Decatur Lake Feasibility Study

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Prepared For:
Decatur Lake and Mill Race Association, WI

Project 1780

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1 Introduction

In 2017, the Decatur Lake Mill Race Association (DLMRA) applied for and received a Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant to conduct an objective assessment to identify planning options for improving water quality, habitat, and recreational uses of Decatur Lake. Between May 2017 and December 2017, staff from Montgomery Associates: Resource Solutions LLC (MARS), LVBrown Studio LLC, and Underwater Habitat Investigations LLC worked with the DLMRA to conduct the assessment. The assessment included a review of historical data and previous reports, site visits, engineering analysis, and a series of public meetings.

The objective of this project was to identify the key issues limiting habitat and public use of Decatur Lake, and develop a range of short- and long-term planning strategies for meeting the DLMRA's stated management objectives. These objectives include improving public access, fishing, waterfowl habitat, paddling, and motor boating conditions. This report documents existing conditions in the lake and assesses the feasibility of several potential lake management options, with a focus on identifying feasible, fundable projects that the DLMRA feels will encourage public usage of the lake and encourage more people to be part of a larger future vision for Decatur Lake and the Sugar River watershed.

2 Decatur Lake Background

2.1 Current Conditions

Decatur Lake is an approximately 110-acre lake located near Brodhead, WI (**Figure A1**). The lake is an impoundment of the Sugar River controlled by the Decatur Dam, which is owned and operated by the City of Brodhead. The lake is connected to the Mill Race, a constructed waterway that flows adjacent to the Pearl Island Recreational Corridor and the City of Brodhead before rejoining the Sugar River downstream of the dam. Decatur Lake is a public water body with public access points along the lake and the Mill Race.

Over the past several decades, sedimentation and associated shallowing have changed the lake's character and affected traditional recreational opportunities. Motor boat and pontoon usage are restricted by both shallow depths and aquatic vegetation, and navigating both in the lake and upstream to the Sugar River requires intimate familiarity with narrow lanes of deeper water and/or specialized equipment (surface drive motors or similar). As a result, motor boat and pontoon usage has greatly decreased. Headgates Park does provide an access point with a public boat launch, but the connection between the lake and the City of Brodhead via the Mill Race is limited to narrow boats and paddlers due to the narrow opening through the headgates structure. The DLMRA feels that the filling-in of the lake has negatively impacted both lake residents and community members, and there is a perception that the lake is now seen more as a private area than as a public community asset.

Invasive species and water quality are also of concern. Floating masses of filamentous algae are common during most summers, and carp contribute to poor water quality by resuspending fine bottom sediments, particularly in backwater areas where they also prevent beneficial aquatic vegetation from growing. Improving water quality is largely beyond the control of lake management actions, as the upstream Sugar River watershed is large (522 sq. mi.) and is dominated by agricultural land use. While best-management agricultural practices have some momentum in the watershed, agricultural lands will likely continue to contribute high nutrient and sediment loads to the lake for the foreseeable future.

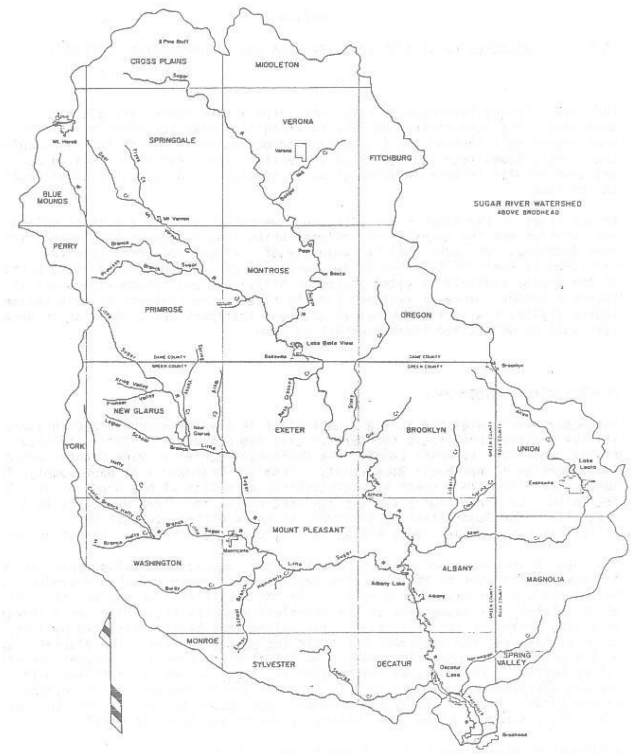


Figure 1. Decatur Lake watershed (from UW-Madison, 1983).

Despite challenges associated with sedimentation and water quality, there are positive aspects and opportunities in Decatur Lake. The lake's fishery is known to include smallmouth and largemouth bass, rock bass, bluegill, orange spotted sunfish, green sunfish and yellow bullhead, in addition to the invasive common carp. Treefalls around the lakeshore provide favorable habitat for bass, bluegill and channel catfish. The western shoreline is reported to have the best fishing in the lake, due to the greater water depth and prevalence of tree falls. While the pondweed growing in the lake does inhibit navigation, it also provides important fish and duck habitat. The transitional area between the Sugar River and Decatur Lake provides diverse and high-quality stream and wetland habitat, and hosts a number of bird species. Paddling can be enjoyed throughout most of the lake and the upper transitional area, and land-based access to the lake has been enhanced by improvements at Headgates Park and the Pearl Island Recreational Corridor. Additionally, there is a committed group of stakeholders, including the DLMRA and the Lower Sugar River Watershed Association, who are working to improve conditions in the lake through outreach, planning, and water quality monitoring in the lake, river, and tributaries.

2.2 Previous Studies

UW-Madison Water Resources Management Workshop (1982)

In 1982, students from the University of Wisconsin's Water Resources Management (WRM) program published a report describing field work and several analyses on Decatur Lake. Their report, "Decatur Lake and Watershed: A Report to the City of Brodhead, Wisconsin", helped to inform several analyses and management options investigated for the current project. In particular, students looked at sedimentation rates and the potential for restoring the lake to historical depths via non-dredging and dredging techniques.

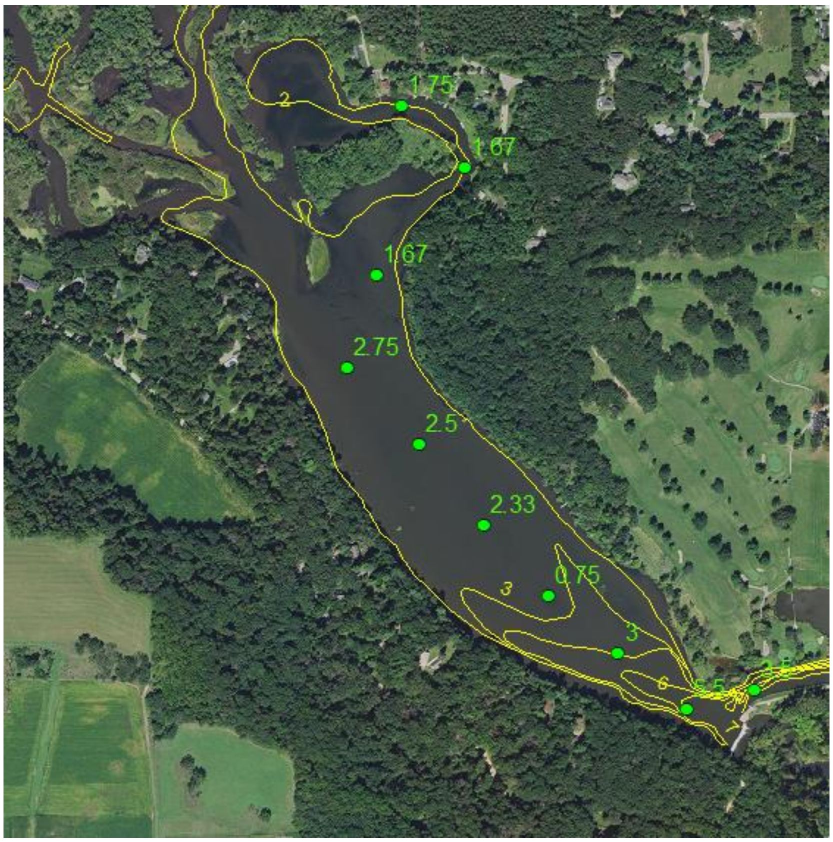


Figure 2. Decatur Lake water depth in feet. Contours for 1982 (adapted from UW-Madison, 1983; electronic data from UW-Platteville, written communication) and point measurements from 2011 collected by Meredith and Dick Tripp (written communication).

DLMRA Dredging Cost Estimate (2013)

In 2013, the DLMRA generated a cost estimate for hydraulic and mechanical dredging of the lake, based in part on assumed sediment volumes reported from the WRM workshop. The estimated cost for dredging the entire lake was $2 – 3 million. This estimate helped to guide current DLMRA activities away from dredging the entire lake due to the large expenses involved with such a project. Costs estimates generated for the current project (see **Sections 4.2** and **4.3**) were compared to those generated by the DLMRA.

UW-Platteville (2016)

In 2016, students from the University of Wisconsin-Platteville completed a report describing an analysis of hydraulic options for addressing sedimentation issues in Decatur Lake. Their report, "Decatur Lake Channelization", assessed two alternatives with forced channelization of the lake as well as an alternative with complete removal of the dam. The channelization options utilized large wing dams placed in the lake to promote scouring of narrow channels during flood events, along with dredging of the narrow channels prior to wing dam placement. The study estimated costs of approximately $500,000 - $750,000 for these alternatives. Obtaining regulatory permits to place the structures on the lakebed would be very difficult given the impacts of the numerous wing dams on habitat and public use of the lake. Given the cost and impacts to the lake, the DLMRA has chosen not to evaluate this option further.

WDNR Directed Lake Study (ongoing)

The WDNR is conducting an ongoing Directed Lake Study on Decatur Lake. While the data collected by this study may ultimately prove useful for lake management, information from the study was not readily available for use on the current project. Data from the study and ongoing water quality measurement will be available in WDNR's SWIMS online database.

3 Methods

The project team used a variety of methods to conduct this feasibility study, summarized below.

3.1 Data review

- Analyzed previous reports and available data from WDNR, United States Geological Survey (USGS), the City of Brodhead, and DLMRA.
- Reviewed literature on aquatic vegetation management, sediment transport, and recreational access management.
- Reviewed publicly-available aerial imagery (1937, 1960, 1995, current) showing lake changes and sedimentation.

3.2 Site visits

- Lake and river boat tour by MARS on June 3, 2016 to observe conditions and plan the lake grant application.
- Project Team and DLMRA site visit on August 25, 2017
    - Conducted boat-based tour of Decatur Lake and transitional area to Sugar River, including mouth of Searles Creek.
    - Collected sediment samples for grain size analyses (**Appendix B**) and measured water depths at selected locations.
    - Measured water quality field parameters in several locations in Decatur Lake and the Sugar River (**Appendix C**).
    - Observed aquatic habitat and vegetation conditions in the lake and river.

- Decatur Dam Park visits by DLMRA representatives on November 15, 2017 and by Lauren Brown on December 13, 2017 to identify park and lake access enhancement opportunities.
- Ongoing DLMRA observations
    - Observed lake depths, vegetation, and other conditions in the lake throughout summer and fall 2017.
    - Conducted water quality sampling in the lake and river.

3.3 Public input

- Community workshop on September 10, 2017
    - Presented a slide show and posters summarizing Decatur Lake issues and a preliminary analysis of potential actions (e.g. **Figure A4**) to interested stakeholders.
    - Received comments on the preliminary analysis and new ideas.
- Final community presentation on December 16, 2017
    - Presented a slide show and updated posters summarizing Decatur Lake conditions and recommended alternatives to interested stakeholders.
    - Proposed next steps for priority projects.

3.4 Engineering analysis and design

- Developed and refined potential management options.
- Consulted with WDNR staff, contractors, and others to estimate costs and identify key permitting issues.
- Consulted with WDNR biologists on fish and mussel habitat in the lake and river (**Appendix C**).
- Created figures and maps highlighting current conditions, potential future conditions, and opportunities for improving habitat and access in Decatur Lake.

4 Feasibility Analysis

4.1 Do Nothing

Description

The point of departure for this feasibility analysis is considering the future of Decatur Lake if no action is taken to address the sediment and nutrient loads from the Sugar River watershed. The most rapid deposition is occurring at the upstream (northern) end of the lake, where the Sugar River enters it. New islands and bars are forming here, with noticeable changes from year to year. Deposits are primarily sand in this high energy setting, while silt is the predominant sediment elsewhere in lower energy settings throughout the lake (**Appendix B**).

Although land management in the watershed has gradually improved and reduced soil loss rates from agricultural fields, it will likely take many decades for the sediment load to the lake to substantially decrease. This is due to the large volume of sediment stored on the floodplain and other parts of the drainage system that is available for continued downstream transport. Therefore, the historical sedimentation in the lake (**Figure A2**) can be used to estimate the future growth of sediment deposits (**Figure A3**). Although the precise locations of future islands and sand bars are unknown, it can reasonably be concluded that sand deposits will progressively build southward into the lake. As a result, the lake will gradually become more of a riverine environment, with a main channel or channels, islands, bars and quiet backwaters.

Analysis

Because the precise locations of future sediment deposits are unknown, impacts to specific lakefront properties and specific navigation routes are uncertain. However, it is clear lake depth will generally decrease, and boating in much of the lake will become more difficult. Access to the lake at some properties may be affected by formation of sediment deposits, making current docks and boat launches unusable. We expect that a route will remain open through the sediment deposits, because the river will continue to scour a channel through them, but the location of the channel will likely shift from year to year, as it does at the current upstream end of Decatur Lake.

The formation of new bars and islands will likely increase habitat diversity in the lake, with more areas like the network of islands upstream of the lake. This will create main channel areas, backwater sloughs, and wetlands in various stages of succession from open vegetation to forest. These changes will also likely increase the variety of paddling routes in what is now the lake.

Cost

Taking no action would incur no direct costs, but there would be consequential changes in property values and other costs to lake users, including the need for changes in watercraft to navigate shallow waters, extensions of docks, and other adjustments to changing conditions.

Conclusions

Some amount of transition from open lake to a riverine environment appears inevitable, even if mitigation measures such as described below, are taken. Therefore, some degree of adaptation to changing conditions will be necessary. Any of the alternatives discussed below could be part of those adaptations.

4.2 Dredging the Northeast Meander

Description

Due to the prohibitive cost of dredging most of the lake described above, more limited dredging in areas of greatest need were considered in this analysis. The first alternative is to dredge the former river meander channel at the northeast end of the lake, where numerous cottages are located, to improve navigation (**Figure A5**). Typical water depths in this area are less than 2 ft, and bottom sediments are predominantly muck. Circumnavigation of the large island on the west side of the meander has historically been possible, but sand deposits along the main river channel on the west side of the island frequently block boat passage.

A potential dredging project in this area would entail removal of approximately 10,000 yd^3 of sediment to create a 20-ft-wide channel 6 ft deep along approximately 1800 ft of the meander. This would remove approximately 2 ft of silt and 2.5 ft of underlying sand. Gentle excavation side slopes would be needed to reduce sloughing of sediment back into the dredge area. Based on experience with past projects, we assumed 4:1 slopes in sand and 10:1 slopes in muck. This would result in a total width of 80 ft for the dredge area.

Although the extent of dredging is much less than the entire lake, this would still be a large construction project taking several weeks or more to complete and requiring the services of a contractor with dredging experience.

Analysis

Either hydraulic or mechanical dredging methods could potentially be used for this project. An advantage of hydraulic dredging is the ability to access the lake at an established boat launch since equipment is on boats and/or barges. Since the lake cannot be drawn down, mechanical excavating equipment would need to work from the shoreline, temporary access roads built in the water and removed after the project is completed, floating platforms, or combinations of these. Shoreline access is limited because the dredge area is primarily bordered by residential lots, and the 80-ft width of the potential dredge area is beyond the reach of mechanical excavating equipment working from the shoreline. Floating platforms could be used in areas that have been dredged to create sufficiently deep water, where equipment could reach farther into the dredge area. Using sandy dredge spoils to create temporary platforms for excavators and dump trucks to access the dredge area may be the most viable option for mechanical dredging. Access to the water across one or more private properties would need to be negotiated for mechanical equipment.

For any dredging method, a location for disposal or reuse of the spoils must be identified. A typical option is disposal on an upland property, such as a farm field, where the nutrient-rich spoils can be worked into fields to augment existing topsoil. Spoils would need to be temporarily contained for dewatering either within a constructed berm with a sediment trap and engineered outlet (for either dredging method), or in geotextile bags (for hydraulic dredging). The bags require less area but are typically more expensive. Another option is to use the spoils to create new wetlands near the dredge area, such as at the Lake Belle View restoration upstream on the Sugar River in Belleville. This typically requires building a containment structure such as a rip rap revetment in the waterbody to prevent the spoils from washing away, and the difficulty in constructing this would depend on the location, equipment access, current and wave exposure, and other factors. Wetland establishment would also require some effort to achieve adequate hydrology (i.e. not filling spoils too high above the lake level) and establish native vegetation.

