- trace elements and metals (antimony [Sb], arsenic [As], barium [Ba], beryllium [Be], boron [B], cadmium [Cd], chromium [Cr], cobalt [Co], copper [Cu], lead [Pb], mercury [Hg], molybdenum [Mo], nickel [Ni], selenium [Se], thallium [Tl], uranium [U], vanadium [V], and zinc [Zn];
- petroleum hydrocarbon fractions 1 through 4G (PHC F1 through F4G);
- benzene, toluene, ethylbenzene and xylenes (BTEX); and
- polycyclic aromatic hydrocarbons (PAHs).

Analytical data are summarized in Table App-1B. The analyzed parameters which were measured at concentrations/levels exceeding the generic CCME soil quality guidelines included:

Parameter	Range of Values	95th Percentile Value
EC	0.35 to 2.7 dS/m	2.3 dS/m
As	4.0 to 15 mg/kg	9 mg/kg
Mo	1.2 to 45 mg/kg	9.9 mg/kg
Se	0.25 to 3.0 mg/kg	0.93 mg/kg
Tl	0.15 to 2.6 mg/kg	Not calculated

In addition to the above noted guideline exceedances at background locations, concentrations of one or more BTEX and PHC parameters below the applicable CCME guidelines were present in all of the samples analyzed. Maximum reported values for Island Subsurface Soil included: Benzene (0.0025 mg/kg), Toluene (0.01 mg/kg), Ethylbenzene (0.02 mg/kg), Xylenes (0.02 mg/kg), PHC F1 (31 mg/kg), PHC F2 (220 mg/kg), PHC F3 (410 mg/kg) and PHC F4 (130 mg/kg). The naturally occurring levels of PHC F3, in particular, should be considered when determining appropriate soil remediation objectives relative to background conditions. The reported maximum PHC F2 concentration exceeds the CCME Parkland use guideline (150 mg/kg) for fine-grained surface soil. This hydrocarbon exceedance was at one location (BIBG-10-3 @ 0.3-0.6 mbgs).

None of the PAH analytical results for background locations exceeded the applicable CCME Parkland use guidelines for fine-grained surface soil.

The few (three) locations with EC values above CCME Parkland guidelines are not associated with chloride, a typical indicator of industrial impact. Based on the available data set, it is considered likely that the above listed parameters and concentrations are naturally occurring.

1.2.3 Background Bedrock Chemistry

Siltstone

Samples of the weathered siltstone bedrock encountered in the majority of sampling locations on the Mainland were collected from four background locations. A total of eight samples have been analyzed to date for chemical analyses, including:

- detailed salinity (pH, electrical conductivity [EC], major soluble ions [calcium, sodium, magnesium, potassium, sulphate and chloride], and sodium adsorption ratio [SAR];
- trace elements and metals (antimony [Sb], arsenic [As], barium [Ba], beryllium [Be], boron [B], cadmium [Cd], chromium [Cr], cobalt [Co], copper [Cu], lead [Pb], mercury [Hg], molybdenum [Mo], nickel [Ni], selenium [Se], thallium [Tl], uranium [U], vanadium [V], and zinc [Zn];
- petroleum hydrocarbon fractions 1 through 4G (PHC F1 through F4G);
- benzene, toluene, ethylbenzene and xylenes (BTEX); and
- polycyclic aromatic hydrocarbons (PAHs).

Analytical data are summarized in Table App-1B. The analyzed parameters which were measured at concentrations/levels exceeding the generic CCME soil quality guidelines included:

Parameter	Range of Values	95th Percentile Value
SAR	0.28 to 26	17.9
As	7.6 to 24 mg/kg	23 mg/kg
Ni	22 to 64 mg/kg	63 mg/kg
PHC F2	5 to 1200 mg/kg	899 mg/kg
PHC F3	58 to 2900 mg/kg	2144 mg/kg

In addition to the above noted guideline exceedances at background locations, concentrations of PHC F1 and F4 parameters below the applicable CCME guidelines were present in all of the samples analyzed. Maximum reported values for siltstone bedrock included: PHC F1 (80 mg/kg) and PHC F4 (1,100 mg/kg). The naturally occurring levels of PHC F3, in particular, should be considered when determining appropriate soil remediation objectives relative to background conditions.

The elevated hydrocarbon concentrations that are intermittently reported in the Mainland siltstone bedrock are interpreted to be associated with the presence of natural hydrocarbon seeps that have been documented throughout the Site, particularly on the lower terrace of the Mackenzie River where bedrock may be present at or near surface. The seeps generally occur at the mineral soil/bedrock interface. This interface is found at greater depths with distance from the river.

None of the PAH analytical results for background location bedrock samples exceeded the applicable CCME land use guidelines for fine-grained surface soil.

The few (three) locations with EC values above CCME Parkland guidelines are not associated with chloride, a typical indicator of industrial impact. Based on the available data set, it is considered likely that the above listed parameters and concentrations are naturally occurring.

Shale

As noted above, shale bedrock from the Town of Norman Wells quarry located to the northeast of the IOL Site has been extracted for use as fill material both on the Site and throughout the developed Town site.

To date, a limited number of shale samples have been collected for laboratory analysis for the purpose of characterizing background conditions. These samples were obtained from the Town of Norman Wells quarry rather than the Site, to minimize the potential for industrial effects. Additional investigations are on-going into the potential for this shale fill to affect underlying and adjacent soil and/or water chemistry.

Analytical results for four shale samples have been included in this background characterization section. The analysis included pH, and trace elements/metals.

Analytical data are summarized in Table App-1B. The analyzed parameters which were measured at concentrations/levels exceeding the generic CCME soil quality guidelines included:

Parameter	Range of Values	95th Percentile Value
As	7.19 to 42.9 mg/kg	39.6 mg/kg
Mo	29.8 to 66.4 mg/kg	64.7 mg/kg
Se	4.38 to 7.9 mg/kg	7.56 mg/kg
Tl	0.88 to 2.33 mg/kg	2.29 mg/kg

Summary

From the review of the available background data, some general trends are apparent:

- concentrations of one or more metals/trace elements (As, Mo, Ni, Se, Tl and Zn) exceeding CCME guidelines have been confirmed in background organic surface soil, mineral subsurface soil, and underlying siltstone bedrock on the Mainland.
- concentrations of As, Mo, Se and Tl exceeding CCME guidelines have also been confirmed in shale bedrock samples collected from the Town of Norman Wells quarry. This shale material is used as fill throughout the Site and the adjacent Town.

- above guideline SAR values have been measured/calculated for a limited number of mineral subsurface soil samples on the Mainland, as well as the siltstone bedrock.
- in the Island soils, background metals concentrations in surface mineral soil are typically below CCME Parkland use guidelines. However, several metals (As, Mo, Se, Tl) may be present at concentrations above guidelines in the subsurface soil.
- EC levels above CCME Parkland guidelines (2 dS/m) may be present in both organic and mineral soil on both the Islands and the Mainland. The EC is typically associated with concentrations of sulphate, calcium and magnesium ions rather than chloride, an indicator of industrial activities.
- one or more BTEX and PHC F1 through F4 parameter concentrations above detection limits but generally below CCME guidelines have been reported in all strata and may be associated with organic matter and / or hydrocarbon seeps at the bedrock / soil interface, particularly in the vicinity of the Mackenzie River.
- background data sets for the organic and mineral surface soil on the Islands, as well as the underlying bedrock are very limited and should be interpreted/referenced with caution.

2. GLOSSARY OF SOIL QUALITY PARAMETERS

2.1 General Soil Parameters

pH

Soil pH provides a measurement of the relative acidity/alkalinity of a soil/water solution, and is strongly dependent on the salt concentration in the solution. Soil pH could be affected by both natural processes (vegetation cover and geology), and industrial activities (accidental release of acids, or caustic substances). Soil pH <4.5 will result in reduced crop yield, and pH >8.5 will limit fertilizer and micronutrient uptake from the soil by plants. The optimum soil pH range for growth of most plant species is typically 6.0 to 8.0. However, local geological and biological conditions can result in natural soil pH outside this range. For example, soil developed under coniferous forest cover (spruce or pine) or muskeg (sphagnum peat) is naturally acidic with pH below 6.

Electrical Conductivity (EC)

Soil EC is a measure of a dissolved salts in a soil/water solution, prepared at a specified ratio. The accumulation of soluble salts (e.g. sodium (Na) and chloride (Cl)) may affect plant growth by limiting moisture availability, creating nutrient imbalances, or producing ion-specific toxicity. Plants such as rye grass, wheat grass, alfalfa and sweet clover are able to grow in soil with higher EC (>8 deci-siemens per metre (dS/m)), whereas plants such as potatoes, peas, timothy and red clover have quite low tolerance for higher salt concentrations in the soil (prefer EC <4 dS/m). Plant responses to EC, measured in dS/m, include:

EC (dS/m)	Plant Response
0 - 2	No salinity problems
2 - 4	Restricts growth of salt sensitive plants, delays seed germination
4 – 8	Restricts growth of most plants
8 – 14	Restricts growth of all except salt tolerant plants, seed germination reduced or prevented
>14	Prevents growth of almost all plants

Note that naturally saline (e.g. marine) environments have a different (higher) baseline salinity, and vegetation may have already adapted to naturally higher salt levels in the soil.

Sodium Adsorption Ratio (SAR)

Soil sodicity is expressed as SAR, which is a ratio of sodium to calcium and magnesium concentrations present in the soil solution. High SAR can have an adverse effect on soil structure by creating “hard pan” layers in the profile, which in turn restrict plant root development and infiltration of precipitation. Soil structure is not usually affected at an SAR value less than 7 or 8. The SAR guidelines in the NT have been set at 5 for Parkland use, and 12 for Industrial land use.

2.2 Major Ions

Calcium (Ca) and Magnesium (Mg)

Calcium and magnesium naturally present in soil result from the weathering of Ca and Mg-rich rocks. These parameters are not usually indicators of contamination in soil. There are no current regulatory guidelines for Ca or Mg in soil. Soluble salt levels are measured and monitored indirectly through the EC parameter noted above.

Sodium (Na)

Sodium is a naturally occurring element; however, if present in large concentrations, soil structure can be adversely affected. There is no current regulatory guideline for sodium levels in soil – this parameter is usually measured indirectly through the SAR ratio noted above.

Potassium (K)

Potassium is an essential nutritional element for humans, animals and plants, and is naturally occurring in soils. However, at high concentrations (>100 milligrams per litre (mg/L)) this constituent may be an indicator of spills of specific materials such as drilling muds/fluids. There is no current regulatory guideline for potassium in soil. Soluble salt levels are measured and monitored indirectly through the EC parameter noted above. Optimum available potassium levels for good plant growth should be around 200 parts per million (ppm).

Chloride (Cl) Higher chloride levels in soil (i.e. >500 mg/L) can be an indicator of industry related impact; as this constituent is not usually present at high concentrations in a natural non-marine, non-saline environment. However, in marine or naturally saline environments, high concentrations (>1,000 mg/L) of chloride may be common in soils. There is no current regulatory guideline for chloride in soil. Soluble salt levels are measured and monitored indirectly through the EC parameter noted above.

Sulphate (SO_4) High concentrations of soluble sulphate in soils (i.e. >1,000 mg/L) are usually an indicator of naturally occurring salinity. There is no current regulatory guideline for sulphate in soil. Soluble salt levels are measured and monitored indirectly through the EC parameter noted above. Optimum levels of sulphate for good plant growth are around 10 ppm available sulphate.

Nitrate and Nitrite (NO_3 and NO_2) Nitrate and nitrite occur in natural and contaminated soil. Common sources include food preservatives, commercial fertilizers, sewage and manure. Nitrate presence in soil is essential for plant growth; optimum levels are plant-specific, but should generally be around 40 ppm available nitrate.

2.3 Secondary Constituents

Metals Metals in soil naturally result from the weathering of mineral and rock fragments present in the subsurface. Industry related sources may include commercial fertilizers, sewage, drilling fluids/muds, process waters, industrial combustion and smelting activities. When present at high concentrations, some metals can be toxic to plants and soil micro-organisms. At northern sites, metals are of particular importance as certain constituents (e.g. arsenic, molybdenum, nickel, selenium) occur naturally at high concentrations due to the bedrock geochemistry. There are a number of metals that are currently regulated by NT and CCME as listed below, along with the respective CCME (1999 and updates) Parkland and Industrial guideline concentrations, and interpreted background levels in milligrams per kilogram (mg/kg).

Metals	Parkland Guideline (mg/kg)	Industrial Guideline (mg/kg)	Interpreted Background Level (mg/kg)
Arsenic (As)	12	12	See Table App-B2
Barium (Ba)	500	2,000	
Cadmium (Cd)	10	22	

Metals	Parkland Guideline (mg/kg)	Industrial Guideline (mg/kg)	Interpreted Background Level (mg/kg)
Chromium (Cr)	64	87	
Hexavalent Chromium (Cr^{6+})	0.4	1.4	
Cobalt (Co)	50	300	
Copper (Cu)	63	97	
Lead (Pb)	140	600	
Mercury (Hg)	6.6	50	
Molybdenum (Mo)	10	40	
Nickel (Ni)	50	50	
Selenium (Se)	1	3.9	
Thallium (Tl)	1	1	
Zinc (Zn)	200	360	

2.4 Soil – Volatile Organics

BTEX

BTEX is comprised of four different constituents - benzene, toluene, ethylbenzene, and xylenes. Benzene is a common constituent of gasoline, but may also be associated with unrefined petroleum products. This compound is the most soluble of the BTEX constituents, and is a known cancer causing agent in humans. Therefore, guidelines of 0.5 mg/kg and 5 mg/kg have been set for NT soils under Parkland and Industrial use respectively. Under CCME, the most conservative recent benzene guideline for Parkland and Industrial use, fine-grained soil, drinking water protection pathway, is 0.0068 mg/kg.

Toluene, ethylbenzene and xylenes primarily originate from the petroleum industry, but are also present in various solvents, gasoline additives, and manufactured chemicals. Unlike benzene, these compounds are not classified on the basis of potential health effects. This is a function of their differing physical and chemical properties. The current NT soil guidelines for toluene, ethylbenzene and xylenes under Industrial land use, fine-grained soil, groundwater protection pathway, are 0.8 mg/kg 20 mg/kg and 20 mg/kg, respectively. However, the most recent CCME soil guidelines for these same parameters are 0.08 mg/kg, 0.018 mg/kg, and 2.4 mg/kg, respectively.

2.5 Soil – Hydrocarbons

Petroleum Hydrocarbon Fractions 1 (PHC F1), 2 (PHC F2), 3 (PHC F3) and 4 (PHC F4)

Petroleum products such as crude oil, jet fuel, and heating oil contain numerous compounds in varying proportions. For the purpose of regulating these compounds, CCME (2008) and NT have classified the hydrocarbons on the basis of specified ranges of carbon present. For soils, petroleum hydrocarbon fractions (PHC) include F1 (C6 to C10 excluding BTEX), F2 (>C10 - C16), F3 (>C16 - C34), and
F4 (>C34 - C50+). Due to the more complex molecular structure, these compounds tend to be less soluble than the lighter hydrocarbons, such as the BTEX components. As soil texture is one of the primary factors governing hydrocarbon migration through soil, regulatory guidelines have been recommended for both fine- and coarse-grained soil as defined by having a median grain size <75 µm (fine) or >75 µm (coarse).

The CCME PHC guidelines for soil are currently set as follows for Parkland and Industrial land uses (based on ecological soil contact pathway).

Land Use	Soil Texture	PHC F1 (mg/kg)	PCH F2 (mg/kg)	PCH F3 (mg/kg)	PCH F4 (mg/kg)
Parkland	Fine	210	150	1,300	5,600
	Coarse	30	150	300	2,800
Industrial	Fine	320	260	2,500	6,600
	Coarse	320	260	1,700	3,300

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, from the burning of tobacco, and are present in charbroiled foods. PAHs are also present in crude oil, bitumen, coal, tar pitch, creosote, and roofing tar. These organic compounds generally occur as complex mixtures (for example, as part of combustion products such as soot), and not as single compounds.

PAHs enter the environment mostly as releases to the air from volcanoes, forest fires, residential wood burning, exhaust from automobiles and trucks and discharges from industrial facilities. These compounds tend to adsorb to organic matter in the subsurface, and are therefore not that mobile. Exposure of animals to high concentrations of some PAHs has been linked to the development of cancer.

NT and CCME regulatory soil guidelines for some of the more common PAHs include.

PAH	Parkland Guideline (mg/kg)	Industrial Guideline (mg/kg
Benzo(a)pyrene	0.7	0.7
Naphthalene	0.6	22
Phenanthrene	5	50
Pyrene	10	100

3. REFERENCES

CCME (Canadian Council of Ministers of the Environment), 1999 and updates. Canadian Environmental Quality Guidelines. Updated September 2007.

CCME (Canadian Council of Ministers of the Environment), 2008. Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil. Canadian Council of Ministers of the Environment, Winnipeg. January 2008.

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Table App-1A

BACKGROUND SOIL/BEDROCK SAMPLING LOCATIONS

AREA	LOCATIONS							
	Organic Surface Soil		*Mineral Surface Soil*		*Mineral Subsurface Soil*		*Bedrock*	
	Borehole ID	No. of Samples	Borehole ID	No. of Samples	Borehole ID	No. of Samples	Borehole ID	No. of Samples
Mainland	PEAT 03-01	1	MCBG-12-1	1	CLAY PIT#1	1	SILTSTONE	
	PEAT 03-02	1	MLS-09-22	1	CLAY PIT#2	1	MEBG-12-2	1
	S98-35A	1	S12-6	6	A45X OVERBURDEN 1	1	MWBG-10-01	1
	MCBG-10-02	1	MWBG-10-03	1	A45X OVERBURDEN 2	1	MEBG-10-3	4
	MEBG-10-01	1	MWBG-12-2	1	B38X98-1	2	MWBG-12-2	2
	MEBG-12-1	1			WBIO 08-1	2		
	MEBG-12-2	1			WBIO 08-2	2		
	MWBG-10-01	1			WBIO 08-3	2		
	MWBG-10-02	1			MCBG-10-02	3	SHALE	
	MWBG-12-1	1			MCBG-12-1	3	S12-Quarry 1	1
					MEBG-10-01	3	S12-Quarry 2	1
					MEBG-10-2	4	S12-Quarry 3	1
					MEBG-12-1	2	SHALE-1	1
					MEBG-12-2	2		
					MWBG-10-01	2		
					MWBG-10-02	3		
					MLS-09-22	1		
					MWBG-12-1	2		
					MWBG-10-03	4		
					MWBG-12-2	2		
Bear / Frenchy's/Goose Islands	BI 08-01	1	BIBG-10-3	1	BI 08-01	2	--	0
			BIBG-10-2	1	BIBG-10-3	4		
			FIBG-10-1	1	BIBG-10-2	4		
			GIBG-10-1	1	BIBG-10-1	2		
			GIBG-10-2	1	BIBG-12-1	5		
					BIBG-12-2	3		
					FIBG-10-1	3		
					GIBG-10-1	3		
					GIBG-10-2	4		

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Table App-1B
Soil and Bedrock Background Geochemical Statistical Summary

Background Geochemical Statistics for Soil and Bedrock: Salinity Parameters

Imperial Oil - Norman Wells	pH (pH units)	EC (dS/m)	SAR (ratio)
CCME Residential/Parkland Fine Surface	6 - 8	2	5
CCME Industrial Fine Surface	6 - 8	4	12
95th Percentile Background - Organic Surface Soil (Mainland)	7.54	2.35	0.45
Maximum Background - Organic Surface Soil (Mainland)	7.57	2.7	0.5
95th Percentile Background - Mineral Surface Soil (Mainland)	7.53	0.76	1.8
Maximum Background - Mineral Surface Soil (Mainland)	7.72	0.78	2
95th Percentile Background - Mineral Surface Soil (Islands)	7.76	2.7	0.72
Maximum Background - Mineral Surface Soil (Islands)	7.77	2.9	0.8
95th Percentile Background - Mineral Subsurface Soil (Mainland)	8.1	1.82	2.26
Maximum Background - Mineral Subsurface Soil (Mainland)	8.1	2.4	2.2
95th Percentile Background - Mineral Subsurface Soil (Islands)	7.78	2.3	0.46
Maximum Background - Mineral Subsurface Soil (Islands)	7.81	2.7	0.54
95th Percentile Background - Bedrock (Mainland Siltstone)	7.76	0.95	17.9
Maximum Background - Bedrock (Mainland Siltstone)	7.78	0.97	26

Background Geochemical Statistics for Soil and Bedrock: Metals and Trace Elements

Imperial Oil - Norman Wells	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Boron (Hot Water Soluble) (mg/kg)	Cadmium (mg/kg)	Chromium (6+) (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Thallium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
CCME Residential/Parkland Fine Surface	20	12	500	4	--	10	0.4	64	50	63	140	6.6	10	50	1	1	23	130	200
CCME Industrial Fine Surface	40	12	2000	8	--	22	1.4	87	300	91	600	50	40	50	2.9	1	300	130	360
95th Percentile Background - Organic Surface Soil (Mainland)	NC	16.6	424	1.2	3.55	3.85	NC	48.5	25.9	76.2	17.6	NC	45.4	29.1	68.6	NC	6	51.5	357
Maximum Background - Organic Surface Soil (Mainland)	2	17.1	430	1.4	4.1	5.6	0.15	65	26	98.1	18.1	0.14	46.8	29.9	81.6	2.5	7	56	435
95th Percentile Background - Mineral Surface Soil (Mainland)	NC	9.5	399	0.81	0.85	0.94	NC	21.9	10.2	21.6	11	NC	1.86	31	0.65	0.15	1.1	43.8	133.8
Maximum Background - Mineral Surface Soil (Mainland)	0.5	11	402	0.87	0.89	1.09	0.075	22	11	23	11	0.09	2	33	0.67	0.15	1.2	45.1	150
95th Percentile Background - Mineral Surface Soil (Islands)	Nc	7.8	346	NC	Nc	0.6	Nc	26.6	7.8	16.4	11.4	NC	3.84	30	0.6	Nc	Nc	24.6	84.6
Maximum Background - Mineral Surface Soil (Islands)	0.5	8	390	0.2	0.3	0.6	0.075	30	8	37	12	0.07	4.1	32	0.6	0.15	1	25	85
95th Percentile Background - Mineral Subsurface Soil (Mainland)	NC	27.1	340	0.9	4.01	0.92	NC	37	19	38	16	NC	6.1	63	1.3	NC	NC	50	156
Maximum Background - Mineral Subsurface Soil (Mainland)	1	49	390	1.4	10	2	0.18	39	25	45	26	0.33	11	127	2.7	0.8	2.3	66	350
95th Percentile Background - Mineral Subsurface Soil (Islands)	NC	9	337	NC	0.41	0.68	NC	17	8.8	23	11.7	NC	9.9	30	0.93	NC	NC	34	96
Maximum Background - Mineral Subsurface Soil (Islands)	2	15	400	0.55	0.58	0.7	0.075	20	9.4	25	12	0.07	45	35	3	2.6	3	61	120
95th Percentile Background - Bedrock (Mainland Siltstone)	NC	29	257	0.83	2.4	NC	NC	42	22	45	13.6	NC	NC	63	NC	NC	NC	84	140
Maximum Background - Bedrock (Mainland Siltstone)	0.5	34	240	0.95	3.1	0.37	0.075	42	22	53	15	0.12	1.5	64	0.25	0.15	0.5	94	150
95th Percentile Background - Bedrock (Mainland Shale)	2.12	38.6	354	0.65	NC	0.74	NC	51.2	6.97	42.5	10.8	0.284	64.7	49.2	7.56	2.29	NC	125.7	106.2
Maximum Background - Bedrock (Mainland Shale)	2.13	42.9	370	0.66	NC	0.82	NC	53.6	7.16	43.6	11	0.312	66.4	49.6	7.9	2.33	NC	129	108

Background Geochemical Statistics for Soil and Bedrock: Petroleum Hydrocarbon Parameters

Imperial Oil - Norman Wells	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Xylenes (Total) (mg/kg)	PHC-F1 (-BTEX) (mg/kg)	PHC-F2 (mg/kg)	PHC-F3 (mg/kg)	PHC-F4 (mg/kg)
CCME Residential/Parkland Fine Surface *	2.1	110	120	65	210	150	1300	5600
CCME Industrial Fine Surface *	2.8	330	430	210	320	260	2500	6600
95th Percentile Background - Organic Surface Soil (Mainland)	NC	NC	NC	NC	NC	NC	442	231
Maximum Background - Organic Surface Soil (Mainland)	0.17	0.24	0.29	0.6	29	150	460	240
95th Percentile Background - Mineral Surface Soil (Mainland)	NC	NC	NC	NC	NC	NC	93	54
Maximum Background - Mineral Surface Soil (Mainland)	0.0025	0.01	0.005	0.02	NC	19	97	57
95th Percentile Background - Mineral Surface Soil (Islands)	NC	NC	NC	NC	NC	61.6	322	122
Maximum Background - Mineral Surface Soil (Islands)	0.0025	0.01	0.019	0.087	14	72	370	140
95th Percentile Background - Mineral Subsurface Soil (Mainland)	NC	NC	NC	NC	NC	NC	401	141
Maximum Background - Mineral Subsurface Soil (Mainland)	0.019	0.18	0.059	0.34	21	72	530	220
95th Percentile Background - Mineral Subsurface Soil (Islands)	NC	NC	NC	NC	NC	NC	304	NC
Maximum Background - Mineral Subsurface Soil (Islands)	0.0025	0.01	0.02	0.02	31	220	410	190
95th Percentile Background - Bedrock (Mainland)	NC	NC	NC	NC	67.4	899	2144	859
Maximum Background - Bedrock (Mainland)	0.0025	0.01	0.005	0.02	80	1200	2900	1100

* denotes criteria with drinking water protection guideline eliminated
Shading indicates parameters above most restrictive guidelines selected

Appendix I

Groundwater Background Data (from Imperial 2015)

APPENDIX E
DETERMINATION OF GROUNDWATER GEOCHEMICAL BACKGROUND AND GLOSSARY OF GROUNDWATER QUALITY PARAMETERS

1. DETERMINATION OF GROUNDWATER GEOCHEMICAL BACKGROUND

In order to effectively evaluate the origin of groundwater parameters which may exceed regulatory guidelines (in this case, CCME FWAL criteria), it is important to defensibly determine naturally occurring background concentrations for the parameters of interest. Background monitoring wells would ideally be installed in an undisturbed, up-gradient area, isolated from any potential sources of anthropogenic impact. However, these locations tend to be heavily influenced by permafrost in the vicinity of Norman Wells. Previous attempts to install background wells in up-gradient areas of the lease, removed from the IOL facilities and in areas of natural vegetation, have resulted in rapidly frozen groundwater monitoring wells that consistently remain frozen. As such, the use of the term “background” in this report does not necessarily mean the groundwater monitoring well is installed in an undisturbed, up-gradient area. Rather, the term is used for locations inferred to be removed from site facilities and free of facility-related impacts.

In an effort to improve characterization of background soil and groundwater conditions, the 2010 and 2012 Phase II ESA programs focused on installation of new potential background wells in surficial sediments. This included six new wells on the Natural Islands and 5 wells distributed throughout Mainland East, Central, and West areas over the past three years. As a result of these new wells, supplemented by annual groundwater sampling from 1997 to 2012, a sufficient database has now been compiled to determine a statistical background for key geochemical parameters from a range of hydrogeological units of interest. As summarized in Table App -1C, 24 wells within the monitoring network have been identified as background locations. These wells are separated into four groups, based on the hydrogeological zone where the well screen is completed, as follows:

- surficial sediments on Mainland (10 wells, nine producing water, total 28 samples);
- surficial sediments on Natural Islands (seven wells, all producing water, total 20 samples);
- shallow bedrock on Mainland (three wells, all producing water, total 21 samples); and
- deeper bedrock on Mainland (four wells).

Data from the first three hydrogeological is of primary interest for analysis of the environmental monitoring results collected to date. As such the statistical background analyses concentrated on these categories. The deep bedrock category is not characterized to the same extent, and considering that groundwater quality in the deeper bedrock is less important for comparison to the environmental monitoring program, deeper bedrock data will not be considered further in this discussion.

A geometric mean, minimum, maximum, and 95th percentile value for each parameter listed below was determined for each of the three hydrogeological units of interest.

Indicator Parameters		
pH	Iron	Nitrite as N
Chloride	Sulphate	Nitrate as N
DOC	TDS	Phenols
Fluoride		
Hardness		

Dissolved Metals and Trace Elements			
Aluminum	Boron	Mercury	Thallium
Antimony	Cadmium	Molybdenum	Titanium
Arsenic	Chromium	Nickel	Uranium
Barium	Copper	Selenium	Zinc
Beryllium	Lead	Silver	

One of the key aspects of the statistical calculations is the method of dealing with results reported below the laboratory method detection limit (MDL), which is a frequent occurrence with some of the dissolved trace metals in particular. In order to calculate the 95th percentile value, a real number is required rather than a “less than” result. The approach used was as follows. In cases where the MDL is the normal precision reported for that particular parameter, then a real number value of ½ the MDL is used in the calculation. For example, if the dissolved copper result was reported as <0.001 mg/L, then a real number value of 0.0005 mg/L is assumed for the statistical calculations. In cases where matrix interferences increase the MDL, this method cannot be used and the data point is typically discarded for the purpose of the 95th percentile calculation. Note that although this method is acceptable for 95th percentile calculations, it is much more problematic in the calculation of geometric means (U.S. EPA Unified Guidance, 2009).

Results of the statisitical analyses are provided in Table App-1D. The following results are of particular note in the interpretation of data in the attached report:

- the CCME FWAL water quality guidelines for a number of trace metals vary depending on the pH and total hardness of the water (see footnotes of Table 9). For the purpose of selecting appropriate guidelines for comparison to Norman Wells water samples, the pH value is considered greater than 6.5, and the total hardness as calcium carbonate (CaCO3) is greater than 180 mg/L (very hard water). The 95th percentile value for groundwater samples from background locations was as follows:
  - surficial sediments on mainland, pH of 7.1 and hardness of 1,345 mg/L;
  - surficial sediments on islands, pH of 7.2 and hardness of 1,681 mg/L; and
  - shallow bedrock, pH of 7.8 and hardness of 254 mg/L.
- the attached analysis of background geochemistry in local groundwater has intentionally avoided using chloride values derived from a background well which is located within a historically documented natural seepage zone on the Mackenzie River shore, directly south of the Former Refinery. Well NWR 03-38-3 represents a natural crude oil and saline formation water seepage zone, where shallow bedrock subcrops within a few metres of ground surface under sediments along the shoreline. Chloride readings from this well, on the order of 250 mg/L, have been discounted in the determination of the 95th percentile chloride value for surficial sediments on the Mainland;
- the 95th percentile analyses indicate that the following parameters may naturally exceed the applied CCME FWAL criteria in groundwater at this site:
  - groundwater from surficial sediments on Mainland sites - iron, phenols, arsenic, cadmium, copper, selenium, uranium, and zinc. Chloride and petroleum hydrocarbons can also occur above the applied guideline in natural seepage zones;
  - groundwater from surficial sediments on Natural Islands sites - iron, phenols, cadmium, copper, selenium, uranium, and zinc; and
  - groundwater from shallow bedrock – chloride, iron, phenols, aluminum, arsenic, copper, and selenium. As noted previously, petroleum hydrocarbons would also be expected within areas of natural seepage in the upper bedrock.

2. GLOSSARY OF GROUNDWATER TERMS

2.1 General Water Parameters

pH

One of the main objectives in controlling the pH is to minimize corrosion and encrustation in the household water distribution system. This can result from the complex relationships between pH and other constituents, such as carbon dioxide, hardness, alkalinity and temperature. The Canadian Council of Ministers

of the Environment (CCME 2007 and updates) guideline for protection of Freshwater Aquatic Life (FWAL) is 6.5 to 9.0.

Alkalinity

Alkalinity is caused by the presence of carbonates, bicarbonates and hydroxides of various minerals. Not considered to be detrimental to humans, alkalinity is generally associated with pH values, hardness, and the presence of excessive amounts of dissolved solids. There is no set limit for alkalinity in the current CCME FWAL guidelines.

Electrical Conductivity (EC)

EC is a measure of the water's capacity to carry electrical current. This is in turn, directly related to the concentration of ionized inorganic compounds in the water. Values of EC can vary considerably from well to well, and depend on the well location, depth of completion, and type of aquifer sediments completed in. Values in excess of 2,000 μS/cm would be considered elevated for fresher waters. There is no set limit for EC in the current CCME FWAL guidelines.

Hardness (as $CaCO_3$)

Public acceptability of the degree of hardness may vary considerably from one community to another. The hardness of water is caused by dissolved, polyvalent ions (principally calcium and to a lesser extent magnesium). Depending on the interaction of other factors, such as pH and alkalinity, water with a hardness above 200 mg/L may cause the build-up of scale deposits in water delivery systems. There is no set limit for hardness in the current CCME FWAL guidelines.

2.2 Major Ions

Calcium (Ca)

Calcium in groundwater results from the weathering of Ca-rich rocks and soils. It is important as a constituent or hardness (see hardness). Excess calcium may be detrimental for domestic uses such as washing, bathing, and laundering because of its tendency to neutralize soap and cause encrustations plumbing fixtures. There is no set limit in the current CCME FWAL guidelines.

Magnesium (Mg)

Magnesium is also a constituent of hardness, and an essential element in human metabolism. At high concentrations, magnesium may have a laxative effect, particularly upon new users. Nevertheless, the body can develop a tolerance over time. There is no direct evidence of adverse health effects associated with magnesium; therefore no limit has been set for Canadian drinking water. There is no set limit in the current CCME FWAL guidelines.

Sodium (Na)	Sodium is not considered to be acutely toxic to humans, and up to 5 grams/day are consumed by the average person without apparent adverse effects. The average intake of sodium from water is only a small fraction of that consumed in a normal diet. There is no set limit in the current CCME FWAL guidelines.
Potassium (K)	Potassium is an essential nutritional element in human metabolism. However, at high concentrations (>1,000 mg/L) this constituent may have laxative effects. Concentrations rarely exceed this value (in most potable aquifers). There is no set limit in the current CCME FWAL guidelines.
Chloride (Cl)	Concentrations of chloride are generally quite low in most shallow groundwater systems. However, due to the presence of natural shallow seeps containing hydrocarbon and associated produced water at the Norman Wells site, significant measurable chloride can be locally present. The current CCME FWAL guidelines is 120 mg/L chloride.
Sulphate (SO_4)	No serious health effects are associated with high sulphate levels. At concentrations above 500 mg/L, sulphate may impart a noticeable taste to the water and cause a laxative effect in occasional users. There is no set limit in the current CCME FWAL guidelines.
Bicarbonate (HCO_3)	Bicarbonate is formed by the weathering of organic matter and carbonate-bearing minerals (e.g. limestone) present in the subsurface. The concentration of this anion in natural and contaminated waters is related to such factors as temperature, pH, concentrations of other dissolved solids, and biological activity. This parameter is not considered a health hazard. There is no set limit in the current CCME FWAL guidelines.

2.3 Secondary Constituents

Nitrate and Nitrite (NO_2 and NO_3)	Nitrite-nitrogen (NO_2) and nitrate-nitrogen (NO_3) occur in natural and contaminated waters. The current CCME FWAL guidelines are 0.06 mg/L and 3.0 mg/L for nitrite and nitrate as N, respectively.
Iron and Manganese (Fe and Mn)	Although iron and manganese are essential elements in humans and animals, drinking water is not considered to be an important source. At high enough levels these metals can stain laundry and plumbing fixtures, and causes an undesirable taste in beverages. The precipitation of excess iron gives an objectionable reddish-brown colour to drinking water. There is no set limit in the current CCME FWAL guidelines for manganese. The CCME FWAL guideline for dissolved iron is 0.3 mg/L.

Trace Metals

Metals are a common occurrence in groundwater, and result from the weathering of mineral and rock fragments present in the subsurface. There are a number of dissolved metals, other than iron and manganese, which are currently regulated for protection of Freshwater Aquatic Life under the Canadian Council of Ministers of the Environment guidelines (CCME 2007 and updates).

2.4 Organic Indicators

Dissolved Organic Carbon (DOC)

DOC provides a measure of the total amount of dissolved organic matter in water. This bulk parameter cannot be used to distinguish between the various compounds making up the organic loading of a sample; therefore it is only used as an indicator of organic loading.

High DOC readings can be related to soluble compounds originating from the breakdown of natural organic matter in the subsurface, or soluble hydrocarbon components originating from an industrial source. DOC concentrations in most natural waters generally fall within the range of 10 mg/L or less (Hem 1989). Higher concentrations (up to 60 mg/L) can sometimes occur in pore waters associated with organic-rich soils, such as lake and swamp sediments and muskeg deposits (Thurman 1985). There is no current CCME FWAL guideline for DOC.

Phenols (total)

Phenols are a common occurrence in groundwater. This class of compounds is derived from the degradation of natural organic matter, the distillation of wood and coal, and the refining of oil. Phenols are also associated with heavy oil. Phenols are quite soluble in water, and easily degraded by subsurface bacteria. At present the CCME FWAL guideline for phenols is 0.004 mg/L.

Concentrations of total phenols are generally quite low in most natural groundwater systems. However, due to the presence of shallow natural hydrocarbon seeps at the Norman Wells site, measurable phenols are also present.

Phenols analyses are performed at Maxxam Analytics (Maxxam) using the 4-AAP colorimetric method. This method yields a single phenols value. However, there are limitations to the colorimetric method, including interference with other compounds in a sample. Plastics, phenol-decomposing bacteria, oxidizing and reducing substances and alkaline pH can interfere with the natural amount of phenols in a sample. These interferences could result in false-positive results and/or poor precision. However, while limitations are present, the colorimetric method is considered to be a useful screening tool for phenols.

2.5 Volatile Organics

BTEX

BTEX is comprised of four different constituents - benzene, toluene, ethylbenzene, and three isomers of xylene (o-, m-, and p-). BTEX compounds are associated with both refined petroleum products and crude oil, and represent some of the more soluble components of petroleum hydrocarbon mixtures.

The CCME FWAL guidelines for benzene, toluene, and ethylbenzene are 0.37, 0.002, and 0.09 mg/L respectively. There is no current CCME FWAL guideline set for xylenes.

2.6 Hydrocarbons

Total Purgeable Hydrocarbons (TPH)

Due to the more complex molecular structure, these compounds tend to be less soluble than the lighter hydrocarbons, such as the BTEX components.

Total Extractable Hydrocarbons (TEH)

These parameters can only be used to indicate the presence of higher molecular weight hydrocarbons, as the method of analysis is incapable of distinguishing between the different compounds present. However, the results can be used to more fully characterize areas identified by key indicator parameters such as DOC and phenols. Therefore these analyses are useful as an indicator parameter of higher-order hydrocarbons.

Petroleum Hydrocarbon Fractions 1 and 2 (PHC F1, PHC F2)

The former TPH and TEH scans have been replaced with the newer petroleum hydrocarbon fractions, which include PHC F1 (C_6 through C_{10}, excluding BTEX) and PHC F2 ($C_{>10}$ through C_{16}). No CCME FWAL guidelines are defined for PHC F1 and F2.

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Table App-1C

Groundwater Background Wells Geochemical Statistical Summary

Background Geochemical Statistics for Groundwater: Indicators and Phenols

	Field pH (ph units)	Chloride (mg/L)	Dissolved Organic Carbon (DOC) (mg/L)	Fluoride (mg/L)	Hardness (as $CaCO_3$) (mg/L)	Iron (mg/L)	Sulphate (mg/L)	Total Dissolved Solids (TDS) (mg/L)	Nitrite as N (mg/L)	Nitrate as N (mg/L)	Phenols (mg/L)
CCME Freshwater Aquatic Life, 2012	(6.5 - 9)	120	---	---	---	0.3	---	---	0.06	3	0.004
Federal Interim Groundwater Quality Guidelines, Res/Parkland, 2010 [1]	(6.5 - 9)	230	---	0.12	---	0.3	100	---	0.06	3	0.004
95th Percentile Background - Surficial Sediments - Mainland	7.1	15	44	0.4	1345	1.7	720	1945	0.031	0.17	0.021
95th Percentile Background - Surficial Sediments - Islands	7.2	13	no data	no data	1681	3.2	1125	2490	0.025	0.42	0.006
95th Percentile Background - Shallow Bedrock	7.8	332	33	0.3	254	0.8	65	1936	<0.005	<0.02	0.022

Background Geochemical Statistics for Groundwater: Dissolved Metals and Trace Elements

	Aluminium (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)
CCME Freshwater Aquatic Life, 2012	0.1	---	0.005	---	---	1.5	0.00031	0.0089	0.004	0.007
Federal Interim Groundwater Quality Guidelines, Res/Parkland, 2010 [1]	0.1	1.6	0.005	2.3	0.0053	---	0.00031	0.0089	0.004	0.007
95th Percentile Background - Surficial Sediments - Mainland	0.048	0.0160	0.0090	0.79	< 0.001	0.708	0.00046	0.0040	0.014	0.0029
95th Percentile Background - Surficial Sediments - Islands	0.011	0.0005	0.0020	0.22	< 0.001	0.040	0.00042	<0.001	0.012	<0.0002
95th Percentile Background - Shallow Bedrock	0.176	0.006	0.054	6.15	< 0.001	1.36	<0.0001	<0.002	0.016	0.0023

	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Titanium (mg/L)	Uranium (mg/L)	Zinc (mg/L)
CCME Freshwater Aquatic Life, 2012	0.000026	0.073	0.15	0.001	0.0001	0.0008	---	0.015	0.03
Federal Interim Groundwater Quality Guidelines, Res/Parkland, 2010 [1]	0.000026	0.073	0.15	0.001	0.0001	0.0008	0.1	0.3	0.03
95th Percentile Background - Surficial Sediments - Mainland	< 0.00005	0.0030	0.028	0.0020	< 0.0001	< 0.0002	< 0.001	0.025	0.036
95th Percentile Background - Surficial Sediments - Islands	< 0.00005	0.0025	0.025	0.0009	< 0.0001	< 0.0002	< 0.001	0.024	0.030
95th Percentile Background - Shallow Bedrock	< 0.00005	<0.005	<0.008	0.0032	<0.0001	<0.0001	< 0.003	0.0019	0.018

Superscript 1 - Guidelines shown for Federal Interim Groundwater Quality Guidelines for Residential/Parkland Land Use are Tier 2, with the Marine Life pathway eliminated.

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Table App-1D

Background Wells and Hydrogeologic Unit

PROJECT NO. C53761200 Monitoring Station	Depth Interval of Sandpack *(m bgs)*	Dominant Hydrogeologic Unit for Well screen	Lithology Within Screened Interval	Comments
Background Locators With Groundwater from Surficial Sediment				
Mainland Locations				
NWR 03-38-3	0.50 - 3.00	Surficial sediment	Sand and clay	Former refinery area, known seepage zone, shale fill present
B38 93-2-4	less than 4 m	Surficial sediment	no borehole log	Mainland east area, shale fill present
MEBG-10-1-3	1.00 - 3.00	Surficial sediment	Silty Sand / Clayey Silt	Mainland east area, shale wellpad 3 m away
MLS 09-6-2	0.80 - 2.20	Surficial sediment	Silty clay and bedrock	Mainland sumps area, shale roadbed 3 m away
BT3 97-2-5	1.10 - 4.60	Surficial sediment	Silt	Mainland central area, shale roadbed 3 m away
MCBG-10-1-3	0.80 - 2.50	Surficial sediment	Clayey Silt / Peat / Silty Clay	Mainland central area, shale helipad 10 m away
MCBG-12-1-2	0.50 - 3.00	Surficial sediment		Mainland central area, shale roadbed 3 m away
MWBG-10-1-3	0.80 - 2.70	Surficial sediment	Silt / Clay	Mainland west area, shale roadbed 3 m away
MWBG-12-1-3	1.20 - 3.00	Surficial sediment		Mainland west area, shale roadbed 3 m away
WBIO-08-1-2	0.60 - 2.40	Surficial sediment	Sandy clay / Silty sand	Mainland west area, shale roadbed 20 m away
Island Locations				
BI 08-1-4	0.60 - 2.40	Surficial sediment	Silty clay	Bear Island
BIBG-10-1-4	0.78 - 4.10	Surficial sediment	Silty Clay / Sand	Bear Island, shale fill present
BIBG-10-2-4	0.50 - 3.77	Surficial sediment	Sand	Bear Island
BIBG-12-2-4	0.70 - 4.20	Surficial sediment		Bear Island
FIBG-10-1-4	0.69 - 3.97	Surficial sediment	Silty Clay / Sand	Frenchies Island
GIBG-10-1-5	1.20 - 4.50	Surficial sediment	Sandy Silt	Goose Island
GIBG-10-2-3	1.30 - 3.00	Surficial sediment	Sand	Goose Island
Background Locators With Groundwater from Shallow Bedrock				
NWR 98-18-15	11.00 - 14.70	Shallow bedrock	Siltstone	Upgradient of former refinery area
NWR 99-16-17	12.60 - 17.00	Shallow bedrock	Siltstone	Upgradient of former refinery area
RB 02-3-2	0.60 - 3.30	Shallow bedrock	Siltstone / Shale	Former refinery area, known seepage zone, screen intercepts shale
Background Locators Not Used in Statistics (all deeper bedrock)				
B38 00-32-44	37.30 - 43.40	Deep bedrock	Sandstone and shale	delete from list - too deep for our study
BT3 00-28-44	39.50 - 43.30	Deep bedrock	Shale	delete from list - too deep for our study
NWR 00-25-36	30.90 - 36.30	Deep bedrock	Siltstone and shale	delete from list - too deep for our study
NWR 00-26-40	33.30 - 39.60	Deep bedrock	Siltstone	delete from list - too deep for our study

Appendix J

LTMF HELP Model Outputs

Average Annual Values Over 66 Years	0.5 Gravel + HDPE		0.5 Gravel + HDPE 5 m waste soil		0.5 Gravel + HDPE 20 m waste soil		
	66 yrs	(mm)	66 yrs	(mm)	66 yrs	(mm)	
Annual Precipitation	20620	312.42	20620	312.42	20620	312.42	
Runoff	2317.4	35.11	3897.7	59.06	3897.7	59.06	
Evapotranspiration	10840	164.24	15276	231.45	15276	231.45	
Change in Water Storage	10.661	0.16	99.997	1.52	179.34	2.72	
Water budget balance	-0.0003097	0.00	-0.0003097	0.00	-0.00030969	0.00	
soil water	1798	27.24	80395	1218.11	272920	4135.15	
snow water	2518.6	38.16	2518.6	38.16	2518.6	38.16	
lateral drainage in gravel	0.1093	0.00	10.377	0.16	10.377	0.16	
perk through HDPE	7452.2	112.91	1362.2	20.64	1362.2	20.64	Leakage through bottom of cap
% leakance		36.1%		6.6%		6.6%	
perk through bottom of waste	-	-	1336.5	20.25	1257.1	20.25	Leakage through base of waste and into the leachate collection layer
% leakance		-		6.5%		6.5%	

Parameters and input into HELP Model:
a) 66 years of weather data from Norman Wells Airport weather station (temperature and precipitation)
b) Bare Soil (i.e. no vegetation/grass)
c) 10% slope on final cap
d) slope length 242.5m
e) 0.5 m Gravel parameters (from HELP Model)

Material Category: [HELP] Lateral Drainage Layer — Material: Gravel

General | Lateral Drainage Layer Parameters

Parameter	Value	Units	Comment
total porosity	0.397	vol/vol	Total fraction of voids
field capacity	0.032	vol/vol	Moisture content at 1/3 bar
wilting point	0.013	vol/vol	Moisture content at 15 bar
sat.hydr.conductivity	0.3	cm/sec	permeability under unit pressure gradient
subsurface inflow	0	mm/year	inflow from external source into the layer

f) HDPE Liner parameters (from HELP Model)

Material Category: [HELP] Geomembrane Liner — Material: High Density Polyethylene (HDPE)

General | Geomembrane Liner Parameters

Parameter	Value	Units	Comment
sat.hydr.conductivity	2E-13	cm/sec	permeability under unit pressure gradient
pinhole density	2	#/ha	# of holes (1 mm) per unit area resulting from manufacturing flaws
installation defects	2	#/ha	# of holes (1 cm2) per unit area in result of installation
placement quality	4	-	quality range of contact between the geomembrane liner and the undersoil: 1 - perfect, 2 - excellent, 3 - good, 4 - poor, 5 - bad, 6 - geotextile, which is not counted as a layer, separates the Liner and the subsoil (input geotextile transmissivity)
geotextile transmissivity	0	cm2/sec	the product of saturated hydraulic conductivity and thickness of the geotextile

g) Waste soil 5 or 20 m thick parameters (from HELP model)

Material Category: [HELP] Vertical Percolation Layer — Material: Sandy Loam

General | Vertical Perc. Layer Parameters

Parameter	Value	Units	Comment
total porosity	0.453	vol/vol	Total fraction of voids
field capacity	0.19	vol/vol	Moisture content at 1/3 bar
wilting point	0.085	vol/vol	Moisture content at 15 bar
sat.hydr.conductivity	7.2E-4	cm/sec	permeability under unit pressure gradient
subsurface inflow	0	mm/year	inflow from external source into the layer

Weather is generated using precipitation and temperatures values, average wind speed, and relative humidity values from Norman Wells Airport Env Canada weather station.
Evaporative zone depth is estimated to be 25 cm, leaf index is 1.8, growing season start 166 end 231 based on Valdez Alaska (nearest weather station).
Solar radiation based on Edmonton weather data, no weather data for Fort Nelson, or anywhere in NWT or Yukon.

Appendix K

LTMF Siting Option Assessment

.1 LTMF Siting Options

The LTMF siting options were selected to highlight the influence of a range of key design issues on facility characteristics and costs. Two broad siting concepts were considered, specifically:

- LTMF base "at depth": maximizing overlap with the contaminated soil footprint; and
- LTMF base "at grade": minimizing overlap with the contaminated soil footprint.

For both concepts, air space capacities that accommodate the proposed cleanup criteria (i.e., CCME Industrial on the Mainland and Parkland elsewhere on the Proven Area) were provided.

For the "at depth" concept, two different siting options were considered, while a single siting option was evaluated for the "at grade" concept. The "at depth" siting options examined the influence of bedrock depth on LTMF designs and costs (i.e., one site is in an area of shallow bedrock, while for the other, the bedrock is comparatively deep).

At Depth Concept

Deep Bedrock Siting Option

The basic LTMF features assumed for the "at depth" option over deep bedrock were as follows:

- LTMF sited in the Mainland Tank Farm area and adjacent lands exhibiting comparatively extensive and deep soil contamination;
- LTMF base situated about 2 m above bedrock in the area and configured to roughly parallel the bedrock slope to the south;
- the south LTMF face would daylight at or near the river escarpment (daylighted slopes would be protected as necessary from river ice and flooding actions);
- contaminated soils would be progressively mined from the LTMF footprint and placed directly into completed and lined sections of the LTMF (i.e., double handling after the first soil cut would be minimized via progressive removal, base construction and material placement); and
- if necessary, perimeter upslope drains discharging via gravity to the escarpment face would be constructed to depress the water table below the LTMF base (alternately, the LTMF leachate management system would be designed and sized to accommodate elevated groundwater levels).

Shallow Bedrock Siting Option

The basic LTMF features assumed for the "at depth" option over shallow bedrock were as follows:

- LTMF sited in the Mainland sumps area coincident with the contaminated area footprint;
- LTMF base situated at, or just above, the bedrock contact and configured to roughly parallel the bedrock slope to the south;

- contaminated soils progressively mined and placed in much the same way as described for the deep bedrock option; and
- similarly, any groundwater depression required would be undertaken using a perimeter drainage system consistent with that described for the deep bedrock option, albeit with a longer and deeper gravity discharge line to the river escarpment.

The potential advantages and disadvantages of the "at depth" LTMF configurations are summarized below.

Advantages

- Positioning the LTMF over any deep, localized Long Term Management Areas (LTMAs) associated with contamination extending into the bedrock would consolidate LTMAs within a footprint that does not extend beyond the perimeter required in any case for LTMF construction. (Note LTMAs have not been identified to date in the particular LTMF sites evaluated; however, more localized zones of bedrock contamination might come to light as the project is developed.)
- The coincident positioning of source area excavations and finished LTMF air space capacity reduces the net source area backfilling liability and, therefore, materials handling requirements and costs.
- The reduced fill liability limits the overall disturbance footprint of the remedial program.
- The relatively deep LTMF base lowers the overall height of the facility and, therefore, reduces the associated aesthetic impacts.

Disadvantages

- Positioning the LTMF base below the local water table may create some regulatory concerns that would require mitigation via a relatively extensive permitting effort.
- Positioning an LTMF slope at or near the escarpment may increase the susceptibility to erosion and/or flooding impacts and increase the associated mitigative requirements (applies to the deep bedrock siting option).
- At depth excavations may require the removal of permafrost and/or the mitigation of permafrost degradation in adjacent lands.

At Grade Concept

The basic LTMF features assumed for the "at grade" option were as follows:

- LTMF sited in a disturbed area just east of Bosworth Creek and south of the Bypass Road in an area exhibiting relatively minor soil contamination;
- while the LTMF base would be excavated below grade as necessary to provide the necessary slopes, most of the facility would be built-up above the existing ground; and

- the source area fill liability would be addressed via developing the clean overburden borrow areas as extensions of source excavations, and/or by backhauling from existing shale sources/stockpiles.

The potential advantages and disadvantages of the above grade LTMF configuration are summarized below.

Advantages

- Provides supplementary containment benefits via the layer of overburden between the facility base and bedrock.
- Maintains the landfill base above the water table and, therefore, reduces the potential regulatory and leachate management liabilities.
- Limits source area double handling requirements because of the ability to direct haul and place into a pre-constructed LTMF capacity.
- Provides for a greater offset from the river escarpment and any associated concerns about erosion and/or flooding impacts.

Disadvantages

- Maximizes the post-remediation footprint of long term liabilities and disturbed areas.
- Relatively high fill liability with the associated materials handling requirement (i.e., doesn't use a local cut/fill earthworks balance to construct the LTMF berms).
- Maximizes the height and profile of the LTMF and, therefore, its potential aesthetic impact.

.2 Conceptual Designs and Costs

LTMF Evaluation Workbook

The evaluation workbooks included in Appendix L were used to consider the LTMF Siting Concepts described above. The LTMF concepts costed in these workbooks are based on the descriptions outlined above and the following:

- regrading the existing ground to create a smooth slope from one end of the LTMF to the other;
- excavation below existing ground;
- construction of perimeter berms to serve as surface water control to prevent surface water from running into the LTMF and contacting contaminated materials and leachate containment to prevent leachate escaping the LTMF;
- installation of a composite lining system consisting of a geomembrane installed directly over a Geosynthetic Clay Liner throughout the base and side slopes of the LTMF;

- installation of a leachate collection system above the composite liner that includes a cushion layer of sand, drainage rock and perforated pipes that will collect and drain leachate to the low point of the LTMF;
- installation of a leachate removal system to allow for the collected leachate to be removed from the LTMF and sent to an existing injection well for disposal during LTMF construction and to a dedicated water treatment plant thereafter;
- placement of the contaminated materials within the LTMF to final design elevations;
- installation of a final capping system including a geosynthetic barrier layer, an infiltration drainage layer and a final cover soil layer over the top of the cap; and
- installation of a perimeter security fence around the LTMF.

Once the LTMF has been capped, the following post-closure maintenance and monitoring program was assumed:

- installation of groundwater monitoring wells;
- ongoing monitoring and reporting of groundwater;
- ongoing maintenance of the LTMF including repairs to the cap structure as required; and
- ongoing maintenance of the leachate collection and disposal system including the water treatment plant.

Three estimates were prepared based upon the above parameters and the three siting options described in Appendix K. The cost estimates are presented in a series of activities related to the construction, closure and monitoring as described in the table below.

Sheet Title	Description
Summary	▶ summarizes the quantity in tonnes and cubic metres of contaminated material to be placed in the LTMF; ▶ provides general information about LTMF including: o dimensions at the top inside of the perimeter berms; o the approximate depth of the LTMF below ground; o the approximate height of the perimeter berms; o the approximate height of waste above the berms; and o the final slopes on the contaminated material in the LTMF. ▶ summarizes the costs associated with the LTMF in total dollars, cost per cu. m. and cost per tonne.
Quantities	▶ summarizes the quantities of: o excavation, fill, contaminated soil excavation for the development of the LTMF; o areas for composite liner installation; and o volumes of materials for the leachate collection system.
Development Costs	▶ calculates the cost of construction of the LTMF using the quantities calculated above and estimated unit rates for each activity or item.
General Improvement Costs	▶ calculates the cost for general facilities required to provide access to the LTMF such as roads; ▶ calculates costs for construction of the leachate treatment plant.

Sheet Title	Description
Contaminated Soil Excavation and Relocation Costs	▶ calculates the costs for excavating the contaminated soil from throughout the Norman Wells Operating Facility and transporting them to the LTMF; ▶ assumes that a certain percentage of the total volume of soil has to be double handled to accommodate development of the LTMF within an area over contaminated soil or to accommodate for scheduling of activities such as excavation and transportation during winter periods when the LTMF may not be ready to receive the materials; ▶ accounts for reduced volumes of clean soil to be found when the LTMF is constructed within areas of contaminated soil; and ▶ the quantities applied in this worksheet are extracted from calculations in the Appendix O Materials Management Workbook.
Source Area Backfilling Costs	▶ calculates the costs of relocating shales and overburdens to backfill source area excavations; ▶ the quantities applied in this worksheet are extracted from calculations in the Appendix O Materials Management Workbook.
Final Cap Installation	▶ calculates the costs for installing the final cap layers.
Post-closure maintenance and monitoring costs	▶ calculates an annual cost for completing annual maintenance of the LTMF, operating and maintaining the water treatment plant for leachate management and groundwater monitoring and reporting; and ▶ calculates a Present Value cost for the annual maintenance and monitoring assuming a 50 year post-closure period.

