DUFRESNE GROUP CONSULTING ENGINEERS

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July 7, 2015

Steve Roy, PE,
Burlington Public Works
53 Lavalley Lane
Burlington, VT 05401

Re: Concerns regarding a Proposed Marina near the Water Treatment Facility
DG: 4150008

Dear Steve:

We are pleased to submit this engineering report addressing City concerns regarding a proposed marina project adjacent to the Water Treatment Plant at 234 Penny Lane. This report is based on the May 18, 2015 request for technical assistance.

Executive Summary:

Our analysis indicates that although the proposed marina requires almost no physical improvements such as buildings and other "permanent" facilities, planned marina use such as parking and access to the launching area on the south side of the treatment building would unduly restrict chemical deliveries at the Water Treatment Facility. Relocation of these facilities is possible, but there are disadvantages related to alternative locations include land acquisition and extended traffic delay in the alleyway during chemical deliveries. In addition, even if the liquid chemical fill stations are relocated, access to the existing loading dock would still be required for dry materials.

Although our analysis indicates that many potential process enhancements that may be required to meet future regulations could be completed without an expansion of the existing roof lines, restricting available space for future unit operations would limit flexibility in implementing potential treatment schemes. Finally our analysis indicates that the security risk of long-term parking adjacent to the south wall of the facility would not be acceptable.

Eight areas of concern previously identified by City Staff are further evaluated in regard to a potential marina project in close proximity to the Burlington Water Treatment Plant (WTP) on Penny Lane. We summarized the results of our investigations listed below by the item of concern.

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1. *The Water Plant footprint is bound by a small area which is needed to perform maintenance tasks. On example is removal of vertical turbine pumps from the ABW filter area on the west side of the building. How can conflicts be averted?*

Although the available area around the existing Water Treatment Facility is already constricted and the marina project would further limit the area available for operational tasks, we did not find that with the exception of chemical and dry goods deliveries (which is discussed under Item 3) the proposed use of the areas identified by the marina would unduly restrict maintenance tasks required to be performed by WTP operational staff.

2. *As future regulations develop that may require different treatment, can the area as depicted with the Marina allow room to upgrade, replace, or expand the water purification processes such as GAC or other technologies?*

Although regulatory standards and requirements will likely be significantly more stringent in the future, the facility has substantial flexibility due to a large pretreatment unit operation which is not used. The unused tankage provides opportunity for both Granular Activated Carbon (GAC) contactors that would reduce total organic carbon prior to disinfection and for a Dissolved Air Floatation (DAF) unit that would support enhanced coagulation to reduce total organic carbon (TOC) in the water applied to the filters. It is also recommended that new processes such as Miex® be reviewed, which may allow effective treatment and eliminate the need for both of these unit operations. In addition, conversion of primary disinfection using free chlorine to ultraviolet light units would not require a building addition. Also secondary disinfection methods using monochloramine could be completed without any roof line changes. The only potential treatment method that would not be available to the facility would be ozonation. The need to provide storage for large liquid oxygen tanks would conflict with the area proposed for parking along the south side of the facility. An alternative location for these tanks was not identified.

3. *Delivery of chemicals and other materials for water treatment operations is a routine occurrence and cannot be impinged upon by parking displacing this activity.*

Chemical deliveries are made about twice per month to the loading dock on the southeast side of the Water Treatment Facility. The existing access area south of the facility is not adequate for the size of some of the existing trucks attempting to access the loading dock and the chemical fill stations. The trucks spend hours jockeying into position and in the past some trucks have been damaged without any vehicles parked in this area. Although the marina developer would propose an increase in width of this area, chemical deliveries to the existing fill stations would not be possible if cars are parked in this area. This issue was identified as a significant conflict. Potential mitigation measures were identified including use of the area for WTP employees only, a valet system for marina staff to transfer cars when needed, and to relocate the chemical fill stations to other areas. The alternative of using the area exclusively for

WTP staff was viable but burdensome. The alternative of using marina personnel to transport cars to suit chemical delivery was found not viable. The relocation of the chemical feed lines may be feasible but required negotiation of turnaround areas with the State of Vermont and possibly the Coast Guard. In addition, it should be recognized that the flow of traffic through Penny Lane alleyway will be greatly constricted during chemical deliveries. We estimate the cost of relocating the chemical fill stations at $40,000, not including land acquisition or the alternative access to the State boat launch.

4. *Our active 30-inch water intake is laid on the lake bottom and cold be susceptible to boat anchors or sinking docks/vessels from storm events. What types of mitigation measures could be implemented.*

The potential effects of the marina project on the intake line were investigated and found not to be significant. However, methods yet to be defined for anchoring the dock system to the lake bottom should be reviewed for potential effects on the intake line after specific methods are proposed.

