2011 Project Abstract
For the Period Ending June 30, 2015

PROJECT TITLE: Restoration Strategies for Ditched Peatland Scientific and Natural Areas
PROJECT MANAGER: Michele Walker
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 04q and M.L. 2014, Chapter 226, Section2, Subdivision 19.

APPROPRIATION AMOUNT: $200,000

<u>Overall Project Outcomes and Results</u>

The patterned peatlands of Minnesota are unique in the world and formed from slow flowing groundwater and surface water. The Winter Road Peatland Scientific and Natural Area (SNA) is one such peatland. Ditches installed in the early 1900's increased the water flow through this system and altered the peat and the vegetative habitat. The current effect of the ditches was evaluated by monitoring the peatland hydrology (groundwater and surface water) and vegetative habitat over three years at four different sites within the most visually impacted and accessible part of the peatland. In addition, the work was conducted to determine if ditch abandonment will improve the ecological health of this patterned peatland.

The monitoring network consisted of 8 surface water monitoring sites and 39 monitoring wells at 4 sites; A, B, C and D. Vegetation monitoring consisted of 19 relevé sites and 8 vegetative transects co-located with the groundwater monitoring sites.

Hydrologic data showed that the ditches were removing water from the peatland and that water was removed faster when water levels were low. In addition, the digging of the ditch created a ditch spoil pile/berm on one side that now acts as a dam to groundwater flow, primarily when placed perpendicular to groundwater flow. This is probably due to the compaction of the peat beneath the berm. Peat sampling also showed that the peat is more decomposed next to the ditches. This is due to the lower water levels next to the ditch allowing the peat to dry out and decompose.

The vegetation data identified 106 different species and showed that within 30 meters of the ditch, the wetland condition is of poorer quality. After 30 meters, vegetation rebounds to more normal wetland conditions with minimal impacts at 100 meters away. The poorer quality wetland near the ditch occurs because the spoil piles raise the ground surface and allow lower quality wetland species to establish. It also is a result of the peat decomposing and drying out near the ditch.

The Natural Resources Research Institute evaluated the data from the monitoring and recommended that a limited approach to restoration be conducted at this time, after evaluation of other restoration sites in progress in the State. Site A should be restored first because it is more remote and will have limited upstream effects. Site A is located in the NNW section of the peatland and within a small lateral ditch just outside of the SNA but within the SNA watershed protection area. Restoration should begin by removing vegetation from the spoil/berm. Ditch blocks should be installed to stop flow from this ditch with subsequent partial removal of the spoil/berm. Continued monitoring is necessary to evaluate the effectiveness of this restoration. Restoration would reduce the risk of invasive species establishment near ditches, provide water-quality improvement, flood attenuation, and increase recreational opportunities.

Project Results, Use and Dissemination

Project results will be primarily used to guide restoration of the peatland scientific and natural area as priorities allow. The data will also be used by wetland managers to define negative impact thresholds for wetlands affected by high capacity pumping.

The intention is to publish the data, give presentations to local government units and work with the regional information officer to disseminate the information to the community. The information from this report will be available on the DNR website at:
http://www.dnr.state.mn.us/waters/groundwater_section/publications/restoration_strategies_ditched_peatland_sna.pdf

Copies of the report have been or will be made available to all the interested parties and land owners including MN DNR (Wildlife and Scientific and Natural Areas), Red Lake Nation, MN Board of Water and Soil Resources, Lake of the Woods County Environmental Director and the U.S. Army Corps of Engineers.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2011 Work Plan-Final Report

Date of Status Update: **8/15/2015**

Final Report

Date of Work Plan Approval: 8/11/2011

Project Completion Date: 6/30/2015

Project Title: Restoration Strategies for Ditched Peatland Scientific and Natural Areas

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Location:

Counties Impacted: Lake of the Woods, Roseau

Ecological Section Impacted: Northern Minnesota and Ontario Peatlands (212M)

Total ENRTF Project Budget:

ENRTF Appropriation $:	200,000
Amount Spent $:	**167,307**
Balance $:	**32,693**

Legal Citation: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 04q and M.L. 2014, Chapter 226, Section2, Subdivision 19.

Appropriation Language:
$100,000 the first year and $100,000 the second year are from the trust fund to the commissioner of natural resources to evaluate the hydrology and habitat of the Winter Road Lake peatland watershed protection area to determine the effects of ditch abandonment and examine the potential for restoration of patterned peatlands. This appropriation is available until June 30, 2014, by which time the project must be completed and final products delivered.

Carryforward: The availability of the appropriations for the following projects are extended to June 30, 2015: (7) Laws 2011, First Special Session chapter 2, article 3, section 2, subdivision 4, paragraph (q), Restoration Strategies for Ditched Peatland and Scientific and Natural Areas

I. PROJECT TITLE: Restoration Strategies for Ditched Peatland Scientific and Natural Areas

II. PROJECT SUMMARY: Minnesota is home to unique boreal peatland systems called patterned peatlands. These peatlands form where water levels are near the surface and water flow through the system is slow. This allows for slower decomposition of plant tissues and thus an accumulation of peat. The hydrology of the peatland controls the accumulation of peat and resulting peatland landforms and vegetation. Alterations of the hydrology can have profound impacts on the peat, landforms and vegetation. Ditching within the ecologically significant Winter Road Peatland Scientific and Natural Area (SNA) appears to have affected the hydrology and habitat of this peatland.

To evaluate the effects of the ditching on the hydrology and habitat of the Winter Road Lake Peatland; we propose to establish a long-term monitoring network of the peatland hydrology and habitat. The monitoring network will consist of two (2) automated gaging stations which will continuously monitor surface water levels in two of the three rivers draining the peatland, allowing calculation of drainage per square mile of peatland. Monitoring of precipitation (input into the system) at each of these two stations will also be conducted. Eight (8) vegetation plots will be located primarily in the center of the peatland where ditching appears to have had the most impact. These vegetation plots will be co-located with up to forty (40) ground water measurement sites. These wells will each have pressure transducers and dataloggers installed for collection and storage of groundwater levels. Eight (8) synoptic (manually measured) surface water measurement stations will be established throughout the peatland to measure surface water flows in various ditches away from the automated sites. The synoptic surface water, groundwater and vegetative measurement sites will be co-located as much as possible to facilitate concurrent groundwater, surface water, and vegetative monitoring and evaluate the three subwatersheds within the peatland as established by LiDAR data (Light Detecting and Ranging data-planned release date in July 2010). The project will be conducted over three (3) years with automated data to be collected during the last two years of the project.

The collected data will be used to examine the functional relationship of ditches to their associated drainage systems, affected properties and habitat. The data will be used to determine if ditch abandonment will improve the ecological health of this patterned peatland.

III. PROJECT STATUS UPDATES:

Amendment Request and Project Status as of December 30, 2011:

Site evaluation during late summer and fall of 2011, along with evaluation of aerial photos and LiDAR data gave us new information about accessibility and potential damage to the peatland during access. Placement of the automated satellite surface water monitoring stations (stations) in the peatland itself will not be possible. To understand the drainage from the peatland, monitoring will occur at the outlets of the peatland. The number of stations has been reduced to two to monitor the drainage from the two most actively drained parts of the peatland in the north and west. The eastern section of the peatland will be monitored with non-automated equipment. The locations of sites for synoptic surface water measurements were also determined.

Due to the change in automated station locations, the wells within the peatland (co-located with the vegetation plots) will need to be monitored with dataloggers/pressure transducers that will be installed in the wells and manually downloaded during each site visit. In addition, the number of wells has been increased to better monitor groundwater and surface water effects on the vegetation near the ditches noted during site visits this year. Water levels will also be collected in the ditch next to the peatland wells to determine groundwater flow into and out of the ditches. Equipment savings will result from replacing one automated satellite surface water monitoring station with manually downloaded water level monitoring equipment. These savings will be used to purchase and place the additional dataloggers/pressure transducers for the additional wells in the peatland and pay for the increased site visits to download data and measure water levels to calibrate the data collected by the dataloggers.

Due to the limited site access and minimal ditch effects in parts of the peatland, the number of vegetation plots has been reduced to eight (8) instead of ten (10). The vegetation sampling has also been reduced to once during the peak of growing season to better capture vegetation diversity along with most if not all rare species, while minimizing damage to the peatland.

The attached map (figure 2) shows the locations of all planned monitoring locations, digital elevation model of LiDAR data, and the sub watershed boundaries in the peatland.

Amendment Approved by LCCMR 1/3/12

Project Status as of July 30, 2012:

All piezometers were installed, instrumented with dataloggers/pressure transducers and surveyed into a common datum by the end of May, 2012. Initial water levels were taken and loggers set to take water levels hourly. One barologger was placed in a central location to allow for collection of barometric readings used to correct water levels. The attached maps (figures 3 and 4) show the piezometer locations and initial water elevations.

Vegetation transects were established and data collection finished by July 20th. Collected vegetation data are being evaluated and verified by the contractor and DNR Natural Resource Specialist. A report is due by spring 2013.

The surface water monitoring equipment has been ordered and is anticipated to be received soon. The equipment should be installed and data collected by the next update report.

Amendment Request and Activity Status as of December 30, 2012:

Surface water monitoring equipment (auto gaging stations) was received, assembled and installed by October 23, 2012. The auto-gaging stations are currently collecting and transmitting data. Capital equipment costs were higher than expected because of the need to re-configure the equipment to monitor the type of flows where installed. The remaining part of the equipment costs were lower than expected and this amendment is requesting a shift of dollars between categories.

Piezometers/stilling wells will be installed in the ditches next to the peat piezometers as soon as the water in the ditches thaws (anticipated April/May 2013). Animal damage to one piezometer was noted and will need to be repaired in spring 2013. Dataloggers/pressure transducers were removed October 23, 2012 to prevent winter freezing and will need to be replaced in the spring.

Piezometers will need to be re-surveyed to determine if peat movement affected piezometer elevations over the winter. The vegetation transects were established and field work completed by July 30, 2012 with a final report due next year.

Project Status as of July 30, 2013:

By May 27, 2013, stilling wells were installed in the ditches next to the piezometers in the peatland and in the outlet of Winter Road River. Dataloggers/pressure transducers were also reinstalled in the piezometers and installed in the stilling wells. All piezometers and stilling wells were surveyed to obtain water elevation data. The autogaging stations were maintained and running throughout the winter. Data from the autogaging stations is available at: http://www.dnr.state.mn.us/waters/csg/index.html . The datums for the gaging stations need to be surveyed to allow for comparison to groundwater levels. This work is planned for July/August 2013. Comparison of survey data from spring 2012 to fall 2012 show no significant difference in top of casing elevation over the summer growing season. The top of casing elevation was, however, significantly different from fall 2012 to spring 2013. This shows that the well construction is stable for the growing season but is not stable over the winter. Our conclusion is that wells constructed in peat will need to be re-surveyed every spring to verify the measuring point elevation. We plan to vent the piezometer caps to determine if this will minimize piezometer heaving over the winter.

Analysis of the vegetation data has not been completed. The data are currently being entered into various databases, including the DNR's statewide database managed by the Minnesota Biological Survey (MBS). Preliminary analysis does note differences in vegetation between samples observed near ditches and those seen farther away. Typically, woody vegetation was more dense and taller along the ditch than further from the ditches. In addition, vegetation more distant from the ditch is composed of plants strongly characteristic of rich fens while vegetation near the ditch is comprised of species common to several wetland classification types rather than just fens. While the data are unanalyzed at this time; it does appear that ditches reduce fen biodiversity by favoring common species near the ditches that out-compete rich-fen species.

Data from the first year of groundwater level monitoring have been partially analyzed. As expected, groundwater levels are lower next to the ditch and higher further away from the ditch. Evaluations are continuing on the orientation of the ditch to groundwater flow. Preliminarily, it appears that placement of the ditch perpendicular to groundwater flow has a more pronounced effect on draining than parallel to flow. More analysis needs to be conducted to understand this.

Amendment Request and Activity Status as of December 30, 2013:

Preliminary analysis of data logger water elevations in the peatland show:

1. Due to higher precipitation during the 2013 season, water levels were approximately 1 ft higher in the peatland than in 2012.
2. All of the ditches had the spoil pile placed on only one side of the ditch. Generally, the spoil pile, and associated compression of underlying material, acts as a semi-permeable dam to groundwater flow which slows the exchange of water to and from the ditch.
3. Water elevation (head) differences show a groundwater flow gradient from the farthest piezometers to the ditch. This gradient extends up to approximately 370 feet from the ditch and is variable, depending on the water level stage of the peatland. During high water levels, the gradient tends to be flat. During low water levels, the gradient tends to be steep. This implies that the ditches have a greater impact during low levels than high levels.

Analysis of the vegetation data has not been completed. The data are currently being entered into various databases, including the DNR's statewide database managed by the Minnesota Biological Survey (MBS) and will be available on-line as soon as it is completed. Data analysis to this point has focused on Site A although the analysis isn't complete yet. Overall at Site A, the ditch berm appears to block eastward water flow from going into the ditch, causing the wetland to be wetter on the west side of the ditch and the vegetation to be less diverse and of shorter stature. On the east side of the ditch, taller and denser shrub growth of species typical to this type of peatland are found indicating the ditch appears to have caused the area to dry out. The berm itself is high and dry enough to have developed a more complex and diverse community than the surrounding area, with many non-peatland species. We anticipate more quantitative analysis and modeling of all the Sites in the June 30, 2014 report with an electronic link to the data and analysis.

Water level data and preliminary vegetation transect and relevé data has been supplied to the subcontractor, University of Minnesota Natural Resources Research Institute (NRRI) for Activity 3 of the project, Peatland Hydrology and Vegetation Restoration Alternatives of the SNA/WPA. NRRI has begun the evaluation of the data and will have a full report completed by June 30, 2014.

We are requesting a year extension for the project pending approval from the legislature. We are requesting this extension because the data from re-installing the monitoring equipment will require more time to process than we originally anticipated.
Amendment Approved: 05/09/14

Project Status as of June 30, 2014:
The loggers were re-installed in the piezometers in May 2014. Surface water monitoring continued in the peatland over the winter at all points where there was flowing water. The auto-gaging stations continue to transmit data and this data is available at:
http://www.dnr.state.mn.us/waters/csg/index.html

All vegetation data that fits DNR protocols has been submitted for inclusion into the state-wide database and is in the process of being incorporated into that database. Statistical analysis was conducted on this data and preliminarily shows that the influence of the ditches on vegetation extends 20-30 meters into the peatland. This implies that the segments of the transects farther away represent either unaltered peatland or a minor ditch effect that extends over very long distances (>100 meters). With the extension of the funding to June 30, 2015, additional statistical analysis will occur that will include an evaluation of water levels over time in relation to vegetation types and proximity of the ditch.

Project Status as of July 30, 2014:
No additional data has been downloaded from the piezometer and stilling well loggers. Surface water monitoring continues in the peatland with one additional manual measurement to calibrate the auto-gaging stations since the June 30, 2014 update report. The auto-gaging stations continue to transmit data and this data is available at:
http://www.dnr.state.mn.us/waters/csg/index.html Analysis of existing and new data will continue and be reported in the December 30, 2014 update report.

Project Status as of December 30, 2014:

All data loggers were removed from the piezometers by October 21, 2014. The downloaded data shows similar trends as previously seen. During times of low water levels, the difference in water levels between the ditch and piezometers show a steeper gradient and more flow from the peatland to the ditch. When water levels are high, the difference in water levels between the ditch and piezometers is very small indicating less flow from the peatland to the ditch.

Surface water monitoring continued in the peatland at all points where there was flowing water. The auto-gaging stations continue to transmit data and this data is available at: http://www.dnr.state.mn.us/waters/csg/index.html. Hydrographs of the updated data are shown in Figures 9 and 10. The surface water data fluctuations, not surprisingly, reflect changes in precipitation amounts over the area.

Additional analysis of the vegetation data has been started using the assessment tool, Floristic Quality Assessment (FQA) and the fidelity index for Minnesota wetland species. Results at Site A indicate the peatland adjacent to the ditch/berm is of good to fair quality. This is distinctly degraded from the exceptional quality found farther from the ditch. Using all measures applied thus far, the ditch and berm are having a detrimental impact to the peatland. Additional analysis will include applying the FQA to all the sites. Species fidelity measures are also being evaluated to determine where there are degraded flarks and strings. We are attempting to integrate the hydrologic and the vegetation information.

The primary work focus of Activity 3 (Peatland Hydrology and Vegetation Restoration Alternatives) has been to identify and evaluate similar peatland restoration projects that have been completed or proposed, and use this and other relevant information to determine restoration possibilities for the Winter Road Lake Peatland SNA. Several projects were identified where large-scale ditch blocking was conducted to restore hydrology. Information from these projects was reviewed and preliminary recommendations for the Winter Road Lake Peatland SNA Restoration Project were developed. Preliminary recommendations include restoration activities at Site A with a combination of ditch blocking and spoil pile berm breaching.

Project Status as of June 30, 2015:

All data loggers were removed from the piezometers by October 21, 2014. Data loggers were not re-installed. Surface water monitoring continued until May 27, 2015 when the instrumentation was shut down. Rating curves were developed for each of the autogage stations to allow for quick comparison between gage readings and discharge values. This will be used in the future to evaluate changes in surface water flow at the East Branch of the Warroad River and the West Branch of the Warroad River.

Additional analysis was completed on the peat core samples collected during vegetation sampling using the von Post method. The analysis showed that degradation of the peat occurred near the ditch while further away; degradation was minimal or did not occur. A complete report from the subcontractor is included in Appendix A for this report.

The final FQA results are not completed, but the data shows consistency across all sites sampled. The preliminary results demonstrate that the farther from the ditch, the fewer ditch effects and the higher quality the peatland.

A limited analysis was completed by the cooperative agency, Natural Resources Research Institute (NRRI), on restoration alternatives and is included in Appendix B. If restoration is to begin at Winter Road Lake Peatland, NRRI recommends a limited approach. Site A was considered the best site to begin restoration and ditch removal. However, NRRI recommended waiting to restore the Winter Road Lake Peatland until other projects in the State are completed.

Completing the other projects in the State would provide a wealth of information on restoration techniques and ditch blocking/filling strategies to restore peatland hydrology and vegetation without negatively affecting the current hydrology and vegetation of the Winter Road Lake Peatland Scientific and Natural Area.

Overall Project Outcomes and Results

Minnesota is home to unique boreal peatland systems that are dependent on the flow of both groundwater and surface water. Ditching within the Winter Road Peatland Scientific and Natural Area appeared to have affected these flows and the vegetative habitat. To evaluate ditching effects, monitoring of the peatland hydrology and vegetation occurred over three years.

The surface water monitoring network consisted of a combination of automated gaging and manually measured stations. The collected data showed that the ditches were connected to the peatland and were removing water. Surface water gage rating tables developed during the monitoring will be used in the future to understand the impacts of ditch closure to the peatlands surface water.

The groundwater monitoring network consisted of 39 groundwater measurement sites instrumented with pressure transducers and dataloggers to collect and store groundwater levels. The data showed that when water levels are low, the ditches were more effective at removing water. When water levels are high, the ditches were less effective. The data also showed that the ditch spoil pile/berm slows the exchange of water to and from the ditch.

Vegetation plots were co-established with the groundwater monitoring sites. Each site had at least two relevés, one vascular plant transect, and one moss transect. The data collected was evaluated using ordination analysis and floristic quality assessment techniques. The analysis showed that within 30 meters of the ditch the peatland is significantly impacted by the ditch and berm. After 30 meters, degradation decreases with minimal impacts at 100 meters from the ditch.

The Natural Resources Research Institute evaluated the data from the monitoring and recommended that a limited approach to restoration be conducted at this time, after evaluation of other restoration sites in progress in the State. If restoration is to be conducted, they recommend starting with Site A.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Hydrologic Assessment and Monitoring of the SNA/WPA

Description: Establish and map internal watershed boundaries and conceptual water budgets using available LiDAR data. Install and maintain automated gaging sites which will record precipitation and measure water velocity in the adjacent stream. Install and monitor piezometers in vegetation monitoring sites and nearby ditches. Take surface water measurements in ditches at various locations throughout the peatland. Data will be used to evaluate existing hydrologic conditions and potential benefits and locations of ditch abandonment.

Summary Budget Information for Activity 1: **ENRTF Budget: $ 147,940**
Amount Spent: $ 122,913

Balance: $ 25,027

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Establish internal watershed boundaries (map) and conceptual water budgets. Identify and evaluate potential monitoring sites.	10/31/2011	$ 5,040
2. Install and maintain two (2) automated precipitation, and ditch gaging stations with satellite telemetry. Conduct annual synoptic surface water flow measurements at eight (8) sites four (4) times per year. Install and maintain pressure transducers and dataloggers in peatland wells.	5/31/2014	$ 130,257
3. Install wells at each vegetation monitoring plot for groundwater level measurements.	10/31/2014	$ 6,437
4. Compile collected data and report the results with a determination of the peatland water budget.	5/31/2014	$ 6,206

Amendment Request and Activity Status as of December 30, 2011:
The internal watershed boundaries have been mapped and established using available LiDAR data. The attached map shows the chosen locations for automated gaging stations, monitoring wells, synoptic surface water measurement sites, and vegetation plots along with the internal watershed boundaries and the digital elevation model from the LiDAR data.

The locations for automated satellite surface water monitoring stations (stations) have been determined from the site visits and evaluation of LiDAR data. The stations consist of bulky and heavy equipment which require mechanical assistance to transport to the monitoring locations. Mechanical means of transporting the equipment would damage the peatland and is not allowed in the Scientific and Natural Area (SNA). In addition, using the ditches for access is precluded by the many beaver dams. Therefore the stations cannot be placed within the peatland itself. There are three (3) rivers that drain the peatland; the West Branch of the Warroad River to the west, the East Branch of the Warroad River to the north, and the Winter Road River to the east. All three rivers were visited in the late summer and fall and were evaluated for automated station placement. It was determined that two of the three rivers would allow automated station placement. We will place the automated stations at the East Branch of the Warroad River to the north and the West Branch of the Warroad River to the west to evaluate total drainage from the peatland to those rivers. From these data we will be able to calculate the drainage per square mile of peatland or discharge from the peatland. The Winter Road River, which drains the eastern portion of the peatland, does not have permanent flow at all times of the year as determined by a fall site visit. Therefore, this site will have a manually downloaded datalogger/pressure transducer installed in a stilling well within the river to monitor water levels in the river. This, coupled with synoptic surface water measurements will provide data on the peatland drainage to this river.

Because the automated stations will be placed at the outlets of the peatland, they will not be connected to the wells within the peatland. Therefore, we will install a datalogger/pressure transducer in each well within the peatland to better evaluate groundwater levels. To evaluate groundwater flow to/from the ditches, water levels will be collected in the ditch next to these peatland wells using the same datalogger/pressure transducer equipment in a stilling well. This will enable comparison of water levels in the ditch relative to the water levels in the wells. Water levels will be collected and stored every hour, 24 hours per day for manual download during site visits. The standard pressure transducers used by DNR (Rugged Trolls) are non-vented and therefore the data needs to be corrected for changes in water levels due to barometric pressure changes. A datalogger/pressure transducer designed to track barometric pressure will be installed in a dry well near the center of monitoring to collect barometric pressure data. These standard datalogger/pressure transducers require the same docking station to transfer data from the equipment to a hand held storage device. This DNR standard hand held device (Rugged Reader Handheld PC) is specific for these loggers and docking station, is small for ease in portability to the farthest monitoring plots and has a rugged construction including a waterproof design and all day battery for field applications.

The wells in the peatland and ditches will be co-located with the vegetation plots. Site visits in the late summer and fall of 2011 showed that vegetation was often different on one side of the ditch than the other. Sometimes one side had significantly more shrub/tree vegetation than the other. To determine if this difference in vegetation is due to groundwater levels, the number of shallow wells monitored will be increased to a maximum of four on each side of a ditch. Dataloggers as described above will be placed in each well. Hand measurements of water levels will be made during all site visits (including by the vegetation contractor) and used to calibrate the data collected from the loggers during these same visits. The number of deep wells will remain the same. The equipment savings from eliminating one automated satellite surface water monitoring station will be used to purchase and install the additional wells and associated dataloggers/pressure transducers in the peatland and pay for the increased staff costs to manually download and the collected data.

Amendment Approved by LCCMR 1/3/2012

Activity Status as of July 30, 2012:
Piezometer sites were flagged and designated as Sites A, B, C and D (Figure 3) by 5/21/12. All piezometers were installed and instrumented with Rugged Troll 0-30 ft dataloggers and pressure transducers by May 23, 2012. All piezometers were surveyed into North American Datum NAD83 zone 15N, vertical datum 1988, using a Trimble TSC2 survey controller with survey grade accuracy. Initial water levels were taken and loggers set to take water levels hourly. A barologger was installed in a central location (Piezometer BW4) to collect barometric data for barometric correction of water levels. Initially, two barologgers were purchased to be installed at Sites A and B. However, one barologger was defective from the factory and has been sent back for replacement. The second logger was to act as a backup to the first logger and also cover differences in barometric readings across the site. Once the barologger is replaced, it will be placed in a well in Site A to collect readings there. The initial collected data is currently being evaluated. The location of the piezometers and the initial water levels are shown in the attached maps (Figures 3 & 4).

A minimum of 4 piezometers were installed on each side of the ditches at sites A, B, C, and D. One deep mineral soil piezometer was installed at site AW, CS, and DS and nested with one of the shallow piezometers. Deep mineral soil piezometers already existed at sites BE and BW. One well in each of these locations will be instrumented with a datalogger/pressure transducer if well access and funding allows. All piezometers were installed per the construction plan with the exception of needing to purchase and use a 2 inch peat coring auger to cut through the dense root mat and the up to 12 inch ice layer found at the Sites.

Because of the shallow nature of the piezometers, many of the loggers will need to be removed prior to freeze-up due to potential freeze damage. The loggers are planned to be removed prior to heavy frost and replaced prior to spring thaw.

The surface water monitoring equipment is being ordered at this time and will be installed as soon as possible after arrival. The data will be downloaded and processed prior to the December update report.

After consultation with the MN Department of Health (MDH), the wells have been renamed as piezometers to comply with MDH regulations and definitions. All construction followed previously submitted plans.

Amendment Request and Activity Status as of December 30, 2012:
Surface water monitoring equipment (auto gaging stations) was received and installed by October 23, 2012. The physical configuration of the two outlets required slightly different equipment than originally proposed. Instead of two (2) Design Analysis Water Log Series Data Collection Platforms; one (1) 350XL High-Level Data Logger and one (1) H-3551 "SMART GAS" System were installed. Instead of two (2) Sontek Uplooker Acoustic Velocity Meters, two (2) Argonaut-SW 3.0-MHz Systems, one for each automated station, were installed to measure ditch flow. Although the equipment is slightly different, it is the only equipment that is appropriate for the locations where the gaging stations were installed. The non-capital equipment costs were lower than estimated while the capital equipment costs were higher than estimated for these stations. This amendment requests shifting non-capital equipment cost savings to capital equipment costs.

The auto gaging stations have been collecting and transmitting data since October 29, 2012. The gaging stations have not been surveyed and this will be done by spring 2013. The transmitted data is available on-line at: http://www.dnr.state.mn.us/waters/csg/index.html. The eastern gage is located at the East Branch of the Warroad River and is designated as gage #: 80017001. The western gage is located at the West Branch of the Warroad River and is designated as gage #: 80025001.

Dataloggers/pressure transducers collected water level data from 5/23/12 to 10/23/12 in the 35 installed dataloggers/pressure transducers. Over 3,000 records per piezometer were recorded and downloaded. The collected data are currently being evaluated and calibrated with hand readings. Preliminary evaluation shows water levels in the fall slightly lower than spring levels with the biggest decrease in the piezometers adjacent to the ditches. The amount of collected data requires more staff time to analyze than originally anticipated. This amendment requests shifting non-capital equipment costs savings to staff time to analyze these data.

Piezometers were re-surveyed to determine if peat movement affected piezometer elevations over the summer. The difference in elevations between spring and fall was within the margin of error of the survey equipment. This indicates that the well construction appears to be stable for at least non-winter conditions. The piezometers will be re-surveyed in the spring to determine if winter conditions (freeze thaw) affect well stability. If winter conditions affect well stability, yearly surveying may be needed throughout the project in order to be able to compare water levels from year to year. The re-surveying has and will require more staff time than anticipated. This amendment requests shifting non-capital equipment costs savings to staff time to conduct the additional surveys.

The dataloggers/pressure transducers were removed October 23, 2012 to prevent winter freezing and will be re-installed next spring. The additional piezometers will also be installed at the same time in the ditches next to the peat piezometers to evaluate ditch and groundwater connectivity. Additional site visits will be needed to install dataloggers/pressure transducers in the spring and remove them before winter freeze up. This will require more staff time than anticipated. This amendment requests shifting non-capital equipment costs savings to staff time to conduct this work.

The fall site visit to remove the dataloggers/pressure transducers noted that one piezometer, CS 3, was damaged from what was presumed to be an animal collision. This piezometer will need to be repaired with new couplings and casing. It will then need to be re-surveyed. This will require additional staff time. This amendment requests shifting non-capital equipment cost savings to staff time to conduct this work.

Activity Status as of July 30, 2013:
Stilling wells were installed in the ditches next to the piezometers in the peatland and in the outlet of Winter Road River (Figures 5a & 5b). Dataloggers/pressure transducers were reinstalled in the piezometers and installed in the stilling wells. During the site visits, it was noted that the piezometers were heaved up approximately 6 inches on average from last fall. We believe that air trapped in the well by the non-vented caps contributed to this piezometer movement. All piezometers were pushed back into the peat as far as possible and re-surveyed. The difference in elevation from fall 2012 to spring 2013 is shown in Table 1 following Figures 5a and 5b. The survey data show that the wells are stable over the growing season but not stable over the winter. Since un-vented caps were used over the winter, we believe that the contraction and expansion of air trapped inside the wells was responsible for the well movement. We plan to use vented caps this winter and resurvey the wells next spring to see if this reduces or eliminates well movement.

Preliminary analyses of the collected water levels show that groundwater levels are lower near the ditch and higher further away from the ditch. Preliminarily, ditch drainage effects also appear to be more prevalent in ditches that are perpendicular to groundwater flow rather than parallel to groundwater flow. This could be due to placement of the spoil pile, more ditch area to intercept groundwater flow or a combination of the two. Figures 6a and 6b contains the graphs of the hand levels taken during the two years. Further analysis will be conducted to evaluate water levels in relation to time, season, and proximity to the ditch along with ditch orientation.

Amendment Request and Activity Status as of December 30, 2013:
The piezometer CS3 was reconstructed, installed and surveyed by August 1, 2013. This well's datalogger/pressure transducer was reinstalled on that date also. The dataloggers/pressure transducers were removed from all piezometers and stilling wells October 29, 2013 to prevent winter freezing and will be re-installed next spring. Vented caps or no caps were placed on all piezometers over the winter. No caps were placed on the ditch stilling wells.

The datalogger data collected to date were processed and corrected for barometric fluctuations using the barometric recording logger at Site B. The data are currently being quality checked. The data are considered provisional and may need to be revised at a future date. Final data will be available on the DNR website.

Monthly precipitation totals were obtained from the Norris Camp weather station. The growing season precipitation data was compared for the years 2012 and 2013 (Figure 7). The year 2013 had higher precipitation monthly totals than 2012 and resulted in generally higher water levels in the peatland during 2013.

Following is the summary of the preliminary analysis for each of the Sites.

Site A:

The Site A ditch is oriented parallel to the site's remnant flarks and strings. Flarks and strings are a series of hummocky ridges and hollows that form perpendicular to slow groundwater movement. Therefore, Site A ditch is perpendicular to groundwater flow. There is an obvious spoil pile left from ditch construction on the west side of the ditch.

Figure 8A contains a summary of water levels (low, average and high water levels) found at Site A using the datalogger/pressure transducer data for both 2012 and 2013 seasons. The graphs are a cross section of the site's piezometers. AW 4 and AE4 are the furthest piezometers west and east of the ditch respectively. The graphs were made with that year's highest, average, or low water levels.

During 2012, water appeared to be at or just below the peat surface during the site visits of 2012. Water levels were higher farthest from the ditch and lowest at the ditch. This water level difference, or head difference, indicates a groundwater flow gradient towards the ditch. The exception to this pattern was observed in piezometer AW1. This piezometer was placed in the spoil pile on the side closest to the open water of the ditch. This piezometer had consistently lower water levels than any of the other piezometers and may be an indication that the spoil pile may be impacting water levels.

During the two site visits of 2013, May and October 2013, water was above the peat surface and presumably at or just below the peat surface during the remainder of the season. Water levels generally were approximately 1 foot higher than 2012 and water levels on the east side were generally 0.5 feet higher than on the west side. During high water levels, the gradient (difference in water elevations at the site) was flat, indicating the ditch is not as effective at draining groundwater from the site. During average water levels for 2013, there was a slight gradient on the west side and a steeper gradient on the east side. During low water levels, the gradient on both sides increased with a steeper gradient on the east side. This indicates that as water levels decrease, the ditch has more of an impact.

AW1 continued to have generally lower water levels than the remainder of the piezometers with the exception of during high water levels indicating again that the spoil pile impacts water levels. The difference in water levels at AW1 versus the remainder of the site also indicates that the mineral spoil pile is affecting groundwater gradient at AW1. It appears to be acting as a semipermeable dam (barrier) slowing water flow into and from the ditch and only during very high water level times is its impact not evident. The east side (with no spoil pile) appears to be more directly connected to the ditch and thus more directly impacted by it.

Site B:
The ditch at Site B is oriented parallel to the site's flarks and strings and again appears to be constructed perpendicular to groundwater flow. The Norris Roosevelt road is also located on the west side of the ditch. No obvious spoil pile was observed at Site B but there was a slight elevation on the east side of the ditch which may have been a remnant spoil pile or similar disturbance.

Figure 8B contains a summary of water levels (low, average and high water levels) found at Site B using the datalogger/pressure transducer data for both 2012 and 2013 season. The graphs are a cross section of the site's piezometers. BW 4 and BE4 are the furthest piezometers west and east of the ditch respectively. The graphs were made with that year's highest, average, or low water levels.

During 2012, Water appeared to be at or just below the peat surface during the site visits of 2012. Water levels were higher farthest from the ditch and lowest at the ditch on the east side. This water level difference, or head difference, indicates a groundwater flow gradient towards the ditch. The exception to this was piezometer BE2 which had consistently lower water levels than the remainder of the site. No obvious spoil pile was observed, however, this piezometer may have been placed on the flank of a remnant spoil pile which could be impacting water levels. Generally, there were no significant differences in water elevations on the west side of this site during high or average water levels and only a slight difference in water elevations during low water levels.

During the two site visits of 2013, May and October 2013, water was above the peat surface and presumably at or just below the peat surface during the remainder of the season. Water levels generally were approximately 1 foot higher than 2012. Generally, there were no significant differences in water elevations (no gradient) on the west side of this site during high, average and low water levels. During high water levels, there was no gradient on the east side. During average and low water levels, there was an obvious gradient towards the ditch on the east side.

The western side of this site (Site BW) seems to be fairly removed from ditch effects, as evidenced by similar water elevations in all the piezometers across the season. The eastern side of this site (Site BE) has more pronounce water elevation differences, especially during average and low water levels. This indicates that the ditch has more of an impact on this side when water levels are lower. The road may also be impacting the flow at this site; however no data have been gathered to date to evaluate this.

Site C:
The ditch at Site C is oriented semi-perpendicular to the site's flarks and strings and therefore appears to be constructed semi-parallel to groundwater flow. There is an obvious spoil pile left from ditch construction on the North side of the ditch.

Figure 8C contains a summary of water levels (low, average and high water levels) found at Site C using the datalogger/pressure transducer data for both 2012 and 2013 season. The graphs are a cross section of the site's piezometers. CS4 and CN4 are the furthest piezometers south and north of the ditch respectively. The graphs were made with that year's highest, average, or low water levels.

During 2012, Water appeared to be at or just below the peat surface during the site visits of 2012. During high water levels for that year, the difference between the highest piezometer water elevation and the lowest water elevation was approximately 0.1 ft with water levels on the north side being slightly lower (approximately 0.1 ft) than the south. No significant gradient was seen in the high water levels. During average water levels, the difference between the piezometers with the highest water elevation and the lowest was approximately 0.8 ft on both the north and south sides of the ditch. This difference occurred immediately next to the ditch and spoil pile (CS2 and CN2) with levels further into the peatland being within 0.1 foot of each other. The gradient on both sides indicates groundwater flow towards the ditch. During low water levels, a similar gradient was observed but the gradient was extended throughout the distance between the piezometers rather than existing only next to the ditch.

During the two site visits of 2013, May and October 2013, water was above the peat surface and presumably at or just below the peat surface during the remainder of the season. Water levels generally were approximately 1 foot higher than 2012. Generally, there were no significant differences in water elevations (no gradient) on the north and south sides of this site during high and average water levels. During low water levels, a slight gradient was observed immediately next to the ditch. It should be noted that the low water levels of 2013 were similar in elevation to the high water levels of 2012.

The water levels collected to date indicate that the ditch is in communication with both sides of the ditch and the ditches have more of an impact during low flows. This is evidenced by the lack of significant difference in water levels during high water levels in the peatland, indicating no or low groundwater gradient. When the peatland has low water levels, the groundwater gradient is much more pronounced and extends to the distance of the farthest piezometers.

Site D:
The ditch at Site D is also oriented semi-perpendicular to the site’s flarks and strings and therefore appears to be constructed semi-parallel to groundwater flow. There is an obvious spoil pile left from ditch construction on the North side of the ditch.

Figure 8D contains a summary of water levels (low, average and high water levels) found at Site D using the datalogger/pressure transducer data for both 2012 and 2013 season. The graphs are a cross section of the site’s piezometers. DS4 and DN4 are the furthest piezometers south and north of the ditch respectively. The graphs were made with that year’s highest, average, or low water levels.

During 2012, Water appeared to be at or just below the peat surface during the site visits of 2012. During high, average and low water levels, water elevations on both sides of the ditch indicated a groundwater flow gradient towards the ditch with steeper gradients closer to the ditch.

During the two site visits of 2013, May and October 2013, water was above the peat surface and presumably at or just below the peat surface during the remainder of the season. Water levels generally were approximately 1 foot higher than 2012. There were no obvious gradients between piezometers.

The water levels collected to date indicate that the ditch is in communication with both sides of the ditch but is more effective at removing groundwater during low flows. This is evidenced by the lack of significant difference in water levels during high water levels in the peatland, with no or low groundwater gradient. When the peatland has low water levels, the groundwater gradient is much more pronounced and extends to the distance of the farthest piezometers.

Analysis continues on the water level data collected to date. Data loggers/pressure transducers will be placed back into the piezometers and stilling wells as early as possible this spring to collect additional data prior to the end of the project.

Surface water stage and discharge data continue to be collected at the East Branch Warroad River and the West Branch Warroad River in addition to precipitation data. Synoptic surface water data were collected at the proposed sites several times during the year. Preliminary discharge data are shown for the East Branch of the Warroad River and the West Branch of the

Warroad River in Figure 9A and 9B. The remaining surface water stage and discharge data are being calibrated and input into a database and will be reported in the next report along with a link to a website containing the data.

We are requesting a year extension for the project pending approval from the legislature. We intend to re-install the monitoring equipment early this spring to complete the data collection and will require more time to process. In addition, we have used less money than we expected because we have combined the winter road work with other work in the area, reducing travel and staff time charged to the project. We would like to use this cost savings to continue to take water level measurements in the piezometers and the surface water gaging stations for an additional field season. All data collected would be incorporated in a final report to be submitted by 6/30/15. The additional data will be incorporated in our current analysis and will allow us to better understand the hydrologic system of the peatland and provide a better basis for restoration work.
Amendment approved: 05/09/14

Activity Status as of June 30, 2014:
The dataloggers/pressure transducers were placed back into the piezometers and stilling wells during the week of May 12^{th}. All of the piezometers and stilling wells were re-surveyed at the same time (collected data added to Table 1). Several of the wells did 'pop up' over the winter and had to be pushed back down into the peat. It seems as if leaving the caps off the wells helped with the winter heaving although did not completely eliminate it.

No additional groundwater data was collected over the winter. Manual water levels were collected when installing the dataloggers/pressure transducers in May 2014. Updated charts for manual data are shown in Figures 6a and 6b. The hydrographs shown in Figures 8A-8D were not updated as no additional logger data was available.

The gaging stations transmitted data over the winter and continue to transmit. The autogage data is available for both sites (West Branch Warroad River #80025001 and East Branch Warroad River # 80017001) at: http://www.dnr.state.mn.us/waters/csg/index.html and is shown updated to June , 2014 in Figures 9A and 9B. The synoptic surface water data points have had enough data collected now to create hydrographs. The site locations for this data are shown in Figure 10 with hydrographs of flow and water elevation data shown in Figure 10a. The hydrographs from all the monitoring points show that the flows in this area follow typical peak flows in the springtime, lower flows later in the summer and the lowest flows occurring in the winter. The additional year of monitoring will help to establish a better rating curve for the two major rivers here. With sufficient measurements of flow over a variety of water levels (including extreme lows and highs), a water level-discharge relationship is established at each location so that the discharge can be computed from measured water levels.

Activity Status as of July 30, 2014**:** No additional data has been downloaded from the loggers at this time. Monitoring continues remotely with planned retrieval of the loggers in October or November, 2014; depending on weather. One surface water manual measurement has been taken since the last report at both of the gaging sites to calibrate the automatic measurements. The auto-gaging stations continue to transmit data and this data is available at: http://www.dnr.state.mn.us/waters/csg/index.html . The gaging site hydrographs will be updated in the December 30, 2014 update report.

Activity Status as of December 30, 2014:

The dataloggers/pressure transducers were removed from all piezometers and stilling wells by October 21, 2014 to prevent winter freezing. All the caps were removed from the wells to help reduce the amount of frost heaving over the winter.

The datalogger data collected to date were processed and corrected for barometric fluctuations using the barometric recording logger at either Site A or Site B. The data are currently being quality checked. The data are considered provisional and may need to be revised at a future date. Final data will be available on the DNR website.

Monthly precipitation totals were obtained from the Norris Camp weather station and compared to the daily precipitation data obtained at the two auto-gaging sites (West Branch of Warroad River and East Branch of Warroad River) when data was available. The growing season precipitation data was compared for the 3 years of monitoring; 2012, 2013, 2014 (Figure 7-updated). The year 2013 had the highest total precipitation for the year and generally had the highest monthly totals over 2012 and 2014. This resulted in generally higher water levels in the peatland. The year 2012 had the lowest total precipitation for the year and generally had the lowest monthly totals over 2013 and 2014. This resulted in generally lower water levels in the peatland. The 2014 year had wider fluctuations in precipitation throughout the year which resulted in similar fluctuations in water levels in the peatland as the prior two years.

During 2014, water levels in the peatland began the season above the peatland surface. Over the course of the season, water levels fluctuated in relation to the amount of precipitation. This seasonal fluctuation reflected the range of water levels seen in the previous 2 years. Following is the summary of the preliminary analysis for each of the Sites for the 2014 year. The previous year's summaries are noted in prior update reports.

Site A:

The Site A ditch is oriented perpendicular to groundwater flow. Figure 8A has been updated and contains a summary of water levels (low, average and high water levels) found at Site A using the datalogger/pressure transducer data for all three years. The graphs are a cross section of the site's piezometers. AW 4 and AE4 are the furthest piezometers west and east of the ditch respectively.

Unlike previous years, water levels in AW1 were consistently higher than the levels found in the ditch and generally reflected the same fluctuations in water levels as the ditch. This was also the case with AE1. The piezometers farther from the ditch mimicked the changes in water levels of the ditch but the effect was much more muted (Figure 8A). In addition, the water levels in the piezometers on both sides of the ditch were similar in elevation when similar in distance from the ditch. This is unlike previous years where the west side had lower water elevations and a less steep gradient than the east side.

Similarly to previous years, the hydraulic gradient steepens towards the ditch during low flows which indicates that the ditch but is more effective at removing groundwater during low flows.

Site B:

The ditch at Site B is oriented parallel to the site's flarks and strings and is perpendicular to groundwater flow. The Norris Roosevelt road is located on the west side of the ditch and east of the piezometers at Site BE. No obvious spoil pile was observed at Site B but there was a slight elevation on the east side of the ditch which may have been a remnant spoil pile or similar disturbance.

Figure 8B contains an updated summary of water levels (low, average and high water levels) found at Site B using the datalogger/pressure transducer data for 2012, 2013, and 2014 seasons. The graphs are a cross section of the site's piezometers. BW 4 and BE4 are the furthest piezometers west and east of the ditch respectively.

The western side of this site (Site BW) seems to be fairly removed from ditch effects, as evidenced by lower water elevations in the piezometers than the ditch regardless of season. This may be because the road is between these piezometers and the ditch and the road base may be impeding flow between the west side and the ditch.

The eastern side of this site (Site BE) had higher water elevations than the western side. The ditch generally had a slightly higher elevation than BE1 during all flows with the remaining piezometers. The general gradient was towards the ditch. The road may also be impacting the flow at this site; however no data have been gathered to date to evaluate this.

Similarly to previous years, the hydraulic gradient steepens towards the ditch on the East side during low flows which indicates that the ditch is more effective at removing groundwater during low flows. The gradient on the West side generally remained the same throughout the season. This may be because the West side of the ditch is more impacted by the road.

Site C:
The ditch at Site C is oriented semi-perpendicular to the site's flarks and strings and therefore is semi-parallel to groundwater flow. There is an obvious spoil pile left from ditch construction on the North side of the ditch.

Figure 8C contains an updated summary of water levels (low, average and high water levels) found at Site C using the datalogger/pressure transducer data for 2012, 2013, and 2014 season. The graphs are a cross section of the site's piezometers. CS4 and CN4 are the furthest piezometers south and north of the ditch respectively.

CS1 and CN 1 are the closest piezometers to the ditch and had generally lower water elevations than the remaining piezometers and the ditch itself. In addition CN2 (placed north of the spoil pile) had higher water elevations than the remaining piezometers on the north side of the ditch. It is possible that these piezometers have filled with sediment and are no longer in direct communication with the peat.

The water levels collected to date indicate that the ditch is in communication with both sides of the ditch and the ditch has more of an impact during low flows as evidenced by steeper groundwater gradients towards the ditch during low flows. The north side of the ditch had a smaller gradient towards the ditch during the low flow than the south side. This may be a result of the berm that exists on the north side of the ditch impeding flow.

Site D:
The ditch at Site D is also oriented semi-perpendicular to the site's flarks and strings and was constructed semi-parallel to groundwater flow. There is an obvious spoil pile left from ditch construction on the North side of the ditch.

Figure 8D contains an updated summary of water levels (low, average and high water levels) found at Site D using the datalogger/pressure transducer data for 2012, 2013, and the 2014 season. The graphs are a cross section of the site's piezometers. DS4 and DN4 are the furthest piezometers south and north of the ditch respectively.

During 2014, groundwater levels at Site D were fairly similar across the cross section of the ditch. The steepest groundwater gradients (less than ½ foot of difference) occurred during the lowest flow which indicates that the ditch is more effective at removing groundwater during low flows.

The water levels collected to date indicate that the ditch is in communication with both sides of the ditch. As water levels rise and fall in the ditch, water levels rise and fall in the peatland similarly. When the peatland has low water levels, the groundwater gradient is much more pronounced and extends to the distance of the farthest 2 piezometers.

Analysis continues on the water level data collected to date. A concern is that piezometers may have gradually filled with sediment over the 3 years of the study. Plans are in place to check each piezometer in the spring for connectivity to the groundwater. Any piezometers that have reduced or no connectivity will be redeveloped.

Surface water stage and discharge data continue to be collected at the East Branch Warroad River and the West Branch Warroad River in addition to precipitation data. Synoptic surface water data were collected at the proposed sites (Figure 10) several times during the year. Preliminary discharge data for the entire period of record are shown for the East Branch of the Warroad River and the West Branch of the Warroad River in Figure 9A and 9B. The remaining surface water stage and discharge data are being calibrated and input into a database and will be reported in the next report and available on the website http://www.dnr.state.mn.us/waters/csg/index.html.

It is obvious from the hydrograph that the 2012 season had the lowest flows while the highest flow occurred in the 2013 season. The largest fluctuations in flows occurred in the 2014 season with most of the year having higher levels especially in the East Branch of the Warroad River. This mimics the groundwater level data found in the peatland.

Activity Status as of June 30, 2015:
No additional groundwater levels were collected in the piezometers. The piezometers remain in place for possible future restoration work. Lake of the Woods County has started to explore the process of abandoning the ditches in this part of the peatland and possibly restoring the peatland to a pre-ditching ecosystem at some future time if funding becomes available. The piezometers will be used to monitor restoration activity in the future but will need to be re-developed at that time to ensure they are monitoring water levels correctly.

A comparison of the water levels over the years confirms that 2012 had the lowest water levels and the lowest precipitation measurements. The year 2013 had the highest water levels and the highest precipitation measurements and 2014 was a more normal year.

Surface water stage and discharge data was collected until 5/27/15 at the East Branch Warroad River and the West Branch Warroad River in addition to precipitation data. Synoptic surface water data were collected at the proposed sites (Figure 10-updated) several times during the year. Discharge data for the entire period of record are shown for the East Branch of the

Warroad River and the West Branch of the Warroad River in Figure 9A and 9B. A gage rating table for each location was also developed based on this data. These gage rating tables are shown in Figures 9C and 9D. The gage rating table is used to determine instantaneous discharge from gage height and will be used in the future to understand the impacts to surface water flow if ditch closure occurs. Future calibration of these tables would need to be conducted at that time.

The surface water stage and discharge data are also available on the website http://www.dnr.state.mn.us/waters/csg/index.html. The data is considered provisional until all quality assurance/control checks are completed.

Final Report Summary:
A comparison of the water level data collected from 2012 to 2014 confirms that 2012 had the lowest water levels. The low water levels coincided with the the year of the lowest precipitation. Data collected in 2013 documented the highest water levels The high water levels corresponds to the highest recorded precipitation while 2014 water levels and precipitation indicated a more normal year.

Site A
The Site A ditch is oriented perpendicular to groundwater flow. There is an obvious spoil pile present from ditch construction on the west side of the ditch. Comparison of the water levels recorded in the piezometers installed in the peatland and those recorded in the piezometers installed closest to the ditch indicates groundwater flows from the peatland towards the ditch. The difference in water levels defines a hydraulic gradient. The gradient was more pronounced during the low water levels in the peatland and ditches recorded during the period of low precipitation. The ditch spoil pile appears to be acting as a semipermeable dam (barrier) slowing water flow into and out of the ditch and only during very high water level times in the peatland and ditches is its impact not evident. Water levels in the peatland on the east side (with no spoil pile) appear to be more directly connected to the ditch and thus respond more directly to water level changes in the ditch.

Site B
The ditch at Site B also appears to be constructed perpendicular to groundwater flow. The Norris Roosevelt road is located on the west side of the ditch. No obvious spoil pile was observed at Site B but there is a slight rise in elevation on the east side of the ditch which may have been a remnant spoil pile or similar disturbance. Water levels recorded on the eastern side of this ditch indicate the presence of a hydraulic gradient from the interior of the peatland to the ditch, primarily when water levels were low or average in the peatland and ditches. Water levels on the western side of the ditch were less impacted by the ditch and may be more impacted by the adjacent road.