LTMF Conceptual Designs

The LTMF evaluation workbooks (Appendix L worksheets) were used to identify basic geometries anticipated to provide the required capacities in facilities sited as described in Appendix K. These geometric concepts were then developed and refined in AutoCAD Civil 3D 2012 using the site-specific topographic and stratigraphic models described in Section 5.5.1.1. The resulting civil designs for the siting options are provided on Figures M1 through M39 of Appendix M. These figures depict the following options:

- Option 1 - At Depth LTMF (Deep Bedrock) - 670 km^3 capacity;
- Option 3 - At Grade LTMF - 670 km^3 capacity; and
- Option 5 - At Depth LTMF (Shallow Bedrock) - 670 km^3 capacity.

The locations of these LTMF options are shown on Figure M5 in Appendix M. Option 1 is in the Mainland Tank Farm area, Option 3 in the area north and east of Bosworth Creek, and Option 5 in the Mainland Sumps area. Note that Appendix M also includes figures for larger LTMFs (i.e., Options 2, 4 and 6 with a 970 km capacity) that were not considered in this assessment.

For each of the three LTMF options considered, the set of figures provides the:

- base design;
- top of waste and cover topography;
- major section profiles;
- depth contours between the design base and existing ground;

- depth contours between the design base and bedrock; and
- depth contours for the top of cover (i.e., the height of the LTMF).

LTMF Concept Costs

The LTMF workbooks provided the cost estimates for the Appendix L options that are summarized in Table K-1.

Table K-1: NW LTMF Option Cost Estimates

Option	Capacity (m^3)	Total Cost (Rounded)	Unit Cost ($/$m^3$ Capacity)
1. At Depth (Deep Bedrock)	670,000	$33,000,000	$49.00
3. At Grade	670,000	$36,000,000	$53.00
5. At Depth (Shallow Bedrock)	670,000	$35,000,000	$52.00

Appendix L

LTMF Siting Option Evaluation Workbooks

OPTION 1 - 670,000 m^3 Below Ground Long Term Management Facility

Summary

Location of Facility Mainland East

Reclamation Criteria Industrial on Mainland and Parkland on Islands

Waste Material	Total Quantity	Expected in-place density	Total Volume
	(tonnes)	(tonnes/m^3)	(m^3)
Contaminated soil	**1,206,000**	**1.80**	**670,000**

Long Term Management Facility Information				
Dimensions	**240**	m by	**341**	m
Approximate depth below ground	**4.00**	m		
Approximate height of berm above ground	**2.00**	m		
Elevation on top of waste	**72.0**	mASL		
Maximum height of waste above top of berm	**14**	m		
Slope on top of waste	**6.5%**			
Area Required for Landfill	**9.18**	hectares		
	23.32	acres		

Cost Summary	
Long Term Management Facility Construction Cost	$8,880,500
Facility Improvement Costs	$2,322,900
Contaminated Soil Excavation and Relocation Cost	$9,647,300
Clean Soil Replacement Cost	$4,378,600
Final Capping Cost	$5,616,100
Total Capital Cost	**$30,845,400**
Total Maintenance and Monitoring Cost	**$1,944,100**
Total cost	**$32,789,500**
Cost per cubic metre	**$49.00**
Cost per tonne	**$27.19**

OPTION 1 - 670,000 m3 Below Ground Long Term Management Facility

Quantities

General Information							
Dimensions at top inside of berms	240	m by	341	m			
Approximate depth below ground	4	m					
Approximate heigth of berms	2	m					
Total approximate depth	6						
Side slopes	3	H to	1	V			
Dimensions at base of cell	204		305				
Dimensions at outside toe of slope	276		377				
Leachate Collection Pipe Lengths							
Main spine							305
Laterals	spacing	30	m	10	laterals at	204	2074
Total							2379

Quantities from Civil 3D Model		
Airspace	696,000	m3
Contaminated Soil (Scen2)	220,808	m3
Total Cut	293,340	m3
Total Fill	18,900	m3
ENTIRE FOOTPRINT AREA	91,830	m2
SIDE SLOPE AREA INSIDE	21,540	m2
BASE FLOOR AREA	61,100	m2
TOP WASTE AREA	82,250	m2
PERIMETER OF INSIDE CREST	1,165	m

Volumes of Contaminated Soil and Backfill Required

Major Area	Contaminated Soil Quantity	Hauling Distance to LTMF	Backfill Volume Required	Backfill Volume Available In Area	Surplus / Deficit	Backfill Hauling Distance	Comments on Backfill Soil Hauling
	m3	km	m3	m3	m3	km	
Goose Island	10,584	6.8	10,584	423,200	412,616	0.5	from Goose Island shale borrow areas
Bear Island	37,575	4.5	37,575	400,058	362,483	0.5	from Bear Island shale borrow areas
Bear Island Sumps	130,775	4.5	130,775	0	130,775	0.5	from Bear Island shale borrow areas
Mainland West	67,676	2.2	67,676	323,559	255,883	0.5	from Mainland West shale and overburden borrow areas
Mainland Central	99,827	1.2	99,827	387,701	287,874	0.5	from Mainland Central shale and overburden borrow areas
Mainland East	238,873	0.1	18,065	214,754	196,689	1.2	LTMF is located at Mainland East
Mainland Sumps	76,525	1.4	76,525	333,328	256,803	0	from Mainland Sumps stockpiles
Artificial Islands	7,583	2.5	0	0	0		no backfilling to be completed
Total	669,418		441,027				

Swell Factor 0%

Compaction factor 0%

OPTION 1 - 670,000 m3 Below Ground Long Term Management Facility

Development Cost Estimate

Item	Qty.	Unit	Rate	Total
Excavation/Berms				
Excavation	293,340	cu.m @	**$6.25**	$1,833,400
Berm embankment	18,900	cu.m @	**$3.75**	$70,900
Run-on ditches	1,306	l.m. @	**$25.00**	$32,700
Liner System				
Fine gravel below GCL	16,528	cu.m @	**$31.25**	$516,500
GCL liner	82,640	sq.m @	**$12.50**	$1,033,000
Geomembrane liner	82,640	sq.m @	**$12.50**	$1,033,000
Geonet drainage layer (w. geotextile) on side slopes	21,540	sq.m @	**$18.75**	$403,900
Sand cushion	9,165	cu.m @	**$43.75**	$401,000
Drainage rock	18,330	cu.m @	**$62.50**	$1,145,600
Geotextile above drainage rock	61,100	sq.m @	**$5.00**	$305,500
Leachate collection pipes	2,379	l.m @	**$156.25**	$371,700
Geomembrane rub sheet below collection pipes	2,379	sq.m @	**$12.50**	$29,700
Geotextile below rub sheet	2,379	sq.m @	**$5.00**	$11,900
Leachate Handling System				
Leachate collection manhole	1	l. s. @	**$68,750.00**	$68,800
Leachate pump	1	l. s. @	**$2,500.00**	$2,500
Leachate forcemain	1,000	l. m. @	**$250.00**	$250,000
Power supply	1	l. s. @	**$100,000.00**	$100,000
Cell Access				
Access ramp Into cell (clean fill material)	500	cu.m @	**$0.00**	$0
Fencing with gates	1,306	l.m @	**$81.25**	$106,100
Gates	1	l. s. @	**$6,250.00**	$6,300
Lights at Facility	0	l. s. @	**$0.00**	$0
			Longterm Management Facility Subtotal	**$7,722,500**
Other Cost Items				
Mobilization/Demobilization				$1,158,000
Engineering - construction supervision and design				$0
Geomembrane QA/QC	0	weeks @	**$6,000.00**	$0
Materials testing	0	LS @	**$15,000.00**	$0
Installation of groundwater monitoring wells	0	LS @	**$50,000.00**	$0
			Other Cost Items Subtotal	**$1,158,000**
			Estimated Long Term Management Facility DevelopmentTotal	**$8,880,500**

Assumptions:

- depth of fine gravel below GCL	**0.2**	m
- thickness of sand cushion at base of LF	**0.15**	m
- thickness of drainage rock at base of LF	**0.3**	m
- base of cell is	4.0	m below surface
- fence encloses area of cell plus	**0**	m
- mobilization and demobilization at	**15%**	of contract price
- construction supervision and design	**0%**	of contract price

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 1 - 670,000 m3 Below Ground Long Term Management Facility

General Improvement Costs

Item	Qty.	Unit	Rate	Total
On-site access road				
Common Fill	1,500	cu.m @	**$10.00**	$15,000
Surface Gravel	500	cu.m @	**$20.00**	$10,000
Proof Roll For Base of Road	3,000	sq.m @	**$0.10**	$300
Miscellaneous (culverts, crossings)	1	l.s. @	**$15,000.00**	$15,000
Construct ice road				
Construct ice road	1	l.s. @	**$600,000.00**	$600,000
Water Treatment Plant (Leachate Treament Post Closure)				
Plant Utilities	1	l. s. @	**$100,000.00**	$100,000
Building	144	sq. m @	**$3,400.00**	$489,600
Treatment Skid 1 (Separation/GAC, Reverse Osmosis)	1	l. s. @	**$200,000.00**	$200,000
Treatment Skid 2 (Chystallizer)	1	l. s. @	**$250,000.00**	$250,000
Runoff and Leachate Management During LTMF Construction				
Temporary ditching and sump	1	l. s. @	**$140,000.00**	$140,000
Downhole disposition	1	l. s. @	**$200,000.00**	$200,000
			Infrastructure Subtotal	**$2,019,900**
Other Cost Items				
Mobilization/Demobilization				$303,000
Engineering - construction supervision and design				$0
Materials Testing				$0
			Other Cost Items Subtotal	**$303,000**
INFRASTRUCTURE TOTAL				**$2,322,900**

Assumptions:

Private Road

	500	m	in length
	8	m	in width
	2	:1	shoulders
raise	**0.3**	m	using common fill
	0.2	m	pitrun gravel
	0.1	m	surface gravel

On-site Access Road

	1000	m	in length
	5	m	in width
	2	:1	shoulders
	0.1	m	thick surface gravel
	0.3	m	common fill

- common fill consists of native clay material readily available along road alignment

Mobilization/ Demobilization	**15%**	of contract price
Engineering and Supervision	**0%**	of contract price

OPTION 1 - 670,000 m3 Below Ground Long Term Management Facility

Contaminated Soil Excavation and Relocation Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Excavation and Relocation Costs				
Goose Island				
Excavate contaminated soil	10,584	cu.m.	$9.38	$99,225
Haul distance	6.8	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	129,548	tonnes-km	$1.50	$194,322
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	8,467	cu.m.	$2.00	$16,934
Placement of soil in Management Facility in next year after excavation	2,117	cu.m.	$4.00	$8,467
Bear Island				
Excavate contaminated soil	37,575	cu.m.	$9.38	$352,266
Haul distance	4.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	304,358	tonnes-km	$1.50	$456,536
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	30,060	cu.m.	$2.00	$60,120
Placement of soil in Management Facility in next year after excavation	7,515	cu.m.	$4.00	$30,060
Bear Island Sumps				
Excavate contaminated soil	130,775	cu.m.	$9.38	$1,226,016
Haul distance	4.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,059,278	tonnes-km	$1.50	$1,588,916
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	104,620	cu.m.	$2.00	$209,240
Placement of soil in Management Facility in next year after excavation	26,155	cu.m.	$4.00	$104,620
Mainland West				
Excavate contaminated soil	67,676	cu.m.	$6.25	$422,975
Haul distance	2.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	267,997	tonnes-km	$1.50	$401,995
Placement in Management Facility	67,676	cu.m.	$2.00	$135,352
Mainland Central				
Excavate contaminated soil	99,827	cu.m.	$6.25	$623,919
Haul distance	1.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	215,626	tonnes-km	$1.50	$323,439
Placement in Management Facility	99,827	cu.m.	$2.00	$199,654
Mainland East				
Excavate contaminated soil	238,873	cu.m.	$6.25	$1,492,956
Haul distance	0.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	42,997	tonnes-km	$1.50	$64,496
Placement in Management Facility	238,873	cu.m.	$2.00	$477,746
Mainland Sumps				
Excavate contaminated soil	76,525	cu.m.	$6.25	$478,281
Haul distance	1.4	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	192,843	tonnes-km	$1.50	$289,265
Placement in Management Facility	76,525	cu.m.	$2.00	$153,050
Artificial Islands				
Excavate contaminated soil	7,583	cu.m.	$9.38	$71,091
Haul distance	2.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	34,124	tonnes-km	$1.50	$51,185
Placement in Management Facility	7,583	cu.m.	$2.00	$15,166
			Excavation and Relocation Subtotal	**$9,547,293**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,206,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Excavation and Relocation Costs Subtotal	**$9,647,293**
Contingency	0%			$0
			Estimated Relocation & Backfilling Costs Total	**$9,647,293**

Assumptions:

contingency @ **0%** of contract price

OPTION 1 - 670,000 m3 Below Ground Long Term Management Facility

Backfilling Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Backfilling Costs				
Goose Island				
Excavate backfill soil from stockpiles	10,584	cu.m.	$6.25	$66,150
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul backfill soil	9,526	tonnes-km	$1.50	$14,288
Placement in excavation	10,584	cu.m.	$3.00	$31,752
Bear Island				
Excavate backfill soil from stockpiles	37,575	cu.m.	$6.25	$234,844
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	33,818	tonnes-km	$1.50	$50,726
Placement in excavation	37,575	cu.m.	$2.00	$75,150
Bear Island Sumps				
Excavate backfill soil from stockpiles	130,775	cu.m.	$6.25	$817,344
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	117,698	tonnes-km	$1.50	$176,546
Placement in excavation	130,775	cu.m.	$2.00	$261,550
Mainland West				
Excavate backfill soil from stockpiles	67,676	cu.m.	$6.25	$422,975
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	60,908	tonnes-km	$1.50	$91,363
Placement in excavation	67,676	cu.m.	$2.00	$135,352
Mainland Central				
Excavate backfill soil from stockpiles	99,827	cu.m.	$6.25	$623,919
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	89,844	tonnes-km	$1.50	$134,766
Placement in excavation	99,827	cu.m.	$2.00	$199,654
Mainland East				
Excavate backfill soil from stockpiles	18,065	cu.m.	$6.25	$112,906
Haul distance (from nearby stockpiles)	1.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	39,020	tonnes-km	$1.50	$58,531
Placement in excavation	18,065	cu.m.	$2.00	$36,130
Mainland Sumps				
Excavate backfill soil from stockpiles	76,525	cu.m.	$6.25	$478,281
Haul distance	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	68,873	tonnes-km	$1.50	$103,309
Placement in excavation	76,525	cu.m.	$2.00	$153,050
Artificial Islands				
Excavate backfill soil from stockpiles	0	cu.m.	$0.00	$0
Haul distance	0.0	km		
Soil density	0.0	t/cu.m.		
Haul contaminated soil	0	tonnes-km	$0.00	$0
Placement in excavation	0	cu.m.	$0.00	$0
			Backfilling Subtotal	**$4,278,586**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,206,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Backfilling Costs Subtotal	**$4,378,586**
Contingency	0%			$0
			Estimated Backfilling Costs Total	**$4,378,586**

Assumptions:

contingency @ **0%** of contract price

OPTION 1 - 670,000 m3 Below Ground Long Term Management Facility

Final Cap Placement Cost Estimate

Item	Qty.	Unit	Rate	Total
Landfill Cap				
Geomembrane Barrier Layer	82,250	sq.m. @	**$18.75**	$1,542,200
Geocomposite drainage Layer	82,250	sq.m. @	**$18.75**	$1,542,200
Place and Compact Soil over geomembrane	41,125	cu.m. @	**$43.75**	$1,799,200
			Cap Construction Subtotal	**$4,883,600**
Other items				
Mobilization/demobilization				$732,540
Engineering - construction supervision and design				$0
Materials testing				$0
			Other items subtotal	**$732,540**
			Longterm Management Facility Cap Total	**$5,616,140**

Assumptions:

Subsoil Thickness	**0.5**	m
Mob/demob as % of landfill cap subtotal	**15%**	
Engineering/Supervision as % of landfill cap subtotal	**0%**	

OPTION 1 - 670,000 m3 Below Ground Long Term Management Facility

Post-closure Maintenance and Monitoring Cost Estimate

Item	Qty.	Unit	Rate	Total
A) Maintenance Costs				
Annual LTMF Maintenance	1	L.S.	$25,000	$25,000
			Maintenance Subtotal	**$25,000**
B) Leachate Treatment				
Water treatment plant Operation & Maintenance	1700	m3	$15	$25,500
Disposition of treatment residuals	3	m3	$5,000.00	$15,000
			Leachate Subtotal	**$40,500**
C) Environmental Costs				
Monitoring and Reporting	1	L.S.	$25,000	$25,000
			Environmental Costs Subtotal	**$25,000**
			Estimated Annual Post Closure Subtotal	$90,500
Contingency	0%			$0
			Estimated Annual Post Closure Total	**$90,500**

Years for annual monitoring	50
Total cost	$4,525,000
Discount rate	4%
Net present value	$1,944,138

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 2 - 970,000 m^3 Below Ground Long Term Management Facility

Summary

Location of Facility Mainland East

Reclamation Criteria Parkland on Mainland and Parkland on Islands

Waste Material	Total Quantity	Expected in-place density	Total Volume
	(tonnes)	(tonnes/m^3)	(m^3)
Contaminated soil	**1,746,000**	**1.80**	**970,000**

Long Term Management Facility Information				
Dimensions	**240**	m by	**480**	m
Approximate depth below ground	**3.50**	m		
Approximate height of berm above ground	**2.50**	m		
Elevation on top of waste	**72.0**	mASL		
Maximum height of waste above top of berm	**14**	m		
Slope on top of waste	**6.5%**			
Area Required for Landfill	**12.86**	hectares		
	32.66	acres		

Cost Summary	
Long Term Management Facility Construction Cost	$12,577,800
Facility Improvement Costs	$2,506,900
Contaminated Soil Excavation and Relocation Cost	$12,463,300
Clean Soil Replacement Cost	$7,827,200
Final Capping Cost	$7,883,800
Total Capital Cost	**$43,259,000**
Total Maintenance and Monitoring Cost	**$2,631,600**
Total cost	**$45,890,600**
Cost per cubic metre	**$47.00**
Cost per tonne	**$26.00**

OPTION 2 - 970,000 m3 Below Ground Long Term Management Facility

Quantities

General Information							
Dimensions at top inside of berms	240	m by	480	m			
Approximate depth below ground	3.5	m					
Approximate heigth of berms	2.5	m					
Total approximate depth	6						
Side slopes	3	H to	1	V			
Dimensions at base of cell	204		444				
Dimensions at outside toe of slope	276		516				
Leachate Collection Pipe Lengths							
Main spine							444
Laterals	spacing	30	m	14.8	laterals at	204	3019.2
Total							3463.2

Quantities from Civil 3D Model		
Airspace	1,000,000	m3
Total Cut	444,630	m3
Total Fill	25,100	m3
ENTIRE FOOTPRINT AREA	128,570	m2
SIDE SLOPE AREA INSIDE	26,716	m2
BASE FLOOR AREA	89,835	m2
TOP WASTE AREA	115,460	m2
PERIMETER OF INSIDE CREST	1,440	m

Volumes of Contaminated Soil and Backfill Required

Major Area	Contaminated Soil Quantity	Hauling Distance to LTMF	Backfill Volume Required	Backfill Volume Available In Area	Surplus / Deficit	Backfill Hauling Distance	Comments on Backfill Soil Hauling
	m3	km	m3	m3	m3	km	
Goose Island	10,584	6.8	10,584	423,200	412,616	0.5	from Goose Island shale borrow area
Bear Island	37,575	4.5	37,575	400,058	362,483	0.5	from Bear Island shale borrow area
Bear Island Sumps	130,775	4.5	130,775	0	130,775	0.5	from Bear Island shale borrow area
Mainland West	77,026	2.2	77,026	323,559	246,533	0.5	from Mainland West shale and overburden borrow areas
Mainland Central	146,464	1.2	146,464	387,701	241,237	0.5	from Mainland Central shale and overburden borrow areas
Mainland East	456,015	0.1	225,303	214,754	10,549	0.5	LTMF is located at Mainland East
Mainland Sumps	101,250	1.4	101,250	333,328	232,078	0.5	from Mainland Sumps borrow area
Artificial Islands	7,583	2.5	0	0	0		no backfilling to be completed
Total	967,272		728,977				

Swell factor	Compaction factor
0%	0%

OPTION 2 - 970,000 m3 Below Ground Long Term Management Facility

Development Cost Estimate

Item	Qty.	Unit	Rate	Total
Excavation/Berms				
Excavation	444,630	cu.m @	**$6.25**	$2,778,900
Berm embankment	25,100	cu.m @	**$3.75**	$94,100
Run-on ditches	1,584	l.m. @	**$25.00**	$39,600
Liner System				
Fine gravel below GCL	23,310	cu.m @	**$31.25**	$728,400
GCL liner	116,551	sq.m @	**$12.50**	$1,456,900
Geomembrane liner	116,551	sq.m @	**$12.50**	$1,456,900
Geonet drainage layer (w. geotextile) on side slopes	26,716	sq.m @	**$18.75**	$500,900
Sand cushion	13,475	cu.m @	**$43.75**	$589,500
Drainage rock	26,951	cu.m @	**$62.50**	$1,684,400
Geotextile above drainage rock	89,835	sq.m @	**$5.00**	$449,200
Leachate collection pipes	3,463	l.m @	**$156.25**	$541,100
Geomembrane rub sheet below collection pipes	3,463	sq.m @	**$12.50**	$43,300
Geotextile below rub sheet	3,463	sq.m @	**$5.00**	$17,300
Leachate Handling System				
Leachate collection manhole	1	l. s. @	**$68,750.00**	$68,800
Leachate pump	1	l. s. @	**$2,500.00**	$2,500
Leachate forcemain	1,000	l. m. @	**$250.00**	$250,000
Power supply	1	l. s. @	**$100,000.00**	$100,000
Cell Access				
Access ramp Into cell (clean fill material)	500	cu.m @	**$0.00**	$0
Fencing with gates	1,584	l.m @	**$81.25**	$128,700
Gates	1	l. s. @	**$6,250.00**	$6,300
Lights at Facility	0	l. s. @	**$0.00**	$0
			Longterm Management Facility Subtotal	**$10,936,800**
Other Cost Items				
Mobilization/Demobilization				$1,641,000
Engineering - construction supervision and design				$0
Geomembrane QA/QC	0	weeks @	$6,000.00	$0
Materials testing	0	LS @	$15,000.00	$0
Installation of groundwater monitoring wells	0	LS @	$50,000.00	$0
			Other Cost Items Subtotal	**$1,641,000**
			Estimated Long Term Management Facility DevelopmentTotal	**$12,577,800**

Assumptions:

- depth of fine gravel below GCL	0.2	m
- thickness of sand cushion at base of LF	0.15	m
- thickness of drainage rock at base of LF	0.3	m
- base of cell is	3.5	m below surface
- fence encloses area of cell plus	0	m
- mobilization and demobilization at	15%	of contract price
- construction supervision and design	0%	of contract price

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 2 - 970,000 m3 Below Ground Long Term Management Facility

General Improvement Costs

Item	Qty.	Unit	Rate	Total
On-site access road				
Common Fill	1,500	cu.m @	**$10.00**	$15,000
Surface Gravel	500	cu.m @	**$20.00**	$10,000
Proof Roll For Base of Road	3,000	sq.m @	**$0.10**	$300
Miscellaneous (culverts, crossings)	1	l.s. @	**$15,000.00**	$15,000
Construct ice road				
Construct ice road	1	l.s. @	**$600,000.00**	$600,000
Water Treatment Plant (Leachate Treament Post Closure)				
Plant Utilities	1	l. s. @	**$100,000.00**	$100,000
Building	144	sq. m @	**$3,400.00**	$489,600
Treatment Skid 1 (Separation/GAC, Reverse Osmosis)	1	l. s. @	**$200,000.00**	$200,000
Treatment Skid 2 (Chystallizer)	1	l. s. @	**$250,000.00**	$250,000
Runoff and Leachate Management During LTMF Construction				
Temporary ditching and sump	1	l. s. @	**$200,000.00**	$200,000
Downhole disposition	1	l. s. @	**$300,000.00**	$300,000
			Infrastructure Subtotal	**$2,179,900**
Other Cost Items				
Mobilization/Demobilization				$327,000
Engineering - construction supervision and design				$0
Materials Testing				**$0**
			Other Cost Items Subtotal	**$327,000**
INFRASTRUCTURE TOTAL				**$2,506,900**

Assumptions:

Private Road

	500	m	in length
	8	m	in width
	2	:1	shoulders
raise	**0.3**	m	using common fill
	0.2	m	pitrun gravel
	0.1	m	surface gravel

On-site Access Road

1000	m	in length
5	m	in width
2	:1	shoulders
0.1	m	thick surface gravel
0.3	m	common fill

- common fill consists of native clay material readily available along road alignment

Mobilization/ Demobilization	**15%**	of contract price
Engineering and Supervision	**0%**	of contract price

OPTION 2 - 970,000 m3 Below Ground Long Term Management Facility

Contaminated Soil Excavation and Relocation Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Excavation and Relocation Costs				
Goose Island				
Excavate contaminated soil	10,584	cu.m.	$9.38	$99,225
Haul distance	6.8	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	129,548	tonnes-km	$1.50	$194,322
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	8,467	cu.m.	$2.00	$16,934
Placement of soil in Management Facility in next year after excavation	2,117	cu.m.	$4.00	$8,467
Bear Island				
Excavate contaminated soil	37,575	cu.m.	$9.38	$352,266
Haul distance	4.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	304,358	tonnes-km	$1.50	$456,536
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	30,060	cu.m.	$2.00	$60,120
Placement of soil in Management Facility in next year after excavation	7,515	cu.m.	$4.00	$30,060
Bear Island Sumps				
Excavate contaminated soil	130,775	cu.m.	$9.38	$1,226,016
Haul distance	4.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,059,278	tonnes-km	$1.50	$1,588,916
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	104,620	cu.m.	$2.00	$209,240
Placement of soil in Management Facility in next year after excavation	26,155	cu.m.	$4.00	$104,620
Mainland West				
Excavate contaminated soil	77,026	cu.m.	$6.25	$481,413
Haul distance	2.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	305,023	tonnes-km	$1.50	$457,534
Placement in Management Facility	77,026	cu.m.	$2.00	$154,052
Mainland Central				
Excavate contaminated soil	146,464	cu.m.	$6.25	$915,400
Haul distance	1.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	316,362	tonnes-km	$1.50	$474,543
Placement in Management Facility	146,464	cu.m.	$2.00	$292,928
Mainland East				
Excavate contaminated soil	456,015	cu.m.	$6.25	$2,850,094
Haul distance	0.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	82,083	tonnes-km	$1.50	$123,124
Placement in Management Facility	456,015	cu.m.	$2.00	$912,030
Mainland Sumps				
Excavate contaminated soil	101,250	cu.m.	$6.25	$632,813
Haul distance	1.4	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	255,150	tonnes-km	$1.50	$382,725
Placement in Management Facility	101,250	cu.m.	$2.00	$202,500
Artificial Islands				
Excavate contaminated soil	7,583	cu.m.	$9.38	$71,091
Haul distance	2.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	34,124	tonnes-km	$1.50	$51,185
Placement in Management Facility	7,583	cu.m.	$2.00	$15,166
			Excavation and Relocation Subtotal	**$12,363,320**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,746,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Excavation and Relocation Costs Subtotal	**$12,463,320**
Contingency	0%			$0
			Estimated Relocation & Backfilling Costs Total	**$12,463,320**

Assumptions:

contingency @ **0%** of contract price

OPTION 2 - 970,000 m3 Below Ground Long Term Management Facility

Backfilling Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Backfilling Costs				
Goose Island				
Excavate backfill soil from stockpiles	10,584	cu.m.	$6.25	$66,150
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul backfill soil	9,526	tonnes-km	$1.50	$14,288
Placement in excavation	10,584	cu.m.	$3.00	$31,752
Bear Island				
Excavate backfill soil from stockpiles	37,575	cu.m.	$6.25	$234,844
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	33,818	tonnes-km	$1.50	$50,726
Placement in excavation	37,575	cu.m.	$3.00	$112,725
Bear Island Sumps				
Excavate backfill soil from stockpiles	130,775	cu.m.	$6.25	$817,344
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	117,698	tonnes-km	$1.50	$176,546
Placement in excavation	130,775	cu.m.	$3.00	$392,325
Mainland West				
Excavate backfill soil from stockpiles	77,026	cu.m.	$6.25	$481,413
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	69,323	tonnes-km	$1.50	$103,985
Placement in excavation	77,026	cu.m.	$3.00	$231,078
Mainland Central				
Excavate backfill soil from stockpiles	146,464	cu.m.	$6.25	$915,400
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	131,818	tonnes-km	$1.50	$197,726
Placement in excavation	146,464	cu.m.	$3.00	$439,392
Mainland East				
Excavate backfill soil from stockpiles	225,303	cu.m.	$6.25	$1,408,144
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	202,773	tonnes-km	$1.50	$304,159
Placement in excavation	225,303	cu.m.	$3.00	$675,909
Mainland Sumps				
Excavate backfill soil from stockpiles	101,250	cu.m.	$6.25	$632,813
Haul distance	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	91,125	tonnes-km	$1.50	$136,688
Placement in excavation	101,250	cu.m.	$3.00	$303,750
Artificial Islands				
Excavate backfill soil from stockpiles	0	cu.m.	$0.00	$0
Haul distance	0.0	km		
Soil density	0.0	t/cu.m.		
Haul contaminated soil	0	tonnes-km	$0.00	$0
Placement in excavation	0	cu.m.	$0.00	$0
			Backfilling Subtotal	**$7,727,156**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,741,090	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Backfilling Costs Subtotal	**$7,827,156**
Contingency	0%			$0
			Estimated Backfilling Costs Total	**$7,827,156**

Assumptions:

contingency @ **0%** of contract price

OPTION 2 - 970,000 m3 Below Ground Long Term Management Facility

Final Cap Placement Cost Estimate

Item	Qty.	Unit	Rate	Total
Landfill Cap				
Geomembrane Barrier Layer	115,460	sq.m. @	**$18.75**	$2,164,900
Geocomposite drainage Layer	115,460	sq.m. @	**$18.75**	$2,164,900
Place and Compact Soil over geomembrane	57,730	cu.m. @	**$43.75**	$2,525,700
			Cap Construction Subtotal	**$6,855,500**
Other items				
Mobilization/demobilization				$1,028,325
Engineering - construction supervision and design				$0
Materials testing				**$0**
			Other items subtotal	**$1,028,325**
			Longterm Management Facility Cap Total	**$7,883,825**

Assumptions:

Subsoil Thickness	**0.5**	m
Mob/demob as % of landfill cap subtotal	**15%**	
Engineering/Supervision as % of landfill cap subtotal	**0%**	

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 2 - 970,000 m3 Below Ground Long Term Management Facility

Post-closure Maintenance and Monitoring Cost Estimate

Item	Qty.	Unit	Rate	Total
A) Maintenance Costs				
Annual Maintenance	1	L.S.	**$35,000**	$35,000
			Maintenance Subtotal	**$35,000**
B) Leachate Treatment				
Water treatment plant Operation & Maintenance	2500	m3	$15	$37,500
Disposition of treatment residuals	5	m3	$5,000.00	$25,000
			Leachate Subtotal	**$62,500**
C) Environmental Costs				
Monitoring and Reporting	1	L.S.	**$25,000**	$25,000
			Environmental Costs Subtotal	**$25,000**
			Estimated Annual Post Closure Subtotal	$122,500
Contingency	0%			$0
			Estimated Annual Post Closure Total	**$122,500**

Years for annual monitoring	50
Total cost	$6,125,000
Discount rate	4%
Net present value	$2,631,567.62

OPTION 3 - 670,000 m^3 Above Ground Long Term Management Facility

Summary

Location of Facility Mainland Central

Reclamation Criteria Industrial on Mainland and Parkland on Islands

Waste Material	Total Quantity	Expected in-place density	Total Volume
	(tonnes)	(tonnes/m^3)	(m^3)
Contaminated soil	**1,206,000**	**1.80**	**670,000**

Long Term Management Facility Information				
Dimensions	**240**	m by	**370**	m
Approximate depth below ground	**0.50**	m		
Approximate height of berm above ground	**4.50**	m		
Elevation on top of waste	**77.0**	mASL		
Maximum height of waste above top of berm	**15**	m		
Slope on top of waste	**10.0%**			
Area Required for Landfill	**10.69**	hectares		
	27.16	acres		

Cost Summary	
Long Term Management Facility Construction Cost	$7,878,400
Facility Improvement Costs	$2,322,900
Contaminated Soil Excavation and Relocation Cost	$10,781,700
Clean Soil Replacement Cost	$6,505,800
Final Capping Cost	$6,093,200
Total Capital Cost	**$33,582,000**
Total Maintenance and Monitoring Cost	**$1,944,100**
Total cost	**$35,526,100**
Cost per cubic metre	**$53.00**
Cost per tonne	**$29.00**

OPTION 3 - 670,000 m3 Above Ground Long Term Management Facility

Quantities

General Information							
Dimensions at top inside of berms	240	m by	370	m			
Approximate depth below ground	0.5	m					
Approximate heigth of berms	4.5	m					
Total approximate depth	5						
Side slopes	3	H to	1	V			
Dimensions at base of cell	210		340				
Dimensions at outside toe of slope	270		400				
Leachate Collection Pipe Lengths							
Main spine							340
Laterals	spacing	30	m	11	laterals at	210	2380
Total							2720

Quantities from Civil 3D Model		
Airspace	716,000	m3
Total Cut	30,100	m3
Total Fill	90,435	m3
ENTIRE FOOTPRINT AREA	106,939	m2
SIDE SLOPE AREA INSIDE	14,310	m2
BASE FLOOR AREA	75,240	m2
TOP WASTE AREA	89,235	m2
PERIMETER OF INSIDE CREST	1,120	m

Volumes of Contaminated Soil and Backfill Required

Major Area	Contaminated Soil Quantity	Hauling Distance to LTMF	Backfill Volume Required	Backfill Volume Available In Area	Surplus / Deficit	Backfill Hauling Distance	Comments on Backfill Soil Hauling
	m3	km	m3	m3	m3	km	
Goose Island	10,584	7.6	10,584	423,200	412,616	0.5	from Goose Island shale borrow areas
Bear Island	37,575	5.4	37,575	400,058	362,483	0.5	from Bear Island shale borrow areas
Bear Island Sumps	130,775	5.4	130,775	0	130,775	0.5	from Bear Island shale borrow areas
Mainland West	67,676	1.1	67,676	323,559	255,883	0.5	from Mainland West shale and overburden borrow areas
Mainland Central	99,827	0.5	86,627	387,701	301,074	0.5	LTMF is located at Mainland Central
Mainland East	238,873	1.8	238,873	214,754	24,119	0.5	from Mainland Central borrow area
Mainland Sumps	76,525	1.3	76,525	333,328	256,803	0.5	from Mainland Sumps borrow areas
Artificial Islands	7,583	3.3	0	0	0		no backfilling to be completed
Total	669,418		648,635				

Swell factor 0%

Compaction factor 0%

OPTION 3 - 670,000 m3 Above Ground Long Term Management Facility

Development Cost Estimate

Item	Qty.	Unit	Rate	Total
Excavation/Berms				
Excavation	30,100	cu.m @	**$6.25**	$188,100
Berm embankment	90,435	cu.m @	**$3.75**	$339,100
Run-on ditches	1,340	l.m. @	**$25.00**	$33,500
Liner System				
Fine gravel below GCL	17,910	cu.m @	**$31.25**	$559,700
GCL liner	89,550	sq.m @	**$12.50**	$1,119,400
Geomembrane liner	89,550	sq.m @	**$12.50**	$1,119,400
Geonet drainage layer (w. geotextile) on side slopes	14,310	sq.m @	**$18.75**	$268,300
Sand cushion	11,286	cu.m @	**$43.75**	$493,800
Drainage rock	22,572	cu.m @	**$62.50**	$1,410,800
Geotextile above drainage rock	75,240	sq.m @	**$5.00**	$376,200
Leachate collection pipes	2,720	l.m @	**$156.25**	$425,000
Geomembrane rub sheet below collection pipes	2,720	sq.m @	**$12.50**	$34,000
Geotextile below rub sheet	2,720	sq.m @	**$5.00**	$13,600
Leachate Handling System				
Leachate collection manhole	1	l. s. @	**$68,750.00**	$68,800
Leachate pump	1	l. s. @	**$2,500.00**	$2,500
Leachate forcemain	1,000	l. m. @	**$250.00**	$250,000
Power supply	1	l. s. @	**$100,000.00**	$100,000
Cell Access				
Access ramp Into cell (clean fill material)	500	cu.m @	**$0.00**	$0
Fencing with gates	1,340	l.m @	**$31.25**	$41,900
Gates	1	l. s. @	**$6,250.00**	$6,300
Lights at Facility	0	l. s. @	**$0.00**	$0
			Longterm Management Facility Subtotal	**$6,850,400**
Other Cost Items				
Mobilization/Demobilization				$1,028,000
Engineering - construction supervision and design				$0
Geomembrane QA/QC	0	weeks @	**$6,000.00**	$0
Materials testing	0	LS @	**$15,000.00**	$0
Installation of groundwater monitoring wells	0	LS @	**$50,000.00**	$0
			Other Cost Items Subtotal	**$1,028,000**
			Estimated Long Term Management Facility DevelopmentTotal	**$7,878,400**

Assumptions:

- depth of fine gravel below GCL	**0.2**	m
- thickness of sand cushion at base of LF	**0.15**	m
- thickness of drainage rock at base of LF	**0.3**	m
- base of cell is	4.5	m below surface
- fence encloses area of cell plus	**0**	m
- mobilization and demobilization at	**15%**	of contract price
- construction supervision and design	**0%**	of contract price

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 3 - 670,000 m3 Above Ground Long Term Management Facility

General Improvement Costs

Item	Qty.	Unit	Rate	Total
On-site access road				
Common Fill	1,500	cu.m @	**$10.00**	$15,000
Surface Gravel	500	cu.m @	**$20.00**	$10,000
Proof Roll For Base of Road	3,000	sq.m @	**$0.10**	$300
Miscellaneous (culverts, crossings)	1	l.s. @	**$15,000.00**	$15,000
Construct ice road				
Construct ice road	1	l.s. @	**$600,000.00**	$600,000
Water Treatment Plant (Leachate Treament Post Closure)				
Plant Utilities	1	l. s. @	**$100,000.00**	$100,000
Building	144	sq. m @	**$3,400.00**	$489,600
Treatment Skid 1 (Separation/GAC, Reverse Osmosis)	1	l. s. @	**$200,000.00**	$200,000
Treatment Skid 2 (Chystallizer)	1	l. s. @	**$250,000.00**	$250,000
Runoff and Leachate Management During LTMF Construction				
Temporary ditching and sump	1	l. s. @	**$140,000.00**	$140,000
Downhole disposition	1	l. s. @	**$200,000.00**	$200,000
			Infrastructure Subtotal	**$2,019,900**
Other Cost Items				
Mobilization/Demobilization				$303,000
Engineering - construction supervision and design				$0
Materials Testing				**$0**
			Other Cost Items Subtotal	**$303,000**
INFRASTRUCTURE TOTAL				**$2,322,900**

Assumptions:

Private Road

	500	m	in length
	8	m	in width
	2	:1	shoulders
raise	**0.3**	m	using common fill
	0.2	m	pitrun gravel
	0.1	m	surface gravel

On-site Access Road

	1000	m	in length
	5	m	in width
	2	:1	shoulders
	0.1	m	thick surface gravel
	0.3	m	common fill

- common fill consists of native clay material readily available along road alignment

Mobilization/ Demobilization	**15%**	of contract price
Engineering and Supervision	**0%**	of contract price

OPTION 3 - 670,000 m3 Above Ground Long Term Management Facility

Contaminated Soil Excavation and Relocation Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Excavation and Relocation Costs				
Goose Island				
Excavate contaminated soil	10,584	cu.m.	$9.38	$99,225
Haul distance	7.6	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	144,789	tonnes-km	$1.50	$217,184
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	8,467	cu.m.	$2.00	$16,934
Placement of soil in Management Facility in next year after excavation	2,117	cu.m.	$4.00	$8,467
Bear Island				
Excavate contaminated soil	37,575	cu.m.	$9.38	$352,266
Haul distance	5.4	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	365,229	tonnes-km	$1.50	$547,844
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	30,060	cu.m.	$2.00	$60,120
Placement of soil in Management Facility in next year after excavation	7,515	cu.m.	$4.00	$30,060
Bear Island Sumps				
Excavate contaminated soil	130,775	cu.m.	$9.38	$1,226,016
Haul distance	5.4	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,271,133	tonnes-km	$1.50	$1,906,700
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	104,620	cu.m.	$2.00	$209,240
Placement of soil in Management Facility in next year after excavation	26,155	cu.m.	$4.00	$104,620
Mainland West				
Excavate contaminated soil	67,676	cu.m.	$6.25	$422,975
Haul distance	1.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	133,998	tonnes-km	$1.50	$200,998
Placement in Management Facility	67,676	cu.m.	$2.00	$135,352
Mainland Central				
Excavate contaminated soil	99,827	cu.m.	$6.25	$623,919
Haul distance	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	89,844	tonnes-km	$1.50	$134,766
Placement in Management Facility	99,827	cu.m.	$2.00	$199,654
Mainland East				
Excavate contaminated soil	238,873	cu.m.	$6.25	$1,492,956
Haul distance	1.8	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	773,949	tonnes-km	$1.50	$1,160,923
Placement in Management Facility	238,873	cu.m.	$2.00	$477,746
Mainland Sumps				
Excavate contaminated soil	76,525	cu.m.	$6.25	$478,281
Haul distance	1.3	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	179,069	tonnes-km	$1.50	$268,603
Placement in Management Facility	76,525	cu.m.	$2.00	$153,050
Artificial Islands				
Excavate contaminated soil	7,583	cu.m.	$9.38	$71,091
Haul distance	3.3	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	45,043	tonnes-km	$1.50	$67,565
Placement in Management Facility	7,583	cu.m.	$2.00	$15,166
			Excavation and Relocation Subtotal	**$10,681,719**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,206,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Excavation and Relocation Costs Subtotal	**$10,781,719**
Contingency	0%			$0
			Estimated Relocation & Backfilling Costs Total	**$10,781,719**

Assumptions:

contingency @ **0%** of contract price

OPTION 3 - 670,000 m3 Above Ground Long Term Management Facility

Backfilling Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Backfilling Costs				
Goose Island				
Excavate backfill soil from stockpiles	10,584	cu.m.	$6.25	$66,150
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul backfill soil	9,526	tonnes-km	$1.50	$14,288
Placement in excavation	10,584	cu.m.	$3.00	$31,752
Bear Island				
Excavate backfill soil from stockpiles	37,575	cu.m.	$6.25	$234,844
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	33,818	tonnes-km	$1.50	$50,726
Placement in excavation	37,575	cu.m.	$3.00	$112,725
Bear Island Sumps				
Excavate backfill soil from stockpiles	130,775	cu.m.	$6.25	$817,344
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	117,698	tonnes-km	$1.50	$176,546
Placement in excavation	130,775	cu.m.	$3.00	$392,325
Mainland West				
Excavate backfill soil from stockpiles	67,676	cu.m.	$6.25	$422,975
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	60,908	tonnes-km	$1.50	$91,363
Placement in excavation	67,676	cu.m.	$2.00	$135,352
Mainland Central				
Excavate backfill soil from stockpiles	86,627	cu.m.	$6.25	$541,419
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	77,964	tonnes-km	$1.50	$116,946
Placement in excavation	86,627	cu.m.	$2.00	$173,254
Mainland East				
Excavate backfill soil from stockpiles	238,873	cu.m.	$6.25	$1,492,956
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	214,986	tonnes-km	$1.50	$322,479
Placement in excavation	238,873	cu.m.	$2.00	$477,746
Mainland Sumps				
Excavate backfill soil from stockpiles	76,525	cu.m.	$6.25	$478,281
Haul distance	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	68,873	tonnes-km	$1.50	$103,309
Placement in excavation	76,525	cu.m.	$2.00	$153,050
Artificial Islands				
Excavate backfill soil from stockpiles	0	cu.m.	$0.00	$0
Haul distance	0.0	km		
Soil density	0.0	t/cu.m.		
Haul contaminated soil	0	tonnes-km	$0.00	$0
Placement in excavation	0	cu.m.	$0.00	$0
			Backfilling Subtotal	**$6,405,830**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,206,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Backfilling Costs Subtotal	**$6,505,830**
Contingency	0%			$0
			Estimated Backfilling Costs Total	**$6,505,830**

Assumptions:

contingency @ **0%** of contract price

OPTION 3 - 670,000 m3 Above Ground Long Term Management Facility

Final Cap Placement Cost Estimate

Item	Qty.	Unit	Rate	Total
Landfill Cap				
Geomembrane Barrier Layer	89,235	sq.m. @	**$18.75**	$1,673,200
Geocomposite drainage Layer	89,235	sq.m. @	**$18.75**	$1,673,200
Place and Compact Soil over geomembrane	44,618	cu.m. @	**$43.75**	$1,952,000
			Cap Construction Subtotal	**$5,298,400**
Other items				
Mobilization/demobilization				$794,760
Engineering - construction supervision and design				$0
Materials testing				$0
			Other items subtotal	**$794,760**
			Longterm Management Facility Cap Total	**$6,093,160**

Assumptions:

Subsoil Thickness	**0.5**	m
Mob/demob as % of landfill cap subtotal	**15%**	
Engineering/Supervision as % of landfill cap subtotal	**0%**	

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 3 - 670,000 m3 Above Ground Long Term Management Facility

Post-closure Maintenance and Monitoring Cost Estimate

Item	Qty.	Unit	Rate	Total
A) Maintenance Costs				
Annual Maintenance	1	L.S.	**$25,000**	$25,000
			Maintenance Subtotal	**$25,000**
B) Leachate Disposal Well Maintenance Costs				
Water treatment plant Operation & Maintenance	1700	m3	$15	$25,500
Disposition of treatment residuals	3	m3	$5,000.00	$15,000
			Leachate Subtotal	**$40,500**
C) Environmental Costs				
Monitoring and Reporting	1	L.S.	**$25,000**	$25,000
			Environmental Costs Subtotal	**$25,000**
			Estimated Annual Post Closure Subtotal	$90,500
Contingency	0%			$0
			Estimated Annual Post Closure Total	**$90,500**

Years for annual monitoring	50
Total cost	$4,525,000
Discount rate	4%
Net present value	$1,944,137.71

OPTION 4 - 970,000 m^3 Above Ground Long Term Management Facility

Summary

Location of Facility Mainland Central

Reclamation Criteria Parkland on Mainland and Parkland on Islands

Waste Material	Total Quantity	Expected in-place density	Total Volume
	(tonnes)	(tonnes/m^3)	(m^3)
Contaminated soil	**1,746,000**	**1.80**	**970,000**

Long Term Management Facility Information				
Dimensions	**240**	m by	**485**	m
Approximate depth below ground	**1.00**	m		
Approximate height of berm above ground	**4.00**	m		
Elevation on top of waste	**78.0**	mASL		
Maximum height of waste above top of berm	**15**	m		
Slope on top of waste	**10.0%**			
Area Required for Landfill	**13.82**	hectares		
	35.10	acres		

Cost Summary	
Long Term Management Facility Construction Cost	$10,229,400
Facility Improvement Costs	$2,506,900
Contaminated Soil Excavation and Relocation Cost	$14,471,900
Clean Soil Replacement Cost	$9,969,000
Final Capping Cost	$7,986,900
Total Capital Cost	**$45,164,100**
Total Maintenance and Monitoring Cost	**$2,631,600**
Total cost	**$47,795,700**
Cost per cubic metre	**$49.00**
Cost per tonne	**$27.00**

OPTION 4 - 970,000 m3 Above Ground Long Term Management Facility

Quantities

General Information							
Dimensions at top inside of berms	240	m by	485	m			
Approximate depth below ground	1	m					
Approximate heigth of berms	4	m					
Total approximate depth	5						
Side slopes	3	H to	1	V			
Dimensions at base of cell	210		455				
Dimensions at outside toe of slope	270		515				
Leachate Collection Pipe Lengths							
Main spine							455
Laterals	spacing	30	m	15	laterals at	210	3185
Total							3640

Quantities from Civil 3D Model		
Airspace	980,000	m3
Total Cut	42,300	m3
Total Fill	122,560	m3
ENTIRE FOOTPRINT AREA	138,200	m2
SIDE SLOPE AREA INSIDE	17,036	m2
BASE FLOOR AREA	100,240	m2
TOP WASTE AREA	116,970	m2
PERIMETER OF INSIDE CREST	1,450	m

Volumes of Contaminated Soil and Backfill Required

Major Area	Contaminated Soil Quantity	Hauling Distance to LTMF	Backfill Volume Required	Backfill Volume Available In Area	Surplus / Deficit	Backfill Hauling Distance	Comments on Backfill Soil Hauling
	m3	km	m3	m3	m3	km	
Goose Island	10,584	7.6	10,584	423,200	412,616	0.5	from Goose Island shale borrow areas
Bear Island	37,575	5.4	37,575	400,058	362,483	0.5	from Bear Island shale borrow areas
Bear Island Sumps	130,775	5.4	130,775	0	130,775	0.5	from Bear Island shale borrow areas
Mainland West	77,028	1.1	77,028	323,559	246,531	0.5	from Mainland West shale and overburden borrow areas
Mainland Central	146,464	0.5	117,810	387,701	269,891	0.5	LTMF is located at Mainland Central
Mainland East	456,015	1.8	456,015	214,754	241,261	0.5	from Mainland Central borrow area
Mainland Sumps	101,250	1.3	101,250	333,328	232,078	0.5	from Mainland Sumps borrow areas
Artificial Islands	7,583	3.3	0	0	0		no backfilling to be completed
Total	967,274		931,037				

Swell factor	Compaction factor
0%	0%

OPTION 4 - 970,000 m3 Above Ground Long Term Management Facility

Development Cost Estimate

Item	Qty.	Unit	Rate	Total
Excavation/Berms				
Excavation	42,300	cu.m @	**$6.25**	$264,400
Berm embankment	122,560	cu.m @	**$3.75**	$459,600
Run-on ditches	1,570	l.m. @	**$25.00**	$39,300
Liner System				
Fine gravel below GCL	23,455	cu.m @	**$31.25**	$733,000
GCL liner	117,276	sq.m @	**$12.50**	$1,466,000
Geomembrane liner	117,276	sq.m @	**$12.50**	$1,466,000
Geonet drainage layer (w. geotextile) on side slopes	17,036	sq.m @	**$18.75**	$319,400
Sand cushion	15,036	cu.m @	**$43.75**	$657,800
Drainage rock	30,072	cu.m @	**$62.50**	$1,879,500
Geotextile above drainage rock	100,240	sq.m @	**$5.00**	$501,200
Leachate collection pipes	3,640	l.m @	**$156.25**	$568,800
Geomembrane rub sheet below collection pipes	3,640	sq.m @	**$12.50**	$45,500
Geotextile below rub sheet	3,640	sq.m @	**$5.00**	$18,200
Leachate Handling System				
Leachate collection manhole	1	l. s. @	**$68,750.00**	$68,800
Leachate pump	1	l. s. @	**$2,500.00**	$2,500
Leachate forcemain	1,000	l. m. @	**$250.00**	$250,000
Power supply	1	l. s. @	**$100,000.00**	$100,000
Cell Access				
Access ramp Into cell (clean fill material)	500	cu.m @	**$0.00**	$0
Fencing with gates	1,570	l.m @	**$31.25**	$49,100
Gates	1	l. s. @	**$6,250.00**	$6,300
Lights at Facility	0	l. s. @	**$0.00**	$0
			Longterm Management Facility Subtotal	**$8,895,400**
Other Cost Items				
Mobilization/Demobilization				$1,334,000
Engineering - construction supervision and design				$0
Geomembrane QA/QC	0	weeks @	$6,000.00	$0
Materials testing	0	LS @	$15,000.00	$0
Installation of groundwater monitoring wells	0	LS @	$50,000.00	$0
			Other Cost Items Subtotal	**$1,334,000**
			Estimated Long Term Management Facility DevelopmentTotal	**$10,229,400**

Assumptions:

- depth of fine gravel below GCL	**0.2**	m
- thickness of sand cushion at base of LF	**0.15**	m
- thickness of drainage rock at base of LF	**0.3**	m
- base of cell is	1.0	m below surface
- fence encloses area of cell plus	**0**	m
- mobilization and demobilization at	**15%**	of contract price
- construction supervision and design	**0%**	of contract price

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 4 - 970,000 m3 Above Ground Long Term Management Facility

General Improvement Costs

Item	Qty.	Unit	Rate	Total
On-site access road				
Common Fill	1,500	cu.m @	**$10.00**	$15,000
Surface Gravel	500	cu.m @	**$20.00**	$10,000
Proof Roll For Base of Road	3,000	sq.m @	**$0.10**	$300
Miscellaneous (culverts, crossings)	1	l.s. @	**$15,000.00**	$15,000
Construct ice road				
Construct ice road	1	l.s. @	**$600,000.00**	$600,000
Water Treatment Plant (Leachate Treament Post Closure)				
Plant Utilities	1	l. s. @	**$100,000.00**	$100,000
Building	144	sq. m @	**$3,400.00**	$489,600
Treatment Skid 1 (Separation/GAC, Reverse Osmosis)	1	l. s. @	**$200,000.00**	$200,000
Treatment Skid 2 (Chystallizer)	1	l. s. @	**$250,000.00**	$250,000
Runoff and Leachate Management During LTMF Construction				
Temporary ditching and sump	1	l. s. @	**$200,000.00**	$200,000
Downhole disposition	1	l. s. @	**$300,000.00**	$300,000
			Infrastructure Subtotal	**$2,179,900**
Other Cost Items				
Mobilization/Demobilization				$327,000
Engineering - construction supervision and design				$0
Materials Testing				**$0**
			Other Cost Items Subtotal	**$327,000**
INFRASTRUCTURE TOTAL				**$2,506,900**

Assumptions:

Private Road

	500	m	in length
	8	m	in width
	2	:1	shoulders
raise	**0.3**	m	using common fill
	0.2	m	pitrun gravel
	0.1	m	surface gravel

On-site Access Road

1000	m	in length
5	m	in width
2	:1	shoulders
0.1	m	thick surface gravel
0.3	m	common fill

- common fill consists of native clay material readily available along road alignment

Mobilization/ Demobilization	**15%**	of contract price
Engineering and Supervision	**0%**	of contract price

OPTION 4 - 970,000 m3 Above Ground Long Term Management Facility

Contaminated Soil Excavation and Relocation Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Excavation and Relocation Costs				
Goose Island				
Excavate contaminated soil	10,584	cu.m.	$9.38	$99,225
Haul distance	7.6	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	144,789	tonnes-km	$1.50	$217,184
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	8,467	cu.m.	$2.00	$16,934
Placement of soil in Management Facility in next year after excavation	2,117	cu.m.	$4.00	$8,467
Bear Island				
Excavate contaminated soil	37,575	cu.m.	$9.38	$352,266
Haul distance	5.4	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	365,229	tonnes-km	$1.50	$547,844
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	30,060	cu.m.	$2.00	$60,120
Placement of soil in Management Facility in next year after excavation	7,515	cu.m.	$4.00	$30,060
Bear Island Sumps				
Excavate contaminated soil	130,775	cu.m.	$9.38	$1,226,016
Haul distance	5.4	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,271,133	tonnes-km	$1.50	$1,906,700
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	104,620	cu.m.	$2.00	$209,240
Placement of soil in Management Facility in next year after excavation	26,155	cu.m.	$4.00	$104,620
Mainland West				
Excavate contaminated soil	77,028	cu.m.	$6.25	$481,425
Haul distance	1.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	152,515	tonnes-km	$1.50	$228,773
Placement in Management Facility	77,028	cu.m.	$2.00	$154,056
Mainland Central				
Excavate contaminated soil	146,464	cu.m.	$6.25	$915,400
Haul distance	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	131,818	tonnes-km	$1.50	$197,726
Placement in Management Facility	146,464	cu.m.	$2.00	$292,928
Mainland East				
Excavate contaminated soil	456,015	cu.m.	$6.25	$2,850,094
Haul distance	1.8	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,477,489	tonnes-km	$1.50	$2,216,233
Placement in Management Facility	456,015	cu.m.	$2.00	$912,030
Mainland Sumps				
Excavate contaminated soil	101,250	cu.m.	$6.25	$632,813
Haul distance	1.3	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	236,925	tonnes-km	$1.50	$355,388
Placement in Management Facility	101,250	cu.m.	$2.00	$202,500
Artificial Islands				
Excavate contaminated soil	7,583	cu.m.	$9.38	$71,091
Haul distance	3.3	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	45,043	tonnes-km	$1.50	$67,565
Placement in Management Facility	7,583	cu.m.	$2.00	$15,166
			Excavation and Relocation Subtotal	**$14,371,861**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,746,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Excavation and Relocation Costs Subtotal	**$14,471,861**
Contingency	0%			$0
			Estimated Relocation & Backfilling Costs Total	**$14,471,861**

