Appendix F Soils and Terrain Supporting Information

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Abbreviations

%	percent
>	greater than
AENV	Alberta Environment
AGRASID	Agricultural Region of Alberta Soil Inventory Database
AI	Additional Information
AP	Approved Project
CC&R	closure, conservation and reclamation
CNRL	Canadian Natural Resources Limited
DEM	digital elevation model
e.g.	for example
EPEA	*Environmental Protection and Enhancement Act*
GIS	geographic information system
ha	hectare
i.e.	that is
JNMP	Joslyn North Mine Project
LCC	Land Capability Classification
MP	Modified Project
N/A	not applicable
RMS	reclamation material stockpile
SLM	Soil Landscape Model
SMU	soil map unit

Appendix F Soils and Terrain Supporting Information

F1 Project Modifications

The project modifications relevant to the soils and terrain assessment since submission of the 2010 AI Project Update include:

- addition of the West Extension Area related to changes to mine and tailings plans (see Section 3.3, Section 3.4 and Section 3.6)
- timing and sequence of mining (see Section 3.4)
- revisions to the CC&R Plan (see Section 3.10)

F2 Approach and Methods

The approach for the soils and terrain assessment focused on the evaluation of project-only predicted residual effects related to the MP footprint. Predicted residual effects of the MP are compared to the predicted residual effects for the AP.

The 8981 ha MP footprint (see Table F2-1) used for this assessment:

- includes an AP footprint with an area of 7412 ha
- extends west to include the West Extension Area that covers an additional 1569 ha (see Figure F2-1)

Table F2-1 Footprint Adjustments Associated With the Modified Project

Project Feature	Approved Project Footprint (ha)	Adjusted Approved Project Footprint (ha)[1]	West Extension Area (ha)	Modified Project Footprint (ha)
mine development area	7,098	6,947	1,569	8,516
offstream storage pond (OSSP)	270	270	0	270
camp	165	165	0	165
water supply corridor	30	30	0	30
Total	**7,563**	**7,412**	**1,569**	**8,981**

NOTE:
[1] The adjusted AP footprint area is the portion of the AP footprint that overlaps the MP footprint. The adjustment removes two sections from the AP footprint, one in the northeast corner and the second in the area where Canadian Natural plans a dyke associated with the Horizon Project.

Indicators evaluated in this assessment are similar to those included in the soils and terrain assessment for the AP, and include:

- soil map units
- soil quality (in relation to soil salvage and replacement)
- landscape changes (i.e., slope gradient)
- soil erosion
- site type (replacement for Land Capability Classification System
- soil sensitivity to acid deposition)

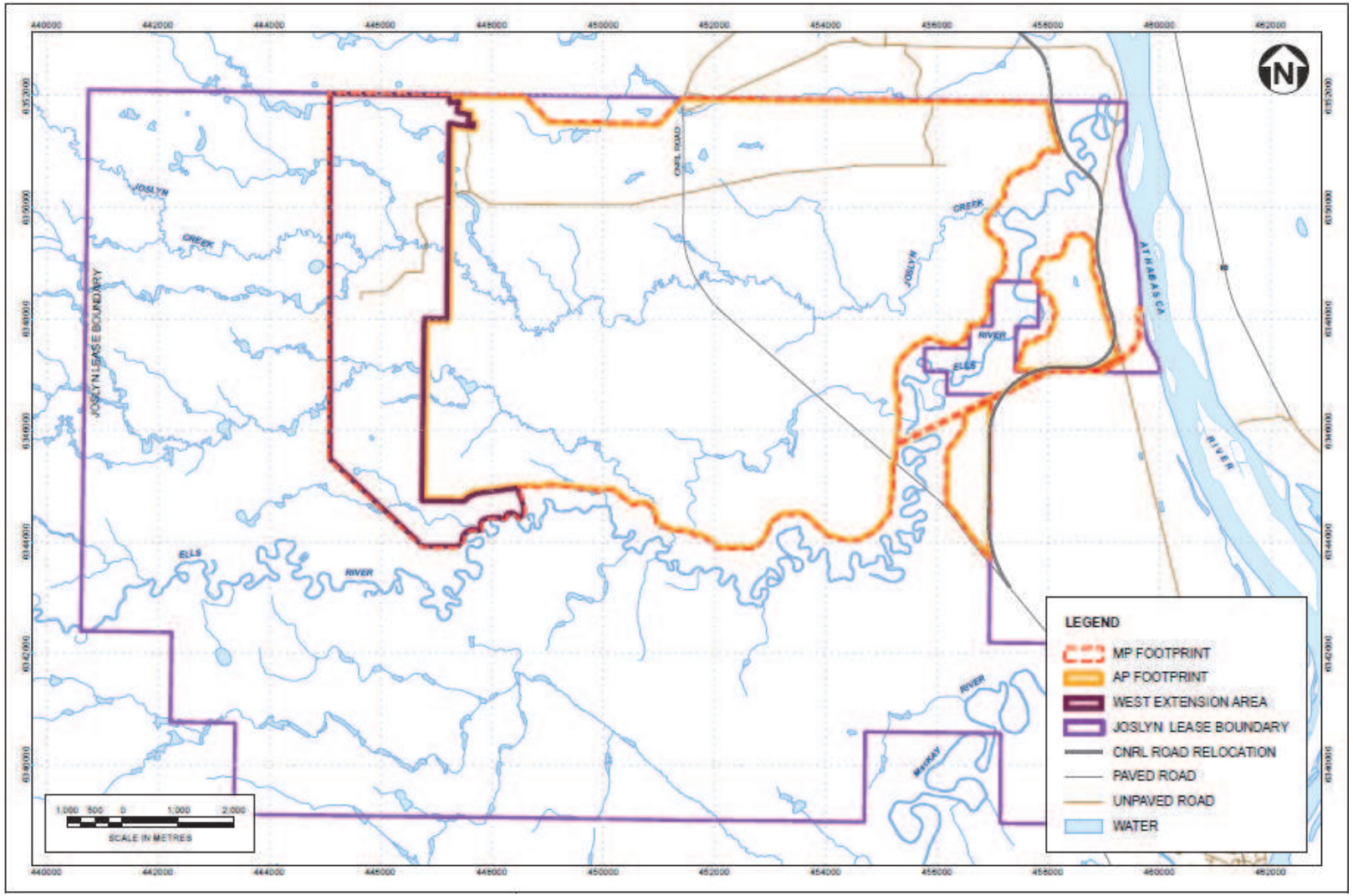

Figure F2-1 Project Footprints

F2.1 Modified Biophysical Setting

The biophysical setting of the MP is based on 2010 conditions for the AP (as described in the 2010 AI Project Update) and 2013 conditions for the West Extension Area.

The biophysical setting was completed to:

- define the distribution of soil map units, slope gradient classes, and site types for the MP, including current information (i.e., 2012 to 2013) for the West Extension Area reflecting new disturbances
- reflect additional field survey data collected in 2013 for the West Extension Area

Methods related to soils and terrain mapping, and descriptions of soils are generally consistent with those used in the 2006 Integrated Application (see Volume 4, Consultant Report 10), except as indicated in Table F2-2.

F2.2 Soil Map Units

The soils and terrain assessment includes the delineation of soil map units (SMUs), disturbed land and reclaimed land. Soil map units are displayed using a label (e.g., BMT3/U1h) with the SMU (e.g., BMT3) followed by a landscape descriptor (e.g., U1h).

See Table F2-2 for details on the SMUs found in the MP footprint at biophysical setting. This table also notes the soil map units present in the West Extension Area. For the distribution of SMUs at biophysical setting in the MP footprint, see Figure F2-2, and for the MP at closure, see Figure F2-3.

Areas of reclaimed soil at closure were determined using information from the MP and AP CC&R Plans. Areas of water at closure were determined from the closure drainage plans from the respective MP and AP CC&R Plans.

