Summary of Upper Lake Whitney Management Study January 23, 2002

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The South Central Regional Water Authority (the Authority) has commissioned this Upper Lake Whitney Management Study to assess long-term water supply implications and address public concerns regarding ongoing sedimentation in the Upper Basin of the Lake Whitney Water Supply Reservoir. The Upper Basin is the area between Waite Street and Connolly Parkway. The study documents existing resource conditions and evaluates the potential impacts of alternative management options. The goal of the study is to determine the most environmentally sensitive and cost effective way to manage upper Lake Whitney as a water supply while maintaining the ecological and aesthetic quality of the area. The study includes analysis of upstream Mill River watershed factors that affect environmental conditions in upper Lake Whitney. Also discussed are the implications of reduced groundwater withdrawals on the ecological health of the Mill River.

Plans are currently under way to construct a new treatment plant and re-establish Lake Whitney as an active water supply source by 2004. The highest withdrawals will generally occur during periods of high river flow typical of winter and spring.

The Authority selected Milone & MacBroom, Inc. (MMI) of Cheshire, Connecticut; CH2M Hill of Boston, Massachusetts; ENSR of Westford, Massachusetts; and Roald Haestad, Inc. of Waterbury, Connecticut as the project team.

The Management Study addresses the following issues:

1. ***Existing Conditions of the Reservoir:*** Including storage volume, sediment quantity and quality, sedimentation rates and biological diversity and quality.
2. ***Management Alternatives:*** Alternatives for maintaining the water supply, ecological, aesthetic and social value of the reservoir. These alternatives were evaluated based on the results of a survey of stakeholders and a technical assessment of management methods.
3. ***Selection of a Management Alternative:*** A management alternative is selected based on the results of an alternatives assessment.

Lake Whitney and Its Watershed

Lake Whitney is located within the Mill River watershed. According to the Authority's Land Use Plan (1996), the Authority owned property in the Lake Whitney watershed totals approximately 750 acres, or about 3% of the 23,296-acre watershed.

The lake consists of five basins separated by five roadways and has an average depth of 15 feet. However, depths vary from less than five feet in the upper basin to up to 30 feet in the lower basin. Results of a bathymetric survey completed for this study indicate that the reservoir's water surface area is 154 acres. Table ES-1 provides the area of each basin based on the results of this survey.

Table ES-1 **Reservoir Areas**	
Segment	**Area, Acres**
Lower Basin	28.71
Lower Middle Basin	45.81
Upper Middle Basin	20.30
Upper Basin	59.40
Total	**154.22**

The bathymetric survey was used to estimate the sediment area that would be exposed in the Upper and Upper Middle Basin during a variety of drawdown scenarios that could occur when the reservoir is being used for public water supply. Table ES-2 provides the results of this analysis.

Table ES-2 **Summary of Reservoir Drawdown versus Exposed Sediment Areas In Upper and Upper Middle Basin Existing Conditions**	
Drawdown (Feet below Spillway)	**Exposed Area** (Acres)
0	0
1	4.35
2	13.40
3	23.16
4	35.17
5	58.92

Drawdown Modeling

A mass balance hydrologic model of the reservoir was developed by Roald Haestad Inc. (Haestad) as part of this report to estimate the frequency and magnitude of lake drawdowns after the new plant is operating. This model uses data from historical stream flows representing a normal rainfall year (1974), a dry year (1981), and a year within a multi-year drought (1966). A wet year was not modeled because previous modeling of the representative wet year of 1975 determined that the lake remains above the spillway elevation 100% of the time during these periods (CH2M Hill, 1998). New information that was not available during the previous modeling effort was incorporated into the updated model, including the following:

- ***Reduced wellfield withdrawals:*** The new water treatment plant, working in tandem with three new pumping stations, will allow the Authority to move treated water more efficiently from the southern to northern reaches of its water distribution system. This will allow less reliance on the four existing wellfields that pump groundwater from the Mill River aquifer. Reduced groundwater withdrawals will benefit the aquatic environment by increasing base flows in the upper Mill River from south Cheshire to Lake Whitney.

