Water Treatment Facility
Desktop Evaluation
January 27, 2011 (draft)

The Exeter Reservoir and Existing Surface Water Treatment Facility

The original Exeter Water Filtration plant was constructed in 1886. The treatment plant has been upgraded and modified many times over the ensuing years, the most recent renovations occurred in 1974 and 1994. The surface water plant is currently serving as the Town's principle source of potable water, treating source water from the adjacent Exeter Reservoir and also water pumped from the Exeter River.

In 2003, the Town designed and proposed constructing a new water treatment plant on property adjacent to the existing facility and above the floodplain. The costs of the new surface water treatment plant where such that the required Town meeting majority vote of 60% was unsuccessful. Therefore; the Town has been re-exploring other options to upgrade their water system infrastructure. These include the potential reactivation of the Stadium and Gilman wells and related ground water treatment facilities for those wells and the existing Lary Lane well. Combined, these sources are estimated to be able to supply about 1.25 million gallons of water, enough to supply the Town of Exeter's needs for most of the year. With a groundwater system such as this on line, the existing surface water plant would then be used in conjunction with and a supplement to the groundwater supply. There are many benefits to the Town with this approach and these have been presented as part of other W&S studies. However; one benefit that hasn't fully been presented is the fact that if adequate groundwater is on-line in the system, the Town could theoretically be able to take the existing surface water system off-line for an extended period of time to allow for significant construction upgrades to occur.

At the time of the writing of this report, the surface water plant is having the existing controls upgraded and a state of the art Supervisory Control and Data Acquisition System (SCADA) installed. This should offer improved operational control of the facility and allow better monitoring of treatment conditions throughout the various treatment processes.

Future operations of the surface water plant will still be challenged by the following:

- **Flooding:** The water plant site is prone to flooding and has experienced damaging flooding most recently 1996 (shown in the adjacent photo). Improvements to the reservoir spillway, gates and operations during high precipitation events have enabled the system to avoid flooding during recent events. However; the facility should be operable during the 200-year flood and access roads should be elevated to be above the 100-year flood elevation. Recommended additional buffers and facility retrofits to protect from flooding which might include:
  - Elevating the southern wall of the spillway from the reservoir to the culverts. This item could be done in conjunction with the raising of the roadway coming into the facility.
  - Retrofitting building doors and windows with rubber gaskets and removable metal shields that can be installed to keep water out during flooding events.
  - Elevating as much electrical equipment as possible above the highest anticipating flooding level.
  - Continue to improve the monitoring of weather conditions so that the reservoir level can be dropped as much as possible ahead of major anticipated storm events.

- **Source Water Quality:** The variable water quality of the Exeter River and the shallow and nutrient rich Exeter Reservoir has challenged the operations of the surface water plant. W&s recommends the following options for improving these conditions:
  - Dredging of the reservoir would most likely improve the water quality by removing organic and manganese laden material that is known to cause treatment issues when the reservoir gets warm in the summer. A copy of an updated cost estimate for further study and analysis of the reservoir bathymetry and bottom is attached.
  - The reservoir itself could be partitioned to allow the operators access to 2- weeks volume of raw water (14 to 20 million gallons, depending on raw water flow). The partioned portion of the reservoir's bottom could be improved by installing a barrier between the organic materials and the water in storage.
  - Better aeration of the reservoir has been suggested in other reports and was also discussed in the W&S Water Supply Alternatives Report (2009) and is again recommended here.

- **Aging Infrastructure:** The original water treatment process concrete tankage has been modified over the years to increase capacity and treatment capability of the plant. That said; the treatment process at the plant has not proven sufficiently robust to treat the variable raw water quality. The Town's overall water supply plan should recognize this and plan on having the surface water plant off line during periods of problematic raw water excursions.

