Willow Brook

Natural Resource Management Plan

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June, 2014

This Natural Area Management Plan and Work Plan has been reviewed and approved by:

Landowner: Minnesota Department of Resources

_____ Date: _____
Name, Title, Entity

Minnesota Land Trust or County

_____ Date: _____
Name, Title, Entity

Table of Contents

INTRODUCTION **5**

SITE INFORMATION **7**

LANDSCAPE CONTEXT **9**

SITE GEOLOGY AND GROUNDWATER **11**

Figure 3. Surficial Geology and Bedrock (bedrock in insert in lower right corner). **12**

SOILS AND TOPOGRAPHY **14**

RARE SPECIES **18**

HISTORIC VEGETATION **19**

HISTORIC AND EXISTING LAND USE **21**

WATER RESOURCES **25**

Surface Waters (Lakes, Streams, Rivers, Wetlands, etc.) 25

Groundwater Recharge or Infiltration Areas 29

Stormwater Management Issues 30

Ecological Threats 30

ADJACENT LAND USE **32**

EXISTING LAND COVER & ECOLOGICAL MANAGEMENT RECOMMENDATIONS **34**

Lowland Hardwood Forest (LFH-1, LFH-2) (19.2 ac) 36

Cattail Marsh (1.8 ac), Altered Seasonally Flooded Shrubland (1.29 ac), Mixed Emergent Marsh Seasonally Flooded (1.23 ac), and Mixed Emergent Marsh (Mx-Em-Marsh-1 [3.64 ac], Mx-Em-Marsh-2 [6.29 ac] (total = 14.3 ac) 37

Altered Deciduous Forest (Alt-Dec-For-1, Alt-Dec-For-2, total = 8.6 ac) 47

Buildings and Pavement with 26% (8.2 ac) 49

Altered Grassland (Alt-Gr-1, Alt-Gr-2, Alt-Gr-3) and Altered Grassland with Sparse Deciduous Trees (Alt-Gr-DecTr) (6.0 ac) 53

Oak Woodland-Brushland (OW-Br-1, OW-Br-2, OW-Br-3) (4.4 ac) 55

Oak Forest (OF-1, OF-2) (2.0 ac) 59

Floodplain Forest (1.6 ac) 60

Dry Prairie (0.8 ac) 61

Oak Savanna (0.01 ac) 61

RESTORATION PROCESS **65**

Restoration Goals 65

Target Plant Communities 66

Site-Wide Invasive Woody Plant Removal/Control 71

Restoration Priorities 71

RESTORATION SCHEDULE AND COST ESTIMATES **74**

Long-Term Monitoring and Maintenance 77

INFORMATION SOURCES **79**

APPENDICES **84**

APPENDIX A. Plant Species Recorded at the Willow Brook Property **84**

APPENDIX B. Plant Species for Restoration at Willow Brook Property **1**

APPENDIX C. Methods for Controlling Exotic, Invasive Plant Species **1**

APPENDIX D. Ecological Contractors **1**

APPENDIX E. Tamarack Ecology **1**
Appendix G. Map from City of St. Paul **1**
Appendix H. Woody Biomass Project Map, 2012 ..... **1**
Appendix I. Teachable Opportunities **1**

Figures

1. Property Parcels Map
2. Landscape Context Map
3. Geology Map
4. Aquifer Sensitivity Map
5. Soils Map
6. Topography Map
7. Pre-settlement Vegetation Map
8. Historical Aerial Photo, 1923
9. Historical Aerial Photo, 1937
10. Historical Aerial Photo, 1940
11. Historical Aerial Photo, 1957
12. Aerial Photo, 2012
13. National Wetland Inventory Map
14. Dump Site Map
15. Adjacent Landuse, Aerial Photo, 2012
16. Existing Landcover Map
16A. Notable Features Map
17. Ecological Subsections Map
18. Target Plant Communities Map

Tables

1. Soils
2. Elements occurrence
3. NWI Wetlands
4. Restoration Target Plant Communities for Existing Landcover
5. Restoration Schedule and Cost Estimates

INTRODUCTION

The 70 acres of land surrounding what is today the MN DNR Central Region Headquarters has undergone many changes over the past century and a half. In presettlement times, the majority of this land was occupied by tamarack and black ash swamp, marsh, and sedge meadow, being fed by numerous seeps, springs, and small meandering streams and rivulets. The upland areas were occupied primarily by oak savanna. The region was rich with diversity, with the Mississippi River nearby to the south, the bluffs of the river that contained bedrock bluff prairie to the north, west, and southeast, uplands expanding on all sides, covered with prairie and savanna, and many streams, lakes and wetlands scattered throughout. The region contained a great diversity of habitats that provided for an incredible abundance of wildlife.

Glacial meltwater at the end of the last glaciation, circa 11,000 years ago, formed Glacial River Warren, a huge river that carved a gigantic gorge through this part of its reach. After the glaciers melted and the waters receded, the river shrunk in size, eventually taking its present shape and size. Today, the valley is "oversized" for the size of the relatively small river that remains.

Native Americans occupied this area for hundreds of years. At nearby Mounds Park, the Hopewellian, Late-Woodland, and Oneota cultures built burial mounds, over several hundred years, on the ridgeline of the bluffs with commanding views of the river valley (Tix, D, et. al., 2007). Nearby Battle Creek was also an important site for Native Americans.

Europeans settled in this area in the mid-19th century, and brought many changes to the land and ecosystems here. South of the site, railroads had a system of major transportation lines with a hub nearby the site (a terminal and roundhouse). To the north, urban development, with roads and houses, sprung up and encroached on the site. The hydrology changed, due to incremental but steady increases in surface runoff (because of increased amounts of impervious surfaces and altered drainages). Increases in surface flows from the entire Lake Phalen watershed was shunted into the site and caused rises in hydrological levels.

Because it had so many springs and wetlands and a stream, early on the site was utilized for drinking water and other uses such as fish ponds that were used for stocking fisheries and lakes.

During the 20th century disturbance continued. When Interstate 94 was constructed in the 1950's, the site was used as a staging area for materials and as a waste dump. Even today, large chunks of concrete and black top can be seen in portions of the site.

Along with disturbance came introductions of many new plant and animal species to this area. Some of them became established and today this site is replete with a plethora of exotic invasive plant species. In 2011, the site was mapped for terrestrial invasive plant species and numerous species were found. Although highly disturbed and degraded throughout much of its area, this site still actually sort of a "mixed bag" with several areas that contain remnant plant communities with many interesting native plant species, which provide habitat for many birds, small mammals (including beaver and muskrat), and insects. It was mapped by Minnesota County Biological Survey (MCBS) as having "high biological diversity" (Figures 1 & 2), but has been changed to moderate diversity (personal communication with Hannah Texler, 2014). It contains degraded remnant oak savannas, that have the potential to be restored. It also holds a couple small remnant seepage meadows, a remnant wet prairie, and two high quality remnant tamarack/black ash swamps.

The stream has been dammed, on and off, by beavers. The last time beavers dammed the stream, water levels rose greatly and flooded out the valley, killing many of the mature tamarack trees (personal communication with Michele Hanson, 2013). Due to heavy stream flows, the beaver dam was washed out and the beaver couple left their residence here. It may be unsustainable to maintain a beaver dam on this site due to the flashiness of the water levels of the stream, because of greatly increased watershed surface drainage that is funneled to this site.

The 2011 invasive species survey coupled with observations of the stream and beaver dams, has spurred a renewed interest in this site, which has led to efforts to restore and manage it for its natural resources. Since it houses the Central Region's headquarters, this makes sense and is probably long overdue. This site has much potential, and could be used as a "living laboratory" and as a place to educate the public. Hopefully this long-neglected area will be restored to some of its former richness and beauty and be utilized for the great resource that it potentially could be.

SITE INFORMATION

Owner name, address, city/township, county and phone:
Minnesota Department of Natural Resources
1200 Warner Road
St. Paul, MN 55106

Township, range, section:
T28, R22, Sec 3, NW1/4
T28, R22, Sec 4, NE 1/4

Watershed:
Major Watershed: Mississippi River (Province 2)

Watershed District:
Ramsey-Washington Metro Watershed District

Parcel Identification Numbers:
042822140006 (includes the pond on the west side of Warner Rd)
042822110003 (a slice just west of the buildings)
04282214008 (the buildings)
032822230023 (the parking lot west of the buildings)
032822240001 (this is the bulk of the property)
032822240003 (the parcel between 032822240001 and Hwy 61)

Natural Area Conservation Easement:
None aware of by FMR

Element occurrence:
No element occurrences within the boundaries of the site.

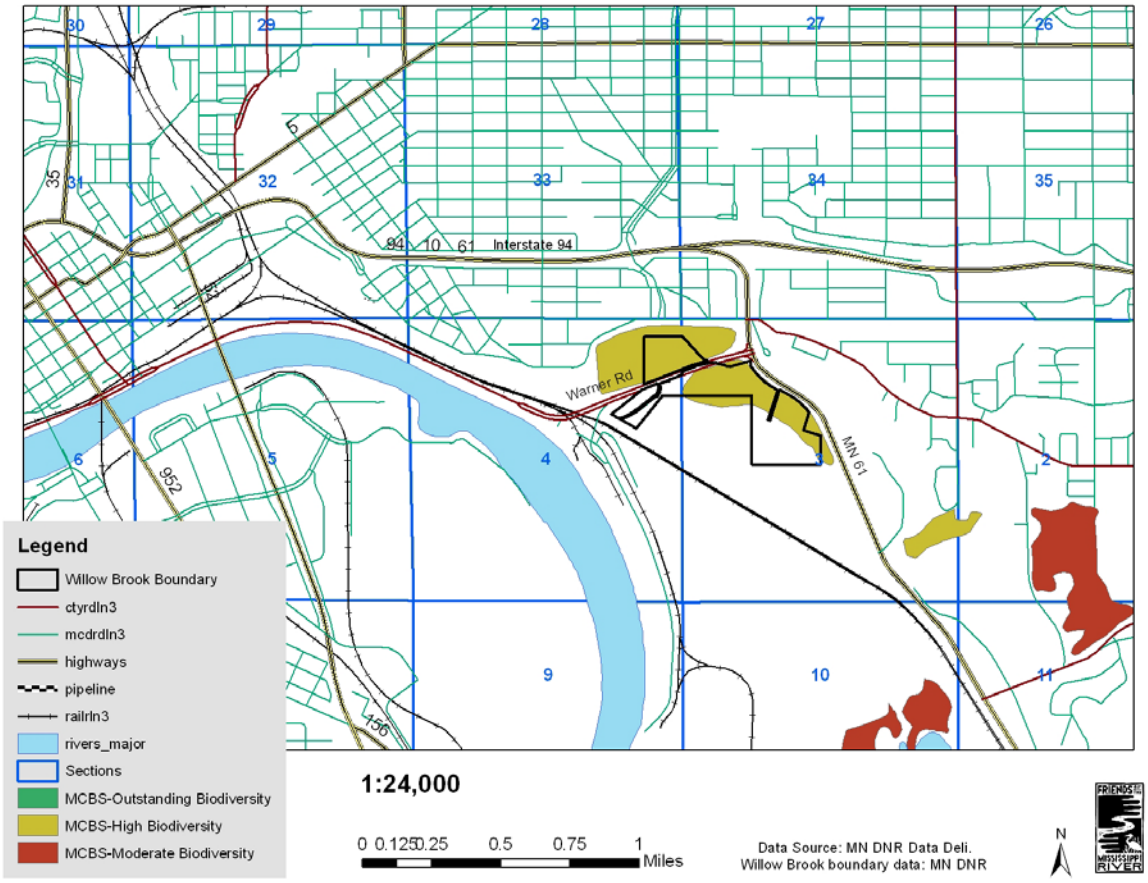
There is one bald eagle (*Haliaeetus leucocephalus)* nest on the north side of Warner Road, just south of Mounds Park, that is within the boundary of the site. Although bald eagles are no longer threatened, they are still being monitored by the DNR.

Within a one-mile radius of the site, there are eight element occurrences:

- *Besseya bullii*, kittentails (five occurrences)
- Dry Sand Gravel Prairie (Southern Type), UPs13b
- *Cycleptus elongates*, Blue Sucker freshwater mussel
- Pro-Glacial River Composite (Quaternary), "Mounds Park Vantage Point"

See **Table 2** for more details concerning these element occurrences.

Figure 1. Property Parcels



LANDSCAPE CONTEXT

Proximity to established greenways

Willow Brook lies within the Metro Conservation Corridor (MeCC), a regional land conservation program administered by the DNR (**Figure 2**). Thus, it should be open to receiving funding from LCCMR, which funds eligible MeCC projects.

This site is also directly adjacent to Battle Creek Regional Park, which includes both Indian Mounds Park and Battle Creek Park. This increases its value since it expands upon an established natural area with significant natural resources. The site is also not far from Pigs Eye SNA and Fish Creek Open Space, about 3 miles to the south, on the river.

In addition, this site is part of the Mississippi River Important Bird Area (IBA), because it lies within one of the major flyways in North America, the Mississippi Flyway, which sees hundreds of species migrating north and south during spring and fall.

Lastly, the site lies within the Mississippi National River and Recreation Area (MNRRA), a 92-acre national park that extends through the Metro Area, and was established in 1990.

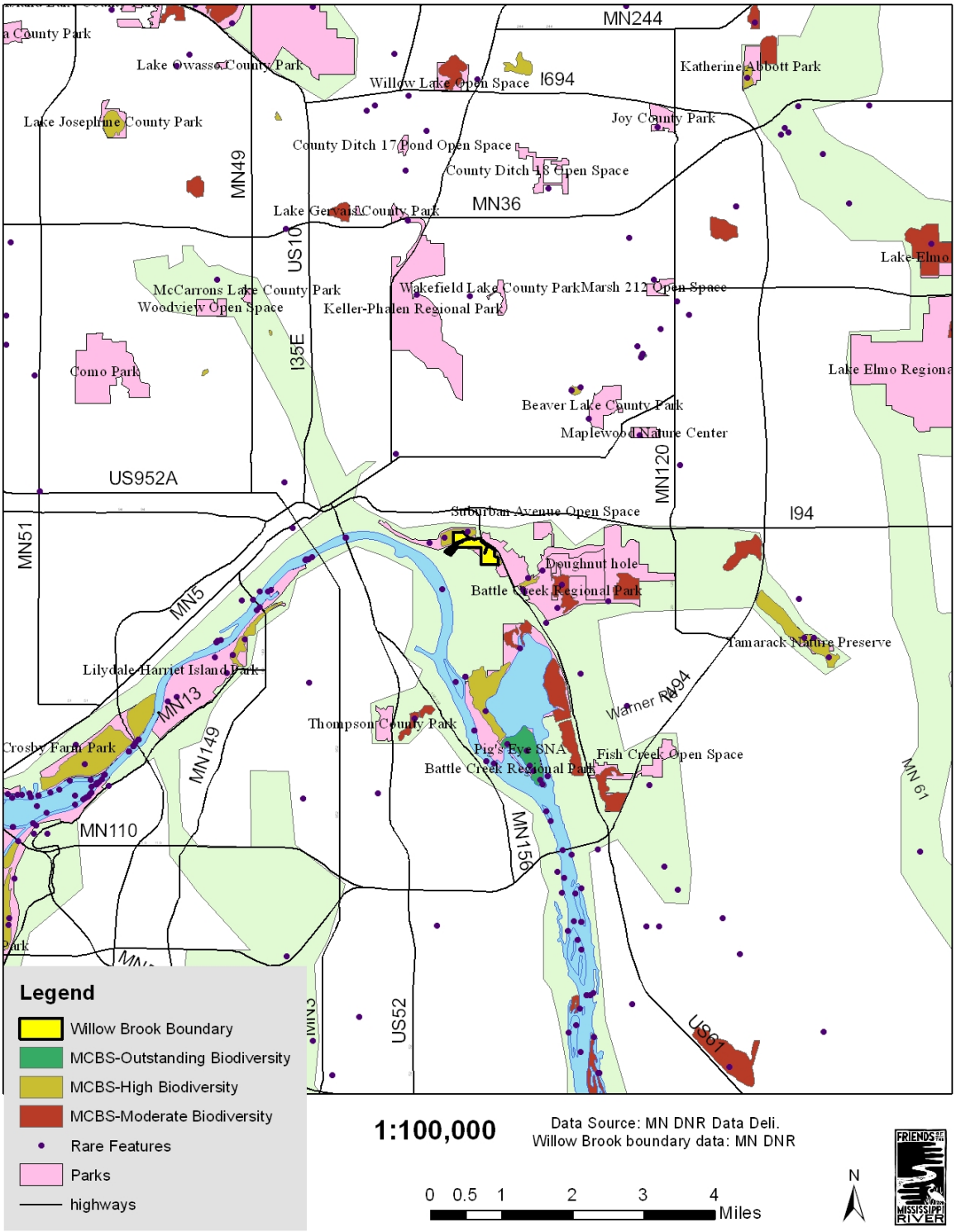
Ecological significance and wildlife value

The majority of the site (over ¾) lies within an area identified by Minnesota County Biological Survey (MCBS) as a "moderate biodiversity" area (**Figures 1 & 2**). This is significant and worth making this site a priority for management and restoration.

The abundance of fresh water and the diversity of habitats make this site very attractive to a variety of wildlife species, including mammals, herptiles, birds, and insects. A bird list has not been generated, to date, but should be started.

The fact that this site contains seepage swamp communities also makes it significant and uncommon for the region. Very few seepage communities exist in the Twin Cities Metro Area (personal communication with Hannah Texler, June 2014).

FIGURE 2. LANDSCAPE CONTEXT



SITE GEOLOGY AND GROUNDWATER

Geomorphology

Bedrock

Bedrock that underlies the site is Prairie du Chien Group primarily, with a small strip of Jordan Sandstone that runs down the western side of the property. Prairie du Chien Group consists of sandy dolostone. The dolostone sediments are derived from carbonate remains of invertebrate shells and algae that accumulated in small banks or reefs and as tabulate layers on the seafloor during the Lower Ordovician (505-478 m .y. ago) when Minnesota was covered by shallow seas (Mossler, J. H., and B. A. Bloomgren, 1992). The sediments then solidified over millennia. The Jordan sandstone is derived from sand sediments that accumulated in nearshore bars and on beaches during a period just prior, the Late Upper Cambrian. Although the Prairie du Chien does not outcrop in Ramsey County, the upper part may contain karst solution cavities, which has implications for groundwater contamination, since it contains the aquifer that provides the Twin Cities Metro Area with most of its drinking water, and therefore is very important to protect.

Surficial Geology

The surficial geology of the site consists of sediments that were deposited primarily by glacial ice and meltwater during the last glaciation (the Wisconsinan Stage) of the Pleistocene Epoch (Mossler, J. H., and Bloomgren, B. A., 1992). In the post-glacial period of the Holocene (the last 10,000 years), the glacial landscape was somewhat altered by soil formation and erosion and some stream deposition. Although considered minor, at a landscape scale, in the case of this property, they are significant. At the Willow Brook site, there are two types of surficial geologic sediments: Stream Sediment (FHo1A) and Hillside Sediment (SWi4T) (**Figure 3**). Stream Sediment consists of sand and gravel with areas of fine sediment and organic material (slack-water deposits). Hillside Sediment consists of 1) deposits on and at the base of steep slopes, 2) angular bedrock fragments, with silt and clay where bedrock is exposed, and 3) slumped till where till forms slopes.

Groundwater

The sensitivity of the Prairie du Chien aquifer to groundwater pollution on the Willow Brook site is “moderate” in the northern portion and “high” in the southern portion (**Figure 4**). The “high” rating is due to high permeability in the surface sediments and shallow water table depths (Twiss, W. P., 1992). The estimated time for water-borne contaminants at the land surface to reach the aquifer for “high” sensitivity rating is ***weeks to years***. Estimated travel time for “moderate” sensitivity is *years to decades*. This has profound implications for management of the site. For instance, the prudent and careful use of herbicides and chemicals is highly recommended to prevent groundwater pollution. Also consider that thousands of gallons of stormwater accumulate onto this site every year—an area of high

sensitivity. Some pre-treatment of stormwater occurs in the wetlands of the site, but they are simply not large to have the capacity to infiltrate and pre-treat the huge volumes that flow here, and the wetlands themselves occur over areas of high sensitivity to groundwater pollution. Historically, the upland soils and subsoils would have treated the influx of water to this site, and emerged in seeps. Today, water is directly piped onto the site from up-watershed. Treatment of stormwater

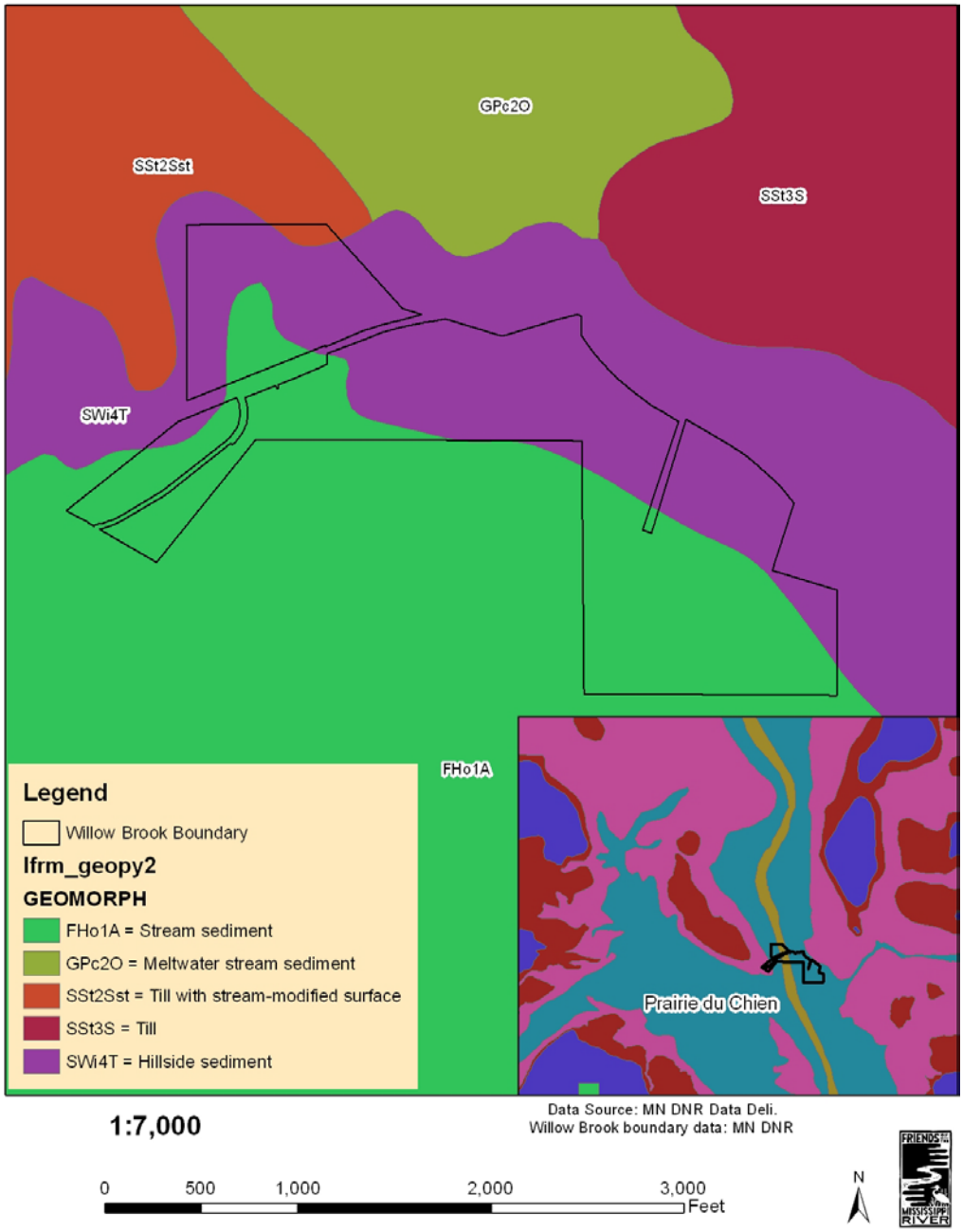


Figure 3. Surficial Geology and Bedrock (bedrock in insert in lower right corner).

should occur up-watershed, on areas that have moderate to low sensitivity. Also consider that the location of the former dump and the Superfund site are also located near and over areas of high sensitivity to groundwater pollution. This is also true of the large new-car lot.

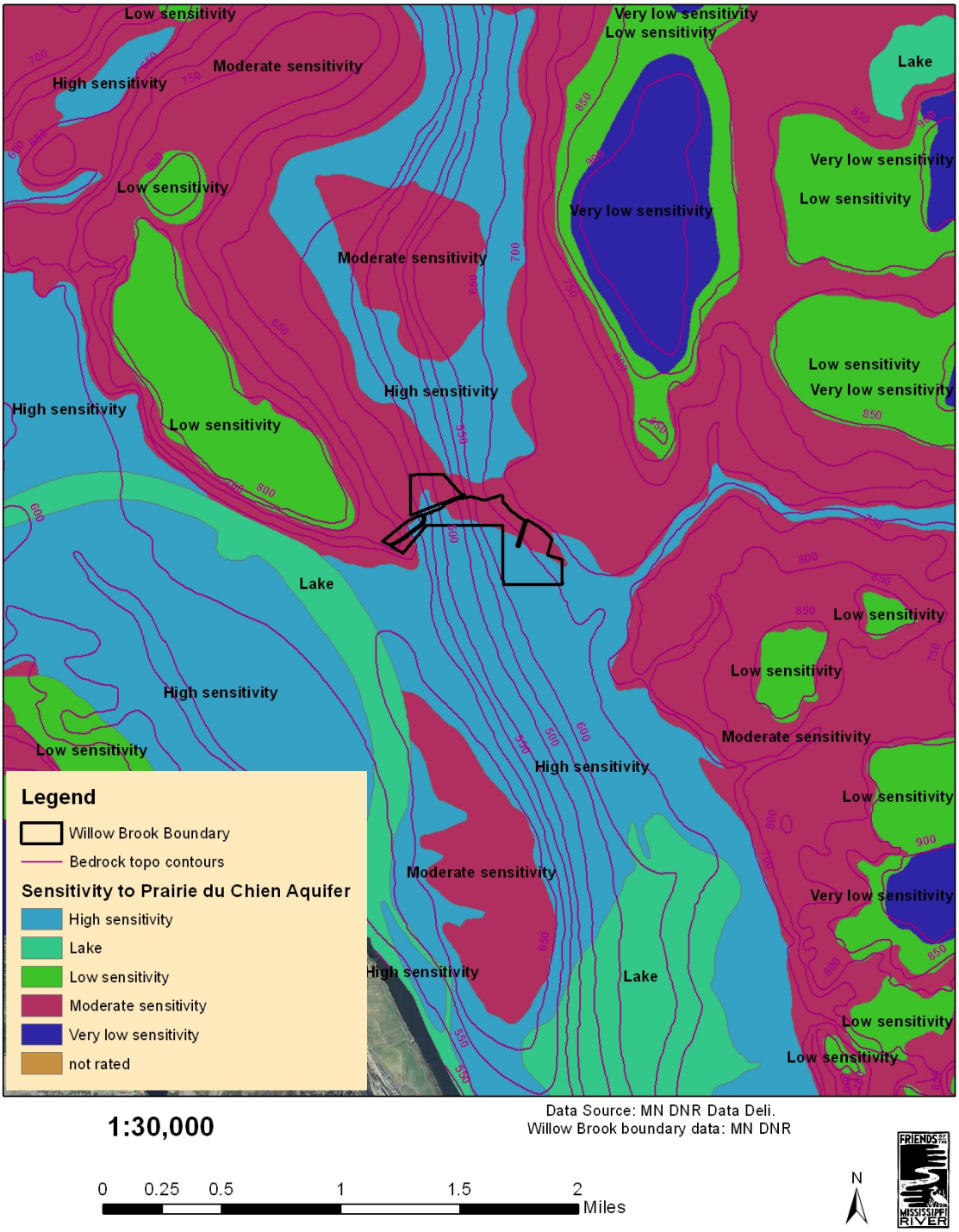


Figure 4. Sensitivity of the Prairie du Chien aquifer to groundwater pollution.