The location of the spoils disposal area will factor into the relative feasibility of hydraulic and mechanical dredging. For hydraulic dredging, the mixture of sediment and water pumped from the lake bed is pumped in a temporary pipeline to the disposal area. Distances of a mile or more are possible with booster pumps, but the longer the distance the greater the cost and complicating factors. Mechanical dredging entails hauling spoils in dump trucks. Since dredging would have to be conducted without drawing down the lake, the spoils would be very wet and require lined and covered trucks to reduce spillage on roads. The farther the haul, the greater the cost and potential for adverse impacts to local roads.

A WDNR dredging Individual Permit would be required, plus approval from the U.S. Army Corps of Engineers. Future maintenance dredging in the same area could be eligible for a streamlined general permit. Dredging permits consider the benefits of dredging, environmental impacts of the dredging and equipment access, and the impacts of the proposed spoils disposal. Individual permits have been successfully obtained for many dredging projects, but they typically require months of work and design modifications to satisfy environmental constraints. Sediment samples will have to be collected from the proposed dredge area and tested for contaminants, based on the WDNR guidance document "Sediment Sampling and Analyses for Dredging Permit Application and Approval". If the spoils qualify as a hazardous waste, disposal in a licensed landfill could be the only option; this is not likely based on the lack of upstream industries and the large watershed area that would dilute potential contaminants, but will need to be confirmed. No samples have been tested for this purpose yet.

A WDNR Interstitial and Carriage Water general permit would also be required for upland spoils dewatering areas. This permit includes requirements for the construction of a containment berm, outlet for drainage of water away from the spoils, and sampling of the drainage water for Total Suspended Solids.

Using the spoils to create new wetlands could be approved as part of the dredging Individual Permit, according to Green County Water Management Specialist Jeff Schure. Placement of dredge spoils on a lakebed is difficult to permit, and this option would likely require greater permitting effort. WDNR and the Corps would evaluate the potential benefits of wetland creation, potential environmental impacts, and likelihood of success.

Most of the northeast channel is a quiet water setting with muck bottom sediments where deposition appears to be very slow, based on the water depth change of only a few inches that can be inferred by comparing water depth data from 1982 and 2011. Therefore, the risk of this area rapidly filling in due to sedimentation from the Sugar River appears low. Sloughing of sediment due to the action of wind, flood currents, boats and carp is a risk that would need to be factored into detailed design in the future. There is more significant risk of rapid sedimentation at the northwest end of the proposed dredge area, where it connects to the Sugar River channel. This is an area of rapid sand deposition, with recent sandbar formation blocking access to the river. Sedimentation at the southern end of the dredge area where it connects to the lake is also a risk; deposition is less rapid than at the upstream end, but it is not far from the new island that has formed at the north end of the lake. Ongoing maintenance dredging can be expected to be necessary in both locations.

Cost

Planning-level cost estimates for this dredging project are similar for both hydraulic and mechanical methods (**Tables 1 and 2**). Note that the distance to the spoils disposal location greatly affects the cost, especially for mechanical dredging and hauling, and no location has yet been confirmed. As noted above, use of the spoils to create wetlands could result in a much shorter hauling or pumping distance, but whether or not this would lower the overall project cost depends on the details of where the spoils would be placed, how they would be stabilized, and what permitting requirements would be for establishment of wetland habitat.

Table 1. Planning-level cost estimate for mechanical dredging of northeast meander.

Item	Description	Quantity	Unit	Unit Price	Estimated Cost
1	Mobilization	1	LS	$20,000	$20,000
2	Traffic control	1	LS	$1,000	$1,000
3	Timber mats for lake access	1	EA	$1,000	$1,000
4	Haul road: construction, removal & restoration	1	LS	$6,000	$6,000
5	Silt curtain	505	LF	$10	$5,100
6	Construct containment area: strip top soil, build berm & sediment trap	2,700	CY	$6	$16,200
7	Seed & mulch berm stabilization	2,889	SY	$1	$2,900
8	Stone weeper outlet	1	EA	$300	$300
9	Dredge and place in spoils area	10,300	CY	$15	$154,500
10	Additional cost to haul dredge spoils (round trip)	15	MI	$5,150	$77,300
11	Spread dewatered spoils onto ag field	10,300	CY	$2	$20,600
Subtotal					$304,900
Estimated Construction Cost with 20% Contingency					$365,900
Engineering and Permitting					$36,590
Total Project Cost (rounded to nearest $1000)					**$402,000**

Table 2. Planning-level cost estimate for hydraulic dredging of northeast meander.

Item	Description	Quantity	Unit	Unit Price	Estimated Cost
1	Mobilization	1	LS	$20,000	$20,000
2	Silt curtain	505	LF	$10	$5,100
3	Construct containment area: strip top soil, build berm & sediment trap	2,700	CY	$6	$16,200
4	Seed & mulch berm stabilization	2,889	SY	$1	$2,900
5	Stone weeper outlet	1	EA	$300	$300
6	Dredge and pump to spoils area	10,300	CY	$25	$257,500
7	Spread dewatered spoils onto ag field	10,300	CY	$2	$20,600
Subtotal					$322,600
Estimated Construction Cost with 20% Contingency					$387,100
Engineering and Permitting					$38,710
Total Project Cost (rounded to nearest $1000)					**$426,000**

Community-based funding sources would be needed to support this project. WDNR has not funded dredging projects for many years, due to the environmental concerns and the typical short life span of projects, and we are not aware of grant programs for other agencies that are likely to fund a dredging project.

Conclusions

It appears feasible to obtain regulatory permits for this dredging project. The largest obstacle is probably funding for the initial dredging project and periodic maintenance dredging. Weighing the cost vs. benefits of this dredging project will be up to the DLMRA and local community.

4.3 Dredging the Upstream End of the Lake

Description

The second dredging alternative is to remove sand where it is rapidly building up at the northwest end of the lake and impeding navigation into the upstream Sugar River and Searles Creek (**Figure A5**). Typical water depths in this area are less than 2 ft, with several exposed bars and islands. Navigation through this area by power boat requires knowledge of the precise route of the main flowlines of the Sugar River. This dredging project could not only improve navigation but also keep some sediment from entering the lake, extending its lifetime.

A potential dredging project in this area would remove approximately 20,000 yd^3 of sediment to restore the original lake depth of approximately 6 ft deep. The existing island building into the lake could remain in place, essentially forming a sediment trap upstream of the island. The dredge area would be approximately 4 acres with a maximum cut depth of 4 ft. For this option to be effective in the long term, this area would need to be regularly dredged to continue to promote settling of sand in this area.

This potential dredging project would remove approximately twice the sediment volume as for the northeast meander, although either project could be redesigned to remove more or less sediment.

Analysis

Hydraulic dredging is probably the only feasible method in this location, because there is no nearby road access to the lake and the dredge area is far from shore. Several farm fields are present to the west and northwest within reasonable pumping distances of 1000 – 3000 feet, although these property owners have not yet been contacted about the possibility of spreading dredge spoils there. As discussed above, spoils would need to be temporarily stored in an engineered facility and could be worked into fields after they are dewatered to augment the topsoil. Using the spoils to create new wetlands in the lake is another option, with the same considerations discussed above.

A WDNR dredging Individual Permit and approval by the Corps of Engineers would be required for the initial dredging, with future maintenance dredging likely eligible for a streamlined general permit. A WDNR Interstitial and Carriage Water general permit would also be required for upland spoils dewatering areas. See Section 4.2 for a discussion of permitting considerations.

The estimated 20,000 yd^3 that would be dredged here is approximately six times the annual deposition rate estimated in 1982 by the WRM workshop (3567 yd^3 or 96,300 ft^3). Therefore, each dredging event in this location might extend the life of the lake by about 6 years on average. Note however that sediment deposition is highly variable from year to year depending on the occurrence of floods that carry large sediment loads. Not all the sediment from the Sugar River would be trapped in this dredge area; much of the sand would likely be deposited here, but most silt would pass through this area into the lake. Thus, even regular dredging of this area would not eliminate sedimentation to the lake. Since only part of the sediment load would be captured, it might take 10 – 20 years for the dredge area to refill with sediment and require additional dredging.

Cost

A planning-level cost estimate for this dredging project is nearly $900,000 (**Table 3**). The dredging cost per cubic yard is the largest variable in determining the overall project cost, and contractors' bids on projects are typically quite variable. This estimate assumes that spoils will be pumped to a nearby upland area for dewatering. As noted above, construction of wetlands with the spoils would shorten the pumping distance, but it is not certain that this would reduce the project cost. As noted above, WDNR and other agency funding programs are unlikely to support a dredging project. Community-based funding sources would therefore be needed.

Table 3. Planning-level cost estimate for hydraulic dredging of the north end of the lake.

Item	Description	Quantity	Unit	Unit Price	Estimated Cost
1	Mobilization	1	LS	$20,000	$20,000
2	Silt curtain	505	LF	$10	$5,100
3	Construct containment area: strip top soil, build berm & sediment trap	6,000	CY	$6	$36,000
4	Seed & mulch berm stabilization	6,000	SY	$1	$6,000
5	Stone weeper outlet	1	EA	$300	$300
6	Dredge and pump to spoils area	22,205	CY	$25	$555,100
7	Spread dewatered spoils onto ag field	22,205	CY	$2	$44,400
Subtotal					$666,900
Estimated Construction Cost with 20% Contingency					$800,300
Engineering and Permitting					$80,030
Total Project Cost (rounded to nearest $1000)					**$880,000**

Conclusions

This project is feasible from an engineering and permitting perspective. However, the cost is very high for relatively short-term improvements to navigation at the north end of the lake and the overall lake lifespan. Extending the project's benefits over the long term would require repeated dredging every decade or two at a similar cost as the initial dredging. Weighing the cost vs. benefits of this dredging project will be up to the DLMRA and local community.

4.4 River Diversion Around Decatur Lake

Description

Diversion of the river channel around Decatur Lake has been identified as a potential way to reduce sediment and nutrient inputs to the lake, and such a diversion has been constructed at Lake Belle View upstream on the Sugar River in Belleville (**Figure 3**). This type of diversion would entail constructing a berm along one side of the lake that would separate the river channel from the lake. This would reduce the overall size of the lake, since the berm and new channel would occupy part of the current lakebed. The height of the berm would be designed to divert the small, frequent floods that dominate the long-term sediment and nutrient loads, with rare large floods overtopping the berm. Separation of the river and lake also would provide an opportunity to reduce the carp population in the lake, but this has proven difficult at Lake Belle View.

Analysis

A major difference between Decatur Lake and Lake Belle View is the long, narrow shape of Decatur Lake. This would require a very long berm and further reduce the width of the lake. Another difference is the presence of residences along both shorelines of Decatur Lake. Residences on the diversion side of the lake would lose direct lake access. In addition, Lake Belle View had an exemption written into Wisconsin State Statute Chapter 30 allowing construction of the berm; a separation berm at Decatur Lake might not be possible to permit.

Cost

No detailed cost estimate was developed for this alternative, but the length of separation berm and permitting challenges would result in a very high cost.

Conclusions

This option is not feasible, given the high cost, unlikelihood of permit approvals, and impacts to lakeshore residents.

Figure 3. Diversion of the Sugar River around Lake Belle View.

4.5 Dam Operation / Design Modifications

Description

Decatur Dam forms the lake and is owned and operated by the City of Brodhead (**Figure 4**). The dam is also important to the community for its role in maintaining flow in the historic mill race. The dam was first built in the 1840s for electrical power generation… Major repairs were completed on the dam in 2002. These included removing aging gates that had been inoperable for the previous 15 years (Richard Vogel, City of Brodhead, personal communication) and had remained closed during that time. The WDNR ordered that the gates be either repaired or removed (Tanya Lourigan, WDNR, written communication), and the City chose to remove them due to their high cost and because they had not been used for years.

Community members asked at public meetings during this project whether removal of the gates reduced scouring of sediment from the lakebed, and if the dam could be operated or modified in a way to reduce sedimentation in the lake. Potential modifications to the dam include adding new gates in the main spillway section to pass more flow and increase flow velocity in the lake and allow lake drawdown, and modifying the mill race spillway in Brodhead to allow lake drawdown.

Figure 4. Decatur Dam. Gates removed in 2002 were located in foreground.

Analysis

The average flow over the dam is dictated by the discharge in the upstream Sugar River and is not affected by dam construction. Additional gates on the dam could increase flow through the dam temporarily by drawing down the lake level. Hydropower generation plants typically operate in this manner, with daily drawdowns to increase flow and power generation during peak demand periods. Regular cycles of opening gates could create repeated periods with higher discharge through the dam, but this would cause frequent lake level fluctuations that would likely impact lakeshore properties and habitat. The drawdown cycles would also affect water levels and flow in the mill race. Significant labor would be necessary to regularly open and shut the gates. As described above, the former gates had not been operable and remained closed for 15 years before the 2002 repairs, so no dam gate operation has occurred since at least the 1980s. Therefore, it is unlikely that removal of the gates had a significant impact on sediment scouring in Decatur Lake.

Drawing down the lake for an extended time could allow mechanical dredging to be performed more efficiently than for a normal lake level, and sediment would be scoured from the lakebed along the river channel that would form upstream of the dam. However, sediment would likely remain throughout most of the lakebed.

Opening gates on the dam to scour sediment would require WDNR approval. WDNR considers downstream impacts of increased sediment discharge through the dam, and such requests have been denied elsewhere for this reason. An attendee at the December 2017 public meeting indicated that WDNR did not approve drawdowns for sediment scouring at Lake Leota in Evansville, Wisconsin for this reason.

Cost

The cost of dam modifications was not evaluated in detail but is expected to be very high, due to significant permitting, construction, and long-term operation and maintenance issues.

Conclusions

Modifying the dam would not likely be effective at removing sediment over most of Decatur Lake, it is likely unacceptable to the City of Brodhead which owns and operates the dam, and it would be difficult to secure WDNR approval for regular drawdowns. Therefore, this option is considered infeasible.

4.6 Marking Navigation Lanes

Description

Informational buoys could be used to mark the best routes around areas of shallow water and aquatic vegetation beds. Passable routes currently exist through much of the lake, but detailed knowledge of conditions is needed to find them. Simple buoys could mark areas with the deepest water in problem areas. Buoys could be relatively small and far apart, since long sight lines exist on the lake. Such buoys are typically anchored to the lakebed, with the floating buoy placed in spring and removed in fall.

Analysis

Buoy placement requires authorization by the municipality with jurisdiction over the lake (presumably the Town of Decatur) and the WDNR. The WDNR has a simple one-page application for buoys. As conditions in the lake change, the locations of buoys can be adjusted accordingly.

An ancillary benefit of concentrating boat traffic in designated lanes is that aquatic plant growth in those locations would likely be suppressed due to the action of boat propellers. Vegetation beds in other parts of the lake would presumably be protected because they would have less boat traffic.

Cost

Informational buoys range in cost from approximately $20 to more than $500 each. The smaller, less expensive style of buoy is probably appropriate for Decatur Lake, where large buoys may be viewed as unsightly and small buoys are likely to be sufficiently visible. Perhaps a dozen buoys would be enough to mark navigation routes in the lake. Assuming a cost of $50 - $100 for each buoy and anchoring hardware, the total materials cost could be in the range of $500 - $1000. Labor could be an additional cost, but deployment could be conducted by volunteers.

Conclusions

Navigation buoys appear to be a feasible, cost effective strategy for adapting to long-term changes in Decatur Lake.

4.7 Vegetation Harvesting

Description

Navigation lanes could also be maintained by mechanical vegetation harvesting methods that cut and remove vegetation from the lake. Harvesting is conducted on many Wisconsin lakes to enhance boating and other forms of recreation. Harvesting is commonly performed by commercial operators, although some governmental agencies own and operate their own equipment. Low-tech methods such as dragging a bedspring behind a boat have also been used by volunteers.

Analysis

A WDNR permit is required for mechanical harvesting of aquatic vegetation. Two major permit conditions are that harvesting cannot be performed in less than 3 feet of water (due to habitat impacts) and that cut vegetation be collected and removed from the waterbody. This water depth constraint precludes harvesting in most of Decatur Lake, and particularly in areas most affected by plant growth. The requirement to collect and remove vegetation can be easily met by commercial harvesters but would be a significant challenge for lower tech volunteer approaches. Most commercial harvesters cannot operate in less than 3 feet of water, so that does not appear to be a viable option for Decatur Lake.

The pondweed beds in Decatur Lake provide valuable fish and waterfowl habitat, and removal efforts should balance maintaining navigation lanes with preserving habitat.

