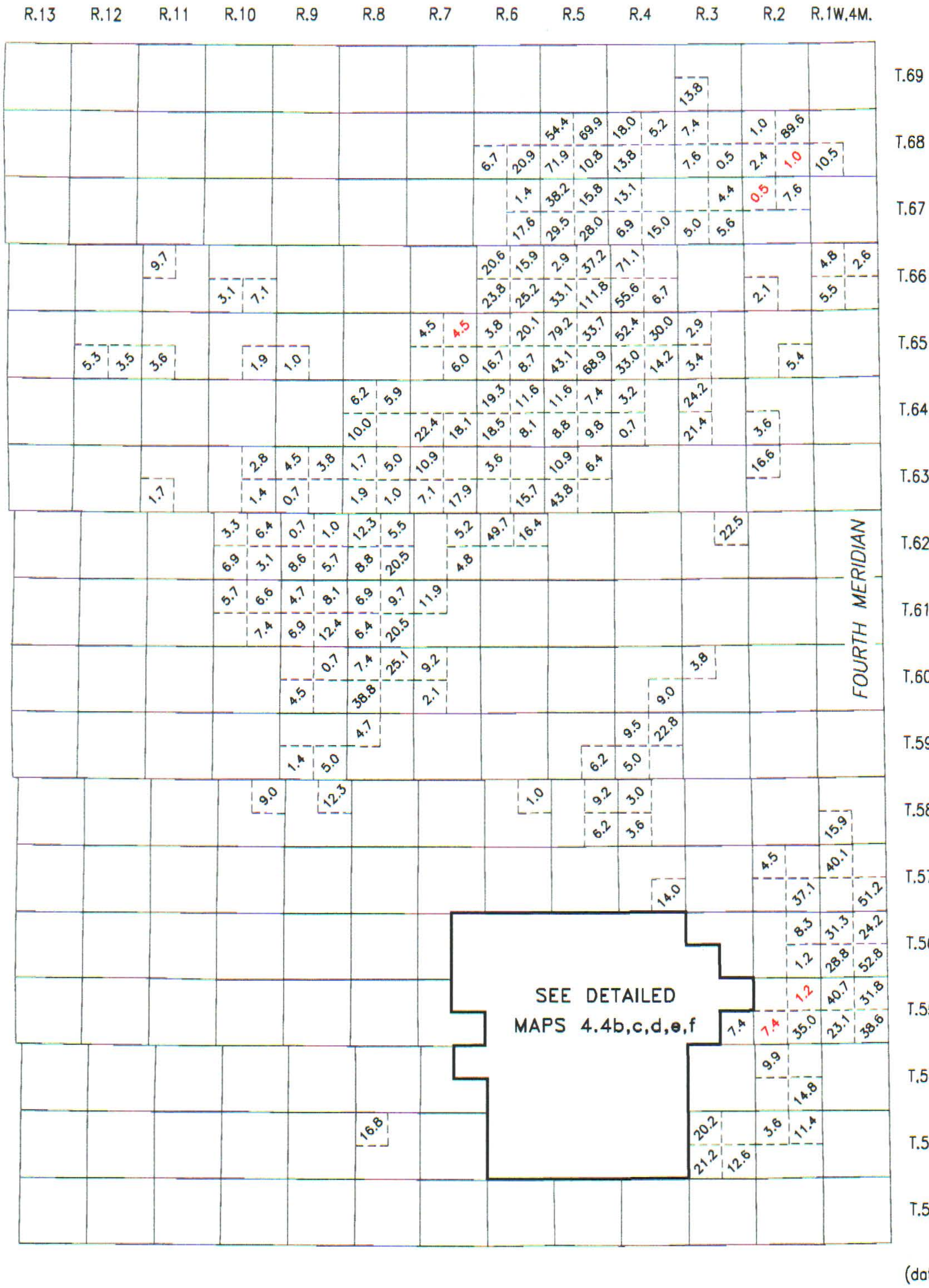
EUB



MAP 4.3 CLEARWATER DEPOSIT
COLD LAKE OIL SANDS AREA
VOLUME IN-PLACE RESERVES $10^6\ m^3$

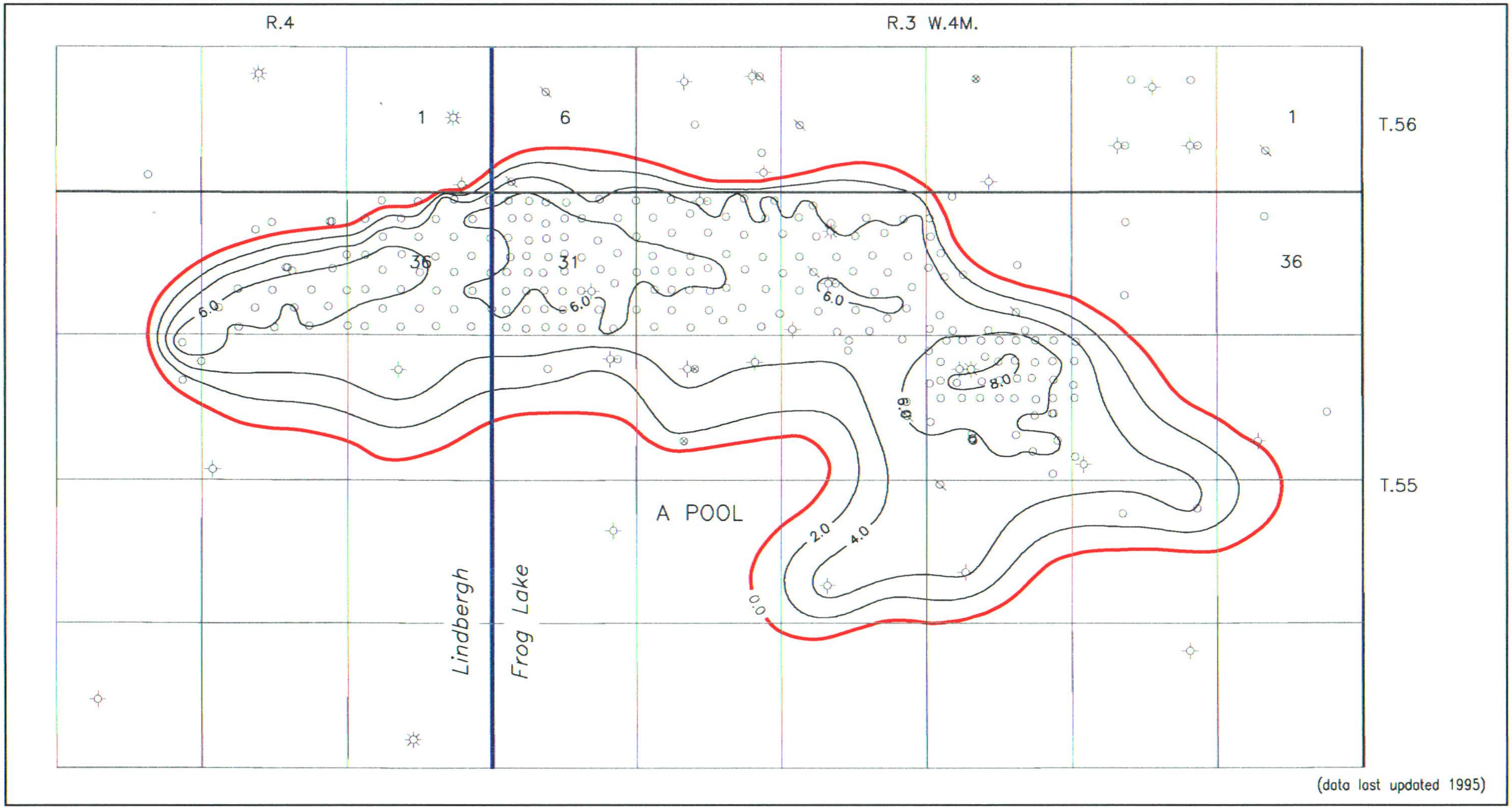
EUB

44.4 Initial
44.4 Inferred



MAP 4.4a WABISKAW–McMURRAY DEPOSIT
COLD LAKE OIL SANDS AREA
VOLUME IN–PLACE RESERVES 10^6 m^3

44.4 Initial
44.4 Inferred

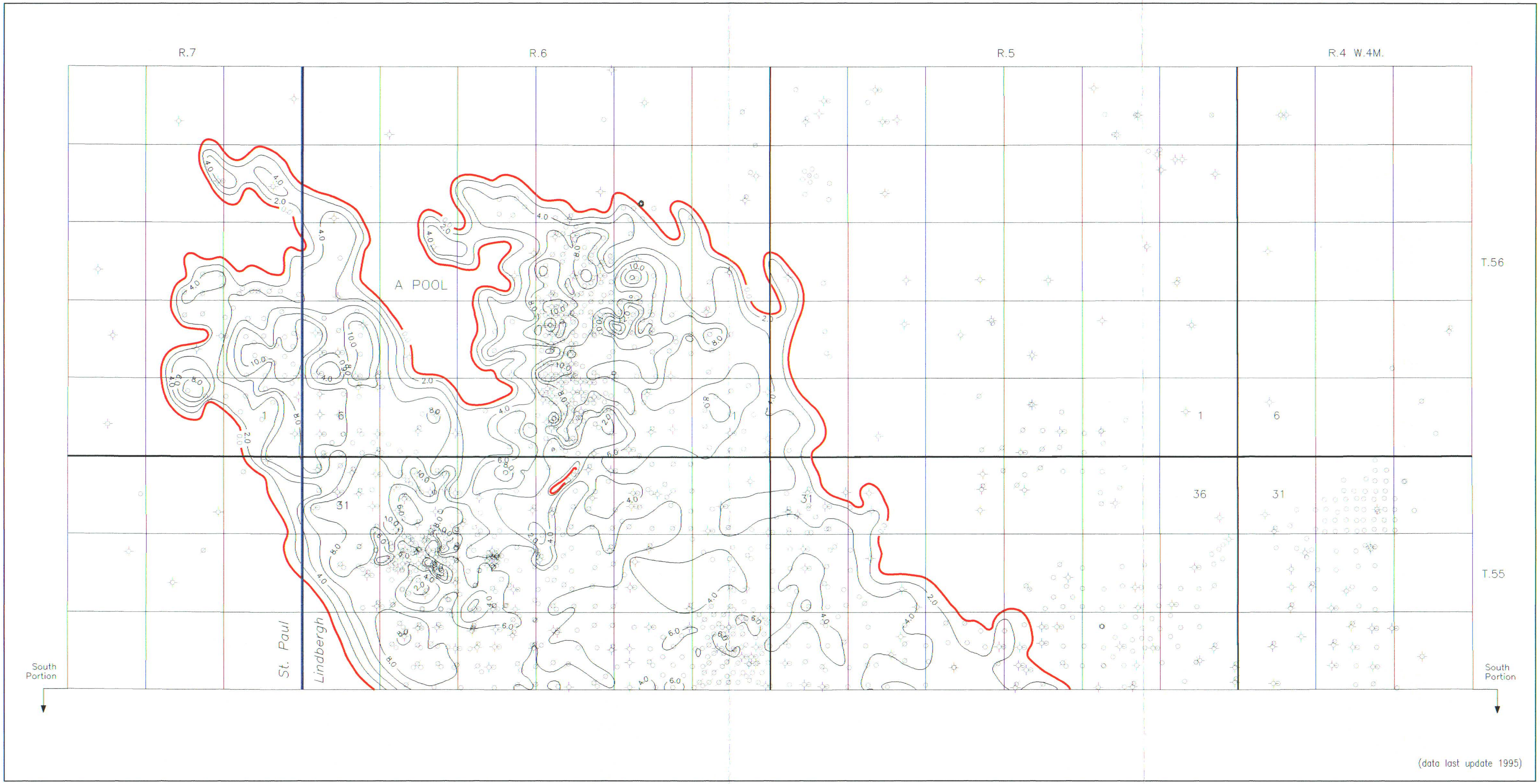


