8. Management Activities

This section of the plan addresses specific issues pertaining to Crooked Lake. The issues discussed are in the order identified at the public participation workshop of major issues facing Crooked Lake held on March 25, 2008.

Problem Title Invasive Species

Eurasian water milfoil & curly leaf pondweed

Problem Statement	In the eyes of the public, the presence of Eurasian watermilfoil and curly leaf pondweed was the most-often cited problem needing to be addressed. Both species interfere with recreational and aesthetic use of the lake.

Watershed & Lake Characteristics

Extensive Littoral Zone and Available Eurasian Water Milfoil Habitat	The littoral zone of Crooked Lake encompasses 73% of the lake surface. This means that 83 of the 114-acre surface is prime habitat for these invasive species. Eurasian water milfoil (EWM) and curly leaf pondweed make up a combined 15.4% of the aquatic macrophyte species in the lake. However, the growth characteristics of the plants combined with the extensive availability of habitat (73% of the lake) makes these plants extremely prevalent and a nuisance for boaters and swimmers.
Lake Sediments	The bottom of Crooked Lake is composed primarily of fine sandy muck, a preferred substrate and growth medium for EWM.
Prevalence Of Seed Source And Propagules	The prevalence of both EWM and CLP and their reproduction and growth characteristics ensure a source of plant reproduction, making eradication nearly impossible.
Increased	Sunlight is readily available to a depth of approximately 6 feet over

Problem Title Invasive Species

Insolation (Sunlight penetration and transmission)	57% of the lake bottom.
History of Both Turbid and Clearwater States	In recent history, Crooked Lake has gone through a turbid state (a period of high algal productivity and low aquatic plant productivity (1970s). The lake has also had periods where it exists in a clear water state (low algal productivity, large aquatic plant community). The drivers that led to the switch from a relatively clear water state in the 1940s, 50s and 60s to a more turbid state in the 1970s is well understood. The switch back to a relatively clear water state by the 1990s is not well understood and appears to coincide with the discovery of Eurasian water milfoil in the lake. The concern about over treating for aquatic macrophytes has to do, in part, with the potential for the lake to switch to a turbid water state as a result of the release of nutrients and the decline in dissolved oxygen as the plants decompose.

Current Management Programs and Policies

Aquatic Plant Management	Pesticide control of aquatic macrophytes on all public waters and watercourses, treatment is limited to: The lesser of 15 percent of the littoral area or a maximum of 100 feet of shoreline per site belonging to an individual riparian property owner may be treated for control of submerged vegetation. Applications for large area or baywide treatment must include a written statement of the plan and a map showing areas proposed to be treated.
Aquatic plants growing in public waters are the property of the state	Because of their value to the lake ecosystem, they may not be destroyed or transplanted unless authorized by the Department of Natural Resources.
Prohibited Plant Control Methods	1. Excavating the lake bottom for aquatic plant control 2. Use of hydraulic jets 3. Destroying or preventing the growth of aquatic plants by using lake bottom or benthic barriers 4. Removing aquatic vegetation within posted fish-spawning areas 5. Removing aquatic plants from an undeveloped shoreline 6. Removing aquatic plants where they do not interfere with swimming, boating, or other recreation

Problem Title Invasive Species

Prevention

Boat Inspection: The Crooked Lake Area Association and the MDNR have periodically instituted inspection programs in an attempt to eliminate any further introduction of invasive species into the lake.

MR 6116 states that individuals may not transport watercraft or related equipment containing prohibited invasive species on public roads.

Treatment & Control

Chemical Control: Eurasian water milfoil was first discovered in 1990. Whole lake treatments to control Eurasian watermilfoil have occurred in 1992 and 2002. Partial treatments (15% of the littoral zone) were conducted by the Crooked Lake Area Association in the years:

Year	Target	Scope	Acres	Sponsor	Cost	$/Ac
1982	CLP		12.5	DNR		
1987	CLP		12.5	DNR		
1990	EWM	15%	12.5	CLAA		
1991	EWM	15%	12.5	CLAA		
1992	EWM	100%	83.0	DNR		
1997	EWM	15%	12.5	CLAA	$3,496	$275
1999	EWM	11%	12.5	CLAA	$3,680	$296
2000	EWM	15%	12.5	CLAA	$5,852	$289
2001	EWM	15%	12.5	CLAA		
2002	EWM	100%	83.0	DNR		
2003	EWM	15%	12.5	CLAA		
2004	EWM	15%	12.5	CLAA		
2008	EWM	15%	9.5	CLAA	$4,350	$458

Fisheries

The lake is currently managed for walleye, channel catfish, and largemouth bass. The lake naturally supports a large population of panfish (Centrarchids and smallmouth bass). Dense cover is vitally important to these species.