SOILS AND TOPOGRAPHY

Soils

The majority of this site is composed of wetlands with hydric soils (**Figure 5**). Some of the areas that are currently occupied by "lowland hardwood forest" were likely formerly wetlands, or mosaics of wetlands and uplands, that were filled when the site was used as a dump. The largest proportion of soil type on the site (46.7 acres) was the *Udorthents, wet substratum* soil type. Much of this soil has been altered by human activity (filled in, dumped on, and constructed upon), thus not a lot of information is available for these soils, compared to the other soil types (**Table 1**). A good deal of this soil type would have been wetland, but we cannot be sure exactly how much. The field survey, by the FMR Ecologist, showed that a substantial

	Mahtomedi-Kingsley complex	Chaska Silt Loam	Kerston Muck	Udorthents, wet substratum	Open Water
% Slopes and shape	25 to 40, Convex	Linear	Linear	Linear	
Code	896F	329	552	1027	W
Acres	8.5	8.2	4.7	46.7	13.7
Type of upper profile	Loamy sand to gravelly coarse sand	Silt loam	Muck		
Parent Material	Outwash	Alluvium	Stratified organic material and alluvium		
Landform	Moraines	Floodplains	Alluvial flats on floodplains	Moraines	
Drainage	Excessively	Poorly	Very poorly		
Depth to Water Table	>80"	0"	0"	>80"	
Freq of Flooding and Ponding	None	Frequent flooding.	Frequent flooding and ponding	None	
Available water storage	4.1"	9.5"	15.4"		
Erodibility	Highly	Not Highly	Not Highly		
Hydric Soil	No	Yes	Yes		
Great Group	Mixed frigid Typic Udipsamment and Coarse loamy, mixed, mesic, Mollic Hapludalfs	Fine-loamy, mixed (calcareous), mesic Mollic Fluvaquents	Euic, mesic Fluvaquentic Medisaprists	Mixed, frigid Udorthents	

Table 1. Summary of Soil Types and their Characteristics.

portion of this unit was occupied by seepage swamp communities. For example, there is a significant seepage swamp area just north of the fish hatchery pond, whose soils would have been either Chaska loam or Muck, but this shows up as "Udorthents" on the soil map. The field survey also discovered that as much as about 10 to 12 feet of fill could have been dumped into the "Lowland Hardwood Forest" area (Photo 1).

Photo 1. FMR Ecologist standing about half way down the slope formed from the dump, located at the border between the south end of LHF-2 unit and the Mixed Emergent Marsh-2 unit. The Ecologist is 6' tall. Also, note the blacktop slabs at the left side of the photo.

The *Open Water* soil type covers 13.7 acres, making it the second largest soil type of the property, and consist of two ponds or lakes—the Fish Hatchery Pond and Little Pigs Eye Lake. Much of this unit probably would have formerly been either seepage swamp or a series of sedge meadow/wet prairie mosaics. These two *Open Water* "soil" units were not present in pre-settlement times, as can be seen from the historical aerial photos (**Figures 8, 9, 10, and 11**). Both have formed over the last 80 years due to human activities (from probably being dredged out, in the case of the Fish Hatchery Pond, and in the case of Little Pig's Eye Lake, from being the repository of large volumes of stormwater that has been shunted onto this site).

Kerston Muck, an organic soil, is at the heart of the marshy areas, and occupies 4.7 acres. Muck soils often harbor unique plant communities because they have such restrictive conditions for plant growth. The *Chaska Silt Loam* soil unit, found in the southern middle portion of the property, is also a hydric soil, and is where the tamarack "bog" is currently located. Now most of the tamaracks have died—for more information on this phenomenon, please refer to the following section entitled "Existing Conditions".

The remaining soil, *Mahtomedi-Kingsley Complex*, is an upland one. It currently occupies about 8.5 acres, and is located on the wooded, steep slope, just north and surrounding the current fish hatchery pond. It is currently occupied by oak woodland-brushland and mesic oak forest plant communities. Historical aerials show that this area was definitely an upland woodland/forest in the recent past. A couple other areas were identified, from the historical aerials, as having large trees in the past. Whether they were dominated by oaks or by cottonwoods/elms/ashes is difficult to ascertain. One of these woodland areas was field-checked, and proved to be a small, half-acre oak woodland/savanna remnant, located on the north side of the middle part of the property, just east of the marsh/seepage swamp. Today this

remnant still contains several large bur and red oak trees. Most of the other treed areas throughout the property did not contain oaks, but rather, were dominated by cottonwood, elm, ash, and hackberry, which indicate a terrace forest or floodplain forest.

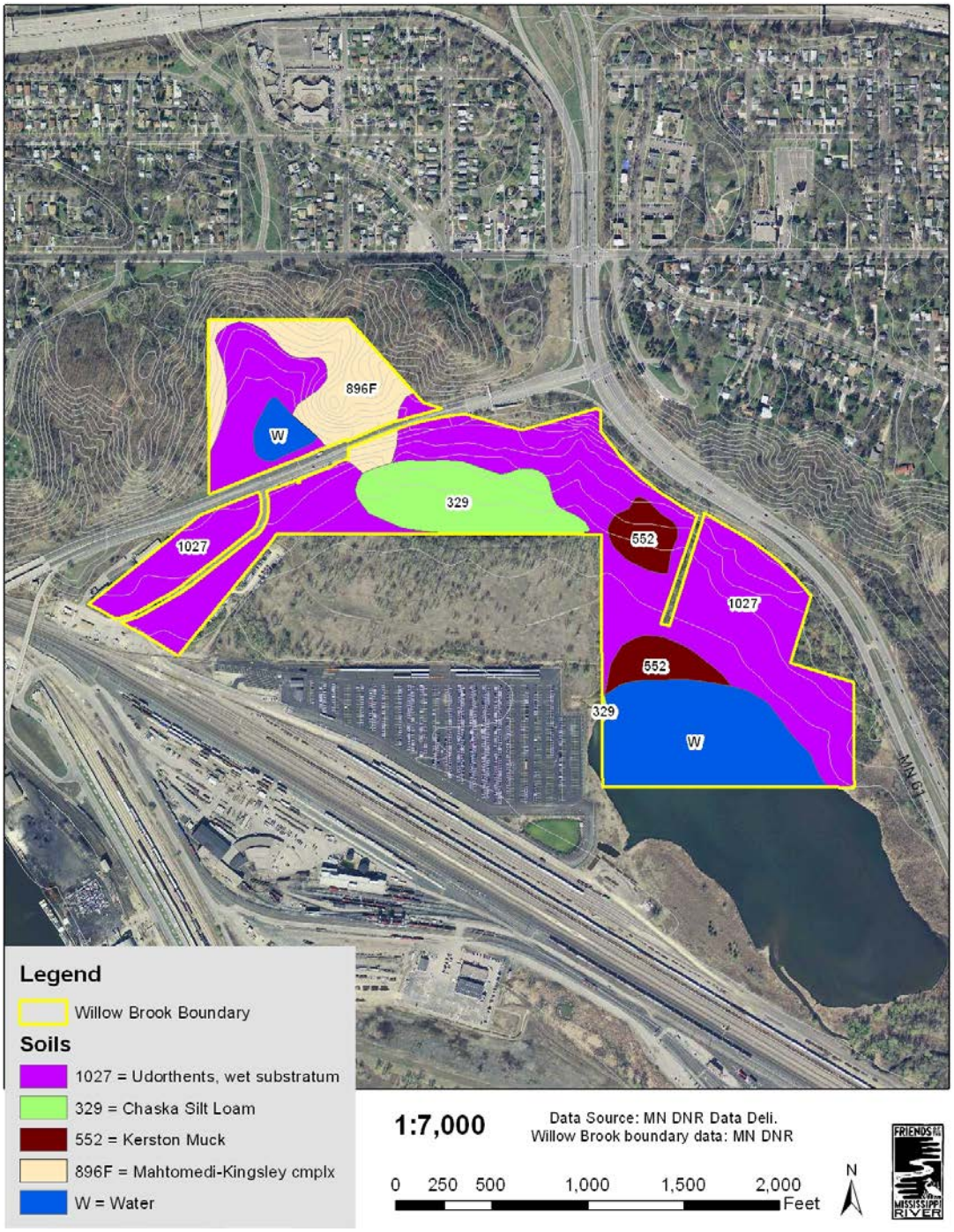


Figure 5. Soils of the Willow Brook site.

Topography

Topography varies from very, very steep on the northwest end of the property (north, east, and west of the fish hatchery pond) to very flat throughout the rest of the property. This type of topography is typical of seepage areas. Seepage swamps would typically have mineral soil (silty colluvium) at the surface, although this can be capped by mucky peat, which matches what would be found in this type of community (DNR 2005). The property is situated on strongly rolling to steeply dissected terrain where there is sufficient relief for groundwater to upwell (DNR 2005)—this describes the Willow Brook property site (**Figure 6**), which, primarily a flat plain, is surrounded on the northeast, north, and northeast, by steep bluffs on nearly all sides. Springheads and rivulets were evident throughout most of the property.

In the disturbed lowland hardwood forest unit, the topography overall was flat, but the soil surface was rolling, but not as would be expected in a seepage swamp, which is characterized by raised peaty hummocks, but rather with irregularly angular small hills and valleys. This landscape feature makes sense, considering the history of this area as a former dump site.

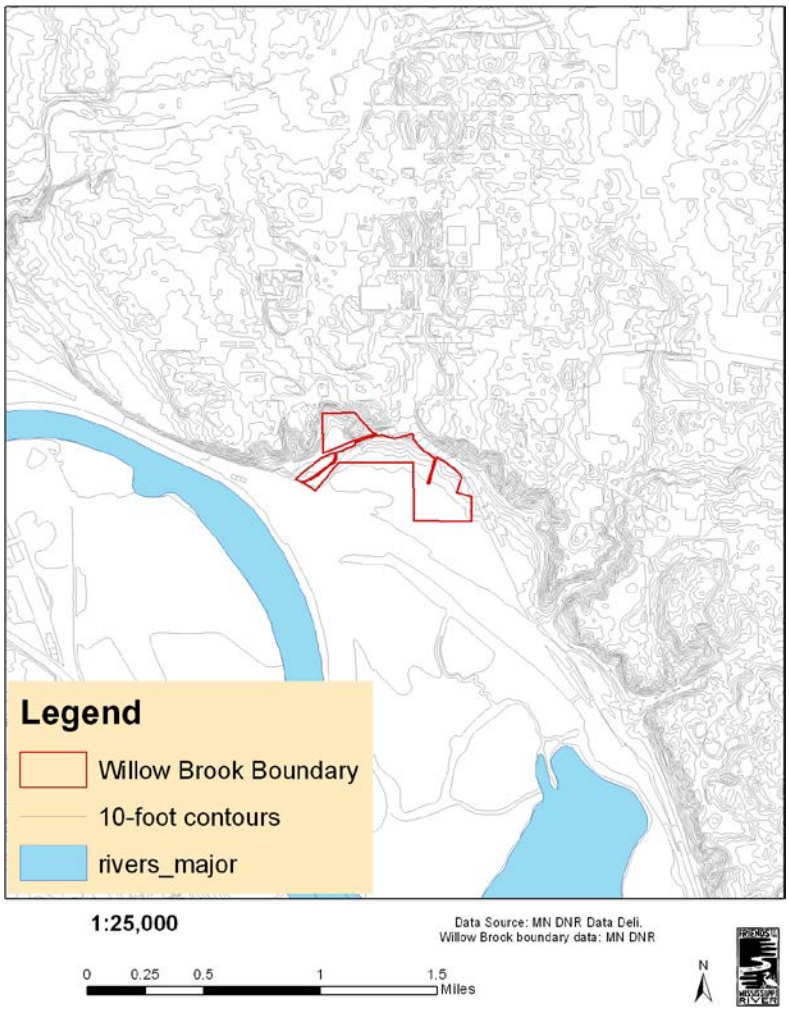


Figure 6. Topography of Willow Brook and the surrounding area.

Note the marked relief of the bluff line, to the north of the site, that forces groundwater to seep out at the low plain on which the property is situated.

RARE SPECIES

No rare species occur within the boundaries of the site. However, there are several elements of occurrence nearby. See Table xx for a summary of elements that occur within one mile of the site.

Common Name	Kittentails	Dry Sand-Gravel Prairie (UpS13b)	Blue sucker	Pro-Glacial River Composite (Quaternary)
Family	Scropulariaceae			
Genus	Besseya		Cycleptus	
Species	bullii		elongatus	
Variation				
Number of records	4	1	1	
Location	Within one mile of the site.	SE of site.	SW of site	
First Observed	1) 5-13-1992, 2) 5-23-1903, 3) 7-13-1884, 4) 7-4-1990	7/3/90	Oct-02	
Last Observed	1) 5-13-1992, 2) 5-23-1903,3) 7-13-1884, 4) 2005	7/3/90	9/15/08	1980
S Rank	S2	S2	S3	
G Rank	G3	NR	G3 G4	
EO Rank	1) C (fair est'd viability), 2) historical, 3) historical, 4) E (verified extent but viability not assessed)		E - verified extent (viability not assessed)	
Surveyor	1) Olfelt, D.; 2) Rosedahl, C. O., 3) ? 4) Morely, T., and J. Moriarity	Morley, T.	Waldhauser, S., K.P. Schmidt, M.R. Haworth	
Surveyor's Notes	1) "The plants were observed growing on more or less flat land, on bluff top above the s-facing slope. In grassy sedge opening under red oaks. 10 plants scattered in a 1/4-acre area. Not much potential habitat. The plants were not seen in degraded prairie opening on th s-facing slope below the collection site".	"Small example of gravel prairie on upper slope of NW-facing ridge. Dom by Amorpha canescens and Stipa spartea, with overgrown oak grubs (bur & pin) that form individual groves or thickets. Other prairie plants are Orbia cor., Menarda fis., Apercynum and., Scorphularia lan, Koeleria, and Galeum bor. Grades into dry prairie (w/ Aster ser., and Coreopsis pal.) below. Prairie needs burning..."	"2008: A total of one specimen was found. Effort: 55 sec. 2002: One blue sucker collected by angling Miss R…in mid-October."	"Mounds Park vantage point. View of Miss R which flows in Glacial River Warren bedrock valley and drains 36,800 square miles upstream. Two more bedrock valleys visible, one to E, and other to NW just E of downtown St. Paul…"
	2) "The plant was observed growing on sandy hillsides, frequent near the fish hatchery"			
	3) "The plant was observed."			

	4) "312 plants were counted near... battle creek. 102 plants found in five main groups spread along 100 m of vegetated...sandstone bluff… Also around 210 plants found in shade on steep slope…"			

Table 2. Element occurrences of rare features within one mile of Willow Brook.

HISTORIC VEGETATION

According to Marschner's Map (a compilation of notes from the original public land surveys in the mid 1800's to the early 1900's), the historic vegetation of the site consisted of two main types: "big woods" and wet prairie. Big woods refers to the eastern deciduous forest cover type, dominated by large hardwoods—oak, maple, basswood, hickory, elm, etc.—which occupied most of the eastern US and extended as far west to Minnesota, roughly coinciding with the Mississippi River Valley. The northern part of the Willow Brook site, according to Marschner's map, was Big Woods (**Figure 7**). Wet prairie is an open, mostly treeless community dominated by shrubs, grasses, sedges, forbs and ferns, where the water table is at or just below the surface of the ground. Marschner's map also shows that the southern portions of the Willow Brook site was dominated by wet prairie. Please note that Marschner's map is a "coarse filter", and that, upon closer inspection, many other smaller units of other cover types may have been present, which is why field surveys are important, because they may discover these inclusions. For example, much of the northern part of the site is actually Black Ash Seepage Swamp and Cattail/Mixed Emergent Marsh, neither of which are either Big Woods or Wet Prairie.

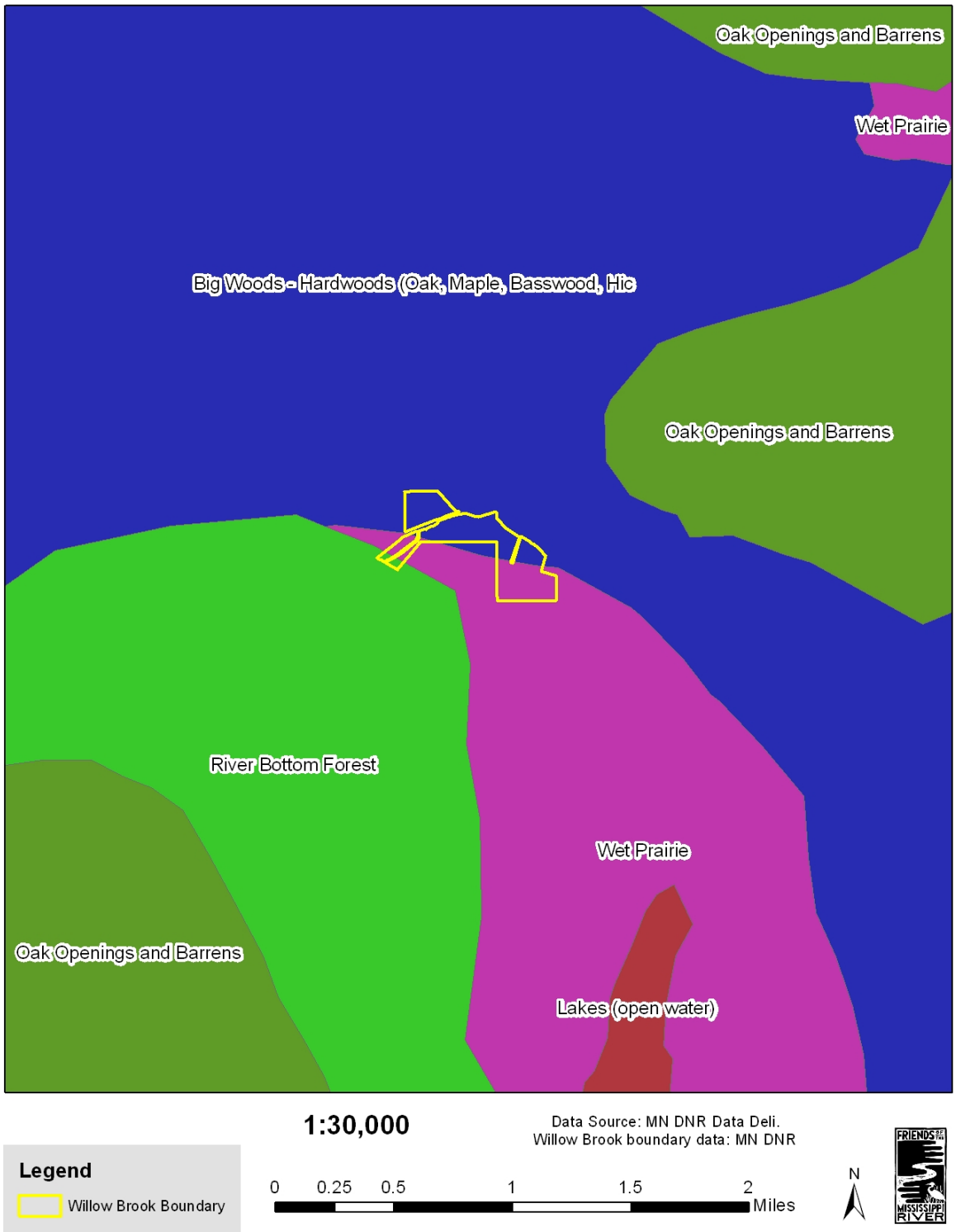


Figure 7. Pre-settlement vegetation of the vicinity surrounding Willow Brook.

HISTORIC AND EXISTING LAND USE

Historically, this site was used for many purposes. Before the formation of the Department of Conservation in 1931, the site was used as a reservoir for drinking water, due to the numerous seeps that occurred there. The hatchery was started in 1870s (**Appendix F**) and by the 1890's it had become a tourist destination with formal gardens, picnic areas and a small zoo. There was an expansion in 1907. In terms of surrounding land use, the area on the north side of Warner had more developed recreation features, including a ski jump, toboggan run and picnic areas.

Some clues to landuse in the 20th Century come from historic aerial photos. **Figures 8, 9, 10, and 11** show historic aerials from the following dates: 1923, 1937, 1940, and 1957. **Figure 12** is from 2012, for comparison. These photos reveal a number of interesting things. In 1923, one of the most striking things is that there is no lake on the southeast part of the property. The signature of this area in 1923, 1937, and 1940 was that of a marsh, wet meadow, or wet prairie. This rather agrees with Marschner's map, which designates this area as wet prairie, not open water, at this location, pre-settlement. The lake formed later, after a huge influx of surface water was shunted to this site from up-watershed (from the Phalen Lake area to the north). Also, the large increase in impervious surfaces (buildings, roads, railways, parking lots, etc.) and loss of local wetlands would have increased surface runoff. This is dramatically illustrated as seen by the formation of this lake, called "Little Pig's Eye", which appears to have started forming some time in the 1930's. By 1937 (**Figure 9**), a small area of open water has formed south of the site, and in 1940 (**Figure 10**) it was about the same size. By 1957 (**Figure 11**), the upper part of the lake had penetrated into the southern end of the site. Compare this to the current situation (**Figure 12**), in which the lake occupies about 1.5 acres of the southern portion of the site.

Other interesting points from the historical aerial photos include:

- As far back as 1923, just south of the site, the railway lines were in place, as well as the terminus (roundhouse area). This area was changed to a large parking lot for new cars and trucks sometime after 1957.
- The upland, forested portions of the site were much more open in the past than they are today. In 1923, 1937, and 1940, there is much more space between trees visible, but in 1957 the spaces have become progressively more filled in, and by 2012, the forested areas are completely closed.
- Prior to 1940, the fish hatchery structures did not exist. They were built between 1937 and 1940. Today they no longer exist, except for one on the north side of Warner Road.
- In 1940 there was a double-lane road where Interstate 94 was going to be built, but it had not yet been built. By 1957, the freeway shows up. This perhaps had a significant impact on the Willow Brook site, in that it may have been an access route for construction equipment or a staging area or a dumping area for construction materials. The southern and southeastern

portions of the site were highly disturbed. Also, the field adjacent and south of the site was a Superfund site.

- The DNR Headquarters buildings did not get constructed until after 1957.
- The trail that traverses the northern half of the property (east-west orientation), existed back as far as 1923. It may have been a farm road.
- The large stream that runs eastward through the southern part of the property did not exist until after 1957.
- Major home and street building occurred between 1940 and 1957, which impacted the site.
-

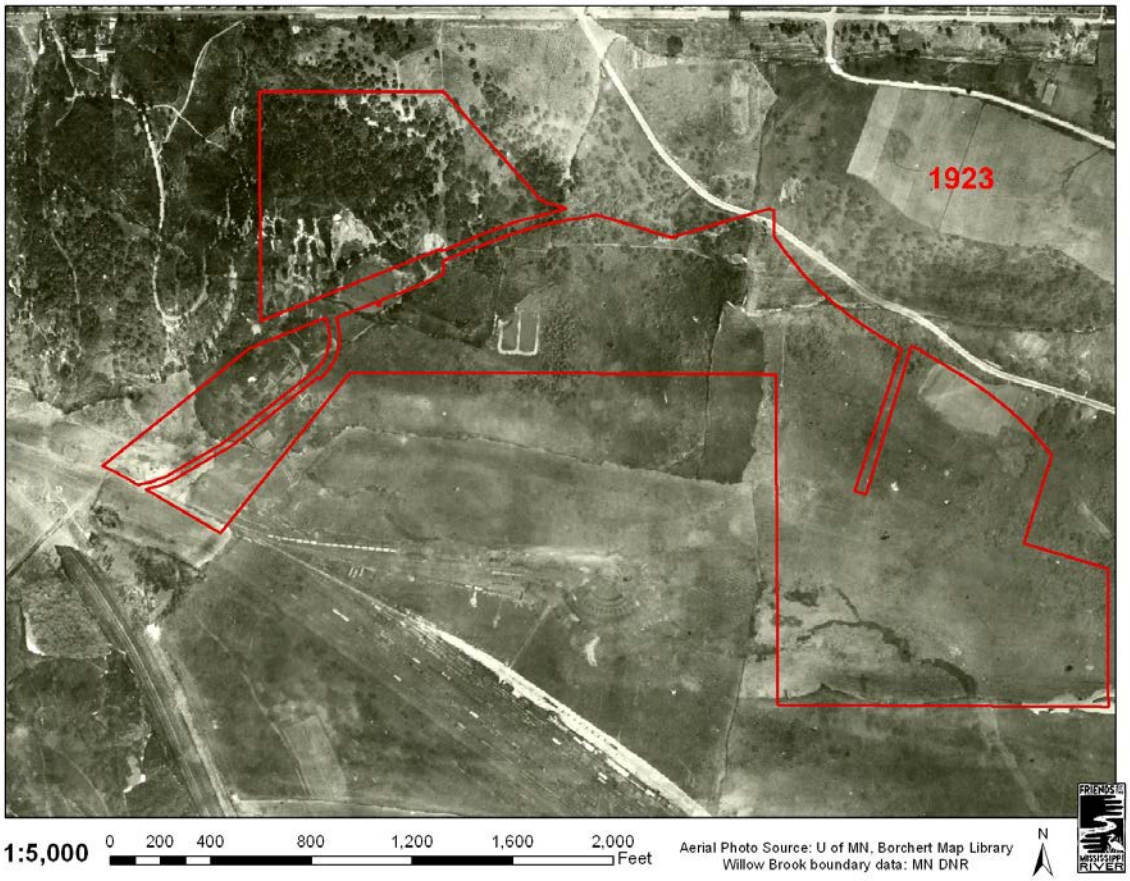


Figure 8. 1923 historical aerial photo of Willow Brook.

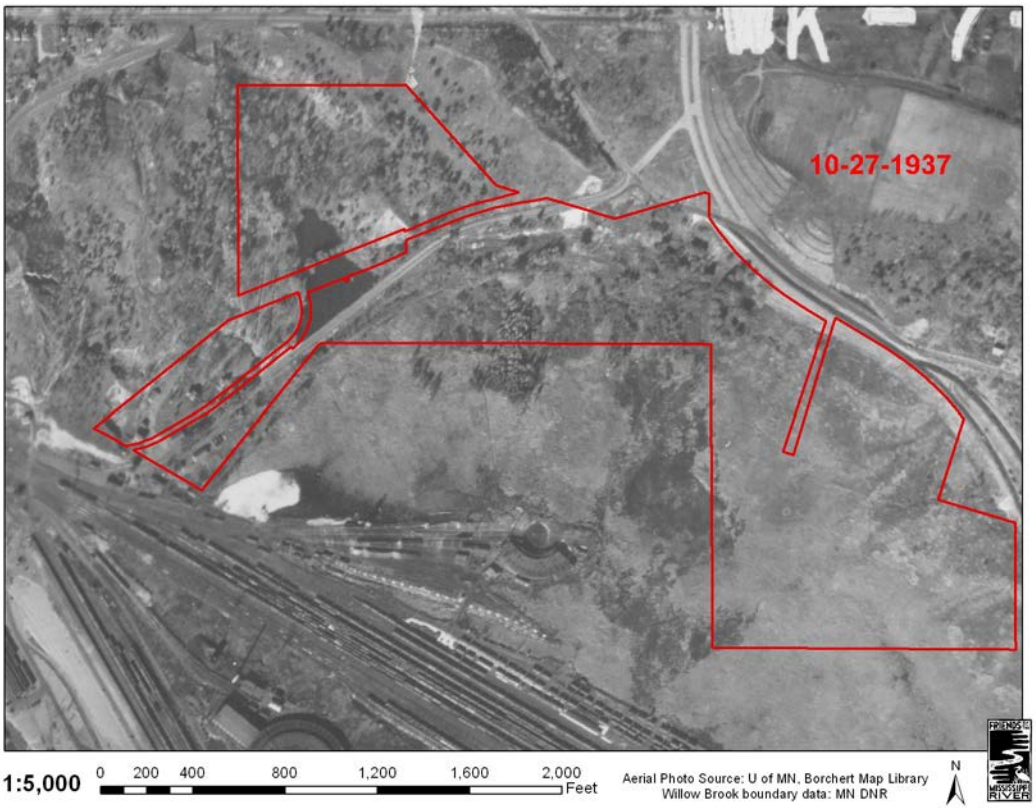


Figure 9. 1937 historical aerial photo of Willow Brook.