Cost

Commercial harvesters typically charge $500 - $800 per acre per harvest. A 20-ft-wide navigation lane along each shoreline of the lake would have a total length of approximately 5000 ft, and an area of approximately 2.3 acres. The cost for each harvest would be about $2000 based on these typical rates, however is it possible that the cost per acre would be higher for this relatively small job. Multiple harvests might be required each growing season.

Conclusions

Mechanical vegetation harvesting appears infeasible for Decatur Lake due to the WDNR requirement that it only be conducted in more than 3 feet of water. Marking navigation lanes with buoys appears to be a more viable strategy.

4.8 Lake and River Habitat Enhancement

Fish Habitat Structures

Nearshore habitat could be improved by adding more woody debris for fish cover and turtle basking. The steep, wooded shoreline in the southwest part of the lake has numerous fallen trees that provide excellent habitat for fish, and turtles can be seen basking on logs in sunny weather. Additional structures could be placed in other areas to enhance habitat. Fish habitat structures range from trees toppled in to the water and anchored to a live tree, to submerged "fish stick" structures constructed with a cribwork of logs. The WDNR has guidance on constructing and placing these structures and a general permit for approving their placement. Costs for tree drop structures could be minimal if suitable trees to fell are available on the shoreline and volunteers can provide the labor. Costs of several hundred dollars each are possible for tree drops or fish stick structures if heavy equipment and contractor labor is required.

Island Vegetation

As new islands and bars form, native vegetation can be established and/or invasive species could be controlled to promote native plant growth. This could enhance the aesthetics of these areas and provide more habitat for pollinators and other wildlife. Natural succession on other islands and bars in this area has been from open vegetation to shrubs to forest, and this pattern can be expected to occur on new sediment deposits. Therefore, open vegetation communities, such as wet meadow, established on islands will transition to shrubs unless they are intensively managed.

Floodplain and Upland Forests

Floodplain forests along the south, east and north sides of the lake, and upland forests on the bluffs on the west side of the lake, could be managed to control invasive species, such as buckthorn, honeysuckle and garlic mustard. This would foster more diverse, native understory plants and improve the habitat value and aesthetics of woodlands along the lakeshore. Volunteers commonly perform this type of vegetation management.

Backwater Restoration

Habitat enhancement in the Sugar River upstream and downstream of Decatur Lake is also possible. The numerous backwaters in these areas provide habitat variety but have been degraded by carp, which disturb the bottom sediments, create turbid water, and disrupt aquatic plant growth. The lagoon at Headgates Park, where Norwegian Creek enters the mill race, is one highly visible example of this type of habitat. A potential restoration strategy is to separate a backwater from the main river channel with a berm to allow removing the carp. This would restore clearer water conditions and allow native vegetation such as white water lily and other floating leaf plants to become established. Panfish populations could thrive in such conditions and provide a new fishing opportunity. Panfish such as bluegill, orange spotted sunfish and green sunfish can reduce common carp reproduction since they can be effective carp egg and fry eaters. However, obtaining regulatory permits for such a diversion berm would be challenging, and accessing many remote backwaters for construction and recreational use would also be difficult. A simpler restoration approach without creating a diversion would be to establish white water lily beds in exclosure cages to reduce carp impacts. Once the vegetation is established, it is resistant to carp because the connected tubers withstand the aggressive feeding behavior of common carp. Even with carp still present in the backwater, the additional vegetation would add fish and wildlife habitat variety and improve aesthetics for paddling and viewing from shore. The cost for this type of vegetation restoration could be low if volunteers provide the labor.

Floating Wetlands

Floating wetlands were suggested at the September public workshop. The project team assessed the feasibility of installing floating wetlands in the lake, both in the upper part of the lake and in the backwater area at Headgates Park. In controlled settings (i.e. stormwater ponds), these man-made features have been shown to be effective at creating wetland habitat, promoting sedimentation in desired locations, and removing nitrogen. Given the size of the lake and watershed, it is unlikely that floating wetlands would have a significant impact on sediment transport or water quality, and would instead provide mainly an aesthetic and habitat creation function. Costs for an installed floating wetland are estimated to be $50 / sq. ft., which would require up to $300,000 just to purchase and install a small (0.15 ac) wetland located near Headgates Park, with additional costs for maintenance and seasonal removal due to ice concerns. Therefore, these potential benefits do not appear to justify the costs associated with permitting, purchasing, planting, anchoring, and maintaining a floating wetland in Decatur Lake.

Mussel Habitat

A participant in the public workshop expressed interest in developing mussel beds in Decatur Lake. Although Sugar River mussels supported a notable pearl trade in the past, current populations are limited by water quality impairment, as juvenile mussels are very susceptible to ammonia and nitrates. The WDNR does not have records of mussel populations in Decatur Lake (Lisie Kitchel, WDNR, personal communication). Most mussel species prefer habitat with flowing water with a sand, gravel or cobble bed. The muck bottom throughout most of Decatur Lake is therefore unsuitable for most mussel species. Although a few species, such as the Giant Floater (*Pyganodon grandis*), can thrive in lakes with soft bottom sediments, the potential to develop substantial mussel beds in Decatur Lake appears very limited.

4.9 Decatur Dam Park Enhancement

Description

Public access to Decatur Lake is limited, however numerous potential opportunities to improve access to the lake and nearby Sugar River exist (**Figure A5**). The most promising opportunity is to enhance existing infrastructure at Decatur Dam Park. This park is owned by the City of Brodhead and located on the west side of Decatur Lake adjacent to the dam and the Pearl Island Recreational Corridor (**Figure A6**). The area offshore of the park is reported to have the best fishing in the lake. The park currently has an access drive off Park Road, a small parking lot, and a picnic shelter. However, the property extends to the northwest along the lakeshore several hundred feet beyond the developed part of the park. This provides an opportunity to create additional lake access for paddling, fishing and other recreation. The steep bluffs and ravines on the property also provide a scenic setting for nature trails (**Figures A7 and A8**).

The concept design developed here (**Figure A9**) includes a gravel footpath to the lakeshore suitable for portaging canoes and kayaks, a short gravel drive and parking area for boat drop-offs at the start of the lake access trail, several benches and areas of tree thinning to enhance views, and rustic nature trails. Control of invasive species in the woodlands, as described above, is also possible.

Analysis

This project would address a need for more public access to the lake, especially from its western shore. The City's Pearl Island Recreational Corridor Committee suggested this project and has indicated initial support and a desire to cooperate with the DLMRA to enhance the park. The presence of the existing infrastructure at the park makes the addition of the proposed improvements very efficient.

Cost

Planning-level costs for different aspects of the proposed park improvements are summarized in **Table 4**. This cost estimate will need to be refined after a more detailed plan is developed. The estimate below assumes that little earthwork will be required to create the gravel drive; if more extensive work is needed to construct it, the cost could substantially increase. If the habitat enhancements can be completed primarily with volunteer labor, then the cost could substantially decrease.

Improvements can be implemented in phases as funding is available, if necessary. The park is within the area covered by the existing WDNR grant for the Pearl Island Recreational Corridor, and these improvements are eligible for 50% funding by that grant.

Table 4. Planning-level cost estimate for Decatur Dam Park enhancements.

Item	Quantity	Unit	Unit Price	Estimated Cost
Trails and related improvements				
Paddling access trail from proposed gravel drive	250	FT	$2	$500
Nature & lakeshore trails	1000	FT	$0.50	$500
Benches	4	EA	$500	$2,000
Subtotal				**$3,000**
Access drive				
Gravel drive to paddling access footpath + parking	1	LS	$2,100	$2,100
Erosion control	1	LS	$500	$500
Subtotal				**$2,600**
Habitat enhancement				
Vegetation assessment	1	LS	$3,000	$3,000
Invasive species control	1	LS	$1,000	$1,000
Tree drop structure(s) in lake	1	LS	$500	$500
Subtotal				**$4,500**
Total				**$10,100**

Conclusions

This project is very feasible and offers a large public benefit for a modest cost. It also could provide valuable aquatic and upland habitat enhancements.

4.10 Additional Public Access Opportunities

Lakeview Circle

An existing easement provides access to the upper mill race from Lakeview Circle (**Figure A10**), where a wide dirt path leads from the street, through an earthen berm and to the water. The easement parcel is adjacent to an undeveloped woodland lot. No signage, parking or other facilities currently exist at the site.

Addition of a small parking area appears feasible, given the width of the parcel and gentle grade of the right-of-way. Bicycle racks could also be added. There is room near the water for a bench and a canoe and kayak storage rack, and the gentle grade to the water lends itself to an accessible kayak and canoe launch. A sign identifying the site as a public access to Decatur Lake is recommended.

The berm creates a sense of privacy that also makes this site an appealing place for quiet nature observation and play for children.

Sugar River Oxbow Trails and Lake Access

A public easement approximately 30 feet wide leads from Lake Drive to wetlands along the Sugar River located on private property (**Figure A11**). The easement site is currently wooded with pine and an understory of woody shrubs. The eastern part of the easement near Lake Drive is relatively level, while the western part of the easement slopes down to a marsh in an old river oxbow. Shrub-covered wetlands are present on the west side of the marsh.

With an easement from the property owner, this location could provide a public access to the Sugar River and Decatur Lake, as well as passive recreation trails. It may be possible to fit two parking stalls off Lake Drive and install a trailhead kiosk with some tree clearing and grading. The nearest access to open water on the river is approximately 300 ft south of the existing easement. Much of the route appears to be wetland, so a boardwalk may be necessary to provide a portage trail to bring canoes and kayaks to the river.

Typical wetland boardwalks cost $20 - $100 per linear foot[1], depending on the design and degree of volunteer labor for construction. The low end of the cost range represents a 4-ft-wide wooden boardwalk with 2 rails, which is probably suitable for the river access trail. If a boardwalk is needed the entire length of the route, the cost could be $5000 or more.

Boardwalks supported by driven piles typically are not regulated as wetland fill and would not require a wetland permit from the WDNR. If trail sections are constructed with some fill, a general permit would be needed. It may be more cost effective to obtain a permit and construct gravel trails in drier wetland areas than to build a boardwalk the entire length.

In addition to this boardwalk access to the Sugar River and Decatur Lake, the site may also be suitable for an upland trail loop with raised wetland crossings. This would provide access to the upland forests and wetlands along the Sugar River that is currently lacking in the area.

[1] Association of State Wetland Managers, 2006. Common questions: constructing wetland boardwalks and trails.

Head Gates Park

Head Gates Park provides a boat launch at the south end of Decatur Lake, connection to the Pearl Island Recreational Corridor trail by crossing the head gates structure, access to Norwegian Creek, two parking areas and toilet facilities (**Figure A12**). The northern parking area is unimproved, but the large open space is suitable for a variety of events. A path leads to Norwegian Creek, where there could be a canoe/kayak launch and a bench for resting and observation of wildlife on the creek and the marsh adjacent to the park. Another path leads to the lagoon where fishing access could be enhanced with some vegetation clearing and/or a floating pier. The wooded area between the parking areas, on the east side of the lagoon, has an open understory that would make a good picnic area. As discussed above, aquatic vegetation restoration in the lagoon could enhance fish and wildlife habitat and aesthetics.

Golf Course Trails

Another opportunity for access and lake visibility is along the edges of Decatur Lake Golf Course along the eastern shore of Decatur Lake (**Figure A13**). This property is currently for sale, with the potential for acquisition for a natural area. In addition, a large lakeshore private property west of the golf course may be donated to the school district in the future. Individually or in combination, these parcels present an opportunity to create approximately a mile of trails and provide access to the eastern shore of Decatur Lake.

Even with the current golf course use, a trail loop could use existing golf cart paths and dirt drives for passive recreation during daily or seasonal off-peak golf times. The trail would provide a variety of landscapes, including woodlands, and manicured golf course areas with expansive views of Decatur Lake and the bluffs on its western shoreline. There is also potential to create a trail along the lake edge or boardwalks to islands that may form in the future.

Searles Creek Water Trailhead

On the northwestern corner of Decatur Lake, there could be an opportunity to provide public access to the lake and the Sugar River water trail (**Figure A14**). Feasibility would depend on negotiating an easement with one or more property owners, as this area is entirely on private property.

There is potential to create a significant recreational amenity just by providing an access drive, small parking area and path to the water for paddling access. A short paddle downstream on Searles Creek leads to the Sugar River channel and the north end of Decatur Lake. A natural paddling loop exists by paddling upstream on one channel of the Sugar River and back downstream on the second of two main channels in this area. This would provide easy access to paddle the network of channels, islands and backwaters upstream of Decatur Lake.

There are two potential put-in locations on the east and west sides of an existing agricultural field. Either access point could be developed, or both could be developed with a trail connecting the two. Some boardwalk trail sections may be needed, depending on conditions that could not be directly observed from the road.

4.11 Watershed Education and Advocacy

The DLMRA can serve a role in providing information, education and advocacy on issues in the Sugar River watershed that affect Decatur Lake. As discussed above, the watershed is very large (more than 500 mi^2), and it will generally take many decades for watershed land use changes to have substantial benefit to Decatur Lake. Nonetheless, promoting beneficial changes in the upstream watershed is in the long-term interest of Decatur Lake and the local community.

DLMRA members are already involved in collecting water quality data on the lake, Sugar River and other tributaries as part of the WDNR's Water Action Volunteers program. These monitoring activities should be continued, and additional outreach on the results of the monitoring would raise public awareness of water quality issues in the lake and watershed.

The DLMRA website has informative descriptions of the features and history of Decatur Lake and the mill race. The website could also be used to disseminate more information on conditions in the lake and watershed. Other outreach strategies that similar volunteer organizations use include giving public presentations, having information tables at local events, and speaking at local government meetings.

With their local knowledge, DLMRA members may be able to connect landowners in the watershed with efforts to improve land management for which funding may be available. For example, the City of Brodhead is negotiating a nutrient trade upstream of Decatur Lake to provide phosphorus reduction credit for the City's wastewater treatment plant. This will provide incremental reduction in sediment and nutrient loads to the lake. The DLMRA could help identify additional landowners interested in participating in these types of programs in the future.

Affecting change in a large watershed is a long-term process and best undertaken with numerous partners. The Lower Sugar River Watershed Association and Upper Sugar River Watershed Association are logical organizations to work with in these efforts, as are county conservation departments, the WDNR, and the Natural Resources Conservation Service.

5 Recommended Next Steps

5.1 Decatur Dam Park

The DLMRA has identified enhancing Decatur Dam Park as the highest priority project. Park enhancements will need to be developed in collaboration with the City of Brodhead and its Pearl Island Recreational Corridor Committee. Recommended next steps for planning these improvements include the following:

- Walk the property with representatives of the City to plan enhancements, including the locations of the access drive, parking area, and trails.
- Develop a more detailed design and cost estimate.
- Identify funding sources to satisfy the 50% match required by the Pearl Island Recreational Corridor grant.

- Apply for permits, if needed for any trails in wetlands or fish habitat structures.
- Determine the desired / required process for hiring a contractor (e.g. competitive bids).

5.2 Navigation Buoys

Marking navigation lanes with buoys has also been identified by DLMRA as a priority project. This would be fairly simple and inexpensive and could be implemented soon. Recommended next steps include the following:

- Discuss this idea with Town of Decatur to confirm they have jurisdiction and support the project.
- Discuss with WDNR to confirm the approval process and to obtain technical advice.
- Plan the locations and types buoys.
- Identify volunteers to deploy and maintain buoys.

5.3 Watershed Education and Advocacy

DLMRA should identify education and outreach priorities for the organization and form strategic partnerships for these efforts. Recommended next steps include the following:

- Continue to work with the WDNR to conduct volunteer monitoring through the Water Action Volunteers program.
- Discuss watershed issues and current information and advocacy activities with potential partner organizations, including the City of Brodhead, the Lower and Upper Sugar River Watershed Associations, and the WDNR.
- Develop priority issues for outreach and advocacy.
- Identify priority outreach and advocacy activities, based on the issues identified above, the target audiences, and the resources available to DLMRA (e.g. volunteer time, website support, etc.)

5.4 Dredging the Northeast Meander

Improving boat access to the northeast meander is a priority for the DLMRA. Given the large estimated cost of dredging, additional steps are recommended to determine if such a project is financially feasible, and if the benefits warrant the cost. These include the following:

- Investigate potential community-based funding sources.
- Identify landowners potentially willing to accept dredge spoils.
- Identify lakeshore property owners potentially willing to grant access for construction equipment between Golf Lane and the northeast channel (necessary for mechanical dredging to be viable).
- Discuss with WDNR's Water Management Specialist for Green County potential locations and details for using dredge spoils to create wetlands in Decatur Lake, to further evaluate the feasibility of this option and overall project cost.

- Collect sediment samples from the potential dredge area for chemical analyses to identify options for and constraints on spoils disposal.
- Collect annual water and soft sediment depth measurements at several fixed locations in the proposed dredge area to monitor sediment accumulation rates and provide more confidence in the lifespan of a dredging project in this location.