MAP 4.4b CUMMINGS #1 SAND
WABISKAW–McMURRAY DEPOSIT
LINDBERGH/FROG LAKE SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND

- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

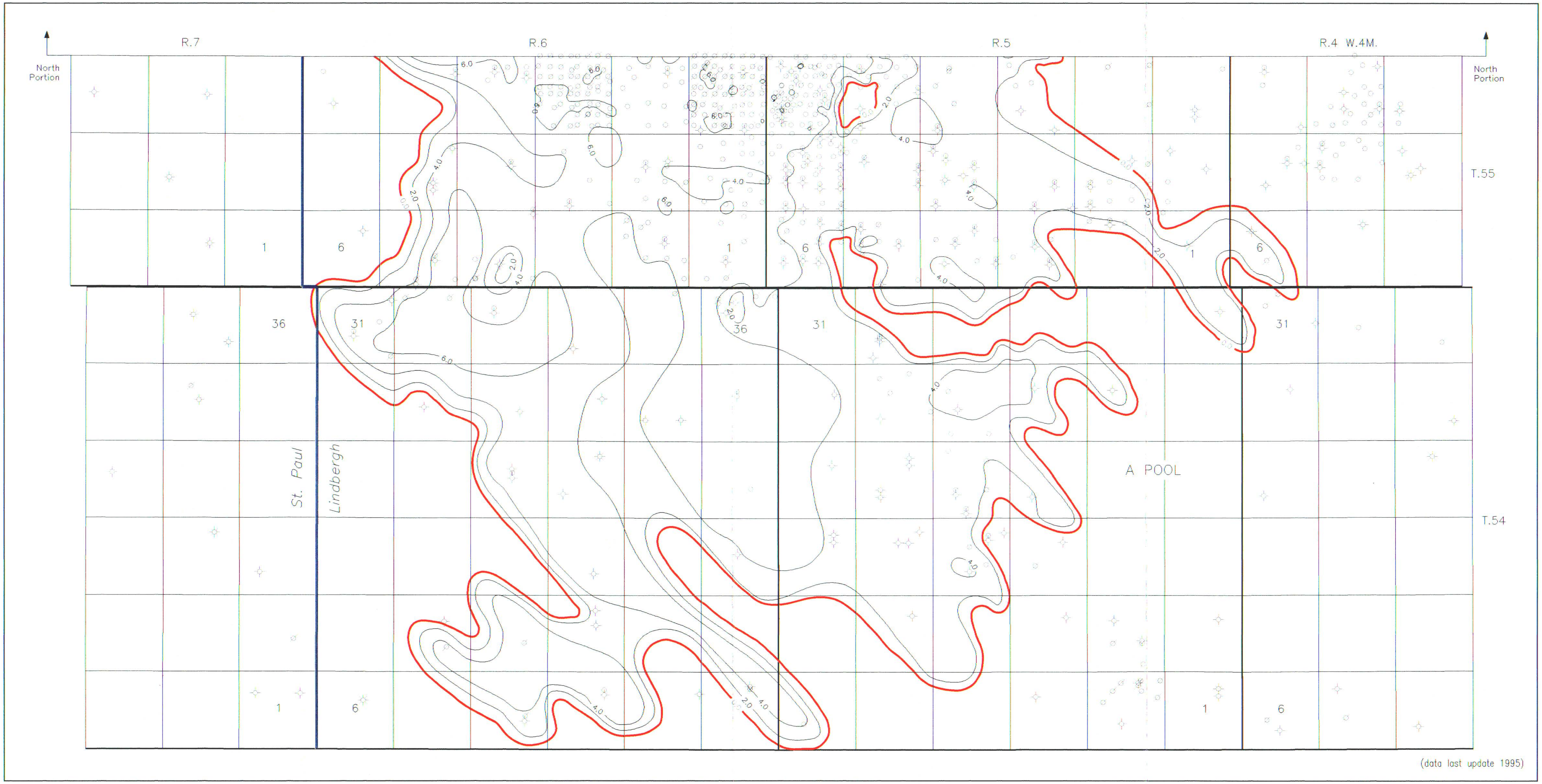
EUB



MAP 4.4c CUMMINGS #1 SAND (north portion)
WABISKAW–McMURRAY DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