Assumptions:

contingency @ **0%** of contract price

OPTION 4 - 970,000 m3 Above Ground Long Term Management Facility

Backfilling Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Backfilling Costs				
Goose Island				
Excavate backfill soil from stockpiles	10,584	cu.m.	$6.25	$66,150
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul backfill soil	9,526	tonnes-km	$1.50	$14,288
Placement in excavation	10,584	cu.m.	$3.00	$31,752
Bear Island				
Excavate backfill soil from stockpiles	37,575	cu.m.	$6.25	$234,844
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	33,818	tonnes-km	$1.50	$50,726
Placement in excavation	37,575	cu.m.	$3.00	$112,725
Bear Island Sumps				
Excavate backfill soil from stockpiles	130,775	cu.m.	$6.25	$817,344
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	117,698	tonnes-km	$1.50	$176,546
Placement in excavation	130,775	cu.m.	$3.00	$392,325
Mainland West				
Excavate backfill soil from stockpiles	77,028	cu.m.	$6.25	$481,425
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	69,325	tonnes-km	$1.50	$103,988
Placement in excavation	77,028	cu.m.	$3.00	$231,084
Mainland Central				
Excavate backfill soil from stockpiles	117,810	cu.m.	$6.25	$736,313
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	106,029	tonnes-km	$1.50	$159,044
Placement in excavation	117,810	cu.m.	$3.00	$353,430
Mainland East				
Excavate backfill soil from stockpiles	456,015	cu.m.	$6.25	$2,850,094
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	410,414	tonnes-km	$1.50	$615,620
Placement in excavation	456,015	cu.m.	$3.00	$1,368,045
Mainland Sumps				
Excavate backfill soil from stockpiles	101,250	cu.m.	$6.25	$632,813
Haul distance	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	91,125	tonnes-km	$1.50	$136,688
Placement in excavation	101,250	cu.m.	$3.00	$303,750
Artificial Islands				
Excavate backfill soil from stockpiles	0	cu.m.	$0.00	$0
Haul distance	0.0	km		
Soil density	0.0	t/cu.m.		
Haul contaminated soil	0	tonnes-km	$0.00	$0
Placement in excavation	0	cu.m.	$0.00	$0
			Backfilling Subtotal	**$9,868,992**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,746,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Backfilling Costs Subtotal	**$9,968,992**
Contingency	0%			$0
			Estimated Backfilling Costs Total	**$9,968,992**

Assumptions:

contingency @ **0%** of contract price

OPTION 4 - 970,000 m3 Above Ground Long Term Management Facility

Final Cap Placement Cost Estimate

Item	Qty	Unit	Rate	Total
Landfill Cap				
Geomembrane Barrier Layer	116,970	sq.m. @	**$18.75**	$2,193,200
Geocomposite drainage Layer	116,970	sq.m. @	**$18.75**	$2,193,200
Place and Compact Soil over geomembrane	58,485	cu.m. @	**$43.75**	$2,558,700
			Cap Construction Subtotal	**$6,945,100**
Other items				
Mobilization/demobilization				$1,041,765
Engineering - construction supervision and design				$0
Materials testing				$0
			Other items subtotal	**$1,041,765**
			Longterm Management Facility Cap Total	**$7,986,865**

Assumptions:

Subsoil Thickness	**0.5**	m
Mob/demob as % of landfill cap subtotal	**15%**	
Engineering/Supervision as % of landfill cap subtotal	**0%**	

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 4 - 970,000 m3 Above Ground Long Term Management Facility

Post-closure Maintenance and Monitoring Cost Estimate

Item	Qty.	Unit	Rate	Total
A) Maintenance Costs				
Annual Maintenance	1	L.S.	**$35,000**	$35,000
			Maintenance Subtotal	**$35,000**
B) Leachate Treatment				
Water treatment plant Operation & Maintenance	2500	m3	$15	$37,500
Disposition of treatment residuals	5	m3	$5,000.00	$25,000
			Leachate Subtotal	**$62,500**
C) Environmental Costs				
Monitoring and Reporting	1	L.S.	**$25,000**	$25,000
			Environmental Costs Subtotal	**$25,000**
			Estimated Annual Post Closure Subtotal	$122,500
Contingency	0%			$0
			Estimated Annual Post Closure Total	**$122,500**

Years for annual monitoring	50
Total cost	$6,125,000
Discount rate	4%
Net present value	$2,631,567.62

Norman Wells Conservation and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 5 - 670,000 m^3 Below Ground Long Term Management Facility

Summary

Location of Facility Mainland Sumps

Reclamation Criteria Industrial on Mainland and Parkland on Islands

Waste Material	Total Quantity	Expected in-place density	Total Volume
	(tonnes)	(tonnes/m^3)	(m^3)
Contaminated soil	**1,206,000**	**1.80**	**670,000**

Long Term Management Facility Information				
Dimensions	**240**	m by	**328**	m
Approximate depth below ground	**2.00**	m		
Approximate height of berm above ground	**3.50**	m		
Elevation on top of waste	**80.0**	mASL		
Maximum height of waste above top of berm	**11.5**	m		
Slope on top of waste	**10.0%**			
Area Required for Landfill	**9.68**	hectares		
	24.59	acres		

Cost Summary	
Long Term Management Facility Construction Cost	$7,476,800
Facility Improvement Costs	$2,322,900
Contaminated Soil Excavation and Relocation Cost	$10,571,600
Clean Soil Replacement Cost	$6,949,200
Final Capping Cost	$5,418,800
Total Capital Cost	**$32,739,300**
Total Maintenance and Monitoring Cost	**$1,944,100**
Total cost	**$34,683,400**
Cost per cubic metre	**$52.00**
Cost per tonne	**$28.76**

OPTION 5 - 670,000 m3 Below Ground Long Term Management Facility

Quantities

General Information							
Dimensions at top inside of berms	240	m by	328	m			
Approximate depth below ground	2	m					
Approximate heigth of berms	3.5	m					
Total approximate depth	5.5						
Side slopes	3	H to	1	V			
Dimensions at base of cell	207		295				
Dimensions at outside toe of slope	273		361				
Leachate Collection Pipe Lengths							
Main spine							295
Laterals	spacing	30	m	10	laterals at	207	2035.5
Total							2330.5

Quantities from Civil 3D Model		
Airspace	725,000	m3
Total Cut	97,100	m3
Total Fill	66,600	m3
ENTIRE FOOTPRINT AREA	96,800	m2
SIDE SLOPE AREA INSIDE	16,600	m2
BASE FLOOR AREA	62,500	m2
TOP WASTE AREA	79,360	m2
PERIMETER OF INSIDE CREST	1,140	m

Volumes of Contaminated Soil and Backfill Required

Major Area	Contaminated Soil Quantity	Hauling Distance to LTMF	Backfill Volume Required	Backfill Volume Available In Area	Surplus / Deficit	Backfill Hauling Distance	Comments on Backfill Soil Hauling
	m3	km	m3	m3	m3	km	
Goose Island	10,584	7.3	10,584	423,200	412,616	0.5	from Goose Island shale borrow areas
Bear Island	37,575	5.2	37,575	400,058	362,483	0.5	from Bear Island shale borrow areas
Bear Island Sumps	130,775	5.2	130,775	0	130,775	0.5	from Bear Island shale borrow areas
Mainland West	67,676	1.9	67,676	323,559	255,883	0.5	from Mainland West shale and overburden borrow areas
Mainland Central	99,827	1.2	99,827	387,701	287,874	0.5	from Mainland Central shale and overburden borrow areas
Mainland East	238,873	1.5	238,873	214,754	24,119	1.5	from Mainland Central borrow areas
Mainland Sumps	76,525	0	0	333,328	333,328	0	LTMF is located at Mainland Sumps
Artificial Islands	7,583	3.1	0	0	0		no backfilling to be completed
Total	669,418		585,310				

Swell factor 0%

Compaction factor 0%

OPTION 5 - 670,000 m3 Below Ground Long Term Management Facility

Development Cost Estimate

Item	Qty.	Unit	Rate	Total
Excavation/Berms				
Excavation	97,100	cu.m @	**$6.25**	$606,900
Berm embankment	66,600	cu.m @	**$3.75**	$249,800
Run-on ditches	1,268	l.m. @	**$25.00**	$31,700
Liner System				
Fine gravel below GCL	15,820	cu.m @	**$31.25**	$494,400
GCL liner	79,100	sq.m @	**$12.50**	$988,800
Geomembrane liner	79,100	sq.m @	**$12.50**	$988,800
Geonet drainage layer (w. geotextile) on side slopes	16,600	sq.m @	**$18.75**	$311,300
Sand cushion	9,375	cu.m @	**$43.75**	$410,200
Drainage rock	18,750	cu.m @	**$62.50**	$1,171,900
Geotextile above drainage rock	62,500	sq.m @	**$5.00**	$312,500
Leachate collection pipes	2,331	l.m @	**$156.25**	$364,100
Geomembrane rub sheet below collection pipes	2,331	sq.m @	**$12.50**	$29,100
Geotextile below rub sheet	2,331	sq.m @	**$5.00**	$11,700
Leachate Handling System				
Leachate collection manhole	1	l. s. @	**$68,750.00**	$68,800
Leachate pump	1	l. s. @	**$2,500.00**	$2,500
Leachate forcemain	1,000	l. m. @	**$250.00**	$250,000
Power supply	1	l. s. @	**$100,000.00**	$100,000
Cell Access				
Access ramp Into cell (clean fill material)	500	cu.m @	**$0.00**	$0
Fencing with gates	1,268	l.m @	**$81.25**	$103,000
Gates	1	l. s. @	**$6,250.00**	$6,300
Lights at Facility	0	l. s. @	**$0.00**	$0
			Longterm Management Facility Subtotal	**$6,501,800**
Other Cost Items				
Mobilization/Demobilization				$975,000
Engineering - construction supervision and design				$0
Geomembrane QA/QC	0	weeks @	**$6,000.00**	$0
Materials testing	0	LS @	**$15,000.00**	$0
Installation of groundwater monitoring wells	0	LS @	**$50,000.00**	$0
			Other Cost Items Subtotal	**$975,000**
			Estimated Long Term Management Facility DevelopmentTotal	**$7,476,800**

Assumptions:

- depth of fine gravel below GCL	**0.2**	m
- thickness of sand cushion at base of LF	**0.15**	m
- thickness of drainage rock at base of LF	**0.3**	m
- base of cell is	2.0	m below surface
- fence encloses area of cell plus	**0**	m
- mobilization and demobilization at	**15%**	of contract price
- construction supervision and design	**0%**	of contract price

OPTION 5 - 670,000 m3 Below Ground Long Term Management Facility

General Improvement Costs

Item	Qty.	Unit	Rate	Total
On-site access road				
Common Fill	1,500	cu.m @	**$10.00**	$15,000
Surface Gravel	500	cu.m @	**$20.00**	$10,000
Proof Roll For Base of Road	3,000	sq.m @	**$0.10**	$300
Miscellaneous (culverts, crossings)	1	l.s. @	**$15,000.00**	$15,000
Construct ice road				
Construct ice road	1	l.s. @	**$600,000.00**	$600,000
Water Treatment Plant (Leachate Treament Post Closure)				
Plant Utilities	1	l. s. @	**$100,000.00**	$100,000
Building	144	sq. m @	**$3,400.00**	$489,600
Treatment Skid 1 (Separation/GAC, Reverse Osmosis)	1	l. s. @	**$200,000.00**	$200,000
Treatment Skid 2 (Chystallizer)	1	l. s. @	**$250,000.00**	$250,000
Runoff and Leachate Management During LTMF Construction				
Temporary ditching and sump	1	l. s. @	**$140,000.00**	$140,000
Downhole disposition	1	l. s. @	**$200,000.00**	$200,000
			Infrastructure Subtotal	**$2,019,900**
Other Cost Items				
Mobilization/Demobilization				$303,000
Engineering - construction supervision and design				$0
Materials Testing				$0
			Other Cost Items Subtotal	**$303,000**
INFRASTRUCTURE TOTAL				**$2,322,900**

Assumptions:

Private Road

	500	m	in length
	8	m	in width
	2	:1	shoulders
raise	**0.3**	m	using common fill
	0.2	m	pitrun gravel
	0.1	m	surface gravel

On-site Access Road

1000	m	in length
5	m	in width
2	:1	shoulders
0.1	m	thick surface gravel
0.3	m	common fill

- common fill consists of native clay material readily available along road alignment

Mobilization/ Demobilization	**15%**	of contract price
Engineering and Supervision	**0%**	of contract price

OPTION 5 - 670,000 m3 Below Ground Long Term Management Facility

Contaminated Soil Excavation and Relocation Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Excavation and Relocation Costs				
Goose Island				
Excavate contaminated soil	10,584	cu.m.	$9.38	$99,225
Haul distance	7.3	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	139,074	tonnes-km	$1.50	$208,611
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	8,467	cu.m.	$2.00	$16,934
Placement of soil in Management Facility in next year after excavation	2,117	cu.m.	$4.00	$8,467
Bear Island				
Excavate contaminated soil	37,575	cu.m.	$9.38	$352,266
Haul distance	5.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	351,702	tonnes-km	$1.50	$527,553
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	30,060	cu.m.	$2.00	$60,120
Placement of soil in Management Facility in next year after excavation	7,515	cu.m.	$4.00	$30,060
Bear Island Sumps				
Excavate contaminated soil	130,775	cu.m.	$9.38	$1,226,016
Haul distance	5.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,224,054	tonnes-km	$1.50	$1,836,081
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	104,620	cu.m.	$2.00	$209,240
Placement of soil in Management Facility in next year after excavation	26,155	cu.m.	$4.00	$104,620
Mainland West				
Excavate contaminated soil	67,676	cu.m.	$6.25	$422,975
Haul distance	1.9	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	231,452	tonnes-km	$1.50	$347,178
Placement in Management Facility	67,676	cu.m.	$2.00	$135,352
Mainland Central				
Excavate contaminated soil	99,827	cu.m.	$6.25	$623,919
Haul distance	1.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	215,626	tonnes-km	$1.50	$323,439
Placement in Management Facility	99,827	cu.m.	$2.00	$199,654
Mainland East				
Excavate contaminated soil	238,873	cu.m.	$6.25	$1,492,956
Haul distance	1.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	644,957	tonnes-km	$1.50	$967,436
Placement in Management Facility	238,873	cu.m.	$2.00	$477,746
Mainland Sumps				
Excavate contaminated soil	76,525	cu.m.	$6.25	$478,281
Haul distance	0.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	13,775	tonnes-km	$1.50	$20,662
Placement in Management Facility	76,525	cu.m.	$2.00	$153,050
Artificial Islands				
Excavate contaminated soil	7,583	cu.m.	$9.38	$71,091
Haul distance	3.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	42,313	tonnes-km	$1.50	$63,470
Placement in Management Facility	7,583	cu.m.	$2.00	$15,166
			Excavation and Relocation Subtotal	**$10,471,567**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,206,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Excavation and Relocation Costs Subtotal	**$10,571,567**
Contingency	0%			$0
			Estimated Relocation & Backfilling Costs Total	**$10,571,567**

Assumptions:

contingency @ **0%** of contract price

OPTION 5 - 670,000 m3 Below Ground Long Term Management Facility

Backfilling Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Backfilling Costs				
Goose Island				
Excavate backfill soil from stockpiles	10,584	cu.m.	$6.25	$66,150
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul backfill soil	9,526	tonnes-km	$1.50	$14,288
Placement in excavation	10,584	cu.m.	$3.00	$31,752
Bear Island				
Excavate backfill soil from stockpiles	37,575	cu.m.	$6.25	$234,844
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	33,818	tonnes-km	$1.50	$50,726
Placement in excavation	37,575	cu.m.	$3.00	$112,725
Bear Island Sumps				
Excavate backfill soil from stockpiles	130,775	cu.m.	$6.25	$817,344
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	117,698	tonnes-km	$1.50	$176,546
Placement in excavation	130,775	cu.m.	$3.00	$392,325
Mainland West				
Excavate backfill soil from stockpiles	67,676	cu.m.	$6.25	$422,975
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	60,908	tonnes-km	$1.50	$91,363
Placement in excavation	67,676	cu.m.	$3.00	$203,028
Mainland Central				
Excavate backfill soil from stockpiles	99,827	cu.m.	$6.25	$623,919
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	89,844	tonnes-km	$1.50	$134,766
Placement in excavation	99,827	cu.m.	$3.00	$299,481
Mainland East				
Excavate backfill soil from stockpiles	238,873	cu.m.	$6.25	$1,492,956
Haul distance (from nearby stockpiles)	1.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	644,957	tonnes-km	$1.50	$967,436
Placement in excavation	238,873	cu.m.	$3.00	$716,619
Mainland Sumps				
Excavate backfill soil from stockpiles	0	cu.m.	$6.25	$0
Haul distance	0.0	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	0	tonnes-km	$1.50	$0
Placement in excavation	0	cu.m.	$3.00	$0
Artificial Islands				
Excavate backfill soil from stockpiles	0	cu.m.	$0.00	$0
Haul distance	0.0	km		
Soil density	0.0	t/cu.m.		
Haul contaminated soil	0	tonnes-km	$0.00	$0
Placement in excavation	0	cu.m.	$0.00	$0
			Backfilling Subtotal	**$6,849,243**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,206,000	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Backfilling Costs Subtotal	**$6,949,243**
Contingency	0%			$0
			Estimated Backfilling Costs Total	**$6,949,243**

Assumptions:

contingency @ **0%** of contract price

OPTION 5 - 670,000 m3 Below Ground Long Term Management Facility

Final Cap Placement Cost Estimate

Item	Qty.	Unit	Rate	Total
Landfill Cap				
Geomembrane Barrier Layer	79,360	sq.m. @	**$18.75**	$1,488,000
Geocomposite drainage Layer	79,360	sq.m. @	**$18.75**	$1,488,000
Place and Compact Soil over geomembrane	39,680	cu.m. @	**$43.75**	$1,736,000
			Cap Construction Subtotal	**$4,712,000**
Other items				
Mobilization/demobilization				$706,800
Engineering - construction supervision and design				$0
Materials testing				$0
			Other items subtotal	**$706,800**
			Longterm Management Facility Cap Total	**$5,418,800**

Assumptions:

Subsoil Thickness	**0.5**	m
Mob/demob as % of landfill cap subtotal	**15%**	
Engineering/Supervision as % of landfill cap subtotal	**0%**	

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 5 - 670,000 m3 Below Ground Long Term Management Facility

Post-closure Maintenance and Monitoring Cost Estimate

Item	Qty.	Unit	Rate	Total
A) Maintenance Costs				
Annual Maintenance	1	L.S.	**$25,000**	$25,000
			Maintenance Subtotal	**$25,000**
B) Leachate Disposal Well Maintenance Costs				
Water treatment plant Operation & Maintenance	1700	m3	$15	$25,500
Disposition of treatment residuals	3	m3	$5,000.00	$15,000
			Leachate Subtotal	**$40,500**
C) Environmental Costs				
Monitoring and Reporting	1	L.S.	**$25,000**	$25,000
			Environmental Costs Subtotal	**$25,000**
			Estimated Annual Post Closure Subtotal	$90,500
Contingency	0%			$0
			Estimated Annual Post Closure Total	**$90,500**

Years for annual monitoring	50
Total cost	$4,525,000
Discount rate	4%
Net present value	$1,944,137.71

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 6 - 970,000 m^3 Below Ground Long Term Management Facility

Summary

Location of Facility Mainland Sumps

Reclamation Criteria Parkland on Mainland and Parkland on Islands

Waste Material	Total Quantity	Expected in-place density	Total Volume
	(tonnes)	(tonnes/m^3)	(m^3)
Contaminated soil	**1,741,090**	**1.80**	**967,272**

Long Term Management Facility Information				
Dimensions	**240**	m by	**450**	m
Approximate depth below ground	**1.00**	m		
Approximate height of berm above ground	**4.00**	m		
Elevation on top of waste	**72.0**	mASL		
Maximum height of waste above top of berm	**14**	m		
Slope on top of waste	**6.5%**			
Area Required for Landfill	**12.95**	hectares		
	32.89	acres		

Cost Summary	
Long Term Management Facility Construction Cost	$10,021,800
Facility Improvement Costs	$2,506,900
Contaminated Soil Excavation and Relocation Cost	$14,114,000
Clean Soil Replacement Cost	$9,212,703
Final Capping Cost	$7,408,500
Total Capital Cost	**$43,263,903**
Total Maintenance and Monitoring Cost	**$2,631,600**
Total cost	**$45,895,503**
Cost per cubic metre	**$47.00**
Cost per tonne	**$26.00**

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 6 - 970,000 m3 Below Ground Long Term Management Facility

Quantities

General Information							
Dimensions at top inside of berms	240	m by	480	m			
Approximate depth below ground	1	m					
Approximate heigth of berms	4	m					
Total approximate depth	5						
Side slopes	3	H to	1	V			
Dimensions at base of cell	210		450				
Dimensions at outside toe of slope	270		510				
Leachate Collection Pipe Lengths							
Main spine							450
Laterals	spacing	30	m	15	laterals at	210	3150
Total							3600

Quantities from Civil 3D Model		
Airspace	1,000,000	m3
Contaminated Soil (Scen2)	100,000	m3
Total Cut	112,000	m3
Total Fill	82,500	m3
ENTIRE FOOTPRINT AREA	129,506	m2
SIDE SLOPE AREA INSIDE	19,900	m2
BASE FLOOR AREA	89,200	m2
TOP WASTE AREA	108,500	m2
PERIMETER OF INSIDE CREST	1,380	m

Volumes of Contaminated Soil and Backfill Required

Major Area	Contaminated Soil Quantity	Hauling Distance to LTMF	Backfill Volume Required	Backfill Volume Available In Area	Surplus / Deficit	Backfill Hauling Distance	Comments on Backfill Soil Hauling
	m3	km	m3	m3	m3	km	
Goose Island	10,584	7.3	10,584	423,200	412,616	0.5	from Goose Island shale borrow areas
Bear Island	37,575	5.2	37,575	400,058	362,483	0.5	from Bear Island shale borrow areas
Bear Island Sumps	130,775	5.2	130,775	0	130,775	0.5	from Bear Island shale borrow areas
Mainland West	77,026	1.9	77,026	323,559	246,533	0.5	from Mainland West shale and overburden borrow areas
Mainland Central	146,464	1.2	146,464	387,701	241,237	0.5	from Mainland Central shale and overburden borrow areas
Mainland East	456,015	1.5	456,015	214,754	241,261	1.5	from Mainland Central borrow areas
Mainland Sumps	101,250	0	1,250	333,328	332,078	0	LTMF is located at Mainland Sumps
Artificial Islands	7,583	3.1	0	0	0		no backfilling to be completed
Total	967,272		859,689				

Swell factor	Compaction factor
0%	0%

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 6 - 970,000 m3 Below Ground Long Term Management Facility

Development Cost Estimate

Item	Qty.	Unit	Rate	Total
Excavation/Berms				
Excavation	112,000	cu.m @	**$6.25**	$700,000
Berm embankment	82,500	cu.m @	**$3.75**	$309,400
Run-on ditches	1,560	l.m. @	**$25.00**	$39,000
Liner System				
Fine gravel below GCL	21,820	cu.m @	**$31.25**	$681,900
GCL liner	109,100	sq.m @	**$12.50**	$1,363,800
Geomembrane liner	109,100	sq.m @	**$12.50**	$1,363,800
Geonet drainage layer (w. geotextile) on side slopes	19,900	sq.m @	**$18.75**	$373,100
Sand cushion	13,380	cu.m @	**$43.75**	$585,400
Drainage rock	26,760	cu.m @	**$62.50**	$1,672,500
Geotextile above drainage rock	89,200	sq.m @	**$5.00**	$446,000
Leachate collection pipes	3,600	l.m @	**$156.25**	$562,500
Geomembrane rub sheet below collection pipes	3,600	sq.m @	**$12.50**	$45,000
Geotextile below rub sheet	3,600	sq.m @	**$5.00**	$18,000
Leachate Handling System				
Leachate collection manhole	1	l. s. @	**$68,750.00**	$68,800
Leachate pump	1	l. s. @	**$2,500.00**	$2,500
Leachate forcemain	1,000	l. m. @	**$250.00**	$250,000
Power supply	1	l. s. @	**$100,000.00**	$100,000
Cell Access				
Access ramp Into cell (clean fill material)	500	cu.m @	**$0.00**	$0
Fencing with gates	1,560	l.m @	**$81.25**	$126,800
Gates	1	l. s. @	**$6,250.00**	$6,300
Lights at Facility	0	l. s. @	**$0.00**	$0
			Longterm Management Facility Subtotal	**$8,714,800**
Other Cost Items				
Mobilization/Demobilization				$1,307,000
Engineering - construction supervision and design				$0
Geomembrane QA/QC	0	weeks @	$6,000.00	$0
Materials testing	0	LS @	$15,000.00	$0
Installation of groundwater monitoring wells	0	LS @	$50,000.00	$0
			Other Cost Items Subtotal	**$1,307,000**
			Estimated Long Term Management Facility DevelopmentTotal	**$10,021,800**

Assumptions:

- depth of fine gravel below GCL	0.2	m
- thickness of sand cushion at base of LF	0.15	m
- thickness of drainage rock at base of LF	0.3	m
- base of cell is	1.0	m below surface
- fence encloses area of cell plus	0	m
- mobilization and demobilization at	15%	of contract price
- construction supervision and design	0%	of contract price

Norman Wells Closure and Reclamation Plan

Base Case Remedation Report

Long Term Management Facility Assessment

OPTION 6 - 970,000 m3 Below Ground Long Term Management Facility

General Improvement Costs

Item	Qty.	Unit	Rate	Total
On-site access road				
Common Fill	1,500	cu.m @	**$10.00**	$15,000
Surface Gravel	500	cu.m @	**$20.00**	$10,000
Proof Roll For Base of Road	3,000	sq.m @	**$0.10**	$300
Miscellaneous (culverts, crossings)	1	l.s. @	**$15,000.00**	$15,000
Construct ice road				
Construct ice road	1	l.s. @	**$600,000.00**	$600,000
Water Treatment Plant (Leachate Treament Post Closure)				
Plant Utilities	1	l. s. @	**$100,000.00**	$100,000
Building	144	sq. m @	**$3,400.00**	$489,600
Treatment Skid 1 (Separation/GAC, Reverse Osmosis)	1	l. s. @	**$200,000.00**	$200,000
Treatment Skid 2 (Chystallizer)	1	l. s. @	**$250,000.00**	$250,000
Runoff and Leachate Management During LTMF Construction				
Temporary ditching and sump	1	l. s. @	**$200,000.00**	$200,000
Downhole disposition	1	l. s. @	**$300,000.00**	$300,000
			Infrastructure Subtotal	**$2,179,900**
Other Cost Items				
Mobilization/Demobilization				$327,000
Engineering - construction supervision and design				$0
Materials Testing				**$0**
			Other Cost Items Subtotal	**$327,000**
INFRASTRUCTURE TOTAL				**$2,506,900**

Assumptions:

Private Road

	500	m	in length
	8	m	in width
	2	:1	shoulders
raise	**0.3**	m	using common fill
	0.2	m	pitrun gravel
	0.1	m	surface gravel

On-site Access Road

	1000	m	in length
	5	m	in width
	2	:1	shoulders
	0.1	m	thick surface gravel
	0.3	m	common fill

- common fill consists of native clay material readily available along road alignment

Mobilization/ Demobilization	**15%**	of contract price
Engineering and Supervision	**0%**	of contract price

OPTION 6 - 970,000 m3 Below Ground Long Term Management Facility

Contaminated Soil Excavation and Relocation Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Excavation and Relocation Costs				
Goose Island				
Excavate contaminated soil	10,584	cu.m.	$9.38	$99,225
Haul distance	7.3	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	139,074	tonnes-km	$1.50	$208,611
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	8,467	cu.m.	$2.00	$16,934
Placement of soil in Management Facility in next year after excavation	2,117	cu.m.	$4.00	$8,467
Bear Island				
Excavate contaminated soil	37,575	cu.m.	$9.38	$352,266
Haul distance	5.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	351,702	tonnes-km	$1.50	$527,553
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	30,060	cu.m.	$2.00	$60,120
Placement of soil in Management Facility in next year after excavation	7,515	cu.m.	$4.00	$30,060
Bear Island Sumps				
Excavate contaminated soil	130,775	cu.m.	$9.38	$1,226,016
Haul distance	5.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,224,054	tonnes-km	$1.50	$1,836,081
Allowance for frozen material to be temporarily stockpiled at LTMF	20%			
Placement of soil in Management Facility in same year as excavated	104,620	cu.m.	$2.00	$209,240
Placement of soil in Management Facility in next year after excavation	26,155	cu.m.	$4.00	$104,620
Mainland West				
Excavate contaminated soil	77,026	cu.m.	$6.25	$481,413
Haul distance	1.9	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	263,429	tonnes-km	$1.50	$395,143
Placement in Management Facility	77,026	cu.m.	$2.00	$154,052
Mainland Central				
Excavate contaminated soil	146,464	cu.m.	$6.25	$915,400
Haul distance	1.2	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	316,362	tonnes-km	$1.50	$474,543
Placement in Management Facility	146,464	cu.m.	$2.00	$292,928
Mainland East				
Excavate contaminated soil	456,015	cu.m.	$6.25	$2,850,094
Haul distance	1.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,231,241	tonnes-km	$1.50	$1,846,861
Placement in Management Facility	456,015	cu.m.	$2.00	$912,030
Mainland Sumps				
Excavate contaminated soil	101,250	cu.m.	$6.25	$632,813
Haul distance	0.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	18,225	tonnes-km	$1.50	$27,338
Placement in Management Facility	101,250	cu.m.	$2.00	$202,500
Artificial Islands				
Excavate contaminated soil	7,583	cu.m.	$9.38	$71,091
Haul distance	3.1	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	42,313	tonnes-km	$1.50	$63,470
Placement in Management Facility	7,583	cu.m.	$2.00	$15,166
			Excavation and Relocation Subtotal	**$14,014,033**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,741,090	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Excavation and Relocation Costs Subtotal	**$14,114,033**
Contingency	0%			$0
			Estimated Relocation & Backfilling Costs Total	**$14,114,033**

Assumptions:

contingency @ **0%** of contract price

OPTION 6 - 970,000 m3 Below Ground Long Term Management Facility

Backfilling Costs

Item	Qty.	Unit	Rate	Sub-Total
A) Backfilling Costs				
Goose Island				
Excavate backfill soil from stockpiles	10,584	cu.m.	$6.25	$66,150
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul backfill soil	9,526	tonnes-km	$1.50	$14,288
Placement in excavation	10,584	cu.m.	$3.00	$31,752
Bear Island				
Excavate backfill soil from stockpiles	37,575	cu.m.	$6.25	$234,844
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	33,818	tonnes-km	$1.50	$50,726
Placement in excavation	37,575	cu.m.	$3.00	$112,725
Bear Island Sumps				
Excavate backfill soil from stockpiles	130,775	cu.m.	$6.25	$817,344
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	117,698	tonnes-km	$1.50	$176,546
Placement in excavation	130,775	cu.m.	$3.00	$392,325
Mainland West				
Excavate backfill soil from stockpiles	77,026	cu.m.	$6.25	$481,413
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	69,323	tonnes-km	$1.50	$103,985
Placement in excavation	77,026	cu.m.	$3.00	$231,078
Mainland Central				
Excavate backfill soil from stockpiles	146,464	cu.m.	$6.25	$915,400
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	131,818	tonnes-km	$1.50	$197,726
Placement in excavation	146,464	cu.m.	$3.00	$439,392
Mainland East				
Excavate backfill soil from stockpiles	456,015	cu.m.	$6.25	$2,850,094
Haul distance (from nearby stockpiles)	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	410,414	tonnes-km	$1.50	$615,620
Placement in excavation	456,015	cu.m.	$3.00	$1,368,045
Mainland Sumps				
Excavate backfill soil from stockpiles	1,250	cu.m.	$6.25	$7,813
Haul distance	0.5	km		
Soil density	1.8	t/cu.m.		
Haul contaminated soil	1,125	tonnes-km	$1.50	$1,688
Placement in excavation	1,250	cu.m.	$3.00	$3,750
Artificial Islands				
Excavate backfill soil from stockpiles	0	cu.m.	$0.00	$0
Haul distance	0.0	km		
Soil density	0.0	t/cu.m.		
Haul contaminated soil	0	tonnes-km	$0.00	$0
Placement in excavation	0	cu.m.	$0.00	$0
			Backfilling Subtotal	**$9,112,703**
B) Environmental and Monitoring Costs				
Monitoring and Reporting	1	L.S.	**$100,000.00**	$100,000
Permit Fees	1,741,090	tonnes @	**$0.00**	$0
			Environmental Subtotal	**$100,000**
			Estimated Backfilling Costs Subtotal	**$9,212,703**
Contingency	0%			$0
			Estimated Backfilling Costs Total	**$9,212,703**

Assumptions:

contingency @ **0%** of contract price

OPTION 6 - 970,000 m3 Below Ground Long Term Management Facility

Final Cap Placement Cost Estimate

Item	Qty.	Unit	Rate	Total
Landfill Cap				
Geomembrane Barrier Layer	108,500	sq.m. @	**$18.75**	$2,034,400
Geocomposite drainage Layer	108,500	sq.m. @	**$18.75**	$2,034,400
Place and Compact Soil over geomembrane	54,250	cu.m. @	**$43.75**	$2,373,400
			Cap Construction Subtotal	**$6,442,200**
Other items				
Mobilization/demobilization				$966,330
Engineering - construction supervision and design				$0
Materials testing				**$0**
			Other items subtotal	**$966,330**
			Longterm Management Facility Cap Total	**$7,408,530**

Assumptions:

Subsoil Thickness	**0.5**	m
Mob/demob as % of landfill cap subtotal	**15%**	
Engineering/Supervision as % of landfill cap subtotal	**0%**	

OPTION 6 - 970,000 m3 Below Ground Long Term Management Facility

Post-closure Maintenance and Monitoring Cost Estimate

Item	Qty.	Unit	Rate	Total
A) Maintenance Costs				
Annual Maintenance	1	L.S.	**$35,000**	$35,000
			Maintenance Subtotal	**$35,000**
B) Leachate Disposal Well Maintenance Costs				
Water treatment plant Operation & Maintenance	2500	m3	$15	$37,500
Disposition of treatment residuals	5	m3	$5,000.00	$25,000
			Leachate Subtotal	**$62,500**
C) Environmental Costs				
Monitoring and Reporting	1	L.S.	**$25,000**	$25,000
			Environmental Costs Subtotal	**$25,000**
			Estimated Annual Post Closure Subtotal	$122,500
Contingency	0%			$0
			Estimated Annual Post Closure Total	**$122,500**

Years for annual monitoring	50
Total cost	$6,125,000
Discount rate	4%
Net present value	$2,631,567.62

Appendix M

LTMF Siting Option Concepts

LEGEND

OPTION 1

0m 100 200 300 400 500 600

1 : 15000

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:

NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

OPTION 1 LOCATION PLAN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B1

LEGEND

OPTION 2

0m 100 200 300 400 500 600

1 : 15000

CLIENT:

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amec foster wheeler
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DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 2 LOCATION PLAN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B2

LEGEND

OPTION 3

0m 100 200 300 400 500 600

1 : 15000

CLIENT:

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DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:

NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

OPTION 3 LOCATION PLAN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B3

LEGEND

OPTION 4

0m 100 200 300 400 500 600

1 : 15000

CLIENT:

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DWN BY:	MDDS
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DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

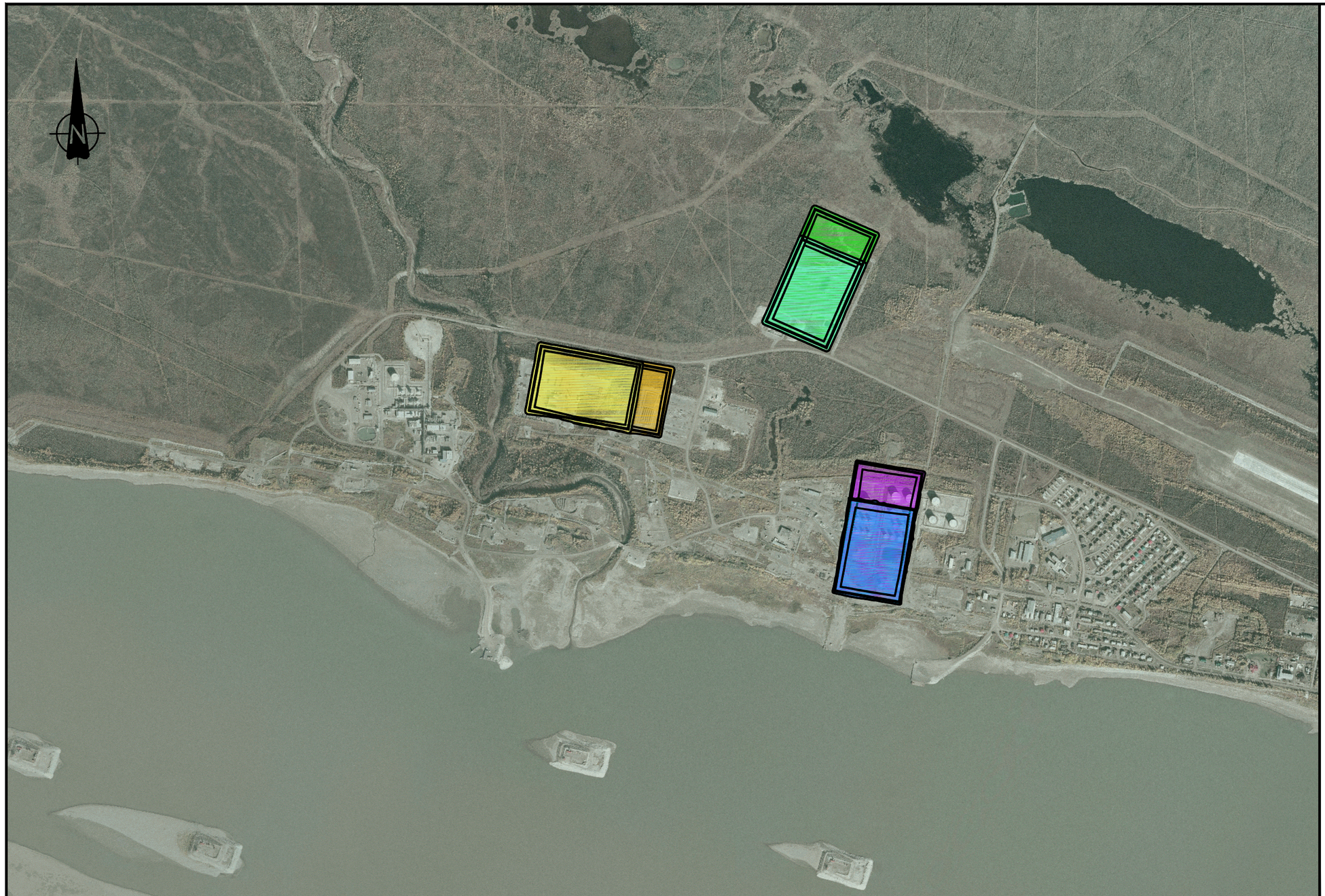
PROJECT:

NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

OPTION 4 LOCATION PLAN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B4



LEGEND

- OPTION 1
- OPTION 2
- OPTION 3
- OPTION 4
- OPTION 5
- OPTION 6

0m 100 200 300 400 500 600

1 : 15000

CLIENT:

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DWN BY:	MDDS
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DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

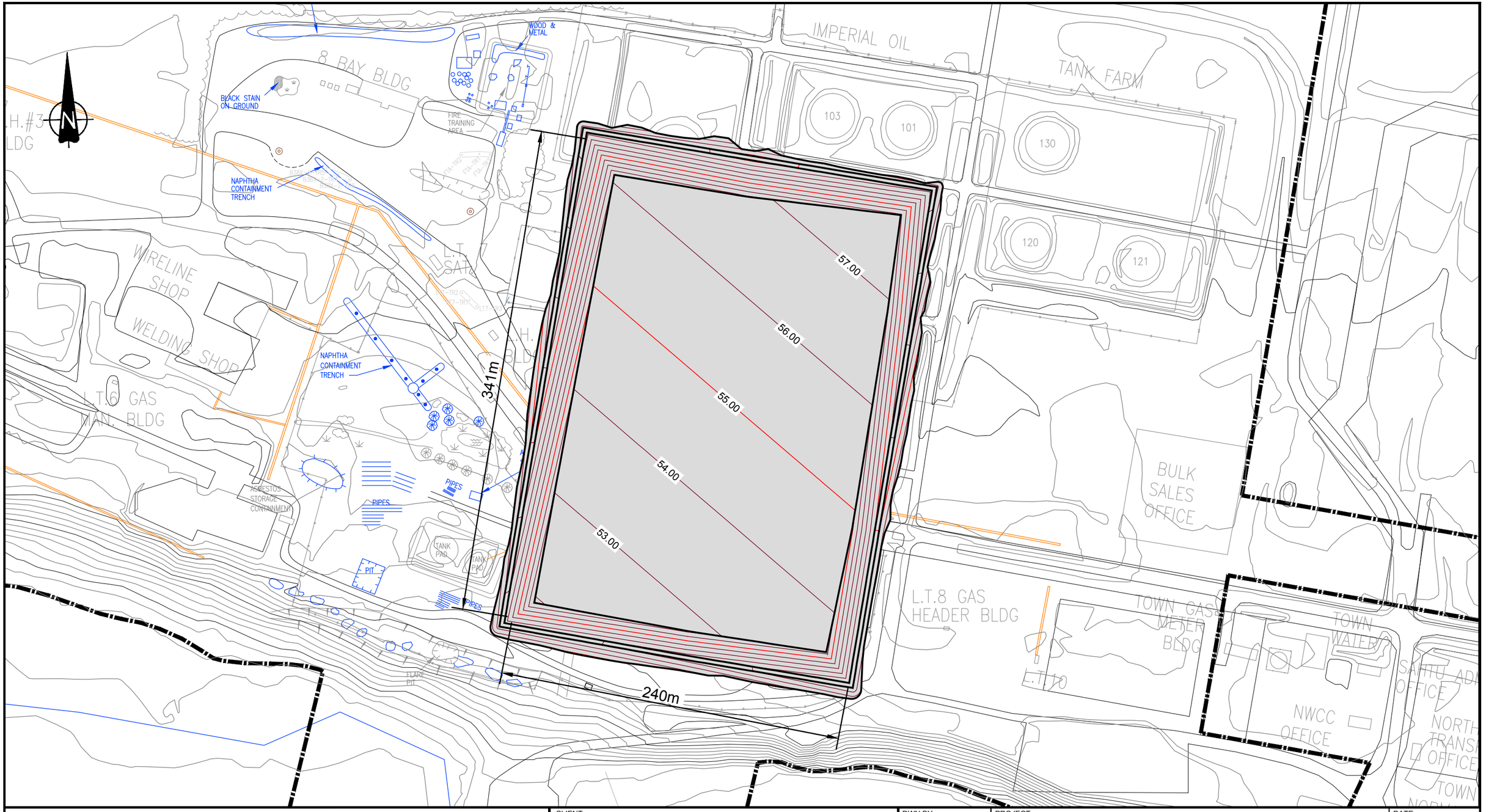
PROJECT:

NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

OPTION 1-6 LOCATION PLAN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B5



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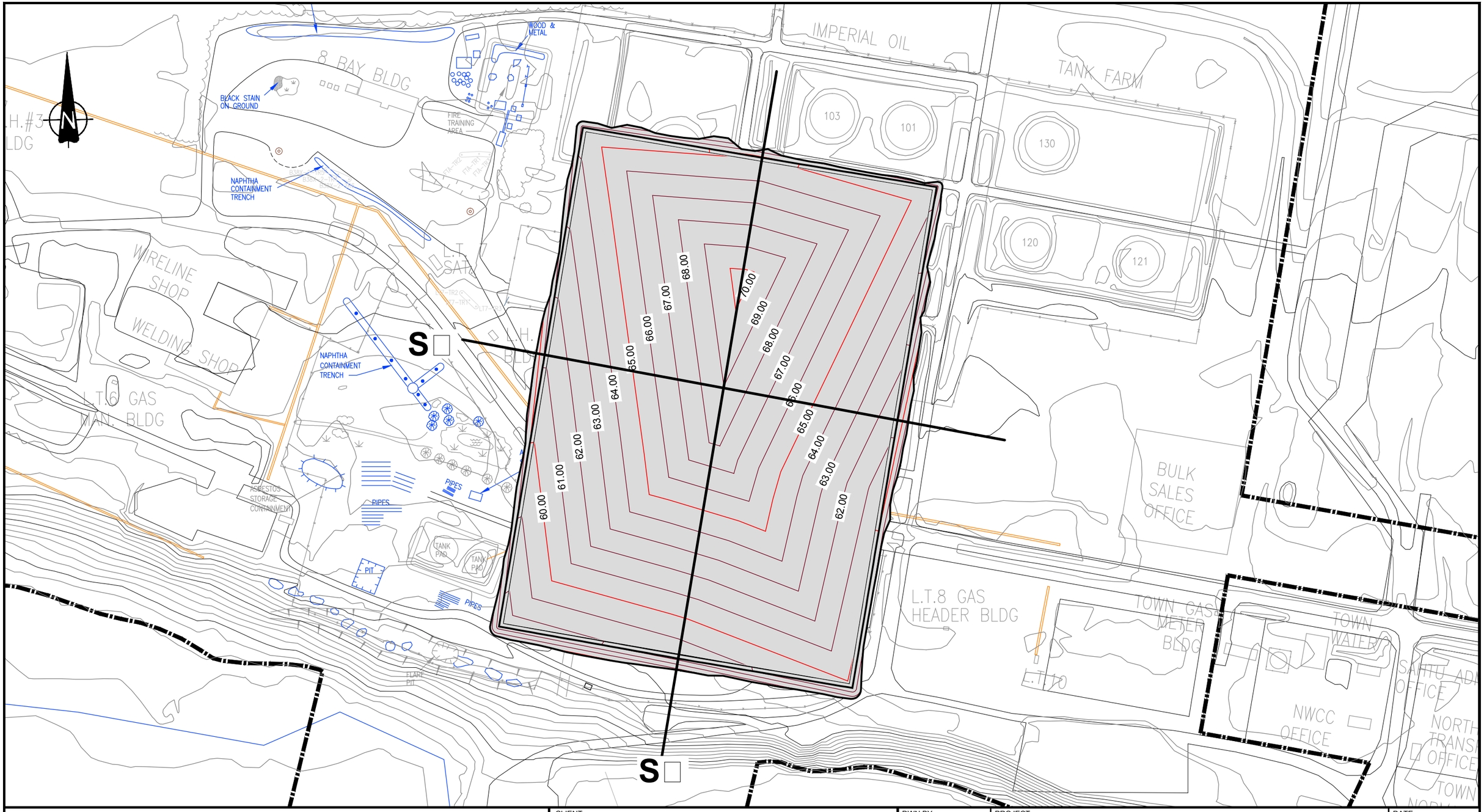
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 1 - AT DEPTH LTMF (DEEP BEDROCK) - 670 km³ CAPACITY BASE DESIGN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B6



0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:

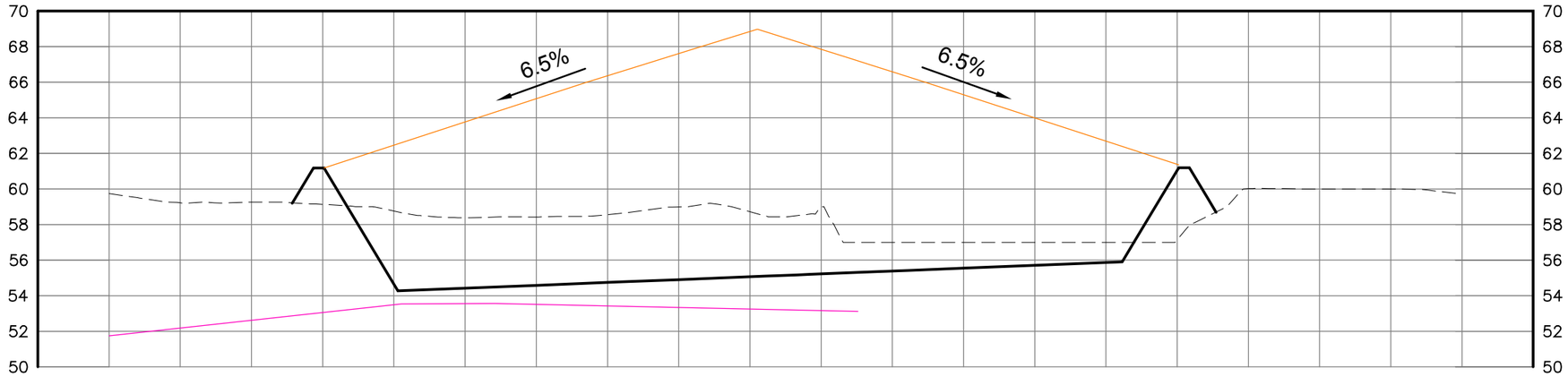
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

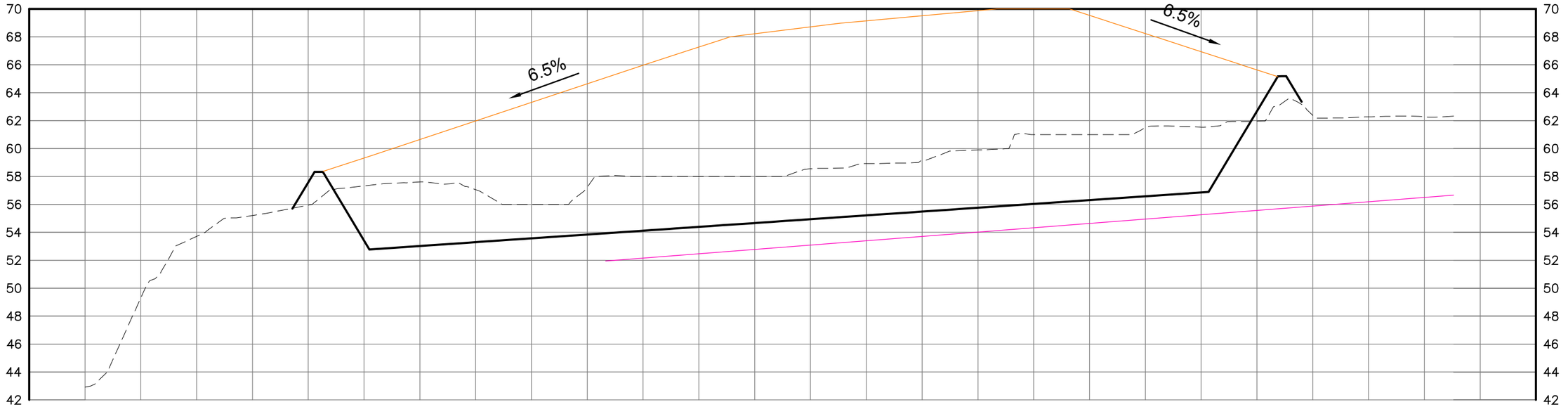
OPTION 1 - AT DEPTH LTMF
(DEEP BEDROCK) - 670 km³ CAPACITY
TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B7

S1 PROFILE



S2 PROFILE



Ground Surface — Approx. Bedrock — Base Design — Top of Cap Design

0m 10 20 30 40 50 60
1 : 1500

0m 3 6 9 12
1:300

CLIENT:
IMPERIAL OIL LIMITED

amec foster wheeler
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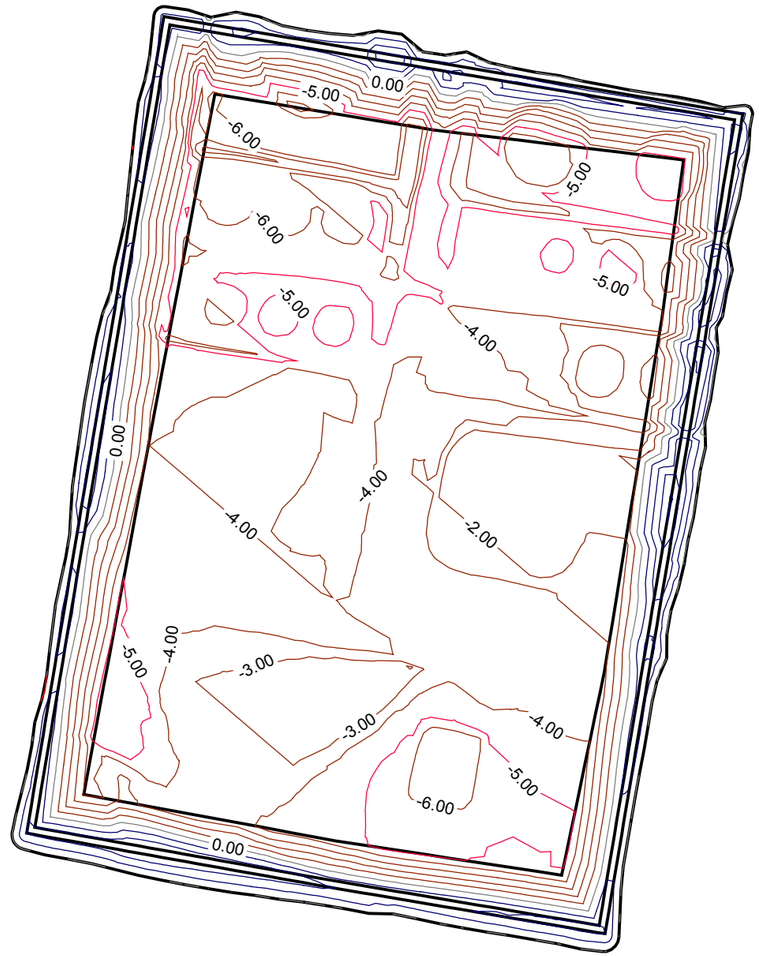
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 1 - AT DEPTH LTMF
(DEEP BEDROCK) - 670 km³ CAPACITY
SECTIONS S1 AND S2

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B8



Project: Norman Wells Landfil Option 1
Date of Isopach: April 3, 2015
Surface 1: Ground Surface
Surface 2: Option 1 Design Base
Volume : CUT = 293,340m3 / FILL = 18,900m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
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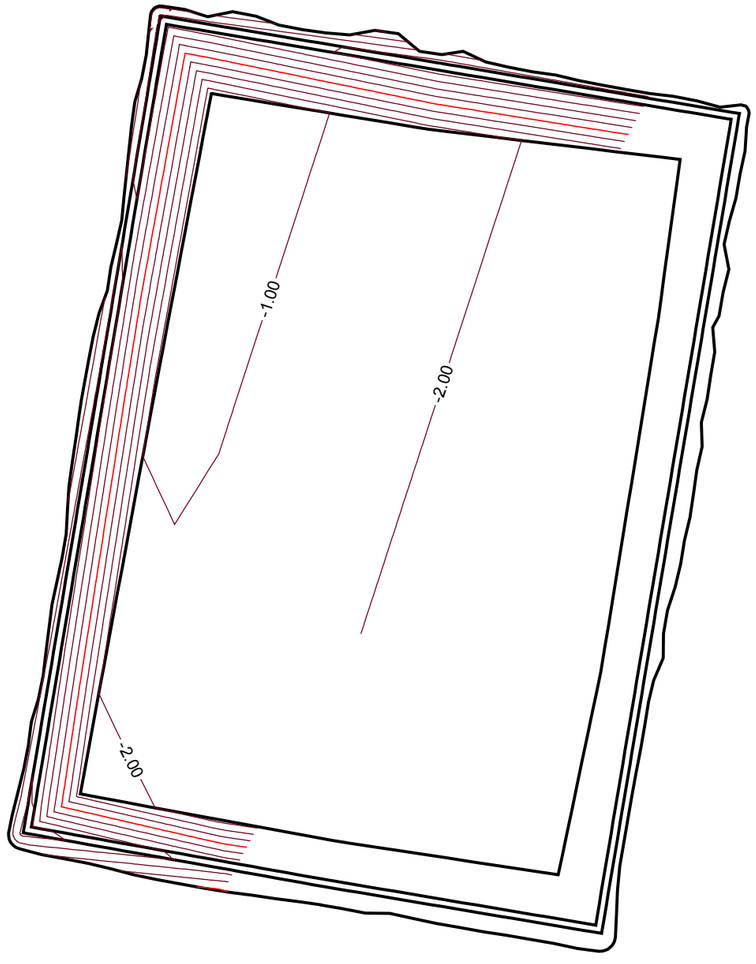
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT: NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE: OPTION 1 - AT DEPTH LTMF (DEEP BEDROCK) - 670 km³ CAPACITY DEPTH CONTOURS BETWEEN GROUND SURFACE AND DESIGN BASE

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B9



Project: Norman Wells Landfil Option 1
Date of Isopach: April 3, 2015
Surface 1: Option 1 Design Base
Surface 2: Bedrock
Volume :
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

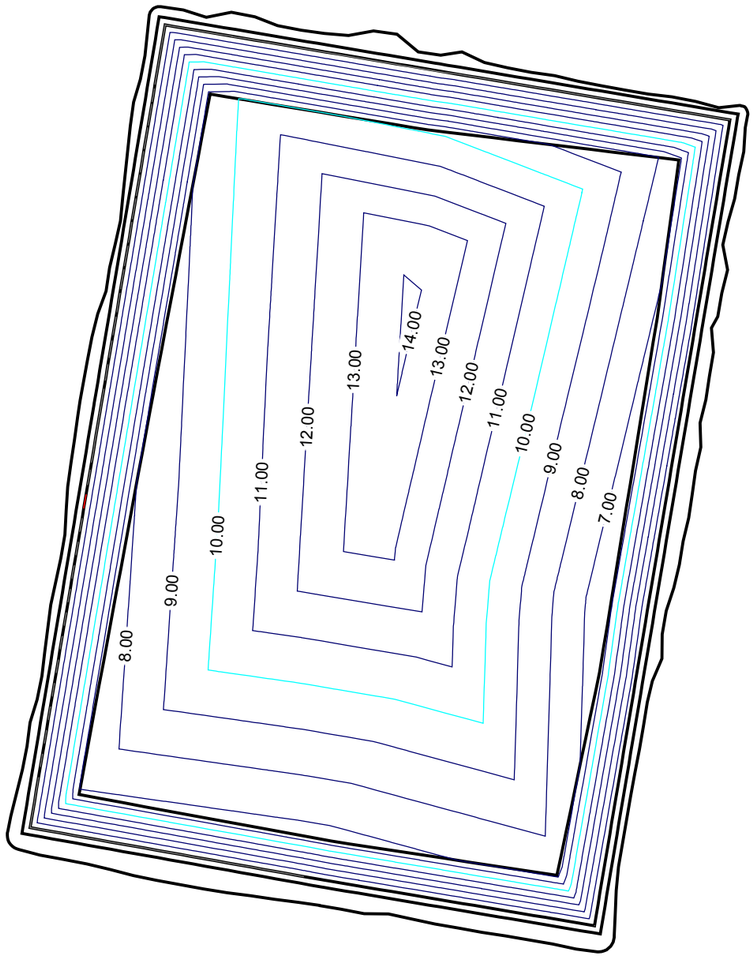
PROJECT:

NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

OPTION 1 - AT DEPTH LTMF
(DEEP BEDROCK) - 670 km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND BEDROCK

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B10



Project: Norman Wells Landfil Option 1
Date of Isopach: April 3, 2015
Surface 1: Option 1 Design Base
Surface 2: Option 1 Top of Cap
Volume : 696,000m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

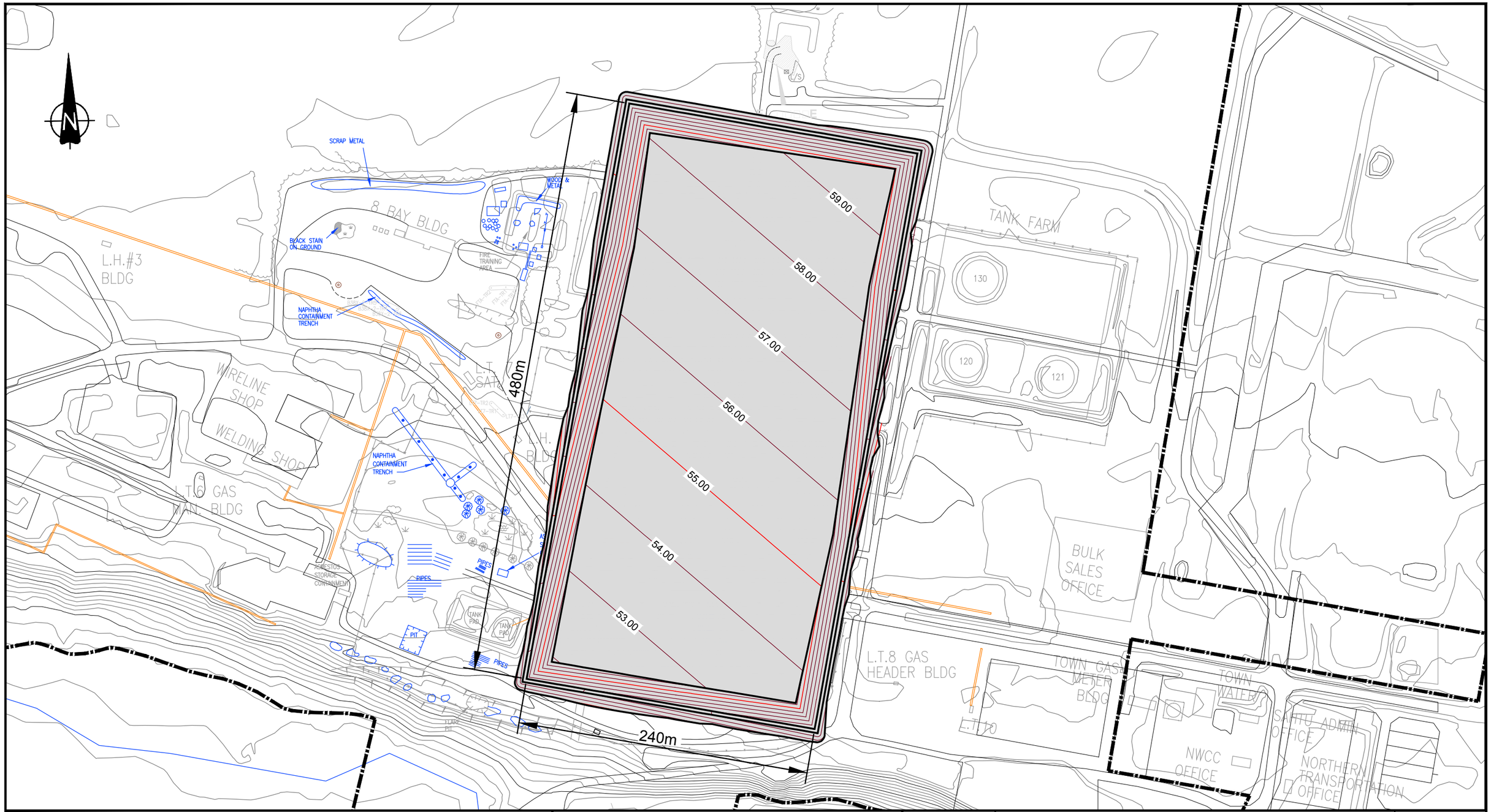
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 1 - AT DEPTH LTMF
(DEEP BEDROCK) - 670 km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B11



0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

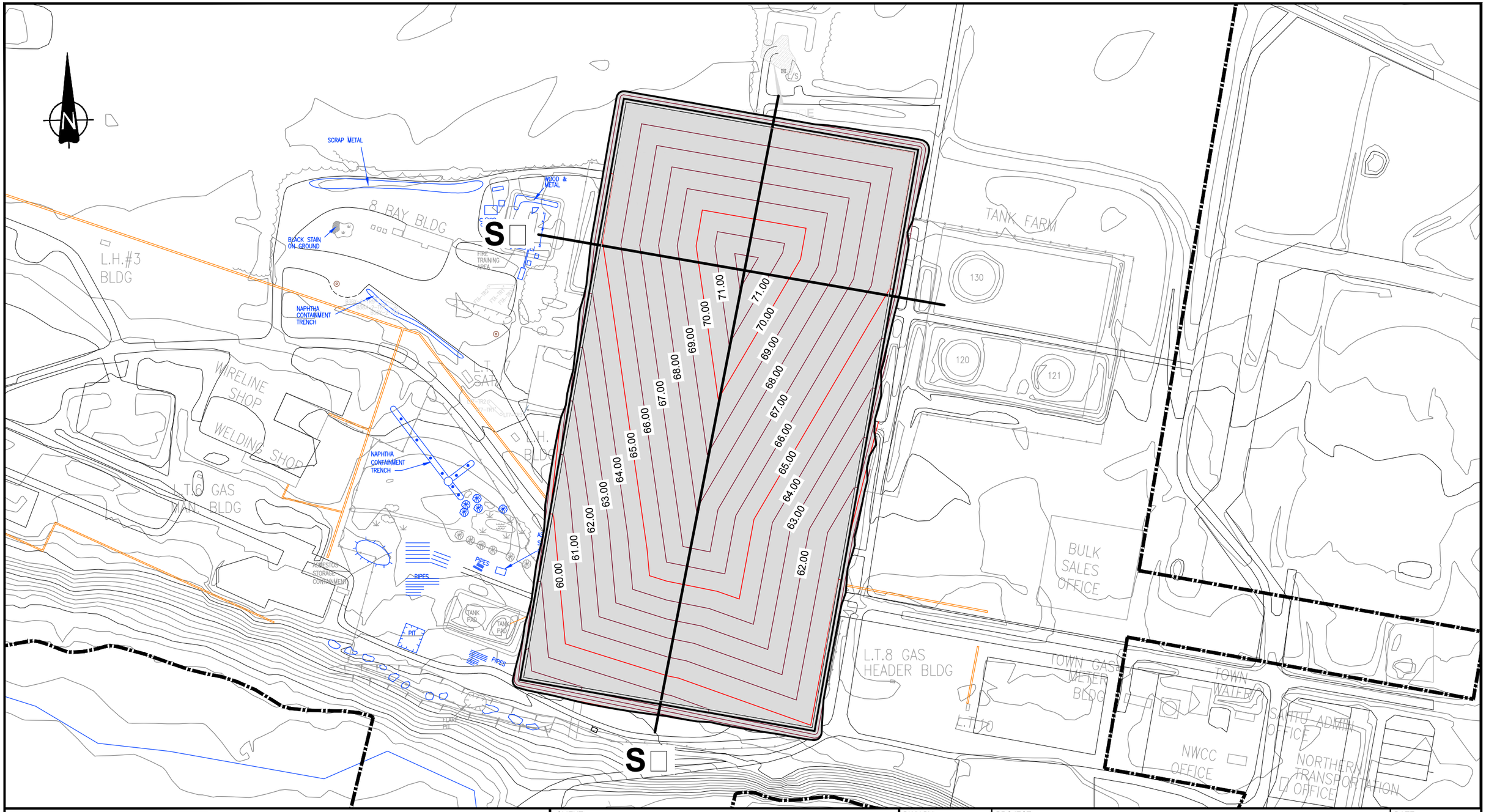
PROJECT:

NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

OPTION 2 - AT DEPTH LTMF
(DEEP BEDROCK) - 970 km³ CAPACITY
BASE DESIGN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B12



0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

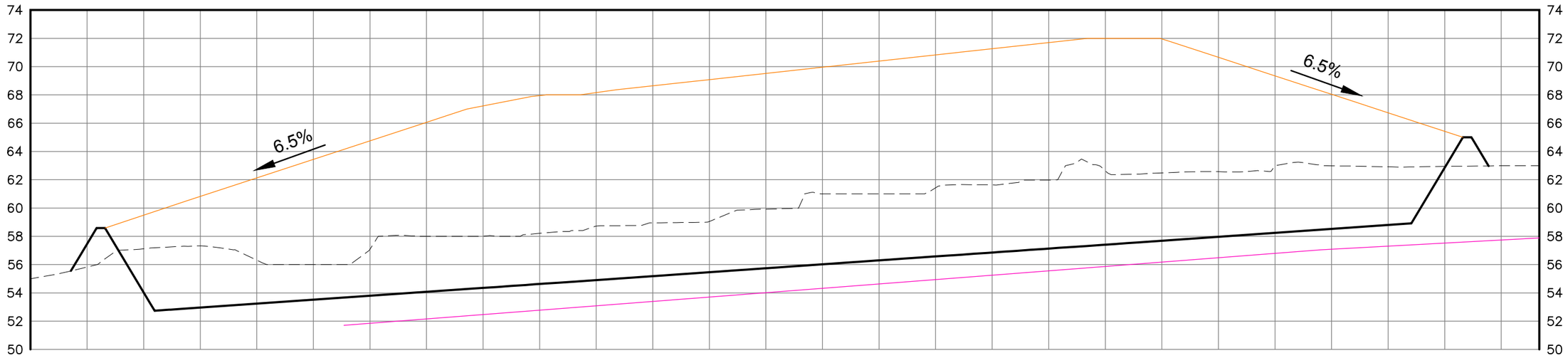
DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

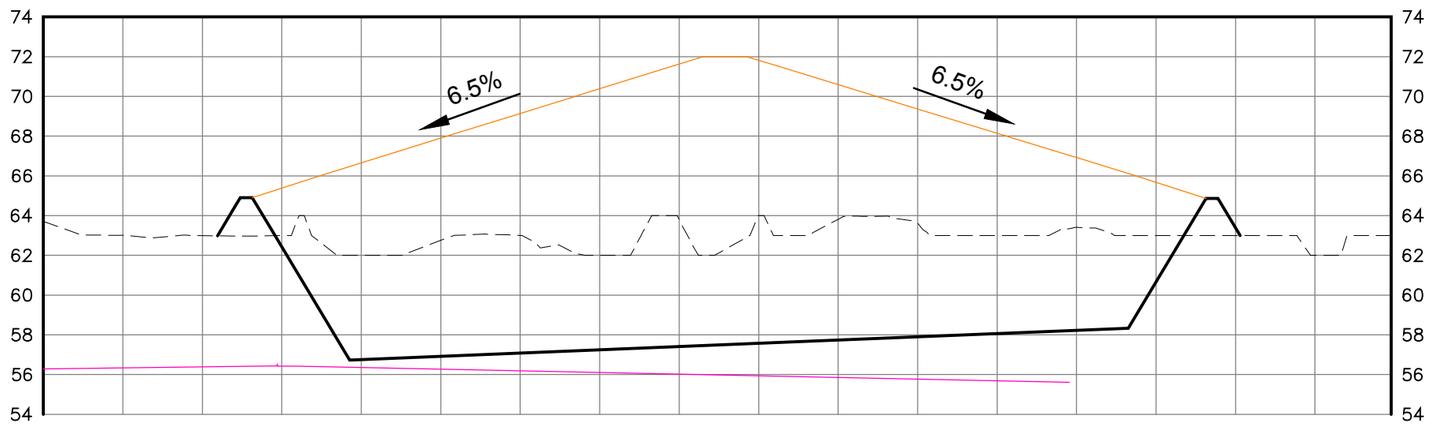
TITLE:
OPTION 2 - AT DEPTH LTMF
(DEEP BEDROCK) - 970 km³ CAPACITY
TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B13

S1 PROFILE



S2 PROFILE



Ground Surface — Approx. Bedrock — Base Design — Top of Cap Design

0m 10 20 30 40 50 60
1 : 1500

0m 3 6 9 12
1:300

CLIENT:
IMPERIAL OIL LIMITED

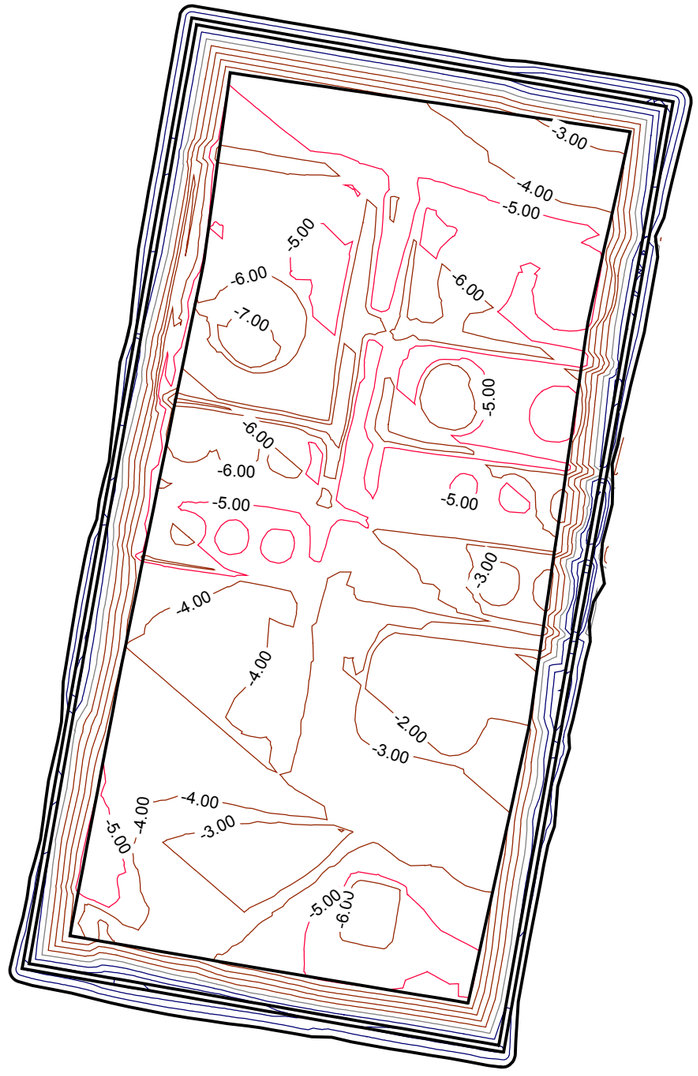
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 2 - AT DEPTH LTMF
(DEEP BEDROCK) - 970 km³ CAPACITY
SECTIONS S1 AND S2

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B14



Project: Norman Wells Landfill Option 2
Date of Isopach: April 6, 2015
Surface 1: Ground Surface
Surface 2: Option 2 Design Base
Volume : CUT = 444,630m3 / FILL = 25,100m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

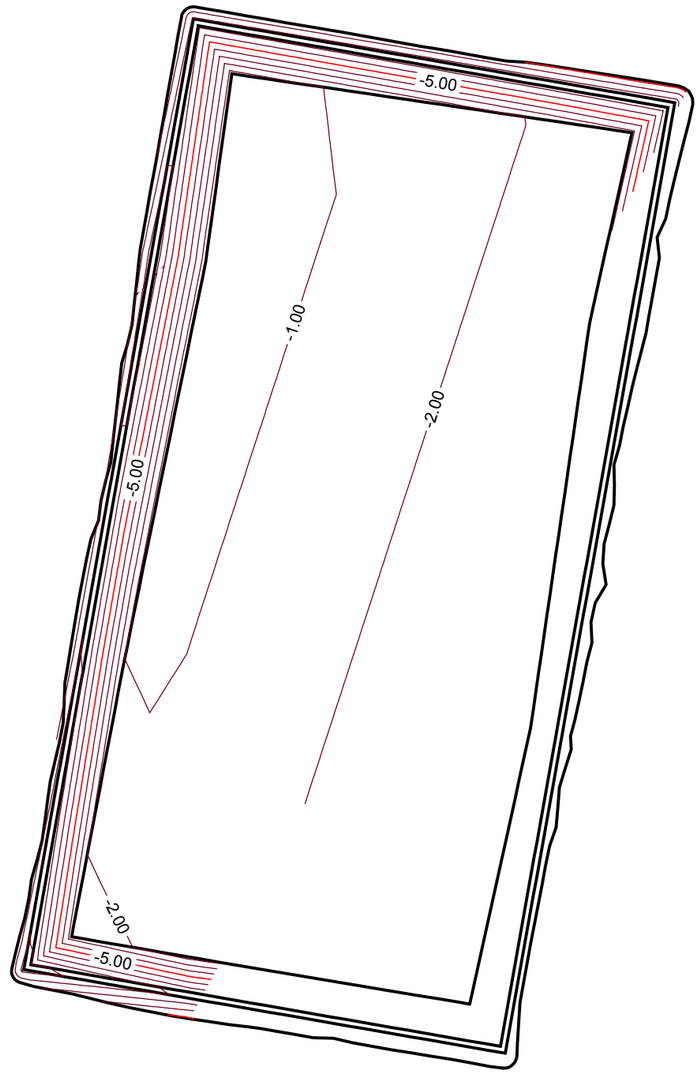
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT: NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE: OPTION 2 - AT DEPTH LTMF (DEEP BEDROCK) - 970 km³ CAPACITY DEPTH CONTOURS BETWEEN GROUND SURFACE AND DESIGN BASE

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B15



Project: Norman Wells Landfill Option 2
Date of Isopach: April 6, 2015
Surface 1: Option 2 Design Base
Surface 2: Bedrock
Volume :
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

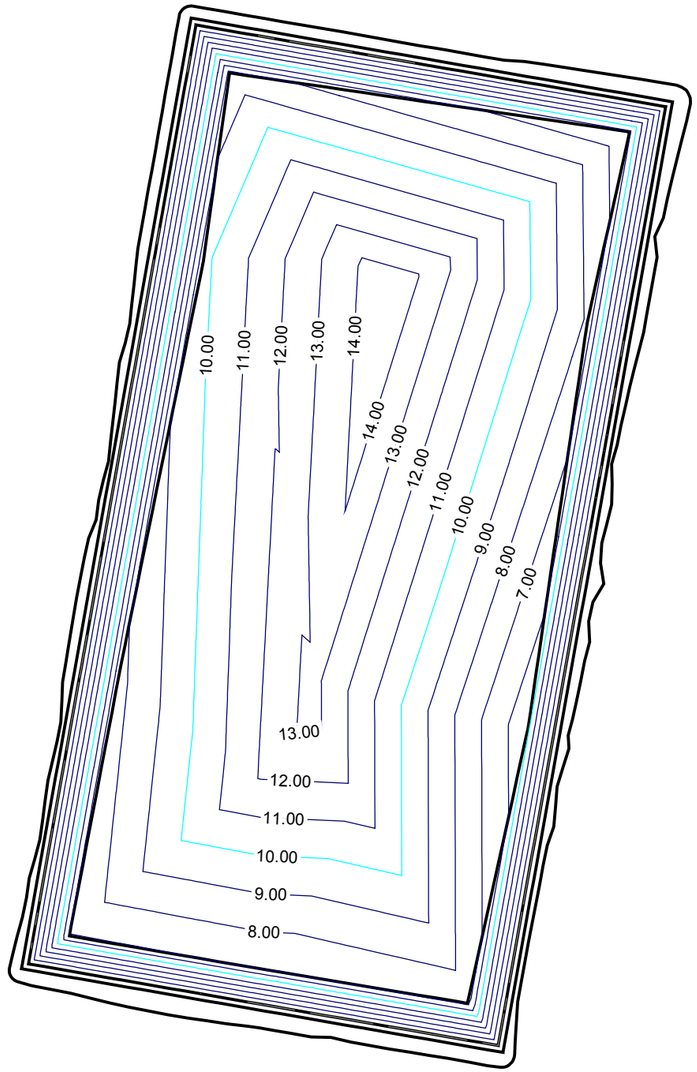
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT: NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE: OPTION 2 - AT DEPTH LTMF (DEEP BEDROCK) - 970 km³ CAPACITY DEPTH CONTOURS BETWEEN DESIGN BASE AND BEDROCK

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B16



Project: Norman Wells Landfil Option 1
Date of Isopach: April 6, 2015
Surface 1: Option 2 Design Base
Surface 2: Option 2 Top of Cap
Volume : 1,000,000m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

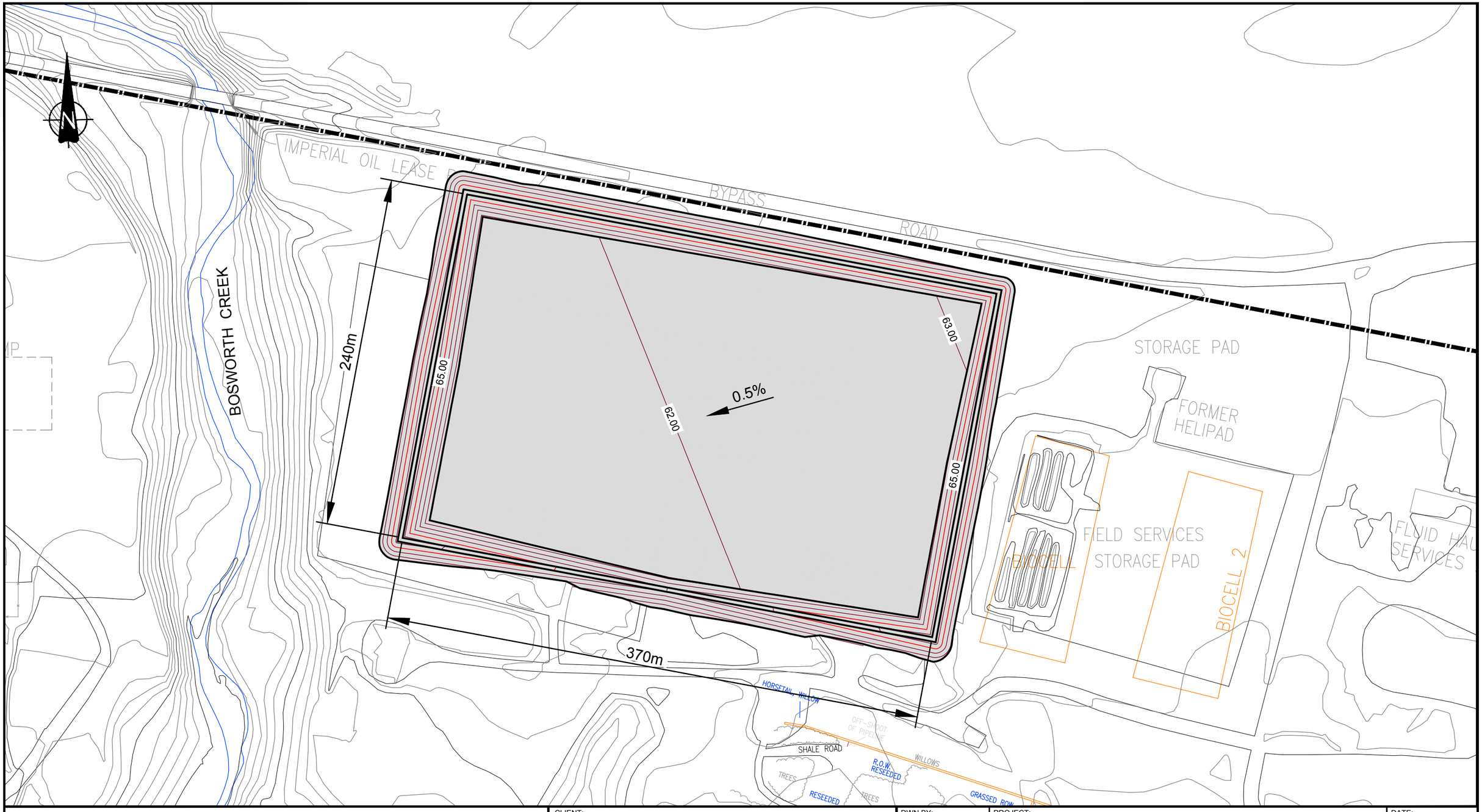
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 2 - AT DEPTH LTMF
(DEEP BEDROCK) - 970 km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B17



0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

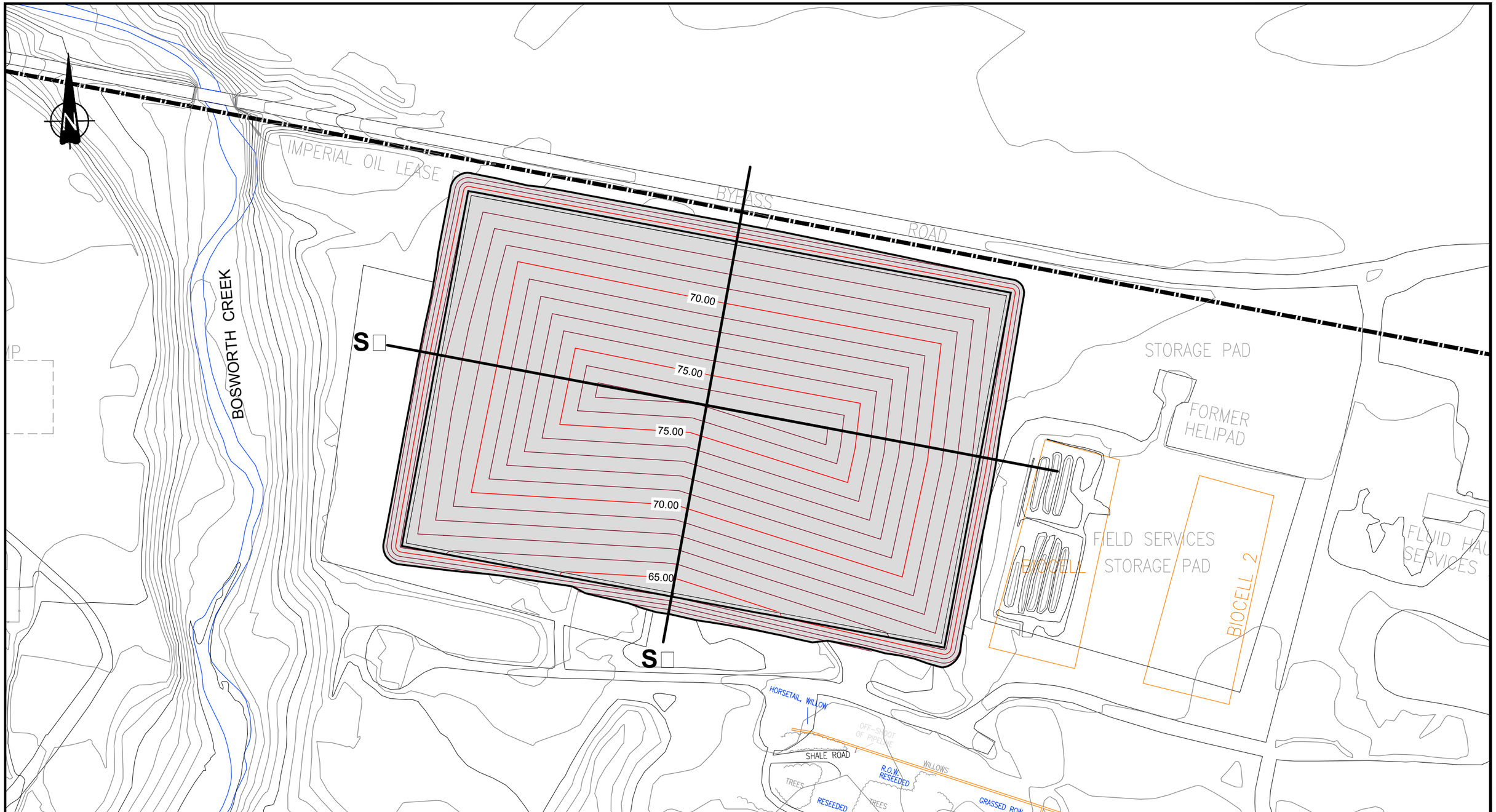
PROJECT:

NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

OPTION 3 - AT GRADE LTMF
670 km³ CAPACITY
BASE DESIGN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B18



0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

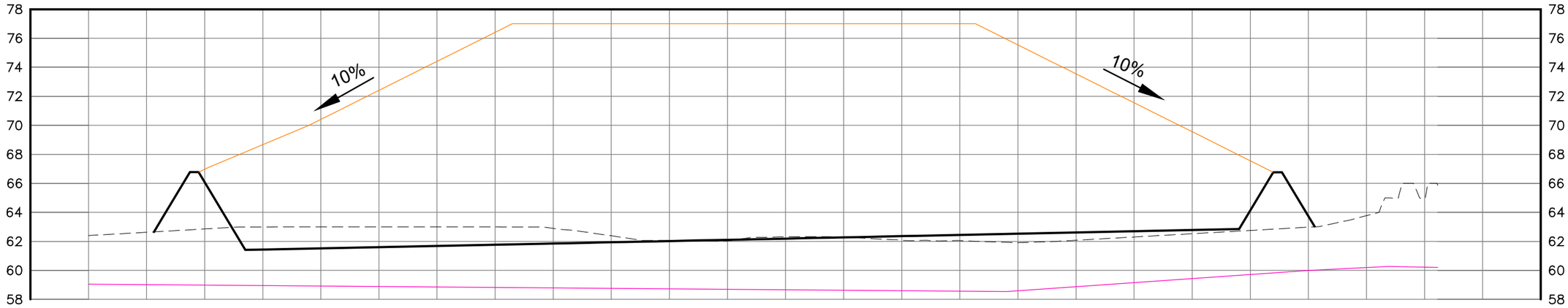
DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

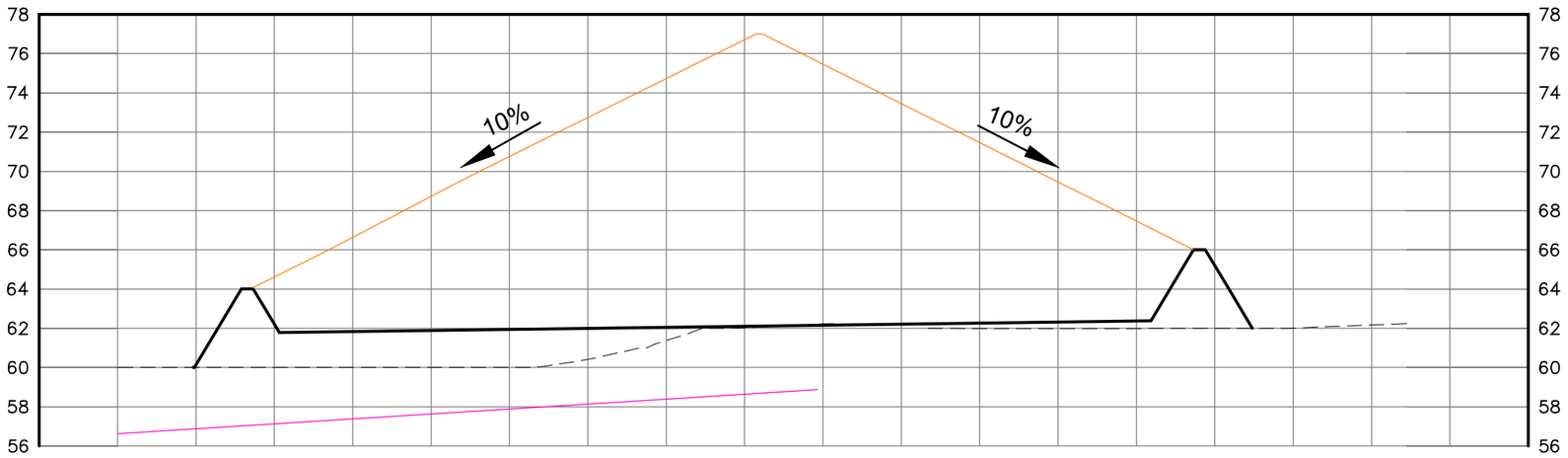
TITLE:
OPTION 3 - AT GRADE LTMF
670 km³ CAPACITY
TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B19

S1 PROFILE



S2 PROFILE



Ground Surface — Approx. Bedrock — Base Design — Top of Cap Design

0m 10 20 30 40 50 60
1 : 1500

0m 3 6 9 12
1:300

CLIENT:
IMPERIAL OIL LIMITED

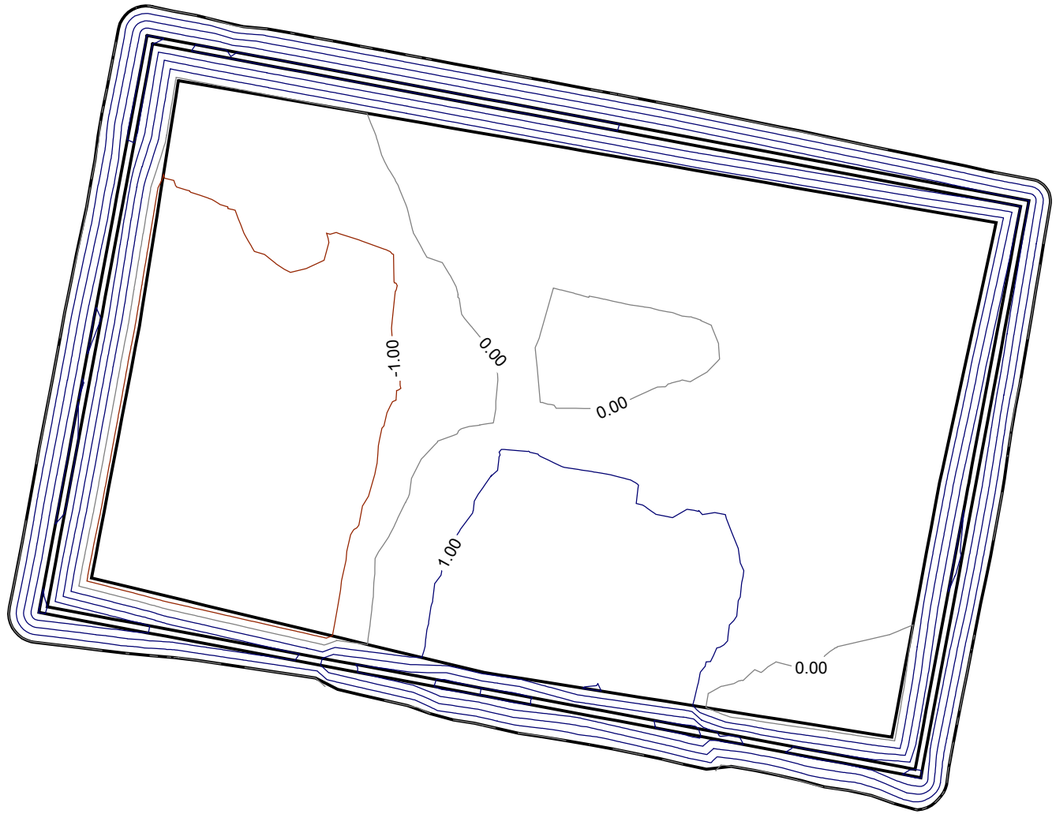
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 3 - AT GRADE LTMF
670 km³ CAPACITY
SECTIONS S1 AND S2

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B20



Project: Norman Wells Landfil Option 2
Date of Isopach: April 4, 2015
Surface 1: Ground Surface
Surface 2: Option 2 Design Base
Volume : CUT = 30,100m3 / FILL = 90,435m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

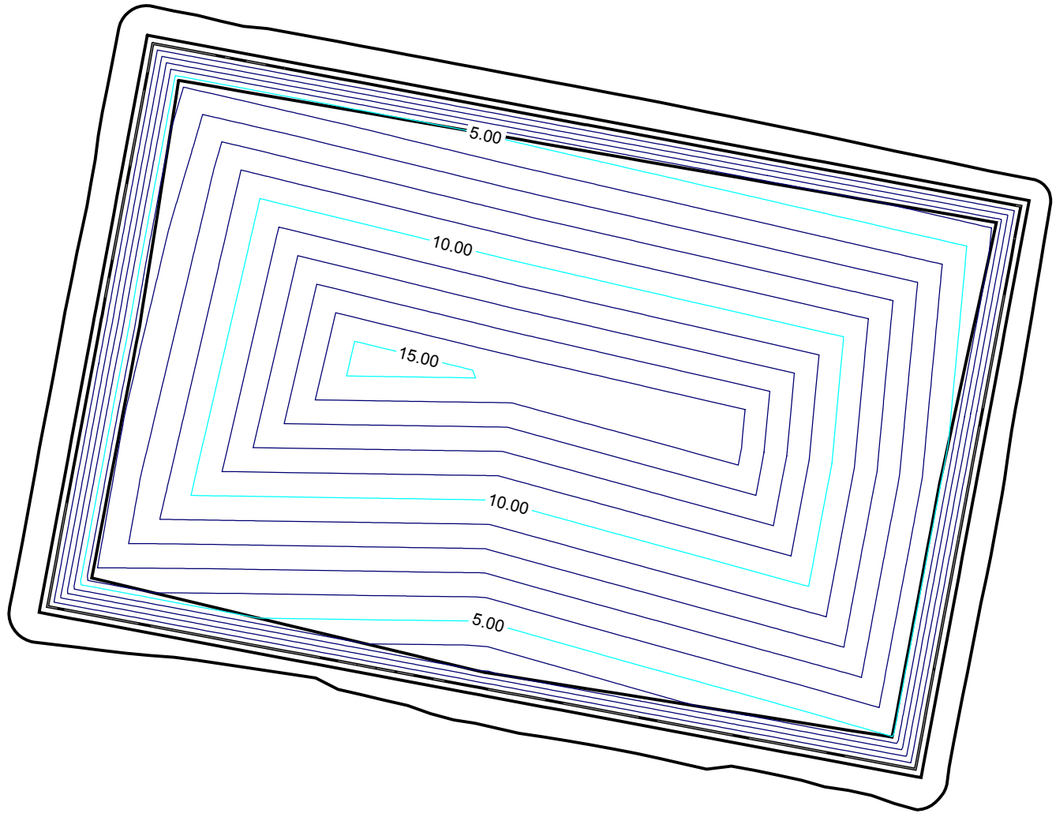
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 3 - AT GRADE LTMF
670 km³ CAPACITY
DEPTH CONTOURS BETWEEN GROUND
SURFACE AND DESIGN BASE

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B21



Project: Norman Wells Landfil Option 2
Date of Isopach: April 4, 2015
Surface 1: Option 2 Design Base
Surface 2: Option 2 Top of Cap
Volume : 716,000m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

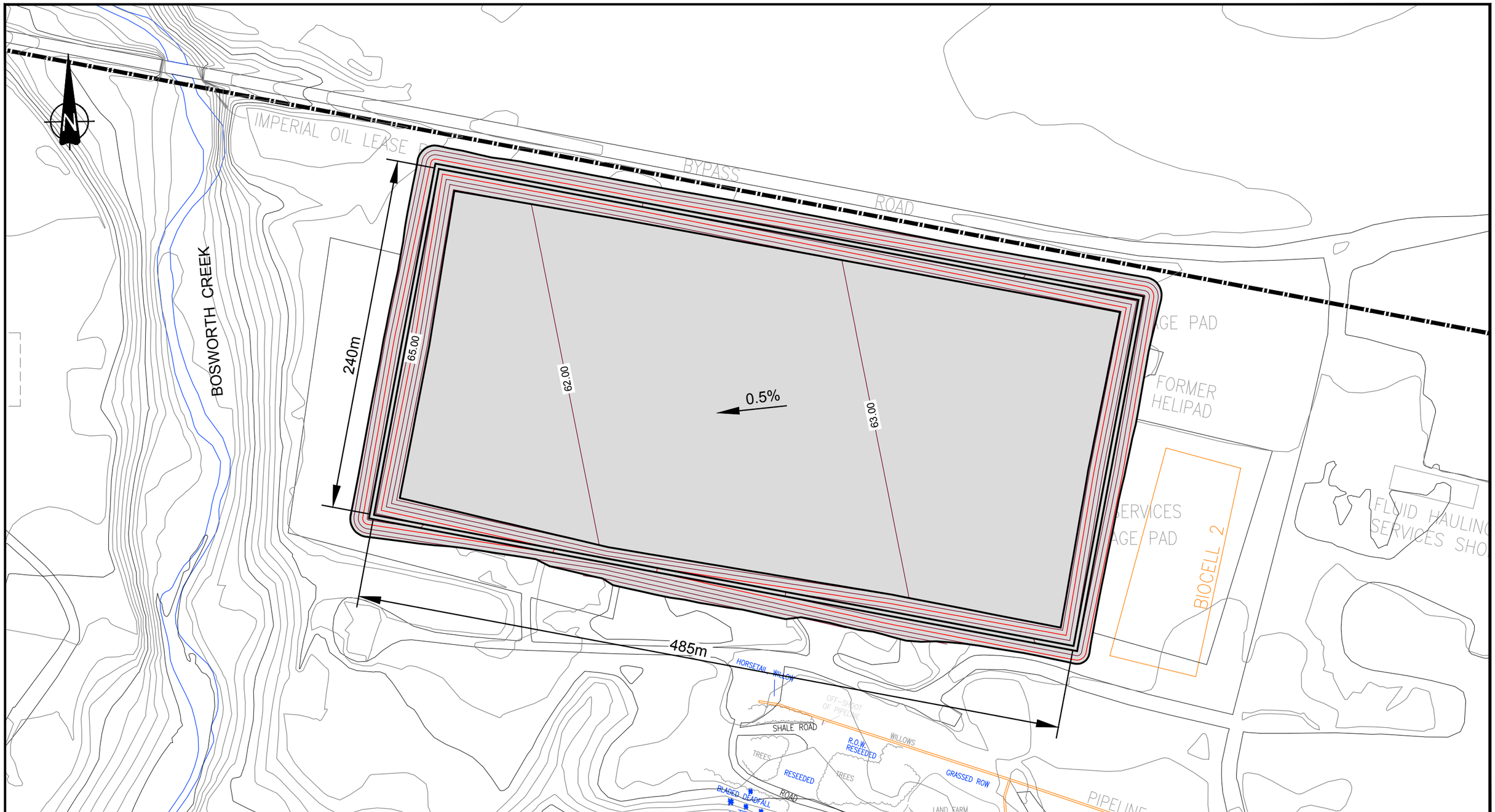
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 3 - AT GRADE LTMF
670 km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B22



0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

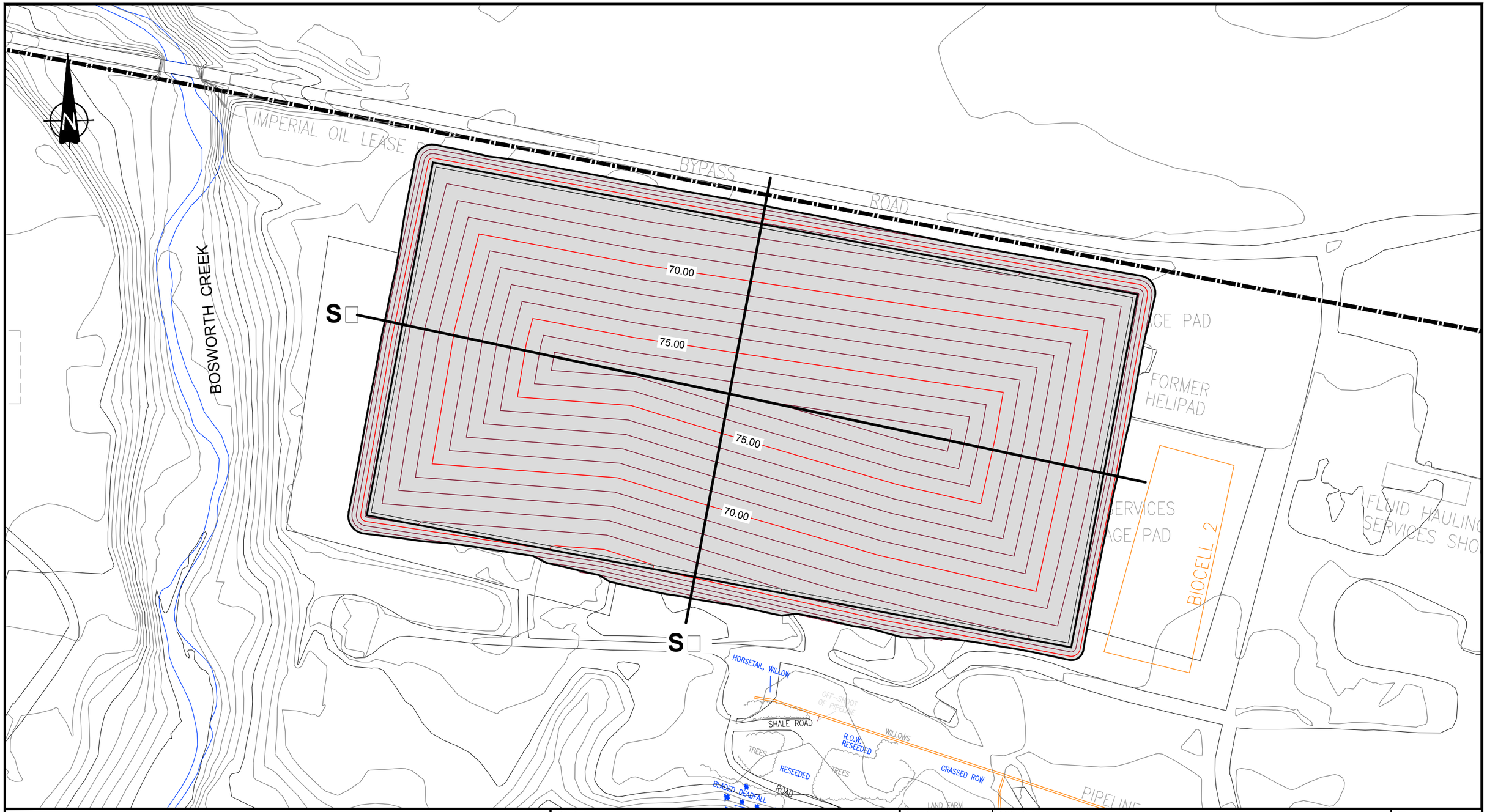
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 4 - AT GRADE LTMF
970 km³ CAPACITY
BASE DESIGN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B23



0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:

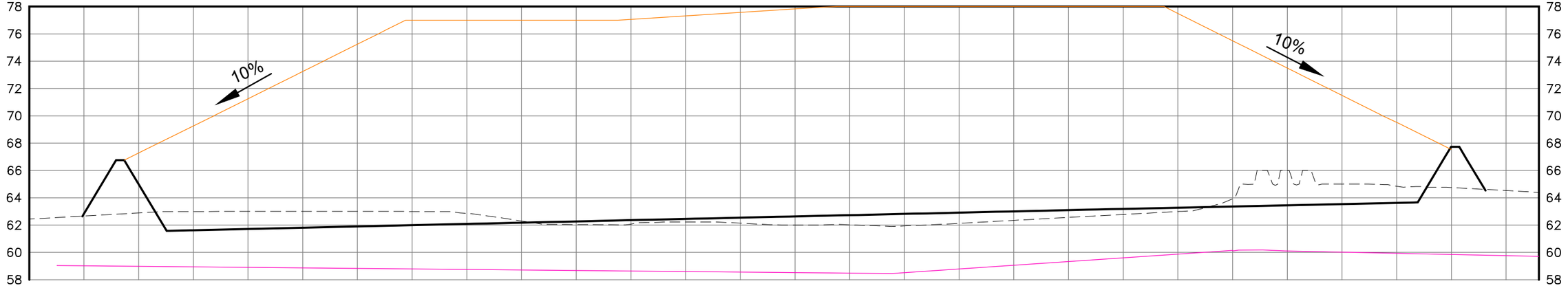
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:

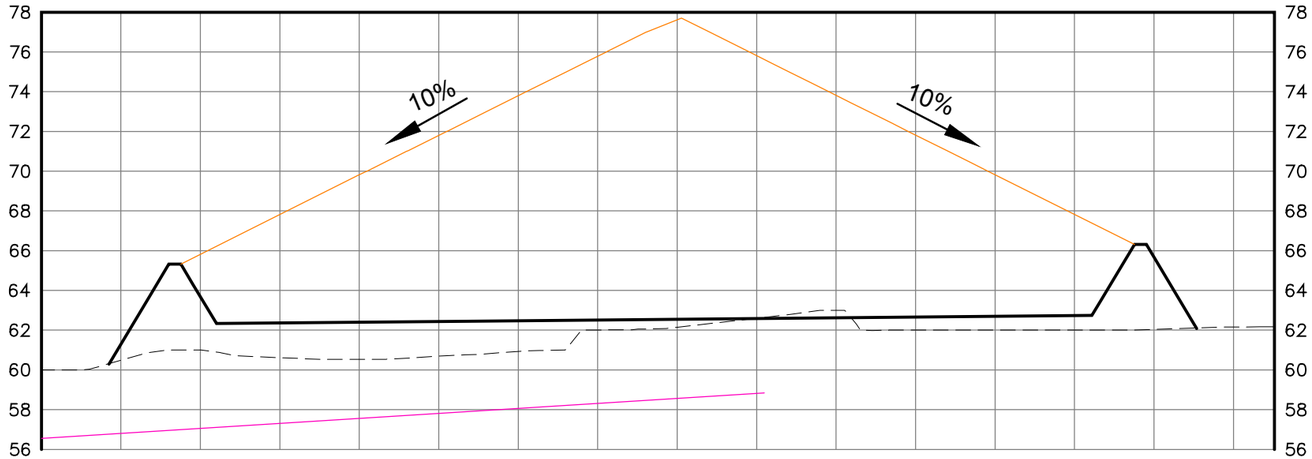
OPTION 4 - AT GRADE LTMF
970 km³ CAPACITY
TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B24

S1 PROFILE



S2 PROFILE



Ground Surface — Approx. Bedrock — Base Design — Top of Cap Design

0m 10 20 30 40 50 60
1 : 1500

0m 3 6 9 12
1:300

CLIENT:
IMPERIAL OIL LIMITED

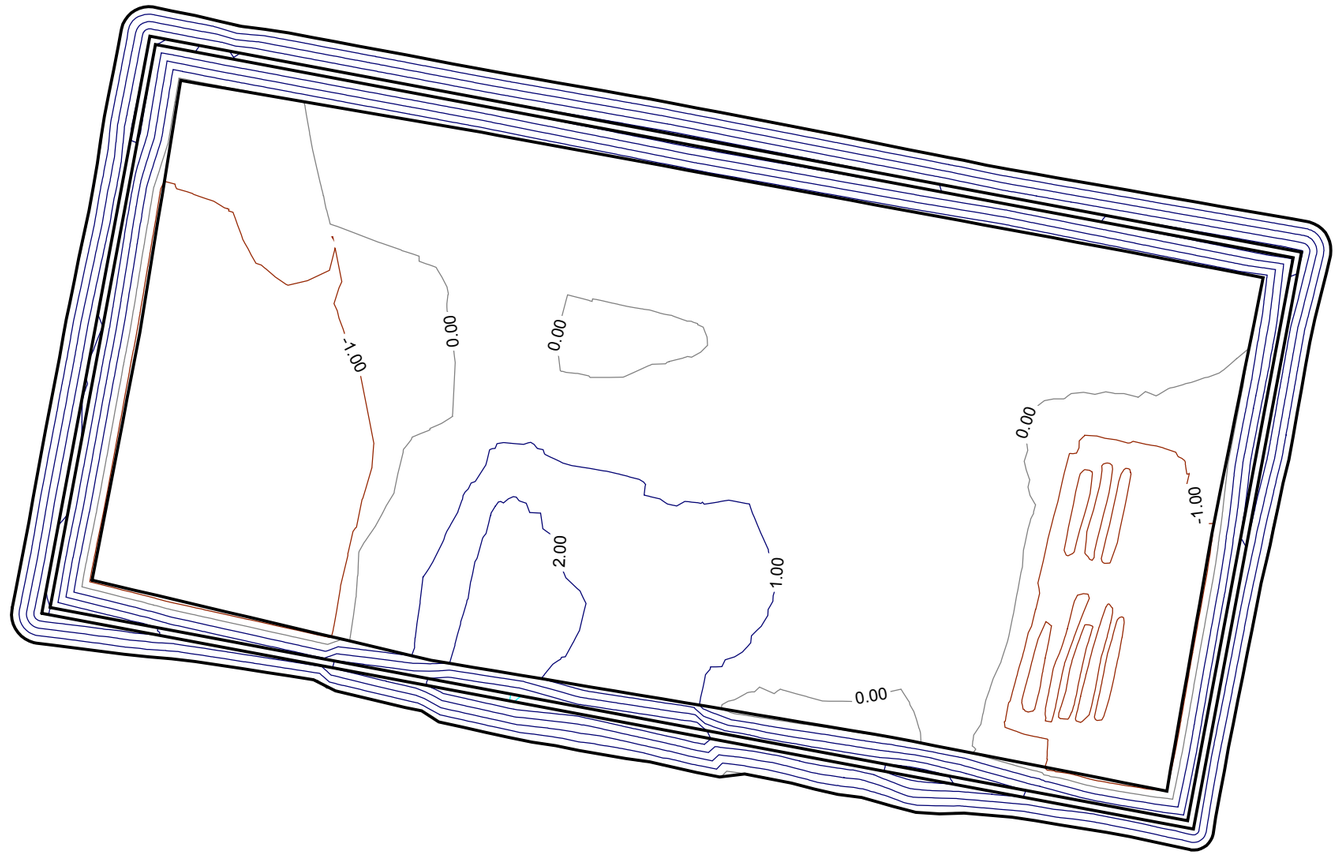
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 4 - AT GRADE LTMF
970 km³ CAPACITY
SECTIONS S1 AND S2

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B25



Project: Norman Wells Landfil Option 3
Date of Isopach: April 4, 2015
Surface 1: Ground Surface
Surface 2: Option 3 Design Base
Volume : CUT = 42,300m3 / FILL = 122,560m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

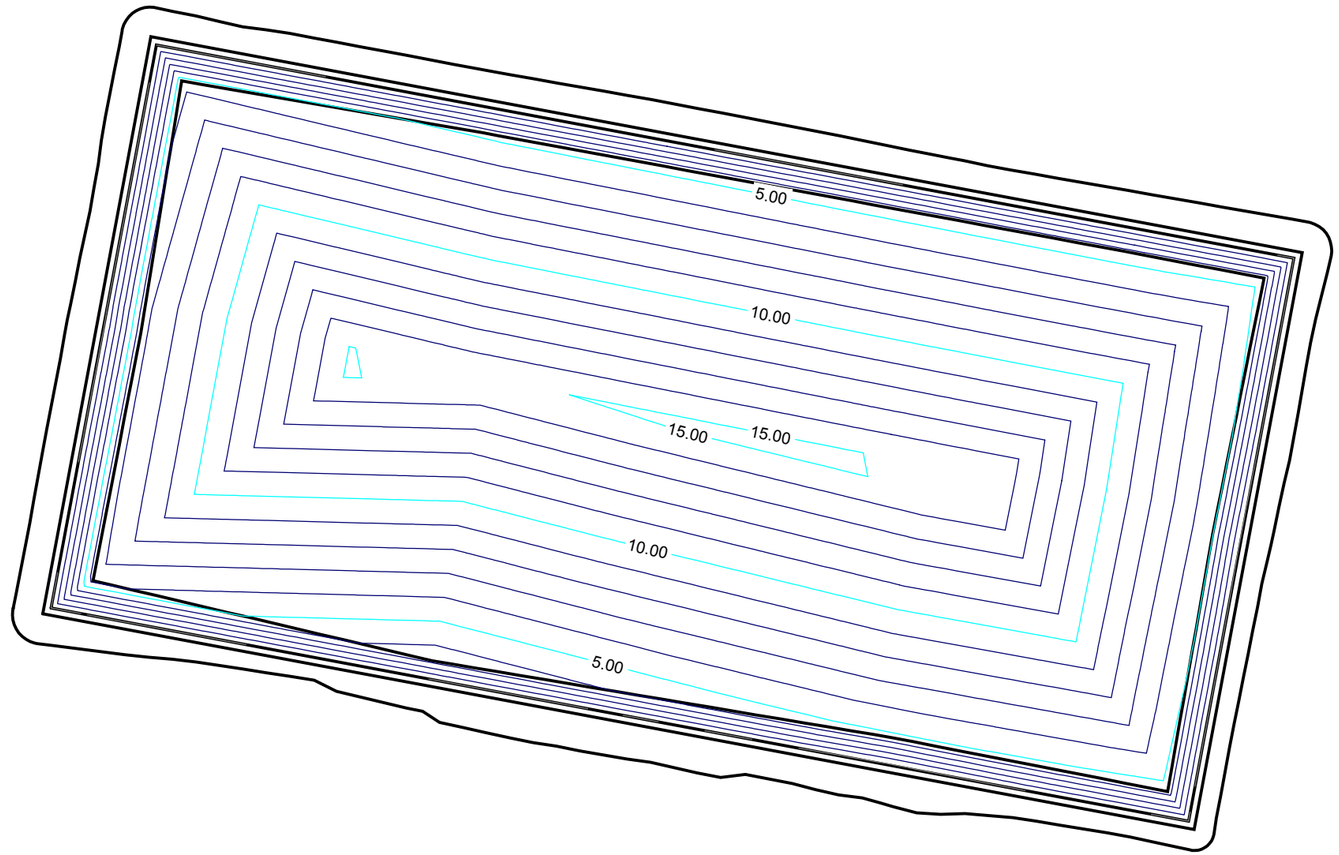
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 4 - AT GRADE LTMF
970 km³ CAPACITY
DEPTH CONTOURS BETWEEN GROUND
SURFACE AND DESIGN BASE

