4. POTENTIAL MEASURES

4.1 General

During preliminary screening of the proposed features, the chemical treatment and island creation features were dropped from further consideration. Specific measures were proposed for the remaining features—river diversion, wetland enhancement, periodic drawdown, fish passage structures, rough fish control, and sediment removal. The discussion of these measures follows, as outlined in Sections 4.2 through 4.7.

4.2 River Diversion (R)

The letter "R" designates this feature.

Feature R: River Diversion		
R0	**No Action Measure**	
	Eastern Diversion Measure	
	R1	Historic Channel/Berm Elevation 862
	R2	Historic Channel/Berm Elevation 863
	R3	Current Channel/Berm Elevation 862
	R4	Current Channel/Berm Elevation 863
	Western Diversion Measure	
	R5	Lake/River Separation
	R6	River Diversion by Rock Structures
	R7	River Diversion by Channel Excavation

4.2.1 No Action (R0). This measure would result in no additional management efforts beyond the existing practices. No habitat gain or loss would be realized other than what might occur naturally.

4.2.2 Eastern Diversion. This measure would involve diverting the Sugar River to the east around Lake Belle View and bypassing the dam. This redirection would place the majority of the flow in a newly excavated channel along the north and east shorelines of the lake. Diversion berms to separate the river from the lake would be constructed using clays removed from an adjacent borrow site. Varying alignments were evaluated. The chosen alignment of the diversion berms in each measure would roughly follow the southern shore of the existing islands. This would save as much of the forested islands in the lake area, while preserving the viewshed.

The diversion would include modifying the millrace gate, removing and reconstructing the Bross Circle Bridge, and protecting the shoreline. A gated inlet structure would be constructed to allow water from the river into the lake. Four possible measures were evaluated. These measures vary in the location of the entrance of the river into the lake and the height of the diversion berms.

Historic Channel/Berm Elevation 862.0 Feet (R1). This measure would consist of the creation of a new channel through a former meander along the northwest side of the lake (Figure 4.1). The diversion berms would be constructed to an elevation of 862.0 feet. With this measure, the

entrance for the river into the lake would be farther upstream in an area that is currently a slough. This would ensure that the lake water levels would be maintained. This measure was dropped from further consideration due the amount of trees that would need to be cleared and the amount of required excavation.

Historic Channel/Berm Elevation 863.0 Feet (R2). This measure would consist of creating a new channel through a former meander along the northwest side of the lake (Figure 4.1). The diversion berms would be constructed to an elevation of 863.0 feet. With this measure, the entrance for the river into the lake would be farther upstream in an area that is currently a slough, thereby ensuring that the lake water levels would be maintained. This measure was dropped from further consideration due the amount of trees that would need to be cleared and the amount of required excavation. This measure also was dropped from further consideration because the height of the berm would impact the 100-year flood profile.

Figure 4.1. River Diversion Measures R1 and R2.

Current Channel/Berm Elevation 862.0 Feet (R3). This measure would consist of using the current channel location as the entrance of the river into the lake. The diversion berms would be constructed to an elevation of 862.0 feet (Figure 4.2). Additional channel excavation would be accomplished via dredging. A spillway would be constructed at elevation 861 (50-year flood protection) at the northwest end of the berm to minimize damage during an overtopping event. An inflow structure would also be added to allow for lake level management.

Current Channel/Berm Elevation 863.0 Feet (R4). This measure would consist of using the current channel location as the entrance of the river into the lake. The diversion berms would be constructed to an elevation of 863.0 feet (Figure 4.2). Additional channel excavation would be

accomplished via dredging. This measure was dropped from further consideration because the height of the berm would impact the 100-year flood profile.