Site C
The ditch at Site C is oriented semi-parallel to groundwater flow. There is an obvious spoil pile remaining from the ditch construction on the North side of the ditch. A hydraulic gradient defined by the difference in water levels recorded in the piezometers within the peatland and the water levels recorded in the piezometers closest to the ditch indicates groundwater flows to the ditch. The gradient was, again, steeper when water levels were low.

Site D

The ditch at Site D also appears to be constructed semi-parallel to groundwater flow. There is an obvious spoil pile on the North side of the ditch remaining from the ditch construction. A hydraulic gradient defined by the difference in water levels recorded in the piezometers within the peatland and the water levels recorded in the piezometers closest to the ditch, indicates groundwater flows to the ditch. Again, the gradient was steeper when water levels were low in the peatland and ditches.

The conclusion from this work shows that the ditches are in communication with the peatland groundwater and are more effective at removing water from the peatland during low water levels in the peatland and ditches. In addition, the spoil pile/berm created when the ditches were constructed may act as a semipermeable dam (barrier) slowing water flow into and out of the ditch. This “barrier” effect was most pronounced at Site A where the ditch is oriented perpendicular to the groundwater flow. The effect was less pronounced at Sites C and D where groundwater flow was semi-parallel to the ditch. The barrier was less pronounced at Site B where the road seemed to be impacting the flow more than any remnant spoil pile.

The surface water monitoring showed that water level changes in the rivers discharging from the peatland mimicked water level changes in the peatland. Further the data highlighted the relationship that more water was discharged from the peatland to the ditch when water levels were higher in the peatland and ditches and flows declined when water levels were lower in the peatland and ditches. This indicates that the ditches are effective at draining water from the peatland. A gage rating table was developed for the two main rivers discharging from the peatland (East Branch Warroad River and West Branch Warroad River) and will be used in the future to understand the impacts of ditch closure to surface water flow. The surface water stage and discharge data are also available on the website http://www.dnr.state.mn.us/waters/csg/index.html. The data is considered provisional until all quality assurance/control checks are completed.

Some problems were encountered during this project. Due to the remote location, the proposed monitoring site locations had to be placed where site access was viable but had to be located to allow assessment of the ditches. The gaging stations were not able to be placed next to the piezometers as originally designed due to limited site access due to the remote location, numerous beaver dams and aquatic vegetation. This was resolved by placing the gaging stations at the outlets of the peatland and placing stilling wells in the ditch next to the piezometers. This configuration provided the hydraulic tie-in needed to evaluate surface water and groundwater interaction within and exiting the peatland.

Yet another issue encountered was the ‘popping up’ of the piezometers over the winter, thus changing the elevation of the measuring point (top of casing). The piezometer top of casing elevation did not change over the summer season. It is postulated that during the winter as the water in the upper surface of the peat froze, the expansion of the freezing water reduced the space available to the trapped air between the cap and the water in the piezometer. This caused the air to press against the cap on the well and moved the entire piezometer out of the ground. The piezometers were pushed back into the ground in the spring however; they needed to be re-surveyed every spring because of this movement over the winter. This was reduced by removing the piezometer caps for the winter but not entirely eliminated. This issue probably can’t be eliminated unless the entire lower portion of the piezometer is completed in the mineral soil beneath the peat. This would be expensive and would make it difficult to install piezometers manually. The re-surveying of the piezometers every spring mitigates the changing elevation over the winter.

Less money was used than expected because the Winter Road work was combined with other work in the area, reducing travel and staff time charged to the project. In addition, during the middle of the project, surface water monitoring crews were stationed in Grand Rapids reducing the travel and staff time costs for the project.

ACTIVITY 2: Vegetative Assessment and Monitoring of the SNA/WPA

Description: Conduct vegetation evaluation and collection at vegetative transect plots to evaluate existing habitat as it relates to ditching.

Summary Budget Information for Activity 2: **ENRTF Budget: $ 10,400**
Amount Spent: $ 10,200
Balance: $ 200

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Conduct plot-based quantitative vegetation and bryophyte sampling at eight (8) sites once in this initial phase of the project.	5/31/2014	$10,400

Amendment Request and Activity Status as of December 30, 2011:

Several site visits were conducted in the late summer and fall of 2011. These site visits, along with evaluation of aerial photos and LiDAR data, eliminated many of the proposed monitoring locations based on near impossibility of site access. Due to difficult site access and minimal ditch effects as evidenced by LiDAR, the vegetation plots in the eastern subwatershed of the peatland have been eliminated. There is no access to the western subwatershed of the peatland. Therefore, the number of vegetation plots has been reduced to eight (8) from ten (10). These eight (8) plots will all be placed in the center subwatershed of the peatland where access is possible and where there are obvious ditch effects, as evidenced by LiDAR and observed during site visits. The plots will be placed next to ditches that are oriented parallel and perpendicular to estimated groundwater flow direction. The groundwater flow direction is estimated to be perpendicular to the peatland flarks and strings.

The transect lengths, plot sizes and type of sampling of each vegetation plot have been determined along with their sampling frequency. Consultation with peatland vegetation experts led us to determine that sampling should occur only once, during the peak of the growing season. This will maximize the vegetation diversity sampled, capture most if not all rare species, and minimize damage to the peatland. It will also provide needed baseline data for future restoration projects. Three sampling methods will be used at each location. Point-intercept transects will run 100m out from the ditch, measuring canopy structure and species dominance/density. Perpendicular to the transects, relevė equivalents will be sampled, sampling all in the same vegetation type, i.e. all in a flark or all in a string. These relevės will allow assessment of the abundance and dominance structure of the peatland and elucidate species relationships. Near the relevės, moss transects will be sampled to help determine peatland chemistry and health and provide baseline species information for use here and in other similar peatlands. Although the number of site visits has been reduced, the remoteness of the plots and complexity of the peatland structure increases the amount of time needed to conduct the work and therefore the cost to do this work has not decreased.

Amendment Approved by LCCMR 1/3/2012

Activity Status as of July 30, 2012:
Vegetation transects were established and completed by July 20th and located adjacent to the piezometers. The costs for the transects and collected data will be shown in the December 30, 2012 update report. Collected vegetation data are being evaluated and verified at this time. Preliminary analysis shows significant vegetation differences on opposite sides of the ditches, possibly due to different groundwater levels, peat depth, peat decomposition and/or mineral soil placement. A report with the results of vegetation analysis is due by spring 2013.

Amendment Request and Activity Status as of December 30, 2012:
Preliminary data have been reported by the vegetation transect subcontractor and are currently being evaluated. Collected moss specimens are being identified by the subcontractor. Data processing and input was and continues to be more intensive than anticipated. A second contract will be issued for the contractor to speed the work and assure quality control. However, this cost should be significantly less than the budgeted amount for vegetation work. The excess funding was shifted from vegetation work to staff costs for increased staff visits for yearly piezometer datalogger/pressure transducer installation and removal, piezometer surveys and surface water equipment maintenance and calibration as described in Activity 1.

Activity Status as of July 30, 2013:

Analysis of the vascular plant data from transects and relevé vegetation plots have not been completed. The data are currently being entered into various databases, including the DNR's statewide database managed by the Minnesota Biological Survey (MBS). Based upon field observations, we can anecdotally report differences in vegetation between samples observed near ditches and those seen farther away. Typically, woody vegetation was more dense and taller along the ditch, often reaching heights of ten (10) feet or more, than the areas further from the ditches. Vegetation growing more distant from the ditch (and more distant from presumed ditch impacts) is composed of plants strongly characteristic of rich fens as would be expected in this type of peatland environment. Vegetation growing near the ditch and its impacts was comprised of species common to several wetland classification types rather than just fens. For example, pussy-willow (*Salix discolor*) would be common along the ditch in dense, tall copses while away from the ditch it was notably absent, being replaced by willow species with low stature (~1.5 ft tall) such as sage-willow (*Salix candida*) – a common species in fens. This pattern appears to be replicated by several other woody and herbaceous species. While the data are unanalyzed; it does appear that ditches reduce fen biodiversity by favoring common species near them that, in turn, out-compete rich-fen species in these impacted areas.

Activity Status as of December 30, 2013:
Analysis of the vascular plant data from transects and relevé vegetation plots continue. The relevé method and transects complement each other by providing a broad picture of the peatland and the changes in the peatland vegetation relative to proximity to ditches. The transects were run perpendicular to the ditches. Each transect was 100m long to measure the ditch effects and the transition to non-impacted peatland. For each site there were two transects – one on the ditch spoil side and one on the non-spoil side. The transects were designed to assess changes in vegetation as a function of distance from the ditch. Data were collected from 100 sample points along each transect. At each sample point, the height of the tallest species, and all other species at that location, was recorded. This combination provided us with a "picture" of the canopy structure and the complexity of the overall community.

Two or three relevés were also completed at each site. Each relevé covered a 20m x 20m area and provided a detailed look at the vertical structure and cover of the sample area, along with some abiotic information, especially related to the substrate. At a minimum, a relevé was placed on or immediately adjacent to the ditch or berm and one placed near the end of each transect, where an initial impression of the vegetation indicated that ditch impacts were not noticeable (or the vegetation had become fairly homogeneous). At some sites, there were additional relevés to record the differences in vegetation between visual flarks (meaning slightly lower areas or pools) and strings (meaning slightly higher areas or ridges).

Data analysis has focused at Site A where ditch effect appears to be most obvious. The ditch at Site A runs north-south with a berm on the west side. The berm is presumably left from the spoils of the ditch construction. Transects were conducted on both the east and west sides of the ditch, with two relevés completed adjacent to each transect per the above description.

Transect ID	Ditch Side: Berm or Non-berm	Visibly Present Flarks/Srings (Y/N)	GPS Location (from ditch)
AE	non-berm	N	0337345E 5397667N
AW	Berm	N	0337331E 5397667N

Relevé ID	Location*	Transect #	GPS Coords (UTM)	Distance to Ditch
AE-R2	ditch	AE	0337348E 5397670N	
AE-R1	mix	AE	0337455E 5397640N	100+
AW-R2	ditch	AW	0337334E 5397670N	
AW-R1	mix	AW	0337246E 5397670N	100+

* Location Options: ditch, flark, string, mix

AW - Western Transect

This transect began at the ditch and continued west 100 meters. The berm was observed to be higher than the surrounding area and had a dense mix of wet-mesic (rather than peatland) shrubs. As the transect continued west, away from the ditch, these mesic species quickly dropped out, and wet shrub and sedge species became the dominant plants. Once past the berm and berm effects (at approximately 6 meters), the western transect had a scattered, open canopy of short statured shrubs and a dense ground layer of sedges, all growing in standing water. Starting at about 6m, the primary canopy was various species of willow. By 50m from the ditch, the dominant shrub had shifted to birch. Thirty-seven species were found along this transect, with the highest diversity found on and near the ditch.

AW Relevé's.

On the west side of ditch, the relevés sampled the berm and the non-impacted area 100m out into the homogeneous peatland. Statistical analysis has not been completed yet. However, there was a clearly visible difference in vegetation between the berm and the non-impacted area. Not only were species different, but so was the complexity and structure. Peatlands such as this one are fairly nutrient poor with a low species diversity. This is reflected at AW-1. AW-2 contained more upland species. We believe this is due to the spoil pile at AW-2 increasing the distance between the water table and the top of the soil, allowing more upland species to colonize the site.

Relevé	Relevé Location	Shrub #	Forb #	Grass/ Sedge #	Total Species in Relevé
AW - 2	Ditch berm	17	14	7	38
AW-1	100m west	8	6	9	23

AE - Eastern Transect
The east side of the ditch was observed to be much drier, with no standing water, and the entire transect was dominated by a dense 1.5 to 2m tall shrub community. Birch and various willow species were found the entire length of the transect, with a few scattered tamarack found near the 100m distance. Diversity was fairly uniform the entire length of the transect and only 29 species were recorded.

AE Relevés
On the east side of the ditch, the relevés sampled the communities adjacent to the ditch and out near the end of the 100m transect. On this side of the ditch, the ditch edge was only marginally higher than the rest of the peatland. Relevé AE-2 was sampled adjacent to the ditch and was more like edge communities. There were more species and more species within each layer of vegetation, probably due to more sunlight availability. Most of the species were the same between the two relevés, however there were some drier/more mesic species at the ditch site and some wetter species out in the peatland.

Relevé	Relevé Location	Shrub #	Forb #	Grass/ Sedge #	Total Species in Relevé
AE - 2	Ditch area	13	9	8	30
AE - 1	100m east	9	9	7	25

Overall at Site A, the ditch berm appears to block eastward water flow from going into the ditch, causing the wetland to be wetter on the west side of the ditch and the vegetation to be less diverse and of shorter stature. The species found here are those typically associated with this type of peatland, with sedges dominant and scattered stunted shrubs. On the east side of the ditch, taller and denser shrub growth of species typical to this type of peatland are found indicating the ditching appears to have caused the area to dry out. The sedge component is there, but buried beneath the shrub layers. The berm itself is high and dry enough to have developed a more complex and diverse community than the surrounding area, with many non-peatland species. Data analysis is not complete at Site A. We anticipate more quantitative analysis and modeling for this site as well as Sites B, C, and D in the June 30, 2014 report with an electronic link to the data and analysis.
Amendment approved: 05/09/14

Activity Status as of June 30, 2014:
Vegetation data was collected in three formats: relevés, vascular plant transects, and moss transects. All data that fits DNR protocols has been submitted for inclusion into the state-wide database and is in the process of being incorporated into that database. Statistical analysis was conducted on this data and preliminarily shows that the influence of the ditches on vegetation extends 20-30 meters into the peatland. This implies that the segments of the transects farther away represent either unaltered peatland or a minor ditch effect that extends over very long

distances (>100 meters). We will be better able to confirm this once the vegetation data is correlated with the hydrologic data.

A summary of some key findings from the statistical work follows:

Transect cover data shows that vegetation is higher near the ditch. Figure 11 shows the height of the vegetation in relation to distance from the ditch. This figure shows that there is variability from one transect to another and from one place to another on a given transect but overall, vegetation is about 0.3 meters higher near the ditch. Figure 11a shows the species type verses height. When height is broken down by species, the tallest species were the willows and grass Phragmites, while the shortest species were the sedges. When those same species were plotted relative to distance from the ditch, we found certain species tended to occur at different distances from the ditch. This is demonstrated in Figure 11b which shows the sedge (Carex lacustris) and willow (Salix planifolia) tend to be found closer to the ditch, while bog birch (Betula pumila), two sedges, (Carex lasiocarpa and Carex prairea), and a grass Phragmites australis tend to be found away from the ditch.

Ordination analysis (Figure 11c): The ordination analysis is a statistical method of arranging or 'ordering' species and/or sample units along gradients. In this case, we were testing the hypothesis that vegetation structure would be related to distance from the ditch. The locations tested were ditch area (D), 100+ meter distance out away from the ditch (mixed vegetation-M), flark (F), or string (S). Figure 11c shows relevés at the ditch to be loosely clustered in the upper right, while the mixed vegetation far from the ditch was fairly tightly clustered in the lower left, and the flark and string relevés were tightly clustered in individual groups in the mid to upper left. This tells us is that the different distances from the ditch show different types of vegetation with the flarks and strings having a very distinct pattern in their vegetation types. This is not as distinct for the mixed communities found far out in the peatlands. In addition, the graph shows us the ditch vegetation is highly complex with higher diversity which results in their varied signature. This same pattern is seen on the transect ordinations.

When we applied this same technique to some select species the same sorting occurred, with certain species being preferentially found farther out in the peatland while others were found almost exclusively at the ditch. Further analysis is planned to see if it can be determined why species grow in these patterns.

When ordination was done with the moss data, it had mixed results. The clearest pattern was associated with the ditch with certain species always being associated with the ditch. Further analysis of this data is planned in correlation with the vascular plants and hydrology to see if more information becomes clear.

Diversity and Species Richness: Another way to look at this data is to evaluate the diversity of the relevés by their location type (Figure 11d). Again the ditches were found to be the most diverse, while the mixed communities out in the peatland were least diverse. Shannon/Hill diversity index "weights" species by their abundance. This means that rare species count less than abundant ones, providing some sense of the dominance as well as structure of the peatland. When just looking at presence/absence of a species, the relevés again show the ditches with the highest variety of species, but in this case, the strings have the lowest number of total species. This analysis shows some species are sorting very specifically to the four distinct parts of the peatland (ditch, string, flark and mixed peatland).

With the extension of the funding to June 30, 2015; additional statistical analysis will occur, including an evaluation of water levels over time in relation to vegetation types and proximity of the ditch along with testing of the data to determine if we can find the flark and string signatures buried in the “noise” of the mixed peatland.

Activity Status as of July 30, 2014: No additional vegetation analysis has been conducted at this time. Analysis will continue and be reported in the next update report.

Activity Status as of December 30, 2014:

The Floristic Quality Assessment (FQA) tool was used to evaluate the effects of the ditching on the peatland vegetation. FQA is a vegetation-based ecological assessment of wetlands. It is based on the premise of a species’ fidelity to a particular habitat and tolerance to disturbance. Thus a species with very specific habitat requirements (needing minimally disturbed sites) will have a high fidelity rating while ones that have a high tolerance for a wide range of conditions have a low fidelity rating. FQA has been tailored to the wetlands of Minnesota and has proven to be a reliable indicator of wetland condition. FQA results in a wetland condition determination of Exceptional, Good, Fair, or Poor. It is recognized by the wetland regulatory and delineation community as a good assessment for determining wetland credits and wetland restoration evaluation.

The FQA has been used to evaluate Site A vegetation, where the most significant differences in vegetation near the ditch and farther away were determined using ordination and the Shannon/Hill diversity index. At Site A, the FQA indicates the peatland farthest from the ditch on both the west and east sides is Exceptional; thus likely experiencing minimal impacts from the ditch and berm. Close to the ditch, the west side peatland quality was evaluated as Fair and on the east side it was evaluated as Good. At approximately 30 meters into the peatland the impacts of degradation decline with minimal discernable impacts at 100 meters from the ditch. The FQA confirms the previous statistical work that the peatland adjacent to the ditch is significantly impacted by the ditch and berm.

We are in the process of applying the FQA to the other sites and the results of that analysis will be incorporated into the restoration recommendations for the June 2015 report. The fidelity analysis used in the FQA will also be applied to select species of the peatland to help us determine which species might be associated with flarks and strings and thus find the locations of the overgrown flarks and strings.

Activity Status as of June 30, 2015:
The vegetation subcontractor collected several peat core samples along the vegetation transects. The subcontractor analyzed these samples for peat degradation. The contractor found that compared to the un-ditched controls collected, ditch effects of peat degradation from between 20-50 cm in depth occurred in 6 of 8 sample cores near ditches. Interior cores taken approximately 100 meters from ditches showed no ditch effect compared to control peat profiles. The report provided by the contractor is shown in Appendix A.

The final FQA results are not completed, but the data shows consistency across all sites sampled. The preliminary results demonstrate that the farther from the ditch, the fewer ditch effects and the higher quality the peatland. These distant sites tentatively evaluated as Exceptional, thus likely experiencing minimal impacts from the ditch or berm. The closer to the ditch, the more degraded. The sites on the berm-side of the ditch showed more impacts (due to flooding and peat compaction) than those on the non-bermed side. At all sites, approximately

30 meters into the peatland the impacts of degradation declined with minimal discernable impacts at 100 meters from the ditch. The FQA appears consistent in confirming the previous statistical work that the peatland area adjacent to the ditch is significantly impacted by the ditch and berm, and that the impact does not spread a great distance into the peatland.

Final Report Summary:

To complement the quantitative analysis work done earlier, the Floristic Quality Assessment (FQA) tool was used to evaluate the effects of the ditching on the peatland vegetation. FQA is a vegetation-based ecological assessment of wetlands. It is designed around the premise of a species' fidelity to a particular habitat and tolerance to disturbance. Thus, a species with a high fidelity to a particular undisturbed system will have a very specific habitat requirement and be designated as a conservative species. This species will have a high Coefficient of Conservatism (C) ranking per the FQA tool. C ranking is on a scale of 0 to 10, where 10's are reserved for the most conservative species and a specific habitat requirement and 0's are used to denote non-native species. A 1 or 2 is for species that have a high tolerance for a wide range of conditions and can thrive almost anywhere. When the Co-efficient of Conservatism is applied to all species found in a wetland and the Floristic Quality Index (FQI) is applied, a determination of wetland condition results. Wetland conditions are rated as Exceptional, Good, Fair, or Poor. The FQA has been tailored to the species and wetlands of Minnesota, and has proven to be a reliable indicator of wetland condition. This assessment system is recognized by the wetland regulatory and delineation community as a good assessment tool for determining wetland credits and evaluating wetland restoration potential.

The FQA has been used to evaluate all of the sample sites (Table 2). Figures 12a and 12b show the location of the vegetation transects, the ditch berms (created by placement of ditch spoil piles), and the relevé plots in relation to the ditches and peatland boundary at each site. Table 3 contains a list of all 106 vegetative species found in the relevés and transects. Although the ditch spoil/berm was placed on the east side of the ditch at site B, there was no obvious spoil pile/berm in this location. It was placed on this side because the height of vegetation on this side mimicked the height of vegetation at Site DN where the spoil pile/berm was located.

The FQA indicates that the peatland farthest from the ditches is rated Exceptional; thus likely experiencing minimal impacts from the ditch and berm. Close to the ditch, most sites were rated Fair with the exception of DS-R2 which was rated Good. This is a clear indication that the ditches have affected the areas next to the ditch.

The side where the ditch spoil materials were placed, creating a berm, also affected the quality of each area. All sites where the ditch spoil materials were placed had the lowest designation (Fair). DS-R2 had a higher rating (Good) and this side did not have the berm created by the ditch spoil pile. This is an indication that the ditch spoil pile and resulting berm increased the impacts to the area.

The coefficient of Conservatism was applied to all species found in the peatland sample areas (Figure 13). Of the 106 species identified along the transects and relevés, two have an extremely high fidelity to this system with a Conservative value of 10, the maximum value possible. One of those species, Eriophorum chamissonis (a species of cotton grass), was only found in two locations, both interior from the ditch and in a flark or in what might be an overgrown flark. The other species, Carex chordorrhiza (creeping sedge), was found scattered along all transects and relevés, and was most common a distance away from the ditch/berm.

Ten of the 106 species (Carex limosa, Carex livida, Eriophorum gracile, Galium labradoricum, Lobelia kalmii, Rubus arcticus acaulis, Salix candida, Salix maccalliana, Solidago uliginosa and Symphytotrichum boreal) have a conservative value of 9. Of these species, almost all individuals were found a distance away from the ditch, although some were found near the disturbed areas. Typically when that was the case, these species (Galium labradoricum, Rubus arcticus acaulis, Salix candida, Salix maccalliana, and Symphytotrichum boreale) were found on the bermed side of the ditch.

Overall, this peatland has some very good species integrity, as the C-values show, with almost 50% of the species having a C value of 7 or greater. With that being the case, it is telling that some of the sample sites are rated as "Fair" by the FQA. All of these sites are located next to the ditches and the lower rating is directly linked to ditch effects.

One of our analysis goals was to determine if there were species with a high correlation to flarks and strings and therefore if we could discern the locations of overgrown flarks and strings. However, not enough sampling points were available to do this analysis completely. Therefore, due to this lack of data, there were no obvious species correlations with flarks and strings.

The FQA confirms the previous statistical work that the peatland adjacent to the ditch is significantly impacted by the ditch and berm up to 30 meters from the ditch. After 30 meters, degradation decreases with minimal discernable impacts at 100 meters from the ditch.

ACTIVITY 3: Peatland Hydrology and Vegetation Restoration Alternatives of the SNA/WPA

Description: Review and analyze data to determine potential restoration methods including ditch blocking and vegetation establishment/management. Evaluate appropriate ditch blocking design, frequency, and materials based on site conditions, desired hydrology and material availability as it relates to habitat improvement. Evaluate the need to establish, restore or manage vegetation to achieve the desired habitat (report). Conduct a preliminary analysis to determine the potential for wetland mitigation credits.

Summary Budget Information for Activity 3: **ENRTF Budget: $ 41,660**
Amount Spent: $ 34,194
Balance: $ 7,499

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Review ditch plans, review potential hydrologic and restoration methods.	9/30/2013	$ 5,046
2. Analyze preliminary results, research and make preliminary recommendations for habitat improvements.	1/31/2014	$ 9,137
3. Analyze final results, research and make final recommendations for habitat improvements in a final report	5/30/2014	$21,751
4. Prepare preliminary information and analysis necessary for potential ditch abandonment, wetland banking, permitting and other regulatory processes in a report.	5/30/2014	$ 5,726

Amendment Request and Activity Status as of December 30, 2011: Not Started Yet.
Amendment Approved by LCCMR 1/3/2012

Activity Status as of July 30, 2012: Not started yet.

Activity Status as of December 30, 2012: Not started yet.

Activity Status as of July 30, 2013: Not started yet.

Activity Status as of December 30, 2013:
Water level data and preliminary vegetation transect and relevé data have been supplied to the subcontractor, University of Minnesota Natural Resources Research Institute (NRRI). NRRI has begun evaluation of the data and will have a full report completed by June 30, 2014.
Amendment approved: 05/09/14

Activity Status as of June 30, 2014:
NRRI made two site visits to the Winter Road Peatland; one in October 2013 and one in May 2014. The site visits were conducted to evaluate the peatland for restoration work. NRRI also visited a ditch blocking site near the Winter Road Peatland called Brown's Lake Restoration to evaluate the feasibility of that design for use in Winter Road. Verbal information was gathered on the ditch block construction at this site along with some written documentation on the ditch block design. It was discovered through informal conversations with DNR that a more recent ditch blocking restoration project was conducted in Lake of the Woods County. This restoration project also received wetland mitigation credits so it will serve as a model for that aspect of future projects at Winter Road Peatland. Further information will be gathered on both of these ditch blocking activities as it becomes available to help in the design of any ditch blocking proposed at the Winter Road Peatland.

Future/Ongoing Tasks
New information gathered since the last progress report and during the May 2014 site visit indicate that the following tasks need to be completed to help formulate the final report:

- Gather all information related to the Brown's Lake Peatland Restoration project.
    - Review all available information.
    - Contact Gretchen Mehmel, Charlie Tucker and Neil Slick of the MNDNR for more specific information on the project.
- Gather all information related to the Lake of the Woods County ditch blocking restoration project.
    - Contact Nathan Kestner (MNDNR) for more information.
    - Review administrative as well as technical information for the project.
- Review and analyze water level data together with Michele Walker (MNDNR).
    - Determine if wetland hydrology criteria are being met according to U.S. Army Corps of Engineers guidelines.
    - Determine what hydrologic modifications (ditch blocking, outlet blocking, water control structures, breaching ditch banks, pushing spoils into ditches, etc.) are feasible for use at the SNA.
    - Determine which specific areas within the SNA would benefit most from hydrologic modifications.
- Review and analyze vegetation data together with Becky Marty (MNDNR).
    - Determine if wetland vegetation criteria are being met according to U.S. Army Corps of Engineers guidelines.

- Review any available historical aerial photos of the SNA to estimate vegetation/hydrology changes over time.
- Apply Floristic Quality Assessment and/or other metrics to plot data at varying distances from the ditches.
- Estimate potential vegetation changes/enhancement that may result from hydrologic modifications.

Activity Status as of July 30, 2014: NRRI continues to evaluate the data and will have additional information in the December 30, 2014 update report.

Activity Status as of December 30, 2014:
The primary work focus since the last progress report was to identify and evaluate peatland restoration projects that have been completed or proposed and to evaluate other relevant information to determine possible restoration activities for the Winter Road Lake Peatland SNA project.

Several projects were identified where large-scale ditch blocking was conducted to restore hydrology. These include the "Brown's Lake Peatland Restoration Project" and the "Bernard Wetland Bank", both located in Lake of the Woods County; and the proposed "Superior Wetland Bank" project for the Sax-Zim Bog in St. Louis County. Pertinent research on the effects of ditching was also found in the report "Hydrological Effect of Ditches and Berms at Beaches Lake Wildlife Management Area, Minnesota". Other peatland restoration projects, such as those for horticultural peat mining operations, do exist in the state, but are quite different than the Winter Road Lake Peatland Site. These peat mining sites have ditch spacing that is very close (every 100-150 feet) and a considerable thickness (2-6 feet) of peat removed. Following are summaries of the evaluations for these projects:

<u>Brown's Lake Peatland Restoration Project</u>
The Brown's Lake Peatland Restoration Project was established in late 1998 – early 1999 by the Minnesota DNR at a site just south of the Winter Road Lake Peatland SNA. The project was established to restore pre-ditching water flow and levels to the Brown's Lake Bog and reduce water from entering a state forest road ditch system. An additional goal of the project was to return forested peatland back to its original open peatland condition and to restore habitat for sharptailed grouse and sandhill cranes. The restoration was conducted by installing several ditch blocks and filling the ditch with the remaining spoil bank where possible using a backhoe and a D-8 bulldozer. Though no final report was written on the project, there exists considerable information on its design, approval, and construction. MNDNR area personnel, Gretchen Mehmel and Charlie Tucker, provided documents regarding the site.
In reviewing the documents a number of important issues stand out:

- The Lake of the Woods County Board had to officially "abandon" the ditch (Judicial Ditch 62) before construction could proceed.
- The pre-ditching water flow was from south to north. The east-west Judicial Ditch 62 intercepted the flow and conveyed the water west. The spoil bank on the north side of the ditch acted as a dike and prevented water from flowing north through the bog and into Brown's Lake.
- The ditch blocks were constructed of a "clay core" of approximately 60 cubic yards surrounded by cover material from the spoil bank.
- Clay was acquired from a site approximately 15 miles north.
- Construction was conducted during early winter (December 1998-January 1999).

- Because of the water flow direction and the ditch spoil bank acting as a dike, "breaching" the spoil bank allowed water to flow north. According to Gretchen Mehmel, she believes this did as much if not more to restore original water flow as the ditch blocks.
- Cattails are found in the vicinity of the ditch blocks. Presumably because of the increased nutrient content in the clay.
- The project was considered a success as the forested areas of the bog have "opened up" providing the desired wildlife habitat.
- No wetland mitigation credit was pursued or received for the project.

Bernard Wetland Bank Project:
Some written information was received from Nathan Kestner (MNDNR) who did considerable work on the wetland mitigation bank known as the "Bernard Wetland Bank" located in Lake of the Woods County. The bank site consists of approximately 634.18 acres of existing wetlands that will be preserved in perpetuity. The objective is to "preserve the functions" of 629.94 acres of Hardwood Swamp, Coniferous Swamp, Shrub Carr-Alder Thicket, Fresh Wet Meadow and Open Bog wetlands. The Bernard Wetland Bank will also "enhance the functions" of 4.24 acres of Open Bog and Hardwood Swamp wetlands. The bank was approved in 2011 and has one recent clay ditch plug that was installed along a county road. A site visit is planned for the spring of 2015, and discussions will continue with Nathan Kestner regarding this wetland bank. This wetland bank is based primarily on "preservation" more so than "restoration". Lake of the Woods County was the lead agency for this wetland bank.

Superior Wetland Bank Project:
A relatively new initiative to restore ditched peatlands in Minnesota has been proposed for the Sax-Zim Peatland located between Duluth and the Iron Range to the east of County Road 7 and north of County Road 52. The proposed "Superior Wetland Bank" site is approximately 21,292 acres in size, including upland buffer areas. The sponsor, Ecosystem Investment Partners, LLC is proposing to get mitigation credit by a combination of restoration and enhancement of wetlands partially drained as part of a County ditch network, and preservation of adjacent pristine wetlands. Ecosystem Investment Partners, LLC is a private equity firm that "acquires, entitles, restores, and manages properties across the US that generate wetland, stream, and endangered species mitigation credits". http://www.ecosystempartners.com/ . They have already established wetland banks in Aitkin and Itasca Counties http://www.minnesotamitigation.com/ and have numerous sites throughout the U.S.

The sponsor of this project has conducted hydrologic studies and Floristic Quality Assessments of vegetation to quantify current conditions and to justify how ditch-blocking will restore and enhance the site. Their use of the Floristic Quality Assessment (FQA) to quantify drainage effects seems reasonable and appears to be accepted by the Army Corps and other regulatory agencies.

How this project may impact the potential for wetland credits from any work on the Winter Road Lake SNA remains to be seen. The sites are similar in that they are for the most part partially drained and ditch-blocking efforts may result in a "functional lift" of the sites. The sponsor proposes a number of methods to block ditches and breach spoil banks to restore hydrology including:

- Install ditch blocks, including imported clay, rock checks and vinyl sheet piling http://cmisheetpiling.com/.
- Install culverts to breach spoil banks.
- Block ditches during the winter or with the use of helicopters to facilitate access.

- The use of spoil bank materials present on-site for ditch blocking will be limited at best because most of the organic spoil bank has subsided leaving little left to work with now.

Beaches Lake Wildlife Management Area Study:
The "Hydrological Effect of Ditches and Berms at Beaches Lake Wildlife Management Area, Minnesota" (Gerla, Autreng, and Snyder, 2009) project was conducted in Kittson County, Minnesota to evaluate the effect of recent maintenance (widening and deepening) of Lateral Ditch 12. Results and recommendations of the report include:

- Model results suggest the ditches lateral effect extends to a maximum of 350 feet (107 meters).
- Compacted ditch berms can be up to 50 times less permeable than loose undisturbed peat.
- Evapotranspiration from plants (willows, etc.) are a major cause of water loss. They should be removed and managed so they will not regrow.
- Clay ditch plugs are not recommended. They will not completely stop drainage and they may introduce weed species.
- Recommendations include filling ditches for their entire length, leveling, seeding native species and managing the site to control invasive species.

Preliminary Recommendations Winter Road Lake Peatland SNA Restoration Project: Review of established and proposed peatland restorations and studies of ditch effects and potential remedies reveal mixed and sometimes contrary solutions. Noting that there are significant effects of ditching on the Winter Road Lake SNA Peatland, the question becomes to what extent is intervention warranted and what are the associated benefits and risks involved. That being the case, a conservative approach is best initially, especially because the Scientific and Natural Area already possesses natural qualities above and beyond other more disturbed peatland sites in Minnesota. With scarce proven research conducted in this area, it is possible that restoration could do more harm than good by introducing invasive species or flooding out native plants. However, NRRI recommends a limited approach, at least initially. This can benefit the site and provide insights into future research needs and restoration activities.

Because of its location away from roads and few potential negative upstream impacts expected as a result of restoration efforts, Site A appears to be the best area for restoration activities.
At Site A the water flows from west to east. The ditch berm blocking the west to east flow is on the west side (upstream side) of the ditch, making the west side wetter. If this berm is breached, it could potentially allow more drainage of the peatland west of the ditch without increasing water levels on the east side (the ditch would intercept the water and convey it south). This situation is unlike the Brown's Lake situation where the water flow is south to north. The ditch berm there is on the north side (downstream side) of the ditch. Breaching this berm removes water from the ditch and conveys it to the north where it is needed. Therefore, just breaching the berm on the west side of the Site A ditch may not help unless one or more ditch blocks are installed to reduce the drainage by the ditch. Breaching the berm alone is not recommended.

Placing a clay ditch block is not without its problems. Access along the ditch can be difficult depending on the integrity of the berm/spoil bank and its ability to support backhoes, bulldozers, trucks and other heavy equipment needed to install the ditch block. Clay is available from the same source used for the Brown's Lake Restoration approximately 10-15 miles north of Site A. Conducting this work in the winter may provide a more stable travel base, but there are associated problems handling frozen clay and other construction materials. Driving heavy equipment and transporting clay along the berm/spoil bank can also increase compaction and reduce permeability further limiting water flow from west to east. A helicopter is also an option, but at a cost of approximately $1,000/hour flight time, it might be prohibitive. Vinyl sheet piling might be a more light weight option as well.

A good compromise for initial restoration efforts would be to clear the vegetation from the berm/spoil bank on the west side of the Site A ditch. This clearing should be done during frozen conditions (early spring) if possible with low ground pressure equipment such as a posi-track or tracked skid steer with bush hog, hydro-ax, or flail mower type implement. It is important that all equipment be meticulously cleaned prior to entering the site to prevent the introduction of weed seeds. This work should be followed up during the growing season with an herbicide application to the stumps to prevent/slow regrowth. The benefits of this work regimen are two-fold: 1) the removal of vegetation adjacent to the ditch reduces evapotranspiration and conserves water, and 2) the berm/spoil bank can be inspected to determine if it will support heavy equipment for potential ditch block construction.

Some administrative issues that need to be addressed prior to restoration work proceeding include:

- Are there any special restrictions on construction or use of equipment in a SNA?
- The ditch at Site A would have to be formally "abandoned" by the Lake of the Woods County Board if any ditch blocks are installed.
- A U.S. Army Corps of Engineers Section 404 permit may be required for filling a wetland when ditch blocks are installed.

Additional issues arise if wetland banking credits are proposed:

- Is a wetland mitigation bank allowed in a SNA?
- A Wetland Bank Plan will have to be developed and approved by the Minnesota Board of Water and Soil Resources prior to construction.
- The U.S. Army Corps of Engineers requires a "Mitigation Banking Instrument" be developed and approved to set forth guidelines for long-term monitoring of the site.

<u>Potential Wetland Mitigation Credit:</u>
According to the "St. Paul District Policy for Wetland Compensatory Mitigation in Minnesota" (2009), wetland mitigation credit can be achieved through wetland "restoration" at a ratio of 2:1 to 1:1 (acres restored to credits generated), "enhancement" (3:1), "creation" (2:1 to 1:1), "preservation" (8:1), and "native upland buffer" (4:1). The Winter Road Lake Peatland SNA would most likely qualify for restoration, enhancement, preservation, and/or native upland buffer. Preservation credits require that a wetland be under "demonstrable threat" and providing important wetland functions. Since the Winter Road Lake Peatland is already preserved as a Scientific and Natural Area, and is not under "demonstrable threat", it would not qualify for preservation credits. The Winter Road Lake Peatland SNA may also qualify for wetland credit if ditch blocking or other hydrologic modifications are implemented to enhance the functions of the wetland currently impacted by ditching. The regulatory agencies most commonly accept Floristic Quality Assessment along with hydrology data to justify wetland mitigation credit. Providing these data and working closely with Lake of the Woods County (who will have to formally abandon the ditch) is the best way to work towards receiving wetland mitigation credits for this project.

These are preliminary recommendations for the peatland restoration at the Winter Road Lake Peatland SNA. They will be reviewed and analyzed, with more information added as it becomes available in the coming months. Site visits and conversations with the project team and other experts will continue as the final report is formulated.

Activity Status as of June 30, 2015 and Final Report Summary:
The NRRI has finalized two reports (Appendix B) on the mitigation and restoration options for the Winter Road Peatland. The subcontractor recommends a conservative approach to restoration which was to wait and see the results from other restorations in the State. If restoration is to be conducted, they recommend starting small with Site A. The work completed by the subcontractor was less costly than estimated leaving the remaining funds.

V. DISSEMINATION:

Description: Update reports will be available on the DNR website at http://www.dnr.state.mn.us/ . The final report on the current hydrology and habitat along with a preliminary evaluation of possible sites for ditch abandonment and road mitigation will also be available on the same website. Hydrologic data collected will be available on an on-going basis at: http://www.dnr.state.mn.us/waters/csg/index.html .

Status as of June 30, 2014: Hydrologic data collected are available on an on-going basis at: http://www.dnr.state.mn.us/waters/csg/index.html .

Status as of July 30, 2014: Hydrologic data collected are available on an on-going basis at: http://www.dnr.state.mn.us/waters/csg/index.html .

Status as of December 30, 2014: Hydrologic data collected are available on an on-going basis at: http://www.dnr.state.mn.us/waters/csg/index.html .

Status as of June 30, 2015: Hydrologic data collected are available on an on-going basis at: http://www.dnr.state.mn.us/waters/csg/index.html. The final report for this project will be made available as requested in addition to placing the final report on the DNR website (address to be determined).

Final Report Summary: Hydrologic data collected are available at: http://www.dnr.state.mn.us/waters/csg/index.html. The final report for this project will be made available as requested in addition to placing the final report on the DNR website at: http://www.dnr.state.mn.us/waters/groundwater_section/publications/restoration_strategies_ditched_peatland_sna.pdf.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget:

Budget Category	$ Amount	Explanation
Personnel:	$ 81,363	Wages and benefits for four Classified Hydrologist 1 (0.99 FTE) and one Classified Hydrologist 3 (0.28 FTE)
Professional/Technical Contracts:	$ 38,180	Vegetation data collection and compilation, moss identification, Assist with review and analysis of data to determine potential restoration methods
Equipment/Tools/Supplies:	$ 31,493	Equipment for vegetation plots and to install and maintain automated monitoring stations and ground

		water piezometers/wells with in-well pressure transducers and dataloggers.
Capital Equipment over $3,500:	$ 27,578	Data collection platforms and acoustic velocity meters for 2 automated monitoring stations.
Travel Expenses in MN:	$ 21,386	One hydrologist 3 and four hydrologist 1 round trips from Bemidji/St. Paul to SNA includes mileage, lodging and meals for equipment installation, maintenance, & monitoring
TOTAL ENRTF BUDGET:	**$200,000**	

Explanation of Use of Classified Staff:
Classified staff has the experience to install, maintain and monitor the equipment used in this project. The MN DNR will either backfill classified staff time spent on this project (Hydrologist 1-0.99 FTE and Hydrologist 3-0.28 FTE) with an unclassified hydrologist 1 position in the DNR Water Monitoring and Surveys Unit in St Paul or the work previously done by this position will be delayed, eliminated, or completed by the start of the project. Classified staff will only charge the project for hours spent on tasks described in the approved work plan.

Explanation of Capital Expenditures Greater Than $3,500: Rental contracts prohibit the necessary modifications needed to use the data collection platforms in this monitoring situation. Renting the one (1) 350XL High-Level Data Logger, one (1) H-3551 "SMART GAS" System and the Argonaut-SW 3.0-MHz Systems to monitor ditch flow for two (2) years is much more expensive than buying them outright. Purchasing also ensures that connections to other equipment in the monitoring are compatible i.e. use the same data platform. In addition, all equipment will be used in the next phases of the project to evaluate restoration.

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation: 0.99 FTE hydrologist 1 and 0.28 FTE hydrologist 3 = 1.27 FTE.

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
State	$ 20,238	$ 20,238	Shared Services (operations support governance) are services that DNR relies on in order to conduct business and support the work of the department. These services are more efficient when shared.
In-kind Personnel	$ 36,160	$ 21,765	Natural Resource Senior and surface water monitoring crew -data compilation, report writing, results analysis, research and recommendations regarding ditch abandonment and habitat improvement. Also, increased site visits for surface water gaging station maintenance and calibration.
TOTAL OTHER FUNDS:	**$47,384**	**$ 42,003**	

VII. PROJECT STRATEGY:
A. Project Partners: MN DNR Groundwater Specialist (0.28 FTE Salary, Benefits and travel=$26,567); DNR Water Monitoring Crew (0.99 FTE Salary, Benefits and travel =$49,158); Contractor for ditch abandonment, habitat restoration and wetland banking analysis ($29,180). Private contractors will be used for vegetation evaluation, moss collection and identification ($12,000). In addition, uncompensated work and/or direction will be provided by NRRI, DNR

unclassified Staff as needed, Lake of the Woods County Environmental Director, MN DNR Groundwater Unit Supervisor; MN DNR NW Regional Ecologist; US Army Corps of Engineers – Regulatory Branch.

B. Project Impact and Long-term Strategy:
This project will help establish relationships between hydrologic and habitat conditions. The goal will be to determine if ditch abandonment will result in habitat improvement to the peatland system, assess possible ditch abandonment and road mitigation methods, and analyze implications of ditch abandonment for the ditch authority and regulatory agencies (e.g. affected properties, public benefits and utility, potential wetland credits).

This proposed work will contribute to the development, implementation and monitoring of improved peatland management practices. Public land administrators, regulators and Watershed Districts will be able to evaluate the effects of the ditches and the hydrology on the peatland habitat, analyze the viability of the habitat for SGCNs, and make changes to improve habitat. The proposal will also provide site-specific information tools interdisciplinary area teams need to maintain or enhance the SGCN habitats and other conservation values for this and other, similar peatland areas. Another benefit will be to objectively determine if ditch abandonment can occur and the appropriate ditch abandonment method for similar peatland areas.

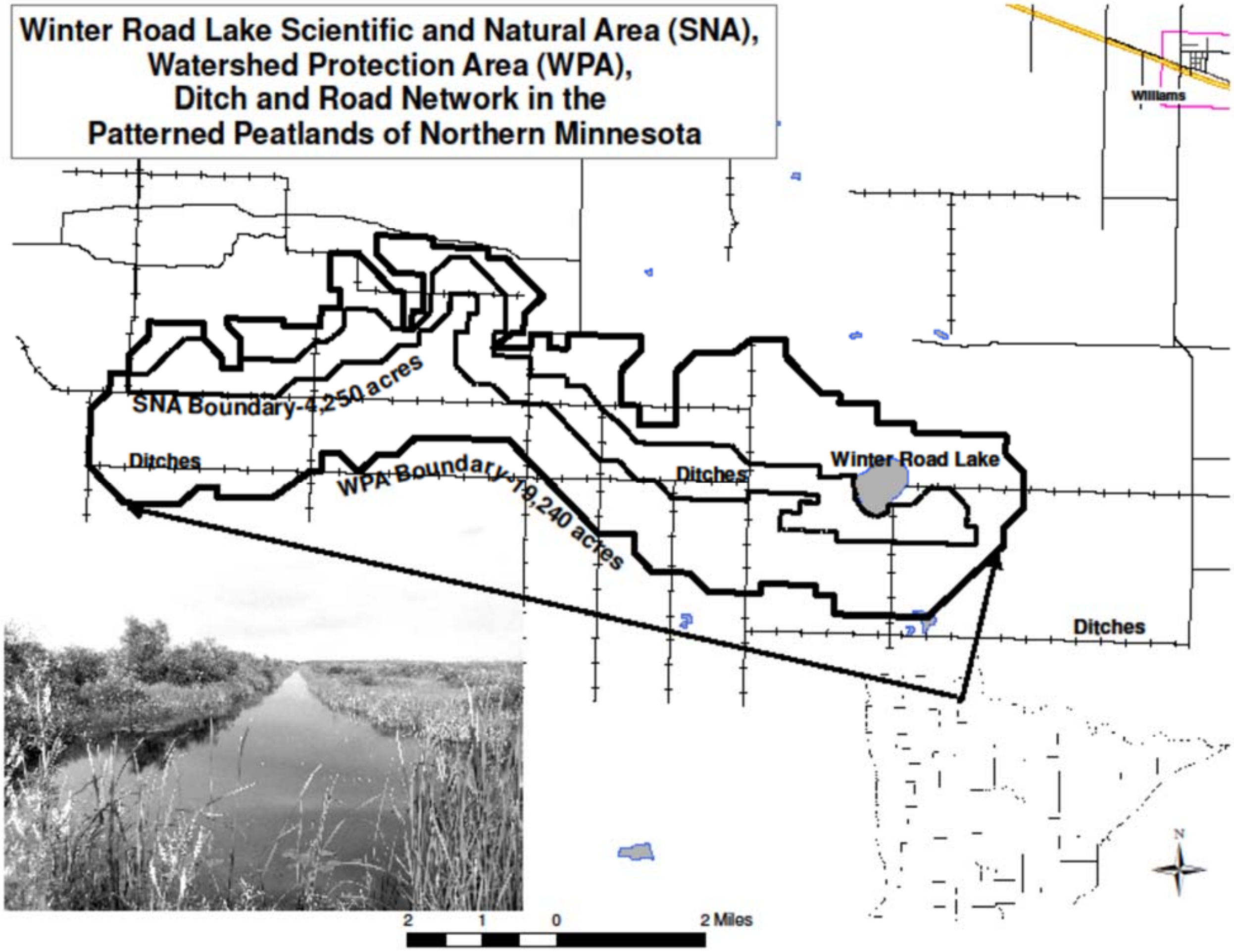
If the data show that ditch abandonment is a viable method for habitat restoration, future work will involve determining which ditches will be abandoned followed by design and implementation of these projects. Technical analysis and engineering would be completed to determine if wetland banking restoration credits would apply. This work will also include recommendations to mitigate the negative impacts of the road.

C. Spending History: *Not applicable, see Budget Detail for more information.*

Funding Source	M.L. 2005 or FY 2006-07	M.L. 2007 or FY 2008	M.L. 2008 or FY 2009	M.L. 2009 or FY 2010	M.L. 2010 or FY 2011

VIII. ACQUISITION/RESTORATION LIST: NA

IX. MAP(S):



X. RESEARCH ADDENDUM:
Attached

XI. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted not later than December 30, 2011, July 30, 2012, December 30, 2012, July 30, 2013, December 30, 2013, June 30, 2014, July 30, 2014, December 30, 2014 and June 30, 2015. A final report and associated products will be submitted between June 30 and August 1, 2015 as requested by the LCCMR.

Figure 2 Lidar map with subwatersheds.

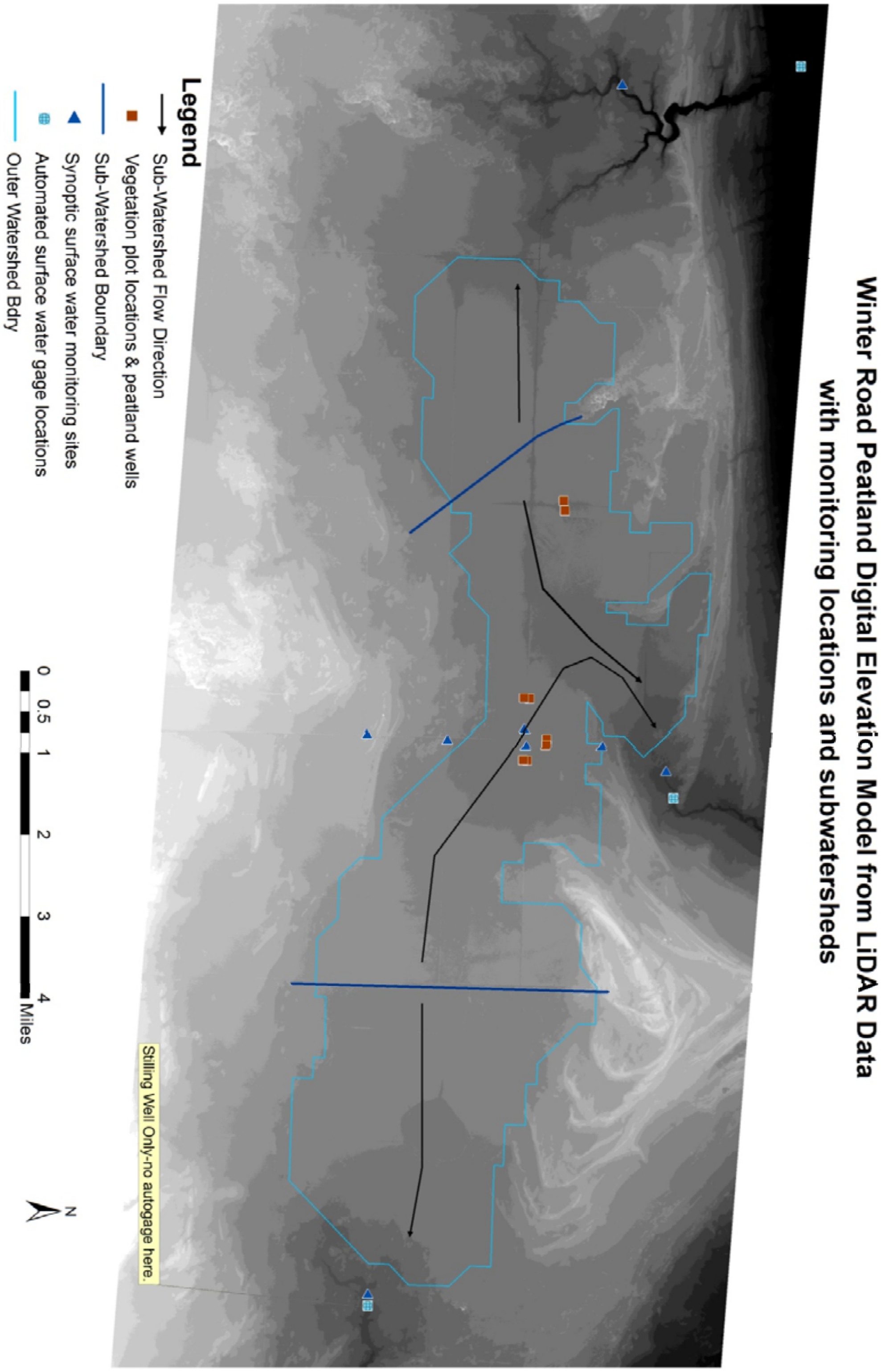


Figure 3. Piezometer locations.