Table F2-2 Soil Map Units in the Biophysical Setting

SMU Label[1]	Soil Composition[2]			Landscape Slope Class[3]
	Dominant Soil 1[2,5]	Dominant Soil 2[2,5]	Significant Soil[5]	
BMT5/L1	Bitumount	no other reported dominant soils	Bitumount-fine phase	2
CHMM1/FP3[1]	Chateh	Mamawi	no other reported soils	2
CHMM1/U1l	Chateh	Mamawi	no other reported soils	2
DAN9/HR2h	Daphne	no other reported dominant soils	Gleysolic soils and coarser textured soils	5
DASU18/HR2m	Daphne	Sutherland	other soils[4]	4
DASU18/U1h	Daphne	Sutherland	other soils[4]	3
DASU18/U1l	Daphne	Sutherland	other soils[4]	2
DOHR2/U1h	Dover	Horse River	Gleysolic soils	3
DOKM2/U1h[1]	Dover	Kilome	Gleysolic and shallow Organic soils	3
DOLV6/U1h	Dover	Livock-xc	coarser textured soils	3
DOLV6/U1l	Dover	Livock	coarser textured soils	2
DOLV9/H1l	Dover	Livock-xc	KME, LVKgl	4

Table F2-2 Soil Map Units in the Biophysical Setting

SMU Label[1]	Soil Composition[2]			Landscape Slope Class[3]
	Dominant Soil 1[2,5]	Dominant Soil 2[2,5]	Significant Soil[5]	
DOLV9/U1h	Dover	Livock-xc	KME, LVKgl	3
DOLV9/U1l	Dover	Livock-xc	KME, LVKgl	2
DOSE1/H1l[1]	Dover	Steen	no other reported soils	4
DOSE2/H1l[1]	Dover	Steen	Gleysolic and shallow Organic soils	4
DOV10/U1h[1]	Dover	Kilome; Livock-gl	Steen	4
DOV10/U1l	Dover	Kilome; Livock-gl	Steen	2
FRDA6/R2lr	Fort; Fort-xl	Daphne	Coarser textured soils	4
FRLV2/U1h	Fort	Livock-xc	Gleysolic and shallow Organic soils	3
FRLV2/U1l	Fort	Livock-xc	Gleysolic and shallow Organic soils	2
KMLV1/U1h[1]	Kilome	Livock-gl	Dover; Livock-xc	3
KMLV1/U1l[1]	Kilome	Livock-gl	Dover; Livock-xc	2
KMLV2/U1h[1]	Kilome	Livock-gl	Gleysolic and shallow Organic soils	2
KMLV2/U1l	Kilome	Livock-gl	Gleysolic and shallow Organic soils	2
LVK11/l4	Livock-xc	no other reported dominant soils	Eroded and Regosolic soils	6 to 8
LVK12/l5[1]	Livock	no other reported dominant soils	other soils[4]	6 to 7 or 6 to 8
MIFR5/U1h	Mildred	Fort	finer textured soils	3
MIFR5/U1l	Mildred	Fort	finer textured soils	2
MIL1/U1h	Mildred	no other reported dominant soils	no other reported soils	3
MIL1/U1l	Mildred	no other reported dominant soils	no other reported soils	2
MIL5/U1h	Mildred	no other reported dominant soils	finer textured soils	3
MLD1c-G/O3[1]	McLelland-xc	no other reported dominant soils	Gleysolic soils	2
MLD1c-G/O5	McLelland-xc	no other reported dominant soils	Gleysolic soils	3
MLD1m-G/O3[1]	McLelland-xm	no other reported dominant soils	Gleysolic soils	2
MLD1m-G/O5	McLelland-xm	no other reported dominant soils	Gleysolic soils	3
MLD1s-G/O5	McLelland-xs	no other reported dominant soils	Gleysolic soils	3
MLD2c/O1	McLelland over clay	no other reported dominant soils	no other reported soils	3
MLD2m/O1[1]	McLelland over medium	no other reported dominant soils	no other reported soils	3
MLD2s/O1	McLelland over sand	no other reported dominant soils	no other reported soils	3

Table F2-2 Soil Map Units in the Biophysical Setting

SMU Label[1]	Soil Composition[2]			Landscape Slope Class[3]
	Dominant Soil 1[2,5]	Dominant Soil 2[2,5]	Significant Soil[5]	
MLD2s-G/O1	McLelland over sand	no other reported dominant soils	Gleysolic soils	3
MLD3/O2	McLelland	no other reported dominant soils	no other reported soils	3
MMW1/U1l	Mamawi	no other reported dominant soils	no other reported soils	3
MMW2/FP3[1]	Mamawi	no other reported dominant soils	open water	2
MMW21/U1h	Mamawi	no other reported dominant soils	Gleysolic and shallow organic soils	3
MMW21/U1l	Mamawi	no other reported dominant soils	Gleysolic and shallow organic soils	2
MMY2/SC1[1]	McMurray	McMurray gleyed	Gleysolic soils	4
MMY6/SC2r	McMurray	no other reported dominant soils	Mildred and lithic phases	3
MUS1c-G/O5	Muskeg over clay	no other reported dominant soils	Gleysolic soils	3
MUS1m-G/O5[1]	Muskeg over medium texture	no other reported dominant soils	Gleysolic soils	3
MUS1s-G/O5	Muskeg over coarse	no other reported dominant soils	Gleysolic soils	3
MUS2c/O1[1]	Muskeg over clay	no other reported dominant soils	no other reported soils	3
MUS2m/O1[1]	Muskeg over medium texture	no other reported dominant soils	no other reported soils	3
MUS3/O2[1]	Muskeg	no other reported dominant soils	no other reported soils	3
PELV12/SC2[1]	Peavine	Livock	other soils[4]	3
PELV2/L3[1]	Peavine	Livock	Gleysolic soils	Some 2 and some 3
PELV9/U1h	Peavine	Livock	gleyed subgroups and coarser textured soils	3
PELV91/U1h	Peavine	Livock	other soils[4]	3
Water[1]	Open water	N/A	N/A	N/A
ZDL[1]	Disturbed soil	N/A	N/A	N/A
Reclaimed Land	Reclaimed soil	N/A	N/A	Various slope classes

NOTES:
-xc over clay textured material.
-xm over medium textured material.
-gl gleyed subgroups and imperfectly drained conditions.

[1] Denotes SMU present in West Extension Area.
[2] Characteristics of SMUs provided in the 2006 Integrated Application (Volume 4, Consultant Report 10).
[3] Soil Landscape Model (SLM) codes as defined in the original mapping from 2006 do not match the slope limits assigned to these SLMs in the Landscape Slope Class. It appears that a process of generalization has occurred since the original data were captured. The imposed changes are not entirely consistent.
[4] Usage of soil model numbers after 2006 has evolved away from standard AGRASID definitions such that the actual meaning of unit number (12, 18, 91) is unclear.
[5] Dominant soils are considered to occupy more than 60% of a delineation when only one present; when two soils are listed as dominant then each is considered to represent 30% to 50% of the soil delineation. Significant soils are considered to occupy from 10% to 30% of the soil delineation.

N/A = Not applicable.