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B26



Project: Norman Wells Landfill Option 3
Date of Isopach: April 4, 2015
Surface 1: Option 2 Design Base
Surface 2: Option 2 Top of Cap
Volume : 980,000m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

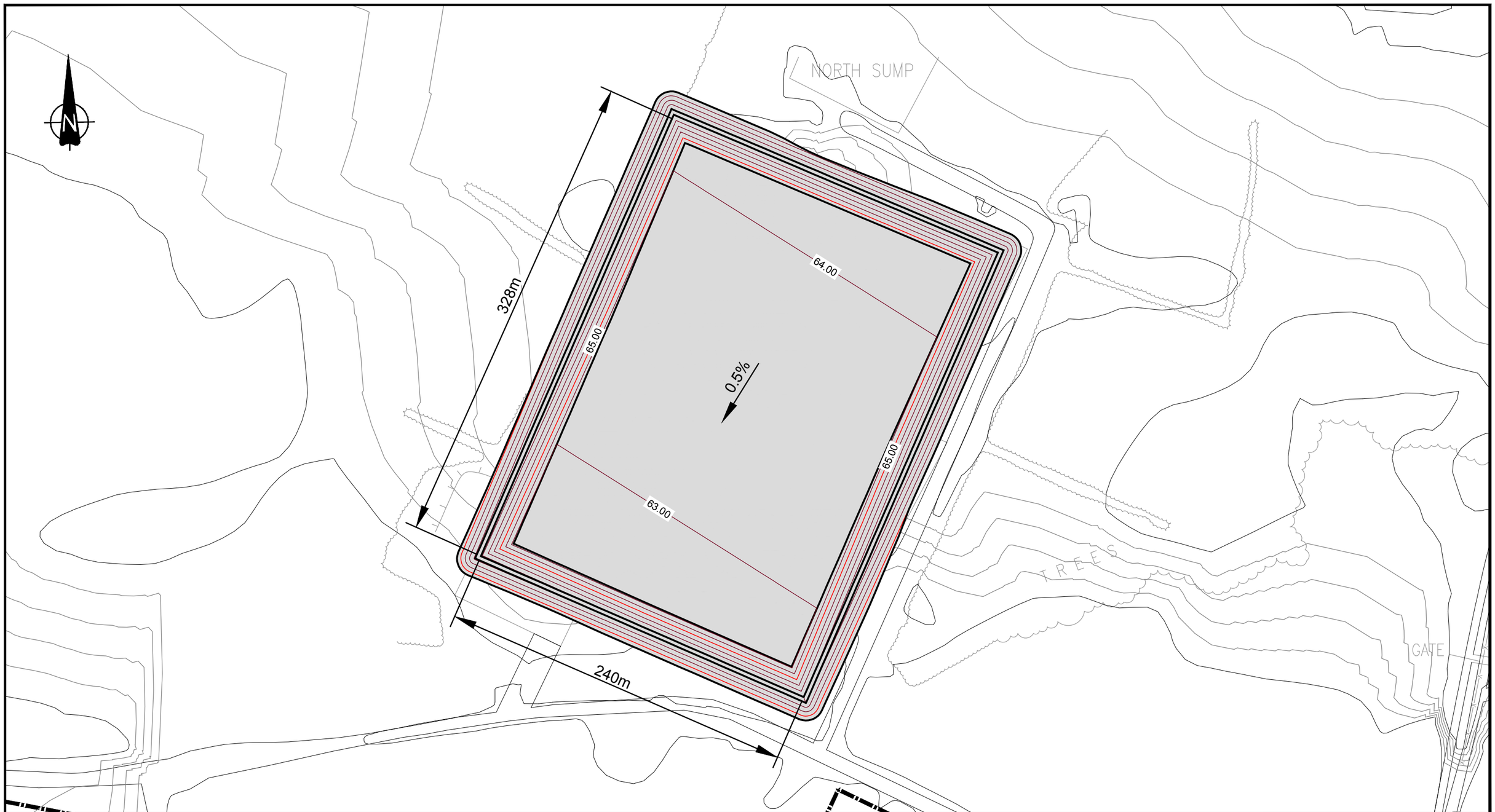
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 4 - AT GRADE LTMF
970 km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B27



0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

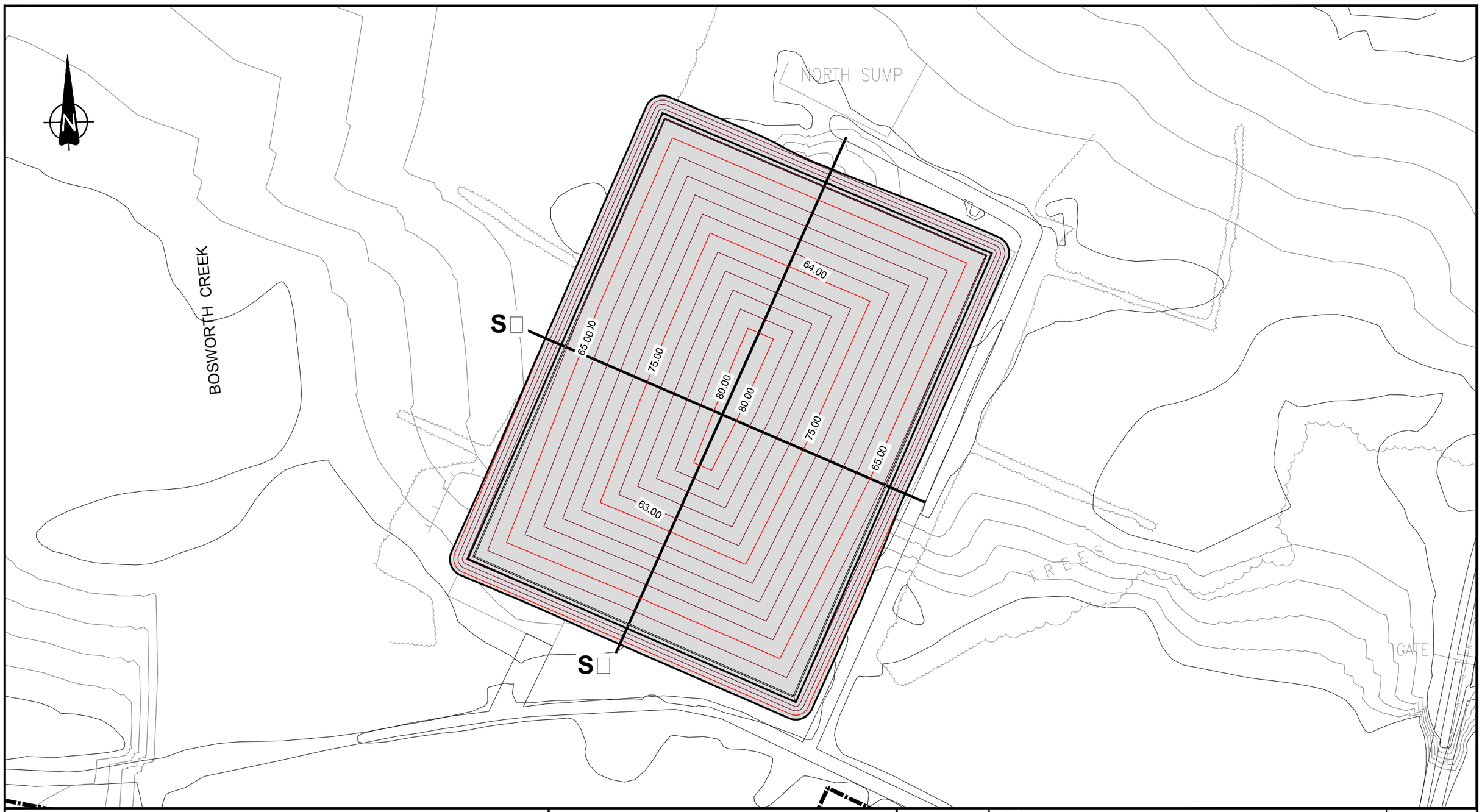
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 5 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 670 km³ CAPACITY
BASE DESIGN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B28



0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

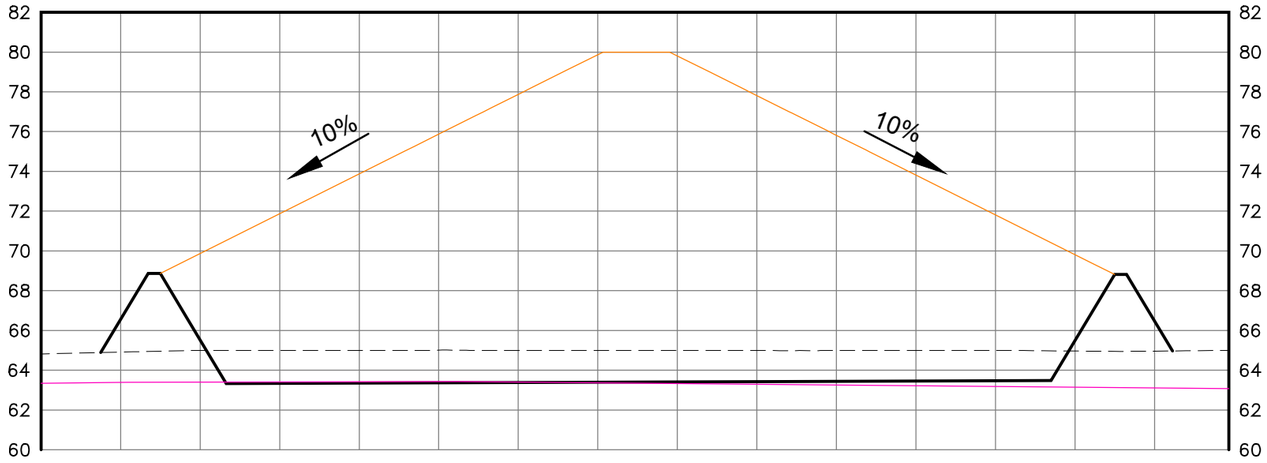
DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

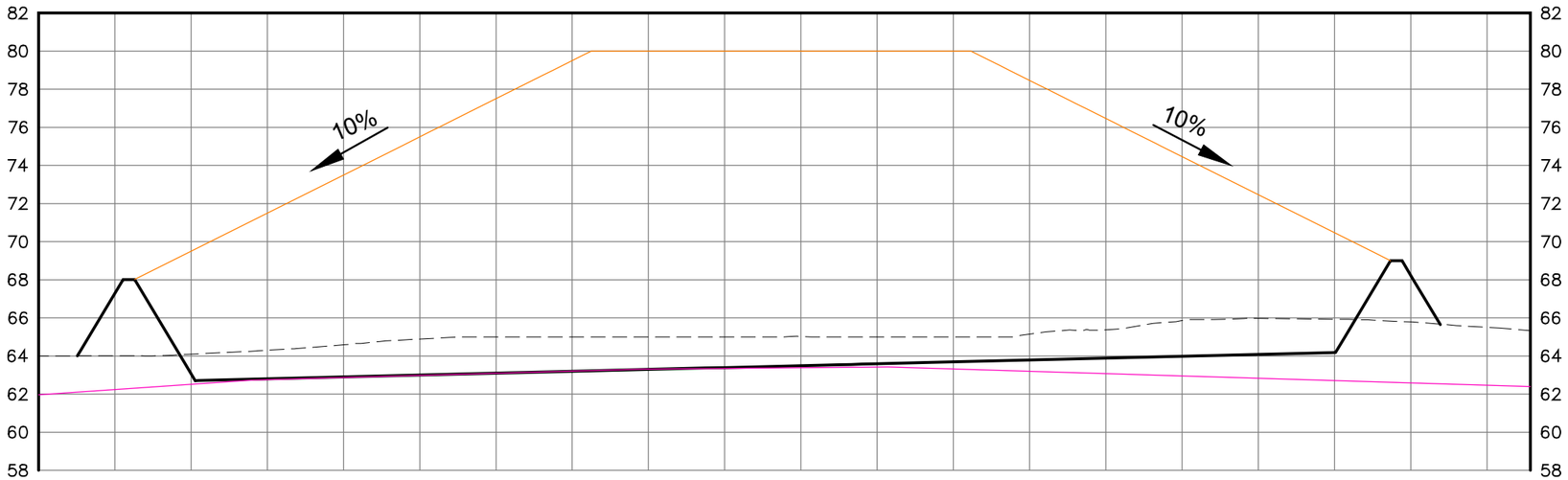
TITLE:
OPTION 5 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 670 km³ CAPACITY
TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B29

S1 PROFILE



S2 PROFILE



Ground Surface — Approx. Bedrock — Base Design — Top of Cap Design

0m 10 20 30 40 50 60
1 : 1500

0m 3 6 9 12
1:300

CLIENT:
IMPERIAL OIL LIMITED

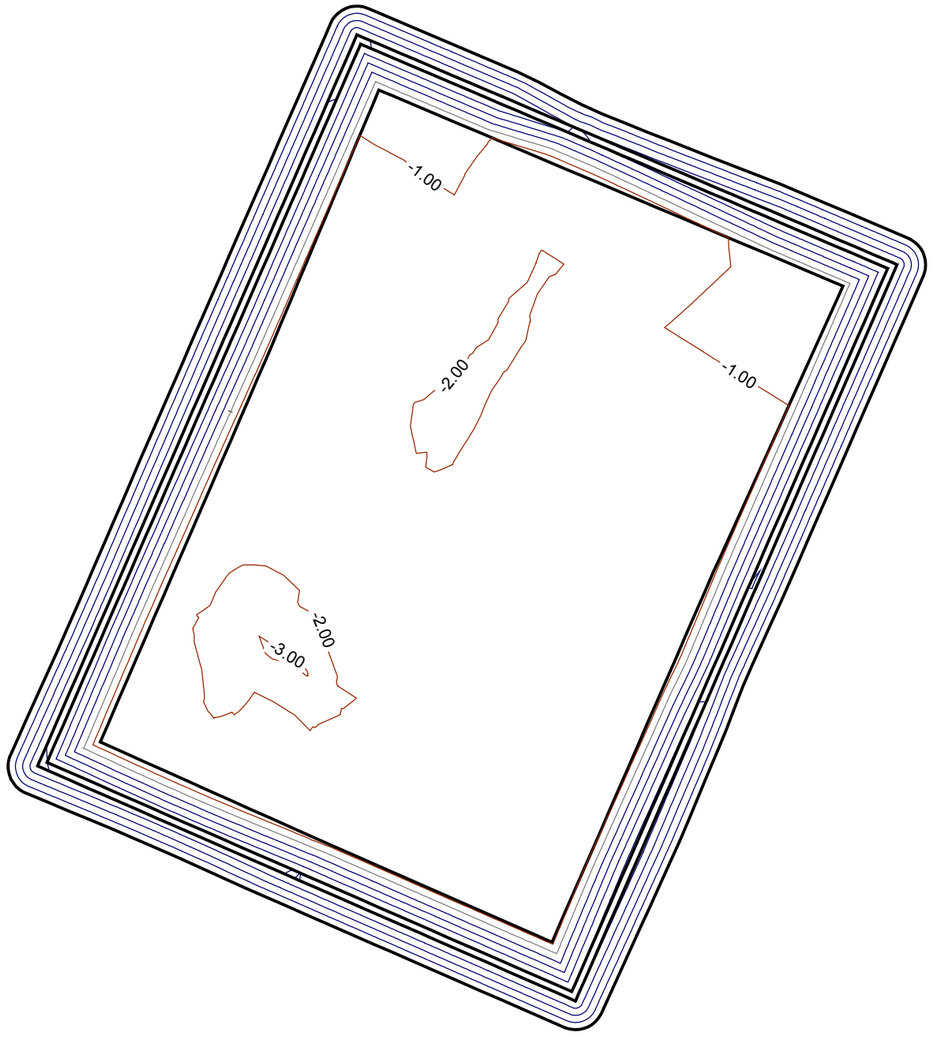
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 5 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 670 km³ CAPACITY
SECTIONS S1 AND S2

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B30



Project: Norman Wells Landfil Option 3
Date of Isopach: April 22, 2015
Surface 1: Ground Surface
Surface 2: Option 5 Design Base
Volume : CUT = 97,174m3 / FILL = 66,640m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

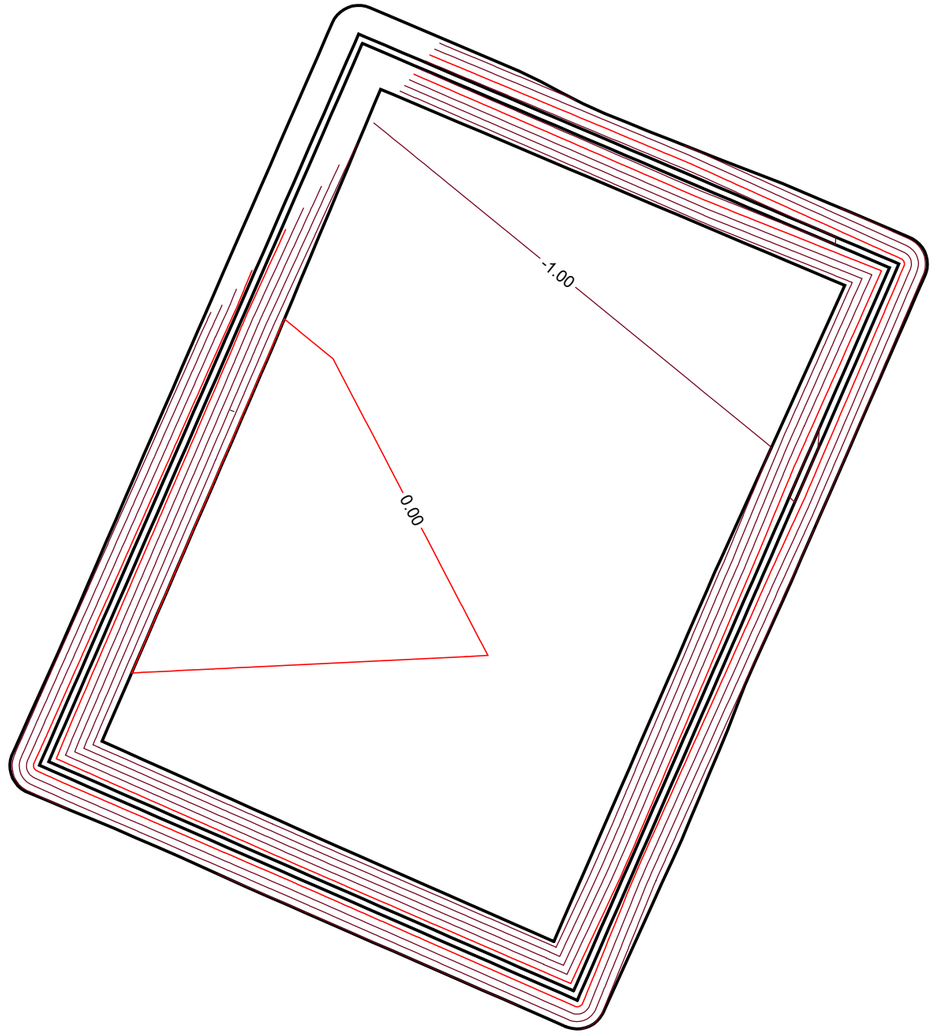
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 5 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 670 km³ CAPACITY
DEPTH CONTOURS BETWEEN GROUND
SURFACE AND DESIGN BASE

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B31



Project: Norman Wells Landfil Option 3
Date of Isopach: April 22, 2015
Surface 1: Option 5 Design Base
Surface 2: Bedrock
Volume :
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

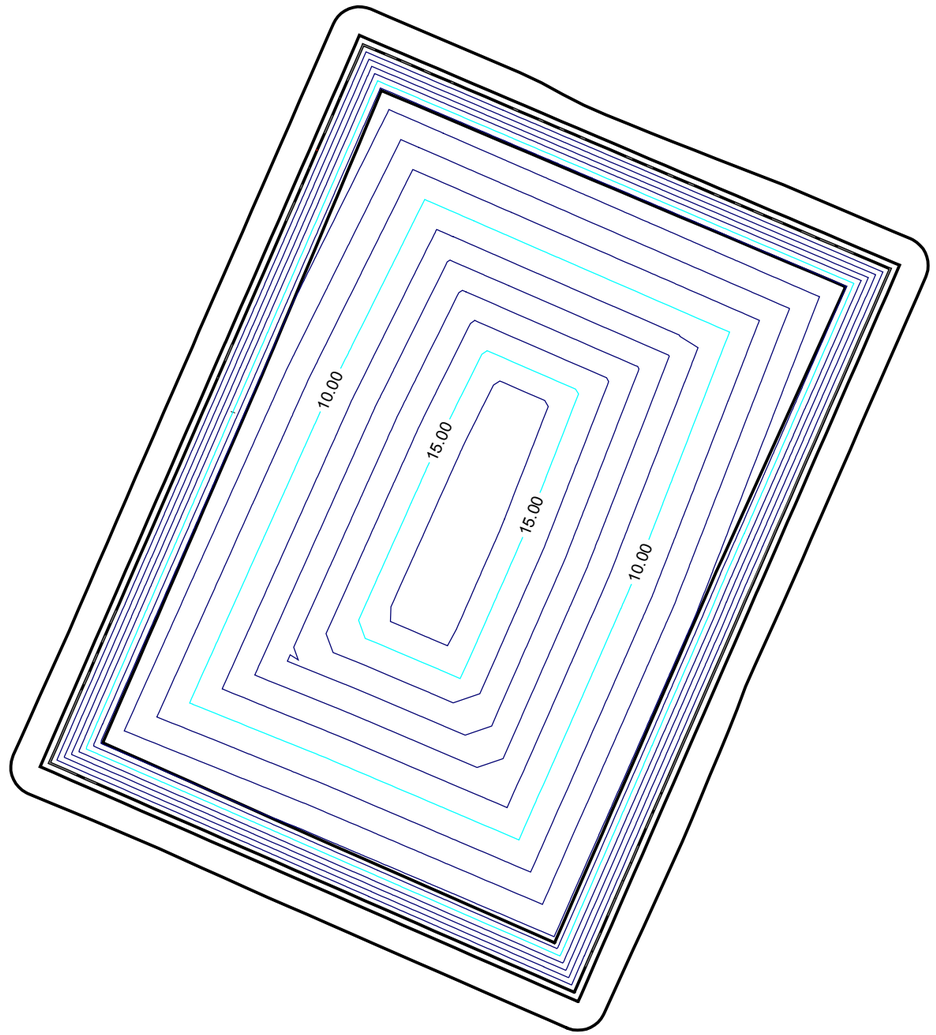
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 5 - AT DEPTH LTMF (SHALLOW BEDROCK) - 670 km³ CAPACITY DEPTH CONTOURS BETWEEN DESIGN BASE AND BEDROCK

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B32



Project: Norman Wells Landfill Option 3
Date of Isopach: April 22, 2015
Surface 1: Option 5 Design Base
Surface 2: Option 5 Top of Cap
Volume : 725,000m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

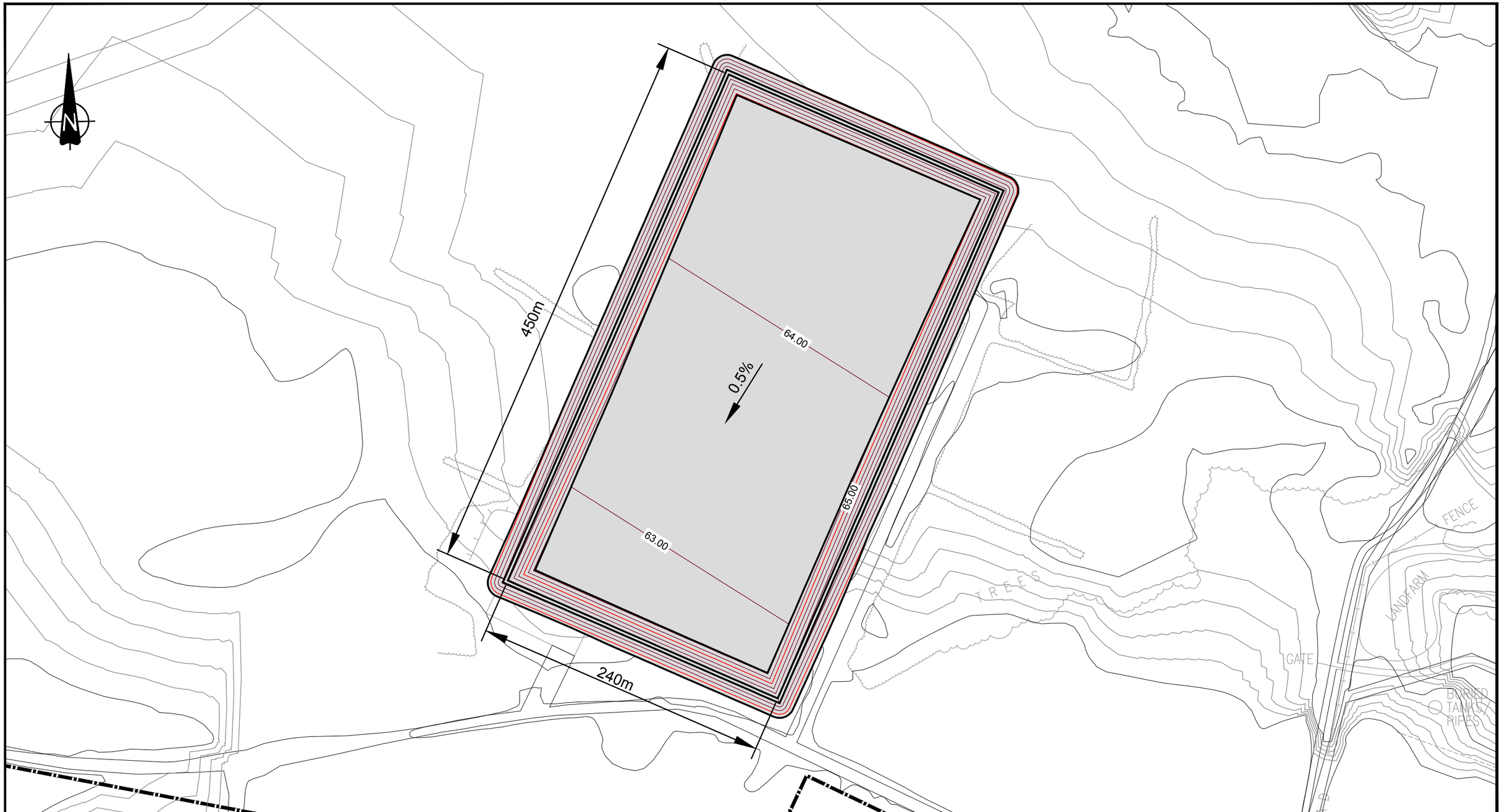
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 5 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 670 km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B33



0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

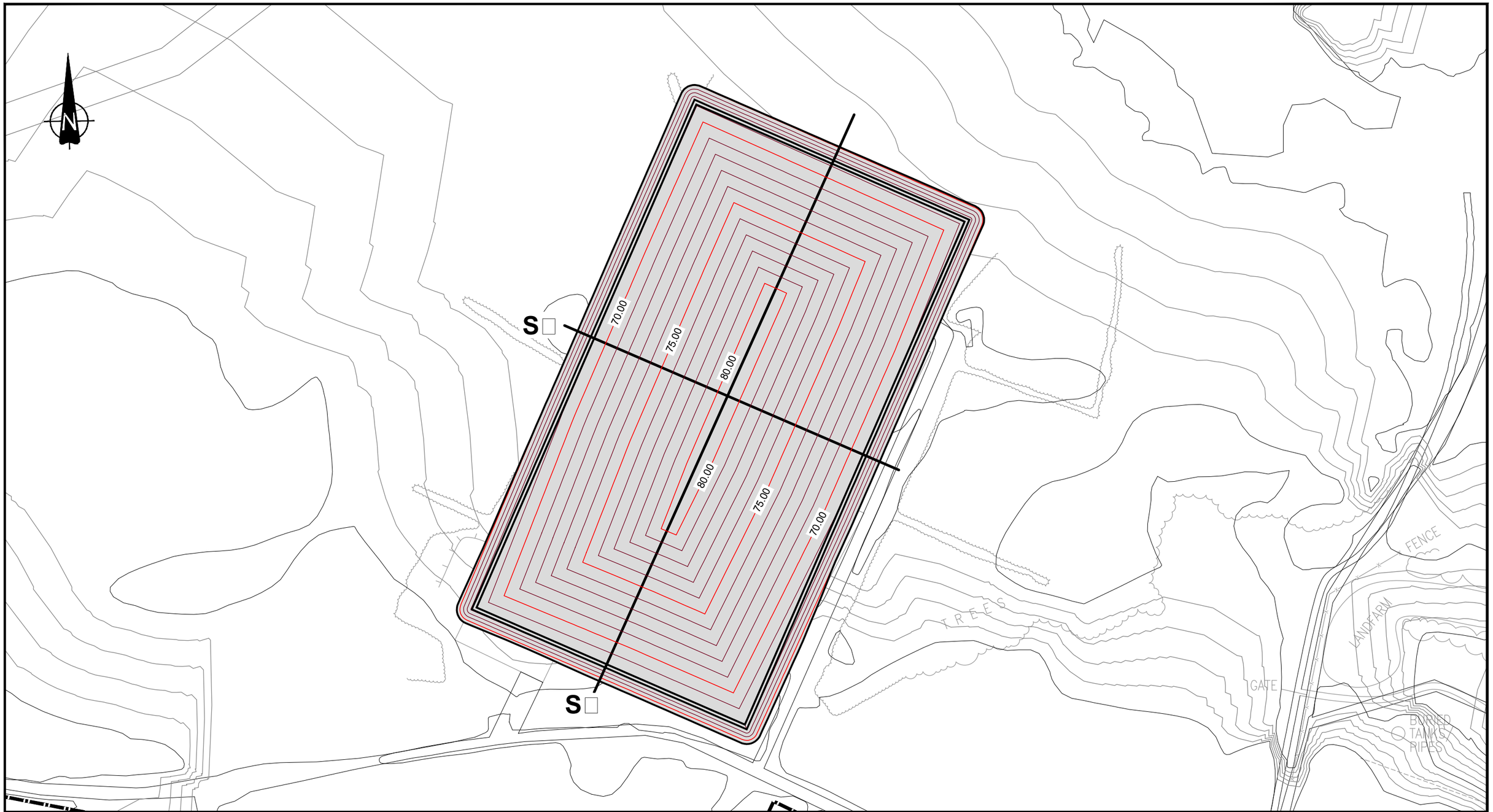
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 6 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 970 Km³ CAPACITY
BASE DESIGN

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B34



0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

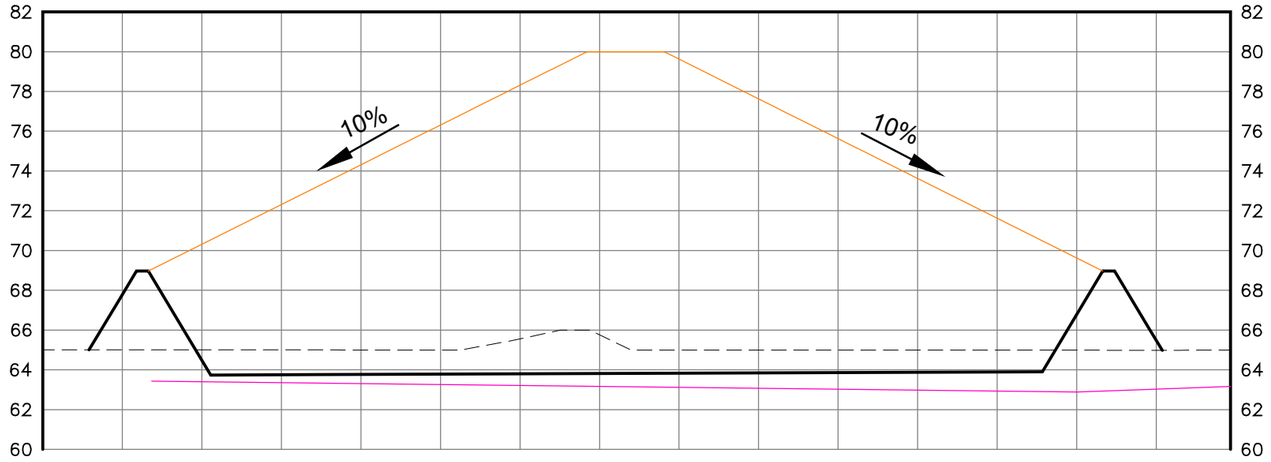
DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

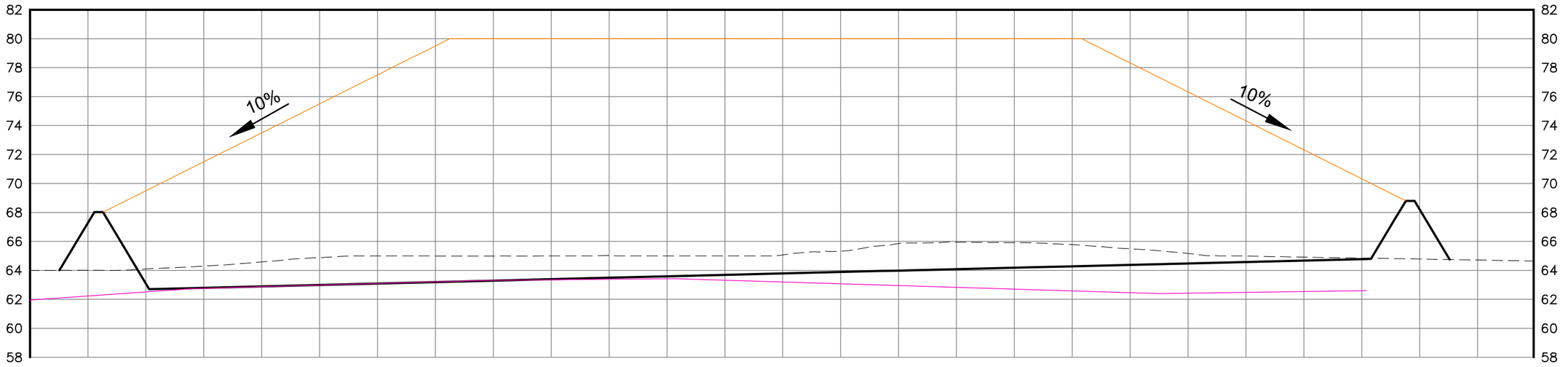
TITLE:
OPTION 6 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 970 Km³ CAPACITY
TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B35

S1 PROFILE



S2 PROFILE



Ground Surface — Approx. Bedrock — Base Design — Top of Cap Design

0m 10 20 30 40 50 60
1 : 1500

0m 3 6 9 12
1:300

CLIENT:
IMPERIAL OIL LIMITED

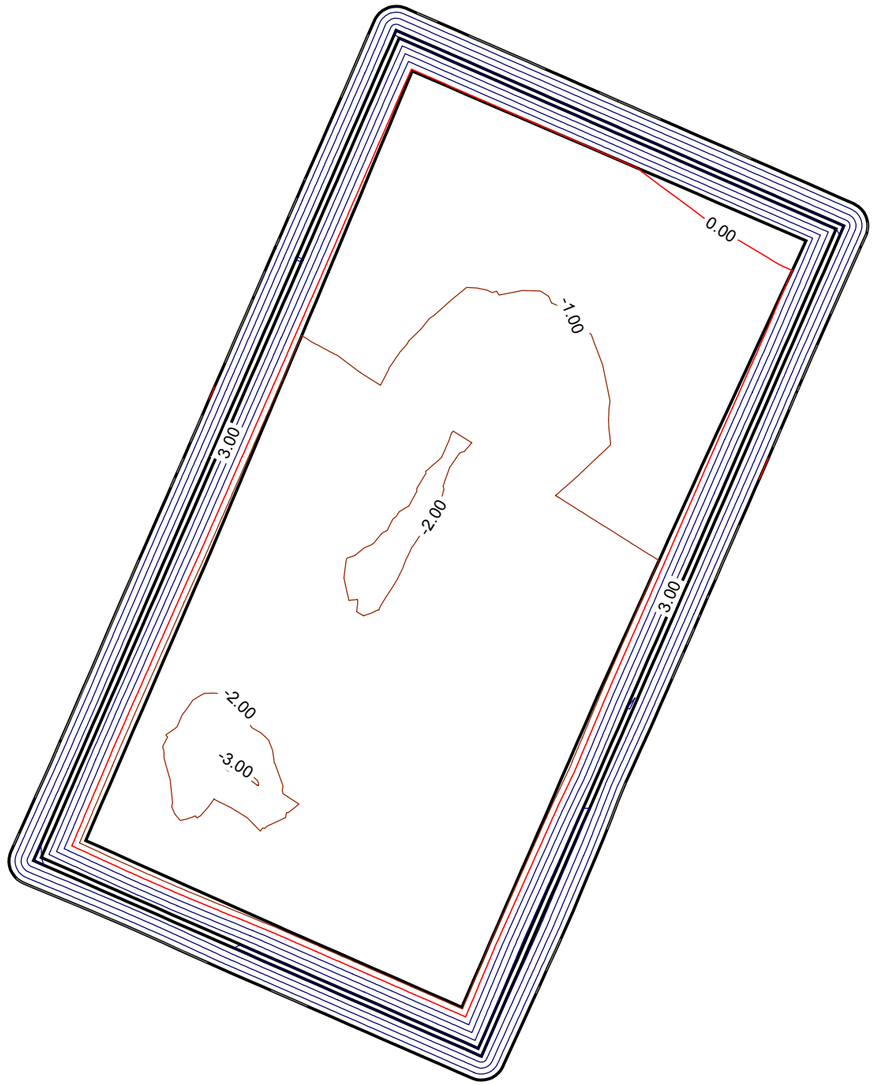
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 6 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 970 Km³ CAPACITY
SECTIONS S1 AND S2

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B36



Project: Norman Wells Landfil Option 3
Date of Isopach: April 22, 2015
Surface 1: Ground Surface
Surface 2: Option 6 Design Base
Volume : CUT = 112,030m3 / FILL = 82,513m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

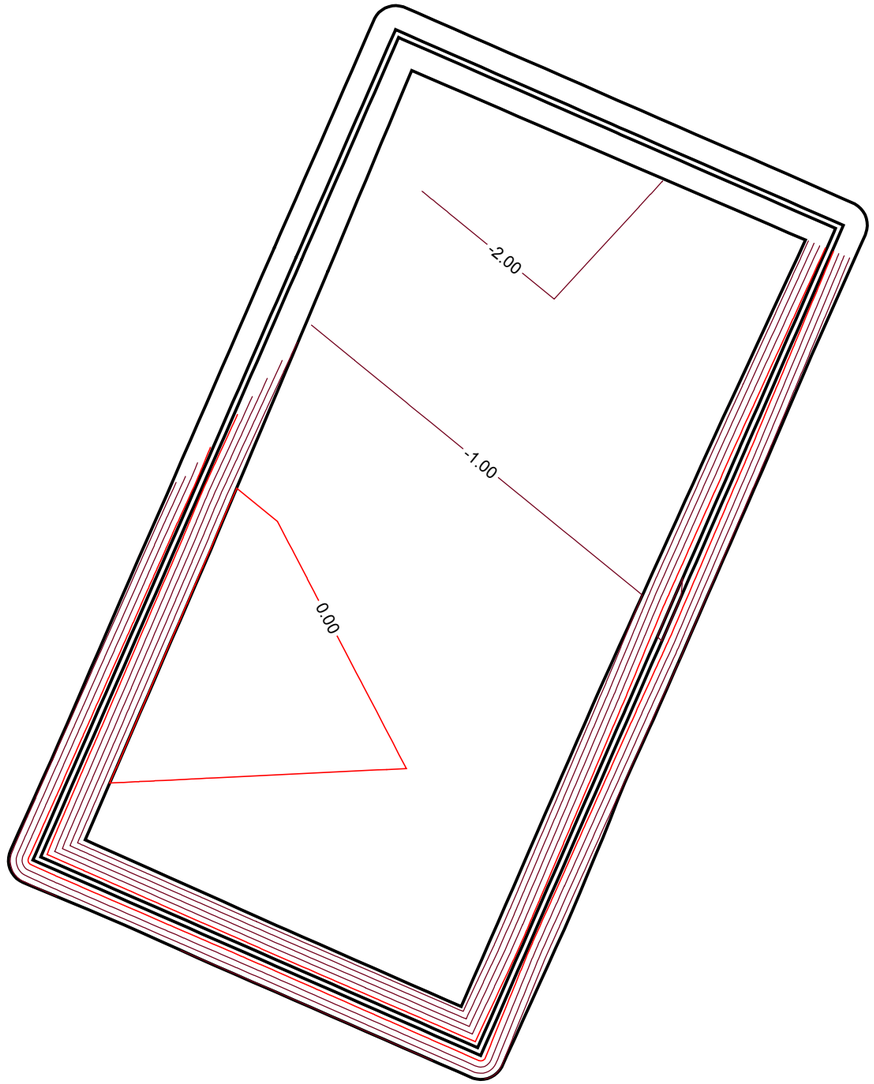
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 6 - AT DEPTH LTMF (SHALLOW BEDROCK) - 970 Km³ CAPACITY DEPTH CONTOURS BETWEEN GROUND SURFACE AND DESIGN BASE

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B37



Project: Norman Wells Landfil Option 3
Date of Isopach: April 22, 2015
Surface 1: Option 6 Design Base
Surface 2: Bedrock
Volume :
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 30 60 90 120

1 : 3000

CLIENT:

IMPERIAL OIL LIMITED

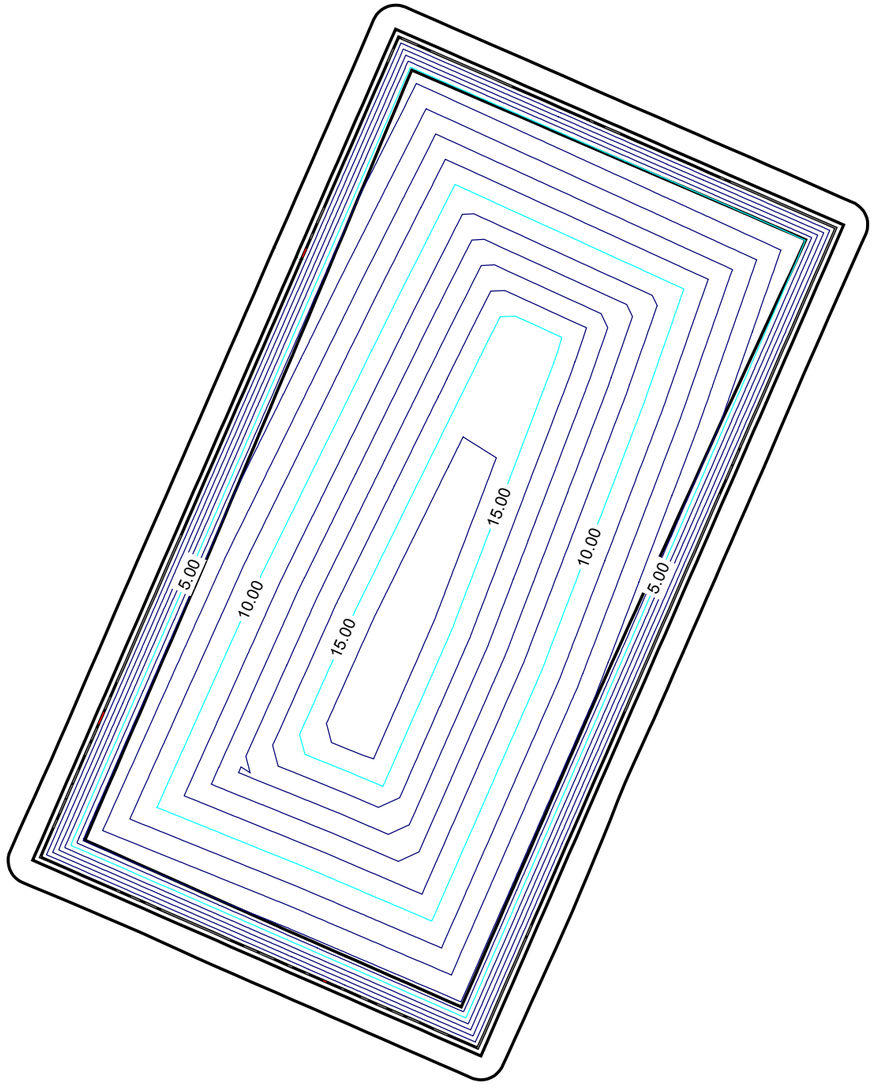
amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 6 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 970 Km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND BEDROCK

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B38



Project: Norman Wells Landfill Option 3
Date of Isopach: April 22, 2015
Surface 1: Option 6 Design Base
Surface 2: Option 6 Top of Cap
Volume : 1,000,000m3
Notes:

Cut Contours means Surface 1 is Higher than Surface 2

Fill Contours means Surface 1 is Lower than Surface 2

0m 20 40 60 80 100

1 : 2500

CLIENT:

IMPERIAL OIL LIMITED

amec foster wheeler
140 Quarry Park Boulevard SE, Calgary, AB, Canada, T2C 3G3
Tel. (403) 248-4331

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:
NORMAN WELLS CONSERVATION
AND RECLAMATION PLAN
BASE CASE REMEDIATION AND RECLAMATION REPORT

TITLE:
OPTION 6 - AT DEPTH LTMF
(SHALLOW BEDROCK) - 970 Km³ CAPACITY
DEPTH CONTOURS BETWEEN
DESIGN BASE AND TOP OF CAP

DATE:	APRIL 2015
PROJECT No.:	CC4058.300
REV. No.:	A
FIGURE No.:	FIGURE B39

Appendix N

Imperial Well Inventory

Well ID	Well Name	Well Operator	Well Status	Classification	SPUD Date	Rig Release Date	Region	NAD 27 Lat	NAD 27 Long	UWI	Comment
2	DISCOVERY NO.1	Northwest Oils Ltd	Abandoned	Exploratory Well	11-May-1921	1-Jan-1923	NWT Mainland	65° 16' 54.0"	126° 51' 7.0"	300O376520126451	
6	BEAR ISLAND NO.1 (F-56)	Imperial Oil Limited	Abandoned	Exploratory Well	15-Jul-1921	24-Jul-1923	NWT Mainland	65° 15' 15.0"	126° 55' 29.0"	300F566520126450	
13	CANOL 6X	Imperial Oil Limited	Abandoned	Development Well	3-Jul-1942	17-Jul-1942	NWT Mainland	65° 16' 57.0"	126° 51' 23.0"	302O376520126450	
7	C-1 LOCATION (LINK)	Northwest Oils Ltd	Abandoned	Development Well	25-Aug-1921	15-Jun-1922	NWT Mainland	65° 14' 0.0"	126° 50' 0.0"	300C256520126450	
9	C-2 LOCATION (LINK)	Northwest Oils Ltd	Abandoned	Development Well	8-Nov-1922	23-Sep-1923	NWT Mainland	65° 14' 0.0"	126° 50' 0.0"	302C256520126450	
10	DISCOVERY NO.2	Northwest Oils Ltd	Abandoned	Development Well	1-Jul-1924	12-Aug-1924	NWT Mainland	65° 16' 54.6"	126° 50' 58.1"	300P376520126450	
11	DISCOVERY NO.3	Northwest Oils Ltd	Abandoned	Development Well	5-Jul-1939	27-Jul-1940	NWT Mainland	65° 16' 48.0"	126° 50' 5.0"	300N276520126450	
12	DISCOVERY D-36X	Northwest Oils Ltd	Injector	Development Well	6-Sep-1940	27-Sep-1940	NWT Mainland	65° 16' 58.0"	126° 51' 34.0"	300N376520126450	
14	CANOL C-41X	Imperial Oil Limited	Other	Development Well	4-Jul-1942	12-Aug-1942	NWT Mainland	65° 16' 31.0"	126° 57' 7.0"	302P376520126450	Observation Well
15	CANOL B-40X	Imperial Oil Limited	Producer	Development Well	10-Jul-1942	25-Jul-1942	NWT Mainland	65° 16' 57.0"	126° 50' 46.0"	303P376520126450	To be suspended in 2013
16	CANOL E-33X	Imperial Oil Limited	Producer	Development Well	20-Jul-1942	29-Jul-1942	NWT Mainland	65° 16' 58.0"	126° 52' 7.0"	300M376520126450	To be abandoned in 2013
17	CANOL B-38X	Imperial Oil Limited	Producer	Development Well	22-Jul-1942	10-Aug-1942	NWT Mainland	65° 17' 2.8"	126° 50' 59.9"	300A386520126450	
18	CANOL A-45X	Imperial Oil Limited	Abandoned	Development Well	29-Jul-1942	24-Aug-1942	NWT Mainland	65° 16' 52.0"	126° 49' 53.0"	302N276520126450	Well abandoned in 2009
19	CANOL C-34X	Imperial Oil Limited	Producer	Development Well	31-Jul-1942	21-Aug-1942	NWT Mainland	65° 17' 6.0"	126° 51' 37.0"	300C386520126450	To be suspended in 2013
20	CANOL E-30X	Imperial Oil Limited	Injector	Development Well	3-Aug-1942	18-Aug-1942	NWT Mainland	65° 17' 0.0"	126° 52' 30.0"	300A486520126450	
21	CANOL F-21X	Imperial Oil Limited	Abandoned	Development Well	14-Aug-1942	20-Sep-1942	NWT Mainland	65° 17' 10.0"	126° 54' 1.0"	300D486520126450	
22	CANOL C-36X	Imperial Oil Limited	Producer	Development Well	23-Aug-1942	24-Sep-1942	NWT Mainland	65° 17' 4.0"	126° 51' 19.0"	300B386520126450	
23	CANOL D-32X	Imperial Oil Limited	Injector	Development Well	28-Aug-1942	10-Sep-1942	NWT Mainland	65° 17' 4.0"	126° 52' 0.0"	302C386520126450	
24	CANOL C-27X	Imperial Oil Limited	Injector	Development Well	28-Aug-1942	20-Sep-1942	NWT Mainland	65° 17' 17.0"	126° 52' 39.0"	300H486520126450	
25	CANOL 17X	Imperial Oil Limited	Abandoned	Development Well	3-Sep-1942	27-Sep-1942	NWT Mainland	65° 16' 40.0"	126° 48' 51.0"	300I276520126450	
26	CANOL E-33-1X	Imperial Oil Limited	Producer	Development Well	2-Oct-1942	16-Oct-1942	NWT Mainland	65° 16' 51.0"	126° 52' 6.0"	302M376520126450	
27	CANOL E-32X	Imperial Oil Limited	Producer	Development Well	2-Oct-1942	16-Oct-1942	NWT Mainland	65° 16' 54.0"	126° 52' 23.0"	303M376520126450	
28	CANOL D-36-1X	Imperial Oil Limited	Suspended	Development Well	3-Dec-1942	29-Sep-1943	NWT Mainland	65° 16' 52.0"	126° 51' 35.0"	302N376520126450	
29	CANOL E-35X	Imperial Oil Limited	Injector	Development Well	2-Dec-1942	29-Sep-1943	NWT Mainland	65° 16' 50.0"	126° 51' 51.0"	303N376520126450	
31	CANOL E-28X	Imperial Oil Limited	Producer	Development Well	10-Jan-1943	7-Jun-1943	NWT Mainland	65° 17' 4.0"	126° 52' 45.0"	302A486520126450	
32	CANOL GOOSE ISLAND O-12X	Imperial Oil Limited	Producer	Development Well	15-Jan-1944	2-Mar-1944	NWT Mainland	65° 16' 32.0"	126° 56' 39.0"	300I676520126450	
33	CANOL GOOSE ISLAND O-29X	Imperial Oil Limited	Injector	Development Well	19-Feb-1943	2-Apr-1943	NWT Mainland	65° 15' 54.0"	126° 54' 20.0"	300M466520126450	To be suspended in 2013
34	CANOL BEAR ISLAND N-42X	Imperial Oil Limited	Injector	Development Well	28-Mar-1943	23-Apr-1943	NWT Mainland	65° 15' 33.0"	126° 52' 32.0"	300H666520126450	
35	CANOL BEAR ISLAND NO.4(B-36)	Imperial Oil Limited	Abandoned	Development Well	3-May-1943	23-Jun-1943	NWT Mainland	65° 15' 6.0"	126° 51' 8.0"	300B366520126450	
37	CANOL D-29X	Imperial Oil Limited	Abandoned	Development Well	11-Jun-1943	8-Jul-1943	NWT Mainland	65° 17' 10.0"	126° 52' 33.0"	303A486520126450	
38	CANOL BEAR ISLAND N-44X	Imperial Oil Limited	Injector	Development Well	26-Jun-1943	14-Aug-1943	NWT Mainland	65° 15' 30.0"	126° 52' 10.0"	300L366520126450	Converted to injector in 2009
39	CANOL E-27X	Imperial Oil Limited	Suspended	Development Well	12-Jul-1943	9-Aug-1943	NWT Mainland	65° 17' 6.0"	126° 53' 1.0"	300B486520126450	To be abandoned in 2013
41	CANOL BEAR ISLAND N-34X	Imperial Oil Limited	Producer	Development Well	20-Aug-1943	15-Oct-1943	NWT Mainland	65° 15' 39.0"	126° 53' 22.0"	300N466520126450	
42	CANOL GOOSE ISLAND O-15X	Imperial Oil Limited	Producer	Development Well	27-Aug-1943	6-Oct-1943	NWT Mainland	65° 16' 22.0"	126° 56' 24.0"	300H676520126450	
44	CANOL GOOSE ISLAND Q-05X	Imperial Oil Limited	Abandoned	Development Well	19-Oct-1943	23-Dec-1943	NWT Mainland	65° 16' 31.0"	126° 57' 59.0"	300L676520126450	
47	CANOL BEAR ISLAND O-41X	Imperial Oil Limited	Producer	Development Well	12-Jan-1944	22-Feb-1944	NWT Mainland	65° 15' 26.0"	126° 52' 53.0"	300H466520126450	
48	CANOL D-31X	Imperial Oil Limited	Injector	Development Well	26-Jan-1944	6-Mar-1944	NWT Mainland	65° 17' 4.0"	126° 52' 17.0"	300D386520126450	
49	CANOL E-25X	Imperial Oil Limited	Producer	Development Well	17-Feb-1944	11-Mar-1944	NWT Mainland	65° 17' 9.0"	126° 53' 19.0"	302B486520126450	
50	CANOL BEAR ISLAND O-43X	Imperial Oil Limited	Producer	Development Well	24-Feb-1944	30-Mar-1944	NWT Mainland	65° 15' 21.0"	126° 52' 32.0"	302H466520126450	
51	CANOL GOOSE ISLAND P-12X	Imperial Oil Limited	Producer	Development Well	6-Mar-1944	5-Apr-1944	NWT Mainland	65° 16' 23.0"	126° 56' 54.0"	300G676520126450	
52	CANOL D-27X	Imperial Oil Limited	Injector	Development Well	14-Mar-1944	31-Mar-1944	NWT Mainland	65° 17' 12.0"	126° 52' 51.0"	304A486520126450	
53	CANOL BEAR ISLAND M-41X	Imperial Oil Limited	Abandoned	Delineation Well	18-Mar-1944	25-Apr-1944	NWT Mainland	65° 15' 40.0"	126° 52' 32.0"	302I466520126450	Well abandoned in 1972
54	CANOL BEAR ISLAND N-39X	Imperial Oil Limited	Injector	Development Well	1-Apr-1944	28-Apr-1944	NWT Mainland	65° 15' 37.0"	126° 52' 57.0"	303I466520126450	
55	CANOL C-30X	Imperial Oil Limited	Producer	Development Well	4-Apr-1944	23-Apr-1944	NWT Mainland	65° 17' 13.0"	126° 52' 16.0"	302D386520126450	To be suspended in 2013
56	CANOL GOOSE ISLAND P-10X	Imperial Oil Limited	Abandoned	Development Well	6-Apr-1944	19-Jun-1944	NWT Mainland	65° 16' 31.0"	126° 57' 7.0"	300J676520126450	
57	CANOL C-32X	Imperial Oil Limited	Producer	Development Well	24-Apr-1944	9-May-1944	NWT Mainland	65° 17' 11.0"	126° 51' 55.0"	303C386520126450	
58	CANOL BEAR ISLAND O-46X	Imperial Oil Limited	Producer	Development Well	28-Apr-1944	24-May-1944	NWT Mainland	65° 15' 18.0"	126° 52' 2.0"	300E366520126450	
59	CANOL BEAR ISLAND P-38X	Imperial Oil Limited	Producer	Development Well	30-Apr-1944	23-May-1944	NWT Mainland	65° 15' 30.0"	126° 53' 19.0"	300J466520126450	
60	CANOL B-30X	Imperial Oil Limited	Abandoned	Development Well	11-May-1944	25-May-1944	NWT Mainland	65° 17' 18.0"	126° 52' 2.0"	300F386520126450	Well abandoned in 2012
61	CANOL BEAR ISLAND Q-39X	Imperial Oil Limited	Injector	Development Well	24-May-1944	17-Jun-1944	NWT Mainland	65° 15' 21.0"	126° 53' 16.0"	300G466520126450	
62	CANOL BEAR ISLAND P-35X	Imperial Oil Limited	Injector	Development Well	5-Jun-1944	3-Jul-1944	NWT Mainland	65° 15' 35.0"	126° 53' 44.0"	300K466520126450	
63	CANOL GOOSE ISLAND P-17X	Imperial Oil Limited	Injector	Development Well	22-Jun-1944	19-Jul-1944	NWT Mainland	65° 15' 12.0"	126° 56' 12.0"	300D576520126450	
64	CANOL GOOSE ISLAND O-17X	Imperial Oil Limited	Producer	Development Well	28-Jun-1944	17-Jul-1944	NWT Mainland	65° 16' 22.0"	126° 55' 56.0"	300E576520126450	
65	CANOL GOOSE ISLAND Q-15X	Imperial Oil Limited	Producer	Development Well	20-Jul-1944	27-Aug-1944	NWT Mainland	65° 16' 13.0"	126° 56' 35.0"	300A676520126450	To be suspended in 2013
66	CANOL GOOSE ISLAND N-14X	Imperial Oil Limited	Producer	Development Well	21-Jul-1944	16-Aug-1944	NWT Mainland	65° 16' 32.0"	126° 56' 12.0"	300L576520126450	To be suspended in 2013
69	CANOL GOOSE ISLAND P-07X	Imperial Oil Limited	Abandoned	Development Well	19-Aug-1944	6-Sep-1944	NWT Mainland	65° 16' 31.0"	126° 57' 36.0"	300K876520126450	
70	CANOL GOOSE ISLAND Q-10X	Imperial Oil Limited	Producer	Development Well	27-Aug-1944	13-Sep-1944	NWT Mainland	65° 16' 20.0"	126° 57' 40.0"	300F676520126450	To be suspended in 2013
71	CANOL GOOSE ISLAND O-07X	Imperial Oil Limited	Injector	Development Well	10-Sep-1944	1-Oct-1944	NWT Mainland	65° 16' 45.0"	126° 57' 40.0"	302K876520126450	
73	CANOL BEAR ISLAND M-43X	Imperial Oil Limited	Producer	Development Well	18-Oct-1944	9-Nov-1944	NWT Mainland	65° 15' 37.6"	126° 52' 14.3"	302L366520126450	
74	CANOL C-44X	Imperial Oil Limited	Injector	Development Well	26-Oct-1944	10-Nov-1944	NWT Mainland	65° 16' 55.0"	126° 50' 30.0"	300M276520126450	
75	CANOL BEAR ISLAND M-46X	Imperial Oil Limited	Producer	Development Well	11-Nov-1944	7-Dec-1944	NWT Mainland	65° 15' 31.9"	126° 51' 48.8"	300K366520126450	
76	CANOL B-42X	Imperial Oil Limited	Injector	Development Well	15-Nov-1944	2-Dec-1944	NWT Mainland	65° 16' 55.0"	126° 50' 30.0"	302M276520126450	To be abandoned in 2013
79	SEEPAGE LAKE NO.1(L-28)	Imperial Oil Limited	Abandoned	Exploratory Well	5-Dec-1944	14-Dec-1944	NWT Mainland	65° 17' 40.0"	126° 50' 24.0"	300L286520126450	
81	SEEPAGE LAKE NO.1A(2L-28)	Imperial Oil Limited	Abandoned	Exploratory Well	15-Dec-1944	11-Jan-1945	NWT Mainland	65° 17' 30.0"	126° 50' 0.0"	302L286520126450	
77	CANOL BEAR ISLAND R-36X	Imperial Oil Limited	Injector	Development Well	15-Nov-1944	31-Dec-1944	NWT Mainland	65° 15' 16.0"	126° 54' 1.0"	300E486520126450	
80	CANOL BEAR ISLAND N-47X	Imperial Oil Limited	Injector	Development Well	9-Dec-1944	4-Jan-1945	NWT Mainland	65° 15' 21.0"	126° 51' 46.0"	300F366520126450	
83	CANOL GOOSE ISLAND O-20X	Imperial Oil Limited	Producer	Development Well	1-Jan-1945	29-Jan-1945	NWT Mainland	65° 16' 12.0"	126° 55' 45.0"	300C576520126450	
84	CANOL BEAR ISLAND Q-42X	Imperial Oil Limited	Injector	Development Well	6-Jan-1945	10-Feb-1945	NWT Mainland	65° 15' 15.0"	126° 52' 53.0"	303H466520126450	

