CEMVP-OP-R 12 September 2011

MEMORANDUM

SUBJECT: *Distinguishing Between Bogs That Are Entirely Precipitation Driven Versus Those with Some Degree of Mineral Inputs from Groundwater and/or Surface Water Runoff*

1. Introduction. For purposes of addressing potential indirect impacts of the proposed Polymet project, the Wetlands Workgroup recommended that wetlands identified as open bogs or coniferous bogs under the Eggers and Reed (1997) classification system[1] be subcategorized as either ombrotrophic (hydrology and mineral inputs entirely from direct precipitation) or somewhat minerotrophic (some degree of mineral inputs from groundwater and/or surface water runoff). This is important because ombrotrophic bogs would likely not be impacted by groundwater draw downs associated with proposed mining operations, whereas more minerotrophic bogs would have a higher likelihood of being impacted.

2. Data Collection. Field work conducted 8-9 September 2010 involved groundtruthing a representative cross section of wetland types within the proposed Polymet site. I compiled a vegetation species list for each numbered wetland polygon inspected. Be advised that this was a one-time meander survey and is not by any means a complete species list. I noted percent areal cover of *Sphagnum* mosses – a major factor in distinguishing bogs from other wetland types. I also identified dominant plant species (Table 1).

During the 8-9 September 2010 field work, John Coleman, GLIFWC, collected pH and specific conductivity data based on grab samples. It should be noted that the pH strips used are generally within one unit of accuracy (e.g., pH of 6 to 7, or 7 to 8). The equipment used to measure conductivity was also limited in accuracy and samples were often taken in standing, open water where particulates or other factors could have influenced the measurement. Many variables come into play with collecting these data (e.g., type of instrument; accuracy of equipment; location of the sample point within the wetland (e.g., edge, middle,); depth where the water sample was taken; whether the sample was from water in a microdepression or an auger hole; whether water was bailed and allowed to refill before sampling). Similar to a one-time vegetation survey, these data were used to provide a general understanding of the wetlands field inspected.

On 31 May 2011, Daniel Jones of Barr Engineering conducted a vegetation survey of three additional sites – Wetlands 83, 90A and 700. Plant species and their cover classes were recorded. These data are included as Table 2. As discussed in the following paragraph, cover classes reflecting dominance and abundance of ombrotrophic species are more informative compared to a simple presence/absence test.

3. Indicator Species of Ombrotrophic Bogs. The MnDNR classification system for native plant communities[2] includes a table of 25 species that are indicators of ombrotrophic bogs. Eighteen of those species were observed in one or more of the numbered wetland polygons inspected in September 2010

[1] Under the Eggers and Reed classification system, acid peatlands with a more or less continuous carpet of *Sphagnum* mosses key out to coniferous bogs (black spruce and/or tamarack tree layer) or open bogs (heath family shrubs and/or sedges and forbs tolerant of low nutrient conditions).

[2] Minnesota Department of Natural Resources. 2003. *Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province*. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Non-Game Research Program. St. Paul, MN. 394 pp.

and May 2011. The discussion of ombrotrophic indicator species in the MnDNR classification system states that, "…the occurrence of any other species can be considered an indicator of minerotrophic conditions." However, for our purposes, I do not advocate that the presence of a species not on the MnDNR list rules out ombrotrophic conditions for the plant community as a whole. Rather, dominance and abundance of ombrotrophic species should be applied. There are several reasons for this. One, I recorded all plant species observed including single individuals. Therefore, the presence of a species not on the MnDNR list may have been a single individual plant. Second, microtopography, including upland "islands" and inclusions of other wetland communities, occur within each polygon resulting in a mosaic of plant associations. Third, some of the species recorded were on the edge or border with uplands, a disturbance (e.g., road), or a microtopographic feature. Fourth, some polygons are many acres in size so some degree of lumping is unavoidable given the scale and complexity of the Polymet site. Drawing lines across peatland mosaics to delineate breaks between plant communities is a purely artificial exercise that, out of necessity, must include some degree of generalization. Drawing smaller and smaller polygons to tease out patches of different plant communities is not warranted or practical, in my opinion.

