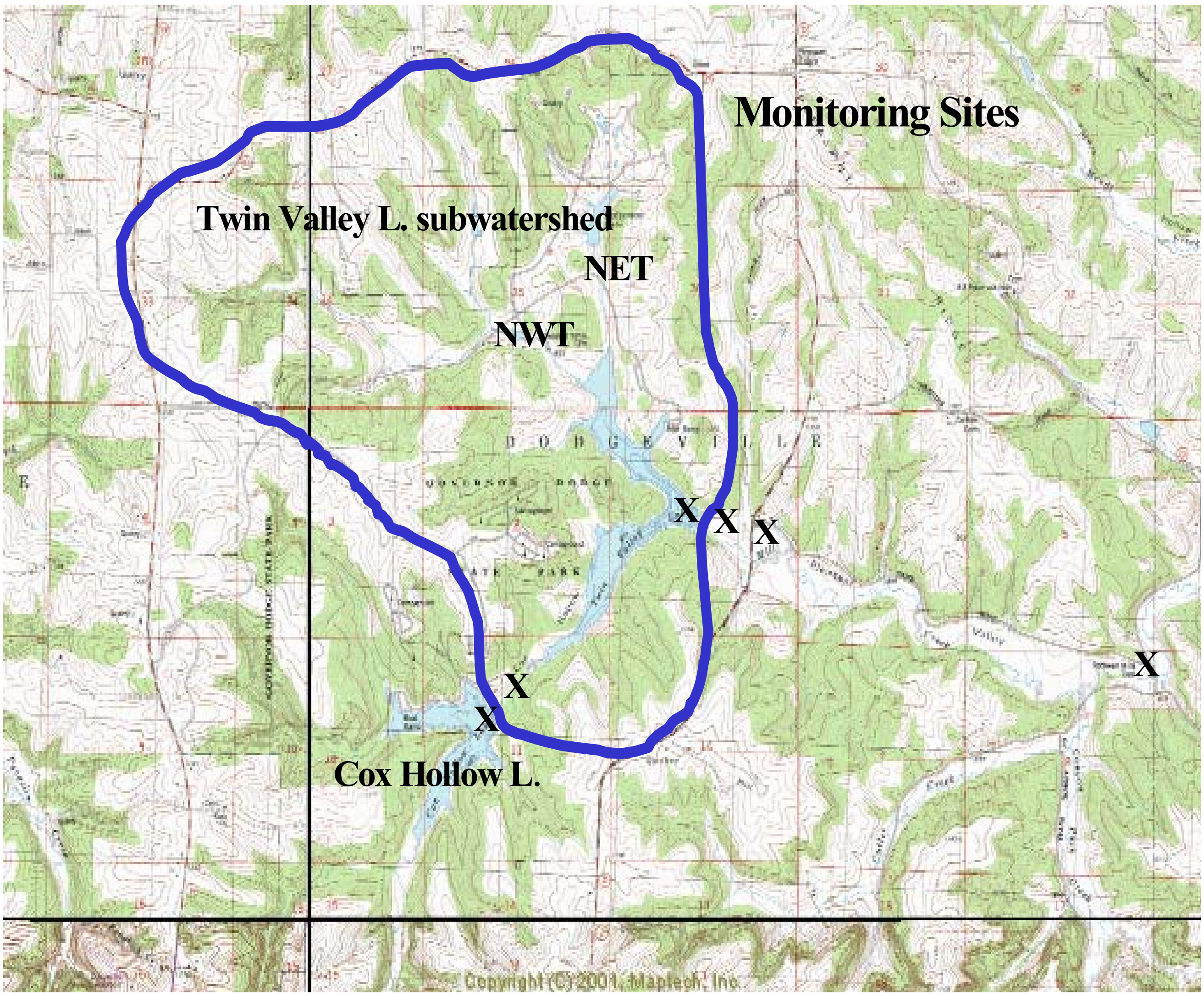
TWIN VALLEY LAKE MANAGEMENT PLAN

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

In cooperation with

NATURAL RESOURCES CONSERVATION SERVICE



December 2004

Scott Hassett, WDNR Secretary

Patricia S. Levenworth, NRCS State Conservationist

By David W. Marshall and Robert A. Ray

WDNR South Central Region Water Program

Summary

During the summer of 2004, the Natural Resources Conservation Service contracted with the Wisconsin Department of Natural Resources to monitor water resources in the Twin Valley Lake Watershed and develop a plan for long-term water resources protection. Constructed in 1965, Twin Valley Lake is a 152 acre impoundment with an outlet structure designed to release cold hypolimnetic water. The bottom water gate was installed in an effort to sustain cold temperatures and trout downstream in Mill Creek. The influence of the existing water level control structure on water quality of both the lake and creek was a major focus of the study.

Twin Valley Lake is one of two impoundments located within Governor Dodge State Park and common watershed. Just upstream of Twin Valley Lake, ninety-six acre Cox Hollow Lake releases predominantly surface water from a spillway instead of a bottom gate. A paired lake sampling design allowed us to examine potential influences of the two different water release systems. In addition to intensive lake monitoring, Twin Valley Lake tributaries and outlet were monitored throughout the 2004 spring and summer seasons. Stream fishes and macroinvertebrates were sampled as well.

Lake monitoring data revealed that Cox Hollow Lake displayed much better water quality than Twin Valley Lake in 2004. Using the standard Trophic State Indicators (total phosphorus, chlorophyll a and secchi), Cox Hollow Lake displayed moderate fertility with conditions ranging from slightly eutrophic to mesotrophic. Twin Valley Lake was very eutrophic as evidenced by high surface phosphorus concentrations, nuisance algae blooms and poor water clarity. The nutrient rich conditions in Twin Valley Lake supported Cyanobacteria blooms including the potentially toxic Cylindrospermopsis, an exotic bluegreen alga.

The water quality disparity between the two lakes would not be obvious by looking at the watershed alone. Cox Hollow Lake intercepts approximately 50% of the surface runoff and over 50% of the phosphorus inputs. Yet the water quality in Cox Hollow was much better than Twin Valley Lake. The primary difference was thermal stratification. Cox Hollow Lake remains thermally stratified during the warm season while near complete water column mixing occurs in Twin Valley Lake throughout the summer. The bottom water discharge depletes the coldwater hypolimnion and mixing of phosphorus rich water from the bottom fuels algae blooms at the surface. While Twin Valley Lake eliminates considerable phosphorus through the bottom gate (75 to 81% of phosphorus inputs in

2004), there is no evidence of water quality benefits related to hypolimnetic phosphorus export based on water quality data collected in 2001, 2002 or 2004. Cox Hollow Lake receives more watershed phosphorus and releases much less, approximately 14% of phosphorus inputs, but displays much better water quality. Given the common watershed and predominant park landscape, the water quality disparity is not watershed driven but rather is linked to thermal stratification. Warm season water column mixing occurs in Twin Valley Lake and causes substantial internal phosphorus loading.

Due to poor water quality conditions and loss of cold temperatures in the hypolimnion, the goal of sustaining trout habitat below Twin Valley Lake is not possible. While poor water quality conditions below the dam were documented in the early 1970's, conditions have not improved in Mill Creek since then. Trout are not found within one mile below the dam, and the fish community is largely composed of pollution tolerant and warmwater species. Data logger results indicated that stream temperatures below the dam are higher than optimum but the primary limiting factor is poor water quality in the stream. Dissolved oxygen levels in the stream dropped below the 5 mg/l warm water quality criteria limit during 16 of 19 days in August. At a distance of 4.9 miles below the dam, Mill Creek partially recovers from the hypolimnetic organic load and supports a mixed fishery with low numbers of brown trout and abundant eurythermal forage species.

The cooperative managers of the Twin Valley Lake dam should consider reducing or completely eliminate the hypolimnetic drain. Blocking off the bottom discharge should improve both lake and stream water quality. A monitoring effort should coincide with any planned alteration to evaluate response of both lake and stream water quality. The potential for establishing a viable trout fishery below the dam is remote due to uncontrollable cultural modifications to the stream. Therefore WDNR should consider changing the stream classification from Class II trout to diverse warmwater fish and aquatic life. A low volume seep in the bottom gate structure at Cox Hollow Lake currently releases organically enriched water that degrades the downstream reach and increases phosphorus loading to Twin Valley Lake. The hypolimnetic seep from Cox Hollow Lake should be repaired if possible.

Introduction

In the heart of 5,029 acre Governor Dodge State Park lie two flood control structures creating two recreationally important lakes. Both Twin Valley Lake and Cox Hollow Lake are both popular destinations for anglers and campers in the lake scarce "Driftless Area" of southwest Wisconsin. The lakes are currently managed for panfish, largemouth bass, walleye and muskellunge. Based on the most recent Master Plan (WDNR 1984), the park provides recreational activities for 650,000 visitors annually including 36,000 angler days of fishing and 10,000 boating days. The larger of the two lakes, Twin Valley Lake was the primary focus of this cooperative study involving the Natural Resources Conservation Service (NRCS) and Wisconsin Department of Natural Resources (WDNR) in 2004. Information was gathered in part to assist NRCS in developing a strategy for future management of Twin Parks Structure 15 (Twin Valley Lake) but also provide insight into management of similar structures across the state. Of particular interest are the effects of hypolimnetic withdrawal systems on both lake and downstream water quality.