5. *There are extensive water utilities on the west side of the filter plant near the existing picnic shelter.*

Marina officials propose use of the area near the picnic shelter to be used as boat storage, maintenance, loading, and launching area. This area is underlain by numerous large diameter pipes and appurtenances. After analysis of the potential wheel loading effects on these existing pipes, concrete encasement is recommended for protection of two large diameter pipes. This work is estimated at $35,000 not including porous pavers for restoration of the surface. In addition, in order to facilitate the marina project the existing flow control vault is recommended to be demolished and the meter relocated for an estimated construction cost of $25,000.

6. *There are extensive water and electric utilities on the north side of the alley that must be unhindered by above activities other than the roadway itself.*

The developer indicated there were no plans for this area and this item was not investigated.

7. *Determine if the plans to remove an existing earthen berm on the south side of the water plant to accommodate additional parking for the proposed marina will compromise the integrity of the structure. This will most likely require a structural analysis of the wall to ensure its stability with appropriate factors of safety due to reduced support.*

In order to maximize the available space for the westerly boat loading area and for parking along the south side of the Water Treatment Facility, a grass berm is proposed for removal. This would lower grade by four feet in this area which is a concern for

protection of existing utilities and for frost penetration along the footing in this area. After structural analysis, there is concern that the existing footing would not have adequate protection in the southwest corner of the building where the slab is stepped up for the ABW filter. We estimate the cost for protecting the building footings at this location at $100,000. But most of the footing along southerly elevation is not affected by the four foot grade modification. However, concrete encasement and insulation is warranted in this area for protection of utilities. The cost for this encasement and insulation is estimated at $25,000.

8. *An additional task was included in the scope of services to review existing security measures at the Water Treatment Facility and make any recommendations for improvement if deemed necessary based on any security implications related to the potential marina project.*

Security measures were investigated and found to be inadequate at the facility given the open public atmosphere around the facility and the existing system should be investigated and upgraded by a security firm. The potential for long-term parking directly adjacent to the south wall as proposed by the marina developer was found to pose significant adverse risks and found to be not acceptable for security reasons.

Planning Objective:

Conduct an engineering review of previously identified local concerns regarding construction and operation of a proposed marina project as it affects the current operation and potential future expansion or upgrade of the Water Treatment Plant (WTP). With one additional task, the concerns previously identified by Public Works officials are as contained in the request for technical assistance and our proposal of June 1, 2015. These concerns are as follows:

1. The Water Plant footprint is bound by a small area which is needed to perform maintenance tasks. One example is removal of vertical turbine pumps from the ABW filter area on the west side of the building. How can conflicts be averted?
2. As future regulations develop that may require different treatment, can the area as depicted with the Marina allow room to upgrade, replace, or expand the water purification processes such as GAC or other technologies?
3. Delivery of chemicals and other materials for water treatment operations is a routine occurrence and cannot be impinged upon by parking displacing this activity.
4. Our active 30-inch water intake is laid on the lake bottom and could be susceptible to boat anchors or sinking docks/vessels from storm events. What types of mitigation measures could be implemented?
5. There are extensive water utilities on the west side of the filter plant near the existing picnic shelter.
6. There are extensive water and electric utilities on the north side of the alley that must be unhindered by above activities other than the roadway itself.

7. Determine if the plans to remove an existing earthen berm on the south side of the water plant to accommodate additional parking for the proposed marina will compromise the integrity of the structure. This will most likely require a structural analysis of the wall to ensure its stability with appropriate factors of safety due to reduced support.
8. An additional task was included in the scope of services to review existing security measures at the Water Treatment Facility and make any recommendations for improvement if deemed necessary based on any security implications related to the potential marina project.

Existing Information:

The informational database for this was provided by both the City of Burlington as relating to the design and operation of the Water Treatment Facility and the marina developer and their consultant. The database is summarized as follows:

1. A set of Record Drawings dated May of 1981.
2. A set of Record Drawings dated October 1993 for the CT Improvement Project by Hoyle, Tanner & Associates, Inc.
3. A 1"=20 feet Progress Plan for the Burlington Harbor Marina Project showing Existing Conditions Partial Site Plan dated 6/3/2015 Drawing No. C1.0 by Civil Engineering Associates, Inc.
4. A 1"=50 feet Progress Plan for the Burlington Harbor Marina Project showing Existing Conditions Partial Site Plan dated 6/3/2015 Drawing No. C1.0 by Civil Engineering Associates, Inc.
5. Information provided by City staff regarding existing operational methods and historical data for the Water Treatment Facility.

