B2.2 SAGD Production Pads and Horizontal Wells

The SAGD process involves drilling two long horizontal wells that are separated vertically by approximately 5 m. The upper wellbore is used to inject steam into the reservoir. The injected steam adds energy in the form of heat to the reservoir, mobilizing the bitumen. The mobilized bitumen then flows by gravity to the lower production wellbore where fluids are gathered and brought to surface. Figure B2.2-1 presents typical wellbore geometries with 1,000 m horizontal sections and 120 m interwell spacing.

B2.2.1 Well Pad Layout and Design

Reservoir characteristics, surface features, directional drilling technologies and well pair completion design influence the location and surface layout of each well pad.

Well pads will consist of one row of well pairs and may accommodate from 4 to 6 well pairs depending on the reservoir continuity and well bore trajectory requirements. Pads are expected to have a total footprint of approximately 157 m x 289 m in size. Eight well pads are proposed for the Leismer Expansion Hub. Figure B2.2-2 shows a typical well pad layout during drilling operations.

Each well pad includes the following systems and equipment;

- High pressure steam distribution pipeline and header system to each well pad.
- Steam injection meters and flow controllers to independently control the steam flow to the toe and heel of each injector.
- Produced fluids gathering lines and flow meters to provide a rough measurement of flow from each producer on a continuous basis.
- A test manifold with separation and analysis equipment to measure the bitumen and water flow from each producer well. Producers will be tested on a routine basis in accordance with regulatory requirements.
- Electric pumps to deliver the produced bitumen and water to the CPF in a surface pipeline.
- Vapour collection header to route produced gas from each producer wellhead to an electric compressor, which in turn delivers the produced gas from all the wells to the CPF in a pipeline.
- Metering and sampling equipment to monitor the flow rate and composition of the produced gas.
- A pop tank to capture emergency relieving conditions and drain liquids from pipelines.
- Control system connections to the CPF via programmable logic controllers and supervisory control and data acquisition systems (PLC/SCADA).
- Access road to the CPF for vehicle and equipment traffic.

- 25 kilovolt overhead power supply, transformer, motor control equipment and electrical backup diesel generator for electric loads at each well pad.
- Control utilities (instrument air) and related electronic controllers.
- Observation wells (separate ground disturbance), plus data monitoring equipment and related data system connection to the CPF.
- Winterization system to protect piping and equipment from frost damage.
- Ditching, berms, and contouring to manage surface water drainage collection. The topsoil will be conserved and stockpiled for reclamation.

B2.2.2 Drilling and Completion

Horizontal well pairs will be drilled vertically from surface to a surface casing depth of approximately 150 to 170 m (Figure B2.2-3). The remaining drill hole will be drilled with the kick off point expected to start at a depth of approximately 175 m. The build section is expected to be drilled at not more than 9-10 degrees of dogleg/30 m, and is expected to intersect the target horizontal section depth at 90 degrees from vertical. Total measured depth of the well is expected to be approximately 1,700 m depending largely on the horizontal section. The surface casing will be cemented with thermal cement and will adhere to requirements of EUB Directive 8.

The intermediate hole will be drilled to minimize build section dogleg, preferably not more than 9 deg/30 m. The gentle build section will be capable of accommodating any required lift equipment. The well bore beyond the surface casing will be drilled with a directional bottom hole assembly (BHA), consisting of a mud motor and measure while drilling (MWD) system. Intermediate casing will be high grade, utilizing premium high-strength connections cemented in place with thermal cement (Figures B2.2-3, B2.2-4, and B2.2-5).

Drilling of the horizontal main hole will be done in conjunction with a gamma ray log to determine sections of pay compromised by clay, inclined heterolithic stratification (IHS) or breccia. The horizontal section will be lined with engineered slotted liner or wire wrap screens. The liner will be anchored and sealed in the production casing with a high temperature sealed liner hanger or packer assembly.

Pad drilling is expected to begin with all surface holes being drilled first. The drilling rig will then return to each well to drill intermediate hole to the horizontal section. Horizontal sections of production wells will be drilled first with the horizontal sections of injection wells being drilled last. Observation wells may be utilized for positioning production well trajectories. Injection wells will be drilled using ranging information from a magnetic source fed into the production wells during drilling. Injections wells ideally will over lay producers by 5 m for the length of the horizontal section.

Disposal of all drilling fluids will be according to EUB Directive 50. Gel chem. drilling fluids will be stored and disposed in remote sump locations yet to be determined based on suitable soil conditions. Total volume of drilling waste will be approximately 450 m^3 per horizontal well pair. It is North American's intent, however, to reduce these volumes by reusing drilling fluids whenever practical. Pad drilling will all be done using a central mud system. Drilling order will also minimize oil and cuttings contamination and maximize the use of drilling fluids.

B2.2.3 Producing Well Completion

Producing wells for the initial circulation phase will be completed with a toe injection string as well as a heel return string. Temperature monitoring will be accomplished with a 38.1 mm instrument string. The circulation phase is expected to last approximately 90 days and serves to heat the bitumen between injector and producer to establish communication. The circulation phase will see steam injected into the toe string, and return up the heel string (Figure B2.2-3).

When the circulation phase is completed the well will be completed with a pump. Currently under consideration are electric submersible pumps (ESP) (Figure B2.2-4) and tubing pumps (Figure B2.2-5).

B2.2.4 Injection Well Completion

The injection well will be completed in a similar manner to the producer for the circulation phase. North American will ensure compliance with EUB Directive 51. During the circulation phase, the injector will be completed with 88.9 mm toe injection and heel return strings (Figures B2.2-3). Also, the well will possibly have a 38.1 mm temperature instrument string. When the circulation phase is completed the injection well completion will be changed for steam injection.

During the steaming phase the injector may be completed with a toe injection string (Figures B2.2-4 and B2.2-5). The majority of the steam will be injected down the casing annulus. The well will have a 60.3 mm guide string, with possibly a 38.1 mm temperature instrument string.

B2.2.5 Observation Wells

Observation wells strategically placed during the pad drilling program will provide information for SAGD well bore placement during the drilling phase, as well as pressure and temperature monitoring throughout the Corner area for the life of the wells. Currently under consideration for monitoring observation wells is fibre optic temperature monitoring equipment and mechanical pressure monitoring equipment on the exterior of the casing. Fibre optic temperature sensing is capable of resolution of 1^{o} temperature/metre. Some of the observation wells will have mechanical pressure monitoring equipment strategically installed depending on the stratigraphy of the formation. The number and density of observation wells will be determined by directional drilling and reservoir monitoring needs.

During the drilling phase of a typical pad, North American may utilize observation wells placed along proposed well bore trajectories to serve as guidance targets. Magnetic source equipment will be placed in the observation well bores to provide ranging measurements. This information would assist in drilling straight horizontal sections.

During the production phase of the Project, selected observation wells may be equipped with temperature and pressure monitoring equipment for ongoing monitoring of steam chamber development, rise rates and overall well bore performance. Figures B2.2-6 and B2.2-7 depict typical temperature only and pressure/temperature observation wells, respectively.

B2.2.6 Water Source and Disposal Wells

Water source wells will be vertical well completions with ESP pump configurations. The wellbore itself is also being considered for wire-wrapped screen and a gravel packed liner for enhanced long term deliverability (Figure B2.2-8).

Water disposal wells will be vertical well completions with surface pumping equipment at the main plant to feed the wells. North American will drill a number of Class 1b water disposal wells, and is giving consideration to drilling one or more Class 1a water disposal wells (Figures B2.2-9 and B2.2-10, respectively). Water disposal well completions will ensure continued compliance with Directive 51.

B2.2.7 Drilling Waste Management

North American plans to use a water-based drilling fluid system. These mud systems generate waste material largely composed of bentonite clay. North American will separate drilling muds that contact oil bearing formations in an effort to minimize drilling mud contamination and therefore drilling waste disposal.

North American waste reduction methods will limit the volume of solid waste from the intermediate and horizontal hole sections. Drilling wastes will be monitored and analyzed and be disposed of according to EUB Directive 50. Special attention will be given to hydrocarbon levels and any materials that comply with Tier I Soil and Water Quality Guidelines for Hydrocarbons (CCME fractions) will be disposed of using the mix-bury-cover method. Any waste not meeting requirements of Directive 50 for hydrocarbon levels will be disposed of at an approved waste disposal facility or treated within the guidelines.

The drilling mud sump will be located nearby and separated into cells to isolate the various phases of drill mud and cuttings. The locations of the sump sites will be selected and constructed after soil sampling ensures the base material meets the required permeability limits.

B2.2.8 Casing Failure Monitoring Program

North American has adopted a very careful approach to the design, material selection, and integrity of the casing, liners, and tubulars. North American has researched the many different options and techniques to provide for long term well bore integrity.

The monitoring program will entail detailed temperature and pressure monitoring of producer and injector instrumentation, as well as injection and production rates to detect early warning signs of compromised casings, liners or tubulars.

North American will develop procedures to track and identify failures (if any). Completion integrity will be monitored by operations staff who will monitor well performance at the production pad. Injection and production well pressures and temperatures will be monitored continuously, as will steam flow rates, and production flow rates. Any unanticipated changes in these parameters will be investigated.

The SAGD operation is a continuous process operated below the formation fracture pressure. As a result, the down hole tubulars are not subjected to the same stresses that occur from the high temperature and pressure fluctuations seen in cyclic steam processes.

B2.2.9 Well Performance Monitoring

Production well testing will be performed on each well pair at least twice per month. Daily oil, gas, and water will be closely recorded and allocated to the wells based on field pro-rations. Injection wells will also be monitored closely for steam injection rate and pressure. These parameters and any changes also provide a good measure of wellbore integrity changes, or breach.

Regular analysis of produced oil, gas, and water will assist North American to understand the reservoir performance and resource recovery.

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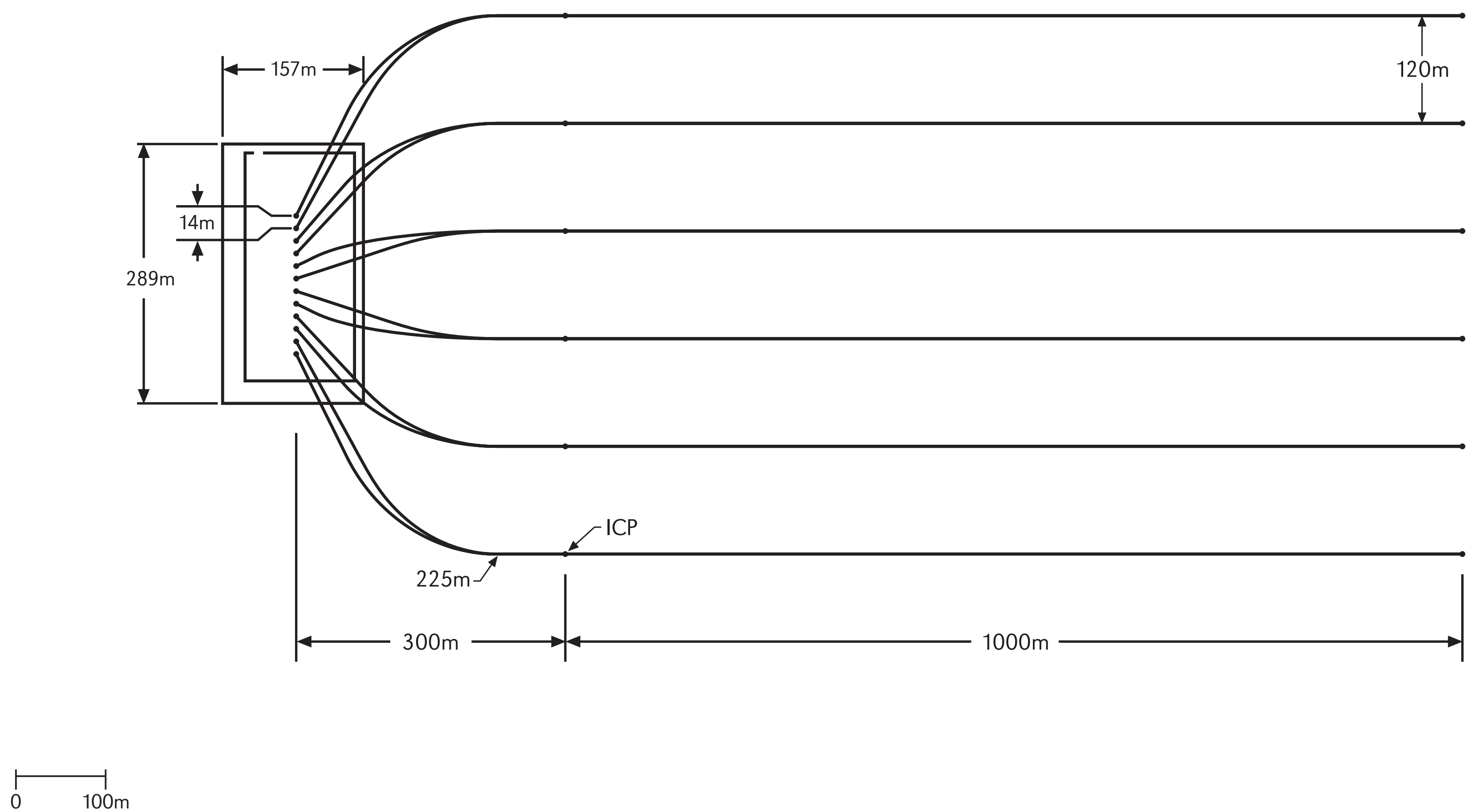
Appendix B - Leismer Stage 2 Expansion

Well Pad and Well Trajectories



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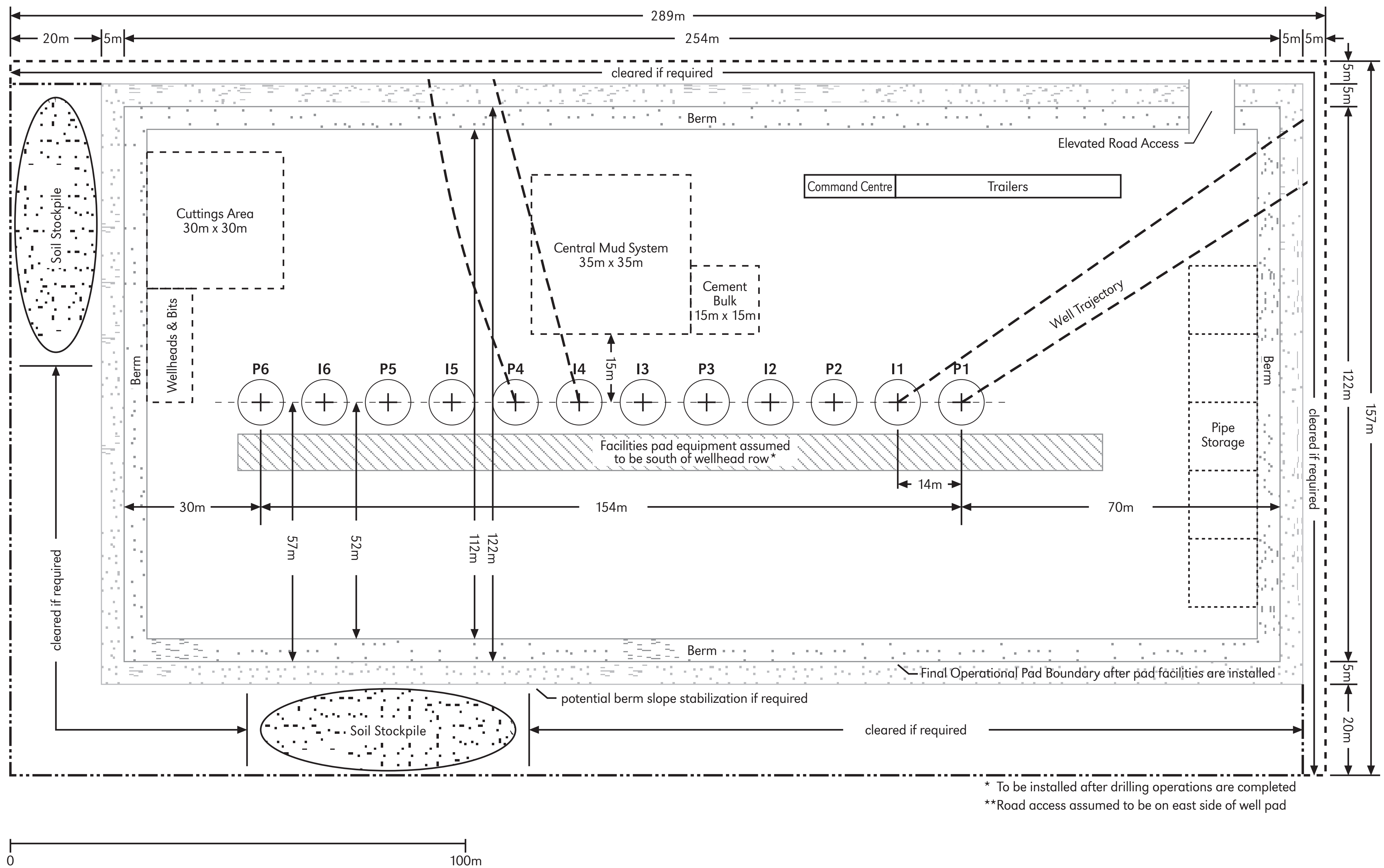
Appendix B - Leismer Stage 2 Expansion

Typical Well Pad Layout During Drilling Operations



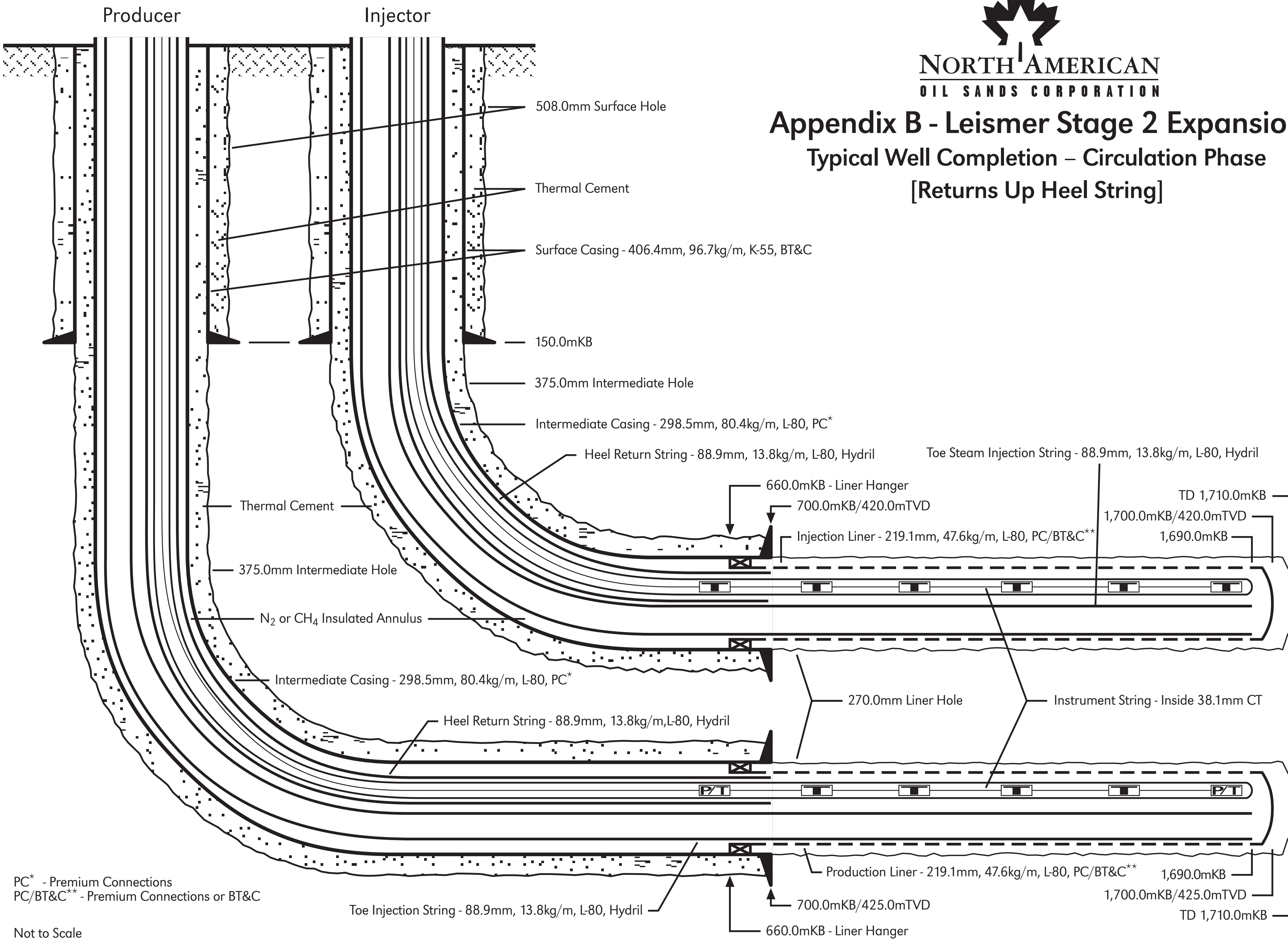
* To be installed after drilling operations are completed

**Road access assumed to be on east side of well pad

Figure 4.3-C L

Appendix B - Leismer Stage 2 Expansion

Typical Well Completion – Circulation Phase [Returns Up Heel String]



PC* - Premium Connections
PC/BT&C** - Premium Connections or BT&C

Not to Scale

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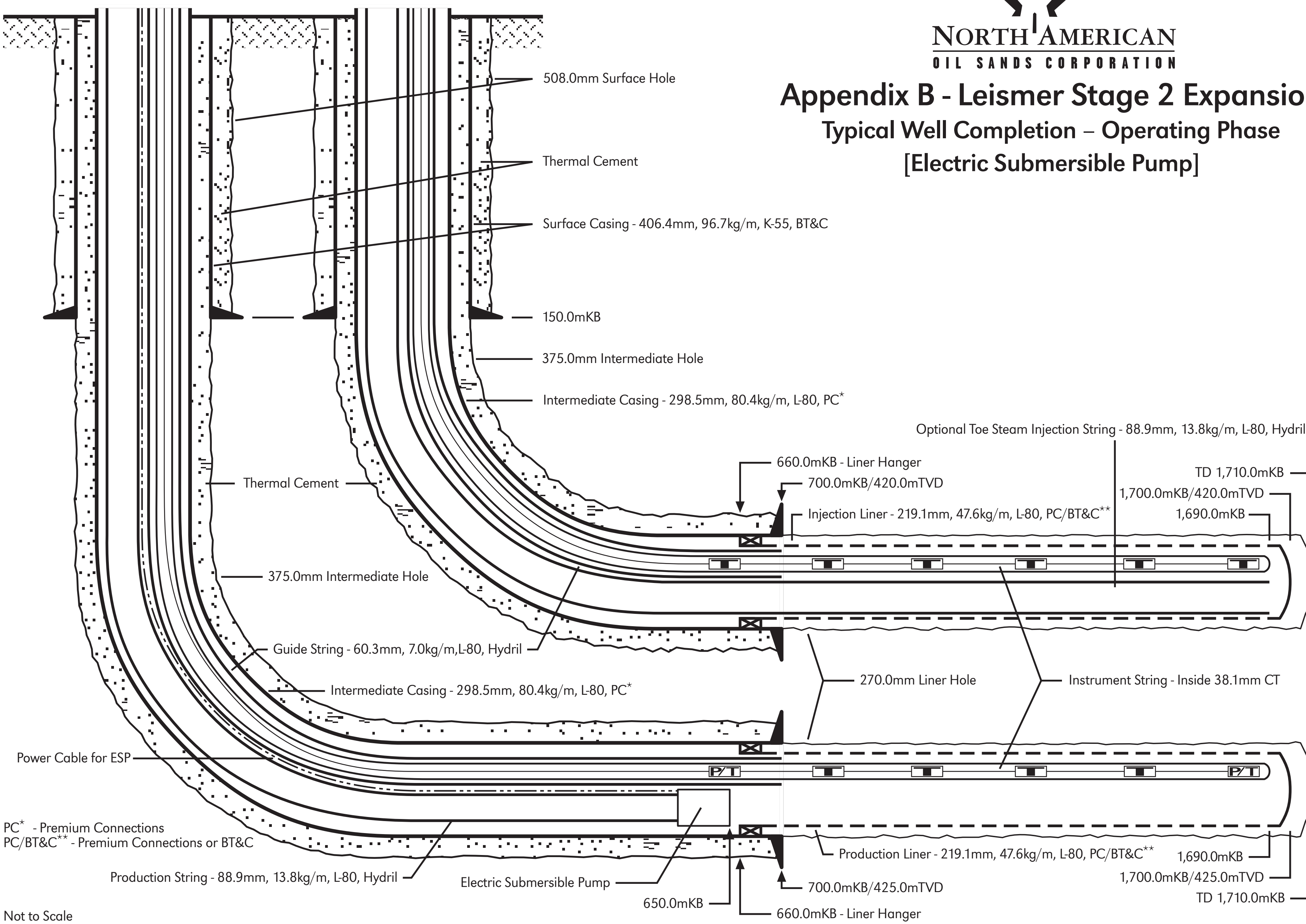
Appendix B - Leismer Stage 2 Expansion

Typical Well Completion – Operating Phase [Electric Submersible Pump]



PC* - Premium Connections
PC/BT&C** - Premium Connections or BT&C

Not to Scale

Figure 4.3-E L

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Appendix B - Leismer Stage 2 Expansion

Typical Well Completion – Operating Phase [Tubing Pump]

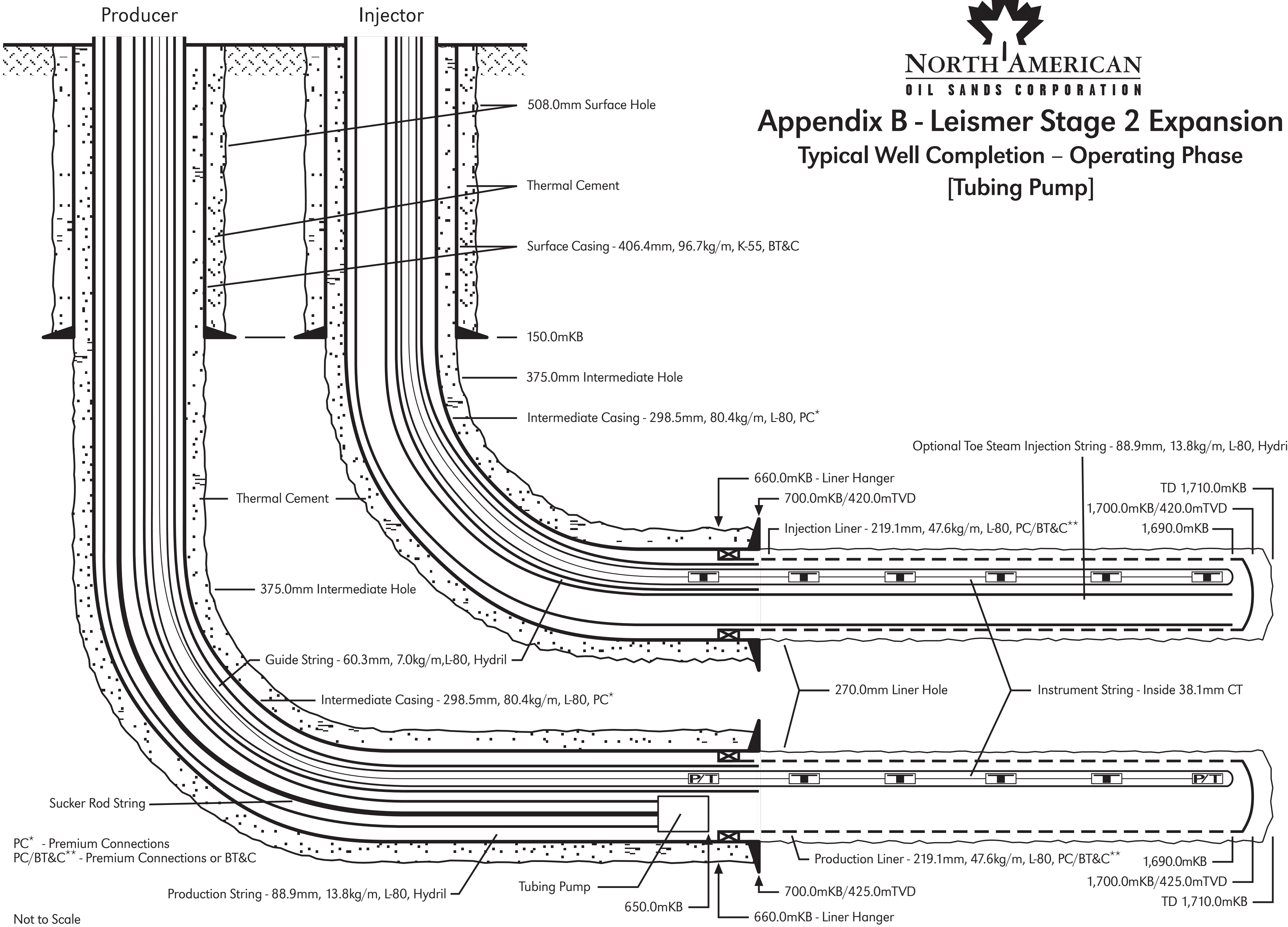

Figure 4.3-E L 070424

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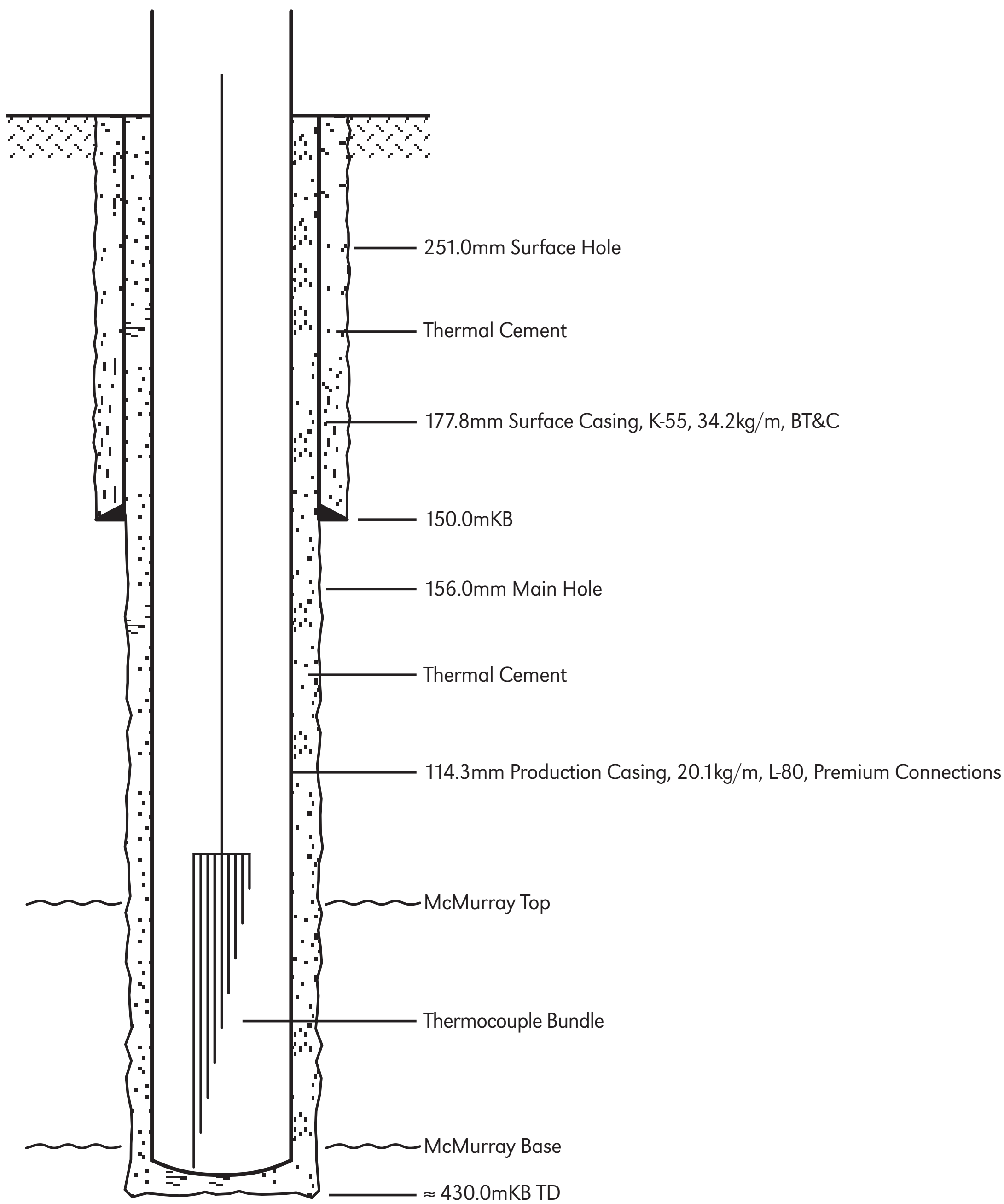
Appendix B - Leismer Stage 2 Expansion

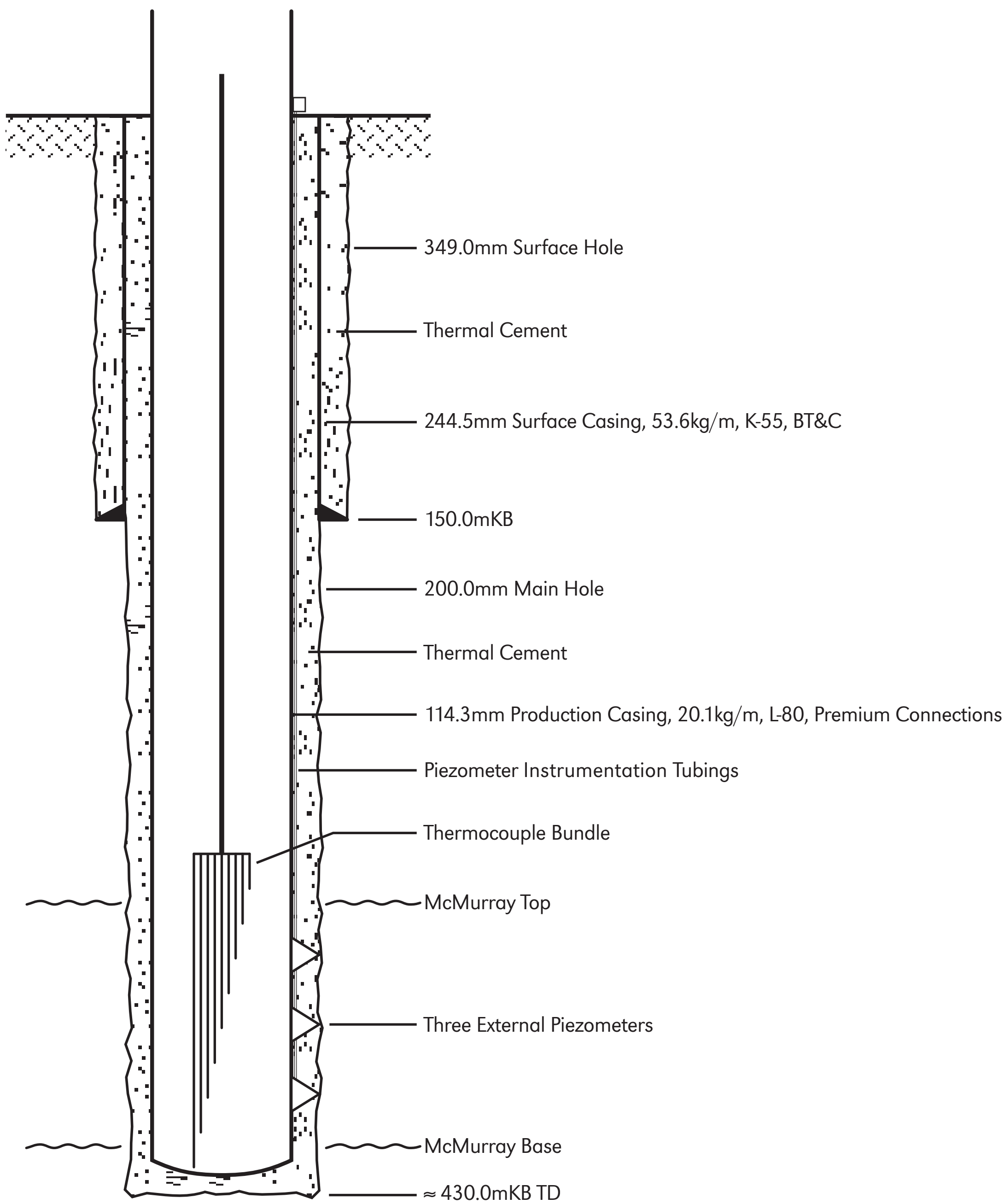
Typical Observation Well (Temperature only)



Not to Scale

Appendix B - Leismer Stage 2 Expansion

Typical Observation Well (Pressure & Temperature)



Not to Scale

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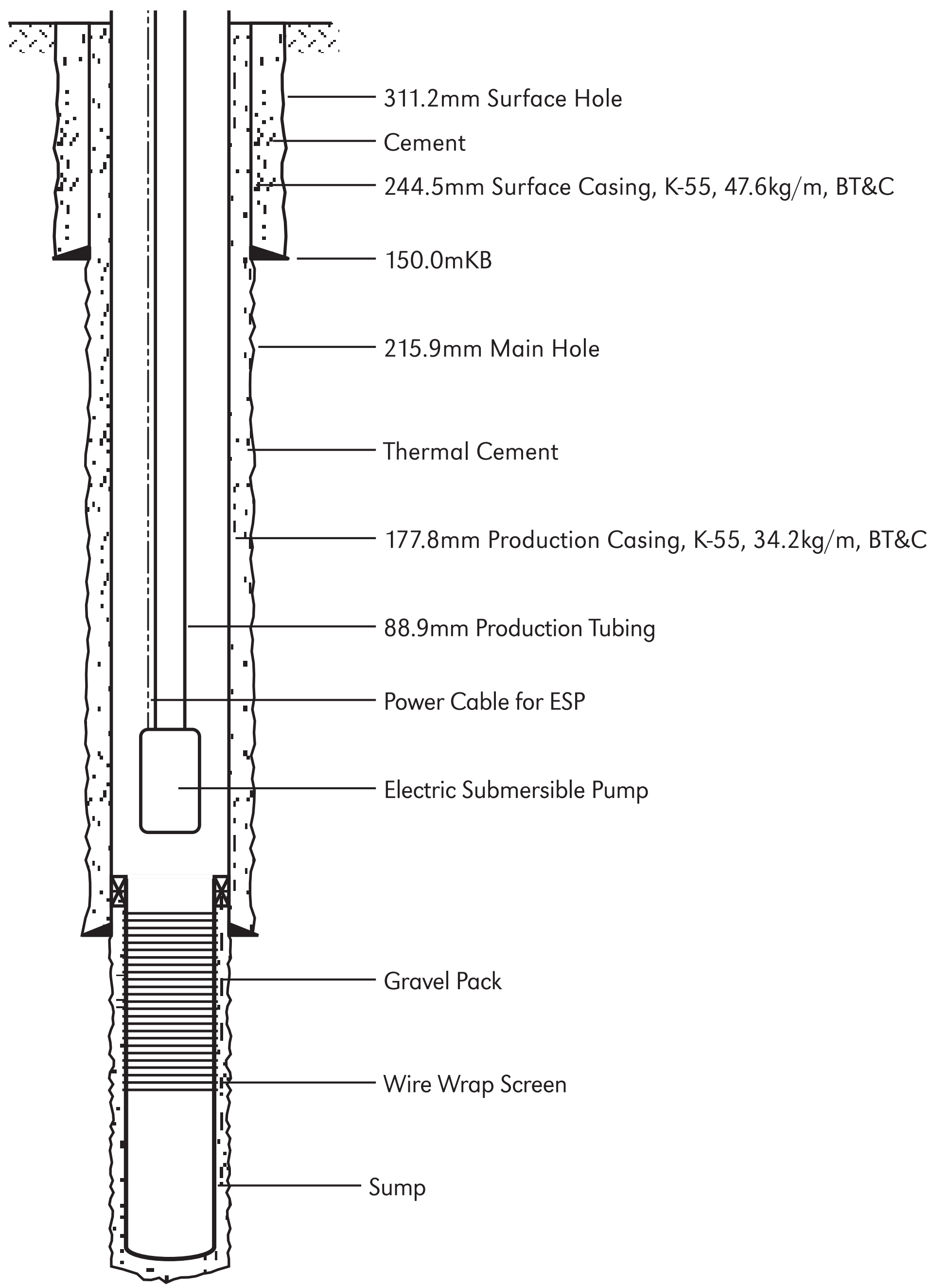
Appendix B - Leismer Stage 2 Expansion

Typical Water Source Well



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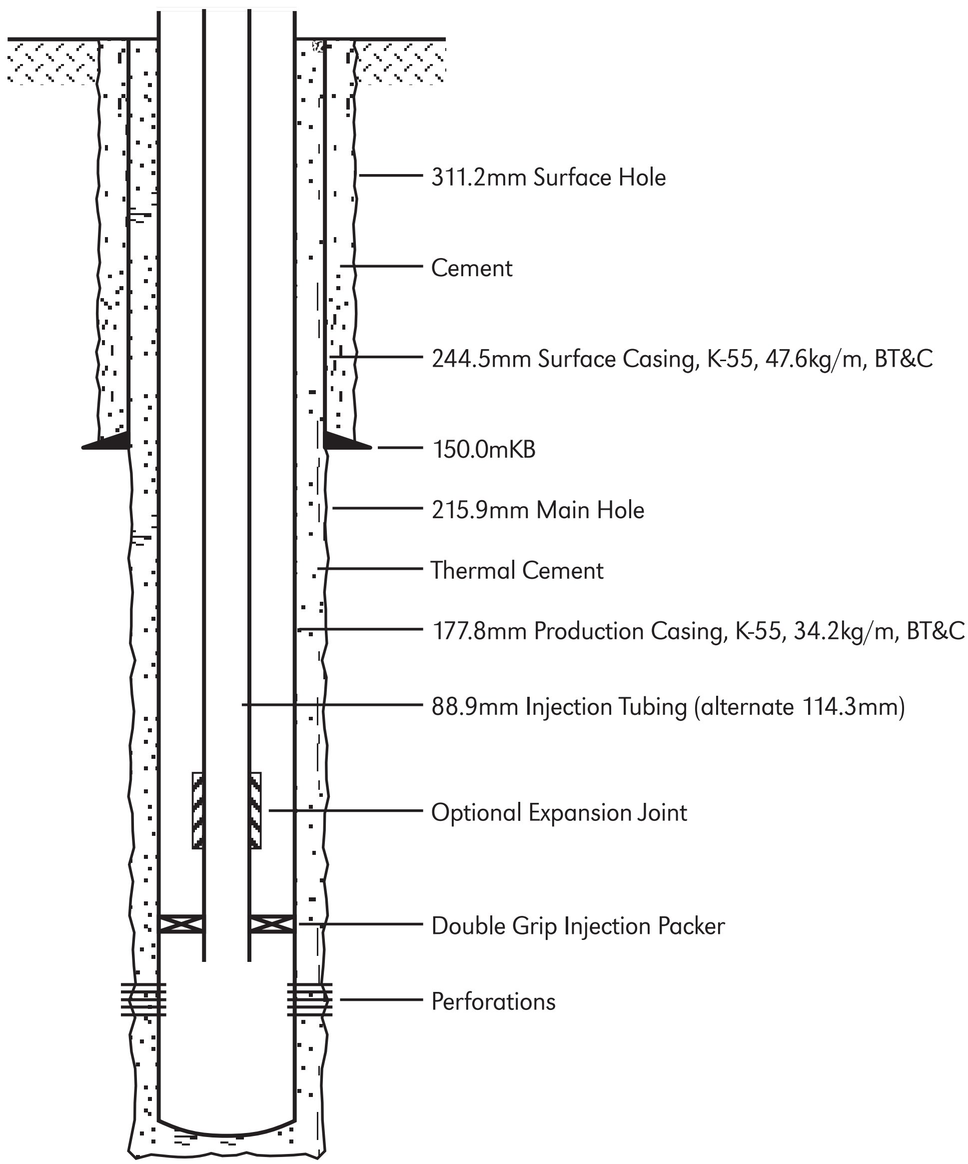
Appendix B - Leismer Stage 2 Expansion

Typical Water Disposal Well (Class 1b)



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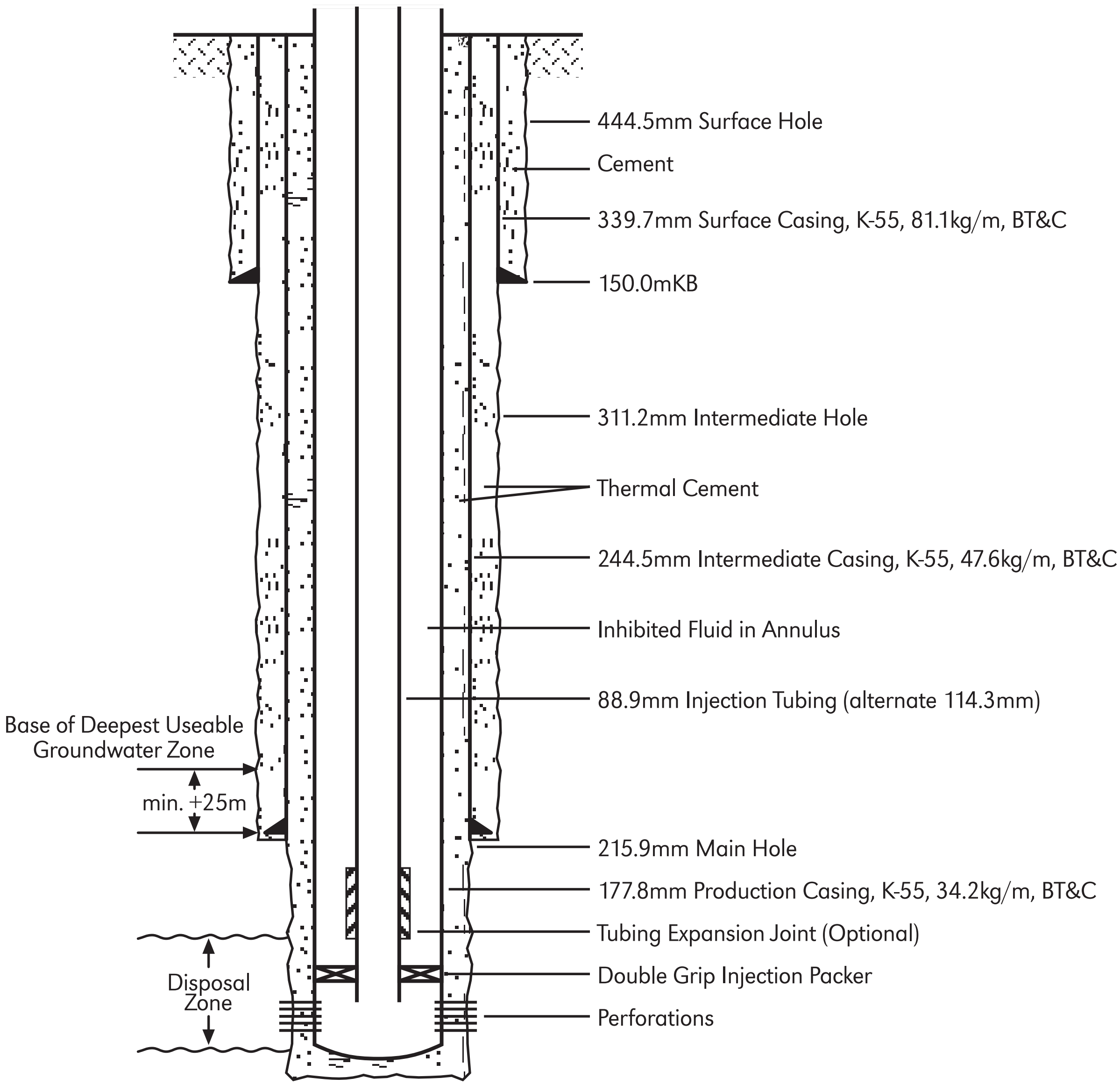
Appendix B - Leismer Stage 2 Expansion

Typical Water Disposal Well (Class 1a)



Not to Scale

B2.3 Central Processing Facility

The Leismer Expansion Hub will use the same production collection and treating processes for produced fluid as the initial Leismer Demonstration Hub and the Leismer Commercial Hub. Figure B2.1-1 presents the Leismer Expansion Hub layout. Increasing the production in the Leismer Development area to a bitumen production capacity of 6,360 m^3/d (40,000 bpd) will require additional facilities, including:

- steam generation equipment
- pumping equipment
- water treating equipment
- oil treating equipment
- deoiling equipment
- heat exchange equipment
- additional source and disposal wells
- associated pipelines to complete integration
- sulphur removal equipment

B2.3.1 Production Treating, Steam Generation, Storage Tanks, Offsites and Utilities

The Leismer Hub will utilize North American's standard process design, as Section 5.2, Volume 1 which consists of bitumen treating, WLS water recycle and OTSGs for steam production. In addition to the process and equipment for the Leismer Commercial Hub, the following components will be added for the Leismer Expansion Hub:

- 4 OTSGs (73 MW, 250 mmBTU/h);
- glycol heater (2.78 MW);
- sulphur plant process heater (2.78 MW);
- high pressure (HP) flare;
- low pressure (LP) flare; and
- emergency power generator.

The Leismer CPF will be provided with the necessary tankage, including diluted bitumen sales oil storage tanks, slop tanks, produced water skim tank, BFW tank, and diluent tank. All tanks will comply with secondary containment as required by EUB Directive 55.

B2.3.2 Sulphur Removal

The maximum sulphur inlet for the Leismer Hub is in the range of one to three tonnes of sulphur per day and, as such, based on EUB Interim Directive 2001-3 requires 70% sulphur recovery. In its entirety, the Kai Kos Dehseh project will have an overall inlet sulphur rate greater than 10 tonnes/day, and, as such, North American has designed each sulphur removal package to meet the 90% removal rate.

Sulphur will be removed from the produced gas prior to mixing with natural gas for combustion in the steam generators. The sulphur recovery unit is a small skid mounted, package unit capable of capturing a minimum of 90% of the sulphur as elemental sulphur of suitable quality for sale. This unit operates similarly to the larger scale Claus type units, where H_2S is oxidized to elemental sulphur over a fixed bed catalytic reactor. The gas phase process maintains the sulphur in the gas phase until it is recovered in the sulphur condenser. The treated gas leaves the process for the fuel gas mix drum prior to being consumed as fuel in the steam generators.

Pretreatment absorbers are expected to be required due to volatile organic compounds present in the produced gas. This would consist of two parallel packed towers upstream of the line labeled “sour gas”. These vessels capture heavy hydrocarbons in the inlet gas stream. The activated carbon media is periodically regenerated and the captured hydrocarbons recycled back into the oil treatment process.

Molten sulphur storage will be provided at the Leismer CPF. The product will be trucked off site for sale.

B2.4 Water

B2.4.1 Camp for SAGD Drilling Program

The SAGD drilling crew will be housed in the existing camp located in NW 14-78-9W4M which has adequate capacity to meet the expansion. This camp was used during the 2006/2007 winter drilling program. This camp has a licensed water well and approved domestic wastewater treatment facility.

B2.4.2 Camp for Construction and Operations

The construction and operations camp for the Leismer Expansion Hub will be the same camp used to house the construction and operations workforce for the Leismer Demonstration and Commercial Hubs. This camp has adequate capacity to meet the expansion.. The camp is an integrated facility located in S1/2 32-78-9 W4 with a total of 450 rooms which accommodates the planned workforce.

The drilling camp in Section 14-78-9 W4 may be used for extra capacity during construction peaks and plant turnarounds.

B2.4.3 Central Processing Facility Potable Water, Utility Water and Domestic Wastewater Treatment

The Quaternary water supply for the Leismer Demonstration/Commercial Hub will be adequate for the Leismer Expansion. Potable water (bottled) is planned to be provided by a commercial supplier.

The domestic wastewater treatment system for the Leismer Demonstration/Commercial Hub will be adequate for the Leismer Expansion.

B2.4.4 Produced Water and Water Reuse Process

The produced water treatment process at the Leismer Expansion Hub consists of deoiling using:

- Skim tank,
- Induced static flotation, and
- Oil removal filters.

Chemicals are added at key points to improve oil and solids removal in the process.

The water reuse plant at the Leismer Expansion Hub consists of the following:

- Warm lime softening for hardness, organics and silica reduction
- After filter for solids reduction
- Two stage weak acid cation exchange for hardness reduction to OTSG specifications.

Chemicals are added at key points to promote silica adsorption, hardness reduction, solids agglomeration, ion exchange regeneration, and oxygen scavenging and hardness chelation. The excess solids produced are stored in a sludge pond, and periodically dewatered and disposed off-site in a Class II (or better) licensed third party landfill.

B2.4.5 Water Management Plan

The water management plan at Leismer Expansion for the increase from 3,180 m^3/d to 6,360 m^3/d bitumen production is based on the following:

- Saline water make-up from the Basal McMurray and reduced Grand Rapids make-up starting the second year of operation.
- Greater than 90% of the produced water is reused after the first year of operation.
- An estimated average of 7% reservoir retention over the life of the project with an estimated 10% maximum reservoir retention after the first year.
- OTSG blowdown recycle to the boiler feedwater with total dissolved solids (TDS) limit of 8,000 mg/L.
- Excess flashed OTSG blowdown will be disposed into the Basal McMurray.

- Balanced push/pull from and to the Basal McMurray is planned. Saline water sources have been identified and confirmatory drilling, testing and modelling programs are being carried out.
- Continued evaluation of the Clearwater Formation, as a viable source of saline makeup water in the Leismer Development area, is planned.

The estimated water makeup and disposal requirements are summarized in Table B2.4-1.

Table B2.4-1 Estimated Leismer Expansion Hub Water Demands

Water Demand	10% Reservoir Retention Long-Term Push-Pull (m^3/ calendar day)	7% Reservoir Retention Long-Term Push-Pull (m^3/ calendar day)
Initial Make-up (Lower Grand Rapids Aquifer)	3,850[1]	3,850[1]
Normal Disposal (Basal McMurray Aquifer)	1,900[3]	1,784
Maximum Disposal (Basal McMurray Aquifer	4,210[2]	3,930[2]
Normal Make-up (Lower Grand Rapids Aquifer)	1,960[3]	1,292
Maximum Make-up (Lower Grand Rapids Aquifer)	3,850[3]	2,730
Normal Make-Up (Basal McMurray)	1,900[3]	1,778

1 Water for one OTSG without produced water returns

2 Short-term – if blowdown recycle to warm lime softening is not functioning

3 Values are shown rounded from Table B2.4-2 and Figure B2.2-4

B2.4.6 Water Balance and Contingency Operating Conditions

The most common upset condition expected at the Leismer Hub is short-term increased reservoir retention. Reservoir retention is the most significant variable affecting the water make-up required to sustain the SAGD process. Reservoir retention is the produced water or condensed steam which does not return from the producing zone.

The consequence of increasing reservoir retention is increased make-up as shown in Table B2.4-2.

In Leismer, with bottom and top water in the reservoir, some production of reservoir water, in addition to the condensed steam, is expected. The exact amount is going to depend on both the detailed geology and the strategies developed and optimized during actual operations. North American plans to operate the SAGD to minimize reservoir retention since it has the negative impact of increasing operating cost and increased water make-up.

Extensive modelling has been done for the Leismer Hub to understand the effects of changing SORs and reservoir retention on the water balance as the Leismer Hub develops and strives to meet the water recycle rates. Table B2.4-1 summarizes key balance parameters based on a produced water TDS of 3,500 mg/L. The actual produced water may vary and is expected to be less saline, however the trends and expected recycle rates are achievable within a plus 10% range on the produced water and easier to achieve with lower TDS concentrations. In order to achieve the 90% recycle rate, a portion of the blowdown must be recycled. The remainder of the blowdown is sent to disposal to purge the TDS from the system, and keep the boiler feedwater TDS below a normal maximum of 8,000 mg/L.

The Table B2.4-2 represents the best estimate of how the reservoir is expected to respond based on evaluation of the geology and experience from other operations. The water reuse plant and the overall project are designed with significant flexibility and are capable and expected to meet or exceed 90% recycle within one year of operation. The following is a discussion of Table B2.4-2:

- It is expected the Leismer Commercial Plant will be operating. In order to increase the rate to 6,360 m3/d of bitumen as requested in this application, additional wells will be brought into production. The start-up of the new wells is anticipated to take approximately 18 months.
- From 0 to 18 months the conversion of all the additional well pairs to SAGD is planned and the production rate should gradually increase. Key aspects of this period are decreasing reservoir retention and decreasing SOR as experience is gained with this reservoir and the steam chamber development continues. Produced water recycle will be at or above plan some days but the average is expected to be slightly above the 90% level. Grand Rapids will continue to be the make-up water source during this period. Disposal of excess OTSG blowdown will be to the Basal McMurray.
- The stream day operation from 18 to 36 months is expected to have a service factor of about 90%, and reservoir retention and SOR are expected to continue to improve. Water recycle should meet or exceed the 90% level and production should be fairly stable at the 6,360 m^3/d level. Greater than 90% water recycle rate is expected to be met on a yearly basis. Push/pull operation into and out of the Basal McMurray will be practiced.
- The stream day operation for the long-term is expected to have a service factor in the range of 92%, and the reservoir retention in the range of 0 to 7%, with SOR in the range of 2.8 to 3.0. Produced water recycle is planned to exceed the 90% recycle rate with partial saline water makeup. The performance of push/pull from and to Basal McMurray should be known. If it is successful, then it will be continued. If it causes bitumen production issues it will be modified or discontinued.

Table B2.4-2 North American Water Management Plan for Leismer Expansion Hub to Bitumen Production Rate of 6,360 m^3/d

		Stream Day			Calendar Day	
		Leismer Commercial Hub	**Leismer Expansion Hub**	**Long Term Operations**	Maximum Reservoir Retention	Average Reservoir Retention
		Operating	**0 to 18 months**	**Long-term High Recycle**	**Long –Term Push-Pull**	**Long –Term Push-Pull**
			Stream Day Factor 90%	Stream Day Factor 92%	**Push - Pull**	**Push - Pull**
Oil Production Rate	m^3/d	3,981	7,073	6,917	6,361	6,361
Reservoir Retention	%	15%	10%	7%	10%	7%
Reservoir Retention	m^3/d	2,388	2,263	1,356	1,908	1,247
SOR		4.0	3.2	2.8	3.0	2.8
Steam (Note 1)	m^3/d	15,923	22,634	19,368	19,083	17,811
BFW Flow	m^3/d	20,545	29,205	24,991	24,623	22,982
BFW TDS	mg/L	5,903	7,435	7,523	7,432	7,521
PW Reuse as per EUB	%	89%	99%	99%	99%	99%
BD Recycle	%	69%	66%	66%	66%	66%
Saline Makeup	%	0%	50%	59%	50%	59%
Source Grand Rapids	m^3/d	3,837	2,317	1,402	1,958[4]	1,292
Source Grand Rapids TDS	mg/L	1,837	1,837	1,837	1,837	1,837
Basal McMurray	m^3/d	0	2261	1936	1902[4]	1778
Source TDS	mg/L	14,061	14,061	14,061	14,061	14,061
Formation Water in PW	%	42%	42%	42%	42%	42%
PW Flow to Reuse	m^3/d	13,534	20,371	18,012	17,175	16,564
PW TDS	mg/L	3,515	3,517	3,519	3,519	3,520
Water lost to BS&W (Note 2)	m^3/d	10	18	17	16	16
Disposal Flow	m^3/d	1,421	2,267	1,940	1,911[4]	1,784
Disposal TDS	mg/L	36,454	46,027	46,595	46,012	46,583
Water lost to Sludge	m^3/d	21	33	29	28	26
Fuel Gas to Steam Plant (Note 3)	sm^3/d	1,136,150	1,615,045	1,381,992	1,361,667	1,270,889

Notes:

1 Cold water equivalent

2 Assumes 50% of BS&W is water.

3 Calculated at 32.7 MJ/m^3, 90% firing efficiency. Produced gas at 17.3 MJ/m^3 also included at same efficiency. GOR 8.0 ^{3}/m^3 fuel for utilities not included.

4 These values are shown rounded in Table B2.4-1.

North American plans to use partial saline make-up water once the plant is through the first phase of production development. North American has tested the Clearwater aquifer at 12-2-78-10 W4M and it shows promise as a viable saline make-up water source. The challenges associated with developing and producing the Clearwater is:

- An increase of 10 km of pipeline and associated infrastructure for the source wells from the Leismer development,
- Gas over water and the associated gas coning and gas locking of pump issues with this type of aquifer, and
- Swelling clays and fines migration in the formation may limit the wells productivity.