- **Drinking Water Quality Regulations:** Due to increasingly stringent disinfection byproduct regulations, the operators may be forced to utilize greater amounts of powdered activated carbon to capture organic carbon (DBP precursors) and taste and odor causing compounds. Correspondence between W&S and Rick Skarinka at the NHDES Drinking Water and Groundwater Bureau verified that Exeter will not be held to a greater TOC removal than they already have; however, they will have to meet the new Stage II disinfection byproducts rule requirements. Therefore; we recommend that carbon feed equipment and the process for solids removal from the Pre Oxidant should be improved and the residuals disposal system upgraded. Additional discussion of disinfection byproducts issues is included at the end of this letter memorandum.

- **Existing Treatment Process:** The short detention time and inherent nature of the buoyant media adsorption clarifiers will continue to challenge the operators both from a water quality effluent point of view and from a net water production point of view. The normal 4 hour backflush and flush to waste sequence is a major number when calculating the net water efficiency (raw water into the plant versus finished potable water transported to the distribution system). Also this type of process is known for the difficulty in predicting and then maintaining (as a function of raw water quality) optimized coagulation chemistry. If two independent coagulation chemical feed systems are maintained along with continuous in line water quality analyzers on the influent and clarifier effluent water, the ability of the operators to optimize coagulation chemistry will be enhanced. It is not unusual for this type of process to have from two to three different coagulation chemistries dependent on season, water temperature and climatic events.

- **Filter System:** The sand filter media and backwash have been recently been serviced. The low end filter loading rates to the filters should be maintained. The filters do not have a filter to waste piping, valves or controls. The current operations practice in newer filtration plants is to operate individual filters in the filter waste mode at the completion of a backwash or when ever the filter turbidities rise above 0.1 NTU. The space available in the filter gallery may be an insurmountable physical limitation to upgrading to a filter to waste type system. A detailed investigation be conducted to:

  - Determine if installation of filter to waste is possible in the limited space available.
  - Evaluate the potential to add UV to filter effluent flows for cypto and/or giadia inactivation.
  - Evaluate the potential to replace the filters with membranes to treat crypto/giardia (and potential decrease the required CT free chlorine dosage).
  - The existing system for storage, thickening, drying residuals and recycling supernatants is inadequate. It also has the potential to cause disruptions in the water treatment system's capabilities. And since the lagoons (shown on the adjacent photo)

discharge into the Town's sewer system it also effects the Town's sewer and wastewater system. Therefore; significant improvements should be made to the residuals handling and disposal system. The Town currently is on the "green" projects list for the 2011 cycle of New Hampshire Drinking Water SRF Funding to investigate options, design and construct upgrades to this system which will enable the recycling of supernatent, thus reducing the waste water lost to the system and increasing water treatment efficiencies. Such a system may also improve source water quality and treatment performance of the existing treatment facility.

- **Building Integrity:** At present, the lower metal wall partitions of the clarifier building are corroding away (as are several metal doors), the roof of the administration/Garage building needs to be replaced and in general the windows and heating systems are not energy efficient. If the Town is dedicating to keeping the plant in operation for the next 20 years, a alternative to just patching and piecing in medal siding repairs would be to construct a 36 inch masonry knee wall that will stand up over time to the snow and acid rain. Some of the buildings and moving equipment at the water plant have reached the age where the equipment/structure has reached its useful life. Also, in anticipation of abandonment of the plant, significant building and infrastructure upgrades were postponed. W&S recommends the Town prepare and then update a rolling 5 year capital plan to keep the water plant buildings, moving equipment and buried infrastructure up to date.

- **Maintenance and Replacement Program:** The current operations staff should be commended on keeping the water treatment systems functioning even when a lot of the components are beyond their useful life. The life of most rotating equipment (pumps, blowers, emergency generators, etc.) is 10 years while underground utilities (water pipes, electric transmission lines) is 50 years. Many large water pumps can have their useful life extended to 25 years if shaft, bearing and impellors are reworked every 10 years. A prudent replacement funding schedule is to estimate the useful life and replacement costs of all the plant equipment, and then budget the resulting annual amount. This annual amount could then be raised as part of the water rate or rolled into large bond issues. This approach will result in rate increase stability over time. The Town should consider establishing a computerized purchase order system that will allow for tracking and documenting equipment maintenance and replacement over time. We recommend the Town adopting a policy to replace equipment with energy efficient equipment and materials once an item is in need of major rehabilitation and or replacement.