Demands and Preferences

Demands and Preferences

The presence of invasive species is seen as the single biggest liability to the use and enjoyment of Crooked Lake and, in some instances, to individual home and property value and enjoyment.

What is desired is a lake where invasive species are either below nuisance levels (not readily seen or interfering with boating or swimming) or eliminated from the lake.

Problem Title Invasive Species

Management

Current Situation

Reduction of invasive species within Crooked Lake must be done in a manner that does not

1. Drive the lake into a turbid water state
2. Remove or eliminate plant cover to the point where the removal adversely affects the fishery.

To achieve this:

1. The reduction of invasives must be accompanied by replacement by native submergent species.
2. The rate of replacement must remain below the level that could drive the lake to switch from a clear to a turbid water state.

Management Goal(s)

1. Reduce Eurasian water milfoil (EWM) and curly leaf pondweed (CLP) to below nuisance levels:
   Plants rarely reach the surface
   Navigation and recreational activities are not generally hindered
   Stem density is 0-160 stems/m^2
   Biomass is 0-50 g dry wt/ m^2
   Estimated Total Phosphorus load is <1.7 lbs/acre

2. Increase abundance of native submersed aquatic plants

Strategies to Achieve these Goals

Plant Survey

Annual Survey of Aquatic Macrophytes: distribution, diversity and frequency of aquatic plants.

Monitoring

Continue Water Quality Monitoring. The existing water quality monitoring effort should be continued.

Prevention

Continued Boat Inspection. Inspecting boats at the public access should be continued. The presence should:

1. Occur during high-use periods
2. Provide an enforcement presence
3. Emphasize invasive species and general public education on the nature of the lake.

Chemical Controls

Continue Chemical Control. Annual chemical treatments should be continued to allow for recreational use and aesthetic enjoyment.

Restoration

Begin plant community restoration within the lake. The lake should be evaluated for its potential in restoring native macrophyte communities to restore native fishery habitat and replace EWM & CLP.

Problem Title Invasive Species

Apply for Treatment of 20% of Littoral Zone	Apply for a permit to apply pesticides to submerged vegetation in 20% of the littoral zone (M.R. 6280.0350, Subp 4, A). Limiting chemical treatment to 15% of the littoral zone is a standard and attempts to allow a reasonable but not excessive portion of the lake to be treated. By limiting treatment areas, the 15% rule also forces treatment to occur in the highest priority areas. However, limiting treatment to 20% of the littoral zone achieves the same ends.

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**
Annual Plant Survey	$5,000	Tech Assist	Finance				Lead
Annual Plant Survey Map	$3,000	Tech Assist		Lead & Finance			
Annual Chemical Treatment	$4,500		Lead		Finance	Finance	Regulatory Oversight
Apply For Treatment of 20% of Littoral Zone	$6,000		Lead & Finance				Regulatory Oversight
Boat Inspection	-		Lead				Tech Assist
Plant Restoration	$10,000	Tech Assist	Finance	Tech Assist			Finance
Water Quality Monitoring	$587	Lead		Finance			

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
Andover	Annual Chemical Treatment	2,250	2,318				$ 4,568
	Treatment of 20% of Littoral Zone			3,000	3,090	3,183	$ 9,273
CCWD	Annual Plant Survey & Map		3,000	3,090	3,183	3,278	$ 12,551
	Water Quality	587	605		641	661	$ 3,116

	Monitoring						
Coon Rapids	Annual Chemical Treatment	2,250	2,318				$ 4,568
	Apply For Treatment of 20% of Littoral Zone			3,000	3,090	3,183	$ 9,273
Crooked Lake Area Assoc.	Plant Restoration	10,000	10,000	10,000	10,000	10,000	$ 50,000
DNR	Annual Plant Survey		5,000	5,150	5,305	5,464	$ 20,918