The TDS of the Clearwater is in the range of 6,000 to 8,000 mg/L at the test well, and therefore it may evolve to be the preferred saline make-up water source as it would allow higher make-up volumes of saline water as compared to the more saline Basal McMurray, hence the greatest reduction in Grand Rapids make-up water. North American is planning further testing of the Clearwater to confirm feasibility as a long-term saline water source.

B2.4.7 Disposal Water Quality

The only planned disposal stream is flashed OTSG blowdown. The TDS of the boiler blowdown will be approximately four to six times the TDS of the boiler feedwater (BFW). The boiler blowdown is planned to be recycled to a BFW TDS limit of 8,000 mg/L, and the boiler blowdown will then be in the range of 32,000 to 48,000 mg/L. The hardness and silica concentrations of the blowdown are estimated at 2 to 6 mg/L and 200 to 300 mg/L respectively. There is limited information on the Basal McMurray in the area. The Basal McMurray is expected to be 11,000 to 20,000 mg/L TDS within two townships of the plant site. The modelling has been done assuming a 14,000 mg/L TDS for the Basal McMurray.

B2.4.8 Evaluation of Disposal Alternatives

The criteria used in evaluating the disposal process were process and operating reliability, and capital and operating cost. The main blowdown disposition alternatives considered for the disposal stream were:

- Disposal into the McMurray bottom water in the vicinity of Leismer,
- Disposal into the McMurray bottom water in the vicinity of Leismer as part of the balanced push-pull concept,
- Disposal into a channel feature in vicinity of 9-2-78-10 W4M which appears to have a significant water section in the McMurray, and
- Mechanical evaporation followed by crystallization of the disposal stream.

Disposal of OTSG blowdown into the Basal McMurray long-term without withdrawal from the same zone was evaluated and judged likely to cause reservoir recovery issues within the SAGD development area.

Basal McMurray disposal is planned for the Leismer Demonstration Hub prior to startup of the Leismer Commercial Hub (Appendix A), and then the push-pull concept is planned to be operational.

The disposal plan for the Leismer Commercial Hub is the balanced push-pull to the Basal McMurray as a source of saline makeup water and as a method of limiting pressure buildup in the McMurray resulting from disposal. Spacing of disposal wells and source wells to prevent short circuiting of disposal fluids and proximity of the source well to SAGD process wells and potential impacts on the SAGD process have been modelled. Further study and additional geological information is required before this option can be fully assessed. The operational results from the Leismer Commercial Hub will be monitored to confirm the viability of the balanced push-pull scheme. The balanced push-pull disposal will be expanded to handle the disposal volumes from the Leismer Expansion Hub.

Disposal into the water section of the McMurray in the vicinity of 9-2-78-10 W4, was evaluated and is considered a fall back option should the push-pull plan prove not feasible. The additional pipeline and infrastructure costs and the remote location cause this option to be a less preferred option than the push-pull in the CPF area.

During the process selection phase, high capital costs and uncertainties over operability of the evaporation/crystallization process in other SAGD applications made McMurray disposal the preferred option for the Leismer Expansion Hub. North American is continuing to monitor the evaporation/crystallization process application at other SAGD projects to better identify the costs and operational issues. The results from current operations and the on-going evolution of this technology may prove it to be a viable alternative for future phases of the North American development, and possibly applied to the Leismer OTSG blowdown if the push-pull concept does not meet expectations.

B2.4.9 Hydrogeologic Evaluation

Start-up of each Leismer Expansion OTSG will require up to 3,850 m^3/d of water (water required for one OTSG). This water demand is the same volume required and permitted to start-up the Leismer Demonstration OTSGs and as such no additional water is required for the Leismer Expansion.

The hydrogeologic assessment, including well testing and numerical groundwater modelling provided in Volume 3 Section 5.6 Impact Assessment, concludes that sufficient water is available to meet the long-term water demands of the Leismer Expansion Hub. To summarize, the total long-term water demands and supporting aquifers for the Leismer Demonstration, Commercial and Expansion Hubs are 1,960 m^3/d from the Lower Grand Rapids Aquifer and 1,900 m^3/d from the Basal McMurray Aquifer. The hub will also dispose of 1,900 m^3/d into the Basal McMurray Aquifer.

B2.5 Chemical Consumption

The following chemical consumption is based on the total Leismer production capacity of 6,360 m^3/d (40,000 bpd). A variety of chemicals, lubricating oils and domestic and office supplies are required for operations at the CPF. Storage and tracking of the supplies and disposal of waste products includes provisions for secondary containment, leak detection and inventory reconciliation as necessary and as required by Regulation. The largest chemical consumption streams include hydrated lime, magnesium oxide (dry), hydrochloric acid (HCl) and sodium hydroxide (NaOH). Storage capacity for chemicals is generally based on ten to fourteen days supply plus one bulk truckload. Smaller amounts of secondary chemicals such as filtration coagulants, demulsifiers, dispersants, and water treatment aids are also consumed. Chemical consumption estimates for these secondary chemicals are provided as part of the detailed design of the CPF. Table B2.3-1 presents the estimated chemicals that will be consumed during operation of the Leismer Hub.

Table B2.5-1 Chemical Consumption

Chemical	Consumption Rate for 6,360 m^3/d (40,000 bpd) bitumen production (t/d)
Hydrated lime	14.71
Magox	7.58
Soda Ash	3.31
HCl (32%)	9.06
Caustic (50%)	6.60
Demulsifier	0.95
Reverse demulsifier	2.23
Flocculant	0.04
Hypochlorite	0.30
Coagulant	0.40
Polymer	0.51
O2 scavenger	0.29
After filter aid	0.03
Chelant	0.10
Filming amine	0.10

B3 APPLICATION FOR APPROVAL

B3.1 Existing Approvals

North American has received EUB approval for the Leismer Demonstration Hub, which is included within the Kai Kos Dehseh Project area.

B3.2 Request for Approval

North American hereby applies for regulatory approval to construct, operate and reclaim the proposed Leismer Expansion Hub on a portion of the oil sands leases located in Townships 76 to 83, Ranges 8 to 13 West of the 4th Meridian. The CPF for the Leismer Expansion Hub will be located in the 7 and 8 - 2-79-10 W4M, adjacent and integrated with the Leismer Commercial Hub.

The Leismer Expansion Hub will use SAGD to produce bitumen at a rate of 3,180 m3/d (20,000 barrels per day (bpd)) on an annual average calendar day basis. The Leismer Expansion Hub, when combined with the Leismer Commercial Hub will increase the bitumen production at Leismer to 6,360 m3/day (40,000 bpd). North American will seek approval for additional phases of the Leismer Hub under future amendments.

This appendix (Application for Approval of the Leismer Expansion Hub of the Kai Kos Dehseh Project) comprises the Application for Approval of the Leismer Expansion Hub and serves to meet requirements under the Alberta Oil Sands Conservation Act (AOSCA), the Alberta Environmental Protection and Enhancement Act (AEPEA) and the Water Act. The document is provided as an integrated Application to the EUB and AENV as outlined in the EUB/AENV Memorandum of Understanding on the Regulation of Oil Sands Developments (IL 96-07).

With this Application, North American is seeking approval from:

1. The EUB for:

   Approval to amend, construct and operate a bitumen recovery scheme, under Section 13 of the Oil Sands Conservation Act, from the Athabasca Oil Sands Deposit in the McMurray Formation, at Oil Sands Leases located in Sections 21, 22, 33 and 34-78-10 W4M and 3-79-10 W4M owned by North American Oil Sands Corporation; and

2. AENV for:

   a. Amendment to construct and operate the Leismer Expansion Hub, including facilities to recover and treat bitumen and produced water, under Division 2 of Part 2 and Section 63 of the AEPEA; and

   b. Amendment of the Conservation and Reclamation Approval, under Division 2 of Part 2 and Part 5 of the AEPEA to develop, operate and reclaim components of the Leismer Expansion Hub.

Original Signed by

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B4 LEISMER EXPANSION HUB RESERVOIR / GEOLOGY UPDATE

B4.1 Geological Description of the Leismer Expansion Hub Development Area

B4.1.1 Geological Database

North American evaluated the regional geology in a Leismer Regional Geological Study Area (RGSA) defined by the south east of Section 6-78-9 W4 and the north west of Section 4-79-10 W4. The Leismer Expansion Hub consists of four pads (20 wells) to the north of and four pads (20 wells) to the south of the Leismer Demonstration/Commercial development area. Map boundaries were selected to include the proposed plant site (LSD's 7 and 8-2-79-10 W4) and proposed source and disposal well areas.

North American has conducted extensive geological and geophysical investigations throughout the Leismer RGSA including 2D and 3D seismic and extensive exploratory and delineation drilling combined with selective coring. Summary maps of Geological and Geophysical Control for the Leismer RGSA illustrate the distribution of wells (Figure B4-1A) and cores and high resolution micro imager logs (Figure B4-1B). Drilling density over the Leismer Expansion Hub development area is approximately one well per 32.4 ha (80 acres) with 3D seismic.

One hundred and nine wells have been drilled in the RGSA and most have been wireline logged. Four wells did not penetrate the full McMurray and do not provide full information on the SAGD potential (6-1-78-10 W4, 1-2-78-10 W4, 7-9-78-10 W4 and 3-2-79-10 W4). In addition, there are 75 high resolution micro imager logs (HMI) in the Leismer RGSA, of which 38 are in the immediate Commercial, Expansion Hub and Plant Site areas.

The Leismer Expansion development area is partly covered by a 25.6 km^2 3D seismic survey acquired by North American in Q1, 2006. An additional 22 km^2 3D seismic survey was added to the existing survey in Q1, 2007 and the new data is integrated and discussed in Section 4.2. Other parts of the Leismer RGSA are less well defined but will be the subject of additional exploration in future years.

The standard log suite for North American wells includes gamma, neutron, density, PE, SP, resistivity, HMI and sonic. Shear dipole sonic logs are available on selected wells.

All seismic data were interpreted in the Seisware geophysical software. Simandoux shaly sand analysis was carried out by petrophysicists at Weatherford Canada. All log data and seismic surfaces used were integrated in the Geographix Discovery geological software.

Additional drilling will continue in areas outside of the Expansion Hub initial development area in future years and will be the subject of future commercial applications.

B4.1.2 Regional and Expansion Hub Geology and Geophysics

The regional geological picture is for the overall Leismer RGSA. This evaluation is closely aligned with the EUB's review of geological data in the area presented in Report 2003-A (EUB-Athabasca Wabiskaw – McMurray Geological Study). Some of the North American formation tops have undergone minor revision (less than 2 m) due to re-interpretation and KB corrections.

B4.1.2.1 Regional Stratigraphy

The bitumen resource is in the McMurray Formation, which is the basal unit of the Lower Cretaceous Mannville Group. In northeastern Alberta, the Mannville Group is composed primarily of unconsolidated clastic sedimentary rocks that are divided into three Formations. From oldest to youngest, these formations are the McMurray Formation, the Clearwater Formation and the Grand Rapids Formation. Figure B4.1-2 illustrates the regional stratigraphy in the Leismer Expansion RGSA.

The McMurray Formation rests unconformably on the carbonates of the Devonian Beaverhill Lake Group. The unconformity at the base of the McMurray Formation was formed during a lengthy period of sub aerial exposure and erosion and resulted in deeply incised valleys that influenced the deposition of the lower McMurray bitumen sand reservoirs. The lower sands are fluvial in nature while the upper sediments are deposited in estuarine and interdistributary bay environments. The basic regional sequence in the project area consists of stacked progradational parasequences designated, from top down, A1, A2, B1, B2 considered to have been deposited in interdistributary bay settings. C channel deposits underlie the parasequences. McMurray estuarine channels originate at many stratigraphic levels within the stratigraphic section. If a McMurray channel is contained within two of the regional muds, it is named after the sequence it is in (a B1 channel is bound by the A2 mud and underlying B1 mud). Any channels that have cut through the B2 muds or are stacked without preserved regional muds are termed “McMurray channels”.

The Mannville Group is overlain by the shales and minor sands of the Colorado Group which are truncated in areas by pre-Quaternary erosion. The Colorado Group is overlain by Tertiary aged sand and gravel and by Quaternary glacial deposits.

B4.1.2.2 Devonian

The relationship between McMurray thickness and paleotopographical relief on the unconformity surface was previously discussed in Section B4.1.2.1. The Devonian in the Leismer RGSA consists of dolomitized fossiliferous limestones and argillaceous limey mudstones of the Beaverhill Lake Group. Figure B4.1-3 shows the Wabiskaw to Sub-Cretaceous Unconformity isopach. This map integrates well control with a depth converted Wabiskaw to Devonian isochron. Most of the isopach displays little relief and generally is between 59 m (well 10-4-78-10 W4) and 67 m (well 4-7-78-9 W4) thick. A rather pronounced thickness on the isopach is evident on the 3D seismic and has been penetrated by several well bores along the western edge of the development area. The isopach attains thicknesses of 75 m to 80 m in a series of wells along the eastern side of Sections 28 and 33-78-10 W4 and attains a maximum thickness of 80 m in the recently drilled well AB/5-34-78-10 W4. Figure B4.1-4 illustrates two seismic plan views of the feature. A gradient edge map illustrates the low feature on the Devonian surface and a timeslice shows the McMurray sediment infilling the low. All of the relief features are were infilled in early McMurray time and are not evident in younger strata.

The erosional low in the Expansion hub displays greatest relief in the northern group of pads where 11 m is present between wells 3-3-79-10 W4 and 11-3-79-10 W4 (Figure B4.1-3).

Figure B4.1-5 shows the present day structure on the Sub-Cretaceous Unconformity. This map was prepared by integrating geological well control with the 3D depth converted structure on the Devonian surface. Similar to the Wabiskaw to Sub-Cretaceous Unconformity isopach (Figure B4.1-3), structural relief is subdued except for a pronounced north trending low on the west edge of the northern portion of the Leismer Expansion Hub. Direct evidence for the abruptness of the low on the Devonian surface can be seen in 40 acre offset wells at 1- 3-79-10 W4 and 2-3-79-10 W4 (17 m difference) and AB/12-27-78-10 W4 and 9-28-78- 10 W4 (14 m difference).

McMurray Formation

General stratigraphy in the RGSA follows that established by the EUB and has been previously discussed (Section B4.1.2.1). The regional sequences consist of basal mudstones grading up to sandier wave rippled to bioturbated sandier facies. The relatively uniform isopach thickness of the regional parasequences (<10m) precludes development of a thick enough sandstone reservoir to be economically exploited with today's SAGD technology. Sedimentary structures and trace fossils indicate deposition in a restricted marine interdistributary bay fill setting. The thicker, exploitable reservoirs occur in the sandstone dominant portions of fluvial and estuarine deposits.

The McMurray Formation ranges from 36.8 m (well 00/7-31-78-9 W4) to 69.6 m (well AB/5-34-78-10 W4) in thickness in the RGSA, as shown in Figure B4.1-6, the McMurray to Sub- Cretaceous Unconformity isopach. Again, the pronounced north trending thickening in the Development area is evident. This map is similar to the Wabiskaw to sub- Cretaceous Unconformity isopach since the Wabiskaw is of relatively uniform thickness. It should be noted that the McMurray isopach presented in Figure B4.1-6 has not included information from the 3D since the Wabiskaw is a more consistent seismic top than the McMurray.

Structure on the top of the McMurray is illustrated in Figure B4.1-7. Present day relief on the top of the McMurray tilts to the SW with a few closures present.

Wabiskaw Member of the Clearwater Formation

The Wabiskaw Member sharply overlies the McMurray Formation. The Wabiskaw consists of transgressive marine glauconitic silty sandstones. The Wabiskaw is approximately 10 m thick in the RGSA and ranges from 9 to 13 m.

Structure on the top of the Wabiskaw is shown in Figure B4.1-8. Since the Wabiskaw is a more consistent seismic pick than the top of the McMurray, the map of Figure B4.1-8 was selected for integration with 3D depth converted isochron data to produce the Structure map on the sub-Cretaceous Unconformity (Figure B4.1-5). The Wabiskaw tilts to the southwest in the RGSA at about 4 m per 1600 m with a low of 254 m (wells 10-4 and 11-16-78-10 W4) and a high of about +272 m at wells 12-19-79-9 W4 and 6-36-78-10 W4.

Clearwater Formation

The Clearwater Formation in the Leismer Expansion Hub development area consists of a basal marine shale (5 to 10 m thick), the Clearwater B sandstone and an upper Clearwater shale. The upper Clearwater A sandstone is not developed in the Leismer RGSA.

Clearwater B Sandstone

The Clearwater B sandstone is up to 40 m thick in the southern portion of the Leismer Expansion RGSA. Gross porous sandstone maps are presented and discussed in Section B4.3.5. The unit is a fine to medium grained glauconitic marine sandstone.

Upper Clearwater Shale

The Clearwater sandstone in the Leismer Expansion Hub development area is sharply overlain by a marine shale about 50 m thick.

Grand Rapids Formation

In the RGSA, the Grand Rapids Formation consists of an Upper and Lower member. The Lower Member is a blocky, clean sandstone and a thin coal (<2 m) is commonly present towards the top. Gross porous sandstone maps are presented and discussed in Section B4.3.4.

The Upper Grand Rapids is 40 to 60 m thick and consists of stacked progradational parasequences with basal marine shales grading up into clean porous sandstones. Gas over water may be locally present in these upper sandstones.

Joli Fou Formation

Tight marine shales of the Joli Fou Formation directly overlie the Upper Grand Rapids Formation. The Joli Fou is truncated by the Quaternary unconformity and is overlain by unconsolidated glacial sediments. In the Leismer Expansion Hub development area, the Viking formation is commonly preserved and locally, Cretaceous sediment as high up as the base of Fish Scales may be present.

Quaternary

The Mannville Group is overlain by the shales and minor sands of the Colorado Group which are truncated in areas by pre-Quaternary erosion. The Colorado Group is overlain by Tertiary aged sand and gravel and by Quaternary glacial deposits.

B4.1.2.3 Leismer Expansion Hub Geology

Type Log of the McMurray Formation

Figure B4.1-9 illustrates well AB/3-34-78-10 W4/00, which was selected as the type log for the Leismer RGSA.

Log and Core Comparison

The Leismer Expansion Hub RGSA has a total of 109 wells with 50 cores in the McMurray. Weatherford Canada was retained to carry out Simandoux shaly sand analyses on the cored wells in the RGSA. Core and log data compared favorably and an example is illustrated in Figure B4.1-10 for the type log AB/03-34-78-10 W4. Log parameters and a Pickett plot, used to determine Rw, as determined by Weatherford, are shown in Figure B4.1-11.

Several things can be noted from the core to log comparison of Figure B4.1-10. Saturations match most closely in the cleaner reservoir intervals. The largest discrepancy can be seen in highly interbedded sections where core sampling tends to high-grade the cleaner sandstone beds and where logs tend to average their response across the interbedded sands and shales.

Net SAGD pay maps for the Expansion Hub were prepared by using 6 weight percent bitumen cutoffs as determined by Simandoux analysis and consistent with Report 2003-A.

Of particular interest, the Rw as determined from the Pickett plot (Figure B4.1-11) and core-log calibrations is quite consistent at a value of 0.55. Rw variations in the McMurray can be quite significant, particularly in areas close to surface or outcrop, and may result in a need for frequent coring to determine oil saturations. North American believes there is already enough core control in the area to verify that Rw is consistent and no additional coring is required in the Leismer Expansion Hub development area to address that specific issue.

Table B4.1-1 summarizes the McMurray reservoir characteristics from the all cores taken in the Kai Kos Dehseh project area.

Table B4.1-1 Reservoir Characteristics from All Cores in the Project Area

Parameter	**Core Range**
Porosity	27-41%
Permeability	2-10 Darcies
Bitumen Saturation	50-90%

Seismic Characterization of the McMurray Formation

North American conducted 3D seismic utilizing a mini-vibrator source in the Leismer area, a portion of which covered the Leismer Expansion Hub development area, in Q1 of 2006. Innovative grid design achieved high resolution sampling, while limiting environmental impact to 10 ha. North American imaged and mapped the Middle McMurray channel sequences and oil sand prone porosity zones, achieving 5 m bed resolution. Coherency and signal to noise of the mini-vibe seismic, spatial sampling and, prestack time migration processing have combined to produce highly interpretable seismic with excellent agreement to the wireline log data. Identification of channel facies from seismic will help refine infill drilling programs and reduce the need for high density drilling patterns to delineate the McMurray channels.

Seismic parameters are as follows:

- 112 m source line interval, 140 m receiver line interval (Reverse acquisition geometry).
- Source: Single Mini-vibe 12,000 lbs. units, non-linear sweep 8-180 Hz.
- Infill dynamite around lakes and impassable areas (about 0.5% of source points).
- 1 millisecond sample rate, ARAM 24 bit recorder.
- Processed by Paradigm, March/April, 2006.
- Imaged 7 m x 7 m bins (10 fold), 10 m x 20 m bins (20 fold) and 14 m x 14 m bins (40 fold) binning options- the best 7 m x 7 m having the highest migration fold.
- Bandwidth in migrated stack 10-165 Hz., after NMO stretch.

- Dominant frequency of 100 Hz., at 2400 m/s- resolving 6 m beds.
- Detection of hard shales within these sands down to 3 m, with gas zones down to 2 m.

Channel fairway interpretation successfully separates the regional wells from the channels with added insight to stacked sequences in “McMurray channels” in certain wells. For example, shallow B1 channels have been interpreted in AA/3-2-79-10 W4, Ab/5-34, AB/4-27, AA/14-21 and AA/6-21-78-10 W4.

3D seismic with high resolution parameters can help map channel fairways and sand prone facies. Integrating the 3D seismic with logs has effectively allowed North American to define the bounding reservoir limits, and combined with oil/water contact information from logs, and effectively place horizontal wells to optimize recovery.

An additional 12.3 sections of 3D was added to the 2006 survey in Q1, 2007. Data have been incorporated into the mapping provided in this application.

Reservoir Characteristics

The Leismer Hub development area can be described as a continuous reservoir bounded to the northeast by a main channel edge, to the west by interbedded, shale dominant channel sequences and at the base by a tilted oil/water contact. As will later be demonstrated, the new horizontal wells will be contained within the bounding features. Figures B4.1-12 and B4.1-13 are east-west and north-south seismic cross sections, respectively, through the Leismer Hub. Figures B4.1-14 and B4.1-14A are west-east and north-south geological cross sections through the northern portion of the expansion area, respectively. Figures B4.1-15 and B4.1-15A are west-east and north-south geological cross sections through the southern portion of the Expansion Area. Figure B4.1-16 is the McMurray Net SAGD Pay map prepared with 6 weight percent bitumen cutoffs and illustrates the main bounding features. Table B4.1-2 summarizes cutoffs used to estimate bitumen resources.

Table B4.1-2 Cut offs Used to Estimate Bitumen Resource

Parameter	**Value**
Bitumen Saturation (core)	6 Wt. %
Bitumen Saturation (logs)	RT ≥ 20 ohms at 27% phi
Sand porosity (density log)	27%
Gamma ray (log)	75 API

The eastern channel edge was previously defined largely by 3D seismic. Drilling has further helped to define this edge and the 10 m SAGD pay contour lies just to the east of 11-3-789-10 W4 (12.5 m) and 3-3-79-10 W4 (14 M) in the northern pads. To the south, wells at 5-14-78-10 W4 and 16-15-78-10 W4 are close to the edge of exploitable bitumen (Figure B4.1-16).

Figure B4.1-16 indicates the presence of additional bitumen resource in the main trend to the north west and south east of the Leismer Expansion Hub and with additional exploitable SAGD pay elsewhere in the RGSA. These deposits will be further delineated in the future and will be the subject of future applications as part of the overall Kai Kos Dehseh Project.

Figure B4.1-17 is the isopach of the B2 Mudstone. The mudstone is only present to the east of the main channel target in the Expansion Hub and will not form a caprock for the SAGD development but may help constrain vertical leakage lateral to thermal operations. Figure A 4-18 is the isopach of the B1 Regional parasequence. The unit forms a caprock over most of the project area with the exception of the down-cutting B1 channel complex. The A2 regional parasequence with the basal A2 mudstone barrier is present throughout the Leismer Expansion Hub and forms the main caprock for the SAGD operation. The basal mudstone isopach (Figure A 4-18) shows the mudstone ranges from 0.4 m thick (well 16-28-78-10 W4) to 2.1 m thick (well AB/14-27-78-10 W4).

Structure maps on the Top and Base of the SAGD Gross Pay (at a 40 ohm cutoff) are shown in Figures B4.1-20 and B4.1-21, respectively. The base of the 6 weight percent bitumen is very close to the oil/water contact and, at 50 % bitumen saturation (6 weight %), is in the lower transition zone. North American wishes to avoid placing wells in the transition zone and proposes to use a 40 ohm cutoff to determine lower well positioning. In areas < 4 m of bottom water, the wells will be placed 1 m above the 40 ohm cutoff. In areas of ≥ 4 m bottom water, the well will be placed 4 m above the 40 ohm cutoff. North American feels the additional standoff is required for the thicker bottom water areas. The transition from water to 6 weight percent to 40 ohms is fairly abrupt in the Leismer Expansion Hub and is usually less than 2 m.

Figure B4.1-20 shows the structure on the top of the gross SAGD pay.

Figure B4.1-21 shows the structure on the base of the 40 ohm SAGD pay. Variation in the elevation on the base of the SAGD Pay in the northern set of pads is unfortunately extreme and will severely limit flexibility in placing horizontal wells. A relief of 7 m is present between wells AB/5-34 and 6-34-78-10 W4. Orienting horizontals to the northwest allows the well trajectories to be sub-parallel to the strike of the tilt on the base of pay so the wells can be stepped down at successively lower elevations to optimize recovery.

Table B4.1-3 includes volumetrics, by pad, for bitumen in place above the producing wells to the top of the 6 weight % pay and volumetrics for stranded oil in place from the producing wells to the base of 6 weight % bitumen. These volumes were calculated in Geographix for the pad areas by using grid operations top and base of net ≥ 6 weight percent bitumen surfaces and a third surface determined by the selected elevations for the horizontal wells with a final gross to net reduction.

Table B4.1-3 SAGD Pad Volumes

Pad	Drainage Area (Ha)	No. of Well Pairs	Volume Classification	Avg Pay Thickness (m)	Avg Bitumen Saturation (fraction)	Avg Porosity (fraction)	Net To Gross (fraction)	6 wt% OBIP (e6m3)	Est. Recovery Factor (fraction)	Est. Recoverable Bitumen (e6m3)
L05	80.0	6	Above Producer Level	17.7	0.817	0.320	0.968	3.584	0.588	2.108
			Below Producer Level	2.0	0.774	0.317	1.000	0.393	0.000	0.000
			Total	19.7				3.977	0.530	2.108
L06	42.0	4	Above Producer Level	23.7	0.828	0.326	0.976	2.621	0.603	1.581
			Below Producer Level	3.3	0.807	0.337	0.961	0.362	0.000	0.000
			Total	27.0				2.984	0.530	1.581
L07	49.6	4	Above Producer Level	25.1	0.715	0.304	0.783	2.118	0.585	1.239
			Below Producer Level	2.1	0.743	0.305	0.927	0.219	0.000	0.000
			Total	27.2				2.337	0.530	1.239
L08	84.4	6	Above Producer Level	18.9	0.756	0.317	0.818	3.126	0.590	1.843
			Below Producer Level	2.0	0.764	0.322	0.847	0.352	0.000	0.000
			Total	20.9				3.478	0.530	1.843
L09	51.7	4	Above Producer Level	15.2	0.832	0.340	0.970	2.155	0.578	1.246
			Below Producer Level	1.2	0.888	0.355	1.000	0.196	0.000	0.000
			Total	16.4				2.351	0.530	1.246
L10	70.0	6	Above Producer Level	14.4	0.726	0.307	0.815	1.830	0.648	1.186
			Below Producer Level	2.4	0.766	0.317	1.000	0.408	0.000	0.000
			Total	16.8				2.238	0.530	1.186
L11	66.7	6	Above Producer Level	19.2	0.827	0.322	0.972	3.316	0.617	2.047
			Below Producer Level	2.9	0.858	0.329	1.000	0.546	0.000	0.000
			Total	22.1				3.862	0.530	2.047
L12	51.0		Above Producer Level	13.1	0.795	0.323	0.907	1.556	0.641	0.998
			Below Producer Level	2.6	0.792	0.325	0.957	0.327	0.000	0.000
			Total	15.7				1.883	0.530	0.998

Figure B4.1-22 shows well pair and pad locations for the Leismer Expansion Hub. Figure B4.1-23 shows the pad and horizontal well locations in conjunction with the structure map on the base of the SAGD pay. Table B4.1-4 lists the producer horizontal wells and the structural elevations used in the calculations for Table B4.1-3. Individual plots of each horizontal producer well in the hub area with a depth converted 3D seismic profile and key horizons are included at the back of this Appendix.

Table B4.1-4 Elevations of Horizontal Producing Wells

Well Pair Name	Well (productive) length (m)	Elevation of horizontal well (TVDSS m) -	Drilling Direction
01-L05-P6	870	208	NNW
02-L05-P5	950	207	NNW
03-L05-P4	960	208	NNW
04-L05-P3	960	210	NNW
05-L05-P2	920	211	NNW
06-L05-P1	940	212	NNW
07-L06-P4	810	208	SSE
08-L06-P3	810	208	SSE
09-L06-P2	780	209	SSE
10-L06-P1	820	209	SSE
11-L07-P4	960	211	SSE
12-L07-P3	820	211	SSE
13-L07-P2	880	210	SSE
14-L07-P1	840	209	SSE
15-L08-P6	1000	207	NW
16-L08-P5	1000	207	NW
17-L08-P4	1000	206	NW
18-L08-P3	1000	206	NW
19-L08-P2	1000	207	NW
20-L08-P1	1000	208	NW
21-L09-P4	1000	212	SE
22-L09-P3	1000	213	SE
23-L09-P2	1000	212	SE
24-L09-P1	1000	212	SE
25-L10-P6	900	211	SE
26-L10-P5	900	211	SE
27-L10-P4	900	211	SE
28-L10-P3	900	211	SE
29-L10-P2	900	212	SE
30-L10-P1	900	212	SE
31-L11-P6	920	212	NW
32-L11-P5	770	211	NW
33-L11-P4	850	210	NW
34-L11-P3	690	210	NW
35-L11-P2	610	210	NW
36-L11-P1	680	210	NW

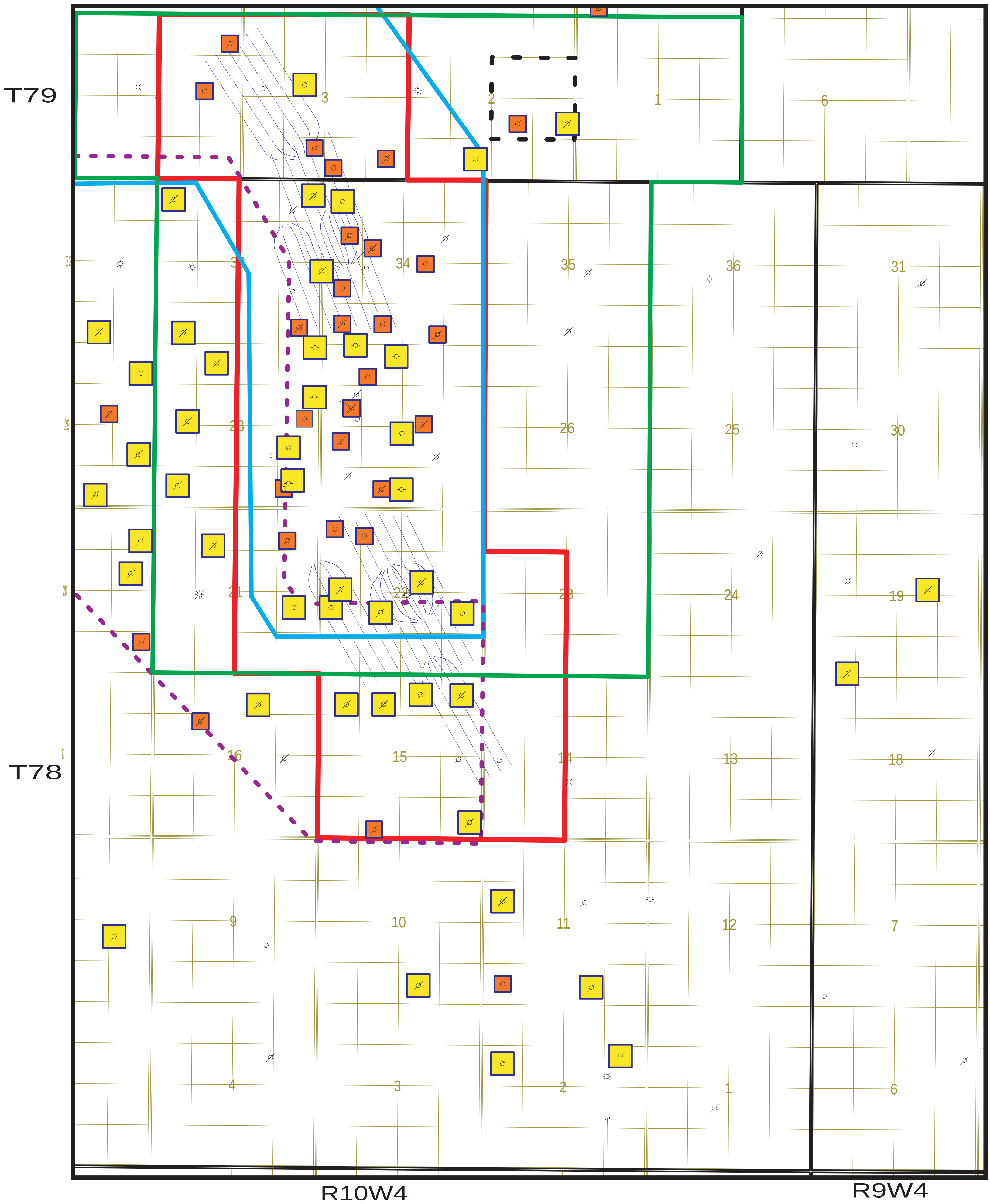
37-L12-P4	960	211	SE
38-L12-P3	960	211	SE
39-L12-P2	960	211	SE
40-L12-P1	960	212	SE

An upper associated top thief zone, generally in continuity with SAGD pay, is locally present in a B1 channel complex. Figure B4.1-24 is a posted isopach of the McMurray associated net gas. This associated gas exclusively occurs in a sandstone found at the top of the B1 cross cutting channel and can be up to 10.8 m thick in the Expansion Hub development area (AB/5-34-78-10 W4). The gas is very conspicuous as a bright spot and the 3D seismic confirms that, although locally thick, the pools are less than 100 m across. This gas has never been produced and pressure data collected during drilling operations indicates that no pressure depletion has occurred.

Non-associated bitumen and non-associated gas are present in the regional sequences (typically A or B1). Non-associated gas (Figure B4.1-26) Figure B4.1-27 is an isopach of the McMurray net associated bitumen. Table B4.1-5 is a listing of all the gas wells, status and owners in the vicinity of the Leismer Expansion Hub.

Table B4.1-5 Gas Wells in the Vicinity of the Project Area

Well	Gas Zone	Status as of May 2007	Owner	Associated or Non Associated	In Project Area?
00/9-6-78-9 W4	McMurray A2, B1 seq	Flowing	BP Canada	N	N
00/12-19-78-9 W4	McMurray A2, B1 seq	Flowing	EnCana Corp.	N	N
00/6-1-78-10 W4	McMurray A2 seq	Flowing	Paramount Energy	N	N
00/9-2-78-10 W4	McMurray A2 seq	Flowing	Paramount Energy	N	N
00/4-11-78-10 W4		Flowing	Paramount Energy		N
00/12-12-78-10 W4	McMurray A2, B1 seq	Flowing	Paramount Energy	N	N
00/7-14-78-10 W4		Flowing	Paramount Energy		N
00/8-15-78-10 W4	McMurray A2 seq	Flowing	Paramount Energy	N	N
00/6-21-78-10 W4	McMurray A1 seq	Suspende d	Paramount Energy	A	N
00/7-22-78-10 W4	Grand Rapids	Flowing	Paramount Energy	N	N
00/5-33-78-10 W4	McMurray 1,A2, B1, Regional	Flowing	Paramount Energy (65%), Primewest Energy (35%)	N	N
00/6-34-78-10 W4	McMurray A1, B1 Regional	Flowing	Paramount Energy (65%), Primewest Energy (35%)	N	Y
00/6-36-78-10 W4	McMurray A2, B1, B2 seq B2 Channel	Flowing	Paramount Energy	N	N
00/12-2-79-10 W4	McMurray A1 Regional	Flowing	Paramount Energy (65%), Primewest Energy (35%)	N	N



Leismer Expansion Area

3D Seismic Survey 2007

3D Seismic Survey 2006

NAOSC Drilled 2007

NAOSC Drilled 2005 & 2006

Project Area

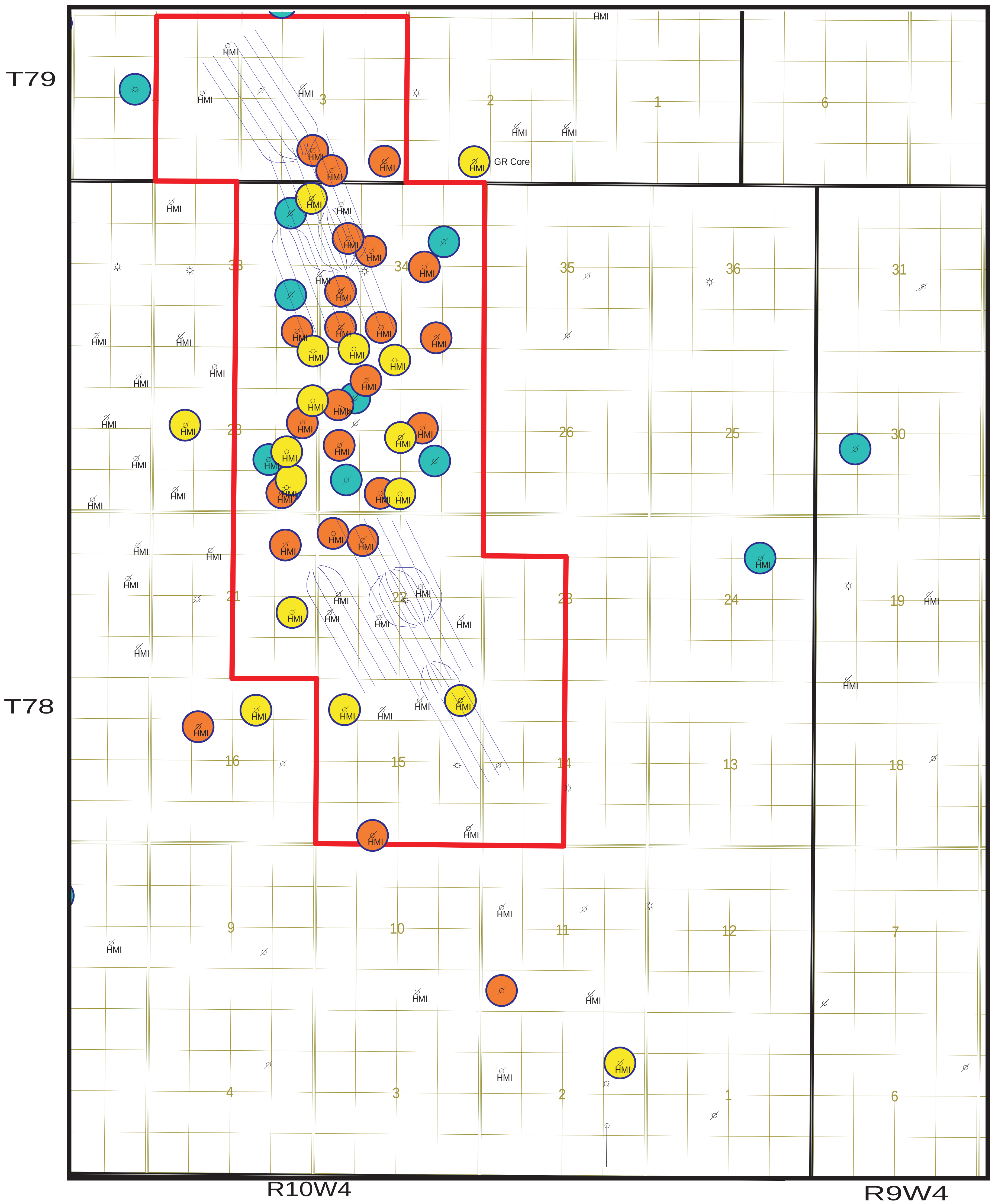
Plant Area

Figure B4-1A Well Control & 3D Seismic

North American Oil Sands Corporation

Leismer
Well Control & 3D Seismic Surveys

Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 9 May, 2007
	Scale: 1:40,000	



Leismer Expansion Area

NAOSC Cored 2007

NAOSC Cored 2005 & 2006

Pre 2005 Legacy Core

HMI NAOSC HMI Logs

Figure B4.1-1B
Cored Wells, HMI Logs

NORTH AMERICAN

Leismer All Cored Wells and HMI Wells		
Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 4 May, 2007
	Scale: 1:40,000	

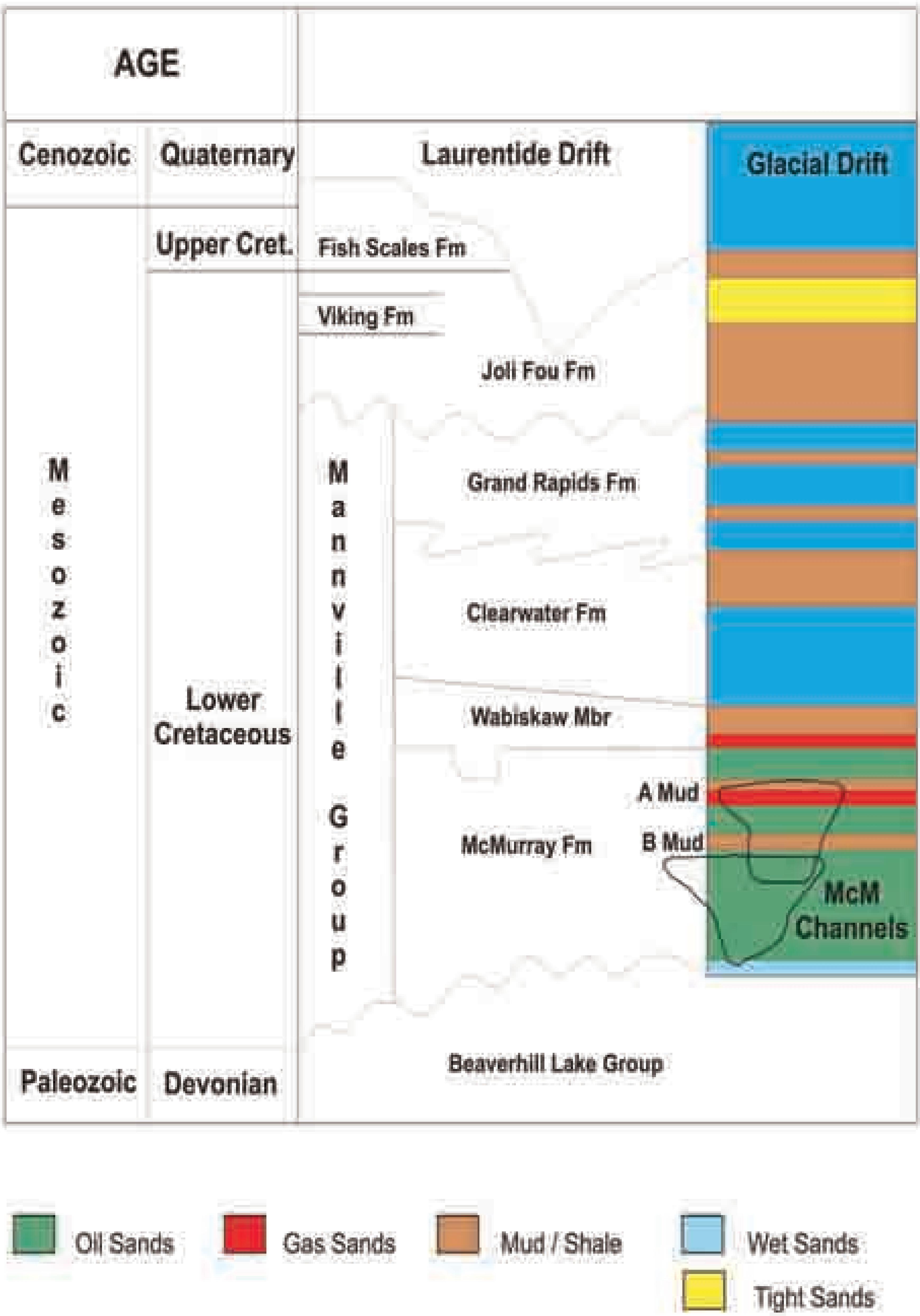
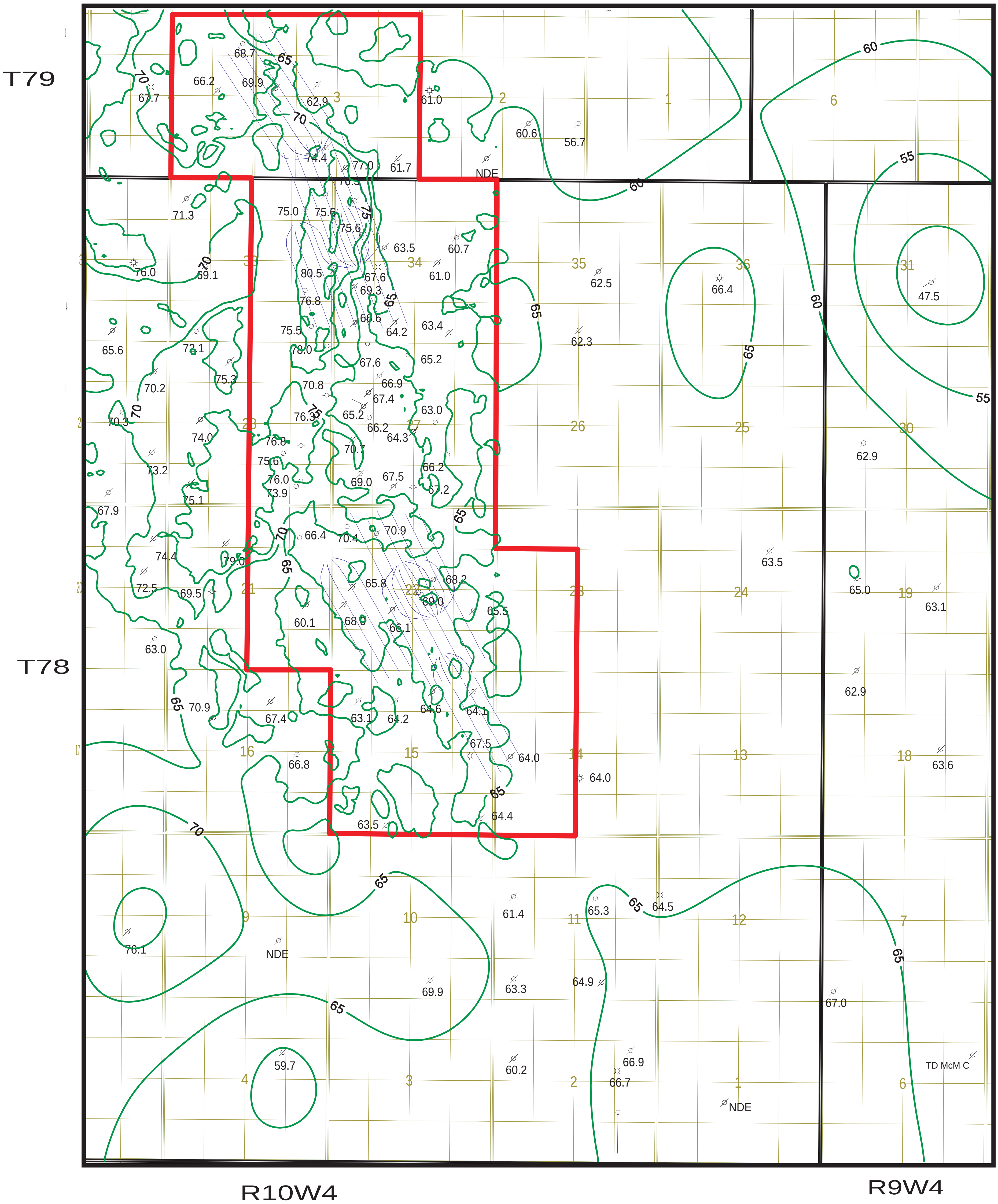


Figure B4.1-2 General Stratigraphy in the Regional Study Area

NORTH AMERICAN OIL SANDS CORPORATION



Leismer Expansion Area

64.5 Wabiskaw to Sub-Cretaceous Unconformity Posted Isopach

TD McM C Total Depth McMurray Channel

NDE Not Deep Enough

Figure B4.1-3 Wabiskaw to Sub-Cretaceous Unconformity Isopach Modified with 3D Seismic

North American Oil Sands Corporation

Leismer
Wabiskaw to Sub-Cretaceous Unconformity
Isopach Modified with 3D Seismic

Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 13 June, 2007
C.I.=5 m	Scale: 1:40,000	

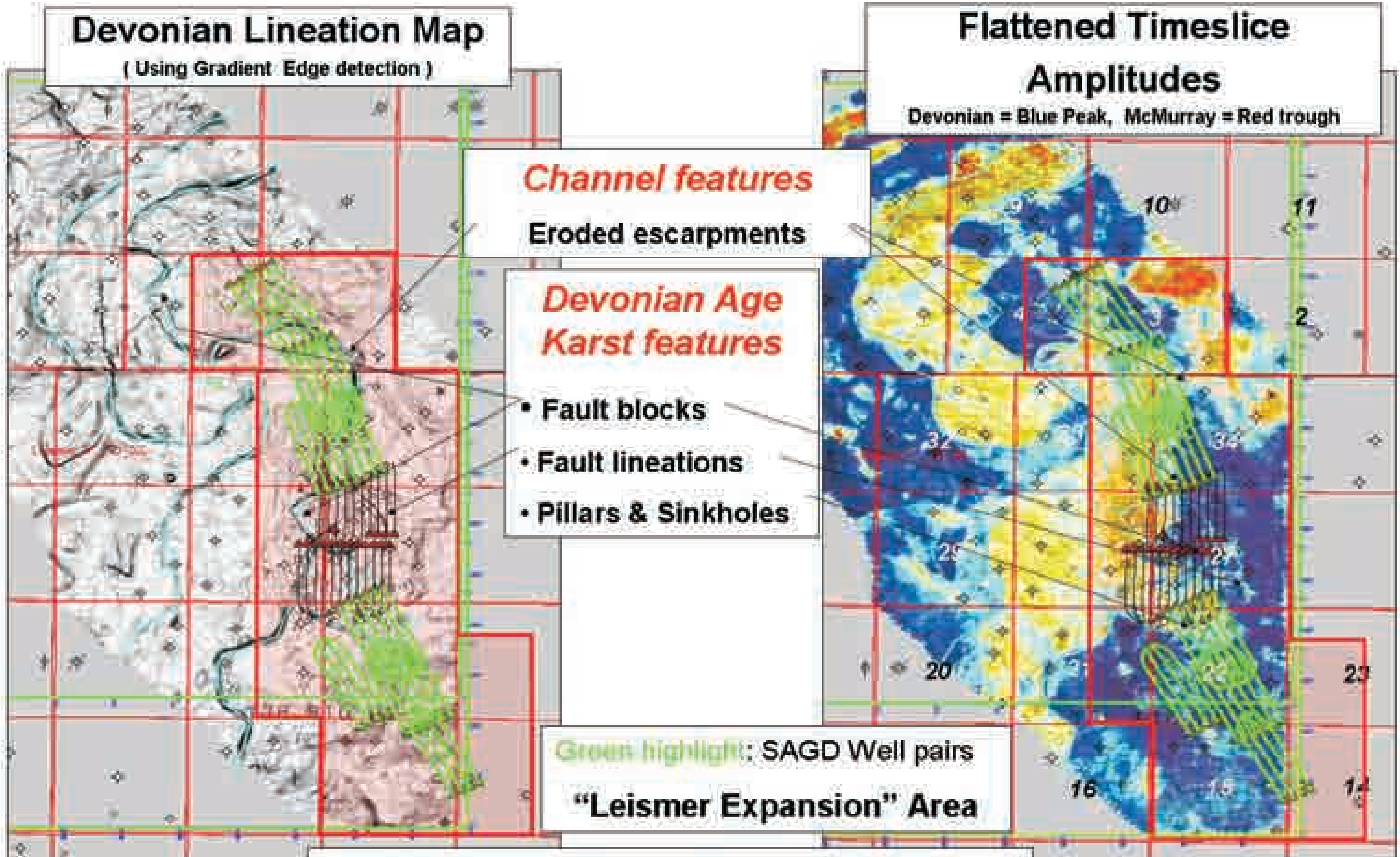
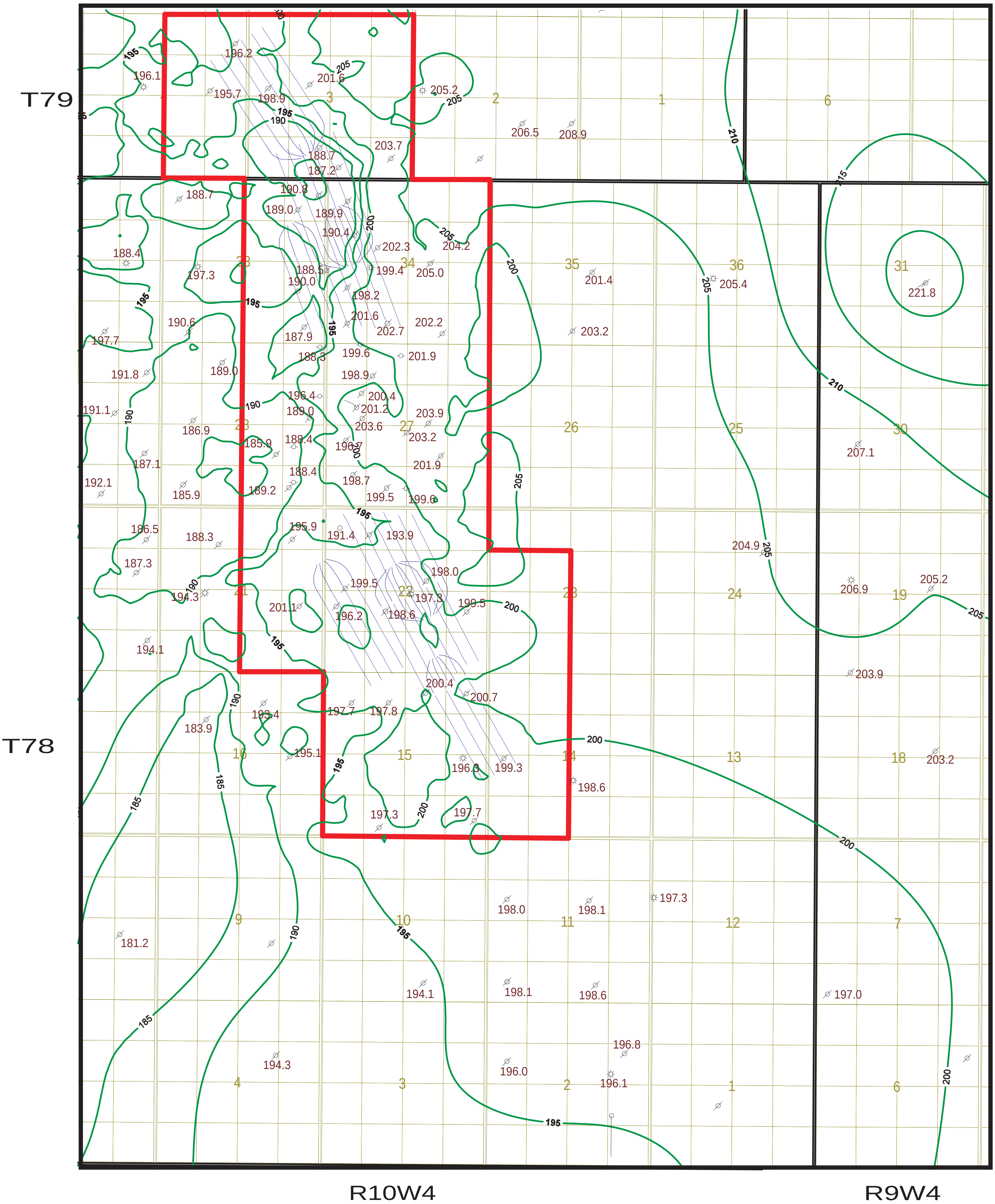


Figure B4.1-4 Paleo Drainage System

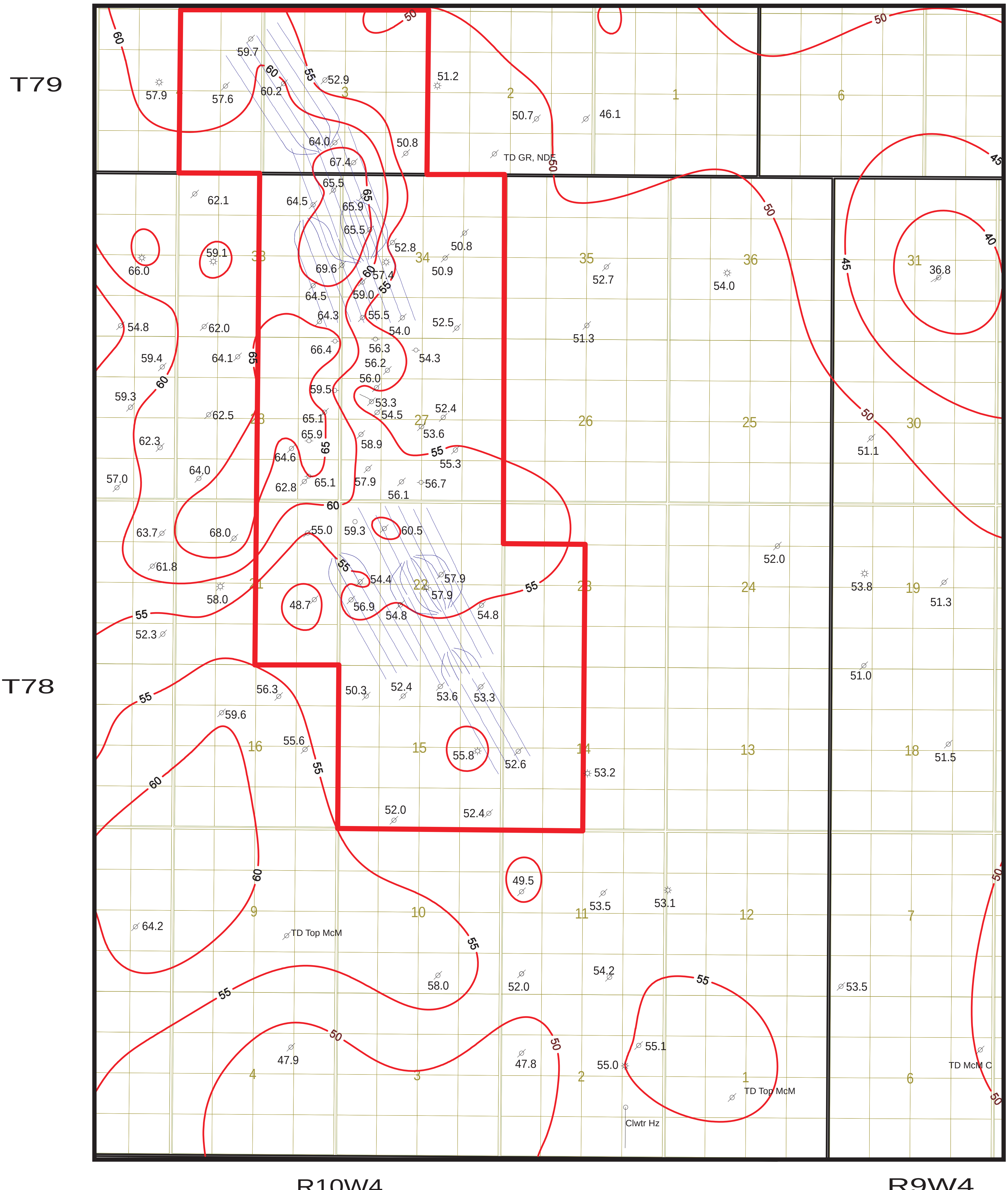


Leismer Expansion Area

198.1 Sub-Cretaceous Unconformity Posted Value

Figure B4.1-5 Sub-Cretaceous Unconformity Structure Modified with Seismic

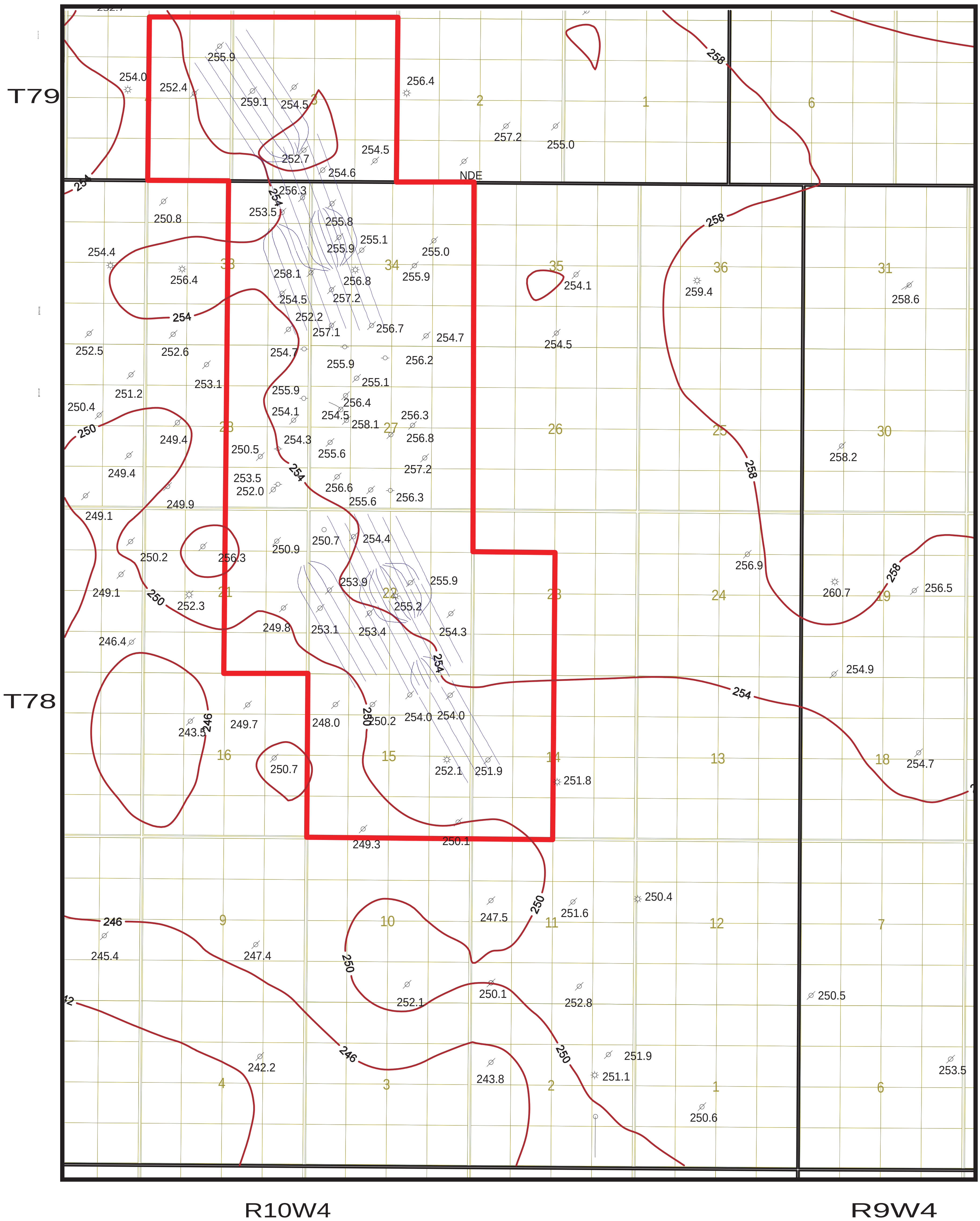
Leismer Sub-Cretaceous Unconformity Structure Modified with Seismic		
Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 18 May, 2007
C.I.=4m	Scale: 1:40,000	



