Lake Belle View Restoration Project

Two Year Evaluation

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Village of Belleville

Agrecol Environmental Consulting LLC

Montgomery Associates Resources Solutions LLC

Large-scale Lake Planning Grant Report

December 2013

Summary

Results of water quality monitoring and biological surveys in 2012 and 2013 demonstrated that common carp had survived the construction drawdown and are thriving in the newly formed Lake Belle View. Poor water clarity, high nutrients and high chlorophyll a concentrations, coupled with a dearth of rooted aquatic plants, were symptoms of an unexpected common carp population in the lake. While the carp had undermined some of the goals for creating a clear off-channel lake, the project was nonetheless successful in diverting a massive watershed sediment and phosphorus load around the lake and providing a much appreciated urban lake for the community. The next focus of the lake restoration project is to control the excessive common carp population that will allow native fishes and aquatic plants to thrive in a floodplain lake; perhaps one of the most threatened water resources in Wisconsin. Our restoration targets include sustaining a diverse off-channel fish community, floating leaf and submersed macrophytes, phosphorus TSI of 54, chlorophyll TSI of 47 and a secchi TSI of 48.

Introduction

Until recently, Lake Belle View was a 90 acre impoundment that was formed in 1920 by the construction of a mill dam. The millpond was severely degraded due to loss of storage capacity, very poor water quality, and very poor habitat due to prolific densities of common carp. It drained a massive 172 square miles (watershed area to lake area ratio of 1100:1) of predominantly intensive agricultural lands along with rapid urban expansion. Although the Sugar River is classified as an Exceptional Resource Water (ERW), it continues to transport enough sediment and phosphorus loads to make inline millpond management unfeasible. It displayed typical problems associated with shallow nutrient rich impoundments, including complete loss of storage capacity. Recreational use was rare and the fishery was dominated by common carp. The Village of Belleville, Wisconsin had proposed various millpond dredging projects over the last 30 years. The proposals were rejected because of high costs, projected poor water quality and short term effectiveness due to projected rapid sedimentation from a massive agricultural watershed.

A watershed diversion project was completed in 2011 and involved the construction of a berm that separates the new off-channel lake from the river. The berm provides access to restored wetland areas and serves as a biking and hiking trail that connects the north part of the Village to its southern business district. To meet federal and local floodplain regulations, the separation berm was designed to prevent river water intrusion under normal flow events (up to the estimated 50 year event). To minimize costs and to expand the floodplain forest wetland, the lakes open water area is reduced in size, with sediment borrowed from lake dredging being used to restore the wetland system.

The lake was designed to mimic natural oxbows that had declined along the river due to floodplain aggradation. The new 40 acre lake has its own water level control system. Twenty-nine fish species were stocked in the lake to provide a diverse fishery that mimics natural oxbow lakes. Aquatic plants stocked in the lake included white water lily, wild celery, Chara and long-leaf pondweed. The new wetland areas, comprised of 27 acres of deepwater wetland habitat, 11.5 acres of emergent wetland, and 11.6 acres of floodplain forest wetlands, provide numerous functional values and educational opportunities. The lake and surrounding floodplain forest provide habitat for the American Bald Eagle and the Prothonotary Warbler. The restoration of the floodplain forest habitat and water quality improvements is expected to provide benefits associated with increased habitat for these species.

The new off-channel lake was expected to display significant water quality and ecological improvements and function as a model for off-channel lake management. This project was conducted to determine if goals of the restoration were achieved and document environmental conditions as a response to the watershed diversion.

Methods

Lake water quality sampling as conducted on a monthly basis from June through September in 2012 and 2013 and through the ice in February of both years. Sampling stations included the deep hole near the park and in the channel. The channel was monitored since it intercepts most of the local watershed runoff.

A YSI Model 52 meter will be used to measure dissolved oxygen and temperature. A YSI Model 63 meter will be used to measure pH and specific conductivity. Calibration of the instruments followed manufacturer recommendations including the 2 point calibration for pH. Growing season secchi transparency measurements were taken in the lake.

Paired testing of the Sugar River and Lake Belle View included use of a 120 cm transparency tube and turbidity measurements using a Hach Model 2100P meter. Nutrient samples were collected and submitted to the State Lab of Hygiene Inorganic Chemistry Unit. The chlorophyll a, phosphorus and secchi data were converted to Trophic State Index (TSI).

Local watershed areas were delineated along with major land uses. Annual phosphorus loading rates were estimated using WILMS and similar models. Nearshore fish population sampling was conducted with a towed single probe DC electroshocker. All specimens were immediately released after field identification and enumeration except where immature specimens required further review. The fish surveys were designed to sample populations of nongame species and juvenile stages of sportfish. The surveys were conducted to assess distribution of fishes that inhabit nearshore areas within floodplain habitats. The surveys were also designed to detect potential common carp reproduction that could threaten the ecosystem.

Since the near shore surveys do not evaluate growth rates, size distribution or population densities of sport fish populations, the WDNR conducted a boom shocking survey to evaluate the sport fish population.

Qualitative biological surveys included birds, furbearer, and herptile sight and sound observations. Watershed boundaries and land uses were delineated along with predicted phosphorus loading to the lake. Storm sewers were identified and storm events monitored.

Findings

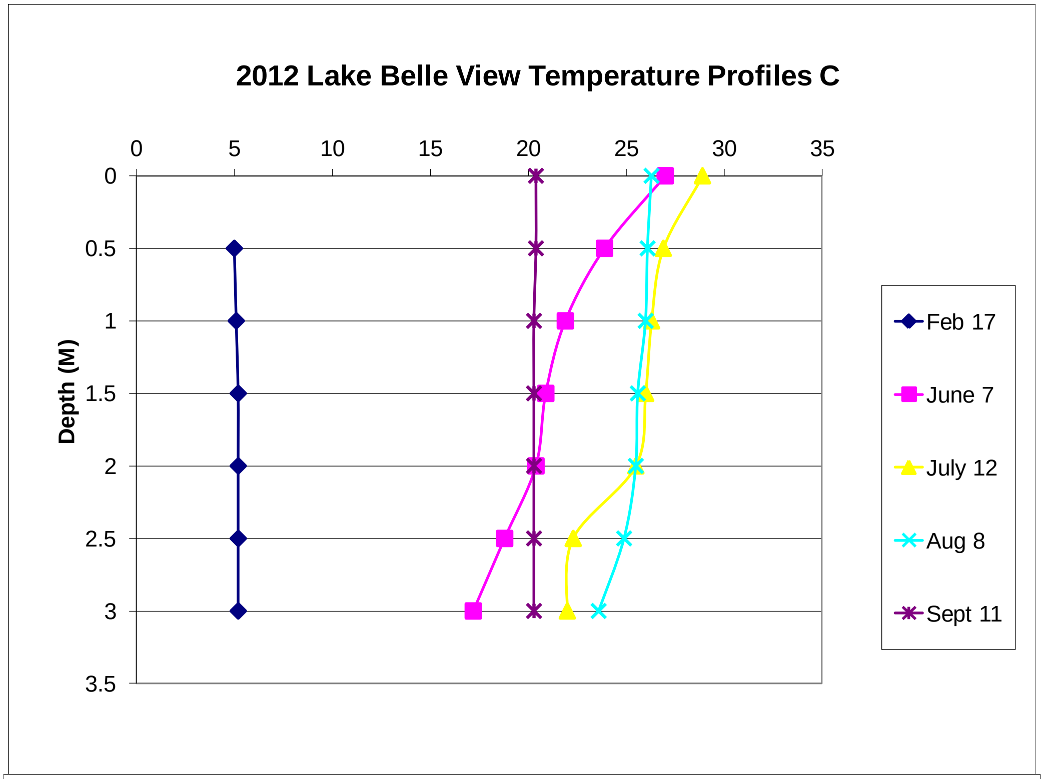
Although the watershed diversion project successfully established an off-channel lake with a berm that bypasses the 172 square mile watershed, the water quality and project goals were tempered by an unexpected population of common carp (*Cyprinus carpio*) in Lake Belle View that likely over-wintered in a shallow pond during the early 2011 construction drawdown. The majority of carp in the lake are now 14 inches long or smaller, indicating that the drawdown refuge likely held mostly young of year carp.

Limnology

The vertical profile data for temperature, dissolved oxygen, pH and specific conductance appear in Figures 1 - 4. One issue of concern during the planning phase of the project was the potential for winterkill conditions. The dissolved oxygen profiles in Figure 2 demonstrated adequate dissolved oxygen levels in the lake but anoxia did occur seasonally near the bottom. In Figure 1, modest thermal stratification was limited to June in both years and reflected mixing in the shallow lake. Therefore, the low oxygen levels near the bottom did not reflect stratification but rather light and photosynthesis limitation. Consistent with decreasing dissolved oxygen levels with depth, pH measurements also declined with depth (Figure 3). Specific conductance levels were typically in the range of 500 – 600 uS/cm except in February of 2013 when levels reached 700 uS/cm, suggesting chloride runoff from street salt applications.

Lake Belle View (millpond) prior to restoration and watershed diversion berm

Figure 1: Lake Belle View Temperature Profiles



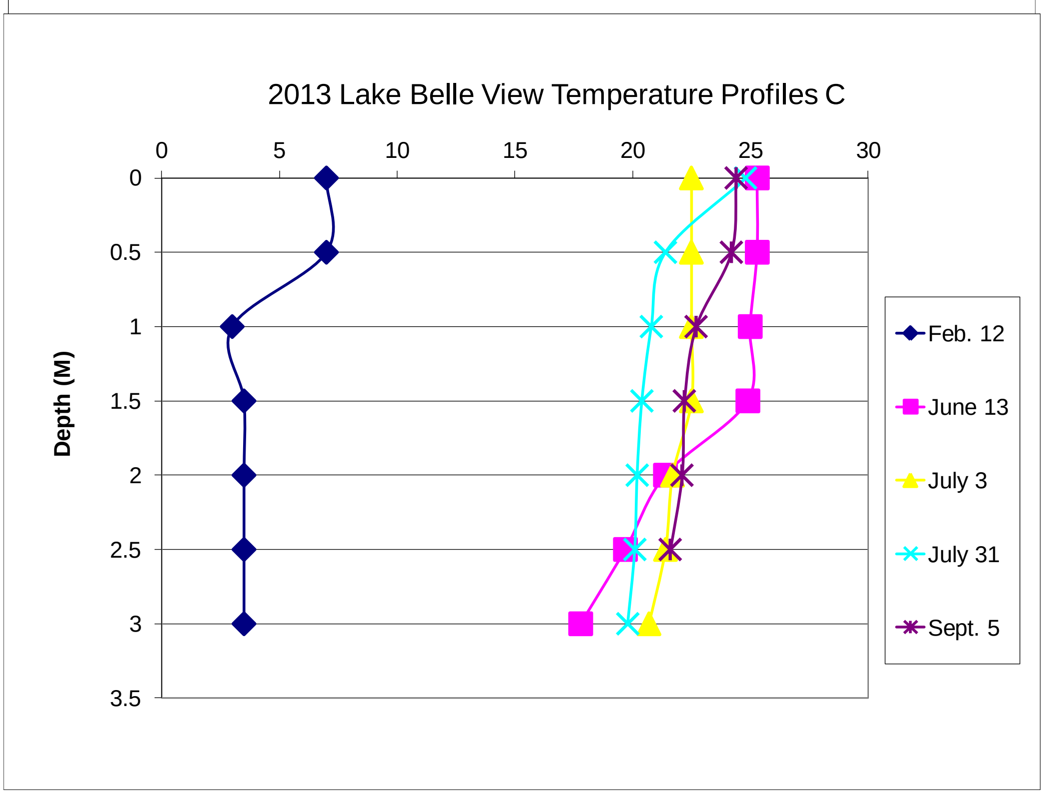
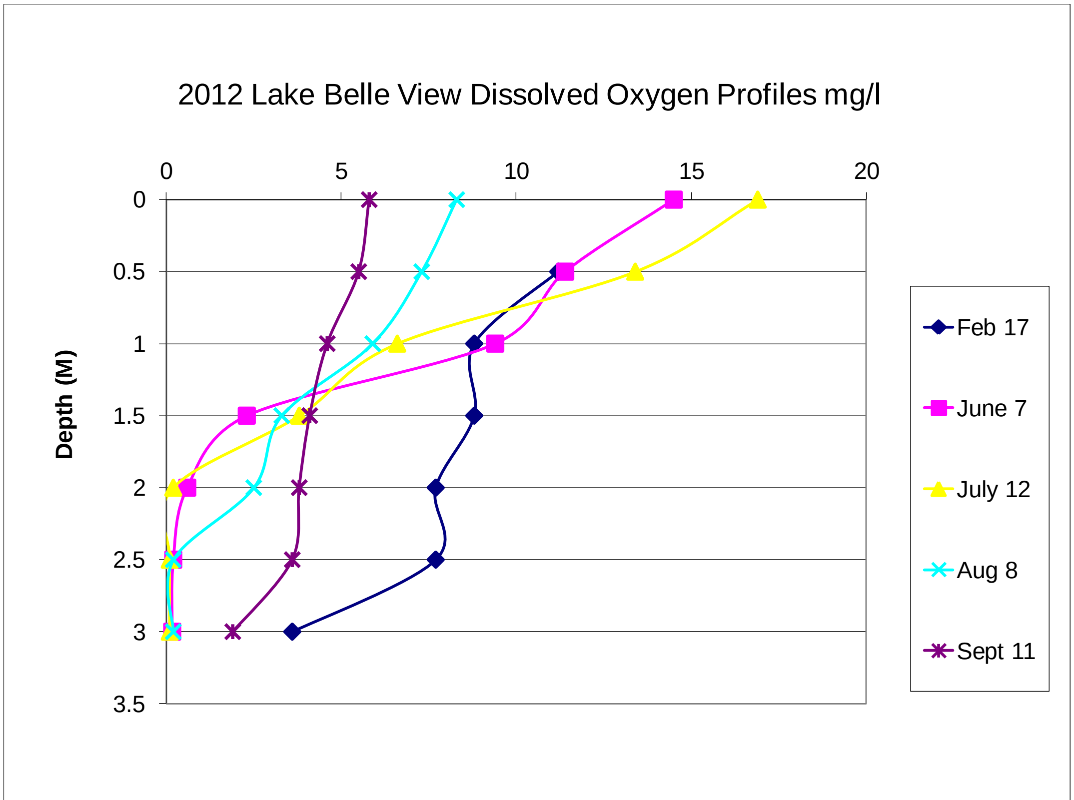