- ***Management Plan withdrawal reductions:*** The Lake Whitney Water Treatment Plant will be operated in accordance with a management plan designed to balance water supply demands and the environmental needs of the Mill River and Lake Whitney. Under most circumstances, withdrawals will be reduced to less than 1/3 of the maximum allowed by the CT DEP when the lake level drops to lower than 0.2 feet (2.4 inches) over the spillway elevation.
- ***Downstream releases:*** The management plan calls for downstream releases of up to 4.2 mgd from Lake Whitney to the lower Mill River when the lake's water level falls below spillway elevation. Since these releases will be a determining factor for water levels in Lake Whitney, they have been incorporated into the updated model.

According to the model results that are presented in Tables ES-3 and ES-4, drawdowns in Lake Whitney of greater than one foot will be a rare occurrence. For comparison, a one-foot drawdown would reduce the lake's water surface area by about three percent.

Table ES-3
Lake Level Model
Maximum Annual And Summer Drawdowns (a)

Modeled Year (b)	**Maximum Annual Drawdown** (ft.)	**Maximum Summer Drawdown** (ft.)
Normal	0.35	0.35
Dry	1.6 (c)	0.51
100 Year Drought	5.5 (c)	1.4

(a) Based on results of analysis completed by Haestad in 2001.
(b) A wet year would have 0 days of drawdown (CH2M HILL, 1998).
(c) Maximum drawdowns in modeled dry and drought years are projected to occur in winter months.

All 12 drawdown days projected in a normal year are predicted to be less than 0.4 feet. As previously stated, the lake would remain above spillway elevation for the entire duration of a wet year.

Modeling was completed based on 1981 rainfall data to determine reservoir drawdowns in a dry year (e.g., with an estimated likelihood of occurring once every 10 to 20 years). The result of this analysis indicated that drawdowns in excess of one foot are estimated to occur on only nine days, all in January and February. Summer and fall drawdowns during a dry year would be 0.5 feet or less.

During the summer months of the worst-case 1 in 100-year drought simulation (based on 1966 rainfall data), summer drawdowns would be between one and 1.5 feet on only 19 days during August and September. Drawdowns would range from three to five and one-half feet on 44 days during the winter season of this same drought year scenario. In both the dry and drought model year's, maximum drawdowns are predicted to occur during the winter season. Exposed mudflat odors and mosquito breeding habitat would not be of concern during winter drawdowns.

Table ES-4
Lake Level Model. Monthly Summary for Normal, Dry and 100-Year Drought Years (a)

Modeled Year (b)	At Spillway or Higher		>0' to 1' Down		>1' to 2' Down		>2' to 3' Down		>3' to 4' Down(c)		>4' to 5' Down(c)		>5' to 5.5' Down(c)	
	# of Days	% of Year	# of Days	% of Year	# of Days	% of Year	# of Days	% of Year	# of Days	% of Year	# of Days	% of Year	# of Days	% of Year
Normal	353	96.7	12	3.3	0	0	0	0	0	0	0	0	0	0
Dry	299	81.9	57	15.6	9(c)	2.5(c)	0	0	0	0	0	0	0	0
100-Year Drought	180	49.3	113	31.0	28	7.7	0	0	8(c)	2.2(c)	7(c)	1.9(c)	29(c)	7.9(c)

(a) Based on results of analysis completed by Haestad in 2001.
(b) A wet year would have 0 days of drawdown (CH2M Hill, 1998).
(c) All drawdown days occur during January and February.

This model analysis supports the premise that implementation of the Management Plan will effectively minimize impacts on upper lake habitats. The most likely reason for extended drawdowns will not be for water supply, but rather for maintenance of the Lake Whitney dam and the public infrastructure around the lake, such as bridges, roads, and sewers. Since the Lake Whitney Water Treatment Plant went off-line in August 1991, there have been four periods of up to six months where the lake was drawn down by as much as 6.7 feet for either dam or bridge maintenance. These intentional drawdowns will continue to occur from time to time regardless of Lake Whitney's future use as a water supply, as they are necessary for public safety and welfare.

The Upper Basin

The Upper Basin of the lake has historically been impacted by sediment deposition and accumulation. Water depths vary from nine feet near the Waite Street bridge to as little as two feet at the mouth of the Mill River.