(red box)	Leismer Expansion Area
55.8	McMurray to Sub-Cretaeceous Unconformity Poster Isopach
TD McM C	Total Depth McMurray Channel
Clwtr HZ	Clearwater Horizontal

Figure B4.1-6 McMurray to SubCretaceous Unconformity Isopach

Leismer
McMurray to SubCretaceous Unconformity
Author: J. Lobsinger, P.GEOL | CUTOFF: | Date: 16 June, 2007
C.I.=5m | Scale: 1:40,000



Leismer Expansion Area

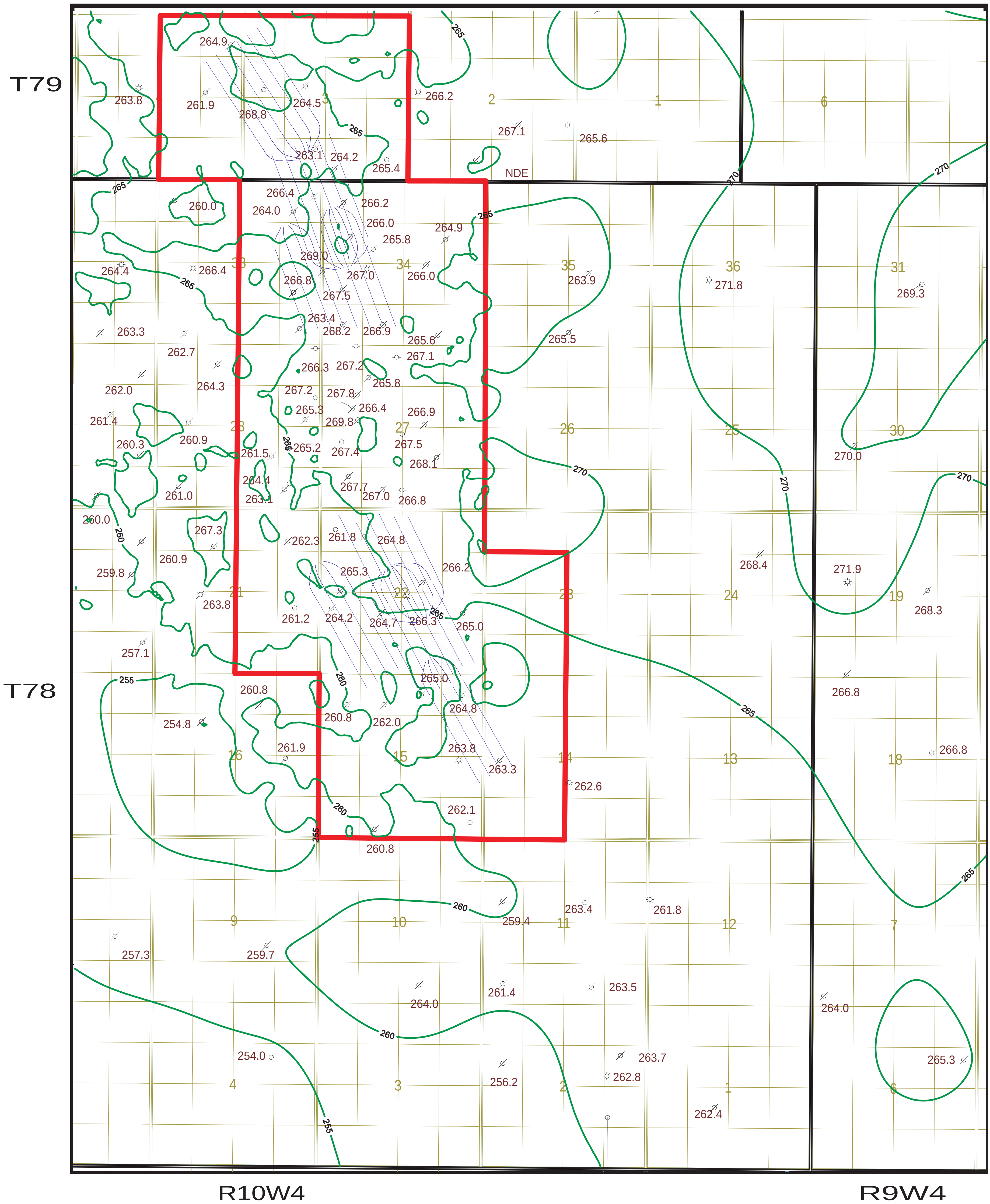
251.6 McMurray Structure Posted Value

Figure B4.1-7
McMurray Structure

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Structure

Author: J.Lobsinger, P. GEOL.	CUTOFF:	Date: 13 June, 2007
CI=4m	Scale:1:40,000	



Leismer Expansion Area

269.4 Wabiskaw Structure Posted Value

Figure B4.1-8 Wabiskaw Structure Modified with 3D Seismic

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Wabiskaw Structure Modified with 3D Seismic

Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 13 June, 2007
C.I.=5m	Scale: 1:40,000	

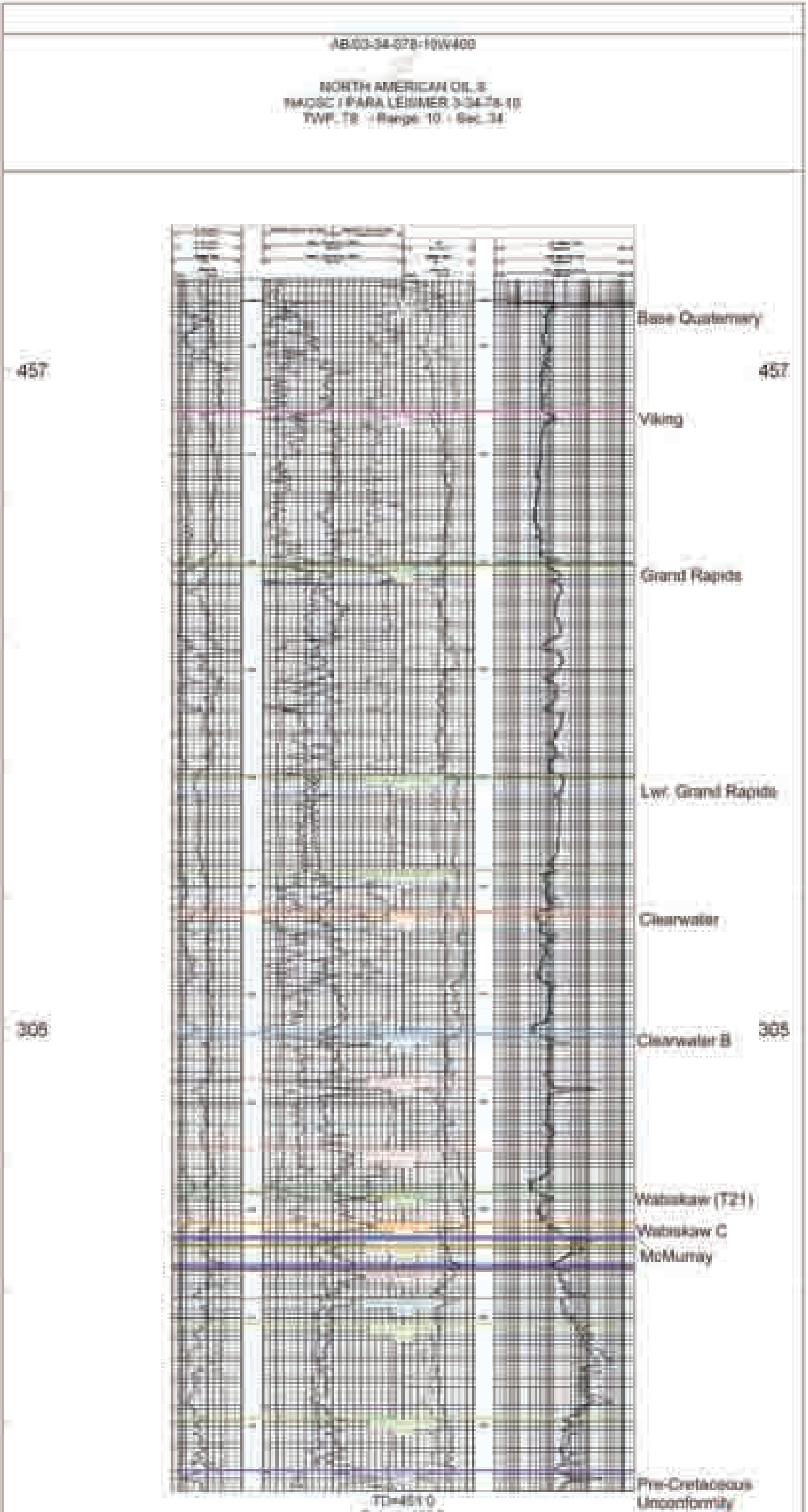


Figure B4.1-9

Type Log
AB/03-34-078-10W4

NORTH AMERICAN

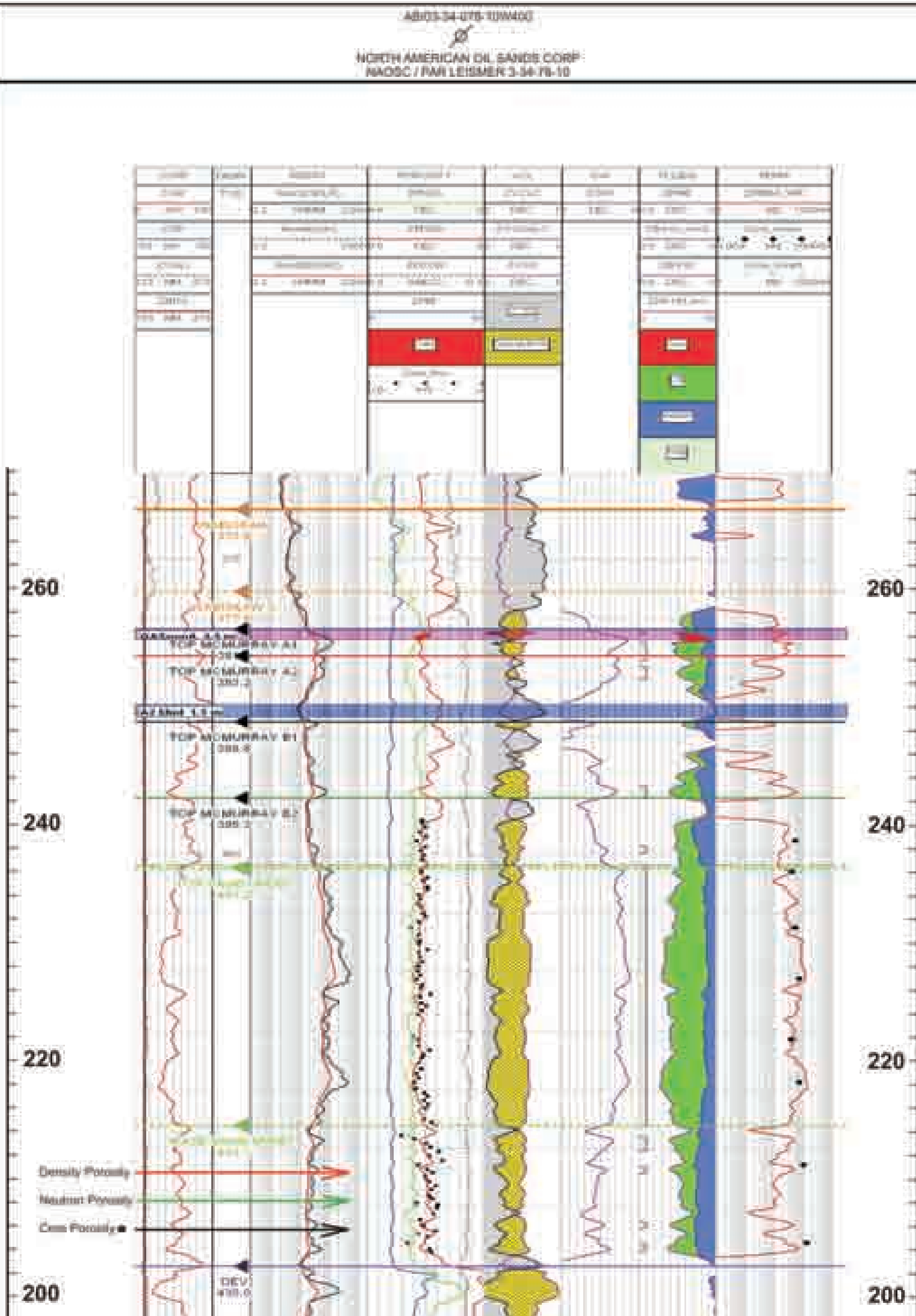
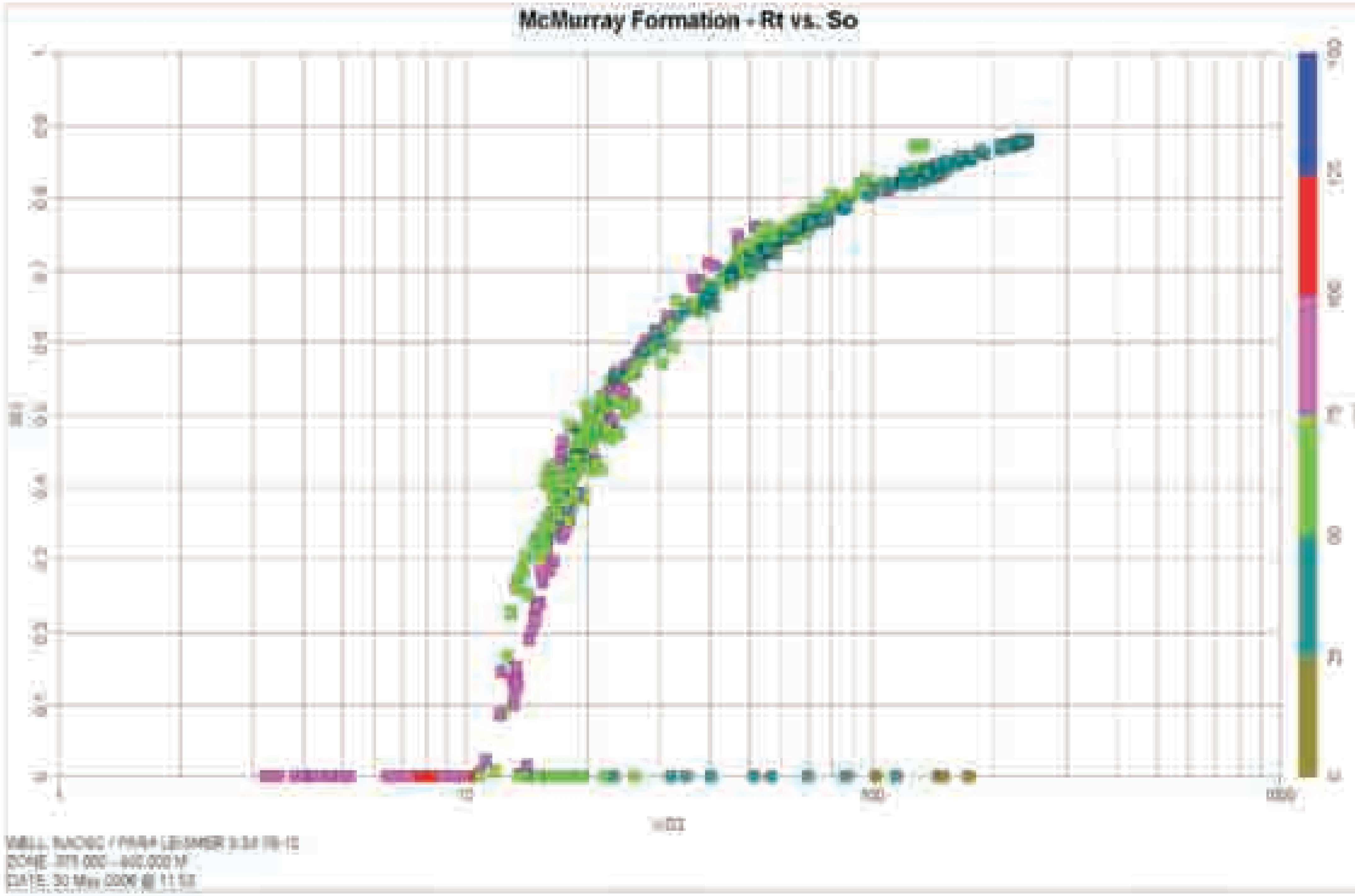


Figure B4.1-10 Core to Log Comparison AB/03-34-078-10W4 Shaly Sand Analysis

Datum=637.7
Ground=635.3
TD=451.0
Spud Date=2/23/2006

NORTH AMERICAN OIL SANDS CORPORATION



ARCHIE'S WATER SATURATION:

$$(SW)^{N} = \frac{A}{(PHI)^{M}} \cdot \frac{RW}{RT}$$

Rw= 0.55, a=1, m=1.8, n=2

Rt@ 20ohms = 50% So ~ 6%wt

Rt@ 40ohms = 70% So ~ 11%wt

NORTH AMERICAN OIL SANDS CORPORATION

Figure B4.1-11 Rt vs So Pickett Plot of 3-34-78-10W4

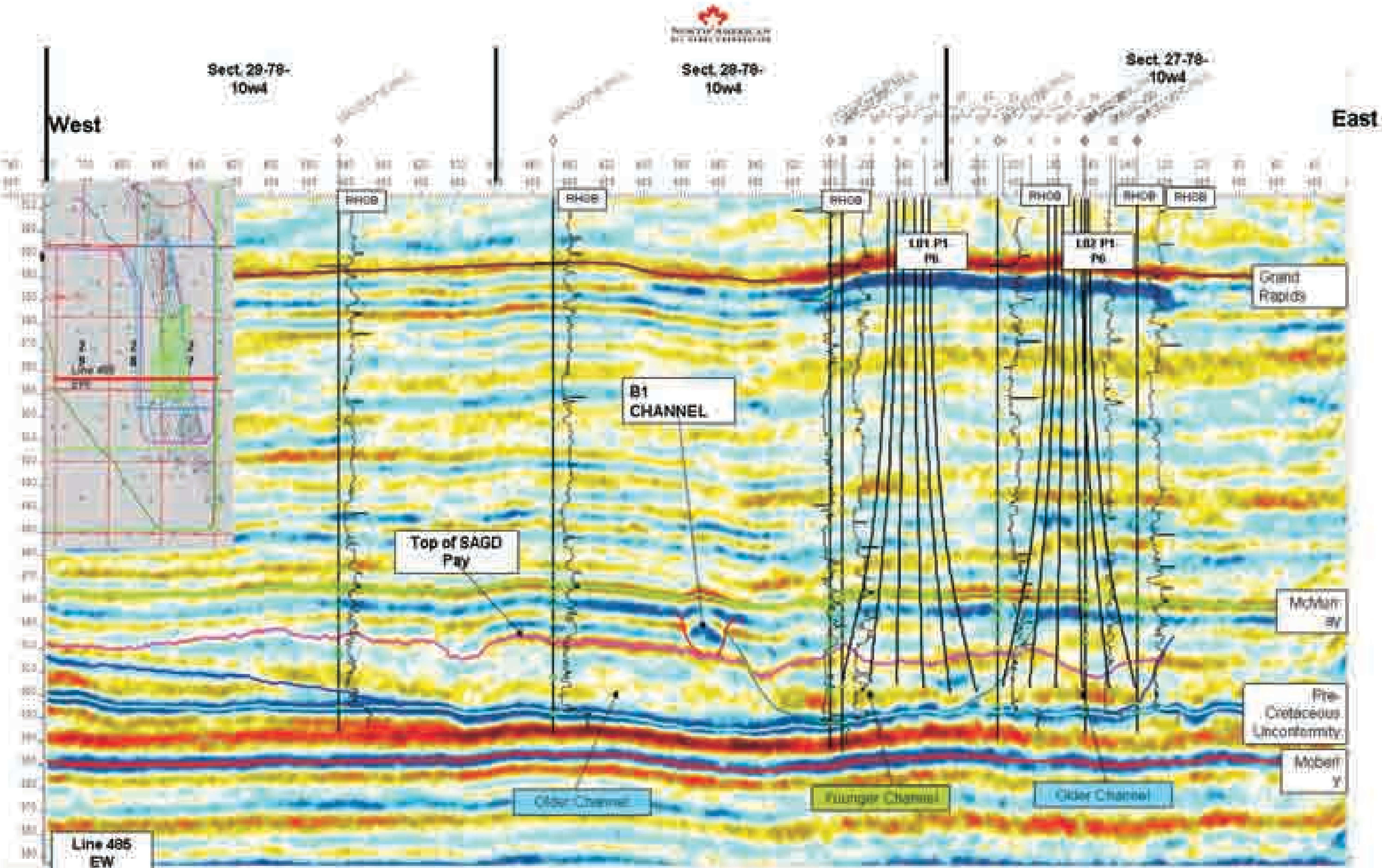


Figure B4.1 – 12 EW Seismic Profile

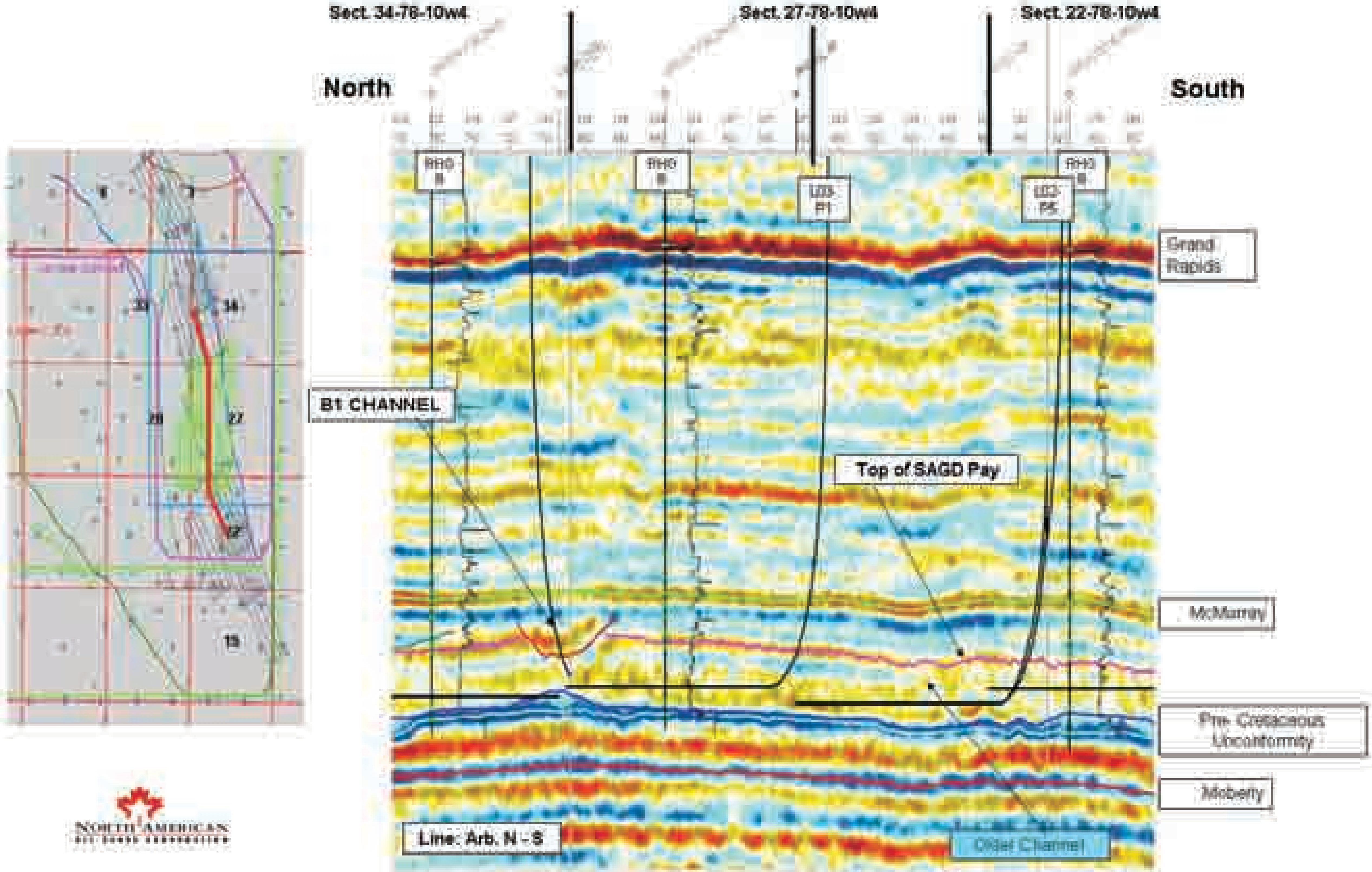


Figure B4.1 - 13 NS Seismic Profile

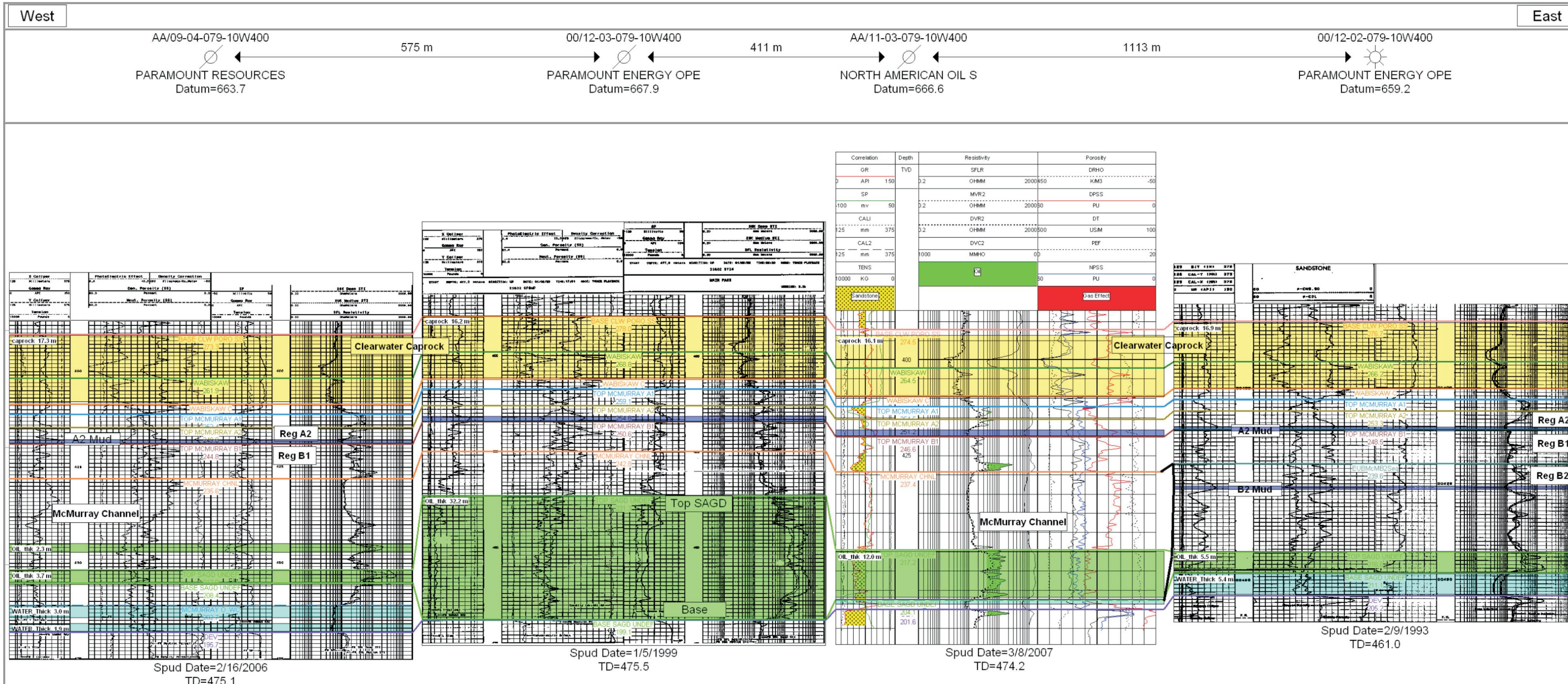


Figure B4.1-14
Leismer Expansion (North)
West to East Cross Section
Structural

NORTH AMERICAN OIL SANDS CORPORATION

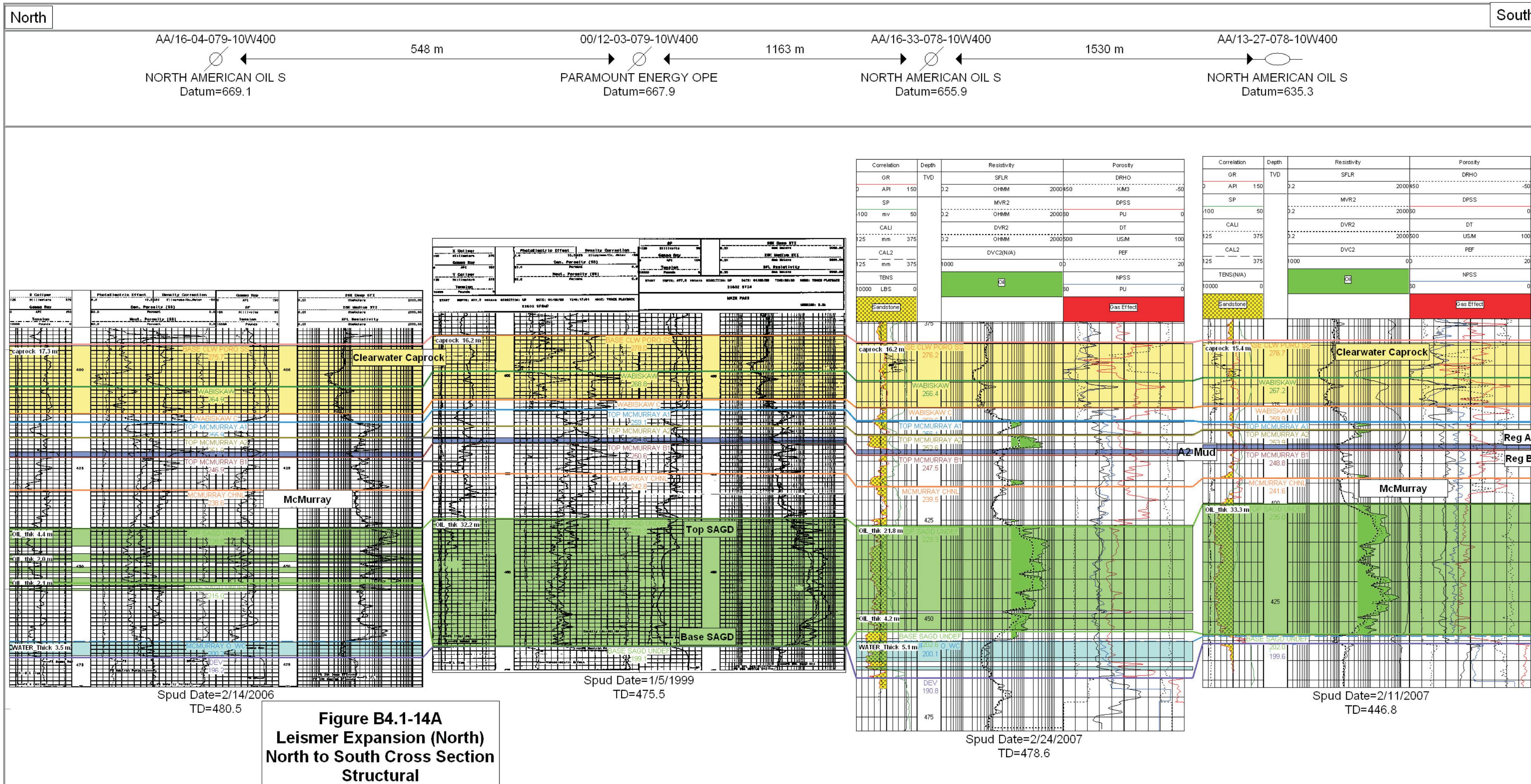


Figure B4.1-14A
Leismer Expansion (North)
North to South Cross Section
Structural

NORTH AMERICAN
OIL SANDS CORPORATION

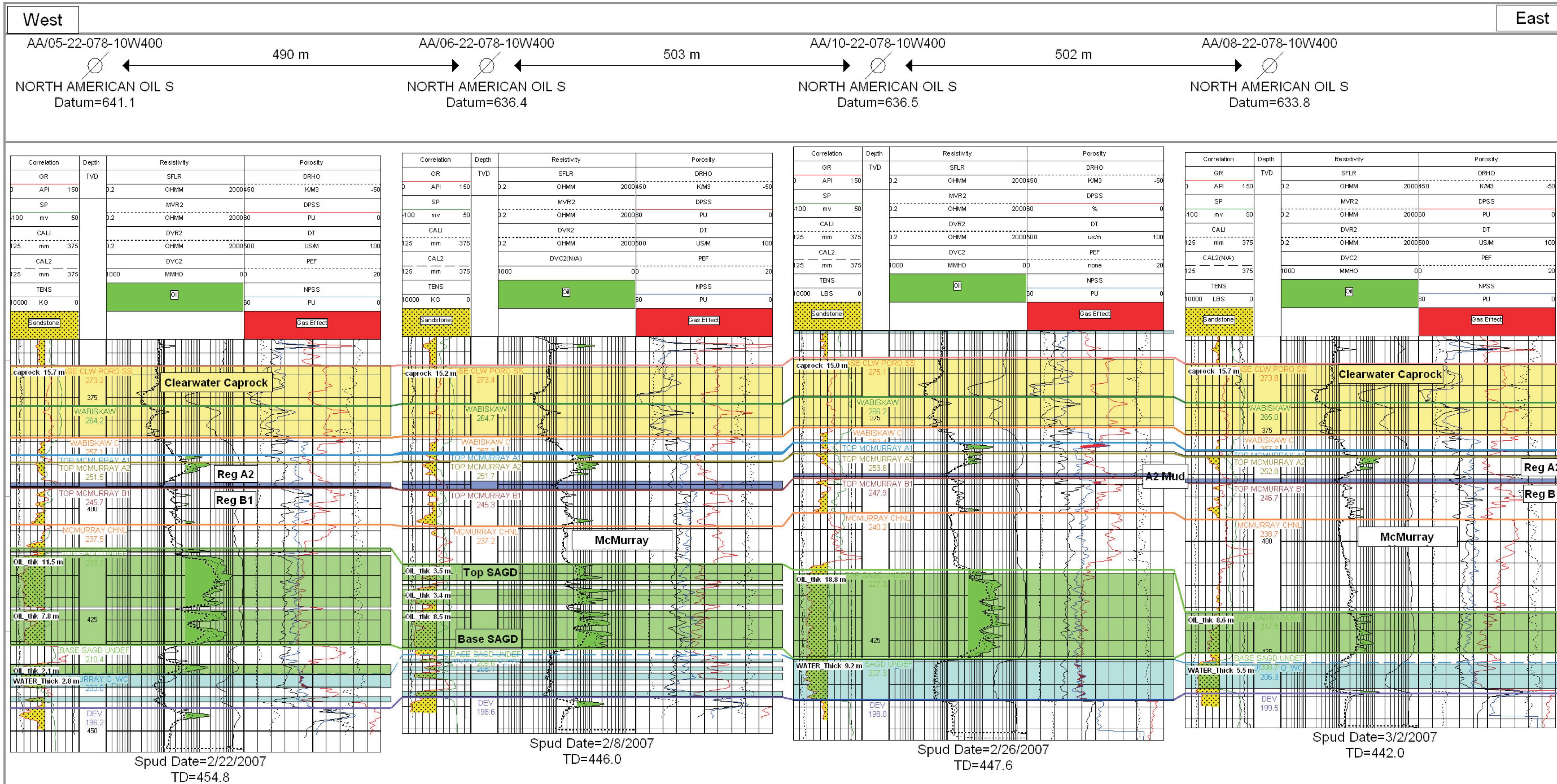


Figure B4.1-15
Leismer Expansion (South)
West to East Cross Section
Structural

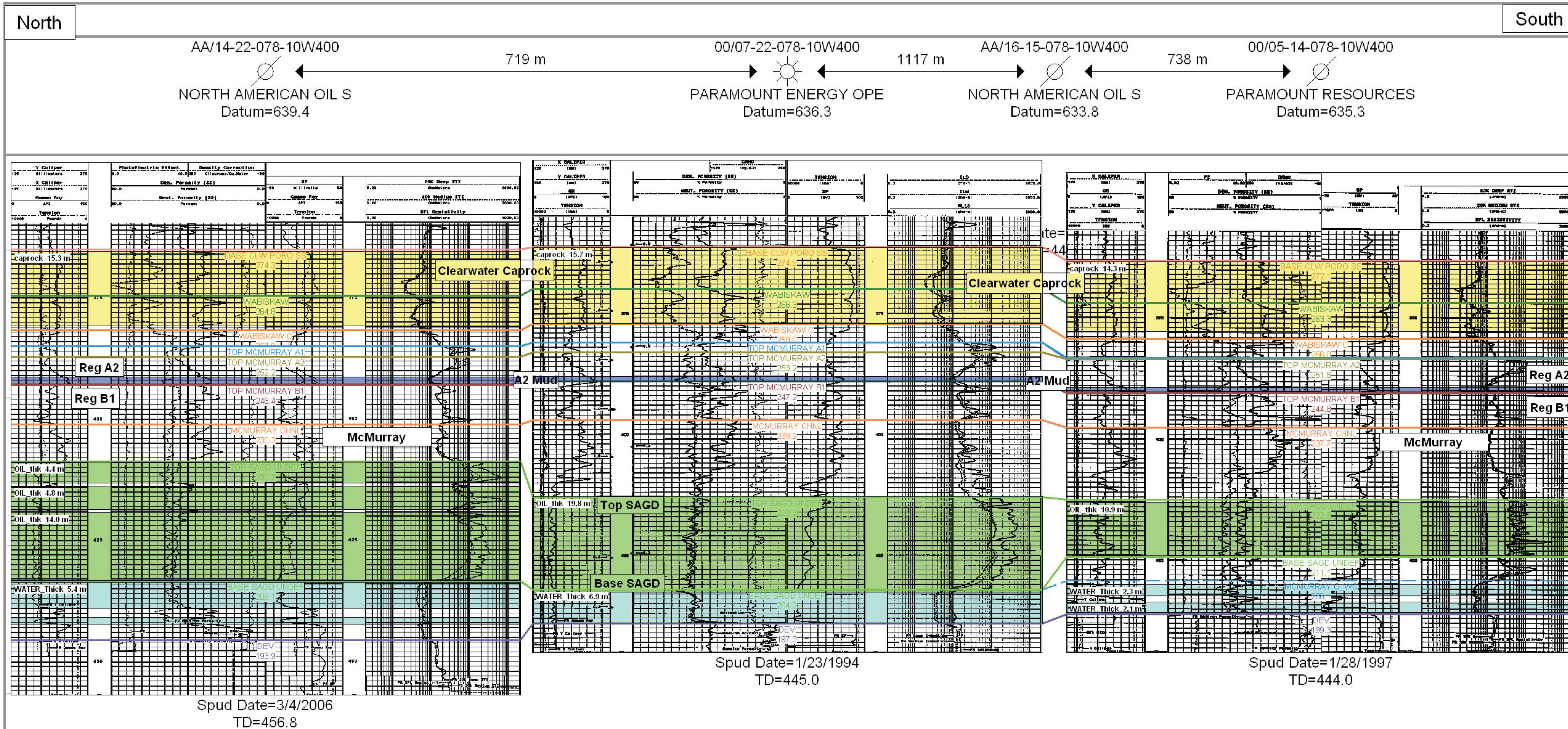
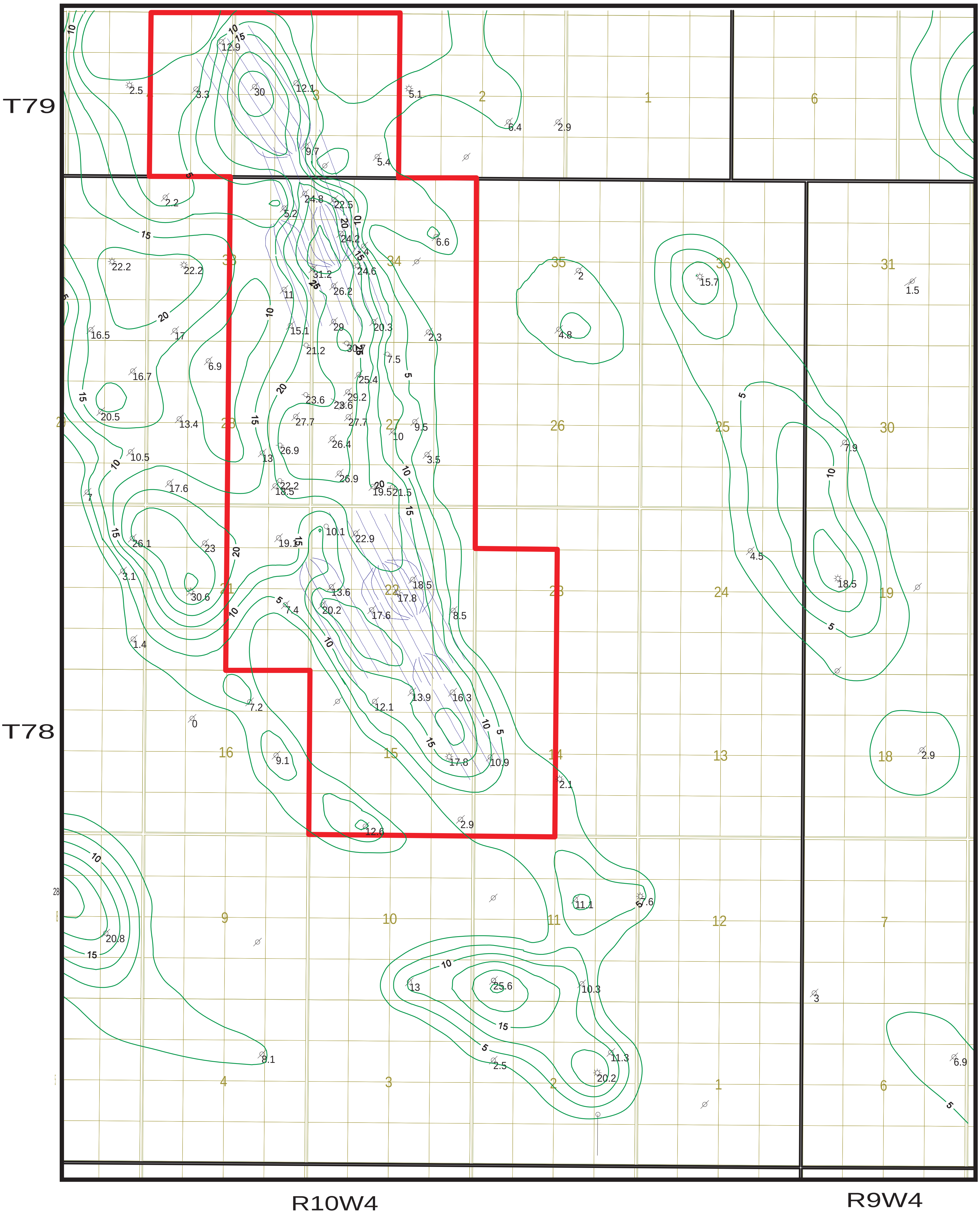


Figure B4.1-15A
Leismer Expansion (South)
North to South Cross Section
Structural

NORTH AMERICAN OIL SANDS CORPORATION



Leismer Expansion Area

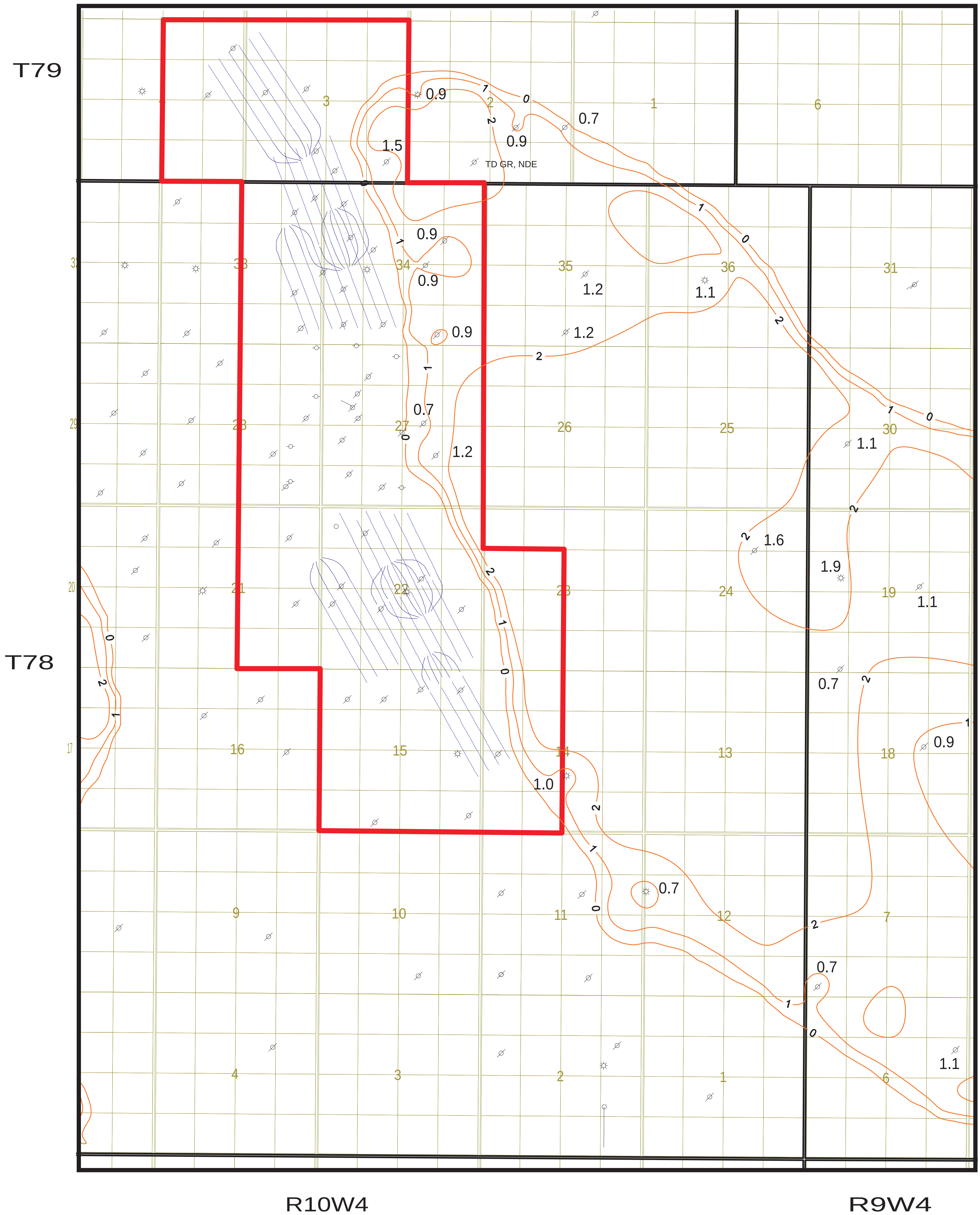
2.2 Net SAGD Pay Posted Isopach Value

Figure B4.1-16 McMurray Net Pay Bitumen (6 Wt% Cutoff)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Net SAGD Bitumen Pay
(6 wt% Cutoff)

Author: J. Lobsinger, P. GEOL.	CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies	Date: 4 July, 2007
	Scale: 1:40,000	



Leismer Initial Development Area

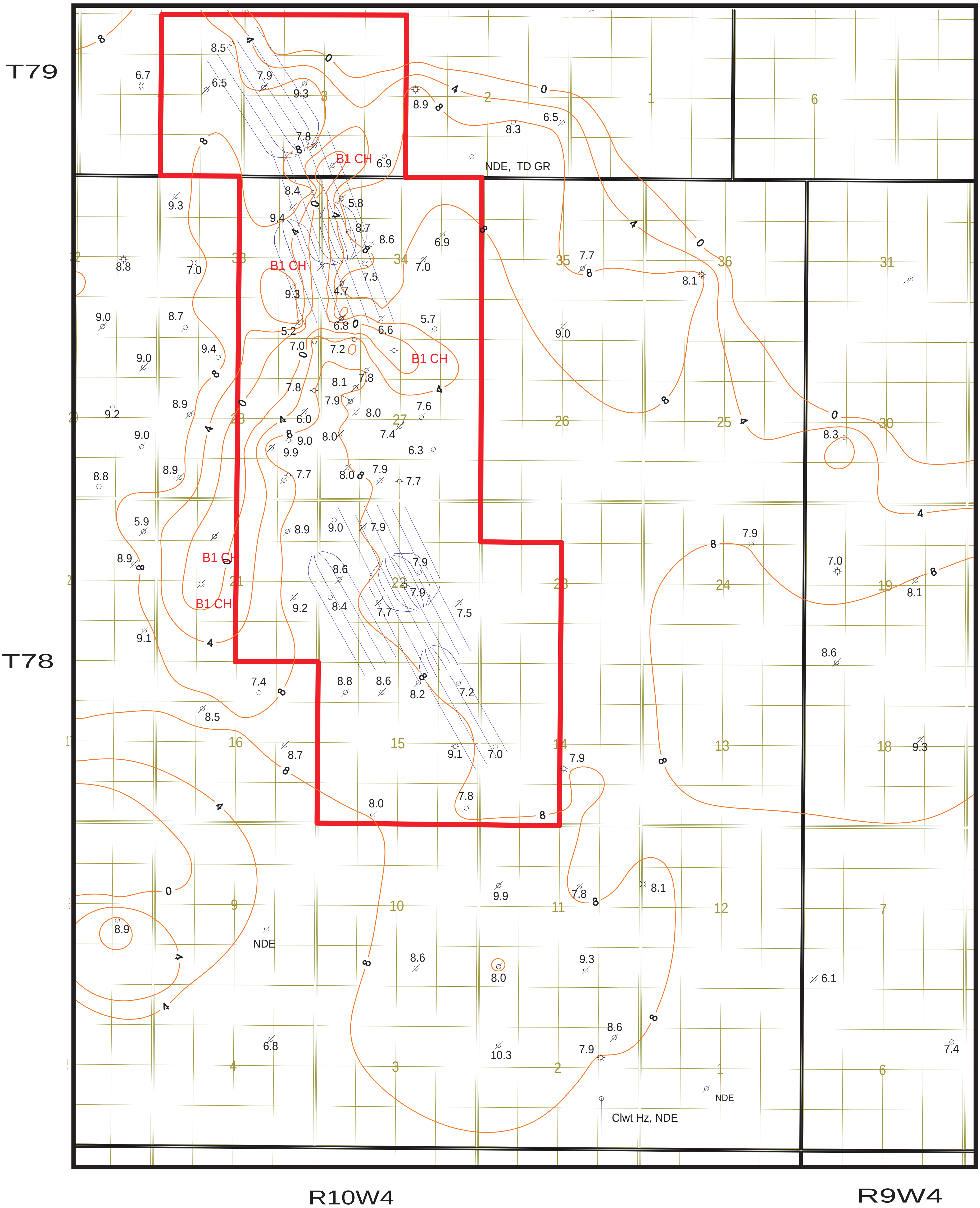
0.7 B2 Mud Posted Isopach Value

Figure B4.1-17 McMurray Channel Cap Rock Isopach (McMurray B2 Mud)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray B2 Mud Distribution
(.5m thickness cutoff)

Author: J. Lobsinger, P. GEOL.	CUTOFF: 10 ohms Resistivity, CNL/FDC divergence	Date: 14 June, 2007
CI: 1m	Scale: 1:40,000	



Leismer Expansion Area

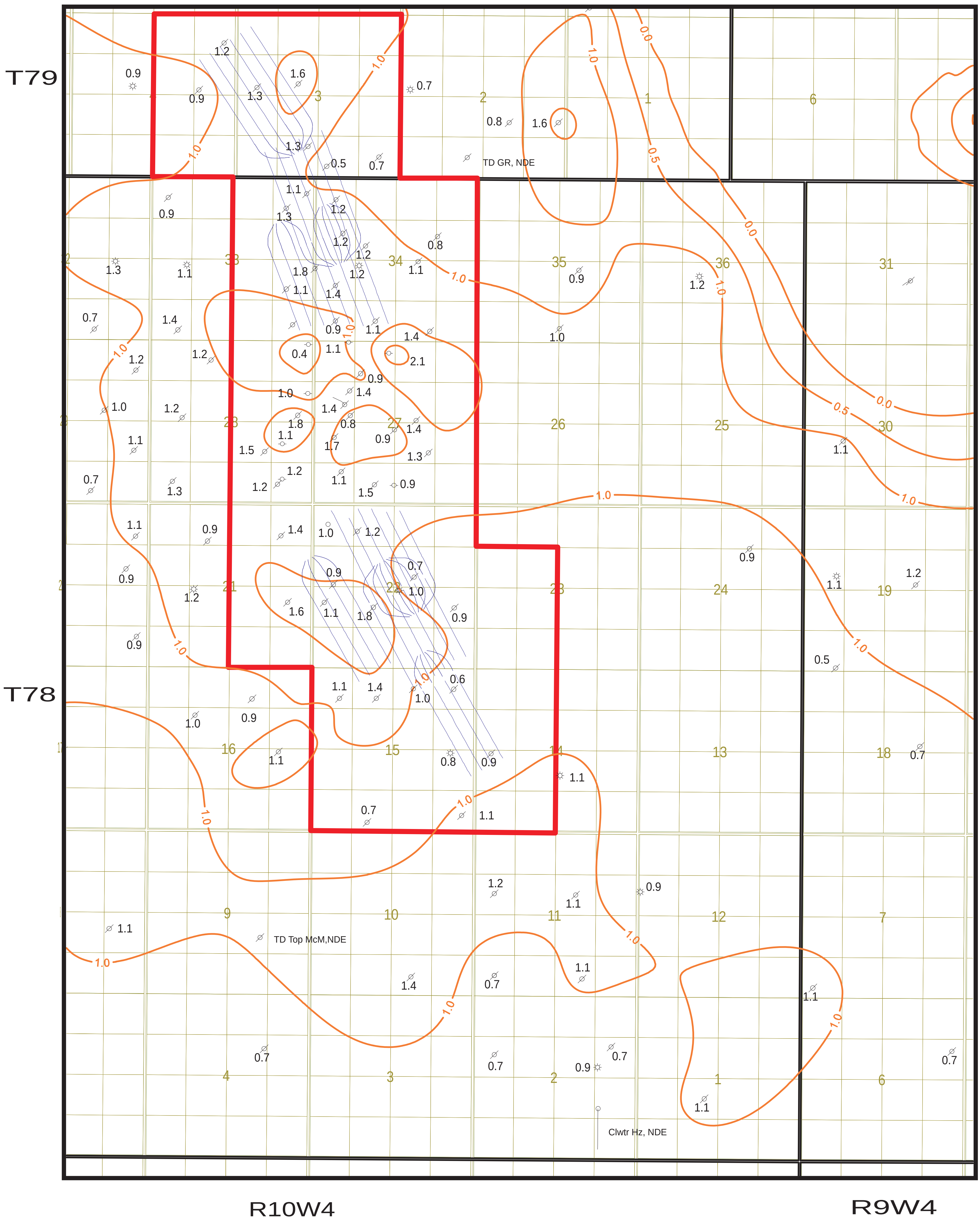
1.1 McMurray B1 Parasequence Isopach Contour

Figure B4.1-18 McMurray B1 Parasequence Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
B1 Parasequence Isopach

Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 14 June, 2007
C.I.=4m	Scale: 1:40,000	



