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Technical Memorandum

To: *City of Franklin IWRP Team*

From: *CDM*

Date: *August 10, 2011*

Subject: *Review of CTE/AECOM Design Report: Franklin Water Treatment Plant dated July 2006*

Executive Summary

As part of its Integrated Water Resources Plan (IWRP) the City of Franklin (City) has undertaken an evaluation of its water treatment plant (WTP). CDM has conducted reviews of previous work focused on addressing regulatory requirements and facility upgrades at the WTP that will be considered as projection options during development of the IWRP. Review of the previous work identified two pending regulatory drivers that would impact decisions regarding project options for the WTP. The first regulatory driver is the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) which requires additional treatment for Cryptosporidium removal/treatment to be implemented by October 2012. Implementation of UV disinfection at the WTP is the most straightforward method of meeting this regulatory deadline. In addition, compliance with new Stage 2 Disinfectants and Disinfection Byproducts Rules (Stage 2 D/DBPR) requirements is also required by October 2012. Management and control of DBPs requires a two-pronged approach that includes addressing initial formation of the DBPs at the WTP and managing water age in the distribution system. The City is currently working with its wholesale water provider to evaluation methods for addressing the DBPs in the purchased water.

In addition updating the previous cost estimates for WTP upgrades required to maintain current plant operations, this technical memorandum provides estimates for implementing UV disinfection at the City's WTP which would aid in minimization of formation of DBPs as well as meet the requirements of the LT2ESWTR. Concurrently, CDM is working with City Staff to evaluate distribution system options to reduce water age; results of this analysis will be provided in a separate technical memorandum.

1.0 Introduction

As part of its Integrated Water Resources Plan (IWRP) the City of Franklin (City) has undertaken an evaluation of its water treatment facility. This evaluation includes a CDM review of the July 2006 CTE/AECOM report entitled Design Report for the Franklin Water Treatment Plant (WTP Report) that was previously produced for the City. Review of this report identified two important issues related to regulatory compliance that are discussed within this technical memorandum. Additionally, comments regarding recommendations for individual process improvements at the

water treatment plant and updated construction cost estimates for these improvements are provided herein. Comments in this memorandum have been organized in the order of the CTE/AECOM report, with regulatory compliance being discussed first, followed by process recommendations and an updated cost estimate for each process alternative.

In addition to review of the WTP Report, CDM reviewed the July 2009 draft Drinking Water Quality Evaluation and Recommendations (draft WQ Evaluation) that were developed by Metcalf & Eddy/AECOM in conjunction with Hazen and Sawyer. The purpose of this report was to identify the most appropriate methods to reduce the potential for water quality issues in the City's distribution system and to identify appropriate system modifications to reduce the risk of non-compliance with future regulations. Specifically, the new disinfection by-product (DBP) regulations were considered; and, data that was not yet available at the time of the development of the WTP Report was also analyzed. CDM has also provided comments on this draft WQ Evaluation document.

2.0 Regulatory Compliance

Sections I and II of the WTP Report describe the Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 D/DBPR) and the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). Potential compliance issues for Franklin Water Treatment Plant (WTP) are not discussed in detail. This may be attributed to the fact that the study was conducted in 2006, before some details related to compliance with this rule were fully defined: specifically, the LT2ESWTR Bin classification for *Cryptosporidium* treatment requirements, as described in the following Sections.

2.1 Stage 2 D/DPBR Compliance

Many water systems treat their water with a chemical disinfectant to inactivate pathogens that cause disease. The public health benefits of chemical disinfection are significant and well-recognized; however, disinfection poses risks of its own. While disinfectants are effective at controlling harmful microorganisms, they react with organic and inorganic matter in the water and form DBPs, some of which pose health risks when present above certain levels. Since the discovery of chlorination byproducts in drinking water in 1974, numerous toxicological studies have been conducted that show some DBPs to be carcinogenic and/or cause reproductive or developmental effects in laboratory animals. As a result, the US Environmental Protection Agency (EPA) promulgated a set of rules to set maximum contaminant limits for DBPs that are protective of human health.