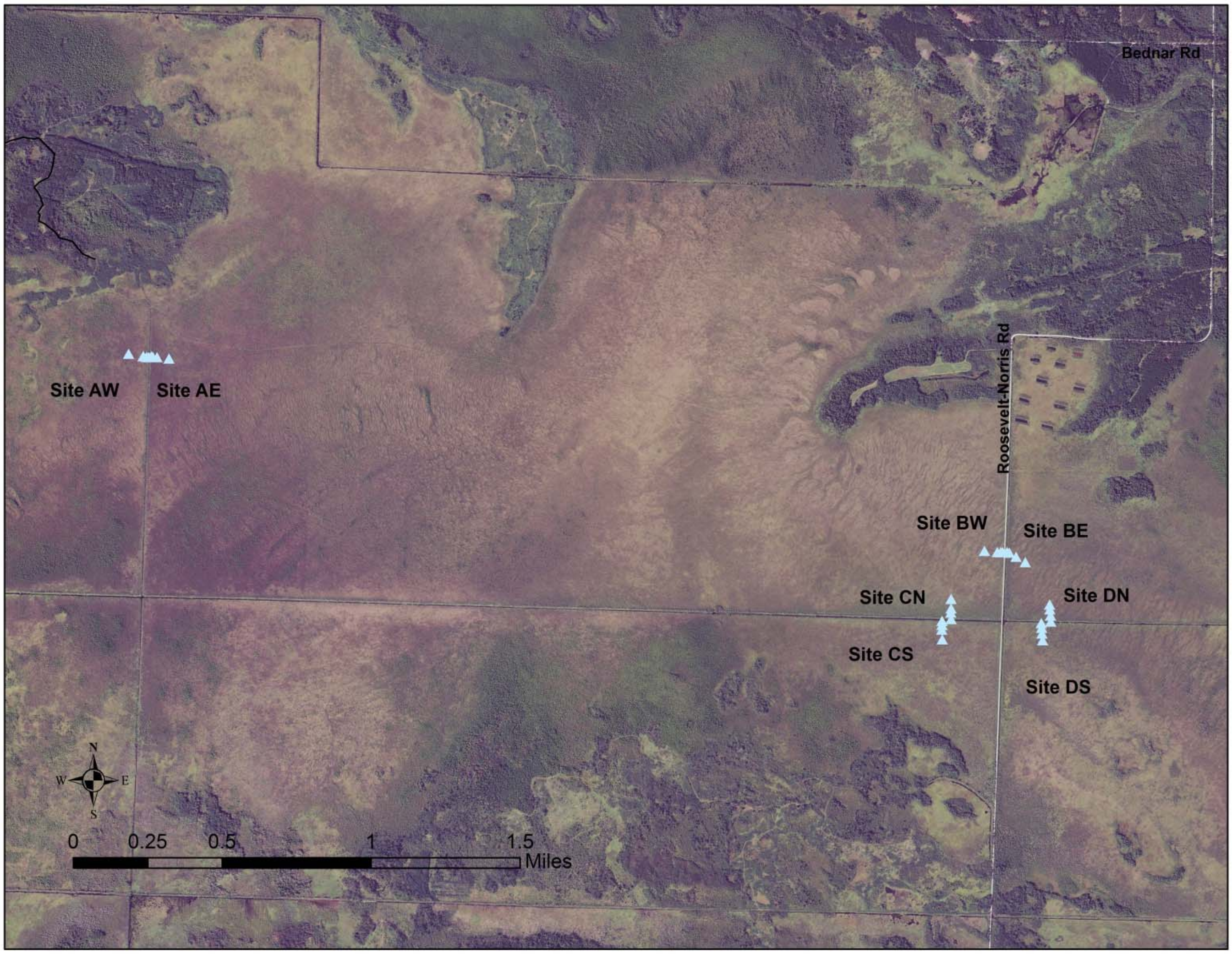
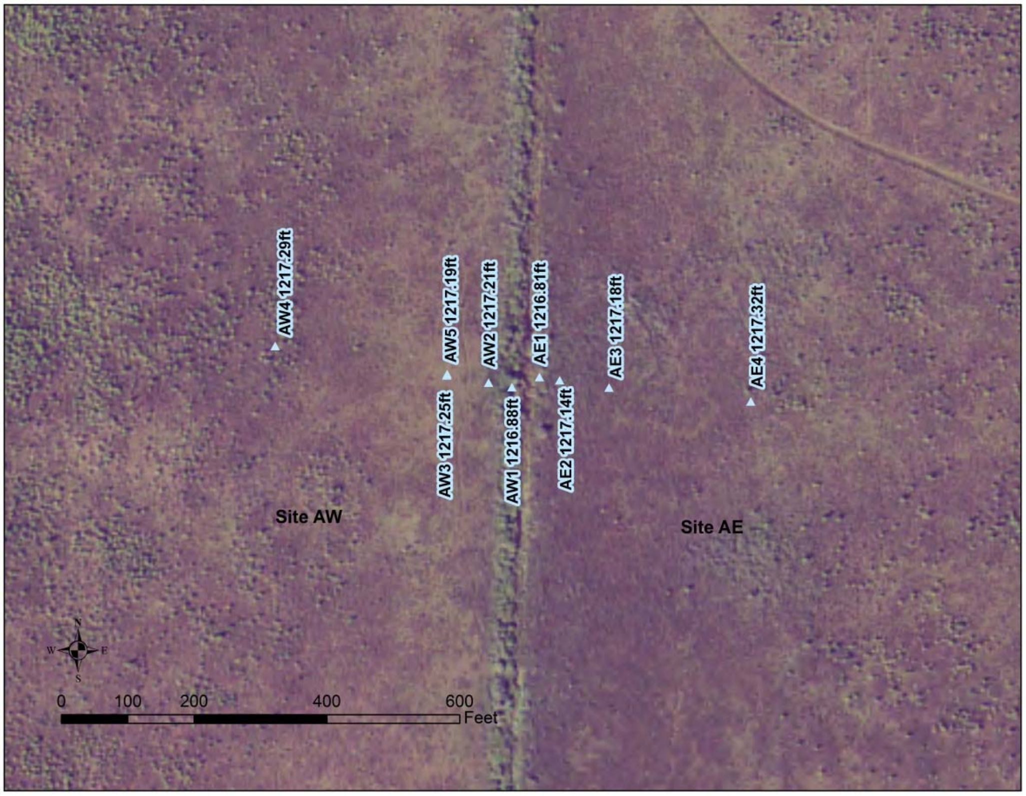


Figure 4: Piezometer Locations and Initial water levels



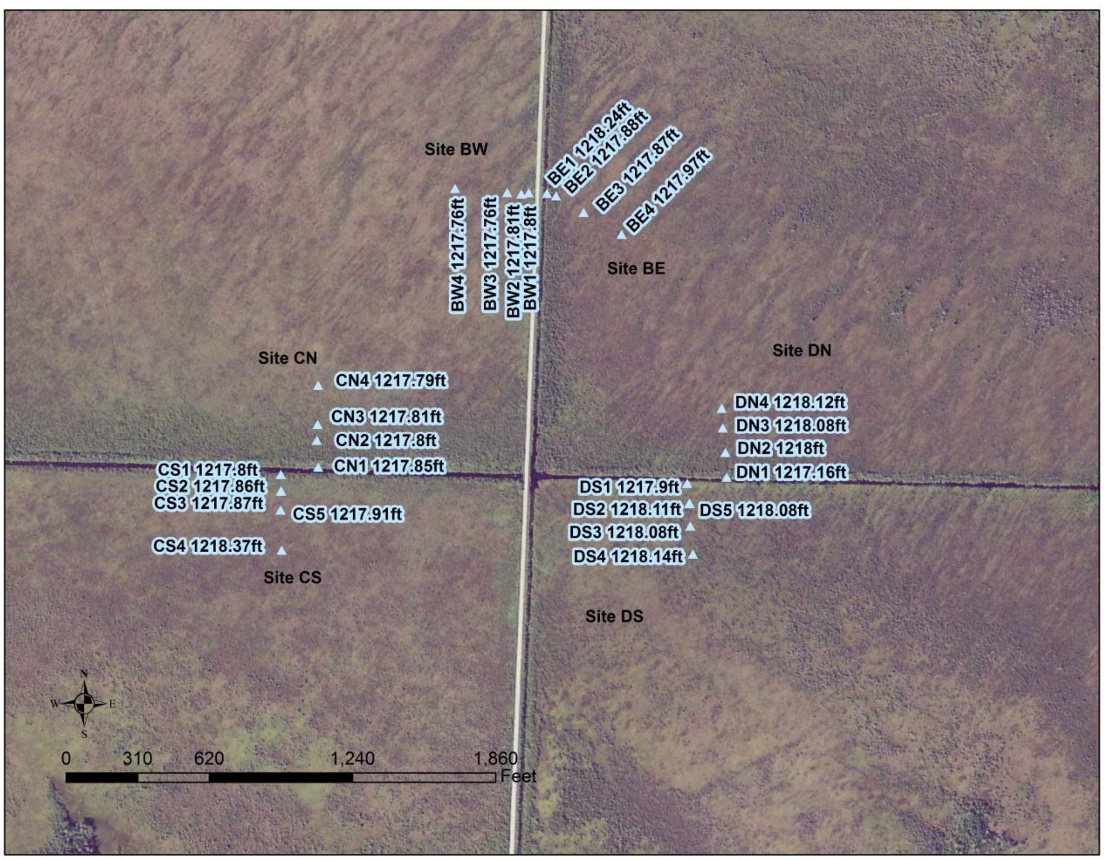


Figure 5a: Piezometer and stilling well locations overview

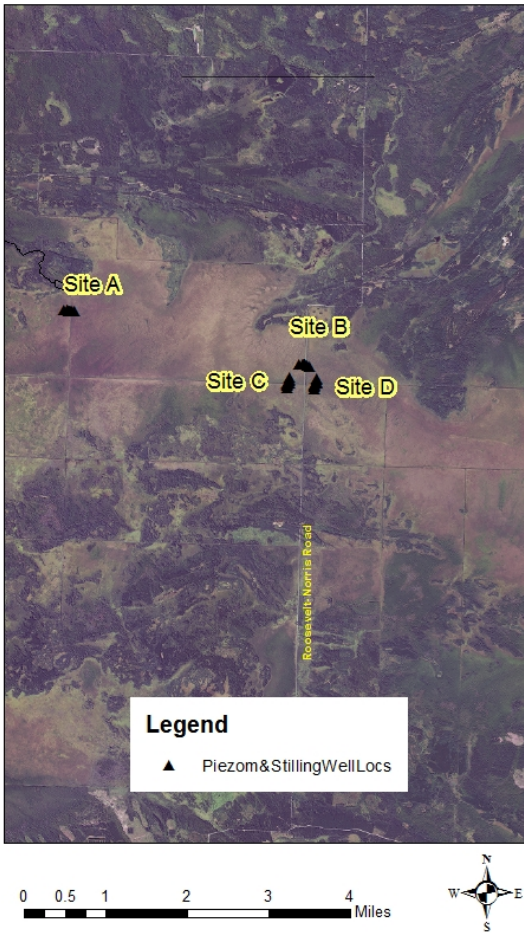
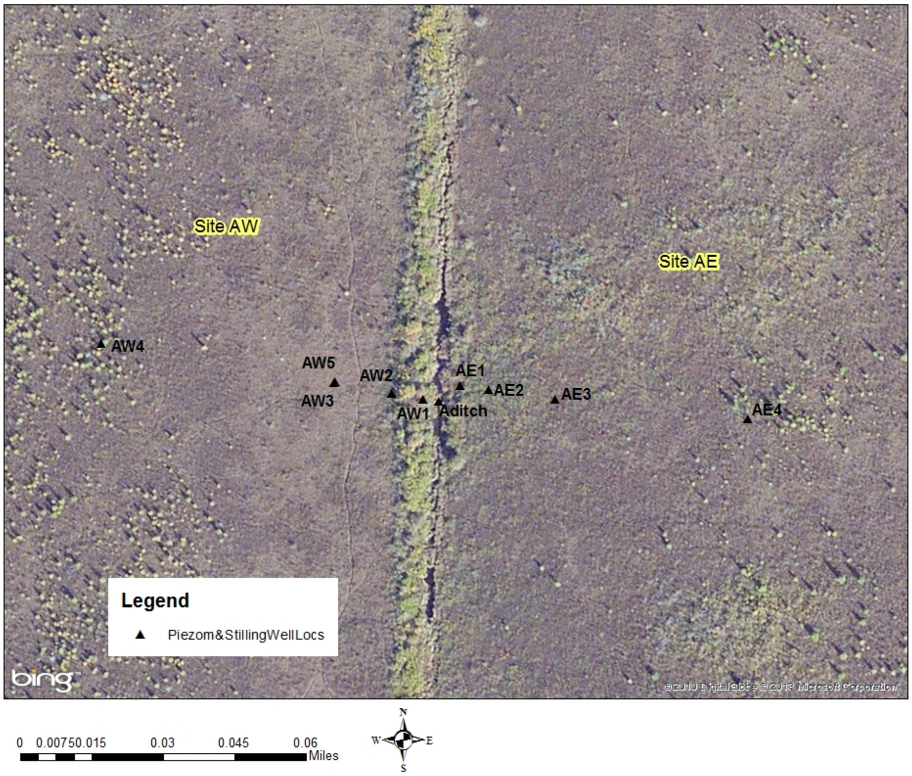


Figure 5b: Sites A, B, C and D Piezometer and Stilling Well Locations



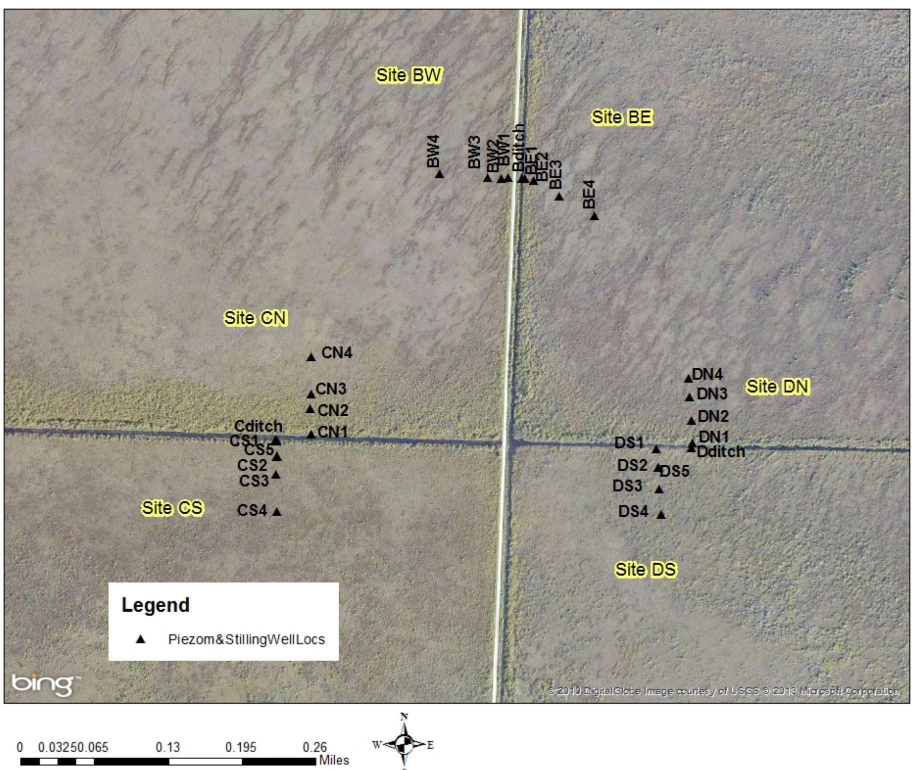
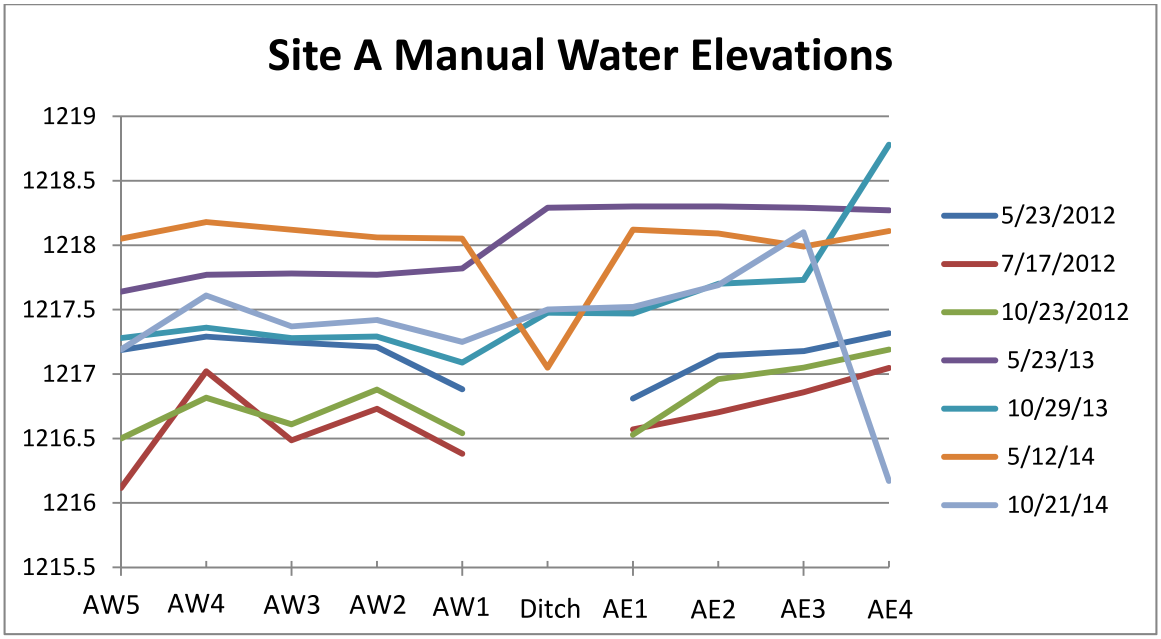


Table 1: Survey information of Measuring Point (Top of Casing)

Well Name	Unique#	May 2012	October 2012	May 2013	May 2014
AE1	272215	1219.21	1219.09	1219.72	1219.45
AE2	272216	1219.703	1219.63	1220.2	1219.95
AE3	272217	1220.558	1220.52	1220.99	1220.49
AE4	272218	1220.597	1220.58	1221.03	1220.77
AW1	272219	1219.782	1219.69	1219.72	1219.85
AW2	272220	1220.36	1220.27	1220.31	1220.5
AW3	272221	1219.546	1219.47	1219.47	1219.68
AW4	272222	1220.601	1220.62	1219.93	1220.4
AW5	272223	1219.806	1219.77	1219.76	1220.11
AW Ditch				1220.41	1219.22
BE1	272224	1221.429	1221.42	1221.39	1221.8
BE2	272225	1221.07	1221.07	1220.96	1221.57
BE3	272226	1220.93	1221.01	1220.92	1221.07
BE4	272227	1222.96	1222.99	1222.74	1222.89
BE Ditch				1220.28	1220.22
BW1	272228	1220.969	1220.99	1220.98	1221.14
BW2	272229	1220.976	1221.02	1221.12	1221.19
BW3	272230	1220.889	1220.93	1220.91	1220.88
BW4	272231	1221.708	1221.78	1221.93	1222.1
CN1	272232	1220.742	1220.84	1219.44	1219.39
CN2	272233	1220.641	1220.74	1220.7	1220.72
CN3	272234	1220.684	1220.75	1220.72	1220.55
CN4	272235	1221.359	1221.46	1221.53	1221.85
CS1	272236	1220.976	1220.97	1221.05	1220.99
CS2	272237	1220.446	1220.49	1220.5	1220.49
CS3	272238	1220.171	1220.17	1222.56	1221.95
CS4	272239	1220.867	1220.86	1220.88	1220.93
CS5	272240	1220.902	1220.9	1220.98	1221.01
CS Ditch				1220.87	1220.73
DN1	272241	1220.756	1220.73	1220.53	1220.34
DN2	272242	1220.882	1220.91	1220.73	1220.81
DN3	272243	1220.884	1220.89	1220.87	1220.85
DN4	272244	1221.131	1221.11	1220.82	1220.75
DN Ditch				1220.67	1220.4
DS1	272245	1221.929	1221.9	1220.92	1220.98
DS2	272246	1221.949	1221.92	1221.94	1221.84
DS3	272247	1222.063	1222	1220.83	1220.94
DS4	272248	1221.432	1221.42	1221.25	1221.39
DS5	272249	1221.135	1221.13	1221.11	1221.23
Winter Road River				1203.94	1203.94

Figure 6a: Graphs of Hand Water Levels at Sites A and B



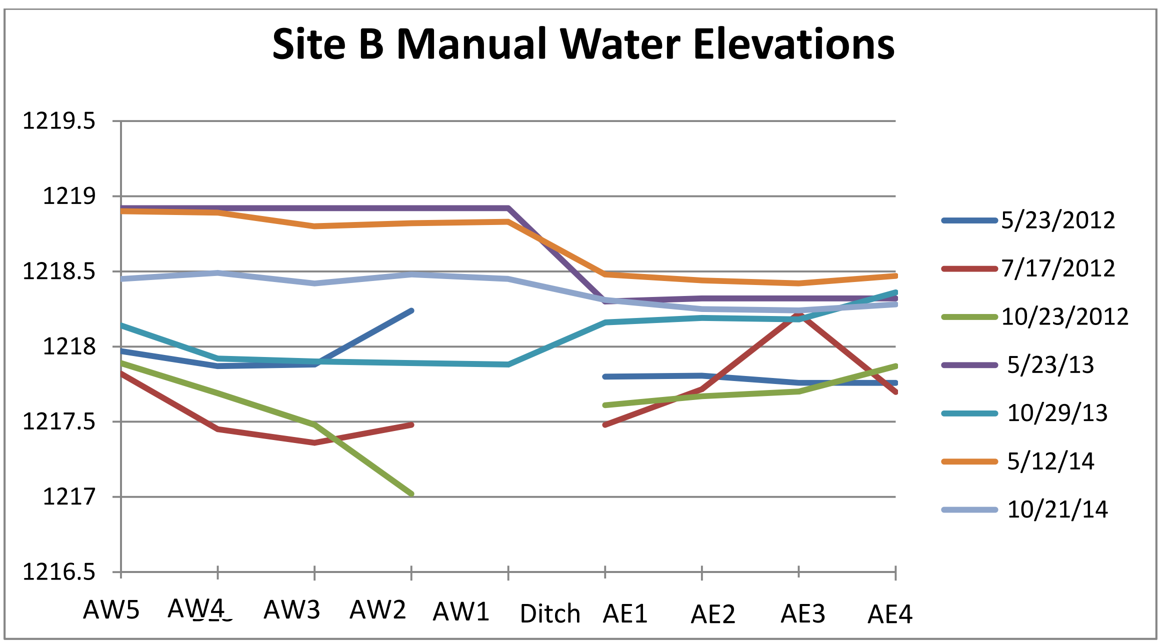
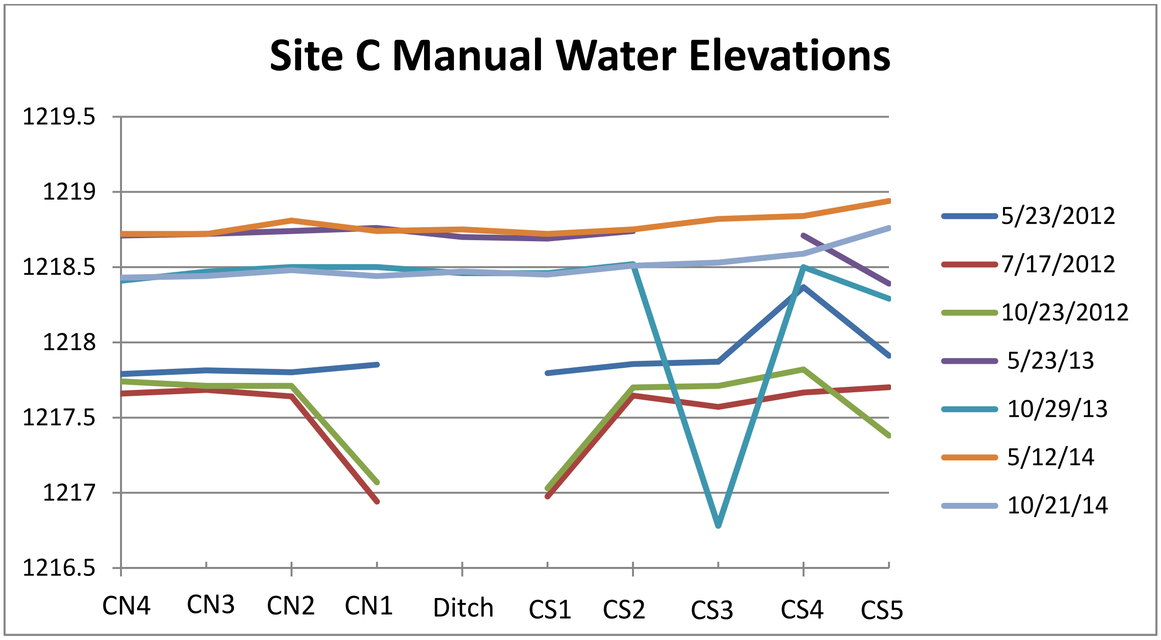


Figure 6b: Graphs of Hand Water Levels at Sites C and D



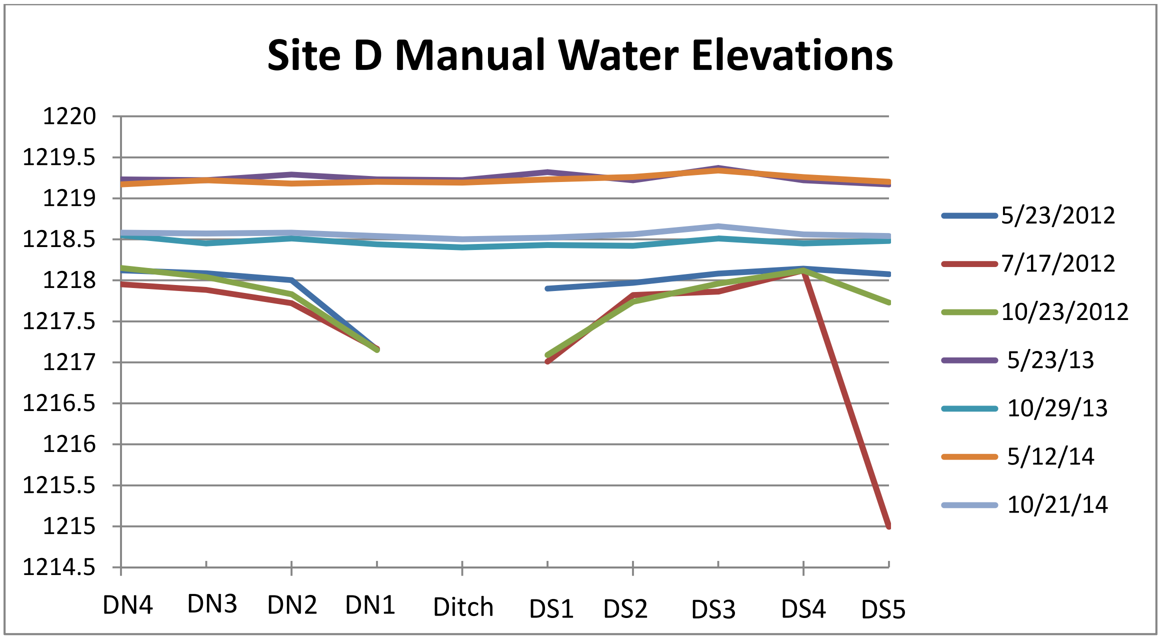


Figure 7: Monthly Precipitation Totals Norris Camp and West Branch Warroad River.

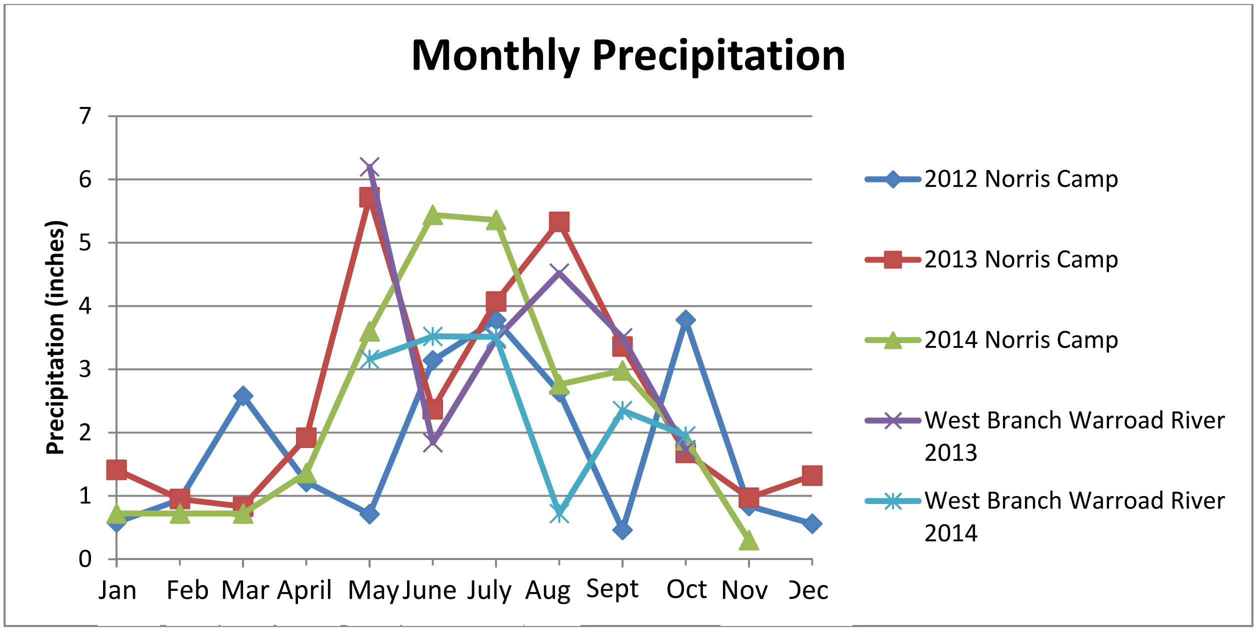


Figure 7a: Daily Precipitation Totals Norris Camp

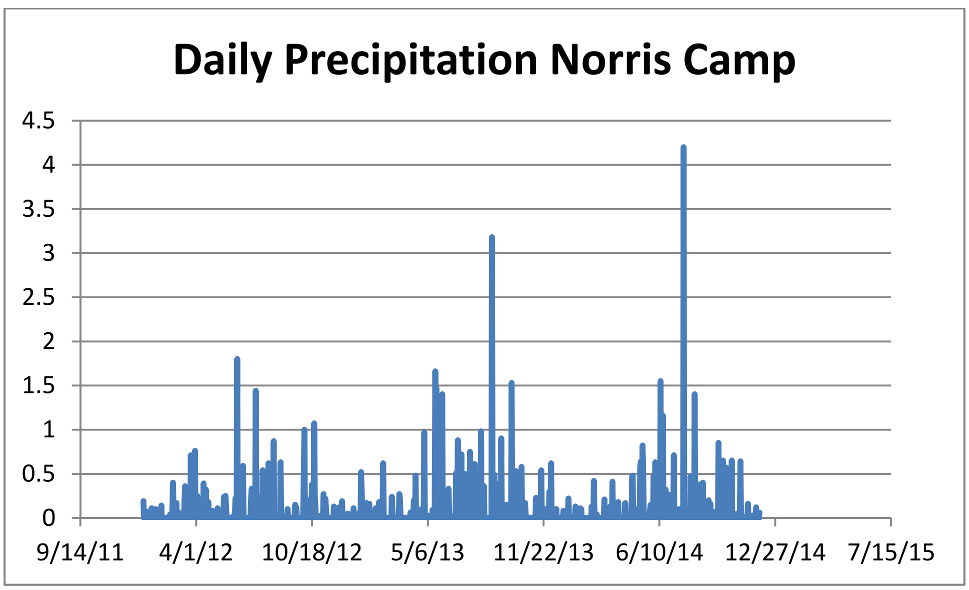


Figure 7b: Daily Precipitation Totals West Branch Warroad River

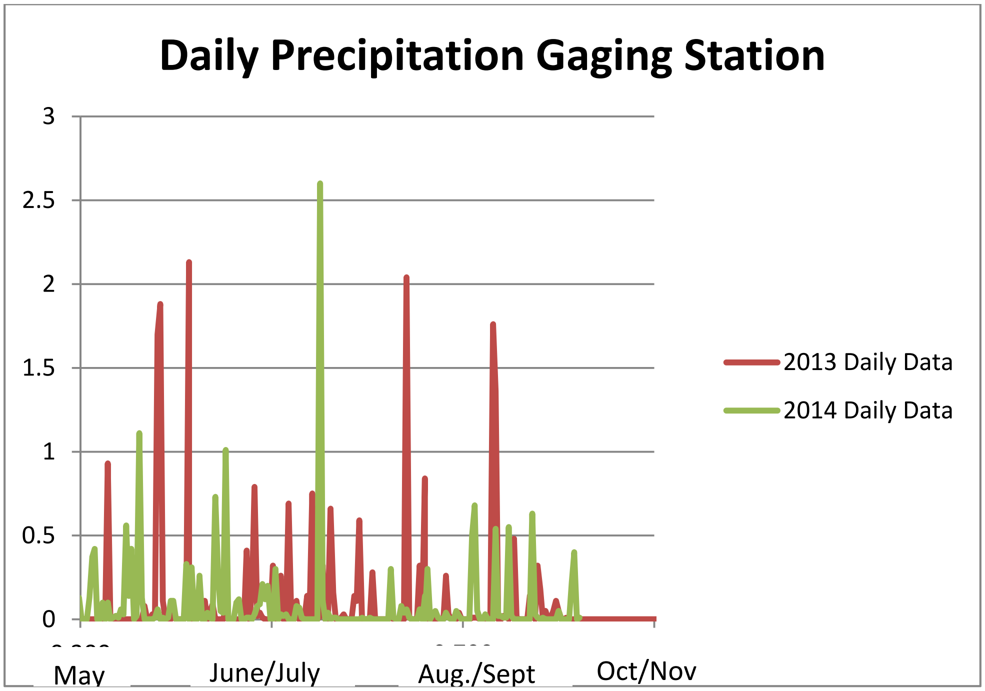
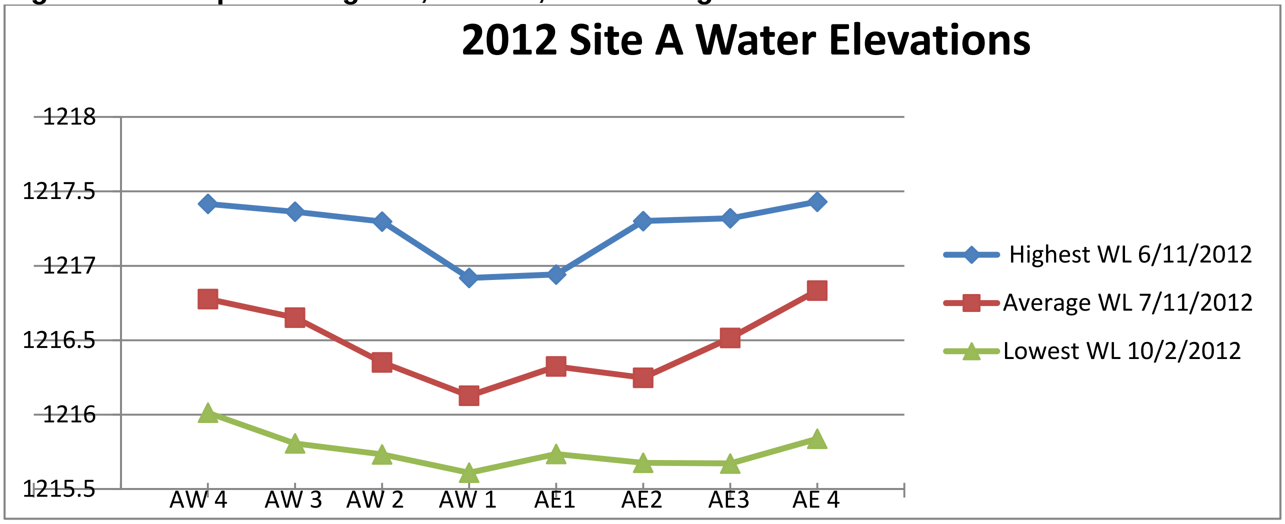
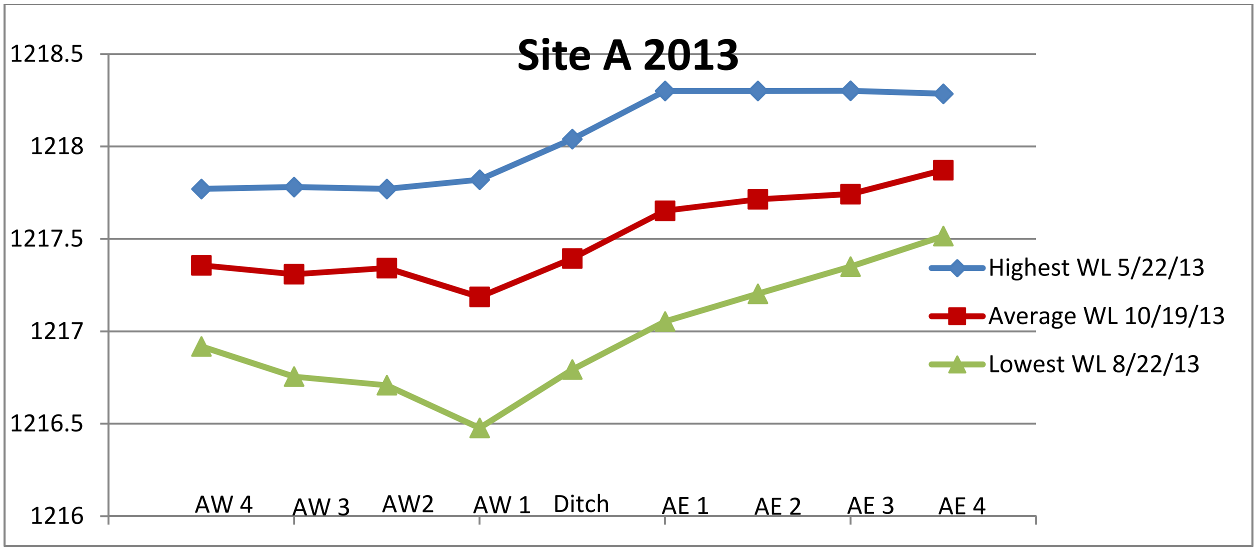


Figure 8A: Graphs of Highest, Lowest, and Average Water Levels Site A





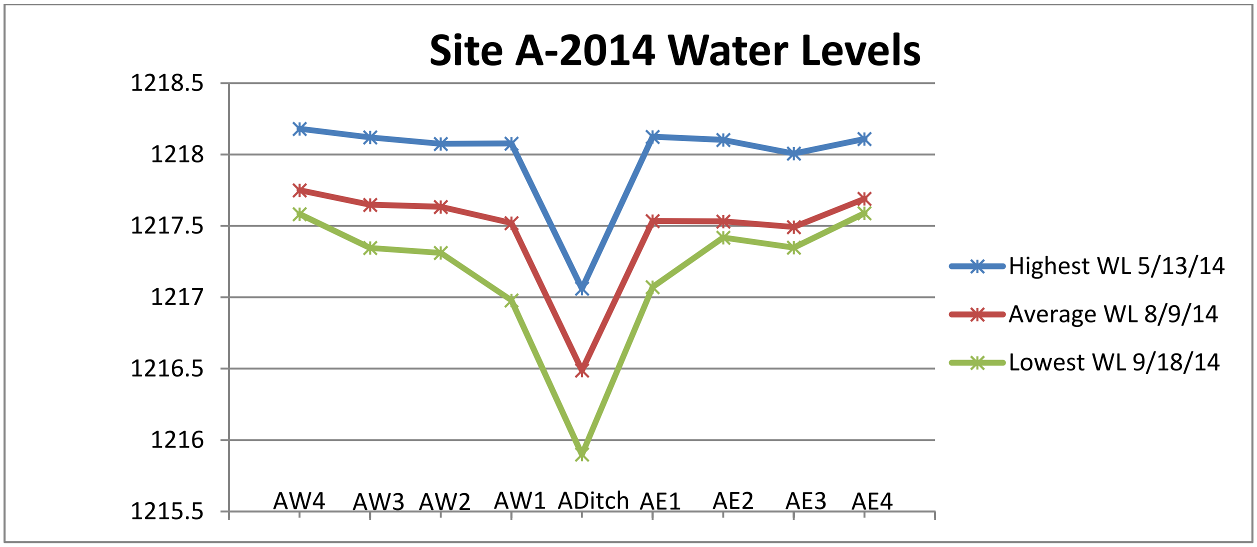
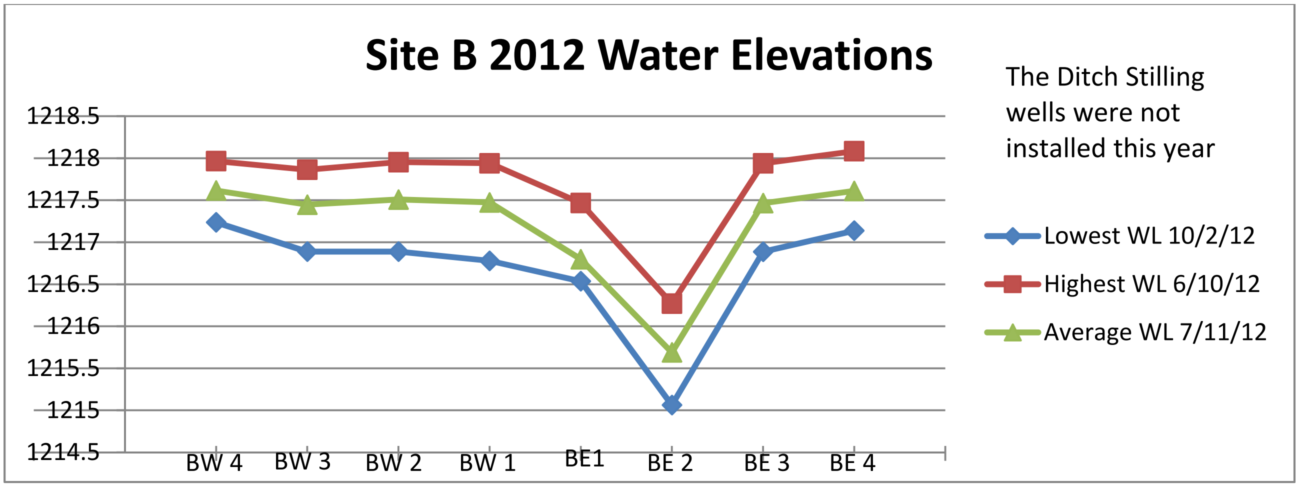
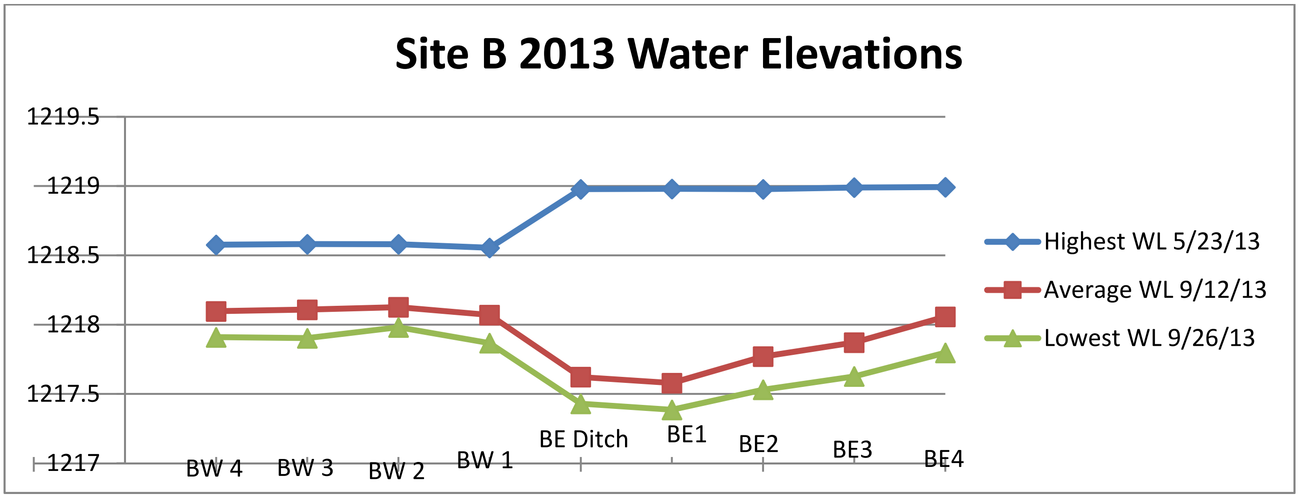


Figure 8B: Graphs of Highest, Lowest, and Average Water Levels Site B





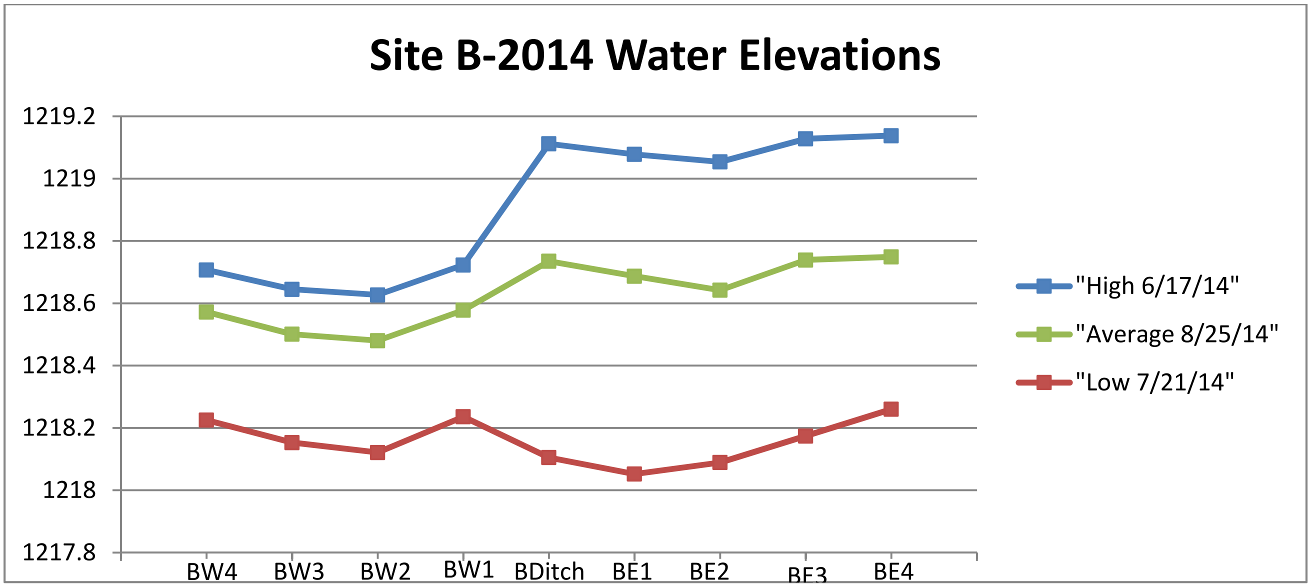
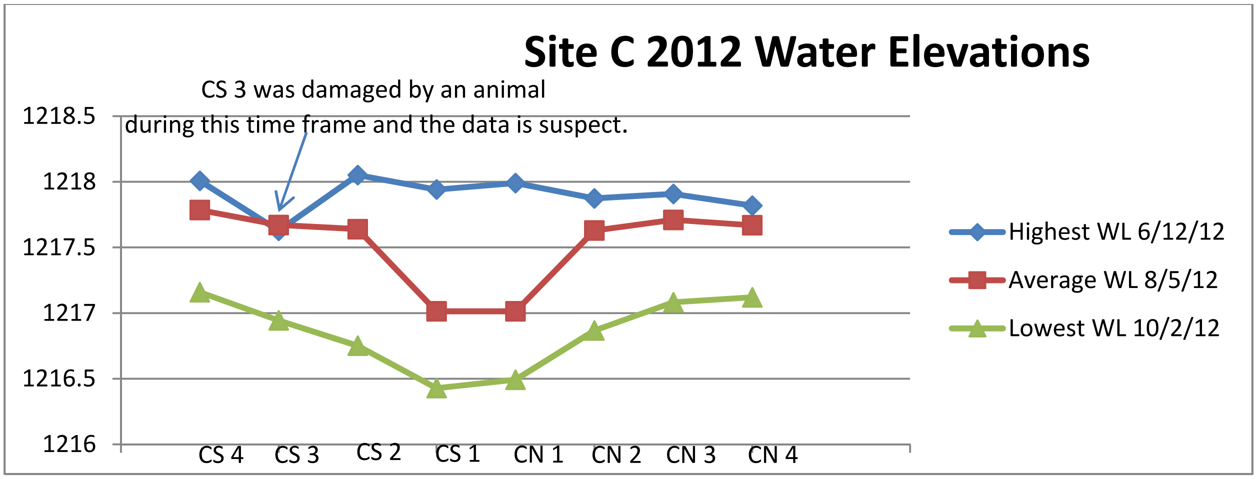
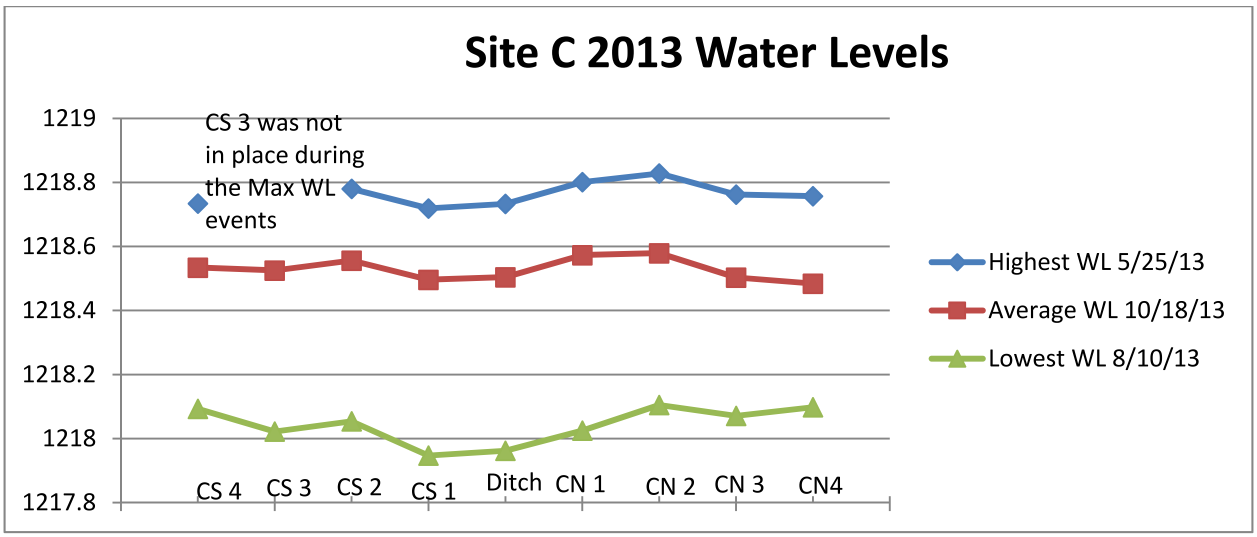