5.5 Dredging the Upstream End of the Lake

Improving navigation between Decatur Lake and the upstream Sugar River is also a DLMRA priority. Considering that the estimated cost is significantly higher than for the northeast channel, and the benefits are expected to be short lived, next steps should help DLMRA decide if this dredging project is a viable management strategy and a priority for funding. Recommended actions include:

- Collect annual water and soft sediment depth measurements at several fixed locations in the proposed dredge area to monitor sediment accumulation rates and provide more information on the expected lifespan of a dredging project in this location.
- Evaluate potential funding sources for the initial dredging and repeated maintenance dredging.
- Identify landowners potentially willing to accept dredge spoils.

5.6 Additional Public Access Opportunities

Lakeview Circle

- Confirm that the Town of Decatur has jurisdiction over this access easement.
- Discuss ideas for access enhancement with the Town of Decatur.
- Work with the Town of Decatur to develop detailed plans and a cost estimate for enhancements.
- Identify funding sources.
- Implement the enhancements.

Sugar River Oxbow Trails and Lake Access

- Discuss ideas for public access with the property owner.
- If the landowner is interested and grants access, walk potential trail routes with an experienced trail designer; note and photograph conditions to identify where boardwalks would be necessary and where other construction methods are applicable.
- Develop a detailed plan and cost estimate for the trails and trailhead improvements.
- Negotiate an access easement.
- Identify a funding source and volunteer labor.
- Apply to the WDNR for a permit to construct trails in wetlands, if necessary. A professional wetland delineation may be required for this, but options should be discussed with WDNR before spending resources.

Head Gates Park

- Discuss park enhancement ideas with the City of Brodhead.
- Develop detailed plans and cost estimates, and develop an order of priority for their implementation.
- Identify funding sources.

Golf Course Trails

- Monitor the status of property ownership of the golf course and adjacent private property. If one or both properties transition to public ownership, elevate the priority of this project to take advantage of public land access.
- Discuss ideas for public access with the property owners.
- Refine plans accordingly, and develop a cost estimate, including an access easement, if necessary.
- Identify a funding source.

Searles Creek Water Trailhead

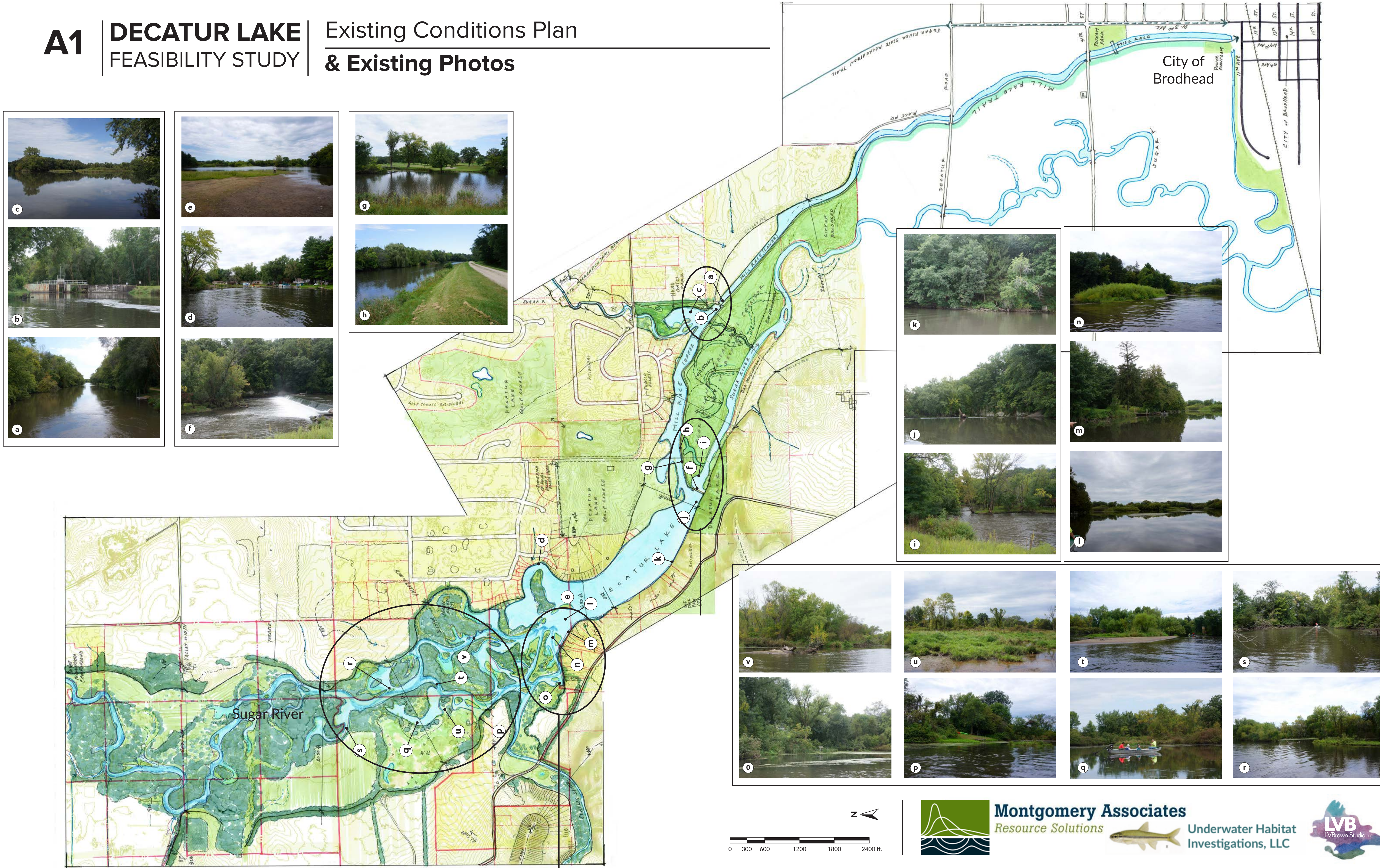
- Discuss access ideas with property owners.
- If a property owner is willing, walk the area with an experienced trail designer to develop a more detailed plan and cost estimate.
- Negotiate an access easement with the property owner.
- Secure funding.

6 Vision for the Future

Decatur Lake is a valuable part of the local community and has been home to abundant wildlife and generations of families. Although the lake has experienced past degradation and continuing changes are inevitable, it is possible for the community to adapt to these changes and continue to enjoy this resource. New ways of experiencing and thinking about the lake may be necessary, but we hope that the ideas described in this report provide a vision for a healthy ecosystem and treasured community asset for years to come.

Appendix A
Figures

A1 | DECATUR LAKE FEASIBILITY STUDY | Existing Conditions Plan & Existing Photos



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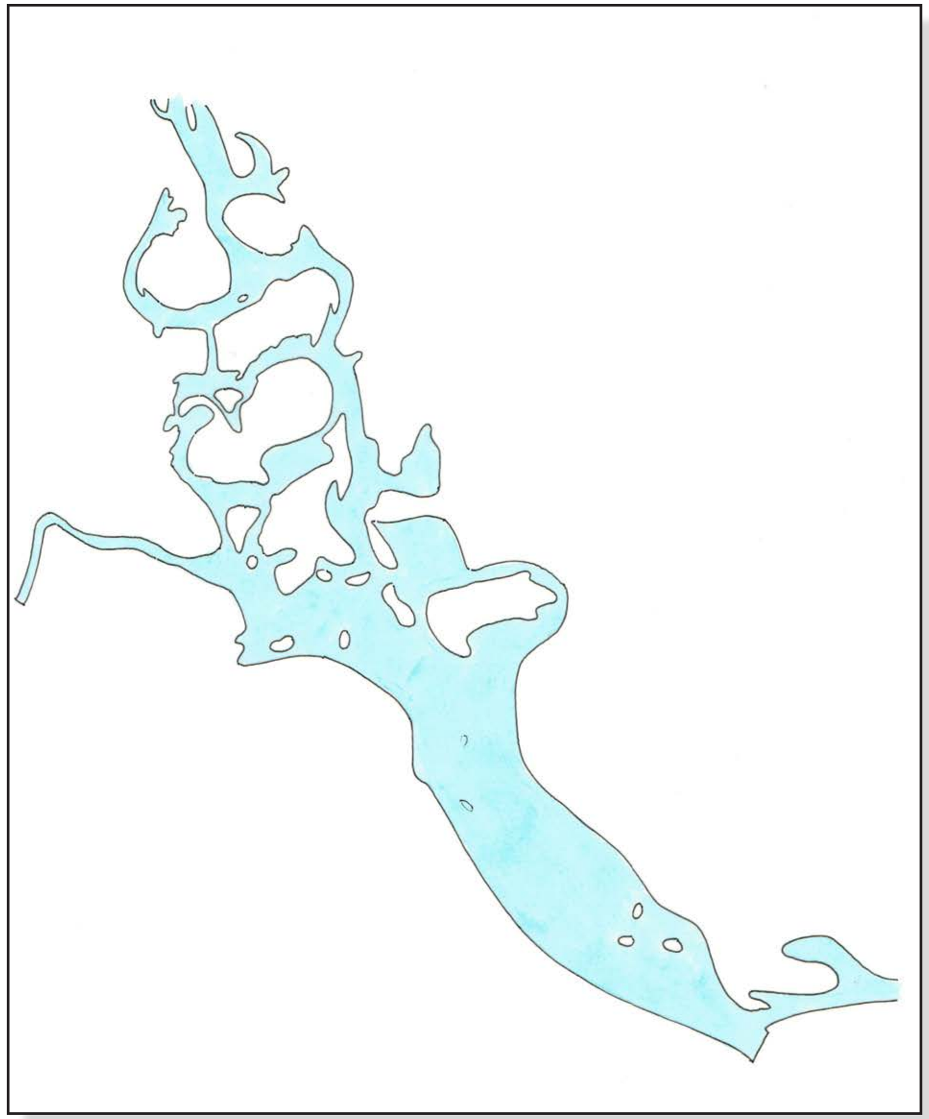
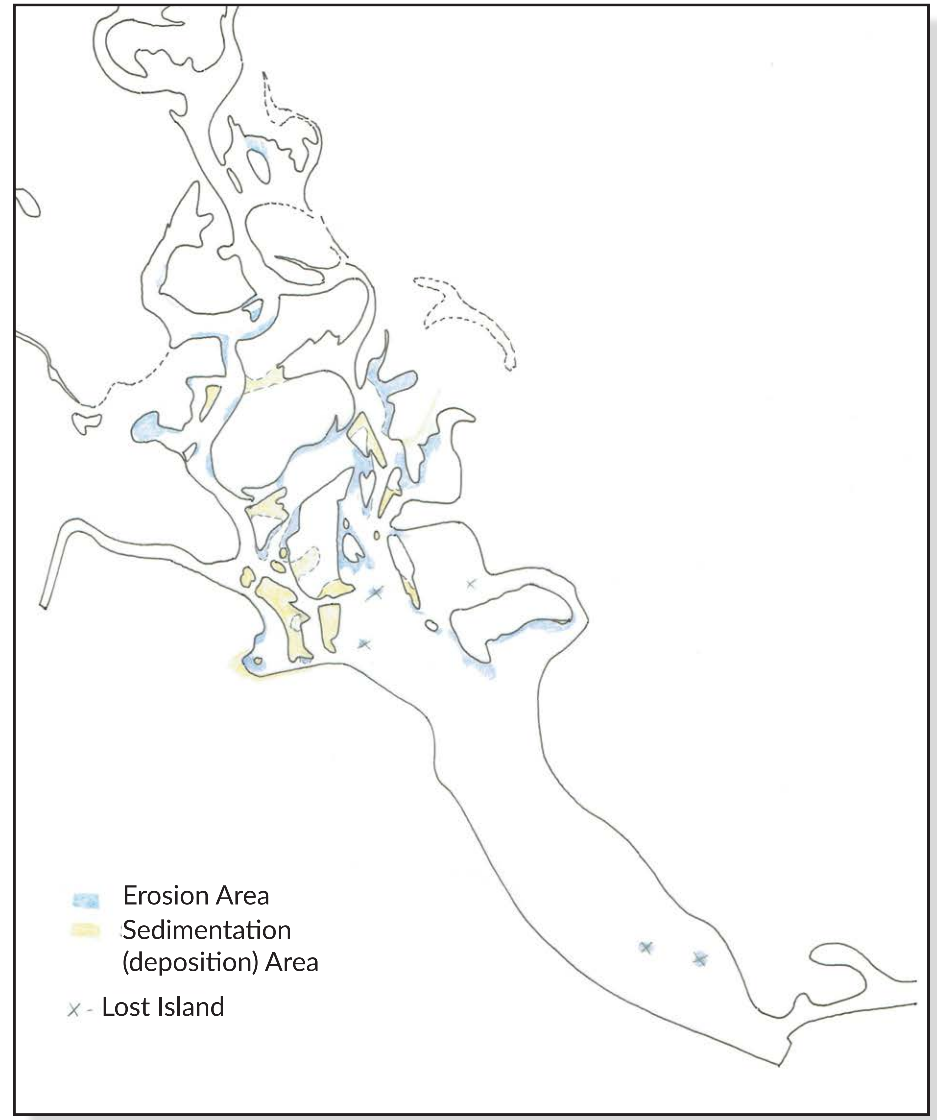
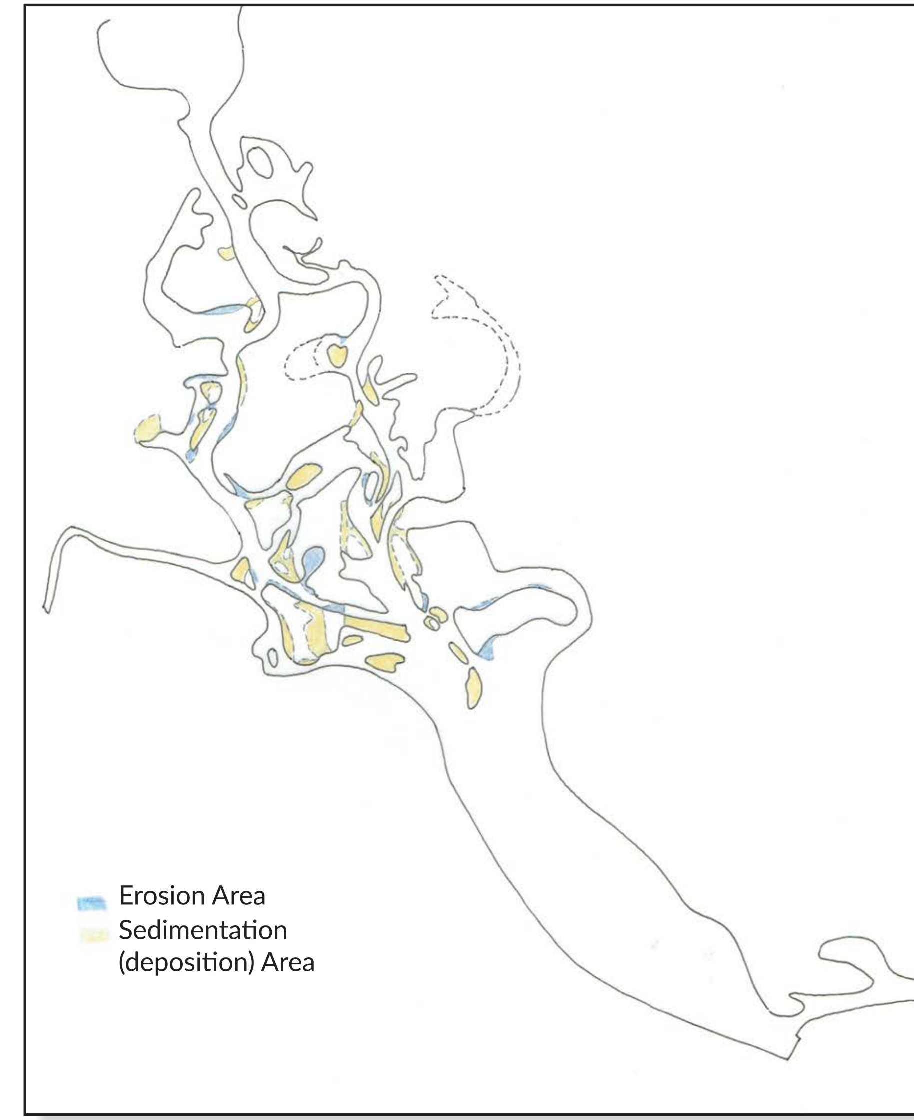