A 1,100-foot long sediment bar has developed at the mouth of the Mill River. The subaqueous portion of the sediment extends another 500 feet into the center of the Upper Basin. The Mill River channel is on the west side of the sediment bar. The area east of the sediment bar is a shallow cove with one to two feet of water. This cove has been created as a result of the Mill River sediment bar, which isolates the cove from currents and wind.

The sediment deposit in this area is the result of both natural riverbank erosion and urbanization within the watershed. During periods of high flows, such as spring storms combined with snowmelt, water velocities within the Mill River channel increase. This increased velocity increases the rate of sediment transport as the small particles from the channel bed and banks are moved downstream. These sediments deposit in areas of low velocity, such as Lake Whitney.

Large diameter sand particles settle faster than smaller silts and clays and so accumulate at the confluence of the river and Lake Whitney.

As the sediment bar began to form, water velocities tended to stay elevated further into the basin. As a result, particles settle out further downstream. As this deposition occurs further and further downstream, the sand bar has become elongated and has taken the shape it has today.

Sediment Dating and Analysis

Seven sediment cores were collected from the Upper and Upper Middle Basins for radioisotope dating. Sediment dating was based on lead (Pb) 210 and cesium (Cs) 137. The sedimentation rate in the Upper Basin was determined to be 0.5 cm/yr (0.2 inches/year) based on cesium dating and 0.6 cm/yr (0.24 inches/yr) based on lead 210.

Additional sampling was completed in the Upper and Upper Middle Basin for chemical and physical analysis. Samples were analyzed for grain size distribution, metals, volatile organics, PCB's, PAH's, and pesticides. Results of the grain size analysis are shown in Table ES-5. Chemical parameters were not identified in any of the samples in concentrations that exceed current limits established by the Connecticut Remediation Standards.

Table ES-5
Summary of Sieve Analysis Results

Boring Location	D50 (mm)	Description
B-1	0.5	Medium sand
B-2	0.42	Medium sand
B-3	0.08	Very fine sand
B-4	0.03	Medium silt
B-5	0.38	Medium sand
B-6	0.017	Medium silt
B-7	0.085	Very fine sand
B-8	0.091	Very fine sand
B-9	0.032	Coarse silt
B-10	0.288	Medium gravel

The Biological Community of the Upper Basin

A biological study was completed to assess the phytoplankton, zooplankton, macrophytes, macro invertebrates, fish and wildlife in the Upper Basin. Nutrient loading was modeled based on the watershed characteristics.

Phytoplankton

Diatoms, green algae and cryptophytes dominated the phytoplankton community. Overall, the biomass accumulation is expected to remain below nuisance levels, although accumulations may increase during drought conditions.

Zooplankton

Zooplankton included protozoans, rotifers, copepods, cladocerans and ostracods. The size and diversity of the zooplankton did not vary appreciably between seasons, and its low abundance provides limited available food for the fish community and almost no grazing pressure on the algae. The relatively low zooplankton abundances are likely a result of predation by planktivores and rapid flushing of water through the Upper Basin.

Macrophytes

While not especially dense, macrophytes are visibly dominant in the Upper Basin of Lake Whitney in the summer months, although open water does remain in the southern portion of this basin. The shallow waters of the Upper Basin contribute to the growth of these species. The most common species identified were duckweed, waterweed, water lilies, and swamp loosestrife. Macrophyte cover was most dense near the Mill River inlet to the basin. Duckweed is generally an indicator of high nitrogen concentrations.

Benthic Macroinvertebrates

Overall, invertebrate numbers were relatively low, likely due to low habitat quality and the presence of predatory fish. Common carp were identified in the Upper Basin, which may explain the limited invertebrate populations.

Fish

Fish species were dominated by carp, white perch, yellow perch, golden shiners and white suckers. Largemouth bass and several species of sunfish were identified by visual observation but not in gill net sampling. Overall, habitat conditions in the Upper Basin are not ideal for fish, yet the basin does support a substantial warm water fish community.

Wildlife

Results of the wildlife and bird study indicate that the upper Lake Whitney area provides valuable wildlife habitat, and future management opportunities should consider impacts to the bird population. The wildlife attributes of the upper lake are in many ways preferable to the remainder of the lake where water is deeper, shoreline slopes are steeper and vegetative cover on and around the lake is thinner.

