CEMVP-OP-R 7 November 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. Ombrotrophic peatlands (hydrology and mineral inputs entirely from direct precipitation) develop from minerotrophic peatlands (some degree of mineral inputs from groundwater and/or surface water runoff) when conditions allow *Sphagnum* peat to accumulate to levels above the groundwater table. Once the peat is above the water table, surface water flows away from or around the elevated peat surface, which reduces inputs of minerals and nutrients (MnDNR 2003, page 215).[1] 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[2] be subcategorized as either ombrotrophic or somewhat minerotrophic. 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.

[1] 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.

[2] 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).

3. Indicator Species of Ombrotrophic Bogs. The MnDNR classification system for native plant communities includes a table of 25 species that are indicators of ombrotrophic bogs (MnDNR 2003, page 309). Eighteen of those species were observed in one or more of the numbered wetland polygons inspected in September 2010 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, qualifications to this statement are made as in the MnDNR description of a typical ombrotrophic bog of this floristic region ("Northern Spruce Bog" [APn80], page 219) which acknowledges that single individuals or clones of minerotrophic species may be present, "…minerotrophic species are absent or *present only as single individuals or single clones*" (emphasis added). For our purposes, I do not advocate that the presence of species other than those on the MnDNR list of ombrotrophic indicator species 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 non-ombrotrophic species may have been a single individual plant. Second, some of the species recorded were on the edge or border with uplands or a disturbance (e.g., road). Third, microtopography, including upland "islands" and inclusions of other wetland communities, occur within each polygon resulting in a mosaic of plant associations. 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 (*Alnus incana* ssp. *rugosa*) and bog birch (*Betula pumila*) are identified by MnDNR (2003) as indicators of minerotrophic conditions in acid peatlands (e.g., "Northern Poor Conifer Swamp," [APn81], page 221). Both of these species were present in two of the wetlands field inspected (885, 780) that were dominated by ombrotrophic species and had the most acidic conditions (pH 5.0, 5.25 and 5.5). Wetland 885 was discussed in the field as being a classic example of an ombrotrophic bog. The presence of speckled alder and bog birch in these cases could have been a single or a few individuals, or could have been individuals along the border with uplands, or could have been a microhabitat within the overall ombrotrophic bog. In any event, the presence of these species should not preclude a determination that the plant community as a whole is ombrotrophic.

Additionally, I do not give much weight to the presence of paper birch (*Betula papyrifera*). Individuals of paper birch were typically growing on high spots or upland inclusions and were not representative of the wetland community as a whole. Note that paper birch "…is occasionally present…" in acid peatlands (e.g., "Poor Black Spruce Swamp" [APn81a], page 224 (MnDNR 2003)).

In summary, the parameters used to classify the field inspected wetlands as ombrotrophic or non-ombrotrophic were the dominance of *Sphagnum* mosses, presence of MnDNR ombrotrophic indicator species and water chemistry data. Lesser weight was given to the water chemistry data because of the limitations of the testing methods and the few samples taken.

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 (2003) 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?

Ombrotrophic peatlands generally have a surface water pH <5.5 while minerotrophic peatlands generally have a surface water pH >5.5 (MnDNR 2003, pages 215-216). Three wetlands (974, 885, 780) had pH readings <5.5 while nine had pH readings of 6.0 to 7.0 (Table 1).

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 were 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 ombrotrophic bog indicator species. The one exception was balsam willow (*Salix pyrifolia*), 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 ten 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. Wetland 742 (Coniferous Bog, Mine Site): Dominated by *Sphagnum* mosses (95% areal cover), tamarack and Labrador tea with another five indicator species of ombrotrophic conditions. Overall, seven of twelve species were indicators of ombrotrophic conditions. Exceptions included speckled alder, bog birch and balsam willow – see comments about these species above. The highest specific conductivity (106 uS/cm) of any of the wetlands field inspected was recorded within this wetland and the pH was >5.5 (see comments about pH readings in 5. below). John Coleman (GLIFWC) commented that classifying this wetland as ombrotrophic based solely on plant composition would be an error. The water chemistry data suggests some degree of minerotrophic conditions. The conflicting indicators of vegetation (ombrotrophic) and water chemistry (minerotrophic) prevent a clear determination – additional sampling is required. Determination: **Inconclusive**.

e. Wetland 780 (Coniferous Bog, Mine Site): Dominated by *Sphagnum* mosses (95% areal cover), black spruce and Labrador tea with another five indicator species of ombrotrophic conditions.