Specific examples illustrate that caution should be used before reading too much into the presence of non-ombrotrophic species. For example, Wetland 77 is dominated by tamarack and Labrador tea and has several other MnDNR ombrotrophic bog indicator species. I also recorded two minerotrophic species (cattail [*Typha* sp.] and blue flag iris [*Iris versicolor*]). However, the cattail and iris were in the bottom of a dry stream channel that was approximately 2.5-3.0 feet below the *Sphagnum* layer, a different microhabitat. The result of deleting the cattail and iris is that 4 of the remaining 5 plant species are MnDNR indicators of ombrotrophic conditions.

Speckled alder, bog birch and balsam willow are ubiquitous as they occur across multiple gradients in peatlands. Their presence (and again it could be one individual or a few scattered individuals) should not preclude a determination that a plant community as a whole is ombrotrophic. Additionally, I do not give much weight to the presence of white birch. Individuals of white birch were typically growing on high spots or upland inclusions. In any event, they were not representative of the wetland community.

4. Data Analysis. Of the 27 wetland polygons inspected, 15 wetlands had greater than 75 percent areal cover of *Sphagnum* mosses. This subgroup of wetlands was selected for further analysis as shown on Tables 1 and 2. MnDNR ombrotrophic bog indicator species are shown in blue font (e.g., black spruce through blueberry on Table 1). The number of ombrotrophic species compared to all species is shown at the bottom of the column for each numbered wetland. Percent of ombrotrophic species ranged from 100% (11 of 11) to 27% (6 of 22). Looking from the left to right columns on Table 1 reveals a gradual gradient where non-ombrotrophic species became more prevalent.

Included in the subgroup are four wetlands within the tailings basin area and eleven wetlands within the mine site with its associated potential for groundwater draw down. Eleven of these wetlands were classified as coniferous bogs in the *NorthMet Project Baseline Wetland Type Evaluation* report (Barr Engineering, April 2011) while four were classified as open bogs. I included the wetlands within the tailings basin area to see if there were any trends or indicators that could be applied across the board, e.g., can all "open bogs" be considered ombrotrophic?

a. Wetland 974 (Coniferous Bog, Tailings Basin Area): Dominated by black spruce, tamarack, Labrador tea, three-seeded sedge (*Carex trisperma*) and *Sphagnum* mosses. One hundred percent of species are MnDNR indicator species for ombrotrophic bogs. Specific conductivity 61 uS/cm; pH 5.5. Determination: **Ombrotrophic**.

b. Wetland 640 (Coniferous Bog, Tailings Basin Area): Dominated by black spruce, tamarack, Labrador tea, leatherleaf, cottongrass and *Sphagnum* mosses. Eight of nine species were

TABLE 1:
Vegetation, pH and Specific Conductivity of Open Bogs and Coniferous Bogs