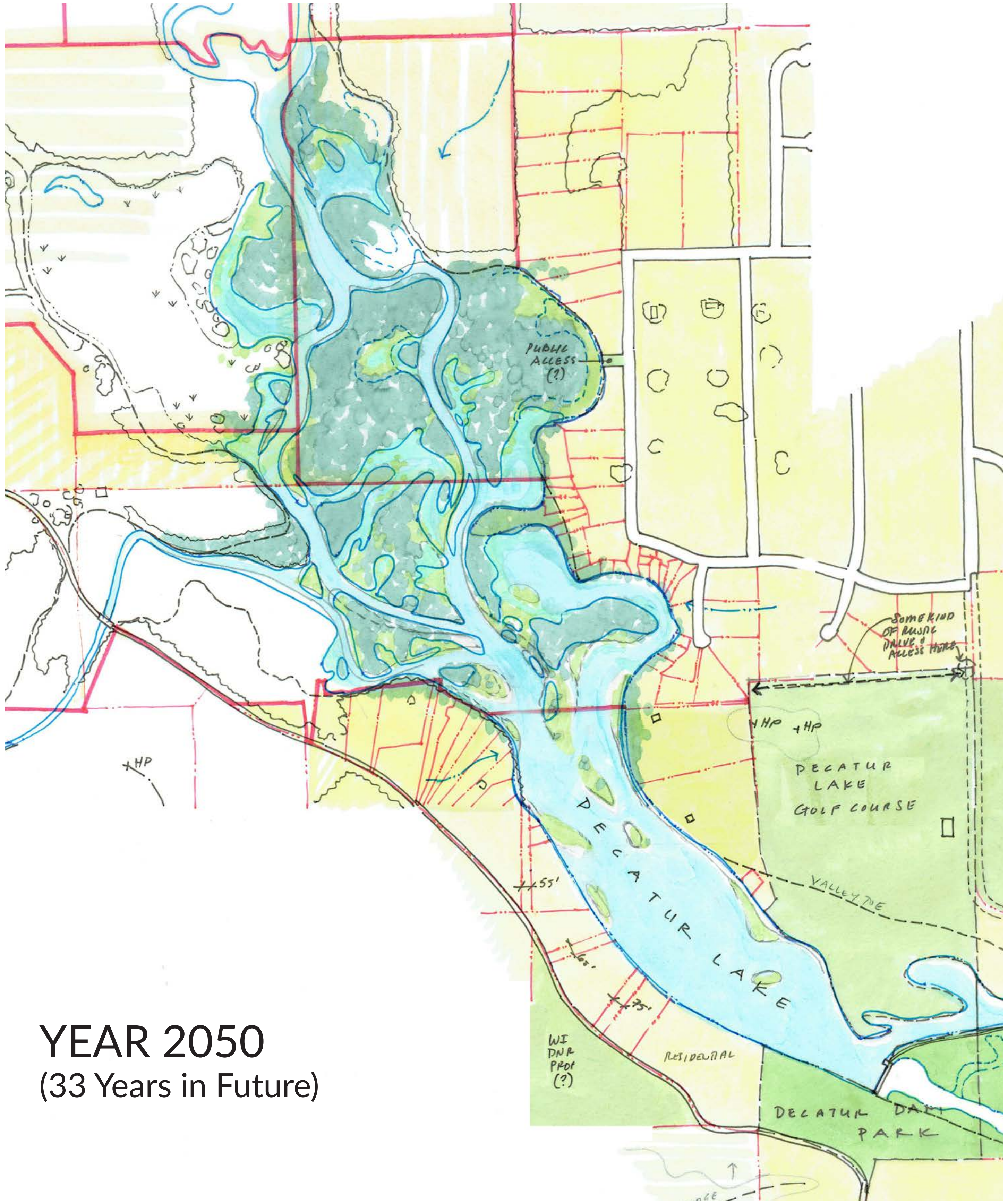
1937 Surface Water Outline



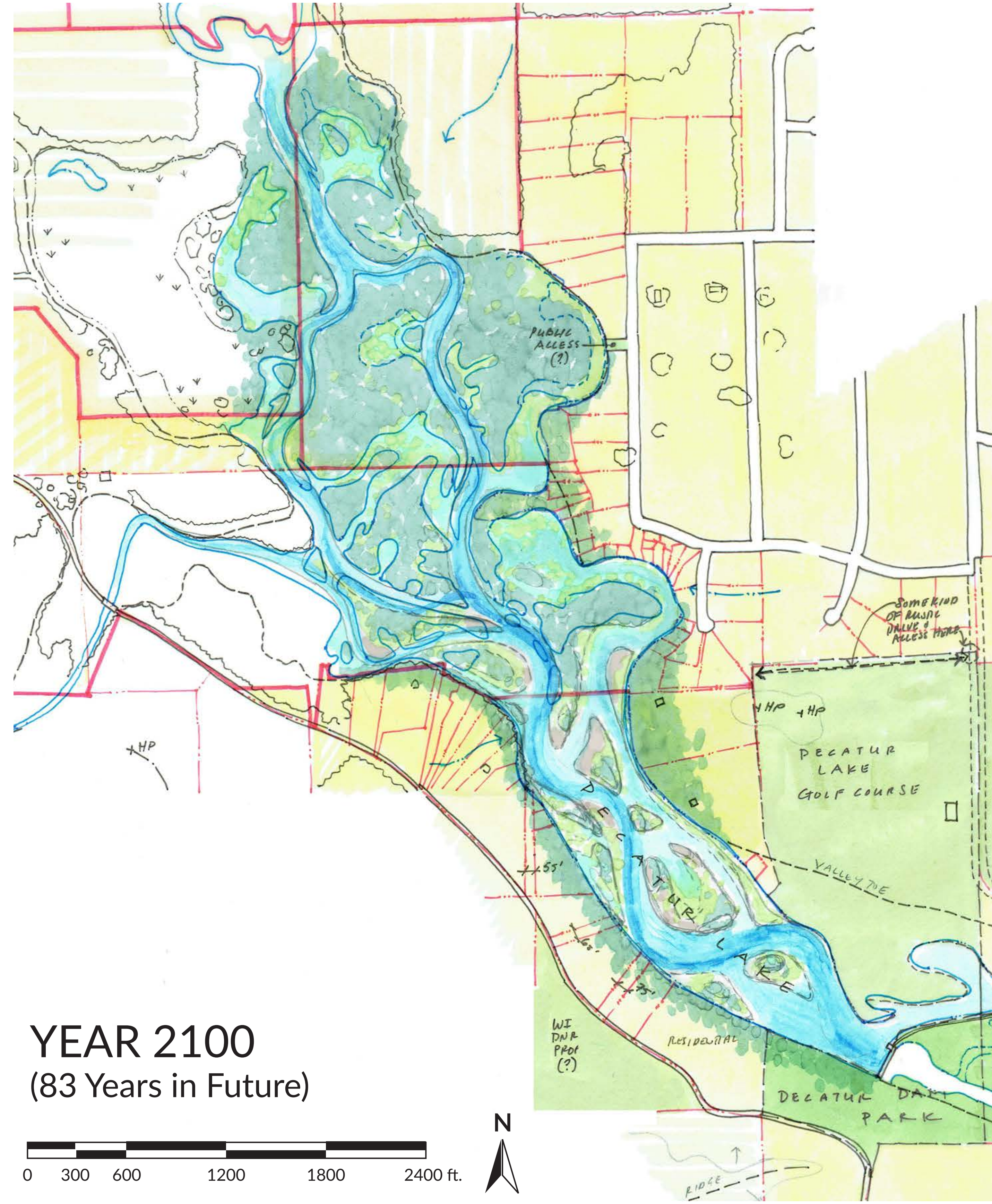
1960 - 1995 (35 YEARS)
Sedimentation & Erosion Diagram



1995 - PRESENT (22 YEARS)
Sedimentation & Erosion Diagram



YEAR 2050
(33 Years in Future)

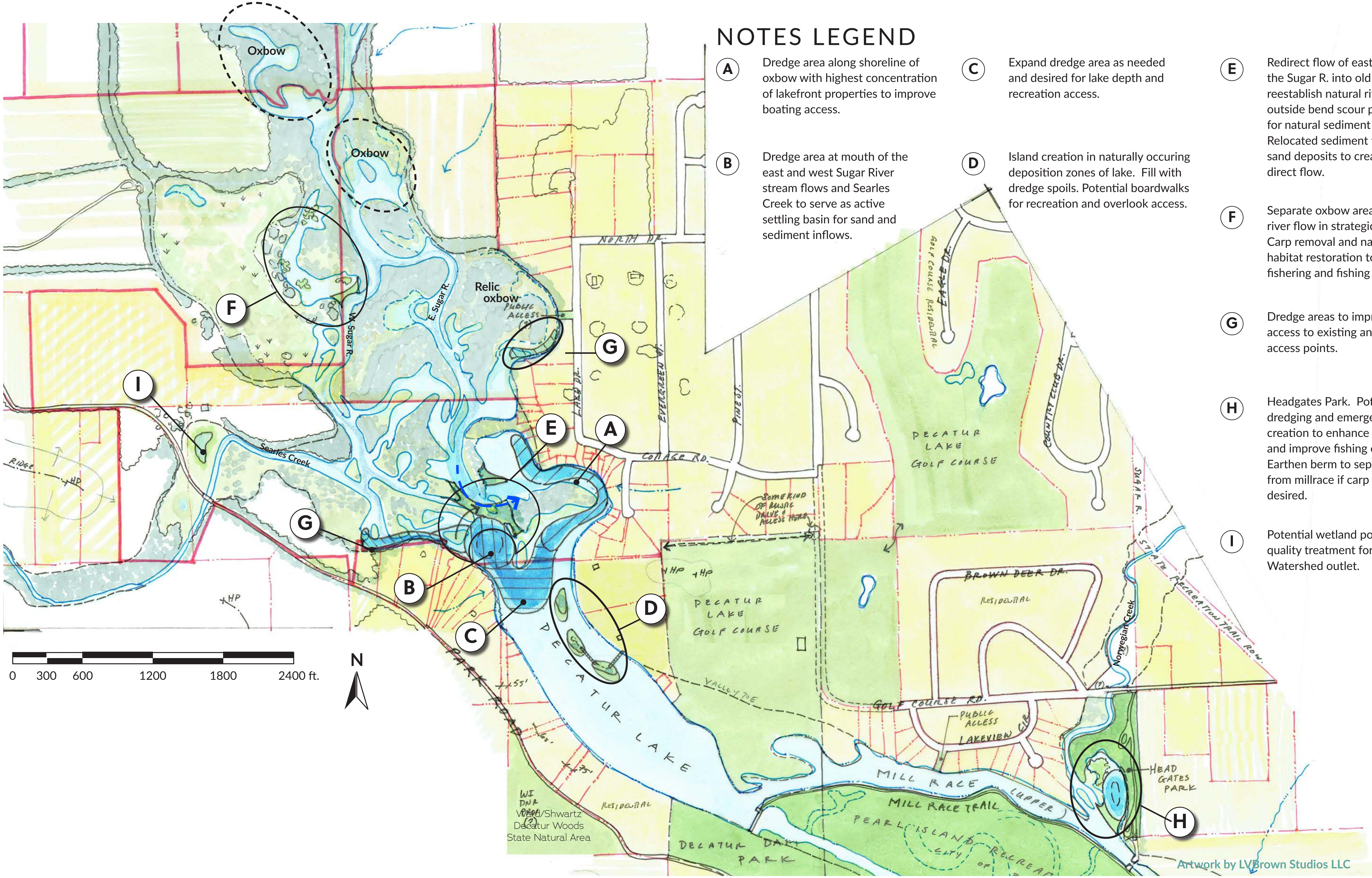


YEAR 2100
(83 Years in Future)

 DECATUR LAKE FEASIBILITY STUDY

Sedimentation Diagrams

Future Projections



NOTES LEGEND

A Dredge area along shoreline of oxbow with highest concentration of lakefront properties to improve boating access.

B Dredge area at mouth of the east and west Sugar River stream flows and Searles Creek to serve as active settling basin for sand and sediment inflows.

C Expand dredge area as needed and desired for lake depth and recreation access.

D Island creation in naturally occuring deposition zones of lake. Fill with dredge spoils. Potential boardwalks for recreation and overlook access.

E Redirect flow of eastern split of the Sugar R. into old oxbow to reestablish natural river flow and outside bend scour processes for natural sediment transport. Relocated sediment from undesired sand deposits to create river bend to direct flow.

F Separate oxbow areas from main river flow in strategic locations. Carp removal and natural aquatic habitat restoration to improve fishering and fishing recreation.

G Dredge areas to improve boating access to existing and future public access points.

H Headgates Park. Potential dredging and emergent marsh creation to enhance aquatic habitat and improve fishing opportunities. Earthen berm to separate pond from millrace if carp removal desired.

I Potential wetland ponds for water quality treatment for Searles Creek Watershed outlet.

Potential Watercourse Alternatives

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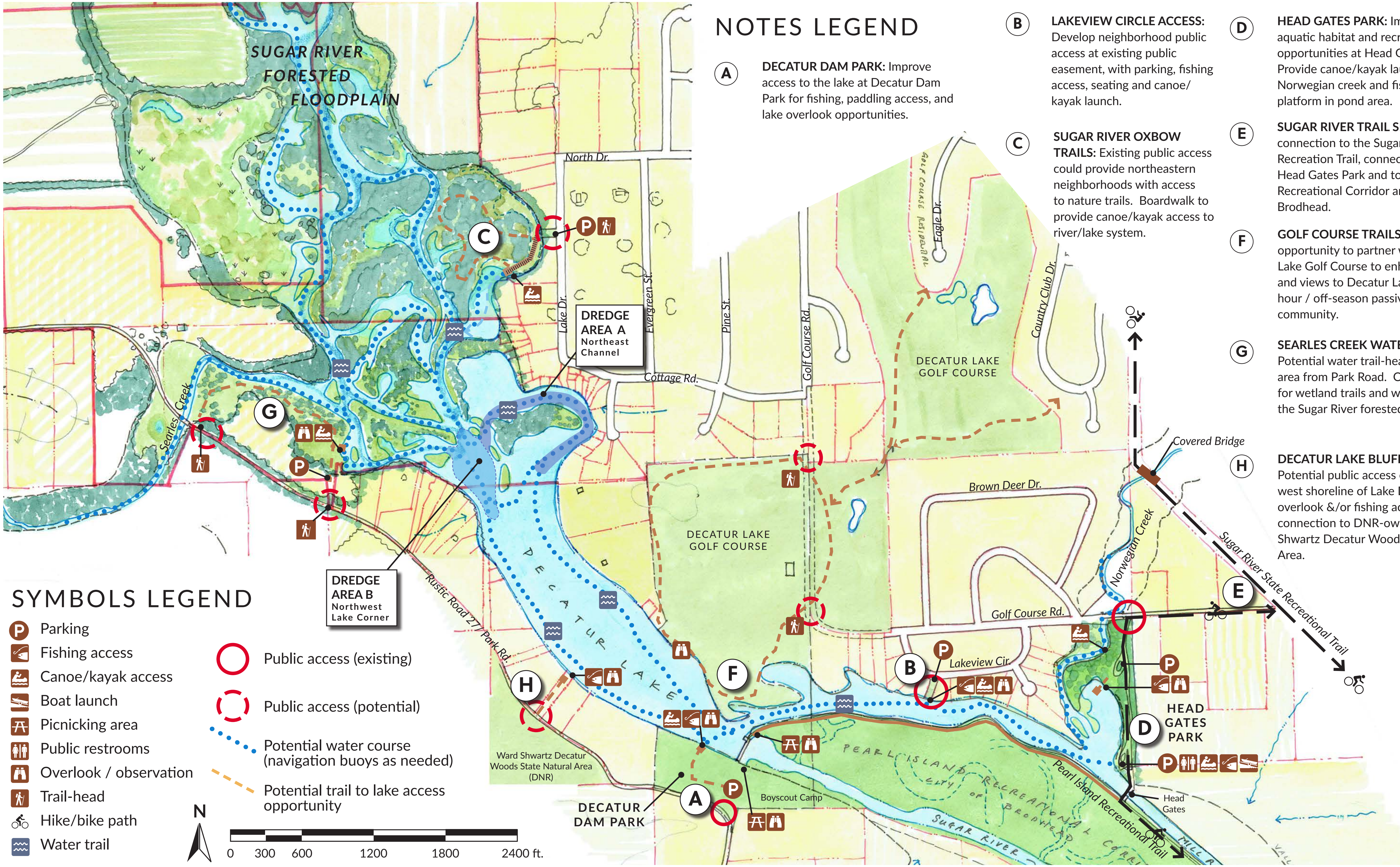

NOTES LEGEND

A **DECATUR DAM PARK:** Improve access to the lake at Decatur Dam Park for fishing, paddling access, and lake overlook opportunities.

B **LAKEVIEW CIRCLE ACCESS:** Develop neighborhood public access at existing public easement, with parking, fishing access, seating and canoe/ kayak launch.

C **SUGAR RIVER OXBOW TRAILS:** Existing public access could provide northeastern neighborhoods with access to nature trails. Boardwalk to provide canoe/kayak access to river/lake system.

D **HEAD GATES PARK:** Improve aquatic habitat and recreation opportunities at Head Gates Park. Provide canoe/kayak launch to Norwegian creek and fishing pier/ platform in pond area.