Nutrient Modeling

The concentrations of nitrogen and phosphorus in the lake were estimated based on the land use characteristics of the watershed using a spreadsheet model. The nutrient model indicated an average phosphorus concentration in the reservoir of 55 parts per billion (ppb). An examination of a large database for New England lakes suggests that most lakes can handle a phosphorus concentration of up to 24 ppb without significant algal problems. A limited historical database of total phosphorus measurements in Lake Whitney suggests that typical phosphorus concentrations are 20 to 80 ppb. Nitrogen concentrations were predicted to be on the order of 1,000 ppb, which is reasonably close to measured concentrations. High nitrogen levels tend to favor the development of green algae over blue-green algae, a fact that was supported by the phytoplankton analysis.

For the Upper Basin of Lake Whitney, nutrient concentrations suggest that algal blooms are likely to develop in the absence of adequate flow to flush the lake regularly. On average, the Upper Basin is flushed every two days, which minimizes phytoplankton accumulations. Lower light and higher turbidity may also limit algal production.

Stakeholder Evaluation

A survey was conducted to evaluate and prioritize the concerns of stakeholders within the community surrounding Lake Whitney. Initial survey materials were sent out in the summer of 2000. At the request of the Spring Glen Civic Association, an additional set of surveys was mailed in May 2001. Table ES-6 provides the priority ranking of stakeholder concerns as determined by the survey.

The initial 2000 survey respondents represented a broad geographic range, including residents living in southern Hamden near lower Lake Whitney and the East Rock area of New Haven. Twenty-eight percent of respondents in 2000 were lake abutters. Overall results of the 2000 survey ranked ecological and environmental quality criteria such as bird and wildlife habitat, wetlands, and downstream conditions as most important, with aesthetic criteria such as odor and open water views in the upper lake ranking somewhat lower.

The vast majority of respondents in the 2001 supplemental survey (84%) lived in close proximity to the upper lake. Mosquitoes scored the highest in the 2001 survey, and aesthetic values (e.g., odor and view) also scored in the top third. The 2001 survey also placed a higher relative importance on construction nuisances and impacts (e.g., from a dredging project).

The ranking of criteria based on the combined results from both surveys strongly reflect the aesthetic criteria scored high in the supplemental survey. Lake abutters represented 53% of the total quantified responses for both surveys. However, the environmental quality criteria also were judged as important in the combined results due to the importance of these factors in the original survey.

TABLE ES-6
Results of Stakeholder Evaluations
Criteria Weights in Order of Rank

2000 Survey		**2001 Survey**		**Combined Results**	
Criteria	**Rank** [(a)]	**Criteria**	**Rank** [(a)]	**Criteria**	**Rank** [(a)]
Bird Habitat	74.7	Mosquitoes	85.3	Mosquitoes	77.7
Downstream Environment	73.3	Time Odor, norm	84.8	Time Odor, norm	75.9
Wildlife Habitat	72.6	Area Odor, norm	83.6	Bird Habitat	75.1
Off-site Wetlands	70.0	Perceived Odor	81.3	Perceived Odor	74.2

Quality Improvement	68.7	Area Odor, dry	76.3	Area Odor, norm	73.5
Mosquitoes	66.9	Bird Habitat	75.5	Wildlife Habitat	72.5
Perceived Odor	64.7	Open Water View	72.9	Open Water View	68.3
Potable Water	63.1	Wildlife Habitat	72.0	Downstream Environment	67.8
Time Odor, norm	62.9	Diversity View	70.8	Area Odor, dry	67.8
Open Water View	60.1	Quality Improvement	65.3	Diversity View	66.8
Diversity View	59.0	Downstream Environment	63.5	Off-site Wetlands	66.5
Area Odor, norm	58.8	Off-site Wetlands	63.3	Quality Improvement	66.5
Sediment Quality	56.5	Human Disturbance	61.7	Human Disturbance	57.9
Area Odor, dry	54.8	Construction Duration	61.6	Potable Water	57.8
Human Disturbance	53.5	Construction Nuisance	61.4	Sediment Quality	56.3
Quality Degradation	43.0	Quality Degradation	59.1	Construction Nuisance	52.7
Construction Nuisance	42.0	Sediment Quality	56.4	Quality Degradation	52.0

Construction Duration	38.4	Potable Water	54.7	Construction Duration	51.2
Recreational Use	37.2	Cost of Alternative	46.4	Cost of Alternative	42.0
Cost of Alternative	37.0	Recreational Use	26.8	Recreational Use	31.7

Notes:
(a) Criteria weight is based on rank of 0 to 100 assigned by stakeholders in the survey.
(b) Percentages of respondents considered lake abutters were 28% in 2000, 84% in 2001, and 53% combined for both surveys.