Figure 8C: Graphs of Highest, Lowest, and Average Water Levels Site C





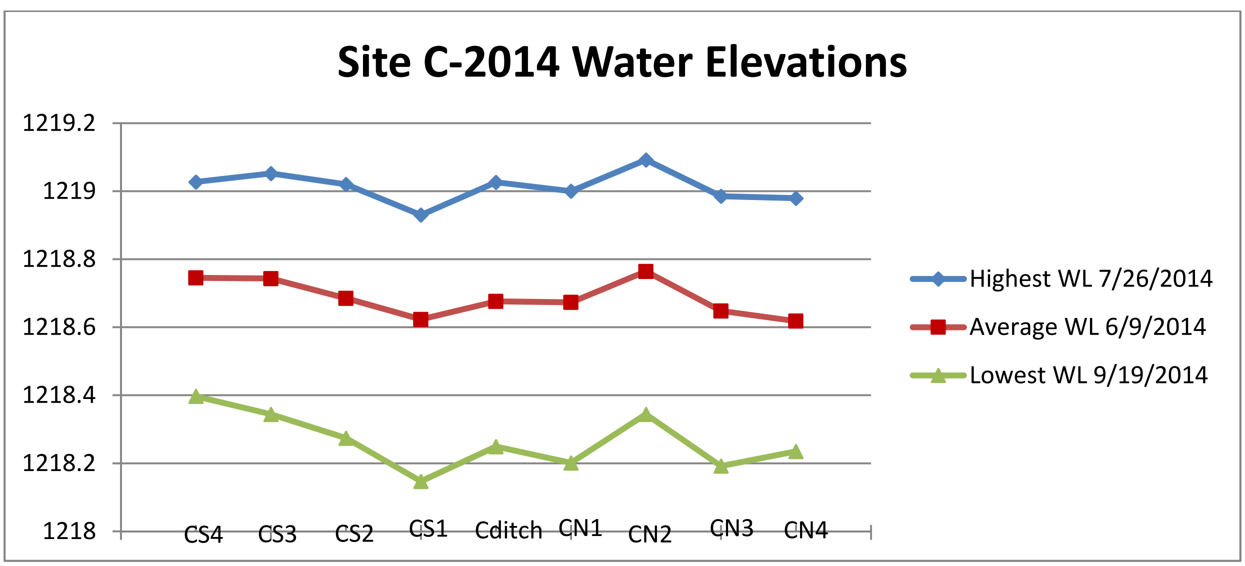
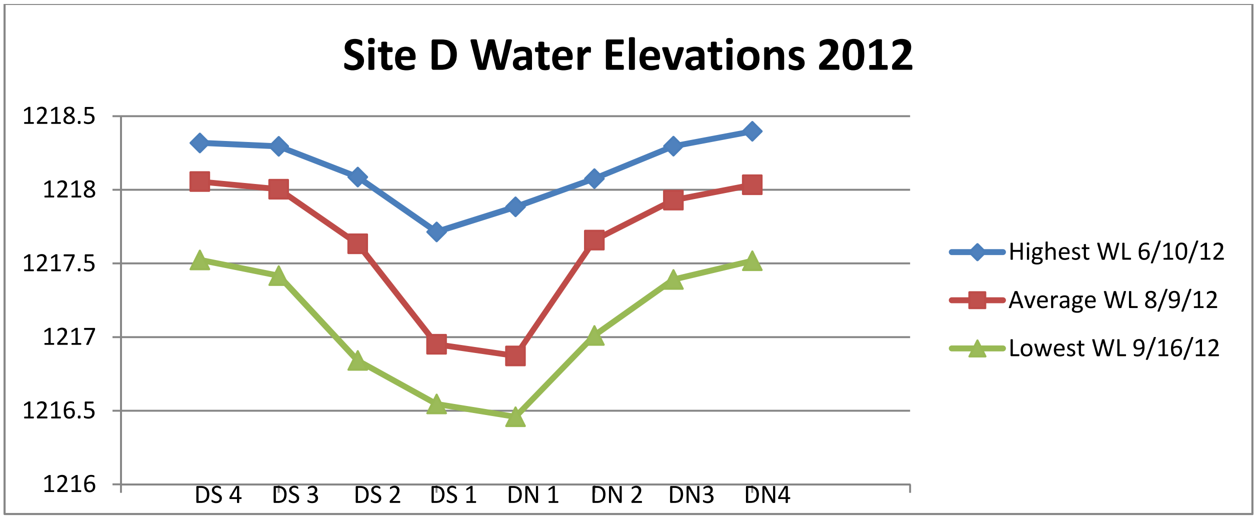
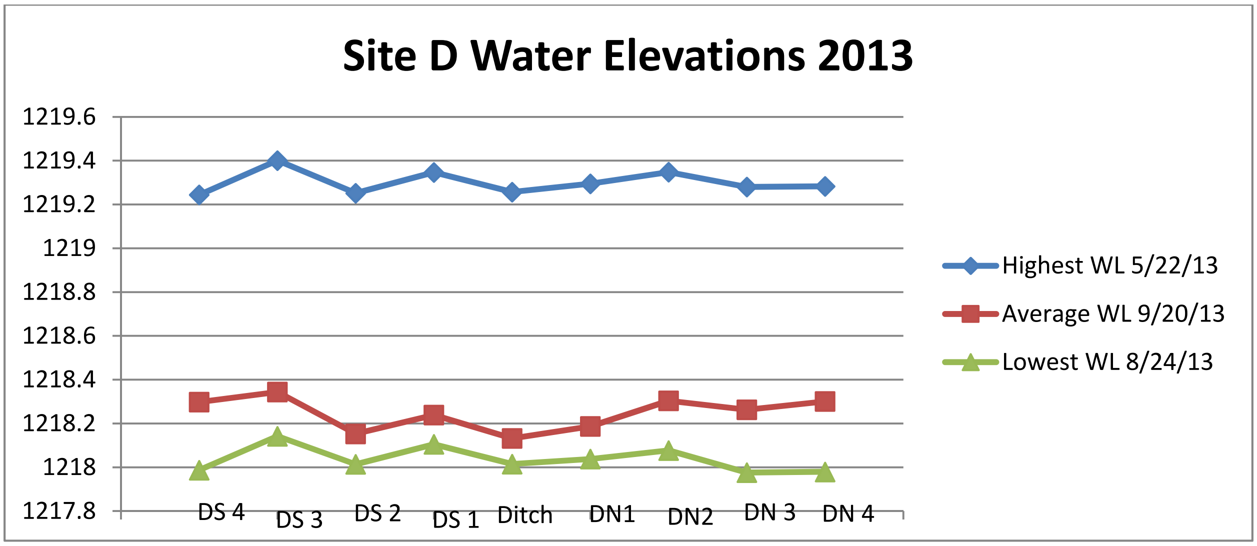


Figure 8D: Graphs of Highest, Lowest, and Average Water Levels Site D





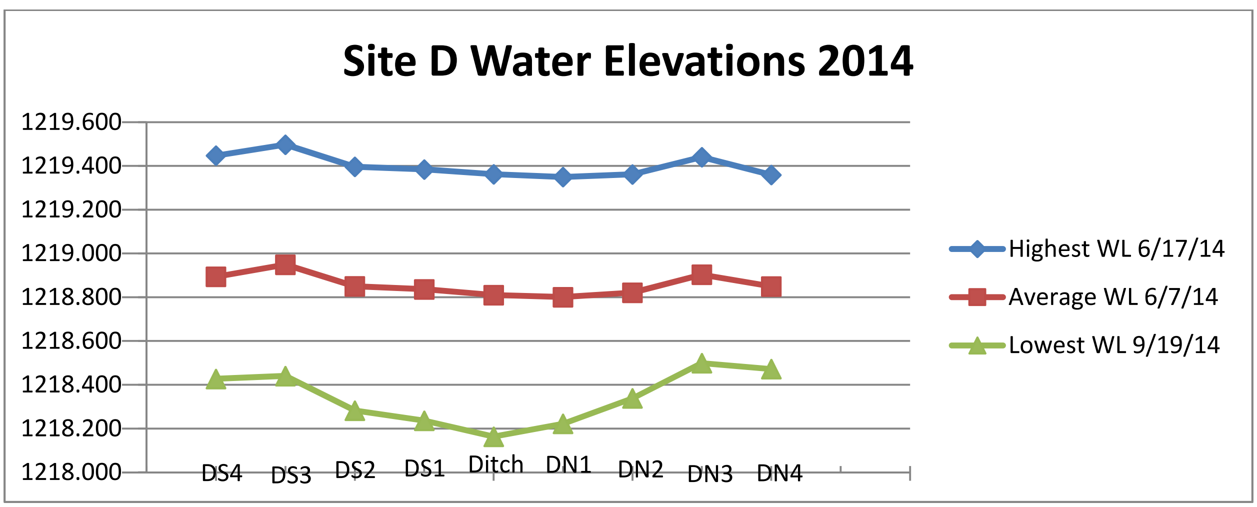
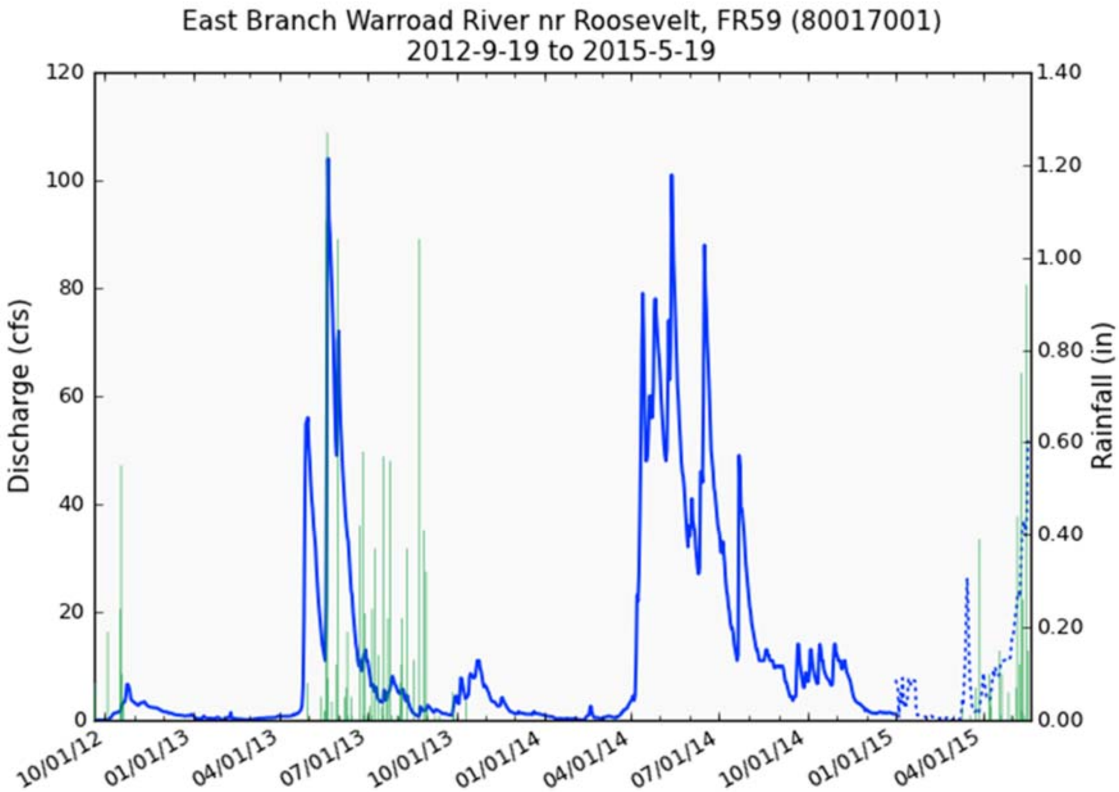


Figure 9A: East Branch Warroad River Discharge Data (blue-cubic feet per second) and precipitation (green-inches)



Please note that provisional data are represented by a dashed line

Figure 9B: West Branch Warroad River Discharge (blue-cubic feet per second) and Precipitation Data (green)

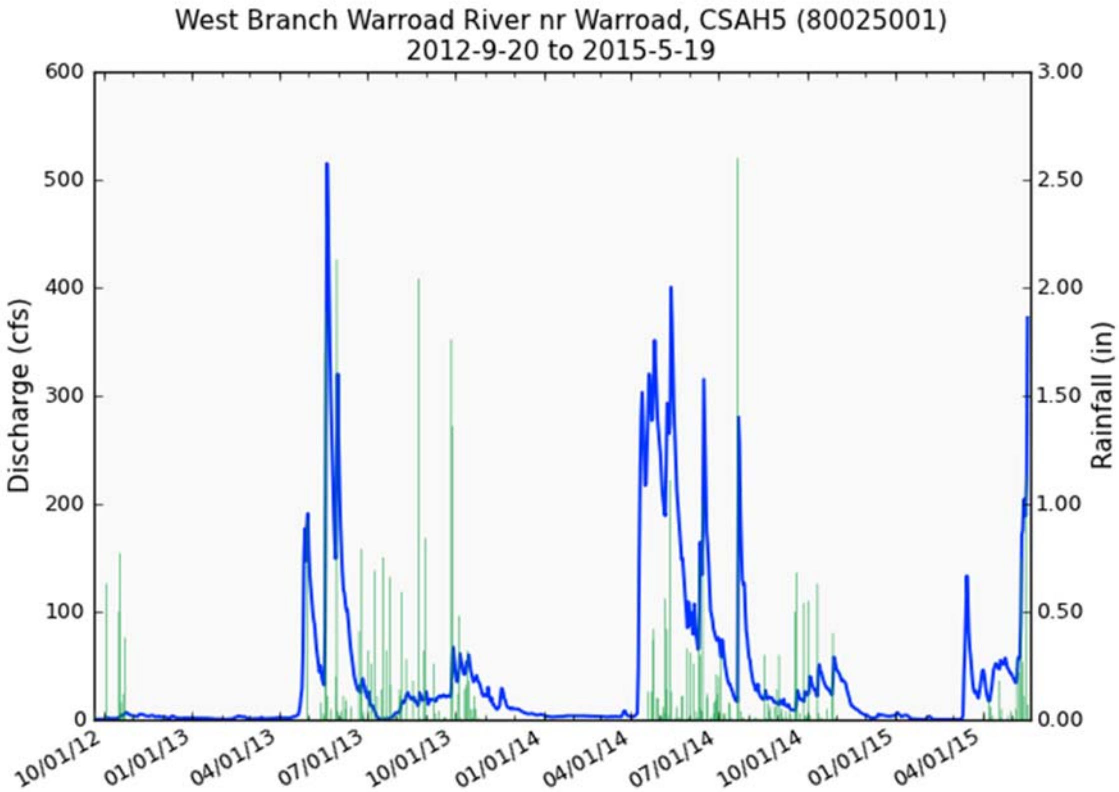


Figure 9C: West Branch Warroad River Gage Rating Table.

MPCA/DNR Cooperative Stream Gaging — HYRATAB V173 Output 03/03/2015

Site H80025001 — West Branch Warroad River nr Warroad, CSAH5
Rating Table 2.00 — 09/19/2012 to Present — Interpolation = Log — PZF = 1153.3600
Converting 233 — Corrected Level in Feet
Into 262 — Discharge in ft3/s

G.H.	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1153.3							0.0^	0.0019	0.0039	0.0058
1153.4	0.0077	0.0097	0.0116	0.0135	0.0155	0.0174	0.0193	0.0213	0.0232	0.0251
1153.5	0.0271	0.029	0.0309	0.0329	0.0348	0.0367	0.0387	0.0406	0.0425	0.0445
1153.6	0.0464	0.0483	0.0503	0.0522	0.0541	0.0561	0.058	0.0599	0.0619	0.0638
1153.7	0.0658^	0.0692	0.0727	0.0762	0.0798	0.0835	0.0873	0.0911	0.095	0.099
1153.8	0.103	0.107	0.111	0.116	0.12	0.124	0.129	0.133	0.138	0.143
1153.9	0.147	0.152	0.160^	0.171	0.183	0.195	0.208	0.221	0.235	0.25
1154	0.265^	0.295	0.336	0.382	0.433-	0.485	0.542	0.604	0.672-	0.739
1154.1	0.812	0.891	0.977	1.07-	1.16	1.26	1.36	1.47	1.60-	1.72
1154.2	1.84	1.97	2.12	2.26	2.42	2.58-	2.74	2.91	3.09	3.27
1154.3	3.46	3.66	3.88-	4.07	4.27	4.48	4.69	4.91	5.14	5.38
1154.4	5.62	5.85	6.07	6.29	6.52	6.76	7	7.24	7.49	7.75
1154.5	8.02	8.29	8.56	8.83	9.12	9.4	9.7	10	10.3	10.6
1154.6	11	11.3	11.6	11.9	12.2	12.5	12.8	13.2	13.5	13.8
1154.7	14.2	14.5	14.9	15.3	15.6	16	16.4	16.8	17.2	17.7
1154.8	18.1	18.5	19	19.4	19.9	20.3	20.8	21.2	21.7	22.2
1154.9	22.6	23.1	23.6	24.1	24.6	25.1	25.6	26.2	26.7	27.2
1155	27.8	28.3	28.8	29.4	29.9	30.4	31	31.5	32.1	32.7
1155.1	33.2	33.8	34.4	35	35.6	36.2	36.8	37.4	38.1	38.7
1155.2	39.4	40	40.7	41.4	42	42.7	43.4	44.1	44.9	45.6
1155.3	46.3	47	47.8	48.5	49.3	50.1	50.8	51.6	52.4	53.2
1155.4	53.9	54.5	55.3	56	56.7	57.4	58.1	58.8	59.6	60.3
1155.5	61.1	61.8	62.6	63.4	64.1	64.9	65.7	66.5	67.3	68.1
1155.6	68.9	69.7	70.5	71.3	72.1	72.9	73.8	74.6	75.4	76.3
1155.7	77.1	78	78.8	79.7	80.5	81.4	82.3	83.2	84.1	85
1155.8	85.9	86.8	87.7	88.6	89.6	90.5	91.4	92.4	93.3	94.3
1155.9	95.3	96.3	97.3	98.3	99.3	100	101	102	103	105
1156	106	107	108	109	110	111	112	113	114	115
1156.1	116	118	119	120	121	122	123	124	125	127
1156.2	128	129	130	131	132	133	134	135	136	137
1156.3	138	140	141	142	143	144	145	146	147	149
1156.4	150	151	152	153	155	156	157	158	159	160
1156.5	162	163	164	165	167	168	169-	170	172	173
1156.6	174	175	177	178	179	181	182	183	185	186
1156.7	187	189	190	191	193	194	195	197	198	199
1156.8	201	202	204	205	206	208	209-	211	212	213
1156.9	215	216	217	219	220	221	223	224	225	227
1157	228	229	231	232	234	235	236	238	239	241
1157.1	242	243	245	246	248	249	251	252	253	255
1157.2	256	258	259	261	262	264	265	267	268	270
1157.3	271	273	274	276-	277	279	280	282	283	285
1157.4	286	288	289	291	292	294	295	297	298	300
1157.5	301	303	304	306	307	309	310	312	314	315
1157.6	317	318	320	322	323	325	326	328	330	331
1157.7	333	334	336	338	339-	341	343	344	346	348
1157.8	349	351	353	354	356	358	359	361	363	364
1157.9	366	368	370	371	373	375	377	378	380	382
1158	384	385	387	389	391	392	394	396	398	400
1158.1	401	403	405	407	409	410	412	414	416	418
1158.2	420	421	423^	425	427	429	431	432	434	436
1158.3	438	440	442	443	445	447	449	451	453	455
1158.4	456	458	460	462	464	466	468	470	472	474
1158.5	476	477	479	481	483	485	487	489	491	493
1158.6	495	497	499	501	503	505	507	509	511	513
1158.7	515	517	519	521	523	525	527	529	531	533
1158.8	535	537	539	541	543^					

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used to indicate stored rating points.
All rated data has been coded as reliable
except where the following tags are used...
Poor Quality Rating Point
Rating Table Extrapolated

Figure 9D: East Branch Warroad River Gage Rating Table.

MPCA/DNR Cooperative Stream Gaging — HYRATAB V173 Output 03/03/2015

Site H80017001 East Branch Warroad River nr Roosevelt, FR59
Rating Table 2.00 09/01/2012 to Present Interpolation = Log PZF = 1200.5000
Converting 233 Corrected Level in Feet
Into 262 Discharge in ft3/s

G.H.	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1200.5	0.0^	0.0172	0.0344	0.0516	0.0688	0.086	0.103	0.12	0.138	0.155
1200.6	0.172^	0.19	0.209	0.228	0.247	0.267	0.286	0.305	0.325	0.344
1200.7	0.364	0.384	0.403	0.423^	0.445	0.468	0.49	0.513	0.536	0.559
1200.8	0.582	0.606	0.629	0.653	0.677^	0.7	0.724	0.748	0.772	0.796
1200.9	0.82	0.844	0.868	0.892	0.917	0.942	0.967^	0.995	1.02	1.05
1201	1.08	1.11	1.14	1.17	1.2	1.23	1.26	1.29	1.33	1.36
1201.1	1.39	1.42^	1.45	1.49	1.52	1.55	1.59	1.62	1.66	1.69
1201.2	1.73	1.76	1.8	1.83	1.87	1.9	1.94	1.98	2.01	2.05
1201.3	2.09^	2.13	2.17	2.22	2.26	2.3	2.35	2.39	2.44	2.48
1201.4	2.53	2.57	2.62	2.66	2.71	2.76	2.8	2.85^	2.91	2.96
1201.5	3.02	3.07	3.13	3.19	3.25	3.3	3.36	3.42	3.48	3.54^
1201.6	3.61	3.69	3.77	3.86	3.94	4.02^	4.14	4.27	4.4	4.54
1201.7	4.68	4.82	4.97	5.12	5.27-	5.4	5.54	5.68	5.82	5.96
1201.8	6.11	6.26	6.41	6.56	6.72-	6.88	7.05	7.23	7.4	7.58
1201.9	7.76	7.95	8.13	8.33	8.52-	8.69	8.87	9.05	9.24	9.43
1202	9.61	9.81	10	10.2	10.4	10.6-	10.8	10.9	11.1	11.3
1202.1	11.4	11.6	11.8	12	12.1	12.3	12.5	12.7	12.8	13
1202.2	13.2	13.4-	13.6	13.8	14	14.1	14.3	14.5	14.7	14.9
1202.3	15.1	15.3	15.5	15.7	16	16.2	16.4	16.6-	16.8	17
1202.4	17.2	17.4	17.6	17.8	18	18.2	18.4	18.6	18.8	19
1202.5	19.3	19.5	19.7	19.9	20.1	20.3	20.6	20.8	21	21.2
1202.6	21.5	21.7	21.9	22.1	22.4	22.6-	22.8	23	23.3	23.5
1202.7	23.7	23.9	24.1	24.4	24.6	24.8	25	25.3	25.5	25.7
1202.8	25.9	26.2	26.4	26.6	26.9	27.1	27.3	27.6	27.8	28
1202.9	28.3	28.5	28.8	29	29.2	29.5	29.7	30	30.2	30.5
1203	30.7	31	31.2-	31.4	31.7	31.9	32.1	32.4	32.6	32.8
1203.1	33.1	33.3	33.5	33.8	34	34.2	34.5	34.7	34.9	35.2
1203.2	35.4	35.7	35.9	36.2	36.4	36.6	36.9	37.1	37.4	37.6
1203.3	37.9	38.1	38.4	38.6-	38.8	39.1	39.3	39.6	39.8	40.1
1203.4	40.3	40.5	40.8	41	41.3	41.5	41.8	42	42.3	42.5
1203.5	42.8	43	43.3	43.5	43.8	44	44.3	44.6	44.8	45.1
1203.6	45.3	45.6	45.8	46.1	46.4	46.6	46.9	47.1-	47.4	47.7
1203.7	48	48.2	48.5	48.8	49.1	49.4	49.7	50	50.2	50.5
1203.8	50.8	51.1	51.4	51.7	52	52.3	52.6	52.9	53.1	53.4
1203.9	53.7	54	54.3	54.6	54.9-	55.3	55.7	56	56.4	56.8
1204	57.1	57.5	57.9	58.3	58.6-	59.1	59.6	60.1	60.6	61.1
1204.1	61.6	62.1	62.6	63.1	63.6	64.1	64.6	65.2	65.7	66.2
1204.2	66.8	67.3	67.8	68.4	68.9-	69.5	70.1	70.7	71.3	71.9
1204.3	72.5	73.1	73.7	74.3	74.9	75.5	76.1	76.8	77.4	78
1204.4	78.6	79.3	79.9	80.6	81.2	81.9	82.5	83.2	83.8	84.5
1204.5	85.2	85.9-	86.5	87.2	87.9	88.5	89.2	89.9	90.6	91.3
1204.6	92	92.7	93.4	94.1	94.8	95.5-	96.2	96.9	97.6	98.4
1204.7	99.1	99.8	101	101	102	103	104	104	105	106
1204.8	107	107	108	109	110	111	111	112	113	114
1204.9	115^									

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used to indicate stored rating points.

All rated data has been coded as reliable
except where the following tags are used...

Poor Quality Rating Point

Rating Table Extrapolated

Figure 10: Synoptic Surface Water Measurement Locations with Autogage and Piezometer Locations

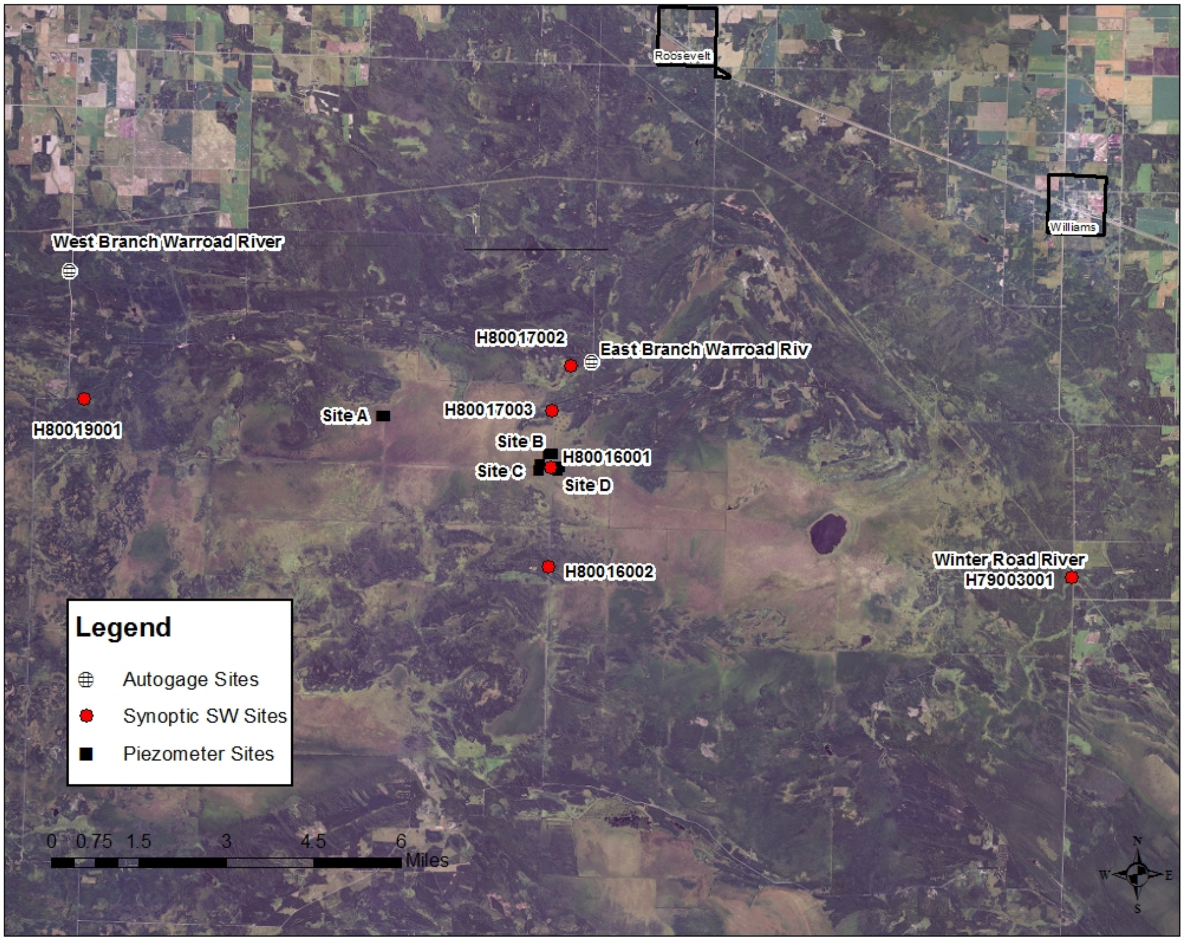


Figure 10a: Hydrographs of Synoptic Surface Water Sites (Data gaps connected by solid line).

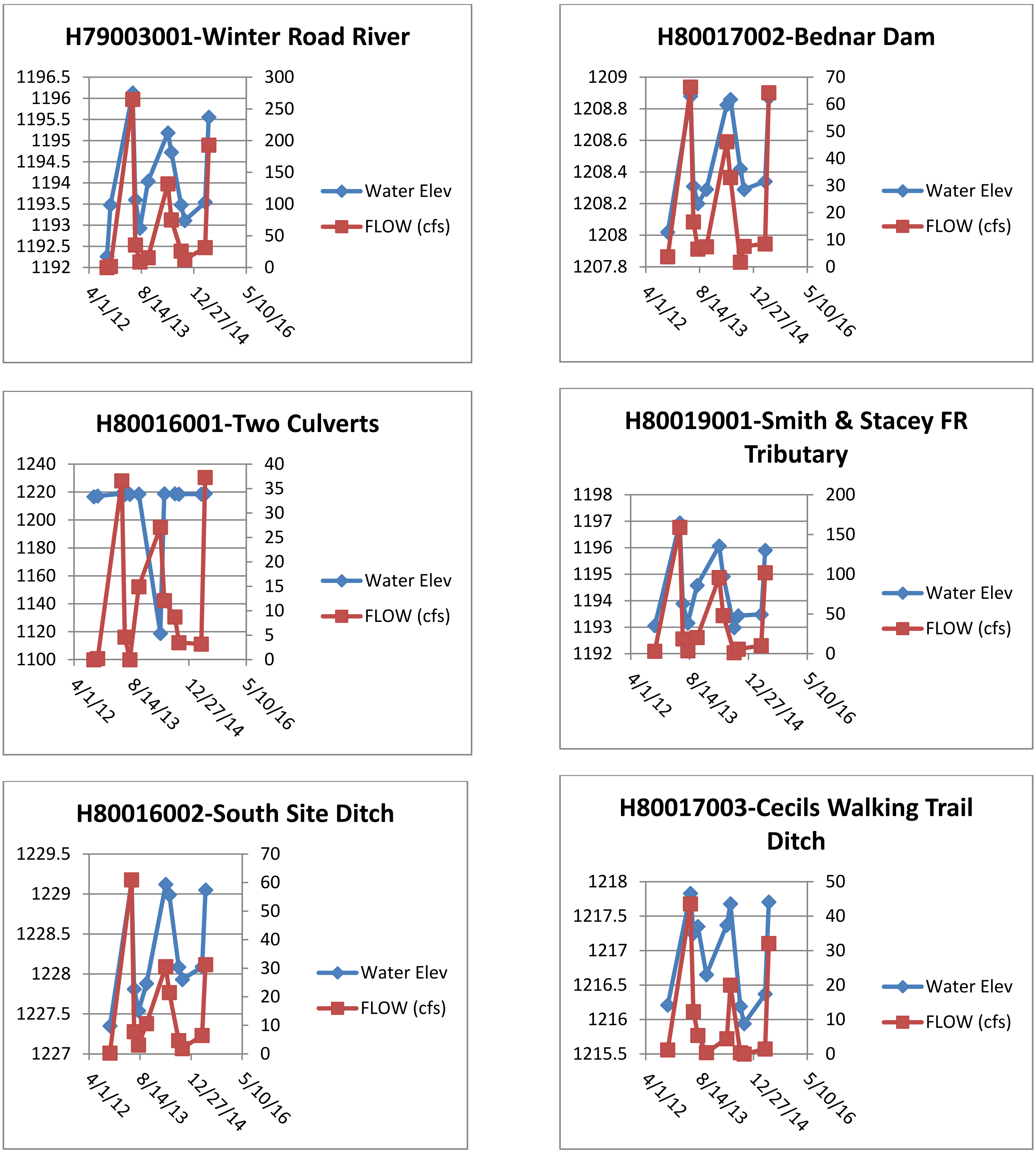


Figure 11: Top Height of all species found vs distance from ditch

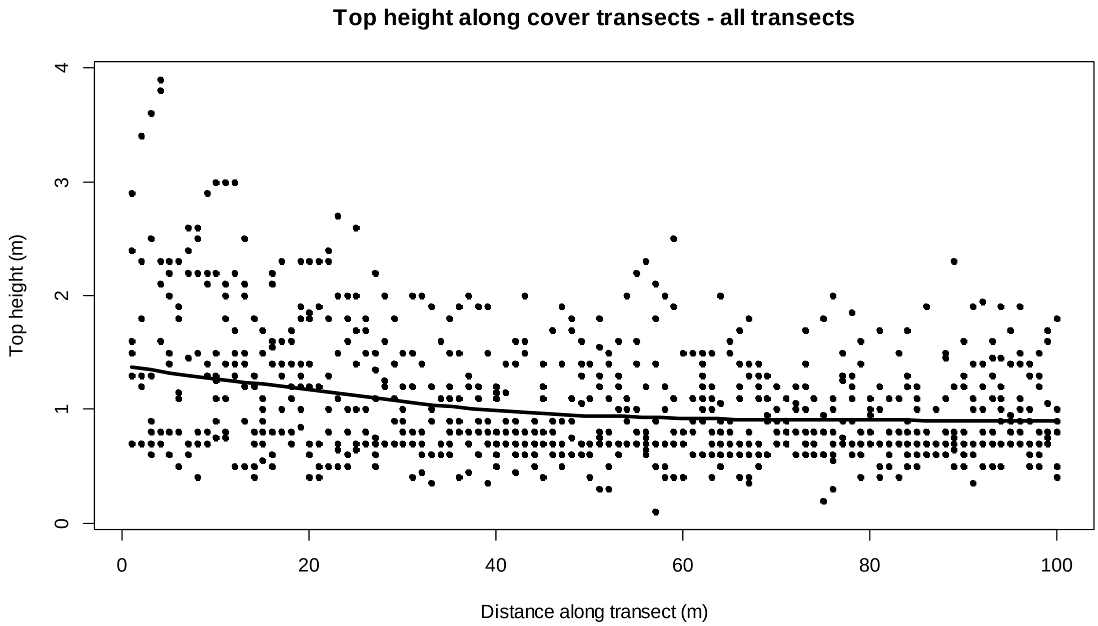


Figure 11a: Mean top height found by species shown as median (dark line), 25th, 75th percentiles and extreme values. The y axis is height in meters and the x axis is species, described using the 8-letter short-hand using their latin names; CWD is woody debris.

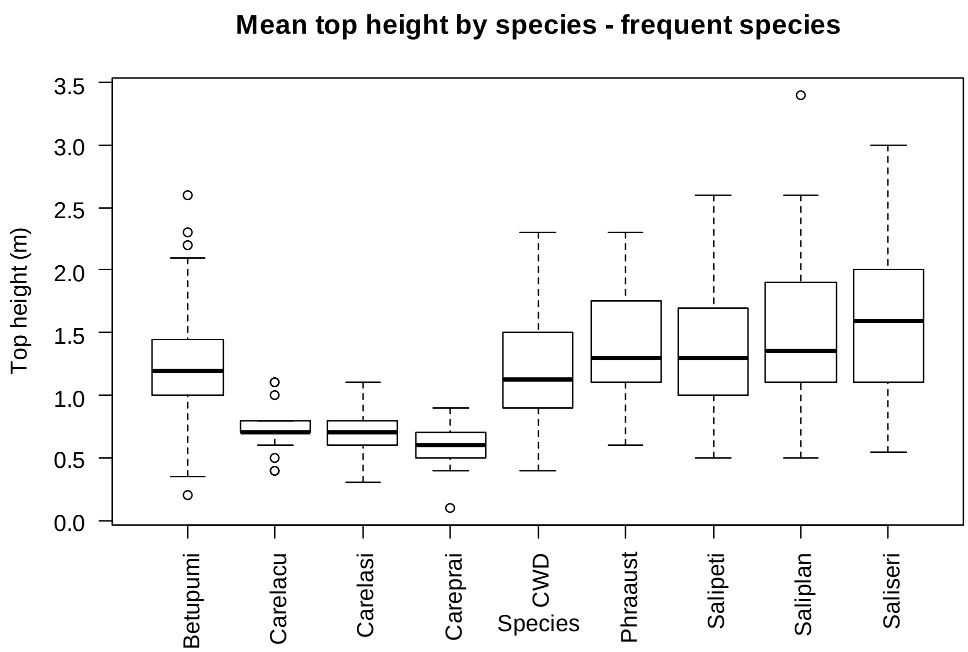


Figure 11b: Transect Position Plot found by Species. Note: this is a “box and whisker” plot, which shows median (dark line), 25th and 75th percentiles and extreme values. The y axis is height in meters and the x axis is species, described using the 8-letter short-hand using their latin names; CWD is woody debris.

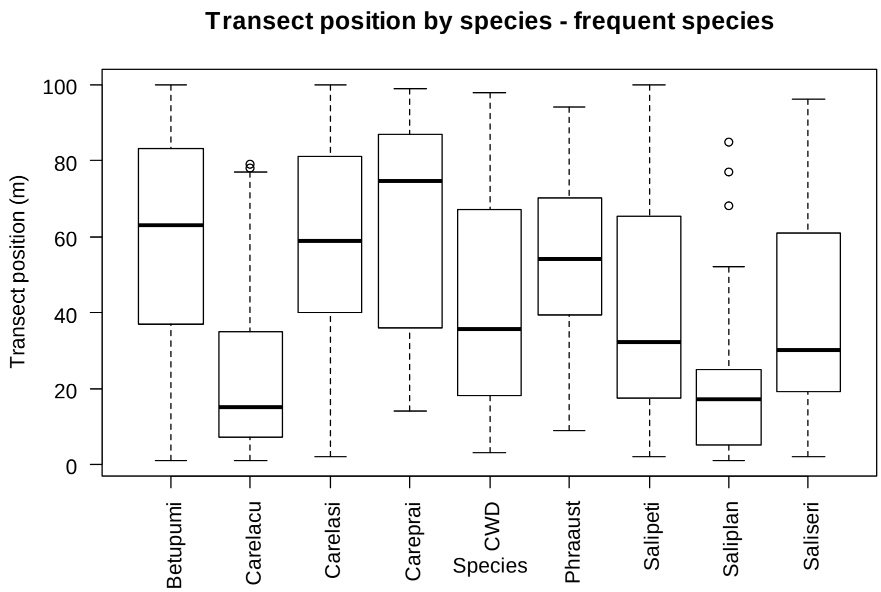


Figure 11c: Ordination analysis plot for relevés. D=ditch, S=String, F=Flark, M=mixed peatland.

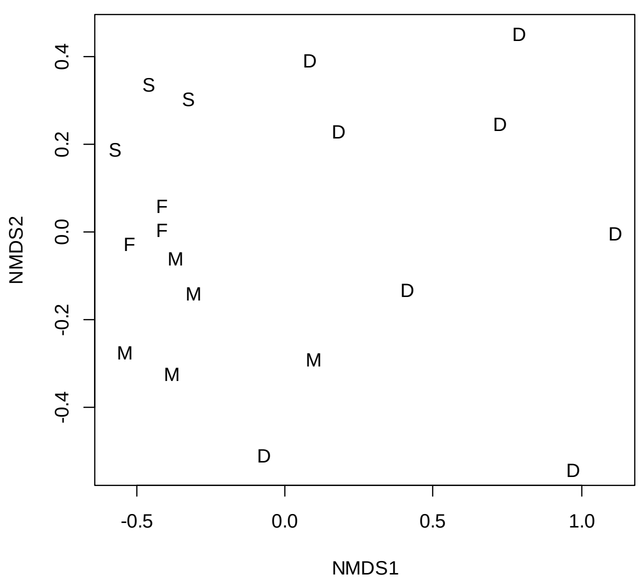
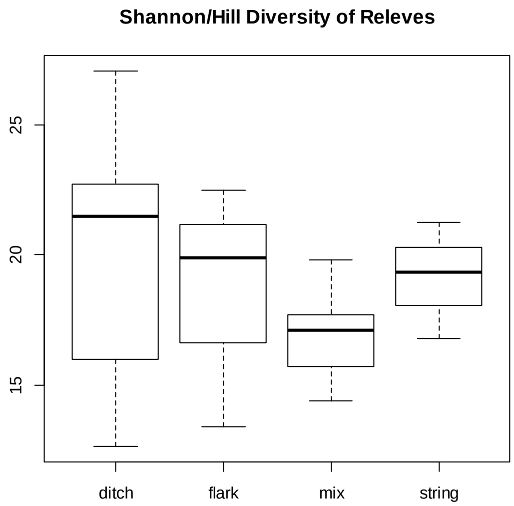


Figure 11d: Diversity and Species Richness plots. Note: These "box and whisker" plots show how the median (dark line), 25th and 75th percentiles and the extreme ranges over which the species within the relevé was found.



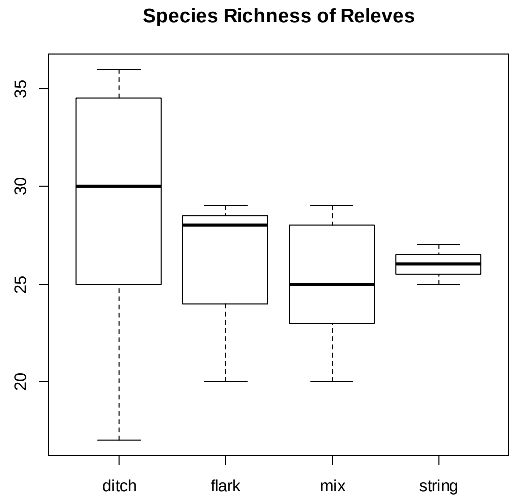


Table 2: Floristic Quality Assessments of Winter Road Lake Peatland

Site & Releve	Total Species Richness (S)	Coefficient of Conservatism (C)	Floristic Quality Index (FQI)	NPC	Floristic Quality Assessment Condition	Location in Peatland
AE-R1	25	7.0	35.0	OPn91a	*Exceptional*	100+m out
AE-R2	27	6.0	31.0	OPn91a	*Fair*	ditch; w/o berm
AW-R1	22	7.1	33.5	OPn91a	*Exceptional*	100+m out
AW-R2	35	5.4	31.8	OPn91a	*Fair*	ditch; berm side
BE - R1	20	6.2	27.7	OPn91b2	*Fair*	ditch (possible berm?)
BE-R2	20	6.9	30.6	OPn91b2	*Exceptional*	flark
BE-R3	24	6.7	32.7	OPn91b2	*Exceptional*	string
BW - R1	29	6.8	36.8	OPn91b2	*Exceptional*	flark
BW-R2	24	6.4	31.4	OPn91b2	*Exceptional*	string
BW-R3	29	6.2	33.2	OPn91b2	*Fair*	ditch; road side
CN-R1	30	7.0	38.3	OPn91b2	*Exceptional*	about 100m out; string
CN-R2	33	5.4	31.0	OPn91a	*Fair*	ditch; berm side
CS-R1	20	7.1	31.5	OPn91a	*Exceptional*	about 100m out
CS-R2	30	5.8	31.6	OPn91a	*Fair*	ditch; w/o berm
DN-R1	34	5.1	30.0	OPn91b2	*Fair*	ditch; berm side
DN-R2	27	6.5	33.7	OPn91b2	*Good*	string
DN-R3	30	6.8	37.4	OPn91b2	*Exceptional*	flark
DS-R1	27	6.2	32.1	OPn91a	*Exceptional*	about 100m out
DS-R2	17	6.1	25.0	OPn91a	*Good*	ditch; w/o berm

Key:
undefined - peatland interior
Flark- peatland interior
String - peatland interior
ditch-side with spoil (berm) or road
ditch-side w/out spoil/berm or road

Table 3: Vegetative Species Found

Species	C value	Species	C value	Species	C value
Carex chordorrhiza	10	Carex interior	7	Salix petiolaris	5
Eriophorum chamissonis	10	Carex lasiocarpa	7	Scutellaria galericulata	5
Andromeda glaucophylla	9	Carex leptalea	7	Spirea alba	5
Aster boreale	9	Carex utriculata	7	Thalictrum dioicum	5
Carex limosa	9	Cicuta bulbifera	7	Asclepias incarnata incarnata	4
Carex livida	9	Dasiphora fruticosa	7	Athyrum filix-femina angustum	4
Eriophorum gracile	9	Eleocharis elliptica	7	Calamagrostis canadensis	4
Eriophorum tenellum	9	Epilobium leptophyllum	7	Eutrochium maculatum	4
Galium labradoricum	9	Equisetum fluviatile	7	Galium trifidum	4
Lobelia kalmii	9	Larix laricina	7	Glyceria striata	4
Rubus arcticus acaulis	9	Potentilla palustris	7	Iris versicolor	4
Salix candida	9	Rhamnus alnifolia	7	Lycopus americanus	4
Salix maccalliana	9	Ribes triste	7	Onoclea sensibilis	4
Solidago uliginosa	9	Rosa acicularis	7	Persicaria amphibia	4
Symphytotrichum boreale	9	Salix serissima	7	Salix eriocephala	4
Calla palustris	8	Salix serissima	7	Agrostis perennans	3
Carex buxbaumii	8	Thelypteris palustris	7	Alnus incana rugosa	3
Carex diandra	8	Caltha palustris	6	Amelanchier humilis	3
Carex echinata	8	Carex brunnescens	6	Carex cristatella	3
Carex magellanica	8	Lysimachia thyrsiflora	6	Cornus sericea	3
Carex prairea	8	Ranunculus gmelinii	6	Corylus cornuta	3
Drosera rotundifolia	8	Ribes hirtellum	6	Mentha arvensis canadensis	3
Eleocharis compressa	8	Rubus pubescens	6	Muhlenbergia mexicana	3
Eriophorum angustifolium	8	Rumex britannica	6	Ranunculus sceleratus	3
Glyceria borealis	8	Salix bebbiana	6	Rubus idaeus strigosus	3
Lonicera villosa	8	Triadenum fraseri	6	Sagittaria latifolia	3
Muhlenbergia glomerata	8	Viola spp	6	Salix discolor	3
Parnassia palustris	8	Campanula aparinoides	5	Solidago gigantea	3
Pyrola americana	8	Carex bebbii	5	Agrostis scabra	2
Salix pedicillaris	8	Carex lacustris	5	Fragaria virginiana	2
Salix planifolia	8	Carex pseudocyperus	5	Typha latifolia	2
Betula pumila	7	Galium obtusum ss obtusum	5	Phragmites australis americanus	1
Calamagrostis stricta	7	Lycopus uniflorus	5	Potentilla norvegica	1
Carex aquatilis substricta	7	Persicaria punctata	5	Cirsium arvense	0
Carex canescens	7	Poa palustris	5	Carex eutriculata	

Figure 12a: Vegetation Transect and Relevé plot locations Site A.

Figure 12b: Vegetation Transect and Relevé plot locations Sites B-D.