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
Goldthread (*Coptis trifolia*)							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
D = Dominant species

*Additional pH readings = 5.0, 5.75

TABLE 2

Common Name	Scientific Name	Cover Values[1] 83	700	90A
	Wetland ID	83	700	90A
	Location	Mine Site	Mine Site	Mine Site
	Classification[2]	Open bog	Open bog	Open bog
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.

Seven of twelve species were indicators of ombrotrophic conditions. Exceptions included speckled alder, bog birch and balsam willow (see comments above). Specific conductivity (uS/cm): 51 and 56; pH: 5.25. Determination: **Ombrotrophic**.

f. Wetland 32 (Coniferous Bog, 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 goldthread – was observed. Five of ten species were indicators of ombrotrophic conditions. Specific conductivity 58 and 64 uS/cm; pH 6.0. Determination: **Not Ombrotrophic**.

g. 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. In total, six of eleven species (54%) were ombrotrophic indicators. Specific conductivity was 87 uS/cm; pH 6.0. Determination: **Not Ombrotrophic**.

h. Wetlands 887 and 900 (Coniferous Bogs, Mine Site). Of 22 species recorded in Wetland 887, only six (27%) were ombrotrophic indicator species. For Wetland 900, four of fourteen (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**.

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

j. Wetland 885 (Open Bog, Northwest of Mine Site): Eleven of fifteen species (73%) were ombrotrophic bog indicators. This was the only wetland inspected where we found bog sedge (*Carex oligosperma*) and pitcher plants. This wetland also 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 ombrotrophic community further attests to the assertion that a few individuals of these species should not rule out a determination that the overall community is ombrotrophic. Specific conductivity (uS/cm): 24, 27, 30 and 33; pH: 5.0, 5.0, 5.5 and 5.75. Determination: **Ombrotrophic**.

k. 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 (80%) were ombrotrophic bog indicators. The exception was speckled alder. Specific conductivity 60 uS/cm; pH 6.0. Determination: **Ombrotrophic**.

l. Wetland 83 (Open Bog, Mine Site): Dominated by *Sphagnum* mosses (85-90% areal cover), speckled alder, labrador tea and snowberry (*Gaultheria hispidula*). Of fourteen species, seven are on the MnDNR list of ombrotrophic species including black spruce (5-25% areal cover). 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: **Not Ombrotrophic**.

m. Wetland 700 (Open Bog, Mine Site): 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, thirteen species were recorded of which eight are on the MnDNR list. Determination: **Ombrotrophic**.

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

5. Results and Discussion. Eight of the 15 coniferous bogs and open bogs described above are recommended for classification as ombrotrophic based on currently available data. This includes two wetlands with pH readings of 6.0 (640, 917), which is above the pH associated with ombrotrophic peatlands (pH <5.5). However, these readings are within the margin of error associated with the sampling method used. Moreover, both of these wetlands had strongly ombrotrophic plant communities (89% and 90% MnDNR indicator species) and very low specific conductivity (19 and 32 uS/cm).

This information is one factor for use in estimating potential wetland impacts due to mine dewatering. It is important to note its limitations. The information gathered does not differentiate ombrotrophic bogs that are hydrologically isolated from the groundwater aquifer (e.g., perched, have an unsaturated zone(s) under the peat) versus those that are hydrologically connected to the groundwater aquifer. The latter case could occur in bogs that are recharge wetlands (water movement through the peat is downward). John Coleman (GLIFWC) advised that if mine dewatering lowered the underlying groundwater aquifer, it could accelerate the *rate* at which precipitation infiltrates and moves downward through the peat.

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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