Alternatives Analysis

The results of the stakeholder survey and the technical evaluation of existing conditions were used to evaluate the three primary reservoir management options – no action, dredging and watershed controls. Within each alternative, there are a number of options (dredging selected areas, creating wetlands with dredge materials). However, for the purposes of this initial analysis, management alternatives were evaluated in broad terms.

Each alternative was ranked on a scale of one to 10 for its ability to meet the goals of each management issue as presented in the stakeholder survey. The technical evaluations were quantitative and objective to the extent possible but, in several cases, professional judgment was required. The technical evaluation was combined with the ranked decision criteria, as determined by the stakeholder surveys, to compare management options.

No Action

The No Action alternative represents no dredging or other modification within the Upper Basin. No measures would be taken elsewhere in the watershed to control sediment loading to the Upper Basin. Consequently, sediment would continue to accumulate at an annual rate of approximately 0.5 cm to 1 cm (0.2 inches to 0.4 inches). The No Action alternative would also not offset inevitable increases in sedimentation from future development within the watershed.

Dredging

Dredging would remove accumulated sediments that will be exposed during drawdown to address aesthetic issues and interrupt the gradual lake sedimentation process. Most likely, this alternative would entail selectively dredging portions of the Upper Basin and Upper Middle Basin (Webb Cove). No measures would be taken elsewhere in the watershed to control sediment loading to the Upper Basin. Dredging can provide fairly long-term benefits but does have significant short-term adverse impacts and costs. Short-term impacts include an increase in suspended solids, construction noise and inconvenience, and dislocation of fish and wildlife. Stockpiling and dewatering of dredge spoils also pose difficult issues. This alternative has the distinct disadvantage of impacting unique bird and wildlife habitat without providing measurable benefits to water quality in the reservoir.

Watershed Management

The goal of the watershed management option is to capture a portion of the silt and sediment load before it reaches Lake Whitney. Water quality and sediment basins would be constructed at key locations throughout the watershed to control contaminants in locations that are easily accessible for maintenance and removal. The Authority has recently constructed two water quality basins of this type: one along Whitney Avenue and one adjacent to Mather Street.

These multi-cell basins are designed to trap sediments near the inlet and also provide sufficient retention time to remove other contaminants, such as nitrogen and phosphorus. Wetland plantings are included in the basins and eventually these areas develop into wetland habitat.

Selection of the Preferred Alternative

A summary of advantages and disadvantages of each of the three alternatives is shown in Table ES-7. Watershed management and controls was selected as the preferred alternative. This alternative meets the Authority's goal of protecting Lake Whitney as a valuable water supply resource, while preserving its environmental integrity to the greatest extent possible. This alternative also meets the stakeholders' foremost goals of improving habitat and developing and protecting off-site wetlands. The preferred alternative will help avoid accelerated sedimentation that may result from future development in the watershed and thus help preserve the existing desirable attributes of the reservoir. No dredging would occur during implementation of this alternative, with the possible exception of Webb Brook Cove. Sediment removal in this area may be completed in conjunction with construction of a water quality basin in the Webb Brook watershed.

Table ES-7
Summary of Management Alternatives

Alternative	**Advantages**	**Disadvantages**
Alternative 1 – No Action	Preserve wading bird & wildlife habitat, no construction impacts, low cost	Future acceleration of sedimentation rates & contaminant inputs (no watershed controls), exposed sediment during >1 ft. drawdown
Alternative 2 – Dredging	Reduce area of exposed sediments during >1 ft. drawdown, increased open water view	Destruction of wading bird & wildlife habitat, very high cost for no water supply benefits, construction impacts, future acceleration of sedimentation rate & contaminant inputs (no watershed controls)
Alternative 3 – Watershed Management	Prevent future acceleration of sedimentation rates and contaminant inputs, trap accidental spills in watershed, preserve wading bird & wildlife habitat, create additional off-site wetland habitats, minimal to moderate construction impacts, cost effective for water supply management	Exposed sediment during >1 ft. drawdown, moderately high cost

Watershed Management Plan

The Lake Whitney watershed has been classified and regulated as a public water supply watershed for many years and, consequently, does not receive any direct discharges of municipal or industrial wastes. However, non-point source pollutants that result from human activities do impact the water body. While sedimentation is the focus of the Upper Lake Whitney Management Plan, reducing the potential for other contaminants to be introduced to the system will further improve water quality.