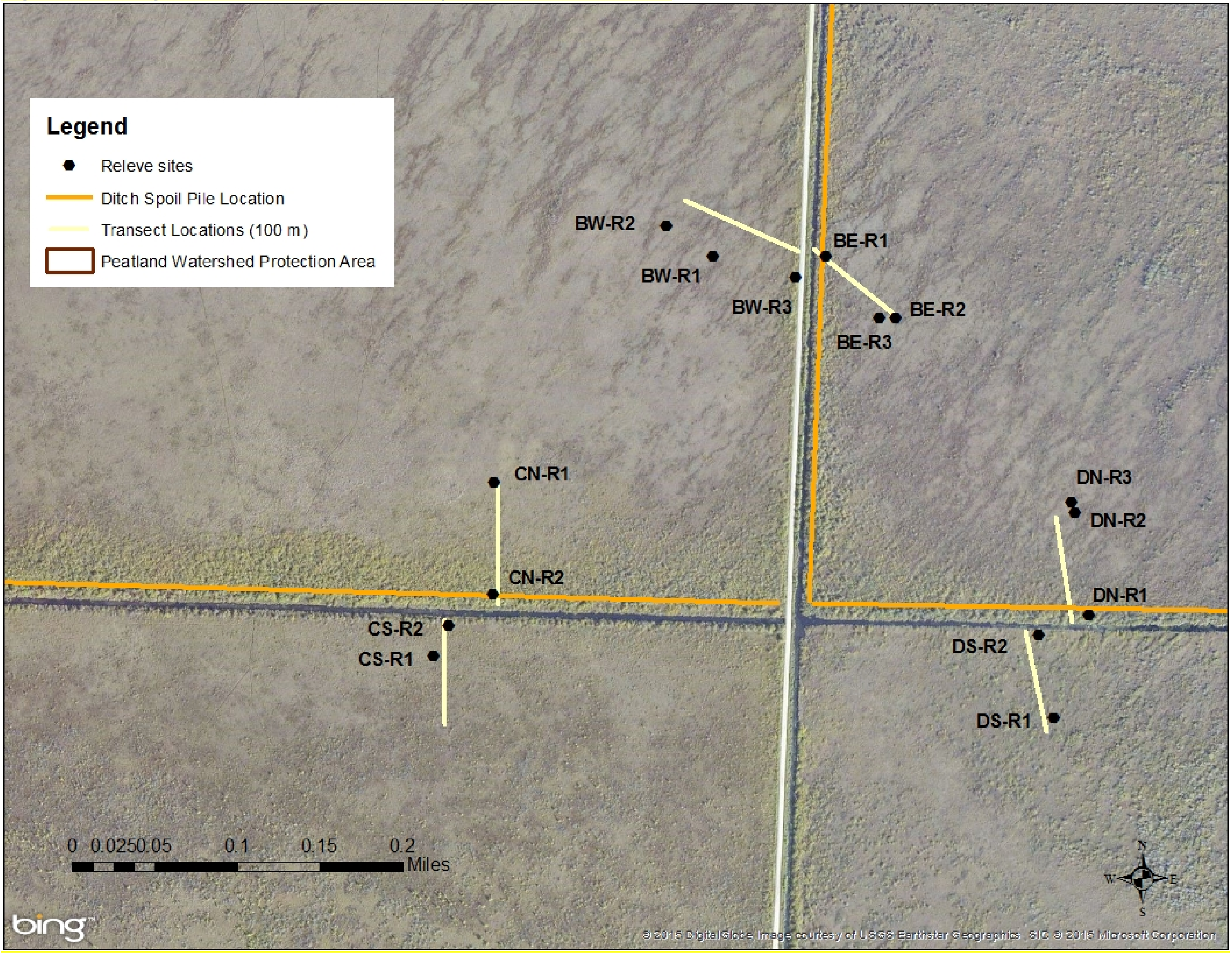
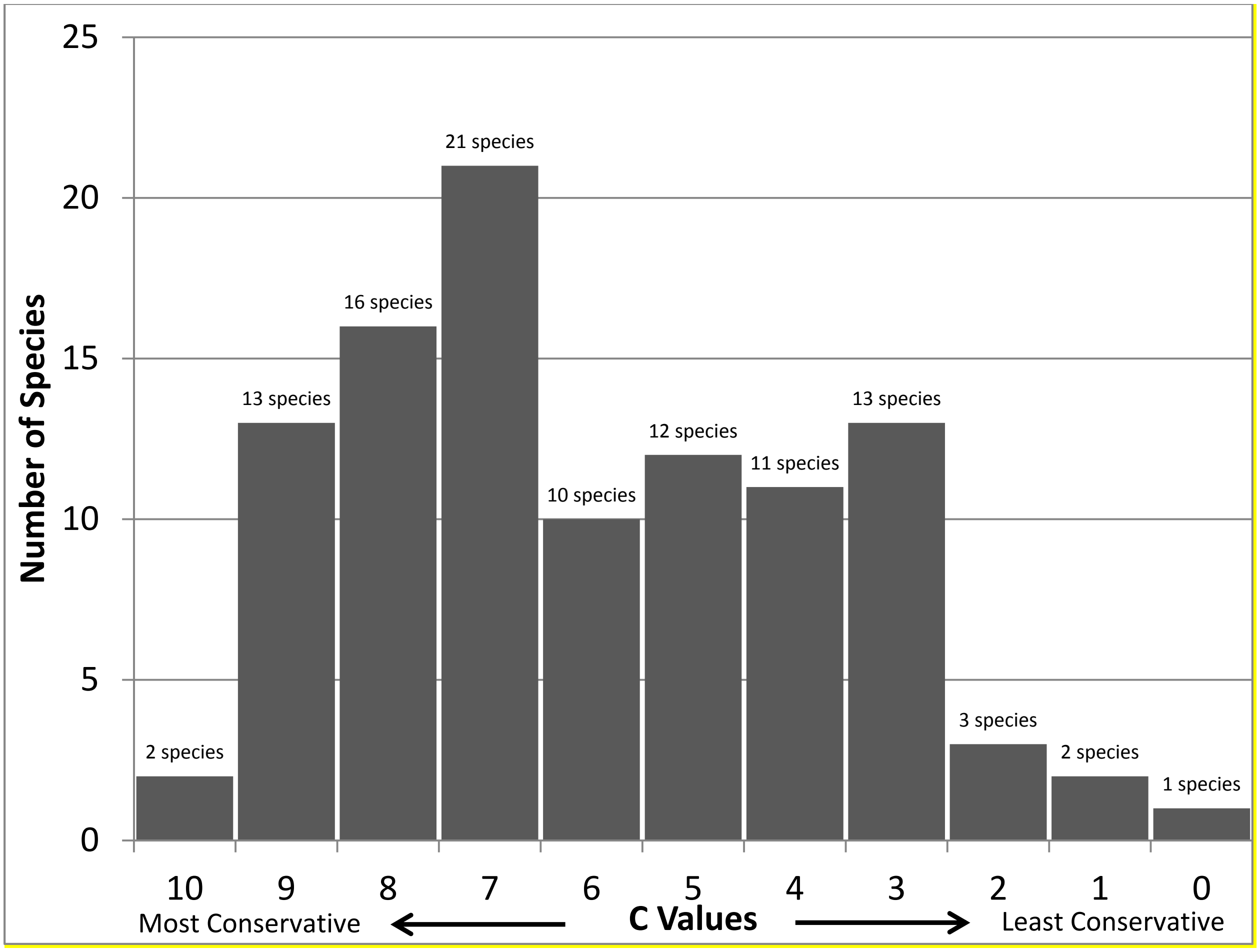


Figure 13: Analysis of the Coefficient of Conservatism values for all species identified in Winter Road Lake Peatland.



Appendix A: Peat Core Analysis Report
By Scott Zager Wildlands Ecology Service

Abstract:

Peat core profiles, sampled with a Macaulay Corer, were collected along both sides of four ditches within a large water track fen within the patterned peatland, Winter Road Lake Peatland SNA of Minnesota.The SNA is located in northwestern Minnesota between the village of Roosevelt and Norris Camp, Wildlife Headquarters for the Red Lake Wildlife Management Area. On both sides of the ditch, peat cores were collected near the ditch adjacent to piezometer wells and other vegetation sampling plots and transects. A second core was sampled at 100 m perpendicular to the ditch near a second well and set of vegetation sample areas. A total of 16 cores were collected in the ditched fen. The peat cores collected the peat profile from the ground surface to mineral soil contact. The cores were sampled and analyzed at major demarcations within the peat profile. Samples were evaluated in the field to ascertain levels of humification using Von Post Method of Peat Humification. The hypothesis to be tested was that cores near ditches will have higher levels of oxidized peat attributed to drawdown of the local water table. Control peat core profiles were sampled within an un-ditched water track fen and adjacent bog in a separate watershed of Brown's Lake.

All von Post values recorded in this study are characteristic of similar peat cores collected by the DNR Peat Inventory within the Red Lake Peatlands (MN DNR 1981, 1982, 1987 & 2007). Artificial drainage causes peat degradation in excess of "Non-Drained Fen & Bog Controls" in the upper profile of "Near Ditch" peat cores from between 20-50 cm of depth. Compared to the un-ditched controls and interior peat cores collected approximately 100 m from the ditch, the results show "Ditch Effects" at near-ditch core profiles in 6 of 8 sample cores. One core had missing Von Post data and is inconclusive. The 2nd core was collected at transect BW and its lack of Ditch Effect is attributed to its 25 m distance away from ditch center. The extra distance crossed Norris Roosevelt Road itself. Interior Fen Cores mostly show NO Ditch Effect compared to control peat profiles. Excessive peat degradation is also attributed to naturally occurring decomposition related to unknown "Site Effects". For example, AW2.2 "Fen Interior" was collected on a slightly elevated dome which may explain excessive peat degradation to 20 cm depth. DS2 core "Fen Interior" also had unexplained "Site Effects" with excessive degradation to 30 cm depth. There were no effects observed associated with the direction of flow.

Measures of Peat Degradation - A Literature Review

Bulk density is a quantitative value of peat degradation or humification. It is one of the criteria used to define peat classifications by the United States Department of Agriculture, Natural Resource Conservation Service (USDA-NRCS). Peat degrades when exposed to oxygen, a consequence from prolong lowering of the water table. As peat decomposes, its bulk density increases. Bulk density values (grams/cubic centimeter - g/cc) for all strata profiles of all peat cores collected within the project area ranges from 0.04-0.23 g/cc (MN DNR 1981, 1982, 1987, 2007). These values are identical to peat core analysis done worldwide (Verry et al. 2011).

Bulk density of the organic portion of peats measures decomposition and is strongly correlated to the hydraulic conductivity of peats (Boelter 1965). Boelter used the borehole and piezometer methods to determine hydraulic conductivity at the Marcell Experimental Forest in Minnesota. As a peat stratum degrades, it compresses and bulk density increases; thus decomposed peat holds less water. At a bulk density of 0.04 g/cc, percent moisture capacity is 95.4%. At bulk density 0.12 g/cc, peat holds 7% less water (88.4%); at 0.21 g/cc, 12.5% less water (82.9%). Furthermore, the velocity by which water can move through peat (measured as hydraulic conductivity) diminishes exponentially as bulk density approaches 0.15 g/cc.

The Von Post Method is an in-the-field method for assessing peat degradation. The Von Post Method defines ten classes for degree of humification (H1-H10). This field-base method is used extensively in Canada and Europe because the method is quick and, with practice, consistent. The Von Post H value correlates well with hydraulic conductivity, fiber content, and drainage porosity and is recommended as an alternative to other laboratory or field determinations of hydraulic conductivity (Verry et al. 2011).Verry et al. (2011) cites research that correlate bulk density with the Von Post degree of humification for Sphagnum, Carex (sedge), and wood peats. Von Post H values have been correlated to more quantitative methods of measuring fiber content, water content, bulk density and water retention at saturation (Verry et al. 2011).

Fiber content in organic soils is the fundamental characteristic that determines bulk density, water retention, hydraulic conductivity, and drainable porosity. Moss or Fibrous peats are comprised of coarse particles. Fibrous peats are predominately of Sphagnum species origin, whereas herbaceous or Hemic peats are predominately sedge (Carex spp.), which are also known as reed-sedge or sedge peats. Hemic peats are comprised of particles intermediate in size. Sapric peats are completely decomposed into very fine sediments. The degree of decomposition is also estimated by the amount of material less than 0.1 mm in size using sieving methods employed the NRCS. Organic material with a fiber size less than 0.1 mm is subcellular and amorphous (Sapric, not Fibrous or Hemic). Sapric peats are highly degraded, or humified, organic material derived from aerobic decomposition with exposure to oxygen. Sapric peat affords strong cation exchange and water retention, but strongly limits hydraulic conductivity because the high percentage of amorphous material. This increases bulk density of the peat and impedes the ability of water to pass through the limited pores of highly humified peat. Verry et al. (2011) considers the Von Post Method more accurate than sieving methods to determine fiber content by particle size percentage.

A more quantifiable version of the humification method determines the solubility of peat in aqueous solution (Farnham and Finney 1965). The USDA pyrophosphate test consists of adding an aqueous sodium pyrophosphate solution and measuring the color intensity of the extract using the Munsel 10YR color chart (Soil Survey Staff 1975). A version of this test uses a light spectrometer to measure the percentage of light transmission values in order to calculate percent humification in lieu of the color chart (Schnitzer and Levesque 1979, Blackford and Chambers 1993). The researchers of this peat project would like to use a similar laboratory test on peat strata samples collected from cores and stored in the freezer (F.M. Chambers et al. 2011). This should yield a more detailed, high-resolution laboratory analysis that can be statistically analyzed and compared with the vegetation data collected in plots and along transects.

Measures of peat degradation indicate that significant ecological impacts can be attributed to ditch drainage. Veery et al. (2011) stated that: "The water table surface away from the drainage ditch tends to pass quickly below H1-H4 fibric peats; the primary impact of ditching is controlled by peat of H5 or greater...". Water movement is completely stopped at Bulk Density of 0.15 g/cc and severely impeded at 0.12 g/cc. In other words, degraded peat severely impedes water movement at Von Post values of H5 and greater! Water can be seen to visibly flow across the upper surface of a compacted peat stratum into soil pits (Zager, pers. comm.). Dense peat prevents ground water from mixing with mineral soil. This leads to the loss of soluble mineral plant nutrients available for plant growth, and eventually leads to expansion of acid peatlands (ombrotrophic) at the expense of rich peatlands (minerotrophic). Furthermore, wetland drainage significantly increases the height of natural vegetation as taller species succeed in drained areas at the expense of wet species of low stature. Veery et al. (2011) stated than when the depth to the water table increases from 5-25 cm: sedges and grasses are replaced by dense tall shrubs, and eventually fully grown trees. Also, species of herbs and graminoids (grasses and sedges) change substantially as the water table diminishes from standing shallow pools in fen flarks to 5 cm depth below the surface (Zager, Pers. Comm.). Species restricted to extremely rich minerotrophic environments are replaced by more ubiquitous species tolerant of a wider range in habitat quality due to changes in pH associated with drainage. It appears that sedge stem density, and the underlying rhizomes, increase dramatically with only slightly lower water tables (Zager, Pers. Comm). Finally, when the amount of drainage exceeds one-third of the watershed area, streamflow peaks can increase two to four times from surface runoff (see Veery et al. 2011; Fig 5.19, p 171).

Peat Sampling Methods

A Macaulay Peat Corer or so-called Russian Corer was used to sample the degree of humification (decomposition) of peat samples taken near well transects at Winter Road Peatland Scientific and Natural Area (SNA). The Macaulay Peat Corer is an easy to operate, manual corer for sampling at different depths in sediment and wet soils, including below the groundwater level Jowsey 1966). The sampling chamber consists of a steel half-cylinder with one sharpened edge, on which a flat steel blade is attached so that it turns around the central axis of the cylinder. The narrower side of the blade fits precisely to turn inside the half-cylinder, while the broader side acts as an anchor to keep the blade in position during sampling. The lower tip of the coring head is shaped as a half-cone, and at its upper end there is a fixture for the sinking rod. When sinking, the half-cylinder is positioned at the rear of the flat blade, and at the sampling depth it is turned 180° by the rod to cut and secure the sample against the blade face. In our survey we used a model with a sample chamber 50 cm long and with inner diameter of 50 mm (Pitkänen 2011).

Peat core samples were taken at each horizon or stratum until contact with mineral-soil was found (Table 1). Each horizon with a different value of humification (H value) was evaluated immediately in the field using the Von Post Field-Test Procedure for H Value (Table 2: modified from Verry et al. 2011). In addition, part of each horizon sample from each peat core was retained and frozen in water tight packages labeled with the core location and depth from surface. The degree of humification or H value in the Von Post Method is based on the amount of peat and the color of water expressed from an egg-sized sample of peat squeezed in the hand. Von Post H values collected for the study are reported in Table 1.

In the field, enough saturated peat was taken to fill the hand when fingers are gently curved against the palm. An egg-shaped soil sample was formed was gently bounced until if fits into the researcher=s hand. The sample is then squeezed as hard as possible while using the other hand to catch the amorphous material and water squeezed between the fingers. The color and turbidity of the free water (water that separated from any amorphous material) was noted and compared with Table 2.

Opening the second hand to thin the water allowed easier viewing of color and turbidity. We then used the fingers of the second hand to scrape amorphous material from between the closed, squeezed fingers of the first hand and then consolidated the material in both hands by gently bouncing the material. Material in both hands was then examined for the relative volume of the fiber material compared to the amorphous material. The relative volume of the amorphous material (in percent) is used to assign the Von Post H value for whole and half-values in the mid-range (Table 2). Half value classes in the mid-range were helpful in differentiating peat layers that were encountered frequently in the partially drained sections of the transect (Table 1). Half-classes in Table 2 were used in the range of H4-H7.5.

Peat Core Locations and Peat Strata Samples

Between July 13 and July 20th, 2012, Peat core profiles were collected and recorded near four ditches within a large Water Track Fen in northwestern Minnesota (Figs 1 & 2). These ditched sites were marked A-D (Figs 3-6). Individual core samples were labeled by ditch letter, the cardinal direction from the ditch (East, West, etc.) and collection number. Sometimes the Macaulay corer would be impeded from collecting a complete sample. Therefore, a second or third core was collected nearby until an adequate sample could be obtained to the mineral soil. For comparative analysis, cores were further labeled as being Near Ditch or Interior Fen. Cores were also identified by location; Up Flow toward the direction of subsurface flow above the ditch, or Down Flow, in the direction flowing away from the ditch. The exact locations of the cores were determined by the proximity of piezometer wells previously installed. The cores were collected near relevé vegetation sample plots and near the beginning and end of 100 m transects for measuring vegetation heights and plant species. The location of each peat core sample was recorded with a Garmin 62s GPS with an accuracy of about 3-4 m in diameter. The distance of the samples from the ditch center was determined by ARCMAP 9.3. These are recorded in Table 3.

In order to establish a set of controls for comparative purposes, an additional set of peat cores were sampled within a separate, undisturbed watershed where the water track fen and adjacent bog were not impacted by ditches (Fig 15). It was believed these control profiles would serve as bench-marks documenting past hydrological conditions (e.g., drawdown associated with periodic drought indicated by a spike in H-values) (Fig 16). Furthermore, the peat profile reflects past vegetation as it developed over 3,500 years ago as the water table rose following natural occurring climate change known as the Holocene Warming Period (Zager 2011, 2013). For example, Figure 16, Von Post H-values show a dramatic increase in humification values from H6 to H10, in the last strata of the peat cores sampled within control bog and fen. These lower strata of sapric peat are believed to be the result of early peat development in prairie pothole marshes and sedge meadows after the post Holocene Warming Period when water tables began to rise to contemporary levels and true peatland communities began to develop (Janssens 1986, Janssens et al. 1992).

Peat Strata Analysis

Von Post H-values cannot be statistically analyzed; a more exacting method of quantitative values evaluated in the laboratory would be required for that. However, we believe that a visual analysis comparing graphed H-values of peat profiles between core samples would perhaps justify the time and expense of analyzing frozen peat strata samples. Toward this end we graphed Von Post H-values over the depth of the peat core strata at its midpoint (Table 1). In Figures 7-14, we compared the core profiles taken at both ends of the vegetation transects. It was thought that notable differences between Near Ditch profiles and Fen Interior profiles could be directly attributed to ditch effects derived from artificial drainage. Other comparisons to determine whether the direction of subsurface flow has an effect on H-values relative to the ditch and core location could be seen between sample profiles on the Up Flow side of the ditch (AW, BE, CS & DS: Figs 8, 10, 12, 14) and profiles from the Down Flow side of the ditch (AE, BW, CN, & DN: Figs 7, 9, 11 & 13). Finally, a comparison between sites A, B, C & D could ascertain whether any Site Effects are in play. In Figures 17-34, a second set of comparisons were made, except the control profiles from the undisturbed fen and bog were added. These comparisons would demonstrate whether or not potential drainage effects were outside the bench-mark range of natural variation.

Results

The results are included in Table 1 and in Figures 7-34. These results are summarized in Table 3. All von Post values recorded in this study are characteristic of similar peat cores collected by the DNR Peat Inventory within the Red Lake Peatlands (MN DNR 1981, 1982, 1987 & 2007). Artificial drainage causes peat degradation in excess of "Non-Drained Fen & Bog Controls" in the upper profile of "Near Ditch" peat cores from between 20-50 cm of depth. Compared to the un-ditched controls and interior peat cores collected approximately 100 m from the ditch, the results show "Ditch Effects" at near-ditch core profiles in 6 of 8 sample cores. One core had missing Von Post data and is inconclusive. The 2nd core was collected at transect BW and its lack of Ditch Effect is attributed to its 25 m distance away from ditch center. The extra distance crossed Norris Roosevelt Road itself. Interior Fen Cores mostly show NO Ditch Effect compared to control peat profiles. Excessive peat degradation is also attributed to naturally occurring decomposition related to unknown "Site Effects". For example, AW2.2 "Fen Interior" was collected on a slightly elevated dome which may explain excessive peat degradation to 20 cm depth. DS2 core "Fen Interior" also had unexplained "Site Effects" with excessive degradation to 30 cm depth. There were no effects observed associated with the direction of flow.

While the Von Post Method gives a reasonable assessment for rapid description of peat stratigraphy; a more detailed, high-resolution sampling and laboratory analysis is necessary if associations with data from piezometer wells and vegetation plots as well as difference in peat quality between near ditch and fen interior are to be determined statistically significant (Chambers et al. 2011).

Site A

The Site A ditch is oriented perpendicular to groundwater flow. The west side is the Up Flow direction, where subsurface water flows toward the ditch. The Near Ditch peat core was sampled approximately 19.8 m from the ditch center and thus avoided the adjacent berm of ditch spoil. Unfortunately, Von Post H-values were lost for the upper strata of the peat core. Therefore no conclusion could be drawn about Ditch Effects. Peat core samples at notable strata were collected for later analysis. The Fen Interior profile was sampled some 114.8 m away from the ditch center. There was some excessive degradation beyond natural variation to 20 cm depth. The H-value was recorded at H4.5, which is higher than H2 recorded in the Fen Control at this depth. This difference is attributed to some Site Effect suggesting some unexplained variable is causing peat humification. During the sampling of core AW2.2, it was observed that the sample occurred on a slight dome or rise in elevation.

The East side of the ditch or the Down Flow side had a notable amount of peat humification to 40 cm depth in the Near Ditch sample recorded some 9.1 m away from the ditch center. H-values were in the Hemic to Sapric range in the upper profile with the highest H-value at H8 on a ten-point scale. This excessive amount of humification is attributed to artificial drainage or Ditch Effect. The Interior Fen sample had a peat profile well within the natural range of variation demonstrated in Figure 20. It is concluded that there are no unusual levels of humification other than natural variation.

Site B

The ditch at Site B is oriented parallel to the site's flarks and strings and is perpendicular to groundwater flow. The Norris Roosevelt road is located on the west side of the ditch and east of the peat core sample locations. The West side is the Down Flow side of the ditch. The Near Ditch core was located 25.7 meters from the ditch center. Curiously, there was no Ditch Effect recorded at this location. In Table 10, the comparison of H-values of the Interior Fen with the Near Ditch profile show negligible differences. In

Figures 23 and 24, it can be seen that core BW1, Near Ditch, and BW2, Fen Interior are nearly identical as well. Both are well within the natural range of variation. In fact, both profiles have H-values of extremely low humification and these are similar to the pristine values recorded from the Bog Control profile. This suggests that there may be an unusual level of high subsurface flow that has maintain peat quality. It also suggests that the Ditch Effects may diminish in the distance of 25 meters to the peat core location. This seems to correspond with piezometer readings and it has been suggested that perhaps the road itself impedes groundwater flow from the west side of Site B to the ditch.

The East side of Site B is the Up Flow side of the ditch. According to piezometer data, the hydraulic gradient steepens towards the ditch on the East side during low flows, which indicates that the ditch is more effective at removing groundwater during low flows. Figure 10 supports this conclusion because the levels of peat humification are much higher in the Near Ditch core than the Interior Fen. H-values shown in Figure 10 suggest that there is excessive peat degradation in the near ditch core, BE3, to a depth of 70 cm compared to the fen interior core, BE2. However, the Near Ditch core only exceeds the Fen Control profile to a depth of 20 cm above expected levels of natural variation. Meanwhile the Fen Interior core at some 97.3 m from the ditch center has near pristine levels of humification closely resembling that of the Bog Control as shown in Figure 26.

Site C

The ditch at Site C has a semi-perpendicular orientation to the site's flarks and strings; and therefore, is has a semi-perpendicular orientation to groundwater flow. According to the piezometer data, the ditch has more of an impact during low flows as evidenced by steeper groundwater gradients towards the ditch during low flows. The north side of the ditch had a smaller gradient towards the ditch during the low flow than the south side. This may be a result of the berm that exists on the north side of the ditch, which may impede flow.

The North Side of Site C is the Down Flow side of the ditch. The Near Ditch core is located about 11.1 m away from the ditch center. Compared to the Fen and Bog Controls in Figure 27, the Near Ditch core at CN1 has the highest levels of peat degradation. Well above the range of natural variation to a depth of 50 cm. H-values are within sapric levels of decomposition and show an extreme peak in the graph to H7 and highest levels of decomposition at that depth compared to all other profiles. In Figure 11, Near Ditch CN1 core always has humification levels higher than the Fen Interior core, CN2, which in Figure 28 exhibits normal levels of H-values characteristic of other fen cores sampled in the Pattern Peatlands (MN DNR 2007).

The South Side of Site C is the Up Flow side of the ditch. Two separate cores were sampled at Near Ditch locations at 8.8 and 12.2 m from the ditch center. H-values charted in Figure 27, suggests that Near Ditch cores have profiles of peat degradation are only slightly higher than the levels of natural variation recorded in the Fen Control to depths of about 30 cm. Figure 12 suggests the differences of one full step in the H class from H3 to H4, hovers at the Fibric-Hemic border and may be indeed negligible. Nonetheless, the Near Ditch cores are listed as having a Ditch Effect. Since no statistics can be employed, these differences may not be significant. The Fen Interior core, CS3, as illustrated in Figure 28, has a humification profile well within natural variation and it corresponds exactly with the profile recorded in the Fen Interior core, CN2 on the north side. Both of these are considered to have normal levels of natural humification.

Site D

The ditch at Site D is oriented semi-perpendicular to the site's flarks and string pattern and was constructed semi-parallel to the direction of groundwater flow. Piezometer data suggests that the ditch is more effective at removing groundwater during low flows. When the peatland has low water levels, the groundwater gradient is much more pronounced and extends to the distance of the farthest 2 piezometers. This conclusion may be supported by the humification profile of the Interior Fen core, DS2, located 96.6 m from the ditch center. The South Side of Site D is the Up Flow side of the ditch.

Humification profiles of Fen Interior core, DS2, in Figure 34 shows that DS2's humification profile exceeds the range of natural variation recorded by the Fen and Bog Controls. This unusual level of peat degradation at a Fen Interior was attributing to some unknown Site Effect with excessive humification to 30 cm depth. Figure 14 demonstrates that the Fen Interior core has a similar humification profile as the Near Ditch core, DS1. In fact, the Fen Interior core, DS2 achieves a higher H-value in the top 10 cm of the core profile before the Near Ditch core, DS1, which suffers a Ditch Effect to 20 cm depth. The Site Effect at core DS2 may well be attributed to the extreme efficiency of the ditch at Site D.

The North side of Site D is on the Down Flow side of the ditch. In Figure 31, the peat humification profile of the Near Ditch core, DN1 demonstrates a Ditch Effect to 30 cm. However, unlike the South Side of Site D, the humification profile of the Fen Interior core is well within the natural range of variation and shows no excessive peat degradation. Very much like similar peat core profiles of humification recorded within the Pattern Peatlands by MN DNR Peat Survey, the peat core profile for the Fen Interior core maintains a consistent level of Hemic humification at H3 within the first 20 cm depth and keeps throughout the 120 cm plus length of the core. This suggests that the ditch isn't as effective at draining the interior peat on the north side as it does on the south side of Site D.

Discussion

Lower water tables causes peat layers to be exposed to oxygen. This promotes the decay of fresh peat with coarse fibers to decompose into fine-textured fibers of black organic silt. Bulk density of various peat strata below the surface becomes greater than 0.12 g/cc, a peat density level that impedes water flow. Likewise Von Post measures of decomposition change from H1-H3 to H5-H10 another qualitative indication of peat layers that impede water flow.

Furthermore, as water tables lower, increases in aeration in the peat substrate allow safe sites for increased woody seedling establishment. This has resulted in dense shrub covers along the ditches. Shrubs were allowed to develop larger individual root masses above the saturated peat. With larger root masses, individual shrubs grew taller crown heights with wider girths unrestricted by a high water table.

Very decomposed peat is compacted to a density that impedes subsurface water flow downward through peat layer. Several research studies have shown that peat decomposition caused by lowered water tables produces dense, compact peat in substrata below the surface (Bulk density > 0.12 & Von Post values >H5). These layers impede water flow (hydraulic conductance) through the peat, thus preventing subsurface water from mixing with mineral soil below peat. The barrier between water in peat and the mineral soil causes lowered dissolved minerals in aqueous solution, and thereby reduces mineral nutrients available to growing plants.

The lack of minerals in solution promotes the transformation of extremely rich fens to poor fens and ultimately bogs through a natural process of ecological succession. This is evident by the absence of extremely rich fen indicator species (i.e., plant species solely associated with and characteristically indicative of extreme rich fens classified as water-track fens (OPn91). As water chemistry changes, rich fen species are replaced by common sedge species that are ubiquitous across the state. These common species are characteristic of NPC habitats that are wide spread, such as poor fens (OPn91), small-basin rich fens (OPn92) and sedge meadows (WMn82). The increased abundance of common sedge species follows an ecological pathway of sedge succession similar to woody plant species along a hydrologic gradient from wet to dry.

Aerated peat promotes sedge growth by increasing stem and rhizome density. This is evident by the absence of "springy" floating vegetation mat. As the density of sedge rhizomes increases, the supporting rhizomatous mat becomes firm to walk upon and not bouncy. It is concluded that lowering of the water table of a mere, few centimeters (<5cm) causes the successional transformation from extremely rich fen species to rich fen/sedge meadow species, whose dense mat of common sedge rhizomes further impedes subsurface water flow.

Lower water tables reduce the presence, frequency and coverage of water-filled hollows on the peat surface. The loss of standing water reduces the biodiversity of habitats and their associated species. This is attributed to the loss of micro-habitats associated with standing water in peat hollows (e.g., flark fens). Even common species are affected. Often, emergent plants, characteristic of wet pools, will persist as relicts surviving among dense sedges without standing water (e.g., blue flag iris). Floating and submergent species have become extirpated from the area.

Biodiversity is further diminished as shaded habitats become more common across the ecosystem. Increased coverage by common woody species inversely diminishes herbaceous species requiring open habitats. Most habitats have become over-grown with shrubs, subshrubs and trees. It usually occurs that an increase in area of shaded-dry habitats only promotes common species of herbaceous plants already ubiquitous across the landscape.

It is hoped that the restoration of the natural hydrology to the Winter Road SNA Peatlands by plugging ditch drainage will return water tables to their historic levels. This will stabilize water tables at peat-maintaining levels especially during droughty seasons. A higher water table will promote continual peat accumulation of moss and sedge biomass, thus removing Carbon from the atmosphere. The peat will remain water logged for a more sustained duration, and thus prevent further decomposition, further density increases and further peat compaction. However, a return to historic water levels will not restore previously decomposed peat strata that have already become dense, water impeding layers.

Higher water tables should help reduce the losses of existing minerotrophic, herbaceous fens (OPn91) or at least slow it down. It should help restore areas to herbaceous vegetation characteristic of fens because as water levels rise and trees and shrubs will perish. This will increase herbaceous species diversity; because, at present, species adapted to open sun and wet minerotrophic peat are diminishing as habitats become darkly shaded and dry.

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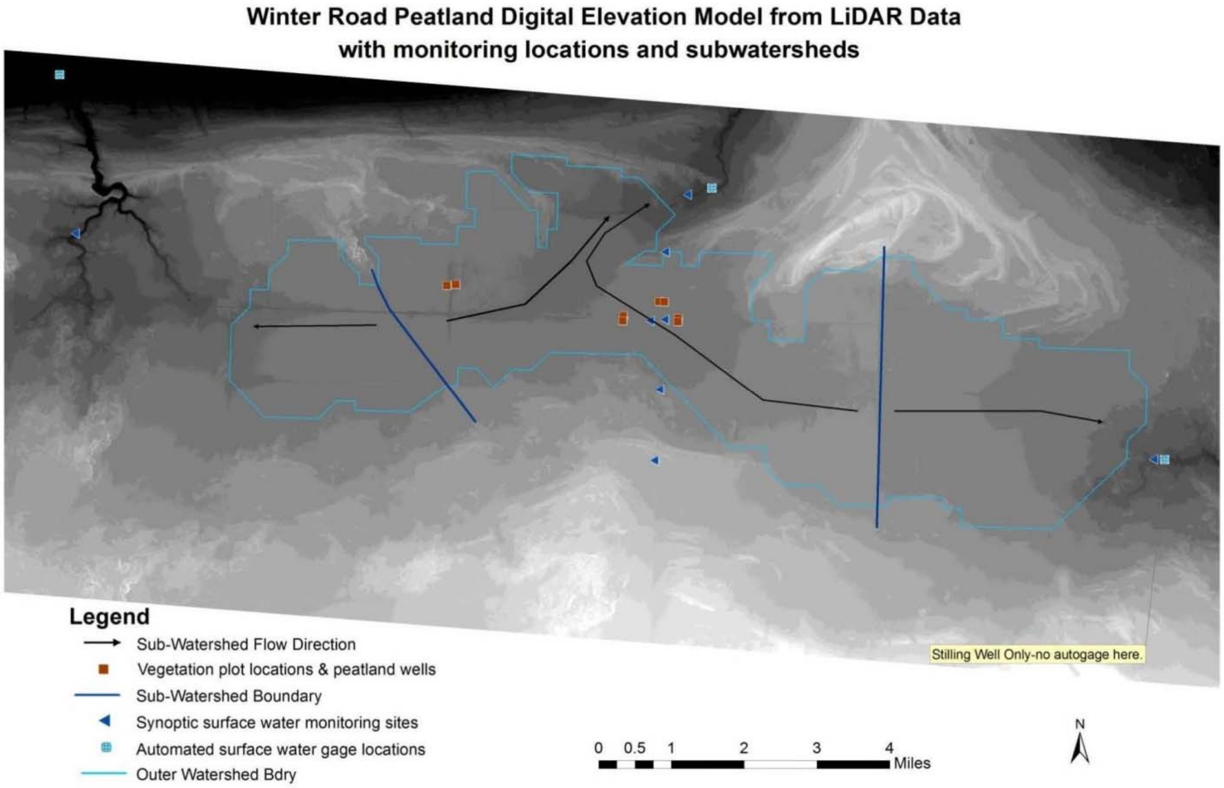


Figure 1: Elevation, watershed & direct of subsurface flow. The dark blue line marks the hydrologic divide from which subsurface water flows away through the peat.

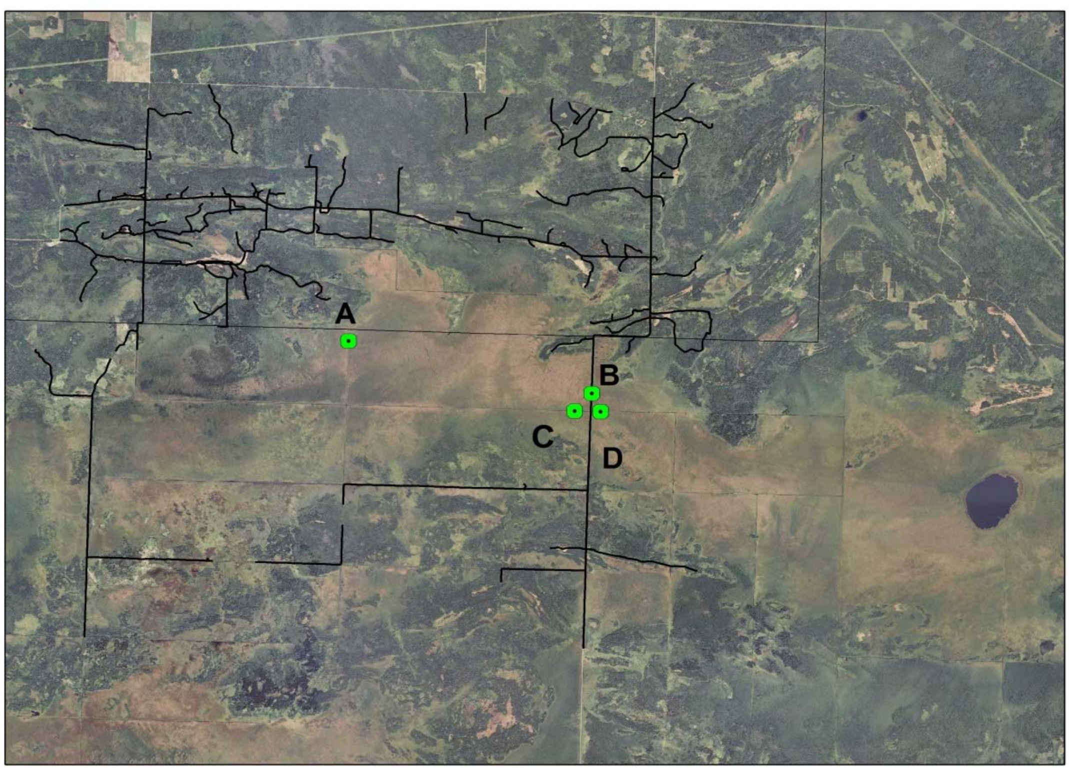


Figure 2: Locations of peat core sample pairs. Core samples were collected at or near the same waypoints recorded for vegetation transects and relevé plots.

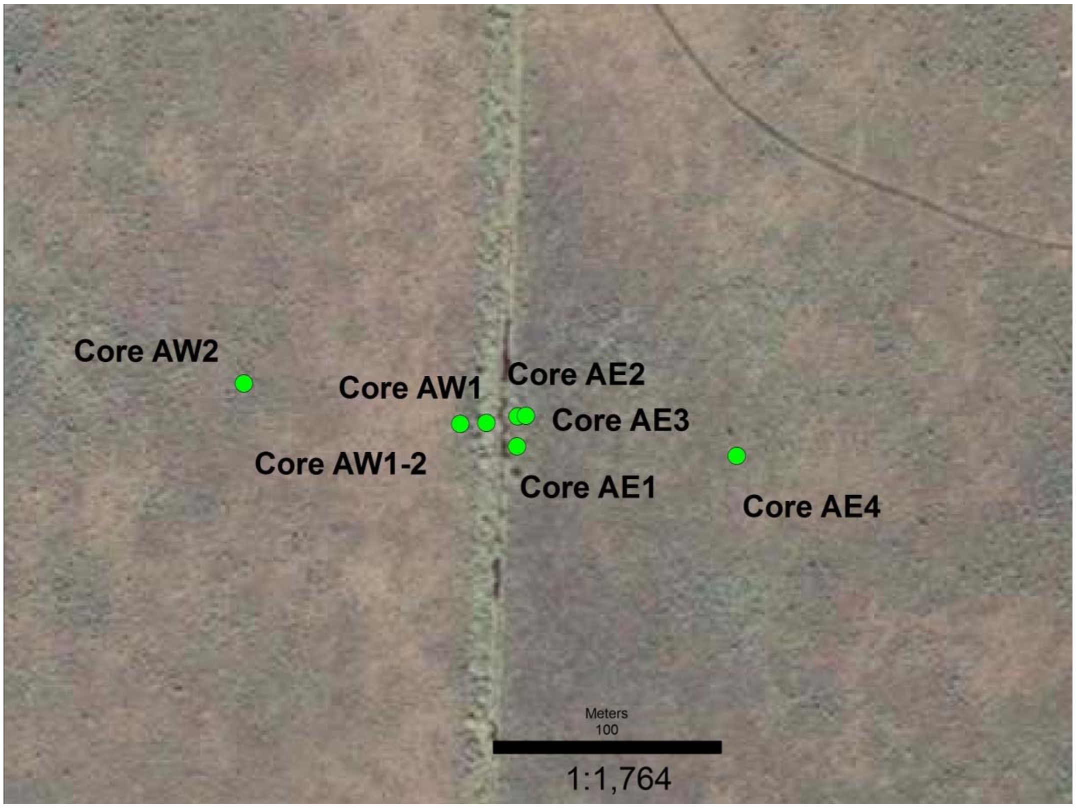
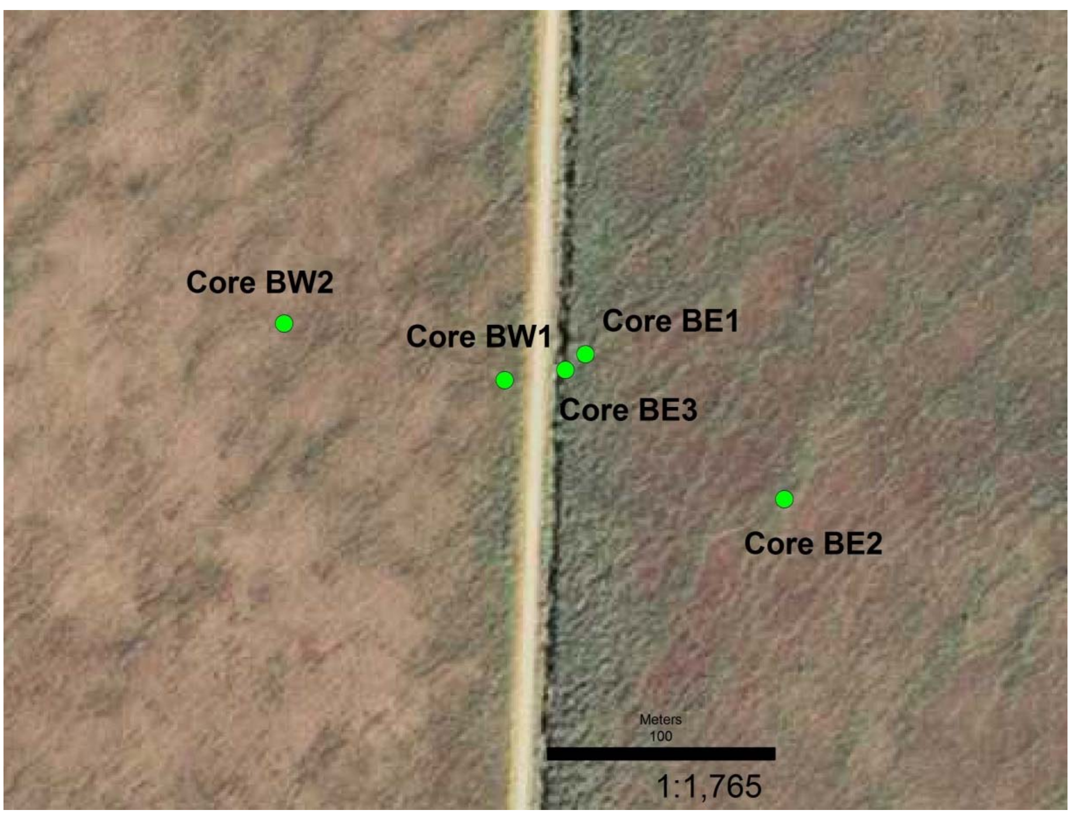


Figure 3: Location of Site A peat core samples. Subsurface flow from west (W) to east (E).



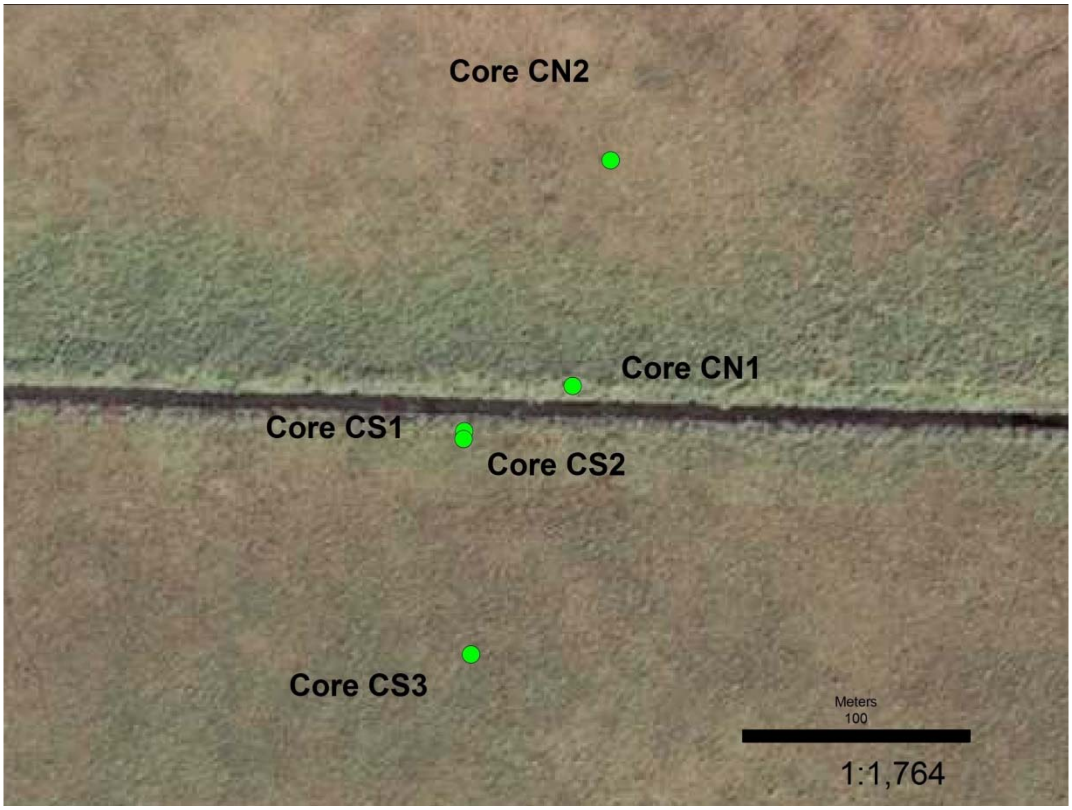
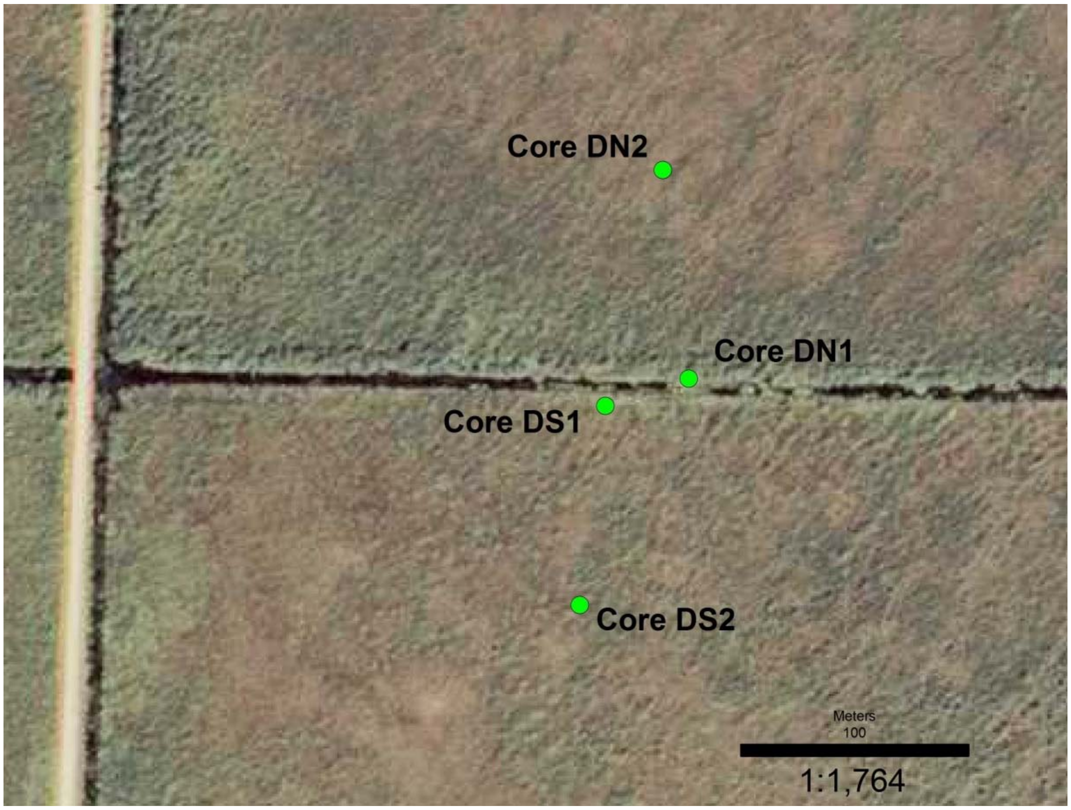


Figure 5: Location of Site C peat core samples. Subsurface flow from south (S) to north (N).



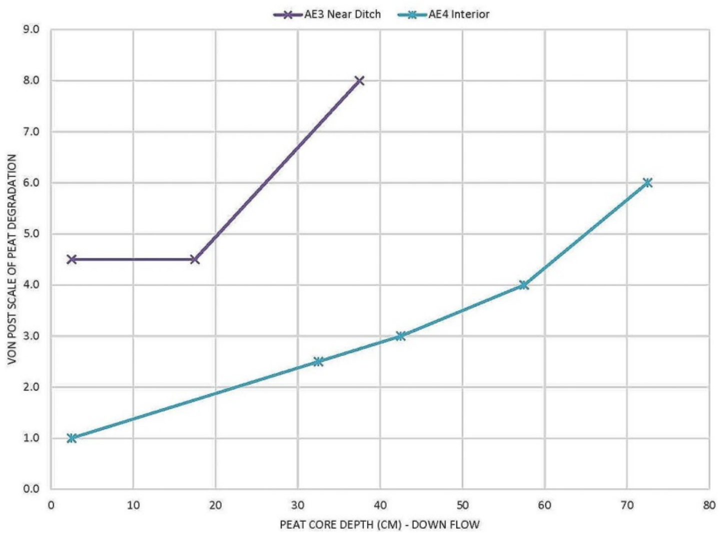


Figure 7: Comparison of peat cores on down flow Site AE (Core AE3: Near Ditch - Core AE4: Fen Interior) with **"Ditch Effects".**

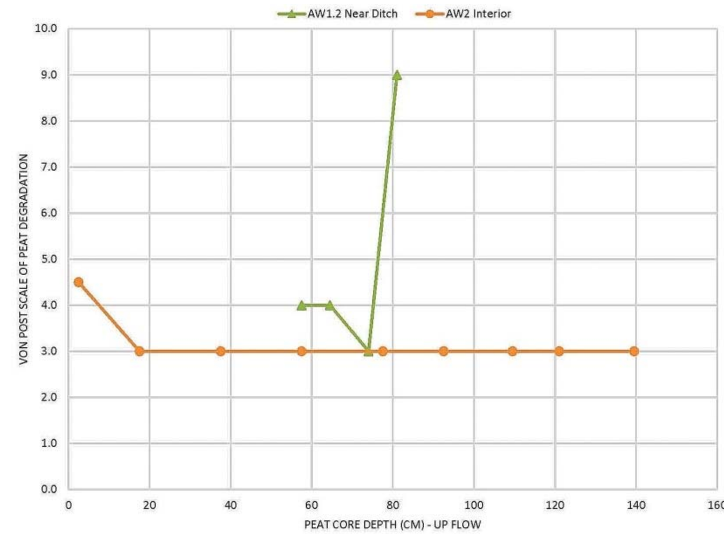


Figure 8: Comparison of peat cores on up flow Site AW (Core AW1.2: Near Ditch - Core AW2.2: Fen Interior) with "**Missing Data" .**

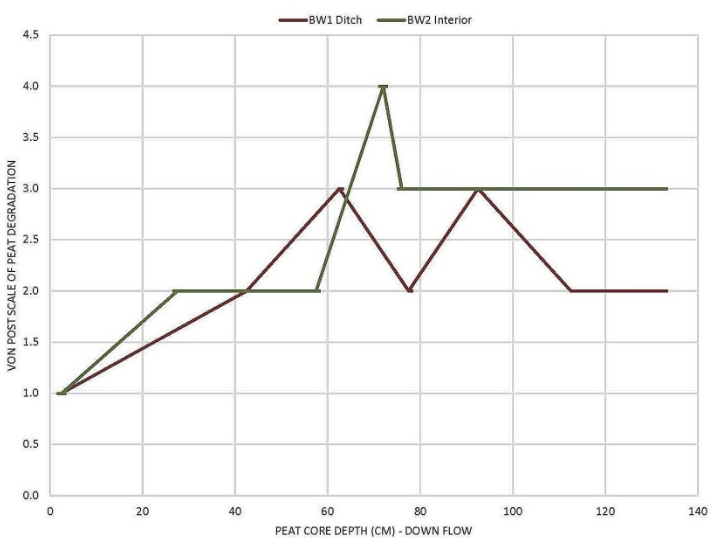


Figure 9: Comparison of peat cores on down flow Site BW (Core BW1: Near Ditch - Core BW2: Fen Interior) with "**No Ditch Effects**".