The most recent changes to the Disinfectants and Disinfection Byproducts Rules are the Stage 2 D/DBPR. This rule, promulgated in January 2006, required systems to first conduct an Initial Distribution System Evaluation (IDSE) to identify compliance monitoring sites for the Disinfection Byproduct Maximum Contaminant Levels (DBP MCLs). The IDSE sample locations are shown in **Figure 1;** sampling results from the IDSE are summarized in **Table 1.** The Stage 2

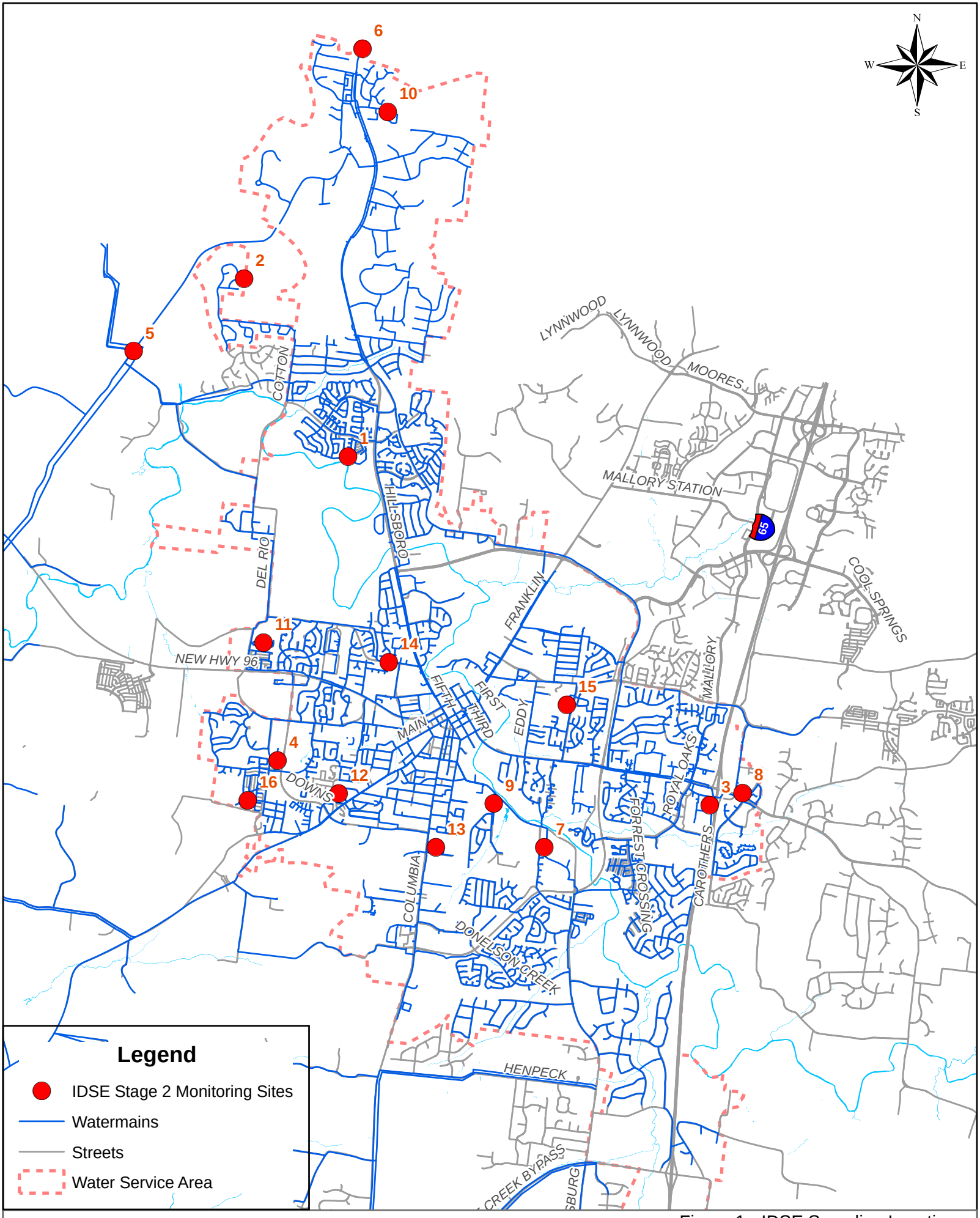

Figure 1 - IDSE Sampling Locations
Water Distribution System
City of Franklin

D/DBPR will apply the current compliance standards of running annual average (RAA) of 80 micrograms per liter (µg/L) for total trihalomethanes (TTHMs) and 60 µg/L of the sum of the five regulated haloacetic acids (HAA5) to individual locations in the distribution system. The City of Franklin falls in the category of a Schedule 2 system, which requires compliance with the new Stage 2 D/DBPR requirements by October 2012.

The change to a location-specific basis for regulating DBPs will have a significant effect on the measures required to achieve compliance, because each location must comply with the DBP MCLs; the ability to average results from sample locations that have elevated TTHM and HAA5 concentrations with those that have lower concentrations will no longer be possible. As shown in **Figures 2** and **3,** there are multiple locations that have average values that exceed the regulatory limits for both TTHM and HAA5 when sample results are averaged on a locational basis. Consequently, changes may be required in the treatment process, in addition to optimization of the distribution system operation, to comply with the Stage 2 D/DBPR.

One important consideration with regard to the overall facility upgrades, in light of DBP management, is the Harpeth Valley Utility District (HVUD) water supply. A cursory review of seasonal variations in DBP concentrations indicates that both TTHM and HAA5 concentrations are higher during seasons when water demands are high and the majority of water is purchased from HVUD. When no water can be withdrawn from the Harpeth River, the City operates the WTP such that a minimum flow of 1 mgd of the water purchased from HVUD is rerouted through the WTP, primarily to address low distribution system pressures in the southern portion of the City's service area. While the primary purpose of this mode of operation is to feed the distribution system to maintain system pressures, it also results in improved water quality with regard to DBPs in the distribution system because it aids in managing water age in the southern portion of the service area. Additional details on the water distribution system will be provided in a separate technical memorandum.

The WTP Report does not include an alternatives analysis for helping the City meet Stage 2 D/DBPR compliance, nor does it include recommendations that would adequately lower DBP concentrations at the compliance sampling locations. The City is already aware of the DBP issues and has already performed some alternative process testing, such as with magnetic ion exchange resin (MIEX), and other alternatives. CDM continues to support the City to evaluate reasonable and feasible options for DBP control both at the WTP and in the distribution system, making use of data already available, to identify the most economical approaches for DBP control.