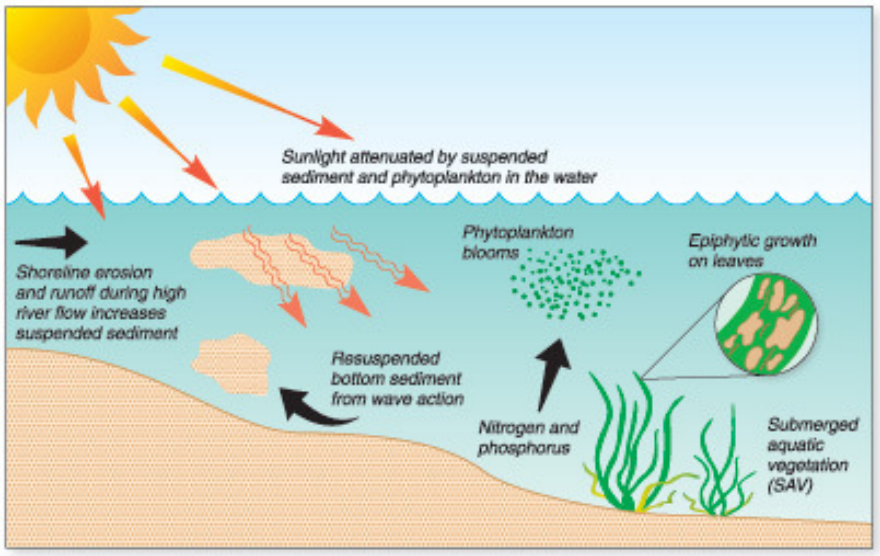
Outcome Measures Decrease in dominance of Eurasian water milfoil and curly leaf pondweed

Milestones

Annual spring treatment for Eurasian water milfoil
Annual monitoring of vegetation
Annual water quality monitoring for at least

1. Clarity
2. Phosphorus
3. Chlorophyll-a

Problem Title **Water Clarity**



Problem Statement

Water clarity/transparency is affected by algae, soil particles, and other materials suspended in the water. The Clarity/ Transparency of the water is measured using a Secchi disk. A Secchi disk is a small disk that is lowered into the water until it cannot be seen. The depth at which it disappears when it is lowered, and reappears when it is raised are recorded and averaged as a measure of clarity/transparency.

Secchi readings are not a direct measure of water quality. However, transparency is often indicative of lake overall water quality, especially the amount of algae present. It is also a measure of light penetration and therefore plant composition and growth.

Watershed & Lake Characteristics

Lower Phosphorous Levels	Phosphorus concentrations have decreased 40% from 1983 to 2006 to an annual average of 30 ug/l. With lower phosphorus levels there is a corresponding decrease in blue green algae, a major detriment to water clarity.
Lower Chlorophyll-a Levels	Chlorophyll-a in the water column is a direct measure of free floating plant growth (usually algae) in the water column. Chlorophyll-a concentrations in Crooked Lake have decreased by almost 52% since 1980 to an annual average in 2006 of 11.6 ug/l.
Prolonged Residence Time	Crooked Lake is a shallow, closed lake basin with an extended residence time (7.4 years).

Problem Title Water Clarity

Current Management Programs and Policies

Research: Water Quality Monitoring

Data on water clarity/transparency began to be collected for Crooked Lake in 1975, and has continued two of every three years since that time. Over that period the lake has exhibited a typical transparency depth of between 3.3 and 5.9 feet, with a 32-year average of 4.7 feet.

The worst years for clarity were 1976 and 1988 when transparency was 3.0 feet. The 'clearest' year was 1992 when clarity averaged 7.5 feet. 1992 was also the year of the whole basin treatment for Eurasian water milfoil which was judged by DNR to have a detrimental affect on the lake and its fishery because of the significant loss and decrease of macrophytic plants.

Water clarity has improved considerably since the late 1970s.

Decade	70s	80s	90s	00s
Avg Secchi Depth (Ft)	3.4	3.6	5.3	6.2

Circulation and Destratification

Aerators have been used on Crooked Lake to prevent or discourage winter kills of the fishery. Aerators keep water moving and are intended to break up stratification within the lake.

Ponding Requirements

Since 1994 Coon Creek Watershed District requires new development or redevelopment of greater than 1 acre that discharges into a lake to pre-treat stormwater to remove 50% to 80% phosphorus.

The 1999 reconstruction of Bunker Lake Blvd routed all storm water to Meadow Creek Church water quality pond for treatment prior to discharge into Crooked Lake. The pond was designed to meet the 50%-80% phosphorus removal efficiency standard.