Twin Valley Lake was originally constructed in 1965 as part of the Twin Parks Watershed Project, funded by the U. S. Soil Conservation Service. A hypolimnetic discharge was designed in the structure with the goal of providing cold water habitat for trout management downstream in Mill Creek. Today the bottom gate continues to function but no longer accommodates the entire baseflow as rates have increased over time (Gebert and Krug 1996).

Hypolimnetic withdrawal has been used to reduce phosphorus concentrations in European lakes since 1961 and in North America since 1983 (Cooke 1986, Nurnberg 1987), but hypolimnetic releases for downstream temperature control in North America precedes 1970. Effective phosphorus removal strategies involve maximum release rates without de-stratifying the water column or significantly lowering water levels (Nurnberg 1987), while phosphorus export exceed inputs (Cooke 1986).

Numerous sources have reported the threats and impacts of anoxic hypolimnetic releases to downstream fisheries and water quality. Cooke (1986) reported that special precautions should be taken to protect downstream fisheries. Nurnberg (1987) reported that wastewater treatment is often necessary to prevent adverse effects downstream of hypolimnetic withdrawals. Twin Valley Lake was the site of an early hypolimnetic release study and negative effects on aquatic invertebrates were reported (Hilsenhoff 1971). Elsewhere, hypolimnetic releases degraded both downstream macroinvertebrate communities (Young et al 1976, Lehmkulm 1972) and fisheries (Edwards 1978).

While hypolimnetic releases typically contain toxic hydrogen sulfide and ammonia concentrations, surface discharges are less disruptive to tailwater biota (Walburg et al 1981). At Lake Redstone in Sauk County, WDNR (2002) evaluated a proposed hypolimnetic withdrawal and potential impacts to diverse fisheries below the dam. WDNR concluded that a hypolimnetic release would not significantly reduce phosphorus levels in the lake and would threaten the diverse warmwater fisheries that thrive below the surface spillway.

As part of the current Twin Valley Lake planning effort, we evaluated hypolimnetic withdrawal in the context of the overall watershed phosphorus budget and water quality. Cox Hollow Lake is an important feature in this analysis since it is both a major resource within the watershed and reduces sediment and phosphorus loading to Twin Valley Lake. Since Cox Hollow Lake releases water from surface spillway, it provides a control site to compare with Twin Valley Lake and the existing hypolimnetic outlet.

Study Area

The backdrop for the study area includes the Lower Wisconsin River Basin and unglaciated "Driftless Area". Governor Dodge State Park and Twin Valley Lake lie just north of Dodgeville in Iowa County. The Twin Valley Lake Watershed is approximately 8,005 acres in area, encompassing the 5,029 acre park. Cox Hollow Lake intercepts runoff from 3,894 acres with the remaining 3,863 acres that drain directly into Twin Valley Lake. The watershed - lake surface area ratios are relatively high for both lakes, 26:1 for Twin Valley Lake and 42:1 for Cox Hollow Lake. Twin Valley Lake is the larger of the two lakes with a maximum depth of 33 feet, 152 acre surface area and storage capacity of 1718 acre feet compared to Cox Hollow Lake maximum depth of 29 feet, 96 acre surface area and storage capacity of 1037 acre/feet. Both lakes impound portions of Mill Creek. Mill Creek is currently classified Class II trout stream but existing conditions below the Twin Valley Lake dam limit numbers of both trout and trout anglers.

Methods

Lake Monitoring

Beginning in August 2004, both Twin Valley Lake and Cox Hollow Lake were sampled on a weekly basis. Secchi water clarity measurements were recorded each week. Dissolved oxygen, temperature, and specific conductivity were measured at one meter intervals at the deepest area, near the dams of each lake. Yellow Spring Instrument meters were used for the profile measurements. We measured pH at the surface and bottom of each lake using a LaMotte temperature compensated meter. Water samples were collected 0.5 m off the bottom, just below the thermocline (or approximate depth in Twin Valley Lake) and 0.5 meters below the surface. Water samples were analyzed at the State Lab of Hygiene for total phosphorus, ammonia, iron, sulfide and chlorophyll-a. The phosphorus, secchi and chlorophyll-a data were transformed into Trophic State Indicators (TSI) using Wisconsin Lake Model Suite (WILMS) software. Maptech software was used to delineate watershed boundaries.

Stream Monitoring

The tributaries to Twin Valley Lake and the outlet were sampled on a weekly basis and during storm events when possible. Flow rates were measured with Swoffer Model 2100 meters. Dissolved oxygen and temperature were measured with YSI Model 58 or 57 meters. State Lab of Hygiene water analysis included total phosphorus and suspended solids. WILMS software was used to predict phosphorus loading rates from unmonitored drainage areas. Onset HOBO data loggers were used to measure hourly temperatures during the summer season. In August, YSI 600XLM water quality data loggers were deployed in Mill Creek 0.5 miles and 4.9 miles below the dam. The units were programmed to sample every hour. Electrofishing surveys were performed at four locations. A 12 volt backpack stream shocker was used to sample fish from two small tributaries to Twin Valley Lake. A towed stream barge with gas powered generator was used to sample fish populations 0.5 miles and 4.9 miles below Twin Valley Lake. Macroinvertebrates were collected in April 2004 at the four stream sites where fish populations were sampled. Both fish and macroinvertebrate data were used assess ecological health of the streams. Baseline sampling protocols were used. The macroinvertebrate data was used to calculate Hilsenhoff Biotic Index (HBI) and Ephemeroptera-Plecoptera-Tricoptera (EPT) scores and fish data to calculate the coldwater Index of Biotic Integrity (CW-IBI).

Results

Lake Monitoring - Paired lake monitoring began on July 7th and weekly sampling began on August 4th. Ten lake surveys were completed on Twin Valley Lake and eight on Cox Hollow Lake. While the lakes are located in close proximity to each other and lie in the same watershed, in Figure 1 Cox Hollow Lake displayed significantly better water quality using all three TSI parameters ($P < .01$). Higher TSI values indicate more eutrophic or less favorable water quality. Figures 2-4 display higher phosphorus and chlorophyll-a in Twin Valley Lake as well as lower water clarity. Mean sample results for Twin Valley Lake and Cox Hollow Lake were 45 and 36 ug/l total phosphorus, 37 and 10 ug/l chlorophyll-a, and 3.2 and 7.3 feet secchi depth respectively. Figure 5 demonstrates that poor water clarity is a frequent characteristic of Twin Valley Lake, looking back several years. Total phosphorus data collected from previous years were statistically similar ($P=.16$) with a slightly lower mean (48 ug/l in 2001-02 compared with 45 ug/l) in 2004. Just as water quality differences were pronounced, so were the vertical lake profile characteristics. Cox Hollow Lake remained stratified throughout the summer while no defined thermocline was detected in Twin Valley Lake. In Figure 6, bottom temperatures in Twin Valley Lake rise rapidly just one meter off the bottom and indicate lack of stratification and mixing occurs. Both lakes sustained reduced conditions near the bottom generating high ammonia, total phosphorus, sulfide and iron.

While temperature data indicate sustained stratification in Cox Hollow Lake and partial mixing within Twin Valley Lake, Figure 7 demonstrates that de-stratification did not expand the oxygen throughout the water column in Twin Valley Lake. Sustained anoxia near the bottom of both lakes created the reduced conditions necessary to liberate sulfides, ammonia, iron, and phosphorus from the bottom sediments. By early August 2004, ammonia concentrations near the bottom had already reached 2.14 mg/l in Twin Valley Lake and 3.29 mg/l in Cox Hollow Lake. In 2002, ammonia concentrations near the bottom in Twin Valley Lake ranged from 3 mg/l in early August to 5 mg/l by the end of the month. In 2004, Sulfide concentrations reached 2 mg/l in Twin Valley Lake and 4 mg/l in Cox Hollow Lake. Iron concentrations reached 8.6 mg/l in Twin Valley Lake. Under anoxia and low redox potential, phosphorus bonding to iron oxides were broken and both iron and phosphorus were mobilized from the sediment. Figure 8 demonstrates the disparity of phosphorus concentrations near the bottom compared to surface concentrations. Maximum hypolimnetic phosphorus concentrations in Twin Valley Lake and Cox Hollow Lake were 2480 and 380 ug/l respectively. Also common to both lakes, pH was significantly lower ($P < .01$) and conductivity was significantly higher ($P < .01$) near the bottom compared with much shallower epilimnetic water.