Leismer Expansion Area

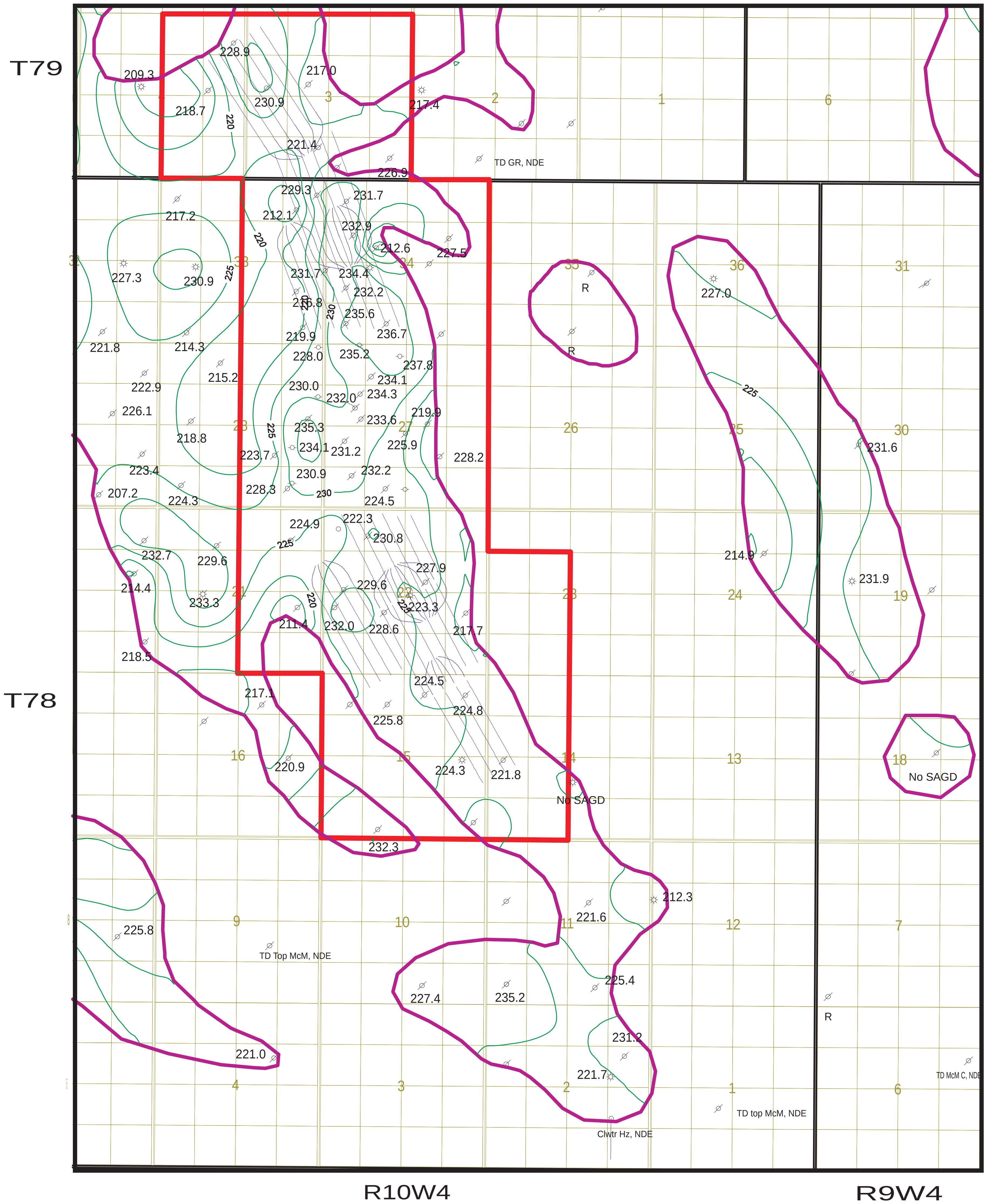
2.2 A2 Mud Posted Isopach Value

Figure B4.1-19 McMurray Channel Cap Rock Isopach (McMurray A2 Mud)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray A2 Mud Distribution
(.5m thickness cutoff)

Author: J. Lobsinger, P. GEOL.	CUTOFF: 10 ohms Resistivity, CNL/FDC divergence	Date: 14 June, 2007
CI: 0.5m	Scale: 1:40,000	



Leismer Expansion Area

Zero Edge SAGD

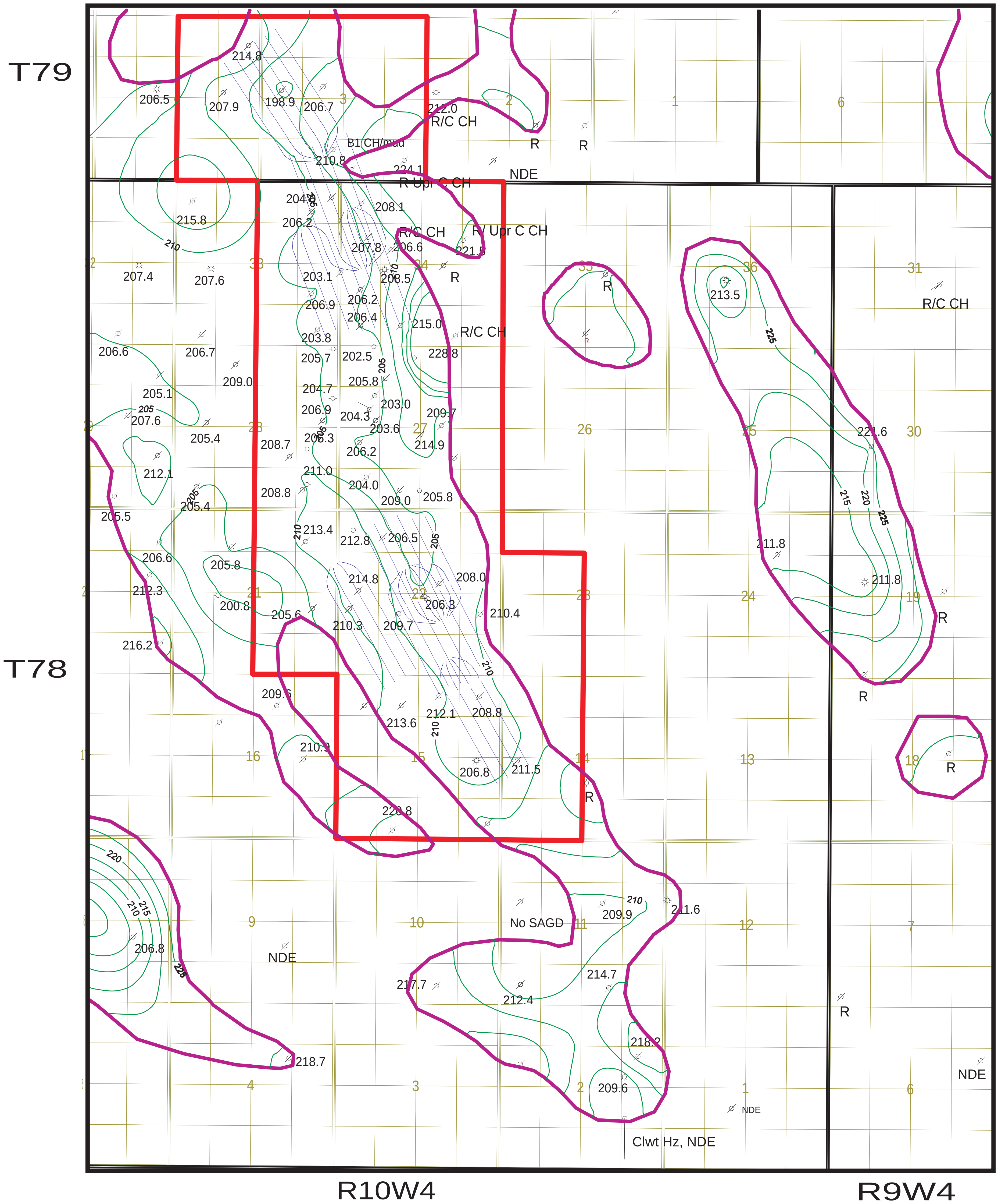
224.3 Top SAGD Posted Structural Value

Figure B4.1-20 Top SAGD Structure

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Top SAGD Structure

Author: J. Lobsinger, P. GEOL.	CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies	Date: 14 June, 2007
CI: 5m	Scale: 1:40,000	



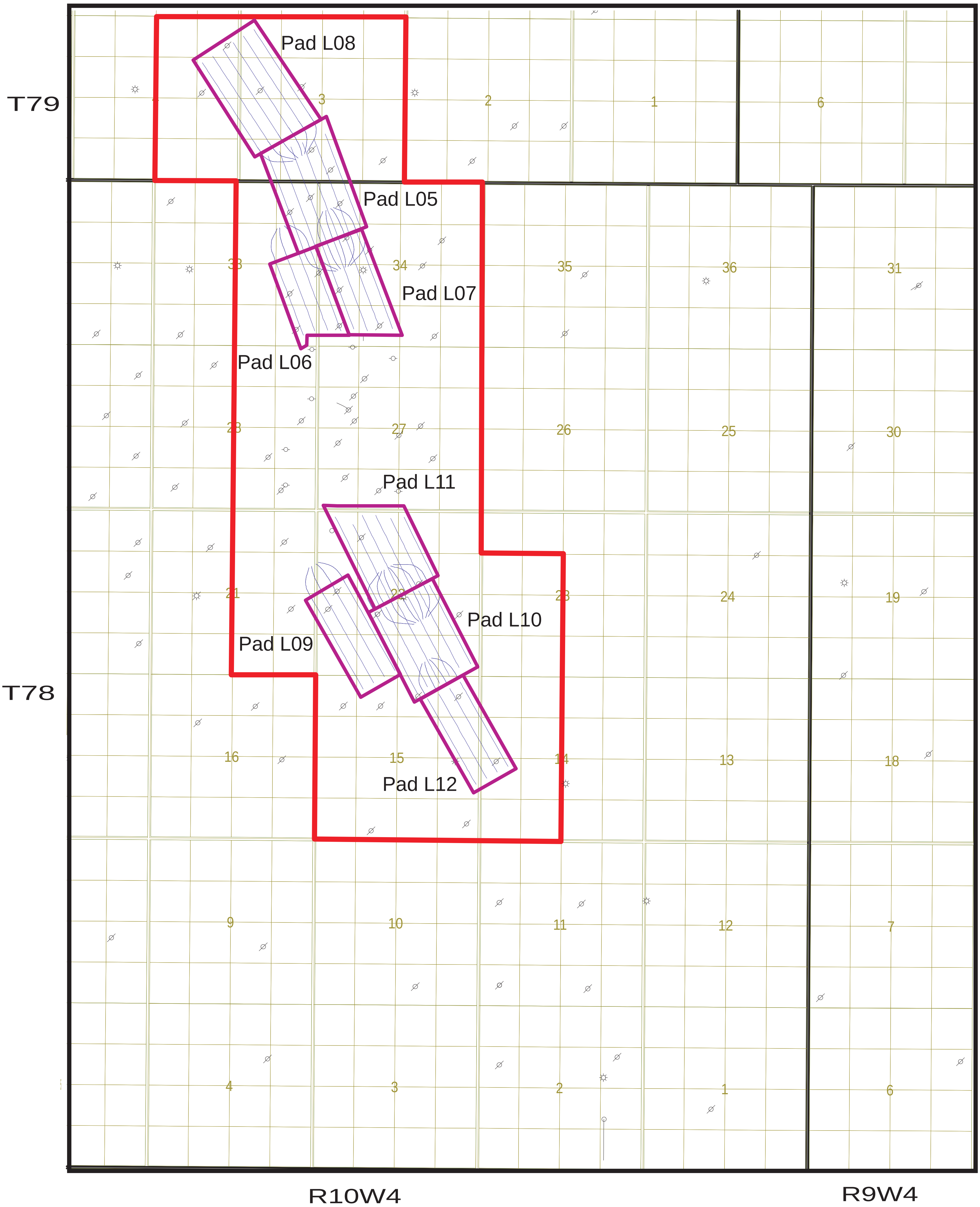
(red outline)	Leismer Expansion Area
(purple outline)	Zero Edge SAGD
NDE	Not Deep Enough
R	Regional
210.5	Base SAGD Posted Structure Value
Clwt, Hz	Clearwater, Horizontal

Figure B4.1-21 Base SAGD Structure

North American Oil Sands Corporation

Leismer
Base SAGD Structure
(0m pay cutoff)

Author: J. Lobsinger, P. GEOL.	CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies	Date: 25 May, 2007
	Scale: 1:40,000	



Leismer Expansion Area

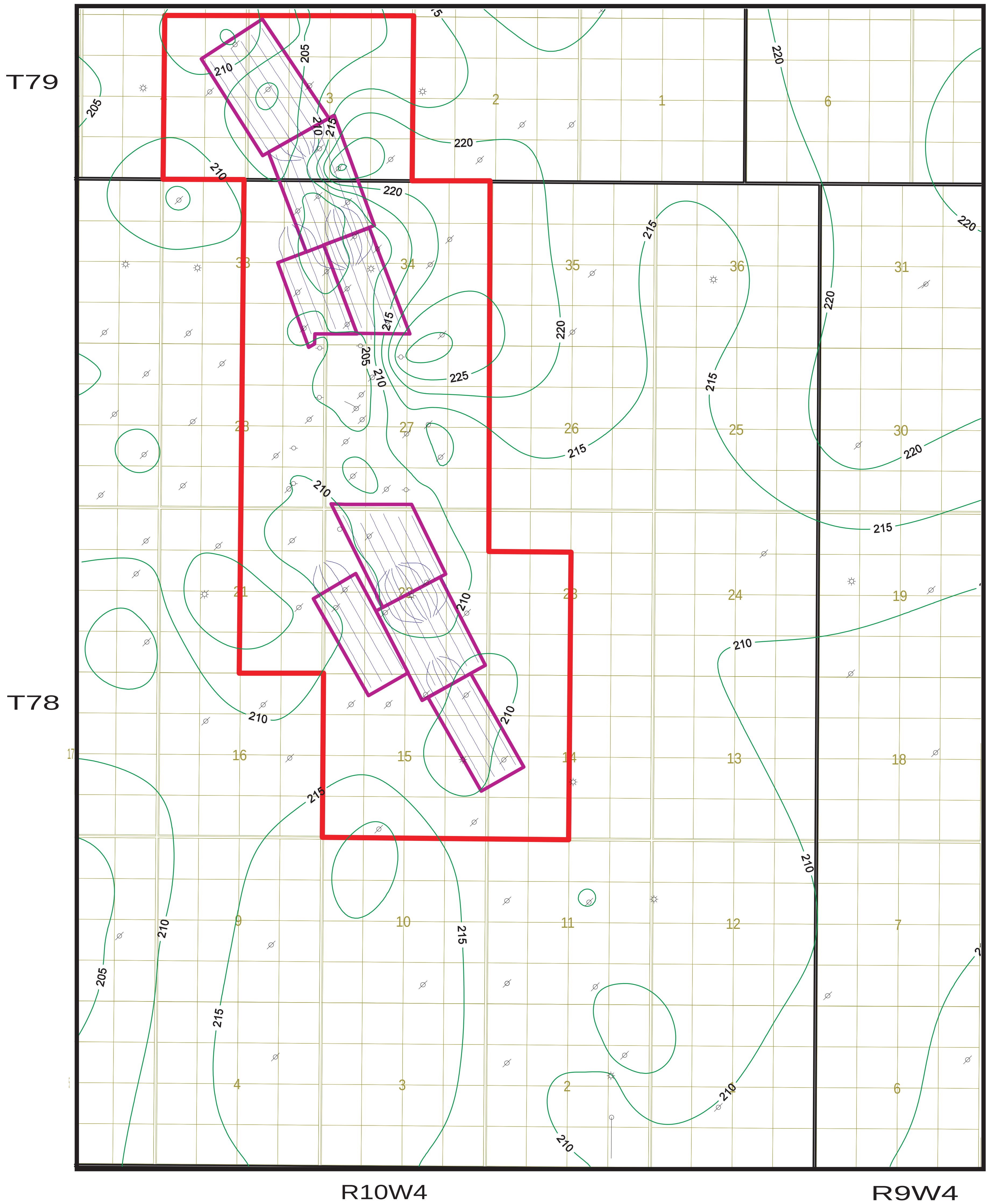
Well Pad Drainage Areas

Figure B4.1-22 Location of Drainage Pads and Horizontal Wells

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Location of Drainage Pads and Horizontal Wells

Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 24 May, 2007
	Scale: 1:40,000	

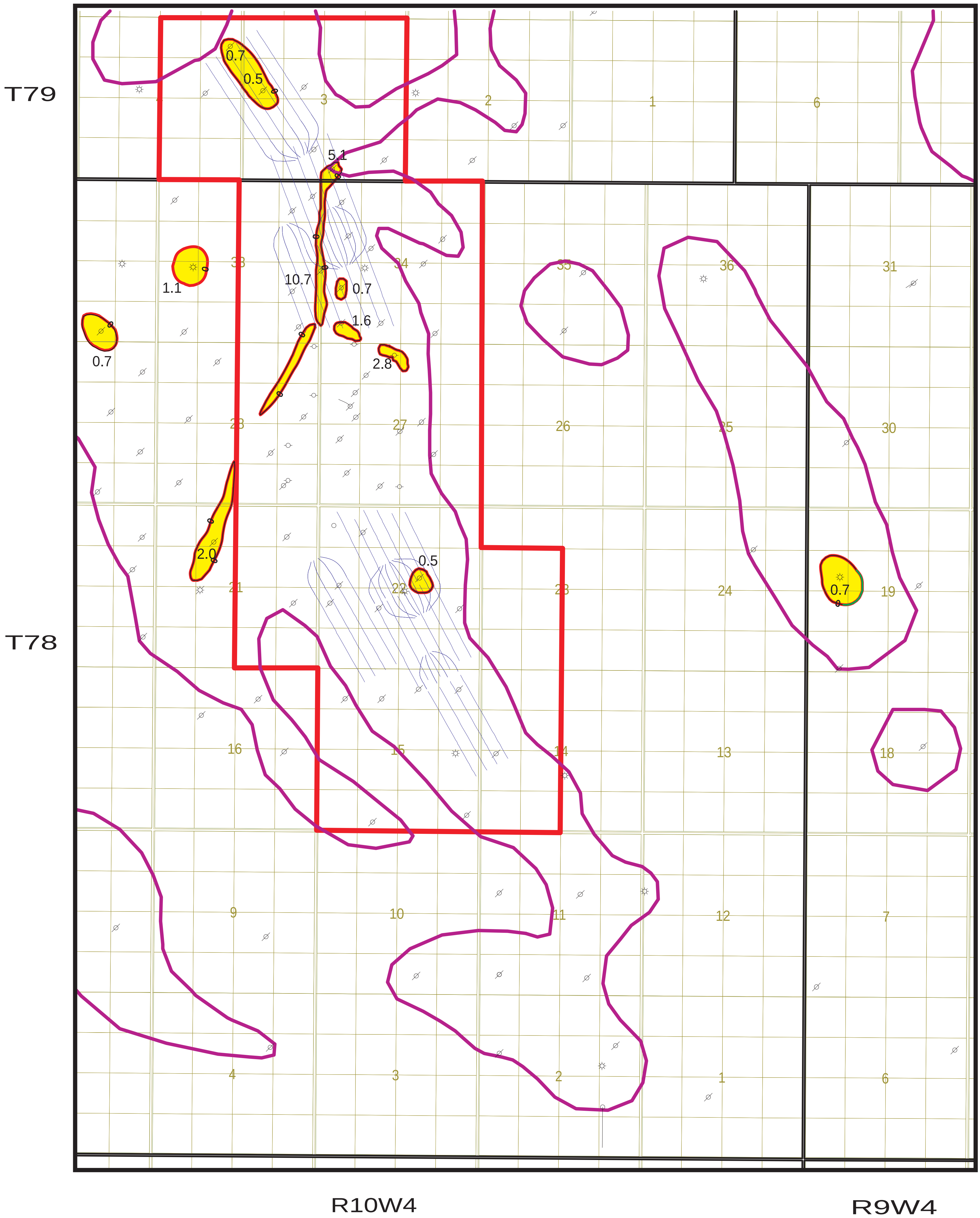


Leismer Expansion Area

Well Pad Drainage Areas

Figure B4.1-23 Drainage Pads and Horizontal Well Pairs with Base SAGD Structure

Leismer Drainage Pads and Horizontal Wells with Base SAGD Structure		
Author: J. Lobsinger, P. GEOL.		Date: 14 June, 2007
CI: 5m	Scale: 1:40,000	



Leismer Expansion Area

SAGD Bitumen Zero Edge

Associated Gas

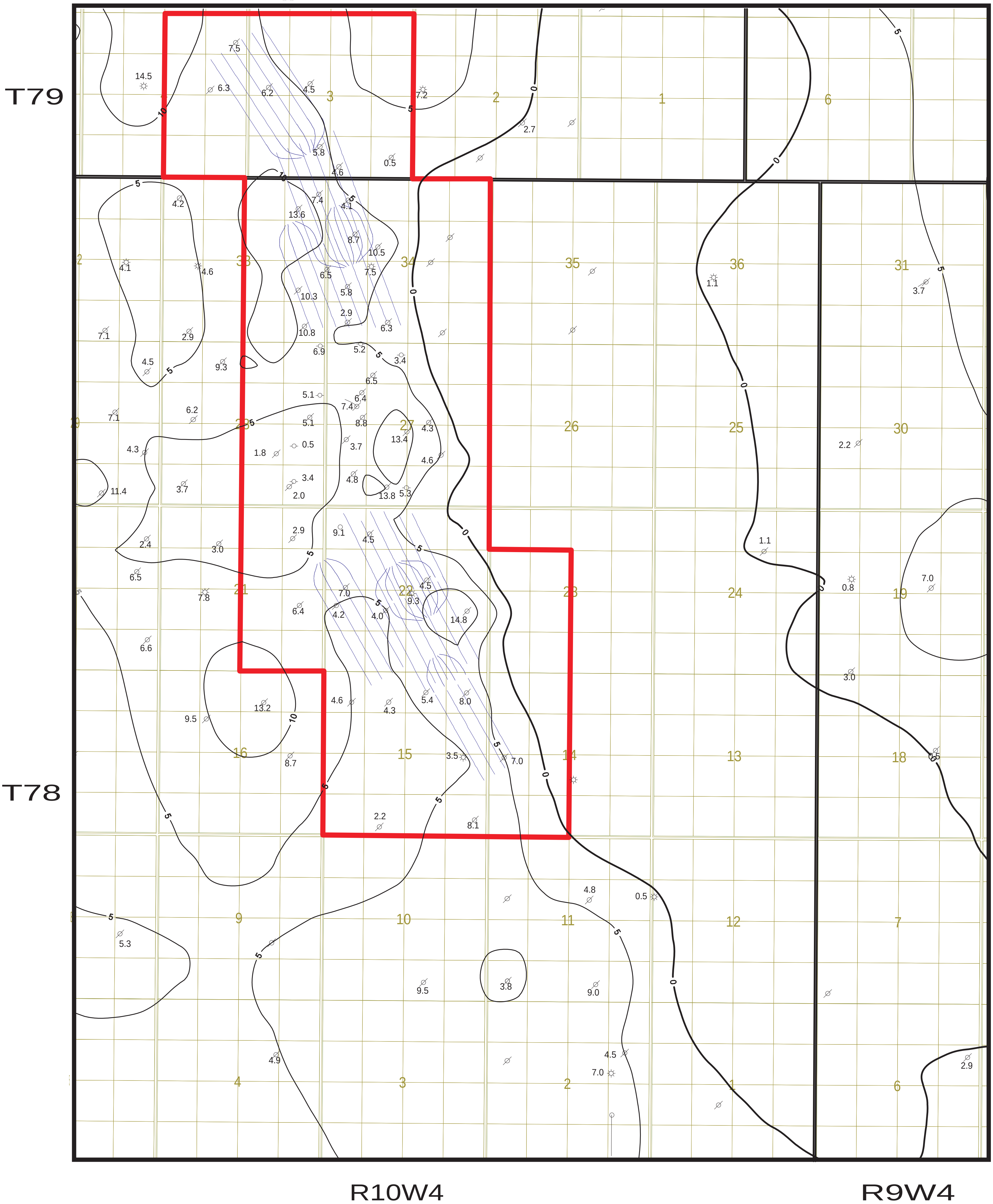
2.2 Associated Gas Posted Value

Figure B4.1-24 McMurray Associated Net Gas Pay (Thief Zone Gas)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Associated Net Gas Pay Isopach

Author: J. Lobsinger, P.GEOL.	CUTOFF:	Date: 9 May, 2007
	Scale: 1:40,000	



Leismer Expansion Area

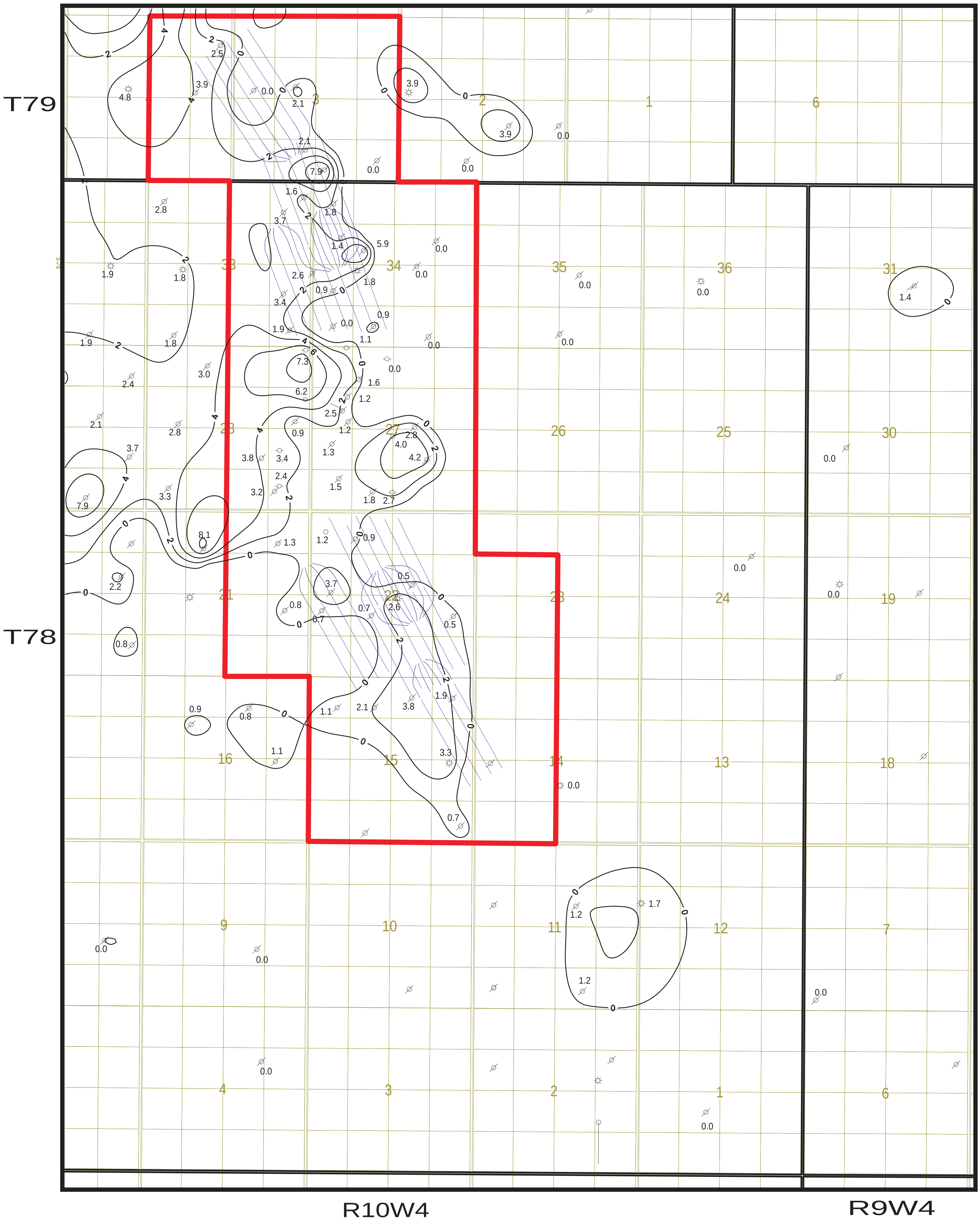
4.4 Net Top Lean & Top Water Posted Value (Thief Zone)

Figure B4.1-25 Net Top Lean & Net Top Water Isopach (Thief Zone)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Net Top Lean & Top Water Isopach
(Thief Zone)

Author: J.Lobsinger, P. GEOL.	CUTOFF: 0 to 40ohms, includes top water, 27% Porosity	Date: 14 June, 2007
CI=5m	Scale: 1:40000	



Leismer Expansion Area

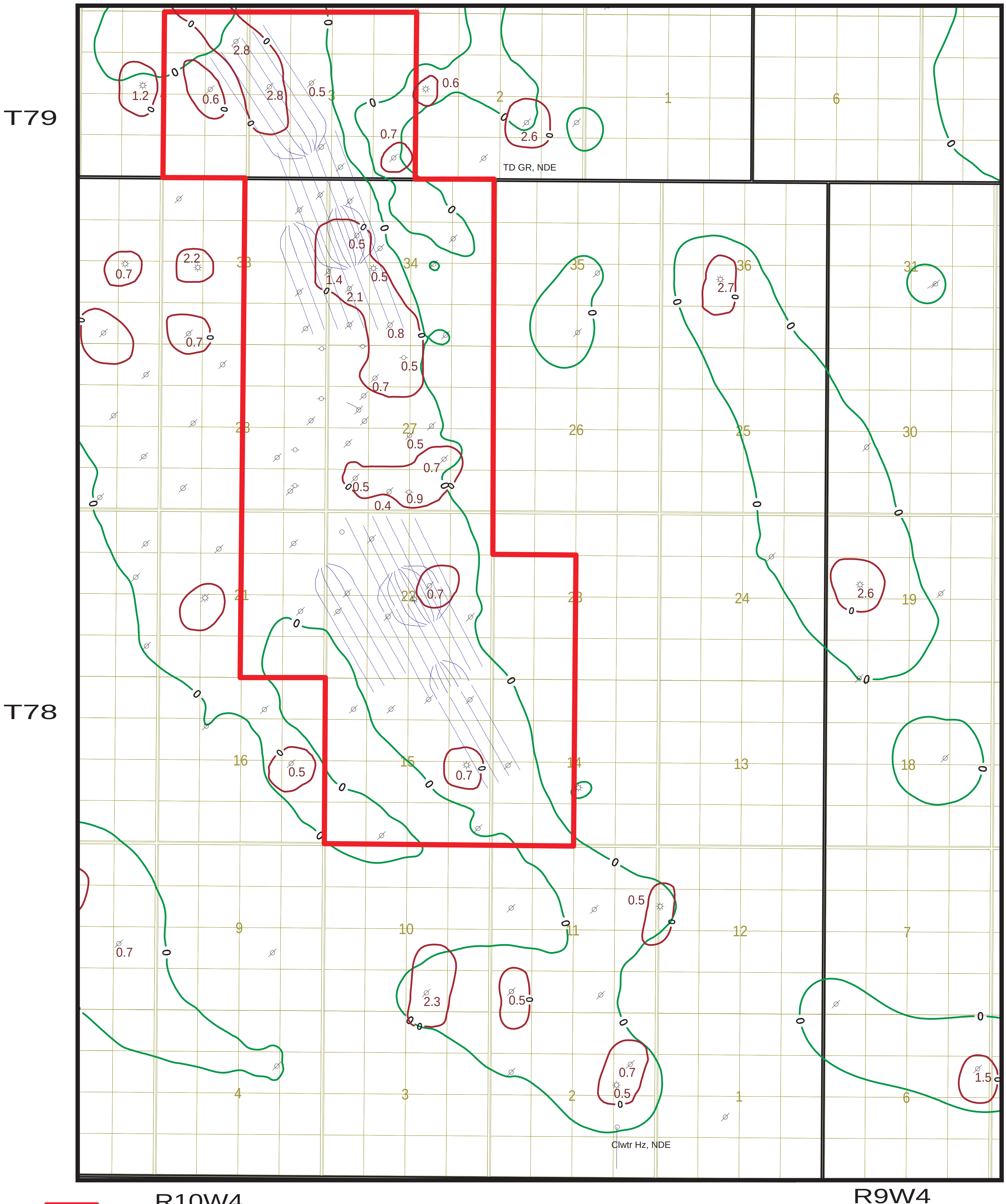
1.3 Associated Net Bitumen Isopach Posted Value (Thief Zone)

Figure B4.1-25A
Associated Net Bitumen Isopach (Thief Zone)

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Associated Net Bitumen Isopach
(Thief Zone)

Author: J.Lobsinger, P. GEOL.	CUTOFF: 40ohms, 27% Porosity	Date: 14 June, 2007
CI=2m	Scale: 1:40000	



Leismer Expansion Area

SAGD Bitumen Zero Edge

Non-Associated Gas Net Gas Pay

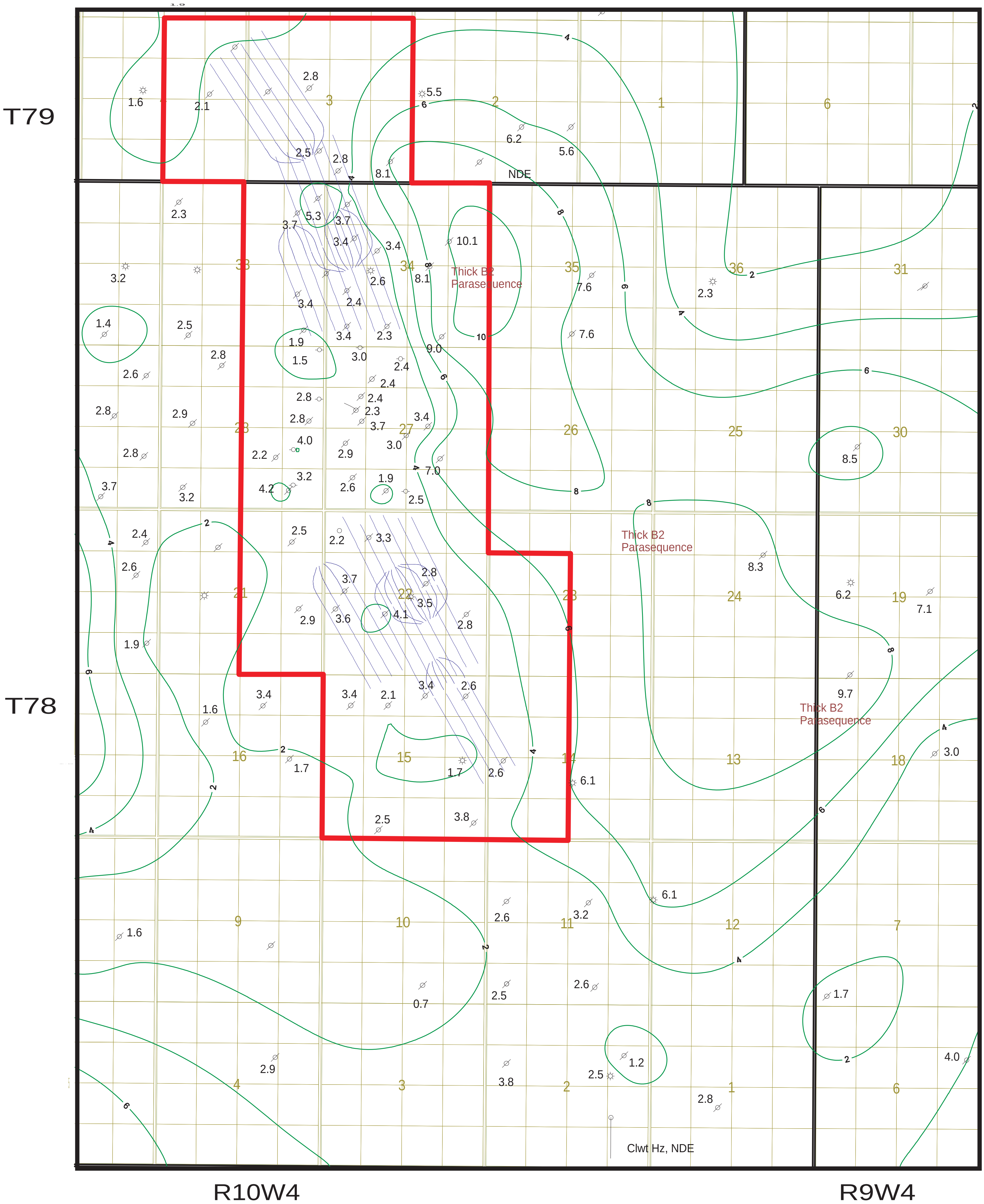
2.2 Non-Associated Gas Posted Isopach

Figure B4.1-26 McMurray Non-Associated Net Gas Pay Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Non-Associated Gas

Author: J. Lobsinger, P. GEOL.	CUTOFF:	Date: 4 April, 2007
	Scale: 1:40,000	



Leismer Expansion Area

2.1 Non-Associated Bitumen Value

Figure B4.1-27
Non-Associated Net Bitumen Isopach

NORTH AMERICAN

Leismer Non-Associated Bitumen Isopach		
Author: J. Lobsinger, P. GEOL.	CUTOFF: 27% Porosity, 40 ohms Resistivity, 2m vertical mud facies	Date: 14 June, 2007
CI: 2m	Scale: 1:40,000	

B4.2 Reservoir Recovery Process

B4.2.1 Recovery Process Selection

North American will employ Steam Assisted Gravity Drainage (SAGD) to recover bitumen from the McMurray formation. SAGD is an in-situ thermal process that has shown commercial viability at a number of operating projects within the province. SAGD has many technological and environmental advantages. It can economically recover on the order of 50% of the developable bitumen in place and requires less fuel for steam generation as compared to other steam processes. SAGD is a continuous process during normal operations and does not have heating and cooling cycles that could damage wellbore casings. It preserves the integrity of the reservoir cap rock because it injects steam below the pressure at which the reservoir can fracture. The process limits land disturbance and environmental impacts because it relies on horizontal wells drilled from fewer surface pad locations.

North American is initially planning to develop areas with 15 m or greater of SAGD pay thickness. Areas with pay less than 15 m are being evaluated for future development and will depend on technology advancements and economic conditions at that time. Due to the immobile nature of the bitumen, areas with less than 15 m of pay will not be affected nor be stranded by the proposed developments – in fact it is anticipated that infrastructure installed for the proposed development will aid in bitumen recovery from areas with pay thinner than the current 15 m cutoff.

Although SAGD recoveries are among the highest of any known commercial recovery process, North American will continue to evaluate any follow-up process that can further increase resource recovery.

B4.2.2 Description of the Process Used

B4.2.2.1 Steam Assisted Gravity Drainage (SAGD)

The SAGD process involves drilling two long horizontal wells that are separated vertically by approximately 5 m. The upper wellbore is used to inject steam into the reservoir. The injected steam adds energy in the form of heat to the reservoir, mobilizing the bitumen. The mobilized bitumen then flows by gravity to the lower production wellbore where fluids are gathered and brought to surface.

The SAGD process can be categorized into three general operating phases; startup, production and blowdown. The startup process involves circulating steam into both the injection and production wellbores until thermal communication is established between the pair, typically after approximately 90 days of circulation. The production phase involves continuous steam injection into the upper wellbore with concurrent bitumen production from the lower production well. The production phase typically runs until the costs of steam injection and associated production operations can not be offset by the revenues of bitumen production. The final phase is blowdown. Currently the injection of non-condensable gases is the leading candidate to optimize bitumen recoveries through the blowdown phase. Steam injection is shut down and replaced by non-condensable gas injection into the injection well. Non-condensable gas injection is used to maintain steam chamber pressures and support continuing bitumen production from the lower production well. The blowdown phase would continue until the costs of gas injection and associated production operations can not be offset by the revenues of bitumen production. North American will continue to investigate other blowdown process options to maximize the economic recovery of bitumen.

B4.2.2.2 Well Pair Geometry and Placement

SAGD well pair spacing will be on the order of 120 m between adjacent wells. SAGD well pair lengths will be on the order of 500 m to 1200 m with an initial target of 1000 m. The actual length of each pair will be a function of pad geometry and local reservoir geology with consideration given to surface access limitations.

In reservoir areas with no bottom water or lower transition zones it is North American intention to place the SAGD production well as close to the base of the clean porous sand as possible, generally within 1 m to 3 m of the reservoir base. In reservoir areas with gradual transition between bottom water and bitumen the horizontal producers will be placed above the transition zone. This position results in a relatively high recovery factor with less risk of encountering problems with horizontal drilling operations (i.e., lost circulation). In areas with thick bottom water (> 5 m), the producer position may be adjusted upwards to approximately 3 m to 5 m above the oil water contact. Under these conditions, numerical model sensitivity studies show recoveries will be better with a slightly higher well pair placement. The higher placement limits the amount of heat lost to the bottom water and reduces the amount of bitumen draining and lost into the water zone. In all areas SAGD production wells will be allowed to deviate a few metres up or down to maximize resource recovery wherever possible.

B4.2.2.3 Reservoir Modelling

North American constructed static reservoir models using a geostatistical approach to populating 3D grid data. The first step was to generate variograms for reservoir properties such as effective porosity and water saturation. The next step involved the construction of an effective porosity trend model. The trend model was made with two vertical trend curves; one trend when inside a McMurray channel (SAGD) interval, and a second trend for the regional McMurray areas. Sequential Gaussian simulation was then used to populate the 3D models with porosity and water saturation values. Several structural controls were used as secondary Gaussian simulation variables in order to realistically constrain the model within geologically-defined bounding surfaces. The models were hung from the Top McMurray surface and ended at the Devonian. Within this interval, top and base of SAGD surfaces were used in the porosity trend modelling. In addition, an oil-water contact surface was used to better conform the transition between bottom water and bitumen. Top gas was estimated directly and based on geological mapping. Horizontal permeability was calculated as a function of the modeled effective porosity and vertical permeability was taken as a fraction of the horizontal permeability

The SAGD recovery process was modeled using CMG's STARS thermal reservoir simulator. Model flow properties were extracted from North American's shaley sand data set, complied over the last few years of delineation drilling throughout the project area. Shaley sand analysis provides shale-corrected porosities, permeabilities and fluid saturations.

Delineation drilling in the Leismer Commercial Project area has encountered bottom water, top lean bitumen (top water) and top gas throughout the project area. The bottom water can be thick and extensive in some project areas and has an initial pressure on the order of 2,500 kPag, measured via an openhole formation pressure tester (SFT). Top water is generally localized and for reservoir modelling it is assumed to be of finite extent. SFT measurements during delineation drilling operations indicate top water is in hydrostatic equilibrium with the underlying bitumen. Top gas can present in associated and non-associated pockets over the project area. Non-associated gas is separated from the SAGD interval with continuous regional mudstones and is not in pressure communication with the lower channels. Associated gas pockets are generally thin and sparse. Encountered associated gas was also SFT pressure tested and indicated it too was is in hydrostatic equilibrium with the underlying bitumen.

SAGD depletion modelling assumed steam chamber pressures on the order of 2,500 kPag. This is the target average operating pressure for long term SAGD depletion.

B4.2.2.4 Performance Prediction

A Leismer performance prediction was derived from a pad model representing a P50 realization of Leismer Pad 07, a four wellpair pad in Section 34-078-10W4M. A representative average wellpair profile is presented in Table B4.2-1. The presented injection and production rates shown are 90% of the simulated rates to account for downtime and non-ideal field operations. The presented rates also account for steam volumes required to start up a SAGD wellpair. Numerically, the SAGD startup was simulated using direct energy injection rather than a rigorously simulated steam circulation phase. Direct energy injection occurs for 90 days with a temperature limit of 240^0 C. This corresponds to an elevated circulation pressure on the order 3,250 kPa. The direct energy injection rate is assumed equivalent to field circulation rates of 120 m3/d CWE steam per individual wellbore (240 m^3/d per SAGD well pair). Using these assumptions North American expects 21,600 m^3 of steam will be required for the circulation startup. This calculated volume has been manually added to the simulated steam volumes in the performance prediction table.

Bitumen recovery factors were determined using the total amount of bitumen in place which includes volumes above and below the SAGD production well depth. The economic life of continuous steaming operations was assumed to end when (a) 50% of the pad OBIP was recovered, or (b) the instantaneous steam oil ratio (ISOR) exceeded 4.0. Under continuous steaming operations the Leismer Commercial pad model exceeded the ISOR upper limit at 43% bitumen recovery. North American expects that optimized blowdown operations will recover an additional 5 – 15% OBIP. Assuming midpoint blowdown recovery factors of 10% North American expects the full cycle bitumen recovery factor in the Leismer Expansion Hub area will be approximately 53% OBIP.

Table B4.2-1 Single Well Pair SAGD Performance Prediction

Year	Leismer Commercial Project		
	Bitumen Production (m^3/d)	Steam Injection (m^3/d)	SOR
1	91	265	2.90
2	170	427	2.51
3	164	468	2.86
4	156	491	3.14
5	146	490	3.37
6	91	265	2.90

B4.3 Hydrogeology

Section 4.3 of Volume 1 provides additional regional hydrogeologic discussion. The following section is a more detailed hydrogeologic assessment of the Leismer area. While North American is not requesting a higher initial source water rate, this information is presented for completeness.

B4.3.1 Hydrostratigraphy

Hydrostratigraphy provides a classification of the geological units according to hydrogeological characteristics. The geological column for the region, shown on the left hand side of Figure B4.3-1, has been arranged into a series of aquifers and aquitards, based on the relative hydraulic characteristics of each unit or adjacent units. Six aquifers have been identified in the region as being feasible for providing the Kai Kos Dehseh Project with some or all of its groundwater demand and meeting some or all of its disposal requirements. These aquifers are listed below (with increasing depth) and are discussed in Sections 4.3.3 to 4.3.7 (Volume 1).

i. Empress Terrace Aquifer

ii. Empress Channel Aquifer

iii. Lower Grand Rapids Aquifer

iv. Clearwater A Aquifer

v. Clearwater B Aquifer

vi. Basal McMurray Aquifer

vii. Grosmont Aquifer

B4.3.2 Methodology

North American has updated its geology since the Application for Leismer Demonstration Hub. Updated geology focussed on the Mannville Group (including the Grand Rapids, Clearwater and McMurray formations) from Township 75, Range 6 to Township 83, Range 14 as part of the Kai Kos Dehseh Project Application. Maps for the Leismer Expansion Hub have been updated for 2007 drilling and are discussed below.

The geology review process paid particular attention to the Lower Grand Rapids, Clearwater A, Clearwater B and Basal McMurray aquifers. The determination of these aquifers was based on the following criteria;

- less than 60 API gamma response;
- greater than 30% density porosity;
- resistivity less than 10 Ω (Basal McMurray Aquifer only); and
- good spontaneous potential response.

B4.3.3 Empress Formation Aquifers

The Empress Formation is defined as all stratified sediments that rest on bedrock and are covered by the first occurrence of glacial till in the area (Andriashek, 2003). These drift sediments consist of Tertiary age “stratified gravel, sand, silt and clay of fluvial, lacustrine, and colluvial origin” (Whitaker and Christiansen, 1972) and exist within bedrock channels (channel aquifer) and on bedrock terraces or interfluve benches (Terrace Aquifer).

The Empress Channel and Empress Terrace Aquifers are important regional aquifers beneath the Project area. Isopach maps of the Empress Channel and Terrace Aquifers are provided as Figures 4.3-2 and 4.3-3 (Section 4.3, Volume 1).

Groundwater in the Empress Aquifers is considered to be non-saline with total dissolved solids (TDS) concentrations expected to be less than 1,000 mg/L. Testing of the North American 11-14-78-9 W4M camp water supply well identified TDS concentrations of 748 mg/L and 816 mg/L.

B4.3.4 Lower Grand Rapids Aquifer

The Grand Rapids Formation of the upper Mannville Group represents a regional regression event (Bachu et al., 1993). The lower portion of the Grand Rapids Formation consists primarily of thick sandstone bounded at the top and bottom by shale (Bachu et al., 1993). The isopach of the Lower Grand Rapids sandstone net water (Figure B4.3-2) has been updated for the Leismer Expansion Area and is laterally continuous in the RGSA with a maximum thickness of 26.6 m.

Groundwater in the Lower Grand Rapids Aquifer is considered to be non-saline with expected total dissolved solids concentrations ranging from 1,000 to 3,500 mg/L.

B4.3.5 Clearwater A and B Aquifers

The Clearwater Formation is composed of several thick, coarsening-upwards, sand successions each separated by thin shale layers (Hitcheon et. al., 1989). Beneath the Kai Kos Dehseh Project area, there are two substantial sand bodies in the Clearwater Formation known as the Clearwater A and B aquifers (Maher, 1989). The Clearwater A Aquifer is not present in the Leismer RGSA and Expansion Hub. The Clearwater B Aquifer is best developed in the southern portion of the RGSA and the net water isopach is shown in Figure B4.3-3.

Tests conducted by North American, during the winter of 2007, identified TDS concentrations in the Clearwater B Aquifer ranging from 6,340 mg/L to 7,610 mg/L.

B4.3.6 Basal McMurray Aquifer

The McMurray Formation consists predominantly of fluvial and estuarine sediments deposited in the valleys of the sub-Cretaceous Unconformity surface (Hitcheon et. al., 1989). The lower sands of the McMurray Formation are fluvial in nature. Fluvial sands that are water saturated are referred to as the Basal McMurray Aquifer. An isopach map of the Basal McMurray Aquifer is provided as Figure B4.3-4. The thickest bottom water is associated with the erosional feature on the pre Cretaceous Unconformity surface along the western edge of the Expansion hub where bottom water can be up to 20 m thick (11-16 and 1-20-78-10 W4). Some wells in the RGSA, do not have bottom water as they are sitting on localized paleotopographical highs, or have thick basal shale. These include 2-27, 13-27, 14-27, 3-34, and 5-34-78-10 W4M and 12-3-79-10 W4M.

Figure B4.3-5 is the Net McMurray Bottom Water isopach and displays similar trends to the gross bottom water.

Figure B4.3-6 is the Structure on the McMurray Bitumen/Water Contact.

Groundwater in the Basal McMurray Aquifer is considered to be saline with TDS concentrations ranging from 10,000 mg/L to 15,000 mg/L. Figure 4.3-11 (Section 4.3, Volume 1) illustrates Basal McMurray Aquifer salinity. Tests conducted by North American, during the winter of 2007, identified TDS concentrations in the Lower Grand Rapids Aquifer ranging from 10,700 mg/L to 13,500 mg/L.

B4.3.7 Hydrogeologic Evaluation

The hydrogeologic assessment, including well testing and numerical groundwater modelling provided in Volume 3 Section 5.6 Impact Assessment, concludes that sufficient water is available to meet the water demands of the Leismer Hub. To summarize, the water demands and supporting aquifers for the Leismer Hub are 1,960 m^3/d from the Lower Grand Rapids Aquifer and 1,900 m^3/d from the Basal McMurray Aquifer. The Leismer Hub will also dispose of 1,900 m^3/d into the Basal McMurray Aquifer.

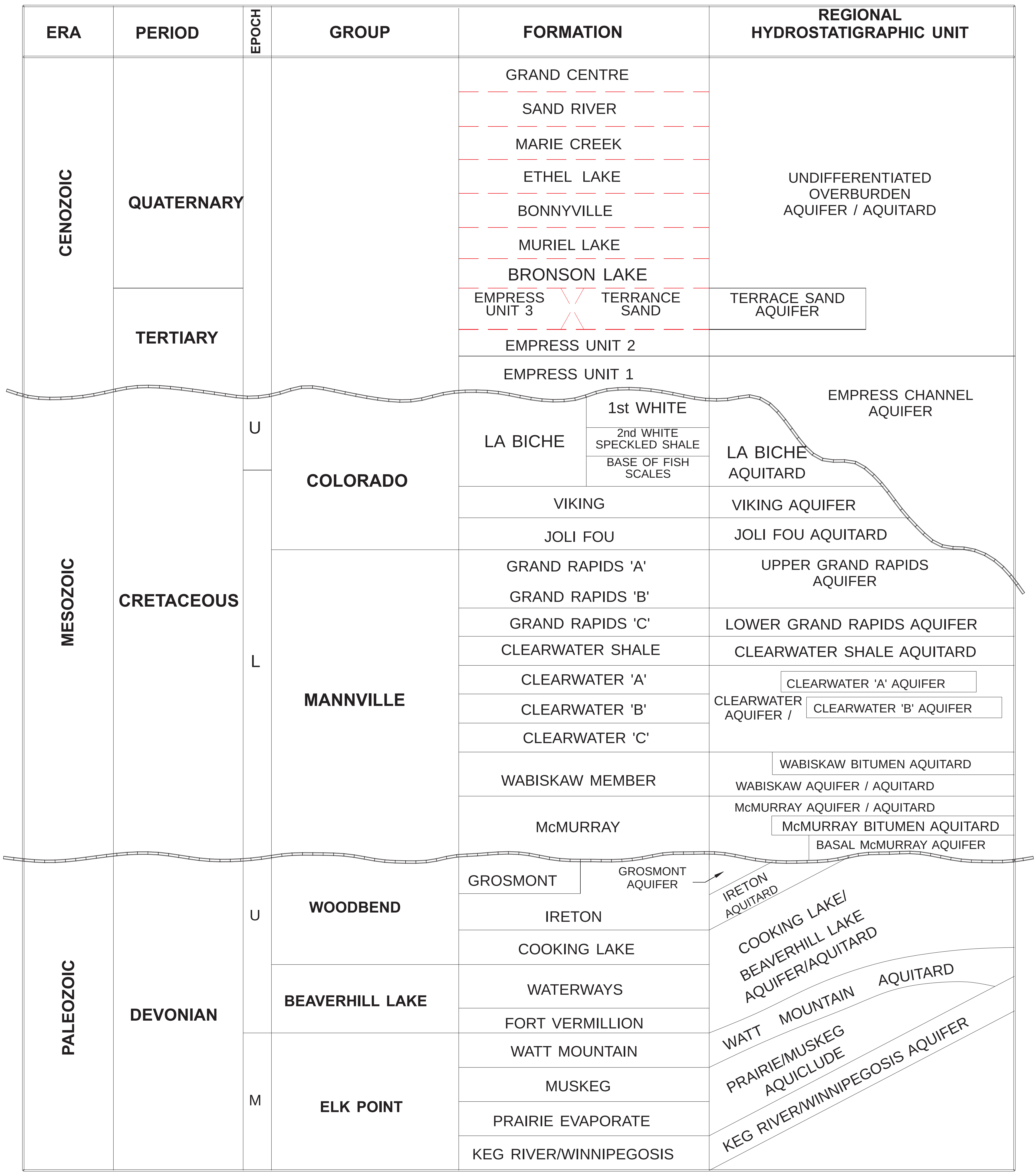
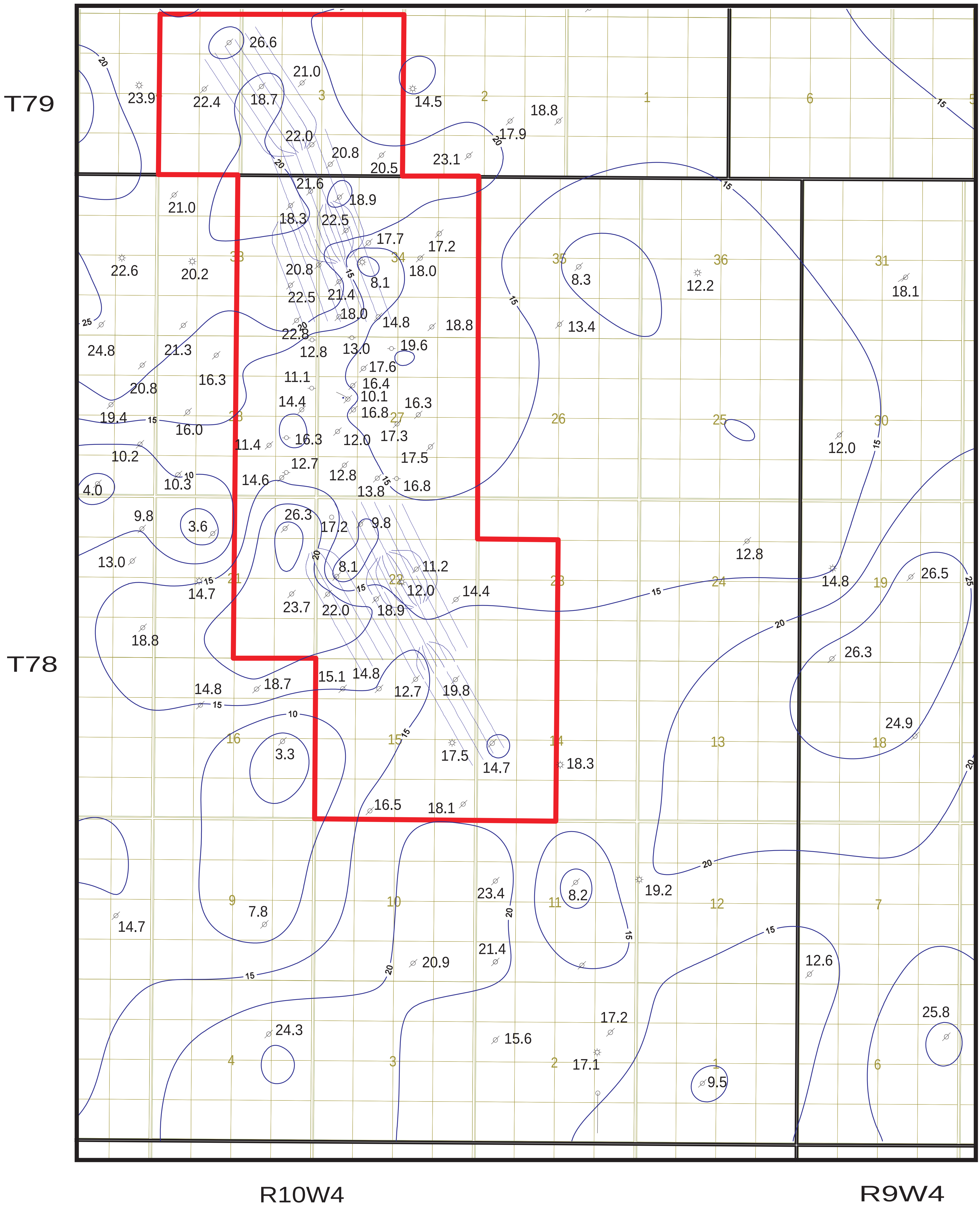


Figure B4.3-1
Geological Column



Leismer Expansion Area

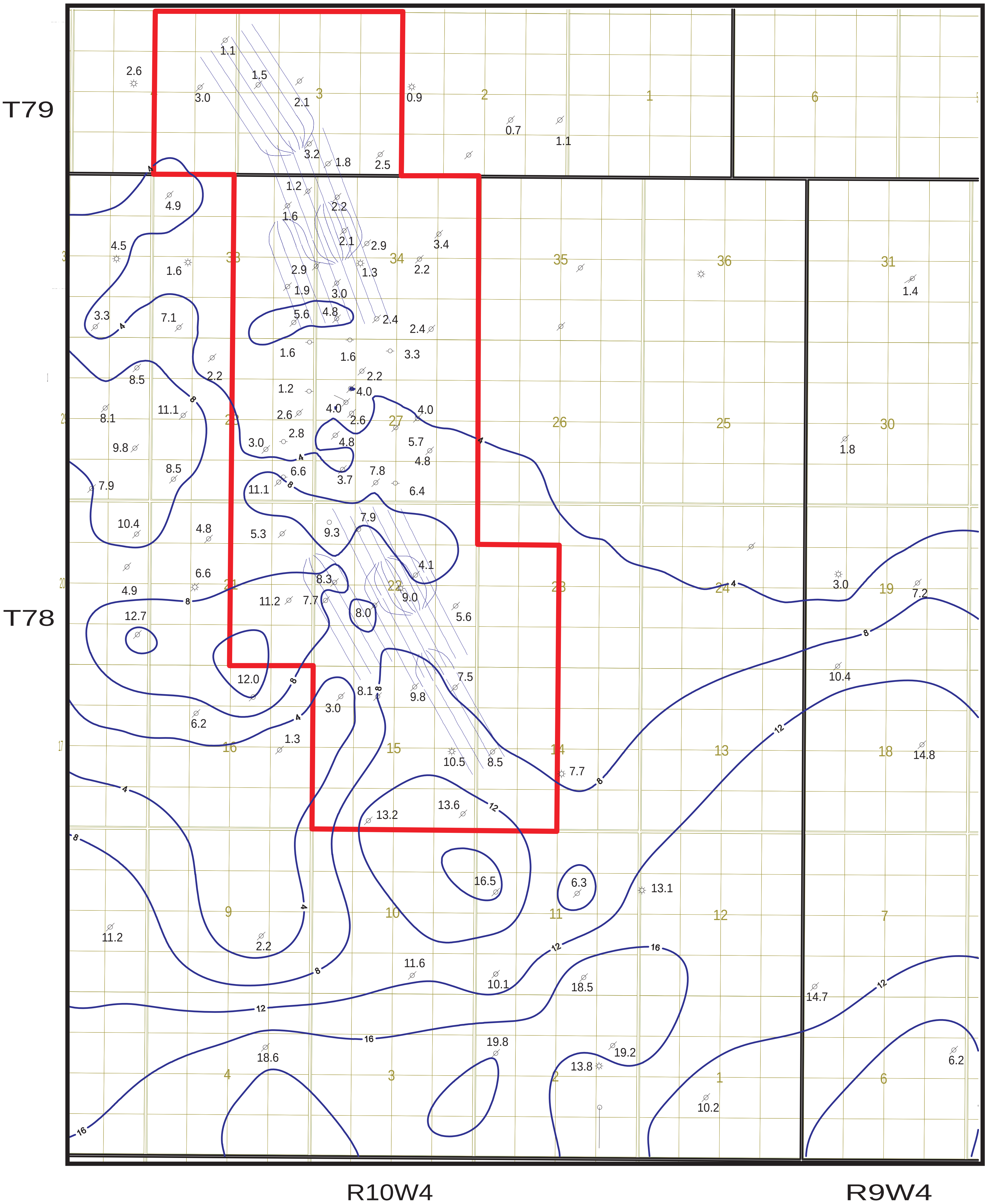
21.7 Lower Grand Rapids Net Water Posted Isopach