Phosphorus Free Fertilizer

In 2005, the non-phosphorus fertilizer law went into effect limiting or prohibiting the inclusion and sale of fertilizer containing phosphorus.

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In-Lake Control: Herbicide Applications

Beginning in 1992 Crooked Lake has seen several herbicide treatments. The 1992 whole lake treatment was conducted on the entire lake. Since then there have also been several private and Crooked Lake Area Association-sponsored treatments limited to 15% of the littoral zone.

It would appear that a decrease in concentrations of both phosphorus and Chlorophyll-a have occurred since that time.

Problem Title Water Clarity

However, no monitoring for these factors was conducted within 2 years before or after the 1992 treatment, so caution should be exercised in too closely drawing a correlation with the increase in water clarity.

Demands and Preferences

First addressed in 1987, water clarity was the fourth most-cited aspect of Crooked Lake that people wanted to see improved. Water clarity 'improvement' however was listed second and was cited as one of the three most important issues facing Crooked Lake.

Current Situation Assessed on an annual basis, water clarity has continued to improve over the past 40 years

Management Goal(s)	Secchi depth of 6 ft.
Strategies to Achieve these goals	Maintaining this goal will require a four prong strategy 1. Monitoring: continue lake water quality monitoring 2. Use aerators when needed 3. Inspect Meadow Creek Pond and repair if needed 4. Inspect aqueduct pond and repair if needed

Recommended Management Activities

Lake Water Quality Monitoring	The existing water quality monitoring efforts which include taking secchi disk depth measurements needs to continue.
Pond Inspection	Inspection of Meadow Creek and Aqueduct ponds as part of the NPDES inspection schedule is essential.
Repair Infrastructure as needed	The Meadow Creek and aqueduct ponds are intended to remove 40 %-60% of phosphorus from runoff. Periodic maintenance of these ponds through dredging is essential.

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**
Monitoring	$240	Lead		Finance			
Regular Pond Inspection	$250			Tech Assist	Lead		

Problem Title Water Clarity

Pond Maintenance as Needed	$2,500	Finance

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
CCWD	Monitoring	$240	$247		$262	$270	$1,019
Andover	Pond Inspection	$250					$250
	Pond Repair						

Outcome Measures Total phosphorus
Chlorophyll-a

Milestones
1. CCWD x ACD Annual Monitoring Plan
2. Andover Annual NPDES Inspection Plan

Problem Title **Muck**

Problem Statement Muck was the third most-often cited issue facing Crooked Lake, yet was listed 6th in the aspects of Crooked Lake that people would like to see improved.

Physical Factors: Watershed & Lake Characteristics

Original Soil and Substrate	A channel from the public access to the main body of the lake is informally maintained through repeated boat traffic traveling to and fro during various water levels. Both the boat hull and engine prop act to mechanically clear a channel of vegetation and push the substrate aside. However, saturated sapric substrate (muck) is largely fluid or viscous and if the channel is not used for a period of time and/or lake levels drop, much of the access channel will readily fill in.
Bathymetry and Slope of North Bay	The north bay is a relatively shallow and flat area of the lake. The 1,000 feet south from the Boat ramp has a fairly uniform and average slope of less than 0.5%. The result is that for each 0.5 feet the lake surface drops in elevation from 860.0 feet, approximately 94 feet of lake bed is exposed and another 94 feet becomes almost too shallow for most boats.
Water Level Fluctuations	Crooked Lake will experience an average annual fluctuation in water levels of approximately 1 foot. Annual high water is typically recorded in May with water levels dropping and reaching an annual low sometime between the end of August and freeze-up.
Historic Water Levels	Prior to 1934, Crooked Lake was at an elevation of approximately 860.0. Between 1934 and 1940 several earthen dams were constructed at the south end of the lake to raise the lake level. The first two dams had leakage problems so were replaced or repaired. The dam raised the normal water level of Crooked Lake first by 1 foot and then 1.6 feet to the current elevation of 861.6.