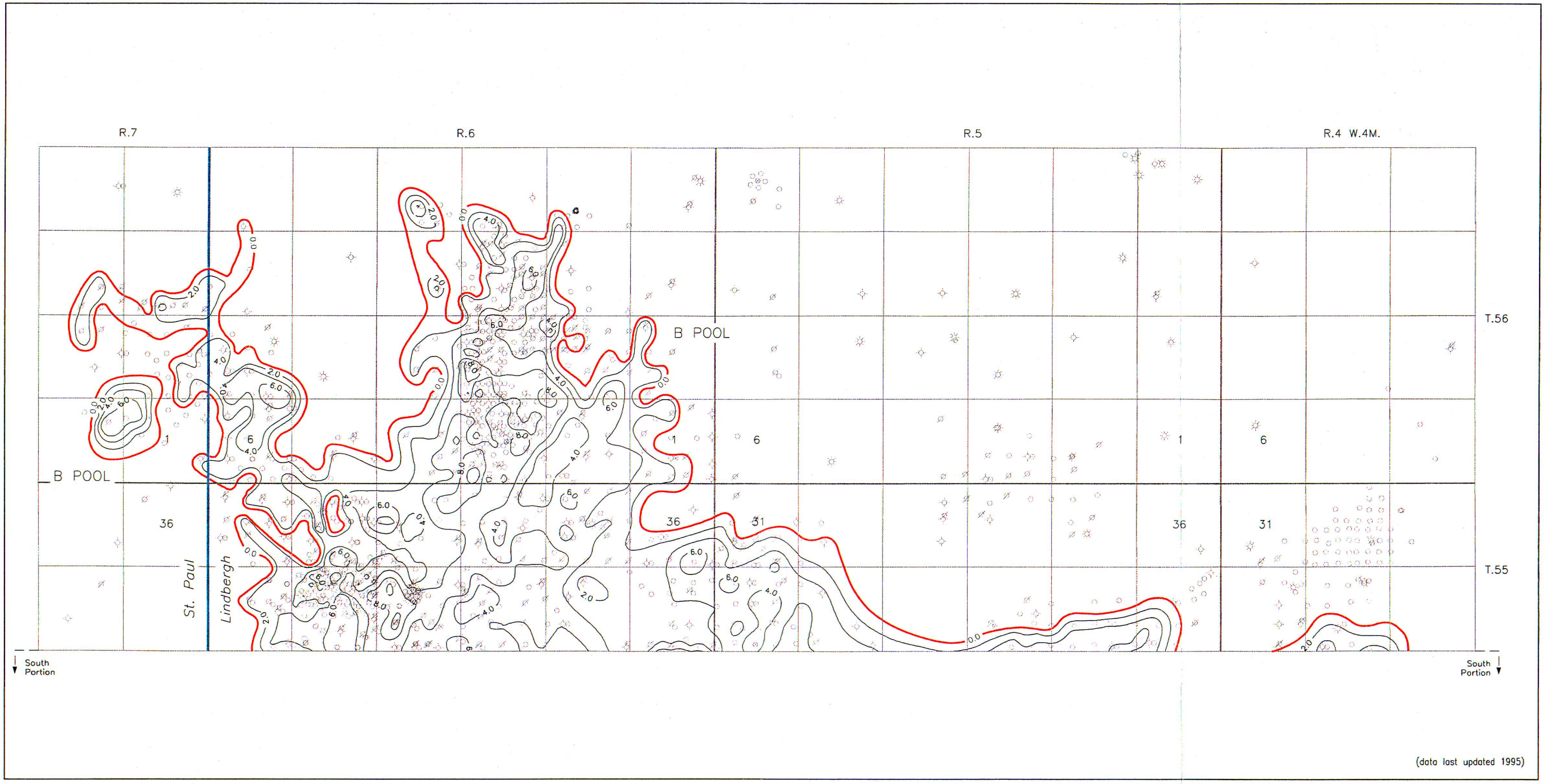
EUB



MAP 4.4c CUMMINGS #1 SAND (south portion)
WABISKAW–McMURRAY DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

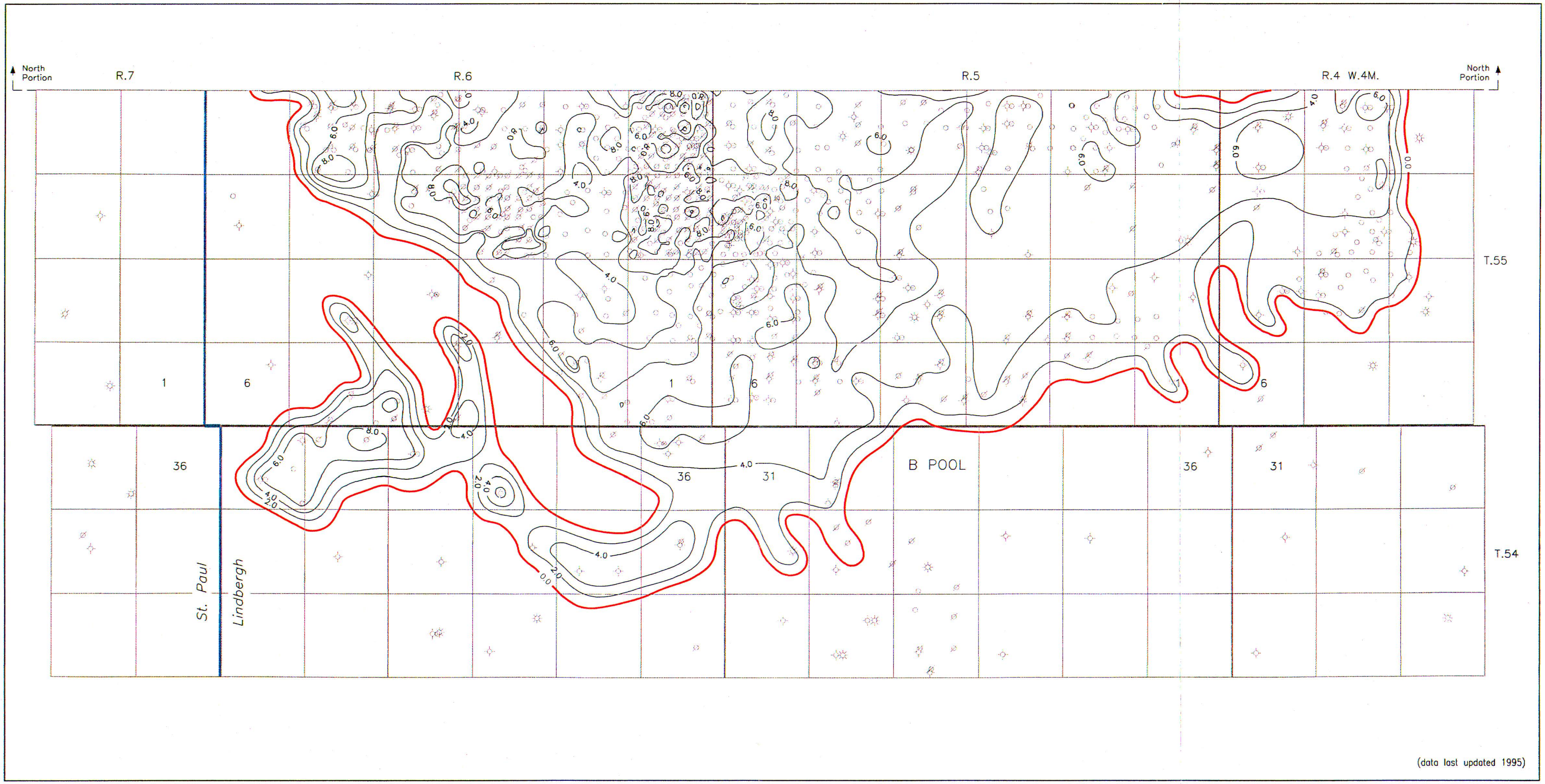
EUB



MAP 4.4d CUMMINGS #2 SAND (north portion)
WABISKAW–McMURRAY DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