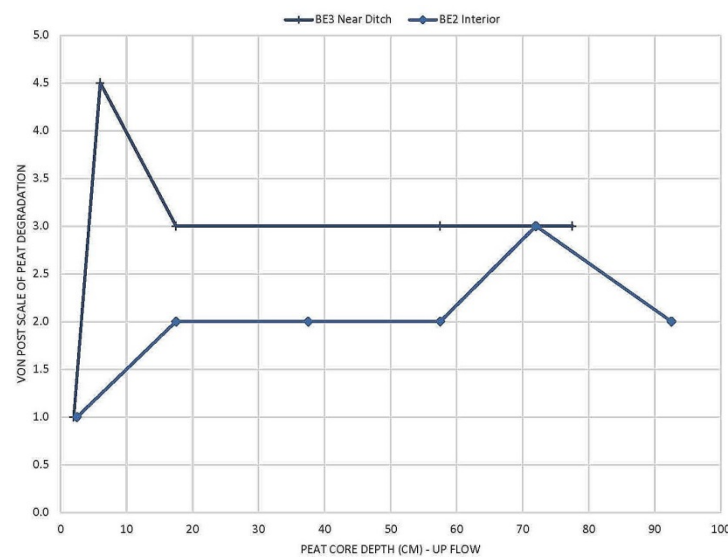


Figure 10: Comparison of peat cores on up flow Site BE (Core BE3: Near Ditch - Core BE2: Fen Interior) with "**Ditch Effects"**.

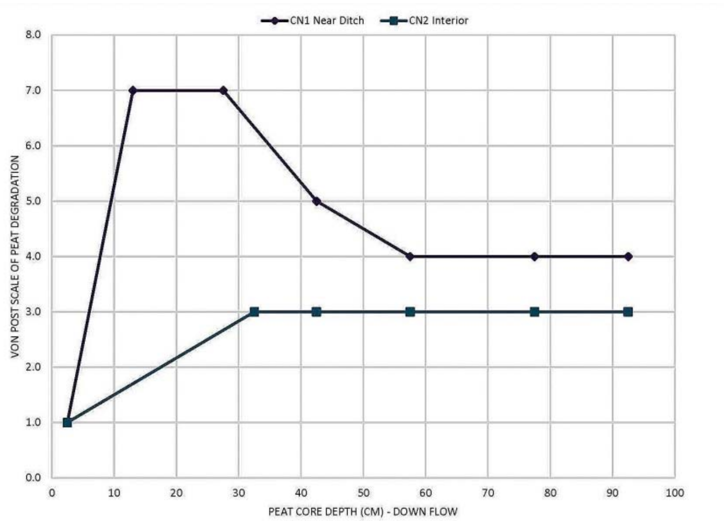


Figure 11: Comparison of peat cores on down flow Site CN (Core CN1: Near Ditch - Core CN2: Fen Interior) with "**Ditch Effects"**.

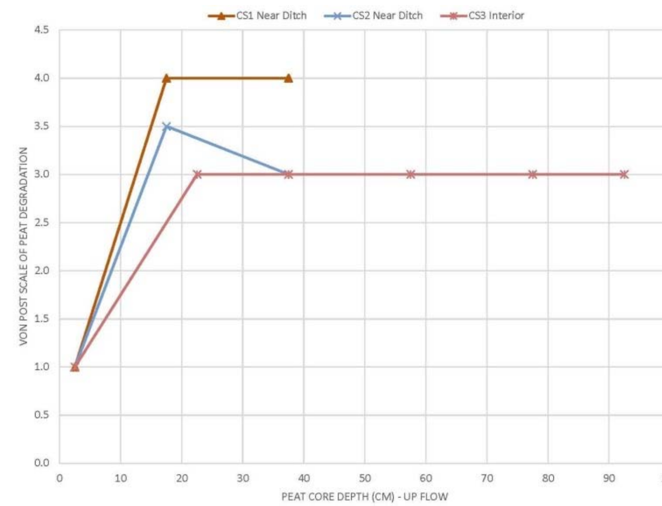


Figure 12: Comparison of peat cores on up flow Site CS (Core CS1 & CS2: Near Ditch - Core CS3: Fen Interior) with " **Ditch Effects"**.

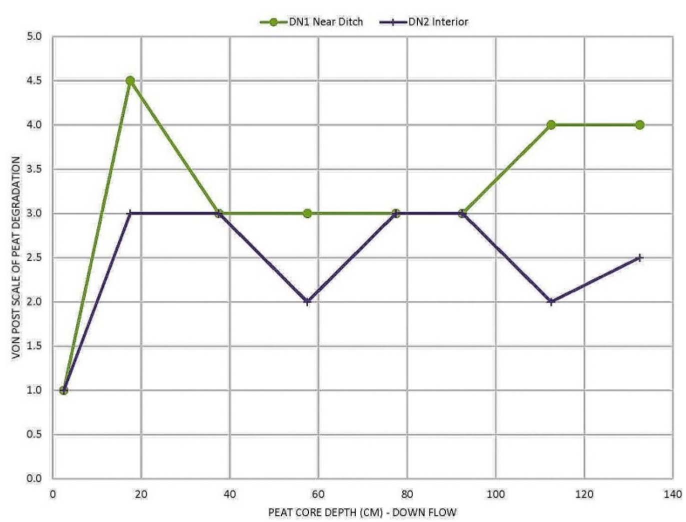


Figure 13: Comparison of peat cores on down flow Site DN (Core DN1: Near Ditch - Core DN2: Fen Interior) with "**Ditch Effects"**.

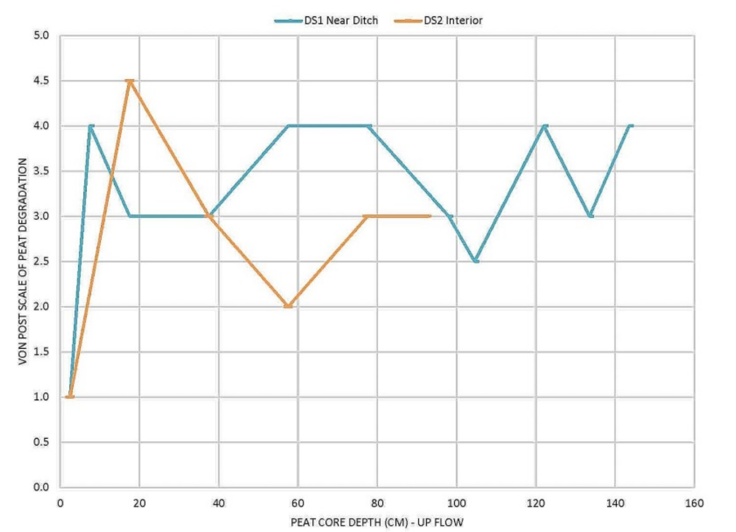


Figure 14: Comparison of peat cores on up flow Site DS (Core DS1: Near Ditch - Core DS2: Fen Interior) with "**Small Ditch Effects"**. Peat degradation in Fen Interior attributed to **"Site Effects"**.

Figure 15: Location of peat cores collected within an "unditched" bog and water-track fen complex. Core data collected for comparison with core samples collected in Winter Road Lake Scientific and Natural Area (SNA).

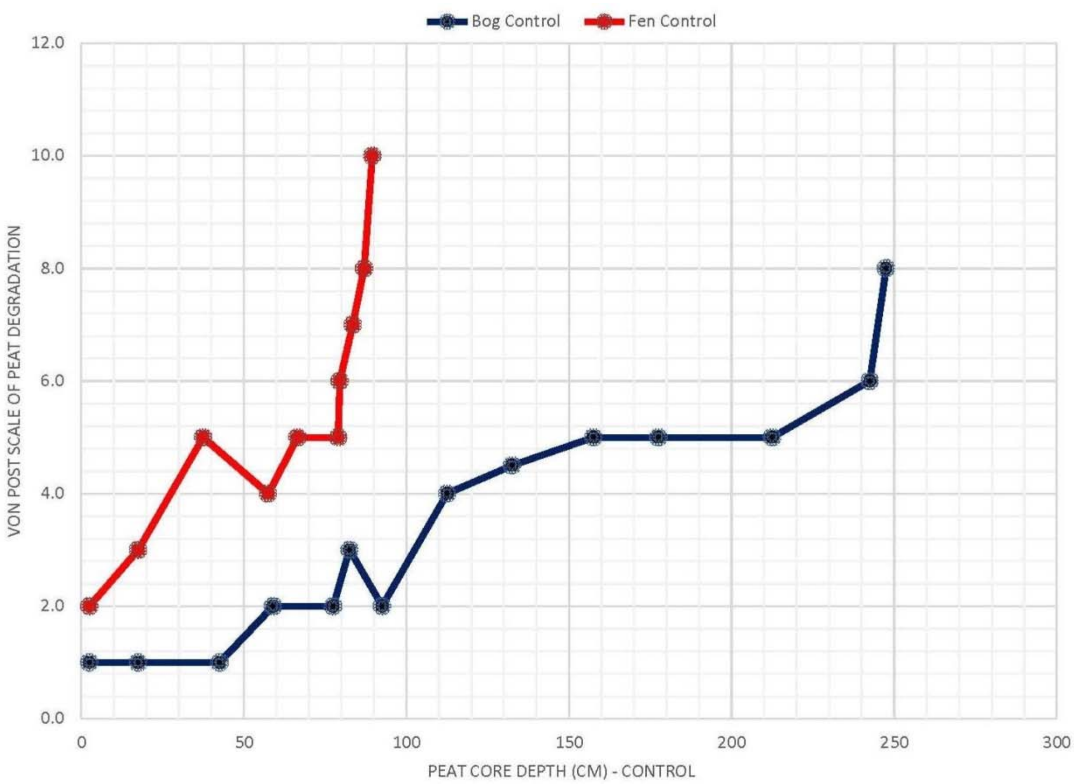


Figure 16: Von Post measures of "naturally occurring" peat degradation collected for sample pair in Brown's Lake Bog and Brown's Lake Water-Track Fen.

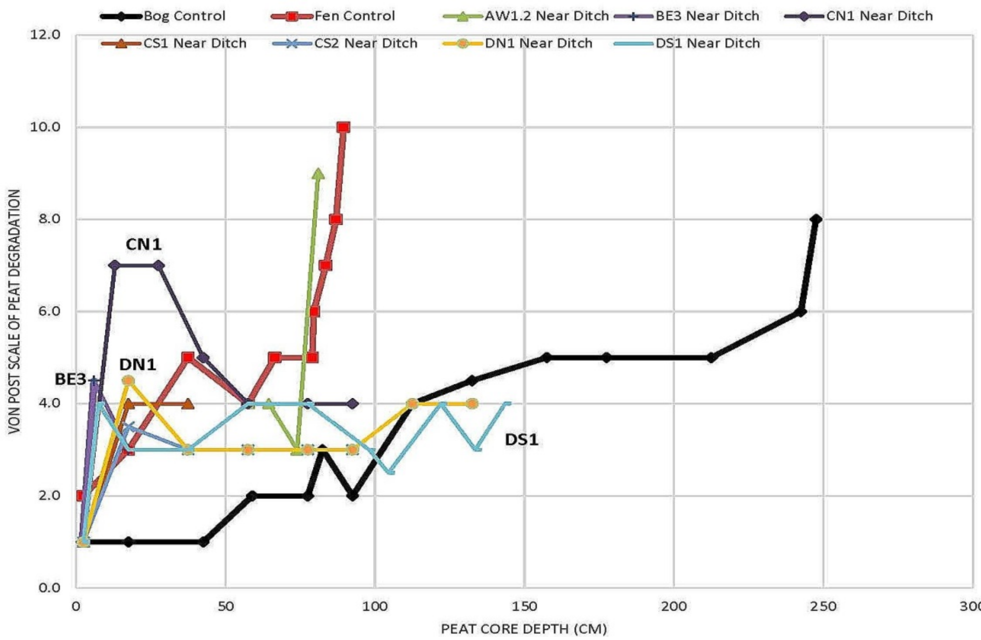


Figure 17: Representative peat core samples of Von Post measures of peat degradation occurring within water-track fens near ditches (Sites A-D). Von Post values for peat core samples were collected near ditches at sites BE3, CN1, DN1 & DS1. Von Post values show that peat degradation is greater than naturally occurring degradation in fens. Excessive degradation is attributed to "Ditch Affects" due to lower water tables from artificial drainage.

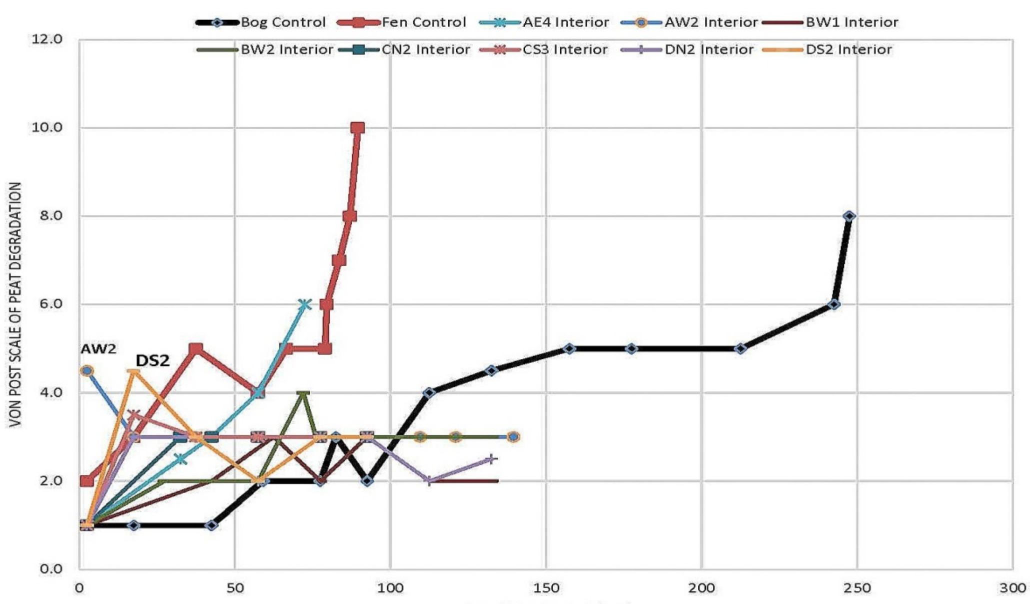


Figure 18: Representative peat core samples showing Von Post values of peat degradation occurring within "Interior" water-track fens (Sites A-D). Von Post values for peat core samples were collected at 100 meters distance from. These core samples show that most peat degradation occurring within the interior of fens can be attributed to "natural occurring decomposition". Excessive degradation at two interior fens are attributed to "Site Effects" associated with their particular location and are not related to "Ditch Affects" from artificial drainage.

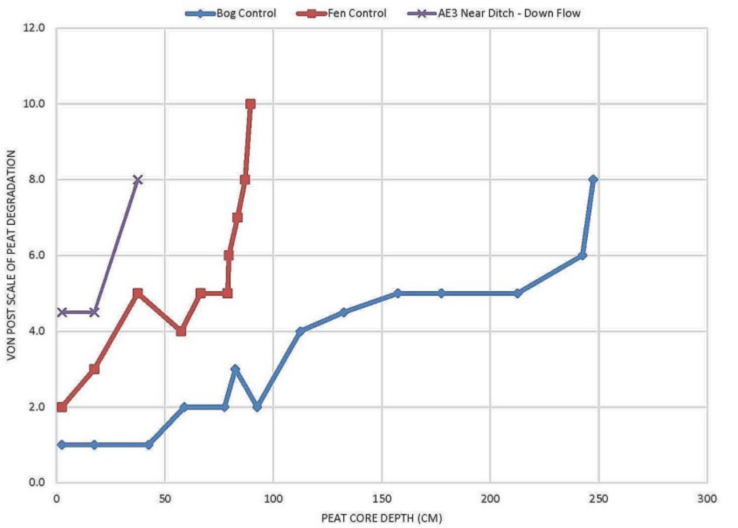


Figure 19: Site A "Near Ditch" Peat Core Samples at Down Flow Locations: Von Post values show **VERY** excessive peat degradation in the upper profile horizons of the peat core sample. **"Ditch Effects" to 40 cm depth.**

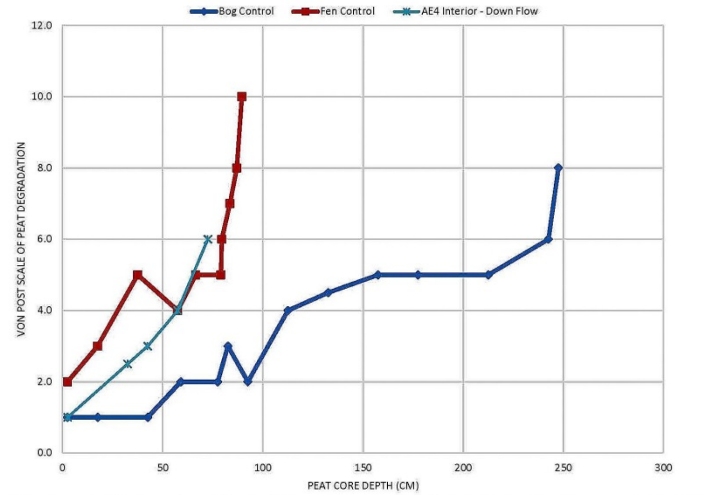


Figure 20: Site A "Interior Fen" Peat Core Samples at Down Flow Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **"No Ditch Effects" - Natural Degradation".**

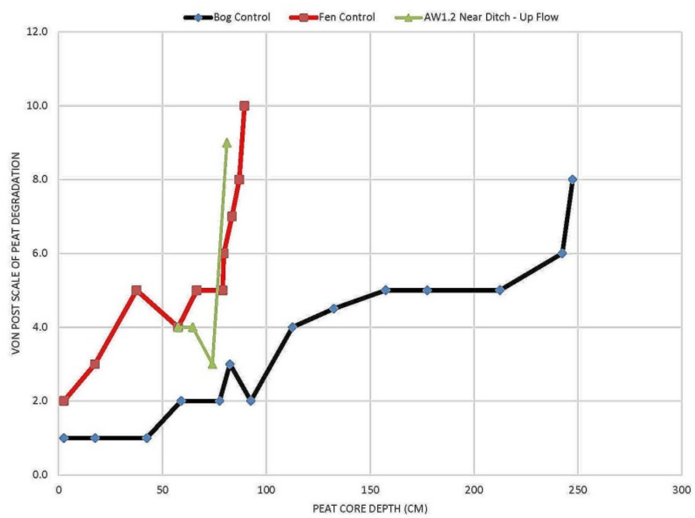


Figure 21: Site A "Near Ditch" Peat Core Samples at Up Flow Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **MISSING DATA "Ditch Effects Uncertain".**

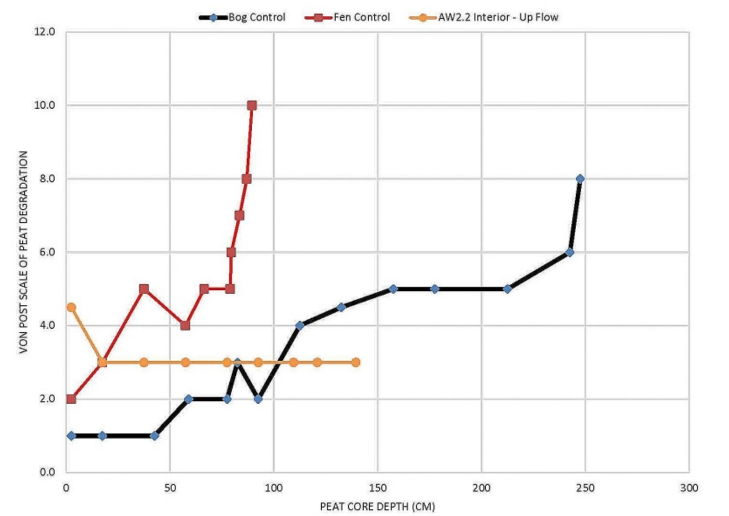


Figure 22: Site A "Interior Fen" Peat Core Samples at Up Flow Locations: Von Post values show **SOME** excessive peat degradation in the upper profile horizons of the peat core sample. **"No Ditch Effects" - 20 cm Depth due to naturally occurring "Site Effects".**

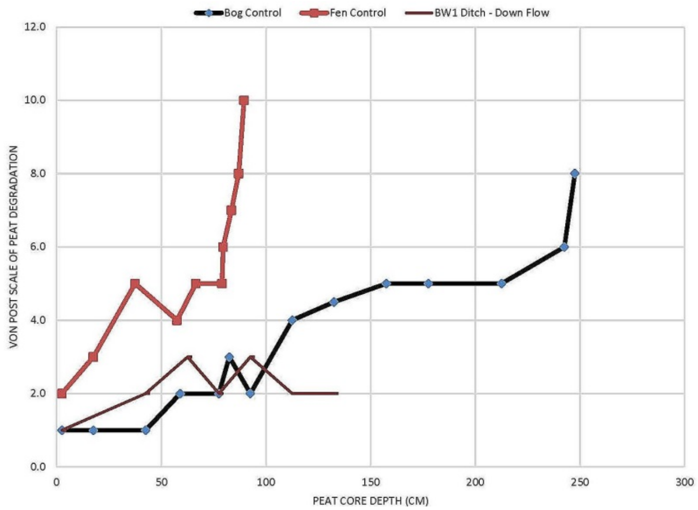


Figure 23: Site **BW1** "**Near Ditch**" Peat Core Samples at **Down Flow** Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **"NO Ditch Effects" attributed to 25 meter distance from ditch center.**

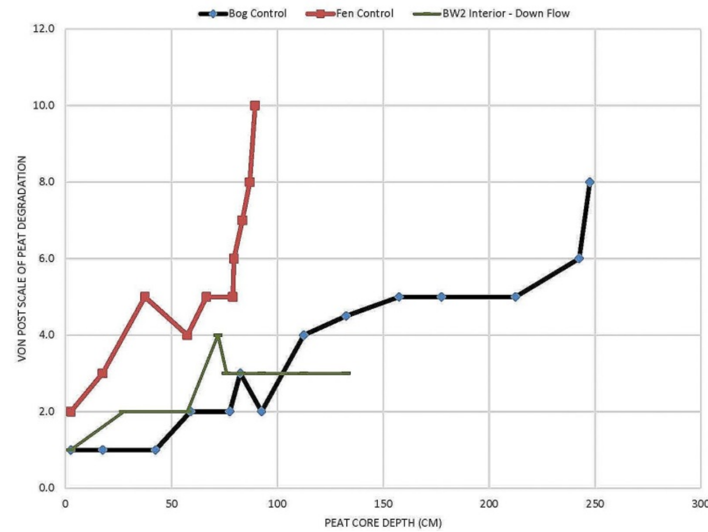


Figure 24: Site **BW2** "**Interior Fen**" Peat Core Samples at Down Flow Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **"NO Ditch Effects".**

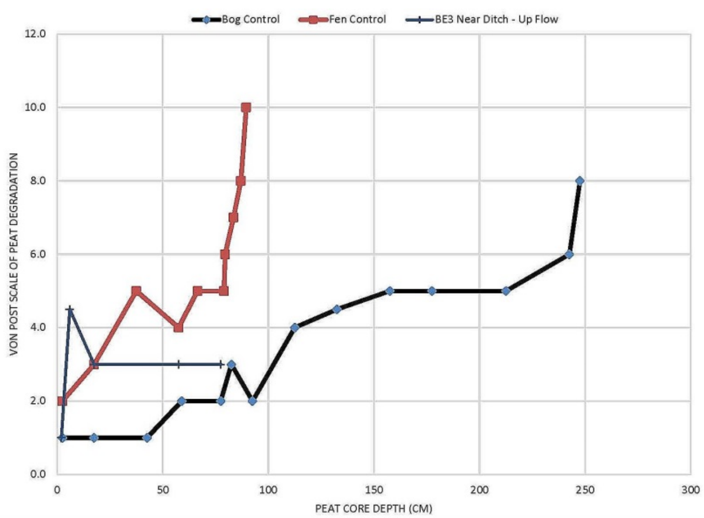


Figure 25: Site **BE3** "**Near Ditch**" Peat Core Samples at **UP Flow** Locations: Von Post values show **SOME** excessive peat degradation in the upper profile horizons of the peat core sample. **"Ditch Effects" to 20 cm Depth.**

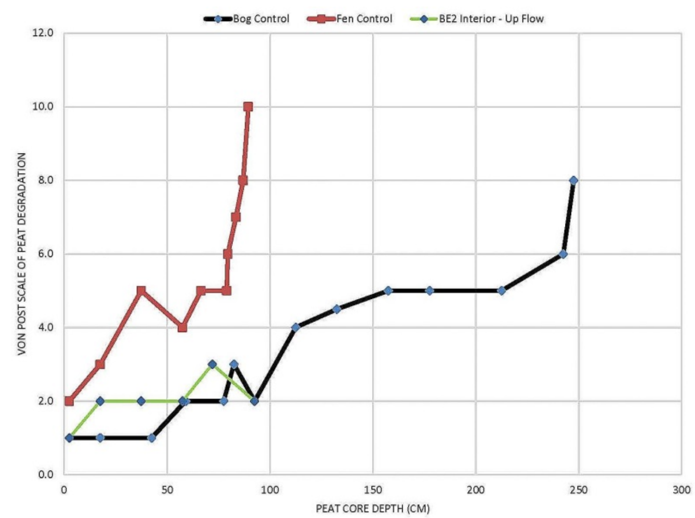


Figure 26: Site **BE2** "**Interior Fen**" Peat Core Samples at **UP Flow** Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **"NO Ditch Effects" .**

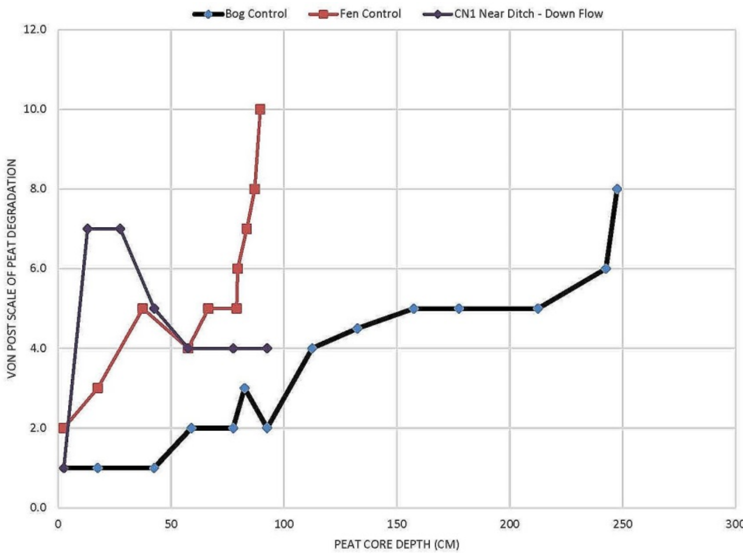


Figure 27: Site **CN1** "**Near Ditch**" Peat Core Samples at **DOWN Flow** Locations: Von Post values show **VERY** excessive peat degradation in the upper profile horizons of the peat core sample. **"Ditch Effects" to 50 cm Depth.**

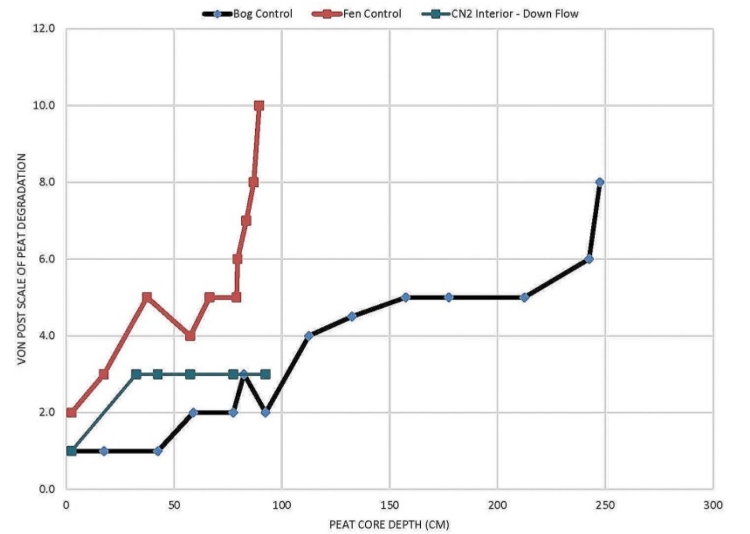


Figure 28: Site **CN2** "**Interior Fen**" Peat Core Samples at **DOWN Flow** Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **"NO Ditch Effects".**

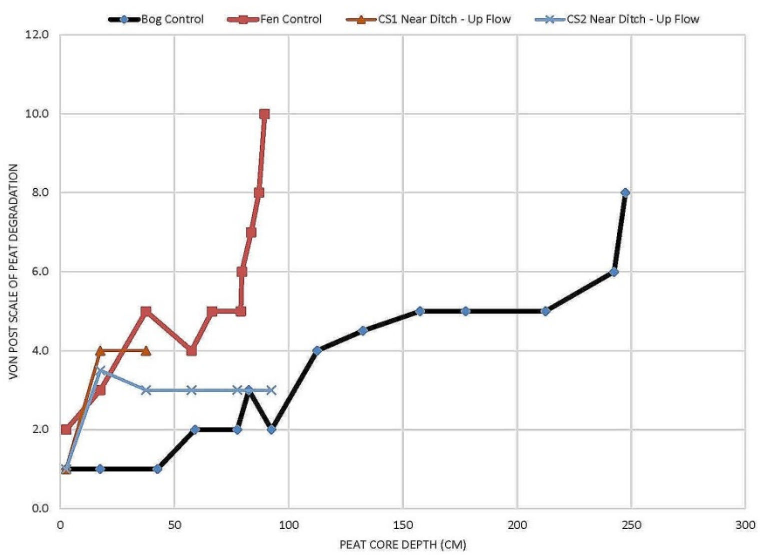


Figure 27: Site **CS1 & CS2** "**Near Ditch**" Peat Core Samples at **UP Flow** Locations: Von Post values show **SOME** excessive peat degradation in the upper profile horizons of the peat core sample. **"Ditch Effects" in two near ditch cores to 30 & 25 cm Depth.**

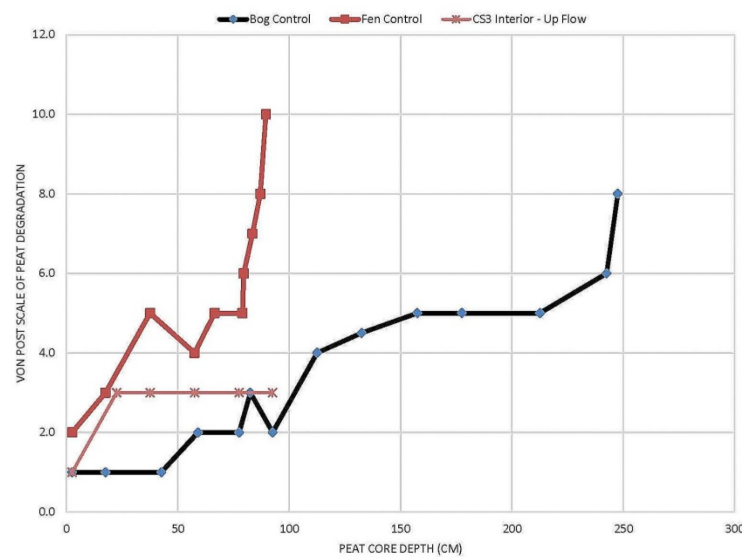


Figure 28: Site **CS3** "**Interior Fen**" Peat Core Samples at **UP Flow** Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **"NO Ditch Effects".**

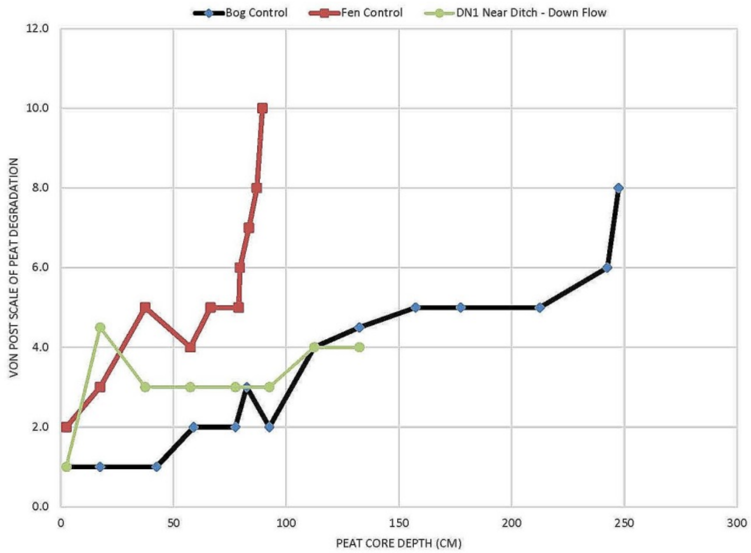


Figure 31: Site **DN1** "**Near Ditch**" Peat Core Samples at **DOWN Flow** Locations: Von Post values show **SOME** excessive peat degradation in the upper profile horizons of the peat core sample. **"Ditch Effects" to 30 cm Depth.**

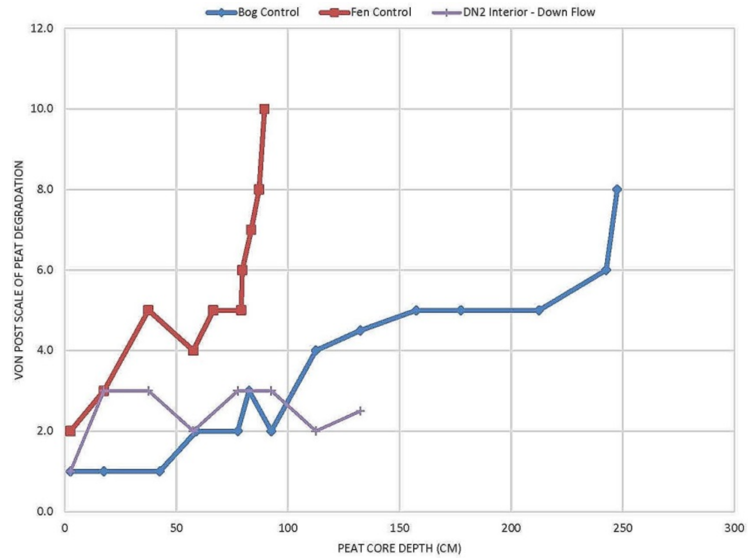


Figure 32: Site **DN2** "**Interior Fen**" Peat Core Samples at **DOWN Flow** Locations: Von Post values show **NO** excessive peat degradation in the upper profile horizons of the peat core sample. **"NO Ditch Effects".**

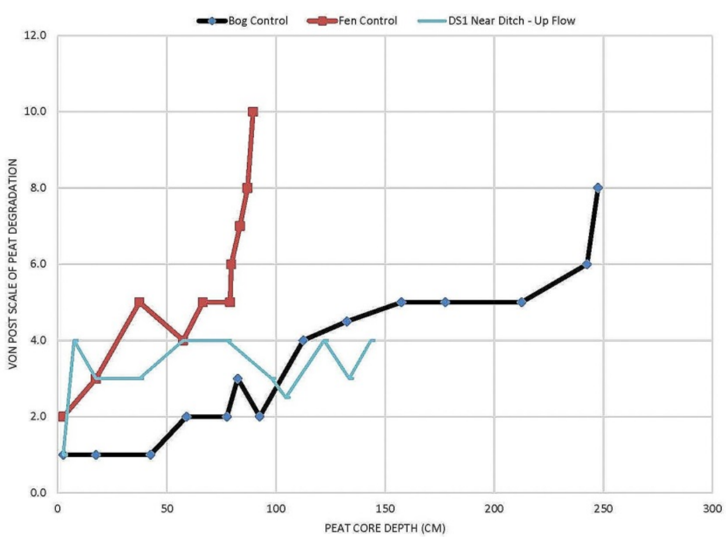


Figure 33: Site **DS1** "**Near Ditch**" Peat Core Samples at **UP Flow** Locations: Von Post values show **SOME** excessive peat degradation in the upper profile horizons of the peat core sample. **"Ditch Effects" in to 20 cm Depth.**

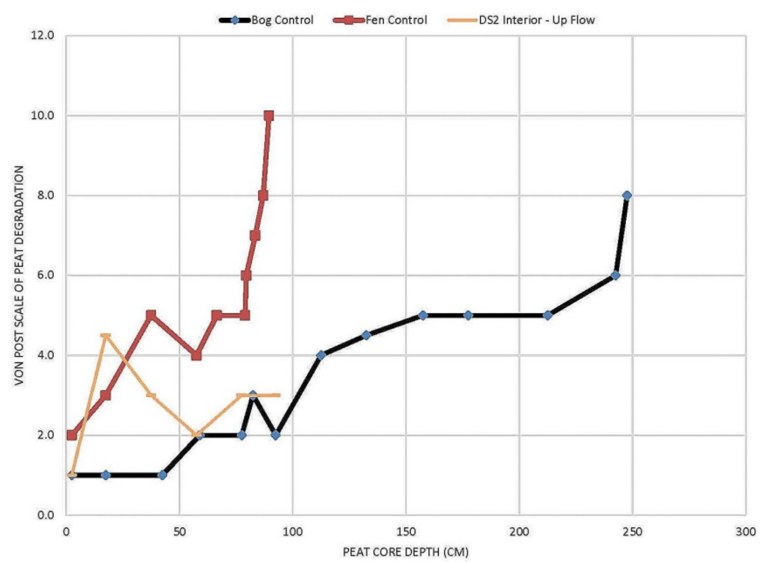


Figure 34: Site **DS2** "**Interior Fen**" Peat Core Samples at **UP Flow** Locations: Von Post values show **SOME** excessive peat degradation in the upper profile horizons of the peat core sample. **"Ditch Effects Unlikely" - 30 cm of peat degradation due to naturally occurring "Site Effects".**

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
1	53	Brown's Bog	2.5	1.0	Yes	Moss			Fibric Shagnum. No compression, no adjustment. 50 cm above water table	0	5	0	5
2	53	Brown's Bog	17.5	1.0	Yes	Moss				15	20	15	20
3	53	Brown's Bog	42.5	1.0	Yes	Moss				40	45	40	45
4	53	Brown's Bog	59	2.0		Moss			Compression 58 cm. Uniform color with one black band.	58	60		
5	53	Brown's Bog	77.5	2.0	Yes	Moss				75	80	75	80
6	53	Brown's Bog	82.5	3.0	Yes	Moss				80	85	80	85
7	53	Brown's Bog	92.5	2.0	Yes	Moss				90	95	90	95
8	53	Brown's Bog	112.5	4.0	Yes	Moss			Catotelm @ 100 cm?	110	115	110	115
9	53	Brown's Bog	132.5	4.5		Sedge			H5/H4	130	135		
10	53	Brown's Bog	157.5	5.0	Yes	Sedge			Sedge peat with preserved seed	155	160	155	160
11	53	Brown's Bog	177.5	5.0	Yes	Sedge			More seeds	175	180	175	180
12	53	Brown's Bog	212.5	5.0	Yes	Sedge			Sedge peat	210	215	210	215
13	53	Brown's Bog	242.5	6.0	Yes	Sedge				240	245	240	245
14	53	Brown's Bog	247.5	8.0	Yes	Sedge				245	250	244	248
15	53	Brown's Bog	251	10.0		Sedge			Extremely difficult to push core sampler past this point	251	251		
16	54	Water Track Fen	2.5	2.0	Yes	Sedge			Compression 7 cm. Acrotelm-catotelm boundary 40 cm	0	5	0	5

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
17	54	Water Track Fen	17.5	3.0	Yes	Sedge				15	20	15	20
18	54	Water Track Fen	37.5	5.0	Yes	Sedge			Living rhizomes	35	40	35	40
19	54	Water Track Fen	57.5	4.0	Yes	Sedge			Sedge roots	55	60	55	60
20	54	Water Track Fen	66.5	5.0	Yes	Sedge			1.5 cm band of sapric material	64	69	64	69
21	54	Water Track Fen	79	5.0		Sedge			12 distinct sapric bands from 64-89 cm.	69	89		
22	54	Water Track Fen	79.5	6.0	Yes	Sedge				78	81	78	81
23	54	Water Track Fen	83.5	7.0	Yes	Sedge			Numerous indistinct bands	82	85	81	85
24	54	Water Track Fen	87	8.0	Yes	Sedge				85	89	85	89
25	54	Water Track Fen	89.5	10.0		Sedge			Distinct 1.5 cm band.	89	90		
26	54	Water Track Fen	90			Sand			Sand, well-rounded, well sorted sand. Fine sand with some organic silt.	90	90		
27	112	AE1			Yes	Sedge	Ditch	Down Flow	From Core			0	5

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
28	112	AE1	2.5	5.0	Yes	Sedge	Ditch	Down Flow	Close to ditch, among sedges with shrubs nearby. Fairly uniform banding througout core. Very little compaction. Decomposed stuff from ditch effect down to 9 cm. From Spade (undisturbed).	0	5	0	5
29	112	AE1	22.5		Yes	Sedge	Ditch	Down Flow				20	25
30	112	AE1	27	4.0	Yes	Sedge	Ditch	Down Flow	darker(?)	25	29	25	29
31	112	AE1	31	3.0	Yes	Sedge	Ditch	Down Flow	lighter	29	33	29	33
32	112		37.5		Yes	Sedge	Ditch	Down Flow				35	40
33	112	AE1	46	4.0	Yes	Sedge	Ditch	Down Flow	darker. Sample core blocked from going deeper. A second core attempted.	44	48	44	48
34	112	AE1	57.5		Yes	Sedge	Ditch	Down Flow				55	60
35	112	AE1	64.5		Yes	Sedge	Ditch	Down Flow				64	65
36	112	AE1	74		Yes	Sedge	Ditch	Down Flow				73	75
37	112	AE1	81		Yes	Sedge	Ditch	Down Flow				80	82
38	114	AE2	2.5	5.0	Yes	Sedge	Ditch	Down Flow	Collected one sample for absorbance analysis. Core seems pretty homogeneous until we hit the sand/clay.	0	5	0	5
39	114	AE2	32.5	5.0	Yes	Sedge	Ditch	Down Flow		30	35	30	35
40	114	AE2	45			Sand/clay	Ditch	Down Flow	Hit sand/clay after 45 cm. Mineral sand acturally quite fine grained.	45	45		
41	115	AE3	2.5	4.5	Yes	Sedge	Ditch	Down Flow	A few more meters back from bank.	0	5	0	5
42	115	AE3	17.5	4.5	Yes	Sedge	Ditch	Down Flow	H4/H5	15	20	15	20
43	115	AE3	37.5	8.0	Yes	Sedge	Ditch	Down Flow		35	40	35	40

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
44	116	AE4	2.5	1.0	Yes	Sedge	Interior	Down Flow	Near end of well transect. Compaction to 18 cm. Light band from 33-35 cm otherwise homogeneous. Peat profile an amalgamation of three core samples in the immediate area. (2nd core sample 25-75).	0	5	0	5
45	116	AE4	32.5	2.5	Yes	Sedge	Interior	Down Flow	H2/H3 light band.	32	33	33	35
46	116	AE4	42.5	3.0	Yes	Sedge	Interior	Down Flow		40	45	40	45
47	116	AE4	57.5	4.0	Yes	Sedge	Interior	Down Flow		55	60	55	60
48	116	AE4	72.5	6.0	Yes	Sedge	Interior	Down Flow	Cores stopped at 75 cm which might be a sign that it has hit clay. H6 at bottom is the most decomposed portion of sample, otherwise sample core is homogeneous.	70	75	70	75
49	116	AE4	80			Sedge	Interior	Down Flow	Third core found clay at base about 80 cm down.	80	80		
50	121	AW1.1	0			Sedge	Ditch	Up Flow	Near ditch, among sedges of large shrubs. This peat sample was spoiled by spoil from ditch construction. Starting at about 9 cm down. Peat is mixed with sand. Thus samples where not collect here.				
51	122	AW1.2	2.5		Yes	Sedge	Ditch	Up Flow	Near ditch, compression to 20 cm. Among sedges and large shrubs.	0	5	0	5
52	122	AW1.2	22.5			Sedge	Ditch	Up Flow		20	25		
53	122	AW1.2	37.5			Sedge	Ditch	Up Flow		35	40		

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
54	122	AW1.2	57.5	4.0		Sedge	Ditch	Up Flow		55	60		
55	122	AW1.2	64.5	4.0		Wood	Ditch	Up Flow	woody peat.	64	65		
56	122	AW1.2	74	3.0		Wood	Ditch	Up Flow	Band of woody peat.	73	75		
57	122	AW1.2	81	9.0		Muck	Ditch	Up Flow	really sapric, grassland or marsh.	80	82		
58	122	AW1.2	83			Sand	Ditch	Up Flow	Sand. Grey-green, medium size, well rounded, well-sorted.	83	83		
59	123	AW2.1	2.5		Yes	Sedge	Interior	Up Flow	duplicate range			0	5
60	123	AW2.2	2.5	4.5	Yes	Sedge	Interior	Up Flow	At end of well transect in moderately dense shrubs. Core chunky, (not a complete half cylinder) until 30 cm. Stuff at very top seems most sapric. H4/H5. Area seems to be a dome caused by spring upwelling. Higher elevation. Presence of bog bean which usually grows in running water.	0	5	0	5
61	123	AW2.2	17.5	3.0	Yes	Sedge	Interior	Up Flow		15	20	15	20
62	123	AW2.2	37.5	3.0	Yes	Sedge	Interior	Up Flow		35	40	35	40
63	123	AW2.2	57.5	3.0	Yes	Sedge	Interior	Up Flow	homogeneous 55-95cm, bit lighter near 95 cm.	55	60	55	60
64	123	AW2.2	77.5	3.0	Yes	Sedge	Interior	Up Flow		75	80	75	80
65	123	AW2.2	92.5	3.0	Yes	Sedge	Interior	Up Flow		90	95	90	95
66	123	AW2.2	109.5	3.0	Yes	Sedge	Interior	Up Flow		105	114	105	111
67	123	AW2.2	121	3.0	Yes	Sedge	Interior	Up Flow		118	124	118	124
68	123	AW2.2	139.5	3.0	Yes	Sedge	Interior	Up Flow		137	142	137	142
69	83	BE1	2.5	1.0	Yes	Sedge	Ditch	Up Flow	Close to ditch. Compression to 30 cm	0	5	0	5
70	83	BE1	37.5	2.0		Sedge	Ditch	Up Flow		35	40		
71	83	BE1	47.5	2.0	Yes	Sedge	Ditch	Up Flow				35	60
72	83	BE1	57.5	2.0	Yes	Sedge	Ditch	Up Flow		55	60	55	60

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
73	83	BE1	77.5	2.0	Yes	Sedge	Ditch	Up Flow		75	80	75	80
74	83	BE1	92.5	2.0	Yes	Sedge	Ditch	Up Flow		90	95	90	95
75	83	BE1	112.5		Yes	Sedge	Ditch	Up Flow		110	115	110	115
76	83	BE1	132.5		Yes	Sedge	Ditch	Up Flow		130	135	130	135
77	84	BE2	2.5	1.0	Yes	Sedge	Interior	Up Flow	Far from ditch. Compression to 12 cm.	0	5	0	5
78	84	BE2	17.5	2.0	Yes	Sedge	Interior	Up Flow		15	20	15	20
79	84	BE2	37.5	2.0	Yes	Sedge	Interior	Up Flow		35	40	35	40
80	84	BE2	57.5	2.0	Yes	Sedge	Interior	Up Flow		55	60	55	60
81	84	BE2	72	3.0	Yes	Sedge	Interior	Up Flow	Darker band, more particulates	68	76	68	76
82	84	BE2	92.5	2.0	Yes	Sedge	Interior	Up Flow		90	95	90	95
83	84	BE2	112.5		Yes	Sedge	Interior	Up Flow		110	115	110	115
84	84	BE2	132.5		Yes	Sedge	Interior	Up Flow		130	135	130	135
85	85	BE3	2	1.0	Yes	Sedge	Ditch	Up Flow	Extra core right on bank. First 50 dm: much darker at top than at bottom. Compression to 3 cm, (kind of chunky (not whole untill 16 cm).	0	4	0	5
86	85	BE3	6	4.5	Yes	Sedge	Ditch	Up Flow	Most decomposed. H4/H5	4	8	4	8
87	85	BE3	17.5	3.0	Yes	Sedge	Ditch	Up Flow		15	20	15	20
88	85	BE3	37.5		Yes	Sedge	Ditch	Up Flow				35	40
89	85	BE3	57.5	3.0	Yes	Sedge	Ditch	Up Flow		55	60	55	60
90	85	BE3	77.5	3.0	Yes	Sedge	Ditch	Up Flow		75	80	75	80
91	71	BW1	2.5	1.0	Yes	Moss	Ditch	Down Flow	Living moss. Compaction 35 cm. Unconsolodated. Near Ditch	0	5	0	5
92	71	BW1	27.5		Yes	Sedge	Ditch	Down Flow				25	30
93	71	BW1	42.5	2.0	Yes	Sedge	Ditch	Down Flow		40	45	40	45
94	71	BW1	62.5	3.0	Yes	Sedge	Ditch	Down Flow		60	65	60	65
95	71	BW1	77.5	2.0	Yes	Sedge	Ditch	Down Flow		75	80	75	80
96	71	BW1	92.5	3.0	Yes	Sedge	Ditch	Down Flow		90	95	90	95
97	71	BW1	112.5	2.0	Yes	Sedge	Ditch	Down Flow		110	115	110	115