E **SUGAR RIVER TRAIL SPUR:** Potential connection to the Sugar River State Recreation Trail, connecting cyclists to Head Gates Park and to the Pearl Island Recreational Corridor and Downtown Brodhead.

F **GOLF COURSE TRAILS:** Potential opportunity to partner with Decatur Lake Golf Course to enhance trails and views to Decatur Lake for off-hour / off-season passive use by the community.

G **SEARLES CREEK WATER TRAILHEAD:** Potential water trail-head and parking area from Park Road. Opportunities for wetland trails and water trail loop in the Sugar River forested floodplain.

H **DECATUR LAKE BLUFF OVERLOOK:** Potential public access easement on west shoreline of Lake Decatur for lake overlook &/or fishing access. Potential connection to DNR-owned Ward Shwartz Decatur Woods State Natural Area.

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A6 **DECATUR LAKE** FEASIBILITY STUDY

Decatur Dam Park

Existing Conditions Map & Photo Key

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Site Photo: Entry view from Rustic Road 27

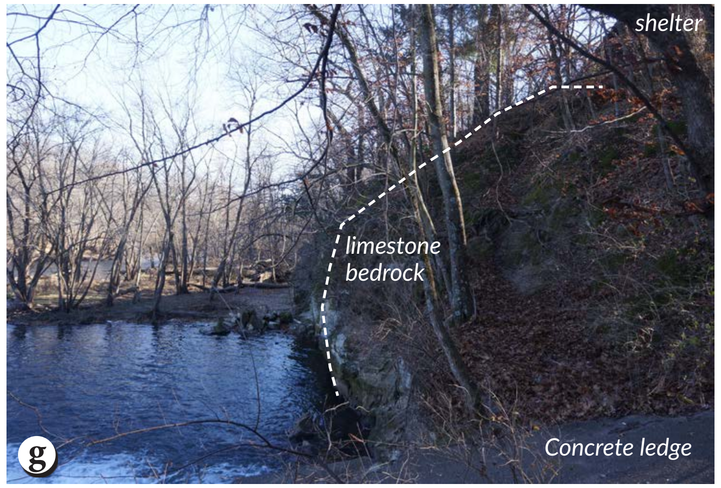
Site Photo: Highpoint of landform

Site Photo: Picnic Shelter

Site Photo: chainlink fence and view to dam from shelter

Site Photo: Looking down existing ravine to dam from shelter

Site Photo: View of dam from bottom of ravine trail



Site Photo: Looking at downstream limestone bedrock.

Site Photo: Steep ravine path looking to dam

Site Photo: Gateway to Boyscout camp drive

Site Photo: Looking towards Boyscout camp structures

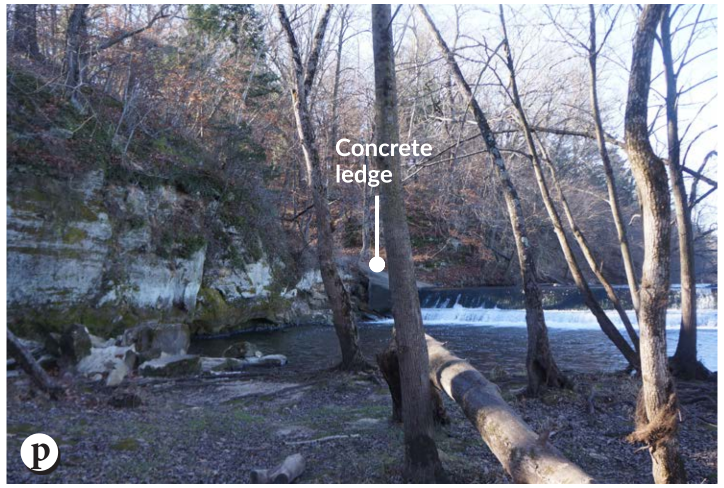
Site Photo: Looking down ravine, boyscout council platform

Site Photo: Boyscout campfire ring

Site Photo: Boyscout camp rustic staircase

Site Photo: Floodplain and limestone bedrock bluff

Site Photo: Floodplain looking toward dam



Site Photo: View of dam waterfall and limestone bluff

Site Photo: Limestone bluff with shelter above

Site Photo: Ravine mouth, potential access point

Site Photo: Steep slope to shelter

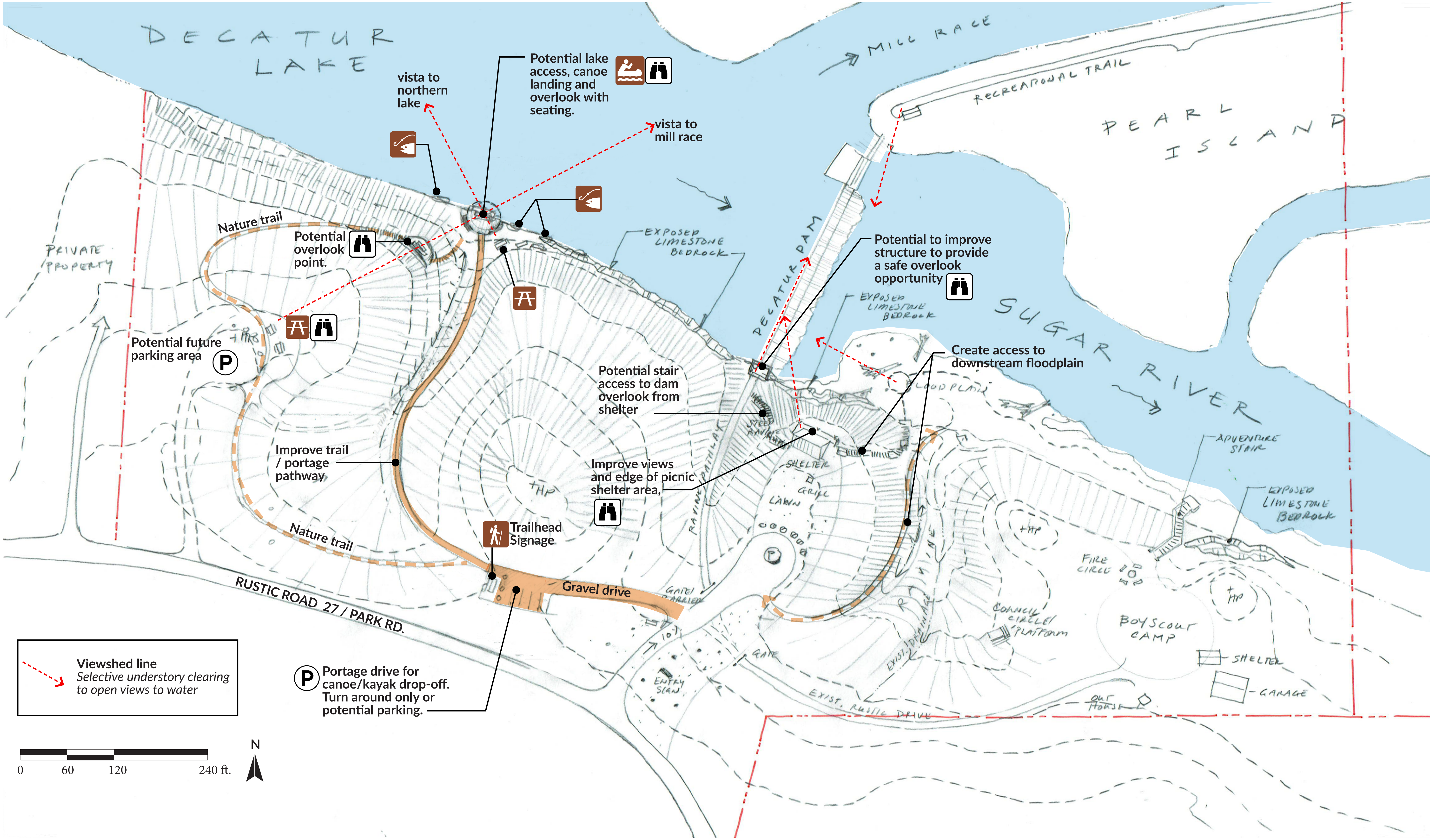
Site Photo: view to dam outside of chainlink fence

Site Photo: Chainlink fence along back edge of shelter

Site Photo: Lawn and picnic area between shelter and parking

Site Photo: Woodland Ravine

Site Photo: View of Decatur Lake from woodland ravine.



A9 | **DECATUR LAKE** FEASIBILITY STUDY

Decatur Dam Park

Opportunities Diagram

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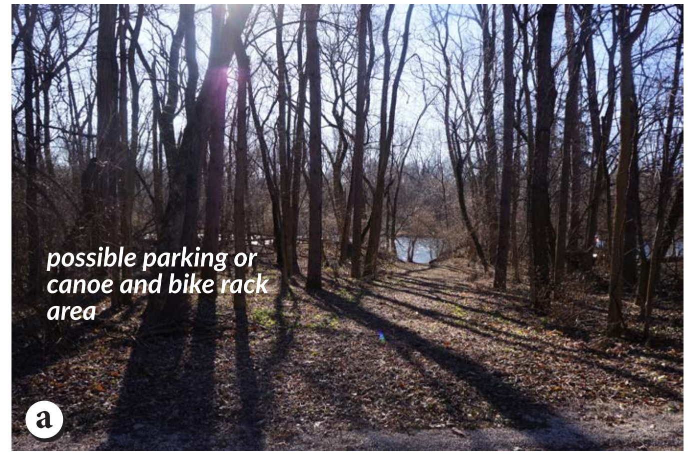
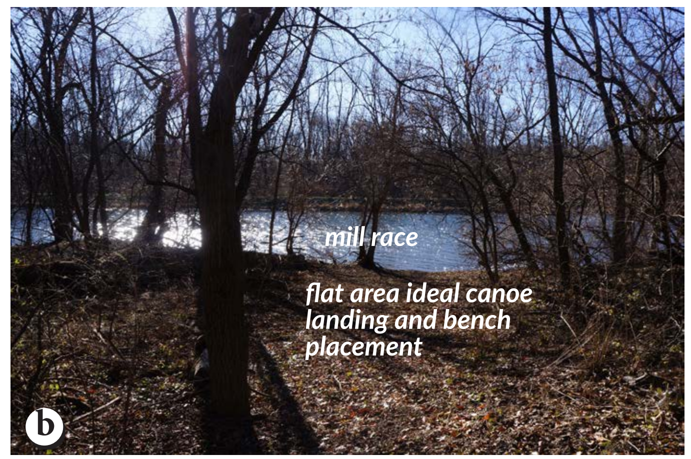
Example image: Public Access Signage



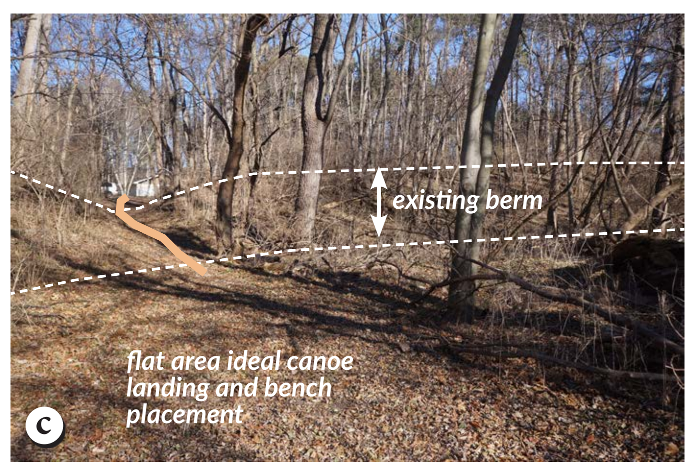
Site Photo: Pathway from roadway to water.


Example image: Site furnishings at water's edge

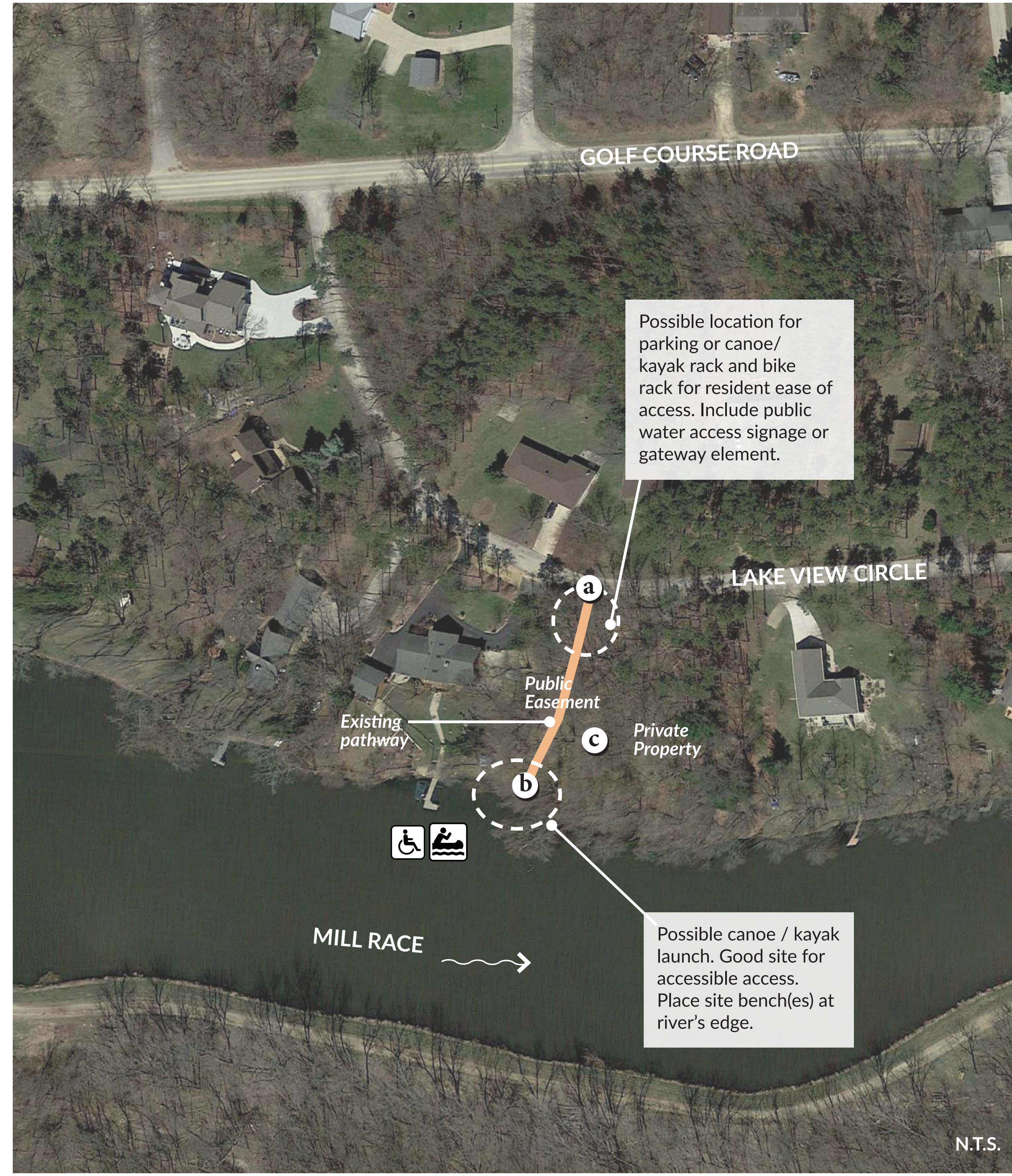


Site Photo: Flat area looking towards water


Example image: Canoe/kayak rack



Site Photo: Looking back to road from waters edge.