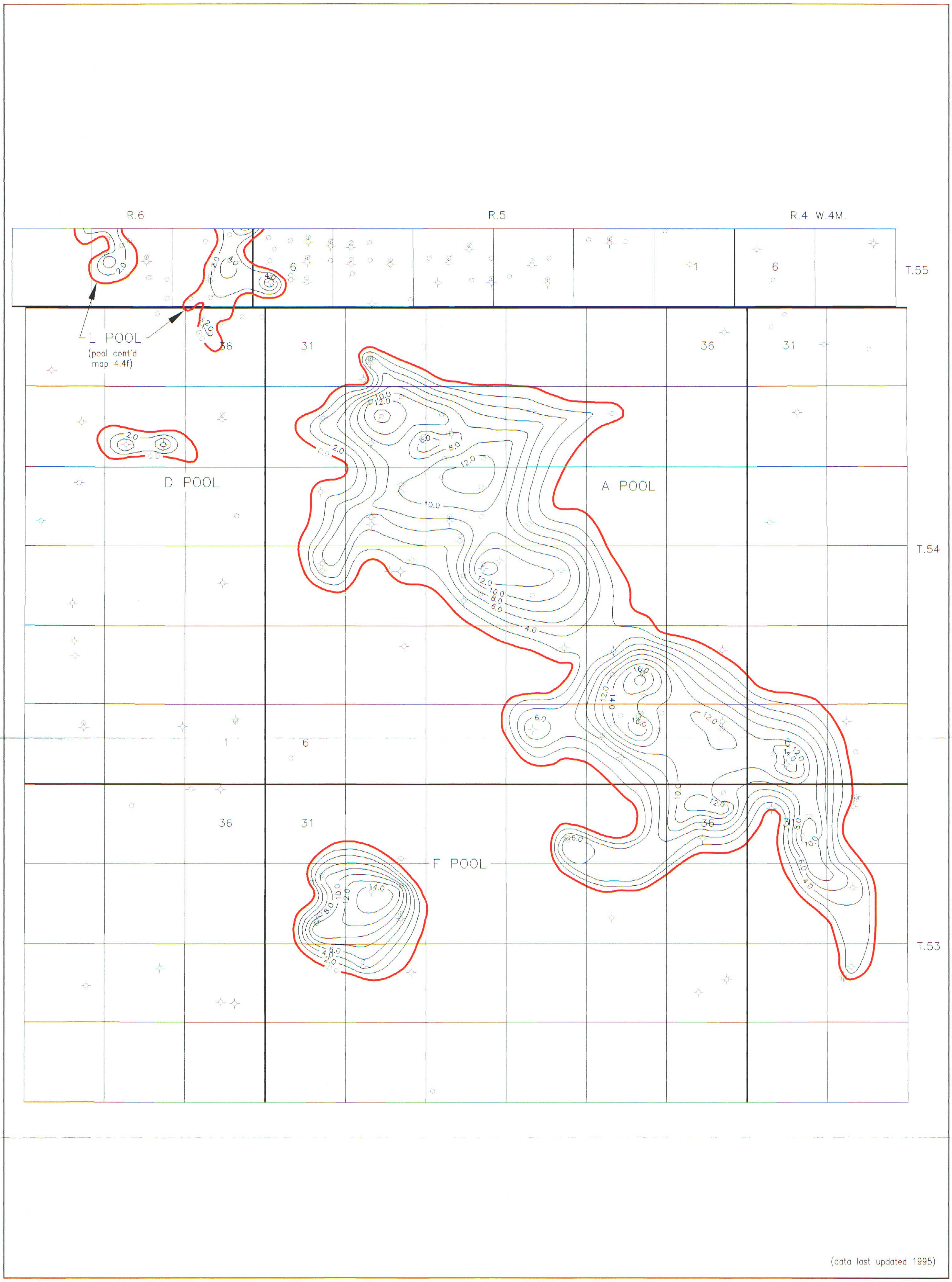
EUB



MAP 4.4d CUMMINGS #2 SAND (south portion)
WABISKAW–McMURRAY DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Sector Line
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

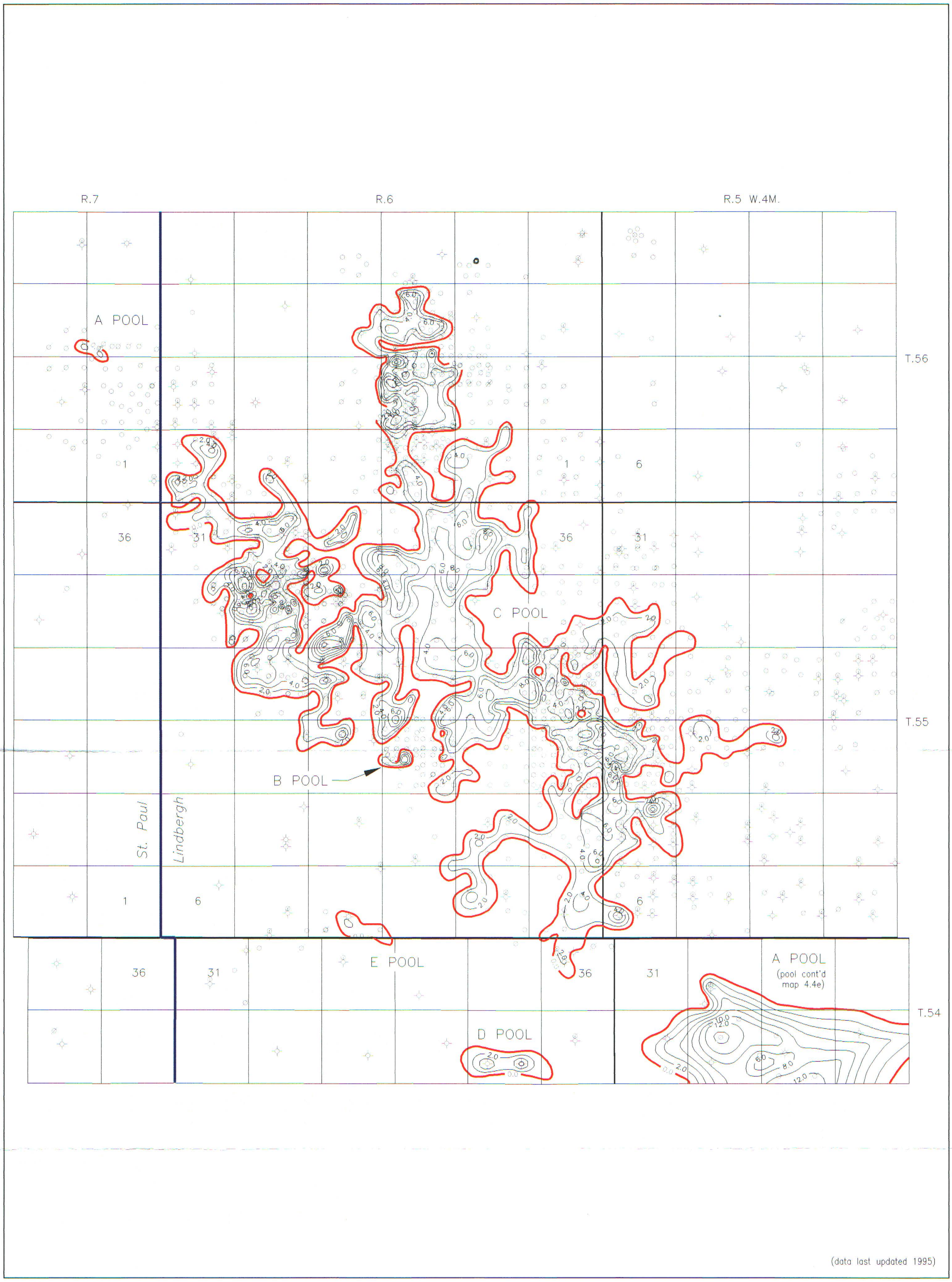
EUB



MAP 4.4e McMURRAY SAND
WABISKAW–McMURRAY DEPOSIT
LINDBERGH SECTOR
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
0.0 Contour Interval = 2.0 meters
Standing/Other Well
Suspended Well
Abandoned Well
Oil Well
Gas Well
Injection Well
Observation Well
Disposal Well

EUB



MAP 4.4f McMURRAY SAND
WABISKAW–McMURRAY DEPOSIT
ST. PAUL/LINDBERGH SECTORS
COLD LAKE OIL SANDS AREA
NET BITUMEN PAY

LEGEND
- 0.0 Contour Interval = 2.0 meters
- Sector Line
- Standing/Other Well
- Suspended Well
- Abandoned Well
- Oil Well
- Gas Well
- Injection Well
- Observation Well
- Disposal Well

EUB

SECTION 5

PEACE RIVER OIL SANDS AREA

5 PEACE RIVER OIL SANDS AREA (OSA 2)

Five deposits are designated in the Peace River OSA. In descending order, these are the Bluesky-Gething, Belloy, Upper Debolt, Lower Debolt, and Shunda. Table 5-1 is a summary of initial in-place reserves for all OSDs in Peace River. Figures 5.1 and 5.2 are type logs for the Peace River deposits.