Cost Estimate and Rate Effect

The attached table provides an overview of the cost estimates and proposed scheduling for a five-year timeframe as they relate to the recommended water treatment facility improvements.

Discussion – Disinfection Byproducts:

The new Stage 2 D/DBP Rule will require Exeter to change the distribution system sampling points to the locations in the distribution system that have the highest DBP concentrations. Four new compliance monitoring sites for TTHM and HAA5 will be added that reflect the following:

- The Stage 1 average residence time site.
- The two highest TTHM sites
- The highest HAA5 site

In addition to new sampling locations, the Stage 2 D/DBP Rule will also report site-specific, instead of combined site averages for meeting the rule requirements. In other words, each monitoring location (LRAA) will have its own average to meet. The rationale for this change is the issue of disparity in DBP exposure across a system and this new regulation strives to equalize DBP exposure for consumers. This will negatively impact the water systems' ability to meet Stage 2 DBP requirements because there will be monitoring locations with poorer water quality and the peak detections cannot be minimized by averaging the results from multiple sample locations that have lower concentrations

Weston & Sampson recommends that Exeter establish a margin of safety goal for DBPs that is below the MCLs. Establishing this goal is consistent with federal rulemaking methodologies. The margin of safety will provide a target that should be met the majority of the time, but can allow a buffer for increased LRAA values that can occur based on seasonal fluctuations in TTHM, changes in water treatment plant operations, variations in source water quality, analytical variability, and other factors that can impact TTHM formation. Weston & Sampson generally recommends a 20% margin of safety goal of 64 µg/L in the context of the local TTHM history. A 20% margin of safety goal of 48 µg/L for HAA5 history.

If Exeter experiences DBP results with LRAA values greater than target values, we recommend Exeter develop a Short-term Strategy to Address DBPs and Chlorine Residual Maintenance Prior to implementation of any change to free chlorine based disinfection

The purpose of this task will to evaluate the potential to make low cost and easily implementable changes to minimize the formation of DBP's. Items that should be addressed include:

- Establish DBP Targets
- Evaluate Impacts of Distribution Storage Tanks on Water age and DBP formation
- Distribution Water Quality Monitoring
- Decrease DBP precursor's by modifying treatment practices

If the short strategy is unsuccessful in addressing DBP Formation, Exeter will have to proceed to evaluating alternatives for decreasing the formation of DBP's in the distribution system. Three water quality management approaches to the DBP problem are available:

1 - Removing DBP Precursors before adding chlorine using the following treatment strategies:

- Enhanced Coagulation
- Mixed Ion Exchange(MIEX)
- Biological GAC (HAA5 only)

2 - Removing Preformed DBP's using the following treatment strategies:

- Enhanced Coagulation
- Granular Activated Carbon (GAC) Adsorption
- Powder Activated Carbon (PAC) Adsorption
- High Pressure Membranes
- Packed Tower Aeration

3- Halting the DBP Formation Reaction Using Chloramines After Primary Disinfection is Achieved. The following issues associated with chloramines will be evaluated:

- Chloramines Conversion Strategy:
- Nitrification Control and Monitoring Plan:
- Potential secondary impacts regarding Lead and Copper Rule
- Establish DBP Reduction Targets
- Public Education and Relations

We believe that Option 3, the use of chloramines, will be the least costly of the three strategies.