Figure 1

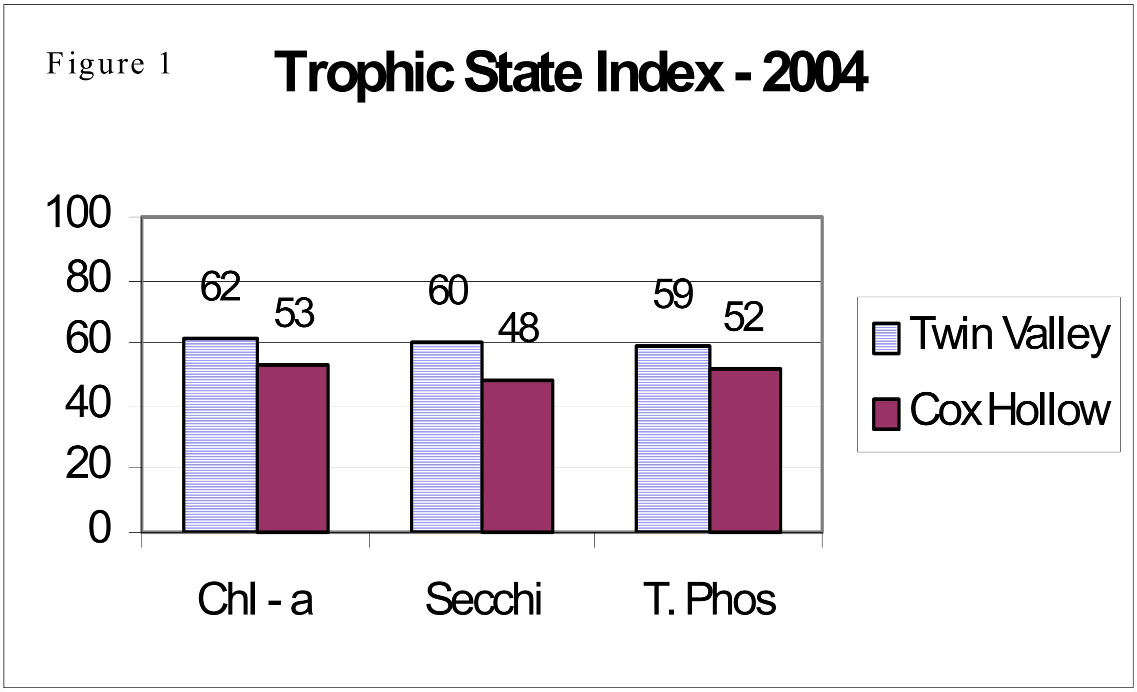
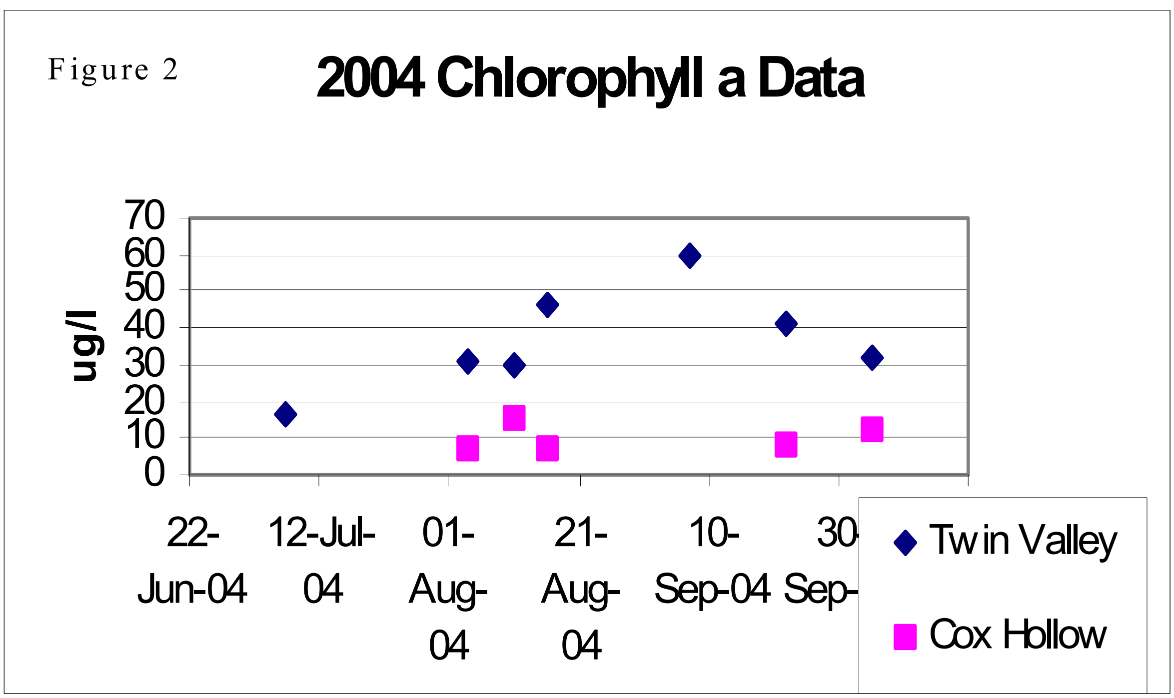
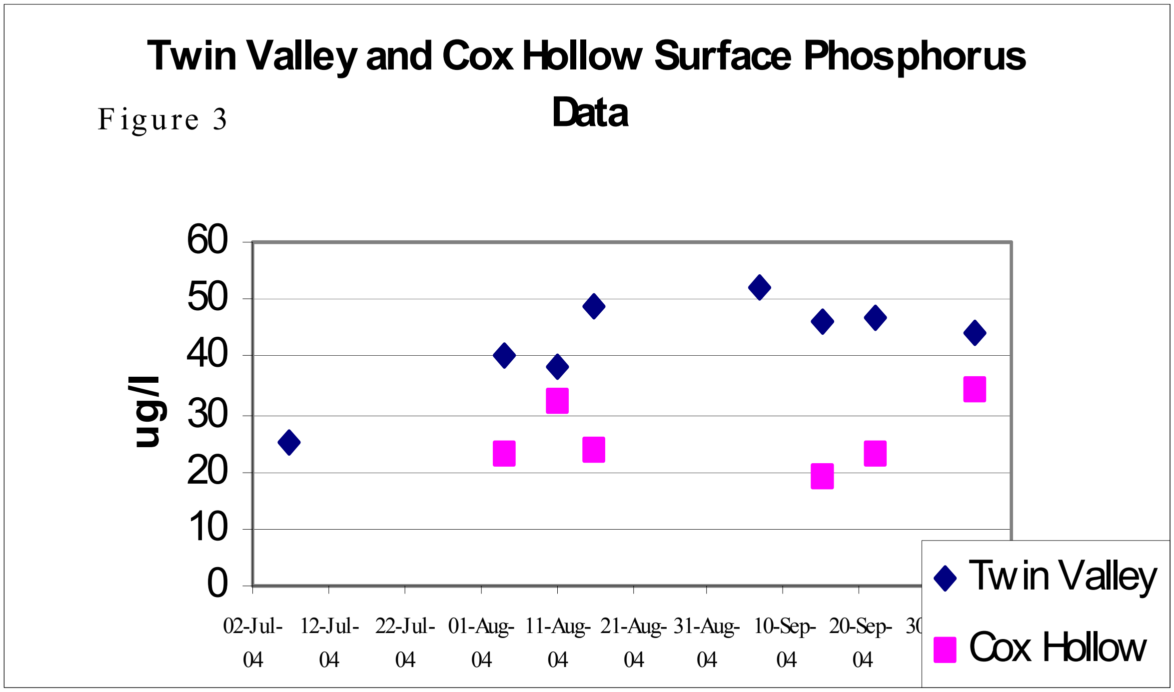


Figure 2




Twin Valley and Cox Hollow Surface Phosphorus Data
Figure 3
ug/l
60
50
40
30
20
10
0
02-Jul-04
12-Jul-04
22-Jul-04
01-Aug-04
11-Aug-04
21-Aug-04
31-Aug-04
10-Sep-04
20-Sep-04
Twin Valley
Cox Hollow