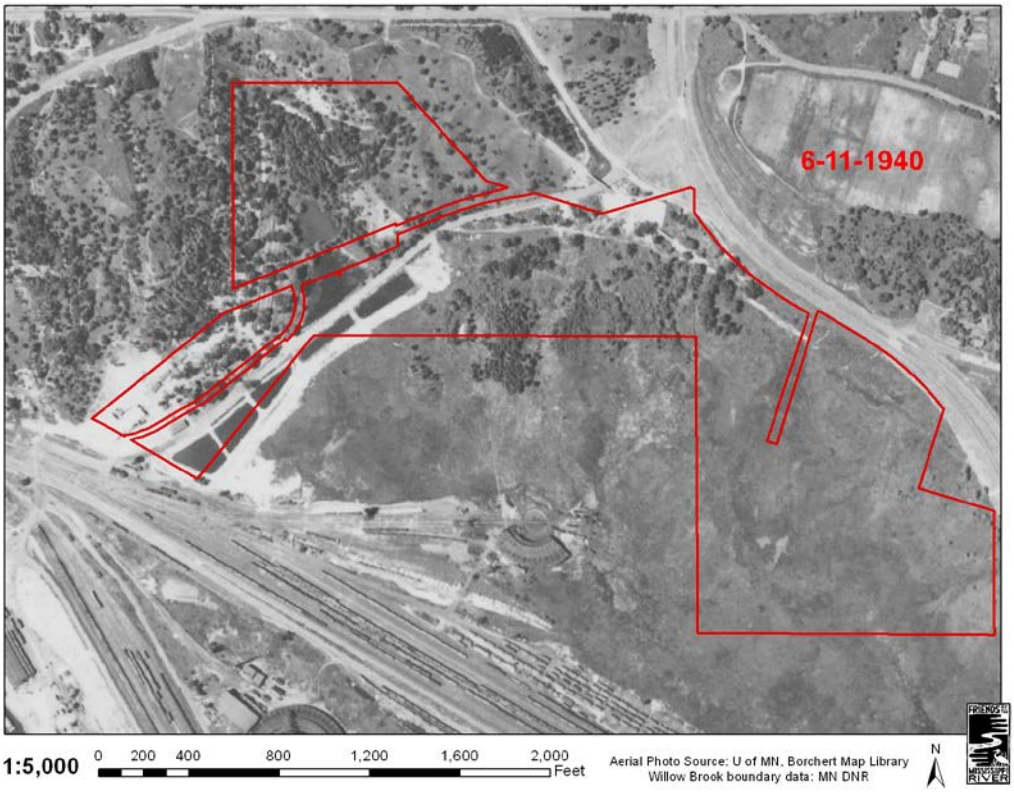


Figure 10. 1940 historical aerial photo of Willow Brook.

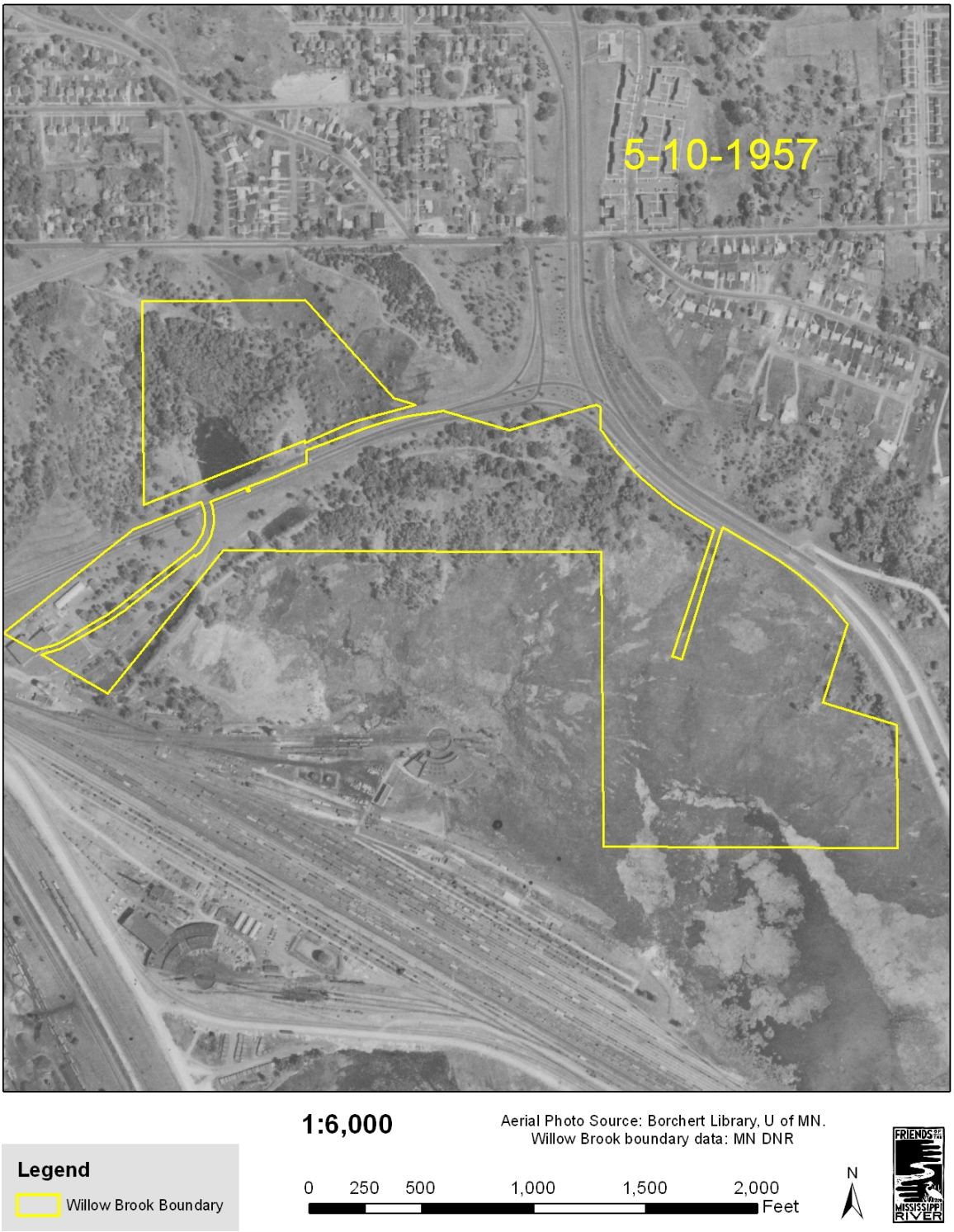


Figure 11. 1957 historical aerial photo of Willow Brook.

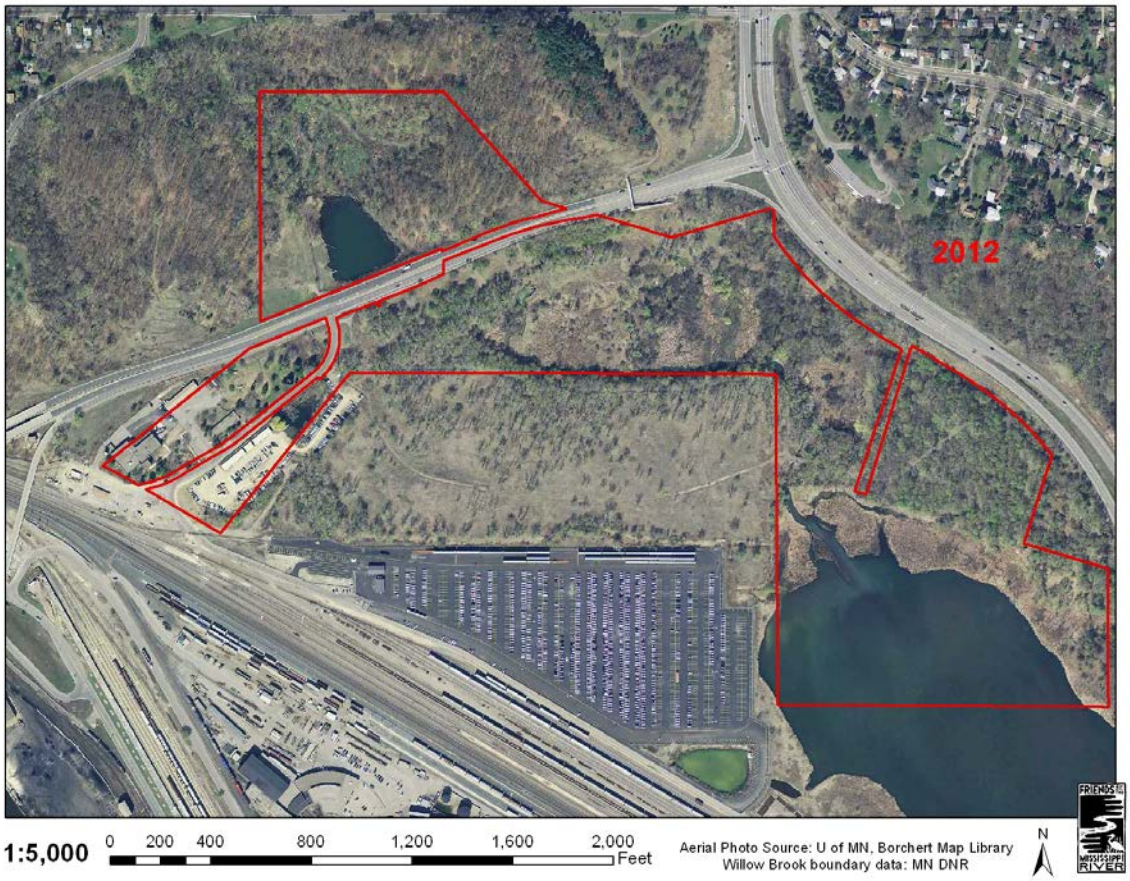


Figure 12. 2012 aerial photo of Willow Brook.

WATER RESOURCES

Surface Waters (Lakes, Streams, Rivers, Wetlands, etc.)

Seeps and Rivulets

There are numerous seeps along the north side of the property. There is a large on north of the Fish Hatchery Pond. This one had been "reinforced" with concrete and brick, at some time in the past (Photo 2). Other seeps occur all along the south side of the northern part of the parcel located just south of Warner Road and Highway 61. Seeps emanate slowly at the base or just down from the base of the slopes. They

Photo 2. "Source" of seep at north end of Mixed Hardwood Swamp-1 unit, with concrete blocks, supposedly constructed to support it.

gradually get larger and faster, forming rivulets that meander southward. They really never conglomerate into larger level streams, however, but sort of fan out across the marsh/seepage swamp basin. Groundwater flows continuously through seepage areas with cold water (DNR Field Guide, 2005).

Streams

There are several mid-sized streams that cut through the portion of the property located south of Warner Road and Highway 61. They are the result of artificially diverted/piped stormwater from up-watershed. They initially flow from north to south, but then turn towards the east, until the water reaches Little Pig's Eye Lake, where they pool. The large force of water that is discharged from inlet pipes is substantial, and has resulted in a good deal of erosion. Side slopes of streambanks are actively eroding, in many spots, especially at their heads, throughout the property (Photos 3 and 4). Larger streams like these probably did not occur historically on this site. The use of rip rap and other stabilizing methods is evident (Photo 5), but, generally, the force of discharge is greater than the streams can handle, and perhaps "bio-engineering" solutions should be investigated and identified to reduce erosion and sedimentation, for example installation of live stakes, fascines, wattles, brush mattresses, etc..

Photo 3. Severe bank erosion on stream that emanates from Beltway Pool in LHF-1.

Photo 4. Another stream eroding. This one is located in the Floodplain Forest unit southwest of the Mixed Emergent Marsh Seasonally Flooded unit.

Photo 5. Inlet pipe with rip rap located at northwest end of LHF-2 unit. Slope in background is the berm from Highway 61.

Ponds

There were two ponds on the property, a small one that was constructed as part of the Beltway, which was located at the west end of the Cattail Marsh unit, and a large one which was located to the north of Warner Road—the Fish Hatchery Pond. The small one was a collector and settling pond for stormwater entering the site from upwatershed. It was very murky and tinted a bluish-grayish color (Photo 6). The Fish Hatchery Pond had a chain link fence surrounding it (Photo 7). The origin of this pond is uncertain, but it is probably fed by the seepage areas that abut it to the north, where cool, fresh groundwater, must be continuously fed to sustain it (**Appendix F**). This pond was probably dredged so that water would pool in its basin.. Whether fish are still hatched here is not known to the FMR Ecologist.

Photo 6. Small settling pond located at the west end of the Cattail Marsh unit.

Photo 7. Fish Hatchery Pond, view looking north from Warner Road.

Lakes

One lake occurs on the far south and east end of the property—Little Pig's Eye Lake (Photo 8). As was stated previously, this lake did not occur historically. Rather, a large expansive natural wetland (sedge meadow/seepage meadow/wet prairie) occupied this area. This is a shallow lake, with a dense growth of aquatic plants. The margins of the lake are dominated by emergent and transitional hydrophytic vegetation. The lake does contain common carp (observed by FMR Ecologist) and may contain other species of fish, so it is probably not a great spawning area for frogs, although the FMR Ecologist heard green frogs (*Rana clamitans*) during the field survey (June 2014). Green frog males set up

Photo 8. View of Little Pigs Eye lake in the distance, with sedge meadow in the foreground.

territories in permanent bodies of water: shallow water lakes, ponds, ditches, or streams.

Typically, the lake bottom and margins of the lake are filled with several feet of loose sediment. Much sediment must enter this basin from the up-watershed stormwater influx and from runoff from roads.

Wetlands

According to the National Wetland Inventory (NWI), just under half, approximately 32 acres, of the area of Willow Brook is covered by wetlands (**Figure 13**). This is an under-estimate, however, since we know there are several additional areas and more expanded existing areas that actually contain wetland, for instance the seepage swamp north of the Fish Hatchery Pond (which is about 3.5 acres). Thus, a more accurate estimate would be more around 38 acres, which is actually more than half of the site. Also, considering that it is possible that a large part of the former dump was wetland prior to being filled, this number would have been even greater in the past. Also consider that the 13 acres of Little Pigs Eye Lake would have been emergent wetland, not a permanently flooded, lacustrine, limnetic wetland.

A summary of wetland types is given in **Table 3**.

NWI Classification Code	Acres	NWI System	NWI Class	NWI Modifier: Water Regime
U	38	Upland		
PUBG	1.5	Palustrine	Unconsolidated bottom	Intermittently Exposed
PFO1/EMC	9	Palustrine	Forested/Emergent	Seasonally flooded
PEMF	6	Palustrine	Emergent	Semi-permanently flooded
PEMC	2.5	Palustrine	Emergent	Seasonally flooded
L1UBH	13	Lacustrine, limnetic	Unconsolidated bottom	Permanently flooded
Total	70			

Table 3. Summary of wetlands and there characteristics for Willow Brook.

Figure 13. National Wetland Inventory map with expanded wetland areas (inserted by FMR Ecologist) in blue.

Groundwater Recharge or Infiltration Areas

Given the position at the bottom of the bluff and other evidence of water behavior in the area, this site is probably primarily a groundwater discharge area, though some recharge could occur (communication with Joe Richter, DNR Hydrologist, June 2014).

Stormwater Management Issues

Increased stormwater runoff is a major issue for this site. It causes streams to erode their banks, increased hydrology during almost all times of the year, increased "flashiness" of the streams, and transports propagules of invasive species and contaminants into the site. So much water is piped here, that a lake has formed (Little Pigs Eye Lake) at the south end of the site, which was not present in the oldest historical aerial photos (1920's and 1930's).

Ecological Threats

Increased hydrology from up-watershed, stormwater runoff. This has been addressed in previous sections.

High potential for groundwater contamination. Although this has also been previously addressed in this document, it may be useful to know the extent of the dump site and how that may effect groundwater. **Figure 14** shows an approximation of the extent of former dump site at the property, based on a remedial investigation report by WCEC from 2013. According to recent findings

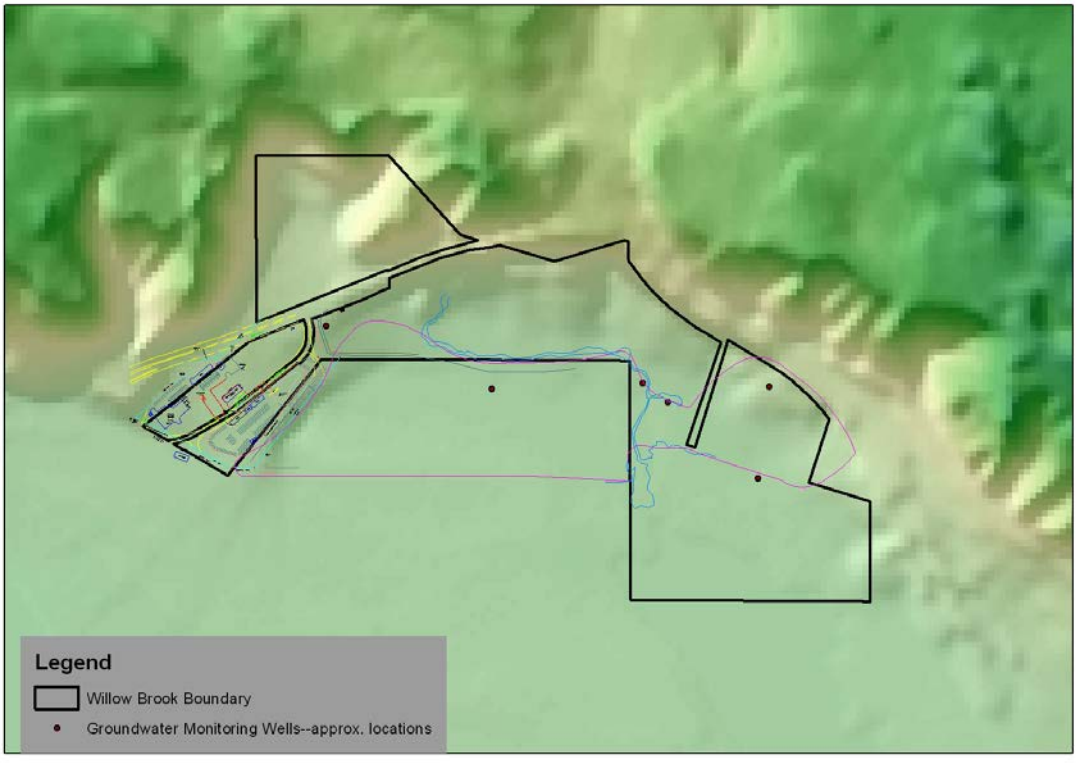


Figure 14. The pink line in the map shows the approximate extent of the dump site. (Data provided by DNR Central Region staff.)

in a study conducted by the USGS between 2009 and 2012 (Erickson, M, et. al., 2014), although no regularly tested chemicals exceeded water quality standards, several "emerging" chemicals are finding their way into groundwater from a variety of sources, including domestic, commercial, and industrial wastewater systems, stormwater runoff, leaking municipal sewer lines, agricultural runoff, and landfills. Four of the most common emerging chemicals found were the antibiotic azithromycin, the antihistamine diphenhydramine, the flame-retardant tributyl phosphate, and the animal antibiotic lincomycin, of which neither the state nor the federal government maintains any health-based water quality standards. One chemical, bisphenol-A, used in making hard plastic bottles and other consumer products, was present mostly in wells near *closed landfills*. The dump site at Willow Brook is being monitored via six groundwater monitoring wells, five of which are located on the property, and one is nearby to the south (**Figure 14**).

Past disturbance has altered and disrupted some native communities. Dumping, railroad activities, and construction activities have caused soil alterations and also driven down biodiversity of some of the natural communities, especially those located on the former dump sites. Restoration will be difficult and possibly prohibitive in certain areas (Lowland Hardwood Forest) because of this.

Hydrological changes due to natural factors = beavers. Beavers have constructed dams, in the recent past, that have flooded the low lying marsh and resulted in mortality of most of the tamarack trees that used to grow there. It is possible that beavers could make dams in the future, again flooding out trees and shrubs planted for restoration.

Nutrient Excess

Due to the influx of sediments to the basins of this seepage area, it is expected to have a nutrient excess for phosphorous. Phosphorous builds up in sediments, because it binds and is not mobile. Nitrogen leaches out. Perhaps testing the sediments for P would be beneficial. It is well known that reed canary grass and hybrid cattail flourish in high-nutrient soils, and these two species are dominant, along with Phragmites, at Willow Brook.

Introduced invasive species are now a big problem for many of the natural communities on the site. There are many introduced plant species that occur throughout the site. The most problematic ones are those that form dense mats or monocultures, excluding most other plants that formerly occupied the space, and thus driving down overall bio-diversity of the site. Examples of the most problematic invasive exotic plant species on the site are giant reed grass, reed canary grass, hybrid cattail, garlic mustard, common buckthorn, and purple loosestrife. Others could become problematic in the future (for example, crown vetch, if it starts to spread onto the upland areas from the bermed regions adjacent to highways at the northern and eastern boundaries of the site). Specific information about how to control these invasive plant species will be given in subsequent sections of this document.

ADJACENT LAND USE

Ecological Isolation

This site is rather isolated, in that it is surrounded by roadways/railways (**Figure 15**). To the north and west is Warner Road, to the east is Highway 61, and to the south is the railroad. Although it is near (about 2000 feet from) the Mississippi River and (about a mile from) Pigs Eye Lake, the site is effectively cut off from land travel to these natural features by the railroad and the highways. Animals (for example birds) and plants that have other dispersal mechanisms will not be as hindered as those that depend more on land travel (for example turtles, snakes, and skippers). On the flip side of this issue, because they are isolated, it is important to conserve the remnant seepage communities and sedge meadow communities at this property.

Roadways and Contamination Issues

Salt spray and salt solution entering from runoff, and other contaminants from the adjacent highways and roadways, will impact the flora and fauna of this site. Sound pollution is also a factor, from nearby roads and railroads. Holman Airfield is also a potential contributor to noise pollution. Water pollution, and to a lesser extent, air pollution are potential threats to the biota of this site.

Invasive Species

As long as there are intact populations adjacent to the site or influx of stormwater into the site from contaminated areas, the invasive marsh plants hybrid cattail (*Typha x-glauca*) and common or giant reed grass (*Phragmites australis*) will be a continual threat to the site. No populations have been observed north of Warner Road, though. Buckthorn and garlic mustard are very well established in upland areas outside of the site, also. Other exotic invasive species to watch are crown vetch, glossy buckthorn, leafy spurge, Canada thistle, and common burdock. Because the site is rather long and narrow, there is a significant amount of "edge", which exacerbates the difficulty of managing invasive species. Keeping the site free of these very invasive plants will be an ongoing challenge. The section called "Management Recommendations" has more information on this subject.

Adjacent Land Ownership

The City of St. Paul owns some of the parcels that abut the Willow Brook property. Most notable among these are the Indian Mounds Park parcels to the north of the site. Mounds Park has a management plan that was written by Great River Greening in 2007 (Tix, Daniel, F. Harris, H. Johnson, and T. Newhouse, 2007), which the City follows to manage the park's natural resources. It is recommended to work in conjunction with the City and with their management plan for the park. **Appendix G** shows a map of planned restoration work for Mounds Park near the Hatchery Pond. For instance, coordination of prescribed burns would be advantageous and cost effective, and benefit both properties. Another parcel that the City owns adjacent to the far eastern and southern end of Willow Brook contains a high quality

seepage meadow community that is contiguous with some high quality wet prairie and seepage communities at that end of Willow Brook, and coordination of management activities is highly recommended also.

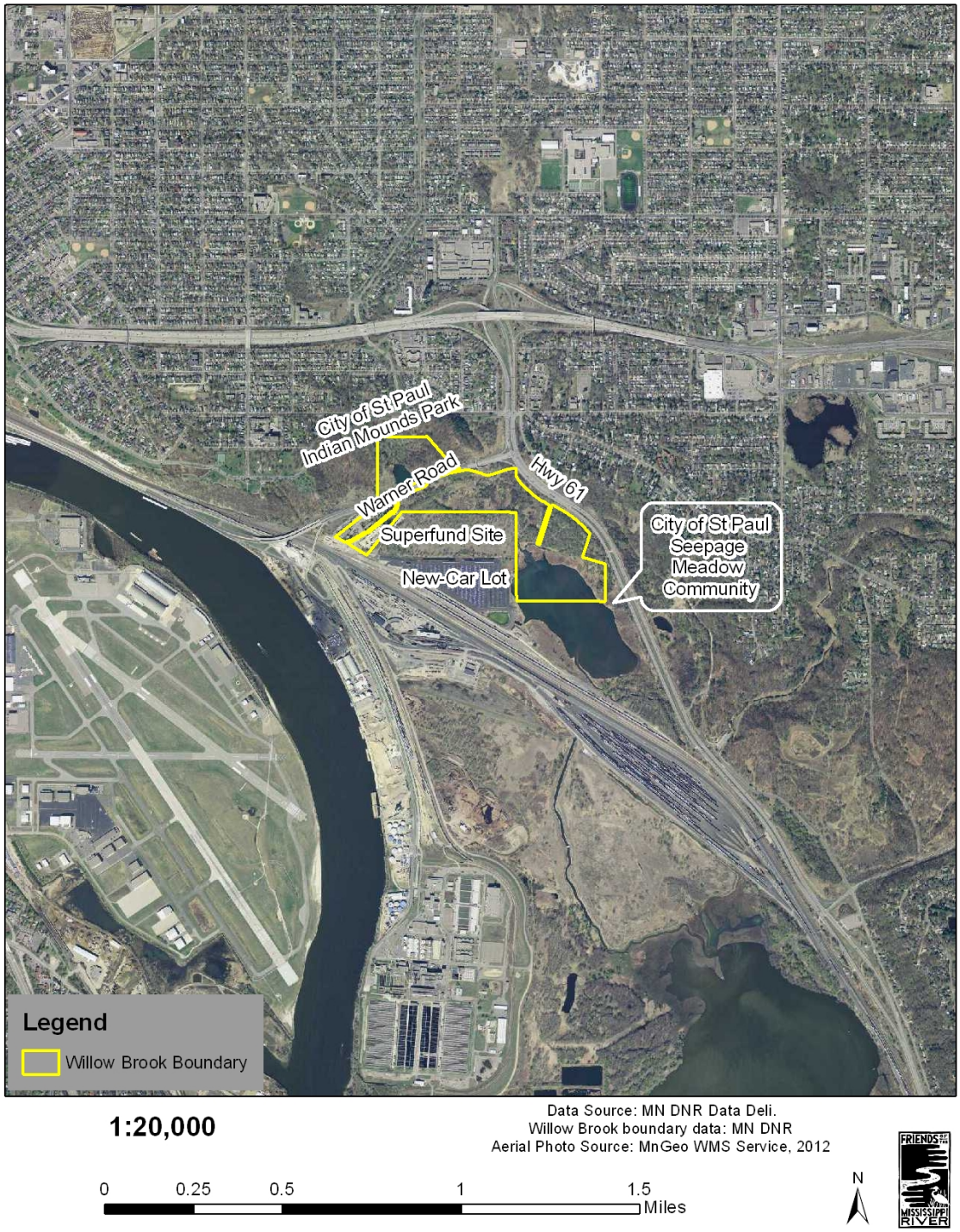


Figure 15. Adjacent Landuse to Willow Brook site.

EXISTING LAND COVER & ECOLOGICAL MANAGEMENT RECOMMENDATIONS

The following are descriptions of the various cover types, found on the property. The cover types were described and designated by Minnesota Land Cover Classification System (MLCCS). Some of the cover types were re-designated to a more appropriate type than was designated by MLCCS. For the most part, the MLCCS was quite accurate, so this was not much of an issue, though. The cover types were then arranged in order of size of area, with the largest cover types listed first and the smallest listed last. Cover types may be represented by multiple units of the same cover type (e.g. Mixed Hardwood Swamp = Mx-Hrdwd-Swmp-1 and Mx-Hrdwd-Swmp-2). Please refer primarily to **Figure 16** (Existing Landcover Map) throughout this section.

The site will be roughly divided into upland areas in the north of the property and wetland areas in the south and middle of the property. Between these two were transitional areas of lowland hardwood forest. The site was mixed with areas that were relatively high quality remnants and areas that were very altered and disrupted. The upper areas were forested or were altered by road construction; some were formerly woodlands and savannas and some were probably former wetlands that have been filled. Most of the wetland areas were dominated by cattail/reedgrass marsh, with seepage swamps and sedge meadows punctuating the wetlands, with streams that cut through the wetlands. The middle 10 acres of the property consist primarily of a large cattail marsh, punctuated by areas of upland (that have been recently cleared of exotic woody brush). There are a handful of tamaracks still surviving there, but many more are dead-standing (having died within the past three to five years). One wetland, the seepage swamp north of the Fish Hatchery Pond, had no populations of cattail/reedgrass, but was heavily infested with reed canary grass on its margins. The far south and east portion of the property is occuppied by limnetic open water, which is rimmed with marshes and sedge meadows.

Lowland hardwood forest (LHF) occupied a large portion of the middle and southern parts of the property. One of the LHF units (LHF-2) covered the former dump site. The LHF units were heavily infested with garlic mustard. Oak forest and woodland (that had been recently cleared of exotic woody brush) occupied the area north of the seepage swamp on the north side of the property near the fish hatchery pond. On the south side of the property there was a remnant oak woodland (formerly savanna). A single, very old bur oak tree was found at the extreme southeast corner of the property, surrounded by buckthorn forest and then by wet prairie/seepage meadow wetlands, some of which were high quality.

Figure 16. Existing landcover at Willow Brook.

Lowland Hardwood Forest (LFH-1, LFH-2) (19.2 ac)

Though it may not contain a very high quality community, this cover type functions as a buffer for the higher quality marsh and seepage swamps communities on the property.

LHF-1 (8.4 ac)

The canopy was continuous to interrupted. The largest trees in the canopy were Eastern Cottonwoods, but even they were not old-growth. The majority (70%) of the canopy consisted of small to medium sized boxelders (Photo 10), with a smattering of American elm, green ash, hackberry, and scattered patches of black locust (exotic to MN). The shrub layer was very sparse, since buckthorn had been removed recently, with only a few scattered chokecherry and elderberries. Ground layer was interrupted to sparse, and quite patchy, and was strongly dominated by garlic mustard. Despite this, the FMR Ecologist observed several bird species using this area, during the field visit, including American redstart, Baltimore oriole, yellow-rumped warbler, catbird, northern cardinal, American robin, black-capped chickadee, yellow warbler, and red-eyed vireo.