5.1 Bluesky-Gething - Map 5.1

The Gething Formation consists of continental and marginal marine sands, silts, and shales overlain by more marine sandstones deposited along the trend of a paleovalley developed on the underlying Paleozoic surface (Leyden and Marion, 1992, Marion and Rottenfusser, 1992). Deposition took place during a transgression from the north and north-west. The Bluesky is a thin reworked Gething sand and represents the marine transgression that flooded the Gething coastal plain (Marion and Rottenfusser, 1992). Together these formations comprise the Bluesky-Gething Deposit (OSD 7). The bitumen is trapped in an updip pinchout of the sands against Paleozoic highs on the sub-Cretaceous unconformity (Wightman *et al.*, 1989). These sands are approximately time equivalent to the McMurray/Wabiskaw sands but are separated from them by highs in the pre-Cretaceous unconformity surface. (Leyden and Marion, 1992).

While high oil saturations occur in widespread shoreline and shallow marine sands, the thickest and most continuous oil sands of this deposit are found in the tidal channel complexes. The reservoir sands have a mixed mineralogy, dominated by quartz, chert, rock fragments, carbonate grains, and minor feldspar. Clay minerals are primarily kaolinite, illite, and minor montmorillonite and chlorite (Wightman *et al.*, 1989).

The building-block reserves for the Bluesky-Gething Deposit is shown on Map 5.1.

5.2 Belloy - Map 5.2

The Belloy Formation is Permian in age, unconformably underlies the Bluesky/Gething, and is unconformably underlain by the Debolt. The reservoir rock consists primarily of sandy dolomite, sandstone, and minor spicular chert. Belloy deposition occurred during a relatively stable time in the tectonically active Peace River Arch area (Barclay *et al.*, 1990, Naqvi, 1972). The sands of the reservoir rock are thought to have been deposited as shoreline related, basin margin sands with the sandy dolomites representing proximal shallow marine facies (Barclay *et al.*, 1990). The Belloy is up to 60 metres thick within the Peace River OSA.

The entire Belloy Deposit has not been evaluated at this time. The in-place reserves for the currently evaluated area are based on the total bitumen metres isopach map (Map 5.2).

5.3 Debolt and Shunda - Maps 5.3 to 5.5

The Debolt and Shunda Formations are Mississippian carbonate formations within the Rundle Group. The Debolt Formation unconformably underlies the Belloy and in turn is unconformably underlain by the Shunda. Both formations occur within the tectonically active Peace River Arch area. They form part of an over all shallowing-upward succession with the Debolt and Shunda representing restricted shelf to peritidal carbonates, siliciclastics, and evaporates (O'Connell *et al.*, 1990). The Upper Debolt is composed of finely crystalline dolomite, interbedded with shale, while the Lower Debolt is a cherty, partly crinoidal, massive, bioclastic limestone with shale interbeds throughout. The Shunda underlies the Debolt and consists of interbedded argillaceous limestones, dolomites, and siltstones.

The EUB maintains separate reserves figures for the Upper Debolt (OSD 15), Lower Debolt (OSD 16) and Shunda (OSD 14) deposits. These deposits are not fully evaluated at this time. Maps 5.3 to 5.5 are the total bitumen metre isopach maps used to calculate in-place reserves for these deposits in the evaluated areas.

TABLE 5-1

OIL SANDS AREA OIL SANDS DEPOSIT OIL SANDS SECTOR, OIL SANDS POOL OVERBURDEN DEPTH (m) OR ZONE	1 INITIAL VOLUME IN PLACE $10^6 m^3$	2 AREA 10^3ha	3 AVERAGE PAY THICKNESS m	4 BITUMEN SATURATION mass frac	 pore vol frac	5 POROSITY frac	6 WATER SATN frac	7 REMARKS
PEACE RIVER								
BLUESKY-GETHING								
300 - 700								
BUILDING BLOCK	527.00	177.00	9.0	0.052	0.47	0.25	0.53	
ISOPACH	13460.00	976.00	6.0	0.061	0.60	0.23	0.40	
SUBTOTAL	13987.00							
BELLOY								
675 - 700	282.00	26.00	8.0	0.078	0.64	0.27	0.36	
SUBTOTAL	282.00							
UPPER DEBOLT								
500 - 800	1830.00	100.00	13.0	0.050	0.61	0.19	0.39	
SUBTOTAL	1830.00							
LOWER DEBOLT								
500 - 800	5970.00	202.00	29.0	0.051	0.67	0.18	0.33	
SUBTOTAL	5970.00							
SHUNDA								
500 - 800	2510.00	143.00	14.0	0.053	0.52	0.23	0.48	
SUBTOTAL	2510.00							
TOTAL	24579.00							DISCREPANCIES IN TOTAL AND SUBTOTALS ARE DUE TO ROUNDING