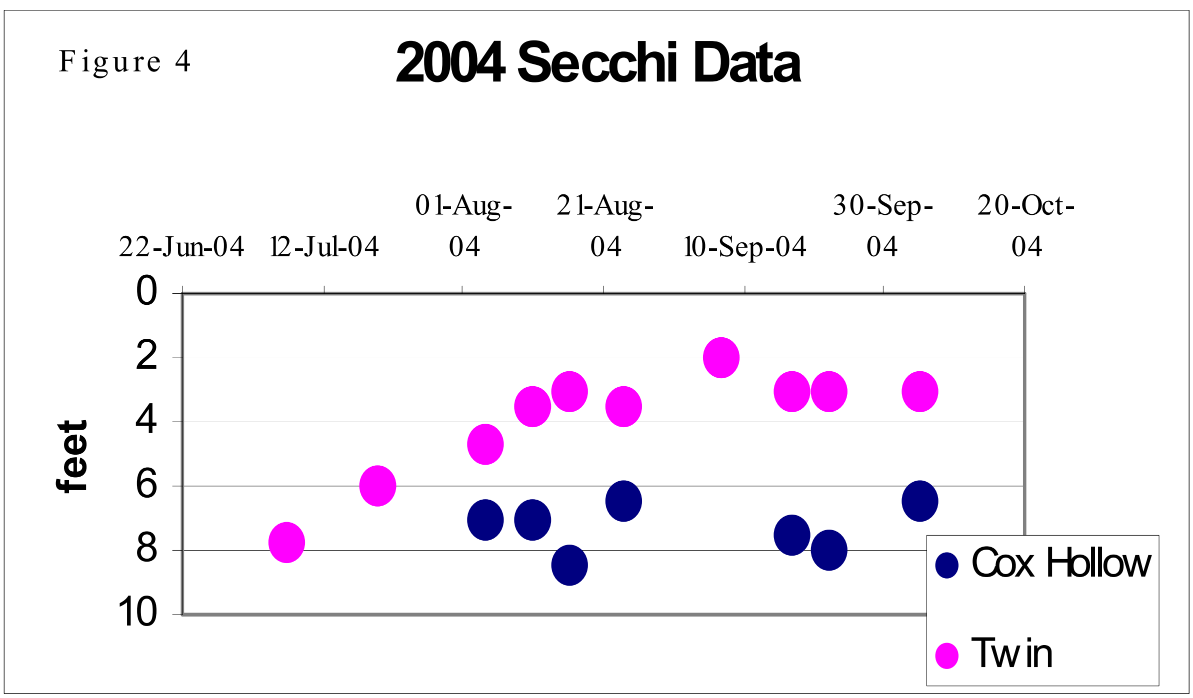


Figure 4
2004 Secchi Data
22-Jun-04
12-Jul-04
01-Aug-04
21-Aug-04
10-Sep-04
30-Sep-04
20-Oct-04
feet
0
2
4
6
8
10
Cox Hollow
Twin

Figure 5

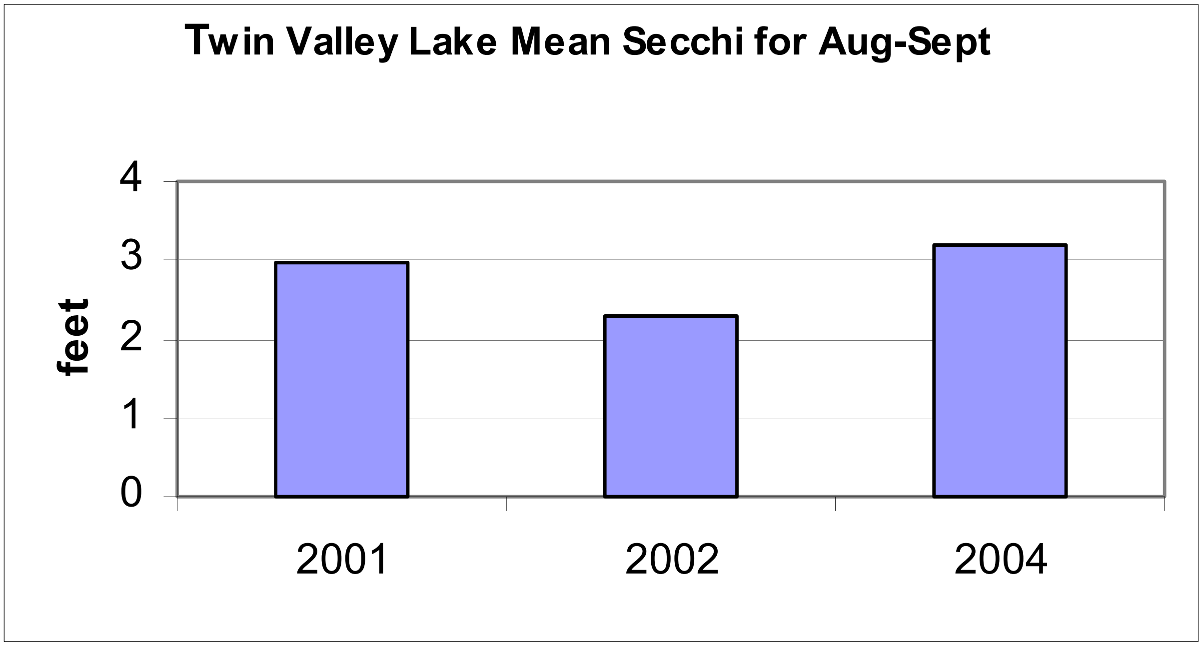
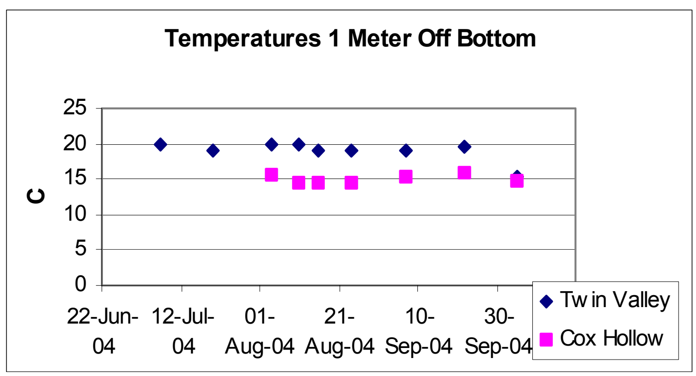


Figure 6



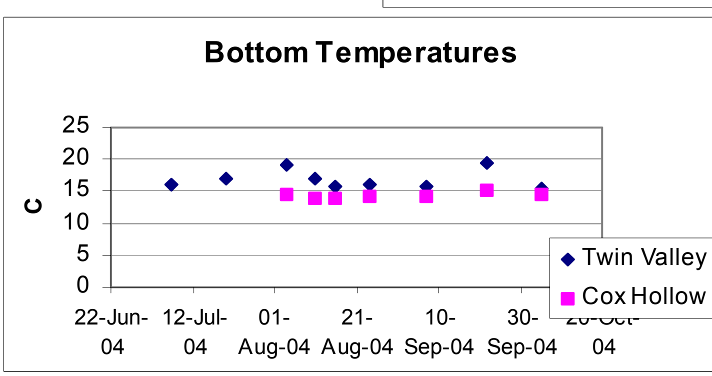


Figure 7

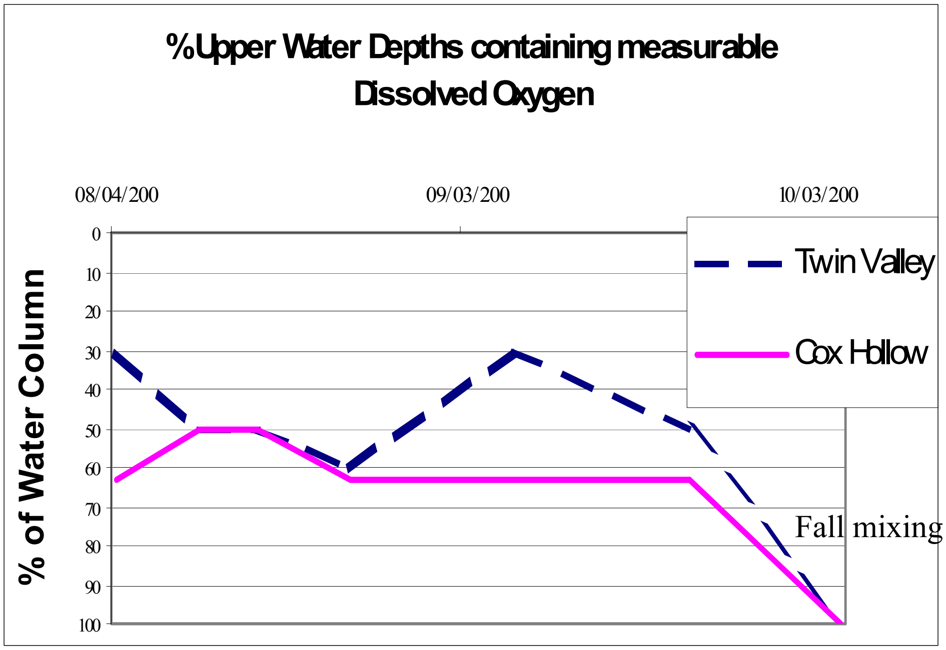
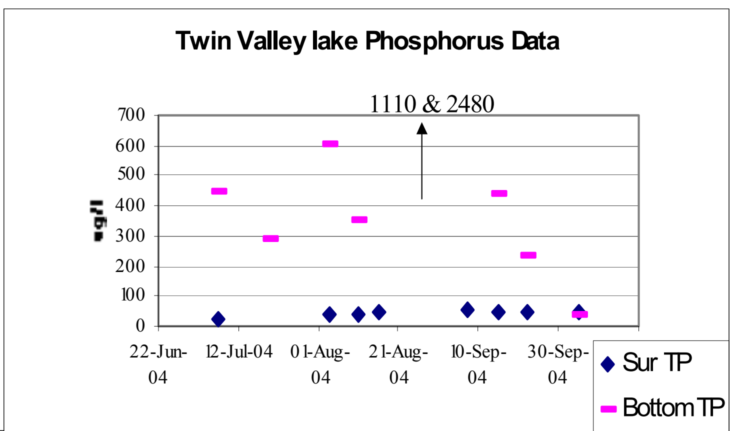
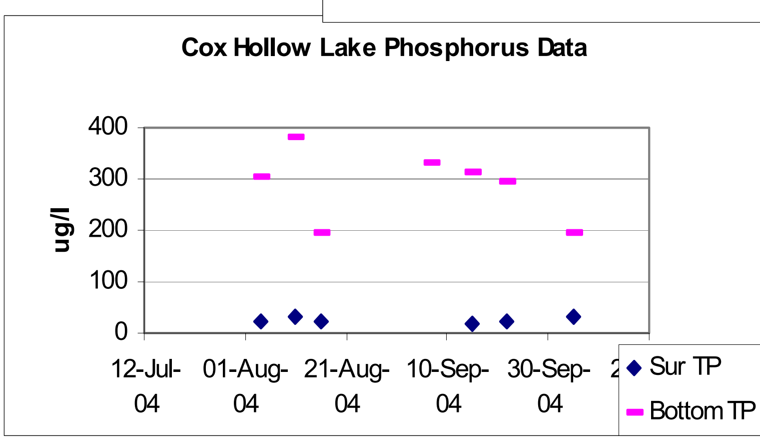