The Authority has played an active role in minimizing the impacts of non-point source pollutants by reviewing site plans for development activities within the public water supply watersheds. Areas that were developed in the early to mid-20th century did not have the same controls and non-point source pollutants were not considered during development.

Watershed management includes four specific recommendations: land conservation, stormwater management, retrofitting urban stormwater treatment systems, and construction of sediment basins. Sediment basins are an effective tool in the less developed areas of the watershed. Retrofitting urban stormwater treatment systems helps to control sediment loading from existing urban areas. Typically, little or no water quality management criteria were placed on developers prior to the 1980's. As a result, older stormwater management systems control the volume of stormwater but have little effect on quality.

Land Conservation

Conservation of important riparian wetlands is critical to the overall health not only of the Mill River but Lake Whitney as well. Conservation includes preservation of the land within the riparian corridor, including both wetland and upland vegetation. The following specific areas in the Mill River watershed were identified as critical areas to consider for conservation:

- Willow Brook - Route 10 north to North Brooksvale Road;
- Butterworth Brook – upstream of River Road
- Eaton Brook - Mill River southwest to Todd Street
- Shepard Brook - Turners Pond north to Sherman Avenue
- Pardee Brook - Mill River to Dixwell Avenue in area of golf course
- Mill River - Axle Shop Pond north to Tuttle Avenue
- Mill River - Dixwell Avenue north to Route 22; an
- Mill River - Cook Hill Road north to Jinny Hill Road;

Stormwater Management

The Authority needs to remain active in reviewing and commenting on development applications within the Mill River watershed towns. New development projects should be required to incorporate structural and non-structural BMP's, a change that must be made within the framework of the local communities. The main watershed communities of Hamden and Cheshire require stormwater controls on some developments. However, runoff volume reduction measures such as groundwater recharge, grass swales, and bioretention basins are not always required.

Specifically, the impacts of development on water quality can be reduced by requiring runoff be infiltrated wherever possible. This includes discharging rooftop runoff to drywells or other infiltration system. Roads and driveways should be curb-less wherever possible to promote sheet flow of runoff. While this is not always practical on roadways with steep grades, it can be a very effective technique in areas with road grades of less than 5%.

Generally, stormwater management should seek to minimize the extent of impervious surface area within the watershed. Impervious surfaces, such as paved driveways and roadways and concrete walkways, have a dramatic effect on stormwater quality. The amount of impervious surface within a watershed increases the velocity of stream flows by accelerating the development of peak flow rates over natural conditions. Increased velocities lead to increased bank erosion and increased sediment transport. As sediment is transported downstream, scour occurs as a result of the movement of the bed load. As a result, the volume of sediment transported increases as the flow moves downstream. Transported sediment material is then deposited in areas where the water velocities decrease, such as Lake Whitney.

Riparian buffer areas of at least 50 feet (preferably 100 feet) should also be maintained. These zones protect watercourses by providing attenuation of overland flows and non-point pollutants, including temperature. Additionally, floodplain encroachments can have severe impacts on river morphology. As channels become confined, flood flow velocities increase, accelerating streambed erosion.

Storm drainage systems should be designed as open conveyance systems (e.g. grass swales) wherever possible. In cases where piped systems cannot be avoided, structural BMP's such as the use of catch basins with sumps and/or Downstream Defender or Vortechnics® units should be required. Other BMP's may be necessary in areas where additional contaminants may be introduced to the system (e.g., large parking lots, industrial storage areas).

Land use practices that are designed to minimize impacted land areas, such as cluster style developments, should be considered wherever possible. While this type of development is not feasible at every site, developers should be encouraged to use this type of development scenario whenever possible. In addition, local land use officials and commissions should be made aware of the positive impacts from this type of development.