Figure 2: Lake Belle View Dissolved Oxygen Profiles



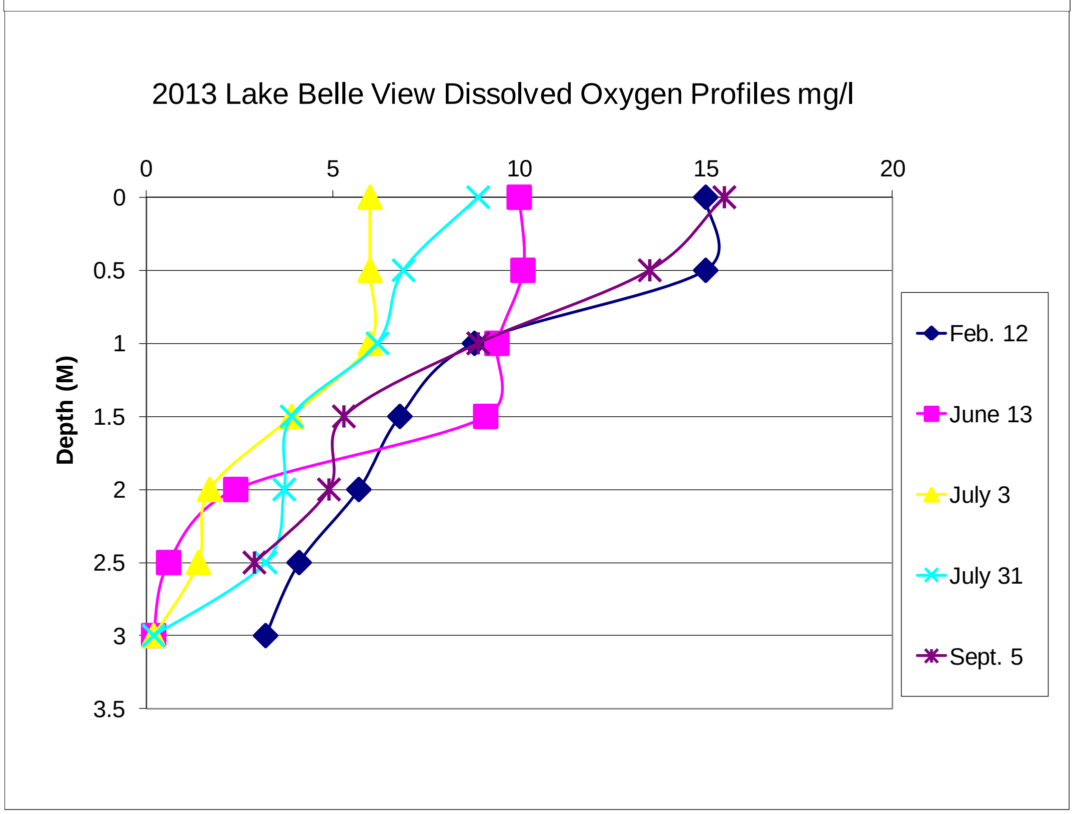
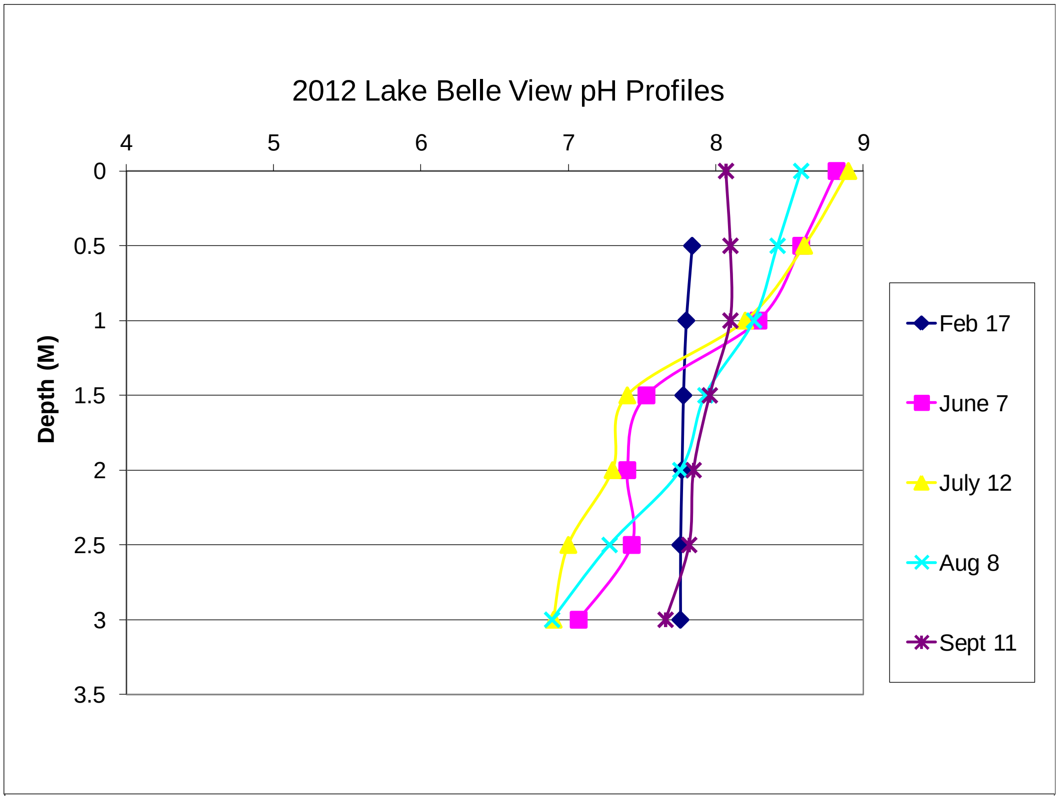


Figure 3: Lake Belle View pH Profiles



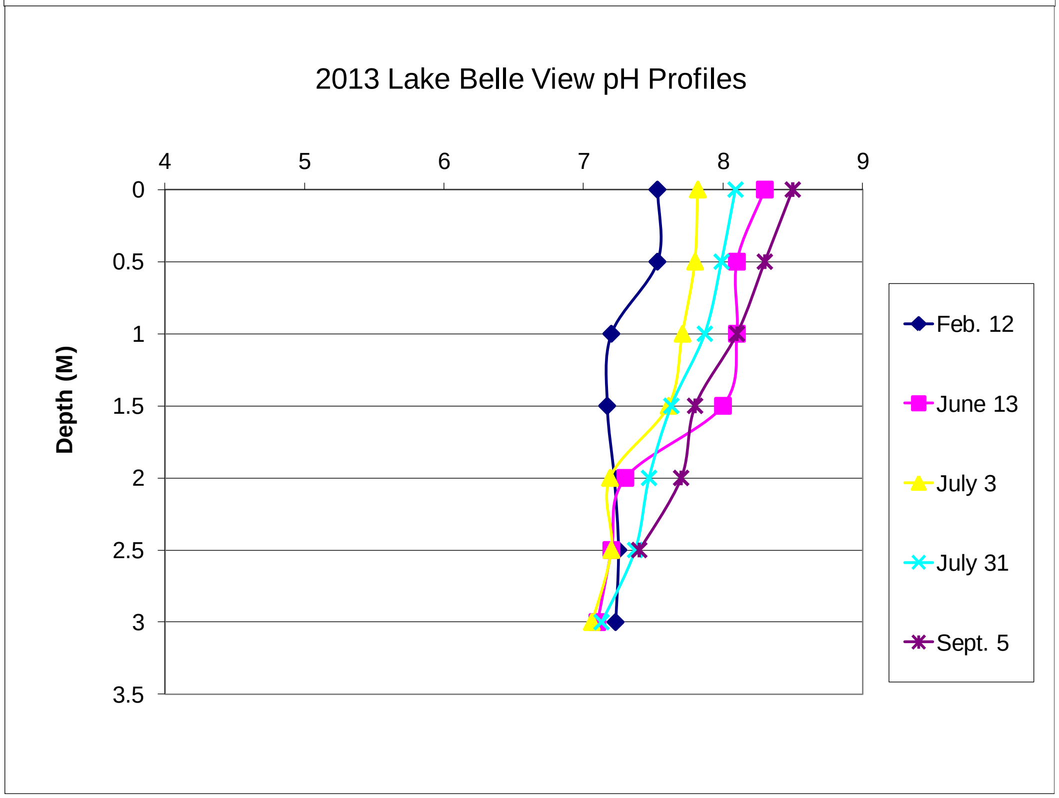
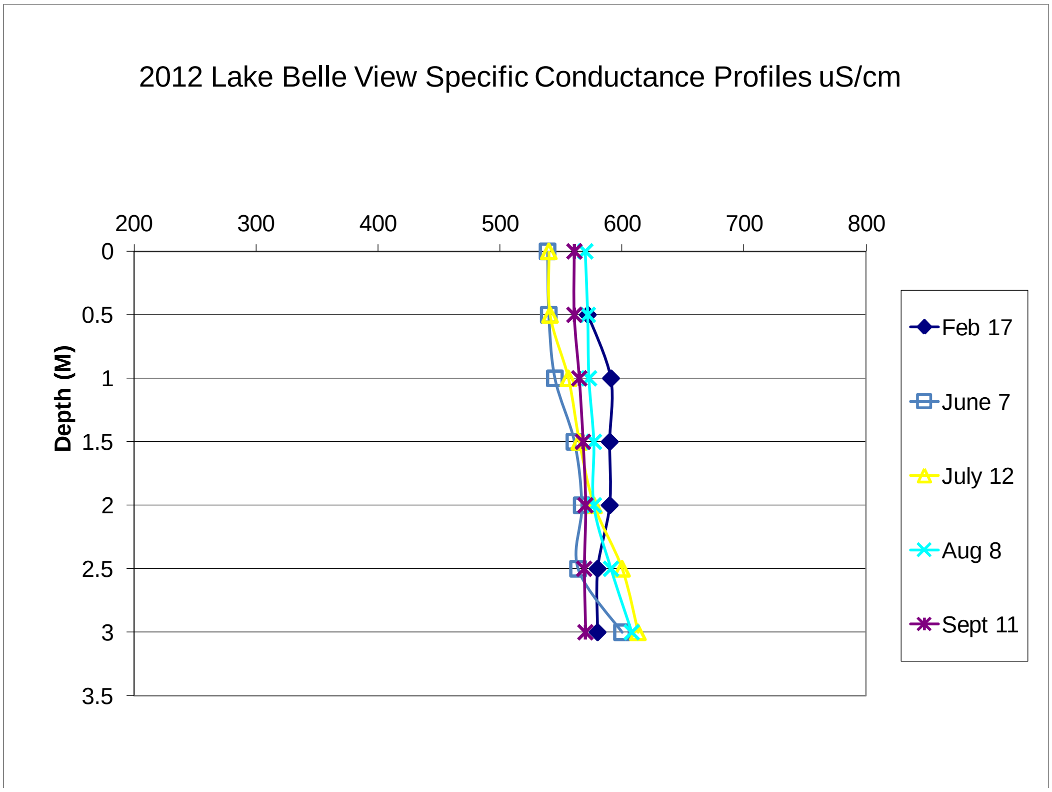
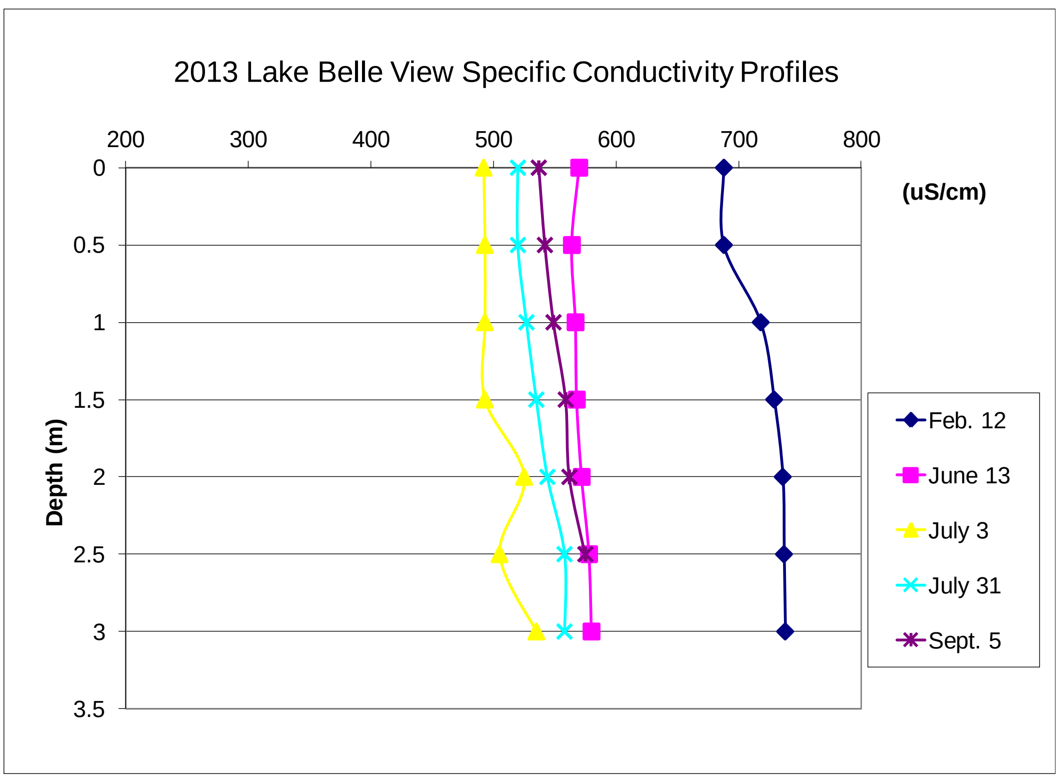