Photo 9. View of LHF-1.

Photo 10. Grove of young boxelder on Warner Road berm.

LHF-2 unit (10.84 ac)

Located over the former dump site, it had a very uneven, irregular shape to the soil surface throughout this unit, which is an artifact of the dumping and fill that underlies the unit. The canopy was 60-70% total cover, consisting of about 80% boxelder (approximately 30-40 years old), and the rest included American elm, Siberian elm, Black locust, and green ash. The shrub layer covered about 40-50% and consisted primarily of buckthorn (70%), but Tartarian honeysuckle, red elderberry, and chokecherry were present too. This unit is probably one of the lowest priority of the entire property, since it will take many years before the soil and topography reach equilibrium. Nevertheless, it still may serve as habitat for forest birds, insects and mammals and provides a buffer to the wetlands from Highway 61. Leakage from the dump material into groundwater may be an issue. There were a few monitoring wells located within this unit.

MANAGEMENT RECOMMENDATIONS:
Canopy Layer:

- LHF-1:
    - Thin out boxelder. Perhaps remove approximately every third tree. This will open up the ground to light, which may help promote cottonwood regeneration. There were masses of cottonwood seeds littering the ground, but no regeneration of seedlings anywhere—probably too shady.
    - Plant a diversity of Wet-Mesic Forest tree species in canopy gaps to replace boxelder and buckthorn.

Shrub Layer:

- LFH-1:
    - Continue to monitor for buckthorn and control seedlings and resprouts via mowing, hand-pulling, and foliar basal bark herbicide applications in fall.
    - Plant a diversity of Terrace Forest shrub species in canopy gaps to replace boxelder and buckthorn.

Ground Layer:

- Do not attempt to restore ground layer until a bio-control for garlic mustard has been developed, which is imminent (Becker, R., et. al., 2013). Once a bio-control is on the market, then release it as soon as possible.
- Once the garlic mustard comes under control (reduction down to 25% cover or less):
    - seed with a diverse mix of Terrace Forest forbs, grasses, and sedges.
    - Plant ferns for diversity, if so desired.
    - This is not a fire-dependent community, so burning is not necessary, but if the edges burn, near adjacent burn units, that could be beneficial. It is generally a good thing not to have "hard edges", so mixing of adjacent community types is desired.

Cattail Marsh (1.8 ac), Altered Seasonally Flooded Shrubland (1.29 ac), Mixed Emergent Marsh Seasonally Flooded (1.23 ac), and Mixed Emergent Marsh (Mx-Em-Marsh-1 [3.64 ac], Mx-Em-Marsh-2 [6.29 ac] (total = 14.3 ac)

The Cattail Marsh, Altered Seasonally Flooded Shrubland, and Mixed Emergent Marsh-1 units consisted of, more or less, one, large, contiguous marsh throughout the middle portion of the property. The other units were very similar in structure and composition, but were separate. Some of the marsh units were identified by MLCCS as "seasonally flooded" and some were not. One unit was identified as having "shrubland", which was truer prior to buckthorn removal, but it did have many of the tamarack trees within its boundaries.

<u>Cattail Marsh Unit</u>
The dominant plant of the marsh units was hybrid cattail, *Typha x-glauca*. In fact, approximately 60-80% of the cover was dominated by hybrid cattail (Photo 11). Hybrid cattail is a hybrid of "broad-leaved cattail", a native (*T. latifolia),* and

"narrow-leaved cattail", an exotic (*T. angustifolia).* Hybrid cattail has inherited the most aggressive characteristics of both parents: high growth rate from long, rhizomatous shoots, from the native parent, and tall-height plus a tendency to form dense thickets, from the non-native parent. When hybrid cattail infests wetland areas it typically suppresses most all other plants.

Photo 11. Cattail marsh. The hybrid cattails are the straw-colored, clonal colony in the center of the photo.

Photo 12. Mx-Em-Marsh-2 unit. Note the Phragmites colonies on the right in foreground and in the left background.

Much of what was now occupied by cattail/reedgrass marsh had formerly been occupied by other types of communities before the cattails and reedgrass invaded. These former communities were likely the following: tamarack bog (located in the center and north center of the marsh), seepage swamp or seepage meadow, sedge meadow, and "horsetail" meadow (scattered throughout the marsh on the borders between upland and bog/swamp), and wet prairie (at the southeastern reaches of the property). Today, all of the "marsh" units look quite similar, due to the advent of *Typha* and *Phragmites*, giving the landscape a superficial homogeneity.

Photo 14. In the foreground, an area where buckthorn was recently cleared. Compare the difference in vegetation to that of the cattail clone in the background. Cattails are starting to invade into the foreground of the photo.

Giant reedgrass, *Phragmites australis* (Photo 12), is actually one species of plants that can compete with, and actually out-compete, hybrid cattail, since it grows taller and forms an even denser mat of roots than cattails. The species of reedgrass found on this site was the exotic one, not the native one. Giant reedgrass was not as extensive at this site as hybrid cattail was, but appears to be increasing its range here. Monitoring of the size and extent of reedgrass populations should be performed, to identify for sure whether reedgrass populations are expanding or not.

Although suppressed, the marsh units contained many other plant species besides these two aggressive/invasive species. In areas that were on edges of uplands, or where buckthorn had been formerly dominant, native plants seemed to flourish most abundantly (Photo 13). In fact, it appeared that where buckthorn had been recently removed, *Typha* was just starting to invade, with small leaves just emerging into a bed of diverse natives. It may be that not only light conditions but also moisture conditions become more favorable (sunnier and wetter) for *Typha* once woody vegetation is removed (since trees and shrubs lower hydrology levels due to increased levels of evapotranspiration). Thus, control of *Typha,* and also of *Phragmites* will be necessary following woody brush removal.

Examples of the suppression of native plants by *Typha* and *Phragmites* can be seen when the culms and leaves of the larger plants are pushed back out of the way. In those instances, a few natives can be found, even under the dense cover of the *Typha* and/or *Phragmites* (Photo 13). If the suppressing influence of *Typha* and *Phragmites* were to be alleviated, the natives may recover. Some of the native species commonly encountered in this unit were marsh marigold, skunk cabbage, lake sedge, tussock sedge, jewel weed, solomon's seal, joe-pye weed, great water dock, little blue violets, dewberry, fowl bluegrass, tall meadow rue, and boneset. The abundance of marsh marigold and skunk cabbage indicates that the majority of the marsh units were formerly black ash seepage swamps.

Photo 13. A marsh marigold plant surviving beneath a canopy of hybrid cattails in the Cattail Marsh.

Photo 14. Rusty-brown substance in seep source area, at western end of Cattail Marsh.

The heads of rivulets and small streams were *seepage areas*. One of these, at the west end of the Cattail Marsh unit, was very wet, with probably a constant flow of cold water. Water emerged at the surface and flowed slowly underneath the surface. A rusty-brown, oily substance floating over the surface of the water was present. The vegetation here was short, and not too dominated by cattails or RCG. Vegetation consisted primarily of small parsleys, jewel weed, with many patches of marsh marigold, horsetails, Carex sedges, and scattered

red dogwood shrubs. Also present were cow parsnip, black raspberry, and a single skunk cabbage plant. Skunk cabbage became gradually more abundant eastward, with large patches of it found around the middle and eastern end of the unit, and also small patches scattered throughout the marsh, underneath the canopy of cattail and reedgrass leaves.

At the west end of the Cattail Marsh landcover unit, there was a pond inside a large concrete inlet structure (Photo 6). This is part of the "beltway", a major pipe for stormwater that flows into and through the north end of the site, and is managed by the Ramsey-Washington Watershed District (RWMD). The water in this pond was cloudy, with a bluish-gray color. It spilled out onto a rocky creek—the rocks had been placed artificially. The creek was higher than the surrounding marsh, which indicates that perhaps fill had been added during construction. There was much erosion on the creek banks, with a nearly vertical, four-foot high bank. Reed canary grass lined the banks, and the exotic forb "absinthe wormwood", as well as black locust trees were abundantly growing here—another indication of alteration and disruption. Not much can be done for it, besides possibly stabilizing the eroding banks to reduce downstream sedimentation.


Photo 15. Shallow rivulet lined with sedges and reed canary grass, and bedded with watercress.

<u>Small streams and rivulets</u>
Small streams and rivulets were shallow, meandering, with cold, clear water. They were almost always lined and bedded with watercress, an exotic herb (Photo 15). Larger streams did not seem to have watercress, which may require cold, steady, continuously running yet meandering water that is provided by seepage rivulets, over the flashy, temperature-variable, entrenched water provided by larger streams fed by stormwater inlets. The watercress did not appear to be causing any ecological problems, however, so no action is probably required to control it. Sedges and RCG dominated the banks, with some forbs and shrubs also present.


Photo 16. Upland extension into marsh.

<u>Seasonally Flooded Shrubland</u>
Not every square foot of area within this cover type was actually saturated marsh. There were several "upland arms" or "fingers" that extended into and sometimes all the way through the marsh (Photo 16). Also, there were several scattered patches of

woody vegetation, variously dominated by buckthorn, boxelder, and green ash. It's possible that these "arm", "fingers", and "islands" may fluctuate between being saturated and not saturated, from year to year, depending on rainfall, which influences water table heights, etc. The mosaic of upland and wetland hydrology and vegetation is generally beneficial, because it provides a more heterogeneous and diverse pattern of vegetation, which benefits and increases the diversity of wildlife habitats.

The nature of the marsh has changed considerably in areas where buckthorn has been removed (which happened during the fall and winter of 2012-13—see map in **Appendix H**). Areas that were once quite infested by common buckthorn have been released, and native marsh and seepage swamp vegetation is recovering. This is quite evident in the Flooded Shrubland unit, with many stumps of former buckthorn shrubs still present. It is also very evident in other similar landcover units, such as the Mixed Hardwood Swamp-2 unit. Some of the more disturbed areas have residual weedy forbs, such as common burdock, Canada thistle, garlic mustard, reed canary grass, etc., which will need to be controlled in subsequent phases of restoration. The important thing is to give the natives a chance to recover.


Photo 16. Tamaracks, living and dead, in "southern population".

Other woody vegetation, besides those already mentioned, that was found in the marsh units, were typically species that have adapted to wet and saturated soil conditions, such as tamarack, green ash, willows, red dogwood, highbush cranberry, American and red currant. Most of the tamarack in the "southern population" (Cattail Marsh, Flooded Shrubland, and Mixed Emergent Marsh-1 units) had died, with only two remaining alive at the time of the field survey. The "northern population" (Mixed Hardwood Swamp-1), had more living tamarack and only a couple of dead ones, but the area was not as large as the area that contained the Southern Population. There were only a few black ash in the Cattail Marsh unit, and these were small. Willows become densest at the eastern end of the Cattail Marsh unit.


Photo 17. Field of *Equisetum palustre* on upland margin of marsh.

Sedges and Horsetails

In transitional areas, between upland and wetland, there were extensive fields of *Equisetum* ("horsetails" and

"scouring rushes"). Two species were found: the shorter *Equisetum palustre* and the taller *E. fluviatile*. Violets, jewel weed, and giant goldenrod were associates with the horsetails.

In wetter transitional areas, often present were extensive to fragmented patches of sedges, dominated by "lake sedge" (*Carex lacustris*). Several other species of sedge were present also, one being tussock sedge (*Carex stricta*). Reed canary grass was consistently found occurring on the upland margins of the sedge patches.

Mixed Emergent Marsh Units

There were two Mixed Emergent Marsh units: unit-1 was in the middle of the property and bordered the stream to the south, and unit-2 was at the southeast end of the property and bordered Little Pig's Eye Lake. Both are long bands of marsh dominated by hybrid cattails, giant reedgrass, and reed canary grass.

Photo 18. Mixed Emergent Marsh-1, view looking eastward.

These units were nearly the same in composition and structure as that at the middle of the property, "cattail marsh—seasonally flooded". Large swaths of monocultural stands of *Typha*, *Phragmites*, and *Phalaris* (reed canary grass) occurred here, along with scattered nearly pure stands of lake sedge (*Carex lacustris*). Again, although many areas were dominated by one or two species, a diversity of native species were observed to be living under the canopy of the invasives.

Mixed Emergent Marsh-1

Mixed Emergent Marsh-1, colored pink on the map in **Figure 16**, contained soils that were wet, spongy, and soft. Hybrid cattails, with patches of giant reedgrass, dominated, but also present were sedges and tall forbs. Marsh marigold and skunk cabbage were also present. This unit was 98% open (few trees). Phragmites had not yet reached the western portion of the unit, but was at the center and eastern end. Many scattered shrubs were present. Two living tamarack trees occurred. Approximately 30 dead-standing tamaracks were present, towards the middle of the unit. The dead tamaracks had no bark, so have been dead for more than three years.

Photo 19. Community of rushes, duckweed and brown moss, pre-cattail invasion.

Along the western border of a dense stand of hybrid cattails was an interesting plant community, which was not yet invaded by cattails, probably because it had recently contained large buckthorn shrubs. Now, post-buckthorn removal, it revealed a diverse mix of species including horsetails, dewberry, lady fern, great water dock, American currant, jack-in-the-pulpit, bull thistle (exotic), and Canada goldenrod. This area should be closely monitored for invading Typha and for germinating buckthorn seedlings. There was also a slight depression in the soil surface, where there was a different sub-community of very small plants, dominated by rushes, sedges, and duckweed (Photo 19). A brown moss or algal mat was present just under the water's surface. This moss stained the fingers brown.


Photo 20. Patch of lake sedge in Mixed Emergent Marsh-2. Note Little Pigs Eye Lake in background. The shrubs lining the bank are false indigo bush.

Mixed Emergent Marsh-2

Mixed Emergent Marsh-2 had several large patches of lake sedge scattered throughout the unit (Photo 20) that was otherwise dominated by hybrid cattail, reedgrass, and RCG. The aerial photographic signature of a sedge patch and a Typha/Phragmites patch is slightly different. T/P looks very bright and light beige (straw-colored), whereas a sedge patch looks more bright green. Buckthorn thickets appear sort of a darker, smudged, grey-green color. Interestingly, a few of the sedge colonies had a patch of sensitive ferns at their center. They appeared to be less invaded by *Typha/Phragmites* than the seepage meadow communities were. It is recommended to study these sedge/fern patches to determine whether and why they might be able to repel invasion by *Typha/Phragmites*.


Photo 21. RCG-free "island" caused from fallen tree. Note the tall RCG in background.

There were large swathes dominated by reed canary grass. One spot was notably devoid of it, though, and here a diversity of natives occurred, including jewel weed, tall meadow rue, and joe pye weed, surrounded by a field of RCG (Photo 21). At first it seemed a mystery why this would be so, until upon further investigation a likely reason emerged: a large cottonwood tree had recently fallen on the spot, and must have smothered the RCG, allowing other species to flourish in its stead. This example gives us hope that, if RCG is

controlled, many native species should be released.

At the farthest eastern end of the Mixed Emergent Marsh-2 unit, there was a small remnant of wet prairie community. Perhaps this is a glimpse of what a large part of the area had been at one time, prior to being altered and disrupted. This plant community was very diverse, with the following species present: mountain mint, giant goldenrod, marsh fern, swamp thistle, boneset, joe pye weed, tall meadow rue, Galeum boreale, bristly crowfoot, Canada anemone, wild goldenglow, lake sedge, tussock sedge, bugleweed, angelica, culver's root, wild garlic, and swamp saxifrage. Adjacent to this remnant, to the north, in a slightly higher and drier spot (see Mixed Hardwood Swamp-Seasonally Flooded), was a large stand of "old growth" buckthorn, with some very large individuals. The buckthorn was expanding out into the wet prairie remnant. It is highly recommended to remove and control buckthorn here, to prevent it's spread into the high quality wet prairie remnant.

Photo 22. Wet Prairie remnant in the southeastern corner of the Mixed Emergent Marsh-2 unit. Note the large buckthorn scattered within this community.

Photo 23. Swamp saxifrage in wet prairie remnant.

Photo 24. Blueflag iris and broad-leaved cattail in sedge/seepage meadow on adjacent property owned by City of St. Paul.

Just beyond the eastern boundary of the property, on City of St. Paul land (parcel ID 032822420007), east of Mixed Emergent Marsh-2, was a high quality remnant of sedge meadow/seepage meadow. This community was a combination between a sedge meadow and a seepage swamp, with representatives of each type intermixed together. Present were blue flag iris, broad-leaved cattail, false indigo bush, lake sedge, tussock sedge, marsh marigold, jewelweed, bugleweed, etc. Also present was purple loosestrife

(exotic). Invading from the north and east was *Phragmites*. It is recommended to control the *Phragmites* and halt its invasion into this community.

Where incoming streams reach their mouth, at Little Pig's Eye Lake, their velocity slows and their sediment loads drop out, accumulating along the border of the marsh and the "lake". Sediments have built up as much as 10 to 14 inches. Where the flowage was slightly faster, sediment levels are markedly lower, as much as one to two feet, and the plant community differs from the more sedimented areas (Photo 25). Lower, less sedimented areas were more diverse, sedge meadows, whereas higher more sedimented areas tended to be dominated by "grass meadows" *Typha/Phragmites/Phalaris*. The sedge meadow communities (Photo 26) consisted of beds of short vegetation dominated by giant bur reed, river bulrush, broad-leaved arrowhead, and abundant patches of rushes, and show up green on aerial photos. The "grass meadows" show up as bright, straw-colored patches on aerial photos. This could be an underlying cause for grass dominance over sedges: additions of layers of nutrient-rich sediment that is laden with exotic propagules. An obvious possible restoration option would be to remove the sediment (about a one-foot layer) throughout the marshy areas that are dominated by grasses. This would not only remove most of the exotic propagules, but also release the underlying seed bed of native sedges and wet prairie. This technique has been tried at other sites, with good success (Jason Husveth, Jason, 2003, wetland restoration project at Pioneer Park, Blaine, MN), however there is no guarantee that it will work, and it could be very expensive. A place for the removed sediment would need to be identified, also (perhaps deeper reaches of Little Pig's Eye Lake?). It is, however, an option.

Photo 25. Illustrates the contrast between "grass meadows" on right and "sedge meadows" on left.

Photo 26. FMR Intern standing near a sedge meadow located where LHF-2 borders Mxd-Em-Marsh-2. The sedge meadow is green and the Phragmites grass is straw-colored.

<u>Mixed Emergent Marsh, Seasonally Flooded</u>

This unit is colored red on the map in **Figure 16**. This unit was similar in hydrology, soils, vegetation, as the other Mixed Emergent Marsh units, but the diversity was

even greater, with an abundance of marsh marigold and skunk cabbage, etc.. Unlike those units, however, the woody brush has not yet been removed. Buckthorn and boxelder punctuated and surrounded this unit, and it should be removed. The south side of this unit changed over to floodplain forest beside a swift-flowing stream, with angelica and other native forbs growing near the banks of the stream, on a level terrace area at the edge of the marsh.

Photo 27. Mixed Emergent Marsh Seasonally Flooded unit. Note the abundant *Caltha palustris*. *Typha* and *Phragmites* are starting to invade and buckthorn has not yet been removed.

Animals Observed

Many animals were observed in these marsh units, during the field survey, including the following:

Birds: common yellow throat, bald eagle, green heron, black bird, red-winged black bird, goldfinch, great blue heron, white egret, wood ducks (one pair),

Herptiles: green frogs, leopard frogs, American toads, painted turtles.

Insects: water beetles, dragonflies, damselflies, etc.

MANAGEMENT RECOMMENDATIONS:

- Control buckthorn

The buckthorn removal project covered about 2/3 of the property, but not the entire thing. The map in Figure xx shows an estimate of the extent of the buckthorn-clearing project, illustrated as a red line. The most eastern portion of the property did not get treated with buckthorn removal. There are many large buckthorn shrubs and much area dominated by seedlings and whips, that should be treated as the other areas have been, namely, cut, removed, and stump-treated. The difference in areas that were treated for buckthorn was quite dramatic, and continuing to remove buckthorn eastward is recommended. Not only buckthorn should be removed, but many boxelders also, that have invaded into the wetter areas and are drawing down the water table, thus changing the hydrology for a whole suite of species. Removing woody brush is the first step in restoration, since it opens the area up to light and restores hydrology levels appropriate for wetland communities.

- Remove the few large boxelders that have invaded the marsh, to help restore hydrology
- Control hybrid cattail, giant reed grass, and reed canary grass

In areas that were already treated for buckthorn, the next steps should be to control Typha/Phragmites/Phalaris. Some options to consider are the following:

1. Hand-wick leaves/culms to prevent invasion into new areas

2. Scrape off the top foot of sediment and discard
3. Harvest the leaves and culms annually and use tops for woody biomass or mulch
4. Broadcast-apply herbicide
5. Burn
6. Do nothing
7. Pre-treat incoming stormwater to settle, filter out, and remove sediment before it enters the marsh. Incoming sediments and stormwater bring with them unwanted propagules of Typha, Phragmites, and Phalaris.

- Control other invasive exotic forbs, such as bull thistle, Canada thistle, purple loosestrife, and garlic mustard.
    - Although purple loosestrife beetles should be well established here, consider re-releasing more purple loosestrife beetles directly onto the site, since the population of purple loosestrife is considerably large.
    - Since garlic mustard (GM) is so abundant on throughout the property, control will be very difficult. Consider hand-pulling in areas where GM is just starting to invade. Otherwise, wait for a bio-control (weevils) to be developed for GM (which is imminent), and then release it onto the property.
- Consider performing a controlled burn periodically, during draw-down episodes in the spring of the year, to help stimulate native seed banks and set back exotic species. Protect mature tamaracks from fire, since they are easily killed by fire. If fire kills them, reseed with tamarack seed onto open areas with full sun and that have no to little slash. Tamarack seedling should show up approximately 6 years afterwards.
- Stabilize banks of eroding stormwater streams, via bio-engineering methods, to reduce erosion and sedimentation into the marsh and beyond.

Altered Deciduous Forest (Alt-Dec-For-1, Alt-Dec-For-2, total = 8.6 ac)

These were relatively long, narrow units, located on the margins of the property. Unit 1 was on the north and west sides of the parcel that contains the Fish Hatchery Pond, and Unit 2 was on the side of a southwest facing slop, forming the buffer between Hwy 61 and the center units of the Willow Brook site.

Photo 28. Black walnut north of the seepage area on an open terrace.

Alt-Dec-For-1 (5.7 ac)
For a forest, this one had a relatively open canopy, with only about 40% total cover. The tallest trees were cottonwoods (60" diameter and 50' tall). The sub-dominant trees were boxelder, green ash, elm, and black walnut. There was one area, just off the property to the north (in Mounds Park),

located north of the source of the seepage area, where butternut and black walnut were common (Photo 28), which is notable, since butternut is a species that is in decline state-wide. Also, another area off property, located on a very steep, sandy slope, was occupied by a large clone of black locust.

The transitional area between the north edge of the seepage zone and the south edge of the forest was distinctive. Here, seepage vegetation with species such as cow parsnip and wild goldenglow was mixed with forest vegetation such as wild ginger, hog peanut, wild sarsaparilla, Canadian honewort, Virginia waterleaf, wood nettle and white grass. Also present was garlic mustard (exotic), wild rye, lady's thumb print, bull thistle (exotic), and large patches of jewelweed. Patches of common burdock were also commonly found, in areas where there were many buckthorn stumps (buckthorn had been removed here). Often, scattered underneath the burdock, wild ginger was wild present.

MANAGEMENT RECOMMENDATIONS:

- Control burdock (via spiking and collecting seed heads). This could be a good volunteer type activity.
- Monitor for buckthorn seedlings and control as necessary
- Work in conjunction with the City of St. Paul to manage the edges of their park property, where it borders Willow Brook property. Consider controlling black locust on the slopes, but must replace with vegetation that will stabilize the soils of these steep slopes.
- Spot treat bull thistle

Alt-Dec-For-2 (2.9 ac)

Because of its proximity with the highway, this unit will never be a high quality area, but it serves well as a buffer to the highway. It consisted of an interrupted to continuous canopy of boxelder, green ash, and cottonwood with hackberry and black willow also present. The shrub layer contained dense thickets of old buckthorn, which were located east of the "buckthorn clearing line", which should be removed. On the east side of the OW-Br-2 unit, it is recommended to continue to sweep through and remove buckthorn, and continue right through the Mixed Emergent Marsh-Seasonally Flooded unit, stopping at the Lowland Hardwood Forest-2 unit. When making brush piles, take care not to stack into the high quality Mxd-Hrdwd-Swmp-2 unit.

MANAGEMENT RECOMMENDATIONS:

- Converting the edges of this unit, where it abuts other units to the south, especially near the Mixed Hardwood Swamp-2 and OW-Br-2 units, is highly recommended, since spill over of invasive species into these higher quality units should be prevented as much as possible.
- There was a disturbed "upland plain" area (about a tenth of an acre), just west of a giant cottonwood located just north of the Mxd-Hrdwd-Swmp-2

and OW-Br-2 units, by the footpath, which could be restored to wet/mesic prairie.

Buildings and Pavement with 26% (8.2 ac)

These areas are located at the far western end of the property and along the roads (Warner Road and Hwy 61). They are not natural areas and are thus outside the scope of this report.

Management of the area around the buildings should be performed by the DNR's buildings and grounds staff, in conjunction with the Regional Planner for the Central Region.

Mixed Hardwood Swamps (Mx-Hrdd-Swmp-1 [3.5 ac], Mx-Hrdd-Swmp-2 [0.4 ac]) and Mixed Hardwood Swamp Seasonally Flooded (2.2 ac) (Total = 6.1 acres)

There are two *Mixed Hardwood Swamp* units, and they contain some of the most interesting, diverse, and highest quality communities on the property. This community type was traditionally known as "Black Ash Seepage Swamp". There is also a "Mixed Harwood Swamp Seasonally Flooded", located at the southeastern end of the property, which is not high quality.

Mixed Hardwood Swamp-1 (3.5 ac)

Located adjacent to the Fish Hatchery Pond, this 3.5 acre seepage area is very diverse (**Figure 16**) (Photo 29). The soils were saturated during the field survey of June 2014. The soils for both units 1 and 2 are Udorthents. Although it is difficult to determine the extent of alteration, there must have been some in the past, during the construction of the Fish Hatchery Pond. Most of the vegetation of the Mixed Hardwood Swamp-1 unit, though, looks quite intact, with few invasive species except for reed canary grass. Notable, there was no Typha or Phragmites. The reason for the paucity of these invasives is unknown. There were no inlets of stormwater into this area, either, at least not evident at the surface. Thus, it would be plausible that no sediments contaminated this unit, which is why it does not have Typha/Phragmites. A high priority is to keep this unit free of Typha/Phragmites.

Photo 29. View of the interior of the Mixed Hardwood Swamp-1 unit.

Although it free of Typha/Phragmites, it is not free of reed canary grass (RCG). There are dense patches of RCG surrounding

the entire unit, on the fringes of the wetland. Controlling RCG is very difficult and probably is not worth the effort. It will probably never be eradicated, and just getting it down to about 25% cover, in dense areas, is a victory. Most treatment methods involve the use of herbicide applications, which should be adequate, since most of the soil under this unit is of "moderate" sensitivity to groundwater contamination. An aquatic-approved herbicide should be used, and care and caution should be used with herbicide, and always follow the label.

Description of the vegetation of the unit follows. The middle of the unit was mostly open with a **canopy** that was about 30% total coverage and consisted of scattered black ash and tamarack trees—about a dozen large trees in total (Photo 30). The northeast end of the unit was much more forested, with many large black ash trees with a canopy of about 50%. Trees became denser towards the margins of the unit, but where the seepage areas had saturated soils, trees were sparse. There were approximately 20 cottonwood snags on the margins of the wetland, which indicates that the seepage area is expanding in recent years. (Incidentally, at the time of the field survey, the cottonwood seed rain was very strong, with the air filled with windborne seeds.) Also, there were some dying basswoods. A few large cottonwood trees had fallen into the seepage area. Decomposition would be fairly slow, if trees were buried in saturated soils, but air exposure should accelerate decomposition rates akin to those in a moist forest.

Photo 30. Tamaracks and black ash of Mx-Hrd-Swmp-1.

Shrub layer was scattered to interrupted, with about 20% coverage total. Shrub species found were nannyberry, high-bush cranberry, American currant, red currant, and some buckthorn, although it was not very prevalent. **The ground layer** had 100% coverage and consisted of the following species: skunk cabbage, tall sedges, jewel weed, currants, RCG, red-stemmed aster, joe-pye weed, yellow flower tall, great water dock, white flowered, and horsetails. On the fringes the species included more of the following: wood nettle, common burdock (exotic), common buckthorn (exotic), garlic mustard (exotic), Lady's thumb print, germander, RCG (exotic), Kentucky bluegrass (exotic).