	Wetland Number											
	974	640	917	885*	742	780	32	48	77	887	900	257
pH	5.5	6.0	6.0	5.0	6.0	5.25	6.0	6.0	6.0	6.0	6.5	7.0
				5.5						6.5		
Specific conductivity (uS/cm)	61	19	32	24, 27	106	51	58	87	60	102	53	87, 65
				30, 33	66	56	64			71		73, 67
Sphagnum spp. percent areal cover	80-90	85	80	100	95	95	100	>75	>75	80-90	90	90
Black spruce (*Picea mariana*)	D	D	D	X	X	D	D	X		X	X	D
Tamarack (*Larix laricina*)	D	D	X		D	X		D	D	X		D
Labrador tea (*Ledum groenlandicum*)	D	D	D	X	D	D	X	D	X	X	X	X
Leatherleaf (*Chamaedaphne calyculata*)	X	D		X	X	X		X	D			X
Bog rosemary (*Andromeda glaucophylla*)	X	X		X	X	X						
Small cranberry (*Vaccinium oxycoccus*)	X	X	X	X	X	X			X			
Snowberry (*Gaultheria hispidula*)	X				X	X	X	X		X	X	X
Cottongrass (*Eriophorum vaginatum*)		D		X								
Bog sedge (*Carex oligosperma*)				X								
Poor sedge (*Carex paupercula*)	X		X									
Few-flowered sedge (*Carex pauciflora*)				X								
Three-seeded sedge (*Carex trisperma*)	D	X	D				X			X	X	X
Pitcher plant (*Sarracenia purpurea*)				X								
3-L. Solomon's seal (*Smilicina trifoliata*)	X		X	X								X
Indian pipes (*Monotropa uniflora*)			X									
Blueberry (*Vaccinium angustifolium*)	X		X	X			X	X		X		X
Speckled alder (*Alnus incana* ssp. *rugosa*)				X	X	X	X	D	D	X	X	X
Balsam willow (*Salix pyrifolia*)		X		X	X	X		X		X		
Bog birch (*Betula pumila*)				X	X	X						
Red maple (*Acer rubrum*)					X	X				X	X	X
Balsam fir (*Abies balsamea*)							X			X	X	
Bunchberry (*Cornus canadensis*)							X	X		X	X	X
Dwarf red raspberry (*Rubus pubescens*)							X	X		X	X	X
Starflower (*Trienalis borealis*)										X	X	X
Goldenthread (*Coptis trifoliata*)							X			X	X	X
Bristly clubmoss (*Lycopodium annotinum*)										X		
Blue-bead lily (*Clintonia borealis*)										X	X	X
Crested shield fern (*Dryopteris cristata*)										X	X	X
Cinnamon fern (*Osmunda cinnamomea*)												X
Lady fern (*Athyrium filix-femina*)												X
Oak fern (*Gymnocarpium* sp.)												
Shield fern (*Dryopteris carthusia*)												X
Wood horsetail (*Equisetum sylvaticum*)												X
Cattail (*Typha* spp.)									X			
Sedges (*Carex* spp.)												X
Iris (*Iris* sp.)									X			
Woolgrass (*Scirpus cyperinus*)			X									
Yellow lake sedge (*Carex utriculata*)				X								
A. red raspberry (*Rubus idaeus* v. *strigosus*)										X		
Red-osier dogwood (*Cornus sericea*)										X		X
White birch (*Betula papyrifera*)					X	X		X		X		
Black ash (*Fraxinus nigra*)										X		
Canada blue-j. (*Calamagrostis canadensis*)										X		X
Mountain ash (*Sorbus* sp.)												X
Swamp currant (*Ribes triste*)												X
Bog goldenrod (*Solidago uliginosa*)												X
Redst. aster (*Symphyotrichum puniceum*)												X
Fowl mannagrass (*Glyceria striata*)												X
Northern white cedar (*Thuja occidentalis*)											X	
Ombrotrophic spp./Total species	11/11	8/9	9/10	11/15	7/12	7/12	5/10	6/11	4/7	6/22	4/14	8/28