Access Opportunity Diagram - Area B

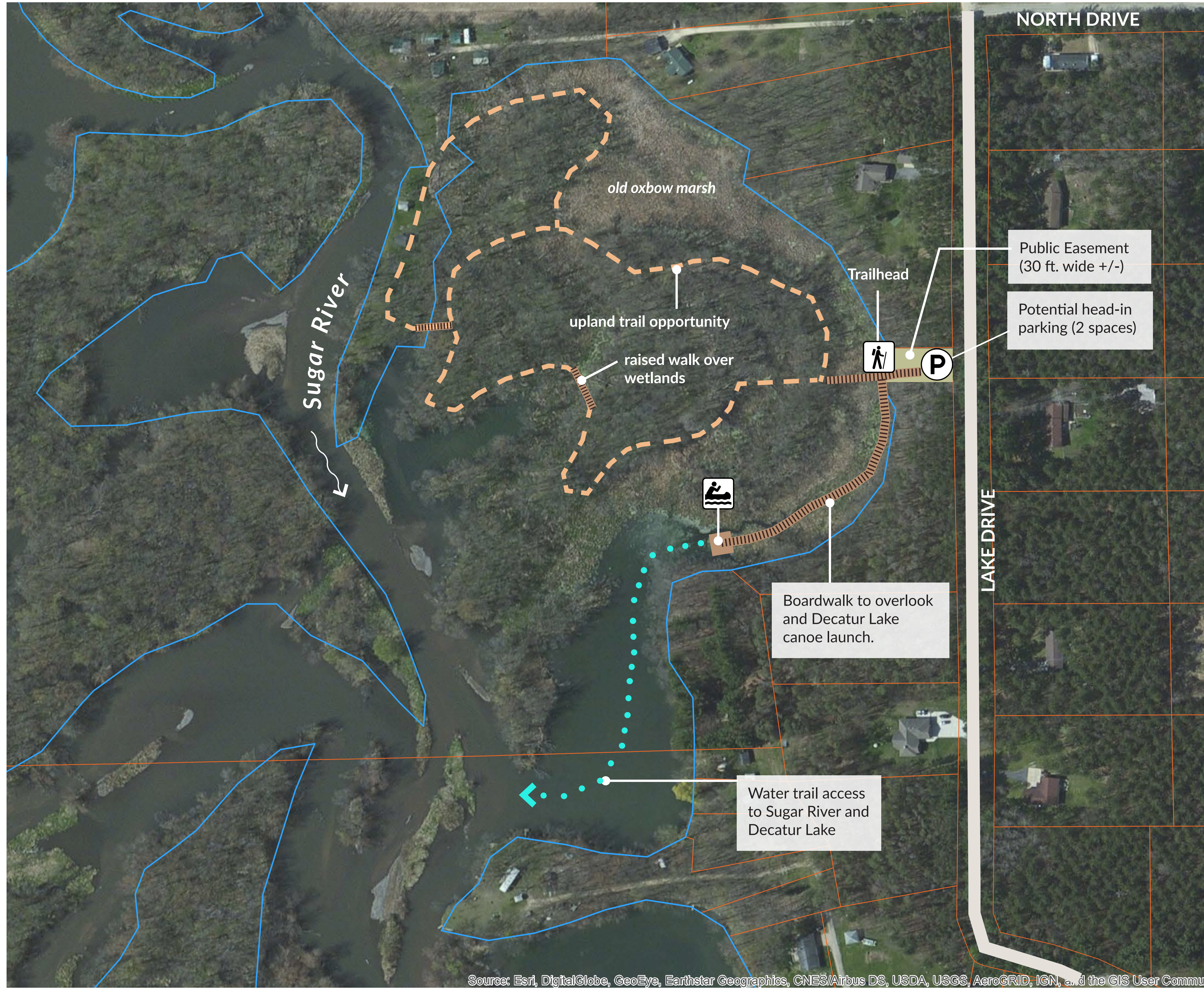
LAKEVIEW CIRCLE ACCESS

Montgomery Associates Resource Solutions
Underwater Habitat Investigations, LLC
LVB LVBrown Studio LLC

Site Photo: Easement area from Lake Drive

Site Photo: Sloped area looking through woods towards marsh

Site Photo: View of marsh at edge of easement



DECATUR LAKE
FEASIBILITY STUDY

Access Opportunity Diagram - Area C

SUGAR RIVER OXBOW TRAILS & LAKE ACCESS

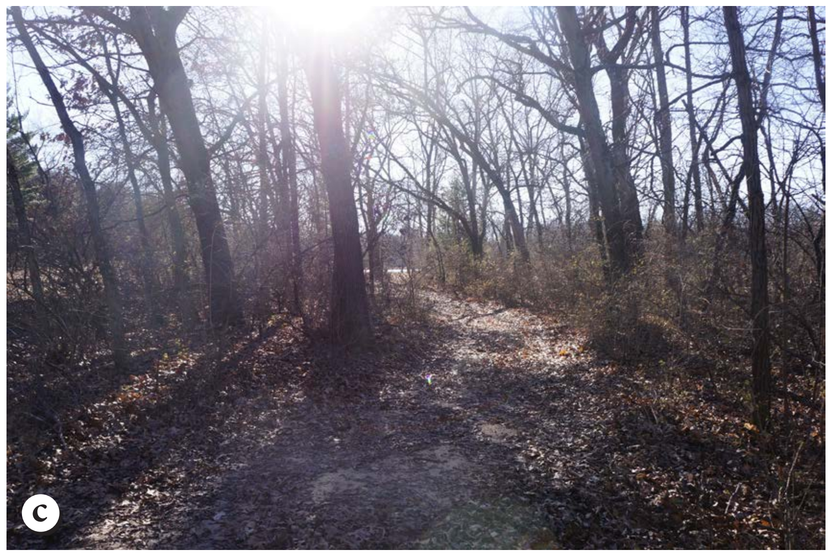
Montgomery Associates
Resource Solutions

Underwater Habitat Investigations, LLC

LVB LVBrown Studio LLC

Site Photo: Existing dirt path to Norwegian Creek

Site Photo: Norwegian Creek looking downstream

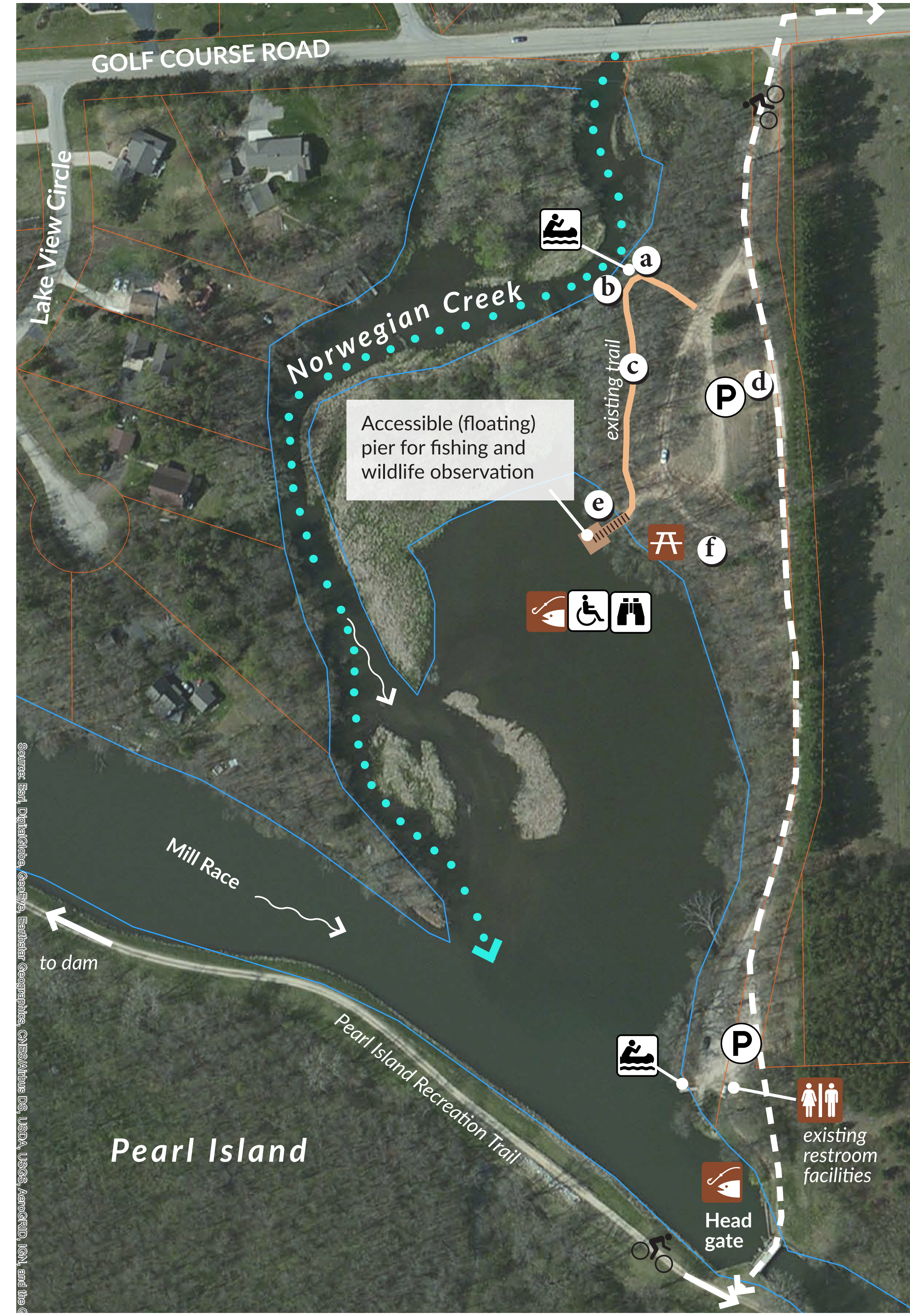


Site Photo: Existing woodland path

Site Photo: Flat area, excavated slope and pine hedge row beyond

Site Photo: Looking out to pond (location of possible pier)

Site Photo: Eastern shoreline of pond (good picknicking site)



A12 DECATUR LAKE FEASIBILITY STUDY

Access Opportunity Diagram - Area D

HEAD GATES PARK

Montgomery Associates Resource Solutions

Underwater Habitat Investigations, LLC

LVB LVBrown Studio LLC

Site Photo: Golf Course Drive from roadway

Site Photo: Existing dirt drive along north golfcourse

Site Photo: Looking towards Decatur lake

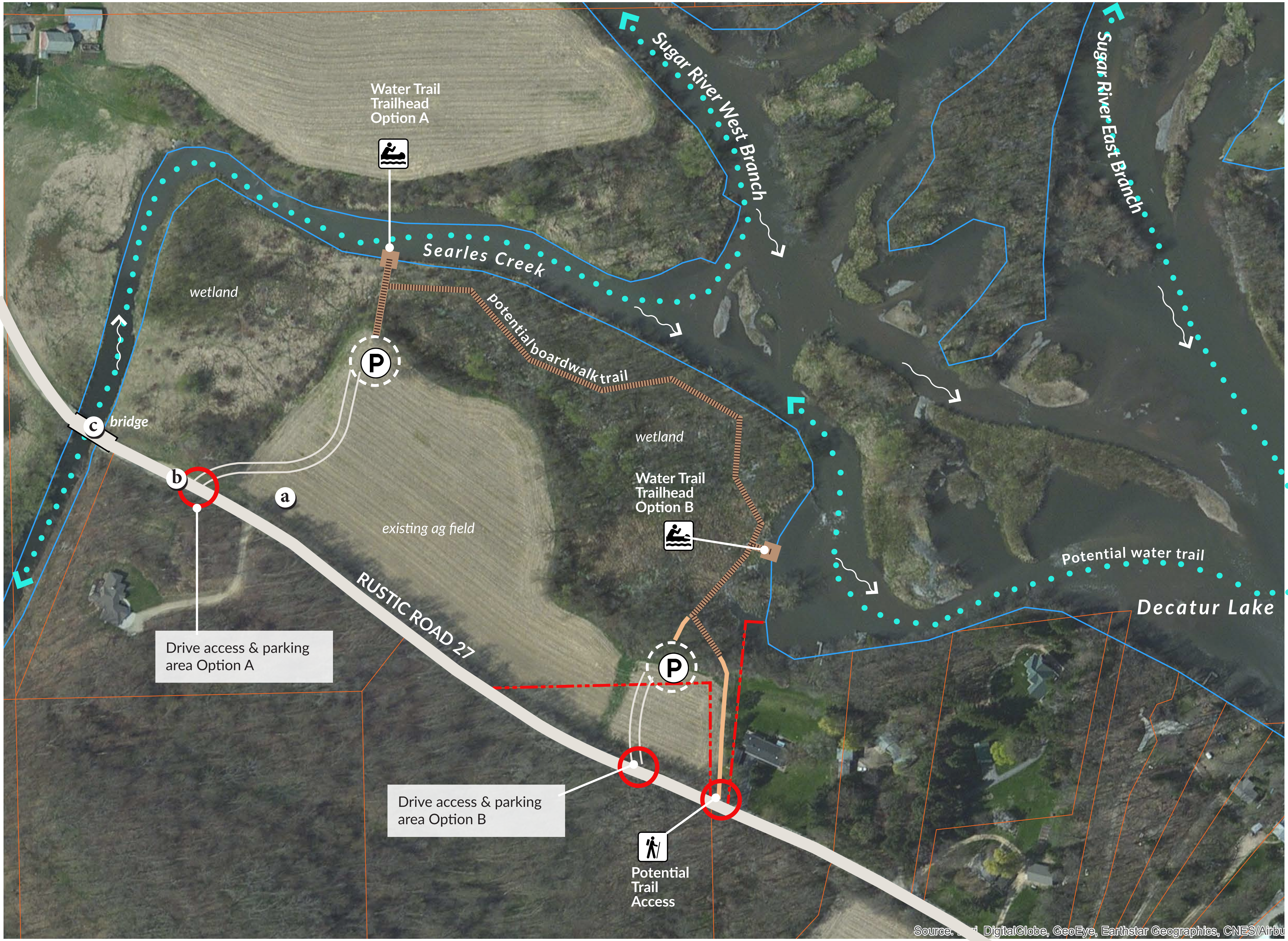
A13 | **DECATUR LAKE** FEASIBILITY STUDY | Access Opportunity Diagram - Area F

GOLF COURSE TRAILS

Montgomery Associates Resource Solutions

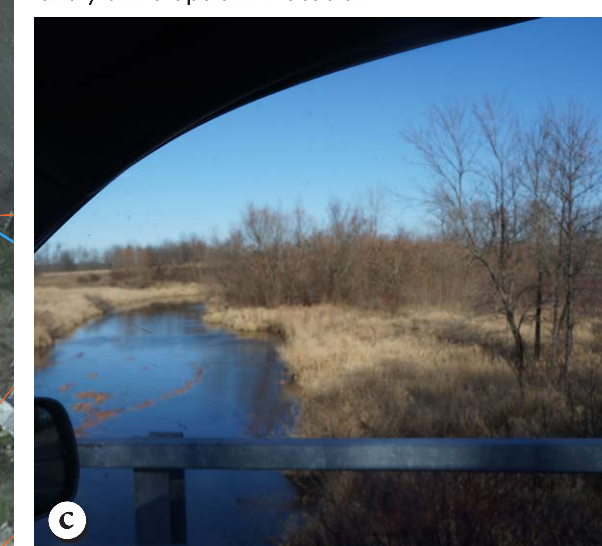
Underwater Habitat Investigations, LLC

LVB LVBrown Studio LLC



Site Photo: western edge of farmfield looking out along potential Option A drive path

Site Photo: Looking west to bridge at potential entry drive option A location



Site Photo: Searles creek downstream of bridge

DECATUR LAKE
FEASIBILITY STUDY

Access Opportunity Diagram - Area G

SEARLES CREEK WATER TRAILHEAD

Montgomery Associates
Resource Solutions

Underwater Habitat Investigations, LLC

LVB LVBrown Studio LLC

Appendix B
Grain Size Analyses

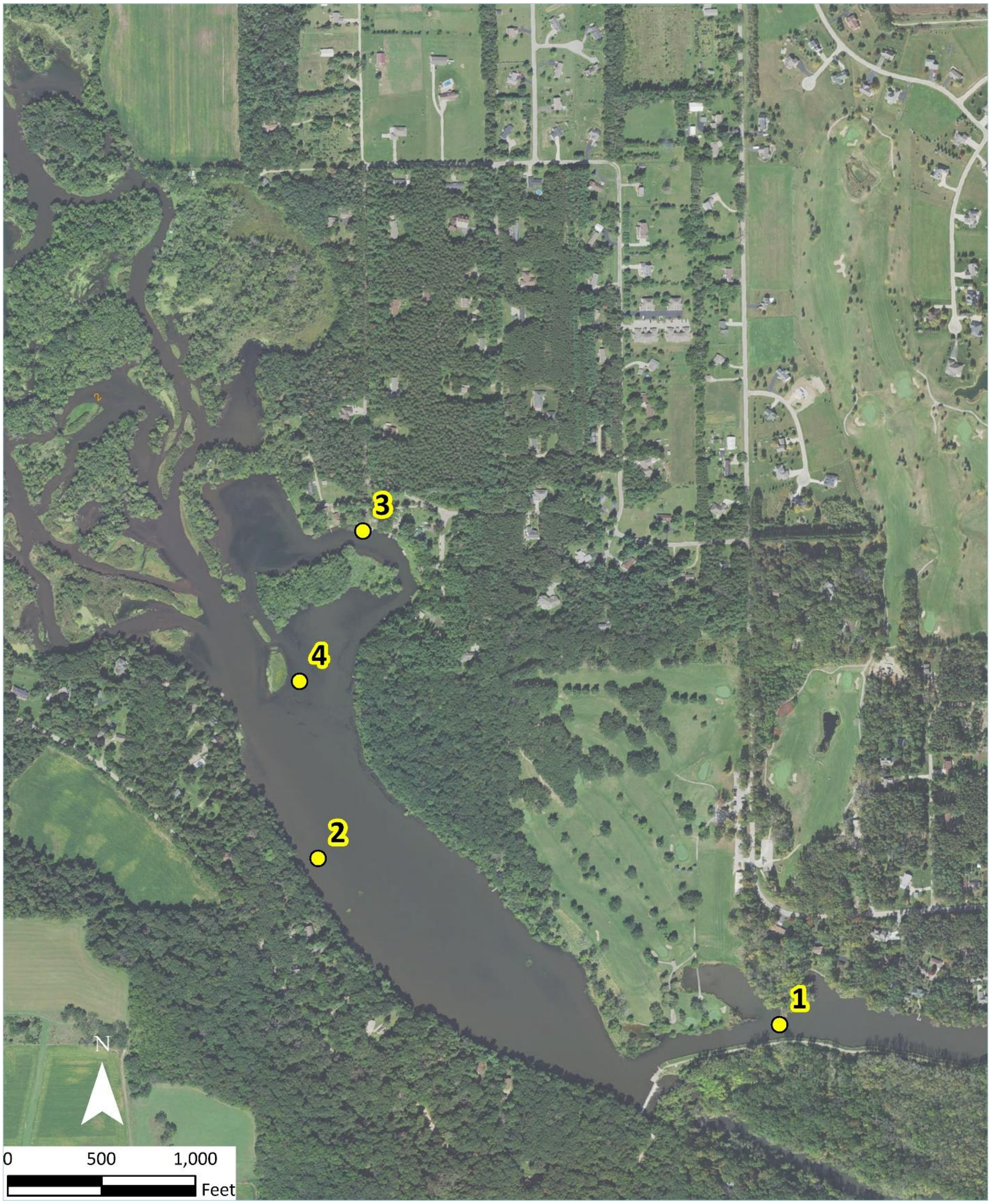


Figure B1. Sediment sample locations.