Town of Exeter, New Hampshire

Draft November 2010
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Projected Capital Needs Plan

Project	Total Estimated Project Cost	2012	2013	2014	2015	2016
Improvements to prevent flooding *	$ -					
Exeter Reservoir Dredging *	$ -					
PAC Feed Improvements	$ 150,000			$ 15,000	$ 100,000	$ 35,000
Pre Oxidation Residial	$ 250,000			$ 50,000	$ 200,000	
Backwash collection and pump system *	$ -					
Filter to Waste Improvements *	$ -					
Residual drying beds and recycle system	$ 400,000			$ 50,000	$ 100,000	$ 250,000
Metal Building Exterior Repairs	$ 250,000	$ 40,000	$ 210,000			
Roof Administration Building	$ 90,000	$ 90,000				
In Plant Water Meter Replacement	$ 50,000	$ 50,000				
Chemical Feed System Improvements	$ 250,000			$ 150,000	$ 100,000	
Additional fencing WTP, Reservoir and Residuals	$ 100,000	$ 50,000	$ 50,000			
Large Pump Maintenance	$ 50,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000
Small pump Maintenance	$ 15,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000
Window and Door Replacements	$ 15,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000
In Line Analizer additions and replacements	$ 35,000	$ 7,000	$ 7,000	$ 7,000	$ 7,000	$ 7,000
Automatic Valve Replacements	$ 37,500	$ 7,500	$ 7,500	$ 7,500	$ 7,500	$ 7,500
	$ 1,692,500	$ 260,500	$ 290,500	$ 295,500	$ 530,500	$ 315,500
Anticipated Rate Effect						
New Bond Impact		$19,869	$20,217	$24,045	$36,920	$35,876
Bonding Cost/year		$19,869	$40,086	$64,131	$101,051	$136,927
Customers	3500					
Annual Rate Effect per Customer		$5.68	$5.78	$6.87	$10.55	$10.25
Average Water Bill (based on 2010 rates)	$368.32	$374.00	$379.77	$386.64	$397.19	$407.44
Annual Percentage Increase if all projects bonded		1.5%	1.5%	1.8%	2.7%	2.6%

Notes:
* These items are placemarks for this draft of the desktop study. This table should be updated based on the water system's 2011 CIP plan, currently in the budgetting progress.

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M E M O R A N D U M

TO: Jennifer R. Perry, P.E., Public Works Director, Exeter, New Hampshire

FROM: Andrew Walker, Emily Faivre, Brian Goetz, Weston & Sampson, Inc.

DATE: August 26, 2010 (revised November 12, 2010)

SUBJECT: Exeter Reservoir – Improvements to Water Quality and Availability

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Overview

As part of the *2010 Groundwater System Preliminary Design* project, Weston & Sampson was tasked with performing a desktop assessment of potential surface water treatment upgrades with approximate cost estimates for planning purposes. In support of that task, Weston & Sampson investigated the potential for improving the water quality and seasonal availability of withdrawals from the Exeter Reservoir. This memorandum summarizes those findings.