Figure B4.3-2 Lower Grand Rapids Net Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Lower Grand Rapids Net Water Isopach

Author: J. Lobsinger, P. GEOL.	CUTOFF: 60api or app 36% density porosity	Date: 14 June, 2007
C.I.=5m	Scale: 1:40,000	



Leismer Expansion Area

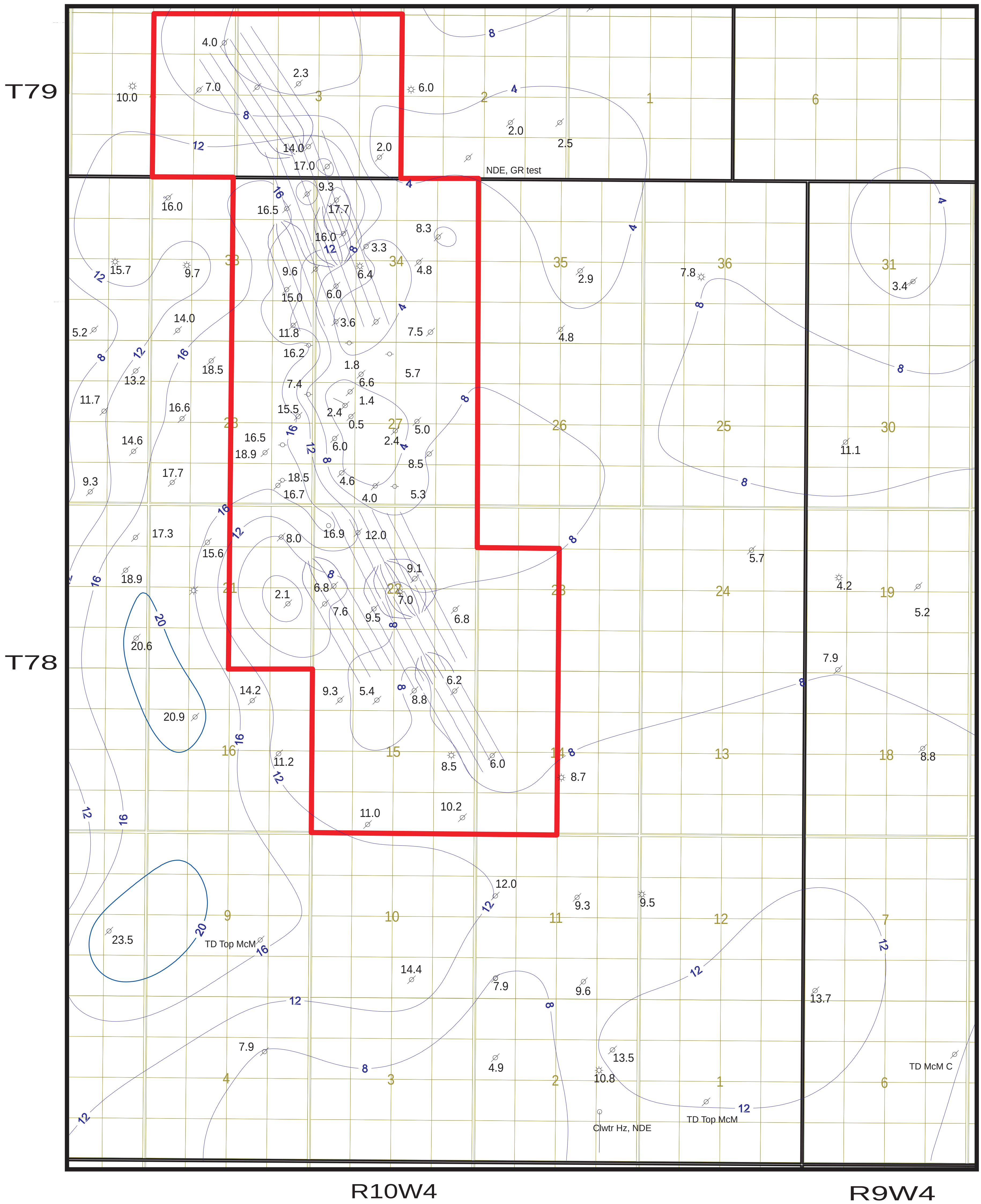
19.8 Clearwater B Net Water Posted Isopach

Figure B4.3-3 Clearwater B Net Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
Clearwater B Net Water Isopach

Author: J. Lobsinger, P. GEOL.	CUTOFF 36% density porosity or approx 60api GR	Date: 18 May, 2007
C.I.=4m	Scale: 1:40,000	



Leismer Expansion Area

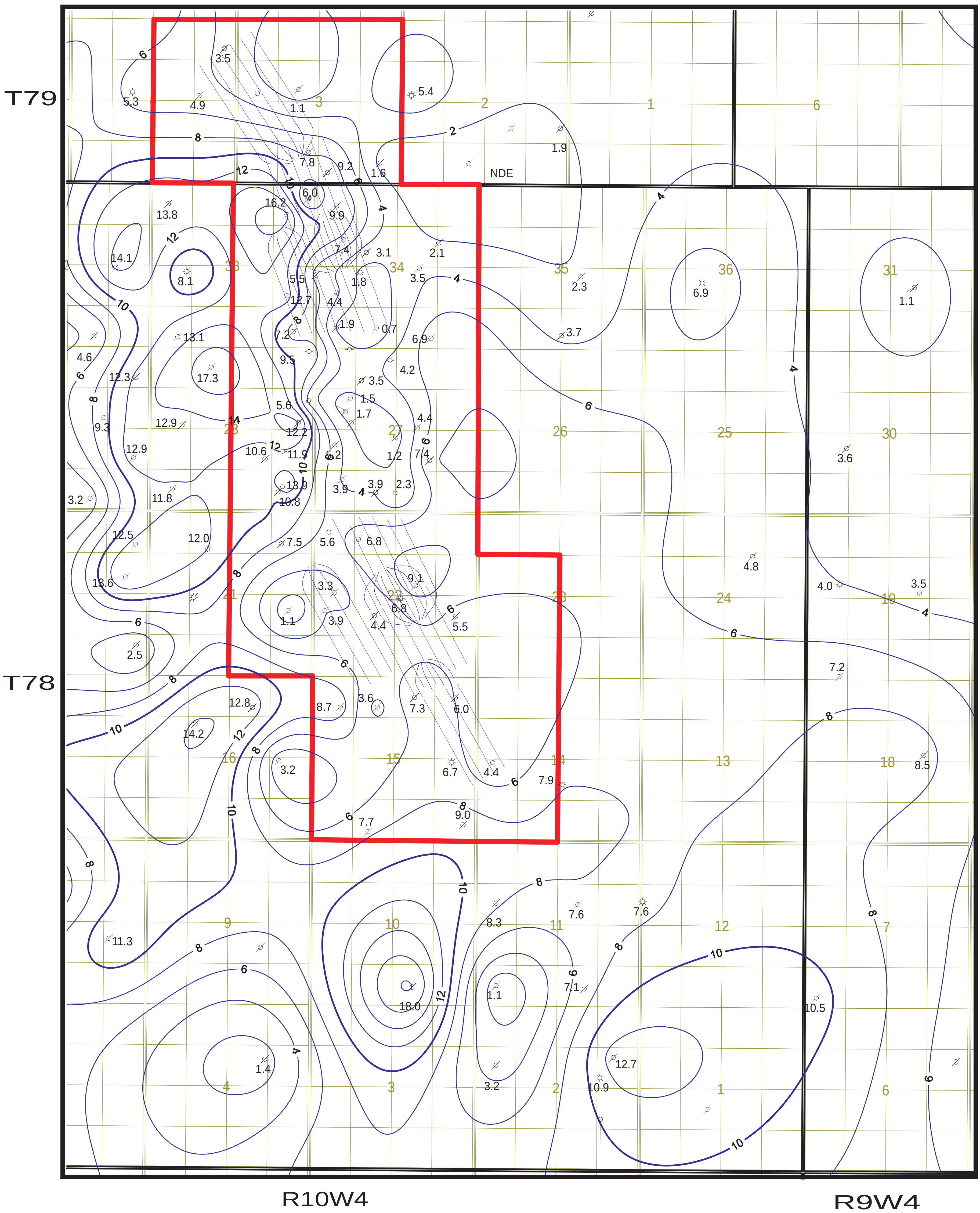
14.4 Gross Bottom Water Isopach Posted Value

Figure B4.3-4 McMurray Gross Bottom Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Gross Bottom Water Isopach

Author: J.Lobsinger, P. GEOL.	CUTOFF: 10ohms, 27% Porosity	Date: 9 May, 2007
CI=4m	Scale: 1:40000	



Leismer Expansion Area

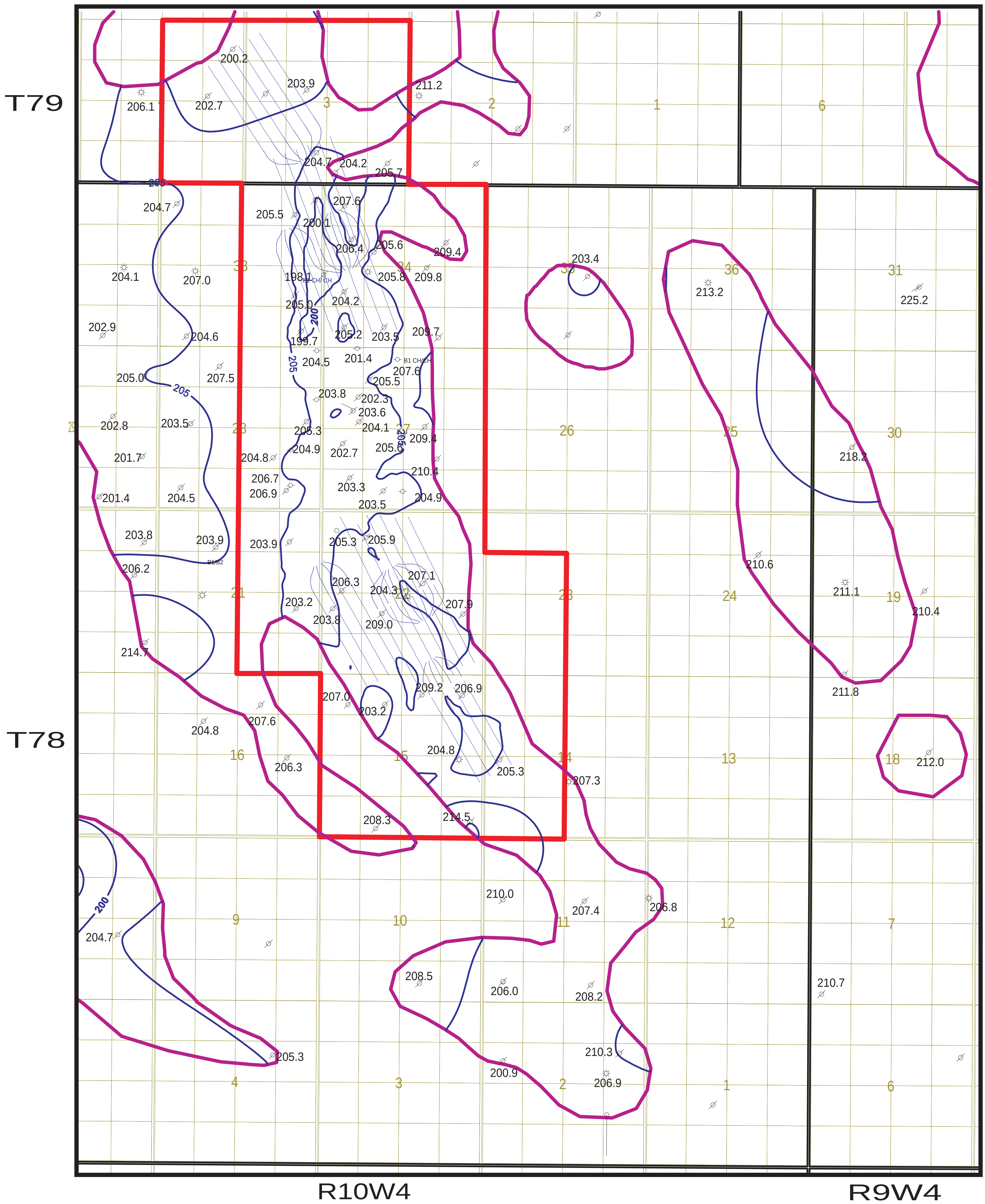
2.2 Net Bottom Water Isopach Posted Value

Figure B4.3-5
McMurray Net Bottom
Water Isopach

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Net Bottom Water Isopach

Author: J.Lobsinger, P. GEOL.	CUTOFF: 10ohms, 27% Porosity	Date: 9 May, 2007
CI=4m	Scale: 1:40000	



Leismer Expansion Area

207.5 Bitumen/Water Contact Structure Posted Value

Zero Edge SAGD

Figure B4.3-6
McMurray Bitumen/Water Contact Structure

NORTH AMERICAN OIL SANDS CORPORATION

Leismer
McMurray Bitumen/Water Contact Structure

Author: J.Lobsinger, P. GEOL.	CUTOFF: 10ohms, 27% Porosity	Date: 15 June, 2007
CI=5m	Scale: 1:40000	

B5 LEISMER EXPANSION HUB C&R PLAN

B5.1 Introduction

This section provides site-specific conservation and reclamation (C&R) practices and mitigation activities for the Leismer Commercial Expansion. General C&R measures (e.g., re-contouring, decompaction, weed/erosion control, surface water management, etc.) applicable to all the Kai Kos Dehseh development areas are presented in the conceptual C&R plan (Volume 1, Section 8).

The linear facilities are often combined into single rights-of-way (ROWs) to minimize disturbance. The ROWs to production pads include access, aboveground and belowground pipelines, and power lines. Thus, parts of some ROWs will have surface soil disturbed (access) while other parts of the same ROW will have only vegetation disturbance or negligible surface disturbance (e.g., powerlines, above-ground pipelines).

Preceding application for approval of the Kai Kos Dehseh Project, North American had applied for regulatory approval of its Leismer Demonstration Project (North American, 2006). As part of the regulatory review, revisions to the original Leismer Demonstration Project C&R plan were made. Specifically, North American has made the following commitments:

- Corduroy will not be used in the construction of pads developed on deep (>40 cm) peats;
- A minimum of 40 cm of peat will be salvaged from areas developed in deep peats; and
- Borrow areas will be developed in upland areas only.

The commitments have been incorporated into the conceptual C&R plan presented in Volume 1, Section 8 and in to this detailed C&R plan. Future Pre-Development Assessments (PDAs) will be done on the Leismer Expansion facility areas to provide additional detail on soils and terrain, and revised site-specific C&R procedures, if required.

B5.2 Leismer Commercial Expansion Facilities

Facilities associated with the Leismer Commercial Expansion include the Expansion CPF, eight production pads (Pads LC5 – LC12) and associated facilities (access road, above and below ground pipelines, power lines). The Leismer Expansion CPF is beside (east of) the Leismer Demonstration CPF. The Al-Pac right-of-way, borrow areas, and water source and disposal wells were included in the Leismer Commercial Hub C&R (Volume 1, Appendix A5).

Table B5.2-1 lists the facility areas on the Leismer Commercial Expansion footprint, Table B5.2-2 presents the soils on the Leismer Commercial Expansion footprint and Figure B5.2-1 illustrates the mapped soil units on the Leismer Commercial Expansion footprint.

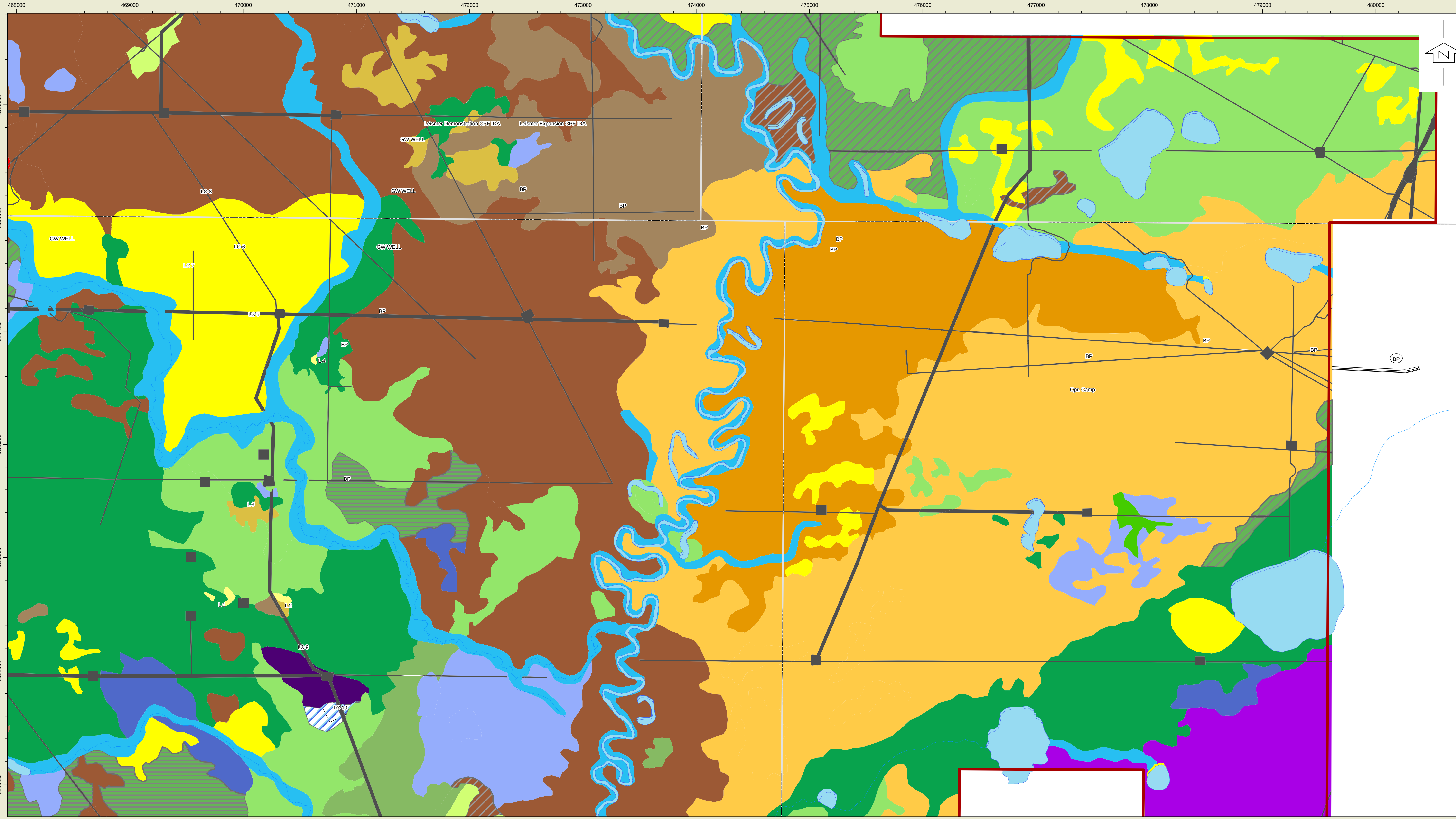
Table B5.2-1 Leismer Commercial Expansion Facilities – Area Extent

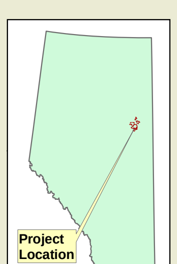
Leismer Commercial Expansion Facilities	Area on Footprint (ha)
1 (Expansion) Central Plant Facility	43.8
8 Production Well Sites	32.7
Roads and facility ROWs	6.7
Total	**83.2**

Table B5.2-2 Leismer Commercial Expansion – Soil Types and Area Extent

Soil Map Units	Expansion CPF	Pad LC5	Pad LC6	Pad LC7	Pad LC8	Pad LC9	Pad LC10	Pad LC11	Pad LC12	Roads / Connectors / ROW	Total
Dover (DOV)						0.7	1.2			1.3	3.2
Hartley (HLY)							0.4		2.8	0.4	3.6
Kinosis (KNS)	35.9				4.4			2.8		0.4	43.5
Mikkwa (MKW)							2.5			0.2	2.7
McLelland (MLD)	0.7					3.4		0.9		1.4	6.4
Mildred (MIL)		3.6	3.5	3.5						1.5	12.1
Mariana (MRN)									0.4		0.4
Steepbank (STP)	5.8										5.8
Surmont (SRT)											0
Existing Disturbance	1.3	0.9	0.2	0.2	0.2	0.5	0.5	0	0.3	1.5	5.5
River/Lake/Stream Channel											0
Total	43.8	4.5	3.7	3.7	4.5	4.5	4.5	3.7	3.5	6.7	83.2

Note: Refer to Figure B5.2-1 for C&R naming convention of pads





Legend

- North American Soils LSA
- Lake
- River / Stream
- L1-L4: Leismer Demonstration Production Well Site
- L6-L10: Leismer Expansion Production Well Site

CPF IDA: Initial Development Area Central Plant Facility
GW Well: Groundwater Well Site
BP: Borrow Pit

Soil Map Units

ALG-1, ALG-2, DOV-1, DOV-2, FIR-1, FRT-1, HLY-1, HLY-2, KNS-1, KNS-2, KNS-3, KNS-4, LVK-1, MIL-1, MIL-2, MKW-1, MLD-1, MLD-2, MRN-1, MRN-2, MRN-3, MRN-4, MUS-1, MUS-2, SRT-1, SRT-2, STP-1, STP-2, Lake, RB, SC, ZUN

1:32,500

0 0.2 0.4 0.8 1.2 1.6 2 km

NAD 83 UTM Zone 12

Title:

SOIL MAP UNITS ON LEISMER INITIAL DEVELOPMENT AREA (IDA) FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

Approved: SC/DH/LZ	Revision Date: July 30, 2007
File: Fig. B 5.2-1 Leismer Ini Dev Area _SMUs _32.5k_TL_20070730	

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TR/JC/LZ	LZ/SC	B 5.2-1

14455-514_NAOSC\FINAL_MAPS\C&R\Fig. B 5.2-1 Leismer Ini Dev Area _SMUs _32.5k_TL_20070730.mxd

B5.3 Land Capability for Forest Ecosystems Classification

Figures B5.3-1 and B5.3-2 illustrate the pre-disturbance and target post reclamation Land Capability Classification for Forest Ecosystems for the Leismer Commercial Expansion footprint.

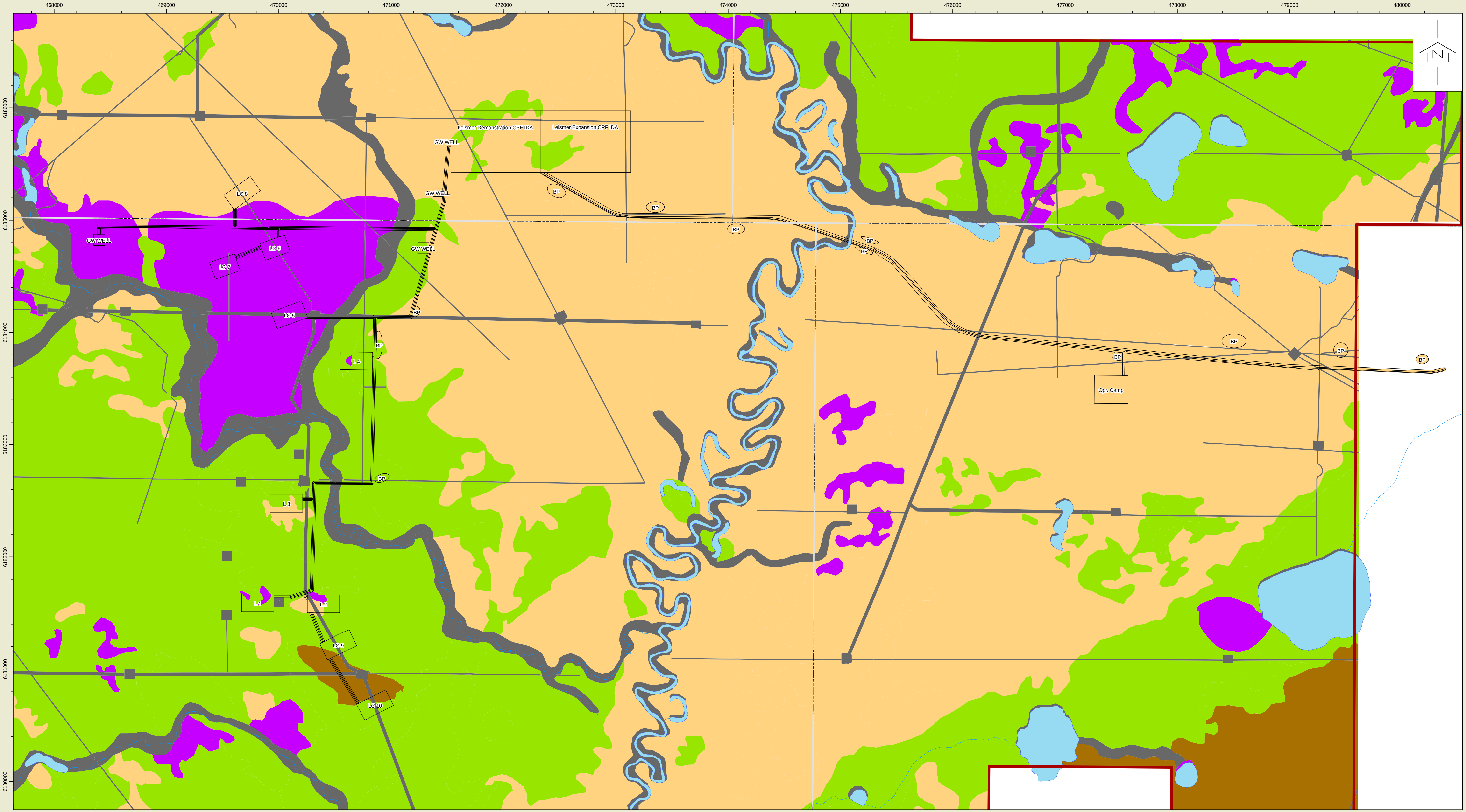
Table B5.3-1 compares the pre-disturbance and post reclamation Land Capability for Forest Ecosystem classes.

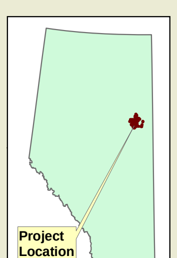
Table B5.3-1 Pre-disturbance and Post Reclamation Land Capability for Forest Ecosystem Classes for the Leismer Commercial Expansion Footprint

Forest Capability Class	Baseline		Post Reclamation	
	Area (ha	% of Footprint	Area (ha)	% of Footprint
Class 1 High Capability	0	0	0	0
Class 2 Moderate Capability	3.1	3.8	3.4	4.1
Class 3 Low Capability	43.3	52.1	45.7	54.9
Class 3/5 (Low Capability/Non-Productive) Complex	0	0	12.4	14.9
Class 4 Conditionally Productive	12.1	14.4	13.8	16.6
Class 5 Non-Productive	18.9	22.7	7.6	9.1
Unclassified (Lakes, Rough Broken, Stream Channel, Disturbed soil map units)	5.8	6.9	0.3	0.4
Total	**83.2**	**100**	**83.2**	**100**

The Class 3/5 complex represents the reclamation approach for padded sites developed on areas of deep peat (Class 5), where a portion will be reclaimed to an upland ecosite phase (dominantly Class 3), and the edges to the ‘transitional g1’ ecosite phase (dominantly Class 5). The areas of padded well sites, CPFs, access roads and camps developed on peatland that will be reclaimed to the ‘transitional g1’ ecosite phase represent the greatest change to land capability from the baseline conditions (see Figures 8.6-3 and 8.6-4 in Volume 1, Section 8).

The siting of well sites, CPFs, access roads and camps on deep peats will result in a reduction of some peatland area; however, reclamation to the ‘transitional g1’ area is an initial step in mitigation of this loss. As experience is gained in reclamation of wetland areas, the area of peatland reclaimed to areas with similar characteristics can be expanded over time.





Legend

North American Soils LSA
Lake
River / Stream
L1-L4: Leismer Demonstration Production Well Site
L6-L10: Leismer Expansion Production Well Site

CPF IDA: Initial Development Area Central Plant Facility
GW Well: Groundwater Well Site
BP: Borrow Pit

Land Capability for Forest Ecosystems

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)

1:32,500

0 0.2 0.4 0.8 1.2 1.6 2 km

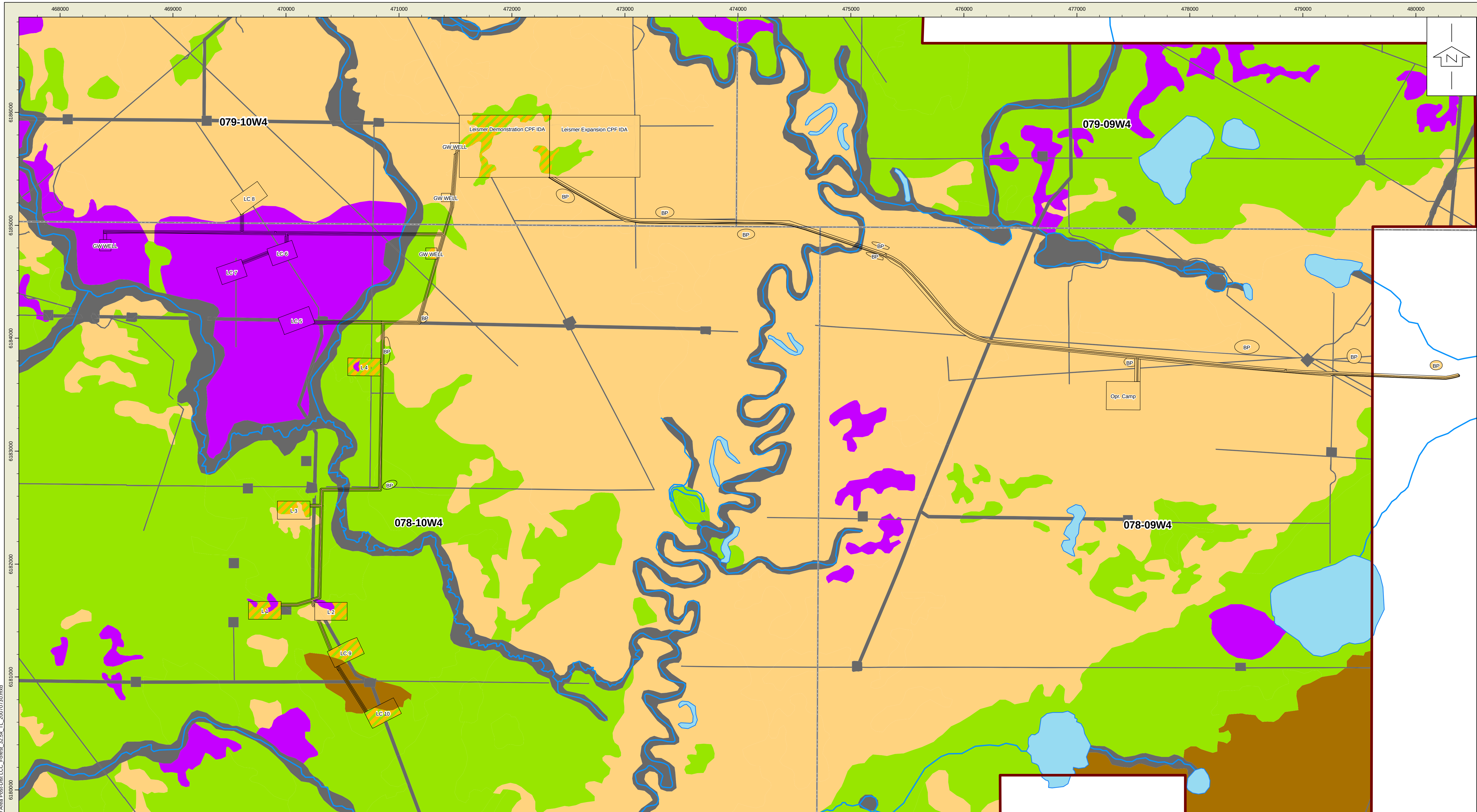
NAD 83 UTM Zone 12

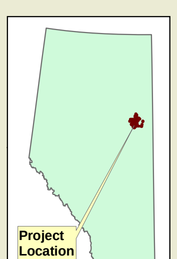
Title:

PRE-DISTURBANCE LAND CAPABILITY FOR FOREST ECOSYSTEMS ON LEISMER INITIAL DEVELOPMENT AREA FOOTPRINT

Approved: SC/DH/LZ	Revision Date: July 30, 2007	
File: Figure. B 5.3-1 Leismer Ini Dev Area Pre-Dist LCC_Forest_32.5k_TL_20070730		
Drawn by: TR/JC/LZ	Checked: LZ/SC	Fig. No.: B 5.3-1

I:\4455-514_NAOSC\FINAL_MAPS\C&R\Figure. B 5.3-1 Leismer Ini Dev Area Pre-Dist LCC_Forest_32.5k_TL_20070730.mxd





Legend

North American Soils LSA
Lake
River / Stream
L1-L4: Leismer Demonstration Production Well Site
L6-L10: Leismer Expansion Production Well Site

CPF IDA: Initial Development Area Central Plant Facility
GW Well: Groundwater Well Site
BP: Borrow Pit

Land Capability for Forest Ecosystems

- Unclassified (Baseline Disturbances, Lakes, Stream Channels, Rough Broken)
- Class 2 (Moderate Capability)
- Class 3 (Low Capability)
- Class 4 (Conditionally Productive)
- Class 5 (Non-Productive)
- Class 3/5 Complex (Low Capability/Non-Productive)

1:32,500

0 0.2 0.4 0.8 1.2 1.6 2 km

NAD 83 UTM Zone 12

Title:

POST-RECLAMATION LAND CAPABILITY FOR FOREST ECOSYSTEMS ON LEISMER INITIAL DEVELOPMENT AREA FOOTPRINT

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
SC/DH/LZ	July 30, 2007

File: Figure. B 5.3-2 Leismer Ini Dev Area Post-Dist LCC_Forest_32.5k_TL_20070730

Drawn by:	Checked:	Fig. No.:
TR/JC/LZ	LZ/SC	B 5.3-2

14455-514_NAOSC\FINAL_Maps\C&R\Figure_B 5.3-2 Leismer Ini Dev Area Post-Dist LCC_Forest_32.5k_TL_20070730.mxd

B5.4 Hydrology

Mitigation measures to prevent impacts on surface water are presented in the conceptual C&R (Volume 1, Section 8.6.2.2) and Hydrology (Volume 3, Section 6), and Fish and Fish Habitat (Volume 3, Section 8) sections of the EIA.

B5.5 Soils Handling Plan

The objective of soil salvage and management is to provide valuable topsoil for reclamation purposes by stripping and storing topsoil in a manner that will minimize loss until it is required for future replacement and reclamation. Through proper handling and conservation, the degradation of topsoil by erosion, compaction, rutting, loss of viable plant material and soil mixing is reduced. For the purposes of salvaging, stockpiling, and replacing soil during reclamation, soil-handling activities have been recommended for the dominant soil series encountered.

B5.5.1 Topsoil and Subsoil Salvage

A professional soil scientist will direct, monitor and document all soil salvage activities according to all applicable regulatory guidelines. All areas of surface disturbance on the Leismer Commercial Expansion footprint will have surface soils salvaged as detailed in Table B5.5-1 (based on average topsoil depths for soil series). Where present, colour change from A to B horizons can also be used to guide topsoil stripping. North American will document the volumes and locations of all salvaged topsoils at the time of salvage. Future PDAs on the Leismer Expansion facility areas will provide additional detailed information on soil depths for soil salvage.

Table B5.5-1 Recommended Topsoil Salvage Depths by Soil Series

Soil Series	Recommended Soil Salvage Depth (cm)
Firebag Fort Kinosis Mildred	LFH and/or shallow peat plus 15 cm topsoil (or to bottom of topsoil if deeper)
Livock Surmont	LFH and/or shallow peat plus 18 cm topsoil (or to bottom of topsoil if deeper)
Algar Lake Dover Steepbank	peat plus 10 cm of underlying mineral soil
McLelland Hartley Mariana	Minimum 40 cm of peat

Where topsoil is being stripped, activities will be suspended immediately if soils become excessively wet, or if any other field conditions or operations occur that will result in the degradation of topsoil quality, e.g., rutting, high winds. Where the development area occurs within wet terrain, stripping will occur during frozen conditions.

Up to 30 cm of suitable subsoil (i.e., subsoil rated as good, fair or poor for reclamation suitability according to the Soil Quality Criteria Relative to Disturbance and Reclamation (Revised) Alberta Agriculture (1987)) will also be salvaged from mineral soil sites. No subsoil will be salvaged from wet (i.e., Organic or Gleysolic) soils. Access roads on mineral soils will have surface duff/peat and surface mineral soil (topsoil) salvaged only.

Salvage and stockpile information will be presented in the Annual Conservation and Reclamation Report.

B5.5.2 Stockpile Management

The mineral topsoil, peat from the Organic soils, and the subsoil will be stored in separate, stable stockpiles on site. Stockpiles will be located such that they will not interfere with on site activities. They will be accessible and retrievable for reclamation. North American has included sufficient stockpile area on the CPF and each pad to accommodate the material volume. Conceptually, the stockpile locations for the Expansion CPF and eight additional pads will be as illustrated in Figures 8.6-2 and 8.6-1, respectively (Volume 1 Section 8); locations will be finalized when the PDAs are done.

Stockpile sites will be documented in the Annual Conservation and Reclamation Report submitted to AENV and staked or marked in the field.

The stockpiles locations will have stable foundations and will also be stabilized to control water and wind erosion. The requirement for immediate erosion control measures, such as erosion control matting, or tackifiers will be determined on a stockpile-specific basis. An ASRD-approved seed mix suitable for the Central Mixedwood Subregion will be used to provide a protective vegetation cover where required. Soil stockpiles will be monitored and additional erosion control measures adopted, as necessary, where seed germination and plant growth have been poor.

B5.6 Reclamation

B5.6.1 End Land Use Objectives

As discussed in Volume 1, Section 8, the disturbed upland mineral soil areas will be reclaimed to an ecosite phase and land capability equivalent to the pre-disturbance conditions. The central areas of the well pads developed on peatland areas will be reclaimed to a target g1 Labrador tea - subhygric Black spruce-Jack pine ecosite phase with a land capability for forest ecosystems of Class 3 to 4. The edges of the pads will be reclaimed to a wetter peat surface area providing a transition between the reclaimed upland area and the existing wetland area. The transition area will have a target ‘transitional g1’ ecosite phase, with an anticipated land capability for forest ecosystems of Class 5 (to 4) as described in Volume 1, Section 8 and illustrated in Figures 8.6-3 and 8.6-4.

The ‘transitional g1’ ecosite phase will have similar target species as the g1 Labrador tea - subhygric Black spruce-Jack pine ecosite phase (black spruce, bog cranberry, bunchberry, blueberry and Labrador tea); however, there will be a decrease in tree species density and an increase in shrub species density. The prescribed vegetation for reclamation is considered to be best suited for the moisture and drainage conditions that will occur in the transition zone, and which will also most closely resemble adjacent existing wetland vegetation.

B5.6.2 Site Reclamation

Reclamation for all the Leismer Commercial Expansion facilities will be carried out as discussed in the conceptual C&R plan (Volume 1 Section 8) and section B5.6.1; the Commercial Expansion Central Plant Facility and well pads are further discussed below. Site preparation for soil replacement will follow the guidelines presented in section 8.6.5 (Volume 1, Section 8).

The C&R procedures for the sites in the Leismer Commercial Expansion are based on the current information. Future Pre-Development Assessments (PDAs) will be done on the Leismer Commercial Expansion facility areas to provide additional detail on soils and terrain, and revised site-specific C&R procedures.

B5.6.2.1 Expansion Central Processing Facility

The Leismer Commercial Expansion CPF is located primarily on mineral soils that are dominated by Kinosis till soils. In the southwest part of the CPF there is a lower, wetter area that is mainly Gleysolic Steepbank soil, though a very small area of Organic McLelland soils extends east from the Leismer Demonstration CPF into the Leismer Expansion CPF.

The mineral soil Expansion CPF area (Kinosis and Steepbank soil units) will be reclaimed to areas with similar soils, terrain, and land capability and target ecosite phases as the pre-disturbance conditions. Terrain will be re-contoured to fit the surrounding terrain, which will result in re-creating the low area in the southwest with the Steepbank soil. The small McLelland soil unit on the southwest border will be reclaimed as part of the same McLelland unit in the adjacent Leismer Demonstration CPF.

As indicated in the C&R plan in Volume 1, Section 8, the Steepbank soil will have surface LFH/shallow peat salvaged along with 10 cm of mineral soil; this depth captures the typical A horizon depth for Steepbank soils encountered in the soil survey. However, if the PDA indicates topsoil is deeper in that area, it will all be salvaged.

B5.6.2.2 Expansion Well Pads LC5 to LC12

Both mineral upland soils (mainly Mildred, Dover and Kinosis soils) and Organic soils occur on Well Pads LC5 to LC12.

Well Pads LC5 to LC7 are mapped on a Mildred-2 map unit with Mildred soils dominant. McLelland and Mikkwa Organic soils also occur in the unit as do Kinosis series as indicated by soil inspection data. The Organic soil on Well Pad LC6 has peat depths near 70 cm. Well Pad LC8 is on dominantly Kinosis till soil. Well Pad LC9 is located on Organic McLelland, and gleyed Dover soils. Well Pad LC10 has gleyed Dover and Kinosis soils in the northeast part of the lease and an Organic Mikkwa soil map unit on the rest. Well pad LC11 is dominantly on Kinosis soil with small areas of McLelland soil along the west side and NE corner of the pad. Well Pad LC12 is dominantly Organic Hartley soil with a small area of Mariana soil along the south border of the pad.

As described in Volume 1, Section 8, the upland mineral soil areas on the sites will be reclaimed to upland areas with similar soils, terrain, and land capability and target ecosite phases as the pre-disturbance conditions. As described in Volume1, Section 8, peatland areas (peat > 40 cm thick) will be reclaimed partly to a reclaimed pad with a target ecosite phase of g1 and a land capability for forest ecosystems of Class 3 (to 4), and the transitional peat surface area with a target ecosite phase of ‘transitional g1’ with a land capability for forest ecosystems of Class 5 (to 4).

Surface and subsoil soil stripping on mineral soils will occur as described in Section B5.5.1. Salvaged soil will be stored and replaced at the site where it was salvaged. Peatland areas (peat > 40 cm thick) will have a minimum of 40 cm of peat separately salvaged for replacement later. The upper lift of LFH/shallow peat/mineral soil A horizons will be replaced on the areas that were pre-disturbance upland mineral soils. On parts of the reclaimed pad that were on peatland areas, the salvaged peat will be replaced in the transition zone (to the elevation of the adjacent undisturbed peatland) and mixed into the mineral surface of the remainder of the pad located on pre-disturbance peatland areas. The salvaged subsoil will be replaced over the part of the lease not included in the peat surface transition zone.

B5.6.3 Material Balance

Table B5.6-1 presents the material balance volumes for the mineral topsoil (including shallow peat and LFH), deep peat, and subsoil material available for salvage and replacement for the Leismer Commercial Expansion. All salvaged soil will be replaced on the site of origin wherever possible; therefore, the target replacement value is shown equivalent to the soil available for salvage. The actual replacement values may be slightly less than the target due to soil loss that may occur during salvage activities. Access roads developed on mineral soils will have surface LFH/peat and surface mineral soil salvaged only.

Table B5.6-1 Surface Soil and Subsoil Available for Salvage and Replacement

Topsoil Volume Available (m^3)	Topsoil Volume Replacement Target (m^3)	Peat Volume Available (m^3)	Peat Material Replacement Target (m^3)	Subsoil Volume Available (m^3)	Subsoil Volume Replacement Target (m^3)
137,030	137,030	47,200	47,200	170,400	170,400

Underground pipeline construction has direct replacement of salvaged soil at the end of construction and powerlines and above-ground pipelines have minimal soil disturbance; therefore these areas are not included in the material balance volumes.

B6 LITERATURE CITED

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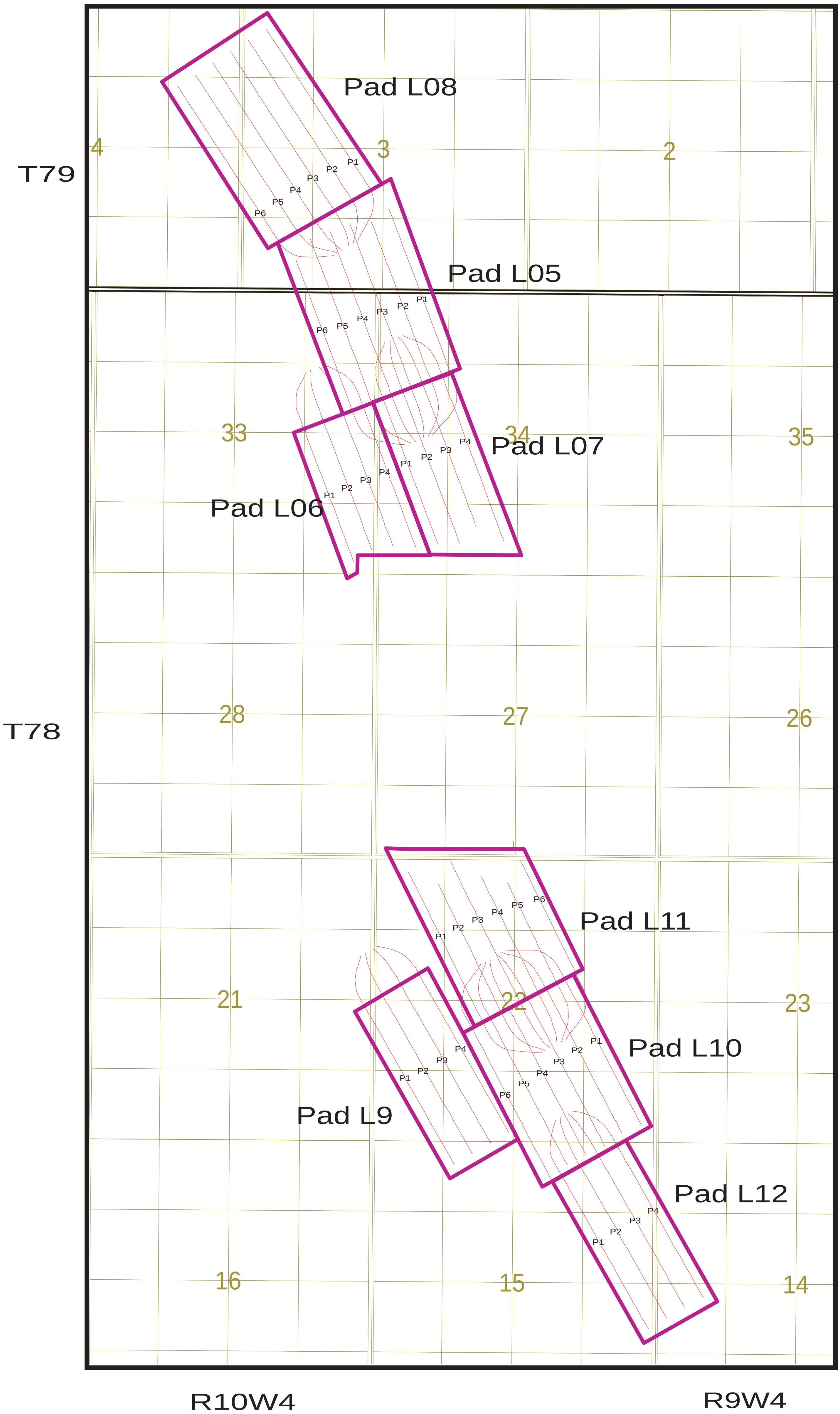
B7 LEISMER EXPANSION HUB HORIZONTAL PRODUCER WELL PLOTS

The following figures present individual plots for each horizontal producer well in the Leismer Expansion Hub development area with a depth converted 3D seismic profile and key horizons.



Pad Outlines

Horizontal Well Pair Seismic Profile Locations

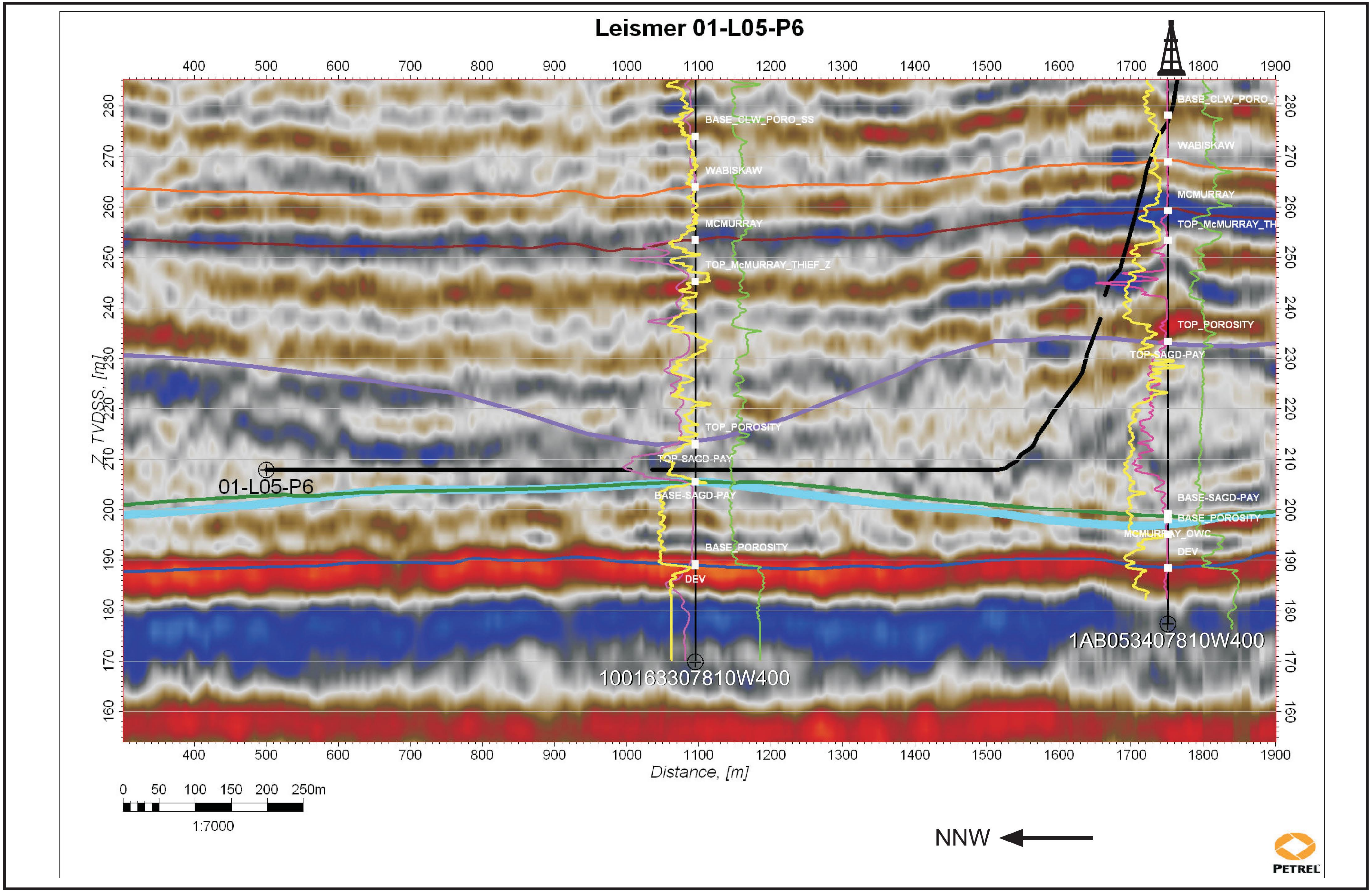
NORTH AMERICAN OIL SANDS CORPORATION

Seismic Profile Base Map

Author: Andy Williams , P. GEOPH	CUTOFF:	Date: 19 July, 2007

Pad #: L5

Producer Well: P6



LEGEND

HORIZONS

- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LOG CURVE LEGEND

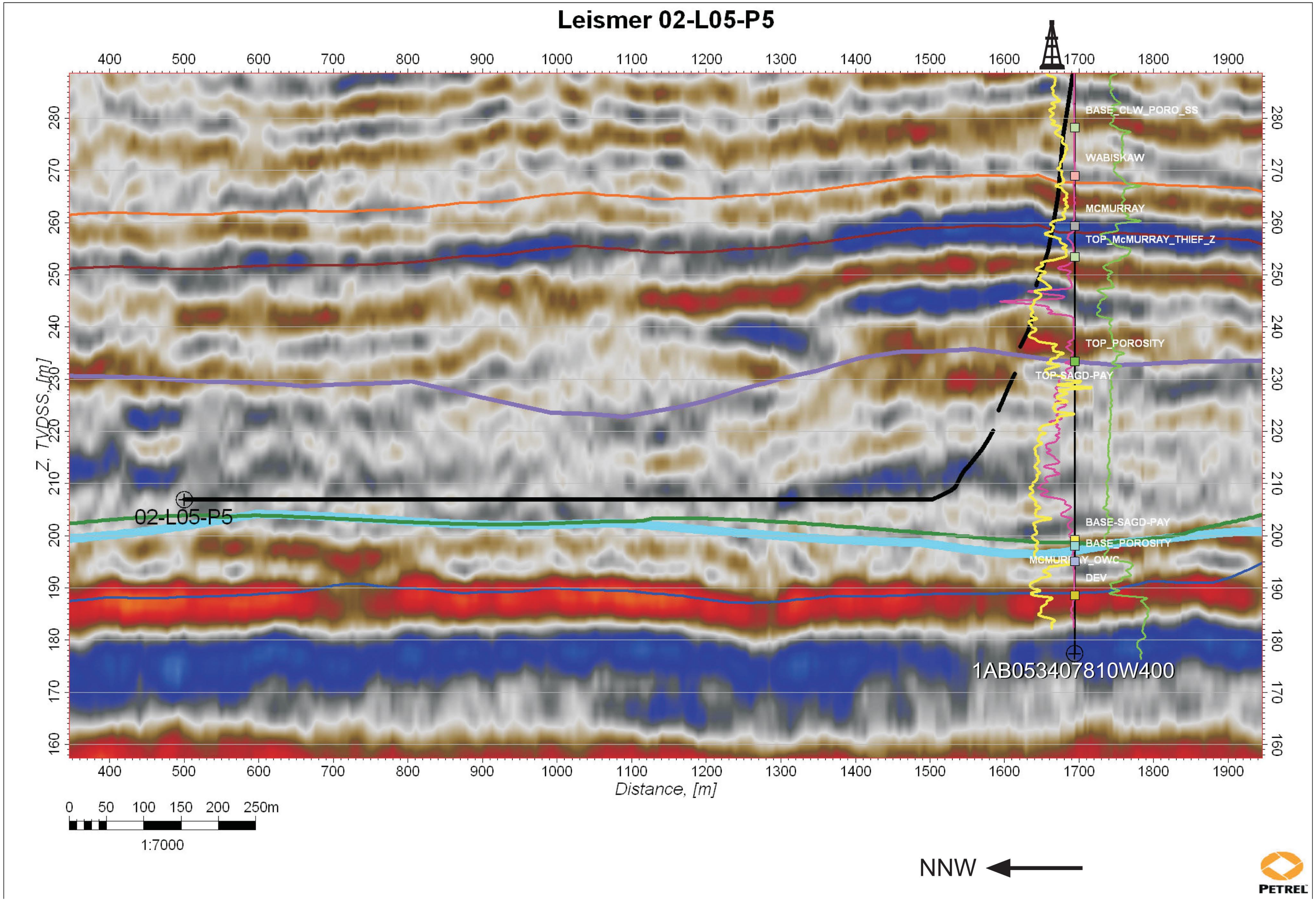
- GR
- RES - D
- RHOB

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L5

Producer Well: P5



LEGEND

HORIZONS

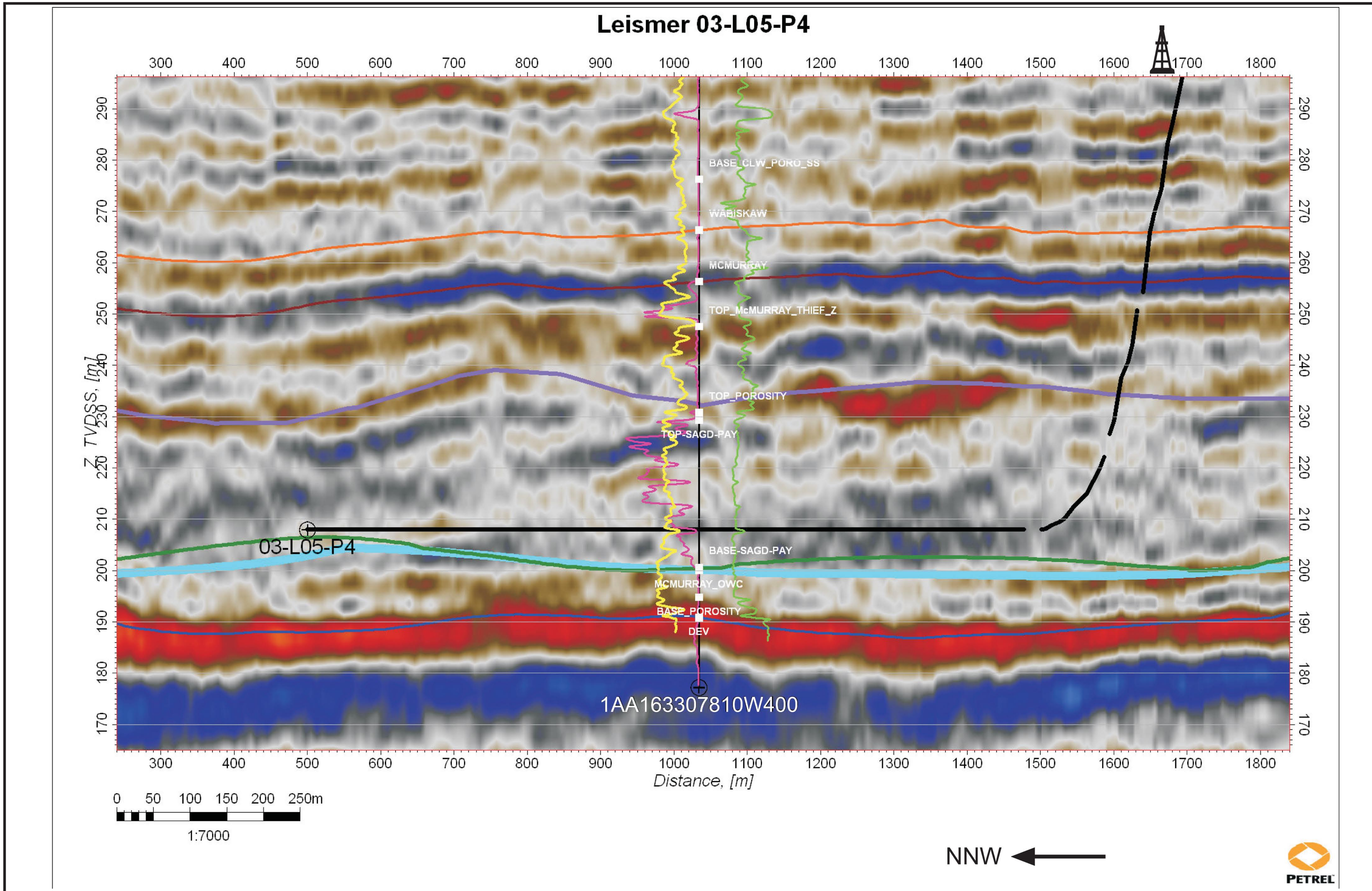
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L5