Table 1
Summary of Stage 2 D/DBPR IDSE Site Data

Site ID	Description	10/8/2007		12/10/2007		2/12/2008		4/8/2008		6/9/2008		8/11/2008		LRAA	
		TTHM mg/L	HAA5 mg/L	TTHM mg/L	HAA5 mg/L	TTHM mg/L	HAA5 mg/L	TTHM mg/L	HAA5 mg/L	TTHM mg/L	HAA5 mg/L	TTHM mg/L	HAA5 mg/L	TTHM mg/L	HAA5 mg/L
1		0.0783	0.0561	0.0492	0.0334	0.0387	0.0324	0.0474	0.0455	0.0648	0.0458	0.0977	0.0528	0.0627	0.0443
2		0.0607	0.0404	0.0493	0.0346	0.0354	0.0289	0.0463	0.0505	0.0615	0.0344	0.1350	0.0602	0.0647	0.0415
3		0.0758	0.0410	0.0654	0.0732	0.0413	0.0443	0.0452	0.0652	0.0901	0.0393	0.1050	0.0566	0.0705	0.0533
4		0.0800	0.0554	0.0628	0.0701	0.0800	0.0408	0.0515	0.0729	0.0850	0.0422	0.1070	0.0588	0.0777	0.0567
5		0.0552	0.0581	0.0394	0.0326	0.0246	0.0212	0.0291	0.0290	0.0602	0.0292	0.0694	0.0354	0.0463	0.0343
6		0.0805	0.0161	0.0327	0.0349	0.0243	0.0261	0.0307	0.0344	0.0537	0.0274	0.0646	0.0411	0.0478	0.0300
7		0.0731	0.0750	0.0334	0.0325	0.0272	0.0255	0.0243	0.0235	0.0619	0.0358	0.0506	0.0580	0.0451	0.0417
8		0.1120	0.0276	0.0853	0.0202	0.0544	0.0410	0.0617	0.0598	0.0876	0.0675	0.1380	0.0396	0.0898	0.0426
9		0.1180	0.0725	0.0476	0.0202	0.0360	0.0317	0.0366	0.0348	0.0855	0.0528	0.1070	0.0554	0.0718	0.0446
10		0.0624	0.0501	0.0404	0.0489	0.0445	0.0289	0.0530	0.0489	0.0777	0.0513	0.0793	0.0514	0.0596	0.0466
11		0.0923	0.0828	0.0635	0.0303	0.0496	0.0446	0.0332	0.0363	0.0644	0.0295	0.0694	0.0388	0.0621	0.0437
12		0.1340	0.0194	0.0534	0.0440	0.0358	0.0420	0.0699	0.0796	0.1500	0.0926	0.0964	0.0655	0.0899	0.0572
13		0.1620	0.1170	0.1630	0.0712	0.0604	0.0566	0.0780	0.0813	0.1710	0.0594	0.1360	0.0076	0.1284	0.0655
14		0.0742	0.0710	0.0573	0.1000	0.0394	0.0325	0.0374	0.0345	0.0548	0.0483	0.0832	0.0497	0.0577	0.0560
15		0.0933	0.0068	0.0602	0.0410	0.0591	0.0472	0.0528	0.0299	0.0853	0.0444	0.1330	0.0548	0.0806	0.0374
16		0.1150	0.0065	0.0877	0.0535	0.0547	0.0444	0.0013	0.0011	0.0058	0.0018	0.0127	0.0000	0.0462	0.0179