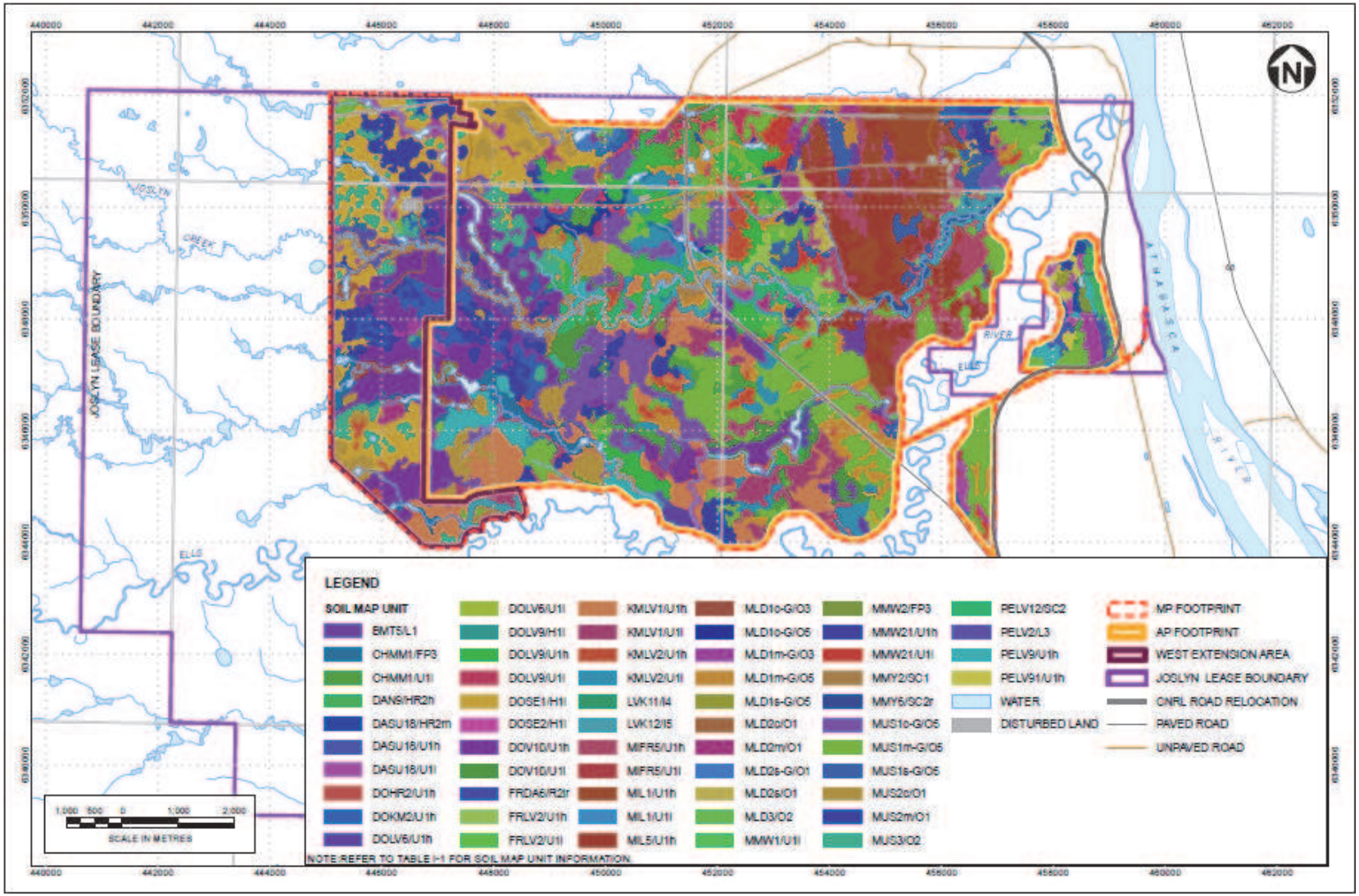

Figure F2-2 Soil Map Units – Biophysical Setting

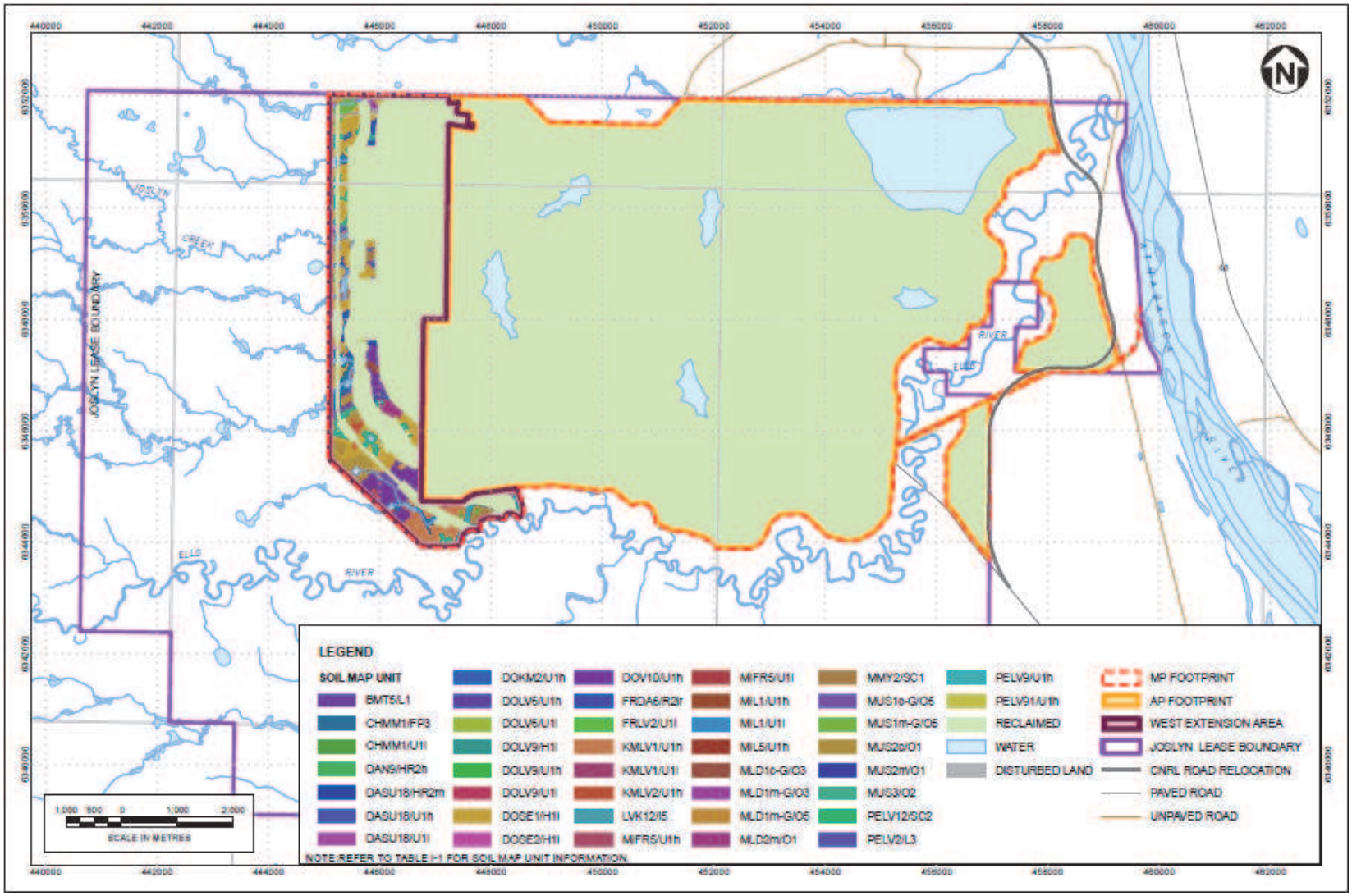

Figure F2-3 Soil Map Units – Modified Project at Closure

F2.3 Landscape Changes

The activities planned for the MP will result in landscape changes, as approved for the AP. The reconstructed landscape for the MP will have more varied slopes than the natural landscape, similar to the AP. Reclaimed slopes will be contoured to replicate natural terrain features and will blend with the surrounding landscape.

For slope classes found in the MP footprint at biophysical setting, see Table F2-3, in which slope classes present in the West Extension Area are noted. For the distribution of slope classes at biophysical setting in the MP footprint, see Figure F2-4, and for the MP at closure, see Figure F2-5.

Slope data for the biophysical setting differed from that used in the AP soil and terrain assessment. Slope calculations in the AP soil and terrain assessmentwere based on GIS analysis of a digital elevation model (DEM). Slope calculations for the are based on slopes assigned to soil delineations during soil mapping (similar to the 2006 Integrated Application). Inconsistencies between the slope class assigned to the map unit delineations and the slope gradient range used in Table F2-3 were noted for certain SMUs.

Slope class at closure was determined by GIS analysis of a DEM surface, which was interpolated from contour data generated for the MP and AP closure drainage plans. Slope classes extents for parts of the closure landscape that were outside of the defined drainage plan were obtained from the biophysical setting dataset. Soil reclamation in these portions of the MP footprint was not assumed to change topography from biophysical setting. For slope classes used for the closure drainage, see Table F2-3.