Stormwater management systems of existing developments can be retrofit if reconstruction of parking lots and/or structures is proposed. These source control measures will minimize the volume of sediment introduced to the system and, consequently, the accumulation of sediments in the Upper Basin of Lake Whitney.

Urban Stormwater Systems

The greatest threat to Lake Whitney is water quality impacts from urban areas and highways. These types of land uses typically contribute the largest sediment loads to natural systems. The most concern is associated with commercial and industrial land uses, high-density residential areas, and high traffic roads and highways. The urban nature of the lower reaches of the watershed result in increased loadings to the Upper Basin.

The Authority has constructed two water quality basin systems in the immediate vicinity of Lake Whitney within the past 10 years. These basins were designed to control pollutant loading from specific urban areas. Based on data collected after construction of the Whitney Avenue basin, the quality of water discharging to the lake was significantly improved by this treatment system. Construction of additional basins in other storm drainage systems would improve the water quality of runoff entering the reservoir.

Specific locations for additional basins would be based on watershed development and stormwater outfall locations. Target areas would be within the lower 15% of the watershed, where the most intense development has occurred. Webb Brook, immediately upstream of its discharge to Lake Whitney, would be a prime location for this type of basin. Its watershed is highly urbanized and clearly contributes significant sediment deposits to Lake Whitney. One clear advantage to constructing a basin at Webb Brook is the fact that the Authority owns land north of Waite Street, where the basin can be constructed. The following is a summary of issues to consider in determining potential locations for water quality basins:

- What is the size of the watershed area discharging to the existing stormwater outfall? It is difficult to control peak flows on larger watershed areas. If the watershed area is too big, then sediments will be flushed from the basin during storm events.
- Does the outfall discharge directly to Lake Whitney? Direct untreated discharges to Lake Whitney from urban watersheds should be the highest priority for stormwater management. Any catastrophic releases of contaminants within these drainage systems will discharge directly to Lake Whitney, with little opportunity for removing the contaminant prior to entering the reservoir.

- How much of the watershed is impervious? The larger the percentage of impervious area within the watershed, the more likely it is to increase velocities within the Mill River, thereby increasing sediment transport to Lake Whitney.
- How much of the watershed is connected to the storm drainage system? Watershed areas that are largely disconnected from the storm drainage system typically provide more opportunities for rainfall to infiltrate to groundwater. When infiltration is increased, peak flows and water velocities are reduced.
- Is sufficient land area available? Is the property owned by the Authority or available for acquisition (whether through purchase or long term lease agreement)? Land area is a critical consideration for constructing water quality basins. In the event that the Authority doesn't own land, then land must be purchased or easements must be obtained. These factors increase the cost and lead time associated with construction.
- Is the land area accessible for future maintenance? Maintenance of stormwater systems is critical to their proper operation. When maintenance is not completed, the management structure ceases to function properly and water quality is not protected. Constructing facilities that are easy to maintain increases the likelihood that proper maintenance will be performed.

Sediment Basins

The tributaries to the Mill River were evaluated for potential sediment basin locations. A number of these watersheds are rural in nature and would not be appropriate locations for sediment basins at this time. Shepard Brook and the main stem of the Mill River are two watercourses that were determined to have potential to develop sediment basins.

The Shepard Brook watershed accepts runoff from a large portion of central Hamden, including residential and industrial areas. The watershed originates in the High Rock area just over the town line into Woodbridge. The upper reaches of the watershed are a combination of residential development and open space. Lower in the watershed, the residential development becomes more dense. The industrial area of Sherman Avenue is also located in the lower reaches. Turner Pond was identified as a potential location for sediment basins. A stone masonry spillway and bypass control discharge from this long narrow impoundment. The pond appears to be shallow at the present time, likely due to the accumulation of sediments. It may be feasible to dredge a portion of the pond and maintain that area as a sediment basin, while the remaining portion of the pond would remain in its present state.