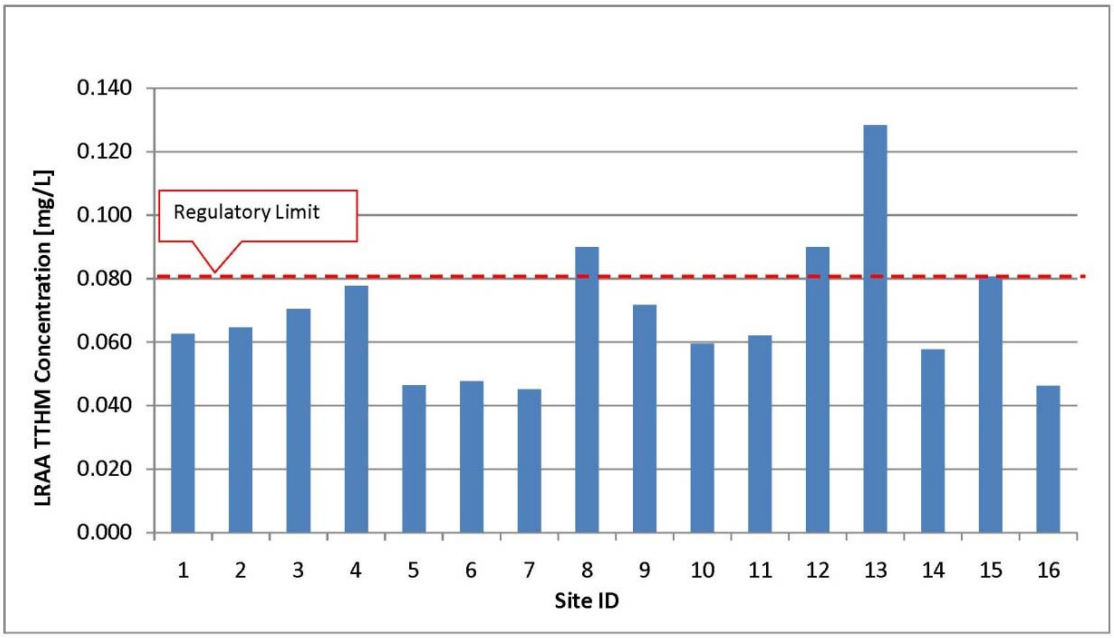

Figure 2
LRAA of TTHM Concentrations at IDSE Sites

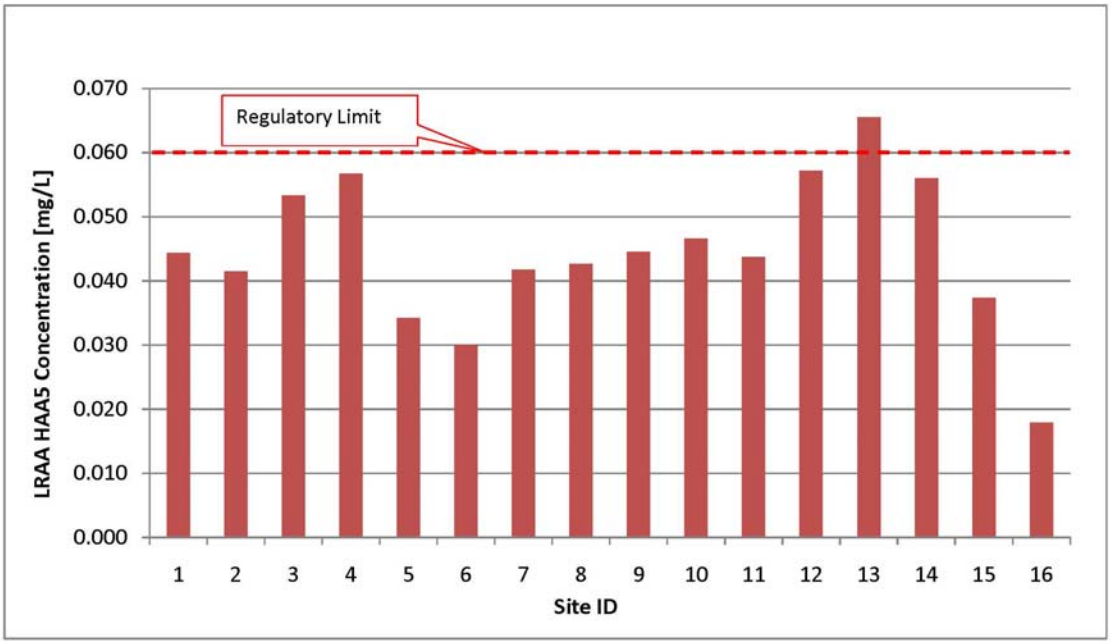

Figure 3
LRAA of HAA5 Concentrations at IDSE Sites

2.2 LT2ESWTR Compliance

The EPA published the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) on January 5, 2006 which was promulgated to improve control of microbial pathogens. The LT2ESWTR is expected to reduce drinking water related exposure to *Cryptosporidium* substantially, thereby reducing both illness and death associated with cryptosporidiosis through source water monitoring, additional treatment techniques, and higher standards for drinking water quality. The LT2ESWTR requires additional treatment for *Cryptosporidium* in cases where source water average concentrations exceed 0.075 oocysts per liter. The City of Franklin source water testing results were slightly above this limit, requiring an additional 1-log removal and/or inactivation for *Cryptosporidium* (e.g., placing the City of Franklin in Bin 2 under the LT2ESWTR).