Producer Well: P4



LEGEND

HORIZONS

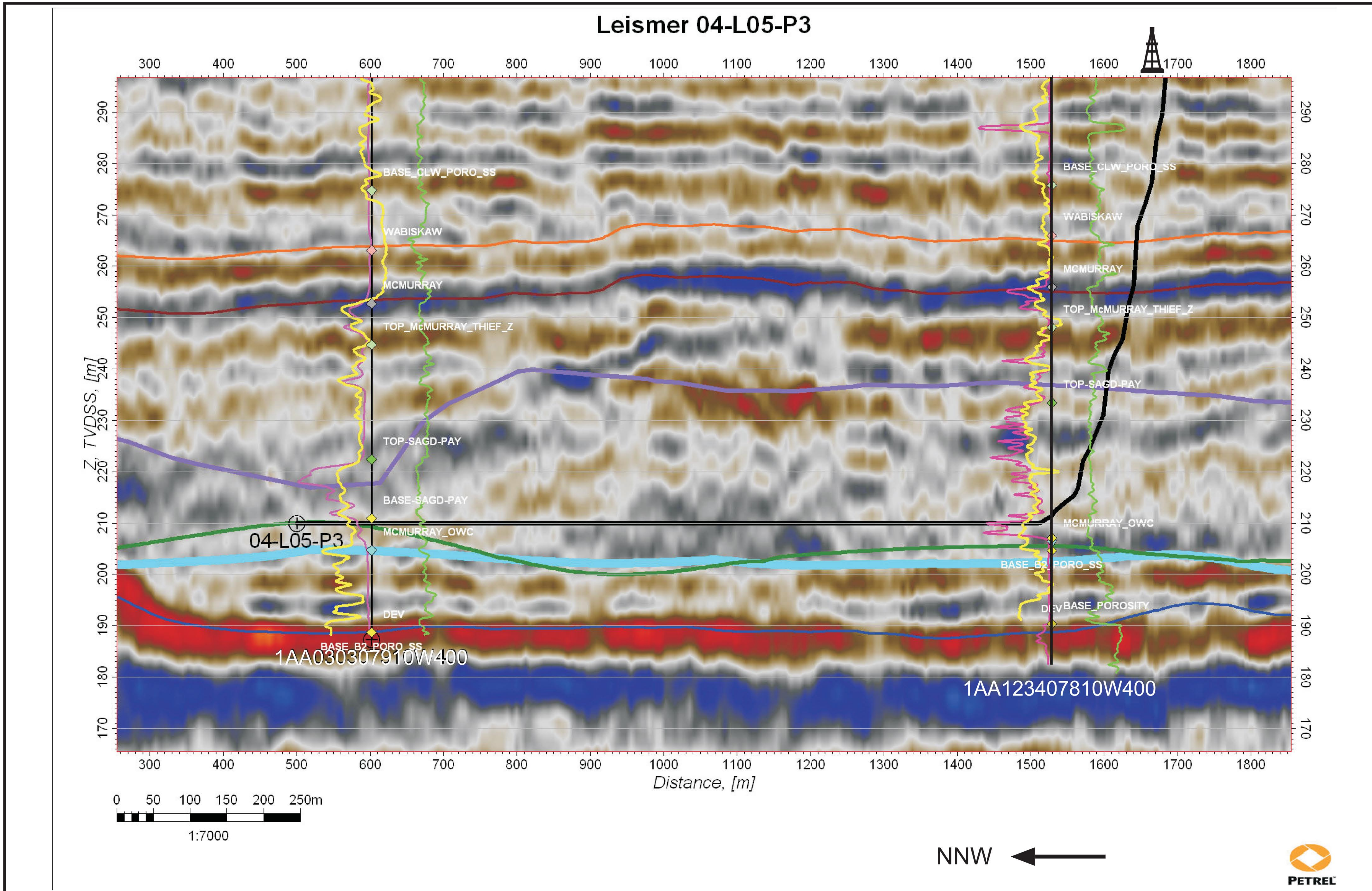
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L5

Producer Well: P3



LEGEND

HORIZONS

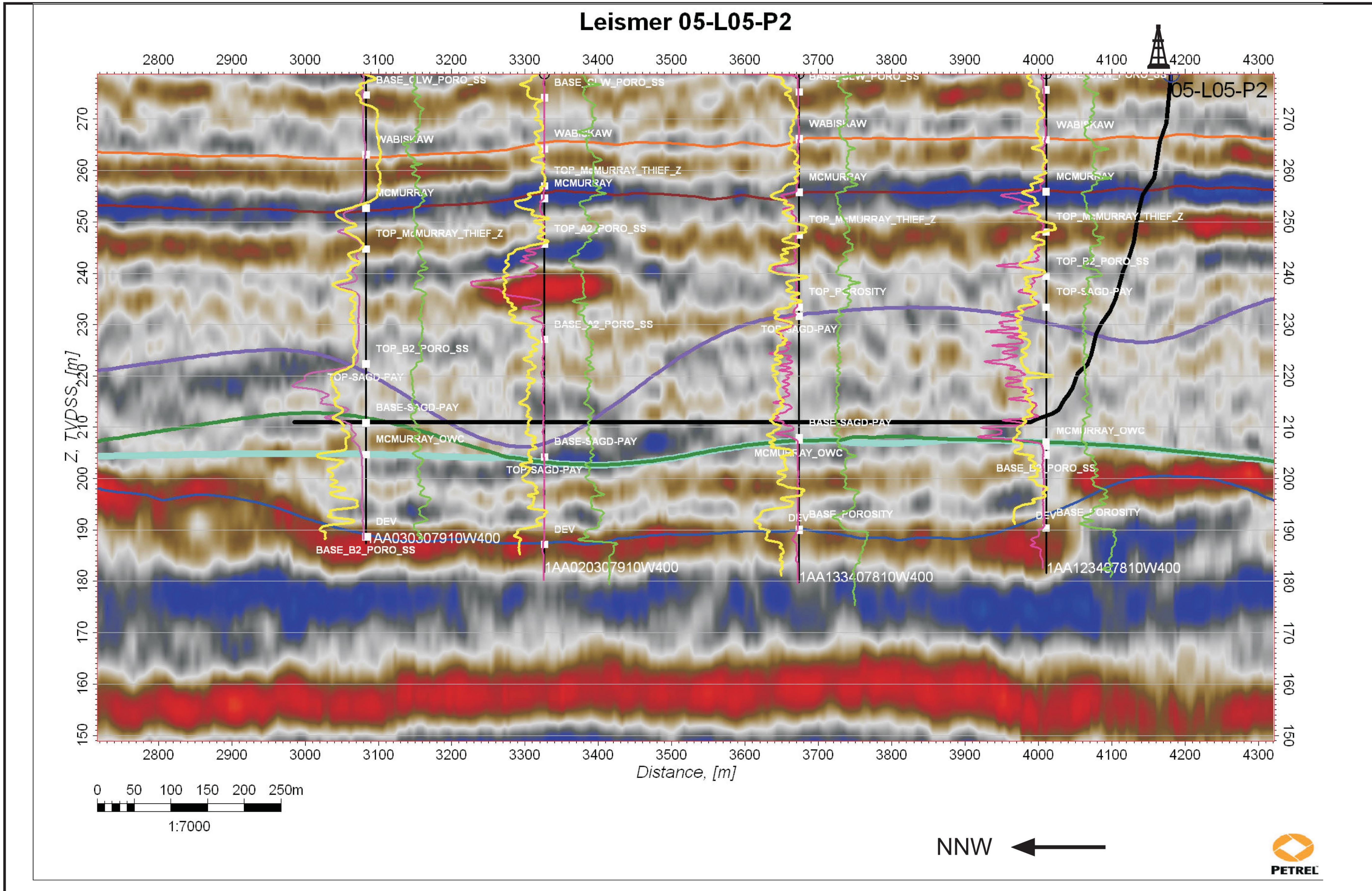
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L5

Producer Well: P2



LEGEND

HORIZONS

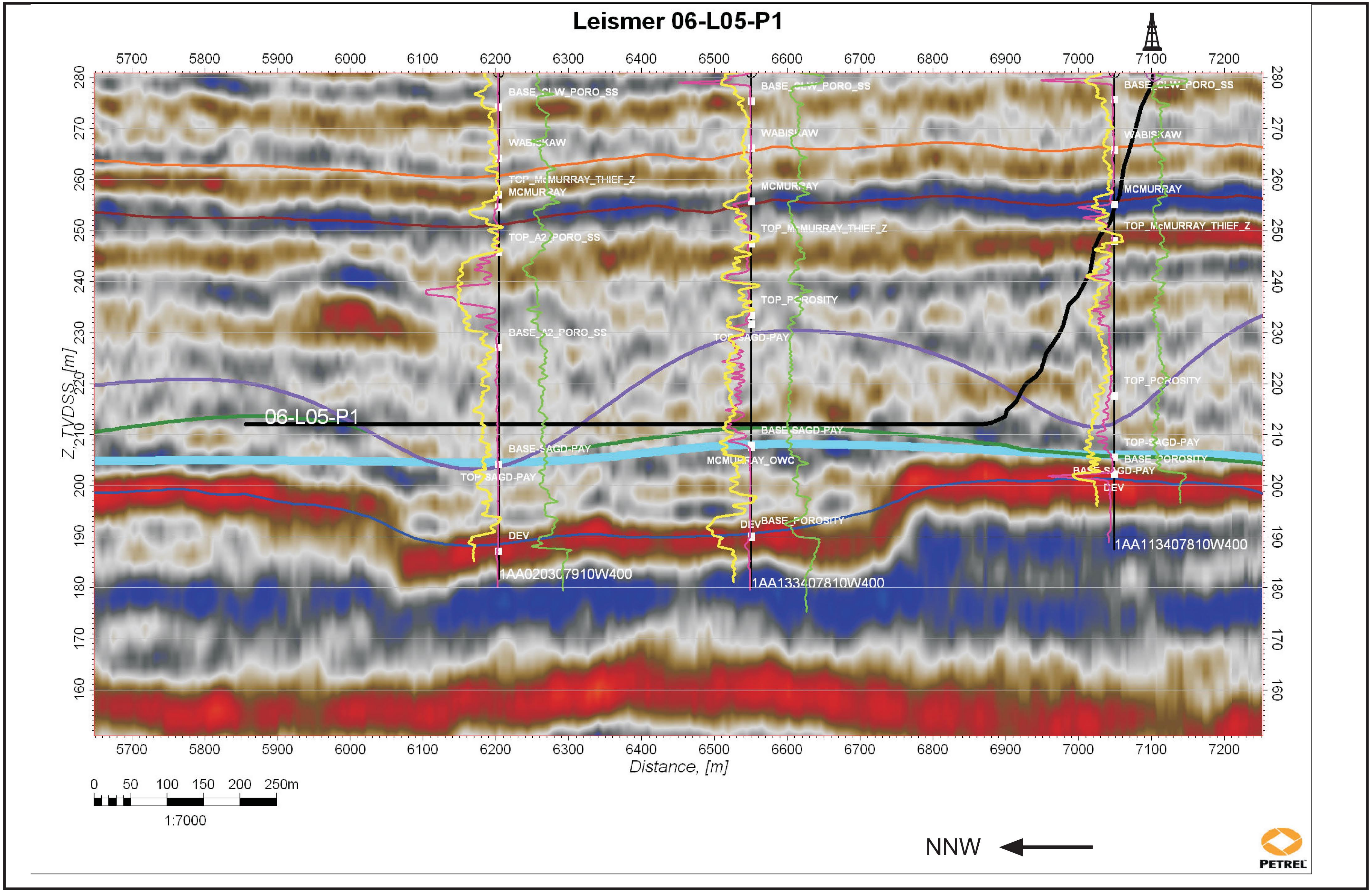
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L5

Producer Well: P1



LEGEND

HORIZONS

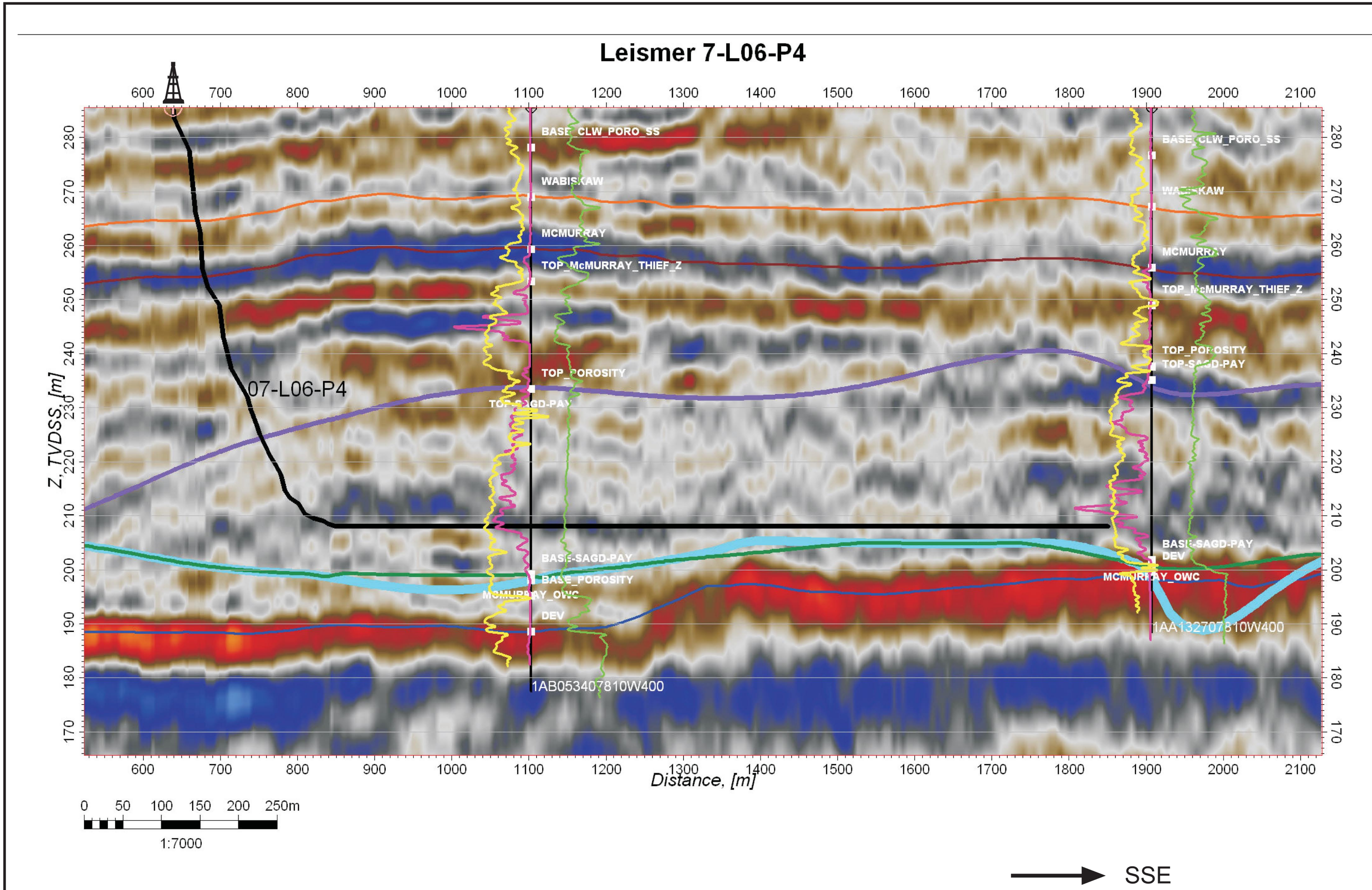
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L6

Producer Well: P4



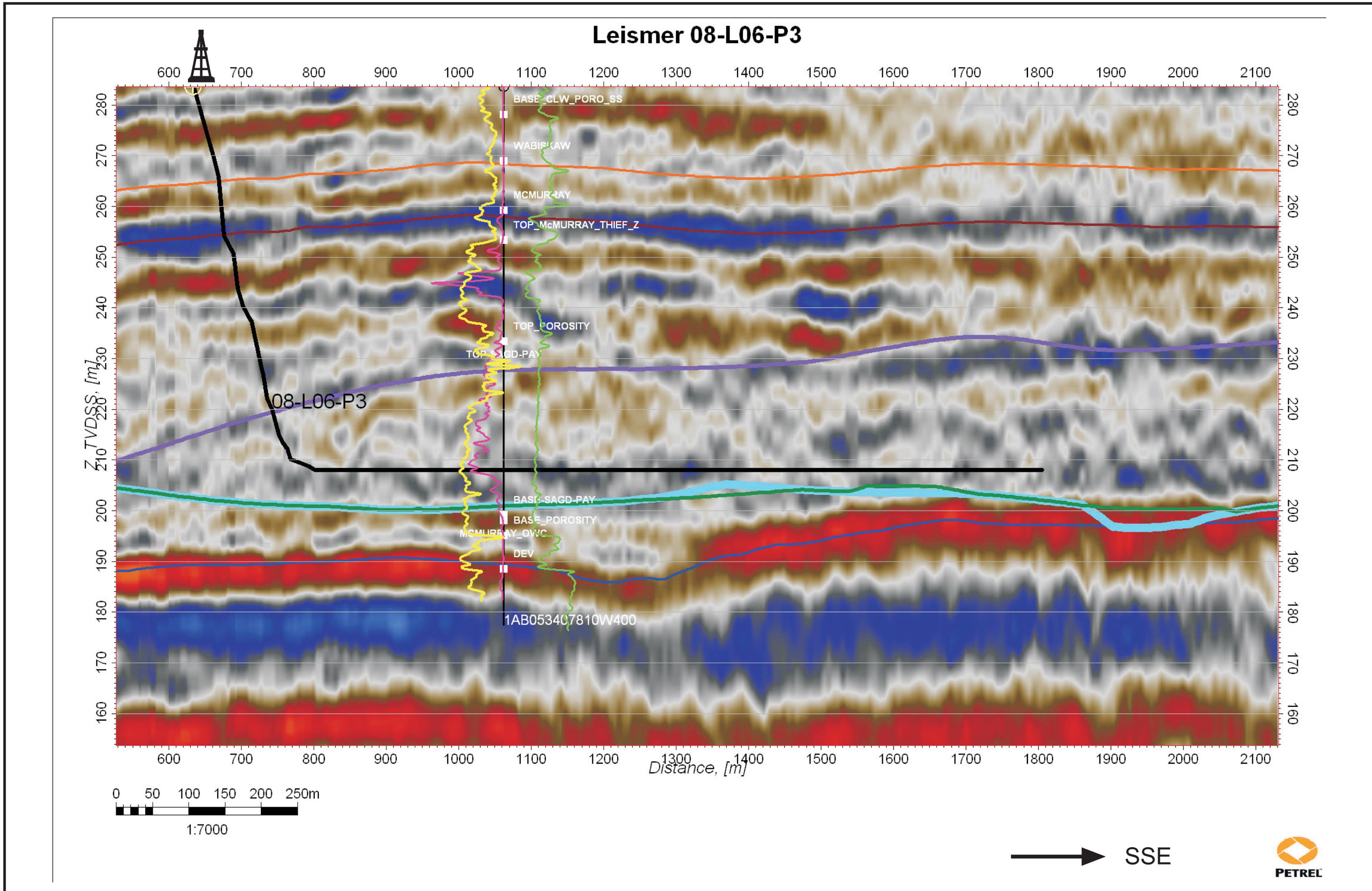
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L6

Producer Well: P3



LEGEND

HORIZONS

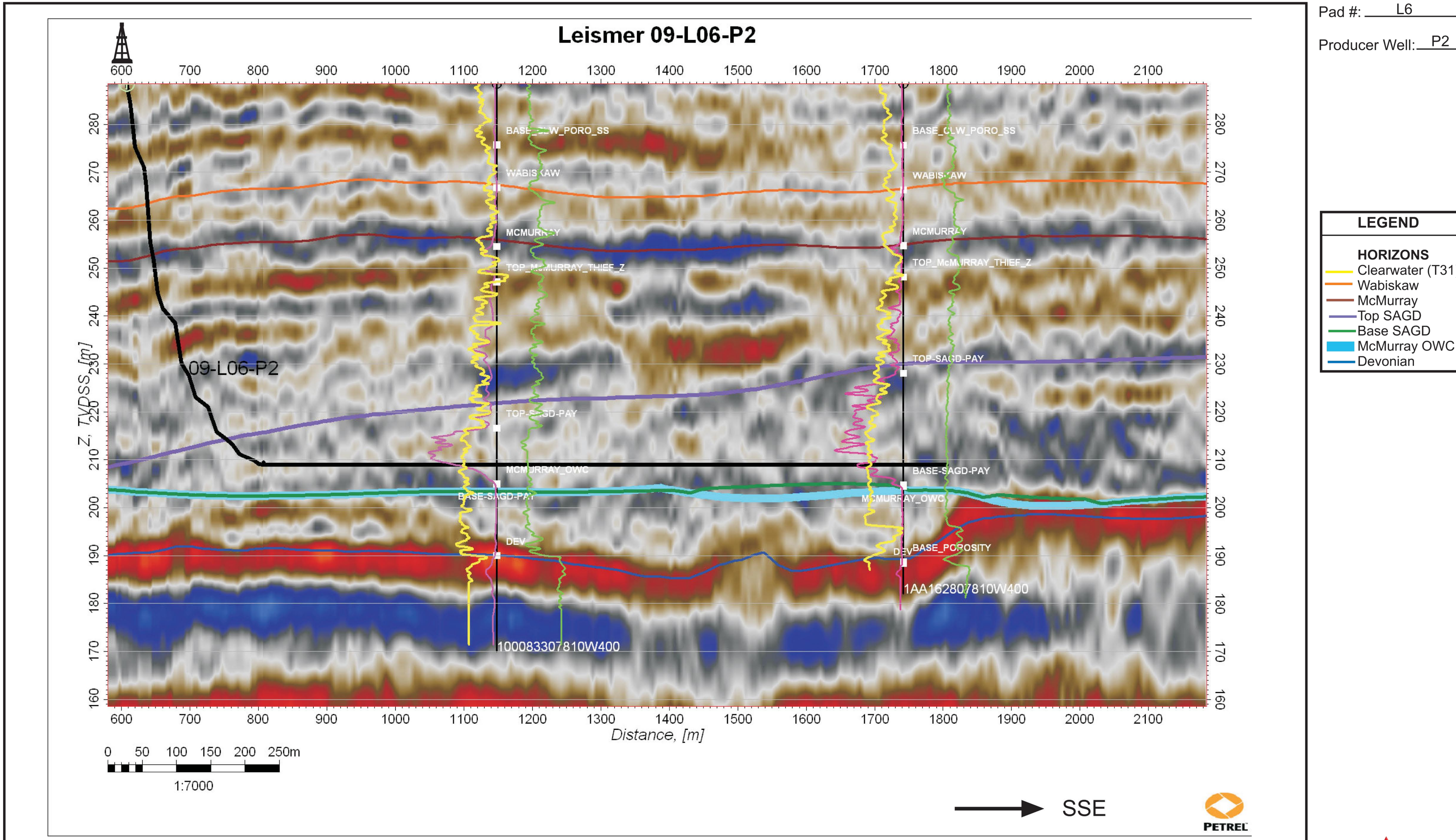
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L6

Producer Well: P2

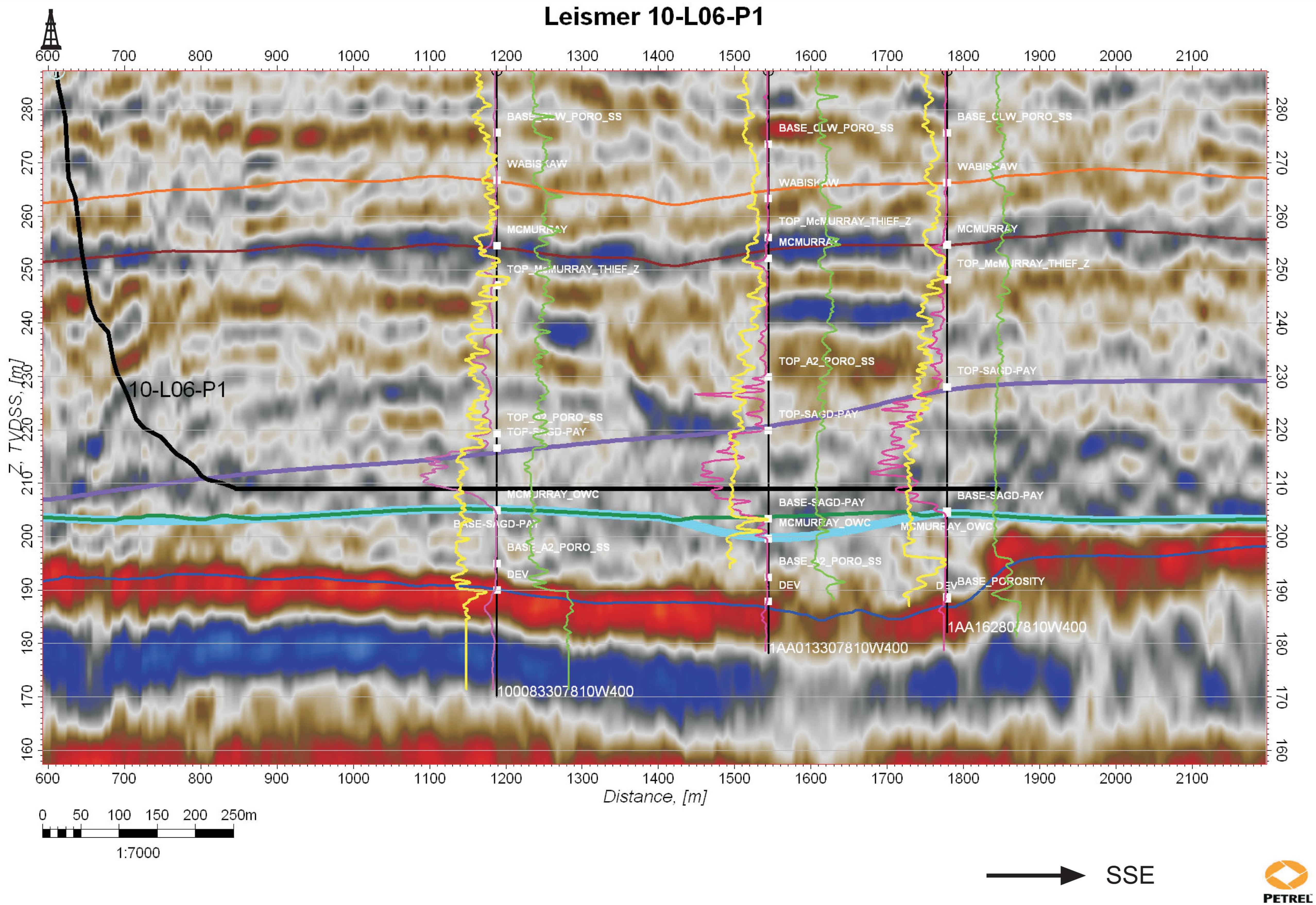


LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L6

Producer Well: P1



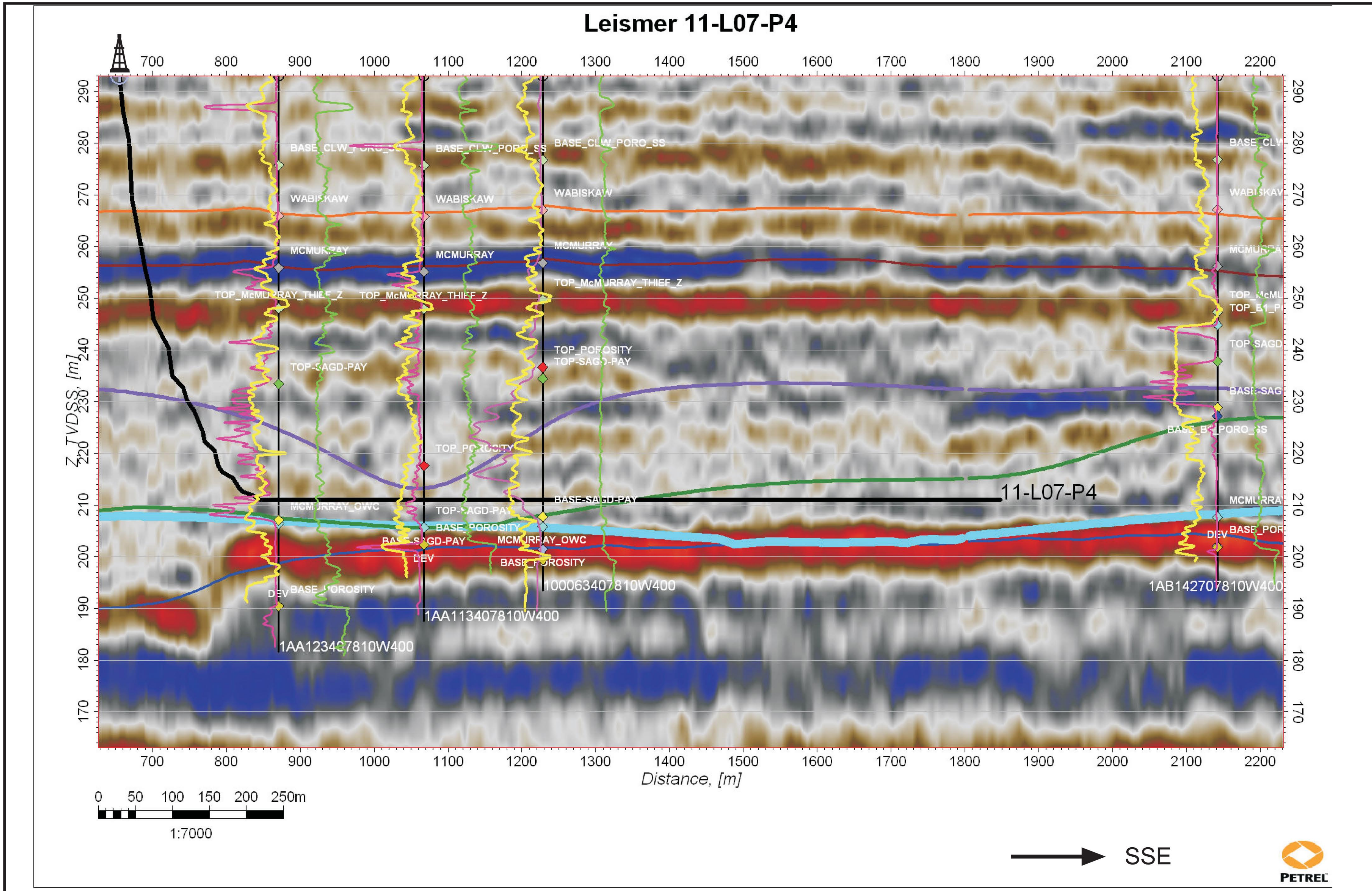
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L7

Producer Well: P4



LEGEND

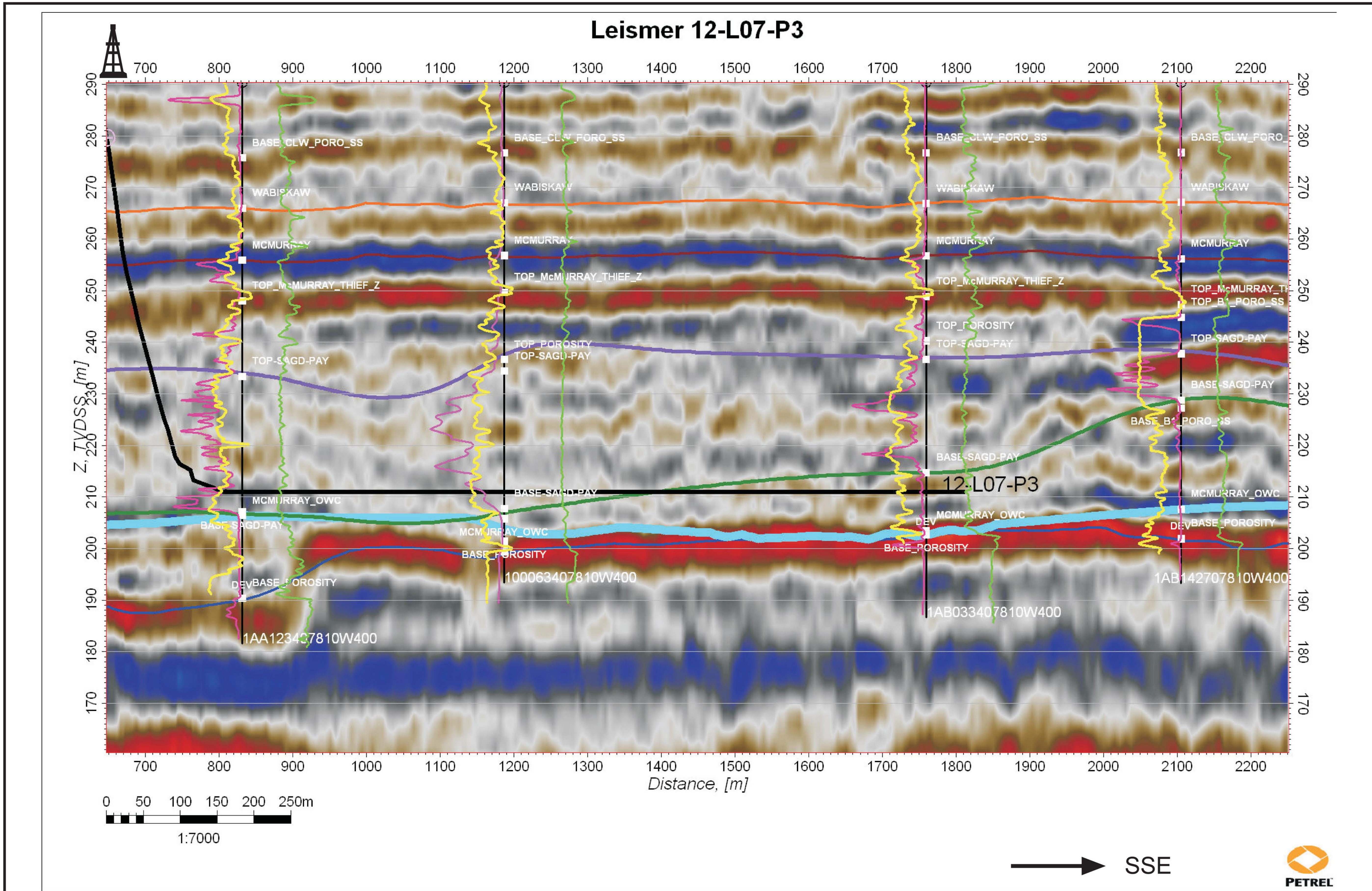
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L7

Producer Well: P3



LEGEND

HORIZONS

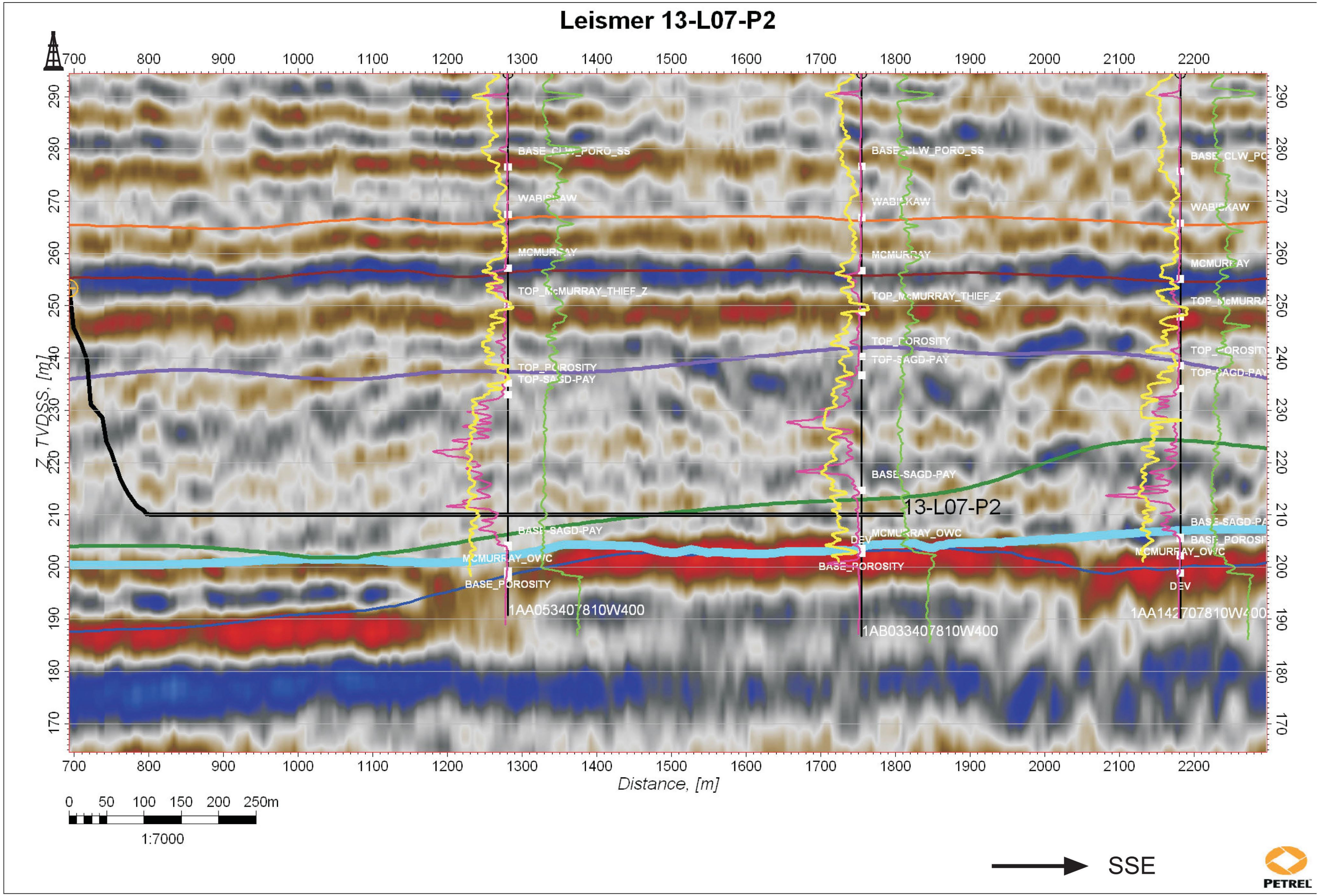
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L7

Producer Well: P2



LEGEND

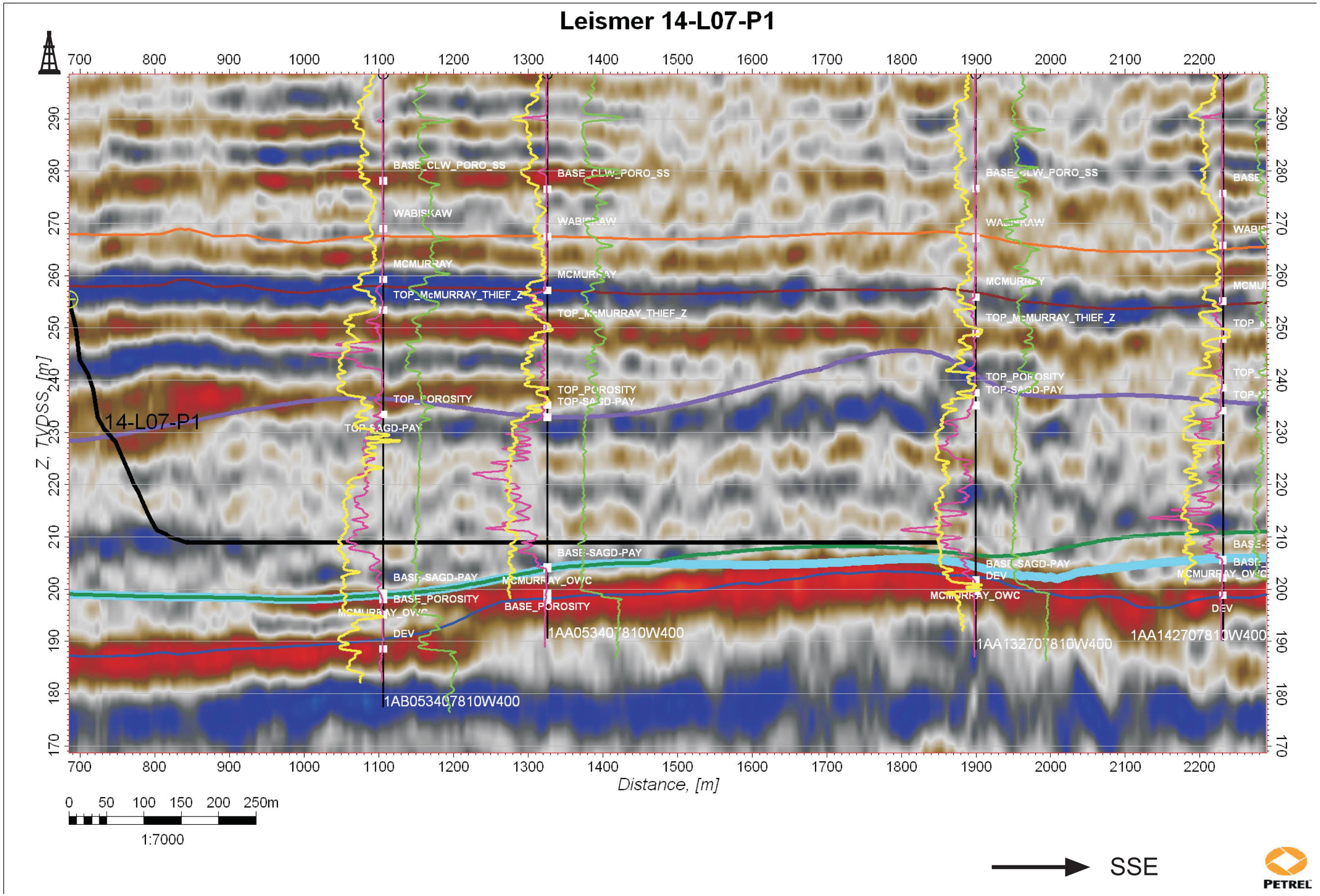
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L7

Producer Well: P1



LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

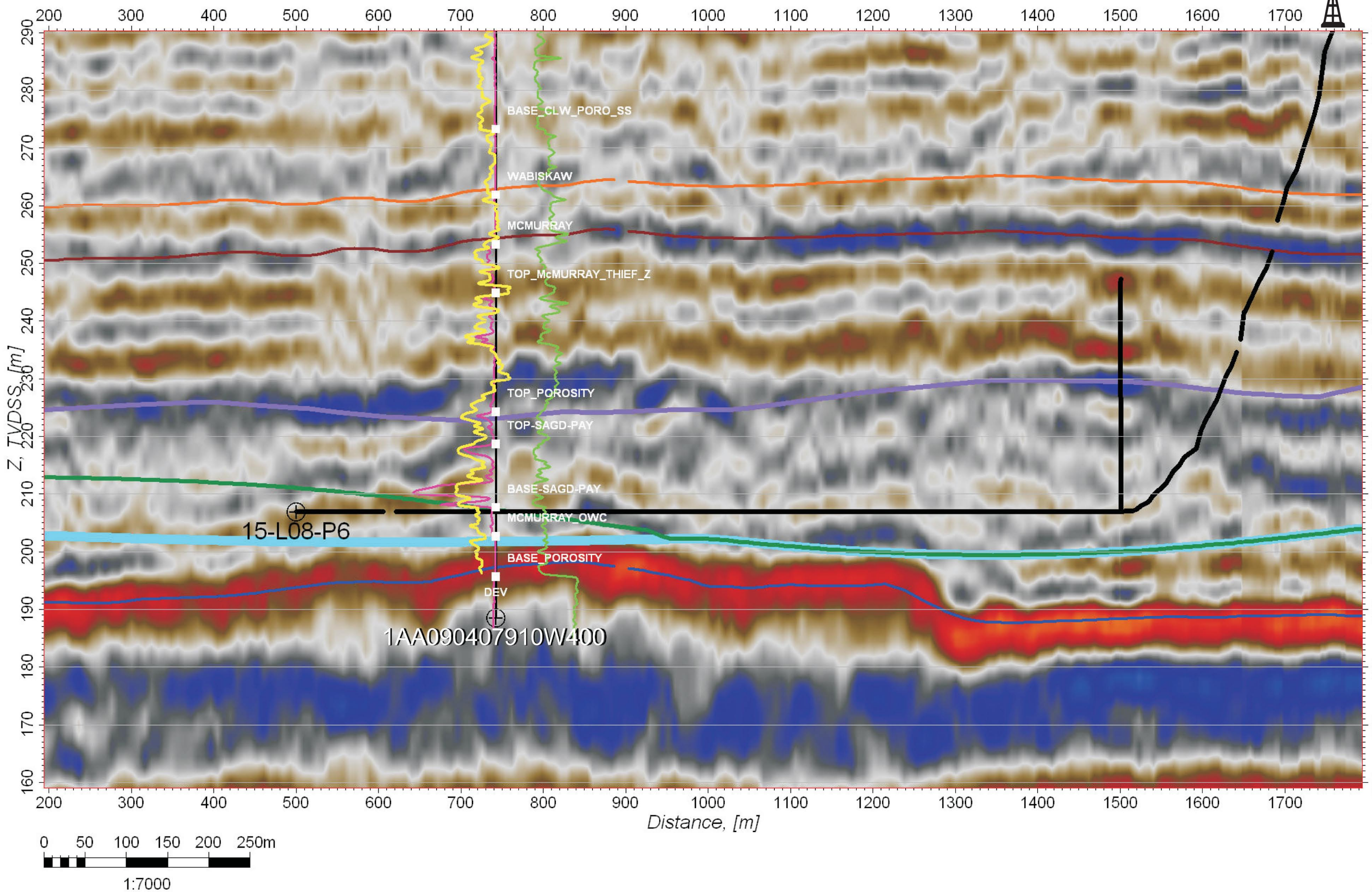
LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L8

Producer Well: P6

Leismer 15-L08-P6

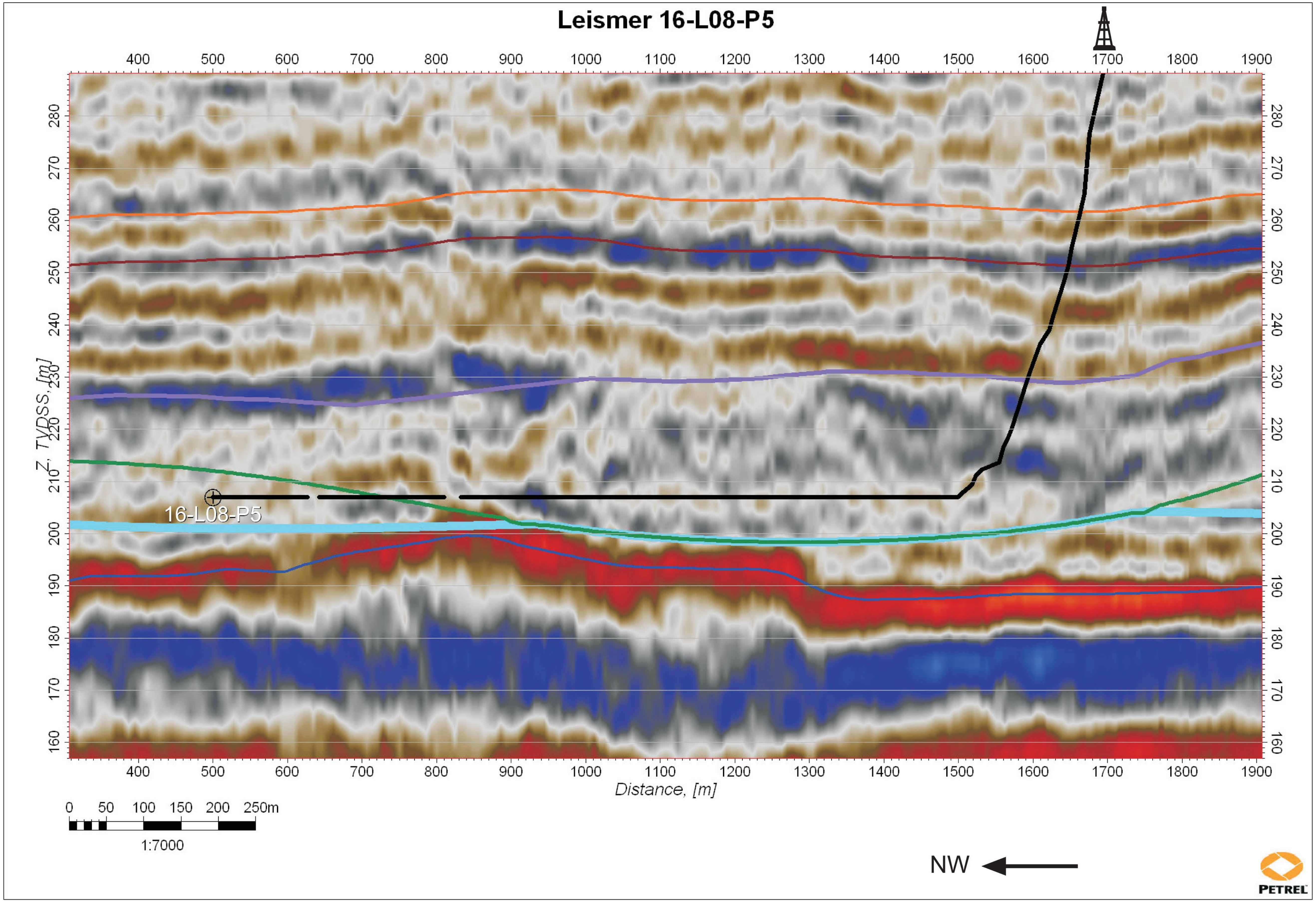


LEGEND

HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION



Pad #: L8

Producer Well: P5

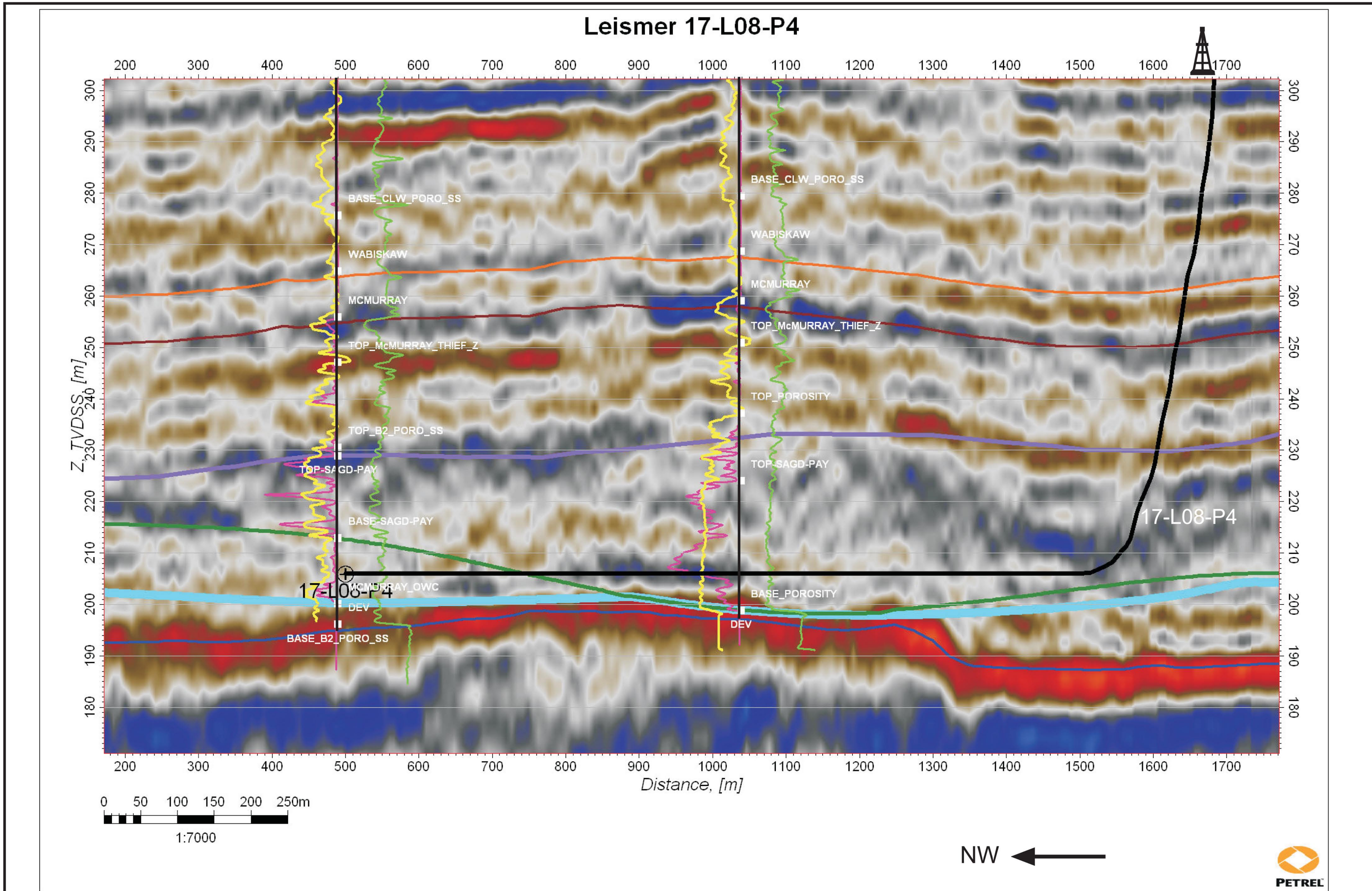
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L8

Producer Well: P4



LEGEND

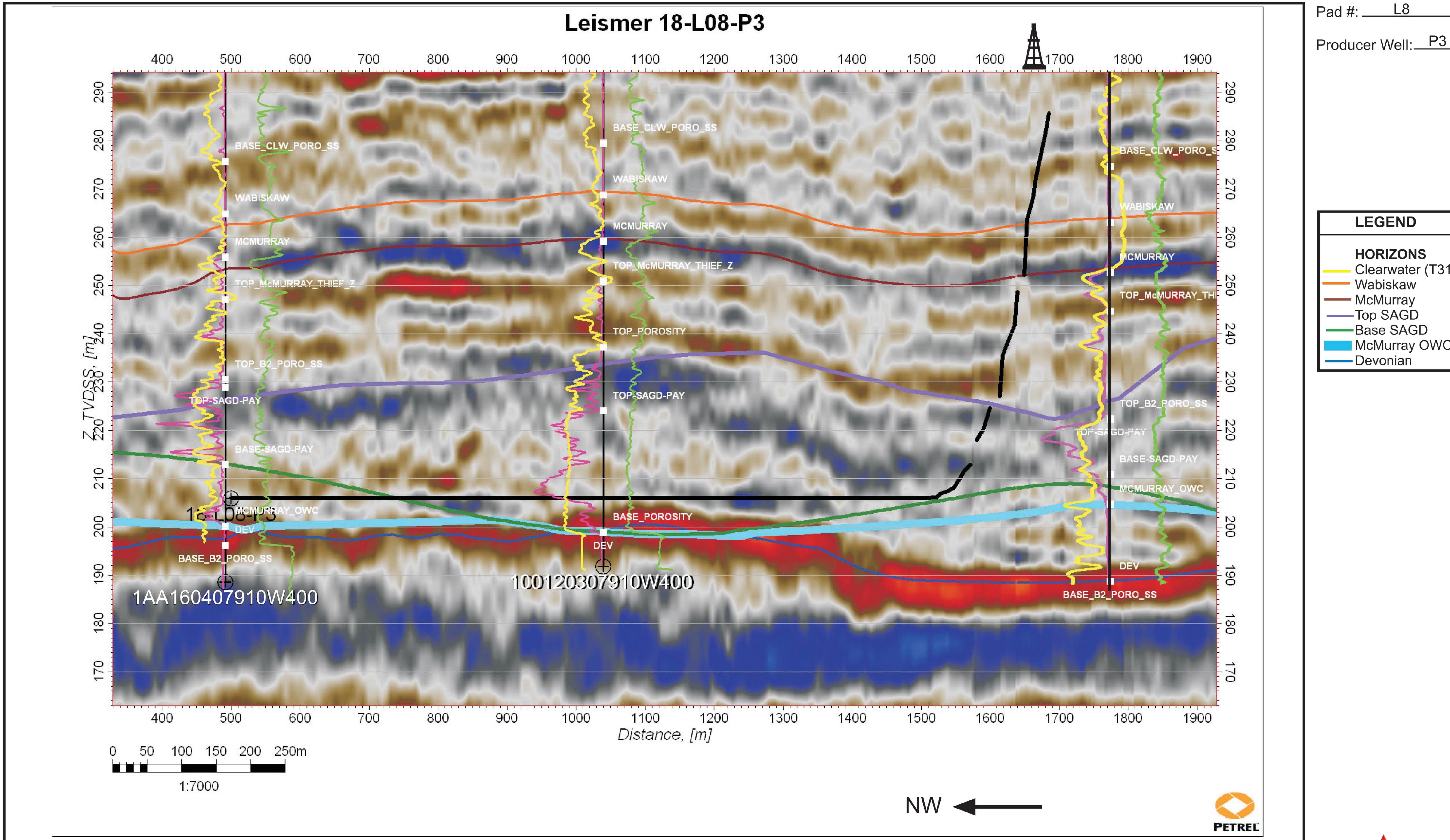
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L8