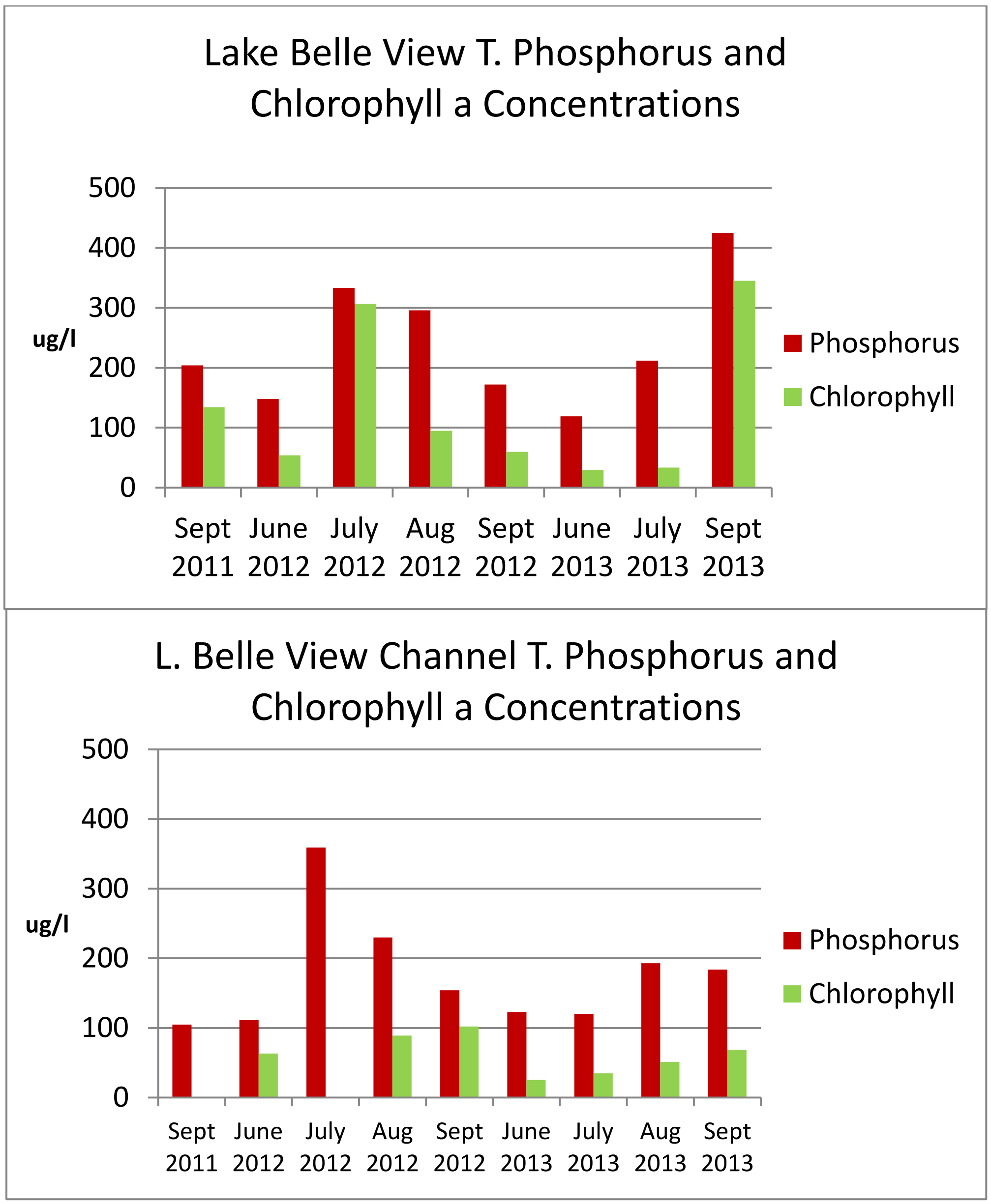
Figure 4: Lake Belle View Specific Conductance Profiles





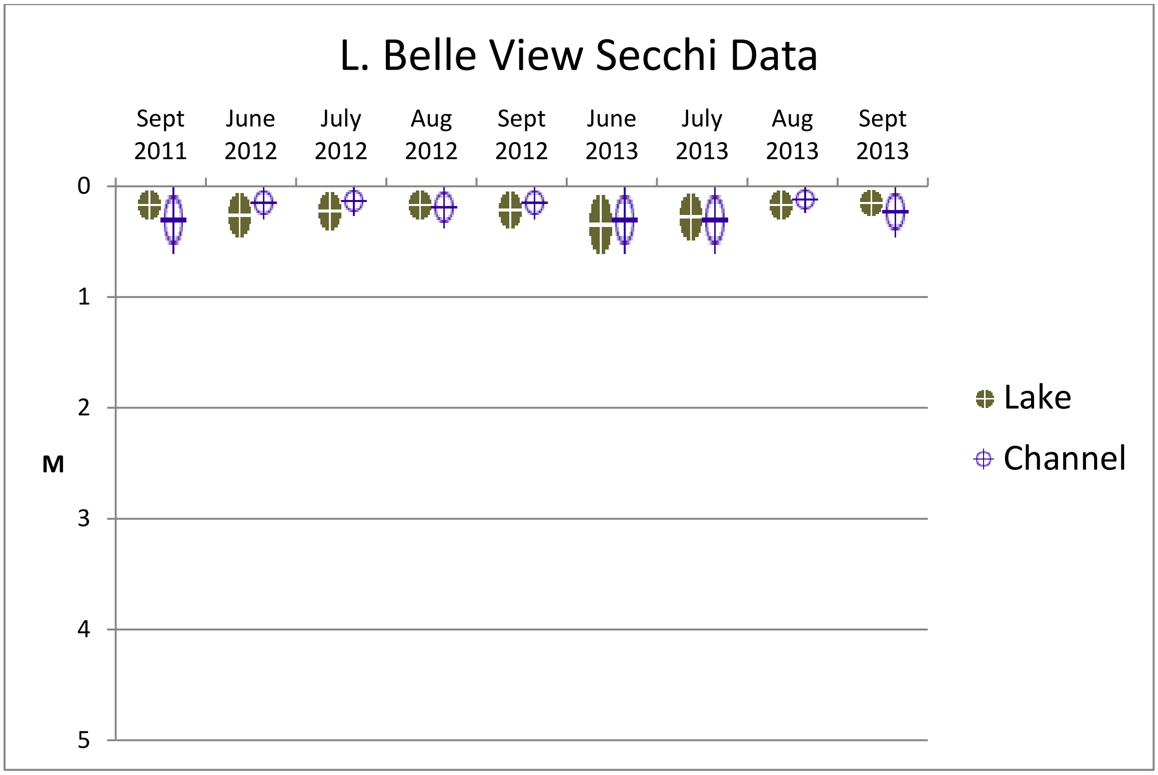
Paired samples at the deep hole and channel indicated that eutrophic conditions prevailed at both locations. Slightly lower nitrogen, phosphorus and chlorophyll concentrations were found in the channel, indicating that surface runoff from the local watershed was not likely a major problem. Detectable nitrates in the channel likely reflected groundwater inputs. High phosphorus concentrations were found throughout 2012 and 2013 and coincided with high chlorophyll a concentrations (Figure 5) and poor water clarity (Figure 6).

Figure 5: Lake Belle View Total Phosphorus and Chlorophyll a Concentrations\



Mean Concentrations: Lake T.P. = 0.24 mg/l and Channel T.P. = 0.18 mg/l, Lake T.N. = 2.56 mg/l and Channel T.N. = 2.20 mg/l, Lake Chlorophyll a = 132 ug/l and Channel Chlorophyll a = 62 ug/l.

Figure 6: Lake Belle View Secchi Data



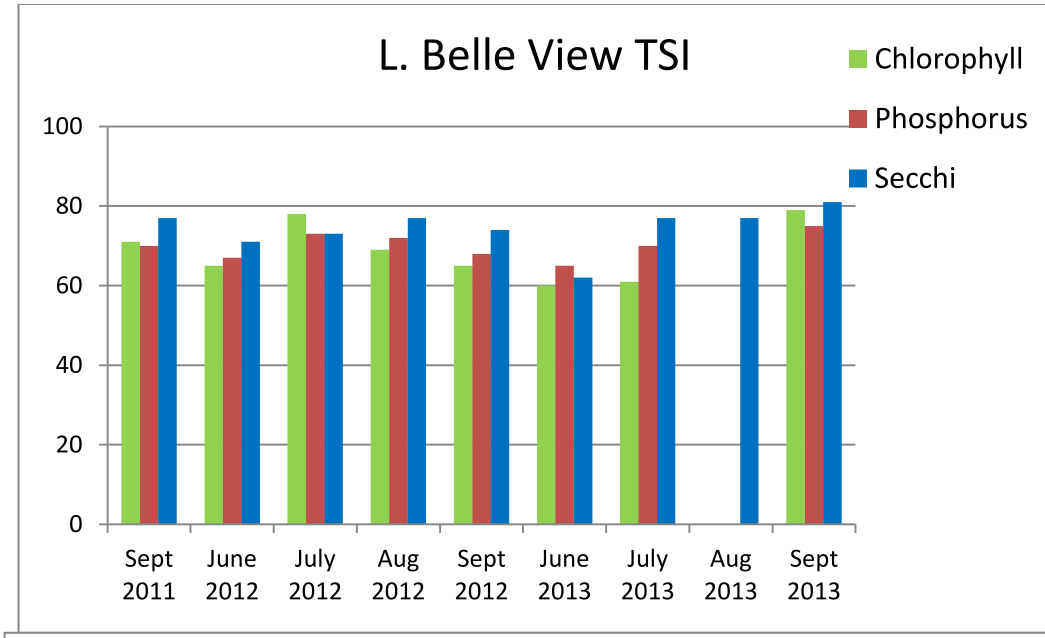
Transformed to Trophic State Index (TSI), both secchi and phosphorus TSI values typically exceeded chlorophyll values and indicated turbidity related to carp disturbances (Figure 7). The very poor water clarity reflected a combination of phytoplankton and sediment related turbidity due to carp. In all cases, the trophic states related to the three measures reflected highly eutrophic conditions. Nitrogen data are presented in Figure 8. Phosphorus concentrations were relatively high compared with nitrogen concentrations and nutrient limitation was often indeterminate or nitrogen limited in the lake and phosphorus limited just twice in the channel (Figure 9).