Photo 31. Mx-Hrd-Swmp-2. View looking southward.

Animals Observed

There was a nesting pair of bald eagles, with a nest in a large cottonwood tree just northwest of the unit. They were raising young in the nest. Other birds noted were red-wing black birds, and chipping sparrows.

Mixed Hardwood Swamp-2 (0.4 ac)

This unit was bounded on the east by a deeply cut stormwater inlet stream, and just over that stream, to the east, was the Oak Woodland Brushland-2 unit; and to the north by an Altered Deciduous Forest unit; and to the northwest by the Lowland Hardwood Forest-1 unit; and to the south by the Mixed Emergent Marsh-1 unit. This unit, Mixed Hardwood Swamp-2, was a very diverse area of seepage swamp, very similar to Mixed Hardwood Swamp-1, except that: 1) tamarack trees were not present, and 2) hybrid cattail was present. The unit had been heavily overgrown with buckthorn (BT), two years ago, but has been recently released after the BT was cut. There are many stumps of BT scattered throughout the unit, with a heavy concentration of stumps at the southeast end. There was still some brush stacked here, on top of the seepage swamp ground layer plants, which should be removed and disposed of.

Photo 32. Left photo is a ragwort species and right photo is bulbous bittercress, or spring cress, both in the Mx-Hrd-Swmp-2 unit.

There was a small stream or large rivulet that meandered through the middle of the unit. This stream was not causing erosion on its banks, and was not entrenched—all signs that it was natural and not augmented by outside stormwater inflows. Like all the other seepage streams on the site, it was bedded with watercress. The soil here was very saturated and soft—feet made deep impressions into it. It's likely that hydrology is re-establishing in the wake of buckthorn removal.

Photo 33. Black ashes in Mx-Hrd-Swmp-2.

Black ash trees were present, but formed a sparse canopy. They were grouped together towards the eastern side of the unit. Some individuals appeared

very old (>30" DBH) (Photo 33). There is concern that black ash will die because of the exotic pest "emerald ash borer" (EAB), so these trees, as well as the ones in Mx-Hrd-Swmp-1 unit, should be monitored closely for signs of EAB. Probably the best replacement trees for this site, if EAB does kill the black ash trees, are tamaracks. Tamarack planting is recommended for this purpose, as well as for regenerating tamaracks themselves, which seems to be not occurring naturally on the site. A volunteer group of students from Harding High School planted tamaracks into the Cattail Marsh Unit during the fall of 2013. The field survey in spring of 2014 proved that most of these trees survived the winter and had been only slightly browsed by deer. It is recommended to continue to monitor these plantings and perhaps plant a few more, especially near the black ash seepage swamp. Protecting with wire cages or fencing is also recommended. Tree planting and fencing is a good activity for volunteers.

The **shrub layer** was non-existent, but had previously been very dense with buckthorn. On the peripheries of the unit, however, many BT seedlings and whips occurred that should be controlled. The **ground layer** was very diverse and species were well dispersed. Natives dominated the unit, with only a few exotics present, especially in the heart of the unit. The biggest problem is that *Typha-X-glauca* was starting to invade, with many small leaves just emerging from the ground scattered throughout the unit. Within a couple of years, cattails will be well established here, and start to suppress the native seepage swamp community. Thus, it is recommended to control the cattails as soon as possible. A recommended method is hand-wicking them with a systemic herbicide (plus a non-ionic surfactant). Although labor intensive, this method is very effective, and really the only way to selectively target the Typha without killing the surrounding native plants. The ground layer consisted of the following species: skunk cabbage, marsh marigold, three species of small sedges, boneset, Joe-Pye weed, *Equisetum palustre*, cow parsnip, hop sedge, wild goldenglow, tall meadow rue, a ragwort species (*Senecio* cf. *pauperculus*) (Photo 32), spring cress (*Cardamine bulbosa*), and hybrid cattail. The exotics bull thistle and purple loosestrife were present at the southeast end of the unit.

Photo 34. Close-up of ground layer in Mx-Hrd-Swmp-2. The small, narrow-leaved plants are hybrid cattail leaves starting to invade the unit.

MANAGEMENT RECOMMENDATIONS:

- Hand-wick *Typha-x-glauca* that is just starting to invade the high quality community in unit Mxd-Hrdwd-Swmp-2.
- Spot treat large patches of reed canary grass to control it

- Control bull thistle, common burdock, and other exotic forbs in disturbed areas on the upland periphery of the units.
- Remove the few large buckthorn shrubs that were missed during the woody biomass project. Monitor for BT seedlings and control them as necessary (hand-pulling and spot treating).
- Monitor black ash trees for EAB. Plant tamaracks to replace dead or dying tamarack and black ash, as necessary.
- Avoid activities in Unit 1 until after July 1, or whenever bald eagle chicks have fledged.
- Protect from fire, since tamarack are easily killed by fire. If fire occurs, broadcast with tamarack seed onto open areas with full sun and that have no to little slash. Tamarack seedlings should show up approximately 6 years after seeding (**Appendix E**).

Mixed Hardwood Swamp Seasonally Flooded (2.2 ac)
Located at the southeastern end of the property on a southwest-facing slope, this unit is not high quality. It contained no black ash or tamarack trees. It was quite disturbed by adjacent highway construction and stormwater runoff. The canopy was interrupted to nearly continuous (50-80%), and was composed primarily of cottonwood, boxelder, and green ash, with black willow also present. The shrub layer is 50% and was strongly dominated by buckthorn. The ground layer had 100% coverage and consisted of large semi-monocultural patches of herbaceous species, including reed canary grass, jewelweed, stinging nettle, garlic mustard, and common burdock. Also present were rice cut grass, white grass, Canada thistle, and a few more forbs.

MANAGEMENT RECOMMENDATIONS:
- Remove large buckthorn and control whips and sprouts
- Identify areas that are covered by exotic herbs, and control them.
- Plant shrubs to increase diversity and improve habitat for wildlife

Altered Grassland (Alt-Gr-1, Alt-Gr-2, Alt-Gr-3) and Altered Grassland with Sparse Deciduous Trees (Alt-Gr-DecTr) (6.0 ac)

These areas were altered and disturbed. They were next to roads or paved trails, and often contained berms or parking areas.

Alt-Gr-1 (1.8 ac)
This unit was completely open (no tree canopy) on level topography. There were power lines present and an parking area pull-off (located on the south side of the unit) for vehicles accessing the Fish Hatchery pond. The vegetation was


Photo 35. South-facing slope of berm of Warner Road. Invasive herbaceous vegetation covers this unit.

strongly dominated by a combination of non-native grasses and forbs, at a total coverage of nearly 100%. Grasses were most abundant, at about 60% coverage, with forbs covering about 40%. Grass species included Kentucky bluegrass, smooth brome, and reed canary grass. Exotic forbs included spotted knapweed, hoary alyssum, wormwood absinthe, gypsy flower, common mullein, bladder campion, and sweet clover. Native forbs present were Virginia creeper, common milkweed, and daisy fleabane. Woody species included Tartarian honeysuckle and buckthorn, but they were small.

MANAGEMENT RECOMMENDATIONS:
It would probably be best to continue to manage this unit as it has been traditionally managed, namely periodic mowing, since it is a parking area and contains power lines.

Alt-Gr-2 (3.2 ac)
This was a very altered and disturbed/disrupted unit. It had been altered by road construction, and now occupies a fairly steep slope adjacent to roadways along Warner Road and Hwy 61 (Photo 35). It contained an area located just south of Warner Road and north of a newly constructed concrete station, that had recently been stabilized, after having a major blow-out of the slope.

The vegetation consisted almost entirely of introduced herbaceous species, with the exception of Canada goldenrod, and common milkweed (natives). The unit was dominated especially by smooth brome, reed canary grass, crown vetch, and also present were spotted knapweed, leafy spurge, and Canada thistle.

MANAGEMENT RECOMMENDATIONS:
Since this unit occupies the slopes of road berms, it will be virtually impossible to convert to natives. It is probably best to manage by mowing annually. Converting the edges of this unit, where it abuts the Lowland Hardwood Forest-1 unit to the south, is recommended to prevent dispersal of invasive exotics (especially crown vetch).

- Promote Canada goldenrod and common milkweed, if possible.
- Monitor and treat the more pernicious and potentially most invasive weeds, including Canada thistle, leafy spurge, spotted knapweed, and crown vetch.
- The non-native grasses are relatively non-threatening, at this point, so they do not need to be monitored.
- Monitor nearby/adjacent units for invasion by the exotic species that are found within this unit.

Alt-Gr-3 (0.3 ac) and Alt-Gr-DecTr (0.8 ac)
These units are located near the paved foot trail (**Figure 16**). There were black locust trees present, which should probably be removed, since they are technically not native to Minnesota and can be quite aggressive. This unit was dominated by

smooth brome, with several non-native forbs commonly found, such as common burdock and garlic mustard.

MANAGEMENT RECOMMENDATIONS:
If the superfund site gets serious about managing for native prairie, then reconstruct these units to mesic savanna, which would be congruent with the superfund site vegetation. If not, then it will probably not be worth the effort to intensively manage these units.

Oak Woodland-Brushland (OW-Br-1, OW-Br-2, OW-Br-3) (4.4 ac)

Three units of oak woodland-brushland occurred on the property:

- OW-Br-1 was located north of Warner Road and was 3.3 acres,
- OW-Br-2 was located at the middle of the property, southwest of Hwy 61 and was 0.9 acres
- OW-Br-3 was located at the far southeast corner of the property and was about 0.2 acres

OW-Br-1 (3.3 ac)

Photo 36. OW-Br-1 unit. Note the absence of large buckthorn and the carpet of young buckthorn mixed with native ground layer vegetation.

This woodland had a dense growth of trees with about 75-85% total canopy cover, which is on the high side for a woodland. The unit was dominated by an even-aged stand of pin oak (90% cover), with some bur oaks (8% cover) and other species (black cherry, hackberry, American elm, green ash) present (2% cover). Sub-canopy was sparse. Shrub layer was virtually non-existent, since this area had been cleared of buckthorn recently (City of St. Paul), but chokecherry was present. Ground layer had about 65% coverage, but was not very diverse, being dominated by garlic mustard, buckthorn seedlings with Virginia stick seed, Pennsylvania sedge, and Virginia creeper common (Photo 36). Present also were golden alexanders in patches. No oak regeneration was observed, but hackberry seedlings were common. Sprengel's sedge was uncommon, found in scattered openings and along foot paths.

At the crest of a knoll that looks onto the river valley from the south and onto the fish hatchery pond to the west, is a small

Photo 37. Dry prairie opening in OW-Br-1.

dry prairie remnant containing a few upland prairie species including big bluestem, switch grass, little bluestem, dogbane, black raspberry, spiderwort, and leadplant (Photo 37). Also common were gypsy flower, Kentucky bluegrass, and hoary alyssum. Wild asparagus was present. Interestingly, oaks seedlings were present, probably because light is adequate for acorn germination.

Just north of a small ponded area located at the base of a southeast-facing slope along Warner Road, was an area with bur oak regeneration, and many bur oak seedlings. This is an encouraging sign, and reason to continue to manage this unit for woodland.

MANAGEMENT RECOMMENDATIONS:

- Continue to perform controlled burns. Burn every 2 to 3 years for the first 10 years. Then switch to a rotation rate of every 9 to 10 years.
- Seed with woodland species directly following a burn.
- Plant native shrubs to increase diversity and replace buckthorn. Protect new shrubs from browsing deer with fencing for the first 4-6 years.
- Gradually expand the prairie remnant on the knoll by cutting back trees in a radius outward from its center.
- Consider thinning pin oaks. Thin oaks gradually over a period of many years. One option would be to girdle trees, but not to kill them. Leave girdled trees dead-standing to provide for wildlife habitat. Allow girdled trees to resprout; they should be controlled by fire.

OW-Br-2 (0.9 ac)

Although altered, this area contained a small remnant patch of large bur oaks, which were at one time open-grown ("savanna oaks"), as evidenced by the low, horizontal branches on their stems (Photo 38). The woody biomass project removed all of the large buckthorn in this remnant, up to the cottonwood-boxelder forest to the east. Woody brush removal is the first step towards restoration (**Appendix H**). Now the next steps should be taken.

Photo 38. Large "savanna" bur oak in OW-Br-2. Note the low, horizontal branches on the stem of the tree. Also not the many small trees growing under the canopy, "crowding" it.

Canopy layer coverage was about 60 to 75%, total. Old bur oaks were dominant. Old red oaks were not present, but one large individual had recently died (suspect oak wilt within the last 3-5 years) and was dead-standing. Since no red oaks were

present, this indicates that the red oaks were eliminated from the woodland by oak wilt disease in the past. Gaps in canopy have been created red oaks would have likely grown. Other trees present were boxelder, hackberry, green ash, and American elm, but were smaller and younger than the oaks. **Shrub layer** was not existent. Buckthorn had been cut out two years ago, and no other shrub species were present at the time of the survey. **Ground layer** was sparse and not diverse; dominated by garlic mustard, buckthorn seedlings and whips, Virginia stickseed, and Canada thistle. Burdock was present. No oak regeneration was observed. Leaf litter was very sparse. The site had undoubtedly been "wormed" long ago.

MANAGEMENT RECOMMENDATIONS:

- Follow up on **buckthorn control**. Control seedlings and resprouts by mowing (throughout the year) and herbicide application (in the fall) or via goat browsing.

- Remove small native trees that are crowding the large savanna oaks.

- Burn the unit often during the first 10 years of restoration. This will help keep woody seedlings at bay and also stimulate the native prairie seeds that may be dormant in the seedbank. Since this area has been quite disturbed, seeding is recommended to increase the diversity of the ground layer. Purchase seed from local sources, as much as possible, but including sources from more than one area, especially more south and west zones, may foster resilience to global warming. Formulate a seed mix that is rather high in the grass component, so that fuel will accumulate, which will enhance conditions for future fires.

After about 10 years, switch to a burn rotation rate of about 3 to 7 years (targeted for savanna). Interseed or plant plugs of more forbs, if desired. Increase diversity of understory by planting a variety of native shrubs to replace buckthorn.

This is a small unit, and may be well suited to be "adopted" by a local volunteer group, for example a group of students from a local school or a group from Urban Roots.

OW-Br-3 (0.2 ac)
This unit is very small and located at the far south and east corner of the property. There was only a single, large, old bur oak growing here. The soil is barely suited for oaks, since it is dark black, high in organic content, but still a mineral soil, since it was adequate for this oak tree to grow here. The oak is surrounded by large, old

Photo 39. Lone, old, savanna bur oak occurring in OW-Br-3. Note the abundant buckthorn surrounding it. Beyond, in the background, is Mx-Em-Marsh-B.

buckthorn shrubs and a plethora of buckthorn whips and seedlings. In fact, the buckthorn is so dense, in spots, that virtually nothing grows on the forest floor underneath them, not even buckthorn seedlings (Photo 40). It was not clear why this was the case, but the shade was very solid, and also could be influenced by the soils and depth of flooding regime. To the north of the unit is a small unit of Mixed Hardwood Swamp-Seasonally Flooded, which was badly overgrown with buckthorn and infested with reed canary grass. To the south of the OW-Br-3 unit is Mixed Emergent Marsh-2 and a small portion of Wet Prairie.

The canopy is completely closed, due to the combination of the large oak and the dense, old-growth buckthorn. There were no other trees present in the canopy. Common buckthorn was the only species present in the shrub layer. The ground layer was dominated by buckthorn seedlings, where present, but some parts were nearly devoid of any vegetation. A sparse covering of native forbs was present, under the old-growth buckthorn; species included: wild geranium, Virginia waterleaf, violet species, and Pennsylvania sedge.

Photo 40. "Old-growth" buckthorn in OW-Br-3 unit. Note the very dark understory with almost no vegetation on the ground. The remnant wet prairie community is in the background.

MANAGEMENT RECOMMENDATIONS:

- Remove large buckthorn and treat stumps with a systemic herbicide labeled for aquatic use OR grind stumps out (no-chemical option) OR mow with forestry mower (no-chemical option).
- Buckthorn whips:
    - Where they are dense, mow buckthorn whips with forestry mower (no chemical option)
    - Where they are sparse and intergrading with native communities, cut buckthorn whips.

- Either treat stems with a systemic herbicide labeled for aquatic use (chemical option), or
- perform "critical cutting" as a non-chemical option. Critical cutting is a method where stems are cut twice per year, for several years, until roots are depleted of energy. Timing is important. Stumps should be allowed to fully resprout before cutting, but plants should not be allowed to grow too much so that they store energy through photosynthesis. Mid-June and again in mid-August is an approximate schedule for critical cutting. This method requires diligence and persistence, and will take several years.
  NOTE: Although this unit is rather remote and no parking or access is close, it lends itself nicely to being managed by a small group of students or volunteers, where they could "adopt" it and do the critical cutting and weeding, etc. on a long-term basis. The adjacent wet prairie remnant and seepage meadow could also be included with site adoption.

- Restore the area to wet prairie. Wet prairie has several species that can tolerate both wet and dry conditions, for example prairie cordgrass, big bluestem, Canada bluejoint, tall meadow rue, heath aster, mountain mint, etc. Species from the nearby remnant wet prairie can be used to help create a seed mix list (**Appendix A**).
- Burn the site often, if possible, during the first 10 years, to control buckthorn seedlings, then switch to a fire rotation of approximately once per 3 years or so.

Oak Forest (OF-1, OF-2) (2.0 ac)

There were two units of oak forest on the site, both located north of Warner Road. OF-1 was a very small (0.4 acres), sliver of unit, located at the western edge of the property, west of the Fish Hatchery pond (**Figure 16**). OF-2 was a larger unit (1.55 acres), located northeast of the pond.

OF-1

This unit was located on a steep, southeast-facing slope. The **canopy layer** was interrupted to continuous (50-100%), more open on the edges, and dominated by large red oak and bur oak. Present also were green ash, cottonwood, and hackberry. The shrub layer was strongly dominated by buckthorn, which was 6 to 8 feet tall. Buckthorn should be removed. Ground layer was strongly dominated by buckthorn whips and seedlings and by

Photo 41. Oak Forest-2 unit. The absence of buckthorn in the shrub layer is refreshing.

garlic mustard. Also present were wild grape and Virginia creeper.

OF-2
This unit was located on a predominantly north-facing slope. The canopy layer was interrupted to continuous (50-100%) and dominated by huge red oaks and large bur oaks (reds were bigger than burs). Also present were Norway maple (exotic), American elm, basswood, and hackberry. The subcanopy layer contained ironwood, basswood, Norway maple, and hackberry. The shrub layer was almost non-existent, since buckthorn had been removed recently, but a chokecherry was present. An interrupted to continuous layer of small (2-3') buckthorn whips occurred throughout the unit. Follow up buckthorn treatment on these whips should occur soon. Ground layer was not diverse.—it was dominated by buckthorn seedlings and garlic mustard. Also present were wild grape, Virginia creeper, and white snakeroot.

MANAGEMENT RECOMMENDATIONS:
Buckthorn Control:

- In areas where large buckthorn has not been removed, remove it. Due to steep slopes, hand-work will probably be required.
- In all other areas, where buckthorn has previously been removed, follow up treatment on whips is required soon.
- Even though fire does not have a frequent occurrence in an oak forest, the recommended treatment is controlled burning (running ground fire). Due to the presence of oaks, this unit should burn well because of the oak leaf litter present on the ground surface. Either a spring or fall burn would suffice.

Planting
Consider planting pods of native shrubs, plugs and seeding to increase diversity and habitat value. Protect plantings with deer exclusion fencing. Planting projects are well suited for volunteers or students.


Photo 42. Eroded streambank in Floodplain Forest unit.

Floodplain Forest (1.6 ac)

Located along the stream, where it bends at the corner of the property, just between the Mixed Emergent Marsh-1, OW-Br-2, and Mixed Emergent Marsh-Seasonally Flooded units and the paved trail, this unit is primarily forested with a mostly continuous canopy of boxelder, cottonwood, green ash, black locust and black willow. Buckthorn still exists in the shrub layer, and should be removed. The ground layer is a mix of

non-native and native species, with reed canary grass, lake sedge, and rice cut grass most abundant.

Animals observed were king fisher, tiger swallowtails, and goldfinches. The intersection of two streams occurs at the north end of the unit, and a large scoured out pool has formed at the intersection.

For the most part, the stream is shallow, and during most times, the water flows slowly. However, the banks of the stream are badly eroded in places, indicating large periodic pulses of stormwater discharge (Photo42). Stabilizing the banks couldn't hurt.

MANAGEMENT RECOMMENDATIONS:

- Remove buckthorn
- Remove black locust
- Thin boxelders
- Stabilize degraded and eroding streambanks

Dry Prairie (0.8 ac)

This is a small area (0.76 acres) that was recently reconstructed to prairie. It is regularly burned by the DNR's Central Region Spring Burn Crew as a training exercise. Diversity was not particularly high here, but was preferable to a field of invasive weeds. This unit makes a nice demonstration prairie for visitors. A group of volunteers of students could successfully weed this unit, as a project.

RECOMMENDATIONS:
Continue to burn every 3 to 5 years. Continue to use as a training exercise for the spring burn crew. Monitor for invasive species that survive and thrive under the current burning regime (example spotted knapweed).

Oak Savanna (0.01 ac)

Because it was such a very small unit (0.01 acres), it should be either included with the Oak Forest unit, in terms of management, or as part of the City of St Paul's management of Mounds Park.

Notable Features

Many of the features from the field survey of the spring of 2014, that were listed in this section, are shown on the map in Figure 16A, called "Notable Features". Please refer to the table that directly follows Figure 16A for a legend to the features shown on the map. Some of these features can be used as "teachable opportunities", such as the beaver dam, butterfly gardens, the oak savanna, seepage swamps, the wet prairie, etc (**Appendix I**). Also, potential sites for building snake hibernacula are shown in the map in **Appendix I**.

Figure 16A. Notable Features from field survey, spring of 2014.

FID	Description
0	Beltway settling pond
1	Beltway
2	Head of natural stream. Seep.
3	Bald eagle's nest
4	Source of seep
5	Prairie remnant on crest of knoll
6	Stormwater inlet structure
7	Stabilized slope from blowout
8	Natural, swift-flowing stream
9	Scrap metal and old wood pile
10	Intersection of steams
11	Large black willow
12	Beautiful meadow of Equisetum and Symplocarpus
13	Cup plant
14	Giant cottonwood snag
15	Peach-leaf willow and small black ash
16	Open, marly pool
17	Sedge patch
18	Large black willow, tipped up
19	Small rivulet. Flowing south.
20	Rivulet
21	Sedge field
22	Holy Grail of seepage swamps
23	Small buckthorn whips and garlic mustard patch
24	Large pipe inlet
25	Giant cottonwood
26	Large dead red oak
27	Large glossy buckthorn
28	Joe-pye weed patch
29	Wet soil under cottonwoods, dominated by RCG
30	Large boxelder; remove.
31	Phragmites patch, 40'x50'
32	Caltha palustris, abundant
33	Sedges abundant
34	Head of stormwater stream
35	Sedge bed
36	Cloudy water entering from culvert
37	Angelica and cow parsnip
38	Lake sedge patch
39	Reed canary grass
40	Lake sedge patch
41	Lake sedge patch
42	Swamp saxifrage in wet prairie remnant
43	Giant bur oak, lone
44	Wild garlic
45	Old growth buckthorn
46	Dense buckthorn
47	Survey monument # 165
48	Typha/Phragmites
49	Seepage meadow, high quality
50	Amorpha fruticosa
51	Culvert inlet stream
52	Sedge bed; Amorpha fruticosa
53	Sedge meadow
54	Superfund dump
55	Paved trail crosses stream

Legend for Notable Features map.

RESTORATION PROCESS

Undertaking a restoration project of this size is a significant task and assistance is available to help landowners with the process. Friends of the Mississippi River can continue to work closely with the DNR, if desired, by helping to secure funding and providing project management and oversight. Although you are probably aware of them already, a list of professional firms that can conduct management tasks are listed in **Appendix D**.

Management recommendations were developed for each land cover area, and included in the previous section with the descriptions of the landcovers. Overall goals for the easement area focused on 1) first, protecting high quality areas (seepage swamps and wet prairie, 2) secondly, restoring areas that still have good diversity and are not too degraded (oak woodlands, emergent marshes and seeapage meadows, and 3) overall, improving wildlife habitat. Overall management practices to achieve those goals were listed in the previous section, but are summarized here:

- In units that have not experienced woody brush removal, remove non-native, invasive, woody species, especially common buckthorn, glossy buckthorn, and siberian elm;
- control non-native invasive herbaceous species, including, hybrid cattail, giant reedgrass, reed canary grass, garlic mustard, common burdock, Canada thistle, crown vetch, etc.;
- Work out from central high quality areas into adjacent surrounding zones, to expand them and promote the dispersal of the species from the remnants out into the buffer zones;
- restore ground layers and shrub layers on steep bluff woodland and forest slopes to prevent erosion and increase wildlife habitat;
- conduct periodic prescribed burning to maintain prairie, woodland vegetation and reduce invasive shrubs and overabundant tree seedlings;
- Stabilize eroding streambanks to reduce erosion and sedimentation problems downstream;
- Analyze inlets and inlet pipe systems to identify solutions for lessening the impact of piped stormwater onto the site. Perhaps create pre-treatment areas for incoming stormwater before it gets to the sensitive wetland communities in the middle and southern portions of the property;
- Consider thinning or girdling boxelder in areas where it is very dense, to allow more light into the understory;
- Keep apprised of the status of garlic mustard bio-control and obtain and release bio-control organisms as soon as they are available;
- institute a monitoring plan to track effectiveness of management and restoration activities; monitor for invasive species also;

Restoration Goals

The primary objective for this site is to improve the composition of the plant communities throughout the property to better reflect the diversity, composition

and structure that would have been present at the time of European settlement and to improve the ecological functions that the historic native plant communities would have provided, including:

- habitat for a diversity of wildlife species,
- nutrient and water cycling,
- carbon storage,
- moderation of water-table levels,
- erosion control,
- filtration of nutrients, sediments and pollutants,
- development and enrichment of soils,
- local temperature moderation.

Though degraded by past uses, the existing plant cover retains a good variety of native species and could be readily improved. A healthy and diverse plant community can provide much greater wildlife value than a degraded one, and tends to be much more stable, and less susceptible to disease, invasive species, and other concerns.

Target Plant Communities

"Target Plant Communities", or TPCs, refers to those specific native plant communities that will be restored to a specific area (**Figure 18** and **Table 4**). The TPCs were composed based on all of the information presented in this document, up until this point. Thus, based on the property's landscape context, ecological significance, geology, groundwater, surface water, soils, pre-settlement vegetation, historical aerial photos, landuse history, and existing conditions, target communities were formulated for the entire property. We also considered relative effort vs. benefits, in other words, if it takes too much effort to restore an area, then the target will be changed to something that requires less effort.