The previous WTP Report assumed that Franklin would be Bin 1 with no additional treatment for *Cryptosporidium* required, although the WTP Report does discuss potentially pursuing a membrane treatment option, if *Cryptosporidium* concentrations are determined to be higher than assumed. Consequently, the WTP Report does not provide an evaluation of the most cost-effective approach for LT2ESWTR compliance. However, complying with this rule is less complicated than meeting Stage 2 D/DBPR compliance. There are fewer options for meeting LT2ESWTR, requiring less study to compare options; and a full study is not necessary, although treatment options and safety factors should be established for this facility. The alternatives for meeting LT2ESWTR compliance include implementation of modified operations management practices, UV disinfection, or membrane filtration. Operational practices involve maintaining turbidity under 0.15 NTU in all filters, over 95 percent of the time every month. This is a low-cost approach but leaves no safety factor and places the plant in the position of being at risk of a Notice of Violation due to a relatively small plant upset. Additional options are provided in the LT2ESWTR Toolbox (http://www.epa.gov/safewater/disinfection/lt2/pdfs/guide_lt2_toolboxguidancemanual.pdf).

While not specifically a part of this review, a cost estimate for the option of a UV disinfection process, that is expandable to a UV-advanced oxidation process (AOP), was developed for the WTP. This information has been developed in conjunction with other ongoing IWRP evaluations. The option was developed such that the initial installation of UV disinfection equipment would address LT2ESWTR compliance requirements, discussed above, and the system would be sized so that it could be upgraded to a UV-advanced oxidation process (UV-AOP), in the future.

Initially, the concept of applying a UV-AOP was considered as an option for implementation at a potential new wastewater treatment plant (WWTP), proposed to be located upstream of the existing WTP. The process was proposed as a method of addressing compounds that would potentially cause taste and odor, as well as other currently unregulated and emerging constituents. Initial UV-AOP equipment capital cost proposals were obtained for the proposed new WWTP; equipment proposals from two vendors were in excess of $18M. This information was presented and discussed with the IWRP Steering Committee; and, based on this discussion the decision was made to evaluate the UV-AOP process option at the WTP. Capital cost proposals

were solicited for UV equipment that would be expandable to UV-AOP at the WTP. Equipment cost proposals were substantially lower in cost than for similar equipment at the proposed new WWTP because of the quality of the water to be treated. The vendor supplied information for UV-AOP at the WTP was used to develop construction cost, which is summarized along with other cost updates in Section 4.0.

3.0 Facility Process Upgrades

Sections III and IV of the WTP Report briefly, but adequately, describe minimum requirements for upgrading the existing water treatment facilities and expanding the treatment capacity from 2.1 to 4.0 million gallons per day (mgd). If the plant capacity is not increased, upgrades to the existing facilities should be prioritized with an implementation schedule and corresponding budget. The City has continued to support facility maintenance and other process improvements, such as installation of a variable speed drive on the river intake pump, to maximize plant efficiency. However, if there is a large project at the plant, such as a treatment capacity expansion, economies of scale would suggest correcting major deficiencies concurrently, as recommended in the WTP Report. CDM comments on recommended upgrades and alternatives for each process are presented in the following Sections.

3.1 Raw Water Intake and Pump Station

The WTP Report covers options for upgrading the traveling screen versus providing new intake screens in the river. Both options are feasible as presented in the WTP Report; however, smaller raw water pumps may merit consideration, if the WTP capacity is to remain at 2.1 mgd.

3.2 Raw Water Reservoir

The WTP Report addresses the importance of repairing the major leak in the raw water reservoir and addressing the buildup of spent backwash waste solids. To date, the reservoir rehabilitation project has been completed with a new storage volume of 113 million gallons.

3.3 Mixing

The WTP Report describes the existing mixers and chemical feed points but makes no recommendations or evaluations regarding changes or improvements. A brief review of mixing intensity and the optimal feed points for chemicals is warranted. For example, powdered activated carbon would be more effective on a per-unit-weight basis, if fed further upstream instead of co-currently with coagulant.

3.4 Flocculation

The age of the existing flocculators justifies consideration of improvement options, but the WTP Report recommends a complete process change from walking beam flocculators to paddle wheel flocculators, without a comparison of alternatives. The WTP Report states, “the equipment is in satisfactory condition but probably needs to be replaced, due to its age and parts availability.”