Well ID	Well Name	Well Operator	Well Status	Classification	SPUD Date	Rig Release Date	Region	NAD 27 Lat	NAD 27 Long	UWI	Comment
85	CANOL GOOSE ISLAND N-19X	Imperial Oil Limited	Injector	Development Well	19-Jan-1945	14-Feb-1945	NWT Mainland	65° 16' 23.0"	126° 55' 32.0"	300F576520126450	
86	CANOL GOOSE ISLAND N-22X	Imperial Oil Limited	Producer	Development Well	1-Feb-1945	22-Feb-1945	NWT Mainland	65° 16' 13.0"	126° 55' 17.0"	300B576520126450	
87	CANOL BEAR ISLAND P-44X	Imperial Oil Limited	Injector	Development Well	12-Feb-1945	6-Mar-1945	NWT Mainland	65° 15' 16.0"	126° 52' 35.0"	304H466520126450	
88	CANOL GOOSE ISLAND P-22X	Imperial Oil Limited	Producer	Development Well	16-Feb-1945	5-Mar-1945	NWT Mainland	65° 16' 3.0"	126° 55' 31.0"	302C576520126450	
89	CANOL GOOSE ISLAND #16	Imperial Oil Limited	Abandoned	Development Well	25-Feb-1945	9-Mar-1945	NWT Mainland	65° 16' 3.0"	126° 55' 1.0"	302B576520126450	
127	NORMAN WELLS D-34X	Imperial Oil Limited	Producer	Development Well	16-Jul-1956	31-Jul-1956	NWT Mainland	65° 16' 57.0"	126° 51' 50.0"	304N376520126450	
128	NORMAN WELLS F-28X	Imperial Oil Limited	Producer	Development Well	4-Aug-1956	8-Sep-1956	NWT Mainland	65° 17' 3.7"	126° 52' 53.0"	305A486520126450	
129	NORMAN WELLS F-29X	Imperial Oil Limited	Injector	Development Well	10-Sep-1956	8-Oct-1956	NWT Mainland	65° 17' 0.0"	126° 52' 38.0"	306A486520126450	
131	NORMAN WELLS F-33X	Imperial Oil Limited	Injector	Development Well	11-Oct-1956	20-Oct-1956	NWT Mainland	65° 14' 0.0"	126° 37' 0.0"	304M376520126450	
400	GOOSE ISLAND N-17X	Imperial Oil Limited	Injector	Development Well	30-Jun-1968	10-Jul-1968	NWT Mainland	65° 16' 28.8"	126° 55' 49.7"	302E576520126450	
402	GOOSE ISLAND M-15X	Imperial Oil Limited	Producer	Development Well	12-Jul-1968	28-Jul-1968	NWT Mainland	65° 16' 34.3"	126° 56' 10.1"	302L576520126450	
404	CANOL GOOSE ISLAND R-05X	Imperial Oil Limited	Injector	Development Well	30-Jul-1968	24-Aug-1968	NWT Mainland	65° 16' 19.9"	126° 57' 46.5"	300E676520126450	
594	NORMAN WELLS T-09X	Imperial Oil Limited	Injector	Development Well	1-Sep-1987	7-Sep-1987	NWT Mainland	65° 16' 12.1"	126° 57' 27.4"	302D676520126450	
1106	NORMAN WELLS E-26X	Imperial Oil Limited	Injector	Development Well	25-Oct-1978	12-Dec-1978	NWT Mainland	65° 17' 8.9"	126° 53' 1.0"	303B486520126450	
1114	MACKENZIE RIVER NO.1(C-47)	Imperial Oil Limited	Abandoned	Development Well	17-Jan-1979	7-Feb-1979	NWT Mainland	65° 16' 12.3"	126° 53' 35.0"	300C476520126450	
1118	MACKENZIE RIVER NO.2(H-57)	Imperial Oil Limited	Abandoned	Development Well	16-Feb-1979	2-Mar-1979	NWT Mainland	65° 16' 24.9"	126° 54' 34.3"	300H576520126450	
1121	MACKENZIE RIVER NO.3(A-47)	Imperial Oil Limited	Abandoned	Development Well	8-Mar-1979	31-Mar-1979	NWT Mainland	65° 16' 8.3"	126° 53' 3.9"	300A476520126450	
1124	NORMAN WELLS G-26X	Imperial Oil Limited	Producer	Development Well	15-Apr-1979	14-May-1979	NWT Mainland	65° 17' 7.2"	126° 53' 5.9"	304B486520126450	
1128	NORMAN WELLS E-43X	Imperial Oil Limited	Injector	Development Well	19-May-1979	5-Jun-1979	NWT Mainland	65° 16' 51.3"	126° 50' 1.7"	300I376520126450	
1131	NORMAN WELLS E-38X	Imperial Oil Limited	Producer	Development Well	9-Jun-1979	26-Jun-1979	NWT Mainland	65° 16' 54.5"	126° 51' 2.2"	304P376520126450	
1134	NORMAN WELLS F-35X	Imperial Oil Limited	Injector	Development Well	4-Jul-1979	19-Aug-1979	NWT Mainland	65° 16' 56.6"	126° 51' 45.5"	305N376520126450	
1136	NORMAN WELLS J-29X	Imperial Oil Limited	Producer	Development Well	9-Jul-1979	28-Aug-1979	NWT Mainland	65° 17' 0.9"	126° 52' 22.2"	303D386520126450	
1142	BEAR ISLAND R-34X	Imperial Oil Limited	Injector	Development Well	7-Oct-1979	25-Oct-1979	NWT Mainland	65° 15' 24.9"	126° 54' 9.0"	302E466520126450	
1144	CANOL BEAR ISLAND M-44X	Imperial Oil Limited	Producer	Development Well	1-Nov-1979	19-Nov-1979	NWT Mainland	65° 15' 35.2"	126° 51' 59.0"	302K366520126450	
1151	NORMAN WELLS F-25X	Imperial Oil Limited	Injector	Development Well	24-Jan-1980	21-Mar-1980	NWT Mainland	65° 17' 7.1"	126° 53' 5.9"	305B486520126450	
1154	MACKENZIE RIVER NO.4(E-27)	Imperial Oil Limited	Abandoned	Development Well	4-Feb-1980	28-Feb-1980	NWT Mainland	65° 16' 19.2"	126° 50' 23.2"	300E276520126450	
1161	NORMAN WELLS B-39X	Imperial Oil Limited	Injector	Development Well	27-Mar-1980	16-Apr-1980	NWT Mainland	65° 16' 54.2"	126° 51' 2.2"	305P376520126450	
1162	NORMAN WELLS D-41X	Imperial Oil Limited	Injector	Development Well	19-Apr-1980	6-Jul-1980	NWT Mainland	65° 16' 54.2"	126° 51' 1.8"	306P376520126450	
1213	NORMAN WELLS G-28X	Imperial Oil Limited	Producer	Development Well	2-Jul-1982	18-Jul-1982	NWT Mainland	65° 17' 7.2"	126° 53' 5.4"	306B486520126450	
1214	NORMAN WELLS B-35X	Imperial Oil Limited	Abandoned	Development Well	4-Jul-1982	13-Jul-1982	NWT Mainland	65° 17' 10.2"	126° 51' 21.9"	302B366520126450	Well abandoned in 2010
1216	NORMAN WELLS D-45X	Imperial Oil Limited	Injector	Development Well	16-Jul-1982	9-Aug-1982	NWT Mainland	65° 16' 48.3"	126° 50' 17.6"	303MZ76520126450	
1217	NORMAN WELLS H-27X	Imperial Oil Limited	Injector	Development Well	17-Jul-1982	4-Aug-1982	NWT Mainland	65° 17' 7.2"	126° 53' 5.6"	307B486520126450	
1222	NORMAN WELLS E-29X	Imperial Oil Limited	Injector	Development Well	7-Aug-1982	12-Aug-1982	NWT Mainland	65° 17' 0.8"	126° 52' 41.1"	307A486520126450	
1223	NORMAN WELLS G-24X	Imperial Oil Limited	Producer	Development Well	12-Aug-1982	26-Aug-1982	NWT Mainland	65° 17' 8.0"	126° 53' 34.4"	300C486520126450	
1224	NORMAN WELLS H-29X	Imperial Oil Limited	Injector	Development Well	13-Aug-1982	24-Aug-1982	NWT Mainland	65° 17' 0.7"	126° 52' 40.7"	308A486520126450	
1226	NORMAN WELLS G-30X	Imperial Oil Limited	Producer	Development Well	24-Aug-1982	4-Sep-1982	NWT Mainland	65° 17' 0.6"	126° 52' 40.3"	309A486520126450	
1227	NORMAN WELLS F-31X	Imperial Oil Limited	Injector	Development Well	29-Aug-1982	15-Sep-1982	NWT Mainland	65° 17' 0.1"	126° 52' 19.3"	305M376520126450	
1228	NORMAN WELLS E-40X	Imperial Oil Limited	Producer	Development Well	7-Sep-1982	17-Sep-1982	NWT Mainland	65° 16' 54.9"	126° 51' 8.6"	303O376520126450	
1229	NORMAN WELLS D-39X	Imperial Oil Limited	Injector	Development Well	17-Sep-1982	27-Sep-1982	NWT Mainland	65° 16' 54.6"	126° 51' 8.2"	305O376520126450	
1230	NORMAN WELLS E-38X	Imperial Oil Limited	Producer	Development Well	17-Sep-1982	27-Sep-1982	NWT Mainland	65° 16' 57.3"	126° 51' 21.2"	304O376520126450	
1231	NORMAN WELLS C-37X	Imperial Oil Limited	Injector	Development Well	30-Sep-1982	14-Oct-1982	NWT Mainland	65° 16' 57.0"	126° 51' 16.6"	306O376520126450	
1232	NORMAN WELLS N-27X	Imperial Oil Limited	Injector	Development Well	1-Oct-1982	12-Oct-1982	NWT Mainland	65° 16' 5.4"	126° 54' 29.0"	300A576520126450	
1234	NORMAN WELLS N-25X	Imperial Oil Limited	Injector	Development Well	14-Oct-1982	20-Oct-1982	NWT Mainland	65° 16' 9.7"	126° 54' 45.4"	302A576520126450	
1236	NORMAN WELLS D-42X	Imperial Oil Limited	Producer	Development Well	18-Oct-1982	27-Oct-1982	NWT Mainland	65° 16' 48.3"	126° 50' 18.0"	304MZ76520126450	
1237	NORMAN WELLS O-23X	Imperial Oil Limited	Injector	Development Well	23-Oct-1982	29-Oct-1982	NWT Mainland	65° 16' 4.3"	126° 55' 15.7"	303B576520126450	
1238	NORMAN WELLS D-44X	Imperial Oil Limited	Producer	Development Well	28-Oct-1982	6-Nov-1982	NWT Mainland	65° 16' 48.3"	126° 50' 17.1"	305MZ76520126450	To be suspended in 2013
1239	NORMAN WELLS P-21X	Imperial Oil Limited	Injector	Development Well	1-Nov-1982	9-Nov-1982	NWT Mainland	65° 16' 7.0"	126° 55' 35.6"	303C576520126450	
1243	NORMAN WELLS D-47X	Imperial Oil Limited	Injector	Development Well	7-Nov-1982	21-Nov-1982	NWT Mainland	65° 16' 48.3"	126° 50' 17.1"	306MZ76520126450	
1245	NORMAN WELLS P-19X	Imperial Oil Limited	Injector	Development Well	12-Nov-1982	19-Nov-1982	NWT Mainland	65° 16' 7.7"	126° 56' 1.3"	302D576520126450	
1246	NORMAN WELLS P-15X	Imperial Oil Limited	Injector	Development Well	23-Nov-1982	1-Dec-1982	NWT Mainland	65° 16' 16.7"	126° 56' 23.4"	302H676520126450	
1247	NORMAN WELLS F-23X	Imperial Oil Limited	Injector	Development Well	26-Nov-1982	4-Dec-1982	NWT Mainland	65° 17' 8.2"	126° 53' 35.3"	302C486520126450	
1248	NORMAN WELLS P-13X	Imperial Oil Limited	Injector	Development Well	4-Dec-1982	11-Dec-1982	NWT Mainland	65° 16' 23.3"	126° 56' 42.8"	303H676520126450	
1249	NORMAN WELLS H-23X	Imperial Oil Limited	Injector	Development Well	4-Dec-1982	16-Dec-1982	NWT Mainland	65° 17' 8.1"	126° 53' 34.9"	303C486520126450	
1252	NORMAN WELLS P-09X	Imperial Oil Limited	Injector	Development Well	14-Dec-1982	25-Dec-1982	NWT Mainland	65° 16' 30.1"	126° 57' 15.6"	302F676520126450	
1253	NORMAN WELLS H-25X	Imperial Oil Limited	Injector	Development Well	17-Dec-1982	25-Dec-1982	NWT Mainland	65° 17' 8.0"	126° 53' 34.0"	304C486520126450	
1256	NORMAN WELLS N-15X	Imperial Oil Limited	Injector	Development Well	29-Dec-1982	2-Jan-1983	NWT Mainland	65° 16' 29.6"	126° 56' 5.1"	303E576520126450	
1257	NORMAN WELLS N-11X	Imperial Oil Limited	Injector	Development Well	29-Dec-1982	4-Jan-1983	NWT Mainland	65° 16' 39.3"	126° 56' 39.3"	302I676520126450	
1259	NORMAN WELLS L-15X	Imperial Oil Limited	Injector	Development Well	5-Jan-1983	15-Jan-1983	NWT Mainland	65° 16' 31.5"	126° 56' 3.3"	303L576520126450	
1260	NORMAN WELLS O-10X	Imperial Oil Limited	Producer	Development Well	7-Jan-1983	12-Jan-1983	NWT Mainland	65° 16' 35.2"	126° 56' 57.0"	302J676520126450	
1261	NORMAN WELLS K-48X	Imperial Oil Limited	Producer	Development Well	16-Jan-1983	28-Jan-1983	NWT Mainland	65° 15' 37.1"	126° 51' 10.2"	300J366520126450	
1262	NORMAN WELLS N-21X	Imperial Oil Limited	Injector	Development Well	18-Jan-1983	23-Jan-1983	NWT Mainland	65° 16' 18.5"	126° 55' 18.6"	300G576520126450	
1265	NORMAN WELLS N-23X	Imperial Oil Limited	Injector	Development Well	25-Jan-1983	30-Jan-1983	NWT Mainland	65° 16' 14.5"	126° 55' 1.0"	304B576520126450	
1267	NORMAN WELLS O-36X	Imperial Oil Limited	Producer	Development Well	1-Feb-1983	13-Feb-1983	NWT Mainland	65° 15' 38.6"	126° 53' 26.3"	302K466520126450	
1268	NORMAN WELLS M-13X	Imperial Oil Limited	Injector	Development Well	2-Feb-1983	7-Feb-1983	NWT Mainland	65° 16' 36.5"	126° 56' 21.4"	304L576520126450	
1269	NORMAN WELLS N-31X	Imperial Oil Limited	Injector	Development Well	10-Feb-1983	16-Feb-1983	NWT Mainland	65° 16' 1.0"	126° 54' 12.2"	302N466520126450	
1273	NORMAN WELLS P-11X	Imperial Oil Limited	Injector	Development Well	16-Feb-1983	22-Feb-1983	NWT Mainland	65° 16' 26.0"	126° 56' 58.2"	302G676520126450	
1275	NORMAN WELLS N-29X	Imperial Oil Limited	Injector	Development Well	17-Feb-1983	21-Feb-1983	NWT Mainland	65° 16' 1.1"	126° 54' 12.6"	300D476520126450	
1276	NORMAN WELLS O-17X	Imperial Oil Limited	Abandoned	Development Well	23-Feb-1983	25-Feb-1983	NWT Mainland	65° 16' 6.3"	126° 56' 21.4"	302A676520126450	

Well ID	Well Name	Well Operator	Well Status	Classification	SPUD Date	Rig Release Date	Region	NAD 27 Lat	NAD 27 Long	UWI	Comment
1279	NORMAN WELLS Q-12X	Imperial Oil Limited	Producer	Development Well	24-Feb-1983	2-Mar-1983	NWT Mainland	65° 16' 17.3"	126° 57' 1.0"	303G676520126450	To be suspended in 2013
1280	NORMAN WELLS R-15X	Imperial Oil Limited	Injector	Development Well	27-Feb-1983	3-Mar-1983	NWT Mainland	65° 16' 3.4"	126° 56' 44.1"	300B676520126450	
1281	NORMAN WELLS R-13X	Imperial Oil Limited	Injector	Development Well	4-Mar-1983	8-Mar-1983	NWT Mainland	65° 16' 6.3"	126° 57' 2.9"	302B676520126450	
1282	NORMAN WELLS R-11X	Imperial Oil Limited	Injector	Development Well	4-Mar-1983	9-Mar-1983	NWT Mainland	65° 16' 12.6"	126° 57' 19.0"	300C676520126450	
1283	NORMAN WELLS Q-17-1X	Imperial Oil Limited	Producer	Development Well	11-Mar-1983	16-Mar-1983	NWT Mainland	65° 16' 6.3"	126° 56' 21.4"	303A676520126450	
1284	NORMAN WELLS I-20X	Imperial Oil Limited	Producer	Development Well	11-Mar-1983	21-Mar-1983	NWT Mainland	65° 17' 10.5"	126° 53' 56.8"	300P576520126450	
1285	NORMAN WELLS N-43X	Imperial Oil Limited	Injector	Development Well	18-Mar-1983	26-Mar-1983	NWT Mainland	65° 15' 28.5"	126° 52' 19.1"	303E366520126450	
1286	NORMAN WELLS H-31X	Imperial Oil Limited	Injector	Development Well	23-Mar-1983	31-Mar-1983	NWT Mainland	65° 16' 54.3"	126° 52' 23.5"	306M376520126450	
1287	NORMAN WELLS N-45X	Imperial Oil Limited	Injector	Development Well	28-Mar-1983	31-Mar-1983	NWT Mainland	65° 15' 24.7"	126° 52' 5.6"	302E366520126450	
1288	NORMAN WELLS O-45X	Imperial Oil Limited	Producer	Development Well	2-Apr-1983	9-Apr-1983	NWT Mainland	65° 15' 20.1"	126° 52' 17.5"	304E366520126450	
1289	NORMAN WELLS C-40X	Imperial Oil Limited	Producer	Development Well	2-Apr-1983	10-Apr-1983	NWT Mainland	65° 17' 1.4"	126° 50' 50.3"	307P376520126450	
1292	NORMAN WELLS P-37X	Imperial Oil Limited	Injector	Development Well	11-Apr-1983	16-Apr-1983	NWT Mainland	65° 15' 28.1"	126° 53' 34.8"	300F466520126450	
1293	NORMAN WELLS C-38X	Imperial Oil Limited	Producer	Development Well	13-Apr-1983	16-Apr-1983	NWT Mainland	65° 16' 59.5"	126° 51' 12.9"	307O376520126450	
1294	NORMAN WELLS D-28X	Imperial Oil Limited	Producer	Development Well	17-Apr-1983	21-Apr-1983	NWT Mainland	65° 17' 11.3"	126° 52' 34.1"	310A486520126450	
1295	NORMAN WELLS B-33X	Imperial Oil Limited	Abandoned	Development Well	23-Apr-1983	27-Apr-1983	NWT Mainland	65° 17' 13.0"	126° 51' 49.0"	304C386520126450	Well abandoned in 2010
1297	NORMAN WELLS L-45X	Imperial Oil Limited	Injector	Development Well	10-Jun-1983	20-Jun-1983	NWT Mainland	65° 15' 35.2"	126° 51' 58.0"	303K366520126450	
1298	NORMAN WELLS K-44X	Imperial Oil Limited	Producer	Development Well	21-Jun-1983	28-Jun-1983	NWT Mainland	65° 15' 35.3"	126° 51' 58.4"	300N366520126450	
1301	NORMAN WELLS L-43X	Imperial Oil Limited	Injector	Development Well	28-Jun-1983	4-Jul-1983	NWT Mainland	65° 15' 35.4"	126° 51' 58.8"	304K366520126450	
1302	NORMAN WELLS I-18X	Imperial Oil Limited	Producer	Development Well	1-Jul-1983	12-Jul-1983	NWT Mainland	65° 17' 13.6"	126° 54' 45.1"	300O576520126450	
1303	NORMAN WELLS K-46X	Imperial Oil Limited	Producer	Development Well	5-Jul-1983	12-Jul-1983	NWT Mainland	65° 15' 34.8"	126° 51' 57.6"	300O366520126450	
1304	NORMAN WELLS J-18X	Imperial Oil Limited	Injector	Development Well	12-Jul-1983	22-Jul-1983	NWT Mainland	65° 17' 15.6"	126° 54' 47.7"	300N576520126450	
1306	NORMAN WELLS N-35X	Imperial Oil Limited	Injector	Development Well	15-Jul-1983	21-Jul-1983	NWT Mainland	65° 15' 38.0"	126° 53' 12.9"	300O466520126450	
1309	NORMAN WELLS M-36X	Imperial Oil Limited	Producer	Development Well	21-Jul-1983	27-Jul-1983	NWT Mainland	65° 15' 38.0"	126° 53' 12.4"	302O466520126450	
1310	NORMAN WELLS G-32X	Imperial Oil Limited	Producer	Development Well	25-Jul-1983	31-Jul-1983	NWT Mainland	65° 16' 59.3"	126° 52' 15.9"	300I476520126450	
1313	NORMAN WELLS N-37X	Imperial Oil Limited	Injector	Development Well	28-Jul-1983	1-Aug-1983	NWT Mainland	65° 15' 38.0"	126° 53' 12.0"	303O466520126450	
1315	NORMAN WELLS M-38X	Imperial Oil Limited	Producer	Development Well	1-Aug-1983	7-Aug-1983	NWT Mainland	65° 15' 38.0"	126° 53' 11.5"	300P466520126450	
1321	NORMAN WELLS L-19X	Imperial Oil Limited	Injector	Development Well	1-Sep-1983	10-Sep-1983	NWT Mainland	65° 16' 36.4"	126° 54' 42.4"	300J576520126450	
1323	NORMAN WELLS K-17X	Imperial Oil Limited	Producer	Development Well	11-Sep-1983	24-Sep-1983	NWT Mainland	65° 16' 36.4"	126° 54' 42.3"	302O576520126450	
1324	NORMAN WELLS I-30X	Imperial Oil Limited	Producer	Development Well	16-Sep-1983	24-Sep-1983	NWT Mainland	65° 16' 23.9"	126° 53' 49.2"	300J476520126450	
1325	NORMAN WELLS K-30X	Imperial Oil Limited	Producer	Development Well	25-Sep-1983	1-Oct-1983	NWT Mainland	65° 16' 23.9"	126° 53' 49.1"	300F476520126450	
1326	NORMAN WELLS M-18X	Imperial Oil Limited	Producer	Development Well	25-Sep-1983	7-Oct-1983	NWT Mainland	65° 16' 36.4"	126° 54' 42.1"	300K576520126450	
1328	NORMAN WELLS I-28X	Imperial Oil Limited	Producer	Development Well	2-Oct-1983	12-Oct-1983	NWT Mainland	65° 16' 24.0"	126° 53' 49.7"	300K476520126450	
1329	NORMAN WELLS M-20X	Imperial Oil Limited	Producer	Development Well	7-Oct-1983	17-Oct-1983	NWT Mainland	65° 16' 36.4"	126° 54' 42.0"	302G576520126450	
1332	NORMAN WELLS K-28X	Imperial Oil Limited	Producer	Development Well	13-Oct-1983	18-Oct-1983	NWT Mainland	65° 16' 24.1"	126° 53' 50.1"	302F476520126450	
1333	NORMAN WELLS K-20X	Imperial Oil Limited	Producer	Development Well	17-Oct-1983	25-Oct-1983	NWT Mainland	65° 16' 36.3"	126° 54' 41.8"	302J576520126450	
1334	NORMAN WELLS M-30X	Imperial Oil Limited	Producer	Development Well	19-Oct-1983	28-Oct-1983	NWT Mainland	65° 16' 24.1"	126° 53' 50.2"	302D476520126450	
1335	NORMAN WELLS M-22X	Imperial Oil Limited	Producer	Development Well	26-Oct-1983	4-Nov-1983	NWT Mainland	65° 16' 36.4"	126° 54' 41.4"	303G576520126450	
1336	NORMAN WELLS I-26X	Imperial Oil Limited	Producer	Development Well	26-Oct-1983	5-Nov-1983	NWT Mainland	65° 16' 24.1"	126° 53' 50.4"	302K476520126450	
1338	NORMAN WELLS M-28X	Imperial Oil Limited	Producer	Development Well	9-Nov-1983	17-Nov-1983	NWT Mainland	65° 16' 24.2"	126° 53' 50.5"	303D476520126450	
1341	NORMAN WELLS K-26X	Imperial Oil Limited	Producer	Development Well	17-Nov-1983	23-Nov-1983	NWT Mainland	65° 16' 24.2"	126° 53' 50.9"	300E476520126450	
1343	NORMAN WELLS M-26X	Imperial Oil Limited	Producer	Development Well	24-Nov-1983	1-Dec-1983	NWT Mainland	65° 16' 24.3"	126° 53' 51.1"	303A576520126450	
1345	NORMAN WELLS L-25X	Imperial Oil Limited	Injector	Development Well	2-Dec-1983	15-Dec-1983	NWT Mainland	65° 16' 24.3"	126° 53' 51.2"	302H576520126450	
1347	NORMAN WELLS M-24X	Imperial Oil Limited	Producer	Development Well	5-Dec-1983	18-Dec-1983	NWT Mainland	65° 16' 36.2"	126° 54' 41.1"	303H576520126450	
1348	NORMAN WELLS L-27X	Imperial Oil Limited	Injector	Development Well	17-Dec-1983	23-Dec-1983	NWT Mainland	65° 16' 24.2"	126° 53' 50.8"	302E476520126450	
1349	NORMAN WELLS I-22X	Imperial Oil Limited	Producer	Development Well	19-Dec-1983	1-Jan-1984	NWT Mainland	65° 16' 36.2"	126° 54' 41.0"	300M476520126450	
1351	NORMAN WELLS J-25X	Imperial Oil Limited	Injector	Development Well	23-Dec-1983	31-Dec-1983	NWT Mainland	65° 16' 24.2"	126° 53' 50.7"	300L476520126450	
1353	NORMAN WELLS J-27X	Imperial Oil Limited	Injector	Development Well	31-Dec-1983	13-Jan-1984	NWT Mainland	65° 16' 24.1"	126° 53' 49.9"	303K476520126450	
1354	NORMAN WELLS I-24X	Imperial Oil Limited	Producer	Development Well	2-Jan-1984	13-Jan-1984	NWT Mainland	65° 16' 36.2"	126° 54' 40.7"	302M476520126450	
1358	NORMAN WELLS K-22X	Imperial Oil Limited	Producer	Development Well	14-Jan-1984	19-Jan-1984	NWT Mainland	65° 16' 36.2"	126° 54' 40.5"	300I576520126450	
1359	NORMAN WELLS L-29X	Imperial Oil Limited	Injector	Development Well	14-Jan-1984	21-Jan-1984	NWT Mainland	65° 16' 24.1"	126° 53' 49.8"	302C476520126450	
1362	NORMAN WELLS K-24X	Imperial Oil Limited	Producer	Development Well	19-Jan-1984	28-Jan-1984	NWT Mainland	65° 16' 36.1"	126° 54' 40.4"	302L476520126450	
1364	NORMAN WELLS J-29-1X	Imperial Oil Limited	Injector	Development Well	22-Jan-1984	29-Jan-1984	NWT Mainland	65° 16' 24.0"	126° 52' 49.5"	303F476520126450	
1366	NORMAN WELLS H-29-1X	Imperial Oil Limited	Injector	Development Well	29-Jan-1984	15-Feb-1984	NWT Mainland	65° 16' 24.0"	126° 53' 49.4"	302J476520126450	
1367	NORMAN WELLS J-21X	Imperial Oil Limited	Injector	Development Well	30-Jan-1984	14-Feb-1984	NWT Mainland	65° 16' 36.3"	126° 54' 41.3"	302P576520126450	
1375	NORMAN WELLS J-19X	Imperial Oil Limited	Injector	Development Well	15-Feb-1984	22-Feb-1984	NWT Mainland	65° 16' 36.3"	126° 54' 41.6"	303O576520126450	
1377	NORMAN WELLS L-31X	Imperial Oil Limited	Injector	Development Well	16-Feb-1984	28-Feb-1984	NWT Mainland	65° 16' 24.0"	126° 53' 49.5"	303C476520126450	
1379	NORMAN WELLS L-21X	Imperial Oil Limited	Injector	Development Well	22-Feb-1984	1-Mar-1984	NWT Mainland	65° 16' 36.3"	126° 54' 41.7"	303J576520126450	
1382	NORMAN WELLS J-23X	Imperial Oil Limited	Injector	Development Well	2-Mar-1984	8-Mar-1984	NWT Mainland	65° 16' 36.3"	126° 54' 41.3"	303L476520126450	
1383	NORMAN WELLS S-12X	Imperial Oil Limited	Producer	Development Well	2-Mar-1984	14-Mar-1984	NWT Mainland	65° 16' 6.0"	126° 57' 19.0"	302C676520126450	
1385	NORMAN WELLS L-23X	Imperial Oil Limited	Injector	Development Well	9-Mar-1984	18-Mar-1984	NWT Mainland	65° 16' 36.2"	126° 54' 40.8"	304H576520126450	
1388	NORMAN WELLS G-48X	Imperial Oil Limited	Producer	Development Well	19-Mar-1984	27-Mar-1984	NWT Mainland	65° 16' 19.4"	126° 50' 49.4"	300D276520126450	
1390	NORMAN WELLS G-40X	Imperial Oil Limited	Producer	Development Well	24-Mar-1984	1-Apr-1984	NWT Mainland	65° 16' 33.7"	126° 52' 3.6"	300G376520126450	
1393	NORMAN WELLS E-46X	Imperial Oil Limited	Producer	Development Well	28-Mar-1984	3-Apr-1984	NWT Mainland	65° 16' 19.4"	126° 50' 49.6"	302E276520126450	
1394	NORMAN WELLS G-38X	Imperial Oil Limited	Producer	Development Well	2-Apr-1984	7-Apr-1984	NWT Mainland	65° 16' 33.7"	126° 52' 3.9"	300F376520126450	
1395	NORMAN WELLS E-44X	Imperial Oil Limited	Producer	Development Well	4-Apr-1984	10-Apr-1984	NWT Mainland	65° 16' 19.5"	126° 50' 49.9"	300L276520126450	
1396	NORMAN WELLS I-38X	Imperial Oil Limited	Producer	Development Well	7-Apr-1984	16-Apr-1984	NWT Mainland	65° 16' 33.8"	126° 52' 4.2"	300E376520126450	
1397	NORMAN WELLS G-48X	Imperial Oil Limited	Producer	Development Well	10-Apr-1984	14-Apr-1984	NWT Mainland	65° 16' 19.5"	126° 50' 50.0"	300A376520126450	
1398	NORMAN WELLS E-42X	Imperial Oil Limited	Producer	Development Well	15-Apr-1984	21-Apr-1984	NWT Mainland	65° 16' 19.5"	126° 50' 50.2"	302I376520126450	

Well ID	Well Name	Well Operator	Well Status	Classification	SPUD Date	Rig Release Date	Region	NAD 27 Lat	NAD 27 Long	UWI	Comment
1399	NORMAN WELLS G-36X	Imperial Oil Limited	Producer	Development Well	16-Apr-1984	23-Apr-1984	NWT Mainland	65° 16' 33.6"	126° 52' 4.5"	300L376520126450	
1403	NORMAN WELLS H-45X	Imperial Oil Limited	Injector	Development Well	21-Apr-1984	27-Apr-1984	NWT Mainland	65° 16' 19.5"	126° 50' 50.5"	302A376520126450	
1404	NORMAN WELLS I-36X	Imperial Oil Limited	Producer	Development Well	24-Apr-1984	1-May-1984	NWT Mainland	65° 16' 33.6"	126° 52' 4.6"	302E376520126450	
1405	NORMAN WELLS F-43X	Imperial Oil Limited	Injector	Development Well	28-Apr-1984	3-May-1984	NWT Mainland	65° 16' 19.6"	126° 50' 50.8"	300H376520126450	
1406	NORMAN WELLS G-34X	Imperial Oil Limited	Producer	Development Well	2-May-1984	7-May-1984	NWT Mainland	65° 16' 33.9"	126° 52' 5.0"	302L376520126450	
1407	NORMAN WELLS G-42X	Imperial Oil Limited	Producer	Development Well	3-May-1984	10-May-1984	NWT Mainland	65° 16' 19.7"	126° 50' 51.5"	302G376520126450	
1408	NORMAN WELLS H-33X	Imperial Oil Limited	Injector	Development Well	5-May-1984	2-Jun-1984	NWT Mainland	65° 16' 33.9"	126° 52' 5.3"	302I476520126450	
1409	NORMAN WELLS H-35X	Imperial Oil Limited	Injector	Development Well	10-May-1984	28-May-1984	NWT Mainland	65° 16' 33.9"	126° 52' 5.1"	303E376520126450	
1410	NORMAN WELLS I-46X	Imperial Oil Limited	Producer	Development Well	10-May-1984	6-Jun-1984	NWT Mainland	65° 16' 19.5"	126° 50' 50.3"	300P366520126450	
1411	NORMAN WELLS I-48X	Imperial Oil Limited	Producer	Development Well	12-May-1984	31-May-1984	NWT Mainland	65° 16' 19.5"	126° 50' 50.2"	302P366520126450	
1413	NORMAN WELLS H-37X	Imperial Oil Limited	Injector	Development Well	2-Jun-1984	7-Jun-1984	NWT Mainland	65° 16' 33.8"	126° 52' 4.7"	304E376520126450	
1414	NORMAN WELLS I-44X	Imperial Oil Limited	Producer	Development Well	7-Jun-1984	14-Jun-1984	NWT Mainland	65° 16' 19.6"	126° 50' 50.6"	300B376520126450	
1415	NORMAN WELLS H-39X	Imperial Oil Limited	Injector	Development Well	8-Jun-1984	12-Jun-1984	NWT Mainland	65° 16' 33.8"	126° 52' 4.1"	302F376520126450	
1417	NORMAN WELLS F-39X	Imperial Oil Limited	Injector	Development Well	13-Jun-1984	17-Jun-1984	NWT Mainland	65° 16' 33.7"	126° 52' 3.5"	300J376520126450	
1418	NORMAN WELLS G-44X	Imperial Oil Limited	Producer	Development Well	14-Jun-1984	21-Jun-1984	NWT Mainland	65° 16' 19.6"	126° 50' 50.9"	302H376520126450	
1419	NORMAN WELLS F-37X	Imperial Oil Limited	Injector	Development Well	17-Jun-1984	22-Jun-1984	NWT Mainland	65° 16' 33.7"	126° 52' 3.8"	300K376520126450	
1420	NORMAN WELLS H-41X	Imperial Oil Limited	Injector	Development Well	21-Jun-1984	26-Jun-1984	NWT Mainland	65° 16' 19.5"	126° 50' 51.3"	303F376520126450	
1421	NORMAN WELLS H-43X	Imperial Oil Limited	Injector	Development Well	26-Jun-1984	1-Jul-1984	NWT Mainland	65° 16' 19.6"	126° 50' 51.2"	302B376520126450	
1424	NORMAN WELLS M-15-1X	Imperial Oil Limited	Producer	Development Well	30-Jun-1984	6-Jul-1984	NWT Mainland	65° 16' 39.7"	126° 56' 26.1"	305L576520126450	
1425	NORMAN WELLS F-41X	Imperial Oil Limited	Injector	Development Well	2-Jul-1984	6-Jul-1984	NWT Mainland	65° 16' 19.6"	126° 50' 51.1"	303G376520126450	
1426	NORMAN WELLS H-47X	Imperial Oil Limited	Injector	Development Well	6-Jul-1984	11-Jul-1984	NWT Mainland	65° 16' 19.5"	126° 50' 50.3"	303A376520126450	
1427	NORMAN WELLS K-14X	Imperial Oil Limited	Producer	Development Well	6-Jul-1984	18-Jul-1984	NWT Mainland	65° 16' 39.8"	126° 56' 26.5"	302N576520126450	
1429	NORMAN WELLS H-49X	Imperial Oil Limited	Injector	Development Well	11-Jul-1984	17-Jul-1984	NWT Mainland	65° 16' 19.4"	126° 50' 49.7"	300M266520126450	
1430	NORMAN WELLS F-45X	Imperial Oil Limited	Injector	Development Well	16-Jul-1984	22-Jul-1984	NWT Mainland	65° 16' 19.4"	126° 50' 49.3"	303H376520126450	
1431	NORMAN WELLS L-13X	Imperial Oil Limited	Injector	Development Well	18-Jul-1984	24-Jul-1984	NWT Mainland	65° 16' 39.8"	126° 56' 26.8"	300M576520126450	
1433	NORMAN WELLS F-47X	Imperial Oil Limited	Injector	Development Well	22-Jul-1984	26-Jul-1984	NWT Mainland	65° 16' 19.4"	126° 50' 49.1"	303E276520126450	
1434	NORMAN WELLS M-12X	Imperial Oil Limited	Producer	Development Well	24-Jul-1984	29-Jul-1984	NWT Mainland	65° 16' 39.9"	126° 56' 27.2"	303I676520126450	
1435	NORMAN WELLS M-10X	Imperial Oil Limited	Producer	Development Well	29-Jul-1984	3-Aug-1984	NWT Mainland	65° 16' 40.0"	126° 56' 27.5"	300P676520126450	
1436	NORMAN WELLS N-09X	Imperial Oil Limited	Injector	Development Well	4-Aug-1984	9-Aug-1984	NWT Mainland	65° 16' 40.1"	126° 56' 27.9"	303J676520126450	
1437	NORMAN WELLS Q-08X	Imperial Oil Limited	Producer	Development Well	16-Aug-1984	22-Aug-1984	NWT Mainland	65° 16' 26.7"	126° 57' 36.7"	303F676520126450	
1440	NORMAN WELLS S-10X	Imperial Oil Limited	Producer	Development Well	25-Aug-1984	1-Sep-1984	NWT Mainland	65° 16' 6.5"	126° 57' 18.7"	303C676520126450	
1441	NORMAN WELLS S-14X	Imperial Oil Limited	Producer	Development Well	1-Sep-1984	6-Sep-1984	NWT Mainland	65° 16' 6.4"	126° 57' 18.4"	300O666520126450	
1442	NORMAN WELLS Q-04X	Imperial Oil Limited	Abandoned	Development Well	10-Sep-1984	19-Sep-1984	NWT Mainland	65° 16' 29.7"	126° 58' 1.5"	300I776520126450	
1446	NORMAN WELLS J-35X	Imperial Oil Limited	Injector	Development Well	28-Sep-1984	5-Oct-1984	NWT Mainland	65° 16' 11.4"	126° 53' 1.4"	300H476520126450	
1448	NORMAN WELLS K-36X	Imperial Oil Limited	Producer	Development Well	6-Oct-1984	11-Oct-1984	NWT Mainland	65° 16' 11.4"	126° 58' 1.5"	302A476520126450	
1449	NORMAN WELLS I-34X	Imperial Oil Limited	Producer	Development Well	12-Oct-1984	19-Oct-1984	NWT Mainland	65° 16' 11.4"	126° 53' 1.6"	302H476520126450	
1451	NORMAN WELLS L-37X	Imperial Oil Limited	Injector	Development Well	20-Oct-1984	26-Oct-1984	NWT Mainland	65° 16' 11.4"	126° 53' 1.8"	302P486520126450	
1453	NORMAN WELLS J-33X	Imperial Oil Limited	Injector	Development Well	26-Oct-1984	1-Nov-1984	NWT Mainland	65° 16' 11.5"	126° 53' 1.9"	300G476520126450	
1456	NORMAN WELLS K-34X	Imperial Oil Limited	Producer	Development Well	2-Nov-1984	5-Nov-1984	NWT Mainland	65° 16' 11.5"	126° 53' 2.1"	300B476520126450	
1457	NORMAN WELLS L-35X	Imperial Oil Limited	Injector	Development Well	6-Nov-1984	12-Nov-1984	NWT Mainland	65° 16' 11.5"	126° 53' 2.2"	302B476520126450	
1459	NORMAN WELLS I-32X	Imperial Oil Limited	Producer	Development Well	13-Nov-1984	22-Nov-1984	NWT Mainland	65° 16' 11.5"	126° 53' 2.4"	303H476520126450	
1461	NORMAN WELLS M-34X	Imperial Oil Limited	Producer	Development Well	22-Nov-1984	28-Nov-1984	NWT Mainland	65° 16' 11.5"	126° 53' 2.5"	304O486520126450	
1462	NORMAN WELLS J-31X	Imperial Oil Limited	Injector	Development Well	30-Nov-1984	5-Dec-1984	NWT Mainland	65° 16' 11.6"	126° 53' 2.7"	302G476520126450	
1464	NORMAN WELLS L-33X	Imperial Oil Limited	Injector	Development Well	6-Dec-1984	12-Dec-1984	NWT Mainland	65° 16' 11.6"	126° 53' 2.8"	303B476520126450	
1465	NORMAN WELLS K-32X	Imperial Oil Limited	Producer	Development Well	13-Dec-1984	19-Dec-1984	NWT Mainland	65° 16' 11.6"	126° 53' 2.9"	304B476520126450	
1469	NORMAN WELLS M-32X	Imperial Oil Limited	Producer	Development Well	19-Dec-1984	28-Dec-1984	NWT Mainland	65° 16' 11.6"	126° 53' 3.1"	304C476520126450	
1475	NORMAN WELLS O-18X	Imperial Oil Limited	Producer	Development Well	11-Jan-1985	16-Jan-1985	NWT Mainland	65° 16' 17.0"	126° 56' 0.0"	304E576520126450	
1481	NORMAN WELLS O-14X	Imperial Oil Limited	Injector	Development Well	21-Jan-1985	25-Jan-1985	NWT Mainland	65° 16' 27.8"	126° 56' 20.6"	304H676520126450	
1488	NORMAN WELLS I-50X	Imperial Oil Limited	Injector	Development Well	2-Feb-1985	26-Feb-1985	NWT Mainland	65° 15' 37.0"	126° 51' 10.3"	302M286520126450	
1496	NORMAN WELLS Q-14X	Imperial Oil Limited	Producer	Development Well	3-Mar-1985	9-Mar-1985	NWT Mainland	65° 16' 14.0"	126° 56' 33.1"	303B676520126450	
1498	NORMAN WELLS Q-41X	Imperial Oil Limited	Producer	Development Well	13-Mar-1985	25-Mar-1985	NWT Mainland	65° 15' 14.5"	126° 52' 48.9"	300B486520126450	
1504	NORMAN WELLS J-43X	Imperial Oil Limited	Injector	Development Well	31-Mar-1985	14-Apr-1985	NWT Mainland	65° 15' 58.5"	126° 52' 12.3"	302N366520126450	
1506	NORMAN WELLS K-42X	Imperial Oil Limited	Producer	Development Well	15-Apr-1985	21-Apr-1985	NWT Mainland	65° 15' 58.5"	126° 52' 12.5"	303N366520126450	
1507	NORMAN WELLS J-41X	Imperial Oil Limited	Injector	Development Well	21-Apr-1985	27-Apr-1985	NWT Mainland	65° 15' 58.5"	126° 52' 12.6"	300C376520126450	
1511	NORMAN WELLS L-41X	Imperial Oil Limited	Injector	Development Well	28-Apr-1985	4-May-1985	NWT Mainland	65° 15' 50.5"	126° 52' 12.8"	300M366520126450	
1512	NORMAN WELLS I-42X	Imperial Oil Limited	Producer	Development Well	4-May-1985	10-May-1985	NWT Mainland	65° 15' 58.5"	126° 52' 12.9"	302C376520126450	
1513	NORMAN WELLS I-40X	Imperial Oil Limited	Producer	Development Well	11-May-1985	3-Jun-1985	NWT Mainland	65° 15' 58.5"	126° 52' 13.2"	303C376520126450	
1514	NORMAN WELLS K-40X	Imperial Oil Limited	Producer	Development Well	13-May-1985	29-May-1985	NWT Mainland	65° 15' 58.5"	126° 52' 13.0"	302M366520126450	
1517	NORMAN WELLS M-40X	Imperial Oil Limited	Producer	Development Well	4-Jun-1985	10-Jun-1985	NWT Mainland	65° 15' 58.6"	126° 52' 13.4"	304I466520126450	
1518	NORMAN WELLS J-39X	Imperial Oil Limited	Injector	Development Well	10-Jun-1985	18-Jun-1985	NWT Mainland	65° 15' 58.6"	126° 52' 13.5"	300D376520126450	
1521	NORMAN WELLS J-37X	Imperial Oil Limited	Injector	Development Well	18-Jun-1985	24-Jun-1985	NWT Mainland	65° 15' 58.6"	126° 52' 13.7"	302D376520126450	
1523	NORMAN WELLS L-39X	Imperial Oil Limited	Injector	Development Well	24-Jun-1985	29-Jun-1985	NWT Mainland	65° 15' 58.6"	126° 52' 13.8"	303F466520126450	
1524	NORMAN WELLS K-38X	Imperial Oil Limited	Producer	Development Well	29-Jun-1985	3-Jul-1985	NWT Mainland	65° 15' 58.6"	126° 52' 14.0"	303D376520126450	
1526	NORMAN WELLS P-45X	Imperial Oil Limited	Injector	Development Well	9-Jul-1985	15-Jul-1985	NWT Mainland	65° 15' 15.3"	126° 52' 30.7"	300D366520126450	
1528	NORMAN WELLS M-46X	Imperial Oil Limited	Producer	Development Well	18-Jul-1985	24-Jul-1985	NWT Mainland	65° 15' 29.1"	126° 51' 41.2"	300G366520126450	
1529	NORMAN WELLS Q-43X	Imperial Oil Limited	Producer	Development Well	27-Jul-1985	2-Aug-1985	NWT Mainland	65° 15' 14.3"	126° 52' 49.3"	300A466520126450	
1532	NORMAN WELLS R-09X	Imperial Oil Limited	Injector	Development Well	6-Aug-1985	13-Aug-1985	NWT Mainland	65° 16' 18.8"	126° 57' 51.2"	304F676520126450	
1535	NORMAN WELLS S-08X	Imperial Oil Limited	Producer	Development Well	15-Aug-1985	21-Aug-1985	NWT Mainland	65° 16' 19.5"	126° 57' 53.2"	300D876520126450	