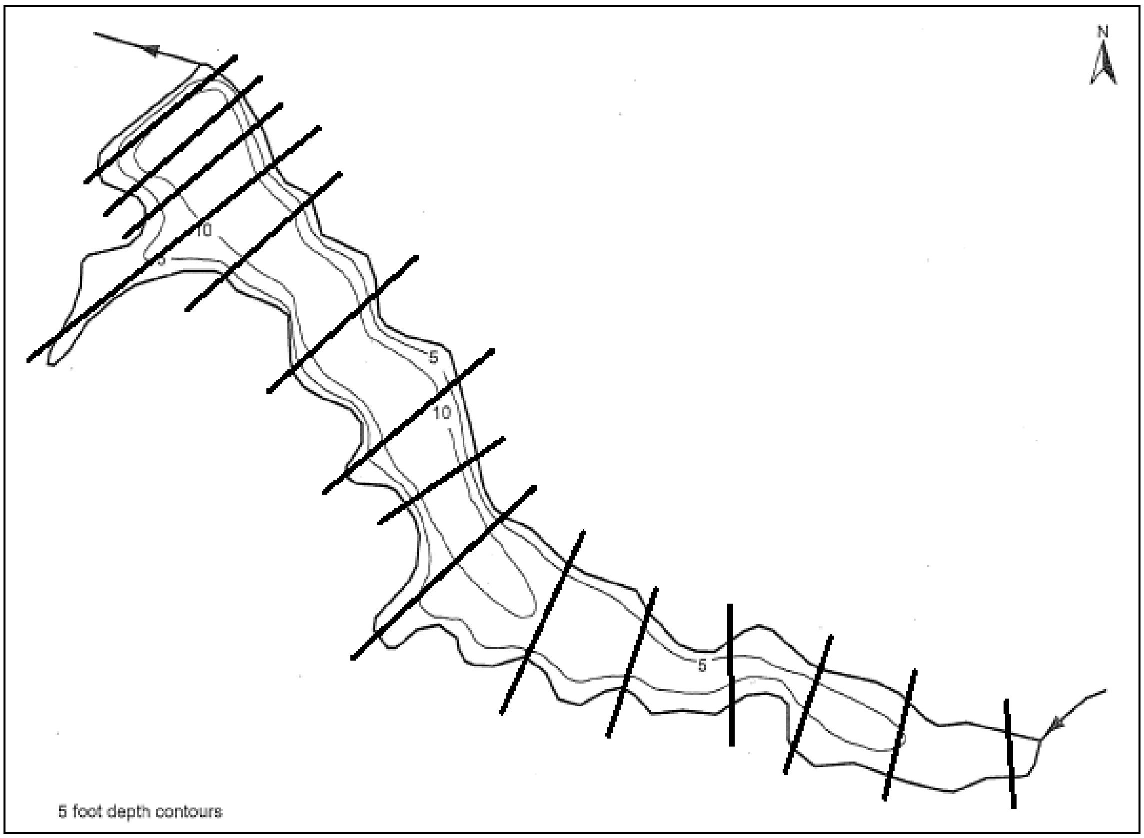
Bathymetric Survey

Weston & Sampson recommends a limited bathymetric survey to provide a better estimate of the storage capacity of the Exeter Reservoir and the extent of lake-bottom sediment accumulation. Relatively little information exists on the bathymetry of the Exeter Reservoir. Estimates of the Reservoir's volume are found in a number of sources, as noted in Weston & Sampson's 2010 River Study report, and range from approximately 26 million gallons to 39 million gallons. This difference of 13 million gallons is significant and represents more than ten days of the Town's average water demand.

A rough bathymetric survey of the Reservoir was completed in 2000 as part of a larger watershed-scale study conducted by the Watershed Management Division of the New Hampshire Department of Environmental Services. That survey produced a map of the Reservoir with depth contours at 5-foot increments, denoting depths of both five and ten feet. However, that same study noted a maximum depth of over 15 feet while still other sources suggested a maximum depth of nearly 20 feet, but no 15-foot contour was indicated on the 2000 survey. In addition, the Reservoir spillway has been updated since 2000, allowing for higher water levels and altering the Reservoir's stage-storage relationship.

A limited bathymetric survey is recommended to answer some of these unknowns. A sufficient survey might consist of 12 to 15 cross-sections with depth readings taken at approximately 50-foot intervals as proposed in Figure 1 below. Such a survey is estimated to take two employees approximately 8 hours to complete. Given the Reservoir's 200-foot average width, such a survey would contain roughly 75 data points all located with geographic positioning equipment. Combined with the rough survey conducted in 2000, these data points would provide a sufficient set of data from which to estimate the Reservoir's stage-storage relationship and guide additional improvements to the Reservoir's water quality and availability.