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
98	71	BW1	132.5	2.0		Sedge	Ditch	Down Flow		130	135		
99	77	BW2	2.5	1.0	Yes	Sedge	Interior	Down Flow	Living sedge roots. Far from Ditch	0	5	0	5
100	77	BW2	22.5		Yes	Sedge	Interior	Down Flow				20	25
101	77	BW2	27.5	2.0	Yes	Sedge	Interior	Down Flow	Sedge roots	25	30	25	30
102	77	BW2	42.5	2.0	Yes	Sedge	Interior	Down Flow	Sedge roots	40	45	40	45
103	77	BW2	57.5	2.0	Yes	Sedge	Interior	Down Flow	Sedge roots	55	60	55	60
104	77	BW2	72	4.0	Yes	Sedge	Interior	Down Flow	Sedge roots	70	74	70	74
105	77	BW2	76	3.0	Yes	Sedge	Interior	Down Flow	Sedge roots	74	78	74	78
106	77	BW2	83	3.0	Yes	Sedge	Interior	Down Flow	Sedge roots	81	85	81	85
107	77	BW2	92.5	3.0		Sedge	Interior	Down Flow	Sedge roots	90	95		
108	77	BW2	112.5	3.0	Yes	Sedge	Interior	Down Flow		110	115	109	116
109	77	BW2	132.5	3.0	Yes	Sedge	Interior	Down Flow	Sedge peat	130	135	130	135
110	66	CN1	2.5	1.0	Yes		Ditch	Down Flow	Next to ditch, compression to 13 cm.	0	5	0	5
111	66	CN1	13	7.0	Yes	Sedge	Ditch	Down Flow		10	16	10	16
112	66	CN1	17		Yes	Sand	Ditch	Down Flow	Interesting band of light brown, fine-grained sand.	16.5	17.5	17	18
113	66	CN1	27.5	7.0	Yes	Sedge	Ditch	Down Flow		25	30	26	30
114	66	CN1	42.5	5.0	Yes	Sedge	Ditch	Down Flow		40	45	40	45
115	66	CN1	57.5	4.0	Yes	Sedge	Ditch	Down Flow		55	60	55	60
116	66	CN1	77.5	4.0	Yes	Sedge	Ditch	Down Flow		75	80	75	80
117	66	CN1	92.5	4.0	Yes	Sedge	Ditch	Down Flow		90	95	90	95
118	66	CN1	106.5			Wood	Ditch	Down Flow	Big wood chip	105	108		
119	66	CN1	112.5		Yes	Sedge	Ditch	Down Flow		110	115	110	115
120	66	CN1	132.5		Yes	Sedge	Ditch	Down Flow		130	135	130	135
121	67	CN2	2.5	1.0	Yes	Sedge	Interior	Down Flow	Away from ditch. Compression 26 cm. Super compressed and very soupy once you get down there. In the first 5 m only about half the core was filled.	0	5	0	5
122	67	CN2	32.5	3.0	Yes	Sedge	Interior	Down Flow		30	35	30	35
123	67	CN2	42.5	3.0	Yes	Sedge	Interior	Down Flow		40	45	40	45

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
124	67	CN2	57.5	3.0	Yes	Sedge	Interior	Down Flow		55	60	55	60
125	67	CN2	77.5	3.0	Yes	Sedge	Interior	Down Flow		75	80	75	80
126	67	CN2	92.5	3.0	Yes	Sedge	Interior	Down Flow		90	95	90	95
127	67	CN2	112.5		Yes	Sedge	Interior	Down Flow		110	115	110	115
128	67	CN2	132.5		Yes	Sedge	Interior	Down Flow		130	135	110	115
129	55	CS1	2.5	1.0	Yes	Sedge	Ditch	Up Flow	Next to ditch. Compressed to 8 cm.	0	5	0	5
130	55	CS1	17.5	4.0	Yes	Sedge	Ditch	Up Flow		15	20	15	20
131	55	CS1	37.5	4.0	Yes	Sedge	Ditch	Up Flow		35	40	35	40
132	55	CS1	41			Muck	Ditch	Up Flow	Below this washed out. Watery muck. Unable to sample.	41	41		
133	56	CS2	2.5	1.0	Yes	Sedge	Ditch	Up Flow	Close to ditch. Negligible compression	0	5	0	5
134	56	CS2	17.5	3.5	Yes	Sedge	Ditch	Up Flow	H4/H3	15	20	15	20
135	56	CS2	37.5	3.0	Yes	Sedge	Ditch	Up Flow		35	40	35	40
136	56	CS2	57.5	3.0	Yes	Sedge	Ditch	Up Flow	quite homogenous	55	60	55	60
137	56	CS2	77.5	3.0	Yes	Sedge	Ditch	Up Flow	quite homogenous	75	80	75	80
138	56	CS2	92.5	3.0	Yes	Sedge	Ditch	Up Flow	quite homogenous	90	95	90	95
139	56	CS2	100			Sand?	Ditch	Up Flow	Unable to reach below 100 cm.	100	100		
140	57	CS3	2.5	1.0	Yes	Sedge	Interior	Up Flow	Near Farthest Well. Compression 16 cm.	0	5	0	5
141	57	CS3	22.5	3.0	Yes	Sedge	Interior	Up Flow		20	25	20	25
142	57	CS3	37.5	3.0	Yes	Sedge	Interior	Up Flow		35	40	35	40
143	57	CS3	57.5	3.0	Yes	Sedge	Interior	Up Flow		55	60	55	60
144	57	CS3	77.5	3.0	Yes	Sedge	Interior	Up Flow		75	80	75	80
145	57	CS3	92.5	3.0	Yes	Sedge	Interior	Up Flow		90	95	90	95
146	103	DN1	2.5	1.0	Yes	Sedge	Ditch	Down Flow	On side of ditch.	0	5	0	5
147	103	DN1	17.5	4.5	Yes	Sedge	Ditch	Down Flow	H5/H4	15	20	15	20
148	103	DN1	37.5	3.0	Yes	Sedge	Ditch	Down Flow		35	40	35	40
149	103	DN1	57.5	3.0	Yes	Sedge	Ditch	Down Flow	Quite homogeneous 55-95 cm.	55	60	55	60

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
150	103	DN1	77.5	3.0	Yes	Sedge	Ditch	Down Flow		75	80	75	80
151	103	DN1	92.5	3.0	Yes	Sedge	Ditch	Down Flow		90	95	90	95
152	103	DN1	112.5	4.0	Yes	Sedge	Ditch	Down Flow		110	115	110	115
153	103	DN1	132.5	4.0	Yes	Sedge	Ditch	Down Flow		130	135	130	135
154	107	DN2	2.5	1.0	Yes	Sedge	Interior	Down Flow	Away from ditch. Compression to 10 cm. Homogeneous otherwise.	0	5	0	5
155	107	DN2	17.5	3.0	Yes	Sedge	Interior	Down Flow		15	20	15	20
156	107	DN2	37.5	3.0	Yes	Sedge	Interior	Down Flow		35	40	35	40
157	107	DN2	57.5	2.0	Yes	Sedge	Interior	Down Flow	Fairly homogeneous with some chunky orange bits 55-95 cm.	55	60	55	60
158	107	DN2	77.5	3.0	Yes	Sedge	Interior	Down Flow		75	80	75	80
159	107	DN2	92.5	3.0	Yes	Sedge	Interior	Down Flow		90	95	90	95
160	107	DN2	112.5	2.0	Yes	Sedge	Interior	Down Flow		110	115	110	115
161	107	DN2	132.5	2.5	Yes	Sedge	Interior	Down Flow	H3/H2. Looks quite homogeneous.	130	135	130	135
162	99	DS1	2.5	1.0	Yes	Sedge	Ditch	Up Flow	Next to ditch. Lots of sedges. Not completely compressed, but chunky (not a whole core) until 25 cm. Not [much] color variation. Might be slighly darker at the top.	0	5	0	5
163	99	DS1	7.5	4.0	Yes	Sedge	Ditch	Up Flow		5	10	5	10
164	99	DS1	17.5	3.0	Yes	Sedge	Ditch	Up Flow		15	20	15	20
165	99	DS1	37.5	3.0	Yes	Sedge	Ditch	Up Flow		35	40	35	40
166	99	DS1	57.5	4.0	Yes	Sedge	Ditch	Up Flow	From 55-100 Fairly homogeneous in color and composition except from about 96-100 cm.	55	60	55	60
167	99	DS1	77.5	4.0	Yes	Sedge	Ditch	Up Flow		75	80	75	80
168	99	DS1	98	3.0	Yes	Sedge	Ditch	Up Flow		96	100	96	100

VP Sample #	VP Wypt	VP Location	Medial Depth cm	Von Post Value	Peat Sample	Fiber	Core Location	Core Hydrology	VP Notes	Von Post Top Layer cm	Von Post Bottom Layer cm	Peat Sample Top	Peat Sample Bottom
169	99	DS1	104.5	2.5	Yes	Sedge	Ditch	Up Flow	Less decomposed (H2/H3). Pretty uniform banding at bottom bands at 104, 105, 110, 112, 113, 115, 118, 122, 124, 126, 129, 131, 134, 137, 139, 140, 142, 145, 147, 149 (all about 1 cm wide).	102	107	102	107
170	99	DS1	122	4.0	Yes	Sedge	Ditch	Up Flow	Darker	120	124	120	124
171	99	DS1	133.5	3.0	Yes	Sedge	Ditch	Up Flow		132	135	132	134
172	99	DS1	143.5	4.0	Yes	Sedge	Ditch	Up Flow	Lighter and coarser	142	145	142	145
173	101	DS2	2.5	1.0	Yes	Sedge	Interior	Up Flow	Away from ditch, among sedges, some willows nearby. Catotelm at about 33 cm. Not too much compression at about 4 cm.	0	5	0	5
174	101	DS2	17.5	4.5	Yes	Sedge	Interior	Up Flow	H5/H4	15	20	15	20
175	101	DS2	37.5	3.0	Yes	Sedge	Interior	Up Flow		35	40	35	40
176	101	DS2	57.5	2.0	Yes	Sedge	Interior	Up Flow	Fairly uniform 55-95.	55	60	55	60
177	101	DS2	77.5	3.0	Yes	Sedge	Interior	Up Flow		75	80	75	80
178	101	DS2	92.5	3.0	Yes	Sedge	Interior	Up Flow		90	95	90	95
179	101	DS2	112.5		Yes	Sedge	Interior	Up Flow	Homogeneous with some roots 110-135.	110	115	110	115
180	101	DS2	132.5		Yes	Sedge	Interior	Up Flow		130	135	130	135

Degree of Decomposition	USDA SCS Classification	Nature of water expressed on squeezing	Proportion of peat extruded between fingers	Nature of peat residues	Decomposition description	Volume Passing through Fingers (%)	Additional Description of Free Water Expressed to the Second Hand
H1	Fibric	Clear, colorless	None, elastic	Unaltered, fibrous	Undecomposed	0	Expressed water is clear to almost clear and yellow-brown in color. Slowly open the second hand and observe color as the water depth thins
H2	Fibric	Almost clear, yellow-brown	None	Almost unaltered	Almost undecomposed	0	
H3	Fibric	Slight turbid, brown	None	Most remains easily identifiable	Very slightly decomposed	0	Water is muddy brown and retained fiber is not mushy
H4	Hemic	Turbid, brown	None	Most remains identifiable	Slightly decomposed	0	Very turbid, muddy water and retained fiber is somewhat mushy
H4.5	Hemic					1	Amorphous material primarily stays on outside of squeezed fingers
H5	Hemic	Strongly turbid, contains a little peat in suspension	Very little	Bulk of remains difficult to identify	Moderately well decomposed	2-10	Use the volume of amorphous material passed. As "With H4 and H4.5, water at the edges of the amorphous material is very turbid and muddy
H5.5	Hemic					11-25	
H6	Hemic	Muddy, much peat in suspension	One third	Bulk of remains unidentifiable	Well decomposed	26-35	
H6.5	Sapric					36-45	
H7	Sapric	Strongly muddy remains	One half	Relatively few identifiable	Strongly decomposed	46-55	Water around the amorphous material is thick, soupy, and very dark
H7.5	Sapric					56-65	
H8	Sapric	Thick mud, little free water	Two thirds	Only resistant roots, fibers, and bark, etc., identifiable	Very strongly decomposed	66-75	There is essentially no free water; it is all amorphous material
H9	Sapric	No free water	Almost all	Practically no identifiable remains	Almost completely decomposed	76-95	There is no free water associated with the amorphous material
H10	Sapric	No free water	All	Completely amorphous	Completely decomposed	95-100	

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Sample Core ID	Ditch Distance (m)	Figure #	Near Ditch or Fen Interior	UP Flow / Down Flow1	Ditch Effect	Outside Range of Natural Variation	Flow Effect	Site Effects	Depth (cm) of Degradation	Possible Explanation
AE3	9.1	7, 19	Near Ditch	Down Flow	Yes	Yes			40	Ditch Effects
AE4	101.7	7	Fen Interior	Down Flow						
AW1.2	19.8	8, 21	Near Ditch	Up Flow	Missing Data	Missing Data	Missing Data	Missing Data		
AW2.2	114.8	8, 18, 22	Fen Interior	Up Flow		Yes		Yes	20	Site Effect on Interior Fen
BW1	25.7	9, 23	Near Ditch	Down Flow	No	No				No Ditch Effects from Near Ditch Profile Due to distance across road.
BW2	122.7	9	Fen Interior	Down Flow						
BE3	1.1	10, 17, 26	Near Ditch	Up Flow	Yes	Yes			20	Ditch Effects
BE2	97.3	10	Fen Interior	Up Flow						
CN1	11.1	11	Near Ditch	Down Flow	Yes	Yes			50	Ditch Effects
CN2	110.2	11	Fen Interior	Down Flow						
CS1	8.8	12, 17	Near Ditch	Up Flow	Yes	Yes			30	Ditch Effects in two near ditch cores, 30 & 25 cm.
CS2	12.2	12	Near Ditch	Up Flow	Yes (duplicate)					
CS3	106.9	12	Fen Interior	Up Flow						
DN1	2.9	13, 17, 31	Near Ditch	Down Flow	Yes	Yes			30	Ditch Effects
DN2	94.4	13	Fen Interior	Down Flow						
DS1	9.1	14, 17, 33	Near Ditch	Up Flow	Yes	Yes			20	Ditch Effects
DS2	96.6	14	Fen Interior	Up Flow		Yes		Yes	30	Site Effects

1 Up Flow: side of ditch toward source of groundwater flow. Down Flow: side of ditch away from source of groundwater flow.

2 Data Missing in the upper strata of peat core.

3 Humification (peat degradation) in upper strata of peat core attributed to lower water table from ditch drainage.

Appendix B: NRRI Report on Winter Road Lake Peatland Mitigation Potential and Restoration Options

Restoration of the Winter Road Lake Peatland SNA
Wetland Mitigation Credit Potential

Kurt Johnson, University of Minnesota Duluth, Natural Resources Research Institute

Introduction

Mitigation is required for unavoidable impacts to wetlands due to mining, road construction, housing or other developments. Wetland mitigation can be achieved through the restoration or enhancement of previously disturbed wetlands or the preservation of wetlands under demonstrable threat. Opportunities for wetland mitigation in northern Minnesota are limited due to the fact that this part of the State still retains greater than 80 percent of its pre-settlement wetlands (Figure 1). There is a considerable need in northern Minnesota for wetland mitigation credits due to ongoing and future mining projects, road construction, and residential/commercial development (MN BWSR, 2007). The restoration of Minnesota's expansive northern peatlands that were ditched extensively in the early 1900s has been considered for some time as a source of wetland credits for the greater than 80 percent part of the state. Ditch abandonment and examining the potential for associated wetland mitigation on some ditch segments within the Winter Road Lake Peatland SNA were recommended in the document "Winter Road Lake Peatland Scientific and Natural Area Management Plan" (MN DNR, 2010). The following describes the general requirements and procedures for establishing a wetland bank and the potential opportunities and challenges for using the Winter Road Lake Peatland and other peatland SNAs for wetland mitigation credit.

Establishing a Wetland Bank in Minnesota

When establishing a wetland mitigation bank in Minnesota there are several steps required under the Minnesota Wetland Conservation Act (WCA) administered by the Minnesota Board of Water and Soil Resources (BWSR). A general summary of the steps required can be found on the BWSR website on the Wetland Banking page www.bwsr.state.mn.us/wetlands. The three part process includes the preparation and submittal by the project sponsor of the: 1) Wetland Bank Plan Scoping Form, 2) Wetland Bank Plan Concept Plan Form, and 3) Wetland Bank Plan Full Application Form. Each of these forms can be found on the BWSR website on the Wetland Banking page (they are also attached in the Appendix). The first step in any potential wetland banking scenario is the submittal of the scoping form and supporting documents, which will start the project review process by the WCA Local Government Unit (LGU) and Technical Evaluation Panel (TEP). This review will identify potential issues and problems to assist the sponsor in determining project feasibility and in developing the subsequent concept plan and full application forms.

There are also Federal guidelines and requirements pertaining to wetland bank establishment administered by the U.S. Army Corps of Engineers (USACE). The "St. Paul District Policy for Wetland Compensatory Mitigation in Minnesota" (USACE, 2009) was developed in cooperation with BWSR as a guidance document pertaining to wetland banking regulatory issues such as ratios, crediting, debiting, bank service areas, and banking procedures. A number of other requirements are also detailed in the document, one of these being the development and approval of a "Mitigation Banking Instrument" (MBI) to set forth guidelines for long-term monitoring and management of the site.

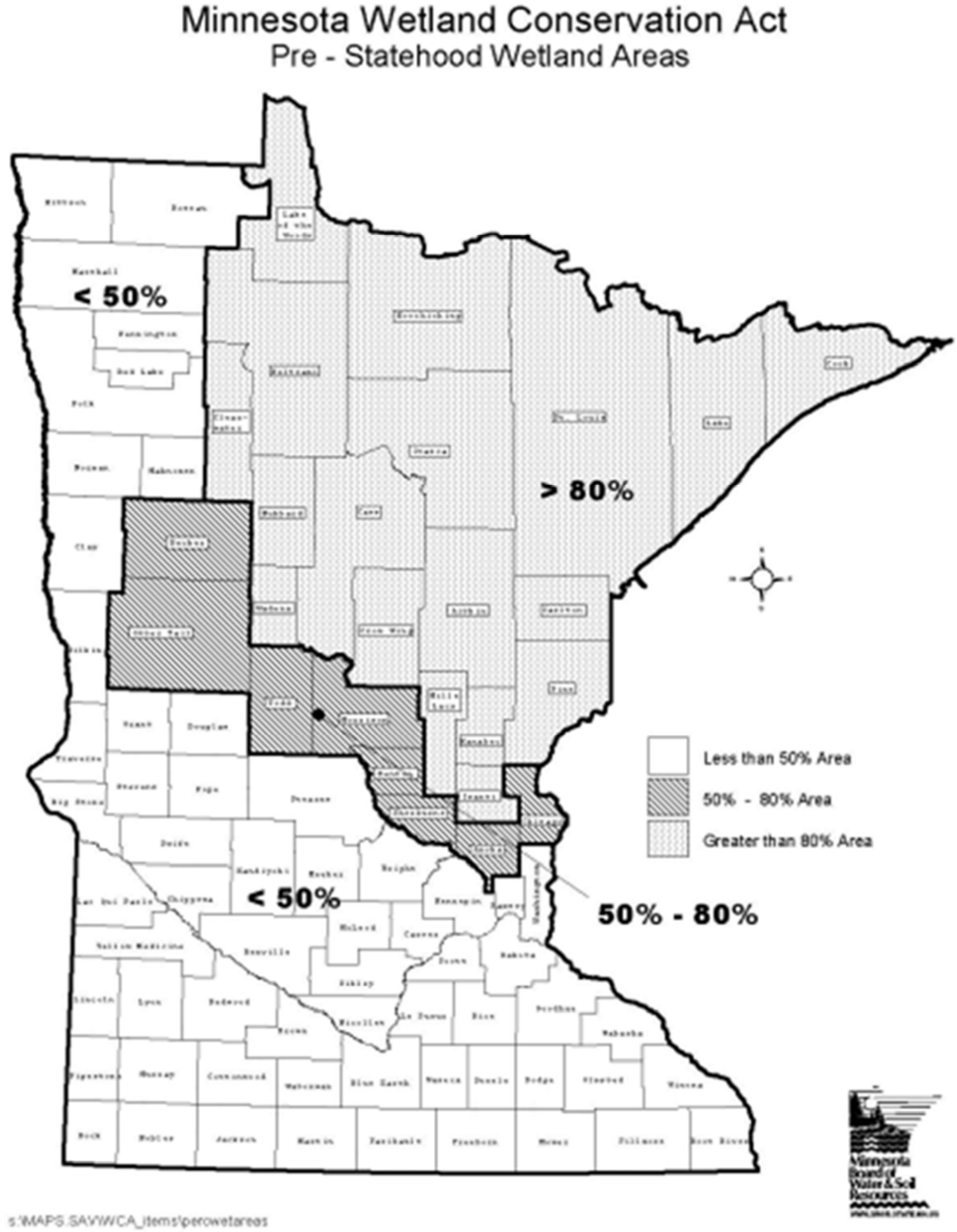

Figure 1: Greater Than 80% Wetland Areas in Northeast Minnesota. Minnesota Board of Water and Soil Resources.

The policy states a preference for the use of wetland banking as opposed to project specific compensation whenever possible. Wetland mitigation credit can be achieved through wetland “restoration” at a ratio of 2:1 to 1:1 (acres restored to credits generated), “enhancement” (3:1), “creation” (2:1 to 1:1), “preservation” (8:1), and “native upland buffer” (4:1). The minimum size for a wetland mitigation bank is 5 credits/acres. Given the 3:1 credit given for enhancement or partial drainage restoration (USACOE, 2009), the minimum size for a wetland bank such as the Winter Road Lake Peatland SNA would be 15 acres.

Potential Wetland Mitigation Credit: Winter Road Lake Peatland SNA Restoration Project
In terms of the techniques and justification for blocking/filling ditches in a peatland and receiving wetland mitigation credit for large-scale restoration activities, the proposed Lake Superior Wetland Bank currently serves as one of the best models in the state. This relatively new initiative to restore ditched peatlands in Minnesota has been proposed for the Sax-Zim Peatland located between Duluth and the Iron Range to the east of County Road 7 and north of County Road 52. The proposed Bank site is approximately 23,223 acres in size, including upland buffer areas. The sponsor, Ecosystem Investment Partners, LLC (EIP) is proposing to get mitigation credit by a combination of restoration and enhancement of peatlands partially drained as part of a County ditch network, and preservation of adjacent relatively pristine peatlands (EIP, 2015). Ecosystem Investment Partners, LLC is a private equity firm that “acquires, entitles, restores, and manages properties across the US that generate wetland, stream, and endangered species mitigation credits”. http://www.ecosystempartners.com/ . They have already established wetland banks in Aitkin and Itasca Counties http://www.minnesotamitigation.com/. This site is similar to the Winter Road Lake Peatland SNA in that they are for the most part partially drained, although the Lake Superior Bank site is more heavily forested, and ditch blocking efforts may result in a “functional lift” of the sites.

EIP has conducted hydrologic studies, LiDAR elevation analysis to determine peat subsidence, and Floristic Quality Assessments of vegetation (MPCA, 2014) to quantify current conditions and to justify how ditch-blocking will restore and enhance the site. Their use of these methods to quantify drainage effects seems reasonable and appears to be accepted by the Army Corps and other regulatory agencies. They claim that the area of subsidence is the most definitive method to determine lateral effects as it is an indication of lowered water table over an extended period of time and propose to use this as their main determination for wetland credits based on restoration or enhancement. According to plans for the Lake Superior Wetland Bank, vegetation restoration would be achieved solely by restoring hydrology to the site that will provide the conditions necessary for native wetland plant communities to establish and thrive. This process is expected to take some time and will not be initially evident, but will occur in the long-term. Active vegetation management in the short-term would be limited to controlling invasive species.

The Lake Superior Wetland Bank project proposes to credit the site based on watershed scale hydrologic restoration to enhance and preserve high quality vegetative communities. Restoration will be achieved by disabling a total of 68.76 miles of ditch by constructing 355 ditch checks, installed along the ditches at intervals coinciding with every one foot drop in elevation. The sponsor will receive a percentage of the total credit for meeting a minimum performance standard for ditches filled. *“The minimum standard for ditch disablement is the construction of ditch checks, and the placement of a minimum of 200 contiguous linear feet upstream, and 100 contiguous feet downstream of natural material to completely fill the channel for the entire width and to the top of the natural bank.”* (EIP, 2015). Meeting this standard will provide 30% minimum ditch fill, and the sponsor will receive 15% of the entire Bank site in wetland credits. Additional credit may be received for additional ditch fill with sponsor receiving 1% wetland credits for each 10% ditch fill, to a maximum of 20% wetland credits.

This somewhat complex approach takes into account the watershed scale hydrologic “restoration” and “enhancement” of the site, and also incorporates the “preservation” of the relatively pristine natural peatlands still occurring within the bank boundaries to maximize credits received. The Winter Road Lake Peatland SNA would most likely qualify for restoration, enhancement, and/or native upland buffer, but preservation credits require that a wetland be under “demonstrable threat” and providing important wetland functions. Since the Winter Road Lake Peatland is already preserved as a Scientific and Natural Area, and is not under “demonstrable threat”, it would not qualify for preservation credits. Without the preservation component available at the Winter Road Lake Peatland SNA, the number of credits would be greatly reduced to include only the lateral effects of the ditches. This would certainly detract from the economic feasibility of a mitigation bank on the site.

The establishment of a wetland bank on a peatland SNA is allowable under current regulations. However, the Minnesota DNR’s policy to date is that if wetland restoration opportunities exist on State lands, the DNR would try to restore these to add to the State’s wetland base, rather than creating a wetland bank to offset wetland impacts elsewhere (Norris, 2015). The conservation community supports this approach by public conservation stewards such as the DNR. Another constraint on the establishment of a wetland bank on an SNA is that under Wetland Conservation Act (WCA) rules, funds designated for conservation purposes cannot be used for wetland mitigation (Powell, 2015).

Recommendations

Although restoration activities may enhance the hydrology and vegetative communities at the Winter Road Lake Peatland SNA, the fact that it is already an SNA means it is already preserved, thus the site’s full potential as a wetland mitigation bank cannot be realized. Conducting restoration on such a large scale in a SNA would require considerably more monitoring and surveying of the site for engineering and construction purposes and is beyond the scope of this current project. Given the uncertainty associated with hydrologic restoration of this scale and the identified potential negative impacts due to construction activities, it is recommended to curtail any restoration work at the Winter Road Lake SNA at the present time. The construction of the Lake Superior Wetland Bank will provide a wealth of information on potential positive and negative effects of ditch blocking/filling to restore wetland hydrology, without the risk of damage to a relatively pristine SNA.

Other impediments to wetland banking on the site include mixed land ownership and the existence of the Norris-Roosevelt Road that may hamper any watershed scale restoration encompassing the entire SNA. The potential surplus of wetland credits resulting from the Lake Superior Wetland Bank project in the near future may also affect the pricing of credits, causing a wetland bank at the Winter Road Lake Peatland SNA to return less on investment and substantially reduce its economic viability.

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Minnesota
Board of Water and Soil Resources
Wetland Banking Forms

Wetland Bank Plan Scoping Document

PROJECT SPONSOR INFORMATION

Sponsor's Full Name					
Complete Mailing Address (Street, RFD, Box No.)			City	State	Zip Code
Phone Number (Home)	Phone Number (Work)	Phone Number (Cell)	E-Mail Address		
Sponsor's Relationship to Property ☐ **Fee Title Owner** ☐ **Contract for Deed Owner** ☐ **Contract or Agreement with Landowner** ☐ **Other:** ______					

PROJECT LOCATION

Project Name (if known)			County	
Est. Easement Size (acres)	Township Name	Section No.	Township No.	Range No.

☐ Check this box to request concurrent review by the U.S. Army Corps of Engineers under the Federal Clean Water Act.

☐ Check this box if credits from this bank are intended for deposit into the Minnesota *Agricultural* Wetland Bank only.

GENERAL INFORMATION

To establish a wetland bank in Minnesota, approval of a wetland bank plan must first be obtained. There is a three-step process for obtaining approval of a wetland bank plan under Minnesota Wetland Conservation Act (WCA) program requirements. The three steps are as follows:

1. Wetland Bank Plan Scoping Document
2. Wetland Bank Plan Concept Document
3. Wetland Bank Plan Full Application

This document is the first step in the process. The submittal of this form and supporting information will initiate a review of the project site by the WCA Local Government Unit (LGU) and/or the Technical Evaluation Panel (TEP).

This review will help the project sponsor identify project opportunities, issues, and potential problems, and will result in findings and recommendations regarding overall suitability of the project site for wetland banking. Early review and input as part of this scoping review allows a potential project sponsor to make an informed decision on the suitability of the site and whether to continue with the application process prior to a substantial investment of time and resources. LGU staff and other TEP members can provide assistance in completing this form and compiling the necessary information.

The project sponsor will receive a copy of the findings and recommendations that result from this this review. These findings and recommendations do not constitute final approval of a wetland replacement project or guarantee success should the project continue with the review process. Only the approval of a full application (step 3) by the LGU constitutes approval of a wetland bank plan for WCA purposes.

LIST OF FIGURES

☐ **Site Locator Map**

☐ **Recent Aerial Photo of Site Showing Property and Planned Project Boundaries**

☐ **County Soil Survey Map** (Include legend and identification of hydric soils)

☐ **Maps/photos of any existing drainage features** (ditches, tile, lift stations, etc.)

☐ **Map of Site Topography** (best available information from LiDAR, USGS maps, or surveys)

☐ **Aerial photos from the past 20 years showing land use and/or cropping history** (when applicable)

☐ **Prior wetland delineations or determinations** (if any have been completed for the project area)

Note: For all mapping products, be sure to show scale and orientation, site boundaries, and other relevant features. Attach additional information as needed.

SCOPING DOCUMENT QUESTIONNAIRE

1. ☐ Yes ☐ No Are there any existing permanent conservation easements within or adjacent to the project area (RIM, WRP, U.S. Fish and Wildlife, Land Trust, etc.)? If yes, please describe.

2. ☐ Yes ☐ No Is some or all of the project area currently enrolled in CRP or another state or federal short term conservation program (EQIP, WHIP, CSP, other)? If yes, please identify the program and briefly describe the activities completed under the program, including contract start and expiration dates. Attach a copy of the contract if available.

3. ☐ Yes ☐ No To the best of your knowledge, are there natural gas, crude oil, refined petroleum pipelines or other utilities located on, or within 200 feet of the project area? If yes, please check all that apply:
   ☐Natural Gas ☐Crude Oil/Refined Petroleum ☐Electric ☐Telephone ☐Fiber Optic ☐ Wind

4. ☐ Yes ☐ No Are there any existing wells within the planned project area? If yes, are they:
   ☐ Active ☐ Inactive – Sealed ☐ Inactive – Not sealed

5. ☐ Yes ☐ No To the best of your knowledge has the project area, or an area within 200 feet of the project area, been used as a storage or disposal area for hazardous substances, pollutants or contaminants, including agricultural chemicals or fertilizer, or been used as a private or public dumpsite? If yes, please explain.

6. **LAND USE INFORMATION**

   a. Briefly describe the current and past land-use history of the project area (e.g. row crops, pasture, forestry/logging, residential, etc.).

b. For agricultural sites with cropping history, approximately how many of the last 20 years has the project area, or portions of the project area, been seeded for crop production? When possible, be specific and identify the corresponding areas on an aerial photo or map.

7. WETLAND INFORMATION

a. Check all applicable boxes below that best describe the activities that have drained or altered wetlands within the project area and identify on attached map or aerial photo.

☐ Private Ditch ☐ Public Ditch ☐ Private Tile ☐ Public Tile ☐ Lift Station
☐ Wetland Filling ☐ Cropping/Tillage ☐ None ☐ Other ______________________________

b. Describe, if known, any private drainage easements or agreements that exist for the property.

c. Describe what activities can be implemented to establish replacement wetland areas on the site (e.g. breaking tile lines, plugging ditches, removing lift stations, converting cropland to wetland, removal of sediment, etc.). Identify locations on attached aerial photo where applicable.

d. Describe any concerns or problems that may exist in implementing any of the above restoration activities.

8. PROJECT GOALS:

Describe any specific project goals you have for the site.

Signature

By signature below I am requesting a technical review of the identified project site by the LGU and/or other members of the TEP. I am familiar with the information contained in this submittal and, to the best of my knowledge and belief, all information is true, complete, and accurate. I understand that the enclosed information does not constitute a complete application for wetland replacement or banking plan approval, but will result in findings and recommendations that can be used in assembling an application should I choose to pursue one. I understand that any resulting findings do not constitute a formal decision nor imply that a complete banking or replacement plan application will be approved by the LGU. If I am not the fee title owner of the project site property, I have obtained permission from the fee title owner to allow access to the site for the LGU and members of the TEP to conduct a review.

______________________________________ ____________________
Signature of Project Sponsor Date

Wetland Bank Plan
Concept Document

PROJECT SPONSOR INFORMATION

Sponsor's Full Name					
Complete Mailing Address (Street, RFD, Box No.)			City	State	Zip Code
Phone Number (Home)	Phone Number (Work)	Phone Number (Cell)	E-Mail Address		
Sponsor's Relationship to Property ☐ **Fee Title Owner** ☐ **Contract for Deed Owner** ☐ **Contract or Agreement with Landowner** ☐ **Other:** ______					

PROJECT LOCATION

Project Name (if known)			County	
Est. Easement Size (acres)	Township Name	Section No.	Township No.	Range No.

☐ Check this box to request concurrent review by the U.S. Army Corps of Engineers under the Federal Clean Water Act.

☐ Check this box if credits from this bank are intended for deposit into the Minnesota *Agricultural* Wetland Bank only.

GENERAL INFORMATION

To establish a wetland bank in Minnesota, approval of a wetland bank plan must first be obtained. There is a three-step process for obtaining approval of a wetland bank plan under Minnesota Wetland Conservation Act (WCA) program requirements. The three steps are as follows:

4. Wetland Bank Plan Scoping Document
5. Wetland Bank Plan Concept Document
6. Wetland Bank Plan Full Application

This document is Step 2 in the process. Applicants should first submit a Wetland Bank Plan Scoping Document and receive an evaluation of their potential project from the WCA Local Government Unit (LGU) and/or the Technical Evaluation Panel (TEP) before completing and submitting this document. The submittal of this form and supporting information will initiate Step 2 of the bank plan review process.

Review of this document will help identify any potential issues with the project design, proposed easement, credit amount, credit criteria, credit release schedule, and any other issues prior to investing the time and expense necessary to complete a final plan and full application.

The project sponsor will receive a copy of the findings and recommendations that result from this concept plan review. These findings and recommendations do not constitute final approval of a wetland replacement project or guarantee success should the project continue with the review process. Only the approval of a full application by the LGU constitutes approval of a wetland bank plan for WCA purposes.

LIST OF FIGURES

List and label all figures and appendices in the order in which they are referenced in this submission form.

The following figures are <u>required</u> (reference them in applicable sections of the narrative):

- ✓ Site Location Map
- ✓ Land Use Map of Project Site and Surrounding Properties
- ✓ Existing Conditions Topographic Map (include topography of adjacent lands if they contribute to or could be affected by the project) – map should at minimum include contours (preferably 1-foot referenced to msl datum), property lines, culverts, bridges, roads, structures, subsurface drainage features, power lines and other utilities, property ownership, benchmarks, north arrow, scale, and proposed easement boundary. In most instances LiDAR data can be used at this stage.
- ✓ Web Soil Survey Map (or other soil information if Web Soil Survey not available for the area)
- ✓ Minor Watershed (DNR 5-digit HUC) Map (show location of site within minor watershed)
- ✓ Existing Wetlands Map (approved delineation or estimate based on best available data)
- ✓ Existing Conditions Vegetation Map (current dominant vegetative cover of site and surrounding area)
- ✓ Map of Proposed Easement Boundaries (preferably overlaid on topo map and/or aerial photo)
- ✓ Credit Area Map (see item # 6)
- ✓ Proposed Vegetation Conditions Map (based on vegetation establishment plan)
- ✓ Concept Plan Map showing anticipated construction features (berms, control structures, inlets, etc.)
- ✓ Monitoring Plan Map showing proposed monitoring locations

The following figures are <u>recommended</u>, if applicable:

- ✓ Historical Air Photo(s) (representative of pre-altered conditions)
- ✓ Site Photographs
- ✓ Photographs of Reference Wetland(s) (reflective of post-plan conditions)

SECTIONS

Do not leave any of the following sections or subsections blank. If a section does not apply to your project, then enter "not applicable" for that section and explain why.

1. Regulatory Review Status and Application History

Identify and discuss the extent of review and comments received on this pending wetland banking project to date. Reference and include review letters and findings related to previous scrutiny of the proposed project by local, state, and federal review entities.

2. Project Sponsor - Landowner

Identify who will be the official project proposer that is ultimately responsible for completing the project and owning the result wetland credits. Discuss any agreements between the sponsor and landowner (if different) or other legal circumstances related to project ownership.

3. Proposed Bank Easement Description

Discuss the proposed easement boundary (a required figure) in terms of its location (e.g. coincides with property line, follows road or ditch right-of-way boundary, etc.) and the reasons for including or excluding certain areas (e.g. excludes field road to allow access to adjacent property, etc.).

4. Existing Conditions

Provide a description of existing physical conditions of the bank site and surrounding area including current land use, vegetation, roads, structures, wells, utility lines, hydrology, etc. For hydrology describe water flow sources and flow directions and identify tiles, ditches and any other drainage components on or near the site. Also include a discussion of existing wetlands on the site including reference to any wetland delineations or determinations previously conducted and approved. Include and reference figures to supplement the narrative.

5. Historical Conditions

Provide an assessment of historical site conditions from pre-settlement to current condition. Utilize historical air photos, soils information, and other available information sources to estimate historical conditions based on available evidence. Discuss the extent of restoration proposed and describe any constraints that prevent full restoration (such as access to other lands, need to maintain drainage from other properties, etc.). If the project is a wetland creation, discuss historic watershed conditions, changes over time, and how the project will replace or enhance important wetland functions. Attach and reference supporting documents as necessary.

6. Project Goals, Expected Outcomes and Crediting

Identify overall project goals and discuss the anticipated project outcomes in terms of hydrology, vegetation, and wetland functions. Identify credit areas on a Credit Area Map and complete the following Wetland Bank Credit Allocation and Proposed Credit Release Tables. Discuss the rationale for the credit release and any possible modifications to credit releases related to project conditions (such as reduced crediting for partial outcome conditions).

Wetland Bank Credit Allocation Table [1]

Map ID	Credit Action [2]	Acres [3]	Credit Allocation			
			Minimum Credit [4]		Maximum Credit [5]	
			% Credit	Credit Amount	% Credit	Credit Amount
	TOTAL EASEMENT SIZE:	0.00	**TOTAL:**	0.00	**TOTAL:**	0.00

[1]A **Wetland Credit Allocation Map** of the project site must accompany this form. The map should:

- Provide a clear depiction/outline of the planned/actual easement boundary
- Show all separate "credit action areas" within the easement boundary using the associated map identifiers (Map ID) from above table.

[2]As identified by MN Statutes Chapter 8420.056.

- **Subp. 2** *Upland Buffer Areas*
- **Subp. 3** *Restoration of Completely Drained or Filled Wetland Areas*
- **Subp. 4** *Restoration of Partially Drained or Filled Wetland Areas*
- **Subp. 5** *Vegetative Restoration of Farmed Wetlands*
- **Subp. 6** *Protection of Wetlands Previously Restored via Conservation Easements*
- **Subp. 7** *Wetland Creations*
- **Subp. 8** *Restoration and Protection of Exceptional Natural Resource Value*
- **Subp. 9** *Preservation of Wetlands Owned by the State or a Local Unit of Government*
- **No Credit** Portions of planned easement area not subject to credit

[3]Acres of land within the planned bank easement that corresponds to the identified credit action. The sum total of these acres must equal the acres of land within the planned or actual easement area.

[4]Enter the lowest credit value expected from the action. Values entered must be consistent with allowable credit yield as defined by associated credit action.

[5]Enter the highest credit value expected from the action. This will be the same as the minimum credit unless a range of credit is proposed based on different possible outcomes (for example: 50% credit for moderate quality, 100% credit for high quality).

Proposed Credit Release Table

% of Anticipated Credits Released	Basis for Credit Release (include basis for both wetland and upland areas)

7. Ecological Suitability and Sustainability

Specifically address the compatibility of the project with surrounding land uses, habitat types, and ecological communities. Discuss the long-term sustainability of the project in terms of hydrology and vegetation. Specifically address the ability of the project to continue to provide important wetland functions in the context of reasonably foreseeable land use and landscape changes.

8. Vegetation Plan

Identify and discuss anticipated actions to restore vegetation including (but not limited to) seeding, planting, invasive species control, and anticipated maintenance/management activities.

9. Construction Plan

Discuss the general design approach proposed to achieve the planned restoration goals for hydrology such as disable drainage system, divert water, impound water, etc. Describe and identify the location of anticipated construction features of the project (berms, tile breaks, scrapes, control structures, etc.) and their purpose. Discuss soils, topography, and hydrology as it relates to the conceptual construction plan. Identify and discuss any anticipated investigations that will be needed prior to development of a final construction plan (soil borings, etc.).

10. Supplemental Information

If the project involves protection of wetlands previously restored via conservation, restoration and protection of exceptional natural resource value, or preservation credit actions (WCA rule subparts 6, 8, and 9 respectively), provide a narrative discussion of how the project meets the requirements of actions. Discuss and reference applicable guidance documents and support materials. If necessary, discuss any other information that is relevant to the plan and not discussed in the other sections of the document.

11. Monitoring Plan

Describe a plan to annually monitor vegetation and hydrology as it relates to the identified credit release criteria. The plan should include anticipated transects and sampling point locations, and a description of the methodology to estimate important measures such as vegetation areal coverage, species diversity, and water table elevations. Plans should identify the proposed frequency and timing of annual monitoring efforts.

12. Special Considerations

WCA rules (8420.0515) identify nine factors that must be considered when submitting a wetland replacement/banking plan. Identify and discuss any and all of these factors that are applicable or potentially applicable to the project and site.

Signature

By signing this form I am authorizing the review of my concept plan as part of the wetland bank application process. I am familiar with the information contained in this submittal and, to the best of my knowledge and belief, all information is true, complete, and accurate. I understand that submission of this form and associated information does not constitute a complete application for Wetland Conservation Act purposes, but will result in review and feedback from the local Technical Evaluation Panel, BWSR and other wetland bank interagency review team members evaluating the project for inclusion in the regulatory wetland banking program. I understand that a favorable review does not constitute a formal decision nor does it guarantee that the final plan will be approved by the Wetland Conservation Act Local Government Unit or the U.S. Army Corps of Engineers. If I am not the fee title owner of property involved in the bank plan proposal, I have obtained permission from the fee title owner to allow BWSR and other members of the Technical Evaluation Panel reasonable access to the property prior to easement conveyance for purposes of the review.

Signature of Project Sponsor | Date

Wetland Bank Plan
Full Application

PROJECT SPONSOR INFORMATION

Sponsor's Full Name					
Complete Mailing Address (Street, RFD, Box No.)		City		State	Zip Code
Phone Number (Home)	Phone Number (Work)	Phone Number (Cell)	E-Mail Address		
Sponsor's Relationship to Property ☐ **Fee Title Owner** ☐ **Contract for Deed Owner** ☐ **Contract or Agreement with Landowner** ☐ **Other:** ______					

PROJECT LOCATION

Project Name (if known)			County	
Est. Easement Size (acres)	Township Name	Section No.	Township No.	Range No.

☐ Check this box to request concurrent review by the U.S. Army Corps of Engineers under the Federal Clean Water Act.

☐ Check this box if credits from this bank are intended for deposit into the Minnesota *Agricultural* Wetland Bank only.

GENERAL INFORMATION

To establish a wetland bank in Minnesota, approval of a wetland bank plan must first be obtained. There is a three-step process for obtaining approval of a wetland bank plan under Minnesota Wetland Conservation Act (WCA) program requirements. The three steps are as follows:

7. Wetland Bank Plan Scoping Document
8. Wetland Bank Plan Concept Document
9. Wetland Bank Plan Full Application

This document is Step 3 in the process. Applicants should first complete Steps 1 and 2. Applicants should receive an evaluation of their potential project from the WCA Local Government Unit (LGU) and/or the Technical Evaluation Panel (TEP) for Steps 1 and 2 before completing and submitting this document. Submittal of this document to the LGU will initiate the formal wetland bank plan review and approval process under WCA rules. Only the approval of a full application by the LGU constitutes approval of a wetland bank plan for WCA purposes.

If the full bank plan application is approved by the LGU, the following will be required before a wetland bank account with available wetland credits can be established:

- Legal boundary survey of easement
- Commitment to Insure and Policy of Title Insurance naming State of Minnesota as insured (BWSR-approved)
- Recorded Wetland Bank Conservation Easement (BWSR-approved)
- Initial project implementation per the approved bank plan
- Construction certification by the LGU (if applicable)
- Request to Deposit Wetland Credits approved by the LGU

LIST OF FIGURES

List and label all figures and appendices in the order in which they are referenced in this submission form.

The following figures are required (reference them in applicable sections of the narrative):

- ✓ Site Location Map
- ✓ Land Use Map of Project Site and Surrounding Properties
- ✓ Existing Conditions Topographic Map (include topography of adjacent lands if they contribute to or could be affected by the project) – map should at minimum include contours (1-foot referenced to msl datum), property lines, culverts, bridges, roads, structures, subsurface drainage features, power lines and other utilities, property ownership, existing easements, benchmarks, north arrow, scale, and proposed easement boundary.
- ✓ Web Soil Survey Map (or other soil information if Web Soil Survey not available for the area)
- ✓ Minor Watershed (DNR 5-digit HUC) Map (show location of site within minor watershed)
- ✓ Existing Wetlands Map (approved delineation or estimate based on best available data)
- ✓ Existing Conditions Vegetation Map (current dominant vegetative cover of site and surrounding area)
- ✓ Map of Proposed Easement Boundaries (preferably overlaid on topo map and/or aerial photo)
- ✓ Credit Area Map (see item # 6)
- ✓ Proposed Vegetation Conditions Map (based on vegetation establishment plan)
- ✓ Seeding/Planting Zone Map – map clearly showing labeled zones where various planting/seeding will be conducted. Use air photo or topographic map as a base.
- ✓ Construction Plan and Specifications – plans need to be drawn to scale and must include:
    - o Detailed layout and plan dimensions of all proposed construction elements
    - o Topography of any adjacent lands that could be affected by the project
    - o Profile and detail drawing(s) of all proposed construction elements (dikes, channels, water control structures, etc.) including dimensions, elevations, and grades as applicable.
    - o Construction notes on plans (as needed) to ensure accurate interpretation of drawings and to supplement construction specifications.
- ✓ Construction materials and methods specifications
- ✓ Monitoring Plan Map showing proposed monitoring locations

The following figures are recommended, if applicable:

- ✓ Historical Air Photo(s) (representative of pre-altered conditions)
- ✓ Site Photographs
- ✓ Photographs of Reference Wetland(s) (reflective of post-plan conditions)

SECTIONS

Do not leave any of the following sections or subsections blank. If a section does not apply to your project, then enter "not applicable" for that section and explain why.

13. Regulatory Review Status and Application History

Identify and discuss the extent of review and comments received on this pending wetland banking project to date. Reference and include review letters and findings related to previous scrutiny of the proposed project by local, state, and federal review entities.

14. Project Sponsor - Landowner

Identify who will be the official project proposer that is ultimately responsible for completing the project and owning the result wetland credits. Discuss any agreements between the sponsor and landowner (if different) or other legal circumstances related to project ownership.

15. Proposed Bank Easement Description

Discuss the proposed easement boundary (a required figure) in terms of its location (e.g. coincides with property line, follows road or ditch right-of-way boundary, etc.) and the reasons for including or excluding certain areas (e.g. excludes field road to allow access to adjacent property, etc.).

16. Existing Conditions

Provide a description of existing physical conditions of the bank site and surrounding area including current land use, vegetation, roads, structures, wells, utility lines, hydrology, etc. For hydrology describe water flow sources and flow directions and identify tiles, ditches and any other drainage components on or near the site. Also include a discussion of existing wetlands on the site including reference to any wetland delineations or determinations previously conducted and approved. Include and reference figures to supplement the narrative.

17. Historical Conditions

Provide an assessment of historical site conditions from pre-settlement to current condition. Utilize historical air photos, soils information, and other available information sources to estimate historical conditions based on available evidence. Discuss the extent of restoration proposed and describe any constraints that prevent full restoration (such as access to other lands, need to maintain drainage from other properties, etc.). If the project is a wetland creation, discuss historic watershed conditions, changes over time, and how the project will replace or enhance important wetland functions. Attach and reference supporting documents as necessary.

18. Project Goals, Expected Outcomes and Crediting

Identify overall project goals and discuss the anticipated project outcomes in terms of hydrology, vegetation, and wetland functions. Identify credit areas on a Credit Area Map and complete the following Wetland Bank Credit Allocation and Proposed Credit Release Tables. Discuss the rationale for *the credit release and any possible modifications to credit releases related to project conditions (such as reduced crediting for partial outcome conditions).*

Wetland Bank Credit Allocation Table [1]

Map ID	Credit Action [2]	Acres [3]	Credit Allocation			
			Minimum Credit [4]		Maximum Credit [5]	
			% Credit	Credit Amount	% Credit	Credit Amount
	TOTAL EASEMENT SIZE:	0.00	**TOTAL:**	0.00	**TOTAL:**	0.00

[1]A **Wetland Credit Allocation Map** of the project site must accompany this form. The map should:

- Provide a clear depiction/outline of the planned/actual easement boundary
- Show all separate "credit action areas" within the easement boundary using the associated map identifiers (Map ID) from above table.

[2]As identified by MN Statutes Chapter 8420.056.

- **Subp. 2** *Upland Buffer Areas*
- **Subp. 3** *Restoration of Completely Drained or Filled Wetland Areas*
- **Subp. 4** *Restoration of Partially Drained or Filled Wetland Areas*
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- **Subp. 9** *Preservation of Wetlands Owned by the State or a Local Unit of Government*
- **No Credit** Portions of planned easement area not subject to credit

[3]Acres of land within the planned bank easement that corresponds to the identified credit action. The sum total of these acres must equal the acres of land within the planned or actual easement area.

[4]Enter the lowest credit value expected from the action. Values entered must be consistent with allowable credit yield as defined by associated credit action.

[5]Enter the highest credit value expected from the action. This will be the same as the minimum credit unless a range of credit is proposed based on different possible outcomes (for example: 50% credit for moderate quality, 100% credit for high quality).

Proposed Credit Release Table

% of Anticipated Credits Released	Basis for Credit Release (include basis for both wetland and upland areas)

19. Ecological Suitability and Sustainability

Specifically address the compatibility of the project with surrounding land uses, habitat types, and ecological communities. Discuss the long-term sustainability of the project in terms of hydrology and vegetation. Specifically address the ability of the project to continue to provide important wetland functions in the context of reasonably foreseeable land use and landscape changes.