Table F2-3 Slope Class Limits Used for Closure Slopes

Slope Class	% Slope (Range)
1	0 to 0.5
2	>0.5 to 2
3	>2 to 5
4	>5 to 10
5	>10 to 15
6	>15 to 30
6 to 7	>15 to 45
6 to 8	>15 to 70
7	>30 to 45
8	>45 to 70
9	>70 to 100
SOURCE: Expert Committee on Soil Survey (1998).	

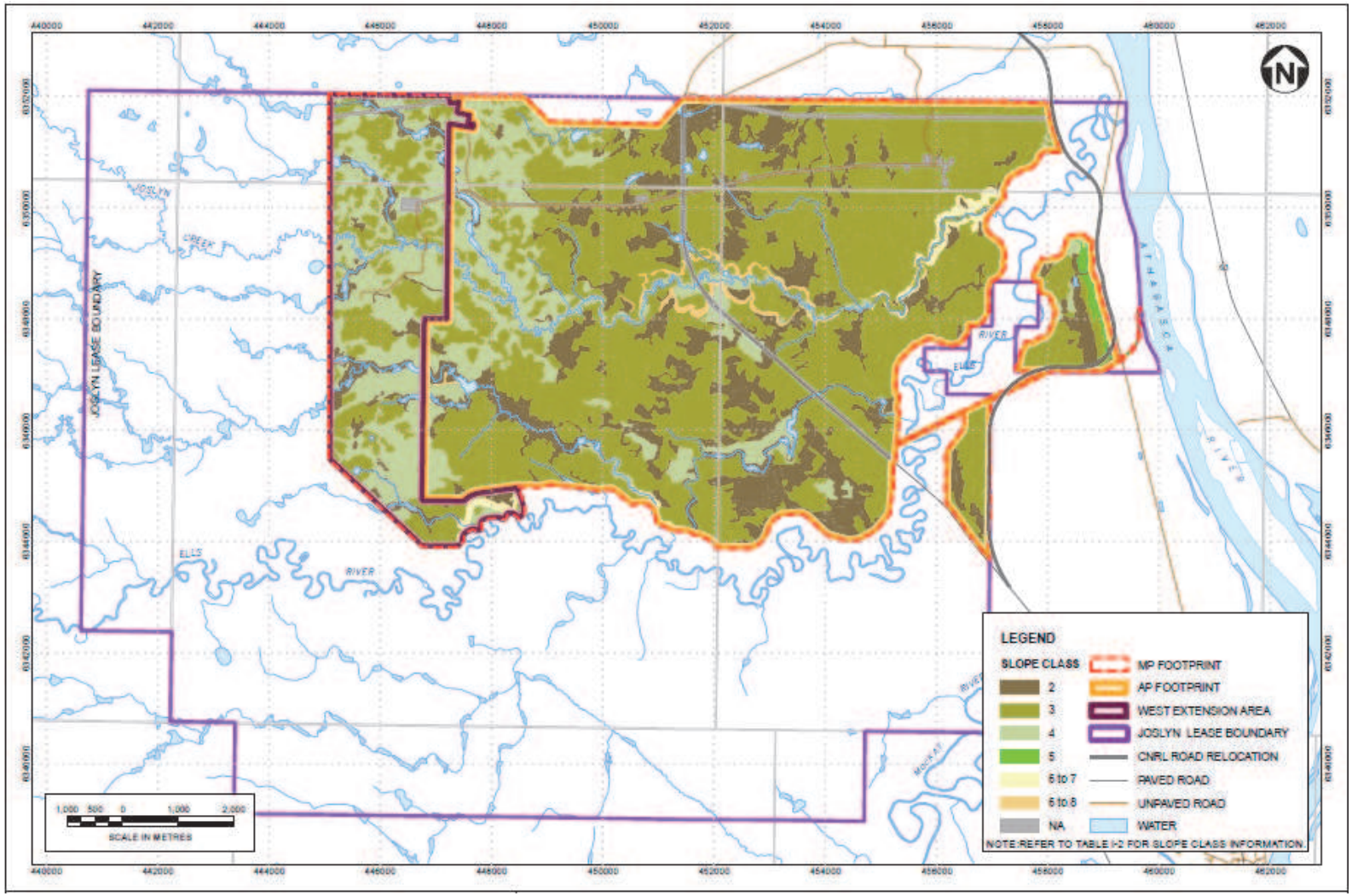

Figure F2-4 Landscape Slope Classes – Biophysical Setting

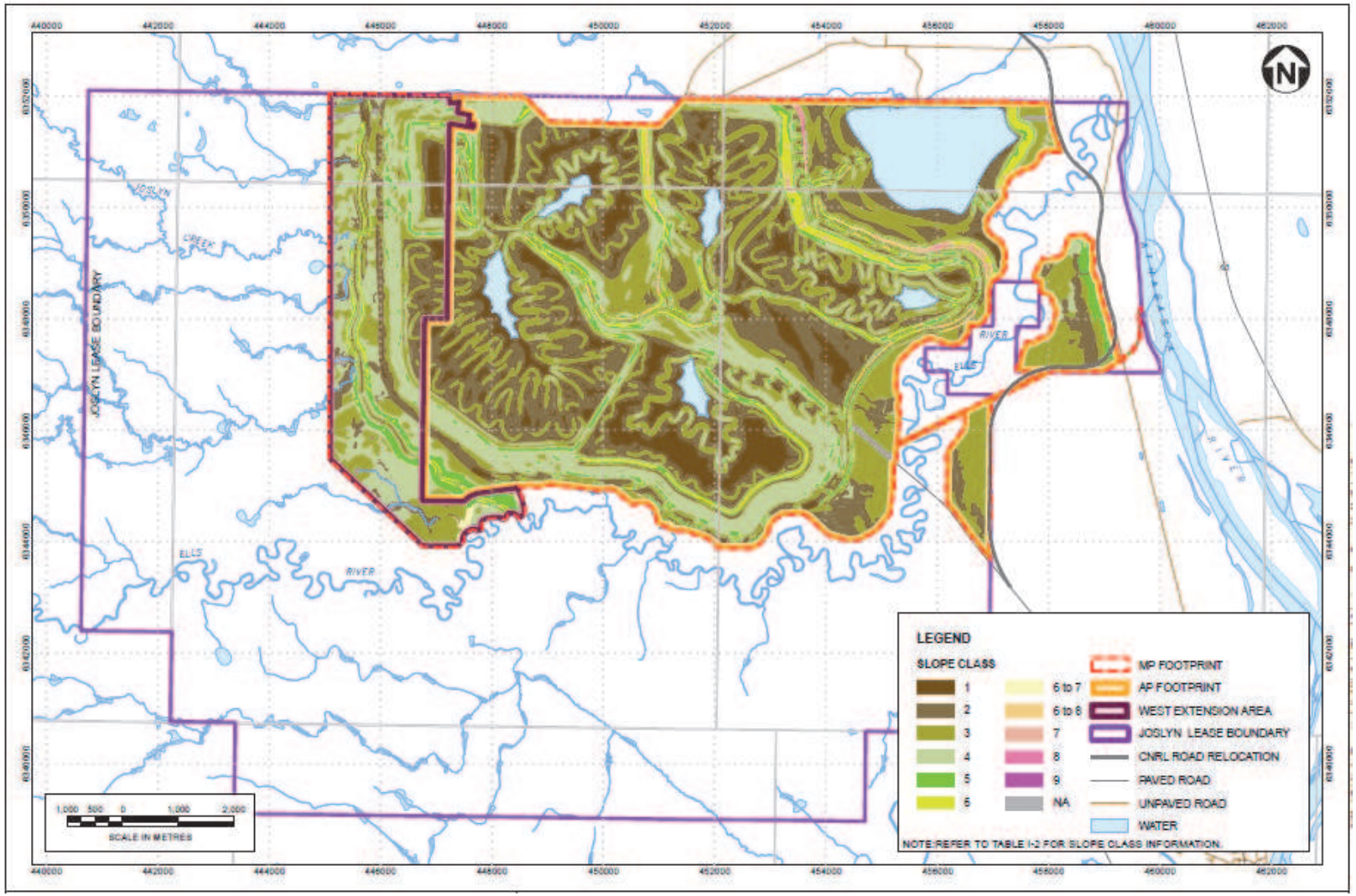

Figure F2-5 Landscape Slope Classes – Modified Project at Closure

F3 Assessment

The MP will change soils and terrain residual effects relative to the AP because of the facilities proposed for the West Extension Area and a revised CC&R Plan. These changes are discussed below for selected soils and terrain indicators. For a discussion on effects to soils resulting from changes to acidifying emissions associated with the MP, see Appendix K.