Producer Well: P3

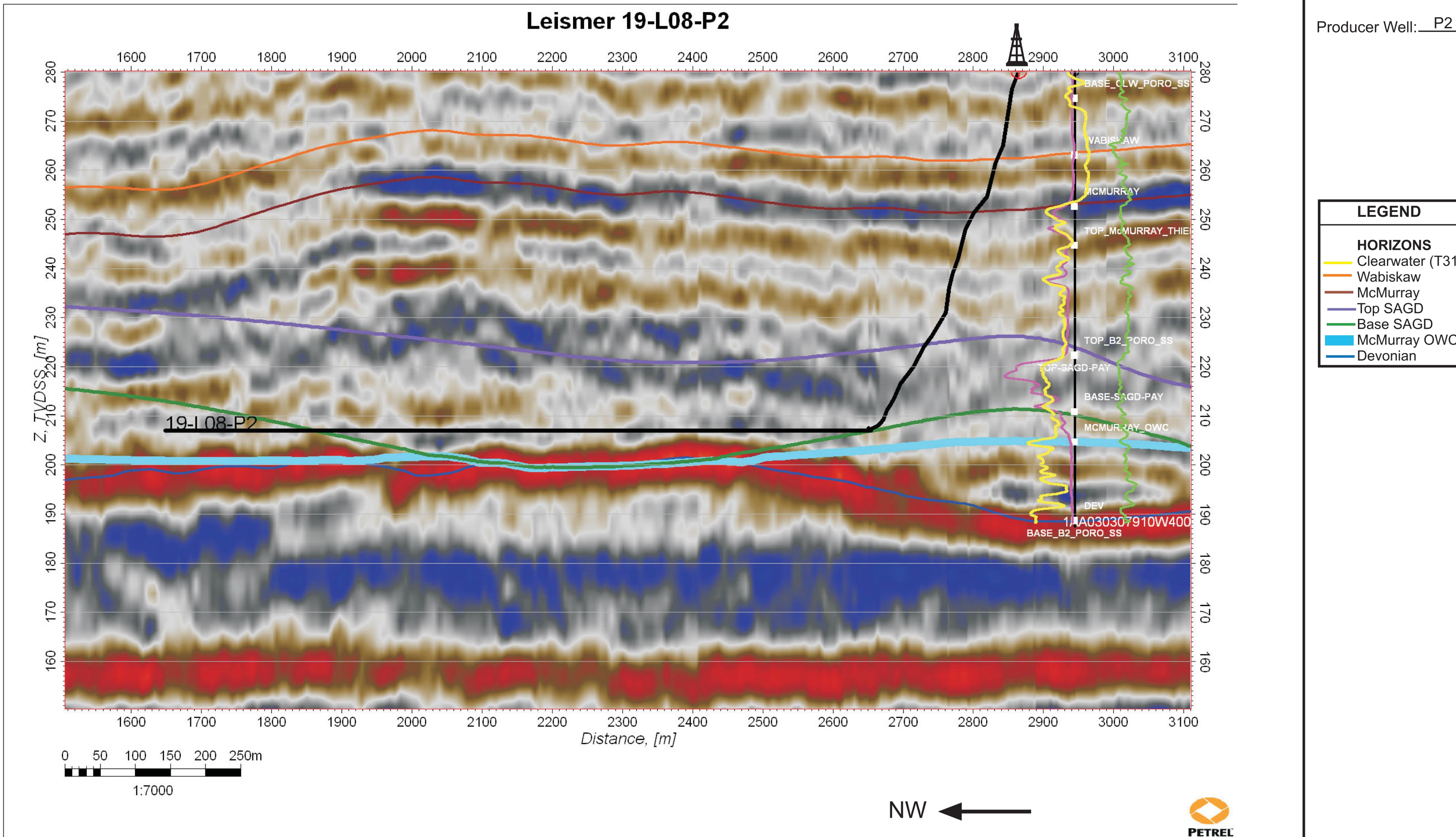


LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L8

Producer Well: P2

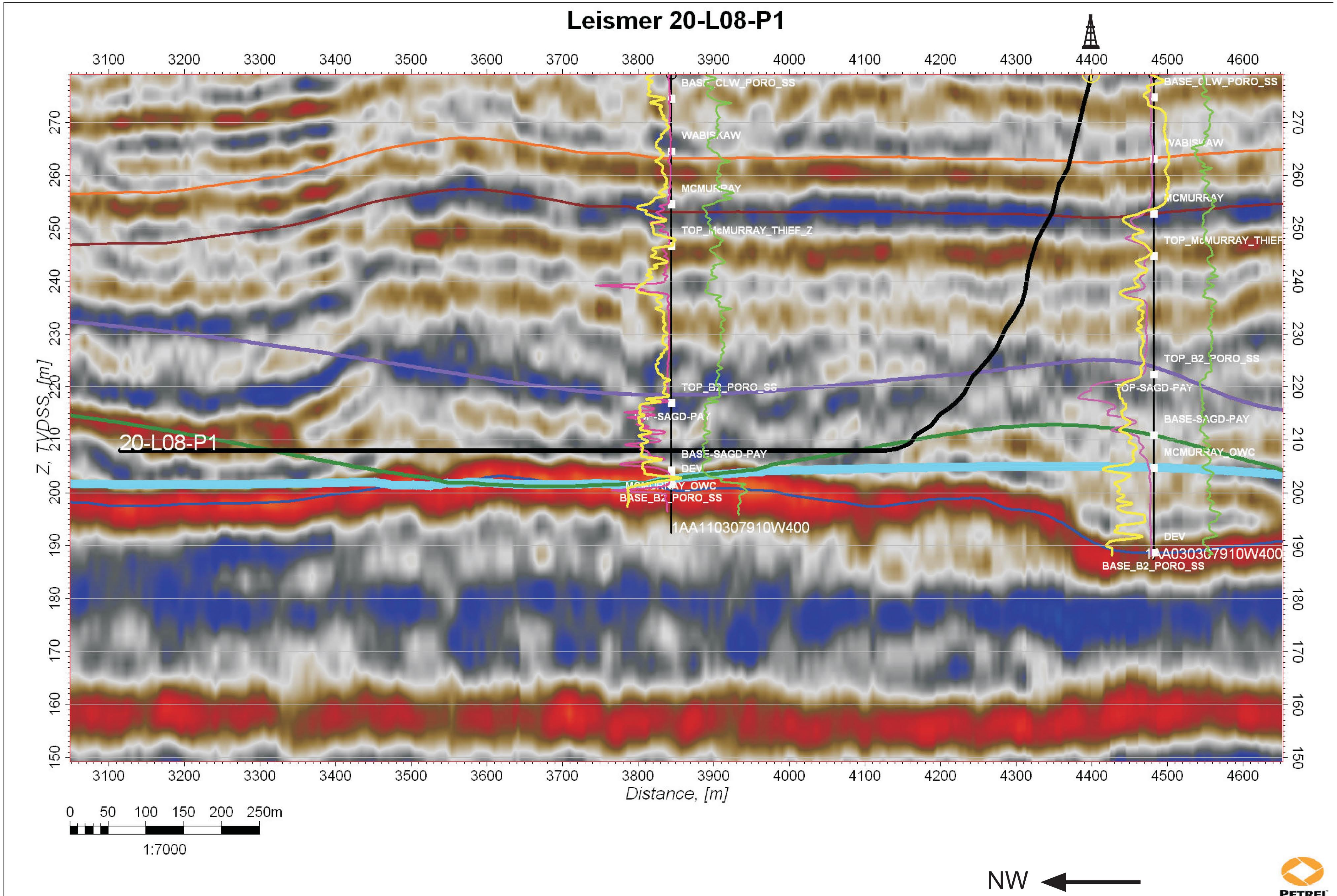


LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L8

Producer Well: P1



LEGEND

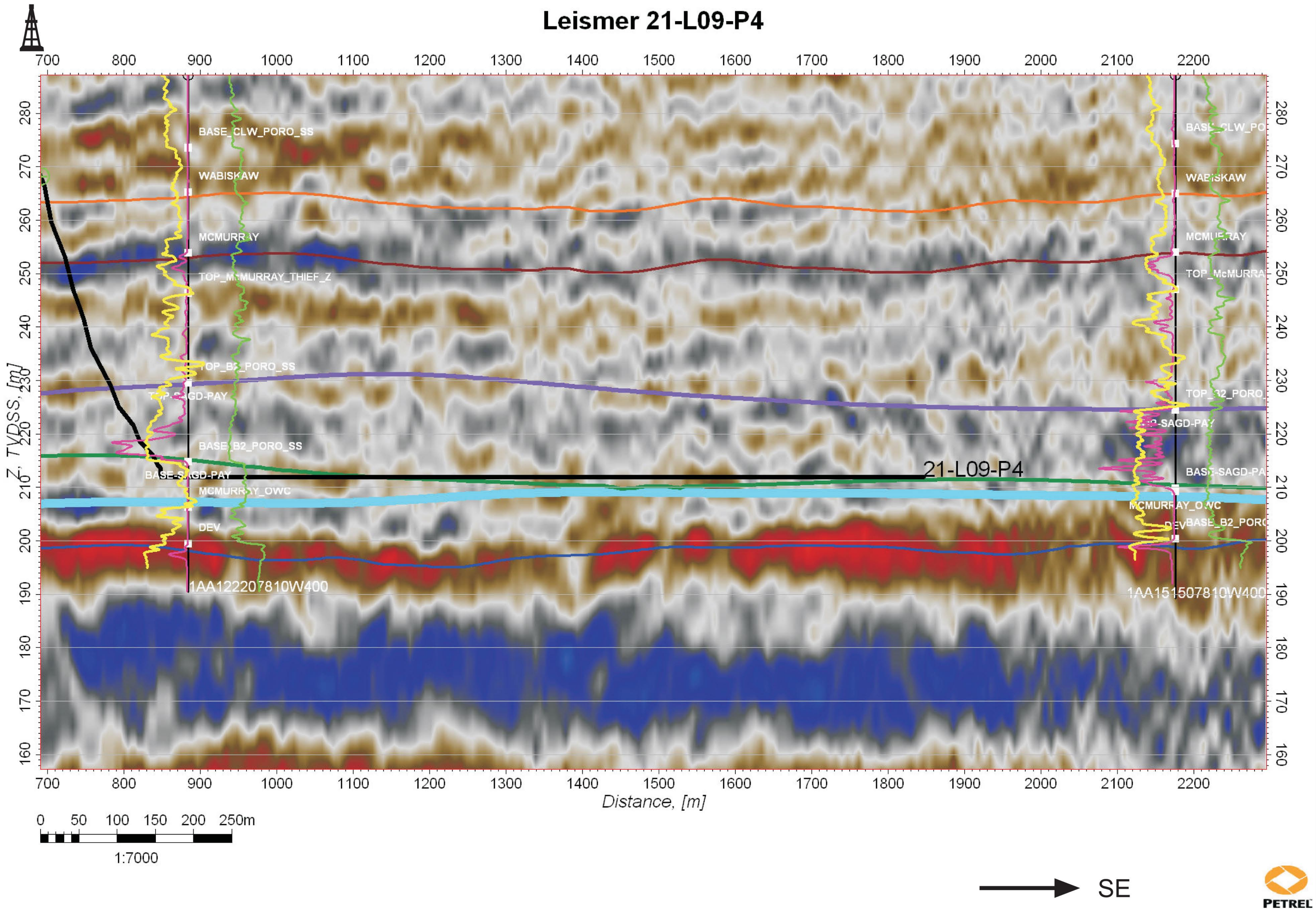
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L9

Producer Well: P4



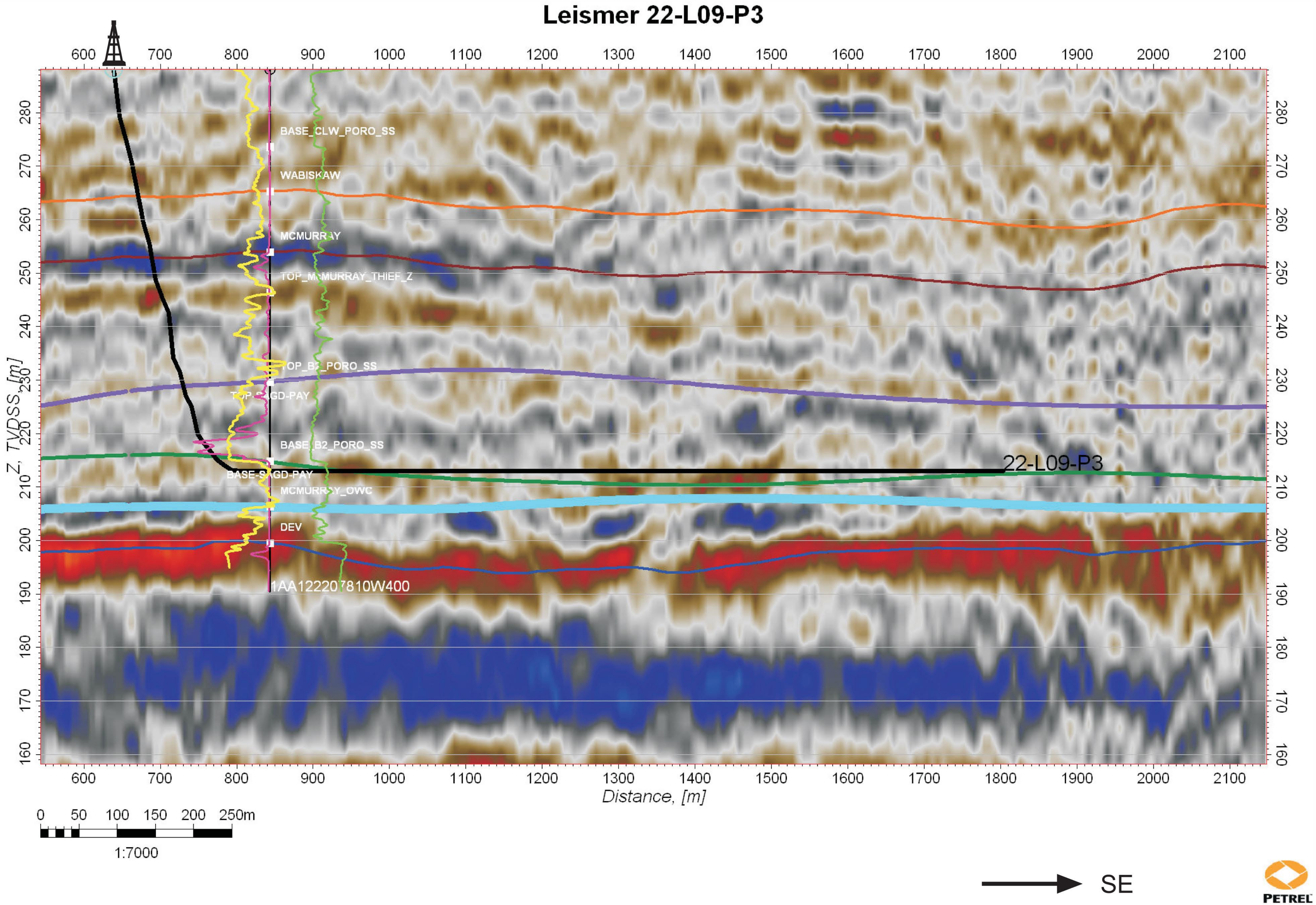
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L9

Producer Well: P3



LEGEND

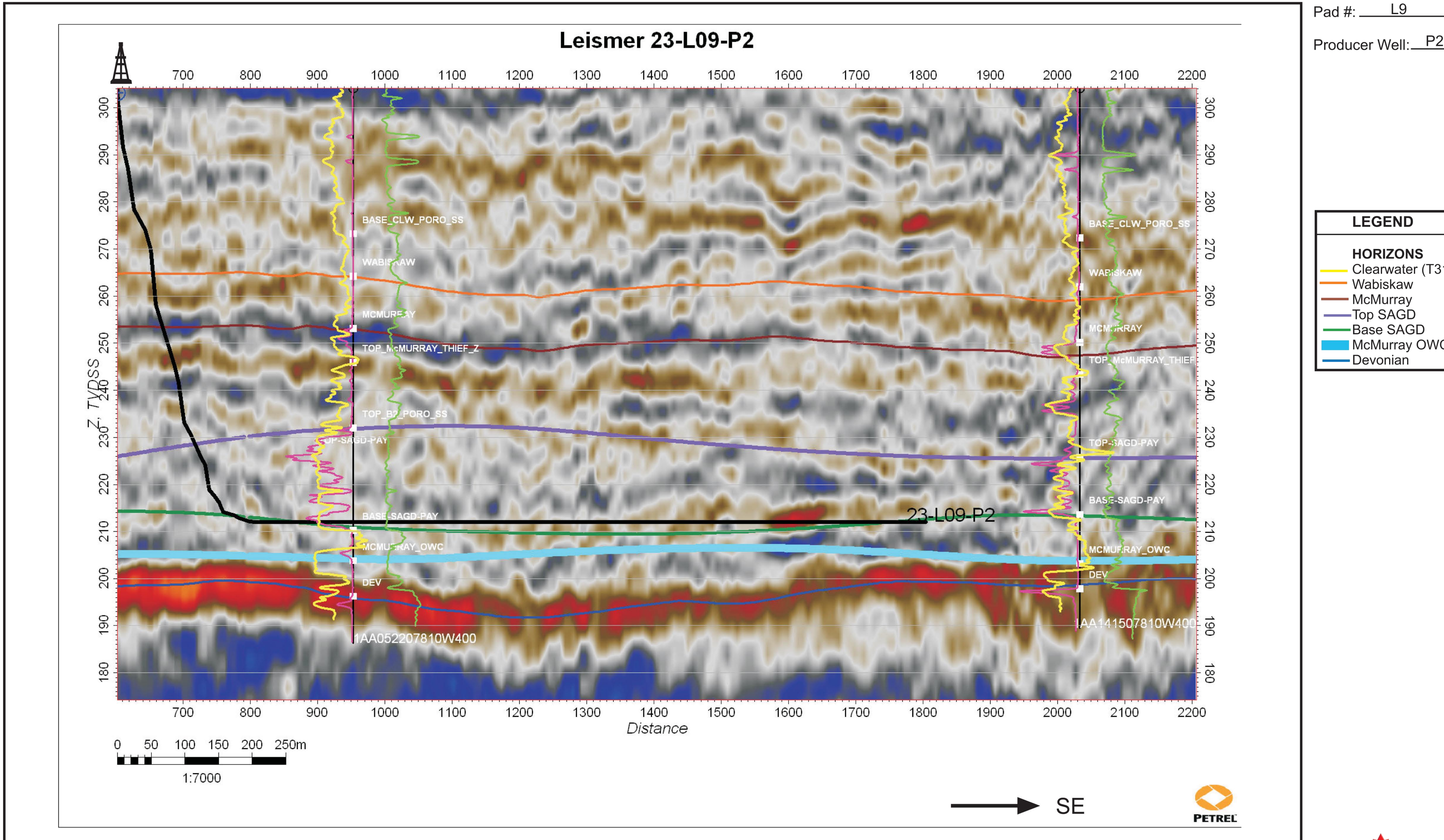
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L9

Producer Well: P2

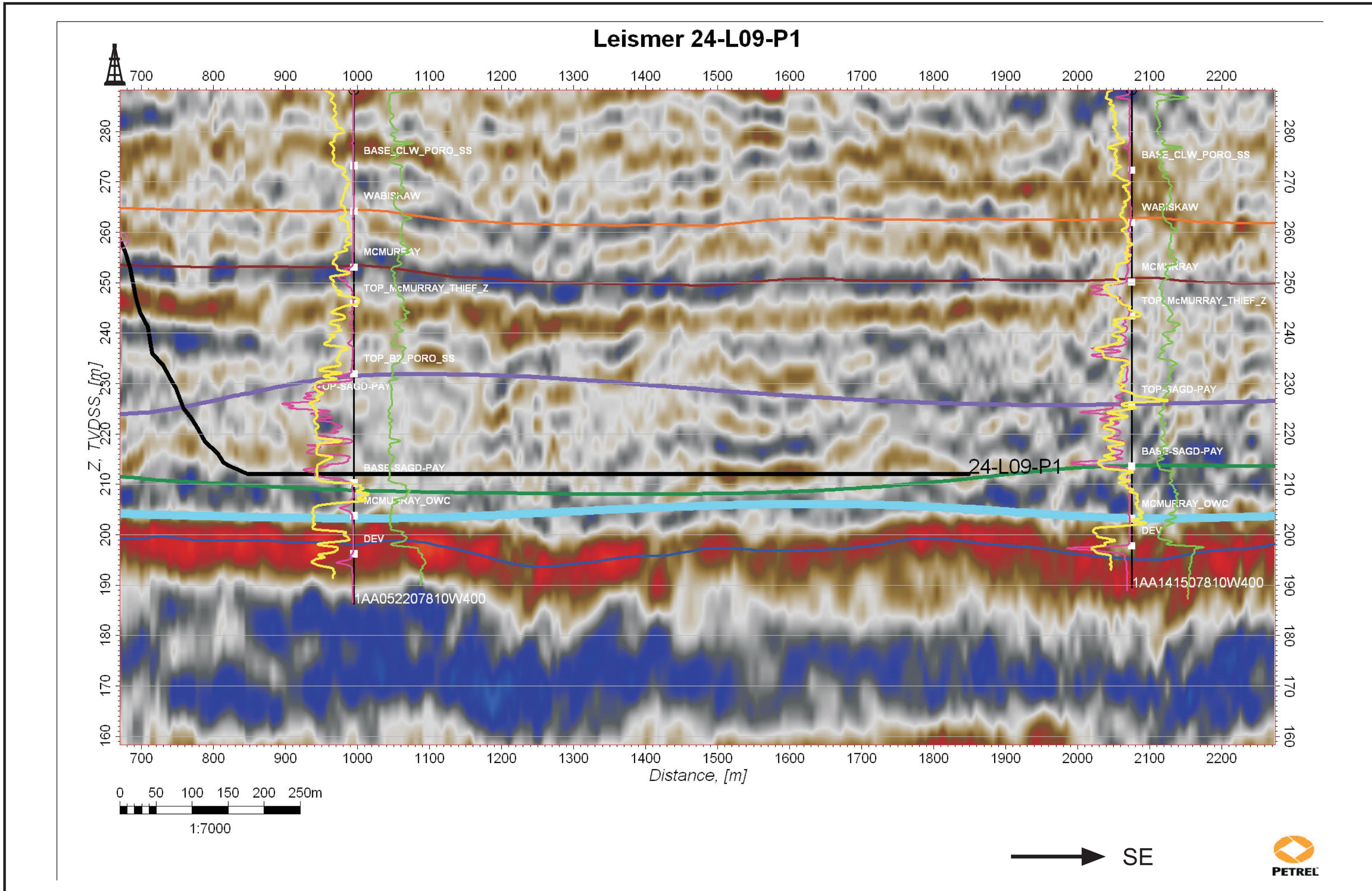


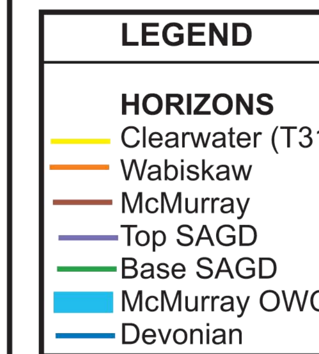
LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L9

Producer Well: P1



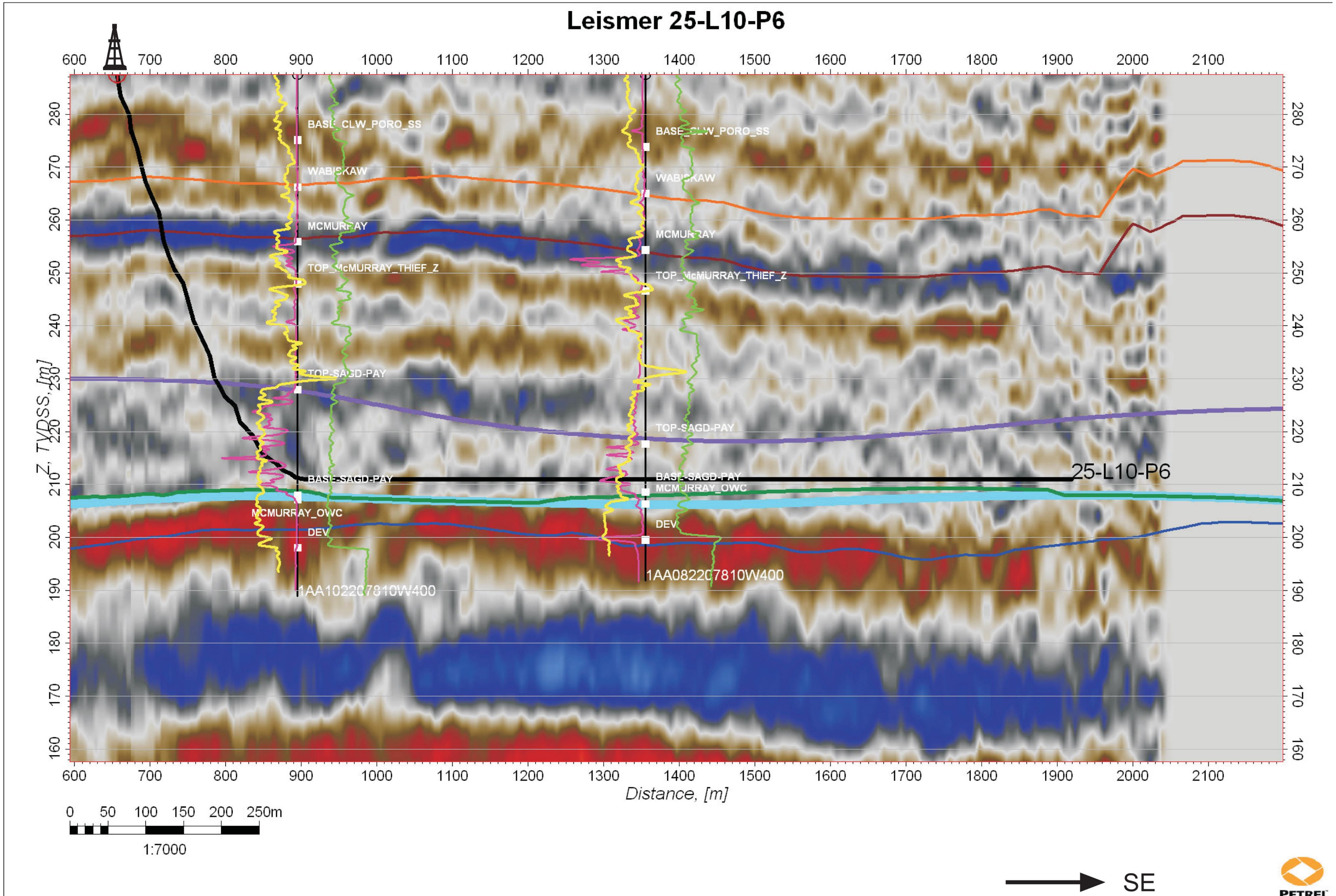


LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L10

Producer Well: P6



LEGEND

HORIZONS

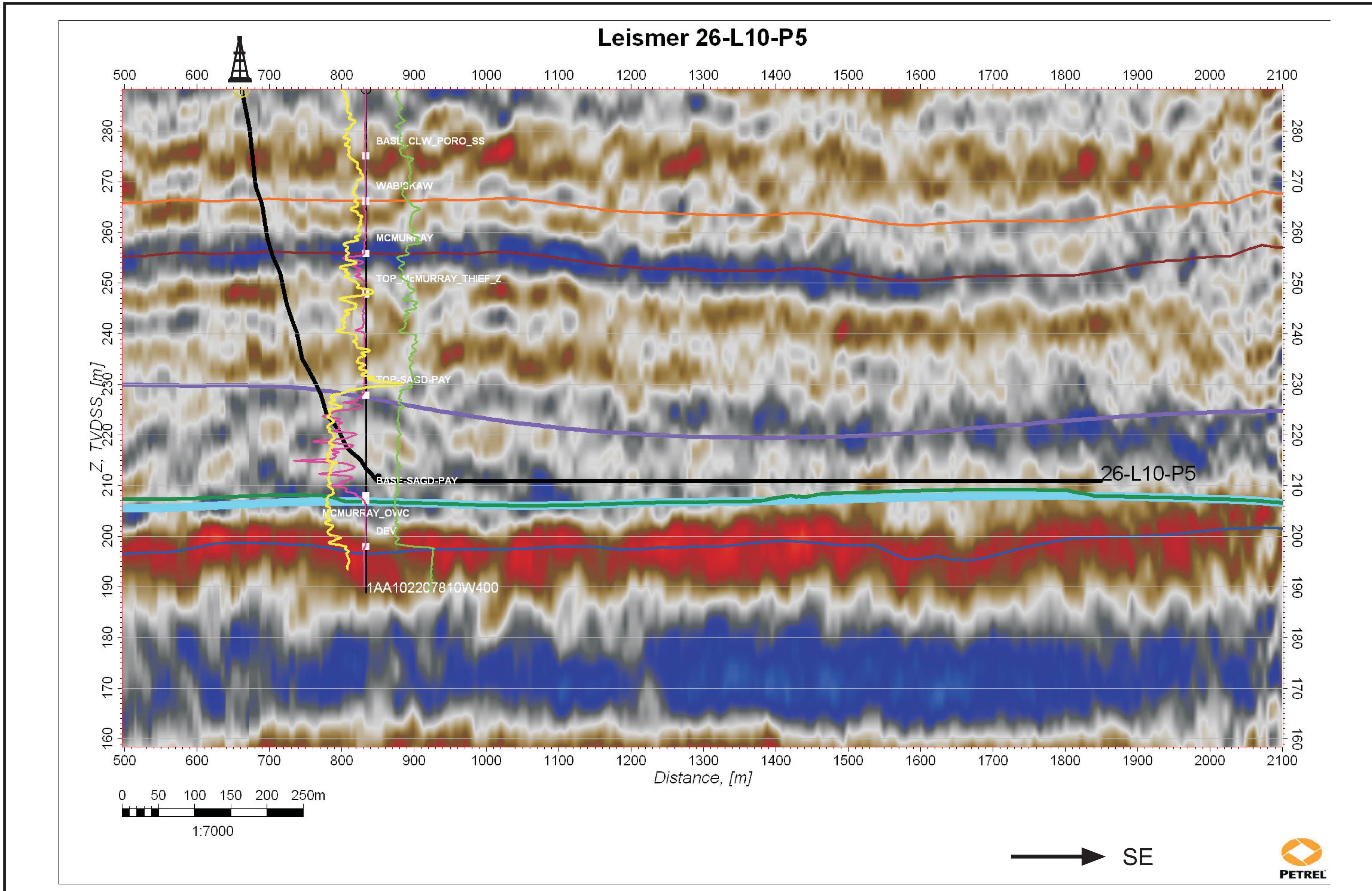
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L10

Producer Well: P5



LEGEND

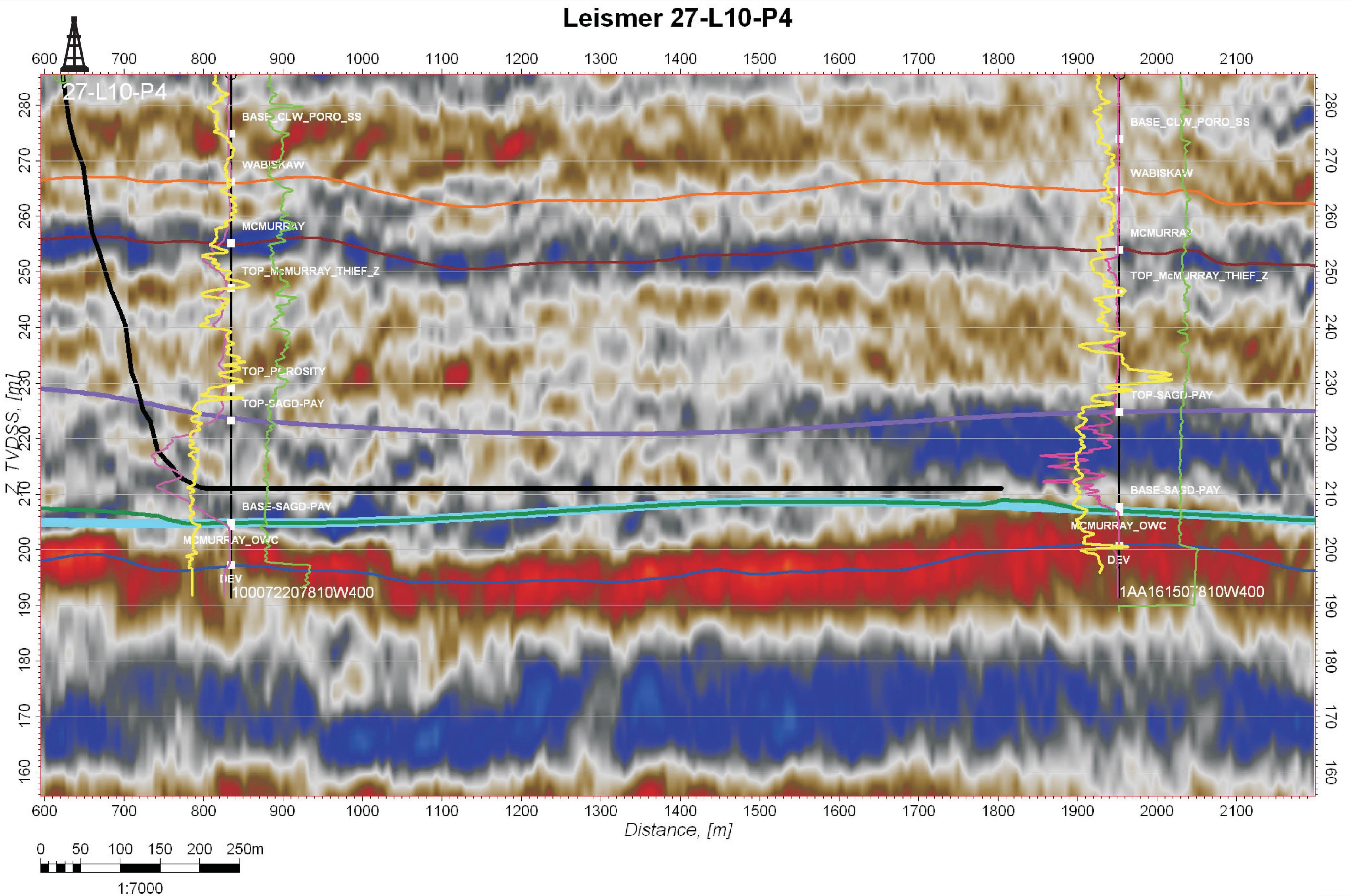
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L10

Producer Well: P4



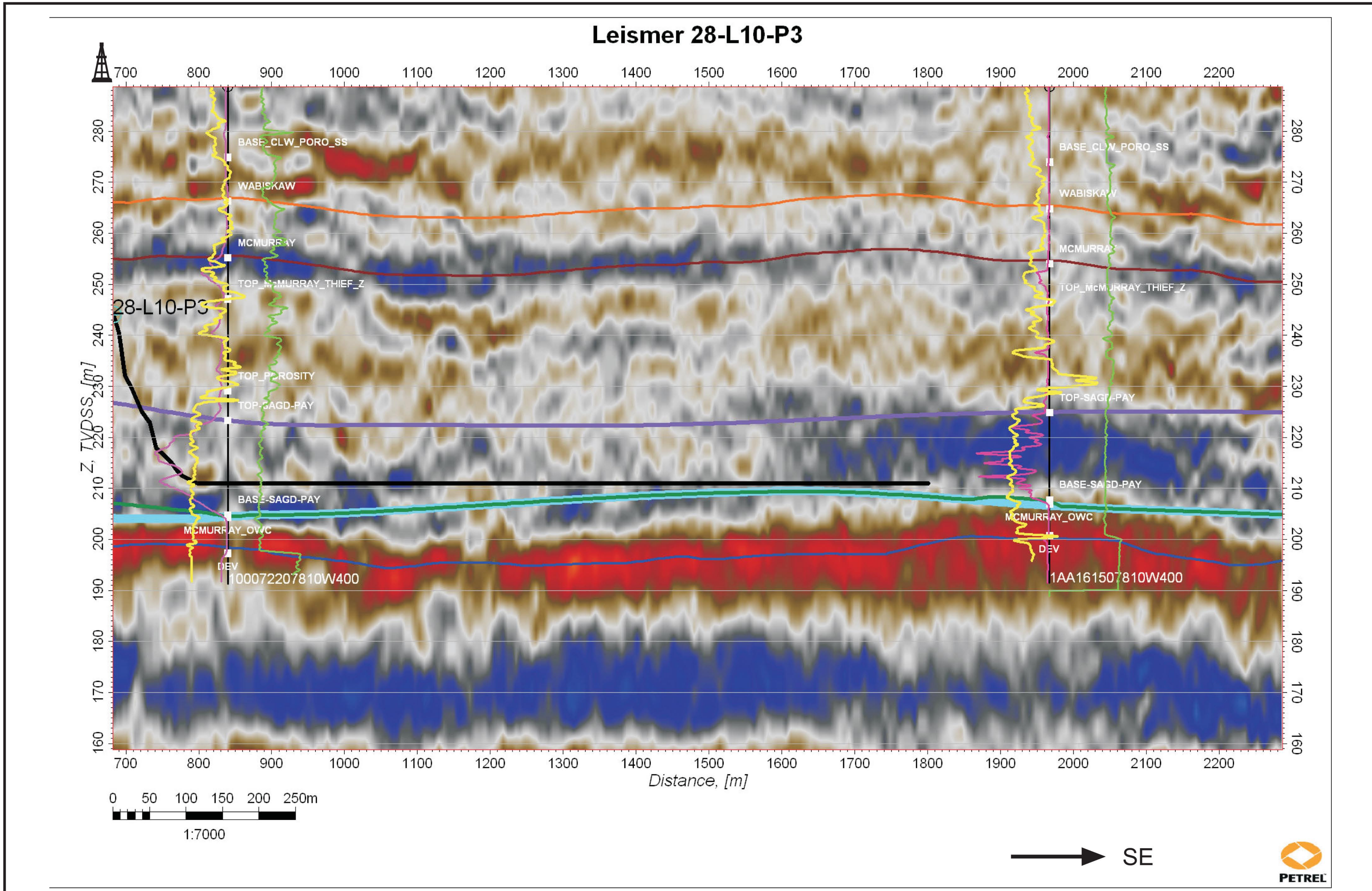
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L10

Producer Well: P3

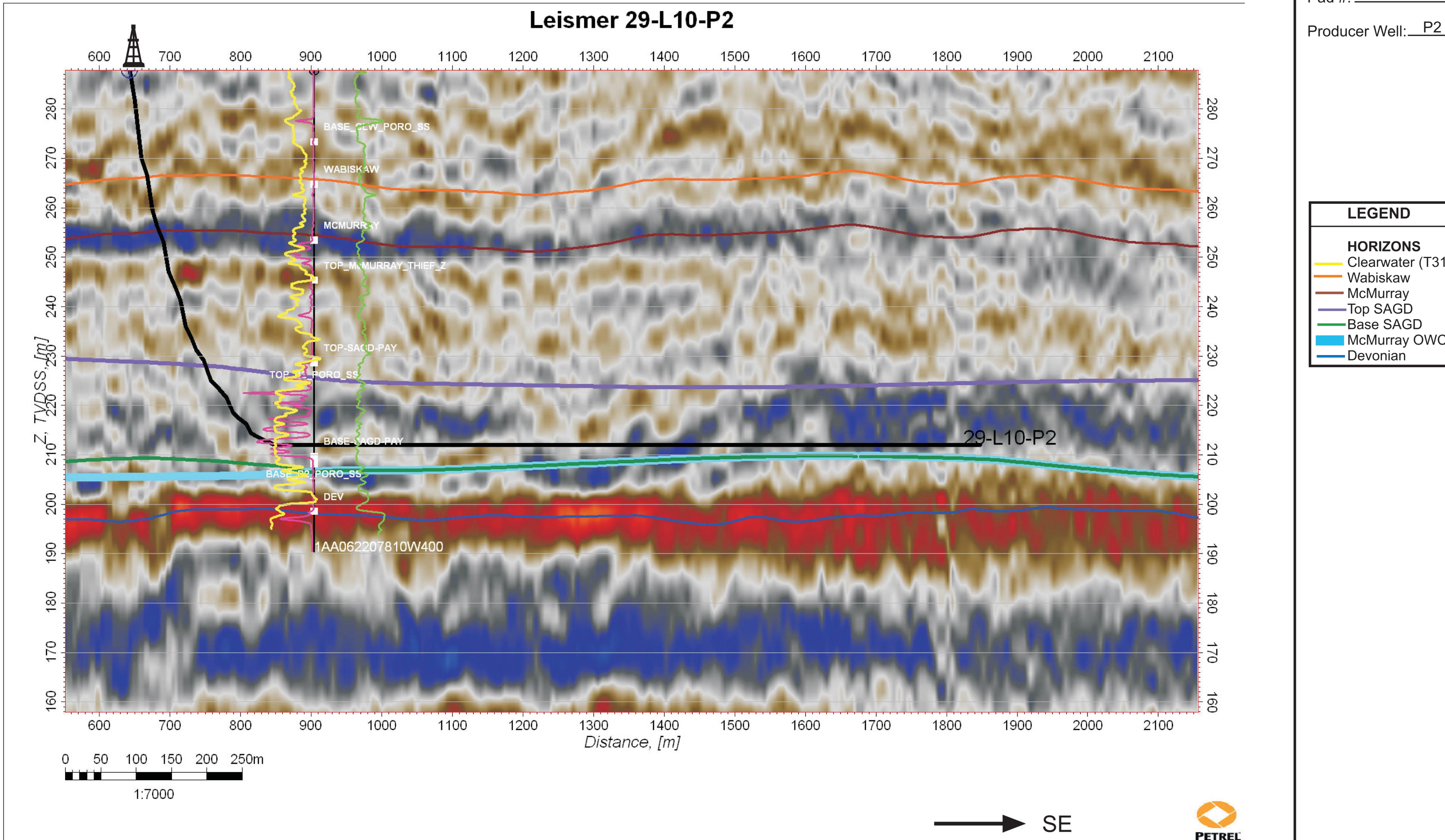


LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L10

Producer Well: P2

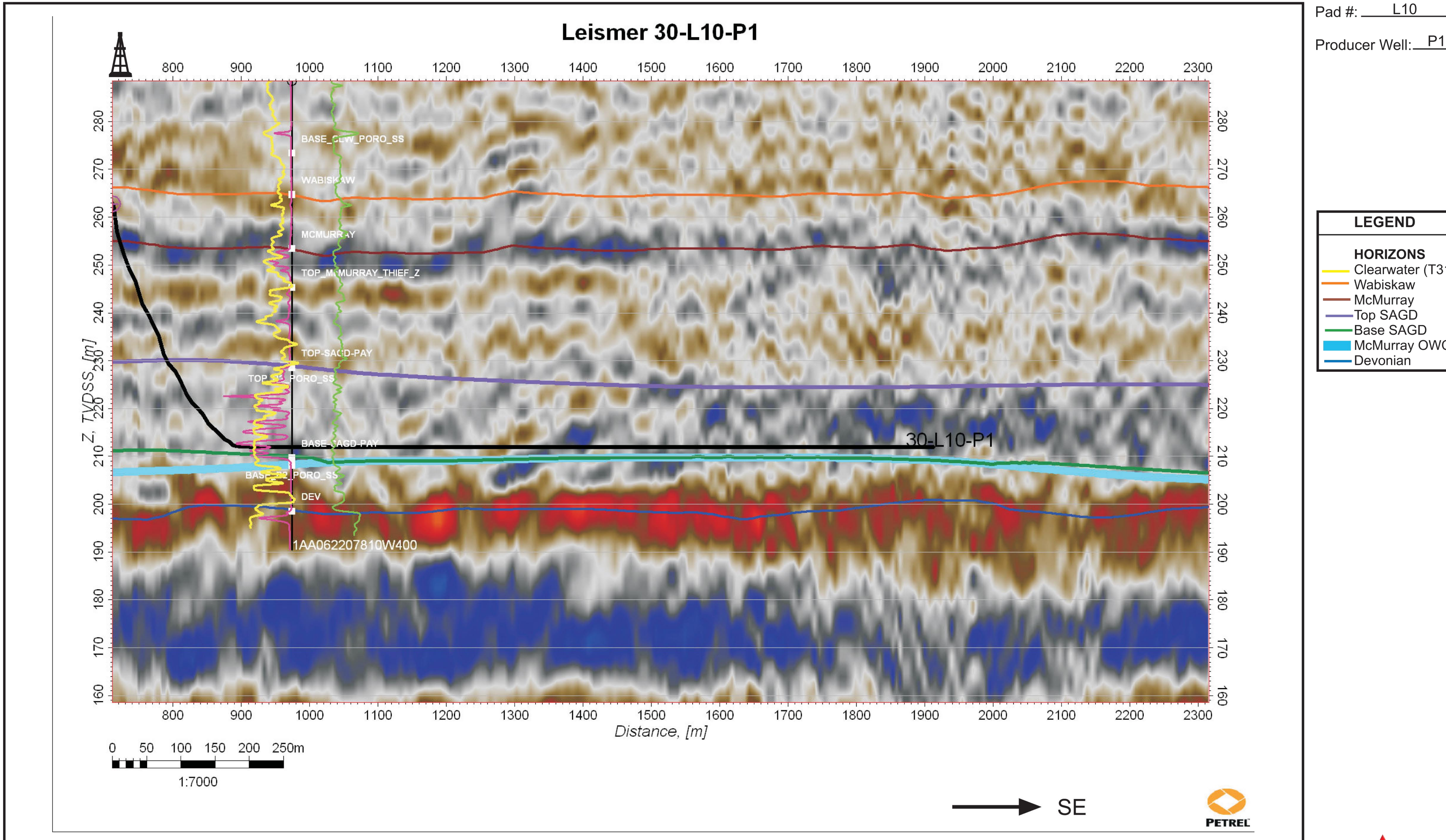


LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L10

Producer Well: P1

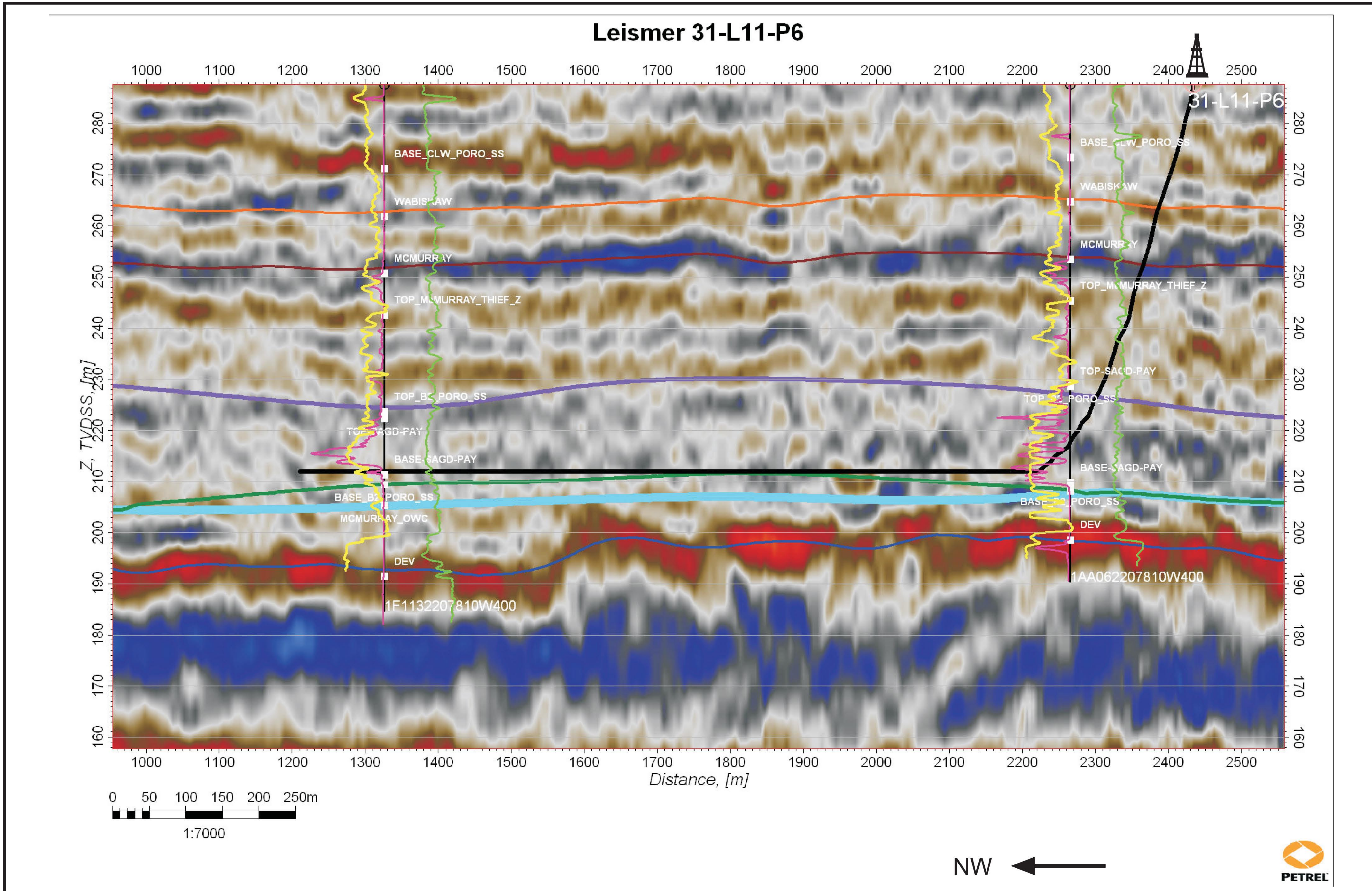


LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L11

Producer Well: P6



LEGEND

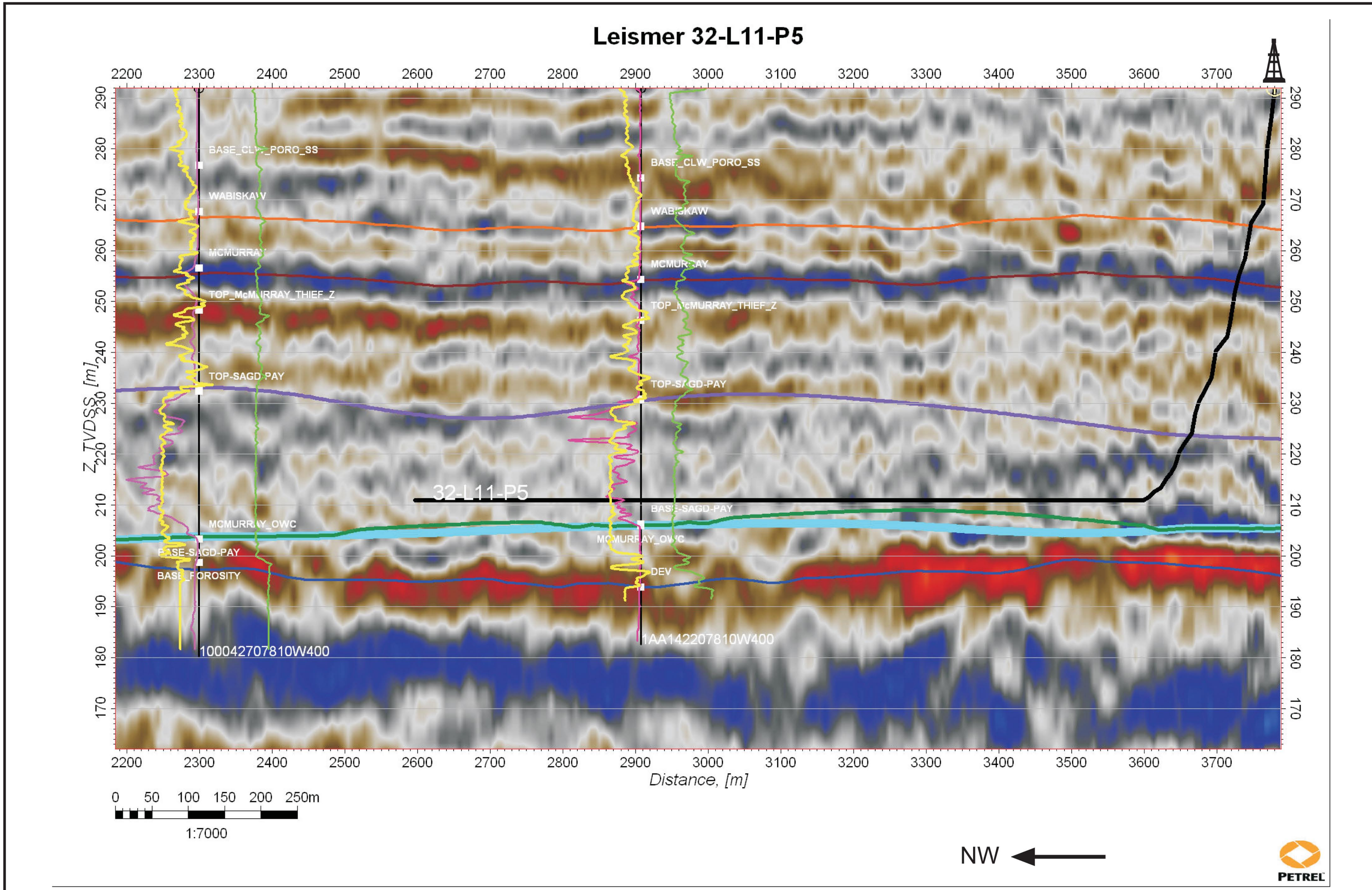
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L11

Producer Well: P5



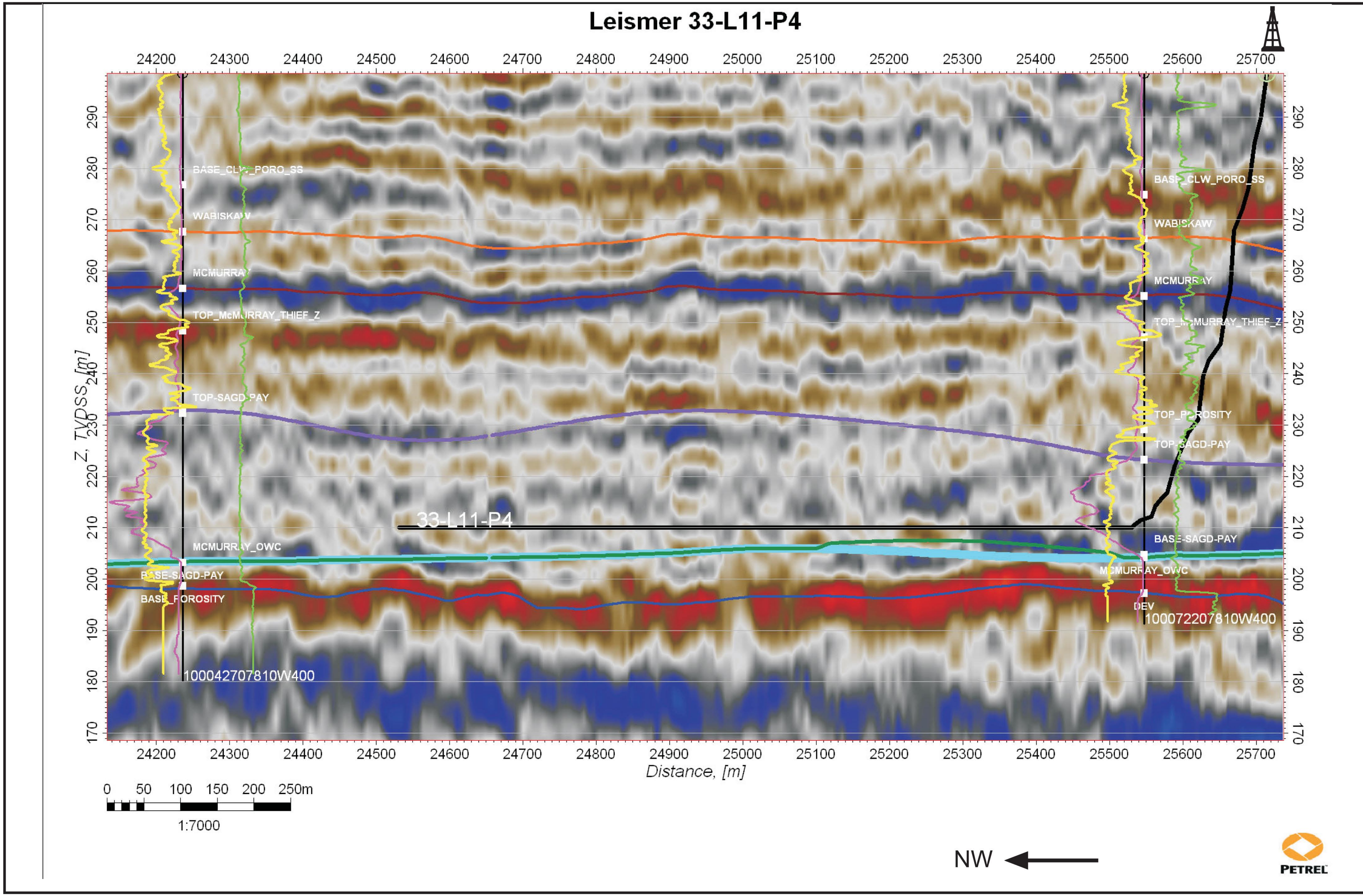
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

Pad #: L11

Producer Well: P4



LEGEND

HORIZONS

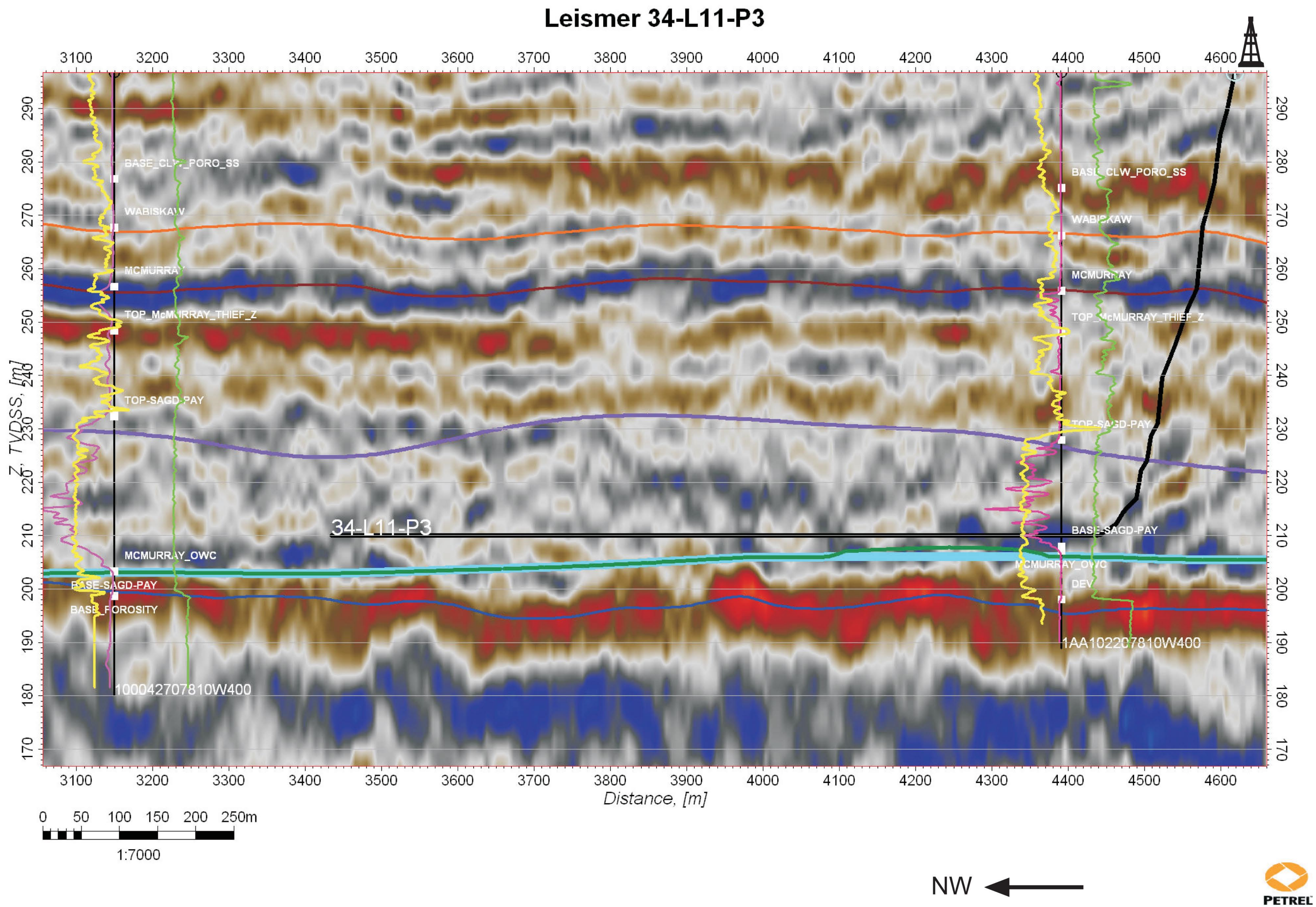
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L11

Producer Well: P3



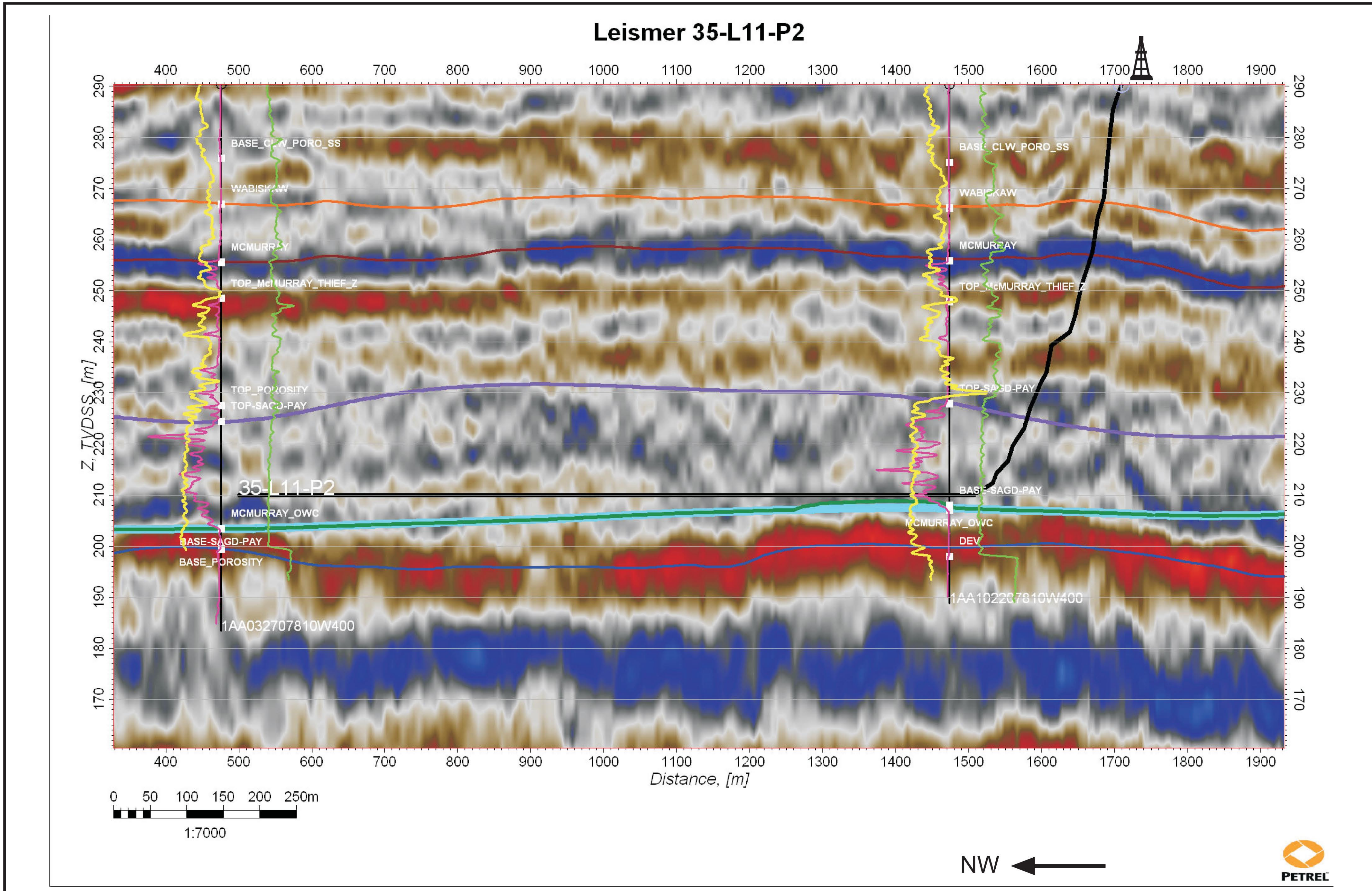
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