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 - FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director - Prof. James J. Schauer, Ph.D., Director

Environmental Health Division

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB ID: WI00007, WI00008 WI DATCP ID: 105-415

WSLH Sample: 342286001

Report To:
STEVE GAFFIELD
MONTGOMERY ASSOCIATES
119 S MAIN ST
COTTAGE GROVE, WI 53527

Invoice To:
JAINE WINTERS
DECATUR LAKE & MILL RACE ASSOCIATION
N3928 PARK RD
BRODHEAD, WI 53520
Customer ID: 351344

Field #: DECATUR 1
Project No: LPL163917
Collection End: 8/25/2017 11:50:00 AM
Collection Start: 08/25/17 09:20
Collected By: STEVE GAFFIELD
Date Received: 9/14/2017
Date Reported: 10/3/2017
Sample Reason:

ID#: 10002694
Sample Location: DECATUR LAKE-SUGAR RIVER
Sample Description: LAKE BED SEDIMENT COLLECTED BY BOAT WITH SAMPLING CUP
Sample Type: SE-SEDIMENT
Waterbody: 879400
Point or Outfall:
Sample Depth: 3IN
Program Code:
Region Code:
County: 23

Inorganic Chemistry

Analyte	Analysis Method	Result	Units	LOD	LOQ
Prep Date 09/29/17 Analysis Date 09/29/17					
Sand	Hydrometer method	8	%		
Silt	Hydrometer method	72	%		
Clay	Hydrometer method	21	%		

List of Abbreviations:

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LOQ = Level of quantification
ND = None detected. Results are less than the LOD
F next to result = Result is between LOD and LOQ
Z next to result = Result is between 0 (zero) and LOD
if LOD=LOQ, Limits were not statistically derived

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D.F. Kurtycz, M.D., Medical Director - Prof. James J. Schauer, Ph.D., Director

Environmental Health Division

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB ID: WI00007, WI00008 WI DATCP ID: 105-415

WSLH Sample: 342286001

Responsible Party

Microbiology: Sharon Kluender, Lab Manager, 608-224-6262
Inorganic Chemistry: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Metals: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Organic Chemistry: Al Spallato, Lab Manager, 608-224-6269
Emergency Chemical Response: Noel Stanton, Lab Manager, 608-224-6251
Environmental Toxicology: Tracy Hanke, Lab Manager, 608-224-6270

Wisconsin State Laboratory of Hygiene
UNIVERSITY OF WISCONSIN–MADISON

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director - Prof. James J. Schauer, Ph.D., Director

Environmental Health Division

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB ID: WI00007, WI00008 WI DATCP ID: 105-415

WSLH Sample: 342286002

Report To:
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Invoice To:
JAINE WINTERS
DECATUR LAKE & MILL RACE ASSOCIATION
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BRODHEAD, WI 53520
Customer ID: 351344

Field #: DECATUR 2
Project No: LPL163917
Collection End: 8/25/2017 11:50:00 AM
Collection Start: 08/25/17 09:20
Collected By: STEVE GAFFIELD
Date Received: 9/14/2017
Date Reported: 10/3/2017
Sample Reason:

ID#: 10002694
Sample Location: DECATUR LAKE-SUGAR RIVER
Sample Description: LAKE BED SEDIMENT COLLECTED BY BOAT WITH SAMPLING CUP
Sample Type: SE-SEDIMENT
Waterbody: 879400
Point or Outfall:
Sample Depth: 3IN
Program Code:
Region Code:
County: 23

Inorganic Chemistry

Analyte	Analysis Method	Result	Units	LOD	LOQ
Prep Date 09/29/17 Analysis Date 09/29/17					
Sand	Hydrometer method	16	%		
Silt	Hydrometer method	60	%		
Clay	Hydrometer method	25	%		

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LOQ = Level of quantification
ND = None detected. Results are less than the LOD
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WSLH Sample: 342286002

Responsible Party

Microbiology: Sharon Kluender, Lab Manager, 608-224-6262
Inorganic Chemistry: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Metals: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Organic Chemistry: Al Spallato, Lab Manager, 608-224-6269
Emergency Chemical Response: Noel Stanton, Lab Manager, 608-224-6251
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director - Prof. James J. Schauer, Ph.D., Director

Environmental Health Division

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB ID: WI00007, WI00008 WI DATCP ID: 105-415

WSLH Sample: 342286003

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N3928 PARK RD
BRODHEAD, WI 53520
Customer ID: 351344

Field #: DECATUR 3
Project No: LPL163917
Collection End: 8/25/2017 11:50:00 AM
Collection Start: 08/25/17 09:20
Collected By: STEVE GAFFIELD
Date Received: 9/14/2017
Date Reported: 10/3/2017
Sample Reason:

ID#: 10002694
Sample Location: DECATUR LAKE-SUGAR RIVER
Sample Description: LAKE BED SEDIMENT COLLECTED BY BOAT WITH SAMPLING CUP
Sample Type: SE-SEDIMENT
Waterbody: 879400
Point or Outfall:
Sample Depth: 3IN
Program Code:
Region Code:
County: 23

Inorganic Chemistry

Analyte	Analysis Method	Result	Units	LOD	LOQ
Prep Date 09/29/17 Analysis Date 09/29/17					
Sand	Hydrometer method	16	%		
Silt	Hydrometer method	68	%		
Clay	Hydrometer method	17	%		

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LOQ = Level of quantification
ND = None detected. Results are less than the LOD
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WSLH Sample: 342286003

Responsible Party

Microbiology: Sharon Kluender, Lab Manager, 608-224-6262
Inorganic Chemistry: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Metals: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Organic Chemistry: Al Spallato, Lab Manager, 608-224-6269
Emergency Chemical Response: Noel Stanton, Lab Manager, 608-224-6251
Environmental Toxicology: Tracy Hanke, Lab Manager, 608-224-6270

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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director - Prof. James J. Schauer, Ph.D., Director

Environmental Health Division

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB ID: WI00007, WI00008 WI DATCP ID: 105-415

WSLH Sample: 342286004

Report To:
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Invoice To:
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N3928 PARK RD
BRODHEAD, WI 53520
Customer ID: 351344

Field #: DECATUR 4
Project No: LPL163917
Collection End: 8/25/2017 11:50:00 AM
Collection Start: 08/25/17 09:20
Collected By: STEVE GAFFIELD
Date Received: 9/14/2017
Date Reported: 10/3/2017
Sample Reason:

ID#: 10002694
Sample Location: DECATUR LAKE-SUGAR RIVER
Sample Description: LAKE BED SEDIMENT COLLECTED BY BOAT WITH SAMPLING CUP
Sample Type: SE-SEDIMENT
Waterbody: 879400
Point or Outfall:
Sample Depth: 3IN
Program Code:
Region Code:
County: 23

Inorganic Chemistry

Analyte	Analysis Method	Result	Units	LOD	LOQ
Prep Date 09/29/17 Analysis Date 09/29/17					
Sand	Hydrometer method	96	%		
Silt	Hydrometer method	2	%		
Clay	Hydrometer method	3	%		

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Environmental Health Division

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB ID: WI00007, WI00008 WI DATCP ID: 105-415

WSLH Sample: 342286004

Responsible Party

Microbiology: Sharon Kluender, Lab Manager, 608-224-6262
Inorganic Chemistry: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Metals: DeWayne Kennedy-Parker, Lab Manager, 608-224-6282
Organic Chemistry: Al Spallato, Lab Manager, 608-224-6269
Emergency Chemical Response: Noel Stanton, Lab Manager, 608-224-6251
Environmental Toxicology: Tracy Hanke, Lab Manager, 608-224-6270

Appendix C
Water Quality Survey and Habitat Review

Decatur Lake Water Quality Survey 8/25/2017

Summary

The Sugar River was visibly turbid, and actual turbidity measurements were recorded using a Hach 2100P Turbidimeter measurements (NTU). Higher productivity occurred in two off channel areas (Sue's Dock and Decatur Lake) based on high D.O. and less turbid water with greater light transparency. pH was also higher in Decatur Lake, reflecting greater photosynthetic response. Except for the marsh upstream of the lake where a chemically reduced shallow groundwater discharge was evident (high iron precipitation), high nitrate concentrations were found in the river (4.5-5.5 mg/l). While the current Impaired Water designation is based on phosphorus (http://dnr.wi.gov/water/waterDetail.aspx?key=4701075), USEPA recommended a Total Nitrogen standard of <2.0 mg/l (Robertson et al. 2006) while Camargo et al. (2005) recommends a nitrate surface water standard of 2.0 mg/l due to toxic effects on environmentally sensitive fish and aquatic organisms. Contaminated groundwater is the primary source of NO_3 to the Sugar River. NO_3 concentrations can increase during drought periods when groundwater contributes a greater fraction of river flow. Minnesota is in the process of adopting nitrate standards for surface waters with a proposed limit of 4.9 mg/l NO_3 for water similar to the Sugar River (MPCA 2010).

Equipment

YSI ODO dissolved oxygen temperature meter, YSI Model 63 pH and Specific Conductance meter, YSI Pro Plus meter with NO3 sensor, Hach Model 2100P Turbidimeter, Garmin GPS Model 76.

Site 1 sediment sample: 42.64590-89.40641

Water temp: 17.3 C, D.O.: 8.2 mg/l, Specific Conductance: 665 uS/cm, pH: 7.9 su, Turb: 34.9 NTU, NO_3: 4.6 mg/l.

Site 2 sediment sample: 42.64836-89.41553

Water temp: 17.3 C, D.O.: 8.6 mg/l, Specific Conductance: 660 sS/cm, pH: 8.0 su, Turb: 18.1 NTU, NO_3: 5.5 mg/l. Sago pondweed, floating leaf Potamogeton sp.

Site 3 sediment sample: 42.65371-89.42148 upstream of Searles Creek confluence

Site 4 marsh discharge to potential oxbow restoration: 42.65715-89.42314

Water temp: 16.5 C, D.O.: 4.1 mg/l, Specific Conductance: 560 uS/cm, pH: 7.1 su, Turb: 49.9 NTU, NO_3: 0.8 mg/l. Water stained orange due to reduced conditions and *Leptothrix* ("Iron") bacteria. High turbidity reflected suspended iron flock and low D.O. and pH reflected chemical reduction. The latter two measurements were likely lower upstream of the oxbow. Coontail, duckweed and lots of carp.

Site 5 potential oxbow: 42.66370-89.42578.

Water temp: 17.9 C, D.O.: 7.2 mg/l. Carp movements and few plants.

Site 6 sediment sample at Sue's Dock: 42.65314-89.41461

Water temp: 18.7 C, D.O.: 14.4 mg/l, Specific Conductance: 661 uS/cm, Site 7 Island: 42.65095-89.41588

Water temp: 18.3 C, D.O.: 9.1 mg/l, Specific Conductance: 663 uS/cm. Sago pondweed, long leaf (*Potamogeton nodosus*) and Elodea (*E. canadensis*).

Site 8 Dam:

Water temp: 18.1 mg/l, D.O.: 9.0 mg/l.

Site 9 Decatur Lake:

Water temp: 19.3 C, D.O.: 14.4 mg/l, Specific Conductance: 617 uS/cm, pH: 8.3 su, Turb: 9.5 NTU, NO_3: 4.5 mg/l.

References

Camargo, J.A., A. Alsonso and A. Salamanca. 2005. Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. Chemosphere 58:1255-1267.

Minn. Pollution Control Agency. 2010. Developing surface water nitrate standards and strategies for reducing nitrogen loading. wq-s6-23.

Monson, P. 2010. Aquatic life water quality standards technical support document for nitrate. Minnesota Pollution Control Agency 9 pp.

Robertson, D.M., D.J. Graczyk, P.J. Garrison, L. Wang, G. LaLiberte and R. Bannerman. 2006. Nutrient concentrations and their relations to the biotic integrity of wadeable streams in Wisconsin. USGS Professional Pager 172.

Fisheries and Freshwater Mussels

At two lake committee member meetings and at two general stakeholder meetings in Brodhead, citizens voiced their interest in improving fishing opportunities and improve the lake ecosystem by developing a freshwater mussel bed. The Sugar River holds a diverse fishery including northern pike, common carp, common shiner, spotfin shiner, sand shiner, redfin shiner, bluntnose minnow, bullhead minnow, quillback, white sucker, silver redhorse, golden redhorse, shorthead redhorse, black bullhead, yellow bullhead, brown bullhead, channel catfish, brook silverside, orange spotted sunfish, bluegill, smallmouth bass, largemouth bass, white crappie, black crappie, Johnny darter, blackside darter, slenderhead darter (http://dnr.wi.gov/water/waterDetail.aspx?key=4701075). However, many of these species are either found primarily in areas of the river with faster currents or are rare. In 2012, a survey of nearshore fish using a towed DC electroshocker found these species in the lake: mudminnow (21), golden shiner (1), bluntnose minnow (29), adult common carp (4), tadpole madtom (2), yellow bullhead (1), green sunfish (13), bluegill (>50), orange spotted sunfish (12), rock bass (3), smallmouth bass (5), largemouth bass (5), johnny darter (3). Where tree falls were evident around the lake, fish likely attracted to this this favorable habitat include largemouth bass, smallmouth bass, rock bass, bluegill and channel catfish. Low numbers of northern pike will likely use these habitats as well. Favorable sunfish spawning habitat was evident where long leaf pondweed grew.

Lisie Kitchel (WDNR ER) provided a list of Sugar River mussels below and also mentioned that there were no records that specifically include Decatur Lake. While the Sugar River was noted in the pearl trade that depleted its mussels, and later recovered, mussel populations were depleted again during the poaching era of the 1980's. The limiting factor now is water quality. She mentioned that juvenile mussels are very susceptible to ammonia and nitrates, as are other species (Camargo et al. 2005), so beds of long lived adult mussels persist in some areas where habitat is favorable, particularly areas with fast current. Habitat modification is also an issue, including stream bank stabilization, channelization, etc. – but presumably less of an issue in the Decatur Lake vicinity. Vegetated buffers along the banks provide a big water quality benefit, helping filter sediment and other runoff-borne contaminants.

Most mussel species prefer clean running water with sand/gravel/cobble substrate and not soft bottom sediment. A few species do well in lake conditions similar to Decatur Lake, such as the Floater. Floater host species are in the Cyprinidae family (including common carp, golden shiners, bluntnose minnows and spotfin shiners). The Pocketbook and Fat Mucket can tolerate lake habitat if the substrate is not muck. Other species can be found if the substrate is fairly stable and there is some flow.

Green County – Sugar River

Common Name - Scientific name (Last observed date)

Buckhorn - *Tritogonia verrucosa* (2012)

Creeper - *Strophitus undulatus* (1976)

Elktoe - *Alasmidonta marginata* (1976)

Fatmucket - *Lampsilis siliquoidea* (1989)

Fragile Papershell - *Leptodea fragilis* (2012)

Giant Floater - *Pyganodon grandis* (1973)

Mucket - *Actinonaias ligamentina* (2012)

Pimpleback - *Quadrula pustulosa* (2012)

Plain Pocketbook - *Lampsilis cardium* (2012)

Threeridge - *Amblema plicata* (1976)

Wabash Pigtoe - *Fusconaia flava* (1976)