F3.1 Soil Map Units

The soils assessment completed for the MP footprint includes soil map units, and disturbed and reclaimed land. For the area of soil map units in the MP, see Table F3-1. Soil map unit areas in the MP represent the sum of the map unit areas in the AP plus the map unit areas in the West Extension Area.

Not all areas of each soil map unit will be disturbed in the MP footprint; 514 ha of the area will not be subjected to grading and soil disturbance although these areas could be subject to vegetation clearing. The mineral soil map unit most affected by development in the West Extension Area is DOV10/Ulh (loss of 346 ha), whereas the organic soil map unit most affected is MUS2m/O1 (loss of 177 ha) (see Table F3-1).

While the distribution and area of individual soil map units will change as a result of the MP, reclaimed soils proposed for the closure landscape will support the development of diverse soil conditions and associated ecosystems with equivalent capabilities to pre-disturbance conditions.

Table F3-1 Change in Soil Map Units

Soil Map Units	Biophysical Setting			Closure				
	AP Area [A]	West Extension Area [B]	MP Area [C=A+B][1]	MP Area with AP Footprint at Closure [D][2]	Change from Biophysical Setting with AP at Closure [E=D-C]	MP Area with MP Footprint at Closure [F][3]	Change from Biophysical Setting with MP at Closure [G=F-C]	Difference Between the MP and AP at Closure [H=G-E]
Units	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
BMT5/L1	81	0	81	2	-79	1	-81	-2
CHMM1/FP3	121	75	196	92	-104	44	-152	-48
CHMM1/U1l	197	0	197	1	-196	1	-196	0
DAN9/HR2h	39	0	39	29	-10	<1	-39	-29
DASU18/HR2m	20	0	20	6	-15	0	-20	-5
DASU18/U1h	33	0	33	7	-26	1	-33	-7
DASU18/U1l	55	0	55	15	-41	2	-53	-12
DOHR2/U1h	<1	0	<1	<1	0	0	<-1	<-1
DOKM2/U1h	98	57	155	67	-88	1	-154	-66
DOLV6/U1h	42	0	42	10	-32	1	-41	-9
DOLV6/U1l	9	0	9	2	-7	<1	-9	-2
DOLV9/H1l	9	0	9	1	-9	0	-9	0
DOLV9/U1h	316	0	316	12	-304	0	-316	-12
DOLV9/U1l	107	0	107	3	-104	<1	-107	-3
DOSE1/H1l	207	374	581	401	-180	135	-446	-266
DOSE2/H1l	0	5	5	5	0	4	-1	-1
DOV10/U1h	490	331	821	428	-394	81	-740	-346
DOV10/U1l	106	0	106	0	-106	0	-106	0
FRDA6/R2lr	7	0	7	7	0	0	-7	-7
FRLV2/U1h	59	0	59	0	-59	0	-59	0
FRLV2/U1l	65	0	65	0	-65	0	-65	0
KMLV1/U1h	325	62	388	135	-253	43	-344	-91
KMLV1/U1l	226	13	239	25	-214	4	-235	-21

Table F3-1 Change in Soil Map Units (cont'd)

Soil Map Units	Biophysical Setting			Closure				
	AP Area [A]	West Extension Area [B]	MP Area [C=A+B][1]	MP Area with AP Footprint at Closure [D][2]	Change from Biophysical Setting with AP at Closure [E=D-C]	MP Area with MP Footprint at Closure [F][3]	Change from Biophysical Setting with MP at Closure [G=F-C]	Difference Between the MP and AP at Closure [H=G-E]
Units	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**
KMLV2/U1h	109	12	121	12	-109	10	-112	-3
KMLV2/U1l	160	0	160	0	-159	0	-160	-1
LVK11/l4	<1	0	<1	<1	<-1	0	<-1	<-1
LVK12/l5	142	26	168	39	-129	11	-157	-28
MIFR5/U1h	266	0	266	8	-257	2	-264	-7
MIFR5/U1l	56	0	56	5	-51	1	-55	-4
MIL1/U1h	310	0	310	0	-310	<1	-310	0
MIL1/U1l	1	0	1	1	0	<1	<-1	<-1
MIL5/U1h	314	0	314	3	-312	1	-314	-2
MLD1c-G/O3	37	37	74	66	-9	11	-63	-54
MLD1c-G/O5	41	0	41	0	-41	0	-41	0
MLD1m-G/O3	113	60	173	77	-96	9	-164	-68
MLD1m-G/O5	266	0	266	25	-241	1	-265	-24
MLD1s-G/O5	19	0	19	0	-19	0	-19	0
MLD2c/O1	10	0	10	3	-7	0	-10	-3
MLD2m/O1	105	18	123	18	-105	10	-113	-8
MLD2s/O1	34	0	34	0	-34	0	-34	0
MLD2s-G/O1	27	0	27	0	-27	0	-27	0
MLD3/O2	1	0	1	0	-1	0	-1	0
MMW1/U1l	1	0	1	1	0	0	-1	-1
MMW2/FP3	78	5	82	16	-67	0	-82	-15
MMW21/U1h	17	0	17	0	-17	0	-17	0
MMW21/U1l	65	0	65	6	-59	0	-65	-6

Table F3-1 Change in Soil Map Units (cont'd)

Soil Map Units	Biophysical Setting			Closure				
	AP Area [A]	West Extension Area [B]	MP Area [C=A+B][1]	MP Area with AP Footprint at Closure [D][2]	Change from Biophysical Setting with AP at Closure [E=D-C]	MP Area with MP Footprint at Closure [F][3]	Change from Biophysical Setting with MP at Closure [G=F-C]	Difference Between the MP and AP at Closure [H=G-E]
Units	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**
MMY2/SC1	191	57	248	70	-177	18	-230	-52
MMY6/SC2r	30	0	30	0	-30	0	-30	0
MUS1c-G/O5	425	0	425	19	-406	<1	-425	-19
MUS1m-G/O5	908	21	929	94	-835	25	-904	-69
MUS1s-G/O5	127	0	127	3	-124	0	-127	-3
MUS2c/O1	211	45	256	90	-166	41	-215	-49
MUS2m/O1	253	179	431	196	-235	19	-412	-177
MUS3/O2	69	122	191	123	-68	51	-140	-72
PELV12/SC2	73	6	79	7	-72	6	-73	-1
PELV2/L3	31	27	58	33	-25	6	-53	-27
PELV9/U1h	141	0	141	73	-68	<1	-140	-72
PELV91/U1h	31	0	31	7	-24	<1	-30	-6
Water and Littoral	2	13	15	441	426	547	532	106
ZDL	134	22	156	31	-125	4	-152	-27
Reclaimed Land	0	0	0	6,266	6,266	7,888	7,888	1,622
Total[4]	**7,411**	**1,569**	**8,981**	**8,981**	**N/A**	**8,981**	**N/A**	**N/A**

NOTES:
[1] See Figure F2-1.
[2] MP area with the AP footprint at closure + West Extension Area biophysical setting (see Figure F2-2).
[3] MP area with the MP footprint at closure (see Figure F2-3). Some soil areas (514 ha) in the West Extension Area are undisturbed.
[4] Values have been adjusted for rounding.
N/A = Not applicable.

F3.2 Soil Quality

Soil quality is affected by soil salvage, storage and replacement. For the updated sequencing, soil salvage, soil replacement and reclamation material balances for the MP, see Section 3.10. The CC&R Plan was designed to include salvage and replacement of appropriate quality soils to meet the targeted closure ecosite phases (see Table F3-2). All uplands surface soil (topsoil) from the MP footprint is planned to be salvaged, including both coarse and fine-textured soil types. In addition, appropriate volumes of peat-mineral mix will be obtained from areas of wetland soil types.