Figure 8





Watershed and tributary monitoring - Three tributaries to Twin Valley Lake were monitored during 2004 in an effort to determine phosphorus loading rates to the lake. The outlet from Twin Valley Lake was sampled as well. Two small tributaries, referred to as Northeast Trib. (NET) and Northwest Trib. (NWT), were sampled 23 times each on a weekly basis and during storm events. The Cox Hollow Lake outlet was sampled 22 times and the outlet from Twin Valley Lake was sampled 20 times. Flow rates ranged from 0.33 to 12.9 cfs (mean = 2.15 cfs) in the NET. Phosphorus concentrations ranged from 36 to 152 ug/l (mean = 85 ug/l) and suspended solids concentrations ranged from 2 to 88 mg/l (mean = 30.8 mg/l). Flow rates in the NWT ranged from 0.52 to 27.9 cfs (mean = 3 cfs). Phosphorus concentrations ranged from 50 to 1100 ug/l (mean = 182 ug/l) and suspended solids ranged from 2 to 970 mg/l (mean = 124 mg/l). Below the Cox Hollow Lake spillway, flow rates ranged from 2.5 to 29.8 cfs (mean 7.25 cfs). Phosphorus concentrations ranged from 24 to 80 ug/l (mean = 50 ug/l) and suspended solids ranged from 0 to 9 mg/l (mean – 3.6 mg/l).

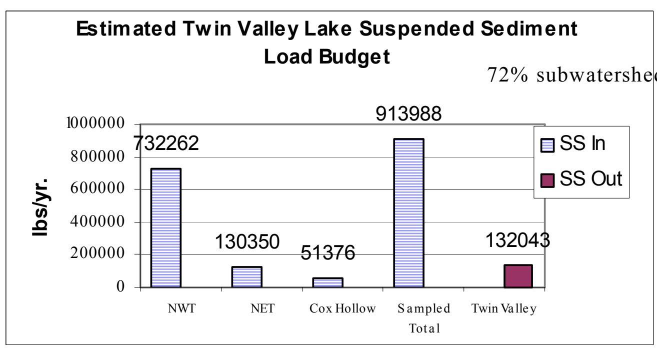
Ammonia analysis was included in the late summer water samples below Cox Hollow Lake. Relatively high values, ranging from .37 to .52 mg/l, reflected a low volume seep from the hypolimnetic outlet. Ammonia and other nutrients from this structure fueled nuisance filamentous bacteria and fungi growths in the stream. Prior to late summer anoxia within the Cox Hollow Lake hypolimnion, we observed abundant panfish in the pool just below the hypolimnetic outlet pipe. When the structure began discharging organically enriched water, the panfish had apparently moved out and the stream became clogged with heterotrophic filamentous growths.

In addition to point source loading data below the Cox Hollow Lake outlet, monitoring results from NWT and NET represented approximately 72% of the Twin Valley Lake subwatershed. Predicted annual phosphorus loading rate to Twin Valley Lake was 2265 lbs./year using the monitoring results along with WILMS predictions encompassing approximately 23% of the Twin Valley Lake subwatershed. Figure 9 displays predicted loading rates during the 2004 season. Based on tributary flow and suspended solids data, Figure 9 also displays the predicted annual suspended sediment loading to be approximately 913,988 lbs./year. The predicted suspended sediment loading is based on 72% of the Twin Valley Lake subwatershed.

Based on Twin Valley Lake outlet monitoring, the phosphorus and suspended sediment retention were approximately 18% and 85% respectively. The actual percent of trapped sediment is higher since only 72% of the Twin Valley Lake subwatershed was monitored and did not include bed load. Compared to Cox Hollow Lake, significantly lower phosphorus retention in Twin Valley Lake reflected anoxic phosphorus release through the hypolimnetic outlet and relatively high outflow rates. Twin Valley Lake outlet flow rates ranged from 6 to 66 cfs (mean = 15.6 cfs). Phosphorus concentrations ranged from 27 to 208 ug/l (mean = 87 ug/l) and suspended solids ranged from 1.8 to 7 mg/l (mean = 4.3 mg/l). Consistent with the Cox Hollow Lake outlet, ammonia levels were high due to hypolimnetic release and ranged from .296 to .834 mg/l. Filamentous bacterial and fungi growths thrived below the Twin Valley Lake outlet by mid-July. None of the discrete "grab" dissolved oxygen measurements taken from the four tributary and outlet sites were below 5 mg/l, the minimum criteria for warm water streams.

Rain gage data collected at Governor Dodge State Park and by NOAA indicated higher than normal precipitation by about 7 inches during the sampling period. Using WILMS to predict phosphorus runoff given the watershed areas and predominant landuses, high range export values were chosen to reflect greater runoff. The high range watershed phosphorus loading rate of 2450 lbs./year is close to the monitored prediction of 2265 lbs./year. The WILMS program was also used to calculate phosphorus loading to Cox Hollow Lake. Given the developed areas and cropland south of the lake, predicted phosphorus loading is actually higher than Twin Valley Lake at 3582 lbs./year. Again the high range values were used. The predicted annual phosphorus release from the outlet of Cox Hollow Lake was 500 lbs./year. Compared with the predicted annual loading rate, phosphorus retention in Cox Hollow Lake was much higher than Twin Valley Lake, 86% versus 18%. These differences in part reflect the function of a surface spillway at Cox Hollow Lake versus a hypolimnetic outlet at Twin Valley Lake. Figure 10 displays the predicted phosphorus loading based on monitored Twin Valley Lake subwatersheds and entirely on WILMS.

Figure 9



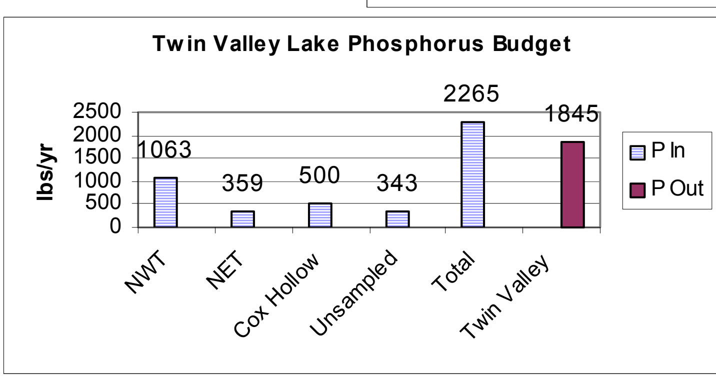
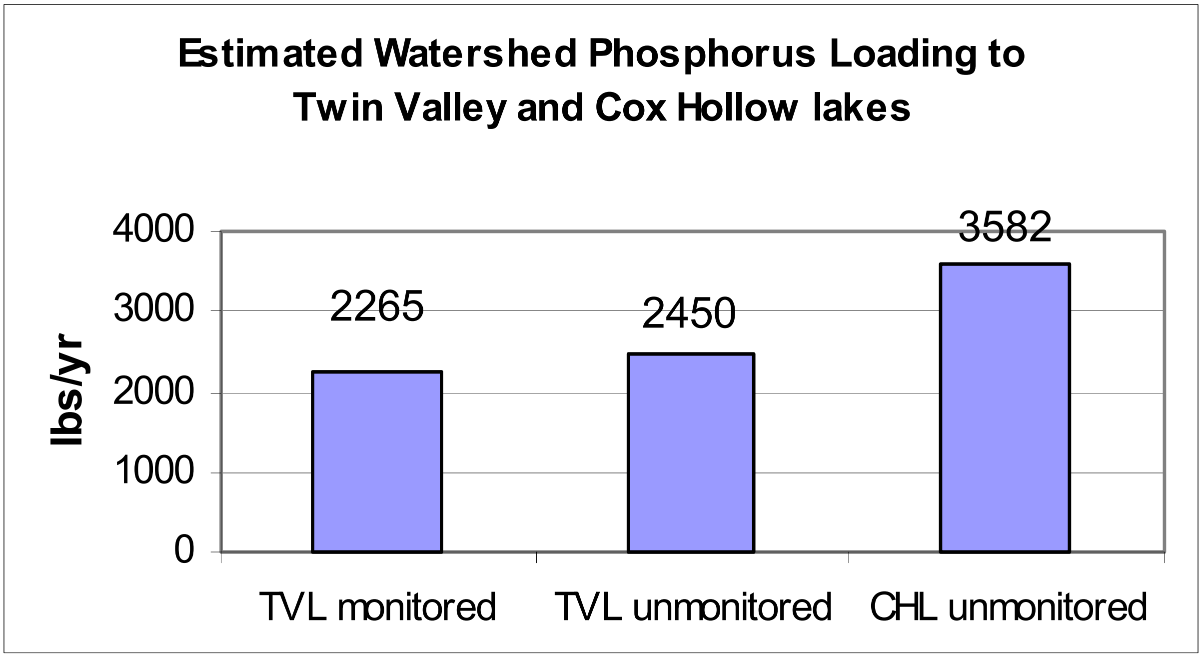