The great majority of TPCs were given a name taken from a 2005 publication from the Minnesota Department of Natural Resources called *The Field Guide to the Native Communities of Minnesota: The Eastern Broadleaf Forest Province ("Field Guide")*. This book describes the system developed by the DNR for identifying ecological systems and native plant community types in the state, based on multiple ecological features such as major climate zones, origin of glacial deposit, plant composition, and so on. There are four ecological provinces in Minnesota (prairie parkland, eastern broadleaf forest, Laurentian mixed forest, and tallgrass aspen parkland), ten sections within the provinces, and 26 subsections **(Figure 17)**. The Willow Brook property is classified as follows:

Ecological Province: Eastern Broadleaf Forest
Section: Minnesota and Northeast Iowa Morainal
Subsection: St. Paul Baldwin Plains & Moraines

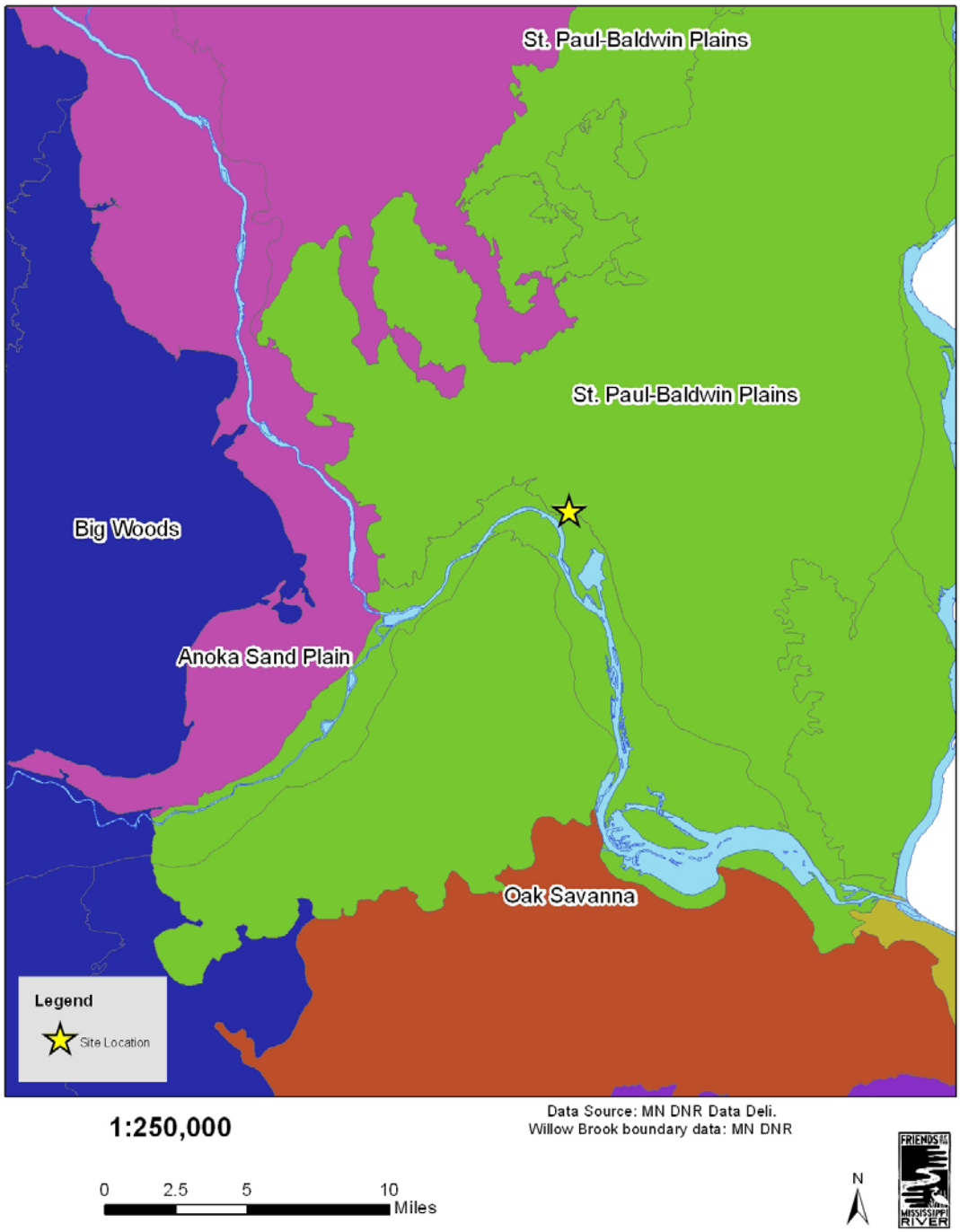


Figure 17. Ecological subsections near Willow Brook.

Information on St. Paul Baldwin Plains & Moraines comes from the *Action Plan for Minnesota Wildlife* (DNR 2006). Seepage swamps are not listed as "key habitats", but non-forested wetlands, Forest-upland-deciduous, and oak savanna are, which all occur on the Willow Brook property. It also states "wetlands do not represent more than 5% of the 1890s or 1990s landcover, but the 1984 Anderson & Craig study indicates wetlands have declined by greater than 50% in this subsection". Thus, a

site like Willow Brook, with its numerous wetlands, should be valued highly. Some of the priority conservation actions listed in the *Action Plan* include incorporating SGCN concerns in management planning, managing for invasive species, using prescribed fire and other practices to maintain fire-dependent communities, encouraging restoration efforts, managing habitats adjacent to wetlands to enhance SGCN values, maintaining good water quality in shallow lakes, and enhancing near-shore terrestrial and aquatic habitats. All of these actions agree with the recommendations made in this document.

Target Plant Communities

Please refer to the *Field Guide* for descriptions of the native plant communities. If an area did not fit into a Native Community Type from the *Field Guide*, most likely due to the fact that it had been altered by human activities, then it was given a name that better suited it, for example "Lowland Hardwood Forest".

The target native plant communities for this property are listed in **Table 4** and mapped in **Figure 18**.

Acres	Existing Landcover Units (MSCCS)	Target Community	NPC_Code
12.82	Mixed Hardwood Swamp-1, 2, Cattail Marsh, Mixed Emergent marsh-1, Shrubland Alt Seasonally Flooded	Northern Wet Ash Swamp	WFn55
12.8	Limnetic Open Water	Shallow Lake	Sh Lake
9.65	Lowland Hardwood Forest-1, 2	Lowland Hardwood Forest	LHF
8.92	Lowland Hardwood Forest, Altered Deciduous Forest, Altered Grassland	Southern Wet-Mesic Hardwood Forest	MHs49
7.07	Buildings and Pavement, Impervious Cover 26-100%	Buildings & Parking Lot	Bldgs & Parking
5.91	Oak Woodland Brushland-1	Southern Dry-Mesic Oak Woodland/Southern Dry Savanna	FDs37/UPs14
5.7	Mixed Emergent Marsh-2	Northern Mixed Cattail Marsh	MRn83
3.87	Lowland Hardwood Forest-1 & 2, Mixed Emergent Marsh-2, Oak Woodland Brushland-1,	Southern Seepage Meadow/Carr	WMs83
3.54	Altered grassland w sparse deciduous trees, Altered grassland-2, Altered Dec For-2	Grassland Altered/Deciduous Forest Altered	Grass/For Alt
2.81	Alt-grassland 1, 2, & 3	Altered Grassland	Grass Alt

1.91	Altered Dec For-1, Oak Forest-1	Southern Dry-Mesic Oak Forest	MHs37
1.62	Palustrine Open Water	Palustrine Pond	Pond
1.34	Oak Woodland Brushland-1 & 2	Southern Dry-Mesic Oak Woodland	FDs37
0.83	Oak Woodland Brushland-3, Mixed Emergent marsh-2	Southern Wet Prairie	WPs54
0.78	Dry Prairie	Southern Mesic Prairie	UPs23
0.58	Altered grassland-2	Altered Forest	Forest Alt
0.5	26-50% Impervious Cover with sparse grasses and small trees	Altered grassland and Paved Trails	Grass Alt & Trail
0.37	Mixed Emergent Marsh-1	Clay/Mud River Shore	RVx54

Table 4. Existing to Restored Communities Table

Figure 18. Target Plant Communities at the Willow Brook

From the TPC map, it can be seen that the communities of the Willow Brook property are a mosaic of types, with not any one being too dominant. Probably the biggest change was in the high quality areas. In the marshy-seepage areas that contained tamarack and black ash--they were designated as *Northern Wet Ash Swamp* (WFn55) and combined with the high quality Mixed Hardwood Swamp areas, because this was the best fit for a forested seepage wetland with tamarack. Mixed Hardwood Swamp-1, the high quality remnant north of the Fish Hatchery Pond, was also designated as WFn55. Several communities of *Southern Seepage Meadow/Carr* (WMs83) were also designated, since they were high quality sedge meadows—they were formerly either lowland hardwood forests, emergent marsh, or oak woodland-brushland. A *Southern Wet Prairie* (WPs54) was designated, at the far south eastern, where the former Oak-Brushland-3 unit was and also incorporated parts of the nearby Mixed Emergent Marsh-2 and Mixed Hardwood Swamp-3 units—this was also a high quality remnant.

The upland communities were designated as Southern Dry-Mesic Oak Woodland (FDs37) or Southern Dry Savanna (UPs14) or a combination of the two (see the Oak Brushland-1 unit), since they often intergrade with each other. The Lowland Hardwood units were often designated as Southern Wet-Mesic Hardwood Forest (MHs49), but sometimes remained Lowland Hardwood Forest, as in the case of the LHF-2 unit, since it was so highly disturbed. Several of the Altered Grassland and Altered Deciduous Forest units also remained an altered community type, since they are very disturbed and not worth restoring. The area around the buildings and parking lots was not re-designated, since that is not really a natural area.

Site-Wide Invasive Woody Plant Removal/Control

Usually, we recommend the first phases of restoration to be site-wide woody plant removal, but in this case over half of the site has already been done. So, removal of the remaining areas that contain woody brush is recommended, since they will be a continual seed source for the areas that are currently "buckthorn-free". This will amount to approximately 19 acres of the eastern portion of the property. Removing buckthorn in the LHF-2 unit, although it is the lowest priority unit on the site, is still recommended to reduce seed source to surrounding communities.

Restoration Priorities

PRIORITY 1: <u>Restore/Protect Northern Wet Ash Swamps</u>

These communities are the highest quality ones on the site, and thus deserve the highest priority. There are two of these communities on the property, one in the north and the other in the middle of the property (**Figure 18**). In cover unit Mx-Hrd-Swmp-2, cattails are just starting to invade the high quality seepage swamp, and should be controlled as soon as possible (see previous section for specific management recommendations). In the rest of the middle WFn55 community, cattails and reedgrass control may bring very beneficial results, but can be very time consuming. Options are given in the Management Recommendations section above.

The Mx-Hrd-Swmp-1 unit, although it has no Typha or Phragmites, could benefit from reed canary grass control on the margins. This also is very time consuming and difficult to sustain. If nothing is done to this unit; that would be a good option too.

Monitoring black ash populations for EAB is highly recommended. Replacing with tamarack may be a solution, but adaptive management should guide this decision. One study done by the U of MN* recommended the following:

> "While EAB does threaten native ash, landowners and managers should focus on maintaining healthy, resilient, and productive stands and not focus solely on one species. Maintaining a variety of species and age classes is an important strategy to foster resilient stands. Landowners should proactively begin to prepare ash stands for the arrival of EAB, but should avoid overreacting by removing all ash in a single treatment. A better approach would be to begin a series of entries designed to remove less than half of the canopy at a time, thereby promoting new regeneration while avoiding major hydrologic changes."

*Sustainable Forests Education Cooperative in conjunction with University of Minnesota's Silviculture Research Lab, 2013

PRIORITY 2: <u>Restore/Protect Southern Wet Prairie (WPs54)</u>

By virtue of its outstanding diversity, this wet prairie remnant deserves high priority. The primary threats are invasion by buckthorn from the cover unit OW-Br-3. This is a fairly remote area, so restoration will be sort of difficult because of the distances to travel to and from the area. The lone bur oak tree will be released also, and it will be interesting to watch what happens in this community as restoration unfolds. Prescribed fire is essential to restoring this area, so it should be part of the plan here.

Since the high quality seepage meadow/carr community on City of St. Paul land is so close by, we recommend partnering with the City to restore this area in conjunction with the WPs54 community. Restoration would involve controlling Typha and Phragmites from continuing to invade into the seepage meadow remnant.

PRIORITY 3: <u>Restore/Protect Southern Wet Meadow/Carr (WMs83)</u>

There are several high quality remnants of wet meadow/carr on the property (**Figure 18**), and they deserve high priority. The remnants scattered throughout the cover unit Mx-Em-Marsh-2 should have Typha/Phragmites controlled to prevent further encroachment. The long, narrow area north of the middle Wet Ash Swamp is high priority because it contains fields of horsetails and also many wet areas with abundances of wetland forbs like joe-pye weed.

The cover type unit Mx-Em-Marsh-Seasonally-Flooded has much potential, but has not yet been cleared of buckthorn. Removing the woody brush in this unit would

help restore wetland hydrology and produce many dividends in terms of wildlife habitat, so it should be a high priority.

Identifying sedge patches within the large cover type unit Mixed Emergent Marsh-2, would help a great deal, since there are several such patches scattered throughout that unit. The sedge patches should be expanded at the expense of Typha/Phragmites/Phalaris.

PRIORITY 4: <u>Restore/Protect Southern Dry-Mesic Oak Woodland (FDs37) and Southern Dry Savanna (UPs14)</u>
Since these units have already been cleared of buckthorn, they require a different strategy for restoration. The main concern now is to restore the understory layers to native species. This is not easy, since woodland forb and graminoid seed is notoriously difficult to germinate. Probably the best strategy is to concentrate on restoring areas under canopy gaps or in open areas that receive adequate light. Prescribed burning is also an important component of woodland and savanna restoration.

The cover type OW-Br-2 could be a good place for a school group or volunteer group to work, since it is not too large—progress would be seen quickly, as opposed to the large community east of the Fish Hatchery pond (which would be more suited to a professional restoration contractor crew).

Since savanna is an ecological subsection "priority conservation action", according the DNR, restoring as much savanna as possible is recommended. Working in conjunction with the City of St. Paul on their Mounds Park property would be a beneficial partnership for areas that are adjacent to their park land.

PRIORITY 5: <u>Restore or Reconstruct Southern Dry-Mesic Oak Forest (MHs37) and Southern Wet Hardwood Forest (MHs149)</u>
Since these communities have been relatively disturbed and altered, they do not have as high a priority. However, they can still provide valuable habitat for wildlife, so therefore they deserve some attention. The primary tasks will be to remove buckthorn in areas that has not been done yet. Managing the edges of higher priority units with the edges of these forest units is advisable, since that will soften the edges, and allow a more natural look to the property. Restoring the understory should not be attempted until a bio-control for garlic mustard is available. Thinning or girdling of undesirable native trees followed by planting with native shrubs is recommended. Removal of the invasive black locust is also recommended.

RESTORATION SCHEDULE AND COST ESTIMATES

Table 5. Willow Brook Restoration Schedule and Cost Estimates

These tables are rough schedules and approximate costs for restoration and management tasks for the Willow Brook property. Both the project tasks and costs are likely to change as the project progresses - these tables should be used only as rough guides. Tasks were phased, with 1 being the highest priority. Work units correspond with those shown in **Figures 16 (Landcover) and 18 (Target Plant Communities)**.

Yr	Season	Units	Activity	Acres	Cost/Ac	Cost Est.
PHASE I: PROTECT and RESTORE HIGH-QUALITY NORTHERN WET ASH SWAMPS						
1	Spring	Mx-Hrd-Swmp-2	Hand-wick *Typha-x-glauca* that is just starting to invade the high quality community in unit Mxd-Hrdwd-Swmp-2	10	$500.00	$5,000.00
1	Late summer	Mx-Hrd-Swmp-1, 2	Spot treat large patches of reed canary grass to control it	13	$400.00	$5,200.00
1	Fall, winter	Mx-Hrd-Swmp-2	Remove the few large buckthorn shrubs that were missed during the woody biomass project. Monitor for BT seedlings and control them as necessary (hand-pulling and spot treating)	10	$900.00	$9,000.00
1	Summer	Mx-Hrd-Swmp-1, 2	Control bull thistle, common burdock, and other exotic forbs in disturbed areas on the upland periphery of the units	13	$400.00	$5,200.00
All	Any	Mx-Hrd-Swmp-1, 2	Monitor black ash trees for EAB. Plant tamaracks to replace dead or dying tamarack and black ash, as necessary	13	$200.00	$2,600.00
All	Spring	Mx-Hrd-Swmp-1	Avoid activities in Unit 1 until after July 1, or whenever bald eagle chicks have fledged	3		$0.00
SUBTOTAL						$27,000.00
PHASE 2: PROTECT and RESTORE HIGH-QUALITY SOUTHERN WET PRAIRIE						
1 or 2	Winter	OW-Br-3, Mx-Em-Marsh-2, Mx-Hrd-Swmp-3	Remove large buckthorn and treat stumps with a systemic herbicide labeled for aquatic use OR grind stumps out (no-chemical option) OR mow with forestry mower (no-chemical option)	1	$1,500.00	$1,500.00

1 or 2	Winter	OW-Br-3, Mx-Em-Marsh-2, Mx-Hrd-Swmp-3	Buckthorn whips: where they are dense, mow buckthorn whips with forestry mower (no chemical option)	1	$700.00	$700.00
1 or 2	Fall	OW-Br-3, Mx-Em-Marsh-2, Mx-Hrd-Swmp-3	Buckthorn whips: where they are sparse and intergrading with native communities, cut buckthorn whips. Treat stems with a systemic herbicide labeled for aquatic use (chemical option)	1	$350.00	$350.00
1 or 2	Spring, summer	OW-Br-3, Mx-Em-Marsh-2, Mx-Hrd-Swmp-3	Buckthorn whips: perform "critical cutting" as a non-chemical option	1	$400.00	$400.00
1 or 2	Spring, summer, fall	OW-Br-3, Mx-Em-Marsh-2, Mx-Hrd-Swmp-3	Seed with wet prairie mix	1	$750.00	$750.00
1 or 2	Spring, summer, fall	OW-Br-3, Mx-Em-Marsh-2, Mx-Hrd-Swmp-3	Burn site during drawdowns, after plants are established	1	$650.00	$650.00
SUBTOTAL						$4,350.00
PHASE 3: PROTECT and RESTORE SOUTHERN SEEPAGE MEADOW CARR COMMUNITIES						
3	Spring	Mx-Em-Marsh-2, Mx-Em-Marsh-Seas-Fld, LHF-2	Control hybrid cattail, giant reed grass, and reed canary grass. Hand-wick leaves/culms to prevent invasion into new areas	4	$500.00	$2,000.00
3	Summer	Mx-Em-Marsh-2, Mx-Em-Marsh-Seas-Fld, LHF-2	Expand remnants by setting back surrounding Typha/Phragmites/Phalaris. Broadcast apply herbicide.	3	$400.00	$1,200.00
3	Late winter, early spring	Mx-Em-Marsh-2, Mx-Em-Marsh-Seas-Fld, LHF-2	Expand remnants by setting back surrounding Typha/Phragmites/Phalaris. Scrape off top foot of sediment and discard.	1	$2,000.00	$2,000.00
SUBTOTAL						$5,200.00
PHASE 4: PROTECT and RESTORE SOUTHERN DRY-MESIC OAK WOODLAND and SOUTHERN DRY SAVANNA						

4	Spring, fall	OW-1 & 2	Continue to perform controlled burns. Burn every 2 to 3 years for the first 10 years. Then switch to a rotation rate of every 9 to 10 years	4.3	$650.00	$2,795.00
4	Spring, summer, fall	OW-1	Follow up on buckthorn control. Control seedlings and resprouts by mowing (throughout the year) and herbicide application (in the fall) or via goat browsing	3.3	$700.00	$2,310.00
4	Spring, fall	OW-1 & 2	Seed with woodland species directly following a burn	4.3	$750.00	$3,225.00
4	Spring, fall	OW-1 & 2	Plant native shrubs to increase diversity and replace buckthorn. Protect new shrubs from browsing deer with fencing for the first 4-6 years	4.3	$250.00	$1,075.00
4	Fall, winter	OW-1	Gradually expand the prairie remnant on the knoll by cutting back trees in a radius outward from its center	3.3	$1,000.00	$3,300.00
4	Any	OW-1	Consider thinning pin oaks. Thin oaks gradually over a period of many years. One option would be to girdle trees, but not to kill them. Leave girdled trees dead-standing to provide for wildlife habitat. Allow girdled trees to resprout; they should be controlled by fire	3.3	$500.00	$1,650.00
4	Winter	OW-2	Remove small native trees that are crowding the large savanna oaks	1	$500.00	$500.00
SUBTOTAL						$14,855.00
PHASE 5: RESTORE OR RECONSTRUCT SOUTHERN DRY-MESIC OAK FOREST and SOUTHERN WET HARDWOOD FOREST COMMUNITIES						
5 to 9	Fall, Winter	LHF-1 & 2, Alt Dec For units, Alt Grassland units, Oak forest, OW-Br-1, & 2	Thin or girdle undesirable trees gradually over a long period	9	$500.00	$4,500.00

5	Spring, fall	LHF-1 & 2, Alt Dec For units, Alt Grassland units, Oak forest, OW-Br-1, & 2	Plant a diversity of native shrubs and trees	9	$300.00	$2,700.00
5	Fall, winter, spring	LHF-1 & 2, Alt Dec For units, Alt Grassland units, Oak forest, OW-Br-1, & 2	Remove exotic woody brush and control resprouts	6	$1,500.00	$9,000.00
SUBTOTAL						$16,200.00
ECOLOGICAL EVALUATIONS						
1 to 9	Spring, summer, fall	All		70	$300.00	$21,000.00
SUM TOTAL						$88,605.00

Long-Term Monitoring and Maintenance

Once the primary restoration tasks are completed, the restoration process will convert to a monitoring and adaptive management phase. Long-term maintenance of Wet Seepage Meadow/Carr areas will consist of burning every 2 to 6 years. For Wet Prairies, burning should occur every 2 to 4 years. Wet Forests should not be burned, except in cases where buckthorn seedlings have become established (perhaps following a multi-year drought) and fire is the best tool to control the seedlings. Reed canary grass will need to be monitored and spot-treated on an on-going basis every other year.

Restored areas must be regularly monitored to identify ecological issues, such as erosion and sedimentation, invasive species, and disease. Monitoring is also important for detecting human-related issues such as illegal activities (hunting, ATV use, tree harvesting, etc.) Early detection of concerns enables quick responses to address them before they become significant problems.

Monitoring animal as well as plant communities is also helpful for evaluating results of the restoration. A comparison of bird populations before and after restoration, for example, would be a valuable tool for quantifying positive impacts on the land.

Reed Canary Grass

Reed canary grass (RCG) is very abundant throughout the seasonal wetlands and wetland fringes of this property. Controlling it would be beneficial, but is also a very

labor intensive and lengthy process. If the option to control reed canary grass is pursued, then the following is a prescription that is recommended:

- **Broadcast-apply glyphosate** (without a surfactant or with non-ionized surfactant—a couple drops of dish soap) to large patches of RCG (or Kentucky bluegrass, too) in late August through September. The majority of the site will contain at least some natives, so broadcast applications will only be needed for portions of the overall site that have large monotypic stands of exotic grasses.
- The rest of the site should receive **wick applications** (sponge applicator wand filled with herbicide) **of glyphosate** (without a surfactant or with non-ionized surfactant) in the late summer/fall, preferably after most natives have gone dormant.
- In upland and wooded areas, Kentucky bluegrass and smooth brome, may be controlled with a **grass-specific herbicide** (sethoxydim), which will not kill sedges or forbs, but will kill all grasses (including natives, so be careful when applying).
- **Controlled burns** should be conducted each spring following fall herbicide treatments to remove thatch and induce RCG seed germination so as to deplete the seed bank.
- Once treatment has started, RCG populations can be controlled by **hand-weeding** and **burning** in early spring and continued **herbicide applications** in the late summer/fall for at least two years (3-4 years is better).
- Following RCG control and seed bank depletion, **native prairie species should be interseeded** into the open gaps, so RCG can get some competition from natives. Particularly good competitors are Lake Sedge (*Carex lacustris)*, Bottle-brush or Porcupine Sedge *(Carex hystericina),* and Canada Bluejoint Grass (*Calamagrostis canadensis).*
- **Long-term monitoring and control** will be required to detect new RCG plants that germinate from seed. Avoid disturbing restored areas, since disturbed soil will germinate any RCG seed that it still holds. In fact, just walking over a newly restored area can "daylight" RCG seed so that it germinates. Deer traffic has the same effect (Simba Blood, personal communication, 2011).

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APPENDICES

APPENDIX A. Plant Species Recorded at the Willow Brook Property

The following plant species were identified at the site by Friends of the Mississippi River in 2014.

Non-Native	Family Name	Scientific Name	Common Name	% Cover*	Diameter (inches)	Comments
Lowland Hardwood Forest-1						
CANOPY		**40-50 ft height**	**Total Cover: 4**			
	Aceraceae	*Acer negundo*	Boxelder	2	4 to 12	
	Ulmaceae	*Celtis occidentalis*	Hackberry		6 to 10	
	Oleaceae	*Fraxinus pennsylvanica*	Green ash		5 to 8	
	Salicaceae	*Populus deltoides*	Cottonwood	3	50 to 60	multi-stem trees
	Ulmaceae	*Ulmus americana*	American elm		6 to 8	
x	Ulmaceae	*Ulmus pulmila*	Siberian Elm		9	
SUBCANOPY		**12 to 20 ft height**	**Total Cover: 3**			
	Aceraceae	*Acer negundo*	Boxelder	2 to 3	1 to 4	
	Oleaceae	*Fraxinus pennsylvanica*	Green ash	1	2 to 6	
	Ulmaceae	*Ulmus americana*	American elm	2	1 to 5	
CLIMBERS			**Total Cover: 1**			
	Vitaceae	*Vitis riparia*	Wild grape	+		
SHRUB LAYER			**Total Cover:**			
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	2		

GROUND LAYER			**Total Cover: 4**		
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	3	
	Araliaceae	*Aralia nudicaulis*	Wild sarsaparilla	+	
x	Asteraceae	*Arctium minus*	Common burdock	+	
	Rubiaceae	*Galium aparine*	Cleavers	+	
x	Lamiaceae	*Leonurus cardiaca*	Common motherwort	2	
x	Lamiaceae	*Nepeta cataria*	Catnip	+	
	Vitaceae	*Parthenocissus quinquefolia*	Virginia Creeper	+	
x	Poaceae	*Poa pratensis*	Kentucky bluegrass	+	
	Rosaceae	*Prunus virginiana*	Chokecherry	+	
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	2	
	Grossulariaceae	*Ribes cynosbati*	Prickly gooseberry	+	
x	Asteraceae	*Taraxacum officinale*	Dandelion	+	
	Lamiaceae	*Teucrium canadense*	Germander	+	

** % Cover: 5 = 75-100%, 4 = 50-75%, 3 = 25-50% 2 = 5-25%, 1 = <5%, + = few individuals, r = rare*

Lowland Hardwood Forest-2

				% Cover	DBH
CANOPY			**Total Cover: 5**		
	Salicaceae	*Populus deltoides*	Cottonwood	2	40 to 55
	Aceraceae	*Acer negundo*	Boxelder	5	8 to 14
SUBCANOPY			**Total Cover: 2**		
	Aceraceae	*Acer negundo*	Boxelder	2	2 to 8
	Oleaceae	*Fraxinus pennsylvanica*	Green ash	1	1 to 8
SHRUB LAYER			**Total Cover: 3**		
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	3	
	Rutaceae	*Zanthoxylum americanum*	Prickly ash	+	

GROUND LAYER			**Total Cover: 4**	
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	4
x	Asteraceae	*Arctium minus*	Common burdock	2
x	Poaceae	*Poa pratensis*	Kentucky bluegrass	1

Altered Grassland-1

				% Cover
GROUND LAYER			**Total Cover: 5**	
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	3
x	Asteraceae	*Artemisia absinthium*	Absinthe wormwood	2
	Asclepiadaceae	*Asclepias syriaca*	Common milkweed	1
x	Brassicaceae	*Berteroa incana*	Hoary alyssum	1
x	Poaceae	*Bromus inermis*	Smooth brome	3
x	Boraginaceae	*Cynoglossum officinale*	Gypsy flower	1
x	Asteraceae	*Centaurea stoebe*	Spotted knapweed	2
	Asteraceae	*Erigeron spp.*	Daisy fleabane	2
x	Caprifoliaceae	*Lonicera tatarica*	Tartarian honeysuckle	1
x	Fabaceae	*Melilotus alba, officinalis*	Sweet clover, white & yellow	3
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	1
x	Poaceae	*Phalaris arundinacea*	Reed canary grass	2
x	Poaceae	*Poa pratensis*	Kentucky bluegrass	2
x	Scrophulariaceae	*Verbascum thapsus*	Common mullein	1
	Vitaceae	*Vitis riparia*	Wild grape	+

Altered Grassland-2

				% Cover
GROUND LAYER			**Total Cover: 5**	
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	4
x	Asteraceae	*Arctium minus*	Common burdock	1

x	Brassicaceae	*Barbarea orthoceras*	Winter cress	1	
x	Brassicaceae	*Berteroa incana*	Hoary alyssum	2 to 3	
x	Asteraceae	*Cirsium arvense*	Canada thistle	1	
x	Asteraceae	*Cirsium vulgare*	Bull thistle	1	
x	Fabaceae	*Coronilla varia*	Crownvetch	5	
x	Poaceae	*Elymus repens*	Quack grass	2 to 3	
x	Scrophulariaceae	*Linaria vulgaris*	Common toadflax	1	
x	Lamiaceae	*Nepeta cataria*	Catnip	1	
x	Poaceae	*Phalaris arundinacea*	Reed canary grass	4 to 5	
x	Poaceae	*Poa pratensis*	Kentucky bluegrass	1	
	Asteraceae	*Solidago canadensis*	Canada goldenrod	1	
x	Asteraceae	*Taraxacum officinale*	Dandelion	1	
	Lamiaceae	*Teucrium canadense*	Germander	2 to 3	
	Urticaceae	*Urtica dioica*	Stinging nettle	1	
x	Scrophulariaceae	*Verbascum thapsus*	Common mullein	1	

Mixed Emergent Marsh-2/Oak Woodland Brushland-3 (including Wet Prairie remnant)