Figure 1 – Proposed Bathymetric Survey of Exeter Reservoir



Lake-Bottom Sediment Analysis

Weston & Sampson also recommends that a study of the Reservoir's lake-bottom sediments be coordinated in conjunction with the proposed bathymetric survey. The Reservoir was initially dammed and excavated in 1886. Over time, sediments have been carried downstream by Dearborn Brook and overland by surface runoff. Due to the negligible velocities found in the Reservoir, smaller lighter particles that were originally suspended in the streamflow have fallen to the bottom of the waterbody, joining larger heavier particles behind the physical barrier of the Reservoir's earthen dam. These lake-bottom sediments now blanket much of the Reservoir's floor to varying degrees, decreasing the active storage capacity of the Reservoir. In addition, the high nutrient and chemical loadings found in this sediment blanket decreases water quality in the hot summer months to such a degree that withdrawals from the Reservoir become cost-prohibitive.

Weston & Sampson recommends taking roughly 25 samples of the lake-bottom sediment using a technique known as soft sediment core sampling. This technique is estimated to take two Weston & Sampson employees approximately 8 hours to complete, and involves pushing or hammering a sample collection tube down into the soft sediments that have accumulated on the Reservoir floor. This technique will preserve the vertical stratification of the samples, allowing them to be analyzed for water content as well as concentrations of total phosphorous, nitrates, manganese, iron, sulfates, among others. Such an analysis would cost approximately $8500. In addition, analysis of the sediment samples will include a "disposal characterization" to determine an appropriate disposal location in the event that the lake-bottom sediments are dredged. By taking sediment samples in this manner at proposed bathymetric survey locations, Weston & Sampson will be able to estimate the horizontal and vertical extent of these sediments and the associated chemicals and nutrients that contribute to the dramatic seasonal drop in water quality. Estimates of the extent and chemical character of accumulated lake-bottom sediments will inform efforts to dredge or otherwise improve the quality and reliability of water withdrawals from the Exeter Reservoir.

Dredging and Permitting

Based on the analysis of lake-bottom sediments in the Exeter Reservoir, it may be that dredging those sediments would improve both water quality and reliability in the Reservoir. Prior to commencement of dredging activities, dewatering the Reservoir would be required to minimize and/or eliminate the introduction of sediment-laden, turbid water to the Exeter Reservoir/Squamscott River aquatic ecosystem. By tracking the change in water level of the Reservoir during the drawdown, additional data could be obtained to supplement stage-storage information collected during the bathymetric survey. Any dredged material will be moved directly from the Reservoir to a suitable removal vehicle and dewatered off-site in preparation for disposal in an appropriate landfill. Dredged material will not be stockpiled at the site.

Based on information provided by Frank Richardson, New Hampshire Department of Environmental Services (NHDES) wetlands permitting reviewer for the seacoast region, the project is likely to require submission of a Standard Dredge and Fill permit application (minor to major level). Although the New Hampshire Code of Administrative Rules specifies maintenance dredging as a "minimum impact" project requiring a reduced submission and no federal (Army Corps of Engineers) involvement, potential dewatering of upstream prime wetlands and the continuous flow of Dearborn Brook through the work site during dredging activities requires additional information for a complete NHDES permit assessment and review.

Components and/or activities associated with submission of the permit may include, but are not limited to:

- Application
- Abutter notification
- Site plans and maps
- Photographs
- Wetlands delineation by NH certified wetland scientist

- Natural Heritage Bureau review
- Vernal pool review
- Construction narrative
- Erosion control narrative

Conclusions

Weston & Sampson recommends conducting a bathymetric survey of approximately 75 data points to determine the stage-storage relationship of the Reservoir. In conjunction with that bathymetric survey, Weston & Sampson recommends taking soft sediment cores of the lake-bottom sediments that have accumulated in the Reservoir and analyzing their chemical content. These relatively simple tasks, estimated at a cost of $8,500, plus laboratory analysis expenses, would provide important information necessary to inform additional improvements to water quality and seasonal availability of the Exeter Reservoir, such as dredging and associated permitting, aeration, and various in-reservoir filtration techniques.

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