Figure 10



Stream Data Logger Results – YSI 600XLM data loggers were deployed in August 2004 at locations 0.5 miles and 4.9 miles below the Twin Valley Lake outlet. At the CTH Z bridge, 0.5 miles below the dam, dissolved oxygen levels dropped below minimum water quality criteria limit of 5 mg/l during 16 of 19 sampling days. All of the violations occurred at night, coinciding with respiration of abundant aquatic plants in the stream. Approximately 4.5 miles downstream at Ridgeview Road, dissolved oxygen levels remained well above minimum criteria for both warm and cold water streams. Minimum dissolved oxygen criteria for trout water is 6 mg/l. Higher dissolved oxygen at Ridgeview Road reflected a combination of increased baseflow, lower aquatic plant densities and assimilation of nutrient loads a considerable distance below Twin Valley Lake. Paired flow measurements indicated that discharge rates typically double five miles below the dam. The data logger results from 2004 (Figure 11) are similar to a three day deployment in August 2002 (Figure 12). The wide dissolved oxygen fluctuations at the CTH Z bridge reflect the abundant aquatic plant growth in the stream and corresponding daily photosynthesis and nighttime respiration.

Onset water temperature recorders were deployed at both locations in Mill Creek from June 18 until August 30, 2004. Minimum, maximum and mean temperatures 0.5 miles and 4.9 miles downstream of the dam were 17.8 - 22.9 – 20 C and 12.4 – 23.5 – 17.8 C respectively. While water temperatures at both sites were comparable from early to

Figure 11

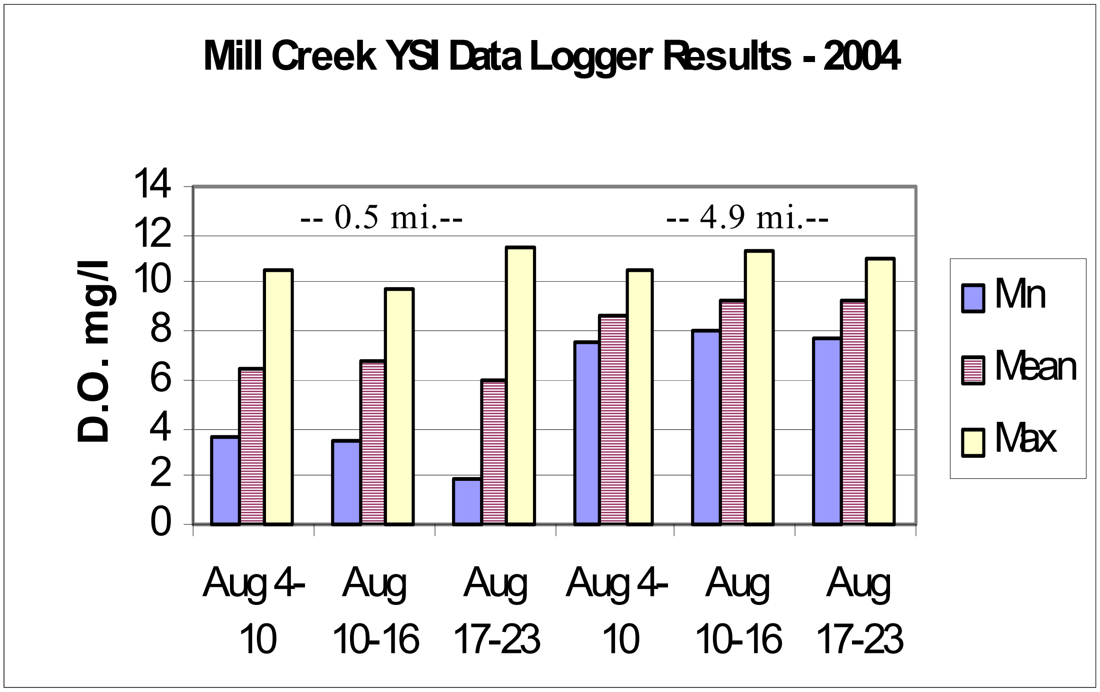
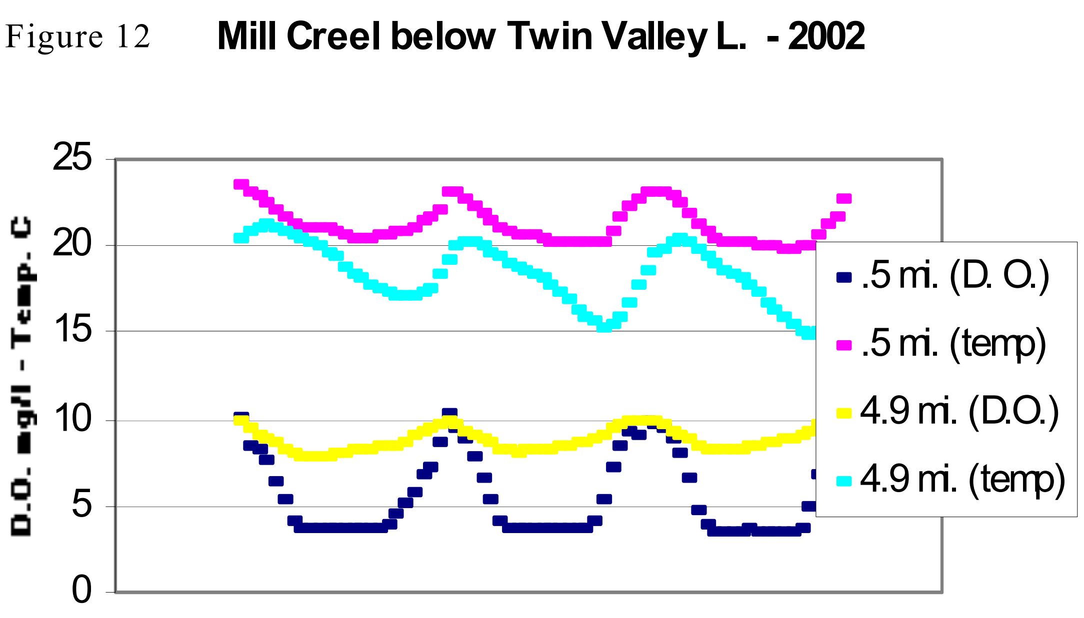
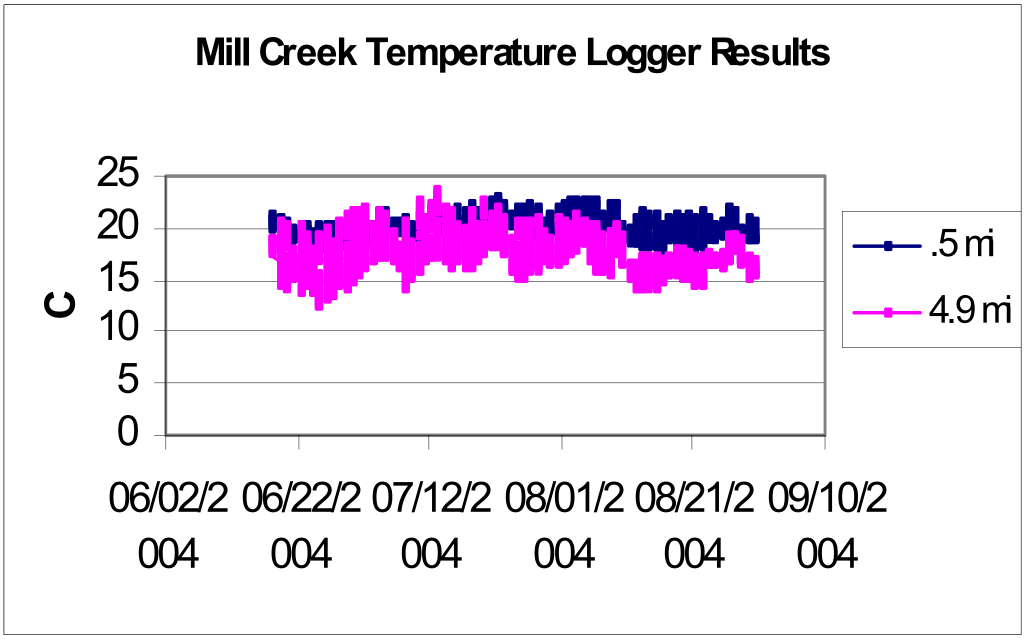