				% Cover	DBH	
CANOPY			**Total Cover: 2**			
	Fagaceae	*Quercus macrocarpa*	Bur oak	2	38	One large tree found
x	Fabaceae	*Robinia pseudoacacia*	Black locust	1	3 to 6	
SHRUB LAYER			**Total Cover: 3**			
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	3		Extremely dense near bur oak
	Caprifoliaceae	*Sambucus canadensis*	Common elderberry	+		
GROUND LAYER			**Total Cover: 5**			
	Liliaceae	*Allium canadense*	Wild garlic	1		On upland edge, between BT & remnant
	Fabaceae	*Amorpha fruticosa*	False indigo	2		Towards

					shoreline
	Apiaceae	*Angelica atropurpurea*	Angelica	+	
	Araceae	*Arisaema triphyllum*	Jack in the pulpit	1	
	Asclepiadaceae	*Asclepias syriaca*	Common milkweed	2	
	Cyperaceae	*Carex lacustris*	Lake sedge	3	patchy
	Cyperaceae	*Carex stricta*	Tussock sedge	2	patchy
	Cyperaceae	*Carex vulpinoidea*	Fox sedge	1	
x	Asteraceae	*Cirsium arvense*	Canada thistle	1	
	Asteraceae	*Cirsium muticum*	Swamp thistle	1	
	Cyperaceae	*Eleocharis palustris*	Swamp rush	1	dense in sedge beds
	Asteraceae	*Eupatorium perfoliatum*	Common boneset	2	
	Asteraceae	*Eutrochium maculatum*	Spotted Joe pye weed	1	
	Geraniaceae	*Geranium maculatum*	Wild geranium	1	
	Hydrophyllaceae	*Hydrophyllum virginianum*	Virginia waterleaf	1	
	Balsaminaceae	*Impatiens capensis*	Jewelweed	2	patchy
	Iridaceae	*Iris versicolor*	Blue flag iris	1	
	Lemnaceae	*Lemna minor*	Lesser duckweed	2	in open pools
	Lamiaceae	*Lycopus spp.*	Bugleweed	1	
x	Lythraceae	*Lythrum salicaria*	Purple loosestrife	2	
	Saxifragaceae	*Micranthes pensylvanica*	Swamp saxifrage	r	only 1 found sometimes at core of sedge
	Dryopteridaceae	*Onoclea sensibilis*	Sensitive fern	1	patch
x	Poaceae	*Phalaris arundinacea*	Reed canary grass	2	patchy
x	Poaceae	*Phragmites australis*	Common reed grass	1 to 2	patchy
	Liliaceae	*Polygynatum pubescens*	Solomon's seal, downy	1	
	Lamiaceae	*Pycnanthemum virginianum*	Virginia mountain mint	2	
	Grossulariaceae	*Ribes americanum*	Wild black currant	1	
	Asteraceae	*Rudbeckia laciniata*	Wild goldenglow	2	
	Alismataceae	*Sagittaria latifolia*	Broad-leafed arrowhead	1	In sedge beds

	Cyperaceae	*Schoenoplectus acutus*	Bulrush	2	in sedge beds
	Asteraceae	*Solidago gigantea*	Giant goldenrod	2	
	Lamiaceae	*Teucrium canadense*	Germander	2	
	Ranunculaceae	*Thalictrum dasycarpum*	Tall meadow rue	1	
x	Typhaceae	*Typha ×glauca*	Hybrid cattail	1	patchy
	Typhaceae	*Typha latifolia*	Broad-leafed cattail	1	
	Urticaceae	*Urtica dioica*	Stinging nettle	2	patchy
	Violaceae	*Violet spp.*	Violet	2	

Cattail/Mixed Emergent Marsh

				% Cover	DBH
CANOPY			**Total Cover: 1**		
	Oleaceae	*Fraxinus nigra*	Black ash	1	
	Pinaceae	*Larix laricina*	Tamarack	+	
	Fagaceae	*Quercus rubra*	Northern red oak	+	
SHRUB LAYER			**Total Cover: 2 to 3**		
	Cornaceae	*Cornus sericea*	Red-osier dogwood	1	
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	1	
	Rosaceae	*Rubus idaeus*	Red raspberry	1	
	Salicaceae	*Salix amygdaloides*	Peach-leaved willow	+	
	Salicaceae	*Salix interior*	Sandbar willow	2	
	Salicaceae	*Salix nigra*	Black willow	1	
	Caprifoliaceae	*Sambucus canadensis*	Common elderberry	1	
GROUND LAYER			**Total Cover: 5**		
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	1	
x	Asteraceae	*Arctium minus*	Common burdock	1	
	Araceae	*Arisaema triphyllum*	Jack in the pulpit	+	
	Dryopteridaceae	*Athyrium filix-femina*	Lady fern	+	

	Brassicaceae	*Barbarea orthoceras*	Winter-cress	1		
	Bryophyta	*Bryophyte species*	Moss species	3		
	Ranunculaceae	*Caltha palustris*	Common marsh marigold	2		
	Brassicaceae	*Cardamine bulbosa*	Spring cress	+		
	Cyperaceae	*Carex spp.*	Carex species	2		
x	Asteraceae	*Cirsium arvense*	Canada thistle	1		
x	Asteraceae	*Cirsium vulgare*	Bull thistle	1		
	Cyperaceae	*Eleocharis* cf*. palustris*	Spikerush, marsh	+		in pools
	Asteraceae	*Eupatorium perfoliatum*	Common boneset	1		
	Asteraceae	*Eutrochium maculatum*	Spotted Joe pye weed	1		
x	Rhamnaceae	*Frangula alnus*	Glossy buckthorn	+		
	Apiaceae	*Heracleum lanatum*	Cow parsnip	1		
	Balsaminaceae	*Impatiens capensis*	Jewelweed	2		
	Lemnaceae	*Lemna minor*	Lesser duckweed	2		
x	Lythraceae	*Lytrhum salicaria*	Purple loosestrife	3		
x	Brassicaceae	*Nasturtium officinale*	Small-leaved water cress	2		in rivulets
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	1		
	Polygonaceae	*Persicaria maculosa*	Lady's thumb	1		
x	Poaceae	*Phalaris arundinacea*	Reed canary grass	2		
x	Poaceae	*Phragmites australis*	Common reed grass	2		
	Grossulariaceae	*Ribes allegheniensis*	Black raspberry species	1		
	Grossulariaceae	*Ribes americanum*	Wild black currant	+		
	Grossulariaceae	*Ribes* cf. *triste*	cf. Swamp red currant	1		
	Asteraceae	*Rudbeckia laciniata*	Wild goldenglow	+		
	Polygonaceae	*Rumex britannica*	Great water dock	+		
	Asteraceae	*Solidago canadensis*	Canada goldenrod	2		
	Araceae	*Symplocarpus foetidus*	Skunk cabbage	2		
	Lamiaceae	*Teucrium canadense*	Germander	1		
	Ranunculaceae	*Thalictrum dasycarpum*	Tall meadow	+		

			rue		
x	Typhaceae	*Typha ×glauca*	Hybrid cattail	5	
	Urticaceae	*Urtica dioica*	Stinging nettle	1	

Mixed Emergent Marsh- Seasonally Flooded					
				% Cover	DBH
CANOPY			**Total Cover: 2**		
	Aceraceae	*Acer negundo*	Box elder	1	4, 5, 8
	Oleaceae	*Fraxinus pennsylvanica*	Green ash	1	2 to 4
SHRUB LAYER			**Total Cover: 2**		
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	2	
GROUND LAYER			**Total Cover: 5**		
	Apiaceae	*Angelica atropurpurea*	Angelica	+	
	Asclepiadaceae	*Asclepias syriaca*	Common milkweed	+	
	Ranunculaceae	*Caltha palustris*	Common marsh marigold	3	
	Brassicaceae	*Cardamine bulbosa*	Spring cress	+	
	Cyperaceae	*Carex cf stricta*	Tussock sedge	1	
	Cyperaceae	*Carex lacustris*	Lake sedge	1	
x	Asteraceae	*Cirsium arvense*	Canada thistle	+	
	Asteraceae	*Doellingeria umbellata*	Flat-topped aster	+	
	Asteraceae	*Eupatorium perfoliatum*	Common boneset	1	
	Asteraceae	*Eutrochium maculatum*	Spotted Joe pye weed	1	
	Apiaceae	*Heracleum lanatum*	Cow parsnip	1	
	Balsaminaceae	*Impatiens capensis*	Jewelweed	2	
	Urticaceae	*Laportea canadensis*	Woodnettle	1	
	Lamiaceae	*Lycopus spp.*	Bugleweed	1	
x	Lythraceae	*Lytrhum salicaria*	Purple loosestrife	2	
x	Poaceae	*Phragmites australis*	Common reed grass	2	
	Poaceae	*Poa palustris*	Fowl bluegrass	+	
	Liliaceae	*Polygonatum*	Solomon's	+	

		pubescens	seal			
	Rosaceae	*Rubus flagellaris*	Northern dewberry	+		
	Polygonaceae	*Rumex britannica*	Great water dock	+		
	Asteraceae	*Solidago gigantea*	Giant goldenrod	1		
x	Asteraceae	*Sonchus oleraceus*	common sow thistle	1		
	Araceae	*Symplocarpus foetidus*	Skunk cabbage	3		
	Ranunculaceae	*Thalictrum dasycarpum*	Tall meadow rue	1		
x	Typhaceae	*Typha ×glauca*	Hybrid cattail	4		
	Violaceae	*Violet spp.*	Violet	1		

Mixed Hardwood Swamp-1, 2

CANOPY			**Total Cover: 3**			
	Oleaceae	*Fraxinus nigra*	Black ash	2	2 to 30	
	Pinaceae	*Larix laricina*	Tamarack	+ to 2	6 to 12	Only 2 alive in unit 2; several alive in unit 1
	Salicaceae	*Populus deltoids*	Cottonwood	+	6 to 55	
	Tiliaceae	*Tilia americana*	Basswood	+	5 to 10	
SHRUB LAYER			**Total Cover: 1**			
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	+		BT recently removed
	Grossulariaceae	*Ribes americanum*	Wild black currant	1		
	Grossulariaceae	*Ribes triste*	Red currant	2		
	Rosaceae	*Rubus idaeus*	Red raspberry	1		
	Caprifoliaceae	*Viburnum trilobum*	Highbush cranberry	1		
GROUND LAYER			**Total Cover: 5**			
	Apiaceae	*Angelica atropurpurea*	Angelica	+		
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	+		on margins
	Araliaceae	*Aralia nudicaulis*	Wild sarsaparilla	+		

x	Asteraceae	*Arctium minus*	Common burdock	1	on margins; patchy in unit 1, often underneath burdock
	Aristolochiaceae	*Asarum canadense*	Wild ginger	+	
	Ranunculaceae	*Caltha palustris*	Marsh marigold	3	
	Brassicaceae	*Cardamine bulbosa*	Spring cress	+	
	Cyperaceae	*Carex lacustris*	Lake sedge	1	
	Cyperaceae	*Carex lupulina*	Hop umbrella sedge	+	
x	Asteraceae	*Cirsium vulgare*	Bull thistle	+	
	Poaceae	*Elymus virginiancus*	Virginia wild rye	+	
	Asteraceae	*Eutrochium maculatum*	Spotted Joe pye weed	1	
	Apiaceae	*Heracleum lanatum*	Cow parsnip	2	
	Hydrophyllaceae	*Hydrophyllum virginianum*	Virgnina waterleaf	1	
	Balsaminaceae	*Impatiens capensis*	Jewelweed	2	
	Urticaceae	*Laportea canadensis*	Woodnettle	1	
	Poaceae	*Leersia virginica*	White grass	+	
	Lemnaceae	*Lemna minor*	Lesser duckweed	2	
x	Brassicaceae	*Nasturtium officinale*	Small-leaved water cress		in rivulets
x	Polygonaceae	*Persicaria maculosa*	Lady's thumb-print	+	
x	Poaceae	*Phalaris arundinacea*	Reed canary grass	2	
x	Poaceae	*Phragmites australis*	Common reed grass	none and 2	None found in unit 1
x	Poaceae	*Poa pratensis*	Kentucky bluegrass	1	
	Asteraceae	*Rudbeckia laciniata*	Wild goldenglow	2	
	Polygonaceae	*Rumex britannica*	Great water dock	1 to 2	
	Brassicaceae	*Senecio cf. pauperculus*	Balsam ragwort	1	
	Asteraceae	*Symphytrichum puniceum*	Red-stemmed aster	1	in unit 1 only
	Araceae	*Symplocarpus foetidus*	Skunk cabbage	3	
	Lamiaceae	*Teucrium canadense*	Germander		

x	Typhaceae	*Typha ×glauca*	Hybrid cattail	none and 4	None found in unit 1

Altered Deciduous Forest

				% Cover	DBH
CANOPY			**Total Cover: 3**		
	Aceraceae	*Acer negundo*	Boxelder		
x	Aceraceae	*Acer platanoides*	Norway maple		
	Oleaceae	*Fraxinus nigra*	Black ash		
	Oleaceae	*Fraxinus pennsylvanica*	Green ash		
	Salicaceae	*Populus deltoides*	Cottonwood		
x	Fabaceae	*Robinia pseudoacacia*	Black locust		
CLIMBERS			**Total Cover:**		
x	Lamiaceae	*Glechoma hederacea*	Creeping charlie		
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper		
	Vitaceae	*Vitis riparia*	Wild grape		
SHRUB LAYER			**Total Cover: 2**		
	Rosaceae	*Prunus americana*	Wild plum		
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn		
	Grossulariaceae	*Ribes oxyacanthoides*	Northern gooseberry		
	Rosaceae	*Rubus idaeus*	Red raspberry		
GROUND LAYER			**Total Cover:**		
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard		
	Araceae	*Arisaema triphyllum*	Jack in the pulpit		
	Aristolochiaceae	*Asarum canadense*	Wild ginger		
	Rubiaceae	*Galium aparine*	Cleavers		
	Balsaminaceae	*Impatiens capensis*	Jewelweed		
	Urticaceae	*Laportea canadensis*	Woodnettle		
	Poaceae	*Leersia virginica*	White grass		
x	Lamiaceae	*Leonurus cardiaca*	Common motherwort		
	Asteraceae	*Solidago gigantea*	Giant goldenrod		
	Lamiaceae	*Teucrium canadense*	Germander		

Oak Forest

				% Cover	DBH
CANOPY			**Total Cover: 3**		
	Oleaceae	*Fraxinus pennsylvanica*	Green ash	1	
	Betulaceae	*Ostrya virginiana*	Ironwood	+	
	Salicaceae	*Populus deltoides*	Cottonwood	2	
	Fagaceae	*Quercus ellipsoidalis*	Northern pin oak	1	
	Fagaceae	*Quercus macrocarpa*	Bur oak	1	
	Fagaceae	*Quercus rubra*	Northern red oak	1	
	Tiliaceae	*Tilia americana*	Basswood	1	
	Ulmaceae	*Ulmus americana*	American elm	1	
CLIMBERS			**Total Cover: 2 to 3**		
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	1	
	Vitaceae	*Vitis riparia*	Wild grape	2	
GROUND LAYER			**Total Cover: 2**		
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	2	
	Cyperaceae	*Carex pensylvanica*	Pennsylvania sedge	+	

Oak Woodland/Brushland

				% Cover	DBH
CANOPY			**Total Cover: 4**		
	Fagaceae	*Quercus ellipsoidalis*	Northern pin oak	4	6 to 18
	Fagaceae	*Quercus macrocarpa*	Bur oak	1	10 to 35
	Fagaceae	*Quercus rubra*	Northern red oak	+	3 to 8
CLIMBERS			**Total Cover: 1**		
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	1	
SHRUB LAYER			**Total Cover: 2 to 4**		
	Ulmaceae	*Celtis occidentalis*	Hackberry	1	

	Rosaceae	*Prunus virginiana*	Chokecherry	2	
x	Rhamnaceae	*Rhamnus cathartica*	Common buckthorn	3	small: 2 - 3' tall
	Rosaceae	*Rubus idaeus*	Red raspberry	1	
GROUND LAYER			**Total Cover: 3**		
x	Brassicaceae	*Alliaria petiolata*	Garlic mustard	2	
	Fabaceae	*Amorpha canescens*	Leadplant	+	in knoll remnant
	Poaceae	*Andropogon gerardii*	Big bluestem		in knoll remnant
	Apocynaceae	*Apocynum sibiricum*	Clasping dogbane	+	in knoll remnant
x	Liliaceae	*Asparagus officinalis*	Asparagus	+	
x	Brassicaceae	*Berteroa incana*	hoary alyssum	1	
	Cyperaceae	*Carex pensylvanica*	Pennsylvania sedge	2	
	Cyperaceae	*Carex sprengelii*	Sprengel's sedge	1	near clearings and trails
x	Boraginaceae	*Cynoglossum officinale*	gypsy flower	1	
	Asteraceae	*Helianthus strumosus*	woodland sunflower		
	Poaceae	*Panicum virgatum*	Switch grass		in knoll remnant
x	Poaceae	*Poa pratensis*	Kentucky bluegrass	+	
	Fagaceae	*Quercus ellipsoidalis*	pin oak	+	in gaps
	Fagaceae	*Quercus macrocarpa*	bur oak	+	in gaps
	Poaceae	*Schizachyrium scoparium*	Little blue stem		in knoll remnant
	Commelinaceae	*Tradescantia spp.*	Spiderwort	+	in knoll remnant
	Apiaceae	*Zizia aurea*	Golden alexanders	1	patchy

** % Cover: 5 = 75-100%, 4 = 50-75%, 3 = 25-50% 2 = 5-25%, 1 = <5%, + = few individuals, r = rare*

APPENDIX B. Plant Species for Restoration at Willow Brook Property

Refer to DNR lists for the following:

- Northern Wet Ash Swamp, WFn55
- Northern Mixed Cattail Marsh, MRn83
- Southern Seepage Meadow/Carr, WMs83
- Southern Dry-Mesic Oak Forest, MHs37
- Southern Wet-Mesic Hardwood Forest, MHs49
- Southern Wet Prairie, WPs54
- Southern Dry-Mesic Oak (maple) Woodland, FDs37
- Southern Dry Savanna, UPs14
- Southern Mesic Prairie, UPs23
- Clay/Mud River Shore, RVx54

Refer to the Management Recommendations section for the following:

- Altered Forest, Forest Alt
- Altered Grassland, Grass Alt
- Altered Grassland & Trail, Grass Alt & Trail
- Altered Grassland/Forest, Grass/For Alt
- Lowland Hardwood Forest, LHF
- Pond
- Shallow Lake, Sh Lake
- Buildings and Parking Lots, Bldgs & Parking

APPENDIX C. Methods for Controlling Exotic, Invasive Plant Species

TREES AND SHRUBS

Common Buckthorn, *Tartarian Honeysuckle*, *Siberian Elm*, and *Black Locust* are some of the most common exotic woody species likely to invade native woodlands or prairies in Minnesota. Buckthorn and honeysuckle are European species that escaped and invaded woodlands in many parts of the country. They are exceedingly aggressive and, lacking natural disease and predators, can out-compete native species. They remain photosynthetically active longer than most other native shrubs and trees, which gives them a competitive advantage. The seeds are disseminated by birds, which makes them especially problematic in open woodlands, savannas, and overgrown prairies. They also benefit from the net actions of invasive earthworms, fire suppression, and high deer populations, forming a synergy that helps set the stage for their establishment and dominance. Invasions eventually result in a dense, impenetrable brush thicket that greatly reduces native species diversity.

Siberian elm, native to eastern Asia, grows vigorously, especially in disturbed and low-nutrient soils with low moisture. Seed germination is high and seedlings establish quickly in sparse vegetation. It can invade and dominate disturbed areas in just a few years. Black locust is native to the southeastern United States and the very southeastern corner of Minnesota. It has been planted outside its natural range (it was promoted as an erosion control species and a soil stabilizer partly since it was falsely assumed to be a nitrogen fixer, and since it quickly colonizes bare slopes), and readily invades disturbed areas. It reproduces vigorously by root suckering and can form a monotypic stand.

Biological Control

Currently there are not biological controls for exotic invasive woody plants in Minnesota. Studies are underway by the DNR and University of MN. So far, no organism has stood up to the standards required of a good bio-control organism, but they are still researching it (http://www.legacy.leg.mn/projects/biological-control-european-buckthorn-and-garlic-mustard).

Chemical Control

The most efficient way to remove woody plants that are 1/2 inch or more in diameter is to cut the stems close to the ground and treat the cut stumps with herbicide immediately after they are cut, when the stumps are fresh and the chemicals are most readily absorbed. Failure to treat the stumps will result in resprouting, creating much greater removal difficulty.

In non-freezing temperatures, a glyphosate herbicide such as Roundup can be used for most woody species. It is important to obtain the concentrated formula and dilute it with water to achieve 10% glyphosate concentration. Adding a marker dye can help to make treated stumps more visible. In winter months, an herbicide with the active ingredient

triclopyr must be used. *Garlon 4* is a common brand name and it must be mixed with a penetrating oil, such as diluent blue. Do not use diesel fuel, as it is much more toxic in the environment and for humans.

Brush removal work can be done at any time of year except during spring sap flow, but late fall is often ideal because buckthorn retains its leaves longer than other species and is more readily identified. Cutting can be accomplished with loppers or handsaws in many cases. Larger shrubs may require brush cutters and chainsaws, used only by properly trained professionals.

For plants in the pea family, such as black locust, an herbicide with the active ingredient clopyralid can be more effective than glyphosate. Common brand names for clopyralid herbicides are Transline, Stinger, and Reclaim.

In the year following initial cutting and stump treatment, there will be a flush of new seedlings as well as resprouting from some of the cut plants. Herbicide can be applied to the foliage of these plants. Fall is the best time to do this, when desirable native plants are dormant and when the plant is pulling resources from the leaves down into the roots. Glyphosate and Krenite (active ingredient – fosamine ammonium) are the most commonly used herbicides for foliar application. Krenite prevents bud formation so the plants do not grow in the spring. This herbicide can be effective, but results are highly variable. Glyphosate or a triclopyr herbicide such as Garlon can also be used. Glyphosate is non-specific and will kill anything green, while triclopyr targets broadleaf plants and does not harm graminoids. All herbicides should be applied by licensed applicators and should not be applied on windy days. Care should be taken to avoid application to other plants. "Weed Wands" or other devices that allow dabbing of the product can be used rather than spraying, especially for stump treatment.

Undesirable trees and shrubs can also be destroyed without cutting them down. Girdling is a method suitable for small numbers of large trees. Bark is removed in a band around the tree, just to the outside of the wood. If girdled too deeply, the tree will respond by resprouting from the roots. Girdled trees die slowly over the course of one to two years. Girdling should be done in late spring to mid-summer when sap is flowing and the bark easily peels away from the sapwood. Herbicide can also be used in combination with girdling for a more effective treatment.

Basal bark herbicide treatment is another effective control method. A triclopyr herbicide such as 10% Garlon 4, mixed with a penetrating oil, is applied all around the base of the tree or shrub, taking care so that it does not run off. If the herbicide runs off it can kill other plants nearby. More herbicide is needed for effective treatment of plants that are four inches or more in diameter.

Mechanical Control

Three mechanical methods for woody plant removal are hand pulling (only useful on seedlings and only if few in number), weed wrenching (using a weed wrench tool to pull

stems of one to two inches diameter), and repeated cutting. Pulling and weed wrenching can be done any time when the soil is moist and not frozen. The disadvantage to both methods is that they are somewhat time-consuming, as the soil from each stem should be shaken off. Weed wrenching also creates a great deal of soil disturbance and should not be used on steep slopes or anywhere that desirable native forbs are growing. The soil disturbance also creates opportunities for weed germination. This method is probably best used in areas that have hardly any desirable native plant cover.

Repeated cutting consists of cutting the plants (by hand or with a brush cutter) at critical stages in its growth cycle. Cutting in mid spring (late May) intercepts the flow of nutrients from the roots to the leaves. Cutting in fall (about mid-October) intercepts the flow of nutrients from the leaves to the roots. Depending on the size of the stem, the plants typically die within three years, with two cuttings per year.

Stems, Seedlings and Resprouts

Prescribed burning is the most efficient, cost effective, and least harmful way to control very small stems, seedlings, and resprouts of all woody plants. It also restores an important natural process to fire-dependant natural communities (oak forests, for example). Burning can only be accomplished if adequate fuel (leaf litter) is present and can be done in late fall or early spring, depending site conditions.

If burning is not feasible, critical cutting in the spring is also effective, though it can impact desirable herbaceous plants as well. Foliar (leaf) application of a bud-inhibitor herbicide (Krenite) during fall is also effective. This method can also affect non-target species, though most natives will be dormant by that time.

Prickly Ash

A native shrub, prickly ash can become excessively abundant, especially in areas that have been disturbed or grazed. Complete eradication may not be necessary, but management may target reducing the extent of a population. Removal is most easily accomplished in the same manner as for buckthorn – cutting shrubs and treating cut stumps with glyphosate herbicide. Cutting can be completed at any time of the year.

Smooth Sumac

Like prickly ash, smooth sumac can become excessively abundant, especially in areas where fire has been suppressed for long periods of time. Unlike prickly ash or buckthorn, however, controlling smooth sumac does not require herbicide applications, since that would require a tremendous amount of herbicide, be quite labor intensive, and probably cause heavy damage to surrounding plants. Control of smooth sumac can be easily be accomplished by cutting and burning, or a combination of these two. To be effective, burn or cut the sumac twice a year: the first time in the late spring, just after it has fully leafed out (expended maximum energy), and the second time in late summer, after it has re-sprouted. Repeat this method annually for two to five years, to deplete the clone of its

energy, working back at the edges of the clone, reducing it from the outside towards the inside. If cutting or burning is performed only once a season, the clone will persist, since this will not be enough to drain the root system of stored energy. Cutting twice a year, and not burning will be effective, but burning is doubly so, since fire tends to benefit herbaceous plants and suppress woody ones.

Disposal

The easiest and most cost-effective method to handle large amounts of woody brush is usually to stack it and burn it. This is most typically done during winter, to lessen the impacts to soil (compaction, erosion, rutting, etc.). Brush piles can be burned during the cutting process, or it they can be burned later time, if fire conditions are not suitable. In areas where brush is not dense, it can be cut up into smaller pieces, scattered, and left on the ground where it will decompose in one to three years (this method is especially useful on slopes to reduce erosion potential). Small brush piles can also be left in the woods as wildlife cover. Where there is an abundance of larger trees, cut trees may be hauled and chipped and used for mulch or as a biofuel. Alternatively, the wood can be cut and used for firewood, if a recipient can be found, or perhaps saved to be used later as waterbars for slope stabilization.

FORBS

Spotted Knapweed

Knapweed is a perennial species, and a pernicious one at that. Of all the typical prairie weeds, spotted knapweed is probably the most troublesome. It cannot be controlled with burning—like sweet clover it actually increases with fire. Hand-pulling individuals or small groups of individuals can be effective, if populations are small. Volunteers work well for hand-pulling knapweed. Knapweed has a fairly large tap root, and can be difficult to pull. Pulling is typically more difficult when soil is hard (dry), clayey, or compacted, but easier when soil is wet (following a rain), sandy, and friable. If knapweed populations are large, a bio-control (knapweed beetles--weevils) is recommended. Knapweed beetles (weevils) are released during summer. Weevils can be purchased online and they are sent via the mail. Knapweed populations should be monitored each year to keep a record of the effectiveness of the bio-control.

Weevils are effective for long-term control, but not a good short-term control option. Spot treatment with a systemic herbicide such as milestone or Transline can be effective for short-term control. Applying herbicide to prairie restoration areas should be done with care. Remnants with high diversity should be spot treated, not broadcast-treated. It is recommended to treat first with the least impactful chemical, monitor to see if that works, and if it does not work, then try another. Degraded and highly disturbed areas can be treated a little less gently, perhaps using broadcast applications. Always follow the product label when using any chemical for weed control. Treatment should be done before plants

form seed, so late spring and early summer are best. Professional pesticide applicators are required for herbicide treatment.

Canada thistle

While native thistles are not generally problematic, exotics such as Canada thistle are clone-forming perennials that can greatly reduce species diversity in old fields and restoration areas (Hoffman and Kearns 1997). A combination of chemical and mechanical control methods may be needed. Chemical control is most effective when the plants are in the rosette stage and least effective when the plants are flowering. A broadleaf herbicide such as 2,4-D where native grasses and sedges are present, since 2,4-D only affects dicots. 2,4-D is most effective when applied 10-14 days before the flowering stems bolt. It is applied at rate of 2-4 lb/acre using a backpack or tractor-mounted sprayer or in granular form. Dicamba could also be used, with the advantages that it can be applied earlier in the spring at a rate of 1 lb/acre. Another chemical that has been used for thistles is aminopyralid ("Milestone"), which can be applied at bud stage. Aminopyralid will affect other species and it has longer residual activity than some other chemicals, so use with caution—typically use it on large patches/clones of thistles and avoid areas of higher diversity. Plants that do not respond to treatment or that are more widely dispersed could be controlled mechanically.

Mechanical control, involving several cuttings per year for three or four years, can reduce an infestation, if timed correctly. The best time to cut is when the plants are just beginning to bud because food reserves are at their lowest. If plants are cut after flowers have opened, the cut plants should be removed because the seed may be viable. Plants should be cut at least three times throughout the season. Late spring burns can also discourage this species, but early spring burns can encourage it. Burning may be more effective in an established prairie, where competition from other species is strong, rather than in an old field, where competition is likely to be weaker.