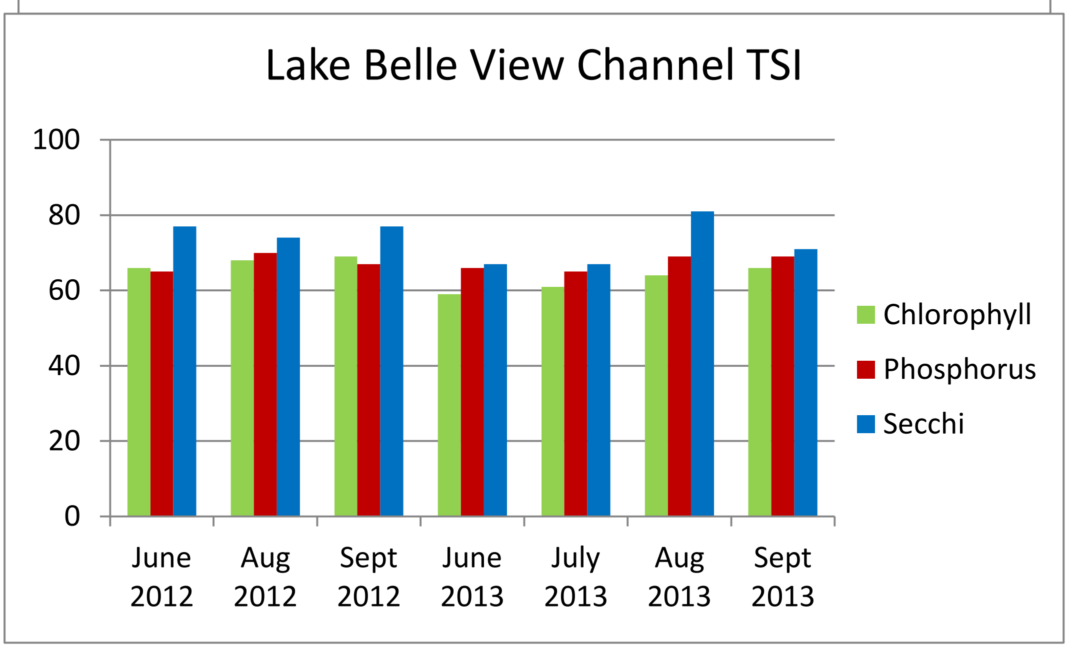
Clear water was another anticipated benefit of the watershed diversion project since the berm diverts approximately 172 square miles of agricultural and urban watershed. To assess effects of the diversion on water clarity, paired turbidity samples and 120 cm transparency tube measurements were recorded from the lake and river. As the data indicates, the common carp population in the lake significantly reduced water clarity as turbidities were significantly higher in the lake and secchi tube measurements significantly lower (Figures 10 and 11). Specific conductance levels in the river were significantly higher in the river and reflected a larger source of road salt and chlorides and other ions linked to point source discharges (Figure 12).

Biological

As part of the restoration, thirty fish species were introduced into newly constructed Lake Belle View including hatchery sportfish and Sugar River predator and nongame species. Nearshore electroshocking surveys were conducted in 2012 and 2013 to assess the status of the native fish.

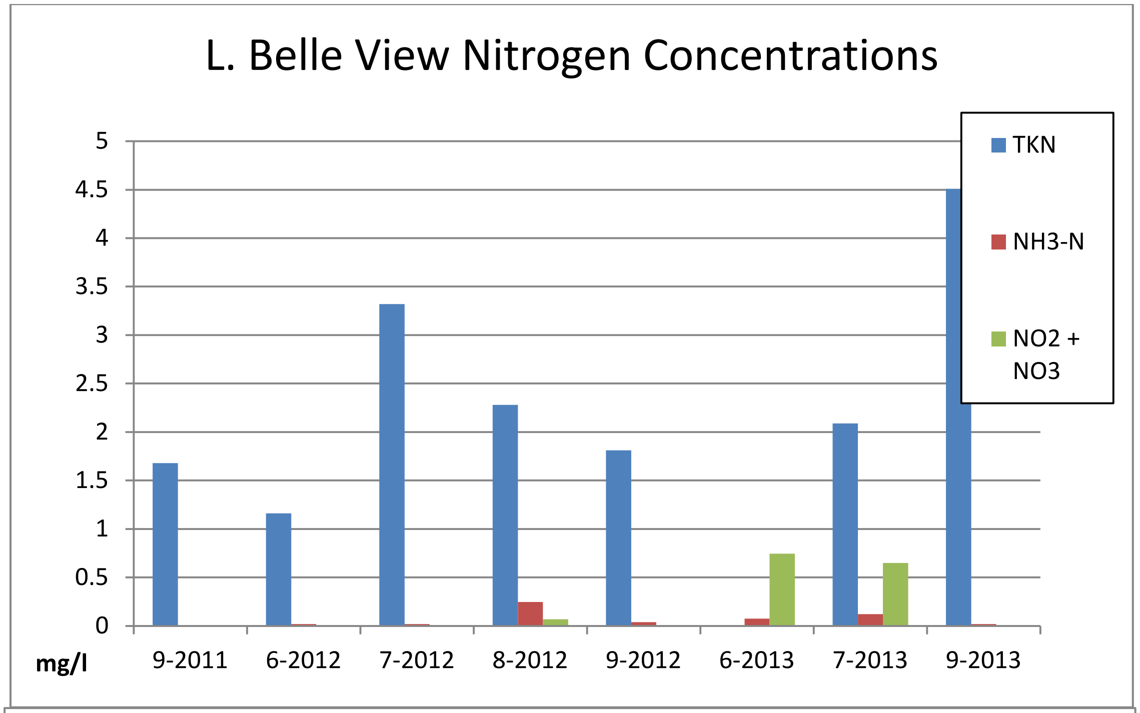
Figures 7: Lake Belle View TSI





(TSI 50 – 70 – eutrophic and > 70 = hypereutrophic)

Figure 8: Lake Belle View Nitrogen Concentrations



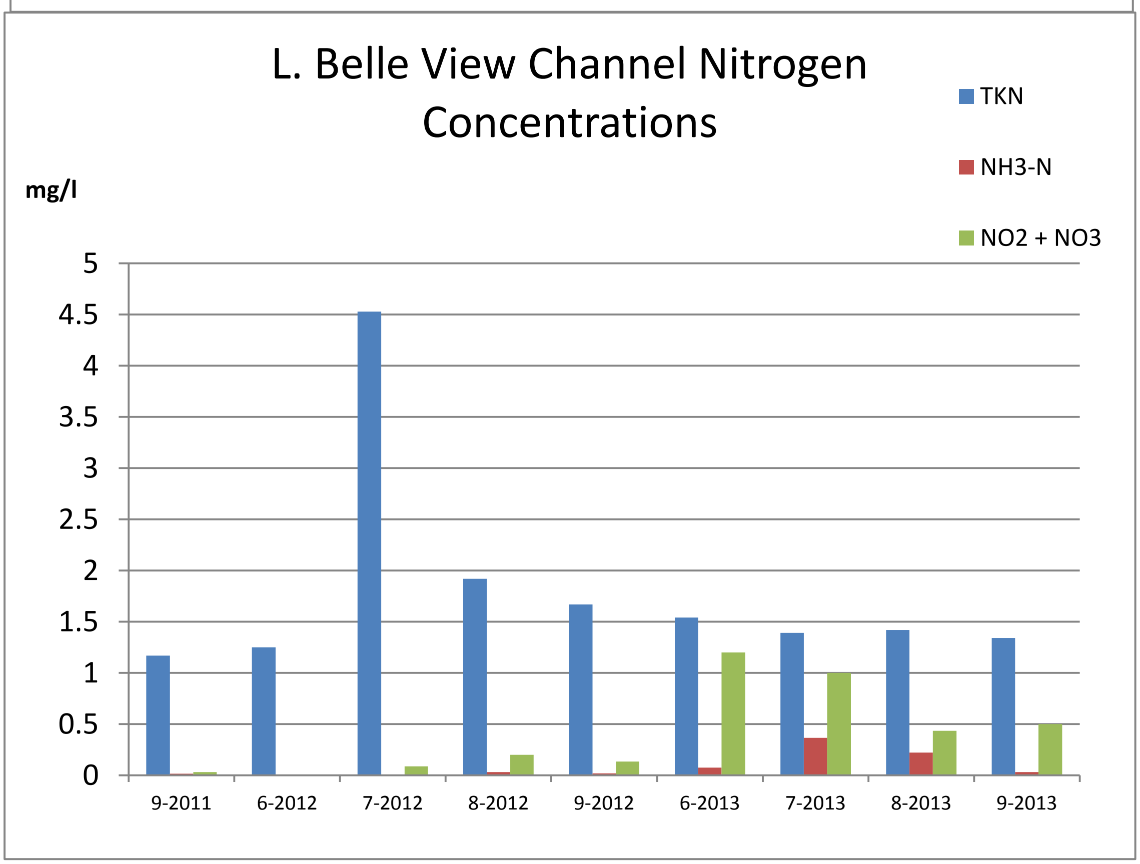
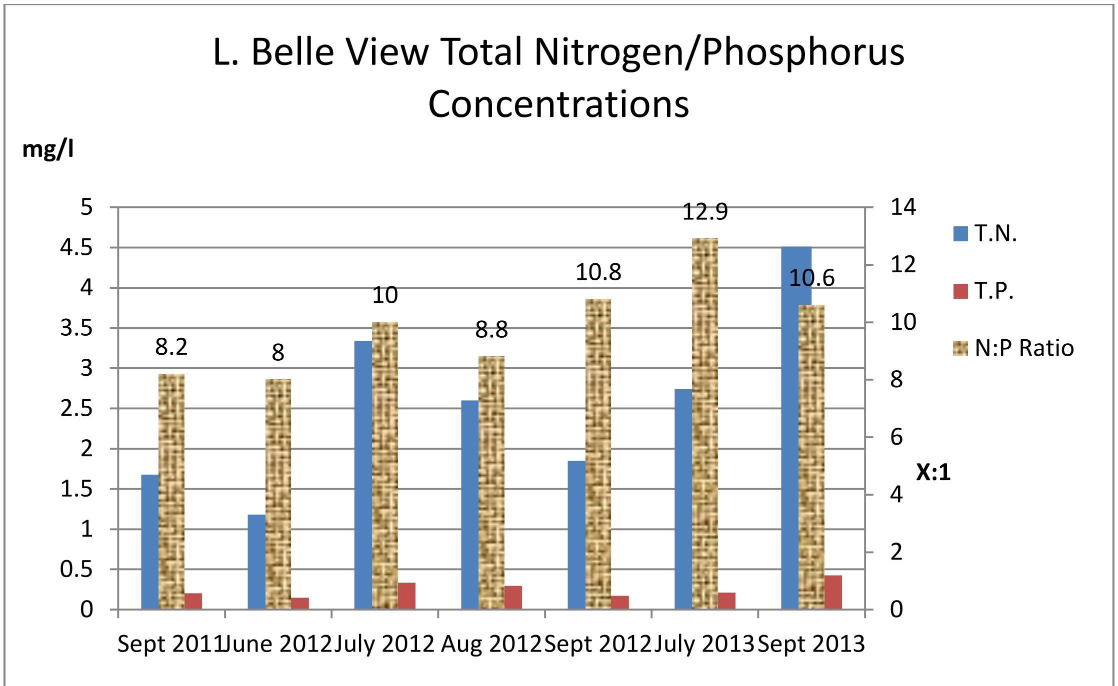
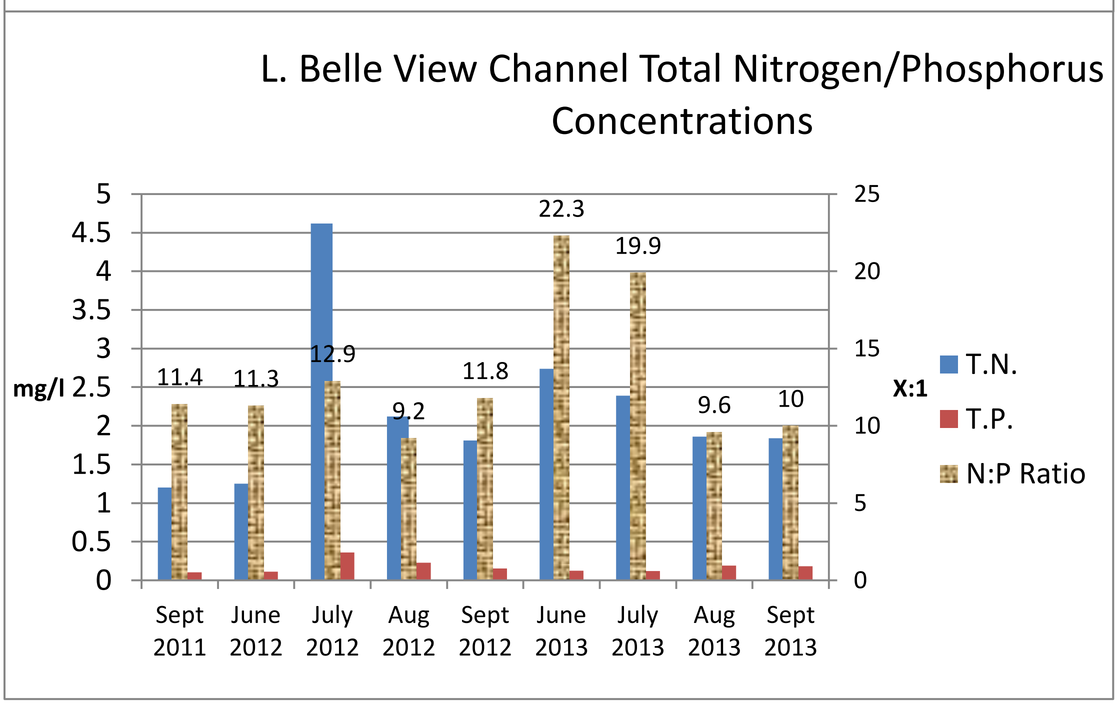