The Mill River originates in Cheshire and flows southerly along Route 10 to the center of Hamden. The river flows southwesterly to Lake Whitney, adjacent to Route 15. Clark's Pond, located on the Mill River near Quinnipiac University, acts to trap large quantities of sediment from the upper Mill River watershed. The Authority has dredged this pond in the past to remove accumulated sediments. It remains one of the best sites to control sediment accumulation upstream of Lake Whitney. Clark's Pond has not been actively maintained as a sediment forebay area; however, it is well suited for this use. Construction of a sediment forebay may be possible at the upstream end to isolate the area where the bulk of sediment would be deposited. This area would require more frequent maintenance, but the maintenance may be completed without disrupting the whole pond area.

The feasibility of constructing a sediment basin on the main stem of the Mill River immediately upstream of Lake Whitney was evaluated during this study. Unfortunately, the contributing watershed to this area is too large for a sediment basin to be effective. The basin would have been undersized and so would have been susceptible to flushing during significant rain events.

Conclusion

Ongoing source control is the key to the successful management of Lake Whitney. While the construction of large sediment basins within the watershed to control sediment accumulation in

Lake Whitney is desirable, they will require large land areas. It is also difficult to accommodate high flows through sediment basins unless the impoundment is large. Clark's Pond and Turner Pond are two viable locations for upper watershed sediment management.

The construction of water quality basins to control non-point source loads into the Mill River and Lake Whitney will provide the most quality improvement. Stormwater discharges from major roadways (Wilbur Cross Parkway, Connolly Parkway, and Whitney Avenue) and shopping areas should be targeted for stormwater quality systems.

One critical factor in controlling future sediment loading to the reservoir is developing land use regulations that will minimize sediment and contaminant loads. This would include establishing road widths based on the volume of traffic projected, allowing stormwater to be conveyed in open channels, and by overland flow instead of the current practice of requiring that piping systems be used.

Due to Lake Whitney’s high ratio of watershed area to storage volume, the vast majority of water withdrawals for public water supply will only be a fraction of the amount of water that overflows Lake Whitney to the Mill River on a daily basis. The Authority’s plan for operating the Lake Whitney Water Treatment Plant generally entails taking the highest amounts of water during high flow periods (such as winter months) when flows over the spillway of 100 to 300 mgd are typical. During the summer months, withdrawals from Lake Whitney will generally be reduced, with the Authority relying more heavily on other supplies such as Lake Gaillard. In addition, the plant will be operated in accordance with a management plan that will include the following measures to protect the environment of Lake Whitney:

- Provisions for reducing water withdrawals based on lake levels;
- A downstream release schedule for periods when the water elevation falls below the spillway that balances the flow needs of the lower Mill River with maintaining adequate water level in the Upper Basin;
- Limiting water level drawdowns to no more than one foot during spring fish spawning season; and
- Advanced treatment technologies that will allow the Authority to avoid using copper sulfate for reservoir algae control.

Based on results of this study, additional action items that would be appropriate additions to the Management Plan include: (1) implementation of watershed management measures to control sediment inputs to Lake Whitney; and (2) using Lake Whitney and the planned pump stations in the northern service areas to reduce groundwater withdrawals from the Mill River aquifer.

Lake Whitney’s hydrology and the proposed operation of the treatment plant will minimize the environmental and aesthetic impacts in the Upper Basin attributable to water supply withdrawals. The extent and frequency of drawdowns in Lake Whitney will largely be a function of intentional lowering of water levels for maintenance of the dam and surrounding infrastructure. This is consistent with the operation of the reservoir over the past 10 years when no water supply withdrawal was occurring.

The reactivation of Lake Whitney as a water supply source in conjunction with operation of new pump stations in the Authority’s northern service area will lessen the dependence on public water supply wells along the upper Mill River. The upper Mill River supports both cold and warm water fish species. The Connecticut DEP stocks over 10,000 trout in the river annually. Other fish species include American eel, largemouth bass, pickerel, white sucker, pumpkinseed, and bluegill. Flows in the upper Mill River are not a function of water surface elevations in Lake Whitney. Thus, water withdrawals from Lake Whitney will not cause lower water levels in the upstream Mill River. On the contrary, reduced groundwater withdrawals will enhance base flows in the upper Mill River from south Cheshire along the river's main stem (including Clark's Pond) to Lake Whitney, thereby benefiting the Mill River’s aquatic habitats. Various streams associated with nine other active Authority water supply reservoirs will also benefit as a result of lessened withdrawals during high flow months when Lake Whitney withdrawals are maximized.