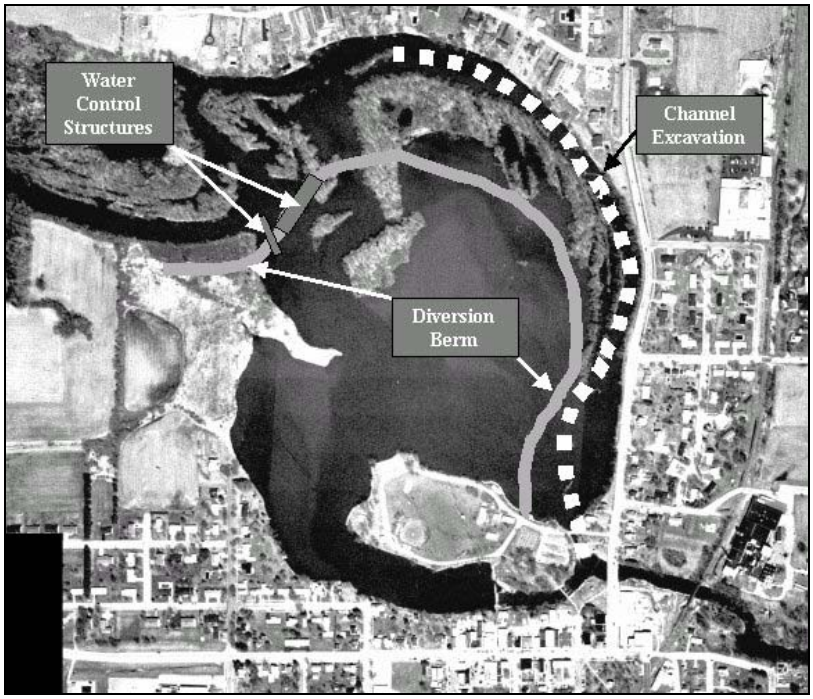

Figure 4.2. River Diversion Measures R3 and R4.

4.2.3 Western Diversion. This measure would involve diverting the Sugar River along the western shore and exiting through the dam. Fish passage structures would be implemented at the dam to allow for upstream movement of fish. Three possible measures were evaluated.

Lake/River Separation (R5). The river would be separated from the lake by constructing clay berms with material taken from an adjacent borrow area (Figure 4.3). Three water control structures would be implemented. An overflow structure between the river diversion and the lake would prevent flood damage to the diversion berm by opening additional flood storage. The inflow structure to the lake allows for inclusion or exclusion of river water, so that the lake levels may be regulated. The outflow structure allows water to exit the lake. This measure would not include channel excavation; however, fish passage would be implemented at the dam to facilitate fish movement.

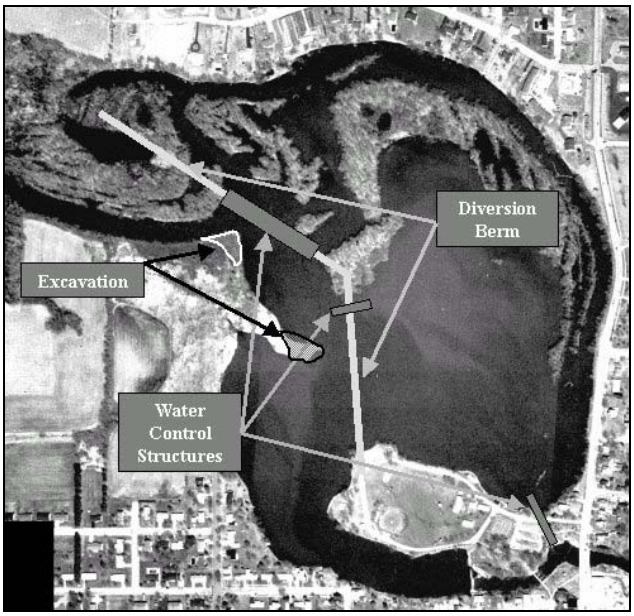

Figure 4.3. River Diversion Measure R5.

River Diversion by Rock Structures (R6). The river would be diverted from entering the lake by placing emergent rock structures (Figure 4.4). Berms would not be constructed. A river channel would not be excavated.