Figure 12



Aug 27 - 30

Figure 13

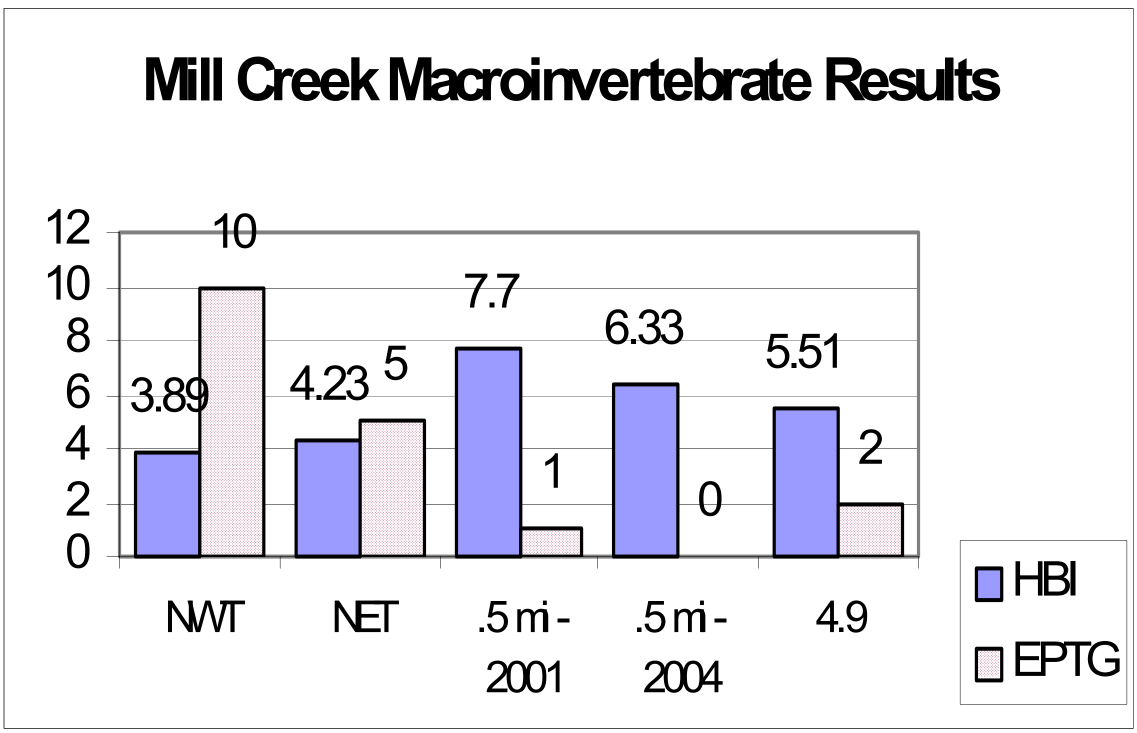


mid-summer, late summer temperatures near the dam were warmer (Figure 13) and coincided with warmer bottom temperatures in Twin Valley Lake. Continuous temperature data collected from NET indicated it is a small cool water stream with maximum and mean temperatures of 22.5 and 17.2 C respectively. NWT was much colder with maximum and mean temperatures of 18.4 and 13.5 C respectively.

Stream Biology – Spring macroinvertebrate samples were collected at the NWT and NET sampling sites and in Mill Creek 0.5 and 4.9 miles below the Twin Valley Lake dam. Pronounced differences were detected among the sites both in EPTG richness and HBI values. The most diverse and healthiest benthic community was found in NWT based on both HBI and EPTG. NWT was the only site with a stonefly representative (Plecoptera) and supported diverse caddisfly populations (Tricoptera). The HBI value of 3.89 indicated "very good" water quality. Macroinvertebrates collected from NET also indicated "very good" water quality (4.23) but EPTG numbers were much lower. While the tributaries indicated good water quality, macroinvertebrate sample below the dam at CTH Z reflected an ecologically unbalanced benthic community with much higher HBI values (7.69 in 2001 and 6.33 in 2004) and dearth of ETPG. At Ridgeview Road 4.9 miles below the dam, the macroinvertebrate sample results indicated a partial recovery with an HBI score of 5.51 (fair) but EPTG numbers remained low.

Stream shocking surveys were performed on the two small tributaries using a battery powered backpack shocker and on Mill Creek using a towed barge with twin electrodes. Based on three shocking surveys (including 2002 data) 0.5 miles below the dam, fish populations did not reflect a trout stream and instead warm water and tolerant species dominated. Approximately five miles downstream of the dam, the stream did support low numbers of typical trout stream cohorts in August 2004 including 16 brown trout, 1 American brook lamprey and 21 mottled sculpin. The cold water IBI score was 20, indicating "poor" conditions. Coldwater IBI scores near the dam were 0 during each survey, or "very poor". Habitat was generally wanting in the two small tributaries due to low flow. In NET, two green sunfish were collected. In NWT, four fantail darters, one creekchub and one brook stickleback were collected.

Figure 14



HBI partial scale: 3.51- 4.5 = v. good, 4.51 - 5.5 = good, 5.51 - 6.5 = fair, 6.51 - 7.5 = fairly poor, 7.51 - 8.5 = poor. Higher EPTG scores are better.

Table 1: Electrofishing results .5 and 4.9 mi. below Twin Valley Lake.

Mill Creek Electrofishing	**.5 mi**	**.5 mi**	**.5 mi**	**4.9 mi**			
Species	02-Jun	04-May	Aug 04	Aug 04	Cold	Intolerant	Tolerant
American brook lamprey	0	0	0	1	x	x	
brown trout	0	0	0	16	x		
mudminnow	0	0	0	1			x
Hornyhead chub	79	104	13	103			
bluntnose minnow	15	20	1	42			x
fathead minnow	1	1	0	2			x
creekchub	0	125	0	59			x
southern redbelly dace	0	1	0	118			
brassy minnow	0	0	0	1	x		
common shiner	309	364	0	157			
blacknose dace	0	0	0	14			x
white sucker	110	23	98	27			x
brook stickleback	1	2	0	8	x		
bluegill	2	0	21	5			
black crappie	0	0	1	0			
largemouth bass	0	0	23	0			
johnny darter	3	10	0	89			
fantail darter	520	0	0	160			
mottled sculpin	0	0	0	21	x	x	
% Cold	<1	<1	0	6			
% Intolerant	0	0	0	3			
% Tolerant	24	26	63	18			
No. Cold Species	1	1	0	4			
No. Intolerant Species	0	0	0	2			
No. Tolerant Species	3	4	2	6			
Total Individuals	520	650	157	824			
shocking length (ft)	580	580	1127	616			

Discussion

The 8,005 acre watershed is divided almost equally between Cox Hollow Lake and Twin Valley Lake. While all of the surface runoff and springflow ultimately drain into Twin Valley Lake, Cox Hollow Lake traps over half of the phosphorus. Twin Valley Lake displays highly eutrophic conditions even though the lakes share a common watershed and Cox Hollow Lake traps over 50% of the total phosphorus load (nutrient trapping occurred previously in Halverson Lake). The primary difference between the much clearer Cox Hollow Lake and algae dominated Twin Valley Lake is thermal stratification. The surface spillway at Cox Hollow Lake does not undermine stratification while the hypolimnetic outlet at Twin Valley Lake causes nutrient mixing. Cox Hollow Lake is more popular among park visitors (Governor Dodge State Park Superintendent Kathleen Gruentzel – personnal communication) and may be related to better water quality in Cox Hollow Lake than Twin Valley Lake. Lake users typically prefer clear water over cloudy or turbid water.

Both lakes trap sediment and phosphorus within the high gradient watershed. Twin Valley Lake traps approximately 86% of the annual suspended solids loading. Total sediment retention is probably much higher because the data does not reflect bed load. NRCS (2002) reported that Twin Valley Lake retained substantially more post-impoundment sediment than White Mound Lake but also retained more sediment than fourteen other Wisconsin impoundments tested with acoustic imaging (Barb Lensch - personal communication). During the 2004 lake planning study, the NWT delivered the highest suspended solids loading and the stream also had a heavy bed load based on field observations. It is not known when most of the sediment was delivered to the lake during its 39 year history but NWT remains a significant source. The NRCS Acoustic Sediment study did not include Cox Hollow Lake but loading rates are probably similar given the common watershed and landuses.

The hypolimnetic outlet at Twin Valley Lake increases phosphorus export yet much higher levels were detected near the bottom compared with Cox Hollow Lake (2480 vs 380 ug/l). More detailed lake profile monitoring would be required to determine why much higher values were found in Twin Valley Lake, however higher bottom temperatures may have been a catalyst for increase chemical and microbial activity.

Based on model predictions used in WILMS and elsewhere, sustained stratification is an important feature related to lake water quality. The water quality implication of weak stratification is a net increase of phosphorus during the growing season due in part to internal mixing (Lillie and Mason 1983). Nurnberg (1987) reported that hypolimnetic releases typically cause water quality problems when destratification occurs. While hypolimnetic withdrawal has been continuous in Twin Valley Lake since 1967, the lake would stratify without a hypolimnetic discharge. A mathematical model developed by Lathrop and Lillie (1980) reveals that Twin Valley Lake meets the physical criteria and stratification should occur during the warm months.