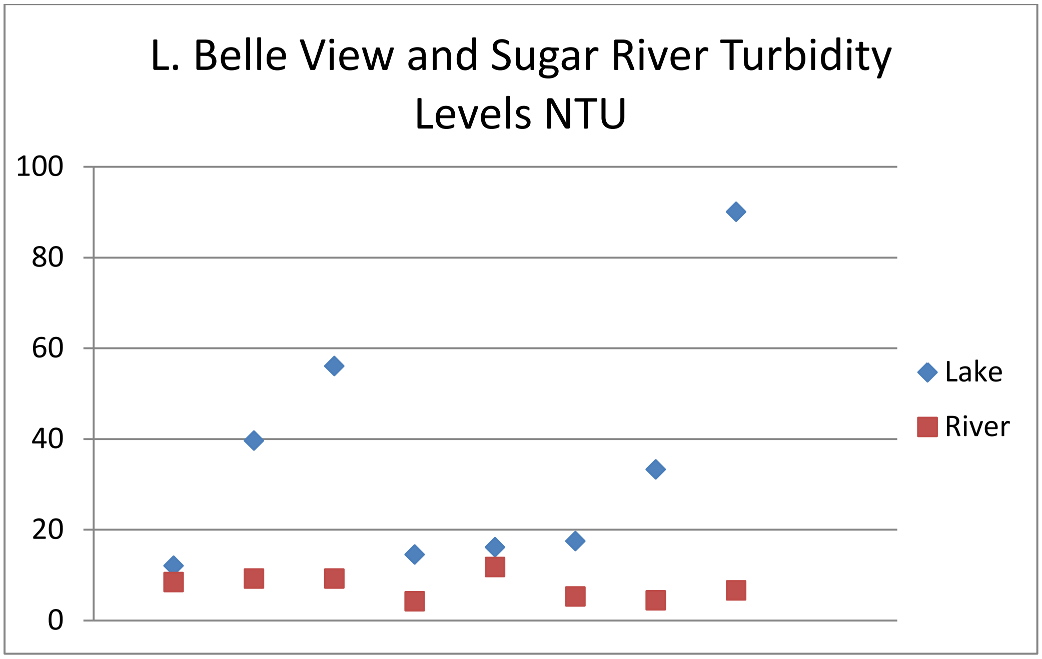
Figure 9: Lake Belle View N:P Ratios





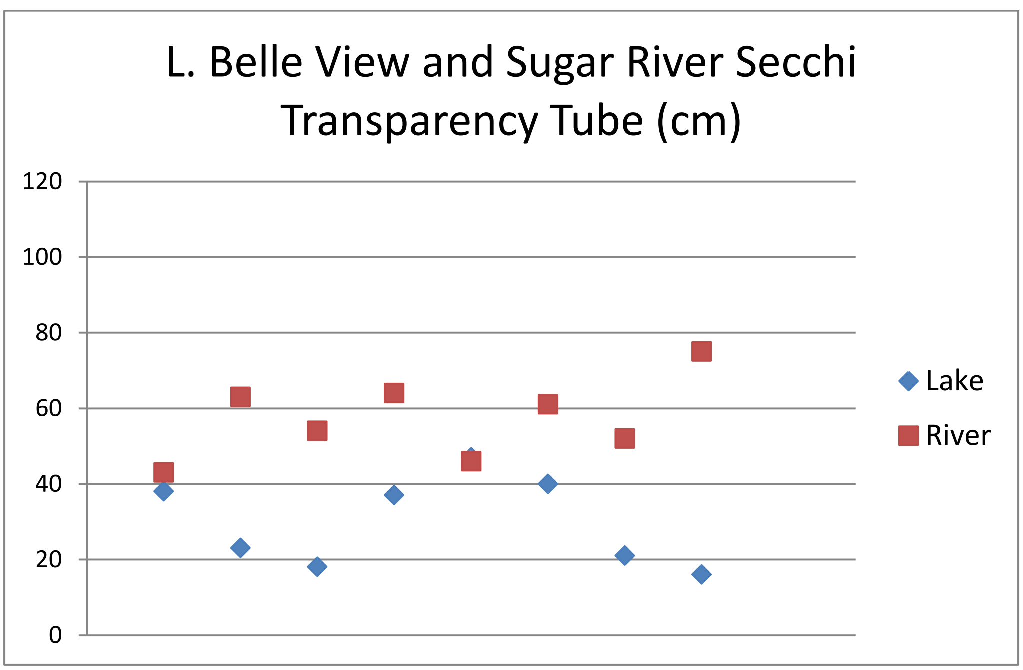
(< 10:1 indicated N limitation, 10:1 – 15:1 indeterminate, >15:1 = P limitation)

Figure 10: Lake Belle View and Sugar River Turbidity Levels (NTU)



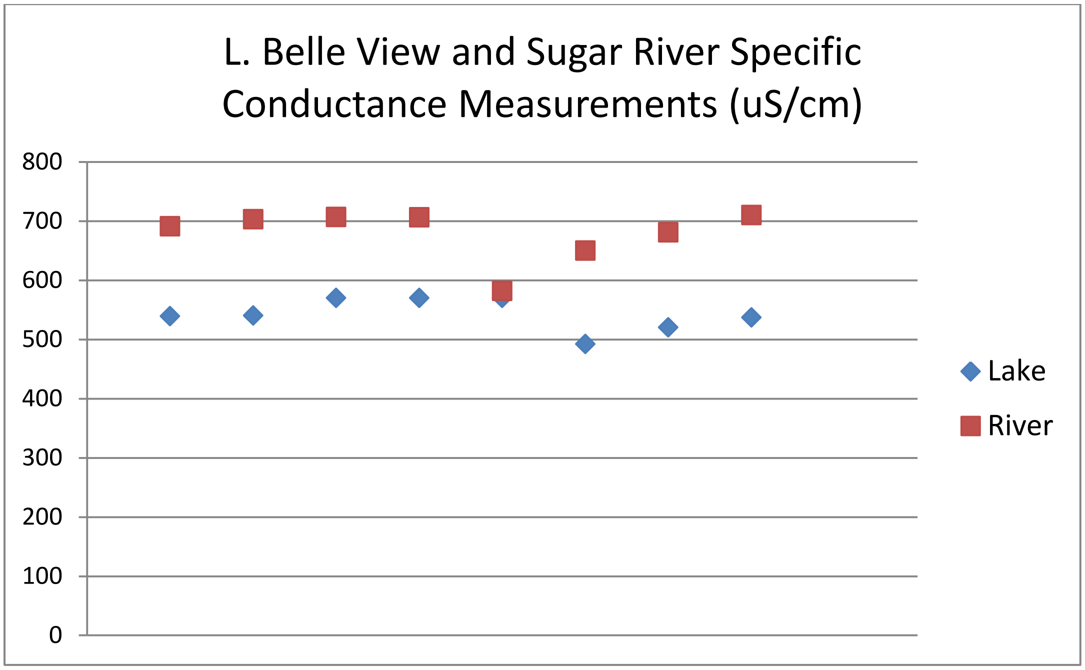
(June, July, Aug., Sept. 2012 and June, July, Aug., Sept. 2013)

Figure 11: Lake Belle View and Sugar River Secchi Tube Transparency Measurements (cm)



(June, July, Aug., Sept. 2012 and June, July, Aug., Sept. 2013)

Figure 12: Lake Belle View and Sugar River Specific Conductance Levels (uS/cm)



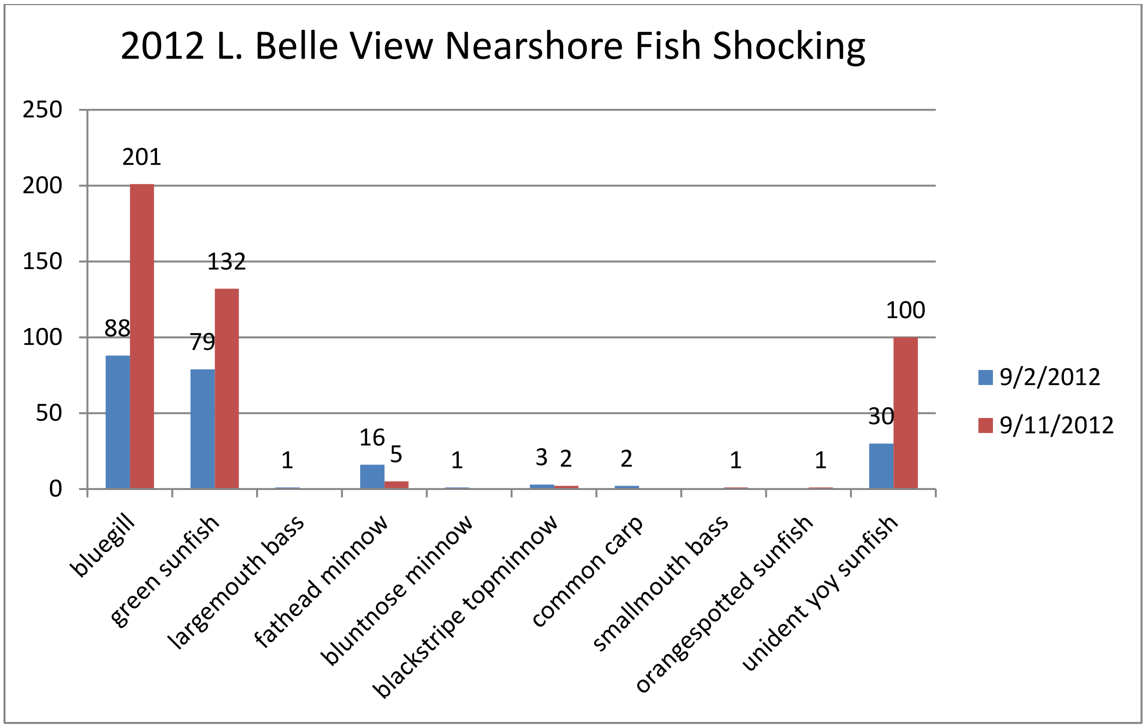
(June, July, Aug., Sept. 2012 and June, July, Aug., Sept. 2013)

Based on two nearshore electroshocking surveys conducted in September 2012, eight native fish species were collected along with the first confirmation that common carp had survived the construction drawdown. Another nearshore electroshocking survey was performed in May 2013 with six native species collected (Figures 13 and 14). The nearshore shocking did not reveal information concerning the status of most native fish species that were stocked in the lake, however an abundance of bluegills (*Lepomis macrochirus*) and green sunfish (*L. cyanellus*) indicate potential predation on common carp eggs and fry. While common carp were not collected during the 2013 nearshore electroshocking survey, numerous common carp catches had been reported by anglers and several were seined along the north end of the lake.