North American Oil Sands Corporation

Pad #: L11

Producer Well: P2



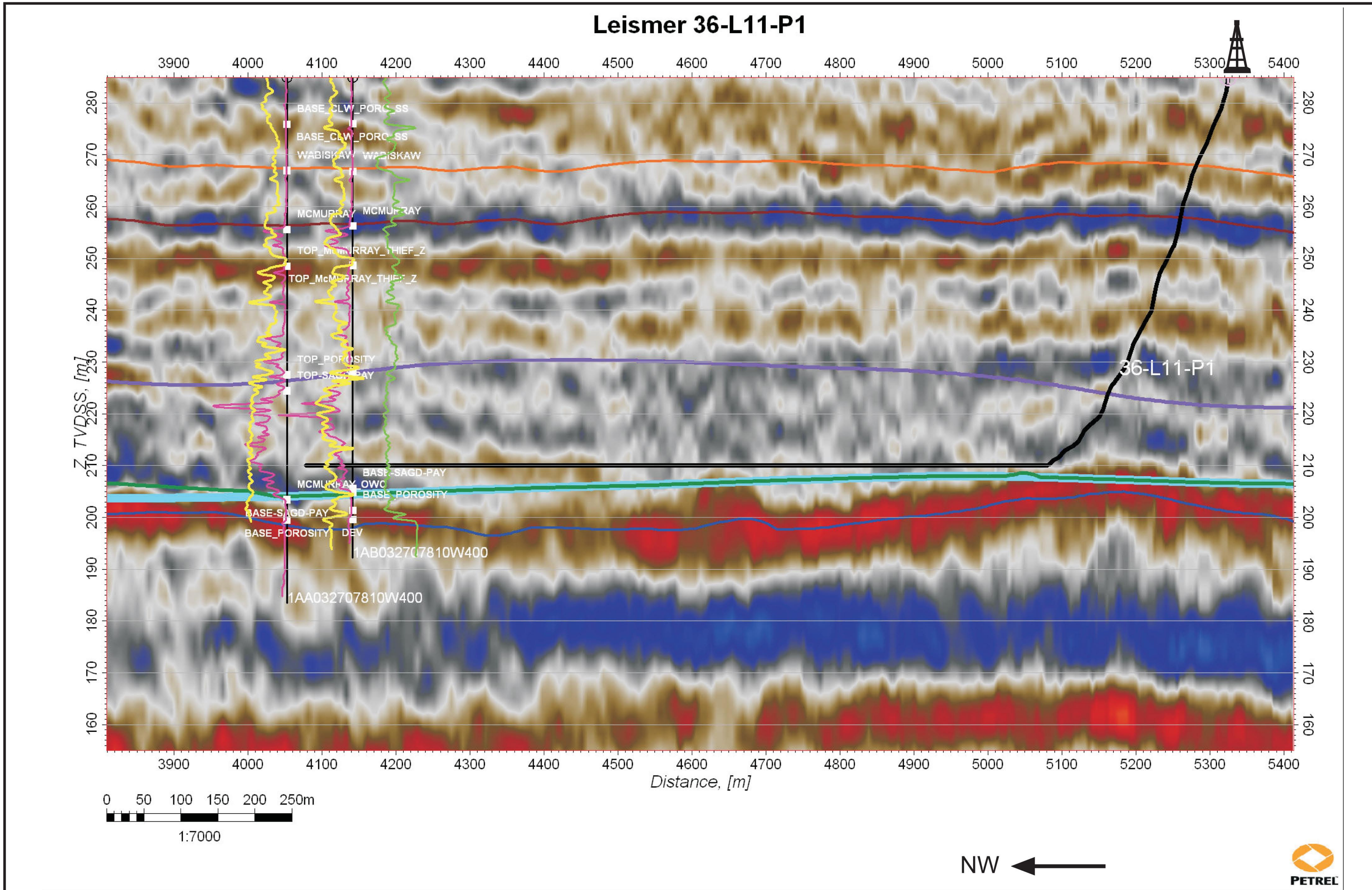
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L11

Producer Well: P1



LEGEND

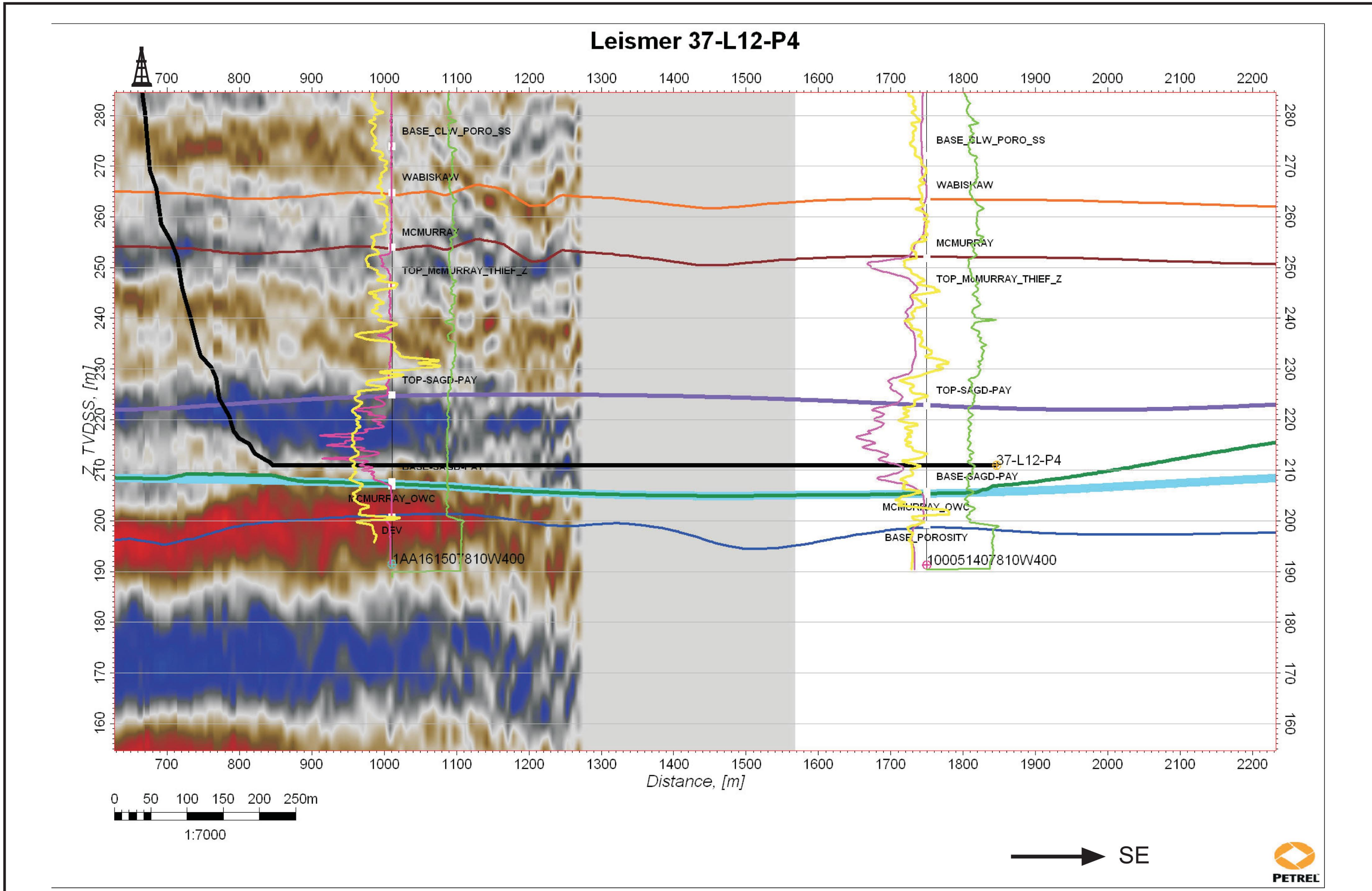
HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L12

Producer Well: P4

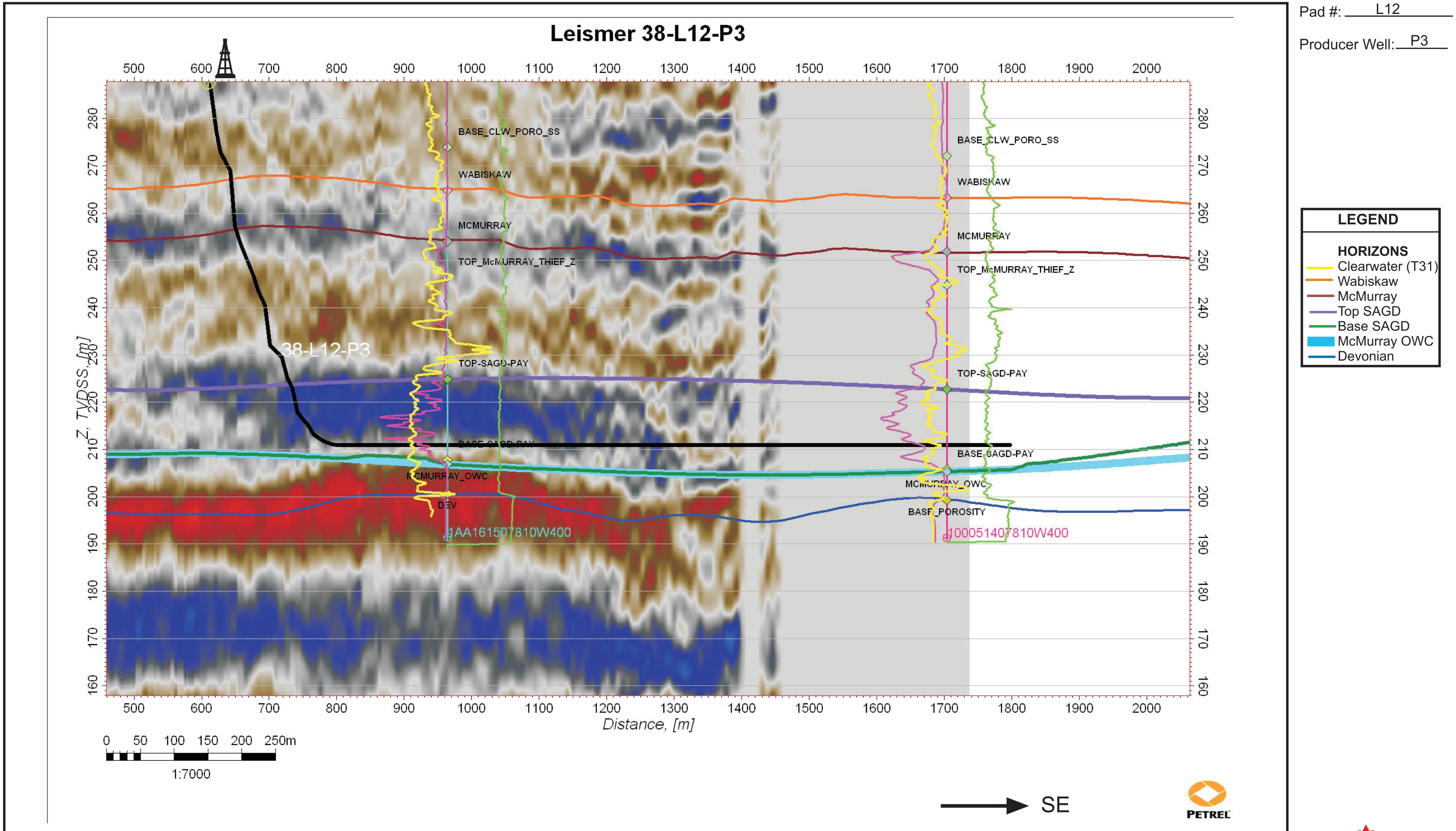


LEGEND

HORIZONS
- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN
OIL SANDS CORPORATION

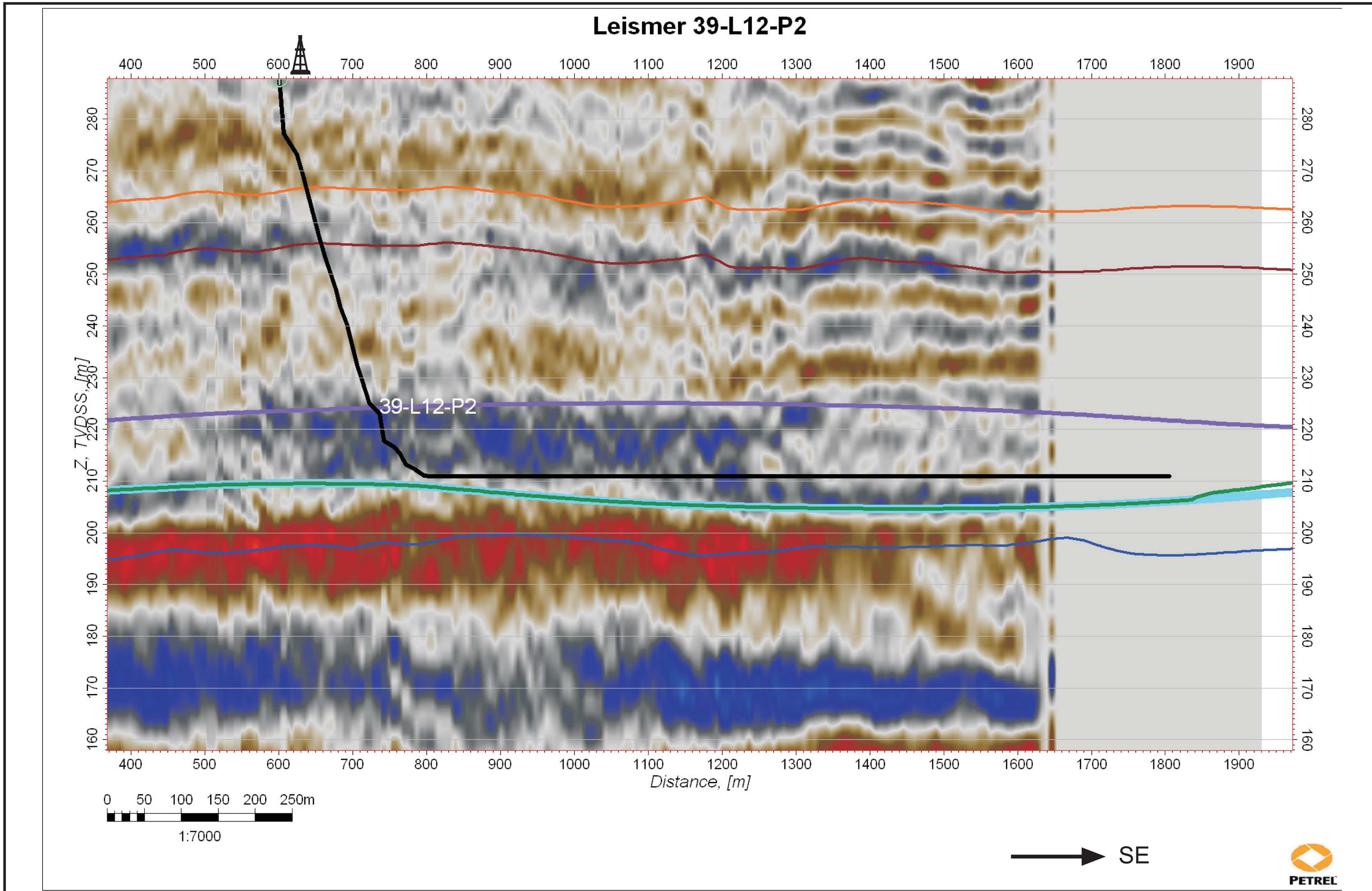


LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L12

Producer Well: P2



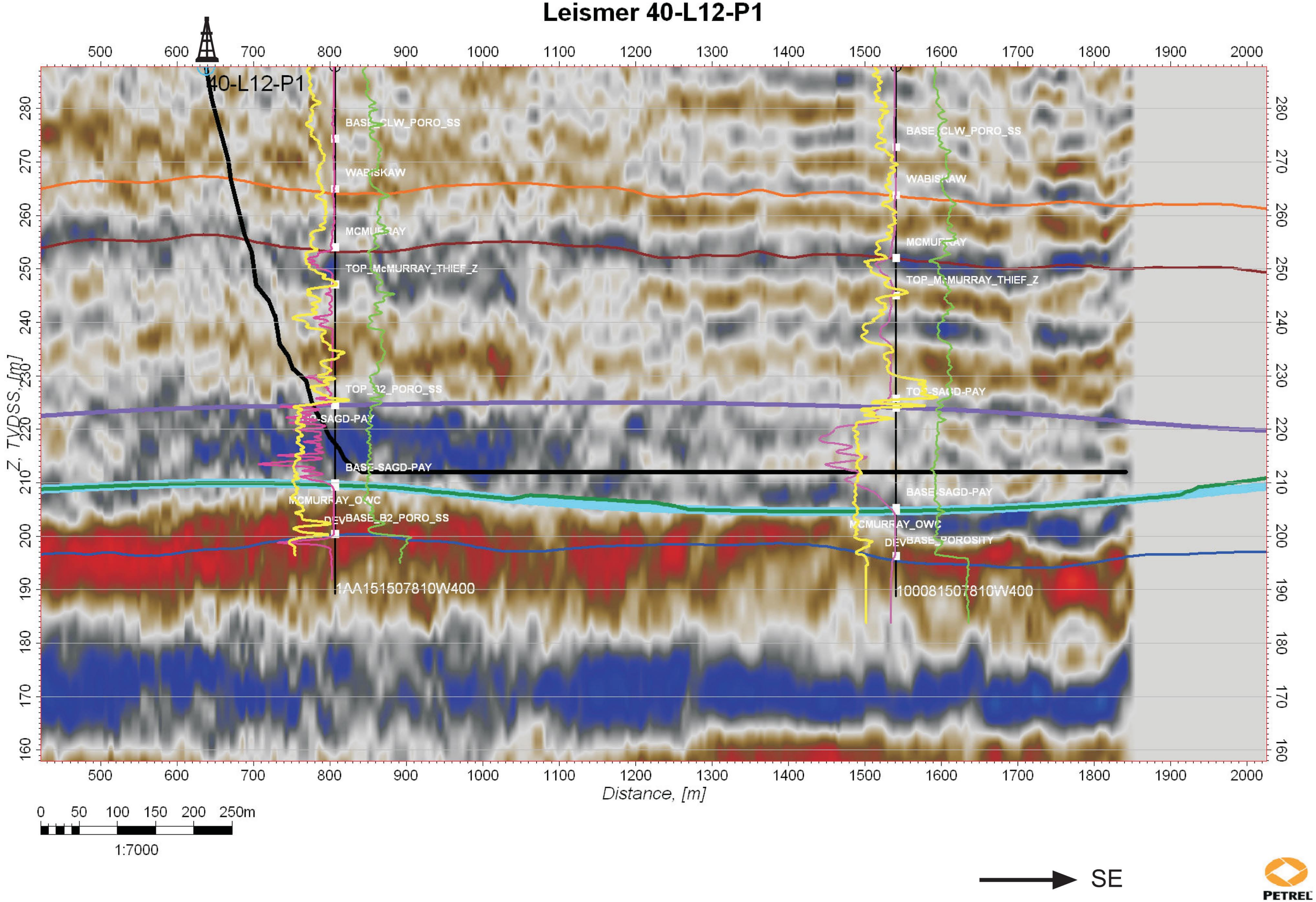
LEGEND
HORIZONS
Clearwater (T31)
Wabiskaw
McMurray
Top SAGD
Base SAGD
McMurray OWC
Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

Pad #: L12

Producer Well: P1



LEGEND

HORIZONS

- Clearwater (T31)
- Wabiskaw
- McMurray
- Top SAGD
- Base SAGD
- McMurray OWC
- Devonian

LEISMER EXPANSION AREA

NORTH AMERICAN OIL SANDS CORPORATION

APPENDIX C

APPLICATION FOR APPROVAL OF THE CORNER HUB OF THE KAI KOS DEHSEH PROJECT

SUBMITTED TO

ALBERTA ENERGY AND UTILITIES BOARD

AND

ALBERTA ENVIRONMENT

SUBMITTED BY

NORTH AMERICAN OIL SANDS CORPORATION

August 2007

TABLE OF CONTENTS

Tables

Figures

C1 INTRODUCTION

North American Oil Sands Corporation (North American) is a Canadian oil sands company operating in northeastern Alberta. The North American management team is recognized for its extensive heavy oil technical and business experience. North American is currently the working interest owner and operator of approximately 12 townships of oil sands leases between Lac La Biche and Fort McMurray. The North American oil sands leases are located in Townships 76 to 83, Ranges 8 to 13 West of the 4th Meridian (Figure C1-1). The oil sands leases are not contiguous and fall within the Rural Municipality of Wood Buffalo and Lakeland County.

This document provides the geological, reservoir and operations overview necessary for the Alberta Energy Utilities Board (EUB) to review the “Application for Approval of the Corner Hub of the Kai Kos Dehseh Project”. This Appendix targets those North American leases located between the southeast portion of Section 34-80-8 W4 to the northwest portion of Section 16-81-9 W4 (Figures C1-2).

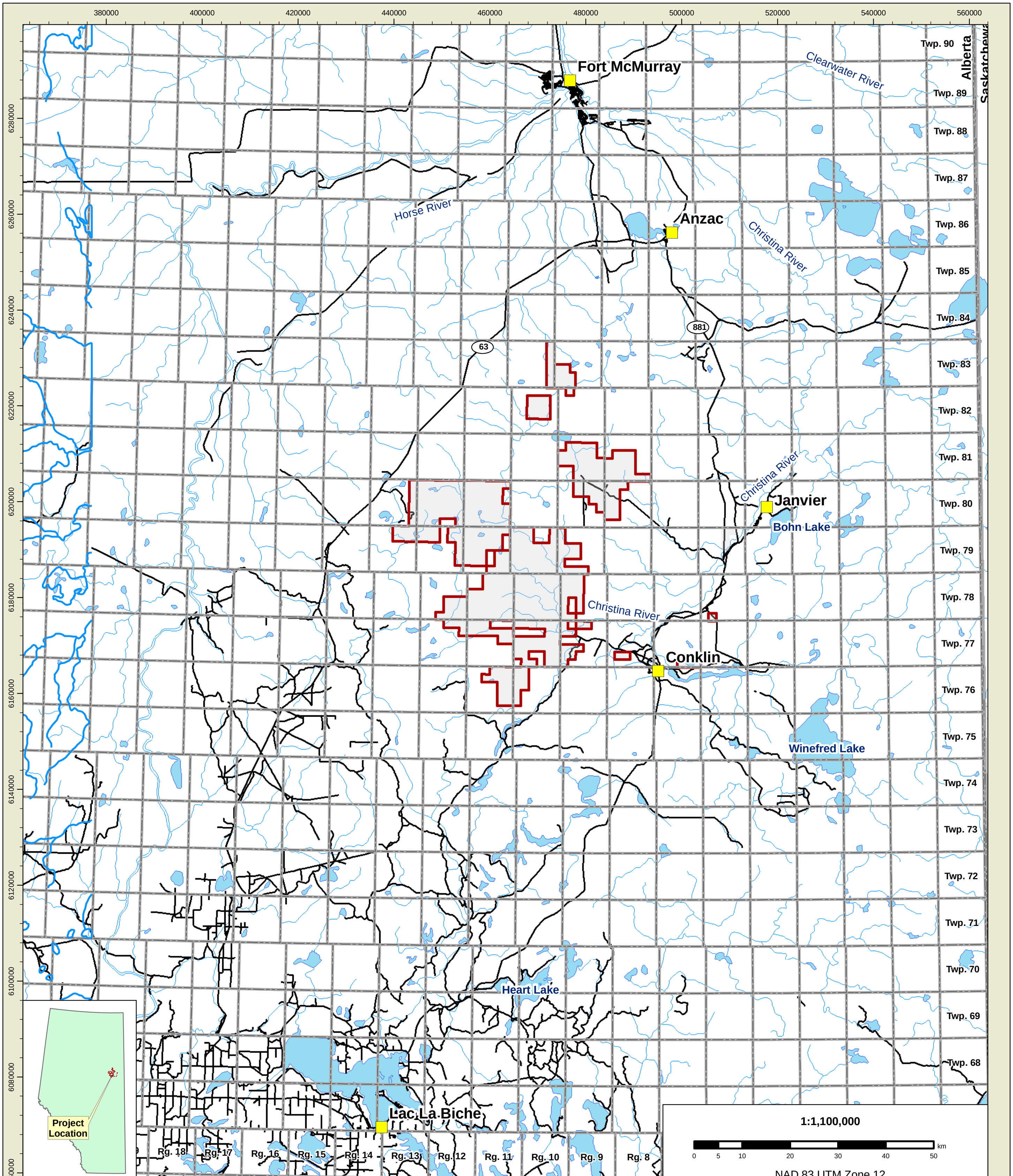
This document includes a description of the geology, reservoir and in the Corner Hub development area (Section C4), including detailed information on the geology and the hydrogeology of the area and an evaluation of resources and reserves.

The Corner Hub will consist of a central processing facility (which will include steam generation, water treatment, emulsion gathering and treating, and sulphur removal equipment) and field facilities (well pads, connecting roads and utilities).

The initial development of the 6,360 m^3/d (40,000 bpd) Corner Hub will consist of 11 pads with 58 well pairs. Future Corner development will be applied for when appropriate as identified in the Kai Kos Dehseh Project application and more are anticipated to be defined by future drilling. Table C1-1 presents the capacity and first steam dates for the Corner Hub.

Table C1-1 Corner Project Development Area and Hub

Project	Development Area	Hub	Capacity (m^3/d)	Capacity (bpd)	First Steam Date
Kai Kos Dehseh	Corner	Corner	6,360	40,000	2012



I:\4455-514_NAOSC\NAOSC_Maps\Maps_Volume1\Figure C 1-1 NAOSC Oil Sands Leases 1.1mil_LP_20070803.mxd

Legend

- North American Lease Boundary
- Provincial Boundary
- Roads
- Lake
- Stream
- Town

Title:

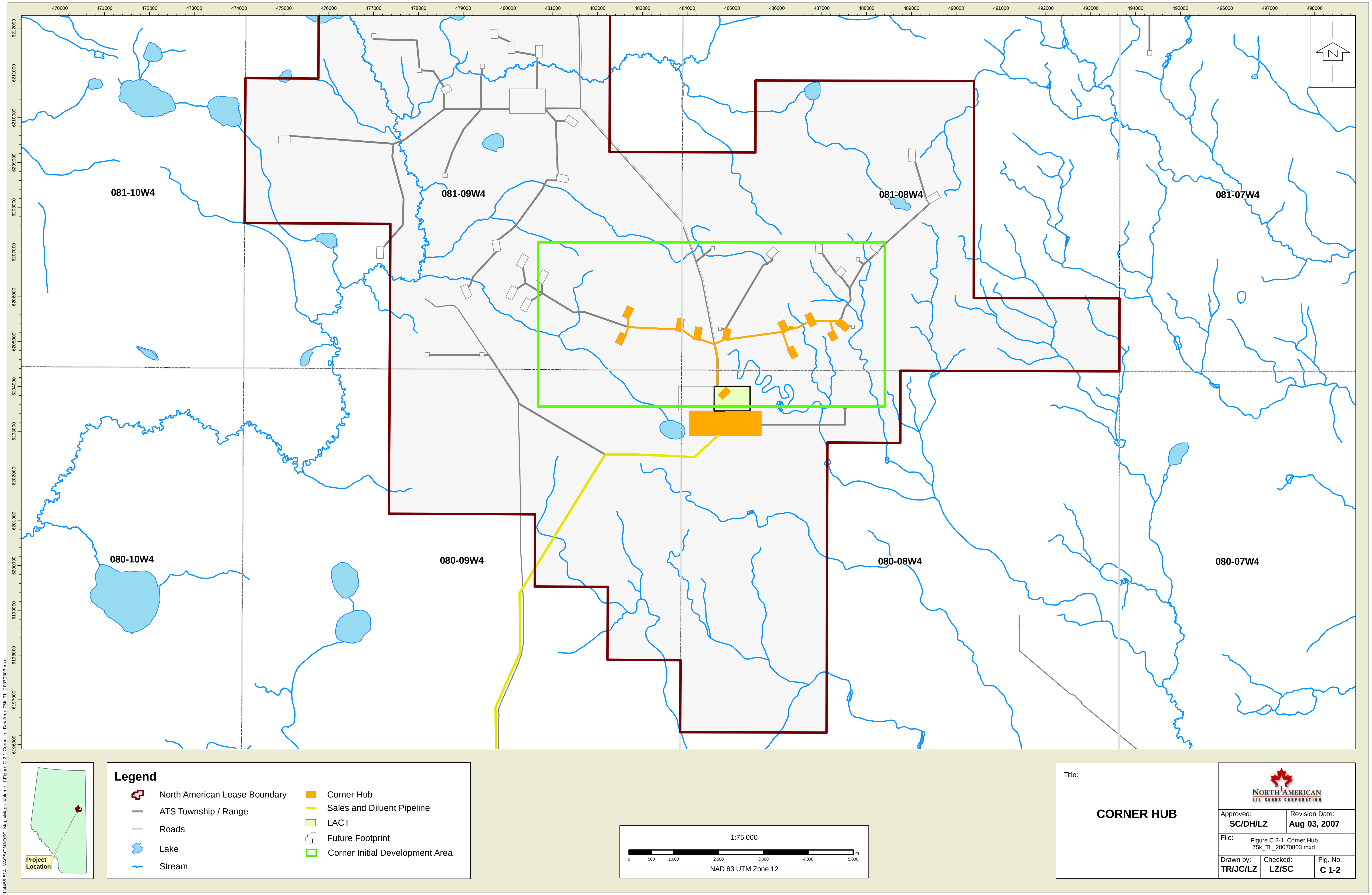
NORTH AMERICAN KAI KOS DEHSEH OIL SANDS LEASES

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
RL/LZ	Aug 03, 2007

File: Figure C 1-1 NAOSC Oil Sands Leases 1.1mil _LP_20070803.mxd

Drawn by:	Checked:	Fig. No.:
JC/TR/LZ	RL/LZ	**C 1-1**


081-10W4
081-09W4
081-08W4
081-07W4
080-10W4
080-09W4
080-08W4
080-07W4
Legend
North American Lease Boundary
ATS Township / Range
Roads
Lake
Stream
Corner Hub
Sales and Diluent Pipeline
LACT
Future Footprint
Corner Initial Development Area
Project Location
1:75,000
NAD 83 UTM Zone 12
Title:
CORNER HUB
NORTH AMERICAN OIL SANDS CORPORATION
Approved: SC/DH/LZ
Revision Date: Aug 03, 2007
File: Figure C 2-1 Corner Hub 75k_TL_20070803.mxd
Drawn by: TR/JC/LZ
Checked: LZ/SC
Fig. No.: C 1-2

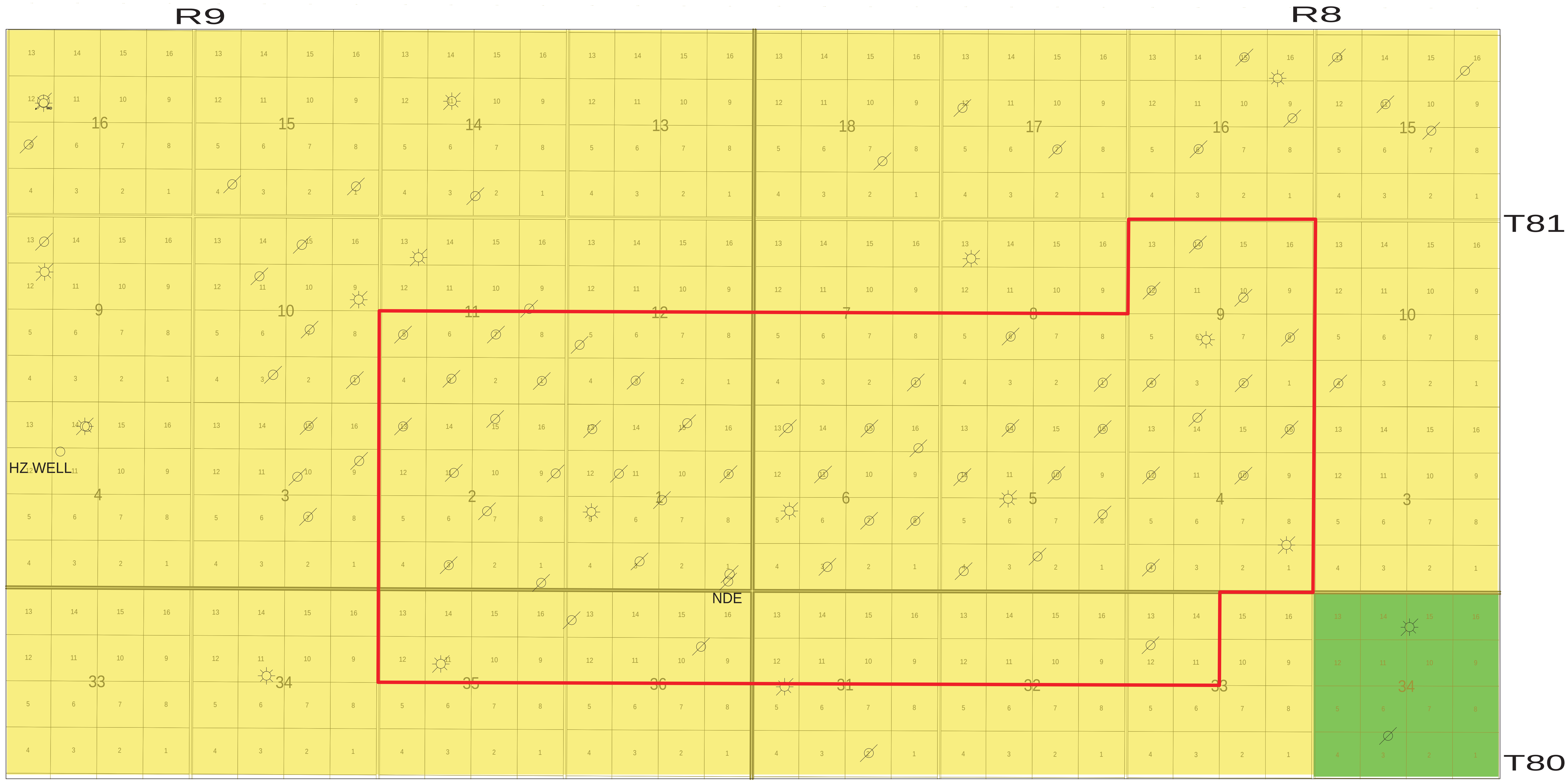
C1.1 Corner Hub Location

The CPF for the Corner Hub will be located in the SE¼ of 31 and the SW¼ 32 in 80-8 W4M, approximately 30 km northwest of Conklin, Alberta and approximately 120 km north of Lac La Biche in the County of Lakeland. The SAGD well pairs will be drilled from eleven surface production pads located in Township 81, Ranges 8 and 9 W4M. Reservoir drainage from these pads will occur in Sections 31 and 32 of 80-08 W4, Sections 4, 5, 6 of 81-8 W4 and Sections 1, 2, 11 and 12 of 81-9 W4M.

C1.2 Land and Mineral Rights

SAGD bitumen production, natural gas production and forestry are the predominant industries in the area surrounding the Corner Hub. It is important that, where appropriate, operators coordinate their activities so the total value is increased. North American is participating with the integrated land management activities of the Chamber of Resources, Alberta-Pacific Forest Industries Inc. (Al-Pac) and other oil and gas operators in the region.

All oil sands leases within the Corner Regional Geological Study Area (Corner RGSA), with the exception of 34-80-8 W4, are owned by North American (Figure C1.2-1). Figure C1.2-2 shows the P&NG rights in the area.



North American Oil Sands Corp. Leases

PetroCan, Imperial, Jacos, Nexen Lease

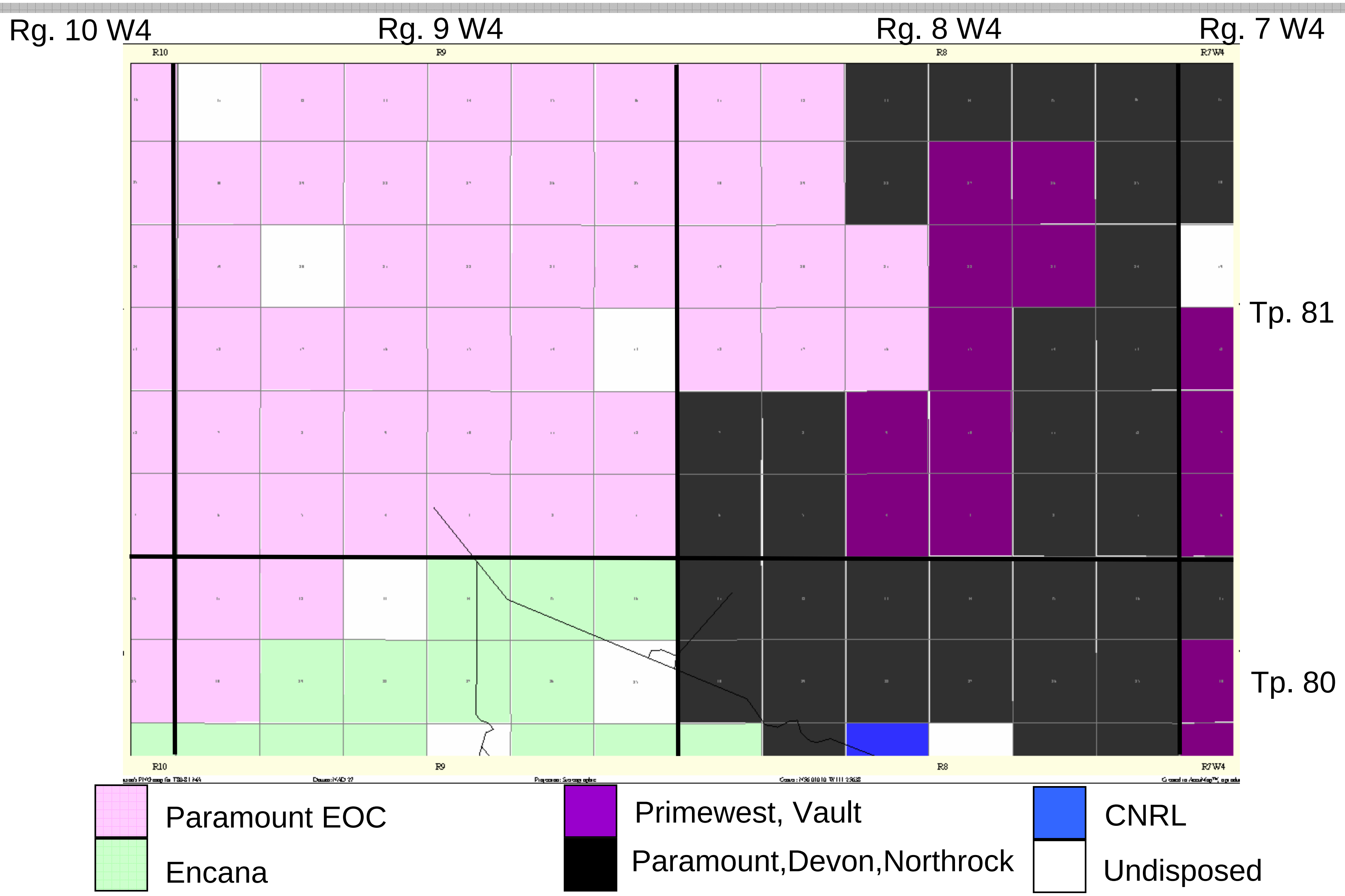
Corner Initial Development Area

HZ WELL Horizontal Well

NDE Not Deep Enough

Figure C1.2-1 Area Oil Sands Lease Owners

Figure C1.2-2 Corner Area P&NG Lease Holders



C1.3 Production Capacity

North American is requesting an approved production capacity of 6,360 m^3/d (40,000 bpd) on an annual average calendar day basis. Adequate resource recovery for the Corner initial development area will be provided by eleven production pads consisting of a total of 58 well pairs.

C1.4 Corner Hub Schedule

The Corner Hub schedule is shown in Table 1.4-1. The schedule is approximate and subject to modification in response to the receipt of regulatory approvals, business considerations and weather factors. Assuming favourable regulatory approval and market conditions, construction of the Corner Hub is scheduled to begin in March 2011 with initial production in August 2012.

Stakeholders have been consulted since the Fall of 2004 and will continue to be involved throughout the development process. It is North American's intention to continue communication and interaction with the surrounding community throughout the life of the Corner Hub.

Table C1.4-1: Schedule for Corner Hub

Quarter	1 2007	2 2007	3 2007	4 2007	1 2008	2 2008	3 2008	4 2008	1 2009	2 2009	3 2009	4 2009	1 2010	2 2010	3 2010	4 2010	1 2011	2 2011	3 2011	4 2011	1 2012	2 2012	3 2012	4 2012	1 2013	2 2013	3 2013	4 2013	1 2014	2 2014	3 2014	4 2014	1 2015	2 2015	3 2015	4 2015	1 2016	2 2016	3 2016	4 2016	1 2017	2 2017	3 2017	4 2017	1 2018	2 2018	3 2018	4 2018
Corner and Corner Expansion Hubs			Appendix C																	Future Applicatioin																												
Engineering and Construction/Drilling																																																
Production/injection operations																																																

C2 CORNER HUB DESCRIPTION

C2.1 Overview

North American is committed to effective resource recovery for the Corner Hub. The Corner Hub will utilize SAGD in-situ technology to recover approximately 6,360 m^3/d (40,000 bpd) of bitumen on an annual average calendar day basis. The layout of the Corner Hub (CPF plot plan) is presented in Figure C2.1-1. Figures C2.1-2 through C2.1-4 present the material, water and energy balances for the Corner Hub.

North American has been conducting seismic and oil sands exploratory (OSE) drilling programs in the Corner Project area. North American acquired 24 km^2 of high resolution 3D seismic in the first quarter of 2006 and an additional 22 km^2 in the first quarter of 2007. Forty new wells have been drilled by North American in the Corner RGSA between the years 2005 to 2007. Well spacing is currently at 32.4 ha (80 acres) with 3D seismic in the main development area and 17 wells have been cored (including 4 historical cores). The drilling and seismic programs confirmed the existence of a significant bitumen resource.

The components of the Corner Hub include horizontal production and injection wells from multi-well pads. In addition to the horizontal wells required for a SAGD project, the Corner Hub will have surface facilities required to generate and distribute steam, gather well production, process oil and emulsions, and treat water. These facilities can be broken down into four components: field facilities (production pads and horizontal wells), CPF, offsite services and connections and camps. The Corner Hub will consist of the following:

Field Facilities:

- SAGD pads, wells and associated facilities;
- Production flowlines;
- Steam distribution flowlines;
- Electrical power distribution lines; and
- Pad access roads.

Central Processing Facility (CPF):

- Steam generation facilities;
- Production treatment (bitumen, water and gas) facilities;
- Sulphur removal equipment;
- Water treatment, recycle and disposal facilities;
- Electrical, air, water and instrumentation utility systems;
- Tankage; and
- Support buildings, including warehouses and operations camp.

Interconnecting Infrastructure:

- Access roads;
- In-field fuel gas pipelines;
- In-field water and gas redistribution pipelines
- In-field diluent supply pipelines;
- In-field diluted bitumen sales lines;
- Electrical power distribution line; and

Camps

- East permanent operations camp (Leismer)
- Temporary construction/drilling camps.

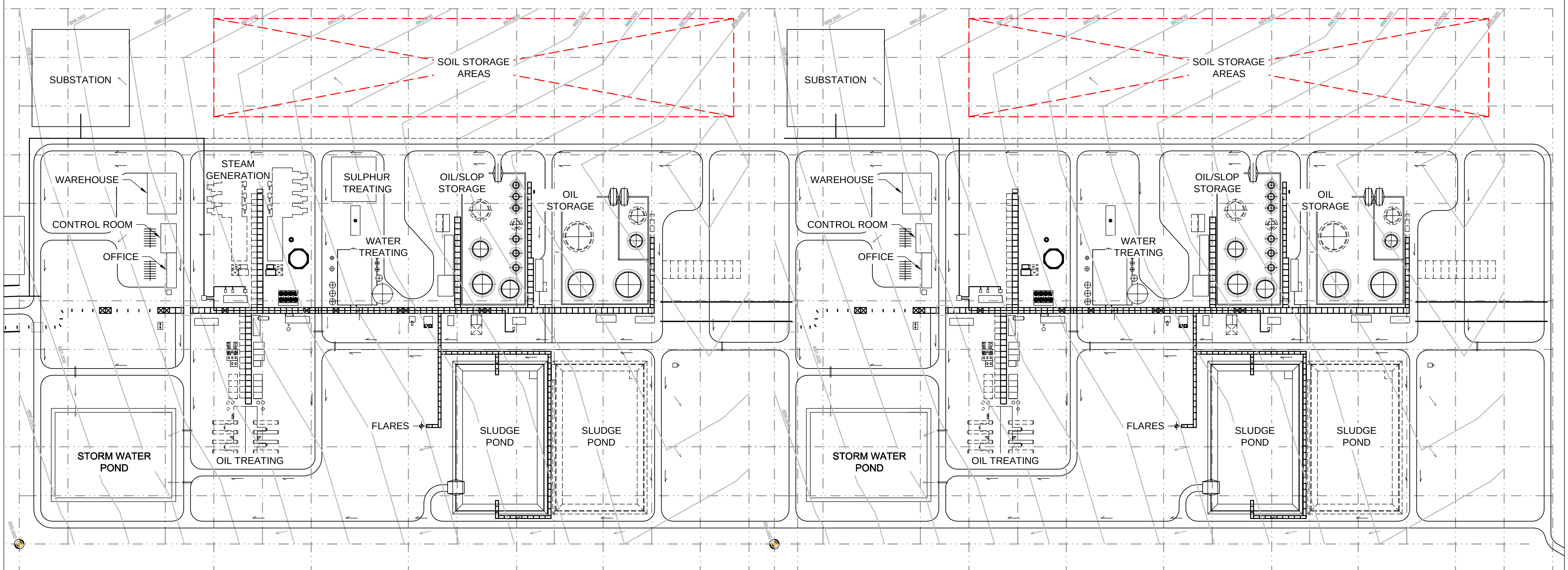
Services (included in this application)

- Water disposal wells and related pipelines;
- Source water wells and related pipelines;

Services (not included in this application)

- Fuel gas pipeline*;
- main diluent supply pipeline*;
- main diluted bitumen sales line*; and
- electrical power transmission line*;

* To be applied for under separate regulatory approval process and as such not considered as part of the Project.



SCALE 1:4000 metres

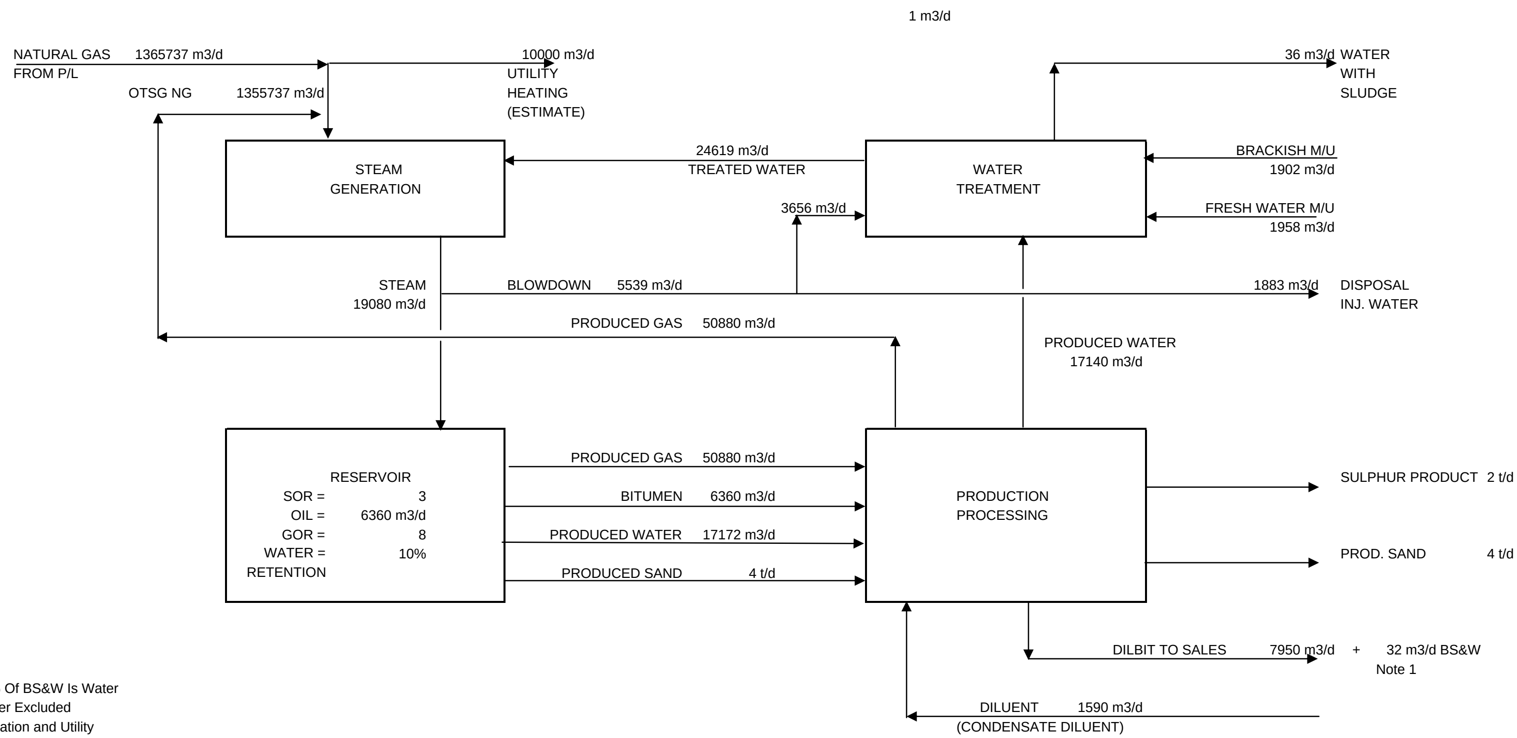
40 0 40 80

Title:

CORNER HUB CPF PLOT PLAN

Approved: ##	Revision Date: 07/06/22
File: 4455-PROCESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	##	**C2.1-1**



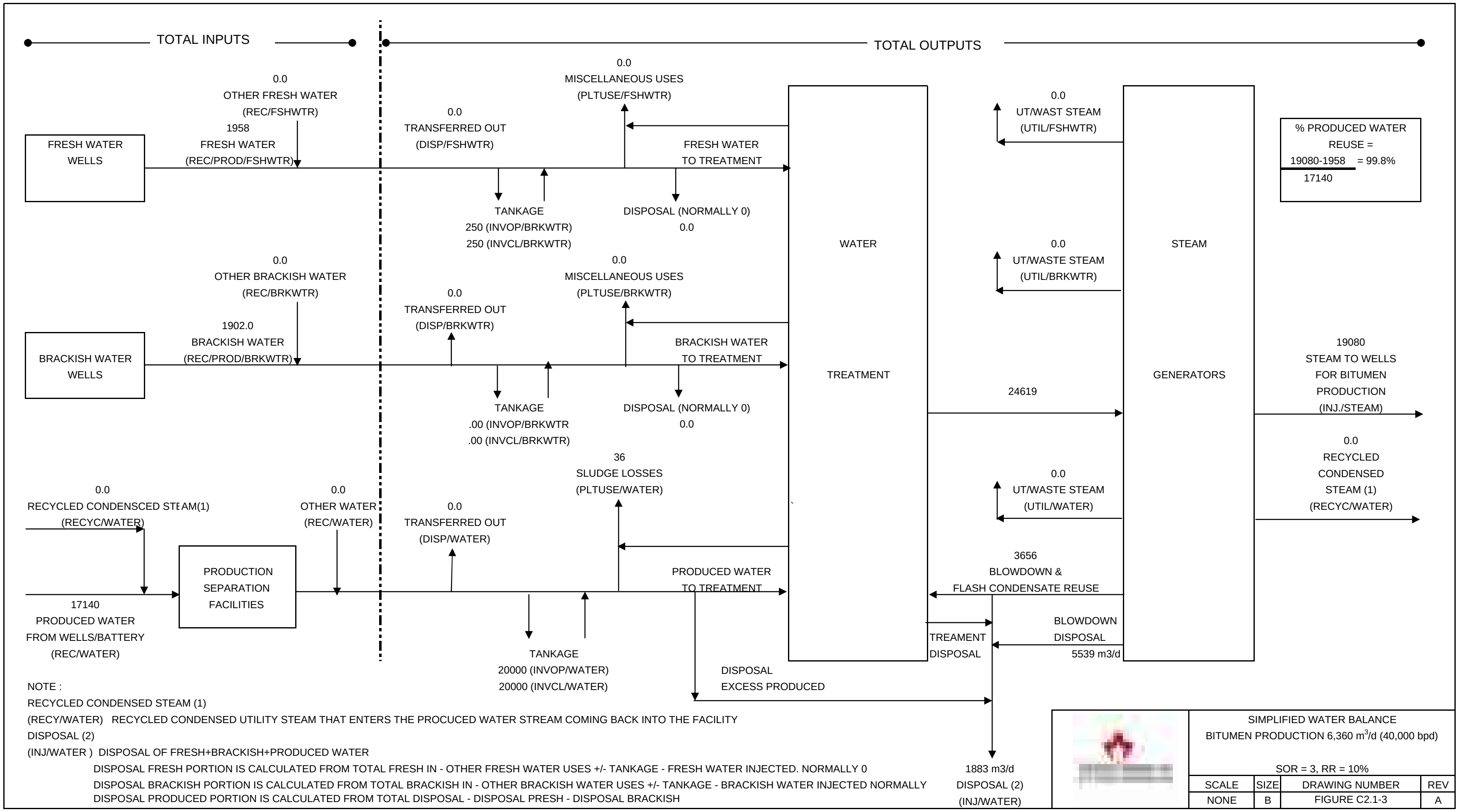
Notes:
1.) Assumes 50% Of BS&W Is Water
2.) Domestic Water Excluded
3.) Pond Evapouration and Utility Losses Excluded

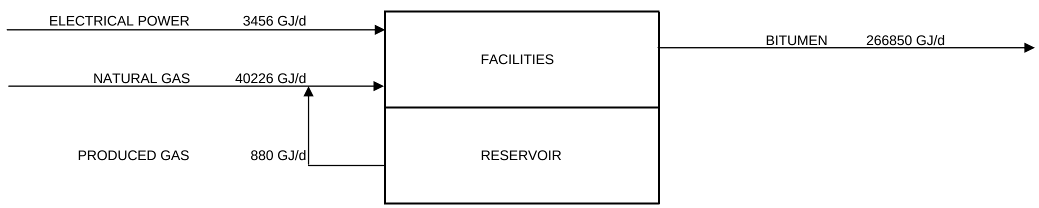
Approximate Stream Rates

NOTE: CALENDAR DAY

Values shown are rounded in Table C2.4-1

MATERIAL BALANCE BITUMEN PRODUCTION 6,360 m^3/d (40,000 bpd) SOR = 3, RR = 10%			
SCALE	SIZE	DRAWING NUMBER	REV
NONE	B	FIGURE C2.1-2	A


TOTAL INPUTS
TOTAL OUTPUTS
0.0
OTHER FRESH WATER
(REC/FSHWTR)
1958
FRESH WATER
(REC/PROD/FSHWTR)
FRESH WATER
WELLS
0.0
TRANSFERRED OUT
(DISP/FSHWTR)
0.0
MISCELLANEOUS USES
(PLTUSE/FSHWTR)
FRESH WATER
TO TREATMENT
TANKAGE
250 (INVOP/BRKWTR)
250 (INVCL/BRKWTR)
DISPOSAL (NORMALLY 0)
0.0
WATER
TREATMENT
0.0
UT/WAST STEAM
(UTIL/FSHWTR)
STEAM
GENERATORS
% PRODUCED WATER
REUSE =
19080-1958 = 99.8%
17140
0.0
OTHER BRACKISH WATER
(REC/BRKWTR)
1902.0
BRACKISH WATER
(REC/PROD/BRKWTR)
BRACKISH WATER
WELLS
0.0
TRANSFERRED OUT
(DISP/BRKWTR)
0.0
MISCELLANEOUS USES
(PLTUSE/BRKWTR)
BRACKISH WATER
TO TREATMENT
TANKAGE
.00 (INVOP/BRKWTR
.00 (INVCL/BRKWTR)
DISPOSAL (NORMALLY 0)
0.0
0.0
UT/WASTE STEAM
(UTIL/BRKWTR)
24619
19080
STEAM TO WELLS
FOR BITUMEN
PRODUCTION
(INJ./STEAM)
0.0
RECYCLED
CONDENSED
STEAM (1)
(RECYC/WATER)
0.0
RECYCLED CONDENSCED STEAM(1)
(RECYC/WATER)
17140
PRODUCED WATER
FROM WELLS/BATTERY
(REC/WATER)
PRODUCTION
SEPARATION
FACILITIES
0.0
OTHER WATER
(REC/WATER)
0.0
TRANSFERRED OUT
(DISP/WATER)
36
SLUDGE LOSSES
(PLTUSE/WATER)
PRODUCED WATER
TO TREATMENT
TANKAGE
20000 (INVOP/WATER)
20000 (INVCL/WATER)
DISPOSAL
EXCESS PRODUCED
0.0
UT/WASTE STEAM
(UTIL/WATER)
3656
BLOWDOWN &
FLASH CONDENSATE REUSE
TREAMENT
DISPOSAL
BLOWDOWN
DISPOSAL
5539 m3/d
1883 m3/d
DISPOSAL (2)
(INJ/WATER)
NOTE :
RECYCLED CONDENSED STEAM (1)
(RECY/WATER) RECYCLED CONDENSED UTILITY STEAM THAT ENTERS THE PROCUCED WATER STREAM COMING BACK INTO THE FACILITY
DISPOSAL (2)
(INJ/WATER) DISPOSAL OF FRESH+BRACKISH+PRODUCED WATER
DISPOSAL FRESH PORTION IS CALCULATED FROM TOTAL FRESH IN - OTHER FRESH WATER USES +/- TANKAGE - FRESH WATER INJECTED. NORMALLY 0
DISPOSAL BRACKISH PORTION IS CALCULATED FROM TOTAL BRACKISH IN - OTHER BRACKISH WATER USES +/- TANKAGE - BRACKISH WATER INJECTED NORMALLY
DISPOSAL PRODUCED PORTION IS CALCULATED FROM TOTAL DISPOSAL - DISPOSAL PRESH - DISPOSAL BRACKISH
SIMPLIFIED WATER BALANCE
BITUMEN PRODUCTION 6,360 m3/d (40,000 bpd)
SOR = 3, RR = 10%
SCALE SIZE DRAWING NUMBER REV
NONE B FIGURE C2.1-3 A



ENERGY BALANCE
BITUMEN PRODUCTION 6,360 m^3/d (40,000 bpd)
SOR = 3, RR = 10%

SCALE	SIZE	DRAWING NUMBER	REV
NONE	B	FIGURE C2.1-4	A

C2.2 SAGD - Production Pads and Horizontal Wells

The SAGD process involves drilling two long horizontal wells that are separated vertically by approximately 5 m. The upper wellbore is used to inject steam into the reservoir. The injected steam adds energy in the form of heat to the reservoir, mobilizing the bitumen. The mobilized bitumen then flows by gravity to the lower production wellbore where fluids are gathered and brought to surface. Figure C2.2-1 presents typical wellbore geometries proposed by North American.

C2.2.1 Well Pad Layout and Design

Reservoir characteristics, surface features, directional drilling technologies and well pair completion design influence the location and surface layout of each well pad.

Well pads will consist of one row of well pairs and may accommodate from 4 to 6 well pairs depending on the reservoir continuity and well bore trajectory requirements. Pads are expected to have a total footprint of approximately 157 m x 289 m in size. Eleven well pads are proposed for the initial development area of the Corner Hub. Figure C2.2-2 shows a typical well pad layout during drilling operations.

Each well pad includes the following systems and equipment;

- High pressure steam distribution pipeline and header system to each well pad.
- Steam injection meters and flow controllers to independently control the steam flow to the toe and heel of each injector.
- Produced fluids gathering lines and flow meters to provide a rough measurement of flow from each producer on a continuous basis.
- A test manifold with separation and analysis equipment to measure the bitumen and water flow from each producer well. Producers will be tested on a routine basis in accordance with regulatory requirements.
- Electric pumps to deliver the produced bitumen and water to the CPF in a surface pipeline.
- A vapour collection header to route produced gas from each producer wellhead to an electric compressor, which in turn delivers the produced gas from all the wells to the CPF in a pipeline.
- Metering and sampling equipment to monitor the flow rate and composition of the produced gas.
- A pop tank to capture emergency relieving conditions and drain liquids from pipelines.
- Control system connections to the CPF via programmable logic controllers and supervisory control and data acquisition systems (PLC/SCADA).
- Access road to the CPF for vehicle and equipment traffic.
- 25 kilovolt overhead power supply, transformer, motor control equipment and electrical backup diesel generator for electric loads at each well pad.