Current Management Programs and Policies

Excavation Of Public Waters	Minnesota Rule 6115.0220 limits the excavation of materials from the beds of public waters in order to: A. preserve the natural character of public waters and their shorelands B. regulate the nature, degree, and purpose of excavations so that excavations will be compatible with the capability of the waters to assimilate the excavation; and

Problem Title	**Muck**
	Prohibited excavation. Excavation is prohibited in the following cases: A. Where it is intended to gain access to navigable water depths when such access can be reasonably attained by alternative means which would result in less environmental impact; C. When the proposed excavation will be detrimental to significant fish and wildlife habitat and there are no feasible, practical, or ecologically acceptable means to mitigate the effects;
Soil Borings	In February, 2008, two borings of the lake bottom were taken on the north end of the lake. The northern most boring showed an undisturbed soil profile with 24 inches of black (N 2.5/) sapric material over a dark to very dark brown sand (10YR 2/2 to 10YR 4/2). The southern boring (which is within the northeast bay that outlets subwatershed 9&10) showed approximately 28 inches of Brownish (7.5YR 4/2 to 7.5YR 6/3) sandy overburden followed by 13 inches of black (N 2.5/) sapric material underlain by 14 inches brown and dark brown (10YR 3/1 & 10YR 5/3) sand with approximately 10% strong brown mottles (7.5YR 5/6). The colors of the overburden are consistent with Hubbard sand, the adjacent upland soils. However, the texture appeared more fine than the coarse sand described for Hubbard soil
Social Factors: Demands and Preferences	
North Bay near Public Access	Discussions with Lakeshore owners and lake users focused on the north bay of the lake in the vicinity of the boat access. Concerns appeared to address: 1. Weed growth 2. The potential contribution of 'muck' from a. Stormsewer outlets b. Carp and turtles stirring up the bottom c. Detritus from previous years plant growth
Current Situation	Muck is the natural substrate of Crooked lake. While it is underlain by a dark brown sand, the upper part which provides an anchoring medium and nutrients for aquatic plants is muck. Muck is by definition organic in nature, meaning it is comprised

usually of plant material that has been broken down to the point where the plant material is no longer identifiable. The source of the organic material is the plant and animal life in and adjacent to the lake.

At present, the lake is in an acceptable resource condition where muck is concerned. A possible issue is the occurrence of a potential area of sedimentation in the northeast bay.

The size and shape of the potential sedimentation area is unknown at this time. Should the sediment need to be removed, a DNR permit for work in public waters would need to be obtained. To obtain that permit, details on the nature and extent of the sedimentation would need to be documented.

Management Goal(s) Determine the nature and extent of sedimentation/fill in the northeast bay of Crooked Lake.

Strategies to Achieve these goals

Investigate the Extent of Sedimentation in the Northeast Bay

Mode of Action	**Advantages**	**Disadvantages**
The southern lake core boring clearly shows approximately 28 inches of fill. The fill has occurred over a long period of time (approx 30 years) as evidenced by the banding in the soil profile.	Determining and mapping the area of fill provides a factual basis for pursuing a dredging in public waters permit.	*Investigation will need to consider existing use of area by fishery and existing macrophyte population.

Dredge Boat Channel for Public Access

Mode of Action	**Advantages**	**Disadvantages**
Mechanical removal of sediment and substrate	Directly clears channel for boating use	* To consider or allow dredging will be evaluated in terms of potential effect on the fishery and plant community of the lake. *Dredging requires a dredge disposal site to allow the material to drain and dry

		before it is removed from the area. * Access for boats would still be dependent on water levels

Recommended Management Activities

Continue Taking Lake Core Samples	Minnesota State University has expressed an interest in continuing to take core samples within Crooked Lake. These samples would be critical in determining the extent and depth of sedimentation in the North bay area.

Education:

Implementation

Method	Unit Cost	Means ACD	CLAA	CCWD	Andover	CR	DNR
Lake Core Samples		Tech Assist	Lead	Tech Assist			
Dredge Boat Channel	5,000-10,000		Lead		Finance		Permit Review

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
Crooked Lake Area Assoc	Lake Core Samples						
	Dredge Boat Channel				5,000 – 10,000		5,000 – 10,000

Outcome Measures 3-D map of lake substrate and extent of sedimentation

Milestones Annual sampling of lake cores
Map of sedimentation area

Problem Title — Nonpoint Source Pollution

Problem Statement — Nonpoint source pollution was the fourth most-often cited problem facing Crooked Lake and tied second for the aspect of Crooked Lake people would like to see addressed.