Blue font = MnDNR listed ombrotrophic bog species

Black font = Non-ombrotrophic species

*Additional pH readings = 5.0, 5.75

D = Dominant species

TABLE 2

		Cover Values[1]		
	Wetland ID	83	700	90A
	Location	Mine Site	Mine Site	Mine Site
	Classification[2]	Open bog	Open bog	Open bog
Common Name	**Scientific Name**			
Sphagnum cover	*Sphagnum* spp.	85-90%	90-95%	90-95%
Black spruce	*Picea mariana*	2	4	3
Tamarack	*Larix laricina*			1
Labrador tea	*Ledum groenlandicum*	3	4	1
Leatherleaf	*Chamaedaphne calyculata*			5
Bog rosemary	*Andromeda glaucophylla*			1
Bog laurel	*Kalmia polifolia*		1	1
Small cranberry	*Vaccinium oxycoccus*			2
Snowberry	*Gaultheria hispidula*	3	2	
Tufted cottongrass	*Eriophorum vaginatum*			1
Three-seeded sedge	*Carex trisperma*		3	
Few-flowered Sedge	*Carex pauciflora*	1		
Three-leaved Solomon's seal	*Smilacina trifolia*	2	1	2
Blueberry	*Vaccinium angustifolium*	2	2	2
Lingonberry	*Vaccinium vitis-idaea*			2
Bluejoint	*Calamagrostis canadensis*	2		
Small white violet	*Viola macloskeyi*	1		
Bunchberry dogwood	*Cornus canadensis*		1	
Paper birch	*Betula papyrifera*	1 (edge)	1	
Balsam fir	*Abies balsamifera*	1 (edge)		
Marsh horsetail	*Equisetum sylvaticum*		1	
Trailing arbutus	*Epigaea repens*		1	
Large cranberry	*Vaccinium macrocarpon*	1	2	1
Speckled alder	*Alnus incana* ssp. *rugosa*	4		
Balsam willow	*Salix pyrifolia*	1		
	Total species	14	13	13
	# of bog species[3]	7	8	12
	% bog species	50	62	92
	Dominant species	5	4	3
	% dominants that are bog spp.	80	100	100

[1]Cover values	Percent Cover
1	<5%
2	5-25%
3	25-50%
4	50-75%
5	>75%

Species in blue font are on MnDNR list of ombrotrophic species.

[2]Barr. April 2011. *NorthMet Project Baseline Wetland Type Evaluation*. Prepared for PolyMet Mining Company.

[3]Species are listed in Appendix D of the *DNR Ecoloigcal Classification System. Field Guide to Native Plant Communities* species of Minnesota, The Laurentian Mixed Forest Province.

ombrotrophic bog indicator species. The one exception was balsam willow, a ubiquitous species in peatlands, which could have been one individual. Specific conductivity 19 uS/cm; pH 6.0. Determination: **Ombrotrophic**

c. Wetland 917 (Coniferous Bog, Tailings Basin Area): Dominated by black spruce, Labrador tea, three-seeded sedge and *Sphagnum* mosses. Nine of 10 species were ombrotrophic bog indicator species. The exception was woolgrass, which could have been one individual. Specific conductivity 32 uS/cm; pH 6.0. Determination: **Ombrotrophic**.

d. Wetlands 742 and 780 (Coniferous Bogs, Mine Site): Dominated by black spruce, tamarack, Labrador tea and *Sphagnum* mosses with another 4 indicators of ombrotrophic conditions. Seven of 12 species were indicators of ombrotrophic conditions. Exceptions were the ubiquitous speckled alder, bog birch and balsam willow. Specific conductivity (uS/cm): 106 and 66 for Wetland 742 while it was 51 and 56 for Wetland 780; pH: 6.0 for Wetland 742 and 5.25 for Wetland 780. Determination: **Ombrotrophic**.

e. Wetland 32 (Coniferous Bogs, Mine Site): Dominated by black spruce and *Sphagnum* mosses with three additional indicators of ombrotrophic conditions. However, an influx of more minerotrophic species – balsam fir, bunchberry, dwarf red raspberry and goldenthread – was observed. Five of 10 species were indicators of ombrotrophic conditions. Specific conductivity 58 and 64 uS/cm; pH 6.0. Determination: **Not Ombrotrophic**.

f. Wetland 48 (Coniferous Bog, Mine Site): Dominated by tamarack, Labrador tea, speckled alder and *Sphagnum* mosses. Black spruce, leatherleaf and two other ombrotrophic indicator species were present. Of the four non-ombrotrophic species, two were balsam willow and white birch. Neither is a good indicator as discussed in 3. above. Specific conductance was 87 uS/cm; pH 6.0. Determination: **Borderline**.