Reclamation materials will be directly placed, when possible, in areas ready to be reclaimed or will be stored in reclamation materials stockpiles (RMS). Forest floor organic material, which contributes both nutrients and additional water and nutrient-holding capacity, will be incorporated into the salvaged mineral topsoil. During topsoil salvage some upland subsoil (B horizon) might also be incorporated in the topsoil (A horizon) and could change the physical and chemical properties of salvaged topsoil. The change in topsoil quality by admixing during salvage will have a negative effect, but of negligible consequence. The incorporation of forest floor organic material will also counteract the effects of admixing subsoil with mineral topsoil.

Salvage, storage and replacement of soils will alter soil quality in the MP footprint. However, the reconstructed soils targeted in the CC&R Plan are designed to support sustainable, diverse ecosystems on the closure landscape with equivalent capabilities to pre-disturbance conditions.

F3.3 Landscape Changes

Similar to the AP, the reconstructed MP landscape will have more varied slopes than the natural landscape. Reclaimed slopes will be contoured to replicate natural terrain features and will blend with the surrounding landscape. For a comparison of MP and AP terrain slopes at closure, see Table F3-3.

At MP closure, Class 2 and Class 3 slopes are nearly equal in area and together are the slope classes of greatest area, covering 5152 ha of the MP footprint. Steeper slopes (greater than Class 5) are relatively uncommon, with 283 ha of slopes greater than Class 5 at MP closure.

The slope characteristics at closure are similar between the MP and the AP, except for minor shifts in the relative area of several individual slope classes (see Table F3-3). There is a shift towards greater area of Class 1, Class 2 and greater than Class 5 slopes in the MP landscape, with a reduction of Class 3 and Class 4 slopes. The small increase in steeper slopes at closure for the MP will contribute to the development of both wetland and pit lake components in the closure ecosystem (see Section 3.10.4), with steeper topography resulting in increased subsurface flow of water towards these parts of the closure landscape.

While the distribution and area of individual slope classes will change for the MP compared with the biophysical setting, closure slopes have the potential to support the development of diverse ecosystems with implementation of mitigation measures to manage stability and water erosion.

Table F3-2 Pre-Development and Closure Ecosite Phases

Ecosite Phase	Pre-Development Ecosite Phases (A)		End of Closure Target Ecosite Phases (B)		Difference (B-A)	
	(ha)	(%)[1]	(ha)	(%)[1]	(ha)	(%)
Upland Ecosite Phases						
a1 – lichen Pj	162	2	0	0	-162	-2
b1 – blueberry Pj-Aw	201	2	262	3	61	1
b2 – blueberry Aw(Bw)	69	1	0	0	-69	-1
b3 – blueberry Aw-Sw	112	1	207	2	95	1
b4 – blueberry Sw-Pj	42	<1	105	1	63	1
c1 – Labrador tea-mesic Pj-Sb	9	<1	565	7	556	6
d1 – low-bush cranberry Aw	1,501	17	1,136	13	-365	-4
d2 – low-bush cranberry Aw-Sw	615	7	1,716	20	1,101	13
d3 – low-bush cranberry Sw	127	1	632	7	505	6
e1 – dogwood Pb-Aw	3	<1	0	0	-3	- <1
e2 – dogwood Pb-Sw	30	<1	127	1	97	1
e3 – dogwood Sw	17	<1	0	0	-17	- <1
f1 – horsetail Pb-Aw	56	1	0	0	-56	-1
f2 – horsetail Pb-Sw	21	<1	175	2	154	2
f3 – horsetail Sw	14	<1	25	<1	11	<1
g1 – Labrador tea-subhygric Sb-Pj	21	<1	2,085	24	2,064	24
h1 – Labrador tea / horsetail Sw-Sb	202	2	97	1	-105	-1
Subtotal Upland Ecosite Phases	*3,202*	*37*	*7,131*	*82*	*3,929*	*46*
Wetlands Ecosite Phases						
i1 – treed bog	467	5	0	0	-467	-5
i2 – shrubby bog	953	11	0	0	-953	-11
j1 – treed poor fen	367	4	0	0	-367	-4
j2 – shrubby poor fen	260	3	0	0	-260	-3
k1 – treed rich fen	167	2	0	0	-167	-2
k2 – shrubby rich fen	582	7	0	0	-582	-7
k3 – graminoid rich fen	141	2	0	0	-141	-2
l1 – marsh	2	<1	144	2	142	2
Riparian margins	0	0	945	11	945	11
Subtotal Wetlands Ecosite Phases	*2,939*	*34*	*1,089*	*13*	*-1,850*	*-21*
Total Anthropogenic	**2,481**	**29**	**0**	**0**	**-2,481**	**-29**
Total Lake and Littoral Area	**0**	**0**	**403**	**5**	**403**	**5**
Total	**8,622**	**100**	**8,622**	**100**	**N/A**	**N/A**

NOTES:
[1] Proportion of total footprint area.
Totals might not equal the sum of individual values because of rounding.
Total area listed in table is less than the MP footprint total because not all areas are developed in the MP footprint.
N/A = Not applicable.

Table F3-3 Changes in Terrain Slope

Slope Class[1]	Biophysical Setting			Closure				
	AP Area [A]	West Extension Area [B]	MP Area [C=A+B][2]	MP Area with AP Footprint at Closure [D][3]	Change from Biophysical Setting with AP at Closure [E=D-C]	MP Area with MP Footprint at Closure [F][4]	Change from Biophysical Setting with MP at Closure [G=F-C]	Difference Between the MP and AP at Closure [H=G-E]
Unit	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**
1	0	0	0	264	264	1,028	1,028	764
2	1,586	202	1,788	1,720	-68	2,536	748	816
3	4,584	538	5,123	3,701	-1,422	2,616	-2,507	-1,085
4	925	767	1,691	2,211	520	1,618	-73	-593
5	39	0	39	207	168	337	298	130
6	0	0	0	251	251	231	231	-20
6 to 7	79	26	105	38	-67	20	-85	-18
6 to 8	63	0	63	28	-35	<1	-63	-28
7	0	0	0	28	28	25	25	-3
8	0	0	0	1	1	6	6	5
9	0	0	0	0	0	<1	<-1	<1
N/A (Water, Disturbed Land)	136	35	171	532	361	564	393	32
Total[5]	**7,412**	**1,569**	**8,981**	**8,981**	**N/A**	**8,981**	**N/A**	**N/A**

NOTES:
[1] See Table F2-3 for slope class definitions.
[2] See Figure F2-1.
[3] MP area with the AP footprint at closure + West Extension Area biophysical setting (see Figure F2-4).
[4] MP area with the MP footprint at closure (see Figure F2-5). Some soil areas (514 ha) in the West Extension Area are undisturbed.
[5] Values have been adjusted for rounding.
N/A = Not applicable.

F3.4 Soil Erosion

Potential for soil erosion on the MP will be controlled through CC&R practices that establish vegetative cover on erosion-prone slopes immediately following reclamation material placement. Coarse woody debris will be distributed in erosion-prone areas to provide initial protection until vegetation is established (see Section 3.10.4.4).

While erosion risk will be altered by the MP relative to the biophysical setting, erosion will be managed by the practices described in the CC&R Plan. The assessment conclusions are consistent with those of the AP (2010 AI Project Update: Section 14.10.3.4).

F3.5 Site Type

In alignment with a provincial regulatory shift away from use of the Land Capability Classification (LCC) for forestry, the JNMP EPEA Approval does not include a requirement to obtain equivalent land capability as defined by the LCC system. Rather, land capability was assessed using site types, as defined in the *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition* (AENV 2010) (see Table F3-4).