Physical Factors: Watershed & Lake Characteristics

Land use and Loadings

70% of the contributing drainage area into Crooked Lake is residential. It is the largest single land use affecting Crooked Lake. Residential land uses contribute approximately 89% (38,395 lbs/acre/yr) of the suspended solids to the lake and approximately 90% of the total phosphorus (132 lbs/acre/yr).

Other contributors are:

- vehicular traffic
- lawn care
- pets
- eroded sediment
- vegetative litter

Low Phosphorus Levels

Phosphorus concentrations have significantly decreased from 1983 to 2006. The annual average phosphorus concentration over the last 12 years is 30 µg/l.

Current Management Programs and Policies

Meadow Creek Church Pond

In 1999 Bunker Lake Blvd was reconstructed. At that time, stormwater from the roadway was routed to the pond at Meadow Creek Church securing treatment of all of Drainage Area 7.

Coon Creek Aqueduct

The aqueduct from Coon Creek to Crooked Lake is the outlet for subwatershed 10. The old channel and the remaining adjacent wetland areas provide sufficient storage for a long enough period of time to gain non-point treatment for subwatershed 10.

Storm Water Pollution Prevention Planning (SWPPP)

The cities of Andover and Coon Rapids and the Coon Creek Watershed District are MS4s under the NPDES program administered by the MPCA. All three units of government are required to develop plans and programs for the protection and improvement of water quality within their jurisdictions to the maximum extent practicable.

Social Factors: Demands and

Nonpoint source pollution was the fourth most often cited problem facing Crooked Lake and tied second for the aspect of

Problem Title — Nonpoint Source Pollution

Preferences	Crooked Lake people would like to see addressed.		
Current Situation	Non-point pollution is pollution that occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up or dissolves pollutants, and deposits them into rivers, lakes, and other waters or introduces them into ground water. Urban surfaces are subject to the deposit of various contaminants which are then subject to wash-off by rainfall or snowmelt. Typical contributors to pollutants in runoff include vehicular traffic, industry, power production, lawn care, pets, eroded sediment, and vegetative litter. The major nonpoint-source pollutants include sediment, nutrients, oxygen-demanding substances, toxic chemicals, chloride, bacteria and viruses, and temperature changes.		
Management Goal(s)	Phosphorus, Total Chlorophyll-a Secchi disk transparency Oxygen, dissolved	40 mg/L <15 mg/L >1.2 meters 5 mg/L daily average 4 mg/L daily minimum	
Strategies to Achieve these Goals			
Buffer Strips: Subwatershed 8/Lakeshore	**Mode of Action** Can nearly halt discharge of water through physical filtering and bio-uptake of surface water flow through obstruction by plants and then bio uptake intercepted nutrients	**Advantages** *****Provides a permanent source of protection to the lake from direct drainage of water borne pollutants. * Provides wildlife habitat immediately adjacent to lake.	**Disadvantages** ***** Homeowner concerns about "looks"
Catch Basin Stenciling	**Mode of Action** Act as a public system to discourage the placement of pollutants in street	**Advantages** *Act to draw public attention to drainage system and that everything is	**Disadvantages** *relies on volunteer effort and compliance

	or curb systems that drain to the lake	connected	
Curb Cut Rain Gardens Subwatersheds 6, 5, & 3	**Mode of Action** Curb cut rain gardens act as a type of infiltration/ bioretention BMP. The rain gardens are installed adjacent to the curb so that stormwater flowing down the curb line is routed into the rain garden where it is either infiltrated or utilized by the landscaping.	**Advantages** * Will treat an average of 65% of total phosphorous generated by drainage area * Can be adapted to 'fit' the landscaping objectives of the property on which they are located	**Disadvantages** * Uncertainty about new practice among home owners * Maintenance of rain gardens and long term performance are unknowns
Clarify Potential Encroachment on Coon Creek aqueduct	**Mode of Action** Air photos appear to indicate that the Coon Creek Aqueduct in subwatershed 10 may have experienced encroachment and fill. If this is the case, then both the storage and water quality benefits provided by this area would be compromised.	**Advantages** If this area needs to be and can be restored, then Crooked Lake would benefit through enhanced water quality treatment.	**Disadvantages** If encroachment has occurred over a long period of time and among numerous owners, then enforcement can be prolonged.