While destratification is a lake water quality concern linked to high bottom withdrawal rates, downstream water quality is also an important issue and so is air quality. Cooke et al (1986) reported that hypolimnetic withdrawals have been terminated due to water quality problems and nuisance hydrogen sulfide odors. At Lake Redstone, Sauk County, WDNR evaluated a hypolimnetic withdrawal proposal and determined that high ammonia and hydrogen sulfide concentrations posed threats to downstream water quality and a diverse warmwater fisheries (Marshall et al 2002). Diverse macroinvertebrate and fish communities currently thrive below the Lake Redstone spillway. These findings were consistent with Walburg (1981) where hypolimnetic releases pose greater threats to streams than surface releases or spillways.

Hypolimnetic withdrawal projects are typically implemented after thorough analysis of potential resource benefits and threats. The Lake Redstone proposal was ultimately abandoned due to high environmental threats and limited potential for water quality benefit. At Fish Lake, Dane County, a hypolimnetic withdrawal proposal was rejected after model analysis determined that external phosphorus sources were more significant. At Devil's Lake, Sauk County, a hypolimnetic release project is currently underway to reduce internal phosphorus loading. Project planning was based on extensive monitoring and research with predictions of significant phosphorus reduction and lake water quality improvement. Protecting downstream water quality and sustaining lake stratification were a part of the environmental analysis as well. WPDES and Chapter 30 permits were part of the approval process. Detailed analysis should be similar for both downstream thermal management and internal lake phosphorus reduction goals since the environmental risks are the same.

An ongoing monitoring program at Devil's Lake will document responses to hypolimnetic withdrawal. Any modification to the outlet regime at Twin Valley Lake should be monitored as well. A proposed monitoring program should also encompass macrophyte abundance and distribution. Thermal stratification may reduce internal phosphorus loading and potential increased water clarity can benefit rooted macrophytes. Expanded macrophyte cover may further reduce phytoplankton growth due to competition for nutrients and other factors (Canfield et al 1983). Park users have complained of macrophyte growths in Cox Hollow Lake (personal communication – Kathleen Gruentzel). Sustained thermal stratification and macrophyte growth may both play a role in observed greater water clarity in Cox Hollow Lake.

Mill Creek is currently listed as a Class II trout stream. The classification apparently preceded construction of the Twin Valley Lake dam. During the 1960's, conventional wisdom suggested that dams and hypolimnetic release were compatible with downstream trout management. This management model was based on large western oligotrophic reservoirs with voluminous hypolimnions. However, in Wisconsin impoundments are often small, eutrophic (Lillie and Mason 1983) and therefore incompatible for hypolimnetic withdrawal. In small impoundments such as Twin Valley Lake, the hypolimnetic volume is both small and highly enriched with potentially toxic nutrients including ammonia and hydrogen sulfide. Given the long history of water quality problems and limited fisheries below Twin Valley Lake, WDNR should re-evaluate the existing coldwater classification.

Experience and research have demonstrated that warm water fisheries are usually more compatible than trout below impoundments. In this report we presented fisheries data that represents a warmwater stream. Historical data suggests that the fisheries has not changed significantly in the last 30+ years. Fago (1992) reported that mostly eurythermal species thrived in Mill Creek during the 1970's. In Surface Water Resources of Iowa County (WDNR 1968), described the main stem of Mill Creek was managed for smallmouth bass and catfish. Consistent with our findings at Lake Redstone, a surface spillway or surface release can support diverse and healthy warm water fishes.

The current Class II trout stream classification ignores the uncontrollable cultural modifications to the stream. Here are some considerations supporting reclassification of Mill Creek to diverse warmwater fish and aquatic life use. First, the hypolimnetic drain has caused long term water quality degradation that will continue without removing the hypolimnetic outlet. Second, sustainable trout management goals have never been achieved and potential is very low. Third, the public has access to high numbers of good quality trout streams locally and throughout southwest Wisconsin so the urgency for managing trout in this particular stream is not there. Fourth, diverse warmwater fisheries can thrive below a surface spillway.

Recommendations

1. The cooperative managers of Twin Valley Lake should reduce or eliminate the hypolimnetic release to restore lake stratification and water quality.
2. WDNR should design a water quality monitoring study to document the response in both lake and stream water quality.
3. WDNR should conduct a stream reclassification review and reclassify Mill Creek below Twin Valley Lake to Diverse Warmwater Fish and Aquatic Life. The total distance encompassed by the reclassification would be based on existing and potential stream biology.
4. While the phosphorus loading from the Cox Hollow Lake hypolimnetic outlet is not significant compared to the overall Twin Valley Lake budget, the nutrient release undermines the stream ecology. The low volume hypolimnetic seep should be blocked.

Acknowledgments

We thank Matt Otto and Tom Krapf for facilitating this study and planning for long term management of Twin Valley Lake. Thanks to Jon Simonsen, Carl Molter, Donna Sefton and Sarah Carter for their valuable field sampling assistance. We thank Vicki Hugill for providing the rain gage data. We appreciate the reviewers of this document including Matt Otto, Tom Krapf, Barb Lensch, Kathleen Gruentzel, Donna Sefton, Jean Unmuth, Carroll Schaal and Greg Searle.

References

Canfield, Daniel E., Kenneth A. Langeland, Michael J. Maceina, William T. Haller and Jerome V. Shireman. 1983. Trophic State Classification of Lakes with Aquatic Macrophytes. Can. J. Fish. Aquat. Sci., Vol. 40.

Cooke, Dennis G., Eugene B. Welch, Spencer A. Peterson, and Peter R. Newroth. 1986. Lake and Reservior Restoration. Butterworth Publishers.

Dunbar, John A., Paul D. Higley and Sean J. Bennett. 2002. Acoustic Imaging of Sediment Impounded Within USDA-NRCS Flood Control Dams, Wisconsin. USDA Research Report No. 30.

Edwards, Robert J. 1978. The Effects of Hypolimnion Reservoir Release on Fish Distribution and Species Diversity. Transactions of the American Fisheries Society. Vol. 107, No. 1.

Fago, Don. 1992. Distribution and Relative Abundance of Fishes in Wisconsin. Summary Report. WDNR Technical Bulletin 175.

Gebert, Warren A. and William R. Krug. 1996. Streamflow Trends in Wisconsin's Driftless Area. Journal American Water Resources Association. Vol. 32.

Hilsenhoff, William L. 1987. An Improved Biotic Index of Organic Stream Pollution. The Great Lakes Entomologist. Vol. 20, No. 1.

Hilsenhoff, William L. 1971. Changes in the Downstream Insect and Amphipod Fauna Caused by an Impoundment with a Hypolimnion Drain. Annals of the Entomolgical Society of America. Vol. 64, No. 3.

Lathrop, Richard C. and Richard A Lillie. 1980. Thermal Stratification of Wisconsin Lakes. Wisconsin Academy of Sciences, Arts and Letters. Vol. 68.

Lehmkuhl, D. M. 1972. Change in Thermal Regime as a Cause of Reduction of Benthic Fauna Downstream of a Reservoir. Journal Fisheries Research Board of Canada. Vol. 29, No. 9.

Lillie, Richard A and John W. Mason. 1983. Limnological Characteristics of Wisconsin Lakes. WDNR Technical Bulletin No. 138.

Lyons, John and Lizhu Wang. 1996. Development and Validation of an Index of Biotic Integrity for Coldwater Streams in Wisconsin. North American Journal of Fisheries Management. Vol. 16, 241-256.

Marshall, D. W., Steven R. Jaeger, John Panuska, R. C. Lathrop, Jean M. Unmuth and Erin Decker. 2002. Feasibility of Releasing Hypolimnetic Water to Reduce Internal Phosphorus Loading in Lake Redstone. Wisconsin Lakes Partnership Planning Grant Report.

Nix, J., D. E. Tillman, S. L. Ashby and M. S. Dortch. 1991. Water Quality of Selected Tailwaters. U.S. Army Corps of Engineers Tech. Report W-91-2.

Nurnberg, Gertrud K. 1987. Technique. Journal of Environmental Engineering. Vol. 113, No. 5.

Panuska, John and Jeff Krieder. 2001. Wisconsin Lake Modeling Suite. WDNR.

Price, R. E. and E. B. Meyer. 1989. Water Quality Management for Reservoirs and Tailwaters. Report 2. U.S. Army Corps of Engineers Tech. Report E-89-1.

Walburg, C. H., J. F. Novotny, K. E. Jacobs, W. D. Swink, T. M. Campbell, J. Nestler and G. E. Saul. 1981. Effects of Reservoir Releases on Tailwater Ecology: A Literature Review. U.S. Army Corps of Engineers Tech. Report E-81-12.

Wisconsin DNR. 1984. Governor Dodge State Park Master Plan. WDNR Madison.

Wisconsin DNR. 1968. Surface Water Resources of Iowa County. Madison, WI.

Young, W. C. D. H. Kent and B. G. Whiteside. 1976. The Influence of a Deep Storage Reservoir on the Species Diversity of Benthic Macroinvertebrate Communities of the Guadalupe River, Texas. The Texas Journal of Science. Vol. 27, No. 1.