Prior to the lake restoration project, a point intercept survey of the former millpond demonstrated that few rooted plants existed and were limited to very low densities of sago pondweed (Potomogeton pectinatus) and curly-lead pondweed (P. crispus). However, updated surveys demonstrated that the common carp population had severely impacted the plant community restoration effort with just small patches of white water lilies (*Nymphaea odorata*), long-leaf pondweed (*P. nodosus*) and sago pondweed occurring along the south, west and north nearshore areas of the lake.

Lacking macrophyte suppression, planktonic algae contributed to the poor water clarity of the lake in 2012 and 2013. In 2013, microscopic analysis revealed that Cyanobacteria dominated the lake phytoplankton. Table 1 lists the species identified by Gina LaLiberte with WDNR ISS.

Figure 13: Lake Belle View Nearshore Fish Shocking Results



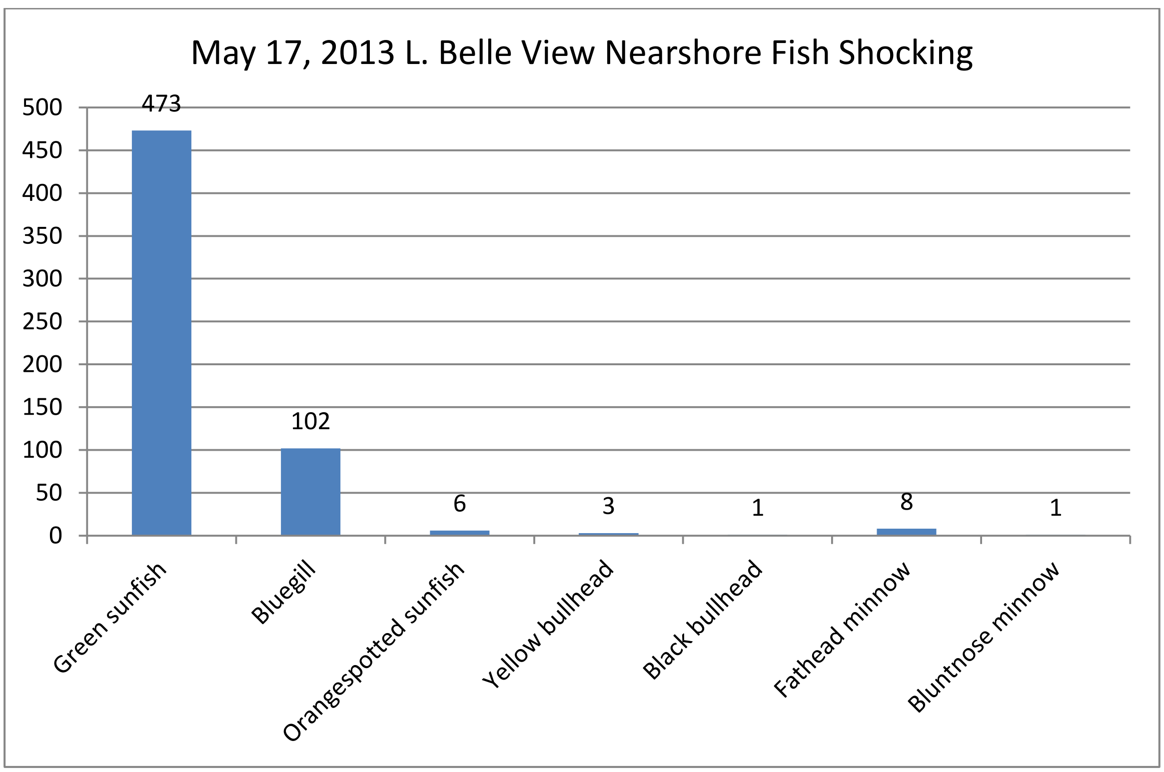


Figure 14: Estimated Numbers of Green Sunfish and Bluegills per Shoreline Mile

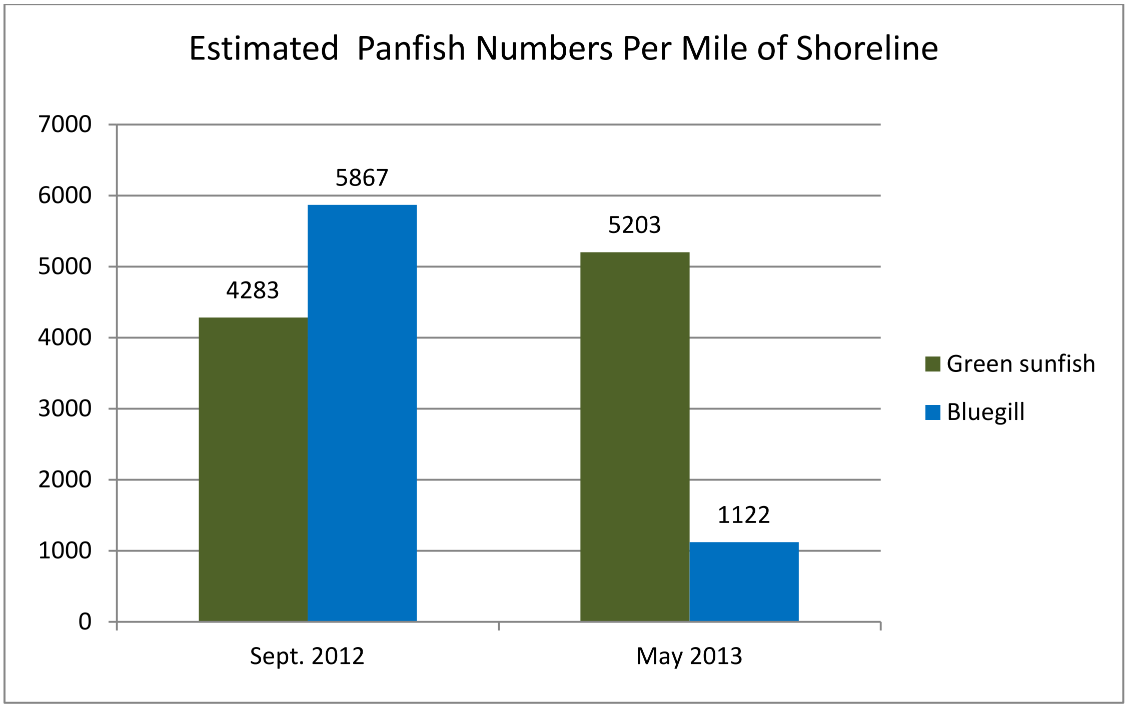


Table 1: Lake Belle View Phytoplankton Population (Aug. 15, 2013)

Species	Cell Count / ml
Chlamydomona	255
Chlorella	6,785
Cosmarium	28
Cryptomonas	653
Cyclotella	369
Euglena	85
Microcystis aeroginosa	13,597
Oocystis	738
Scenedesmus	227
Stephanodiscus	85

Watershed Area, Land Uses and Estimate WILMS Annual Phosphorus Loading

The watershed diversion berm changed the lake catchment area from 172 square miles of mostly agriculture and urbanization to just 161 acres of residential (109 acres), light industrial (27 acres) and row crop (25 acres). The catchment area and phosphorus loading changes represented approximately 99.9% reductions. Figure 15 displays reductions in both catchment area and WILMS estimated annual phosphorus loads.

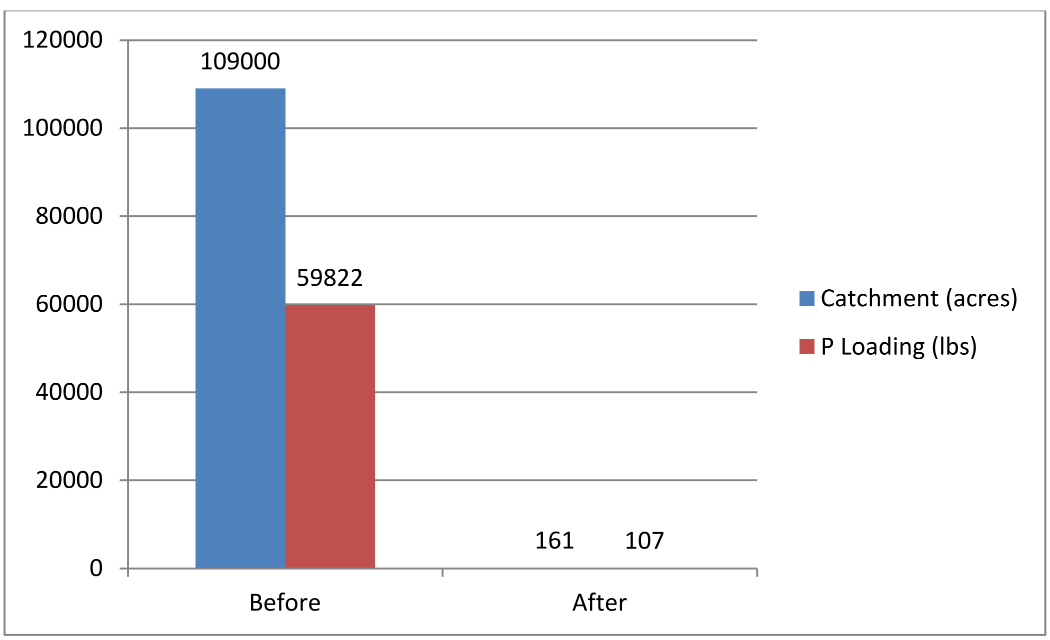
Event Monitoring Results

Grab samples of storm water runoff into Lake Belleville were collected during the summer of 2012. Very few rainfall events occurred given the extensive drought experienced during this time period. However the pollutant concentrations from the rain events collected in August and September of 2012 were on the low side of those that would typically be expected from urban runoff (Table 2).