Recommended Management Activities	1. Install buffer strips on 50% of shoreline 2. Clarify potential encroachment on Coon Creek Aqueduct 3. Install curb cut rain gardens: Subwatersheds 6, 5, & 3 4. Implement SWPPP 5. Stencil catch basins

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**

Problem Title Nonpoint Source Pollution

Stencil catch basins	$400		Lead	Finance		
Install Buffer Strips	$50/lf	Tech Assist	Lead			
Inspect Aquaduct	$250			Tech Assist	Lead	
Install Rain Gardens	$5/sf	Tech Assist		Tech Assist	Lead	
Implement SWPPP				Lead	Lead	Lead

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
CLAA	Stencil catch basins						$0
	Install Buffer Strips		$4,500-7,500	$4,500-7,500	$4,500-7,500	$4,500-7,500	$18,000-30,000
Andover	Inspect Aquaduct	$250					$250
	Install Rain Gardens	$5,000	$5,000	$5,000			$15,000

Outcome Measures

Phosphorus, Total	40 mg/L
Chlorophyll-a	<15 mg/L
Secchi disk transparency	>1.2 meters
Oxygen, dissolved	5 mg/L daily average 4 mg/L daily minimum

Milestones

CLAA stenciling project
Active installation and maintenance of buffer strips
Inspection of Coon Creek Aqueduct
Demonstration project grant to City of Andover for Curb Cut rain gardens

Problem Title	**Trash**
Problem Statement	Trash and garbage were the fifth most-cited issue facing Crooked Lake and the third most-cited issue that citizens noted as wanting to be addressed Attendees to the workshop spoke adamantly about the amount of trash being left at the public access in both summer and winter as well as what appears may be dumping at the public access. In addition, attendees spoke about the amount of trash left on the ice by ice-fishermen and others using the lake in winter.

Physical Factors: Watershed & Lake Characteristics

NA- littering and dumping of garbage are not issues of the natural resource but a by-product of human misuse of the resource.

Current Management Programs and Policies

Enforcement	Crooked Lake is currently patrolled by the Anoka County Sheriff Department at the request of the City of Andover. The public access is also patrolled by the DNR Conservation officer. The public access is part of a routine patrol route.

Social Factors: Demands and Preferences

Increased Enforcement	Citizens on the lake have indicated that they have requested increased enforcement and an increased enforcement presence on the lake from the Cities, Anoka County, and the DNR.
Current Situation	Citizens continue to request increased enforcement and an increased enforcement presence on the lake and at the public access.
Management Goal(s)	Keep Crooked Lake Clean

Strategies to Achieve these Goals

Install garbage cans and signage	**Mode of Action** By making the issue of trash and the need to pick up trash more visible. And by making trash	**Advantages** *Makes the issue of trash, pollution, and public dumping more visible	**Disadvantages** * Can act as an invitation to litter and dump * Increased cost

	containers more available, it is hoped that littering and dumping will decrease.	* Makes disposal easier and more convenient	
Increased frequency of garbage pick up	**Mode of Action** Keeping the public landing picked up should decrease the tendency for littering	**Advantages** *Can decrease the tendency for littering	**Disadvantages** * Increased cost * Building momentum to keep an area looking nice can be a lengthy process and can achieve limited success if increased enforcement does not also occur.
Enforcement blitz/campaign	**Mode of Action** Maintaining a presence or increasing the frequency of a public presence with enforcement ability will decrease littering and potentially displace those individuals	**Advantages** *Catch those individuals who are creating the problem	**Disadvantages** *Increased cost
Recommended Management Activities	Install garbage cans and signage Increased frequency of garbage pick up Enforcement blitz/campaign		

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**
Install garbage cans and signage	$200				Lead		
Increased frequency of garbage pick up	$1,500				Lead		
Enforcement blitz/campaign	5,000				Lead		

Problem Title **Trash**

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
Andover	Install garbage cans and signage	$200					$200
	Increased frequency of garbage pick up	$1,500	$1,500	$1,000			$4,000
	Enforcement blitz/campaign	$5,000	$5,000				$10,000

Outcome Measures Number of garbage pick ups/year
Number of litter pick ups/year

Milestones Keep Crooked Lake Clean Sign
Crooked Lake Area Association Annual Report

Problem Title **Water Levels**

Problem Statement Water levels were the sixth most-cited issue facing Crooked Lake, and the fourth most-cited aspect that workshop attendees wanted to see addressed. It is an issue for boating and lake access at the north and south ends of the lake. The bottom slopes of the lake are very gradual and small variations in the surface elevation of the lake can render both ends un-navigable as well as more conducive to emergent plant growth.