20. Vegetation Plan

Identify and discuss planned actions to restore vegetation including (but not limited to) seeding, planting, invasive species control, and anticipated maintenance/management activities. Include a seeding/planting zone map (a required figure) and correspondingly identify seed mixes, planting materials, planting rates, and installation methods (hand planted, native seed drill, etc.). Include a schedule of anticipated maintenance and aftercare activities for the initial 5 years of the project and beyond as applicable. Identify and discuss any potential issues (invasive species, sedimentation, drown-out, etc.) and potential corrective actions. Attach and reference supporting documents as necessary.

21. Construction Plan

Address the following subparts and attach and reference supporting documents as necessary:

9.1 Design Approach

Discuss the general design approach proposed to achieve the planned restoration goals for hydrology such as disable drainage system, divert water, impound water, etc. Provide a detailed description of the proposed construction work to be performed for each wetland area to be restored or created.

9.2 Site Capability

Discuss the capability of the site to produce and maintain wetland characteristics related to drainage area, wetland area, soils, and topography.

9.3 Site Investigations

Discuss and provide information about the locations, methods, and results of any subsurface investigations and analysis performed for the project site.

9.4 Hydrologic and Hydraulic Analysis

Discuss the hydrologic and hydraulic analyses conducted to define existing site conditions and to design the proposed wetland bank project. Report the following related to hydrology/hydraulics report:

- *Method of analysis, values used for pertinent variable and computed peak flows and water surface elevations for the 2-year, 10-year, 25-year, and 100-year, 24-hour events and associated wetland storage volumes.*
- *Hydraulic design of existing and proposed water control structures.*
- *Discussion of both upstream and downstream impacts.*

22. Supplemental Information

If the project involves protection of wetlands previously restored via conservation, restoration and protection of exceptional natural resource value, or preservation credit actions (WCA rule subparts 6, 8, and 9 respectively), provide a narrative discussion of how the project meets the requirements of actions. Discuss and reference applicable guidance documents and support materials. If necessary, discuss any other information that is relevant to the plan and not discussed in the other sections of the document.

23. Monitoring Plan

Describe a plan to annually monitor vegetation and hydrology as it relates to the identified credit release criteria. The plan should include anticipated transects and sampling point locations, and a description of the methodology to estimate important measures such as vegetation areal coverage, species diversity, and water table elevations. Plans should identify the proposed frequency and timing of annual monitoring efforts.

24. Special Considerations

WCA rules (8420.0515) identify nine factors that must be considered when submitting a wetland replacement/banking plan. Identify and discuss any and all of these factors that are applicable or potentially applicable to the project and site.

Signature

By signing this form I am authorizing the review of my wetland bank plan application by all applicable wetland regulatory review units of government. I am familiar with the information contained in this submittal and, to the best of my knowledge and belief, all information is true, complete, and accurate. I attest to the following:

- No areas proposed to receive wetland bank credit were previously restored or created under a prior approved WCA wetland replacement or banking plan.
- No areas proposed to receive wetland bank credit were impacted under a WCA exemption during the previous 10 years.
- No areas proposed to receive wetland bank credit will be restored, created, or preserved with financial assistance from public conservation programs or for other unrelated regulatory purposes.
- All individuals and entities providing funding for this project are aware that this project will provide credits to offset regulatory wetland impacts.
- The project will be monitored in accordance with the approved monitoring plan.

If I am not the fee title owner of property involved in the bank plan proposal, I have obtained permission from the fee title owner to allow wetland regulatory government entities reasonable access to the property prior to easement conveyance for purposes of the review.

Signature of Project Sponsor	Date

Restoration Options and Recommendations for the Winter Road Lake Peatland SNA

Kurt Johnson, University of Minnesota Duluth, Natural Resources Research Institute

Introduction

Review and analysis of data collected at the Winter Road Lake Peatland Scientific and Natural Area (SNA) as part of this project has shown a significant effect of ditching on the hydrology, soils, and vegetation quality of the site. In general, the water table is lower, the peat is more decomposed and has subsided, and the vegetation quality is lower in close proximity to the ditches as compared to more pristine, undisturbed areas not impacted by ditching. Effects vary by location within the site, with some areas having greater potential for enhancement and improvement in wetland functions resulting from restoration efforts. Large-scale peatland restoration has been conducted or is proposed on several other sites in northern Minnesota. These projects provide some of the best information available regarding restoration methods on sites with similar climate and conditions. The following report details restoration efforts previously conducted or proposed for other similar degraded peatland sites in the state, and opportunities and challenges for restoring the Winter Road Lake Peatland SNA.

Large-Scale Peatland Restoration in Minnesota

Several peatland restoration projects similar to that being considered for the Winter Road Lake Peatland SNA have been completed or proposed in northern Minnesota, providing relevant information and methods helpful for determining the potential for successful restoration of this and other peatland SNAs. Several projects were identified and evaluated where large-scale ditch blocking was conducted to restore hydrology. These projects include the “Brown’s Lake Peatland Restoration Project” and the “Bernard Wetland Bank”, both located in Lake of the Woods County. The “Lake Superior Wetland Bank” is another large-scale peatland restoration project that has been proposed for the Sax-Zim Bog in St. Louis County. Pertinent research on the effects of ditching was also found in the report “Hydrological Effect of Ditches and Berms at Beaches Lake Wildlife Management Area, Minnesota” (Gerla, et al. 2009). Other peatland restoration projects, such as the University of Minnesota’s “Fens Wetland Bank” located in the vicinity of the Sax-Zim Bog in St. Louis County and those required by permit for horticultural peat mining operations, do exist in the state, but are quite different in that ditch spacing is very close (every 100-150 feet) and a considerable thickness (2-6 feet) of peat has been removed. Therefore, restoration methods used at these sites are not directly applicable to the Winter Road Lake Peatland SNA. Summaries and evaluations for each of the pertinent projects are presented in the following sections.

<u>Brown’s Lake Peatland Restoration Project</u>

The Brown’s Lake Peatland Restoration Project was established in late 1998 – early 1999 by the Minnesota DNR at a site just south of the Winter Road Lake Peatland SNA. The project was established to restore pre-ditching water flow and levels to the Brown’s Lake Bog and reduce water going into a state forest road ditch system. An additional goal of the project was convert forested peatland back to its original open peatland condition and to restore habitat for sharptailed grouse and sandhill cranes. The restoration was conducted by installing several clay ditch blocks and filling the ditch with the remaining berm/spoil bank where possible using a backhoe and a D-8 bulldozer (see Figures 1 & 2). Though no final report was written on the project, there exists considerable information on its design, approval, and construction. MNDNR area personnel, Gretchen Mehmel and Charlie Tucker, provided me with documents regarding the site.

In reviewing the documents a number of important issues stand out:

- The Lake of the Woods County Board had to officially “abandon” the ditch (Judicial Ditch 62) before construction could proceed.
- The pre-ditching water flow was from south to north. The east-west Judicial Ditch 62 intercepted the flow and conveyed the water west. The berm/spoil bank on the north side of the ditch acted as a dike and prevented water from flowing north through the bog and into Brown’s Lake.
- The ditch blocks were constructed of a “clay core” of approximately 60 cubic yards surrounded by cover material from the berm/spoil bank.
- Clay was acquired from a site approximately 15 miles north of the construction site.
- Construction was conducted during early winter (December 1998-January 1999).

- Because of the water flow direction and the ditch berm/spoil bank acting as a dike, "breaching" the berm/spoil bank allowed water to flow north. According to Gretchen Mehmel, she believes this did as much if not more to restore original water flow as did the ditch blocks.
- Cattails are found in the vicinity of the ditch blocks, although they are scarce to nonexistent throughout the more pristine areas away from ditch influences. This condition is presumably because of the increased nutrient content in the clay and seed potentially brought in on construction equipment.
- The project was considered a success as the forested areas of the bog have died back and "opened up" providing the desired wildlife habitat.
- No wetland mitigation credit was pursued or received for the project.

Bernard Wetland Bank Project

Written and verbal information regarding the "Bernard Wetland Bank" located in Lake of the Woods County was received from Nathan Kestner (MNDNR) who did considerable work on the wetland mitigation bank. The bank site consists of approximately 634.18 acres of existing wetlands that will be preserved in perpetuity. The objective was to "preserve the functions" of 629.94 acres of Hardwood Swamp, Coniferous Swamp, Shrub Carr-Alder Thicket, Fresh Wet Meadow and Open Bog wetlands. In addition, the bank would also "enhance the functions" of 4.24 acres of Open Bog and Hardwood Swamp wetlands. Hydrology was restored to the site with a single clay ditch plug that was installed along a county road. This wetland bank is based primarily on "preservation" more so than "restoration". Lake of the Woods County was the lead agency for this wetland bank that was approved in 2011.

Lake Superior Wetland Bank Project

A relatively new initiative to restore ditched peatlands in Minnesota has been proposed for the Sax-Zim Peatland located between Duluth and the Iron Range to the east of County Road 7 and north of County Road 52. The proposed "Lake Superior Wetland Bank" site is approximately 23,223 acres in size, including upland buffer areas. The sponsor, Ecosystem Investment Partners, LLC (EIP) is proposing to get mitigation credit by a combination of restoration and enhancement of wetlands partially drained as part of a County ditch network and preservation of adjacent pristine wetlands (EIP, 2015). Ecosystem Investment Partners, LLC is a private equity firm that "acquires, entitles, restores, and manages properties across the US that generate wetland, stream, and endangered species mitigation credits". http://www.ecosystempartners.com/ . They have already established wetland banks in Aitkin and Itasca Counties http://www.minnesotamitigation.com/ and have numerous sites throughout the U.S.

Figure 2: Clay core ditch block at the Brown’s Lake Peatland Restoration site. May 2014.

Figure 3: Ditch filled with remaining berm/spoil bank material at the Brown’s Lake Peatland Restoration site. May 2014.

Although most of this area would still be classified as wetland due to lack of ditch maintenance and the limited lateral effect of the ditches, the project has received broad support from government agencies and environmental groups. This support is most likely due to the fact that it will preserve and enhance the Sax-Zim Bog, a very popular and internationally recognized birding area. The sponsor has conducted hydrologic studies, LiDAR elevation analysis to determine peat subsidence, and Floristic Quality Assessments of vegetation to quantify current conditions and to justify how ditch-blocking will restore and enhance the site. Their use of these methods to quantify drainage effects seems reasonable and appears to be accepted by the Army Corps and other regulatory agencies. This site is similar to the Winter Road Lake Peatland SNA in that they are for the most part partially drained, although the Lake Superior Bank site is more heavily forested, and ditch-blocking efforts may result in a "functional lift" of the sites. The sponsor proposes a number of methods to block ditches and breach berm/spoil banks to restore hydrology including:

- Install ditch blocks, using imported clay, rock checks, berm/spoil bank material, and vinyl sheet piling http://cmisheetpiling.com/.
- Install culverts to breach berm/spoil banks.
- Block ditches during the winter or with the use of specialized low ground pressure equipment or helicopters to facilitate access.

The use of berm/spoil bank materials present on-site for ditch blocking will be limited at best because most of the organic berm/spoil bank has subsided leaving little left to work with now. EIP proposes to supplement the berm/spoil bank material with trees and their attached root balls, and by extracting peat from small "borrow pits" to be located near the ditches. Note that the use of vinyl sheet piling for creating ditch blocks still requires peat or clay material on both sides to shore it up. An example of the use of sheet piling to block a small ditch on a restored bog in Ireland is shown in Figure 3.

More information on the Lake Superior Wetland Bank and how EIP justifies receiving wetland mitigation credit for their activities is presented in an associated report titled "Restoration of the Winter Road Lake Peatland SNA - Wetland Mitigation Credit Potential".

Figure 4: Small ditch blocked using vinyl sheet piling on a restored bog in Ireland. June 2015.

Beaches Lake Wildlife Management Area Study

The "Hydrological Effect of Ditches and Berms at Beaches Lake Wildlife Management Area, Minnesota" (Gerla, et al. 2009) project was conducted in Kittson County, Minnesota to evaluate the effect of recent maintenance (widening and deepening) of Lateral Ditch 12. Results and recommendations of the report include:

- The hydrologic model results suggest that the ditches lateral effects extend to a maximum of 350 feet.

- Compacted ditch berms can be up to 50 times less permeable than loose undisturbed peat interrupting the natural flow of water through a wetland.
- Evapotranspiration from vascular plants (willows, etc.) are a major cause of water loss. They should be removed and managed so they will not regrow to improve hydrologic conditions.
- Clay ditch plugs are not recommended. They will not completely stop drainage and importing clay from off-site has the potential to introduce weed species.
- Restoration recommendations include filling ditches for their entire length, leveling, seeding native species and managing the site to control invasive species.

Ditching Impacts on the Winter Road Lake Peatland SNA
Results of the project hydrologic, vegetation, and peat monitoring have shown a significant effect of ditching on the Winter Road Lake Peatland SNA. In general, water levels are reduced, plant quality is lower, and peat has subsided in close proximity to the ditches as opposed to more pristine areas further away and removed from the effects of the ditches. These effects vary in extent and intensity throughout the site.

Hydrologic monitoring was conducted at several sites throughout the peatland at varying distances from the ditch and is detailed in the comprehensive final report for this project. Monitoring revealed that hydrologic effects vary on either side of the ditch depending on the drainage orientation in relation to the natural flow of water through the peatland, and on which side of the ditch the berm/spoil bank was placed. According to hydrologic data collected for this project, the effect of ditches running perpendicular to groundwater flow is more pronounced than that resulting from ditches running parallel to groundwater flow. The ditch located at Site A runs perpendicular to groundwater flow and modifications to this ditch would likely provide the best opportunity for significant hydrologic improvement. Site A also demonstrates the effect of the berm/spoil bank on site hydrology. The natural water flow is from west to east at this location. The berm/spoil bank is situated on the west (upstream) side of the ditch making this side wetter than the east (downstream) side of the ditch. Hydrologic monitoring also indicated a more pronounced effect of ditches at all sites during the dry summer periods as opposed to the wet spring season.

Changes in hydrology have also influenced the vegetation composition within the lateral effect of the ditches. Vegetation surveys were conducted at varying distances from the ditch and are detailed in the comprehensive final project report. In general, it was found that vegetation near the ditches is generally of lower quality and higher diversity, whereas vegetation in less disturbed areas further away from the ditches is of higher quality and less diverse. The vegetation nearest the ditch/berms is generally woody, taller and more dense. This situation is apparent in the significant shrub growth on the berm/spoil bank at Site A. Evapotranspiration from shrubs such as willows, etc. can be a major cause of water loss (Gerla et al., 2009). Removing and managing this vegetation to prevent regrowth may improve hydrologic conditions for other fen species. The ditches are also reducing the characteristic fen biodiversity, favoring more common species near the ditch that are out-competing the fen species. The Floristic Quality Assessment is a means to quantify the quality and composition of wetland vegetation as it relates to its natural pre-settlement condition (MPCA, 2014). The FQA analysis incorporates a “Biological Condition Gradient” that allows for ranking wetland site conditions into four “condition categories” based on the extent of anthropogenic impacts to the site. These condition categories are described as follows in the Rapid Floristic Quality Assessment Manual (MPCA, 2014).

> *Excellent*
> Community composition and structure as they exist (or likely existed) in the absence of measurable effects of anthropogenic stressors representing pre-European settlement conditions. Non-native taxa may be present at very low abundance and not causing displacement of native taxa.
>
> *Good*
> Community structure similar to natural community. Some additional taxa present and/or there are minor changes in the abundance distribution from the expected natural range. Extent of expected native composition for the community type remains largely intact.
>
> *Fair*
> Moderate changes in community structure. Sensitive taxa are replaced as the abundance distribution shifts towards more tolerant taxa. Extent of expected native composition for the community type diminished.

Poor
Large to extreme changes in community structure resulting from large abundance distribution shifts towards more tolerant taxa. Extent of expected native composition for the community type reduced to isolated pockets and/or wholesale changes in composition.

The FQA conducted at Site A shows a significant effect of the ditch on vegetation characteristics. According to the FQA for Site A, vegetation nearest the ditch/berm has a biological condition category rating of “good” to “fair” quality, while “exceptional” quality vegetation is found further from the ditch. Similar results were found at other sites within the peatland. Based on the condition category descriptions for “exceptional” and “good” wetland sites, it is reasonable to assume that only areas where vegetation quality has been reduced to condition categories “fair” and “poor” would benefit substantially enough to warrant the time, expense, and risk associated with restoration efforts such as ditch blocking. There are currently few non-native invasive plant species on the site with the exception of Phragmites. The goal is to keep other potential invasive species such as purple loosestrife and reed canary grass from establishing (MN DNR, 2010). Invasive narrow leaf cattail can also be a potential problem. The majority of the Winter Road Lake Peatland SNA has been classified as a Rich Fen (MN DNR, 2010). As such, it has a higher nutrient content than other peatland types in Minnesota, such as bogs or poor fens, making it more susceptible to encroachment by invasive species. The disturbance caused by ditch blocking and other restoration procedures may introduce non-native and invasive species and create conditions favorable to their establishment.

Hydrologic changes in close proximity to the ditches can also have an effect on the peat substrate. Analysis of peat cores from the site show that peat degradation is occurring nearer the ditch as evidenced by higher von Post values than found in undisturbed, pristine areas of the peatland. The von Post system rates peat humification on a scale of H1 to H10, with peat having a von Post value of H1 being undecomposed, with its plant remains intact and unaltered, ranging to peat with a von Post value of H10 being completely decomposed with no intact or identifiable plant remains (von Post, 1924). Peat with high von Post values generally indicates substantial oxidation, usually as the result of drainage. Long term drainage of the site has caused this increased peat humification and although not specifically measured, also indicates subsidence. LiDAR or traditional ground elevation surveys of the site should be conducted if wetland banking is being considered to more accurately measure the lateral effects of drainage. Due to differences in groundwater flow patterns, subsidence is not likely to be equal on both sides of the ditch.

Restoring the Winter Road Lake Peatland SNA – Opportunities and Challenges
Considering the various methods and results from other peatland restoration efforts in the State, there are potential opportunities and challenges associated with attempting to restore or enhance the Winter Road Lake Peatland SNA site to its more pristine pre-ditching condition. Ditch abandonment and examining the potential for associated wetland mitigation on some ditch segments within the SNA were recommended in the document “Winter Road Lake Peatland Scientific and Natural Area Management Plan” (MN DNR, 2010).

Monitoring results suggest that there is potential for restoration and significant improvement in both hydrology and vegetation, especially at Site A (Figure 4). There are also several other factors that make Site A the best choice for restoration at the Winter Road Lake Peatland SNA. The ditch and associated berm/spoil bank can be accessed from an upland directly to the north of the site. The site is also located away from roads that could be potentially flooded by ditch blocking. Negative impacts upstream, such as flooding, are unlikely given the drainage system here is not directly connected to any other ditch networks to the north.

At Site A the water flows from west to east. The ditch berm/spoil bank blocking the west to east flow is on the west side (upstream side) of the ditch, making the west side wetter. If this berm/spoil bank is breached, it could potentially allow more drainage of the peatland west of the ditch without increasing water levels on the east side (the ditch would intercept the water and convey it south). This situation is unlike the Brown’s Lake situation where the water flow is south to north. The ditch berm/spoil bank there is on the north side (downstream side) of the ditch. Breaching this berm/spoil bank removes water from the ditch and conveys it to the north where it is needed. Therefore, just breaching the berm/spoil bank on the west side of the Site A ditch may not help unless one or more ditch blocks are installed. Breaching the berm/spoil bank alone will not likely have the desired hydrologic effect.

Placing a clay ditch block as was done for the Brown’s Lake Restoration project is not without its problems. Access along the ditch can be difficult depending on the integrity of the berm/spoil bank and its ability to support backhoes, bulldozers, trucks and other heavy equipment needed to install the ditch block. Clay is available from the same

source used for the Brown's Lake Restoration approximately 10-15 miles north of Site A so that is not a problem. Conducting this work in the winter may provide a more stable travel base, but there are associated problems handling frozen clay and other construction materials. Driving heavy equipment and transporting clay along the berm/spoil bank can also increase compaction and reduce permeability further limiting water flow from west to east. Any work utilizing
heavy equipment on the berm/spoil bank will likely result in increased compaction of the peat, further restricting the natural subsurface flow of water. Research conducted at the Beaches Lake Wildlife Management Area has shown that compacted ditch berms can be up to 50 times less permeable than loose undisturbed peat (Gerla et al., 2009).

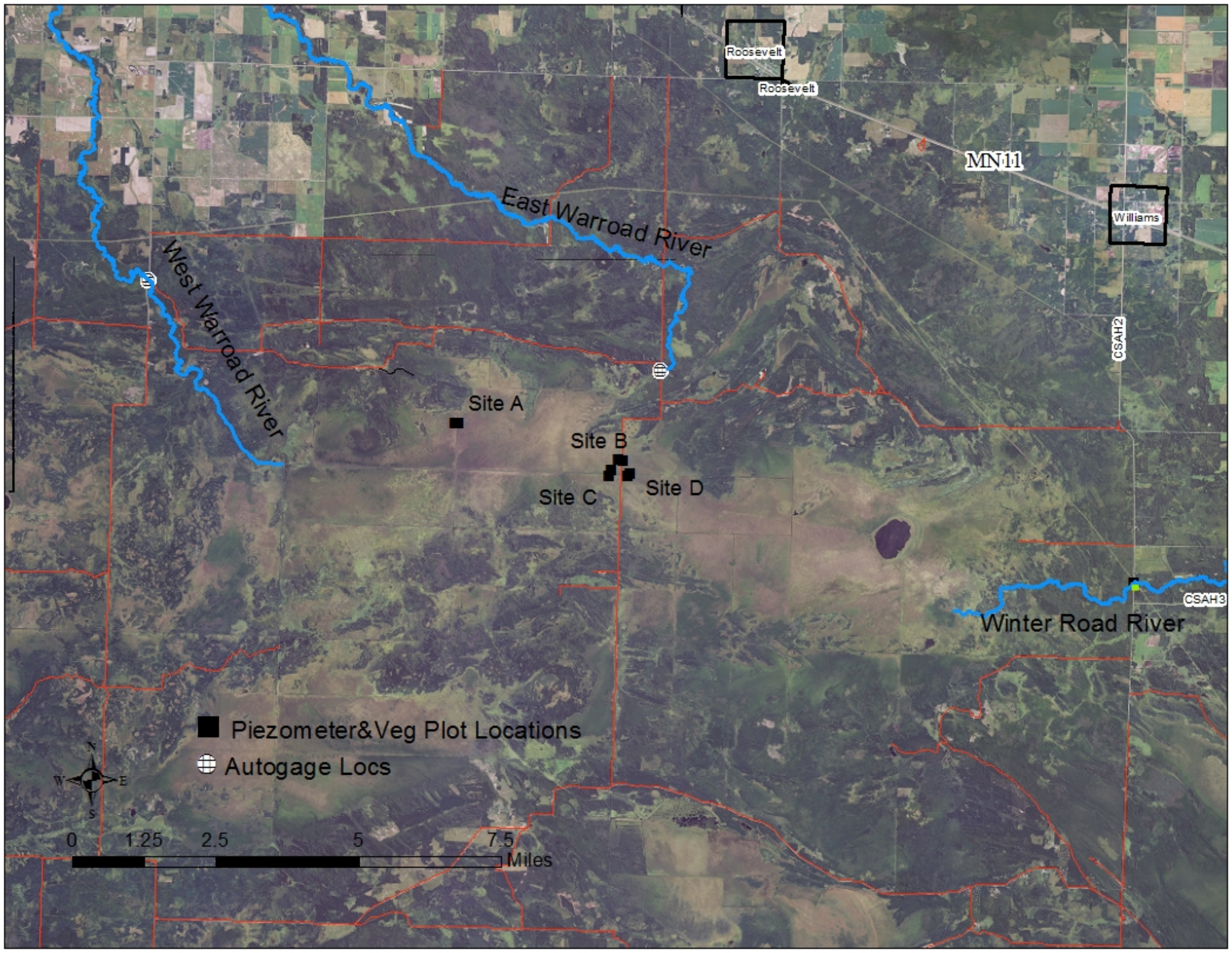

Figure 5: Map of the Winter Road Lake Peatland SNA showing monitoring locations.

The Lake Superior Wetland Bank plan proposes the use of natural materials adjacent to the ditch for blocking/filling the ditches. They include the use of the remaining berm/spoil bank, trees with their attached root systems, vinyl sheet piling, and peat from "borrow pits" dug near the ditches (EIP, 2015). More than one ditch block may be constructed on a segment of ditch depending on the elevation gradient of the ditch. The Lake Superior Bank plan proposes installing ditch blocks coinciding with every one foot drop in elevation. The ditch berms/spoil banks at the Winter Road Lake Peatland SNA have subsided to the extent that they would provide very little material for blocking/filling the ditches. The woody vegetation along these berms/spoil banks consists mainly of shrubs that would not provide much in terms of fill material either. Creating peat borrow pits would destroy existing vegetation and cause disturbance that may encourage the establishment of non-native or invasive plant species. This would require fill material such as clay to be imported, with added cost and transportation issues, along with the potential for introducing additional nutrients and non-native or invasive plants. A helicopter is also an option, but at a cost of approximately $1,000/hour flight time, it is likely cost prohibitive. Vinyl sheet piling might be a more light weight option although heavy equipment would still be required on-site to shore them up with earthen material.

A good compromise for initial restoration efforts would be to clear the shrub vegetation from the berm/spoil bank on the west side of the Site A ditch. This clearing should be done during frozen conditions (early spring) if possible with low ground pressure equipment such as a posi-track or tracked skid steer with bush hog, hydro-ax, or flail mower type implement. It is important that all equipment be meticulously cleaned prior to entering the site to prevent the introduction of weed seeds. This work should be followed up during the growing season with an herbicide application to the stumps to prevent/slow regrowth. The benefits of this work regimen are two-fold: 1) the removal of vegetation adjacent to the ditch reduces evapotranspiration and conserves water, and 2) the berm/spoil bank can be inspected to determine if it will support heavy equipment for potential ditch block construction. A potential drawback to this approach is that it would likely require ongoing maintenance to prevent shrub regrowth. Another potential negative effect of clearing the berm/spoil bank is that it would then be accessible to ATV traffic.

Other potential challenges to restoration of the Winter Road Lake Peatland SNA include mixed land ownership throughout the site and the continued existence and maintenance of the Norris-Roosevelt Road that bisects the site. Activities that negatively impact this road are not acceptable. Also, any ditches proposed to be blocked would first have to be legally “abandoned” by the Lake of the Woods County Board before work could proceed and any upstream interests that could potentially flood would also have to be taken into consideration.

Recommendations

Review of established and proposed peatland restorations and studies of ditch effects and potential remedies reveal mixed and sometimes contrary solutions. Noting that there are significant effects of ditching on the Winter Road Lake SNA Peatland, the question becomes to what extent is intervention warranted and what are the associated benefits and risks involved? That being the case, a conservative approach is probably best initially, especially because the site is a designated and preserved Scientific and Natural Area that already possesses natural qualities above and beyond other more disturbed peatland sites in Minnesota. With scarce proven research conducted in this area, it is possible that restoration could do more harm than good by introducing non-native or invasive species or flooding out native plants. However, a limited approach, at least initially, could benefit the site and provide insights into future research needs and restoration activities.

Although restoration activities may enhance the hydrology and vegetative communities at the Winter Road Lake Peatland SNA, the fact that it is already an SNA means it is already preserved, thus removing that incentive or potential increased benefit. Conducting restoration on such a large scale in a SNA would require considerably more monitoring and surveying of the site for engineering and construction purposes and is beyond the scope of this current project.

The construction of the large-scale Lake Superior Wetland Bank in the very near future will provide a wealth of information on restoration techniques and potential positive and negative effects of ditch blocking/filling to restore peatland hydrology and vegetation, without the risk of damage to a relatively pristine SNA. If the DNR can be involved and monitor this project, it may be a good way to gather information and experience in restoring these peatlands. This experience could be used for restoring the Winter Road Lake Peatland SNA and other similar ditched peatlands throughout the state in the future. At this point in time it is wise to test various methods on a non-SNA site and prove their efficacy and assess any potential negative impacts, rather than risk damaging an established SNA with restoration techniques yet to be proven.

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Final Attachment A: Budget Detail for M.L. 2011 (FY 2012-14) Environment and Natural Resources Trust Fund Projects

Project Title: Restoration Strategies for Ditched Peatland Scientific and Natural Areas
Legal Citation: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 04q
Project Manager: *Michele Walker*
M.L. 2011 (FY 2012-14) ENRTF Appropriation: $*200,000*
Project Length and Completion Date: *3 years, June 31, 2014*
Date of Update: *12/30/2013*

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	**Activity 1 Budget**	**Amount Spent**	**Balance**	**Activity 2 Budget**	**Amount Spent**	**Balance**	**Activity 3 Budget**	**Amount Spent**	**Balance**	**TOTAL BUDGET**	**TOTAL BALANCE**
BUDGET ITEM	**Hydrologic Assessment and Monitoring of the SNA/WPA**			**Vegetative Assessment and Monitoring of the SNA/WPA**			**Peatland Hydrology and Vegetation Restoration Alternatives of the SNA/WPA**				
Personnel (Wages and Benefits) Hydrologist 3, 0.09FTE year 1, 0.08 FTE year 2, 0.11 Year 3=0.28FTE; 20% benefits, 80% salary	17,683	17,683	0	1,200	1,200	0	12,480	7,270	5,210	31,363	5,210
Personnel (Wages and Benefits) Four Hydrologist 1 (varying crews throughout the project), 0.39FTE year 2, 0.23 FTE year 3 = 0.62FTE; 20% benefits, 80% salary	50,000	36,993	13,007	0	0	0	0	0	0	50,000	13,007
Professional/Technical Contracts Vegetation data collection and compilation contractor. Contractor to be selected per DNR requirements for contracting. Vegetative surveys will be conducted at eight (8) groundwater/surface water monitoring sites within the peatland once throughout this project, during the peak of growing season to capture the majority of species in this area. Three sampling methods will be used at each location. Point-intercept transects will run 100m out from the ditch, measuring canopy structure and species dominance/density. Perpendicular to the transects, releve equivalents will be sampled, sampling all in the same vegetation type, ie all in a flark or all in a string. Near the releves, moss transects will also be sampled. Includes $200 for plot markers. 2. Data will be collected, verified and submitted electronically to MN DNR .		0	0	7,000	7,000	0	0	0	0	7,000	0
Professional/Technical Contracts Moss Identification contractor. Contractor to be selected per DNR requirements for contracting. A small sample of each visibly different bryophyte species will be collected by vegetation contractor and shipped to contractor for species identification. Contractor will identify each species and report the results back to MN DNR. Estimating 50 species to be identified.		0	0	2,000	2,000	0	0	0	0	2,000	0
Professional/Technical Contracts NRRI to assist in review and analysis of data to determine potential restoration methods including ditch blocking and vegetation establishment/management and assist in a preliminary analysis to determine the potential for wetland mitigation credits.		0	0		0	0	29,180	26,924	2,256	29,180	2,256
Equipment/Tools/Supplies Overall Budget: This is the best estimate of equipment and costs at the time of the work program. The actual equipment and costs will be adjusted as the project is implemented.	31,293	30,519	774	200	0	200	0	0	0	31,493	974
Equipment/Tools/Supplies: Antenna, cables and lightening protection for Design Analysis Water Log Series Equipment (2 automated groundwater and surface water monitoring stations). Estimated at $840.00											

Final Attachment A: Budget Detail for M.L. 2011 (FY 2012-14) Environment and Natural Resources Trust Fund Projects

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Project Manager: *Michele Walker*
M.L. 2011 (FY 2012-14) ENRTF Appropriation: $*200,000*
Project Length and Completion Date: *3 years, June 31, 2014*
Date of Update: *12/30/2013*

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Balance	Activity 2 Budget	Amount Spent	Balance	Activity 3 Budget	Amount Spent	Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	Hydrologic Assessment and Monitoring of the SNA/WPA			Vegetative Assessment and Monitoring of the SNA/WPA			Peatland Hydrology and Vegetation Restoration Alternatives of the SNA/WPA				
Equipment/Tools/Supplies: Forty one (41) Rugged Troll 200 in-well pressure transducer/dataloggers @ $595 each. Estimated at $24,395.											
Equipment/Tools/Supplies: One (1) Barotroll for barometric corrections of pressure transducer readings. 12/31/2011. Estimated at $595											
Equipment/Tools/Supplies: Cable for installation of rugged trolls. Estimated at $100.											
Equipment/Tools/Supplies: One (1) docking station for downloading rugged troll 200 pressure transducer readings. 12/31/2011. Estimated at $250											
Equipment/Tools/Supplies: One (1) rugged reader Handheld PC to allow downloading pressure transducer readings in the field. 12/31/2011. Estimated at $1,775.											
Equipment/Tools/Supplies: Two (2) data collection platforms one for each automated station. Estimated at $1,120											
Equipment/Tools/Supplies: Two (2) H-250-BRD Mounting Panel-one for each automated station. Total Estimated at $560.											
Equipment/Tools/Supplies: 20 Watt Solar Panel and Regulator. Two solar power stations, one for each automatic data collection station, to provide power @ $330 each. Total Estimated at $660.											
Equipment/Tools/Supplies: Marine Battery. Two battery power supply, one for each automatic data collection station @ $110 each. Total Estimated at $220.											
Equipment/Tools/Supplies: Hoffman Steel Enclosure. Protection for automatic data collection equipment at each of two stations. $1900 each. Total Estimated at $3,800											
Equipment/Tools/Supplies: Texas Electronic Rain Gage. Three Two gages, one at each station. Measures precipitation for ground water recharge measurements and surface water discharge measurements. $220 each. Total Estimated at $440.											
Equipment/Tools/Supplies: Glavanized pipe, conduit, wire and cement to install automated gaging stations. $750 each. Total Estimated at $1,500.											
Equipment/Tools/Supplies: Peat Auger and Schedule 40 PVC Riser pipe with 6 inch stainless steel 10-slot well points for 41 synoptic wells in each of 8 vegetation plots, ditches and winter road river @ $95/well. Total estimated at $3,895.											
Equipment/Tools/Supplies: Vegetation plot markers and flagging. Estimated at $200.											

Final Attachment A: Budget Detail for M.L. 2011 (FY 2012-14) Environment and Natural Resources Trust Fund Projects

Project Title: Restoration Strategies for Ditched Peatland Scientific and Natural Areas
Legal Citation: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 04q
Project Manager: *Michele Walker*
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ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Balance	Activity 2 Budget	Amount Spent	Balance	Activity 3 Budget	Amount Spent	Balance	TOTAL BUDGET	TOTAL BALANCE	
BUDGET ITEM	**Hydrologic Assessment and Monitoring of the SNA/WPA**			**Vegetative Assessment and Monitoring of the SNA/WPA**			**Peatland Hydrology and Vegetation Restoration Alternatives of the SNA/WPA**					
Capital equipment over $3,500 One (1) 350XL High-Level Data Logger and One (1) H-3551 "SMART GAS" System for two (2) automated groundwater and surface water monitoring stations	10,418	10,418	0	0	0	0	0	0	0	10,418	0	
Capital equipment over $3,500 Two Argonaut-SW 3.0-MHz Systems, one for each automated station, to measure ditch flow	17,160	17,160	0	0	0	0	0	0	0	17,160	0	
Total Travel expenses in Minnesota: This is the best estimate of travel expenses at the time of the work program. The actual expenses will be adjusted as the project is implemented.	21,386	10,140	11,246	0	0	0	0	0	0	21,386	11,246	
Travel expenses in Minnesota Hydrologist 3 round trip Bemidji to SNA to identify and evaluate monitoring sites and install synoptic wells. Mileage, lodging, and meals to be reimbursed per union contract. Estimated at $418.												
Travel expenses in Minnesota Four (4) hydrologist 1 round trips from St. Paul to SNA for equipment installation. Mileage, lodging, and meals to be reimbursed per union contract. Estimated at $2,104.												
Travel expenses in Minnesota Two (2) hydrologist 1 round trips from St. Paul to SNA for equipment maintenance (every ~~4~~ 6 weeks for hand calibration), synoptic surface water measurements and ground water measurements. Mileage, lodging, and meals to be reimbursed per union contract. Estimated at $18,864.												
COLUMN TOTAL	**$147,940**	**$122,913**	**$25,027**	**$10,400**	**$10,200**	**$200**	**$41,660**	**$34,194**	**$7,466**	**$200,000**	**$32,693**	$167,307

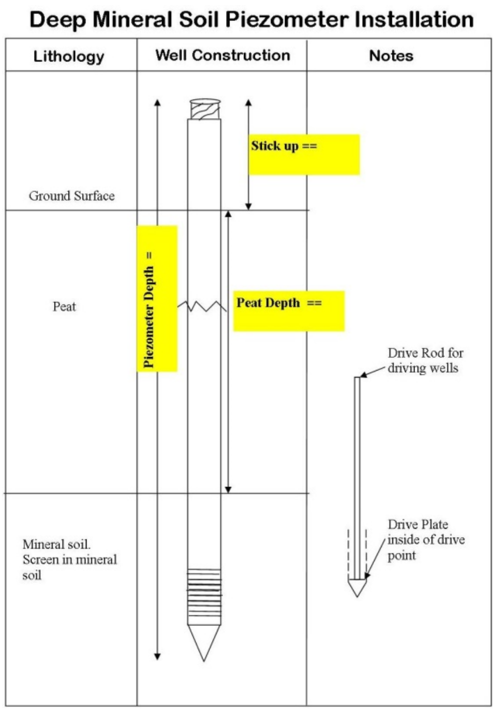
Piezometer Installation at Winter Road Lake Peatland May 2012

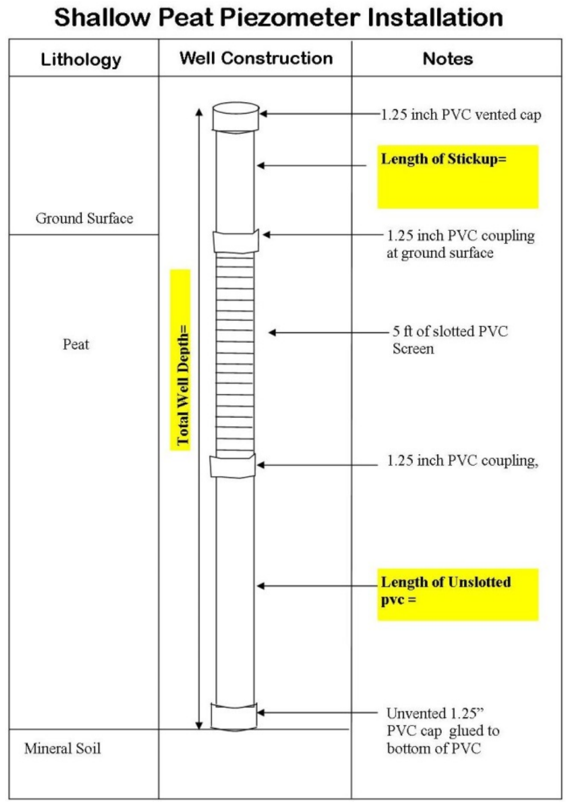
Step 1: Establish vegetation transect locations with flagging tape. Wells are to be co-located with vegetation transects and relevé locations.

Step 2: Place flag at each well location with well name. Wells are placed in three locations: next to the ditch, in or near the ditch spoil pile (if there), some distance away from ditch, and at the end of the 100 meter vegetative transect. The Deep well is placed next within the peatland.

Step 3: Using Re-bar, determine the depth to mineral soil (peat thickness)

Step 4: Pre-construct piezometer to measured peat depth.





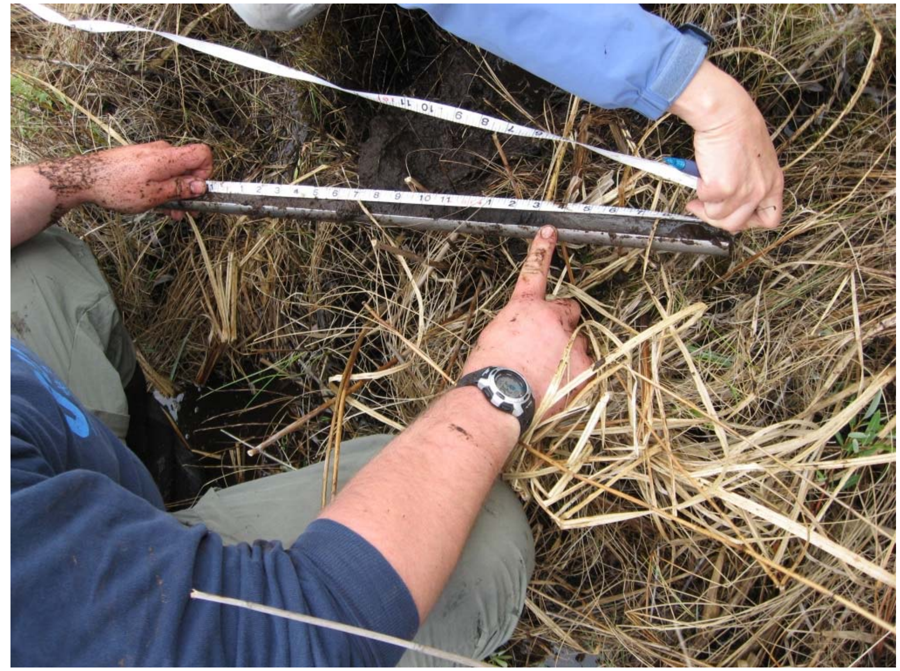
Step 4b: Bring pre-constructed piezometer out to site

Step 5. Auger piezometer hole and fill out construction log.

Peat samples

Sandy Mineral soil sample

Step 6. Evaluate and measure changes in peat/soil layers



Step 7: Install piezometer

Step 8: Survey well locations and top of casing elevation.

Site Piezometers and approximate Vegetation Transect Locations

Piezometer AE1 looking west to Piezometer AW1 across ditch

Piezometer AE1 Looking North

Piezometer AE 2 Looking East

Piezometer AE2

Piezometer AE3 Looking East

Piezometer AE3

Piezometer AE4-Looking South

Piezometer AE4

Piezometer AW1 Looking East to AE1

Piezometer AW1

Piezometer AW2 Looking West

Piezometer AW2 Looking West

Piezometer AW3 Looking East towards Berm

Piezometer AW3 and AW5(deep piezometer) Co-located

Piezometer AW4 Looking West

Piezometer AW4

Piezometer BE1 Looking East

Piezometer BE1 next to existing deep mineral soil piezometer looking west towards ditch

Piezometer BE2 Looking East

Piezometer BE2

Piezometer BE3 Looking east over a flark and towards a string

Piezometer BE3

Piezometer BE4 Looking South

Piezometer BE4

Piezometer BW1 Looking West

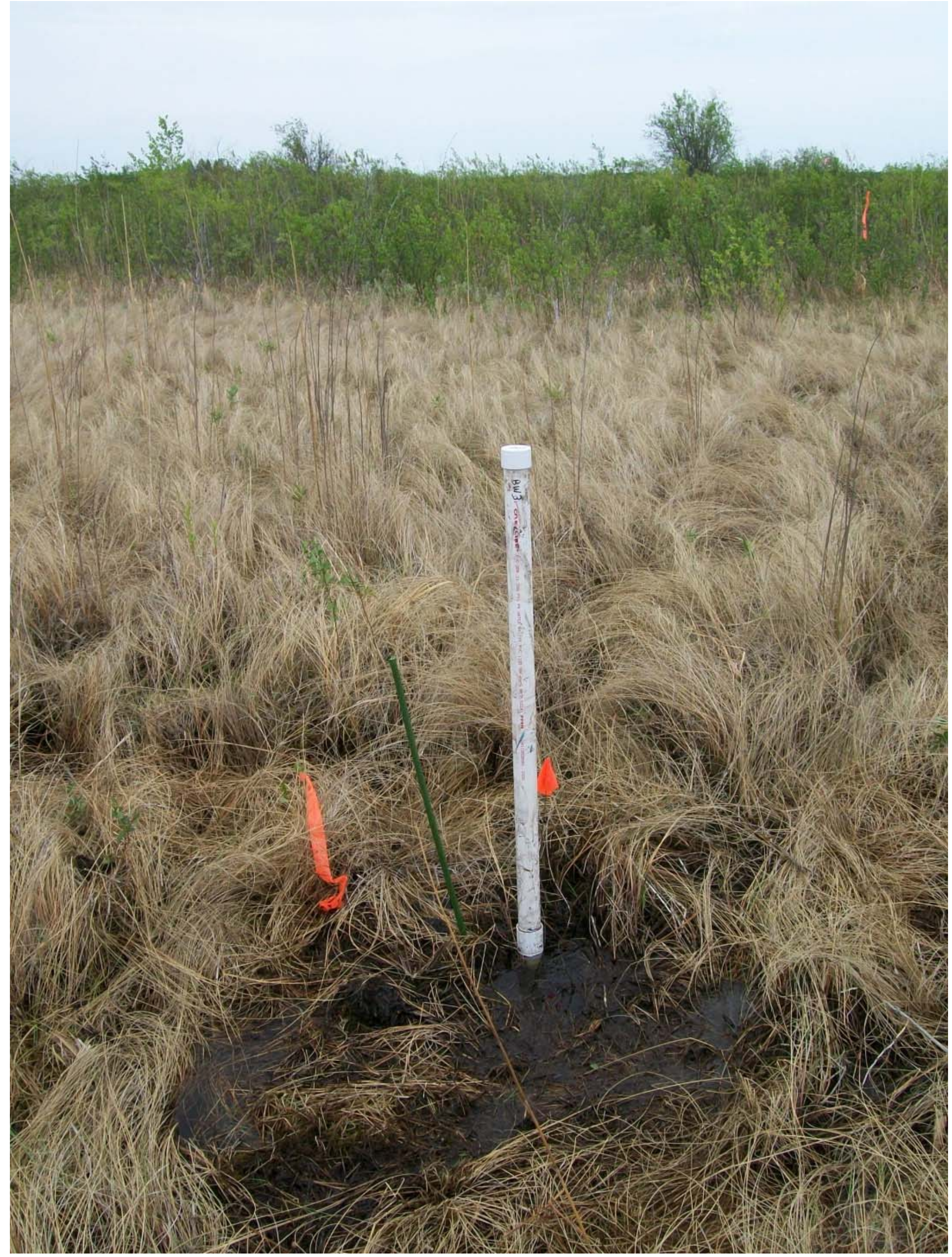
Piezometer BW1

Piezometer BW2 Looking West

Piezometer BW2

Piezometer BW3 Looking West over a flark to a string

Piezometer BW3



Piezometer BW4 Looking west into the unditched peatland

Piezometer BW4 Looking North

Piezometer CN1 looking North towards transect

Piezometer CN1

Piezometer CN2 Looking North

Piezometer CN2

Piezometer CN3 Looking North towards CN4

Piezometer CN3

Piezometer CN4 Looking North over the unditched peatland

Piezometer CN4

Piezometer CS1 Looking South

Piezometer CS1 Looking north towards ditch

Piezometer CS2 Looking South

Piezometer CS2 and CS5 (deep piezometer)

Piezometer CS3 Looking South

Piezometer CS3

Piezometer CS4 Looking South

Piezometer CS4

Piezometer DN1 Looking North at Berm

Piezometer DN1

Piezometer DN2 Looking North

Piezometer DN2

Piezometer DN3 Looking North over yellow transect line

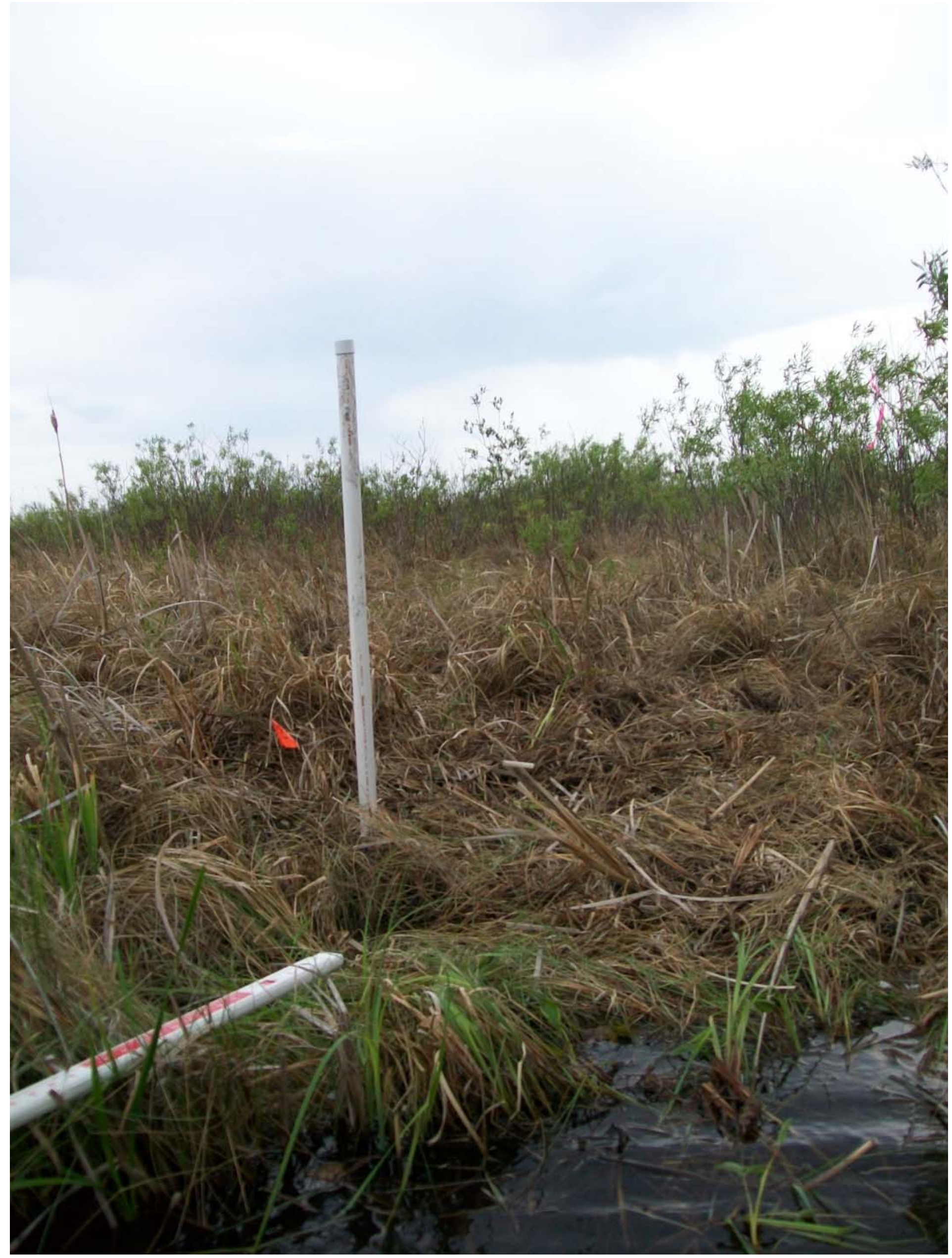
Piezometer DN3

Piezometer DN4 Looking North to unditched peatland

Piezometer DN4

Piezometer DS1 Looking South

Piezometer DS1



Piezometer DS2 Looking South

Piezometer DS2 and DS5 (deep piezometer)

Piezometer DS3 Looking South from a Flark to a String

Piezometer DS3

Piezometer DS4 Looking North towards ditch

Piezometer DS4