However, there are no letters from suppliers of walking beam flocculators to support this claim. Unless City staff has further investigated parts availability, other than that reflected in the WTP Report, contacting alternate manufacturers to obtain quotes on upgrading the existing equipment and comparing alternatives is suggested.

3.5 Settling Basins

The WTP Report presents two options for the settling basins: 1) upgrading and expanding with more conventional basins employing tube settlers or 2) abandoning the conventional basins and retrofitting one of the basins with a dissolved air flotation (DAF) system. This drastic change to a high-rate process is inadequately justified in terms of both cost and performance. There are no pilot testing results demonstrating that one alternative is better through seasonal water quality changes. Plant staff and the Tennessee Department of Environment and Conservation (TDEC) need to be comfortable that any process change can be successfully implemented and that the change would positively result in improved treatment performance. As such, if a DAF process alternative is to be further pursued, then testing should be considered. Also, the economics of proposed alternatives would change, if the existing walking beam flocculators only require minor upgrades or if State requirements result in changes in the design loading rates.

3.6 Filters

The recommendation to upgrade the valves and replace the filter underdrains is not unusual. Filter underdrain inspection could be performed to verify the need for replacement. CDM concurs with the conclusion that conversion to a backwash system that uses air scour alone, as well as in combination with a concurrent water backwash, would reduce finished water usage and improve filter cleaning.

3.7 Transfer Pumps and High Service Pumps

The WTP Report recommends upgrades as needed under the alternatives that expand plant capacity. CDM concurs with the additional recommendation that the exact horsepower and hydraulic conditions should be checked in final design.

3.8 Chemical Systems

CDM is in agreement that chemical systems should be upgraded, as needed, if plant capacity is increased. The City has already upgraded the facility to address issues associated with the use of gas chlorine by switching to use of delivered bulk sodium hypochlorite solution. However, as noted above, optimal chemical feed locations were not evaluated.

4.0 Cost Estimates

The construction cost estimates in the WTP Report were escalated to current dollars and evaluated for reasonableness. Minimal documentation was provided in the WTP Report regarding development of cost estimates, making it difficult to assess the adequacy of

contingencies and other capital cost factors. Given this uncertainty and the early stage of the project, a 25-percent contingency has been provided for other items that will become apparent as the design progresses. Costs have been revised to reflect 2011 dollars, using a 3 percent per year factor. Detailed cost estimate tables for the conventional and DAF options are provided as attachments to this memorandum. The membrane filtration option cost was also updated, because the worst-case, in terms of cost for LT2ESWTR compliance would be adding membrane filtration technology. Updated costs for these project options have been summarized in Table 2 with supporting documentation provided as an attachment to this memorandum.

Less costly options, such as operational modifications and implementation of UV disinfection that meet LT2ESWTR requirements should have been investigated in the WTP Report. CDM has provided an opinion of probable construction costs for UV disinfection, as well as an adder for upgrading for UV-AOP, which is summarized along with cost information in Table 2. Further, it is important to note that the WTP Report did not evaluate DBP control options for future compliance, nor did it include costs for advanced treatment for DBP control. CDM is currently working with City staff to identify distribution system improvements that could aid in managing DBPs, however, additional investigation into other treatment and management options at the WTP are merited.

Table 2
Updated Construction Cost Estimates (Year 2011 Dollars)