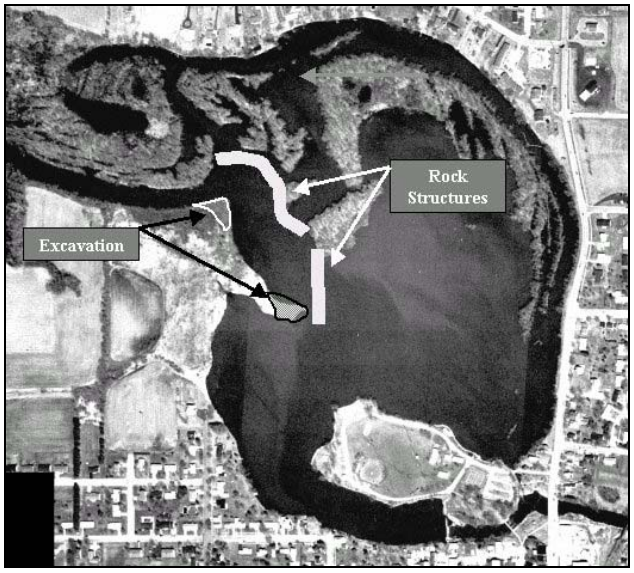

Figure 4.4. River Diversion Measure R6.

River Diversion by Channel Excavation (R7). The river would be diverted from entering the lake by excavating a new channel along the western diversion route (Figure 4.5). The dam would need to be removed to accomplish this measure.

Figure 4.5. River Diversion Measure R7.

4.3 Wetland Enhancement (W)

This feature, designated by the letter "W," consists of the following measures:

Feature W: Wetland Enhancement	
W0	No Action Measure
W1	Western Wetlands Creation Measure
W2	Northern Wetland Restoration Measure
W3	Western and Northern Wetland Complex Measure

4.3.1 No Action (W0). This measure would result in no additional management efforts beyond the existing practices. No habitat gain or loss would be realized other than what might occur naturally.

4.3.2 Western Wetlands Creation (W1). This measure would consist of placing fine-grained dredged material on a 10:1 slope in the western bay that would create a gradual transition from deep water to shallow marsh and emergent wetlands (Figure 4.6). Bathymetric and topographic diversity within and adjacent to the lake bed would be achieved through strategic placement of dredged material. In addition to using the natural seed base, planting of desirable wetland plant species is recommended. Since the placement of the dredged material would be incurred regardless of the location of the placement site, there is no additional cost for this measure. Although this feature is considered separate from dredging, it would not be undertaken without dredging. If dredging is not selected, none of the wetland features would be selected either. Therefore, due to the amount of dredged material that would need to be placed with all proposed dredging features, this measure is not sufficient to accommodate beneficial use of the material. This measure was dropped from individual consideration and was combined with measure W2 to form measure W3.

4.3.3 Northern Wetland (W2). This measure would consist of placing fine-grained dredged material on a 10:1 slope in the existing wetlands in the bays adjacent to existing islands creating a gradual transition from deep water to shallow marsh and emergent wetlands (Figure 4.6). In addition to using the natural seed base, planting of desirable wetland plant species is recommended. Since the placement of the dredged material would be incurred regardless of the location of the placement site, there is no additional cost for this measure. Although this feature is considered separate from dredging, it would not be undertaken without dredging. If dredging is not selected, none of the wetland features would be selected either. Therefore, due to the amount of dredged material that would need to be placed, this measure is not sufficient to accommodate beneficial use of the material. This measure was dropped from individual consideration and was combined with measure W1 to form measure W3.

4.3.4 Creation of Western Wetlands and Restoration of Northern Wetland Complex (W3). This measure would consist of the enhancement of the western wetlands and the enhancement of the northern wetland complex as described above (Figure 4.6). Since the cost of placing the dredged material would be incurred regardless of the location of the placement site, there is no additional cost for this measure.

Figure 4.6. Wetland Enhancement Measures W1, W2, and W3.

4.4 Periodic Drawdown (D)

This feature, designated by the letter "D," consists of the following measures:

Feature D: Periodic Drawdown	
D0	No Action Measure
D1	Periodic Partial Drawdown Measure
D2	Maintenance Drawdown Measure

4.4.1 No Action (D0). This measure would result in no additional management efforts beyond the existing practices. No habitat gain or loss would be realized other than what might occur naturally.

4.4.2 Periodic Partial Lake Drawdown (D1). This measure would involve the periodic drawdown of the lake, thereby compacting sediments, increasing aquatic vegetation in the littoral zone, and increasing habitat diversity. A drawdown of 6 inches would promote vegetation to grow within shallow areas of the lake. This could be accomplished with the current dam. A seasonal drawdown would increase the chances of sustainability and reliable habitat.