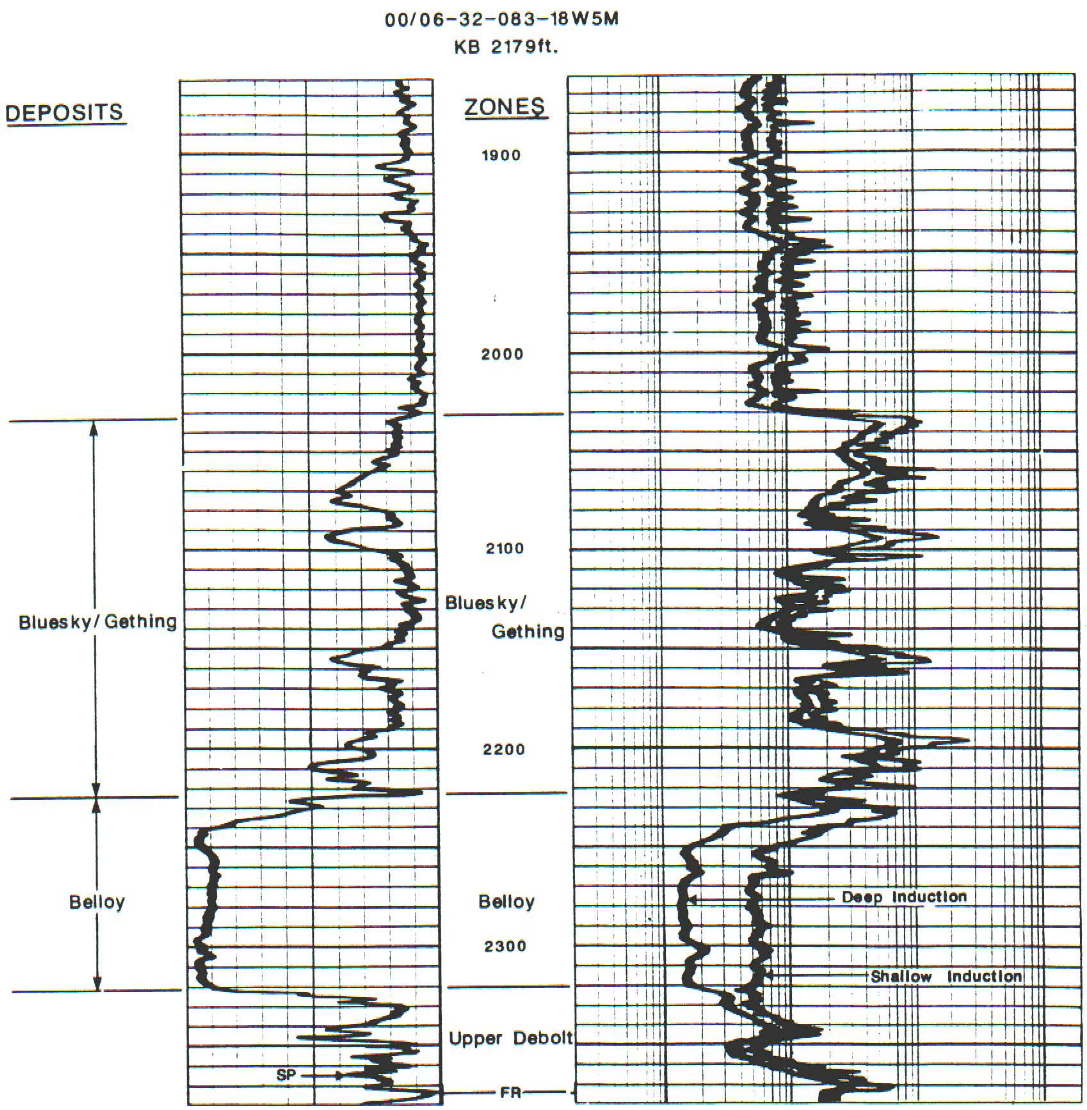


FIGURE 5.1 PEACE RIVER OIL SANDS AREA REFERENCE WELL
BLUESKY/GETHING–BELLOY SECTION
GULF HARMON 6–32–83–18W5M

EUB

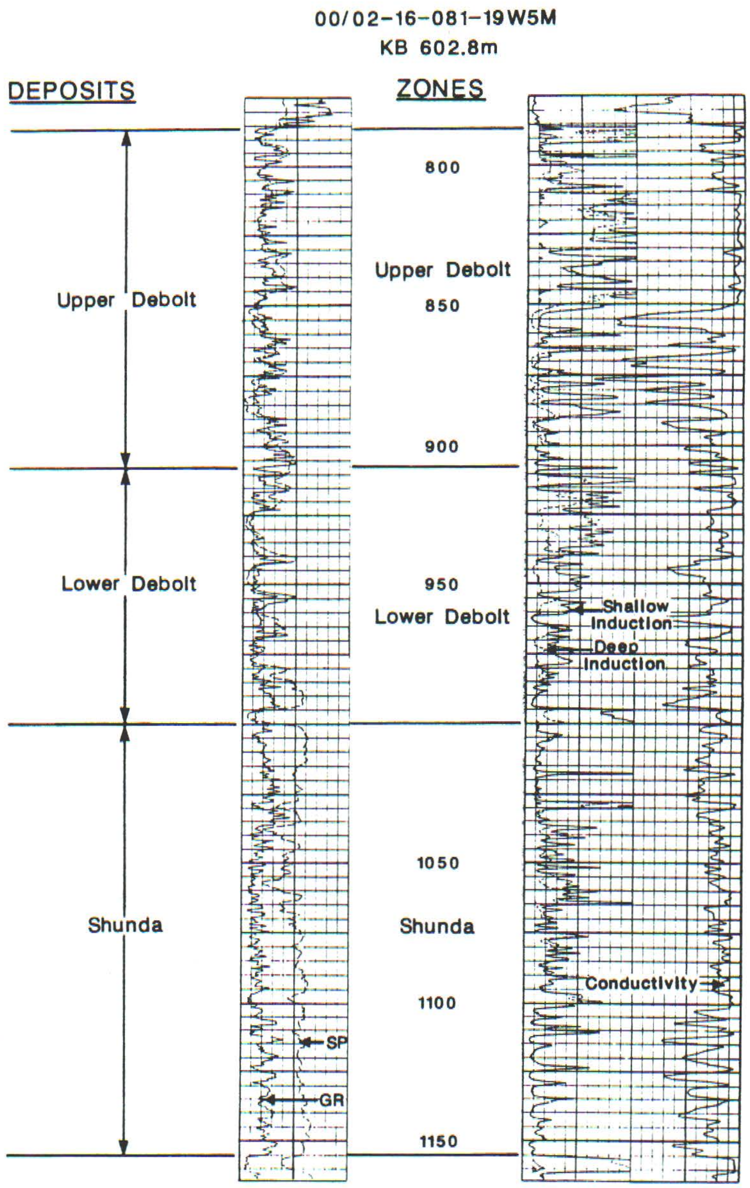
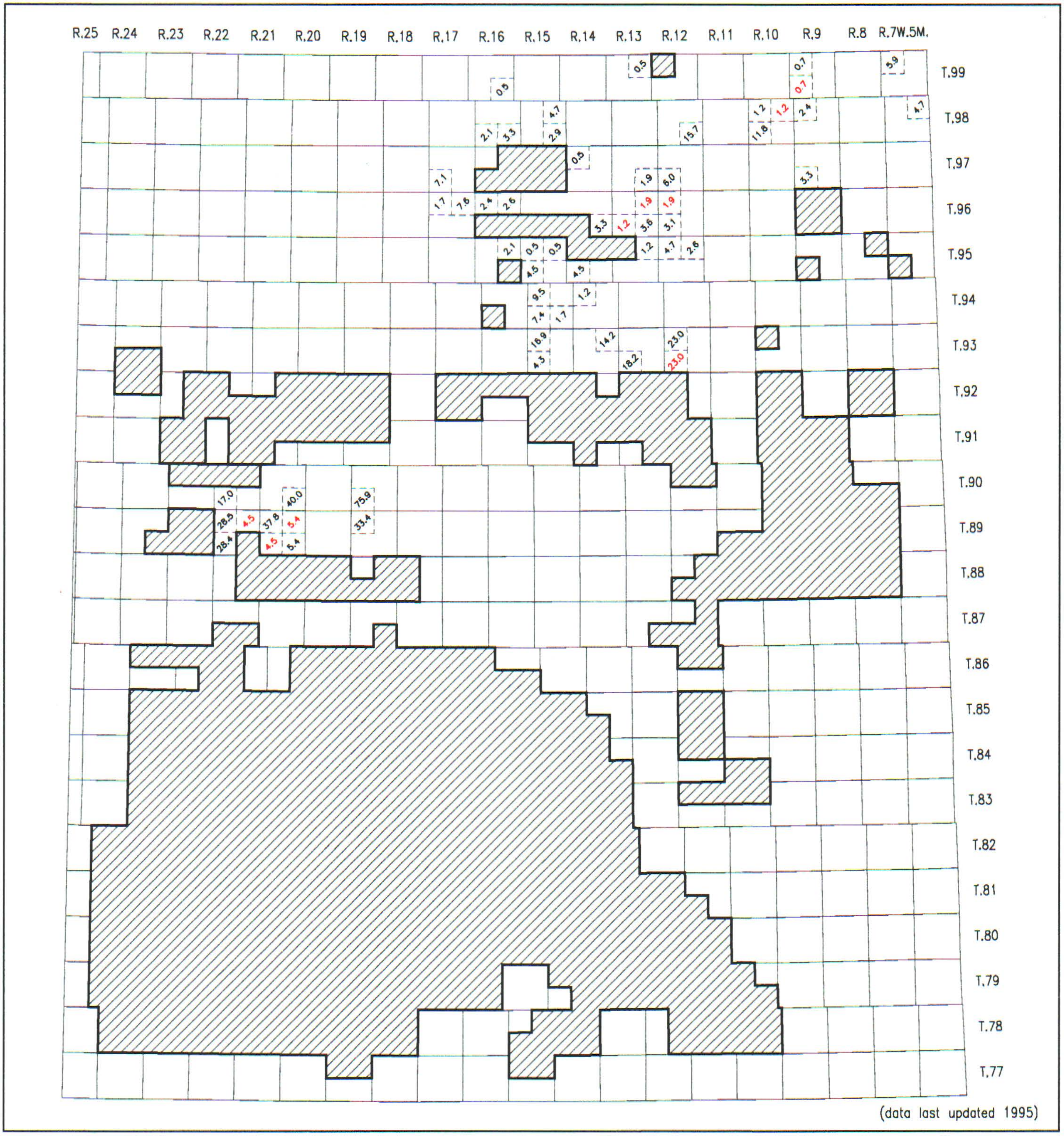