Table 2: Event Monitoring Results

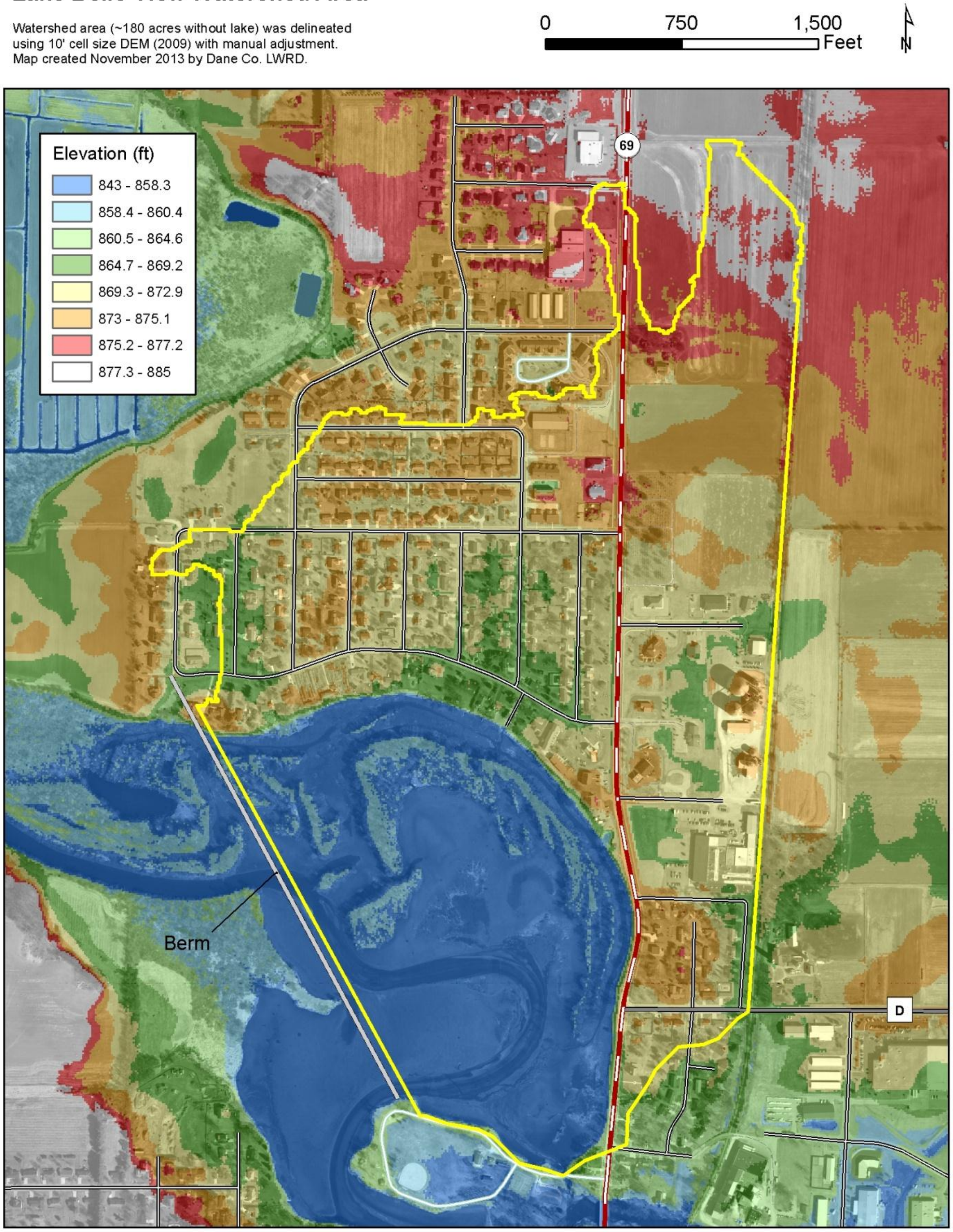
8/9/12 Total Rainfall = 0.6”			
River St. Grab:	BOD = 14.9 mg/l	TSS = 74 mg/l	
Kari St. Grab:	BOD = 15.9 mg/l	TSS = 50 mg/l	
8/15/12 Total Rainfall = 1.2”			
River St. Grab:	BOD = 9.6 mg/l	TSS = 14 mg/l	TP = 0.21 mg/l
Kari St. Grab:	BOD = 14.1 mg/l	TSS = 206 mg/l	TP = 0.25 mg/l
9/25/2012 Total Rainfall = 1.0”			
River St. Grab:	BOD = 7.4 mg/l	TSS = 27 mg/l	TP = 0.23 mg/l
Kari St. Grab:	BOD = 5.2 mg/l	TSS = 7 mg/l	TP = 0.11 mg/l

Figure 15: Changes in L. Belle View Catchment Area and Estimated Annual Phosphorus Loads



Lake Belle View Watershed Area

Watershed area (~180 acres without lake) was delineated using 10' cell size DEM (2009) with manual adjustment. Map created November 2013 by Dane Co. LWRD.



Projected TSI Targets

If the abundant common carp in Lake Belle View can be eliminated or significantly reduced, water quality conditions will likely improve. To establish realistic water quality targets, we looked at water quality data from 13 Lower Wisconsin River shallow macrophyte dominated floodplain lakes that were sampled from 2008-10. If the carp can be controlled, then macrophytes should expand significantly and suppress phytoplankton. Shallow productive floodplain lakes typically have higher phosphorus TSI compared with chlorophyll a and secchi due to phytoplankton suppression. Based on the median TSI results from the 13 Lower Wisconsin River floodplain lakes, the data suggest that phosphorus, chlorophyll a and secchi TSI targets of 54, 47 and 49 respectively are realistic for weedy shallow off channel lakes.

Government Institutional Analysis

The Village of Belleville has adopted a comprehensive stormwater management ordinance based on Dane County's model. Chapter 450 of Belleville's ordinance describes their required stormwater management and erosion control requirements. This ordinance controls building construction, grading, and controls required for development within the new lake's watershed. In addition the village has a stormwater utility which they use for financing various stormwater control systems.

In the new lake's watershed, future development in the industrial park area would be controlled through additional stormwater basins. For new developments, the ordinance requires retention of soil particles greater than five microns on the site (80% reduction) resulting from a one year, twenty four hour storm even, according to approved procedures and assuming no sediment re-suspension.

For redevelopment resulting in exposed surface parking lots and associated traffic areas, design practice to retain soil particles greater than 20 microns on the entire site are required.

Discussion and Conclusion

By spring of 2011, the hydrologic budget analysis accurately predicted that local groundwater flow was sufficient to sustain the lake water level. At this early stage in the restoration, a stable ecosystem had not been established and a major *Hydrodictyon reticulatum* bloom had covered a significant area of the lake. Thanks to rapid response from Dane County Department of Land and Water Resources, a mechanical harvester removed most of the nuisance. Greater ecosystem stability was predicted later that year as native macrophytes and fish populations were planted in the lake. However, the ecosystem instability continues due to an unexpected common carp population. Efforts to eliminate or reduce the carp can result in significant water quality and ecosystem improvements. However, even with the carp, the project has been a major success given the recreational opportunities associated with this project including hiking, swimming, paddling and wildlife viewing. The restored off-channel Lake Belle View offers significant improvements compared to the former highly degraded millpond. And panfish populations, as potential carp egg/fry eaters, have successfully expanded in the new lake and are numerous.

Recommendations

1. Hire commercial fisherman to significantly reduce the common carp population.

2. Continue to monitor lake water quality and native fish populations to determine responses to the carp eradication efforts.

3. Continue to assess stormwater runoff within the Lake Belle View catchment.

Lake Belle View Deep Hole Profiles Data

D.O.	2/17/2012	6/7/2012	7/12/2012	8/8/2012	9/11/2012
0		14.5	16.9	8.3	5.8
0.5	11.2	11.4	13.4	7.3	5.5
1	8.8	9.4	6.6	5.9	4.6
1.5	8.8	2.3	3.8	3.3	4.1
2	7.7	0.6	0.2	2.5	3.8
2.5	7.7	0.2	0.1	0.2	3.6
3	3.6	0.17	0.1	0.2	1.9
D.O.	2/12/2013	6/13/2013	7/3/2013	7/31/2013	9/5/2013
0	15	10	6	8.9	15.5
0.5	15	10.1	6	6.9	13.5
1	8.8	9.4	6	6.2	8.9
1.5	6.8	9.1	3.9	3.9	5.3
2	5.7	2.4	1.7	3.7	4.9
2.5	4.1	0.6	1.4	3.2	2.9
3	3.2	0.2	0.2	0.2	
Temp C	2/17/2012	6/7/2012	7/12/2012	8/8/2012	9/11/2012
0		27	28.9	26.3	20.4
0.5	5	23.9	26.9	26.1	20.4
1	5.1	21.9	26.3	26	20.3
1.5	5.2	20.9	26	25.6	20.3
2	5.2	20.4	25.5	25.5	20.3
2.5	5.2	18.8	22.3	24.9	20.3
3	5.2	17.2	22	23.6	20.3
Temp.	2/12/2013	6/13/2013	7/3/2013	7/31/2013	9/5/2013
0	7	25.3	22.5	24.8	24.4
0.5	7	25.3	22.5	21.4	24.2
1	3	25	22.5	20.8	22.7
1.5	3.5	24.9	22.5	20.4	22.2
2	3.5	21.4	21.7	20.2	22.1
2.5	3.5	19.7	21.4	20.1	21.6
3	3.5	17.8	20.7	19.8	

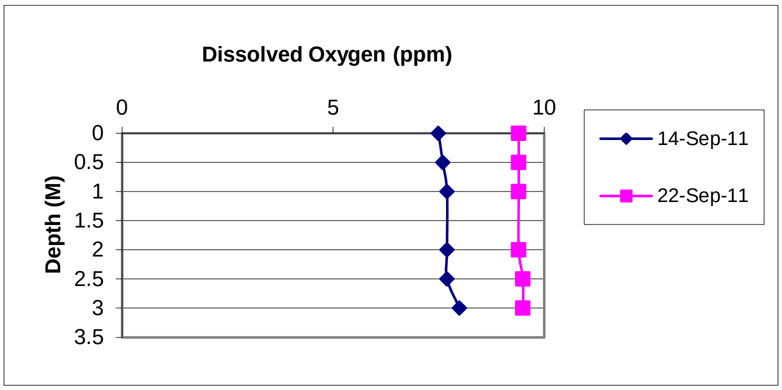
pH	2/17/2012	6/7/2012	7/12/2012	8/8/2012	9/11/2012
0		8.82	8.9	8.58	8.07
0.5	7.84	8.58	8.6	8.42	8.1
1	7.8	8.29	8.2	8.26	8.1
1.5	7.78	7.53	7.4	7.93	7.96
2	7.77	7.4	7.3	7.76	7.85
2.5	7.76	7.43	7	7.28	7.82
3	7.76	7.07	6.9	6.89	7.66

Column1	**Column2**	**Column3**	**Column4**	**Column5**	**Column6**
pH	2/12/2013	6/13/2013	7/3/2013	7/31/2013	9/5/2013
0	7.53	8.3	7.82	8.09	8.5
0.5	7.53	8.1	7.8	7.99	8.3
1	7.2	8.1	7.71	7.87	8.1
1.5	7.17	8	7.61	7.63	7.8
2	7.22	7.3	7.19	7.47	7.7
2.5	7.25	7.2	7.2	7.37	7.4
3	7.23	7.1	7.06	7.13	
Sp. Cond.	2/17/2012	6/7/2012	7/12/2012	8/8/2012	9/11/2012
0		539	540	570	561
0.5	572	540	541	572	561
1	591	545	556	573	565
1.5	590	561	565	577	568
2	590	567	577	577	570
2.5	580	564	600	591	569
3	580	600	613	608	570
Sp Cond	2/12/2013	6/13/2013	7/3/2013	7/31/2013	9/5/2013
0	688	570	492	520	537
0.5	688	564	493	520	542
1	718	567	493	527	549
1.5	729	568	493	535	559
2	736	572	525	544	562
2.5	737	578	505	558	575
3	738	580	535	558	

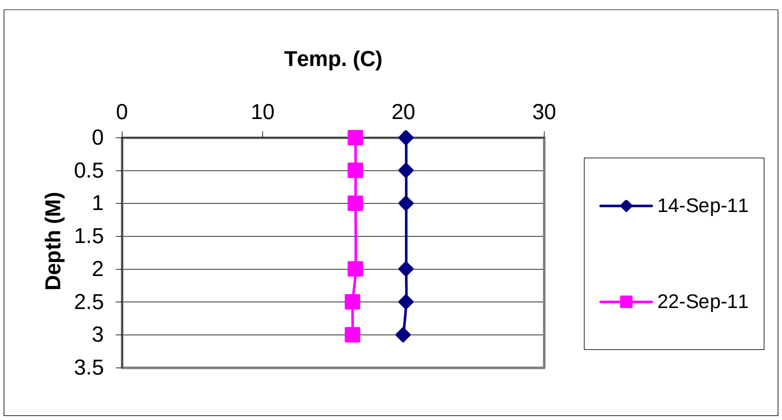
Secchi (M)								
	June 2012	July 2012	Aug 2012	Sept 2012	June 2013	July 2013	Aug 2013	Sept 2013
Lake	0.46	0.4	0.3	0.38	0.61	0.49	0.3	0.27
Channel	0.3	0.27	0.38	0.3	0.61	0.61	0.24	0.46

2011 Lake Belle View Water Quality Monitoring Summary (Field Data)

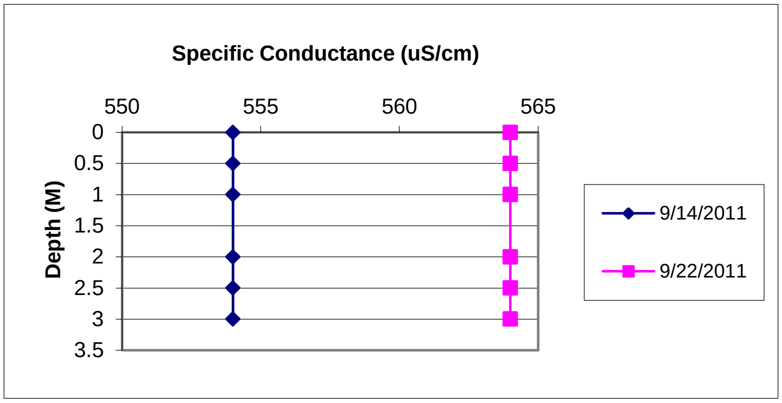
Dissolved oxygen levels remained above the water quality criterion level of 5 mg/l throughout the water column on September 14 and 22.