Item	Upgrade Existing 2.1 mgd WTP	4.0 mgd Treatment Alternative		
		No. 1 (Conventional)	No. 2 (DAF)	No. 3 (Membranes)
Raw Water P.S. w/ Travelling Water Screen	$ 1,330,000	$ 1,330,000	$ 1,330,000	$ 1,330,000
Replace or Upgrade Existing Flocculation Equipment	$ 50,000	$ 50,000	-	$ 50,000
Upgrade Existing Settling Basin Nos. 1, 2, & 3	$ 340,000	$ 340,000	-	-
Construct Settling Basin Nos. 4 & 5	-	$ 2,040,000	-	-
Add DAF to Existing Settling Basin No. 3	-	-	$ 2,480,000	-
Upgrade Existing Filters	$ 1,530,000	$ 1,530,000	$ 1,530,000	-
Replace 2 mgd Clearwell Transfer Pump with 4 mgd Pump	-	$ 260,000	$ 260,000	-
Convert Existing Filters to Membranes	-	-	-	$ 6,500,000
Replace 2 mgd High Service Pumps with 4 mgd Pump	-	$ 760,000	$ 760,000	$ 760,000
Upgrade Existing Chemical Feeders	$ 40,000	$ 70,000	$ 70,000	$ 70,000
Sitework and Buried Piping	-	$ 750,000	$ 750,000	$ 750,000
Subtotal	**$ 3,290,000**	**$ 7,130,000**	**$ 7,180,000**	**$ 9,460,000**
Optional UV Disinfection System	$ 684,000	$ 684,000	$ 684,000	$ 684,000
Optional AOP Adder	$ 750,000	$ 750,000	$ 750,000	$ 750,000
Project Total with UV and AOP Option	**$4,724,000**	**$ 8,564,000**	**$ 8,614,000**	**$10,894,000**
Legal, Technical and Other Costs (15%)	$ 709,000	$ 1,285,000	$ 1,292,000	$ 1,634,000
Project Total	**$ 5.4 M**	**$ 9.8 M**	**$ 9.9 M**	**$ 12.5 M**

5.0 Drinking Water Quality

CDM reviewed the July 2009 draft Drinking Water Quality Evaluation and Recommendations (draft WQ Evaluation) that were developed by Metcalf & Eddy/AECOM in conjunction with Hazen and Sawyer. The purpose of this WQ Evaluation was to identify appropriate methods to reduce the potential for water quality issues in the City's distribution system and to identify additional distribution system modifications to reduce the risk of water quality issues in the future. This draft WQ Evaluation and related work focused on Franklin's distribution system model to simulate chlorine decay and using those results to develop recommendations regarding maintaining chlorine residuals and reducing TTHMs. In summary, CDM is in concurrence with the following findings:

- Reducing water age and reducing chlorine residual can help reduce TTHMs,
- Use of booster chlorine can allow lower residuals earlier in the system and lower TTHMs, and
- Automatic flushing devices can help lessen TTHMs.

However, the draft WQ Evaluation presents and discusses mainly THM data with limited review of the HAA5s. Both classes of these DBPs are regulated and Franklin's IDSE data suggest compliance will be difficult for both THMs and HAAs, as previously described in **Section 2.1**. The WQ Evaluation does not discuss the fact that addition of automatic flushers which can be used to lower water residence time and hence DBPs at the locations feeding the flushers only; and that adding flushers after the IDSE evaluation alters the residence times of specific locations and therefore where maximum TTHM and HAA5 site are located in the system. The end result is that TDEC could request additional TTHM and HAA5 sampling at other locations without flushers or repeating the IDSE. Further, the draft WQ Evaluation does not present all of the TTHM and HAA5 data from the IDSE study and does not describe the four TTHM sites and one HAA5 site that had locational running annual averages (LRAAs) exceeding the Stage 2 DBP compliance limits. It is important to note that several of the higher TTHM and HAA5 sites from the IDSE study are in the portions of the distribution system that are primarily fed from the City of Franklin WTP, thus it is recommended that treatment optimization options at the WTP also be evaluated along with the ongoing efforts to identify distribution system improvements to manage water age.

The draft WQ Evaluation does however, describe that HVUD will be required to assist with TTHM and HAA5 compliance per the State of Tennessee rule that states "parent systems designated by the department that routinely sell water to consecutive systems with MCL violations for TTHM or HAA5 shall meet 0.048 mg/L TTHM and 0.036 mg/L HAA5 at the entry point and master meter for the consecutive system in order to demonstrate enhanced coagulation." This is an important consideration in the overall management of DBPs.