FIGURE 5.2 PEACE RIVER OIL SANDS AREA REFERENCE WELL
DEBOLT/SHUNDA SECTION
ULTRAMAR HARMON VALLEY 2-16-81-19W5M



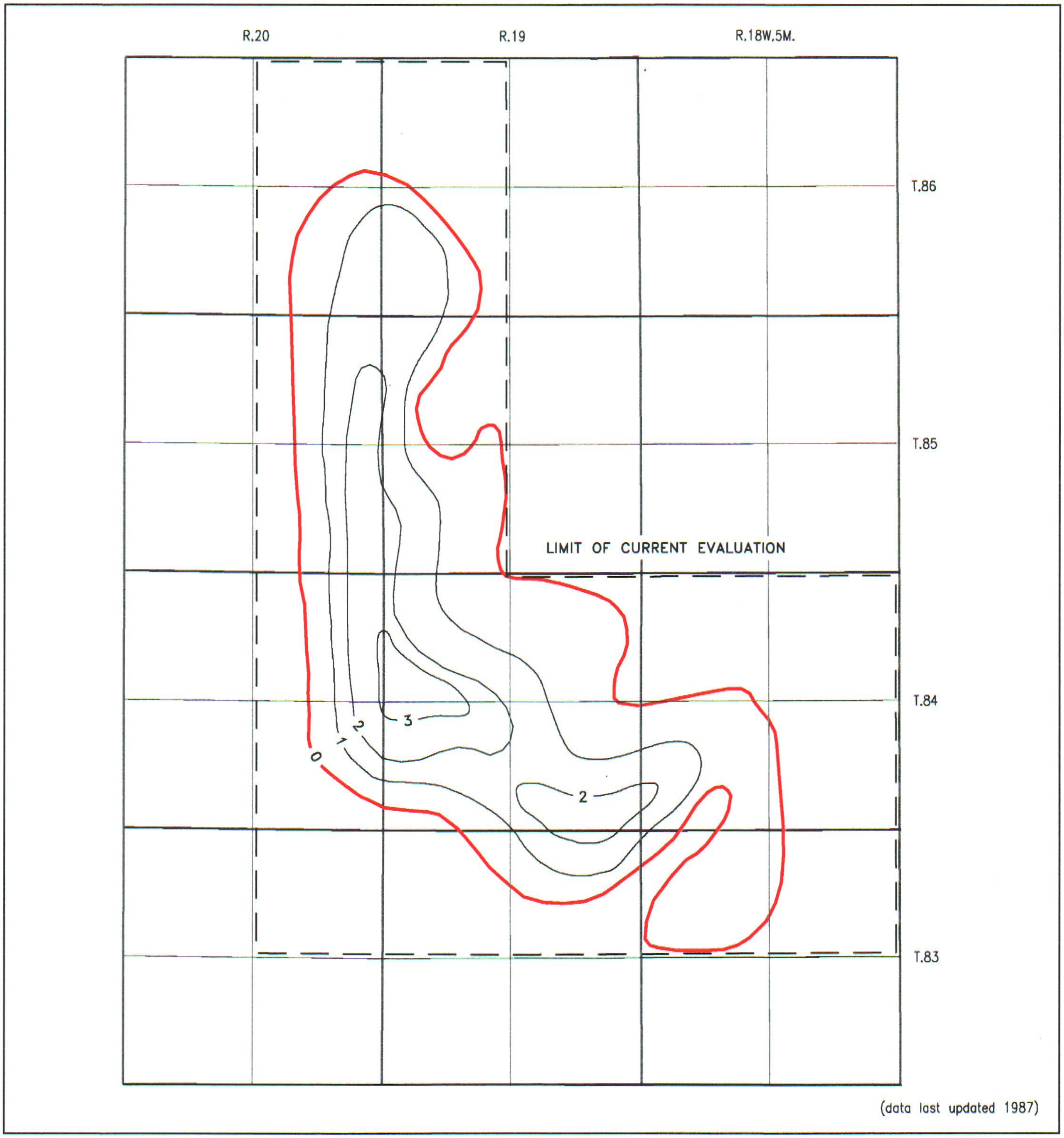
MAP 5.1 PEACE RIVER OIL SANDS AREA
BLUESKY–GETHING DEPOSIT
VOLUME IN–PLACE RESERVES 10^6 m^3

EUB

44.4 Initial

44.4 Inferred

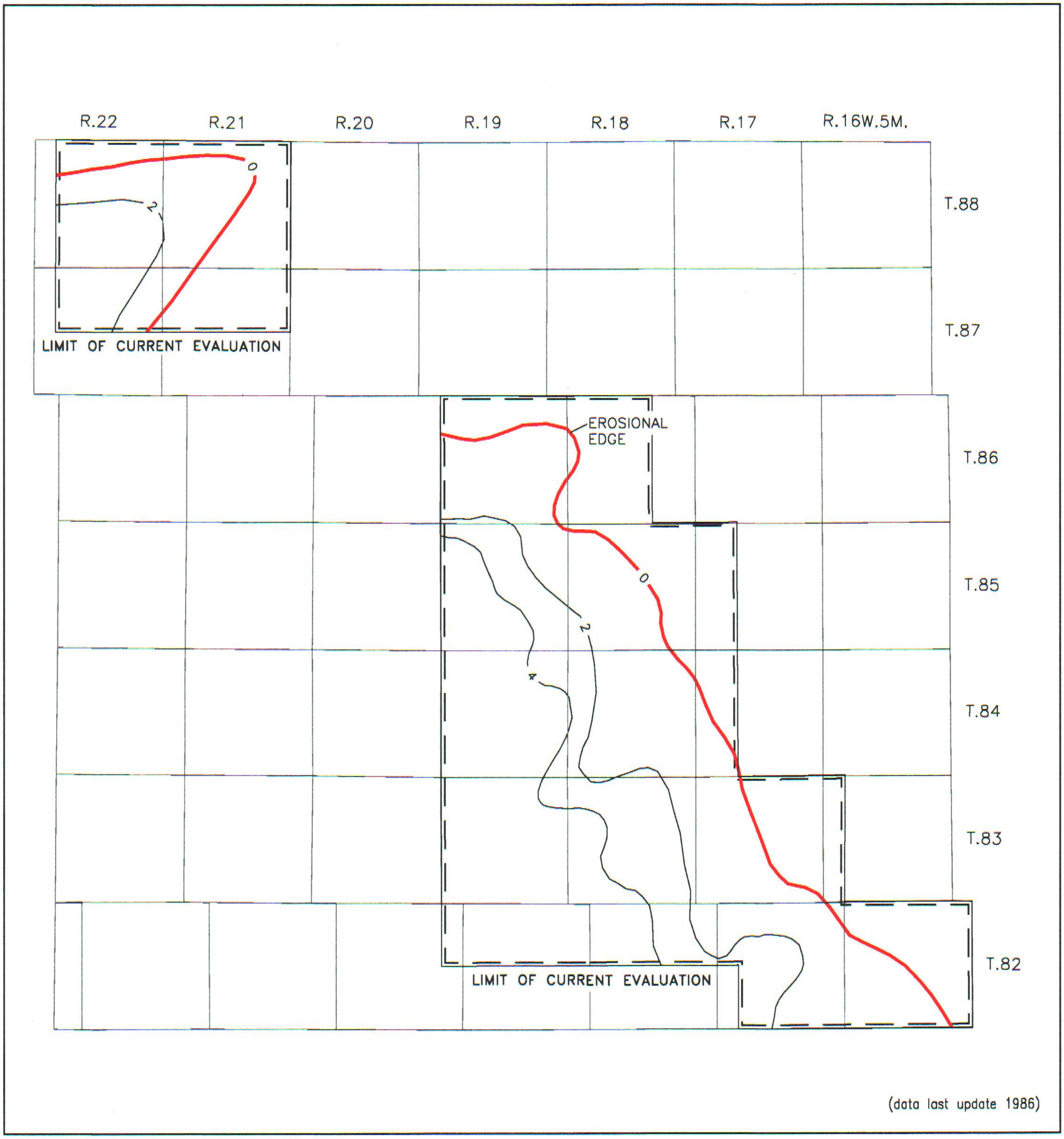
Maps will be available in future publications