4.4.3 Maintenance Drawdown (D2). This measure would allow lake managers to fully drain the lake. This would be done only if future problems occurred with algal-blooms, heavy aquatic vegetation, or carp infestation. This could be accomplished with the current dam with the Eastern Diversion alternatives, or by a modified millrace gate with the Western Diversion alternatives. Complete lake separation from the Sugar River is preferable, but not necessary. Operation costs of this measure would be insignificant. Maintenance costs depend on the durability of the design gate, which would be determined after the feasibility phase of this project.

4.5 Fish Passage Structures (F). This feature, designated by the letter "F," consists of the following measures:

Feature F: Fish Passage		
F0	No Action Measure	
	Riffle Structures Measures	
	F1	North Shore Riffle Structures measure
	F2	Southern Riffle Structures measure
	F3	Western Diversion Riffle Structures measure
	F4	Riffle Structure across Dam measure
F5	Rock Ramp Structure Measure	
F6	Bypass Channel Measure	
F7	Dam Removal Measure	

Figure 4.7. Fish passage measures.

4.5.1 No Action (F0). This measure would result in no additional management efforts beyond the existing practices. No habitat gain or loss would be realized other than what might occur naturally.

Riffle Structures. This measure would involve constructing shallow rapids called riffle structures (Photos 1 and 2, Figure 4.7). The purpose of these structures is twofold:[6]

- To create pools which are characterized by slow flowing, deep water adjacent to areas of fast shallow waters, creating hydrologic diversity that provides feeding, breeding, and cover requirements for a variety of species.

- To act as grade control by bringing the streambed into equilibrium such that the stream is neither eroding nor depositing material. Ancillary benefits can be seen in the naturally sorting properties of the structure. At high flows, boulders in the riffles sort stream gravels so that finer gravels are found in the pools and the coarser materials are found in the riffles. This allows a diversity of fish and aquatic insects to use the bottom of the stream for breeding, resting, and feeding. The natural sorting of material also can promote a diversity of bank vegetation.

[6] Ann L. Riley, Restoring Streams in Cities, 1998.

Photo 1. Example of constructed riffle (from above).

Photo 2. Example of constructed riffle (looking upstream).

4.5.2 North Shore Riffle Structures (F1). This measure would include placing pool and riffle structures constructed of riprap in the newly constructed river channel along the north shore of the lake. These structures also would provide grade control and are only useful in the Eastern Diversion alternatives of the project. The proposed design would mimic naturally occurring riffles and would be nonobtrusive. The crest elevation of the upstream-most riffle structure would be the same elevation as the crest of the dam, to allow flow to pass into the lake and through the river.

4.5.3 Southern Riffle Structures (F2). This measure would include placing pool and riffle structures constructed of riprap in the newly constructed river channel along the east shore of the lake. These structures also would provide grade control and are only combinable with the Eastern Diversion alternatives of the project. The proposed design would mimic naturally occurring riffles and would be nonobtrusive. The crest elevation of the upstream-most riffle structure would be the same elevation as the crest of the dam to allow flow to pass into the lake and through the river. This measure differs from F1 in the placement of riffle structures. It requires less channel dredging and less bank protection.

4.5.4 Riffle Structure Western Diversion (F3). This measure would consist of constructing a rock riffle structure over the full width of the modified dam. The current dam would have its crest lowered by 8 feet. Two upstream riffle structures would be placed within a constructed channel for grade control of the Sugar River. This measure would require that extensively more riprap to be used in order to preserve the current water surface elevation of the lake and to protect adjacent property owners on the southwestern portion of the lake. This measure was dropped from further consideration due to excessive costs and potential structural impact to the dam.

4.5.5 Riffle Structure across Dam (F4). This measure would consist of constructing a rock riffle structure over the full width of the modified dam. The current dam would have its crest lowered by 4 feet. Upstream and downstream riffle structures also would be placed to allow fish passage as well as to provide grade control of the Sugar River. This measure is only combinable with the Western Diversion alternatives of the project. This measure would require extensively more riprap than other measures and was dropped from further consideration due to high cost.