Well ID	Well Name	Well Operator	Well Status	Classification	SPUD Date	Rig Release Date	Region	NAD 27 Lat	NAD 27 Long	UWI	Comment
1536	NORMAN WELLS Q-06X	Imperial Oil Limited	Producer	Development Well	23-Aug-1985	31-Aug-1985	NWT Mainland	65° 16' 29.6"	126° 58' 1.1"	302L676520126450	
1538	NORMAN WELLS S-17X	Imperial Oil Limited	Producer	Development Well	6-Sep-1985	14-Sep-1985	NWT Mainland	65° 15' 53.5"	126° 56' 2.7"	300P666520126450	
1539	NORMAN WELLS R-19X	Imperial Oil Limited	Injector	Development Well	15-Sep-1985	20-Sep-1985	NWT Mainland	65° 15' 53.5"	126° 56' 2.4"	302P666520126450	
1541	NORMAN WELLS S-20X	Imperial Oil Limited	Producer	Development Well	20-Sep-1985	26-Sep-1985	NWT Mainland	65° 15' 53.5"	126° 56' 2.0"	303P666520126450	
1544	NORMAN WELLS Q-20X	Imperial Oil Limited	Producer	Development Well	26-Sep-1985	1-Oct-1985	NWT Mainland	65° 15' 53.5"	126° 56' 1.8"	303D576520126450	
1546	NORMAN WELLS S-22X	Imperial Oil Limited	Producer	Development Well	2-Oct-1985	8-Oct-1985	NWT Mainland	65° 15' 53.6"	126° 56' 1.5"	300L566520126450	
1548	NORMAN WELLS R-21X	Imperial Oil Limited	Injector	Development Well	8-Oct-1985	12-Oct-1985	NWT Mainland	65° 15' 53.6"	126° 56' 1.2"	300M566520126450	
1549	NORMAN WELLS S-24X	Imperial Oil Limited	Producer	Development Well	13-Oct-1985	19-Oct-1985	NWT Mainland	65° 15' 53.6"	126° 56' 0.9"	300K566520126450	
1551	NORMAN WELLS Q-22X	Imperial Oil Limited	Producer	Development Well	20-Oct-1985	27-Oct-1985	NWT Mainland	65° 15' 53.6"	126° 56' 0.6"	300N566520126450	
1552	NORMAN WELLS R-23X	Imperial Oil Limited	Injector	Development Well	27-Oct-1985	2-Nov-1985	NWT Mainland	65° 15' 53.6"	126° 56' 0.3"	302N566520126450	
1554	NORMAN WELLS Q-24X	Imperial Oil Limited	Producer	Development Well	3-Nov-1985	11-Nov-1985	NWT Mainland	65° 15' 53.7"	126° 55' 59.9"	303N566520126450	
1557	NORMAN WELLS R-25X	Imperial Oil Limited	Injector	Development Well	18-Nov-1985	25-Nov-1985	NWT Mainland	65° 15' 50.7"	126° 54' 53.0"	302K566520126450	
1559	NORMAN WELLS Q-26X	Imperial Oil Limited	Producer	Development Well	27-Nov-1985	8-Dec-1985	NWT Mainland	65° 15' 50.7"	126° 54' 52.7"	300O566520126450	
1564	NORMAN WELLS P-25X	Imperial Oil Limited	Injector	Development Well	9-Dec-1985	13-Dec-1985	NWT Mainland	65° 15' 50.8"	126° 54' 52.4"	302O566520126450	
1565	NORMAN WELLS Q-28X	Imperial Oil Limited	Producer	Development Well	14-Dec-1985	19-Dec-1985	NWT Mainland	65° 15' 50.8"	126° 54' 52.1"	300J566520126450	
1568	NORMAN WELLS O-24X	Imperial Oil Limited	Producer	Development Well	20-Dec-1985	26-Dec-1985	NWT Mainland	65° 15' 50.9"	126° 54' 51.8"	305B576520126450	
1572	NORMAN WELLS O-26X	Imperial Oil Limited	Producer	Development Well	27-Dec-1985	1-Jan-1986	NWT Mainland	65° 15' 50.9"	126° 54' 51.5"	304A576520126450	
1573	NORMAN WELLS P-27X	Imperial Oil Limited	Injector	Development Well	2-Jan-1986	6-Jan-1986	NWT Mainland	65° 15' 51.0"	126° 54' 51.3"	300P566520126450	
1574	NORMAN WELLS Q-30X	Imperial Oil Limited	Producer	Development Well	7-Jan-1986	14-Jan-1986	NWT Mainland	65° 15' 51.0"	126° 54' 50.7"	300I566520126450	
1582	NORMAN WELLS P-29X	Imperial Oil Limited	Injector	Development Well	16-Jan-1986	24-Jan-1986	NWT Mainland	65° 15' 51.1"	126° 54' 50.7"	302P566520126450	
1585	NORMAN WELLS O-28X	Imperial Oil Limited	Producer	Development Well	25-Jan-1986	1-Feb-1986	NWT Mainland	65° 15' 51.2"	126° 54' 52.4"	303P566520126450	
1591	NORMAN WELLS P-31X	Imperial Oil Limited	Injector	Development Well	2-Feb-1986	20-Mar-1986	NWT Mainland	65° 15' 51.2"	126° 54' 50.1"	300L466520126450	
1602	NORMAN WELLS O-32X	Imperial Oil Limited	Producer	Development Well	17-Feb-1986	4-Mar-1986	NWT Mainland	65° 15' 51.3"	126° 54' 49.8"	302M466520126450	
1607	NORMAN WELLS O-30X	Imperial Oil Limited	Producer	Development Well	5-Mar-1986	13-Mar-1986	NWT Mainland	65° 15' 51.3"	126° 54' 49.6"	303M466520126450	
1624	NORMAN WELLS Q-38X	Imperial Oil Limited	Producer	Development Well	25-Sep-1986	3-Oct-1986	NWT Mainland	65° 15' 25.6"	126° 53' 21.2"	302F486520126450	
1626	NORMAN WELLS Q-43-1X	Imperial Oil Limited	Producer	Development Well	7-Oct-1986	15-Oct-1986	NWT Mainland	65° 15' 12.6"	126° 52' 52.2"	302A486520126450	
1627	NORMAN WELLS P-33X	Imperial Oil Limited	Injector	Development Well	19-Oct-1986	27-Oct-1986	NWT Mainland	65° 15' 26.5"	126° 53' 31.1"	302L486520126450	
1629	NORMAN WELLS O-34X	Imperial Oil Limited	Producer	Development Well	27-Oct-1986	3-Nov-1986	NWT Mainland	65° 15' 36.6"	126° 53' 30.8"	303K486520126450	
1630	NORMAN WELLS N-33X	Imperial Oil Limited	Injector	Development Well	4-Nov-1986	12-Nov-1986	NWT Mainland	65° 15' 36.6"	126° 53' 30.4"	303N466520126450	
1631	NORMAN WELLS K-50X	Imperial Oil Limited	Producer	Development Well	16-Nov-1986	24-Dec-1986	NWT Mainland	65° 15' 23.4"	126° 51' 54.9"	300L266520126450	
1632	NORMAN WELLS L-47X	Imperial Oil Limited	Injector	Development Well	29-Dec-1986	5-Jan-1987	NWT Mainland	65° 15' 36.1"	126° 51' 11.0"	302J366520126450	
1633	NORMAN WELLS J-45X	Imperial Oil Limited	Injector	Development Well	7-Jan-1987	15-Jan-1987	NWT Mainland	65° 15' 36.4"	126° 51' 10.0"	302O366520126450	
1634	NORMAN WELLS J-47X	Imperial Oil Limited	Injector	Development Well	15-Jan-1987	21-Jan-1987	NWT Mainland	65° 15' 36.5"	126° 51' 9.7"	303O366520126450	
1635	NORMAN WELLS R-07X	Imperial Oil Limited	Injector	Development Well	25-Jan-1987	31-Jan-1987	NWT Mainland	65° 16' 17.5"	126° 57' 38.1"	302E676520126450	
1636	NORMAN WELLS T-13X	Imperial Oil Limited	Injector	Development Well	4-Feb-1987	10-Feb-1987	NWT Mainland	65° 16' 8.5"	126° 57' 13.0"	300N666520126450	
1638	NORMAN WELLS T-11X	Imperial Oil Limited	Injector	Development Well	11-Feb-1987	18-Feb-1987	NWT Mainland	65° 16' 8.7"	126° 57' 12.9"	300M666520126450	
1639	NORMAN WELLS T-15X	Imperial Oil Limited	Injector	Development Well	21-Feb-1987	27-Feb-1987	NWT Mainland	65° 15' 59.6"	126° 56' 36.8"	302O666520126450	
1641	NORMAN WELLS T-19X	Imperial Oil Limited	Injector	Development Well	28-Feb-1987	6-Mar-1987	NWT Mainland	65° 15' 59.4"	126° 56' 36.8"	300I666520126450	
1642	NORMAN WELLS Q-36X	Imperial Oil Limited	Producer	Development Well	10-Mar-1987	15-Mar-1987	NWT Mainland	65° 15' 27.8"	126° 56' 53.0"	303F466520126450	
1643	NORMAN WELLS Q-34X	Imperial Oil Limited	Producer	Development Well	15-Mar-1987	20-Mar-1987	NWT Mainland	65° 15' 27.8"	126° 53' 53.1"	303E466520126450	
1644	NORMAN WELLS Q-32X	Imperial Oil Limited	Producer	Development Well	21-Mar-1987	25-Mar-1987	NWT Mainland	65° 15' 27.9"	126° 53' 53.3"	303L466520126450	
1645	NORMAN WELLS E-32-1X	Imperial Oil Limited	Producer	Development Well	29-Mar-1987	5-Apr-1987	NWT Mainland	65° 15' 59.9"	126° 52' 13.4"	307M376520126450	To be suspended in 2013
1646	NORMAN WELLS H-21X	Imperial Oil Limited	Injector	Development Well	8-Apr-1987	13-Apr-1987	NWT Mainland	65° 17' 9.8"	126° 53' 53.5"	303M476520126450	
1647	NORMAN WELLS G-22X	Imperial Oil Limited	Producer	Development Well	14-Apr-1987	19-Apr-1987	NWT Mainland	65° 17' 7.7"	126° 53' 53.2"	302D486520126450	
1649	NORMAN WELLS C-34-1X	Imperial Oil Limited	Producer	Development Well	22-Apr-1987	25-Apr-1987	NWT Mainland	65° 17' 4.4"	126° 51' 32.4"	305C386520126450	
1650	NORMAN WELLS F-50X	Imperial Oil Limited	Producer	Development Well	26-Apr-1987	4-Jun-1987	NWT Mainland	65° 16' 51.5"	126° 50' 14.6"	302D276520126450	
1652	NORMAN WELLS C-31X	Imperial Oil Limited	Producer	Development Well	5-Jun-1987	12-Jun-1987	NWT Mainland	65° 17' 3.8"	126° 52' 13.0"	304D386520126450	
1655	NORMAN WELLS R-39X	Imperial Oil Limited	Injector	Development Well	5-Jul-1987	11-Jul-1987	NWT Mainland	65° 15' 20.0"	126° 53' 21.3"	300C466520126450	
1656	NORMAN WELLS R-42X	Imperial Oil Limited	Injector	Development Well	11-Jul-1987	23-Jul-1987	NWT Mainland	65° 15' 20.1"	126° 53' 21.0"	302B466520126450	
1658	NORMAN WELLS P-46X	Imperial Oil Limited	Injector	Development Well	25-Jul-1987	4-Aug-1987	NWT Mainland	65° 15' 12.1"	126° 53' 12.4"	302D366520126450	
1660	NORMAN WELLS T-23X	Imperial Oil Limited	Injector	Development Well	28-Sep-1987	4-Oct-1987	NWT Mainland	65° 15' 45.4"	126° 55' 41.0"	302L566520126450	To be suspended in 2013
1662	NORMAN WELLS T-25X	Imperial Oil Limited	Injector	Development Well	5-Oct-1987	11-Oct-1987	NWT Mainland	65° 15' 45.4"	126° 55' 39.9"	302F566520126450	To be suspended in 2013
1663	NORMAN WELLS L-11X	Imperial Oil Limited	Injector	Development Well	15-Oct-1987	20-Oct-1987	NWT Mainland	65° 16' 38.9"	126° 56' 24.7"	302P676520126450	
1665	NORMAN WELLS K-12X	Imperial Oil Limited	Injector	Development Well	21-Oct-1987	30-Oct-1987	NWT Mainland	65° 16' 38.7"	126° 56' 25.1"	302M576520126450	Converted to injector in 1998
1666	NORMAN WELLS M-08X	Imperial Oil Limited	Producer	Development Well	31-Oct-1987	6-Nov-1987	NWT Mainland	65° 16' 39.0"	126° 56' 24.3"	300O676520126450	
1667	NORMAN WELLS T-07X	Imperial Oil Limited	Injector	Development Well	9-Nov-1987	17-Nov-1987	NWT Mainland	65° 16' 20.3"	126° 57' 56.1"	302A776520126450	
1669	NORMAN WELLS S-05X	Imperial Oil Limited	Injector	Development Well	19-Nov-1987	28-Nov-1987	NWT Mainland	65° 16' 20.5"	126° 57' 57.6"	303A776520126450	Converted to injector in 1991
1671	NORMAN WELLS T-08X	Imperial Oil Limited	Suspended	Development Well	1-Dec-1987	8-Dec-1987	NWT Mainland	65° 16' 16.1"	126° 57' 46.8"	304A776520126450	
1673	NORMAN WELLS T-16X	Imperial Oil Limited	Producer	Development Well	11-Dec-1987	18-Dec-1987	NWT Mainland	65° 15' 59.2"	126° 56' 31.8"	300J666520126450	
1677	NORMAN WELLS T-14X	Imperial Oil Limited	Producer	Development Well	17-Jan-1988	24-Jan-1988	NWT Mainland	65° 16' 45.5"	126° 56' 56.3"	303N666520126450	
1679	NORMAN WELLS O-08X	Imperial Oil Limited	Producer	Development Well	27-Jan-1988	3-Feb-1988	NWT Mainland	65° 16' 35.4"	126° 57' 17.3"	303K676520126450	
1682	NORMAN WELLS R-31X	Imperial Oil Limited	Injector	Development Well	13-Feb-1988	19-Feb-1988	NWT Mainland	65° 15' 20.4"	126° 54' 41.8"	300H566520126450	
1683	NORMAN WELLS R-29X	Imperial Oil Limited	Injector	Development Well	19-Feb-1988	25-Feb-1988	NWT Mainland	65° 15' 20.4"	126° 54' 42.5"	303J566520126450	
1684	NORMAN WELLS S-30X	Imperial Oil Limited	Producer	Development Well	1-Mar-1988	6-Mar-1988	NWT Mainland	65° 15' 20.3"	126° 54' 42.9"	300G566520126450	
1688	NORMAN WELLS S-28X	Imperial Oil Limited	Producer	Development Well	1-Mar-1988	6-Mar-1988	NWT Mainland	65° 15' 20.2"	126° 54' 23.2"	302G566520126450	
1691	NORMAN WELLS T-27X	Imperial Oil Limited	Injector	Development Well	7-Mar-1988	13-Mar-1988	NWT Mainland	65° 15' 20.2"	126° 54' 43.5"	303F566520126450	
1692	NORMAN WELLS T-31X	Imperial Oil Limited	Injector	Development Well	13-Mar-1988	18-Mar-1988	NWT Mainland	65° 15' 20.0"	126° 54' 44.2"	303G566520126450	
1693	NORMAN WELLS T-29X	Imperial Oil Limited	Injector	Development Well	18-Mar-1988	25-Mar-1988	NWT Mainland	65° 15' 20.1"	126° 54' 43.9"	304G566520126450	To be suspended in 2013

Well ID	Well Name	Well Operator	Well Status	Classification	SPUD Date	Rig Release Date	Region	NAD 27 Lat	NAD 27 Long	UWI	Comment
1694	NORMAN WELLS S-32X	Imperial Oil Limited	Injector	Development Well	25-Mar-1988	28-Mar-1988	NWT Mainland	65° 15' 20.6"	126° 54' 41.5"	302H566520126450	
1695	NORMAN WELLS S-34X	Imperial Oil Limited	Producer	Development Well	28-Mar-1988	1-Apr-1988	NWT Mainland	65° 15' 20.5"	126° 54' 41.8"	304E466520126450	
1758	NORMAN WELLS T-10X	Imperial Oil Limited	Suspended	Development Well	24-Aug-1987	1-Sep-1987	NWT Mainland	65° 16' 12.7"	126° 57' 26.6"	302M666520126450	
1759	NORMAN WELLS T-12X	Imperial Oil Limited	Suspended	Development Well	16-Aug-1987	22-Aug-1987	NWT Mainland	65° 16' 5.9"	126° 57' 24.0"	302N676520126450	
1760	NORMAN WELLS T-21X	Imperial Oil Limited	Injector	Development Well	7-Aug-1987	14-Aug-1987	NWT Mainland	65° 15' 59.4"	126° 56' 37.1"	302I666520126450	
1795	NORMAN WELLS R-27X	Esso Resources Canada Limited	Injector	Development Well	16-Sep-1987	21-Sep-1987	NWT Mainland	65° 15' 45.4"	126° 55' 40.3"	302J566520126450	To be suspended in 2013
1796	NORMAN WELLS S-26X	Esso Resources Canada Limited	Producer	Development Well	21-Sep-1987	28-Sep-1987	NWT Mainland	65° 15' 45.4"	126° 55' 40.7"	303K566520126450	To be suspended in 2013
1797	NORMAN WELLS S-06X	Esso Resources Canada Limited	Suspended	Development Well	9-Sep-1987	13-Sep-1987	NWT Mainland	65° 16' 17.7"	126° 57' 38.5"	300A776520126450	
1802	NORMAN WELLS C-52X	Imperial Oil Limited	Producer	Development Well	3-Aug-1995	5-Sep-1995	NWT Mainland	65° 16' 51.4"	126° 50' 16.2"	300L176520126450	To be suspended in 2013
1803	NORMAN WELLS D-52X	Imperial Oil Limited	Injector	Development Well	20-Oct-1995	30-Nov-1995	NWT Mainland	65° 16' 48.0"	126° 50' 15.0"	300E176520126450	
1805	NORMAN WELLS A-43X	Imperial Oil Limited	Injector	Development Well	4-Dec-1995	21-Dec-1995	NWT Mainland	65° 16' 48.5"	126° 50' 15.4"	300E286520126450	
1806	NORMAN WELLS F-52X	Imperial Oil Limited	Producer	Development Well	1-Jan-1996	19-Feb-1996	NWT Mainland	65° 16' 19.1"	126° 50' 50.2"	300D176520126450	Completed as producer in 1996
1807	NORMAN WELLS H-52X	Imperial Oil Limited	Injector	Development Well	25-Feb-1996	1-Apr-1996	NWT Mainland	65° 16' 19.3"	126° 50' 48.7"	300P266520126450	
1808	NORMAN WELLS P-46X	Imperial Oil Limited	Injector	Development Well	16-Apr-1996	11-May-1996	NWT Mainland	65° 15' 10.6"	126° 52' 13.4"	300D266520126450	
1809	NORMAN WELLS M-50X	Imperial Oil Limited	Producer	Development Well	14-Jun-1996	9-Jul-1996	NWT Mainland	65° 15' 19.3"	126° 51' 46.7"	300F266520126450	
1810	NORMAN WELLS L-52X	Imperial Oil Limited	Injector	Development Well	9-Jul-1996	15-Aug-1996	NWT Mainland	65° 15' 37.4"	126° 51' 8.2"	300J266520126450	
1811	NORMAN WELLS J-52X	Imperial Oil Limited	Producer	Development Well	17-Aug-1996	13-Sep-1996	NWT Mainland	65° 15' 37.4"	126° 51' 8.7"	302P266520126450	
1821	NORMAN WELLS P-32X	Imperial Oil Limited	Producer	Development Well	16-Jun-1997	7-Jul-1997	NWT Mainland	65° 15' 28.9"	126° 53' 56.4"	304M466520126450	
1822	NORMAN WELLS M-42X	Imperial Oil Limited	Producer	Development Well	13-Jul-1997	16-Aug-1997	NWT Mainland	65° 15' 30.8"	126° 52' 30.9"	303L366520126450	
1824	NORMAN WELLS M-39X	Imperial Oil Limited	Producer	Development Well	17-Aug-1997	29-Aug-1997	NWT Mainland	65° 15' 30.7"	126° 52' 31.0"	304P466520126450	
1825	NORMAN WELLS N-40X	Imperial Oil Limited	Injector	Development Well	30-Aug-1997	5-Sep-1997	NWT Mainland	65° 15' 30.5"	126° 52' 31.2"	305I466520126450	
1826	NORMAN WELLS O-40X	Imperial Oil Limited	Producer	Development Well	7-Sep-1997	13-Sep-1997	NWT Mainland	65° 15' 30.4"	126° 52' 31.3"	302J466520126450	
1828	NORMAN WELLS Q-37X	Imperial Oil Limited	Producer	Development Well	15-Sep-1997	21-Sep-1997	NWT Mainland	65° 15' 28.9"	126° 53' 55.9"	304F466520126450	
1829	NORMAN WELLS O-38X	Imperial Oil Limited	Producer	Development Well	22-Sep-1997	29-Sep-1997	NWT Mainland	65° 15' 28.9"	126° 53' 55.6"	303J466520126450	
1847	NORMAN WELLS P-39X	Imperial Oil Limited	Injector	Development Well	24-Jun-1998	30-Jun-1998	NWT Mainland	65° 15' 21.1"	126° 53' 21.5"	302G466520126450	
1848	NORMAN WELLS O-33X	Imperial Oil Limited	Injector	Development Well	4-Jul-1998	10-Jul-1998	NWT Mainland	65° 15' 37.7"	126° 53' 31.2"	304N466520126450	
1849	NORMAN WELLS N-38X	Imperial Oil Limited	Injector	Development Well	12-Jul-1998	20-Jul-1998	NWT Mainland	65° 15' 37.8"	126° 53' 30.8"	304J466520126450	
1864	NORMAN WELLS E-39X	Imperial Oil Limited	Producer	Development Well	8-Jul-1999	18-Jul-1999	NWT Mainland	65° 16' 56.3"	126° 51' 3.7"	302J376520126450	
1865	NORMAN WELLS G-35X	Imperial Oil Limited	Producer	Development Well	20-Jul-1999	6-Aug-1999	NWT Mainland	65° 16' 59.5"	126° 51' 40.1"	303L376520126450	
1892	NORMAN WELLS J-36X	Imperial Oil Limited	Injector	Development Well	26-Jun-2000	4-Jul-2000	NWT Mainland	65° 16' 11.4"	126° 52' 59.4"	303A476520126450	
1893	NORMAN WELLS K-37X	Imperial Oil Limited	Producer	Development Well	4-Jul-2000	13-Jul-2000	NWT Mainland	65° 16' 11.5"	126° 52' 59.5"	304A476520126450	
1894	NORMAN WELLS L-36X	Imperial Oil Limited	Injector	Development Well	14-Jul-2000	20-Jul-2000	NWT Mainland	65° 16' 11.5"	126° 52' 59.7"	305P466520126450	
1895	NORMAN WELLS I-35X	Imperial Oil Limited	Producer	Development Well	22-Jul-2000	30-Jul-2000	NWT Mainland	65° 16' 11.5"	126° 52' 59.8"	304H476520126450	
1896	NORMAN WELLS M-37X	Imperial Oil Limited	Producer	Development Well	31-Jul-2000	10-Aug-2000	NWT Mainland	65° 16' 11.5"	126° 53' 0.0"	306P466520126450	
1897	NORMAN WELLS L-34X	Imperial Oil Limited	Injector	Development Well	11-Aug-2000	18-Aug-2000	NWT Mainland	65° 16' 11.5"	126° 53' 0.1"	305B476520126450	
1898	NORMAN WELLS K-33X	Imperial Oil Limited	Producer	Development Well	19-Aug-2000	25-Aug-2000	NWT Mainland	65° 16' 11.6"	126° 53' 0.3"	306B476520126450	
1899	NORMAN WELLS M-31X	Imperial Oil Limited	Producer	Development Well	26-Aug-2000	2-Sep-2000	NWT Mainland	65° 16' 11.6"	126° 53' 0.4"	305C476520126450	
1910	NORMAN WELLS O-18X	Imperial Oil Limited	Producer	Development Well	12-Jul-2001	19-Jul-2001	NWT Mainland	65° 16' 24.7"	126° 55' 43.4"	305E576520126450	
1911	NORMAN WELLS O-19X	Imperial Oil Limited	Producer	Development Well	20-Jul-2001	27-Jul-2001	NWT Mainland	65° 16' 24.7"	126° 55' 42.8"	304D576520126450	
1912	NORMAN WELLS M-19X	Imperial Oil Limited	Producer	Development Well	28-Jul-2001	4-Aug-2001	NWT Mainland	65° 16' 24.7"	126° 55' 41.8"	302K576520126450	
1913	NORMAN WELLS N-18X	Imperial Oil Limited	Injector	Development Well	5-Aug-2001	11-Aug-2001	NWT Mainland	65° 16' 24.7"	126° 55' 41.1"	302F576520126450	
2055	NORMAN WELLS M-50-1X	Imperial Oil Resources N.W.T. Limited	Abandoned	Development Well	4-Jul-2008	28-Aug-2008	NWT Mainland	65° 15' 24.1"	126° 51' 56.4"	302F366520126450	Well abandoned in 2008
2056	NORMAN WELLS N-50X	Imperial Oil Resources N.W.T. Limited	Producer	Development Well	15-Sep-2009	21-Sep-2009	NWT Mainland	65° 15' 24.1"	126° 51' 56.4"	303F366520126451	To be activated in NEB Well List
2057	NORMAN WELLS N-13X	Imperial Oil Resources N.W.T. Limited	Producer	Development Well	15-Sep-2008	28-Sep-2008	NWT Mainland	65° 16' 33.4"	126° 56' 26.8"	304I876520126450	
2061	NORMAN WELLS M-50-2X	Imperial Oil Resources N.W.T. Limited	Suspended	Development Well	8-Jul-2009	3-Aug-2009	NWT Mainland	65° 15' 24.1"	126° 51' 56.4"	304F366520126450	
2062	NORMAN WELLS O-42X	Imperial Oil Resources N.W.T. Limited	Producer	Development Well	26-Aug-2009	4-Sep-2009	NWT Mainland	65° 15' 24.4"	126° 51' 57.4"	305F366520126450	To be activated in NEB Well List

Appendix O

Materials Management Workbook

Selected Scenario

This workbook considers 2 land use scenarios and 3 LTMF location options. These scenarios are selected below or from the Scenario Outputs worksheet.

Land Use Option Applied: Industial on Mainland, Parkland on Islands

LTMF Location Applied: Mainland Sumps LTMF

Scenario Name Legend (Selected in Blue)

Scenario		LTMF Siting Option
Mainland East LTMF	Industial on Mainland, Parkland on Islands	**Option 1**
	Parkland on Mainland, Parkland on Islands	**Option 2**
Mainland Central LTMF	Industial on Mainland, Parkland on Islands	**Option 3**
	Parkland on Mainland, Parkland on Islands	**Option 4**
Mainland Sumps LTMF	Industial on Mainland, Parkland on Islands	**Option 5**
	Parkland on Mainland, Parkland on Islands	**Option 6**

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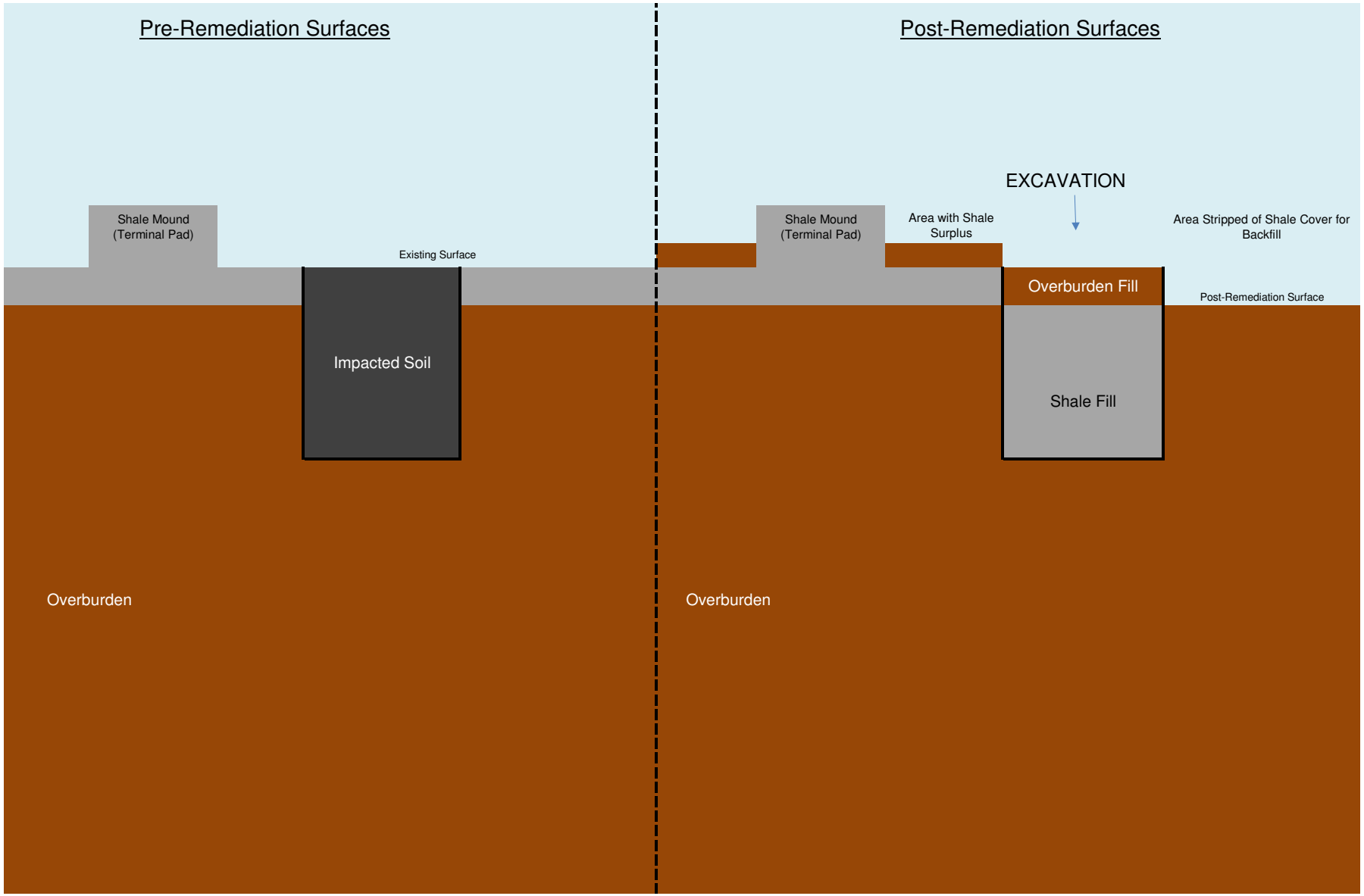
Worksheet Name and Tab Colour

Relocation Scheme	*Material Relocation Scheme*
LTMF Capacity by Option	*LTMF Capacity and Contaminated Soil in the Footprint*
Backfill Management	*Backfill Volumes and Area Transfers*
Material Balances	*Materials Balance Matrix for LTMF Options*
Goose Island Fill	*Goose Island Shale Volume Calculations*
Bear Island Fill	*Bear Island Shale Volume Calculations*
Mainland Fill	*Mainland Shale Volume Calculations*
Natural Island Relocations	*Equipment Requirements for Natural Island Relocations*
Reclamation Requirements	*Summary of Reclamation Areas and Material Requirements*
Goose Island Shale Surfaces	*Goose Island Post-Remediation Shale Surfaces*
Bear Island Shale Surfaces	*Bear Island Post-Remediation Shale Surfaces*
Mainland Shale Surfaces (1)	*Mainland Post-Remediation Shale Surfaces for LTMF Option 1*
Mainland Shale Surfaces (2)	*Mainland Post-Remediation Shale Surfaces for LTMF Option 2*
Mainland Shale Surfaces (3)	*Mainland Post-Remediation Shale Surfaces for LTMF Option 3*
Mainland Shale Surfaces (4)	*Mainland Post-Remediation Shale Surfaces for LTMF Option 4*
Mainland Shale Surfaces (5)	*Mainland Post-Remediation Shale Surfaces for LTMF Option 5*
Mainland Shale Surfaces (6)	*Mainland Post-Remediation Shale Surfaces for LTMF Option 6*

Material Relocation Scheme



Mainland Central LTMF

Option 3: Industrial on Mainland, Parkland on Natural Islands

Major Area	Average Distance to Mainland Central LTMF (km)	Contaminated Soil Quantity (m^3)	Soil Volume Kilometers for Hauling (t .km)	Volume Requiring Backfill (m^3)	Fill Quantity Available in Area (m^3)	Fill Balance (m^3)	Shale Component of Fill Quantity (m^3)
Goose Island	7.6	10,584	144,020	10,584	433,783	423,200	433,783
Bear Island	5.4	37,575	363,200	37,575	400,058	362,483	277,207
Bear Island Sumps	5.4	130,775	1,264,071	130,775	0	-130,775	0
Mainland West	1.1	67,676	133,999	67,676	323,559	255,883	134,752
Mainland Central	0.5	99,827	86,251	86,627	291,584	204,957	158,311
Mainland East	1.8	238,873	769,649	238,873	106,032	-132,841	78,667
Mainland Sumps	1.3	76,525	174,936	76,525	0	-76,525	0
Artificial Islands	3.3	7,583	45,043	0	0	0	0
Totals		**669,418**	**2,981,169**	**648,635**	**1,555,016**	**906,381**	**1,082,720**

Option 4: Parkland on Mainland, Parkland on Natural Islands

Major Area	Average Distance to Mainland Central LTMF (km)	Contaminated Soil Quantity (m^3)	Soil Volume Kilometers for Hauling (t .km)	Volume Requiring Backfill (m^3)	Fill Quantity Available in Area (m^3)	Fill Balance (m^3)	Shale Component of Fill Quantity (m^3)
Goose Island	7.6	10,584	144,020	10,584	433,783	423,200	433,783
Bear Island	5.4	37,575	363,200	37,575	400,058	362,483	277,207
Bear Island Sumps	5.4	130,775	1,264,071	130,775	0	-130,775	0
Mainland West	1.1	77,026	152,512	77,026	323,559	246,533	134,752
Mainland Central	0.5	146,464	126,545	117,810	291,584	173,774	158,311
Mainland East	1.8	456,015	1,469,280	456,015	106,032	-349,983	78,667
Mainland Sumps	1.3	101,250	231,458	101,250	0	-101,250	0
Artificial Islands	3.3	7,583	45,043	0	0	0	0
Totals	**26**	**967,272**	**3,796,129**	**931,035**	**1,555,016**	**623,981**	**1,082,720**

Mainland East LTMF

Option 1: Industrial on Mainland, Parkland on Natural Islands

Major Area	Average Distance to Mainland Central LTMF (km)	Contaminated Soil Quantity (m^3)	Soil Volume Kilometers for Hauling (t .km)	Volume Requiring Backfill (m^3)	Fill Quantity Available in Area (m^3)	Fill Balance (m^3)	Shale Component of Fill Quantity (m^3)
Goose Island	6.8	10,584	128,590	10,584	433,783	423,200	433,783
Bear Island	4.5	37,575	307,063	37,575	400,058	362,483	277,207
Bear Island Sumps	4.5	130,775	1,068,693	130,775	0	-130,775	0
Mainland West	2.2	67,676	269,216	67,676	323,559	255,883	134,752
Mainland Central	1.2	99,827	215,626	99,827	291,584	191,757	158,311
Mainland East	0.1	238,873	21,499	18,065	106,032	87,967	78,667
Mainland Sumps	1.4	76,525	187,333	76,525	0	-76,525	0
Artificial Islands	2.5	7,583	34,260	0	0	0	0
Totals	**23**	**669,418**	**2,232,280**	**441,027**	**1,555,016**	**1,113,989**	**1,082,720**

Option 2: Parkland on Mainland, Parkland on Natural Islands

Major Area	Average Distance to Mainland Central LTMF (km)	Contaminated Soil Quantity (m^3)	Soil Volume Kilometers for Hauling (t .km)	Volume Requiring Backfill (m^3)	Fill Quantity Available in Area (m^3)	Fill Balance (m^3)	Shale Component of Fill Quantity (m^3)
Goose Island	6.8	10,584	128,590	10,584	433,783	423,200	433,783
Bear Island	4.5	37,575	307,063	37,575	400,058	362,483	277,207
Bear Island Sumps	4.5	130,775	1,068,693	130,775	0	-130,775	0
Mainland West	2.2	77,026	306,410	77,026	323,559	246,533	134,752
Mainland Central	1.2	146,464	316,362	146,464	291,584	145,120	158,311
Mainland East	0.1	456,015	41,041	225,303	106,032	-119,271	78,667
Mainland Sumps	1.4	101,250	247,860	101,250	0	-101,250	0
Artificial Islands	2.5	7,583	34,260	0	0	0	0
Totals	**23**	**967,272**	**2,450,280**	**728,977**	**1,555,016**	**826,039**	**1,082,720**

Mainland Sumps LTMF

Option 5: Industrial on Mainland, Parkland on Islands

Major Area	Average Distance to Mainland Central LTMF (km)	Contaminated Soil Quantity (m^3)	Soil Volume Kilometers for Hauling (t .km)	Volume Requiring Backfill (m^3)	Fill Quantity Available in Area (m^3)	Fill Balance (m^3)	Shale Component of Fill Quantity (m^3)
Goose Island	7.3	10,584	139,829	10,584	433,783	423,200	433,783
Bear Island	5.2	37,575	348,997	37,575	400,058	362,483	277,207
Bear Island Sumps	5.2	130,775	1,214,638	130,775	0	-130,775	0
Mainland West	1.9	67,676	236,325	67,676	323,559	255,883	134,752
Mainland Central	1.2	99,827	213,829	99,827	291,584	191,757	158,311
Mainland East	1.5	238,873	649,257	238,873	106,032	-132,841	78,667
Mainland Sumps	0.0	76,525	0	0	0	0	0
Artificial Islands	3.1	7,583	42,313	0	0	0	0
Totals	**25**	**669,418**	**2,845,189**	**585,310**	**1,555,016**	**969,706**	**1,082,720**

Option 6: Parkland on Mainland, Parkland on Islands

Major Area	Average Distance to Mainland Central LTMF (km)	Contaminated Soil Quantity (m^3)	Soil Volume Kilometers for Hauling (t .km)	Volume Requiring Backfill (m^3)	Fill Quantity Available in Area (m^3)	Fill Balance (m^3)	Shale Component of Fill Quantity (m^3)
Goose Island	7.3	10,584	139,829	10,584	433,783	423,200	433,783
Bear Island	5.2	37,575	348,997	37,575	400,058	362,483	277,207
Bear Island Sumps	5.2	130,775	1,214,638	130,775	0	-130,775	0
Mainland West	1.9	77,026	268,976	77,026	323,559	246,533	134,752
Mainland Central	1.2	146,464	313,726	146,464	291,584	145,120	158,311
Mainland East	1.5	456,015	1,239,449	456,015	106,032	-349,983	78,667
Mainland Sumps	0.0	101,250	0	1,250	0	-1,250	0
Artificial Islands	3.1	7,583	42,313	0	0	0	0
Totals	**25**	**967,272**	**3,567,927**	**859,689**	**1,555,016**	**695,327**	**1,082,720**

LTMF Capacity and Contaminated Soil in the Footprint

LTMF Option	Geographic Location	LTMF Soil Capacity (m^3)	Contaminated Soil Volume in the LTMF Footprint (m^3)
Option 1	Mainland East	670,000	220,808
Option 2	Mainland East	970,000	230,712
Option 3	Mainland Central	669,418	13,200
Option 4	Mainland Central	970,000	28,654
Option 5	Mainland Sumps	670,000	100,000
Option 6	Mainland Sumps	970,000	100,000

Backfill Volumes and Area Transfers

Land Use Scenario

Industrial on Mainland, Parkland on Islands

LTMF Siting Option

Mainland Sumps LTMF

Cumulative Fill Hauled (m^3)	**585,310**
Cumulative Fill (t.km)	**883,335**
Cumulative Soil Hauled (m^3)	**669,418**
Cumulative Soil (t.km)	**2,845,189**

LTMF Evaluation Workbook Option: Option 5

Clean Fill Volumes Being Moved Between Areas For Industial on Mainland, Parkland on Islands and Mainland Sumps LTMF

Area		To Area (m^3)							
		Goose Island	Bear Island	Bear Island Sumps	Mainland Central	Mainland East	Mainland West	Mainland Sumps	Total
From Area (m^3)	Goose Island	10,584	0	0	0	0	0	0	10,584
	Bear Island	0	37,575	130,775	0	0	0	0	168,350
	Bear Island Sumps	0	0	0	0	0	0	0	0
	Mainland Central	0	0	0	99,827	132,841	0	0	232,668
	Mainland East	0	0	0	0	106,032	0	0	106,032
	Mainland West	0	0	0	0	0	67,676	0	67,676
	Mainland Sumps	0	0	0	0	0	0	0	0
	Total	**10,584**	**37,575**	**130,775**	**99,827**	**238,873**	**67,676**	**0**	**585,310**

Clean Fill Volume Kilometers Between Areas For Industial on Mainland, Parkland on Islands and Mainland Sumps LTMF

Area		To Area (t . Km)							
		Goose Island	Bear Island	Bear Island Sumps	Mainland Central	Mainland East	Mainland West	Mainland Sumps	Total
From Area (t . Km)	Goose Island	19,050	0	0	0	0	0	0	19,050
	Bear Island	0	67,635	270,704	0	0	0	0	338,339
	Bear Island Sumps	0	0	0	0	0	0	0	0
	Mainland Central	0	0	0	89,844	279,764	0	0	369,608
	Mainland East	0	0	0	0	95,429	0	0	95,429
	Mainland West	0	0	0	0	0	60,909	0	60,909
	Mainland Sumps	0	0	0	0	0	0	0	0
	Total	**19,050**	**67,635**	**270,704**	**89,844**	**375,192**	**60,909**	**0**	**883,335**

Backfill Quantities, Shale Quantities, and Balance Quantities For Industial on Mainland, Parkland on Islands and Mainland Sumps LTMF

Area	Quantity of Soil Removed (m^3)	Quantity Requiring Backfill (m^3)	Available Fill Quantity (m^3)	Initial Fill Balance (m^3)	Final Fill Balance (m^3)	Overburden Used (m^3)	Average Thickness of Overburden Used (m)
Goose Island	10,584	10,584	433,783	423,200	423,200	0	0.00
Bear Island	37,575	37,575	400,058	362,483	231,708	0	0.00
Bear Island Sumps	130,775	130,775	0	-130,775	0	0	0.00
Mainland Central	99,827	99,827	291,584	191,757	58,916	74,357	0.56
Mainland East	238,873	238,873	106,032	-132,841	0	27,365	1.00
Mainland West	67,676	67,676	323,559	255,883	255,883	0	0.00
Mainland Sumps	76,525	0	0	0	0	0	0.00
Total	**661,835**	**585,310**	**1,555,016**	**969,706**	**969,706**	**101,722**	

Inter Area Distances (km)

Area		To Area (km)						
		Goose Island	Bear Island	Bear Island Sumps	Mainland Central	Mainland East	Mainland West	Mainland Sumps
From Area (km)	Goose Island	1.0	3.7	4.2	6.6	6.8	6.0	7.3
	Bear Island	3.7	1.0	1.2	4.5	4.6	3.8	5.7
	Bear Island Sumps	4.2	1.2	0.5	5.0	5.2	4.4	6.3
	Mainland Central	6.6	4.5	5.0	0.5	1.2	1.5	1.4
	Mainland East	6.8	4.6	5.2	1.2	0.5	2.3	1.3
	Mainland West	6.0	3.8	4.4	1.5	2.3	0.5	1.9
	Mainland Sumps	7.3	5.7	6.3	1.4	1.3	1.9	0.3

PROXIMITY RANKING (1 = closest)

		Closest To						
		Goose Island	Bear Island	Bear Island Sumps	Mainland Central	Mainland East	Mainland West	Mainland Sumps
From	Goose Island	1	2	3	5	6	4	7
	Bear Island	3	1	2	5	6	4	7
	Bear Island Sumps	3	2	1	5	6	4	7
	Mainland Central	7	5	6	1	2	4	3
	Mainland East	7	5	6	2	1	4	3
	Mainland West	7	5	6	2	4	1	3
	Mainland Sumps	7	5	6	3	2	4	1

Equipment Requirements for Natural Island Relocations

	Value	Source
Material Handled/Day (m^3):	9240	Model output
Ice Bridge Days:	54	Imperial Oil Limited - Jen's Copy of Avg Ice Road Costs 2005-2015.xlsx. Period open to loads up to 45,000 kg.
Ice Road Days:	30	AmecFW assumption. Period open to loads up to 73,975 kg. This is the loaded weight of a Cat 740 truck described in CAT publication AEHQ6072 (2-2011) available at www.cat.com.
Equipment Productivity Factor:	0.75	AmecFW assumption
Operating hours/day:	20	AmecFW assumption
Excavate/Haul/Spread Days		
LTMF Options 1, 3 and 5:	72	Model output
LTMF Options 2, 4 and 6:	105	Model output

Model Output

LTMF Options 1, 3 and 5	
Winter Excavation and Haul (m^3):	186,517
Winter Haul Days (Island Sources):	20
Summer Excavation and Haul (m^3):	482,901
Summer Haul Days:	52
LTMF Options 2, 4 and 6	
Winter Excavation and Haul (m^3):	186,517
Winter Haul Days (Island Sources):	20
Summer Excavation and Haul (m^3):	780,755
Summer Haul Days:	84

Selected Equipment

Task	Equipment	Productivity (m^3/hr)[a]	No. of Units	Total Productivity (m^3/day)
Excavate	Cat 336 EL	94	5	9375
Haul and Dump	Cat 770	66	7	9240
Spread	Cat D8	225	2	9000

[a] = Equpment productivity (from Caterpillar Performance Handbook Edition 42) * equipment productivity factor (assumed by AmecFW).

LTMF Options 1, 3 and 5 Soil (m^3)

Area	Industrial on Mainland / Parkland on Islands / Total Landfill Volume	Times Handled	Total Excavate / Haul / Spread Volume	Days to Excavate
Mainland West	67,676	1	67,676	8
Mainland Central	99,827	1	99,827	11
Mainland East	238,873	1	238,873	27
Mainland Sumps	76,525	1	76,525	9
Artificial Islands	7,583	1	7,583	1
Goose Island	10,584	1	10,584	1
Bear Island Sumps	130,775	1	130,775	15
Bear Island	37,575	1	37,575	4
Total	**669,418**		**669,418**	**74**

Summary of Reclamation Areas and Material Requirements

Material or Area	Comment	Goose Island	Bear Island	Mainland LTMF Option 1	Mainland LTMF Option 2	Mainland LTMF Option 3	Mainland LTMF Option 4	Mainland LTMF Option 5	Mainland LTMF Option 6	Total for the Natural Islands and Mainland LTMF Option3
Required Shale	The volume of shale required as backfill for excavations.	10,584	168,350	262,093	550,043	469,701	752,101	406,376	680,755	648,635
Unused Shale Area (m^2)	The extent of post-remediation shale-covered areas.	64,678	13,883	32,614	-	-	-	-	-	78,561
Overburden Application Thickness (m)	The assumed thickness of overburden applied to post-remediation shale-covered surfaces.	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
Overburden Relocation Volume (m^3)	The volume of overburden requiring relocation to post-remediation shale-covered areas.	12,936	2,777	6,523	-	-	-	-	-	15,712
Shale Relocation Volume (m3)	The volume of shale to be relocated to exisitng shale-covered areas such as terminals on the islands.	30,417	-	85,409	-	-	-	-	-	30,417
Total Disturbed Surface Area (m^2)	Disturbed surface areas to be revegetated.	211,528	299,769	940,446	940,446	940,446	940,446	940,446	940,446	1,451,743
Total Disturbed Surface Area (ha)		21.2	30.0	94.0	94.0	94.0	94.0	94.0	94.0	145
Total Contaminated Surface Area (m^2)	The extent of post-remediation excavations that require overburden capping material. Rough estimate based on impacted soil areas shown on Figure X in Section X.	4,536	43,675	188,455	229,041	188,455	229,041	188,455	229,041	236,666
Total Contaminated Surface Area (ha)		0.45	4.37	18.85	22.90	18.85	22.90	18.85	22.90	24
Overburden Relocation Volume (m^3)	The volume of overburden requiring relocation to excavated areas.	907	8,735	37,691	45,808	37,691	45,808	37,691	45,808	47,333

Norman Wells Closure & Reclamation Plan - Materials Management Plan

Goose Island Post-Remediation Shale Surfaces

Required Shale:	10,584	Material Balances Worksheet
Unused Shale Area (m^2):	64,678	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	12,936	Model Output
Shale Relocation Volume (m3)[b]:	30,417	Model Output
Total Disturbed Surface Area (m^2):	211,528	Model Output
Total Contaminated Surface Area (m^2)[c]:	4,536	Model Output
Overburden Relocation Volume (m^3)[d]:	907	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Goose Island	Segment 1	3,312	828	Use	828	-
Goose Island	Segment 2	1,608	402	Use	1,230	-
Goose Island	Segment 3	1,232	308	Use	1,538	-
Goose Island	Segment 4	3,016	754	Use	2,292	-
Goose Island	Segment 5	1,128	282	Use	2,574	-
Goose Island	Segment 6	2,696	674	Use	3,248	-
Goose Island	Segment 7	5,104	1,276	Use	4,524	-
Goose Island	Segment 8	9,760	2,440	Use	6,964	-
Goose Island	Segment 9	518	130	Use	7,094	-
Goose Island	Segment 10	784	196	Use	7,290	-
Goose Island	Segment 11	824	206	Use	7,496	-
Goose Island	Segment 12	546	136	Use	7,632	-
Goose Island	Segment 13	299	75	Use	7,707	-
Goose Island	Segment 14	1,656	414	Use	8,121	-
Goose Island	Segment 15	3,024	756	Use	8,877	-
Goose Island	Segment 16	1,512	378	Use	9,255	-
Goose Island	Segment 17	590	148	Use	9,402	-
Goose Island	Segment 18	952	238	Use	9,640	-
Goose Island	Segment 19	13,832	3,458	Relocate	9,640	-
Goose Island	Segment 20	944	236	Use	9,876	-
Goose Island	Segment 21	1,064	266	Use	10,142	-
Goose Island	Segment 22	562	141	Use	10,283	-
Goose Island	Segment 23	928	232	Use	10,515	-
Goose Island	Segment 24	800	200	Use	10,715	-
Goose Island	Segment 25	1,376	344	Relocate	10,715	-
Goose Island	Segment 26	880	220	Relocate	10,715	-
Goose Island	Segment 27	563	141	Relocate	10,715	-
Goose Island	Segment 28	1,392	348	Relocate	10,715	-
Goose Island	Segment 29	638	160	Relocate	10,715	-
Goose Island	Segment 30	2,408	602	Relocate	10,715	-
Goose Island	Segment 31	334	83	Relocate	10,715	-
Goose Island	Segment 32	738	184	Relocate	10,715	-
Goose Island	Segment 33	1,448	362	Relocate	10,715	-
Goose Island	Segment 34	1,328	332	Relocate	10,715	-
Goose Island	Segment 35	5,224	1,306	Relocate	10,715	-
Goose Island	Segment 36	1,048	262	Relocate	10,715	-
Goose Island	Segment 37	816	204	Relocate	10,715	-
Goose Island	Segment 38	346	87	Relocate	10,715	-
Goose Island	Segment 39	5,304	1,326	Relocate	10,715	-
Goose Island	Segment 40	1,520	380	Relocate	10,715	-
Goose Island	Segment 41	322	80	Relocate	10,715	-
Goose Island	Segment 42	2,248	562	Relocate	10,715	-
Goose Island	Segment 43	920	230	Relocate	10,715	-
Goose Island	Segment 44	11,448	2,862	Relocate	10,715	-
Goose Island	Segment 45	10,304	2,576	Relocate	10,715	-
Goose Island	Segment 46	2,296	574	Relocate	10,715	-
Goose Island	Segment 47	2,424	606	Relocate	10,715	-
Goose Island	Segment 48	3,008	752	Relocate	10,715	-
Goose Island	Segment 49	228	57	Relocate	10,715	-
Goose Island	Segment 50	1,168	292	Relocate	10,715	-
Goose Island	Segment 51	799	200	Relocate	10,715	-
Goose Island	Segment 52	1,904	476	Relocate	10,715	-
Goose Island	Segment 53	738	184	Relocate	10,715	-
Goose Island	Segment 54	7,048	1,762	Relocate	10,715	-
Goose Island	Segment 55	750	188	Relocate	10,715	-
Goose Island	Segment 56	1,512	378	Relocate	10,715	-
Goose Island	GIT 4	10,482	61,420	Leave in Place	10,715	10,482
Goose Island	GIT 7	14,040	92,184	Leave in Place	10,715	14,040
Goose Island	GIT 8	20,361	115,815	Leave in Place	10,715	20,361
Goose Island	GIT 9	19,795	123,232	Leave in Place	10,715	19,795
Goose Island	Goose N-18X Pad	17,678	8,839	Relocate	10,715	-

Bear Island Post-Remediation Shale Surfaces

Required Shale:	168,350	Material Balances Worksheet
Unused Shale Area (m^2):	13,883	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	2,777	Model Output
Shale Relocation Volume (m3)[b]:	-	Model Output
Total Disturbed Surface Area (m^2):	299,769	Model Output
Total Contaminated Surface Area (m^2)[c]:	43,675	Model Output
Overburden Relocation Volume (m^3)[d]:	8,735	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Overburden Depth (m)	Overburden Quantity (m^3)	Available Fill Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Bear Island	BI Rd 1	4,648	1162	0	0	1162	Use	1,162	-
Bear Island	BI Rd 2	18,968	4742	0	0	4742	Use	5,904	-
Bear Island	BI Rd 3	4,016	1004	0	0	1004	Use	6,908	-
Bear Island	BI Rd 4	796	199	0	0	199	Use	7,107	-
Bear Island	BI Rd 5	667	167	0	0	166.8	Use	7,274	-
Bear Island	BI Rd 6	1,536	384	0	0	384	Use	7,658	-
Bear Island	BI Rd 7	358	90	0	0	89.6	Use	7,747	-
Bear Island	BI Rd 8	378	94	0	0	94.4	Use	7,842	-
Bear Island	BI Rd 9	534	134	0	0	133.6	Use	7,975	-
Bear Island	BI Rd 10	6,408	1602	0	0	1602	Use	9,577	-
Bear Island	BI Rd 11	7,424	1856	0	0	1856	Use	11,433	-
Bear Island	BI Rd 12	2,920	730	0	0	730	Use	12,163	-
Bear Island	BI Rd 13	1,792	448	0	0	448	Use	12,611	-
Bear Island	BI Rd 14	1,272	318	0	0	318	Use	12,929	-
Bear Island	BI Rd 15	840	210	0	0	210	Use	13,139	-
Bear Island	BI Rd 16	5,272	1318	0	0	1318	Use	14,457	-
Bear Island	BI Rd 17	488	122	0	0	122	Use	14,579	-
Bear Island	BI Rd 18	3,000	750	0	0	750	Use	15,329	-
Bear Island	Bear S-32X Pad	12,348	6174	1	12348	18522	Use	21,503	-
Bear Island	Bear Q-37X Pad	6,625	3313	1	6625	9938	Use	24,816	-
Bear Island	Bear Q-39X Pad	9,455	4728	1	9455	14183	Use	29,543	-
Bear Island	Bear Q-38X Pad	6,270	3135	1	6270	9405	Use	32,678	-
Bear Island	Bear Q-41X Pad	11,803	5902	1	11803	17705	Use	38,580	-
Bear Island	Bear P-45X Pad	6,010	3005	1	6010	9015	Use	41,585	-
Bear Island	Bear K-50X Pad	6,038	3019	1	6038	9057	Use	44,604	-
Bear Island	Bear M-50X Pad	6,410	3205	1	6410	9615	Use	47,809	-
Bear Island	Bear O-46X Pad	2,412	1206	1	2412	3618	Use	49,015	-
Bear Island	Bear N-45X Pad	2,416	1208	1	2416	3624	Use	50,223	-
Bear Island	BIT 3	15,101	75505	0	0	75505	Use	125,728	-
Bear Island	Bear J-52X Pad	8,797	4399	1	8797	13196	Use	130,126	-
Bear Island	Bear M-48X Pad	4,046	2023	1	4046	6069	Use	132,149	-
Bear Island	Bear M-42X Pad	11,248	5624	1	11248	16872	Use	137,773	-
Bear Island	Bear N-43X Pad	2,993	1497	1	2993	4490	Use	139,270	-
Bear Island	Bear N-44X Pad	873	437	1	873	1310	Use	139,706	-
Bear Island	Bear P-48X Pad	6,759	3380	1	6759	10139	Use	143,086	-
Bear Island	Bear O-45X Pad	940	470	1	940	1410	Use	143,556	-
Bear Island	Bear O-43X Pad	1,084	542	1	1084	1626	Use	144,098	-
Bear Island	BIT 4	13,883	124947	0	0	124947	Leave in Place	144,098	13,883
Bear Island	Bear N-33X Pad	8,661	4331	1	8661	12992	Use	148,428	-
Bear Island	Bear P-35X Pad	1,089	545	1	1089	1634	Use	148,973	-
Bear Island	Bear P-37X Pad	2,553	1277	1	2553	3830	Use	150,249	-
Bear Island	Bear O-41X Pad	552	276	1	552	828	Use	150,525	-
Bear Island	Bear P-38X Pad	751	376	1	751	1127	Use	150,901	-
Bear Island	Bear R-36X Pad	1,117	559	1	1117	1676	Use	151,459	-
Bear Island	Bear Island Sumps	86,616	0	0	0	0	Leave in Place	151,459	
Bear Island	Bear R-34X Pad	1,601	801	1	1601	2402	Use	152,260	-

Norman Wells Closure & Reclamation Plan - Materials Management Plan

Mainland Post-Remediation Shale Surfaces for LTMF Option 1

Required Shale:	262,093	Material Balances Worksheet
Unused Shale Area (m^2):	32,614	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	6,523	Model Output
Shale Relocation Volume (m3)[b]:	85,409	Model Output
Total Disturbed Surface Area (m^2):	940,446	Model Output
Total Contaminated Surface Area (m^2)[c]:	188,455	Model Output
Overburden Relocation Volume (m^3)[d]:	37,691	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Mainland Central	Road Segment 1	5,160	1,290	Use	1,290	-
Mainland Central	Road Segment 2	4,736	1,184	Use	2,474	-
Mainland Central	Road Segment 3	2,256	564	Use	3,038	-
Mainland Central	Road Segment 4	1,088	272	Use	3,310	-
Mainland Central	Road Segment 5	502	126	Use	3,436	-
Mainland Central	Road Segment 6	589	147	Use	3,583	-
Mainland West	Road Segment 7	3,040	760	Use	4,343	-
Mainland West	Road Segment 8	255	64	Use	4,407	-
Mainland West	Road Segment 9	9,688	2,422	Use	6,829	-
Mainland Central	Road Segment 10	255	64	Use	6,892	-
Mainland West	Road Segment 11	520	130	Use	7,022	-
Mainland West	Road Segment 12	1,072	268	Use	7,290	-
Mainland West	Road Segment 13	2,000	500	Use	7,790	-
Mainland Central	Road Segment 14	410	103	Use	7,893	-
Mainland East	Road Segment 15	1,608	402	Use	8,295	-
Mainland East	Road Segment 16	2,344	586	Use	8,881	-
Mainland East	Road Segment 17	2,328	582	Use	9,463	-
Mainland East	Road Segment 18	1,888	472	Use	9,935	-
Mainland West	CPF	138,412	103,809	Use	113,744	-
Mainland Central	Warehouses	58,273	43,705	Relocate	113,744	-
Mainland Central	Field Storage Services Pad	37,844	28,383	Relocate	113,744	-
Mainland Central	Fluid Hauling Service Area	32,614	24,461	Leave in Place	113,744	32,614
Mainland Central	Former Battery	15,690	7,845	Use	121,589	-
Mainland Central	Injection Facility	27,052	20,289	Use	141,878	-
Mainland Central	Former Reduced Crude Flare Pit	8,883	4,442	Use	146,320	-
Mainland Central	D-32X Area	19,373	9,687	Use	156,006	-
Mainland Central	C-30X Area	2,309	1,155	Use	157,161	-
Mainland Central	B-33X Area	4,317	2,159	Use	159,319	-
Mainland Central	C-32X Area	1,387	694	Use	160,013	-
Mainland Central	Gas Lift Building	3,685	2,764	Use	162,776	-
Mainland Central	C-34-1-X Area	6,787	3,394	Use	166,170	-
Mainland Central	C-36X Area	2,704	1,352	Use	167,522	-
Mainland East	c-38x aREA	5,122	2,561	Use	170,083	-
Mainland East	E-36X Area	2,003	1,002	Use	171,084	-
Mainland West	LT3 Gas Man. Building	6,406	4,805	Use	175,889	-
Mainland West	E-28X and F-28X	4,486	2,243	Use	178,132	-
Mainland West	Well Area South of CPF	15,260	7,630	Use	185,762	-
Mainland West	E-25X	1,043	522	Use	186,283	-
Mainland West	Well Area SW of CPF	4,833	2,417	Use	188,700	-
Mainland West	Well Area SW of CPF 2	11,110	5,555	Use	194,255	-
Mainland West	Well Area West of CPF	5,529	2,765	Use	197,019	-
Mainland East	Reduced Crude Flare Pit	2,479	1,240	Use	198,259	-
Mainland East	Tank Farm and Surrounding Areas	179,758	-	Use	198,259	-
Mainland East	Welding Shop	17,761	13,321	Relocate	198,259	-
Mainland East	Shore side development South of tank farms	92,158	46,079	Use	244,338	-
Mainland East	Bulk Fuels Unloading Dock	16,564	12,423	Use	256,761	-
Mainland Sumps	Sumps	166,664	-	Use	256,761	-
Mainland Central	Unlabeled Area 2	3,543	1,772	Use	258,532	-
Mainland Central	Unlabeled Area 3	4,929	2,465	Use	260,997	-
Mainland West	Unlabeled Area 4	1,728	864	Use	261,861	-