MAP 5.2 BELLOY DEPOSIT
PEACE RIVER OIL SANDS AREA
TOTAL BITUMEN METRES

— 0 — Contour Interval = 1 metres

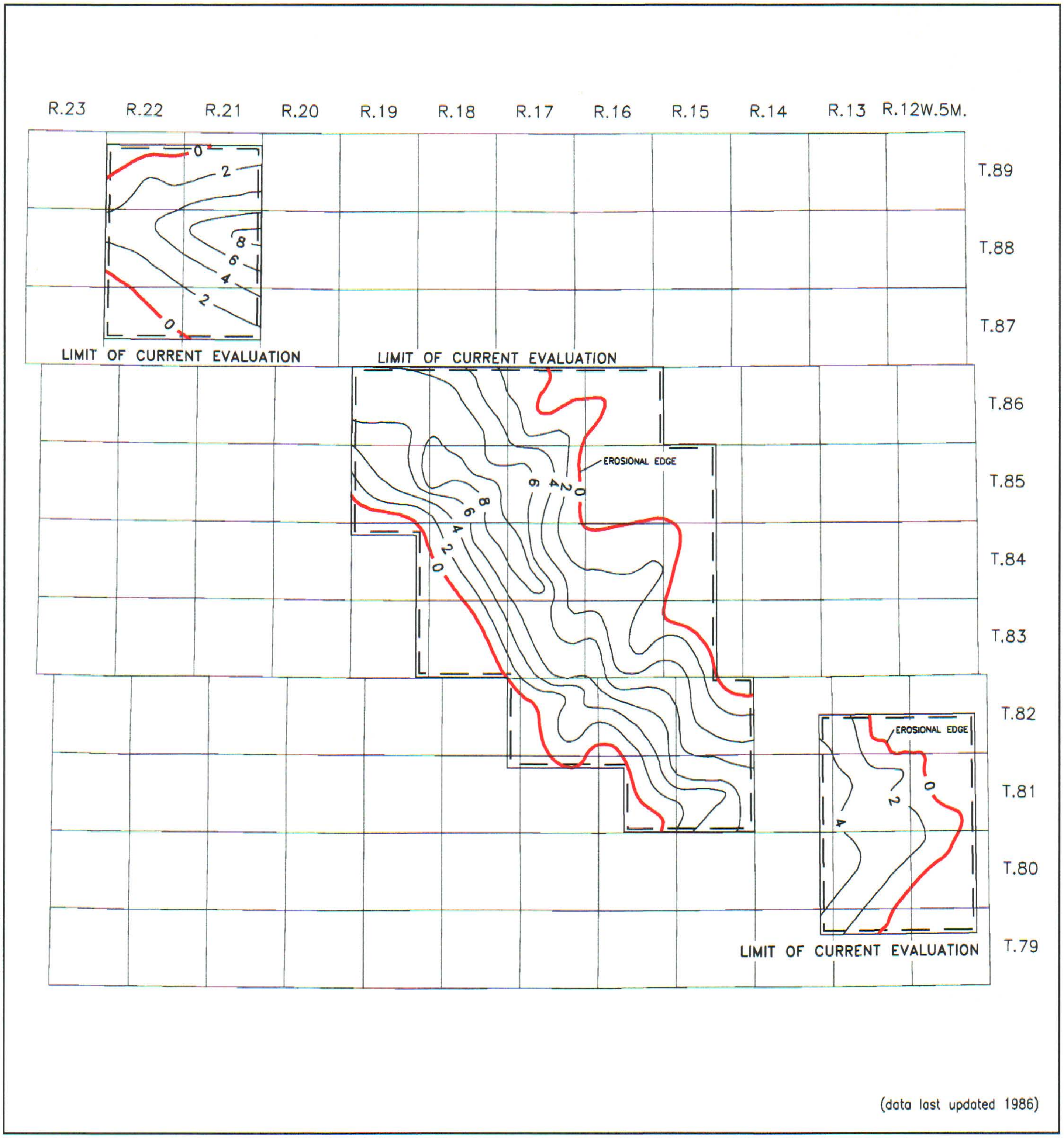
EUB



MAP 5.3 UPPER DEBOLT DEPOSIT
PEACE RIVER OIL SANDS AREA
TOTAL BITUMEN METRES

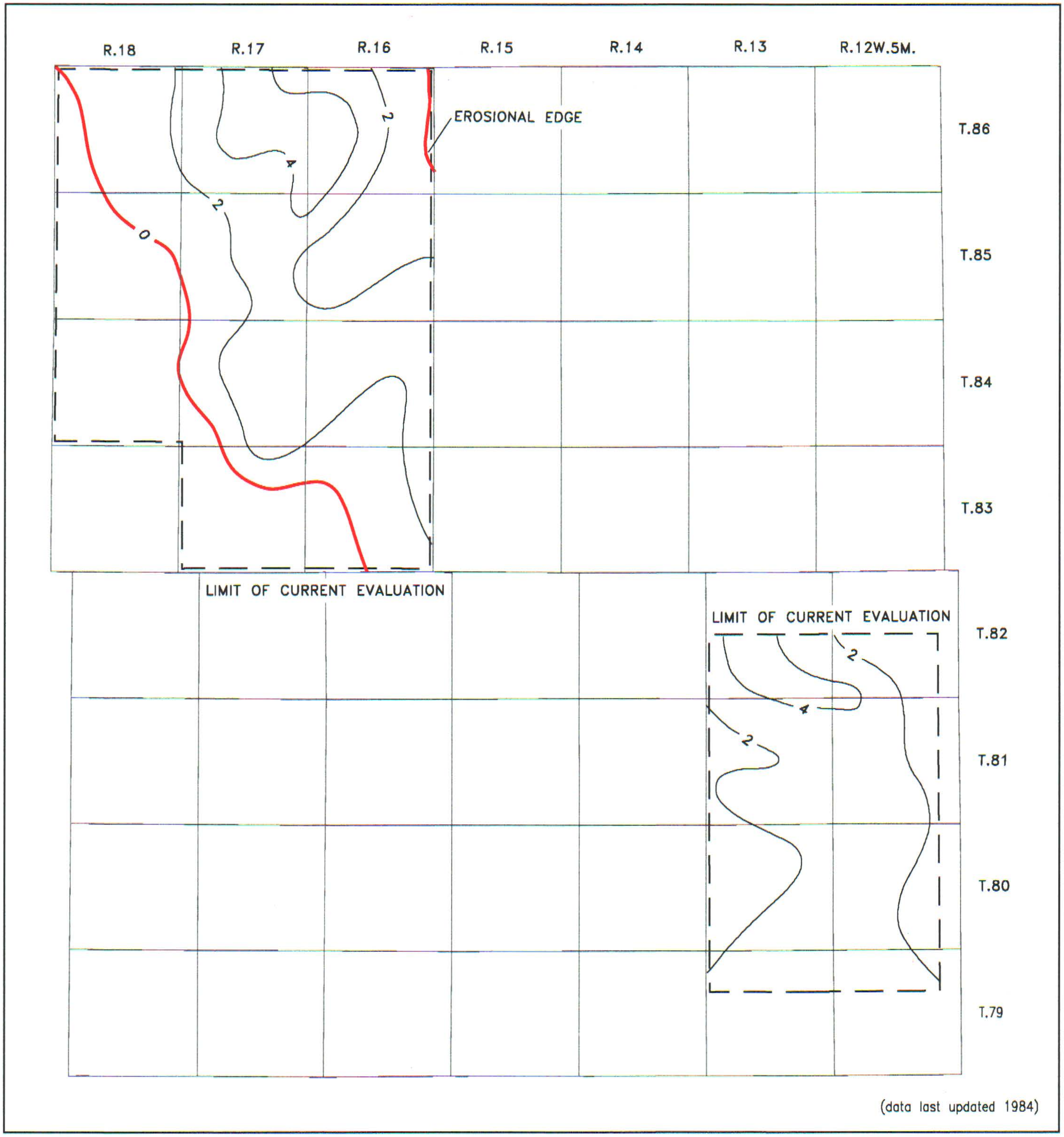
EUB

—0— Contour Interval = 2 metres



MAP 5.4 LOWER DEBOLT DEPOSIT
PEACE RIVER OIL SANDS AREA
TOTAL BITUMEN METRES

0 Contour Interval = 2 metres



MAP 5.5 SHUNDA DEPOSIT
PEACE RIVER OIL SANDS AREA
TOTAL BITUMEN METRES

EUB

— 0 — Contour Interval = 2 metres

SECTION 6

REFERENCES

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