Table F3-4 Site Type Classification

Site Type	Description of Ecosites and Wetlands Classes	Associated Soil Orders	Soil Moisture Conditions	Soil Nutrient Availability
Dry	Sharing characteristics of ecosites a and b	Coarse textured Brunisolic soils	Rapidly drained	Low available nutrients
Moist-Poor	Sharing characteristics of ecosite c	Luvisolic and Solonetzic soils	Well to moderately well drained	Low available nutrients
Moist-Rich	Sharing characteristics of ecosites d and e	Luvisolic soils	Well to moderately well drained	Moderate to high available nutrients,
Wet-Poor	Sharing characteristics of ecosite g	Imperfectly drained Luvisolic and Regosolic soils and poorly drained Gleysolic soils	Imperfectly to poorly drained	Moderate to high available nutrients
Wet-Rich	Sharing characteristics of ecosites f and h	Imperfectly drained Luvisolic soils and poorly drained Gleysolic soils	Imperfectly to poorly drained	Moderate to high available nutrients
Hydric-Poor[1]	Sharing characteristics of bog and fen wetlands classes	Organic and peaty Gleysolic soils	Very poorly drained	Low available nutrients
Hydric-Rich[1]	Sharing characteristics of marsh and swamp wetlands classes	Gleysolic soils	Poorly drained	Moderate to high available nutrients

NOTE:
[1] Wetlands site types developed for this assessment, because they are not included in AENV (2010).
SOURCE: *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition* (AENV 2010).

Site type considers several of the inputs to the LCC, including moisture and nutrient regimes, and is based on the edatopic grid that defines ecosites and ecosite phases. To allow for a fully rounded comparison of all vegetation types in the CC&R Plan, two additional site types are proposed to address wetlands soils that are not considered in the *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition* (AENV 2010). For defined and proposed site types found in the MP footprint, see Table F3-4. For the distribution of site types at biophysical setting in the MP footprint, see Figure F3-1, and for the MP at closure, see Figure F3-2.

The moist-rich (2533 ha) and hydric-poor (3061 ha) site types are the most common in the MP biophysical setting (see Table F3-5). The dominance of these two site types reflects a landscape that consists primarily of well-drained uplands and very poorly drained peatlands and lacks slope positions with imperfect to poor drainage. Areas of open water in the biophysical setting are limited.

At MP closure, the wet-poor site type shows the greatest increases in area, a change of 2034 ha relative to biophysical setting. Moist-rich and moist-poor site types also increase. The hydric-poor is the only type to decrease at MP closure, with a decrease of 1930 ha compared with biophysical setting. There is also an increase of open water for the MP at closure-a change of 363 ha. The changes in site type distribution observed between biophysical setting and MP closure reflect the development of a landscape with a more even distribution of soil drainage regimes, except for very poorly drained sites. In particular there is an increase in imperfectly to poorly drained soils resulting from change in slope characteristics.

The decline of the very poorly drained areas at MP closure (i.e., peatlands) is partially offset as well by the increase in open water. Although peatlands (hydric-poor site type) are not included in the MP CC&R Plan, conditions are established for eventual development of peat-accumulating wetlands. While closure drainage is highly integrated compared with the biophysical setting for both the MP and AP, modification of micro-topography during final reclamation will create locations of very poorly drained areas that will promote the establishment of peat-accumulating wetlands.

Soil salinity will increase in portions of the MP closure landscape relative to biophysical setting. At closure the hydric-rich site type will develop on soils that are expected to salinize over time as a result of drainage from tailings. Salinity in the MP closure landscape will be dynamic, reflecting the variable intensity of salinity reaching wetlands.

In summary, the MP will alter the area and distribution of site types, but diversity of site types will not be reduced on the closure landscape. The reconstructed site types that will develop as a result of the CC&R Plan are designed to support sustainable, diverse ecosystems on the closure landscape with equivalent capabilities to pre-disturbance conditions.