g. Wetlands 887 and 900 (Coniferous Bogs, Mine Site). Of 22 species recorded in Wetland 887, only 6 (27%) were ombrotrophic indicator species. For Wetland 900, 4 of 14 (29%) species were ombrotrophic indicator species. Numerous minerotrophic species were observed including Canada blue-joint grass, blue-bead lily, balsam fir and white cedar. Specific conductivity (uS/cm): 53 for Wetland 900 while it was 71 and 102 for Wetland 887; pH: 6.0 and 6.5 for Wetland 887 and 6.5 for Wetland 900. Determination: **Not Ombrotrophic**.

h. Wetland 257 (Coniferous Bog, Tailings Basin Area). This wetland is dominated by black spruce, tamarack and *Sphagnum* mosses with another 6 species of ombrotrophic indicator species. However, only 8 of 28 species (29%) were indicators of ombrotrophic conditions. Specific conductivity (uS/cm): 65, 67, 73 and 87; pH 7.0. Determination: **Not Ombrotrophic**.

i. Wetland 885 (Open Bog, Northwest of Mine Site): Eleven of 15 species were ombrotrophic bog indicators. This was the only wetland inspected where we found bog sedge (*Carex oligosperma*) and pitcher plants and it produced the lowest pH reading (5.0) of all the wetlands field inspected. The group's consensus in the field was that this was a precipitation-only driven bog. The presence of speckled alder, balsam willow, bog birch and yellow lake sedge in this acidic, *Sphagnum* bog community further attests to the assertion that these species are ubiquitous. Specific conductivity (uS/cm): 24, 27, 30 and 33; pH: 5.0, 5.0, 5.5 and 5.75. Determination: **Ombrotrophic**.

j. Wetland 77 (Coniferous Bog, Mine Site): Dominated by tamarack, leatherleaf, speckled alder and *Sphagnum* mosses. Excluding species found only in the bottom of stream channel (see discussion

above), four of five species were ombrotrophic bog indicators. The exception was the ubiquitous speckled alder. Specific conductivity 60 uS/cm; pH 6.0. Determination: **Ombrotrophic**.

k. Wetland 83: Dominated by *Sphagnum* mosses (85-90% areal cover), speckled alder, labrador tea and snowberry (*Gaultheria hispidula*). Of 14 species, 7 are on the MnDNR list of ombrotrophic species including black spruce (5-25% areal cover). Three of 4 dominants are on that MnDNR list. At first glance, the abundance of speckled alder (50-75% areal cover) suggests classification as alder thicket under Eggers and Reed (1997); however, the carpet of *Sphagnum* mosses, black spruce, labrador tea and snowberry indicates the correct classification as a shrub-dominated bog community. Determination: **Borderline**.

l. Wetland 700: Dominated by *Sphagnum* mosses (90-95% areal cover), black spruce (50-75% areal cover), labrador tea (50-75% areal cover) and three-seeded sedge (*Carex trisperma*)(25-50% areal cover), all of which are on the MnDNR list of ombrotrophic species. In total, 13 species were recorded of which 8 are on the MnDNR list. This is a straightforward call based on the available information. Determination: **Ombrotrophic**.

m. Wetland 90A: Dominated by *Sphagnum* mosses (90-95% areal cover), leatherleaf (>75% areal cover) and black spruce (25-50% areal cover). Twelve of 13 species are on the MnDNR list of ombrotrophic species, as are 100% of the dominant species. Determination: **Ombrotrophic**.

5. Results and Discussion. Nine of the 15 coniferous bogs and open bogs described above are recommended for classification as ombrotrophic based on currently available data.

Interpretation of aerial photography alone is not sufficient to accurately characterize coniferous bogs and open bogs as either ombrotrophic or non-ombrotrophic. A site visit during the growing season by a qualified plant ecologist/botanist is necessary.

6. POC. Questions on the above can be directed to me at steve.d.eggers@usace.army.mil or (651) 290-5371.

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