The water level in Crooked Lake is the oldest issue on the lake, dating back to at least 1934. Prior to 1934, Crooked Lake was at an elevation of approximately 860.0. At that time, the public sought to raise the average lake elevation approximately one foot.

Between 1934 and 1940 several earthen dams were constructed at the south end of the lake to raise the lake level. The first two dams had leakage problems so were replaced or repaired. The dam raised the normal water level of Crooked Lake one foot and then again to the current elevation of 861.6

Physical Factors: Watershed & Lake Characteristics

Current Elevations On November 5, 2007, Crooked Lake was at 860.64. This elevation is 0.06 feet below the 10 year average water level of the Lake and 0.10 feet below of 20 year average. Both fluctuations are well within the normal fluctuating range of 0.86 feet (10.32 inches) for the lake.

On October 24, 2008, the last posted reading for Crooked Lake was an elevation of 859.96.

Water Sources Decreased Precipitation: Four of the last five years have been dry (13.4% below normal). In addition, such droughty conditions have an affect on the amount of runoff due to the decreased amount of soil moisture and a decline in ground water elevations.

Groundwater Flux: Observed values for the permeability of sandy soils is approximately 70 meters/day (230 feet/day).

Water Losses Increased Temperatures/Evapotranspiration. The 1990s and 00s have been 5% to 10% warmer than the long term average. Such a temperature increase will contribute significantly to water loss from the lake through increased evapotranspiration.

Problem Title	**Water Levels**
	Potential Leakage due to declines in surficial aquifer levels. The best available information shows that ground water levels have been as high as approximately 859. The most current information indicates groundwater would intercept the bed of Crooked Lake at an elevation of approximately 850 (18% of the lake bottom) (Hickok & Associates, 1972). Should ground water drop lower, a "slow leak" could be expected.
	Potential leakage of earthen dam. The dam was inspected in fall 2008. Water levels were at least 0.5 feet below the toe of the lake side of the dam. No leakage was observed and no signs of recent discharge were observed.

Current Management Programs and Policies

Dam at South End of Lake with a Runout Elevation of 861.6	In 1940 the State of Minnesota completed an earthen dam with the goal of establishing a new lake level of 861.6.
Lake Level Monitoring	The elevation of the surface of Crooked Lake has been monitored several times a month for the past 30 years.

Social Factors: Demands and Preferences

Water levels were the sixth most-cited issue facing Crooked Lake, and the fourth most-cited aspect that workshop attendees wanted to see addressed. It is an issue for boating and lake access at the north and south ends of the lake.

Current Situation	There are several unknowns about the behavior of water elevations of Crooked Lake, particularly the connection between lake levels and groundwater .
Management Goal(s)	To develop a better understanding of the water budget, particularly water supply of Crooked Lake

Strategies to Achieve these Goals

	Mode of Action	**Advantages**	**Disadvantages**
Inspect Dam	Site inspection by engineer & DNR Hydrologist	Documentation of the condition and performance of the nearly 70 year old structure	

Problem Title	**Water Levels**		
Lake Level Monitoring	**Mode of Action** Weekly to bi-weekly measurements of lake levels	**Advantages** Long and short term record of lake elevations separates perception from reality	**Disadvantages** Causes of lake level fluctuations can not be determined solely through lake level monitoring
Ground Water Monitoring	**Mode of Action** Record depth to ground water in observations wells designed to monitor the surficial aquifer	**Advantages** May provide early warning of declines in ground water and therefore water source for lake	**Disadvantages** Installation of an adequate network of ob-wells to predict impacts on Crooked Lake would be expensive to install and maintain

Recommended Management Activities

Inspect the earthen dam
Continue lake level monitoring
Ground water monitoring

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**
Inspect Dam	$250			Lead			Tech Assist
Lake Level Monitoring	$120	Tech Assist		Lead			
Ground Water Monitoring	$525	Tech Assist		Lead			Tech Assist

Costs

Agency	**Activity**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
CCWD	Inspect Dam	$250					$250
	Lake Level Monitoring	$ 120	124	127	131	135	$637
	Ground Water Monitoring	$1,575	1,575	1,575	1,575	1,575	$7,875

Outcome Measures

Inspection Report every 5 years
Annual county water atlas

Milestones

Inspection Report every 5 years
Annual county water atlas