Norman Wells Closure & Reclamation Plan - Materials Management Plan

Mainland Post-Remediation Shale Surfaces for LTMF Option 2

Required Shale:	550,043	Material Balances Worksheet
Unused Shale Area (m^2):	-	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	-	Model Output
Shale Relocation Volume (m3)[b]:	-	Model Output
Total Disturbed Surface Area (m^2):	940,446	Model Output
Total Contaminated Surface Area (m^2)[c]:	229,041	Model Output
Overburden Relocation Volume (m^3)[d]:	45,808	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Mainland Central	Road Segment 1	5,160	1,290	Use	1,290	-
Mainland Central	Road Segment 2	4,736	1,184	Use	2,474	-
Mainland Central	Road Segment 3	2,256	564	Use	3,038	-
Mainland Central	Road Segment 4	1,088	272	Use	3,310	-
Mainland Central	Road Segment 5	502	126	Use	3,436	-
Mainland Central	Road Segment 6	589	147	Use	3,583	-
Mainland West	Road Segment 7	3,040	760	Use	4,343	-
Mainland West	Road Segment 8	255	64	Use	4,407	-
Mainland West	Road Segment 9	9,688	2,422	Use	6,829	-
Mainland Central	Road Segment 10	255	64	Use	6,892	-
Mainland West	Road Segment 11	520	130	Use	7,022	-
Mainland West	Road Segment 12	1,072	268	Use	7,290	-
Mainland West	Road Segment 13	2,000	500	Use	7,790	-
Mainland Central	Road Segment 14	410	103	Use	7,893	-
Mainland East	Road Segment 15	1,608	402	Use	8,295	-
Mainland East	Road Segment 16	2,344	586	Use	8,881	-
Mainland East	Road Segment 17	2,328	582	Use	9,463	-
Mainland East	Road Segment 18	1,888	472	Use	9,935	-
Mainland West	CPF	138,412	103,809	Use	113,744	-
Mainland Central	Warehouses	58,273	43,705	Use	157,449	-
Mainland Central	Field Storage Services Pad	37,844	28,383	Use	185,832	-
Mainland Central	Fluid Hauling Service Area	32,614	24,461	Use	210,292	-
Mainland Central	Former Battery	15,690	7,845	Use	218,137	-
Mainland Central	Injection Facility	27,052	20,289	Use	238,426	-
Mainland Central	Former Reduced Crude Flare Pit	8,883	4,442	Use	242,868	-
Mainland Central	D-32X Area	19,373	9,687	Use	252,554	-
Mainland Central	C-30X Area	2,309	1,155	Use	253,709	-
Mainland Central	B-33X Area	4,317	2,159	Use	255,867	-
Mainland Central	C-32X Area	1,387	694	Use	256,561	-
Mainland Central	Gas Lift Building	3,685	2,764	Use	259,325	-
Mainland Central	C-34-1-X Area	6,787	3,394	Use	262,718	-
Mainland Central	C-36X Area	2,704	1,352	Use	264,070	-
Mainland East	c-38x aREA	5,122	2,561	Use	266,631	-
Mainland East	E-36X Area	2,003	1,002	Use	267,633	-
Mainland West	LT3 Gas Man. Building	6,406	4,805	Use	272,437	-
Mainland West	E-28X and F-28X	4,486	2,243	Use	274,680	-
Mainland West	Well Area South of CPF	15,260	7,630	Use	282,310	-
Mainland West	E-25X	1,043	522	Use	282,832	-
Mainland West	Well Area SW of CPF	4,833	2,417	Use	285,248	-
Mainland West	Well Area SW of CPF 2	11,110	5,555	Use	290,803	-
Mainland West	Well Area West of CPF	5,529	2,765	Use	293,568	-
Mainland East	Reduced Crude Flare Pit	2,479	1,240	Use	294,807	-
Mainland East	Tank Farm and Surrounding Areas	179,758	-	Use	294,807	-
Mainland East	Welding Shop	17,761	13,321	Use	308,128	-
Mainland East	Shore side development South of tank farms	92,158	46,079	Use	354,207	-
Mainland East	Bulk Fuels Unloading Dock	16,564	12,423	Use	366,630	-
Mainland Sumps	Sumps	166,664	-	Use	366,630	-
Mainland Central	Unlabeled Area 2	3,543	1,772	Use	368,401	-
Mainland Central	Unlabeled Area 3	4,929	2,465	Use	370,866	-
Mainland West	Unlabeled Area 4	1,728	864	Use	371,730	-

Norman Wells Closure & Reclamation Plan - Materials Management Plan

Mainland Post-Remediation Shale Surfaces for LTMF Option 3

Required Shale:	469,701	Material Balances Worksheet
Unused Shale Area (m^2):	-	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	-	Model Output
Shale Relocation Volume (m3)[b]:	-	Model Output
Total Disturbed Surface Area (m^2):	940,446	Model Output
Total Contaminated Surface Area (m^2)[c]:	188,455	Model Output
Overburden Relocation Volume (m^3)[d]:	37,691	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Mainland Central	Road Segment 1	5,160	1,290	Use	1,290	-
Mainland Central	Road Segment 2	4,736	1,184	Use	2,474	-
Mainland Central	Road Segment 3	2,256	564	Use	3,038	-
Mainland Central	Road Segment 4	1,088	272	Use	3,310	-
Mainland Central	Road Segment 5	502	126	Use	3,436	-
Mainland Central	Road Segment 6	589	147	Use	3,583	-
Mainland West	Road Segment 7	3,040	760	Use	4,343	-
Mainland West	Road Segment 8	255	64	Use	4,407	-
Mainland West	Road Segment 9	9,688	2,422	Use	6,829	-
Mainland Central	Road Segment 10	255	64	Use	6,892	-
Mainland West	Road Segment 11	520	130	Use	7,022	-
Mainland West	Road Segment 12	1,072	268	Use	7,290	-
Mainland West	Road Segment 13	2,000	500	Use	7,790	-
Mainland Central	Road Segment 14	410	103	Use	7,893	-
Mainland East	Road Segment 15	1,608	402	Use	8,295	-
Mainland East	Road Segment 16	2,344	586	Use	8,881	-
Mainland East	Road Segment 17	2,328	582	Use	9,463	-
Mainland East	Road Segment 18	1,888	472	Use	9,935	-
Mainland West	CPF	138,412	103,809	Use	113,744	-
Mainland Central	Warehouses	58,273	43,705	Use	157,449	-
Mainland Central	Field Storage Services Pad	37,844	28,383	Use	185,832	-
Mainland Central	Fluid Hauling Service Area	32,614	24,461	Use	210,292	-
Mainland Central	Former Battery	15,690	7,845	Use	218,137	-
Mainland Central	Injection Facility	27,052	20,289	Use	238,426	-
Mainland Central	Former Reduced Crude Flare Pit	8,883	4,442	Use	242,868	-
Mainland Central	D-32X Area	19,373	9,687	Use	252,554	-
Mainland Central	C-30X Area	2,309	1,155	Use	253,709	-
Mainland Central	B-33X Area	4,317	2,159	Use	255,867	-
Mainland Central	C-32X Area	1,387	694	Use	256,561	-
Mainland Central	Gas Lift Building	3,685	2,764	Use	259,325	-
Mainland Central	C-34-1-X Area	6,787	3,394	Use	262,718	-
Mainland Central	C-36X Area	2,704	1,352	Use	264,070	-
Mainland East	c-38x aREA	5,122	2,561	Use	266,631	-
Mainland East	E-36X Area	2,003	1,002	Use	267,633	-
Mainland West	LT3 Gas Man. Building	6,406	4,805	Use	272,437	-
Mainland West	E-28X and F-28X	4,486	2,243	Use	274,680	-
Mainland West	Well Area South of CPF	15,260	7,630	Use	282,310	-
Mainland West	E-25X	1,043	522	Use	282,832	-
Mainland West	Well Area SW of CPF	4,833	2,417	Use	285,248	-
Mainland West	Well Area SW of CPF 2	11,110	5,555	Use	290,803	-
Mainland West	Well Area West of CPF	5,529	2,765	Use	293,568	-
Mainland East	Reduced Crude Flare Pit	2,479	1,240	Use	294,807	-
Mainland East	Tank Farm and Surrounding Areas	179,758	-	Use	294,807	-
Mainland East	Welding Shop	17,761	13,321	Use	308,128	-
Mainland East	Shore side development South of tank farms	92,158	46,079	Use	354,207	-
Mainland East	Bulk Fuels Unloading Dock	16,564	12,423	Use	366,630	-
Mainland Sumps	Sumps	166,664	-	Use	366,630	-
Mainland Central	Unlabeled Area 2	3,543	1,772	Use	368,401	-
Mainland Central	Unlabeled Area 3	4,929	2,465	Use	370,866	-
Mainland West	Unlabeled Area 4	1,728	864	Use	371,730	-

Mainland Post-Remediation Shale Surfaces for LTMF Option 4

Required Shale:	752,101	Material Balances Worksheet
Unused Shale Area (m^2):	-	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	-	Model Output
Shale Relocation Volume (m3)[b]:	-	Model Output
Total Disturbed Surface Area (m^2):	940,446	Model Output
Total Contaminated Surface Area (m^2)[c]:	229,041	Model Output
Overburden Relocation Volume (m^3)[d]:	45,808	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Mainland Central	Road Segment 1	5,160	1,290	Use	1,290	-
Mainland Central	Road Segment 2	4,736	1,184	Use	2,474	-
Mainland Central	Road Segment 3	2,256	564	Use	3,038	-
Mainland Central	Road Segment 4	1,088	272	Use	3,310	-
Mainland Central	Road Segment 5	502	126	Use	3,436	-
Mainland Central	Road Segment 6	589	147	Use	3,583	-
Mainland West	Road Segment 7	3,040	760	Use	4,343	-
Mainland West	Road Segment 8	255	64	Use	4,407	-
Mainland West	Road Segment 9	9,688	2,422	Use	6,829	-
Mainland Central	Road Segment 10	255	64	Use	6,892	-
Mainland West	Road Segment 11	520	130	Use	7,022	-
Mainland West	Road Segment 12	1,072	268	Use	7,290	-
Mainland West	Road Segment 13	2,000	500	Use	7,790	-
Mainland Central	Road Segment 14	410	103	Use	7,893	-
Mainland East	Road Segment 15	1,608	402	Use	8,295	-
Mainland East	Road Segment 16	2,344	586	Use	8,881	-
Mainland East	Road Segment 17	2,328	582	Use	9,463	-
Mainland East	Road Segment 18	1,888	472	Use	9,935	-
Mainland West	CPF	138,412	103,809	Use	113,744	-
Mainland Central	Warehouses	58,273	43,705	Use	157,449	-
Mainland Central	Field Storage Services Pad	37,844	28,383	Use	185,832	-
Mainland Central	Fluid Hauling Service Area	32,614	24,461	Use	210,292	-
Mainland Central	Former Battery	15,690	7,845	Use	218,137	-
Mainland Central	Injection Facility	27,052	20,289	Use	238,426	-
Mainland Central	Former Reduced Crude Flare Pit	8,883	4,442	Use	242,868	-
Mainland Central	D-32X Area	19,373	9,687	Use	252,554	-
Mainland Central	C-30X Area	2,309	1,155	Use	253,709	-
Mainland Central	B-33X Area	4,317	2,159	Use	255,867	-
Mainland Central	C-32X Area	1,387	694	Use	256,561	-
Mainland Central	Gas Lift Building	3,685	2,764	Use	259,325	-
Mainland Central	C-34-1-X Area	6,787	3,394	Use	262,718	-
Mainland Central	C-36X Area	2,704	1,352	Use	264,070	-
Mainland East	c-38x aREA	5,122	2,561	Use	266,631	-
Mainland East	E-36X Area	2,003	1,002	Use	267,633	-
Mainland West	LT3 Gas Man. Building	6,406	4,805	Use	272,437	-
Mainland West	E-28X and F-28X	4,486	2,243	Use	274,680	-
Mainland West	Well Area South of CPF	15,260	7,630	Use	282,310	-
Mainland West	E-25X	1,043	522	Use	282,832	-
Mainland West	Well Area SW of CPF	4,833	2,417	Use	285,248	-
Mainland West	Well Area SW of CPF 2	11,110	5,555	Use	290,803	-
Mainland West	Well Area West of CPF	5,529	2,765	Use	293,568	-
Mainland East	Reduced Crude Flare Pit	2,479	1,240	Use	294,807	-
Mainland East	Tank Farm and Surrounding Areas	179,758	-	Use	294,807	-
Mainland East	Welding Shop	17,761	13,321	Use	308,128	-
Mainland East	Shore side development South of tank farms	92,158	46,079	Use	354,207	-
Mainland East	Bulk Fuels Unloading Dock	16,564	12,423	Use	366,630	-
Mainland Sumps	Sumps	166,664	-	Use	366,630	-
Mainland Central	Unlabeled Area 2	3,543	1,772	Use	368,401	-
Mainland Central	Unlabeled Area 3	4,929	2,465	Use	370,866	-
Mainland West	Unlabeled Area 4	1,728	864	Use	371,730	-

Mainland Post-Remediation Shale Surfaces for LTMF Option 5

Required Shale:	406,376	Material Balances Worksheet
Unused Shale Area (m^2):	-	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	-	Model Output
Shale Relocation Volume (m3)[b]:	-	Model Output
Total Disturbed Surface Area (m^2):	940,446	Model Output
Total Contaminated Surface Area (m^2)[c]:	188,455	Model Output
Overburden Relocation Volume (m^3)[d]:	37,691	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Mainland Central	Road Segment 1	5,160	1,290	Use	1,290	-
Mainland Central	Road Segment 2	4,736	1,184	Use	2,474	-
Mainland Central	Road Segment 3	2,256	564	Use	3,038	-
Mainland Central	Road Segment 4	1,088	272	Use	3,310	-
Mainland Central	Road Segment 5	502	126	Use	3,436	-
Mainland Central	Road Segment 6	589	147	Use	3,583	-
Mainland West	Road Segment 7	3,040	760	Use	4,343	-
Mainland West	Road Segment 8	255	64	Use	4,407	-
Mainland West	Road Segment 9	9,688	2,422	Use	6,829	-
Mainland Central	Road Segment 10	255	64	Use	6,892	-
Mainland West	Road Segment 11	520	130	Use	7,022	-
Mainland West	Road Segment 12	1,072	268	Use	7,290	-
Mainland West	Road Segment 13	2,000	500	Use	7,790	-
Mainland Central	Road Segment 14	410	103	Use	7,893	-
Mainland East	Road Segment 15	1,608	402	Use	8,295	-
Mainland East	Road Segment 16	2,344	586	Use	8,881	-
Mainland East	Road Segment 17	2,328	582	Use	9,463	-
Mainland East	Road Segment 18	1,888	472	Use	9,935	-
Mainland West	CPF	138,412	103,809	Use	113,744	-
Mainland Central	Warehouses	58,273	43,705	Use	157,449	-
Mainland Central	Field Storage Services Pad	37,844	28,383	Use	185,832	-
Mainland Central	Fluid Hauling Service Area	32,614	24,461	Use	210,292	-
Mainland Central	Former Battery	15,690	7,845	Use	218,137	-
Mainland Central	Injection Facility	27,052	20,289	Use	238,426	-
Mainland Central	Former Reduced Crude Flare Pit	8,883	4,442	Use	242,868	-
Mainland Central	D-32X Area	19,373	9,687	Use	252,554	-
Mainland Central	C-30X Area	2,309	1,155	Use	253,709	-
Mainland Central	B-33X Area	4,317	2,159	Use	255,867	-
Mainland Central	C-32X Area	1,387	694	Use	256,561	-
Mainland Central	Gas Lift Building	3,685	2,764	Use	259,325	-
Mainland Central	C-34-1-X Area	6,787	3,394	Use	262,718	-
Mainland Central	C-36X Area	2,704	1,352	Use	264,070	-
Mainland East	c-38x aREA	5,122	2,561	Use	266,631	-
Mainland East	E-36X Area	2,003	1,002	Use	267,633	-
Mainland West	LT3 Gas Man. Building	6,406	4,805	Use	272,437	-
Mainland West	E-28X and F-28X	4,486	2,243	Use	274,680	-
Mainland West	Well Area South of CPF	15,260	7,630	Use	282,310	-
Mainland West	E-25X	1,043	522	Use	282,832	-
Mainland West	Well Area SW of CPF	4,833	2,417	Use	285,248	-
Mainland West	Well Area SW of CPF 2	11,110	5,555	Use	290,803	-
Mainland West	Well Area West of CPF	5,529	2,765	Use	293,568	-
Mainland East	Reduced Crude Flare Pit	2,479	1,240	Use	294,807	-
Mainland East	Tank Farm and Surrounding Areas	179,758	-	Use	294,807	-
Mainland East	Welding Shop	17,761	13,321	Use	308,128	-
Mainland East	Shore side development South of tank farms	92,158	46,079	Use	354,207	-
Mainland East	Bulk Fuels Unloading Dock	16,564	12,423	Use	366,630	-
Mainland Sumps	Sumps	166,664	-	Use	366,630	-
Mainland Central	Unlabeled Area 2	3,543	1,772	Use	368,401	-
Mainland Central	Unlabeled Area 3	4,929	2,465	Use	370,866	-
Mainland West	Unlabeled Area 4	1,728	864	Use	371,730	-

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Mainland Post-Remediation Shale Surfaces for LTMF Option 6

Required Shale:	680,755	Material Balances Worksheet
Unused Shale Area (m^2):	-	Model Output
Overburden Application Thickness[a] (m):	0.2	AmecFW Assumption
Overburden Relocation Volume (m^3):	-	Model Output
Shale Relocation Volume (m3)[b]:	-	Model Output
Total Disturbed Surface Area (m^2):	940,446	Model Output
Total Contaminated Surface Area (m^2)[c]:	229,041	Model Output
Overburden Relocation Volume (m^3)[d]:	45,808	Model Output

[a] The thickness of overburden applied over shale that is left in-place.

[b] The volume of shale relocated to the nearest remaining shale mound.

[c] From Figures X and Y Contaminated soil areas

[d] Overburden required to cover excavations.

Major Area	Segment or Area	Area (m^2)	Shale Quantity (m^3)	Use as Backfill, Leave in Place or Relocate	Cumulative Shale Volume (m^3)	Area of Shale Left in Place (m^2)
Mainland Central	Road Segment 1	5,160	1,290	Use	1,290	-
Mainland Central	Road Segment 2	4,736	1,184	Use	2,474	-
Mainland Central	Road Segment 3	2,256	564	Use	3,038	-
Mainland Central	Road Segment 4	1,088	272	Use	3,310	-
Mainland Central	Road Segment 5	502	126	Use	3,436	-
Mainland Central	Road Segment 6	589	147	Use	3,583	-
Mainland West	Road Segment 7	3,040	760	Use	4,343	-
Mainland West	Road Segment 8	255	64	Use	4,407	-
Mainland West	Road Segment 9	9,688	2,422	Use	6,829	-
Mainland Central	Road Segment 10	255	64	Use	6,892	-
Mainland West	Road Segment 11	520	130	Use	7,022	-
Mainland West	Road Segment 12	1,072	268	Use	7,290	-
Mainland West	Road Segment 13	2,000	500	Use	7,790	-
Mainland Central	Road Segment 14	410	103	Use	7,893	-
Mainland East	Road Segment 15	1,608	402	Use	8,295	-
Mainland East	Road Segment 16	2,344	586	Use	8,881	-
Mainland East	Road Segment 17	2,328	582	Use	9,463	-
Mainland East	Road Segment 18	1,888	472	Use	9,935	-
Mainland West	CPF	138,412	103,809	Use	113,744	-
Mainland Central	Warehouses	58,273	43,705	Use	157,449	-
Mainland Central	Field Storage Services Pad	37,844	28,383	Use	185,832	-
Mainland Central	Fluid Hauling Service Area	32,614	24,461	Use	210,292	-
Mainland Central	Former Battery	15,690	7,845	Use	218,137	-
Mainland Central	Injection Facility	27,052	20,289	Use	238,426	-
Mainland Central	Former Reduced Crude Flare Pit	8,883	4,442	Use	242,868	-
Mainland Central	D-32X Area	19,373	9,687	Use	252,554	-
Mainland Central	C-30X Area	2,309	1,155	Use	253,709	-
Mainland Central	B-33X Area	4,317	2,159	Use	255,867	-
Mainland Central	C-32X Area	1,387	694	Use	256,561	-
Mainland Central	Gas Lift Building	3,685	2,764	Use	259,325	-
Mainland Central	C-34-1-X Area	6,787	3,394	Use	262,718	-
Mainland Central	C-36X Area	2,704	1,352	Use	264,070	-
Mainland East	c-38x aREA	5,122	2,561	Use	266,631	-
Mainland East	E-36X Area	2,003	1,002	Use	267,633	-
Mainland West	LT3 Gas Man. Building	6,406	4,805	Use	272,437	-
Mainland West	E-28X and F-28X	4,486	2,243	Use	274,680	-
Mainland West	Well Area South of CPF	15,260	7,630	Use	282,310	-
Mainland West	E-25X	1,043	522	Use	282,832	-
Mainland West	Well Area SW of CPF	4,833	2,417	Use	285,248	-
Mainland West	Well Area SW of CPF 2	11,110	5,555	Use	290,803	-
Mainland West	Well Area West of CPF	5,529	2,765	Use	293,568	-
Mainland East	Reduced Crude Flare Pit	2,479	1,240	Use	294,807	-
Mainland East	Tank Farm and Surrounding Areas	179,758	-	Use	294,807	-
Mainland East	Welding Shop	17,761	13,321	Use	308,128	-
Mainland East	Shore side development South of tank farms	92,158	46,079	Use	354,207	-
Mainland East	Bulk Fuels Unloading Dock	16,564	12,423	Use	366,630	-
Mainland Sumps	Sumps	166,664	-	Use	366,630	-
Mainland Central	Unlabeled Area 2	3,543	1,772	Use	368,401	-
Mainland Central	Unlabeled Area 3	4,929	2,465	Use	370,866	-
Mainland West	Unlabeled Area 4	1,728	864	Use	371,730	-

Overburden Thickness Allowance (m): 1

Table 1: Goose Island Road Segment Lengths and Shale Volume Calculations

Major Area	Segment	Length (m)	Width (m)	Area (m^2)	Shale Depth (m)	Shale Quantity (m^3)	Overburden Depth (m)	Overburden Quantity (m^3)	Available Fill Quantity (m^3)
Goose Island	Segment 1	414	8	3,312	0.25	828	0	-	828
Goose Island	Segment 2	201	8	1,608	0.25	402	0	-	402
Goose Island	Segment 3	154	8	1,232	0.25	308	0	-	308
Goose Island	Segment 4	377	8	3,016	0.25	754	0	-	754
Goose Island	Segment 5	141	8	1,128	0.25	282	0	-	282
Goose Island	Segment 6	337	8	2,696	0.25	674	0	-	674
Goose Island	Segment 7	638	8	5,104	0.25	1,276	0	-	1,276
Goose Island	Segment 8	1,220	8	9,760	0.25	2,440	0	-	2,440
Goose Island	Segment 9	65	8	518	0.25	130	0	-	130
Goose Island	Segment 10	98	8	784	0.25	196	0	-	196
Goose Island	Segment 11	103	8	824	0.25	206	0	-	206
Goose Island	Segment 12	68	8	546	0.25	136	0	-	136
Goose Island	Segment 13	37	8	299	0.25	75	0	-	75
Goose Island	Segment 14	207	8	1,656	0.25	414	0	-	414
Goose Island	Segment 15	378	8	3,024	0.25	756	0	-	756
Goose Island	Segment 16	189	8	1,512	0.25	378	0	-	378
Goose Island	Segment 17	74	8	590	0.25	148	0	-	148
Goose Island	Segment 18	119	8	952	0.25	238	0	-	238
Goose Island	Segment 19	1,729	8	13,832	0.25	3,458	0	-	3,458
Goose Island	Segment 20	118	8	944	0.25	236	0	-	236
Goose Island	Segment 21	133	8	1,064	0.25	266	0	-	266
Goose Island	Segment 22	70	8	562	0.25	141	0	-	141
Goose Island	Segment 23	116	8	928	0.25	232	0	-	232
Goose Island	Segment 24	100	8	800	0.25	200	0	-	200
Goose Island	Segment 25	172	8	1,376	0.25	344	0	-	344
Goose Island	Segment 26	110	8	880	0.25	220	0	-	220
Goose Island	Segment 27	70	8	563	0.25	141	0	-	141
Goose Island	Segment 28	174	8	1,392	0.25	348	0	-	348
Goose Island	Segment 29	80	8	638	0.25	160	0	-	160
Goose Island	Segment 30	301	8	2,408	0.25	602	0	-	602
Goose Island	Segment 31	42	8	334	0.25	83	0	-	83
Goose Island	Segment 32	92	8	738	0.25	184	0	-	184
Goose Island	Segment 33	181	8	1,448	0.25	362	0	-	362
Goose Island	Segment 34	166	8	1,328	0.25	332	0	-	332
Goose Island	Segment 35	653	8	5,224	0.25	1,306	0	-	1,306
Goose Island	Segment 36	131	8	1,048	0.25	262	0	-	262
Goose Island	Segment 37	102	8	816	0.25	204	0	-	204
Goose Island	Segment 38	43	8	346	0.25	87	0	-	87
Goose Island	Segment 39	663	8	5,304	0.25	1,326	0	-	1,326
Goose Island	Segment 40	190	8	1,520	0.25	380	0	-	380
Goose Island	Segment 41	40	8	322	0.25	80	0	-	80
Goose Island	Segment 42	281	8	2,248	0.25	562	0	-	562
Goose Island	Segment 43	115	8	920	0.25	230	0	-	230
Goose Island	Segment 44	1,431	8	11,448	0.25	2,862	0	-	2,862
Goose Island	Segment 45	1,288	8	10,304	0.25	2,576	0	-	2,576
Goose Island	Segment 46	287	8	2,296	0.25	574	0	-	574
Goose Island	Segment 47	303	8	2,424	0.25	606	0	-	606
Goose Island	Segment 48	376	8	3,008	0.25	752	0	-	752
Goose Island	Segment 49	29	8	228	0.25	57	0	-	57
Goose Island	Segment 50	146	8	1,168	0.25	292	0	-	292
Goose Island	Segment 51	100	8	799	0.25	200	0	-	200
Goose Island	Segment 52	238	8	1,904	0.25	476	0	-	476
Goose Island	Segment 53	92	8	738	0.25	184	0	-	184
Goose Island	Segment 54	881	8	7,048	0.25	1,762	0	-	1,762
Goose Island	Segment 55	94	8	750	0.25	188	0	-	188
Goose Island	Segment 56	189	8	1,512	0.25	378	0	-	378
Total		**16,147**		**129,172**		**32,293**		**-**	**32,293**

Table 2: Goose Island Terminal Shale Volumes

Major Area	Area	Area (m^2)	Shale Depth (m)	Shale Quantity (m^3)	Overburden Depth (m)	Overburden Quantity (m^3)	Available Fill Quantity (m^3)
Goose Island	GIT 4	10,482	7	61,420	0	-	61,420
Goose Island	GIT 7	14,040	9	92,184	0	-	92,184
Goose Island	GIT 8	20,361	9	115,815	0	-	115,815
Goose Island	GIT 9	19,795	10	123,232	0	-	123,232
Goose Island	Goose N-18X Pad	17,678	0.5	8,839.00	0	-	8,839
	Total	**82,356**		**401,490**		**-**	**401,490**

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Overburden Thickness Allowance (m): 1

Table 3: Bear Island Road Segment Lengths and Shale Volume Calculations

Major Area	Segment	Length (m)	Width (m)	Area (m^2)	Shale Depth (m)	Shale Quantity (m^3)	Overburden Depth (m)	Overburden Quantity (m^3)	Available Fill Quantity (m^3)
Bear Island	BI Rd 1	581	8	4,648	0.25	1,162	0	-	1,162
Bear Island	BI Rd 2	2,371	8	18,968	0.25	4,742	0	-	4,742
Bear Island	BI Rd 3	502	8	4,016	0.25	1,004	0	-	1,004
Bear Island	BI Rd 4	100	8	796	0.25	199	0	-	199
Bear Island	BI Rd 5	83	8	667	0.25	167	0	-	167
Bear Island	BI Rd 6	192	8	1,536	0.25	384	0	-	384
Bear Island	BI Rd 7	45	8	358	0.25	90	0	-	90
Bear Island	BI Rd 8	47	8	378	0.25	94	0	-	94
Bear Island	BI Rd 9	67	8	534	0.25	134	0	-	134
Bear Island	BI Rd 10	801	8	6,408	0.25	1,602	0	-	1,602
Bear Island	BI Rd 11	928	8	7,424	0.25	1,856	0	-	1,856
Bear Island	BI Rd 12	365	8	2,920	0.25	730	0	-	730
Bear Island	BI Rd 13	224	8	1,792	0.25	448	0	-	448
Bear Island	BI Rd 14	159	8	1,272	0.25	318	0	-	318
Bear Island	BI Rd 15	105	8	840	0.25	210	0	-	210
Bear Island	BI Rd 16	659	8	5,272	0.25	1,318	0	-	1,318
Bear Island	BI Rd 17	61	8	488	0.25	122	0	-	122
Bear Island	BI Rd 18	375	8	3,000	0.25	750	0	-	750
Total		**7,665**		**61,318**		**15,329**		**-**	**15,329**

Table 4: Bear Island Terminal and Pad Shale Volumes

Major Area	Area	Area (m^2)	Shale Depth (m)	Shale Quantity (m^3)	Overburden Depth (m)	Overburden Quantity (m^3)	Available Fill Quantity (m^3)
Bear Island	Bear S-32X Pad	12,348	0.5	6,174	1	12,348	18,522
Bear Island	Bear Q-37X Pad	6,625	0.5	3,313	1	6,625	9,938
Bear Island	Bear Q-39X Pad	9,455	0.5	4,728	1	9,455	14,183
Bear Island	Bear Q-38X Pad	6,270	0.5	3,135	1	6,270	9,405
Bear Island	Bear Q-41X Pad	11,803	0.5	5,902	1	11,803	17,705
Bear Island	Bear P-45X Pad	6,010	0.5	3,005	1	6,010	9,015
Bear Island	Bear K-50X Pad	6,038	0.5	3,019	1	6,038	9,057
Bear Island	Bear M-50X Pad	6,410	0.5	3,205	1	6,410	9,615
Bear Island	Bear O-46X Pad	2,412	0.5	1,206	1	2,412	3,618
Bear Island	Bear N-45X Pad	2,416	0.5	1,208	1	2,416	3,624
Bear Island	BIT 3	15,101	5	75,505	0	-	75,505
Bear Island	Bear J-52X Pad	8,797	0.5	4,399	1	8,797	13,196
Bear Island	Bear M-48X Pad	4,046	0.5	2,023	1	4,046	6,069
Bear Island	Bear M-42X Pad	11,248	0.5	5,624	1	11,248	16,872
Bear Island	Bear N-43X Pad	2,993	0.5	1,497	1	2,993	4,490
Bear Island	Bear N-44X Pad	873	0.5	437	1	873	1,310
Bear Island	Bear P-48X Pad	6,759	0.5	3,380	1	6,759	10,139
Bear Island	Bear O-45X Pad	940	0.5	470	1	940	1,410
Bear Island	Bear O-43X Pad	1,084	0.5	542	1	1,084	1,626
Bear Island	BIT 4	13,883	9	124,947	0	-	124,947
Bear Island	Bear N-33X Pad	8,661	0.5	4,331	1	8,661	12,992
Bear Island	Bear P-35X Pad	1,089	0.5	545	1	1,089	1,634
Bear Island	Bear P-37X Pad	2,553	0.5	1,277	1	2,553	3,830
Bear Island	Bear O-41X Pad	552	0.5	276	1	552	828
Bear Island	Bear P-38X Pad	751	0.5	376	1	751	1,127
Bear Island	Bear R-36X Pad	1,117	0.5	559	1	1,117	1,676
Bear Island	Bear Island Sumps	86,616	0	-	0	-	-
Bear Island	Bear R-34X Pad	1,601	0.5	801	1	1,601	2,402
Total		**238,451**		**261,878**		**122,851**	**384,729**

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Table 5: Mainland Road Segment Lengths and Shale Volume Calculations

Major Area	Segment	Length (m)	Width (m)	Area (m2)	Shale Depth (m)	Shale Quantity (m^3)	Overburden Depth (m)	Overburden Quantity (m^3)	Available Fill Quantity (m^3)
Mainland Central	Road Segment 1	645	8	5,160	0.25	1,290	0	-	1,290
Mainland Central	Road Segment 2	592	8	4,736	0.25	1,184	0	-	1,184
Mainland Central	Road Segment 3	282	8	2,256	0.25	564	0	-	564
Mainland Central	Road Segment 4	136	8	1,088	0.25	272	0	-	272
Mainland Central	Road Segment 5	63	8	502	0.25	126	0	-	126
Mainland Central	Road Segment 6	74	8	589	0.25	147	0	-	147
Mainland West	Road Segment 7	380	8	3,040	0.25	760	0	-	760
Mainland West	Road Segment 8	32	8	255	0.25	64	0	-	64
Mainland West	Road Segment 9	1,211	8	9,688	0.25	2,422	0	-	2,422
Mainland Central	Road Segment 10	32	8	255	0.25	64	0	-	64
Mainland West	Road Segment 11	65	8	520	0.25	130	0	-	130
Mainland West	Road Segment 12	134	8	1,072	0.25	268	0	-	268
Mainland West	Road Segment 13	250	8	2,000	0.25	500	0	-	500
Mainland Central	Road Segment 14	51	8	410	0.25	103	0	-	103
Mainland East	Road Segment 15	201	8	1,608	0.25	402	0	-	402
Mainland East	Road Segment 16	293	8	2,344	0.25	586	0	-	586
Mainland East	Road Segment 17	291	8	2,328	0.25	582	0	-	582
Mainland East	Road Segment 18	236	8	1,888	0.25	472	0	-	472
	Total	**4,968**		**39,740**		**9,935**		**-**	**9,935**

Table 6: Mainland Facility and Site Shale Volumes **Overburden Thickness Allowance (m): 1**

Major Area	Area	Area (m^2)	Shale Depth (m)	Shale Quantity (m^3)	Overburden Depth (m)	Overburden Quantity (m^3)	Available Fill Quantity (m^3)
Mainland West	CPF	138,412	0.75	103,809	1	138,412	242,221
Mainland Central	Warehouses	58,273	0.75	43,705	0	-	43,705
Mainland Central	Field Storage Services Pad	37,844	0.75	28,383	0	-	28,383
Mainland Central	Fluid Hauling Service Area	32,614	0.75	24,461	1	32,614	57,075
Mainland Central	Former Battery	15,690	0.5	7,845	1	15,690	23,535
Mainland Central	Injection Facility	27,052	0.75	20,289	1	27,052	47,341
Mainland Central	Former Reduced Crude Flare Pit	8,883	0.5	4,442	1	8,883	13,325
Mainland Central	D-32X Area	19,373	0.5	9,687	1	19,373	29,060
Mainland Central	C-30X Area	2,309	0.5	1,155	1	2,309	3,464
Mainland Central	B-33X Area	4,317	0.5	2,159	1	4,317	6,476
Mainland Central	C-32X Area	1,387	0.5	694	1	1,387	2,081
Mainland Central	Gas Lift Building	3,685	0.75	2,764	1	3,685	6,449
Mainland Central	C-34-1-X Area	6,787	0.5	3,394	1	6,787	10,181
Mainland Central	C-36X Area	2,704	0.5	1,352	1	2,704	4,056
Mainland East	c-38x aREA	5,122	0.5	2,561	1	5,122	7,683
Mainland East	E-36X Area	2,003	0.5	1,002	1	2,003	3,005
Mainland West	LT3 Gas Man. Building	6,406	0.75	4,805	1	6,406	11,211
Mainland West	E-28X and F-28X	4,486	0.5	2,243	1	4,486	6,729
Mainland West	Well Area South of CPF	15,260	0.5	7,630	1	15,260	22,890
Mainland West	E-25X	1,043	0.5	522	1	1,043	1,565
Mainland West	Well Area SW of CPF	4,833	0.5	2,417	1	4,833	7,250
Mainland West	Well Area SW of CPF 2	11,110	0.5	5,555	1	11,110	16,665
Mainland West	Well Area West of CPF	5,529	0.5	2,765	1	5,529	8,294
Mainland East	Reduced Crude Flare Pit	2,479	0.5	1,240	1	2,479	3,719
Mainland East	Tank Farm and Surrounding Areas	179,758	0	-	0	-	-
Mainland East	Welding Shop	17,761	0.75	13,321	1	17,761	31,082
Mainland East	Shore side development South of tank farms	92,158	0.5	46,079	0	-	46,079
Mainland East	Bulk Fuels Unloading Dock	16,564	0.75	12,423	0	-	12,423
Mainland Sumps	Sumps	166,664	0	-	0	-	-
Mainland Central	Unlabeled Area 2	3,543	0.5	1,772	1	3,543	5,315
Mainland Central	Unlabeled Area 3	4,929	0.5	2,465	1	4,929	7,394
Mainland West	Unlabeled Area 4	1,728	0.5	864	1	1,728	2,592
Total		**900,706**		**361,795**		**349,445**	**711,240**

Appendix P

Progressive Reclamation To Date;
2014 Work Areas Summary

Appendix F - Norman Wells C&R Work Areas Summary

Norman Wells Area	Phase I ESA	Phase I ESA Update	Phase 2 ESA - Geophysics	Phase 2 ESA - Drilling	Groundwater Monitoring	Dismantling/ Demolition	Remediation	Surface Restoration	Current Status	Planned 2015 Activities
Mainland East										
Office Building						2000				
Abandoned Camp Site	1999	2008	2008	2008					Phase 2 delineation complete	Groundwater Monitoring
Former Refinery	1999	2008	pre-2008	1993, 97, 98, 99, 2000, 02, 03, 08, 09, 2012, 2013	1997-present	1996-1997	1999, 2002 excavations		Phase 2 delineation complete, Screening Level Risk Assessment complete. In-situ remediation at Refinery Bank area from 2003 to present	Groundwater Monitoring, Continue operation of in-situ systems.
API Separator	1999	2008		2003, 2009	2003-present	1997	1997	1997	Phase 2 delineation complete	Groundwater Monitoring
B-38X Well Area	1999	2008	pre-2008	1993, 1997, 1998, 1999, 2000, 2002, 2003, 2008, 2012	1997-present	1992 ongoing	2004-present		In-situ DPE remediation system active seasonally, upgrades and expansion in 2009, expanded solar panel water heater capacity in 2012. Completed 2012 soil & gw sampling to verify current PHC levels in-situ at FTA, LT7, B38.	Groundwater Monitoring, Operation and Optimization of In-situ Remediation System
B-38X Buried Pit/Sump		2008	Pre-2008, 2009	1999, 2000, 2002, 2003, 2010	1998-present		2006-present	2008-2009	Surface restoration complete, delineation drilling to south of former sump in 2010	Vegetation, Groundwater Monitoring
B-40X Well Site	1999	2008		2003, 2008, 2010	2003-present				Phase 2 delineation completed in 2010	Groundwater Monitoring
C-36X Well Site	1999	2008		2009, 2010	2009-present				Phase 2 delineation completed in 2010	Groundwater Monitoring
C-38X Well Site	1999	2008		1997, 2008	2008-present		2005		Phase 2 delineation complete	
D-44X Well Site	1999	2008	2008	2008					Phase 2 delineation complete	
F-50X Well Site	1999	2008		1997					Phase 2 delineation complete	
B-42X Well Site	1999	2008	2013	2006, 2010		2014			Phase 2 delineation completed in 2010, geophysical investigation completed in 2013, wellhead/flowline cut and cap and limited Phase 2 completed in 2014	Reclamation as required to meet CCME Industrial Land Use Standards
B-35X Well Site		2012	2012	2012	2012-present	2012			Well abandoned. Cut and capped in 2012, Phase 2 assessment complete in 2012	Groundwater monitoring
Fire Training Area	1999	2008	pre-2008	1993, 1998, 1999, 2000, 2003, 2008, 2012	1998-present	1992-2008	2008-present		In-situ DPE remediation system active seasonally, upgrades and expansion in 2009. Upgrades ongoing to engineered system in 2013-2014.	Groundwater Monitoring, Operation and Optimization of In-situ Remediation System
Historical Dump Sites and Pits	1999	2008		2009, 2010					On-going	
Former Pits (South of E-38X)		2008		2010					Phase 2 delineation complete	
Reduced Crude Flare Pit	1999	2008	pre-2008	1993, 1998, 1999, 2003, 2009	1998-present	2002	2002, 2003	2004	Remediation complete	Groundwater and Vegetation Monitoring
Refinery Bank, Seeps, Former Flare pit	1999	2008	pre-2008	1993, 1998, 1999, 2001, 2003, 2008, 2009, 2010, 2012, 2013	1998-present		1999, 2003-present		In-situ remediation system active, groundwater pumping system upgraded to run year-round in 2012, MPE running seasonally, Screening Level Risk Assessment complete, soil & gw sampling. Drilling on beach area in 2013. Upgrades to engineered systems ongoing 2013-14.	Groundwater monitoring, operation and optimization of in-situ remediation system
Airport Landfill	1999	2008	pre-2008	1998	1998-present				Preliminary Phase 2 complete	
Airport Landfarm	1999	2008					1996-2004		Closure report complete	
Mainland Tankfarm	1999	2008		1993, 1997, 1998, 2001, 2002, 2003	1997-present				Phase 2 delineation complete, installed 2 thermistors in the area in 2013.	Groundwater Monitoring (under Ops)
Historical Dump Site (NE of C-34-1X)		2008		2010					Phase 2 Assessment complete	
Former Garage Site on Refinery at NWPC Yard		2008		2010	2010				Phase 2 Assessment complete	Groundwater Monitoring
Mainland Tank Farm (former storage yard)		2008							Phase 2 Assessment complete	
Former Drum Storage South of NWPC Yard		2008		2010	2010				Phase 2 Assessment complete	Groundwater Monitoring
Former Fueling Site near Flint shop		2008		2010	2010				Phase 2 Assessment complete	Groundwater Monitoring
Former Camp Site near Flint shop		2008		2009	2009-present				Phase 2 Assessment complete	Groundwater Monitoring
Mainland Central										
A&R Biocell Area (Biocell A)		2008		2008, 2009, 2010, 2012, 2013	2008-present				Soil treatment by twister bucket continued in 2011. Phase 2 ESA delineation of historic hydrocarbon issue south of A&R Biocell complete. Biocells A and B Decommisioned and Reconstructed as 1 larger cell. Remedial excavation of historic hydrocarbon to south initiated in 2013.	Soil treatment by twister bucket. Groundwater Monitoring. Continue remediation of PHC impacted soils to south of biocell, excavate across road.
Operations Biocell (Biocell B)		2008		2009, 2012	2009-2012				Soil treatment by twister bucket continued in 2011. Biocells A and B decommisioned and reconstructed as 1 larger cell in 2012.	See above cell.
B-33X Well Site	1999	2008		2010	2010-2014	2009-2010			Well abandoned in 2009, above-ground infrastructure removed and Phase 2 completed in 2010	Reclamation as required to meet CCME Industrial Land Use standards
Battery #3	1999	2008	pre-2008, 2008	1993, 1997, 1998, 1999, 2000, 2002, 2007, 2012	1997-present	1997-1998	1996, 1999, 2000, 2002		Phase 2 delineation complete, completed Screening Level Risk Assessment. Sampled Tank Farm and Flare Pit areas in 2012.	Groundwater Monitoring. Develop Management Plan for BT3.
Battery #3 Process Area							1999 (metals removal)			
Landfarm North of Battery #3 Flare Pit				2010			1996-2004		Hand sampling completed in 2010	Soil Monitoring for Closure Reporting
Debris storage & dump site north of Battery #3 flare pit		2008	2011	2010					Testpit/soil sampling completed in 2011	Develop management plan

Appendix F - Norman Wells C&R Work Areas Summary

Norman Wells Area	Phase I ESA	Phase I ESA Update	Phase 2 ESA - Geophysics	Phase 2 ESA - Drilling	Groundwater Monitoring	Dismantling/ Demolition	Remediation	Surface Restoration	Current Status	Planned 2015 Activities
Battery #3 Flare Pit (Metals Removal)				2012			2002 (metals removal)		2012 supplementary Phase 2 sampling completed.	Remedial excavation planned for 2014 for source removal of salts/PHC impacted soil.
Battery #3 Wax Pit							1999 (HC removal)	1999		
PCB & Mercury Storage Facility						1996				
Bosworth Creek Weir	1999	2008		2007		2005			Complete, weir removed in 2005	
Bosworth Creek East Bank	1999	2008	2008	1998, 2000, 2006, 2008, 2010, 2013	1998-present		2008, 2009	2008, 2009, 2012	Complete aquatics monitoring, Bank stabilization activities completed in 2012. New drivepoints in 2013	Monitor restored bank for stability, revegetation activities as needed.
Bosworth Creek Delta (E-32X Area)	1999	2008	pre-2008, 2008	1997, 1998, 1999, 2000, 2001, 2007, 2009, 2010	1997-present				Phase 2 delineation complete	Groundwater Monitoring
Bosworth Creek Delta (Well #6 Near D-34X)		2008		2001, 2009, 2010	2001-present				Phase 2 delineation complete	Groundwater Monitoring
Bosworth Creek Delta (D-36X Area)		2008		2001, 2008, 2010	2001-present				Phase 2 delineation complete	Groundwater Monitoring
Bosworth Creek Delta (E-33X Area)	1999	2008	pre-2008, 2013	2009					Phase 2 delineation complete	
C-32X Well Site	1999	2008	2008	1996, 1997, 2007			1996 (Flowline spill site)	1997	Phase 2 delineation complete	Groundwater Monitoring
C-34X Well Site	1999	2008	2008	2007					Phase 2 delineation complete	
F-31X Well Site and Area	1999	2008		1997, 1998, 2000, 2002, 2007, 2010	1997-present		1999 (Flowline spill site)	2000	Phase 2 delineation complete on flowline spill, former dump site to northwest of F-31X	Groundwater Monitoring (under Ops)
North of F-31X (buried metal)		2008							Phase 2 delineation complete	
G-32X Well Site and Area	1999	2008		2009, 2010	2009-present				Phase 2 delineation complete	Groundwater Monitoring
Former Camp Site	1999	2008		2009					On-going	Groundwater Monitoring
Former Pits, Dump Sites	1999	2008		2009					On-going	Groundwater Monitoring
LT11 Satellite Building	1999	2008	pre-2008, 2008	1997, 2007	1997-present				Phase 2 delineation complete	Groundwater Monitoring
Tank 53 Area	1999	2008		1999, 2002	1999-present	2001-2002	2004-present	2009, 2010	Soil remediation complete, revegetation in progress	Closure monitoring of vegetation and subsidence.
Tank 401 Area	1999	2008		1999, 2002, 2006	1999-present	2001		2011, 2012	Excavated, treated and backfilled soil, regraded surface in 2011. Recontoured & seeded in 2012.	Monitor Vegetation, repair any subsidence.
Tank 401 Pumphouse		2008		2010					Phase 2 delineation complete	
D-32X Well Site	1999	2008	pre-2008	2009	2009-present				Phase 2 delineation complete	Groundwater Monitoring
Well services yard & warehouses	1999	2008		1997	1997-present		1997-present		Phase 2 delineation complete	
Historical Camp Site		2008								
C-30X Wellsite		2008		2010	2010				Phase 2 delineation started 2010	Groundwater Monitoring
B-30X Well Site		2012	2012	2012, 2013	2012-present	2012			Well abandoned. Cut and capped in 2012, Phase 2 assessment completed in 2013.	Groundwater monitoring. Develop delineation and management plan.
E-33X Well Site			2013			2014	2014		Well cut and capped in 2014, aboveground infrastructure removed. Preliminary Phase II ESA was completed	Reclamation as required to meet CCME Industrial Land Use Standards
Mainland West										
Former Battery #1 (LH1 Area)	1999	2008	2008	2008, 2010	2008-present	circa 1980			Phase 2 assessment complete	Groundwater Monitoring
CPF	1999	2008		1997, 1998, 2006, 2008, 2009	1997-present				Phase 2 delineation complete	Groundwater Monitoring (under Ops)
E-26X Well Site	1999	2008		2008					Phase 2 assessment complete	
D-27X Utilidor	1999	2008	2008	2008	2008-present				Phase 2 delineation complete	Groundwater Monitoring
E-27X Well Site	1999	2008	2013	2008, 2009	2008-present	2014			Well cut and capped in 2014, above-ground infrastructure was removed. Preliminary Phase II ESA completed	Groundwater monitoring, reclamation as required to meet CCME Industrial Land Use Standards
F-28X Well Site	1999	2008	1997, 2009	1997, 1998, 2009, 2010	1997-present				Phase 2 delineation complete, Screening Level Risk Assessment complete.	Groundwater Monitoring. Develop Management Plan
F-29X & G30X Well Sites	1999	2008	2008	2008, 2009, 2010	2010				Phase 2 delineation complete, Screening Level Risk Assessment complete.	Groundwater Monitoring. Develop Management Plan
Former Pit/Tank/Dump Site Near LT3		2008		2010					Phase 2 delineation complete	
Sumps										
Mainland Drilling Sump	1999	2008, 2012	2008, 2013	1992, 1993, 1997, 1998, 2002, 2008, 2009, 2012, 2013	1997-present	2006	2007, 2008	2008	Decommissioned, contained and capped with surface restoration as of 2009, Phase II ESA complete. Placement of fill and re-contouring of areas with identified depressions to prevent surface water collection in 2014	Preparation of long term Sump Management Strategy. Vegetation and groundwater monitoring.
Well Services Sump	1999	2008	2008	1998, 2002, 2009	1998-present	2006	2007, 2008, 2009	2009	Decommissioned, remediated, restored as of 2009, Phase II ESA complete	Preparation of Sump Management Strategy, Vegetation and groundwater monitoring
Mainland Sumps A to F	1999	2008	2008	1997, 1998, 2002, 2009, 2010, 2012, 2013	1997-present				Decommissioned and capped. Phase II ESA complete. Long term management strategy developed in 2014. Sump fluids removed from I, C and H and depression backfilled with clean soil in 2014	Continued groundwater and vegetation monitoring. Further capping and re-contouring to be completed in 2015 on additional sumps
B-38X Sump	1999	2008	pre-2008	1997, 2006, 2007, 2010	1997-present		2007, 2008	2008	Excavation and surface restoration complete	Vegetation & groundwater monitoring
C-27X Sump	1999	2008	2005, 2008	2008, 2009, 2013	2008-present		2014		Discontinued and capped. Supplementary Phase II ESA works conducted in 2014	Preparation of Sump Management Strategy, groundwater & vegetation monitoring

Appendix F - Norman Wells C&R Work Areas Summary

Norman Wells Area	Phase I ESA	Phase I ESA Update	Phase 2 ESA - Geophysics	Phase 2 ESA - Drilling	Groundwater Monitoring	Dismantling/ Demolition	Remediation	Surface Restoration	Current Status	Planned 2015 Activities
Cemetery Sump	1999	2008	2005, 2013	2005, 2008, 2009, 2010, 2013	2008-present		2010	2010	Phase 2 and 3 delineation complete, Recontouring and interim capping completed 2010, Screening Level Risk Assessment completed 2010. Thermistor installed to characterize permafrost.	Vegetation & groundwater monitoring, development of long term management strategy
Bear Island Sumps 1 to 6	1999	2008	pre-2008, 2013	1997, 1998, 2002, 2008, 2009, 2010, 2013	1997-present				Decommissioned and capped. Supplemental Phase II ESA works conducted in 2014	Groundwater and vegetation monitoring, development of long term management strategy
Bear Island										
Former Drilling Pad Areas	1999	2008		2009	2009-present				Phase 2 assessment ongoing	Groundwater Monitoring
Former Spill Sites	1999	2008		2009	2009-present				Phase 2 assessment ongoing	Groundwater Monitoring
Former Tank Farm & Battery	1999	2008	pre-2008	1998, 2002, 2009	1998-present				Phase 2 assessment complete	Groundwater Monitoring
N-39X Well Site	1999	2008		2008	2008-present					Groundwater Monitoring
O-45X/O-46X Well Sites (former spill sites)	1999	2008	pre-2008, 2008	1997, 1998, 2008, 2009, 2010	1997-present		1997, 1998		Phase 2 assessment complete	Groundwater Monitoring
P-32X Well Site	1999	2008	2008	2008	2008-present					Groundwater Monitoring
1979 Landfarm Area	1999	2008	2008				1979			
Former Battery Site Near N-42X	1999	2008		1998, 2002, 2009, 2010	1998-present				Phase 2 assessment complete	Groundwater Monitoring
N-42X Well Site (former spill site)	1999	2008	pre-2008		2009-present				Phase 2 assessment complete	Groundwater Monitoring
Former Battery West of Q-34X (BI-BT1 area)	1999	2012		2009, 2010, 2012	2009-present				Phase 2 assessment & Phase 3 delineation complete.	Initiate remedial excavation & soil treatment. Groundwater monitoring.
Tank Farm Near Q-38X		2008		2010	2010					Groundwater Monitoring
Lakes and Ponds									Surface Water Monitoring 2009-2010	Surface Water Monitoring
Former Tanks West of R-34X		2008		2010					Brush clearing, testpit and soil sampling in 2011	
Former Flare Pit North of N-42X		2012	2011	2012	2012		2014		Remedial excavation for source removal and supplemental Phase II ESA works undertaken in 2014	Reclamation as required to meet CCME Parkland Standards
Bear Island #1 Well Site, West End		2008, 2012	2012	2010, 2012	2012				Well abandonment/cut&cap complete. Phase 2 assessment complete. Armouring and PHC soil around wellhead removed.	Groundwater monitoring
BIT4 Pigging Station				2010						
Frenchy's Island										
Well Site, Frenchy's Island East End		2008		2010	2010				Phase 2 assessment complete, piezometers destroyed by ice, no further gw monitoring needed.	
Goose Island										
EM Anomalies	1999	2008		2009					Phase 2 delineation complete	
Former Borrow Area (T-10X Area)	1999	2008	2008	2009	2009-present				Phase 2 delineation complete	Groundwater Monitoring (under Ops)
Former Camp Site	1999	2008		2009					Phase 2 delineation complete	
Former Drilling Sumps (sump 2, P-9X Area)	1999	2008		2009	2009-present				Phase 2 delineation complete	Groundwater Monitoring (under Ops)
Former Tank Farm Areas (Q-8X Area)	1999	2008		2009, 2010	2009-present				Phase 2 Delineation Completed 2010	Groundwater Monitoring (under Ops)
GIT 4	1999	2008	2008						On-going	
GIT 7	1999	2008	2008						On-going	
GIT 9	1999	2008	2008						On-going	
Historical Spill Sites (Q-10X Area)	1999	2008		2009					Phase 2 delineation complete	
O-14X Well Site	1999	2008		2009					Phase 2 delineation complete	
O-18X Well Site				2012, 2013	2012-present				Phase 2 delineation & remedial excavations complete	Groundwater Monitoring (under Ops)
N-25X Well Site	1999	2008	2008	2009					Phase 2 delineation complete	
P-11X Well Site	1999	2008	2008	2009, 2010	2009-present				Phase 2 Delineation Completed 2010	Groundwater Monitoring (under Ops)
Wellhead Areas	1999	2008		2009					On-going	
O-29X Well Site						2014			Well cut and capped in 2014, above-ground infrastructure was removed	Reclamation as required to meet CCME Parklands Standards
Town Leases										
A-45X	1999	2008		2008, 2013	2013-present	2009	2013, 2014		Phase 2 and 3 delineation complete, well cut and cap in 2009, excavation and recontour complete 2010. Screening Level Risk Assessment complete. Additional Phase 2 delineation remediation of southwest corner complete in 2013. Additional remedial excavation completed in 2014	Minor delineation and remedial excavation work planned for 2015. Reclamation as required to meet CCME Residential Standards. Preparation to close out lease and return property to productive use.
Lot 1000	1999	2008		2008					Phase 2 and 3 delineation complete, excavation and recontour complete 2010	
Cemetery	1999	2008		2008, 2013					Phase 2 in up-gradient area complete	Continued groundwater monitoring in area upgradient of cemetery

Appendix F - Norman Wells C&R Work Areas Summary

Norman Wells Area	Phase I ESA	Phase I ESA Update	Phase 2 ESA - Geophysics	Phase 2 ESA - Drilling	Groundwater Monitoring	Dismantling/ Demolition	Remediation	Surface Restoration	Current Status	Planned 2015 Activities
Other C&R Initiatives										
Landfill / Borrow Area / Biocell Siting				2009, 2010			2013-2014		Phase 2 ESA completed, remedial excavation initiated in 2013 and continued through 2014. Biocell constructed in Yard D in 2014	Reclamation as required to meet CCME Industrial Land Use standards. Further Remedial excavation in 2015 and Biocell O&M
Metals Stabilization									Co-operative research on-going with Australian Antarctic Research Division, final report received in 2011. Next stage of site samples analysis on-going.	Project report completion.
Soil Ecotoxicity									Research with SRC continued in 2010/11 & 2012. Soil samples collected for invertebrate identification.	Continue development of plant and invertebrate ecotoxicity tests with Norman Wells soil
Revegetation Trial Plots									Plots dismantled at T401 for soil remediation activities in 2011.	Continue closure monitoring on reclaimed T401 site.
Background Conditions in Soil/Groundwater				various years, 1997 to 2012	1997-present				Characterized new inferred background locations in 2010 and 2012 to supplement existing information, completed statistical analysis.	Fill in data gaps as needed.
Monitoring Well Abandonments				2009-2010					Seventy damaged/surplus monitoring wells were abandoned or confirmed destroyed by ice as of 2010	
Thermistor Study				2013					Seven thermistors installed on mainland.	Download data and report annually on temperature profile trends with depth. Consider expanding study to Bear Island sumps area.
Mackenzie River Scour Study									Field work completed in 2012.	Continue data analysis.
Former Production Well Abandonments				2012, 2013		2012, 2014			B-30X and B-35X cut and capped in 2012; O-29X, E-27X, E-33X and B-42X cut and capped in 2014	Cut and cap activities planned for S-06X, T-08X and C-27X wells, with preliminary Phase 2 assessment.

Appendix Q

Limitation of Liability, Scope of Report and Third Party Reliance

Limitation of Liability, Scope of Report and Third Party Reliance

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The investigation undertaken by Amec Foster Wheeler Environment & Infrastructure with respect to this report and any conclusions or recommendations made in this report reflect Amec Foster Wheeler Environment & Infrastructure's judgment based on the site conditions observed at the time of the site inspection on the date(s) set out in this report and on information available at the time of preparation of this report. This report has been prepared for specific application to this site and it is based, in part, upon visual observation of the site, subsurface investigation at discrete locations and depths, and specific analysis of specific chemical parameters and materials during a specific time interval, all as described in this report. Unless otherwise stated, the findings cannot be extended to previous or future site conditions, portions of the site which were unavailable for direct investigation, subsurface locations which were not investigated directly, or chemical parameters, materials or analysis which were not addressed. Substances other than those addressed by the investigation described in this report may exist within the site, substances addressed by the investigation may exist in areas of the site not investigated and concentrations of substances addressed which are different than those reported may exist in areas other than the locations from which samples were taken.

If site conditions or applicable standards change or if any additional information becomes available at a future date, modifications to the findings, conclusions and recommendations in this report may be necessary.

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