Photos 3 and 4. Examples of riffle structure over dam (3 before and 4 after).

4.5.6 Rock Ramp Structure (F5). This measure would consist of constructing a rock ramp structure along the north side of the existing dam. The ramp would be cut through the existing emergency spillway and would extend 380 feet downstream at a 2.9% slope to rejoin the Sugar River just downstream of an existing footbridge (Figure 4.7). This channel would contain 11 riffle steps spaced 32 feet apart. During normal flow conditions, the majority of the river discharge would be directed down this fish passage structure. More details can be found in Appendix H.

4.5.7 Bypass Channel (F6). This measure would consist of constructing a bypass channel around the existing dam, which connects to the main lake above the dam (Photo 5, Figure 4.7). The bypass channel would be cut through an existing road to the north of the emergency spillway and would extend 450 feet downstream at a 2.5% slope to rejoin the Sugar River just downstream of an existing footbridge (Photo 6). This channel would contain 11 riffle steps spaced 38 feet apart. During normal flow conditions, the majority of the river discharge would be directed downstream of this fish passage structure. More details can be found in Appendix H.

Photo 5. F6 Fish Passage Upstream (conceptual view).

Photo 6. F6 Fish Passage Downstream (conceptual view).

4.5.8 Dam Removal and Riffle Structures (F7). This measure would consist of removing the dam and placing pool and riffle structures constructed of riprap in the newly constructed river channel

following the Western Diversion (Figure 4.7). These structures would provide grade control as well. The proposed design mimics naturally occurring riffles and would be nonobtrusive.

4.6 Rough Fish Control (C)

The letter "C" designates this feature.

Feature C: Rough Fish Control	
C0	No Action measure
C1	Carp Gate measure
C2	Carp Nets measure
C3	Periodic Drawdown measure

4.6.1 No Action (C0). This measure would result in no additional management efforts beyond the existing practices. No habitat gain or loss would be realized other than what might occur naturally.

4.6.2 Carp Gate (C1). This measure would involve installing a carp gate adjacent to water intake structures similar to the gates used at Lake Buttes de Mortes, in Wisconsin (Photo 7). The carp gate would allow small boat passage between the Sugar River and Lake Belle View without portaging, while at the same time minimizing or eliminating the ability of adult carp from entering the lake. Elimination of rough fish from the lake would improve water quality, increase lacustrine habitat of preferred fish species, and improve wetland diversification.

Photo 7. Example of carp gate.

4.6.3 Carp Nets (C2). This measure would involve the use of a carp nets to eliminate rough fish from the lake.

4.6.4 Periodic Drawdown (C3). This measure would involve the partial or complete draining of the lake on a periodic basis to promote effective rough fish removal.

4.7 Sediment Removal (S)

The letter "S" designates this feature. Two methods of sediment removal were proposed. **Hydraulic dredging** is described as the use of a floating dredge in the lake. The dredge would use a hose to "vacuum" up the sediments on the lakebed, along with any water. The lake would not have to be dewatered for this method. The discharge from the hose is a slurry of sediment and water. **Mechanical dredging** involves the use of excavation equipment in the lakebed to remove the sediment. The lake would need to be dewatered to implement this method. For all proposed dredging operations, excess dredged material would be placed in the confined disposal facility (CDF), located on the footprint of the adjacent borrow site. To find the optimum use of these methods, the following measures were proposed:

Feature S: Sediment Removal		
S0	No Action	
	Hydraulic Dredging	
	S1	Hydraulic Dredging – 5 acres
	S2	Hydraulic Dredging – 10 acres
	S3	Hydraulic Dredging – 15 acres
	S4	Hydraulic Dredging – 30 acres
	Mechanical Dredging	
	S5	Dewatering with Selective Excavation
	S6	Pond Creation

4.7.1 No Action (S0). This measure would result in no additional management efforts beyond the existing practices. No habitat gain or loss would be realized other than what might occur naturally.