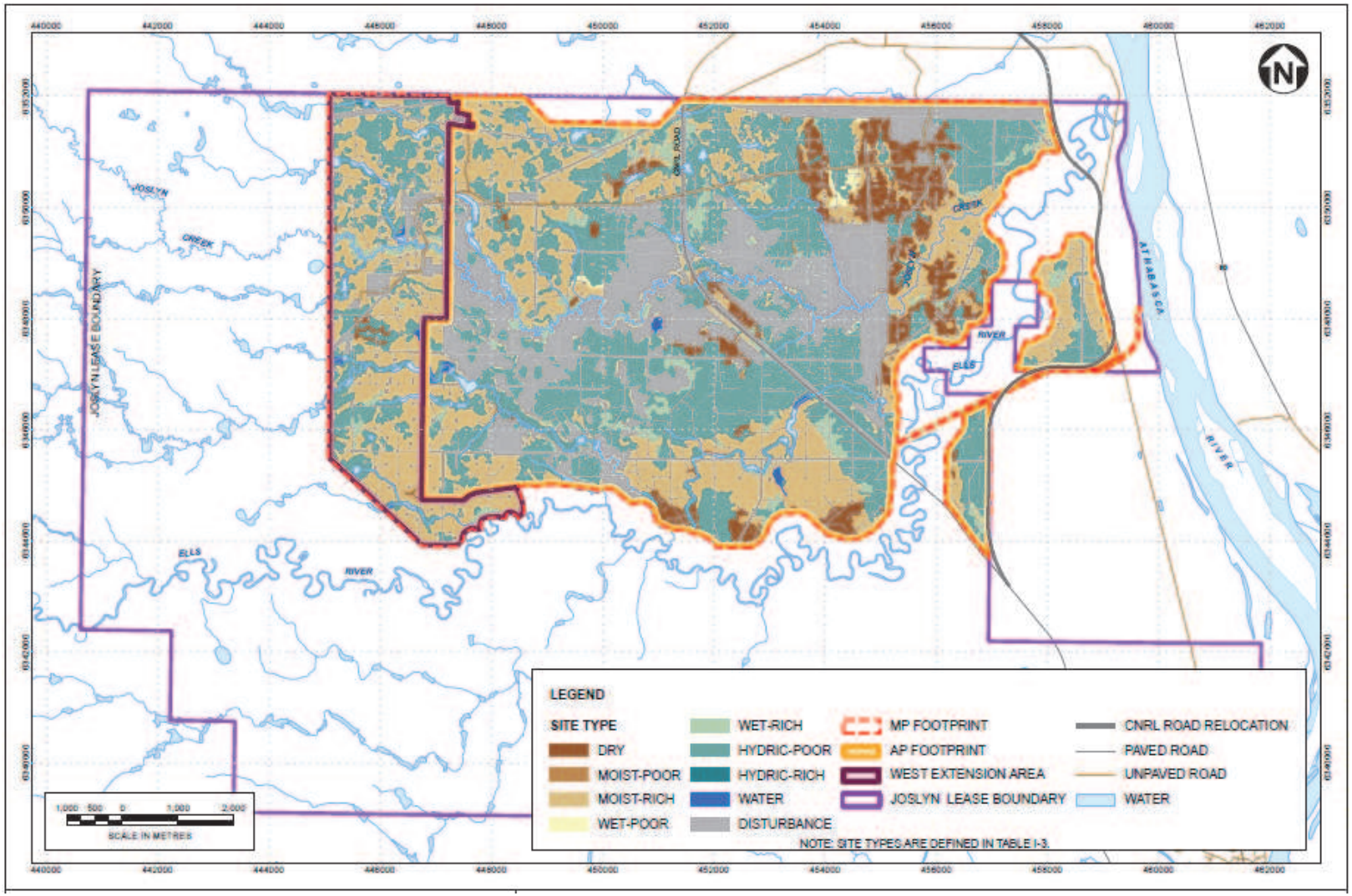

Figure F3-1 Site Types – Biophysical Setting

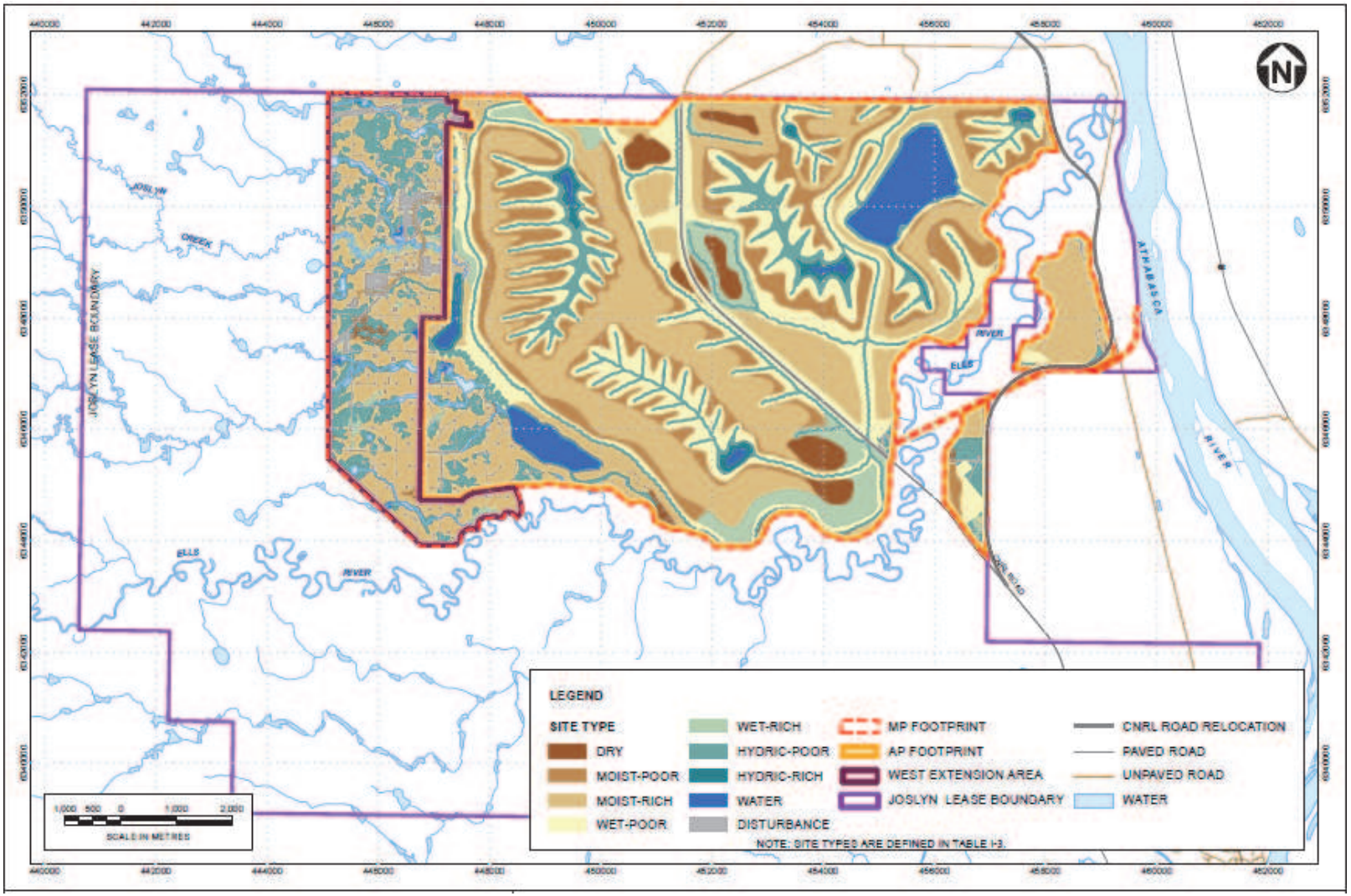

Figure F3-2 Site Types – Modified Project at Closure

Table F3-5 Change in Distribution of Site Types

Site Type	Biophysical Setting			Closure				
	AP Area [A]	West Extension Area [B]	MP Area [C=A+B][2]	MP Area with AP Footprint at Closure [D][2]	Change from Biophysical Setting with AP at Closure [E=D-C]	MP Area with MP Footprint at Closure [F][3]	Change from Biophysical Setting with MP at Closure [G=F-C]	Difference Between the MP and AP at Closure [H=G-E]
Unit	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**	**(ha)**
Dry	576	19	595	259	-336	577	-18	318
Moist-Poor	9	0	9	1,158	1,149	565	556	-593
Moist-Rich	1,764	769	2,533	3,285	752	3,743	1,210	458
Wet-Poor	21	0	21	1,619	1,598	2,055	2,034	436
Wet-Rich	255	58	313	409	96	321	8	-88
Hydric-Poor[4]	2,564	497	3,061	1,464	-1,597	1,131	-1,930	-333
Hydric-Rich	0	4	4	96	92	141	137	45
Subtotal	*5,189*	*1,347*	*6,536*	*8,290*	*0*	*8,533*	*0*	*0*
Cutblocks	1,253	4	1,257	0	-1,257	0	-1,257	0
Disturbed Land	942	201	1,143	321	-822	38	-1,105	-283
Mineral	<1	0	<1	<1	<1	0	<1	<1
Water and Littoral	30	18	48	368	320	411	363	43
Total[5]	**7,412**	**1,569**	**8,981**	**8,981**	**0**	**8,981**	**0**	**0**

NOTES:
[1] See Figure F2-1.
[2] MP area with the AP footprint at closure + West Extension Area biophysical setting (see Figure F3-1).
[3] MP area with the MP footprint at closure. Some soil areas (514 ha) in the West Extension Area are undisturbed (see Figure F3-2).
[4] Includes Sh2 and Sh3 from the AP CC&R Plan and riparian margin from the MP CC&R Plan.
[5] Values have been adjusted for rounding.
N/A = Not applicable.

F4 Mitigation and Management

Soils and terrain mitigation and management measures for the MP will be consistent with that identified for the AP (see Table F4-1 and Section 3.10.4).

Table F4-1 Mitigation and Management Measures

Mitigation and Management Measure	Effect
Salvage surface soil before sequential mine development	Conservation of the soil resource
Use direct placement of mineral soil on reclaimed landscapes when operationally feasible	Early reclamation and establishment of a functioning ecosystem
Revegetate soil stockpiles and reclaimed areas as soon as possible	Protects soil resource from loss to wind and water erosion
Replace coversoil with minimal levelling resulting in soil with low bulk density and increased porosity; these rough surfaces will catch and hold snow, reduce the risk of erosion and provide a greater diversity of microsites	Promotes moisture infiltration, reduce water erosion and encourage plant community development and a functioning ecosystem
Establish nurse crops and spread coarse woody debris on areas with moderate soil erosion potential	Reduces water erosion potential until a target ecosite community is established
Use alternate erosion-control measures (e.g., use coarse woody debris) in addition to nurse crops, in areas of high soil erosion potential	Protects soil resource from water erosion loss and reduces stream sedimentation potential
Use rip-rap or gravel to armour riparian soils or soils subject to convergent flow from hill slope swales	Prevents soil loss by overland flow

Consistent with the practices planned for the AP, soils salvaged and stockpiled and as part of the MP activities will be monitored as per the requirements of the Soil Salvage Plan (Section 3.6.29 of the AP EPEA Approval 22804400-00-00). Following placement of reclamation materials, surveys will be conducted to assess the depth, physical and chemical properties of the soils, as per Section 6.3.23 of EPEA Approval 22804400-00-00.

Information on activities related to soils has been reported to ESRD in the annual Conservation and Reclamation Report submitted in compliance with Section 6.4.48 of EPEA Approval 22804400-00-00, as amended.

F5 Summary

The MP will alter soil and terrain characteristics relative to the biophysical setting. The MP will result in incremental changes to soils and terrain characteristics that are relatively consistent with what was predicted for the AP at closure. These changes relate primarily to the West Extension Area.

The conclusions for the soil and terrain assessment of the MP are consistent with those for the AP (2010 AI Project Update: Section 14.10.5).

F6 References

AENV (Alberta Environment). 2010. *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition*. Prepared by the Terrestrial Subgroup of the Reclamation Working Group of the Cumulative Environmental Management Association, Fort McMurray, AB. December 2009. ISBN: 978-0-7785-8826-9 (On-line).

Expert Committee on Soil Survey. 1998. *The Canadian System of Soil Classification.* 3rd Edition. Agriculture Canada. Ottawa.