Sweet clover

White and yellow sweet clover are very aggressive biennial species that *increase* with fire. Where sweet clover is found, it should be controlled in conjunction with treatment that attempts to eliminate smooth brome, if prairie restoration occurs. Sweet clovers are common plants in agricultural areas, so if restoration is implemented, the project area should be surveyed for this species on an annual basis. Often times, following initial brush removal and/or burning, a flush of weedy annuals and biennials such as sweet clover can occur. Well-timed mowings and burnings are usually adequate to control these species. Mowing the site, as is typically prescribed for prairie restoration maintenance, should occur when all plants on the site (including sweet clovers) are approximately 12 inches in height. Sweet clover can bloom even at a height of 6 inches, but if it is burned or mowed in the following year in the late spring, it should be controlled. On steep sites, brush cutting can be substituted for mowing. Individual plants or small populations can be removed by hand-pulling. If seed production occurs, prodigious amounts of seed can be produced and

spread. Competition from native species also helps control sweet clovers and other weedy annuals and biennials.

To some extent, *Common burdock* and *common mullein* can be treated similarly to sweet clover, since they are both exotic, biennial forbs that are typically found in disturbed areas or restoration projects.

Garlic Mustard

Garlic mustard is an exotic biennial forb of woodlands and woodland edges that is very invasive and aggressive. Following the introduction of just a few plants, populations can rapidly increase and a dramatic "explosion" of garlic mustard plants can occur. Invasion is facilitated in areas of disturbance. Studies have shown, however, that garlic mustard does not necessarily displace other species, but merely occupies a new ecological niche. Nevertheless, garlic mustard can be very invasive in woodlands, and it is recommended to monitor it and remove it as soon as it is detected (early detection and rapid response). Garlic mustard produces a flavonoid (root exudate) that suppresses myccorhizal inoculation. Thus species that are myccorhizae dependent, like oaks, will become stunted and easily out-competed by garlic mustard. The flavonoid persists in the soil years after garlic mustard plants are removed. This is a good reason to keep natural woodlands garlic mustard-free.

Bio-control

There are studies underway by the Minnesota DNR and University of Minnesota that show good potential for bio-control of garlic mustard via an exotic weevil (http://www.legacy.leg.mn/projects/biological-control-european-buckthorn-and-garlic-mustard). The testing phase is complete, but the approval process still needs to be performed. Hopefully, soon bio-control will be available for garlic mustard, which could revolutionize control of this invasive species. Whether it will be effective or not in the landscape is yet to be determined.

Mechanical Control

Probably the best way to control garlic mustard is to closely monitor your site, and if it is found, hand pull it before it spreads. Hand-pulling should occur before siliques (seed pods) form. Once siliques form, removed plants should be bagged and transported from the site, since the plant may have enough energy in the stem and root to make viable seeds, even though it is not growing in the ground. If bagging and transporting are not an option, making weed piles is an option, but prepare to deal with garlic mustard plants in the future at each pile. Garlic mustard plants produce hundreds of seeds per plant—they are very prolific. When pulling the garlic mustard plants, take care to remove the entire root, since they may resprout if part of the root is left in the ground. This can be difficult, since roots are "S-shaped" and tend to break off at ground level.

Chemical control

Chemical control is not recommended except for cases where garlic mustard is growing in large monocultural patches. In such cases, a systemic herbicide may be appropriate.

Glyphosate is non-specific, and will kill any actively growing plant. One technique that has been effective is applying a water soluble herbicide during warm days in the winter, when no snow cover or only a thin snow cover exists. Garlic mustard rosettes (first year plants) remain green mostly all year round, and can be killed during the winter when nearly all other plants are dormant. Another technique is using an herbicide specific to broadleaved plants, like triclopyr (trade name "Garlon"), but one that is water soluble, which can be dispensed with a backpack sprayer or the like; this will not kill grasses or sedges.

GRASSES

Smooth Brome

Burning two years in a row (late-season burns in June) followed by seeding has been shown to be effective in controlling smooth brome. This specie is a cool season one—active early in the growing season in southern Minnesota (April-May-June), and then going semi-dormant in July-August-September. It reproduces by means of underground stems (stolons and rhizomes) called "tillers". The most effective treatment is timed to occur at the same time as the brome is "tillering"—mid to late May in southern Minnesota. Consider that this timing may be a week or two earlier on steep south-facing slopes or in very sandy or sand-gravel soils. Following this method will usually be sufficient to control smooth brome. (Remember to collect native seed on-site first, and if there is not enough, then purchase local ecotype seed from off-site). Evaluate after the two years. If this is not working, perhaps try a cool-season overspray of a grass-specific herbicide either in the spring (April) or in the fall (October). Using glyphosate as a cool-season overspray herbicide application is a last resort, since it kills everything.

To a greater extent, *Kentucky bluegrass* and *creeping fescue* can be treated similarly to smooth brome, since like smooth brome, they are both exotic, stoloniferous, cool-season grasses.

Reed canary grass

This species is extremely difficult to eradicate and requires repeated treatment over a period of one to three years. A combination of burning, chemical treatment and mowing can be used, in accessible areas, or chemical treatment alone in inaccessible areas. The combination method starts by burning in late spring to remove dead vegetation and to stimulate new growth. When new sprouts have reached a height of 4 to 6 inches, the site can be sprayed with a 5% solution of a glyphosate herbicide appropriate for wetland habitat (e.g. Rodeo). The site is then mowed in late summer, followed by chemical application after re-growth. This treatment will stimulate new growth and germination to deplete the seed bank. The sequence of chemical treatment and mowing are repeated for at least a second season, and possibly a third until the grass is completely eradicated. Then native grass and forb seed can be broadcast or drilled.

If reed canary is eradicated from an area, future management of the grassland, namely burning, will likely keep the reed canary in check. Monitoring and mapping new individuals or clumps should continue, however, and treated if burning is not adequate. If

the plants are small they can be removed by digging out the entire root. Generally though, chemical treatment is more feasible. If plants are clumped, they can be treated by tying them together, cutting the blades, and treat the cut surface with herbicide. Otherwise herbicide should only be applied in native planted areas on very calm days to avoid drift to non-target plants.

Hybrid Cattail (Typha X glauca)

Eradication will not be possible, since propagules will continually be re-introduced into the middle and lower portions of the property. However, control is highly recommended, especially in areas where *Typha* is just starting to invade. Several methods are available for cattail control. Mechanical methods are available, and the simplest of these is merely digging out the root and tuber of the plant. This is very difficult to do, and most oftentimes parts of the root are left in place to grow back again. It also causes a great deal of disturbance to the pond bottom, which is not desired. Another mechanical method involves cutting of culms during the winter, when ice covers the pond. This method usually does not work well, though, since it is only successful if the plants are "drowned out" by rising water levels due to spring meltwater. Rarely does there get to be enough melting to raise water levels high enough and for long enough to be effective on cattails.

The best options for large areas are probably chemical methods. The best chemical method is probably *hand-wicking*, which is a selective process. If a non-selective, broadcast applied method were to be used, many nearby plants and ones that are barely eking out an existence underneath the Typha canopy, will be damaged or killed, which is not acceptable. Hand-wicking involves applying a systemic, aquatic-approved herbicide that includes a non-ionic surfactant to penetrate the cuticle and shiny coating of the cattail leaf (drops of dish soap can suffice)—by hand. Typically, a non-absorbent (plastic) glove is first donned and then an absorbent (cotton) one over that, so that the hand is protected from absorbing any herbicide but yet still able to absorb herbicide. Dip your gloves-covered hand into the herbicide solution and wring it out thoroughly before applying. Once wrung out, apply to individual cattail leaves/culms, running up the leaf/culm from the bottom to the top, trying to get good coverage on the leaf/culm. Be careful not to touch other plants, for they will be damaged by the herbicide too. This is a labor intensive process, but worth it in the long run, since little collateral damage occurs to nearby desirable plants. Take care not to spill or empty the contents of the herbicide container—sometimes a squirt container is preferred to an open-top one.

Phragmites

Treat *Phragmites* the same way that you would hybrid cattail. It may require more herbicide than cattail, since it is a larger, more robust plant.

APPENDIX D. Ecological Contractors

Following is a list of contractors to consider for implementing the management plans. While this is not an exhaustive list, it does include firms with ecologists who are very knowledgeable with natural resource management. Unless otherwise noted, all firms do prescribed burning. Many other brush removal companies are listed in the yellow pages (under tree care), but most do not have knowledge or understanding of native plant communities. We recommend hiring firms that can provide ecological expertise. Additional firm listings can be found on the DNR website:
http://www.dnr.state.mn.us/gardens/nativeplants/index.html

Friends of the Mississippi River (FMR) has extensive experience working with landowners to implement natural resource management plans. FMR can assist landowners with obtaining funding for restoration and management projects and providing project management, including contractor negotiations, coordinating restoration and management work, and site monitoring and evaluation.

Applied Ecological Services, Inc.
21938 Mushtown Rd
Prior Lake, MN 55372
952-447-1919
www.appliedeco.com

Conservation Corps Minnesota
2715 Upper Afton Road, Suite 100
Maplewood, MN 55119
(651) 209-9900

Great River Greening
35 West Water St, Suite 201
St. Paul, MN 55107
651-665-9500
www.greatrivergreening.org

Minnesota Native Landscapes, L.L.C. 14088 Highway 95 N.E.
Foley, MN 56329
(320) 968-4222 Phone www.mnnativelandscapes.com

Prairie Restorations, Inc.
PO Box 305
Cannon Falls, MN 55009
507-663-1091
www.prairieresto.co

Stantec
2335 West Highway 36
St. Paul, MN 55113
651-604-4812
www.stantec.com

Wetland Habitats Restoration, LLC.
1397 Chelmsford St.
St. Paul, MN 55108
Cell: 612-385-9105
Fax: 636-333-8834
www.whr.mn
Email: wetlandhabitat@gmail.com

APPENDIX E. Tamarack Ecology

Tamarack is an important food source for only a few species of wildlife (website for USDA Forest Service Plants Database for *Larix laricina*). It is browsed by some animals, but generally to a limited extent. Porcupines feed on the inner bark. White-tailed deer generally avoid tamarack—palatability is low. Red squirrels cut and cache tamarack cones. Pine siskins, crossbills, and probably other seed eating birds eat tamarack seeds. Mice, voles, and shruews consume large numbers of tamarack seeds off the ground (USDA website).

Tamarack is of limited value as cover for mammals and birds because it sheds its needles in the winter and often occurs in rather open stands. Bald eagles occasionally nest in tamarack (USDA website).

Tamarack has a low tolerance for shade, and should not be planted with fast growing trees. It can be established on sites by direct seeding or by transplanting seedlings. It does not exhibit dormancy and can be planted in the spring or fall. Seed should be sown at a depth of about 0.25 inch and remains viable for 4 years when kept in sealed containers at 18-22 degrees F and a seed moisture content of 2 to 5%. Tamarack is easily propagated from cuttings taken from young trees (USDA website).

Tamarack can be used for many things, including fishtraps, boat ribs, dogsled runners, and duck decoys, Indians used roots for cordage, wood for arrow shafts, and bark for medicine. Pioneers used needles for stuffing pillows and mattresses and used large roots for ship building (USDA website).

Tamarack seeds germinate and establish best in the open, and seedlings require nearly full sunlight to survive and grow well. Even-age silviculture is best for them. (USDA website)

Larch sawfly is the most destructive pest of tamarack (USDA website). Epidemics occur periodically across northern US and Canada. Insects defoliate trees and can kill many trees. Trees die after 6-9 years of heavy defoliation. Another insect, larch caseborer, have also caused much mortality during outbreaks. Other insects including the spruce budworm, larch, bud moth, spruce spider mite, larch shoot moth, and several bark beetles also infest tamarack but seldom cause serious injury. Tamarack is resistant to rusts and other fungal diseases.

Tamarack is susceptible to flooding damage and disruptions in groundwater movements. Trees have been killed over large areas where newly constructed roads impede water movements and where beavers dam drainage ditches or small streams.

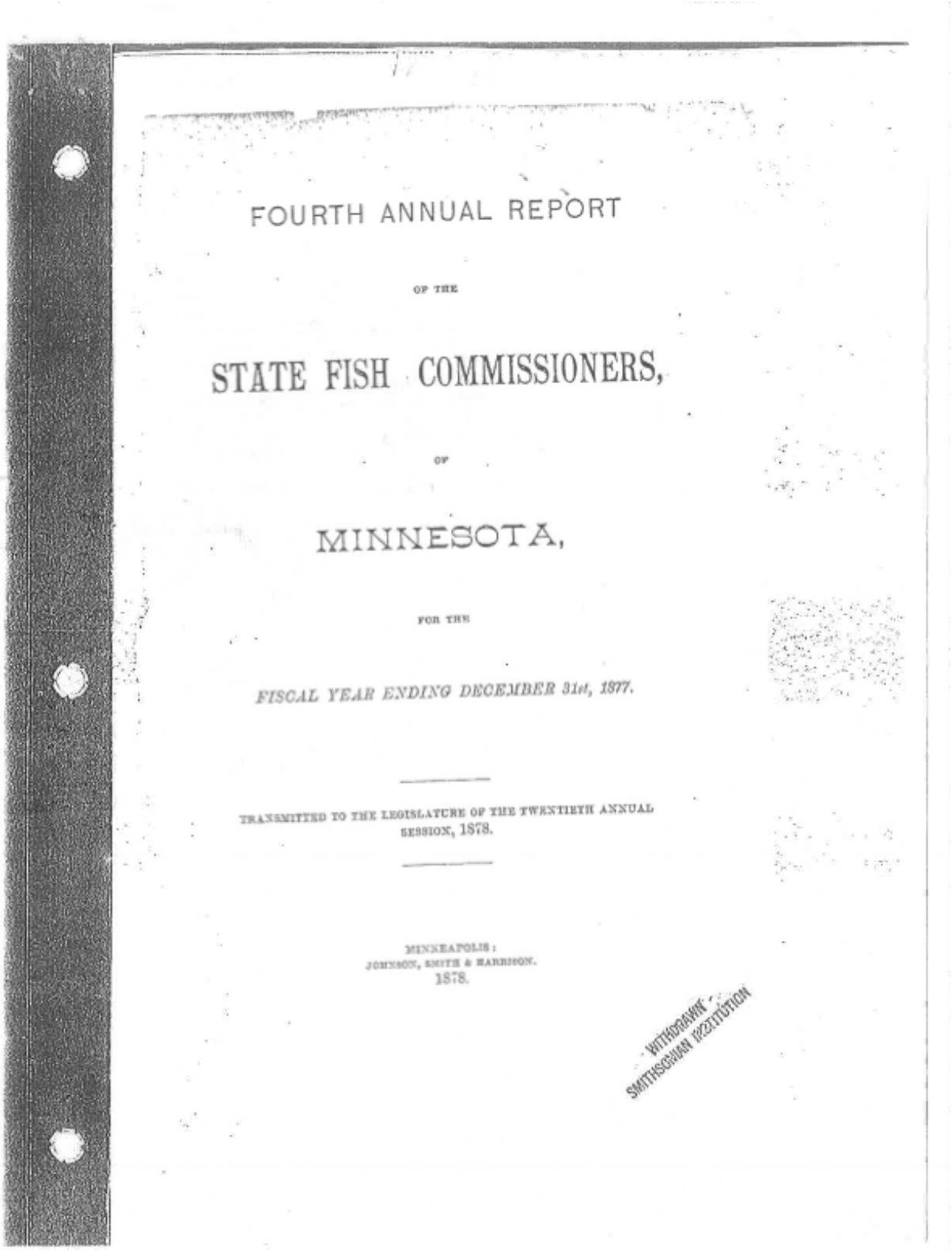
Tamarack stands cast only light shade and have dense undergrowth of shrubs. Tall shrubs associated with them include bog birch, swamp birch, speckled alder, willows, and red-osier dogwood. Low shrubs include bog shrubs. Ground is usually covered with sphagnum and other mosses.

Tamaracks are pioneer species and are often the first to invade open areas. Invasion toward the center or wettest portion of the swamp is common. As substrates become consolidated and firm, often other conifers will replace tamarack, including black spruce on poorly drained acid peatlands. In nutrient rich swamps, it is replaced first by black spruce and later by northern white cedar, balsam fir, and eventually by swamp hardwoods. (USDA website).

In Minnesota, flowering occurs late April to early May. Seedfall begins in early September and is nearly complete by late October. (USDA website).

Tamarack trees are easily killed by fire. It has thin bark and shallow roots. Seed from surviving trees will revegetate burned areas. Generally found in boggy or swampy habitats, pockets of tamarack trees often escape burning due to local topography or extremely wet conditions, then these trees provide seeds for post-fire recovery. Seed is dispersed over short distances, so the species is not well adapted for seeding large burns. It is an "off-site colonizer" and seed is carried by wind postifre years 1 and 2. Seeds on the ground that encounter fire will be readily killed. Cones can survive, but immature seeds will not ripen on fire-killed trees. Tamarack establishes readily on sites where logging slash has been burned, but poorly on sites where slash is untreated. In Minnesota, six years following burning, tamarack seedlings are typically found.

Appendix F. Historic Report, December 31st, 1877.



FOURTH ANNUAL REPORT

OF THE

STATE FISH COMMISSIONERS,

OF

MINNESOTA,

FOR THE

FISCAL YEAR ENDING DECEMBER 31st, 1877.

TRANSMITTED TO THE LEGISLATURE OF THE TWENTIETH ANNUAL SESSION, 1878.

MINNEAPOLIS:
JOHNSON, SMITH & HARRISON.
1878.

to use them for so legitimate a purpose. Hon. H. M. Rice, to whom is due the honor of being the prime mover of our fish operations, and who is always interested in the enterprise, helped hunt up an old French fisherman, who acknowledged the possession of a seine, and induced him to essay netting the river at this point, but after tearing his seine two or three times on the "sticks" with which the river bottom is bristling, abandoned the effort.

The truth is, the pernicious custom of dropping the refuse strips from the saw mills at the falls into the river, has set the river bed in many places like chevaux de frise, which, unless removed, it is hardly possible to draw a seine in this vicinity. We believe this practice is not so great as formerly, and we hope it will be discontinued entirely, as the presence of sawdust and lumber refuse is inimical to all kinds of fish.

At the request of our commission for a further supply of shad to continue the stocking of our river, U. S. Commissioner Baird sent us on July 25th 100,000 young fry, in charge of Messrs. C. W. Schuerman and H. E. Quinn, from South Hadly Falls, Mass. These young fish were planted in the Mississippi opposite the city early in the morning soon after the arrival of the train, with the fervent injunction, go, increase, multiply and replenish the waters.

BROOK TROUT.

The commissioners have been urgently requested both verbally, by letter and by petition from many of our best citizens in different sections of our State, particularly along our river and southern border, to stock the streams in those parts where formerly trout were abundant and where there are few or no lakes. This most reasonable request the commissioners are endeavoring to comply with, and during the past season secured two thousand young trout, which are now at this present time spawning and from which we hope to realize at least 100,000 fry, for distribution next summer. The cost of the two thousand trout placed in the ponds at Red Wing, was just sixty dollars. They are worth now two hundred dollars and will be worth more next year as breeders, than at this time.

The small outlay for these breeders we thought a good investment and justifiable, and one which would give ample returns and gratifying results to all parts of the community.

WHITE FISH.

Our former Commissioners Dr. Day and Gov. Austin, found it impossible to move adult White fish, so delicate are they, that handling them never so gently and with greatest caution they die in a few hours. Our intention was to profit by their experience and bring the impregnated eggs, hatch them and distribute the fry before the yolk sac was absorbed. With this intention Commissioner Sweeny visited the Fishery of Mr. Horace Gray, at Grosse Isle, on the river, twenty-five miles below Detroit, Michigan, where the Michigan Commissioners take their White fish Spawn and to whose kind assistance and many courtesies we are very much indebted.

We procured half a million of impregnated White fish eggs, the result of one nights fishing: after washing, and soaking, and changing water until firm and apparantly in good condition, secured in two fifteen gallon cans with a good supply of water, it was thought quite practicable to carry them safely to St. Paul, a journey of about 36 hours duration. The water was changed many times during the journey, whenever suitable water was to be had, and ice used to keep the temperature down, as there was a fire in the baggage car; all to no purpose however, the long journey, perhaps so soon after fertilizing, was too much for them. Many were dead when they reached St. Paul and the rest survived only a few days. Much to the regret of the Commissioners another failure in the Whitefish manipulations has to be recorded.

SELECTION OF SPRINGS FOR STATE HATCHERY.

The inconveniences and disadvantages of Red Wing, as a point of distribution for the whole State, has been more thoroughly demonstrated in the experiences of the commission, the past year, than in previous seasons, and with this fact in mind the commissioners have examined many streams and springs, seeking to find such place as would combine all the different requirements necessary—such as a sufficient supply of good wholesome water, complete and entire safety from danger of freshet or back floods, and above all, proximity to a railroad centre of distribution.

We think such a place has been happily found and secured by lease to the State, for the term of 13 years, during the minority of the owners, for the nominal rent of the taxes on the property of six acres and a fraction, one half of which is occupied by the State works. The taxes will in all probability never be over fifteen or twenty dollars per annum.

The springs, now named Willowbrook, are l..n. H. upon an artificial terrace or sandy plateau, made by excava..g a hill side by the Chicago, Milwaukee & St. Paul railroad company, in securing sand for construction on their line. The springs upon this plateau are very many and copious, combining within a few hundred feet to make quite a little brook, in which native trout have always been found. Notwithstanding it is within the city limits and exposed to constant fishing, the patient angler is almost always rewarded with one or two even now. A few years ago the stream was well stocked, but the greed of a suburban *game catcher* induced him to *net* them out to sell, hence the depleted condition at this time.

The location of Willowbrook is most admirable for transportation. It is within two miles by wagon road of the various railroad depots in the city, from whence distribution can be made to any point in the State without delay or detention. One end of the premises adjoins the right of way of the Chicago, Milwaukee & St. Paul Railroad, so that by train we may be able to make the distance to the depots inside of fifteen minutes.

In commencing the work, a spot where the water came up very freely, was selected, and there we decided to construct a tank or reservoir to concentrate the springs before conducting to the hatching house. After encountering many vexatious difficulties by hard labor, we succeeded in having built an oval reservoir ten feet wide, fifteen long and six feet deep with walls two feet thick laid in hydraulic cement and plastered inside with the same. Cost of masonry $170. The water in the tank to the overflow stands about four feet deep, running forty inches per second, giving us abundant water in hatching house, and a large stream into the ponds beside. This is but a tithe of the water available if found necessary in the future to utilize it. The hatching house is within twenty yards of the tank and the floor is four feet lower than the supply boxes carrying the water around the house, so that there is a strong head and fall, adjustable to the requirements of the hatching troughs. The troughs are twenty in number, made of galvanized iron, coated with black asphaltum varnish. They have a superficial space for

Eggs, in square inches	24,560
Also twenty wire hatching boxes of capacity, square inches	9,560
Two glass hatching jars equal in space of square inches	3,000
Total superficial egg space of inches	37,080

Or in round numbers a hatching capacity of a million and a half of eggs, which can by slight modifications of the arrangements and apparatus be increased indefinitely to any desired amount.

The building is a plain, substantial quadrangle, with a pyramidal roof and ventilator, 20 by 40 feet, cost $234.00. The Dwelling house is a plain neat structure, eighteen by thirty six feet, containing four rooms and three closets, lathed and plastered with white finish, sided with inch boards, black felt paper, clapboarded and battened, shingle roof, two chimneys, cost $676.00.

The grading and removing of stumps, and rocks, and bushes, from the site of the buildings, cost $50.00. The blasting, construction, and grading of right of way, building culvert, &c., from old "Territorial Road" to Willowbrook, cost $150.00.

Notwithstanding the lateness in the season when we began at Willowbrook the construction of ponds has been prosecuted with great success, and we have now a pure and beautiful body of water, two hundred and forty feet long, twenty four feet wide, and average depth of three feet, clear as crystal, supplied by scores of springs that pour in their pure waters, from bottoms and sides in never failing streams. As yet we have divided only into three ponds of fifty, fifty and one hundred and forty feet. This latter to be further divided in the coming season when the excavation and construction of other ponds should be continued and the grounds filled in and other necessary work done which will make Willowbrook one of the most convenient and efficient hatcheries in the country.

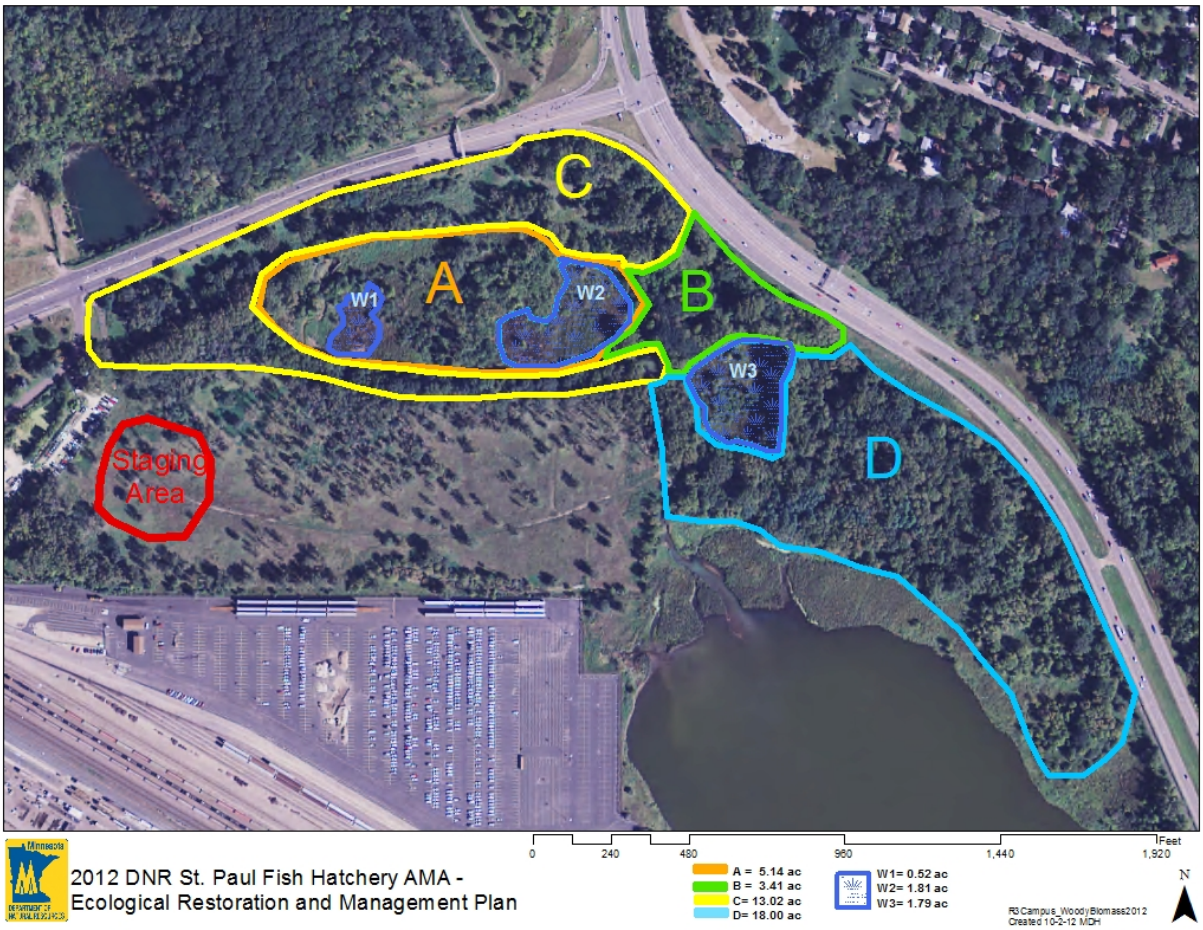
The appropriation of $5.000 which we have for the coming year, is we think ample to finish the necessary work at Willowbrook, and carry on the hatching and distribution with greater success than heretofore, and the expectation is to do more work each year upon the same expenditure than before. In view of the Biennial sessions, and the long time that must elapse before we can get help, we would ask your recommendation to the legislature to appropriate for the use of the commission for the years 1879 and 1880—each, $5,000, to carry on the work.

Below will be found statement of the cash expenditures, with appended particular exhibits or statements in detail of each separate account marked for reference "A," "B," "C," &c. They may be omitted in printing if thought best as the itemizing makes them bulky, and as copies are to be filed together with vouchers in the office of State Auditor.

Appendix G. Map from City of St. Paul

Planned Restoration Work at Mounds Park in Land Adjacent to Willow Brook Hatchery Pond

Appendix H. Woody Biomass Project Map, 2012



Appendix I. Teachable Opportunities

This is a map developed by Christopher Smith, Non-Game Wildlife Specialist, MN DNR.