4.7.2 Hydraulic Dredging. This measure would involve using hydraulic dredging technology to remove sediment from the lakebed. There are four possible measures. These areas of the measures were formulated based on arbitrary increments. The depth of the dredging areas was formulated based on the minimum overwintering depth of 8 feet. Preliminary costs also were calculated for 10-foot-deep dredge cuts but were dropped from further consideration due to the high cost for little added habitat improvement. The dredge cuts would be made in the general area indicated on Figure 4.8. The cuts would be made in a runway pattern to maximize bathymetric diversity. The actual location and configuration of the cuts would be further designed after the feasibility phase of this project.

Figure 4.8. Hydraulic sediment removal measures.

Hydraulic Dredging – 5 acres of lake (S1). This measure would consist of selective hydraulic dredging of 5 acres of lake, 8 feet deep. The fine material would be used to construct the wetland areas. If needed, an additional placement site is an agricultural field adjacent to the lake. The estimated quantity is 44,344 cubic yards.

Hydraulic Dredging – 10 acres of lake (S2). This measure would consist of selective hydraulic dredging of 10 acres of lake, 8 feet deep. The fine material would be used to construct the wetland areas. Additional material would be placed in an agricultural field adjacent to the lake. The estimated quantity is 98,822 cubic yards.

Hydraulic Dredging – 15 acres of lake (S3). This measure would consist of selective hydraulic dredging of 15 acres of the lake, 8 feet deep. The fine material would be used to construct the wetland areas. Additional material would be placed in an agricultural field adjacent to the lake. The estimated quantity is 149,100 cubic yards.

Hydraulic Dredging – 30 acres of lake (S4). This measure would consist of selective hydraulic dredging of 30 acres of the lake. Preliminary evaluation of this submeasure indicated that there is not enough surface area in the designated dredging area to accommodate the dredge cut and needed side slopes once the area is taken up by diversion berms and wetlands. This measure was dropped from further consideration because there would not be 30 acres of lake surface area once the wetlands and berms are constructed.

4.7.3 Mechanical Dredging. This measure would involve using mechanical equipment, such as a backhoe, to remove sediment from the lakebed. There are two possible measures.

Dewatering with Selective Excavation (S5). This measure would consist of dewatering the lake and selective mechanical excavation of up to 4 feet of sediment. A potential benefit from this measure would be the concept of excavating a thalweg (or channel) within the lake bottom. This would decrease the residence time of any overtopping events. Research revealed that the ground

water table in this lake bottom area is close to the surface. When the lake is drained, the lake bottom sediments remain wet. This condition would make it difficult to operate excavation equipment on the lake bottom. It was determined that a dewatering system would be necessary to accomplish this measure. Therefore, this measure was dropped from further consideration due to concerns with constructability and the high cost of a dewatering system.

Pond Creation – 15 acres (S6). This measure would consist of creating a 15-acre pond approximately 3 feet deep through excavation in the lakebed (Figure 4.9). This measure would only be considered with a river restoration component that involves dam removal. By removing the dam and rechanneling the river, the excavated pond would be completely separated from the Sugar River system. This measure was proposed by the WDNR using the La Valle, Wisconsin Dam Removal Project as an example. Site visits to the project revealed that the La Valle project is not similar to the Belleville project site. At the time of the visit, the dam had been removed but the pond had not been excavated.

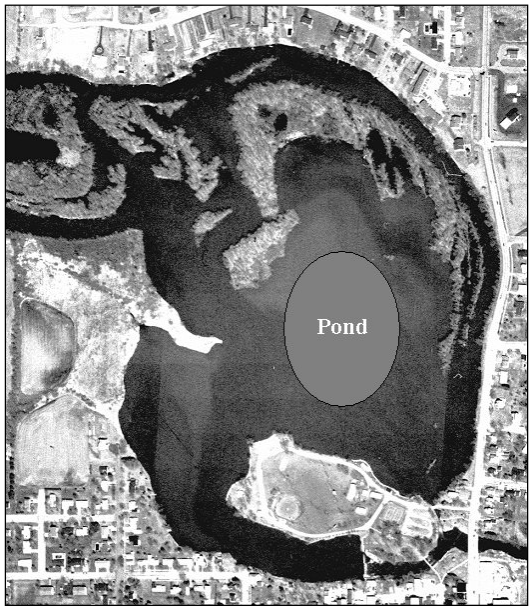

Figure 4.9. Sediment Removal Measure S6.