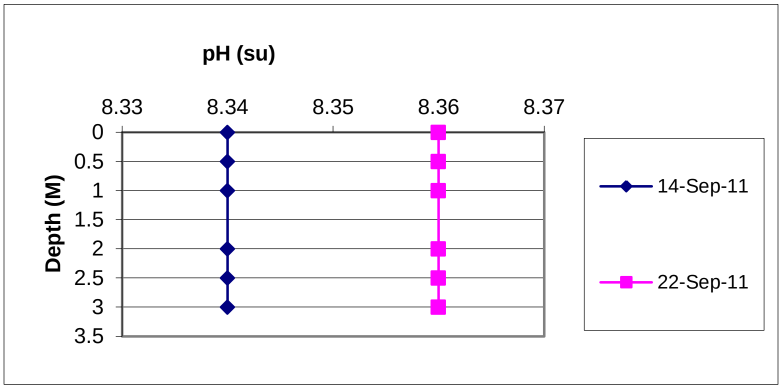


Vertical temperature levels indicated that the lake was well mixed in September.



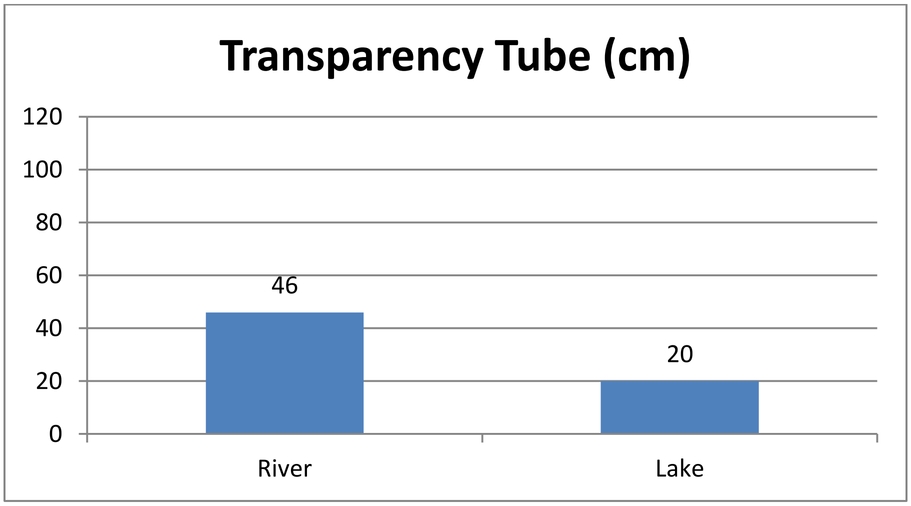
Specific conductance and pH mirrored the mixed water column as well.

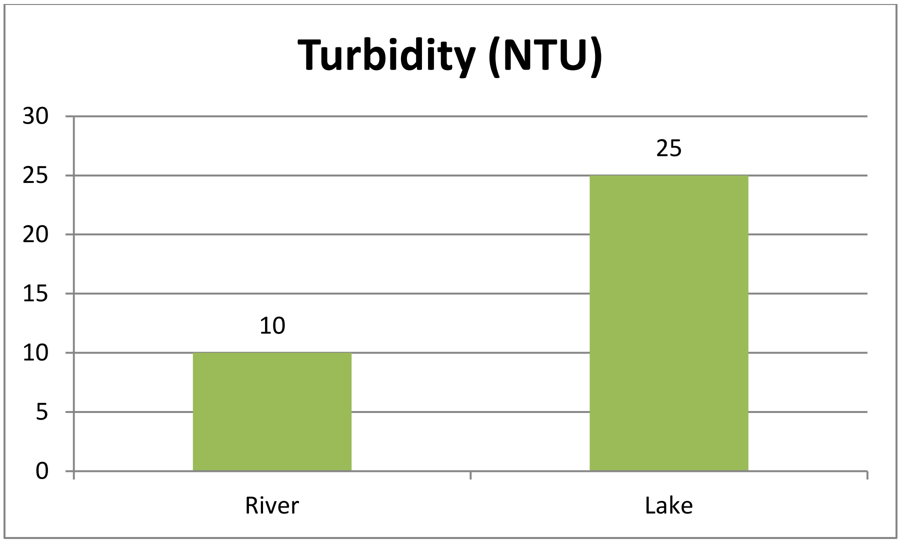




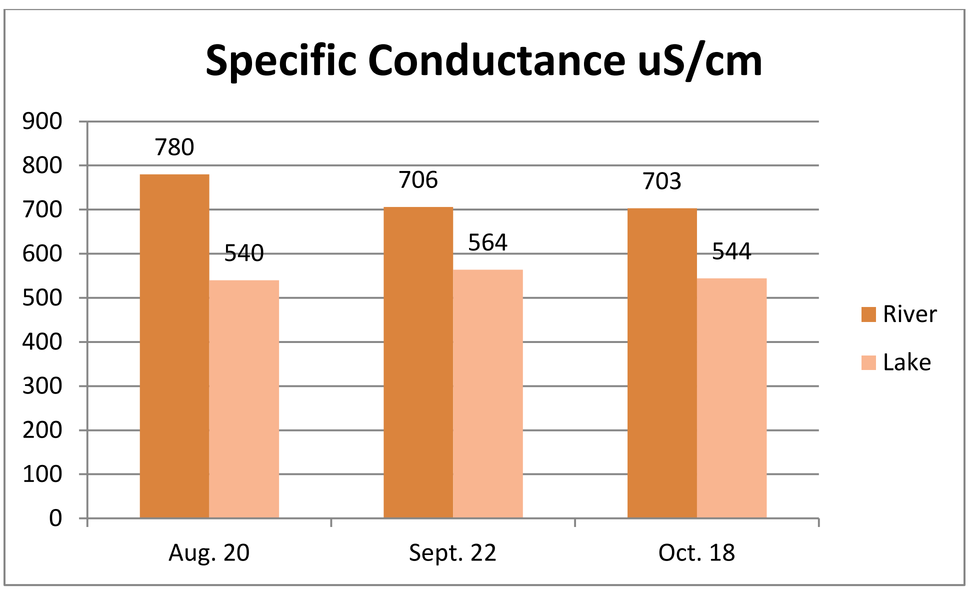
Wind and lack of aquatic vegetative cover over the sediment resulted in turbid conditions based on secchi measurements of 1' (0.31 M) on September 14 and 1.2' (0.37 M) on September 22.

Unlike the summer months, the river water clarity was better in September than in the lake due to the factors mentioned above.

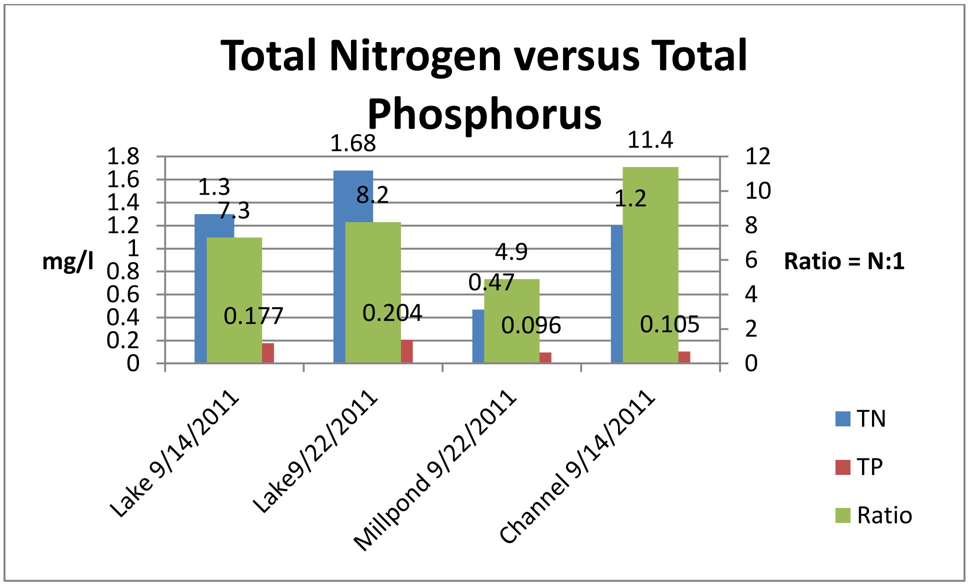




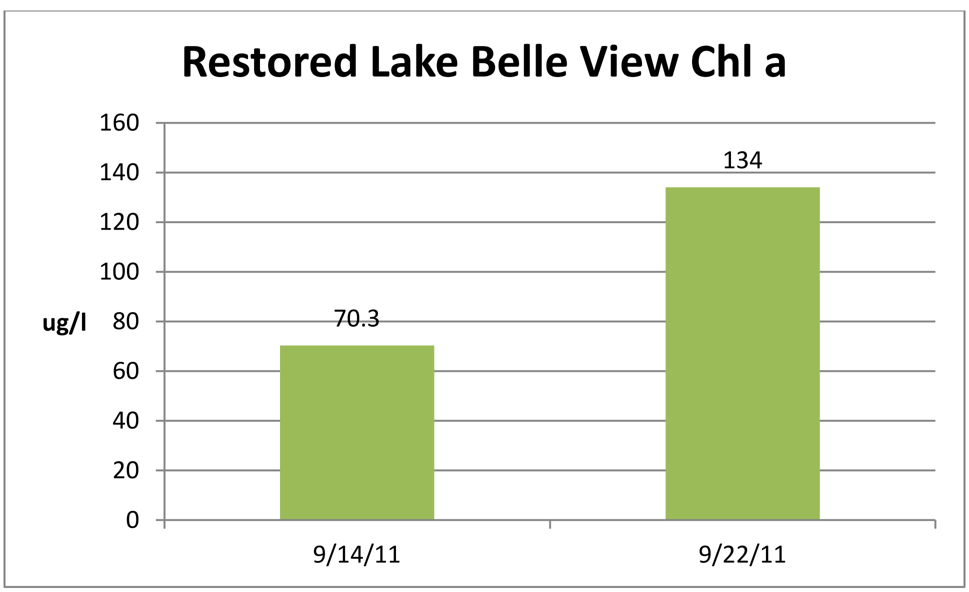
The specific conductance levels in the river were significantly higher than measured in the lake and reflect higher total dissolved solids discharged from the Mt. Horeb wastewater treatment plant to the West Branch Sugar River and Madison Metropolitan Sewerage District discharge to Badger Mill Creek. The levels found in the lake are more typical of groundwater and surface water that drain limestone topographies and therefore reflect better water quality.



2011 State Lab of Hygiene Sample Results



This graph compares total phosphorus with total nitrogen data. Phosphorus concentrations were very high and relatively high in comparison with total nitrogen. In three of four samples, the total nitrogen to total phosphorus ratio was less than 10:1. This occurs in only about 10% of Wisconsin lakes and indicates nitrogen limitation. Given the disturbance conditions that we observed soon after the lake had been constructed, these results likely will not reflect water quality once aquatic vegetation becomes well established in the lake. For that reason, the secchi, total phosphorus and chlorophyll a samples were not converted to Trophic State Index (TSI) and will not likely reflect typical growing season conditions.



Consistent with total phosphorus levels, chlorophyll a concentrations were very high. While water clarity was very low based on secchi depths, the turbid conditions primarily reflected suspended filamentous algae due to wind currents. The high phosphorus and chlorophyll concentrations and poor water clarity likely reflected temporary disturbance conditions that will change/improve once rooted vegetation becomes established in the lake.

Lake Belle View Field Data

Temp C				9/22/2011	River	Lake	Units
Depth (m)	9/14/2011	9/22/2011		Trans tube	46	20	cm
0	20.2	16.6		Turb	10	25	NTU
-0.5	20.2	16.6		pH	8.35	8.36	s.u.
-1	20.2	16.6		Cond.	706	564	uS/cm
-2	20.2	16.5					
-2.5	20.2	16.4			9/14/2011	9/22/2011	
-3	20	16.4		secchi	0.31	0.37	(m)
D.O. mg/l							
Depth (m)	9/14/2011	9/22/2011					
0	7.5	9.4					
-0.5	7.5	9.4					
-1	7.6	9.4					
-2	7.7	9.4					
-2.5	7.7	9.5					
-3	8	9.5					
pH s.u.							
Depth (m)	9/14/2011	9/22/2011					
0	8.34	8.36					
-0.5	8.34	8.36					
-1	8.34	8.36					
-2	8.34	8.36					
-2.5	8.34	8.36					
-3	8.34	8.36					
Cond. uS/cm							
Depth (m)	9/14/2011	9/22/2011					
0	554	564					
-0.5	554	564					
-1	554	564					
-2	554	564					
-2.5	554	564					
-3	554	564					