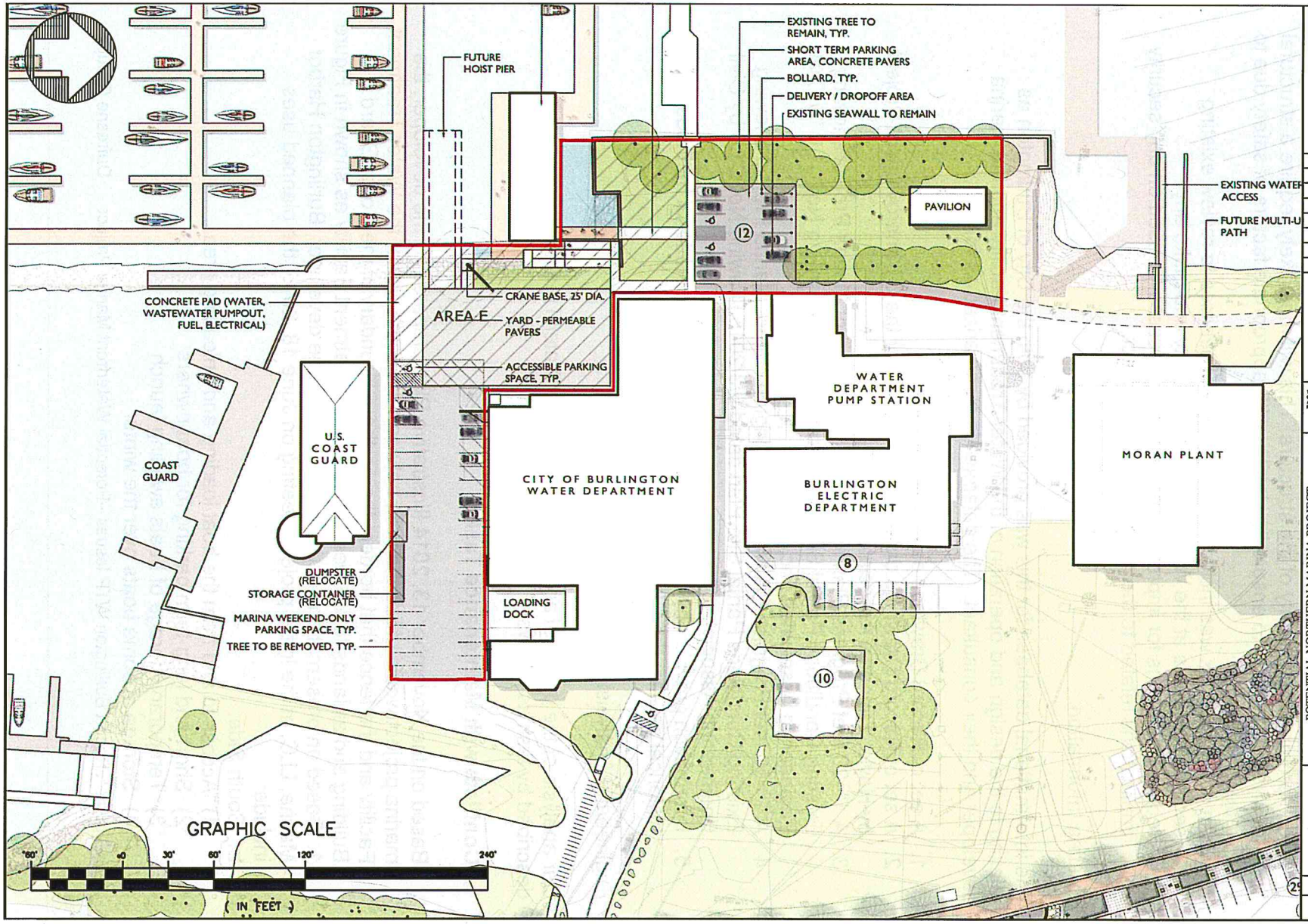
Engineering Analysis:

Our analysis of the potential adverse effects on the Water Treatment Facility is described by task as follows:

1. Conflicts with Maintenance Tasks:

Based on the November 13, 2014 Illustrative Plan prepared by the developer, the marina project would utilize the area between the south wall of the Water Treatment Facility and the fence that borders the northern boundary of the Coast Guard Building and all lands to the west of the Water Treatment Facility as shown in Figure 1. Based on presentations and discussions with the developer, Burlington Harbor Marina, LLC, at the initial project meeting on June 18, 2015, the planned uses include:

a. South Side:
   1) Access to and from the boat loading and unloading area
   2) Short and long-term parking for boat owners
   3) Temporary storage of boats awaiting launch
   4) Storage of some boats over the winter



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Project #	000000
Project Mgr.	RED
Design	NAME
Drawn	EAE
Checked by	R.E. DUFRESNE
Date	JUNE 29, 2015
Scale	AS SHOWN
Approved by	RED

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POTENTIAL NORTHERN MARINA PROJECT

FIGURE 1
ILLUSTRATIVE PLAN
11-13-14

BURLINGTON, VERMONT

FIG 1

DWG. NO. turning radius.dwg

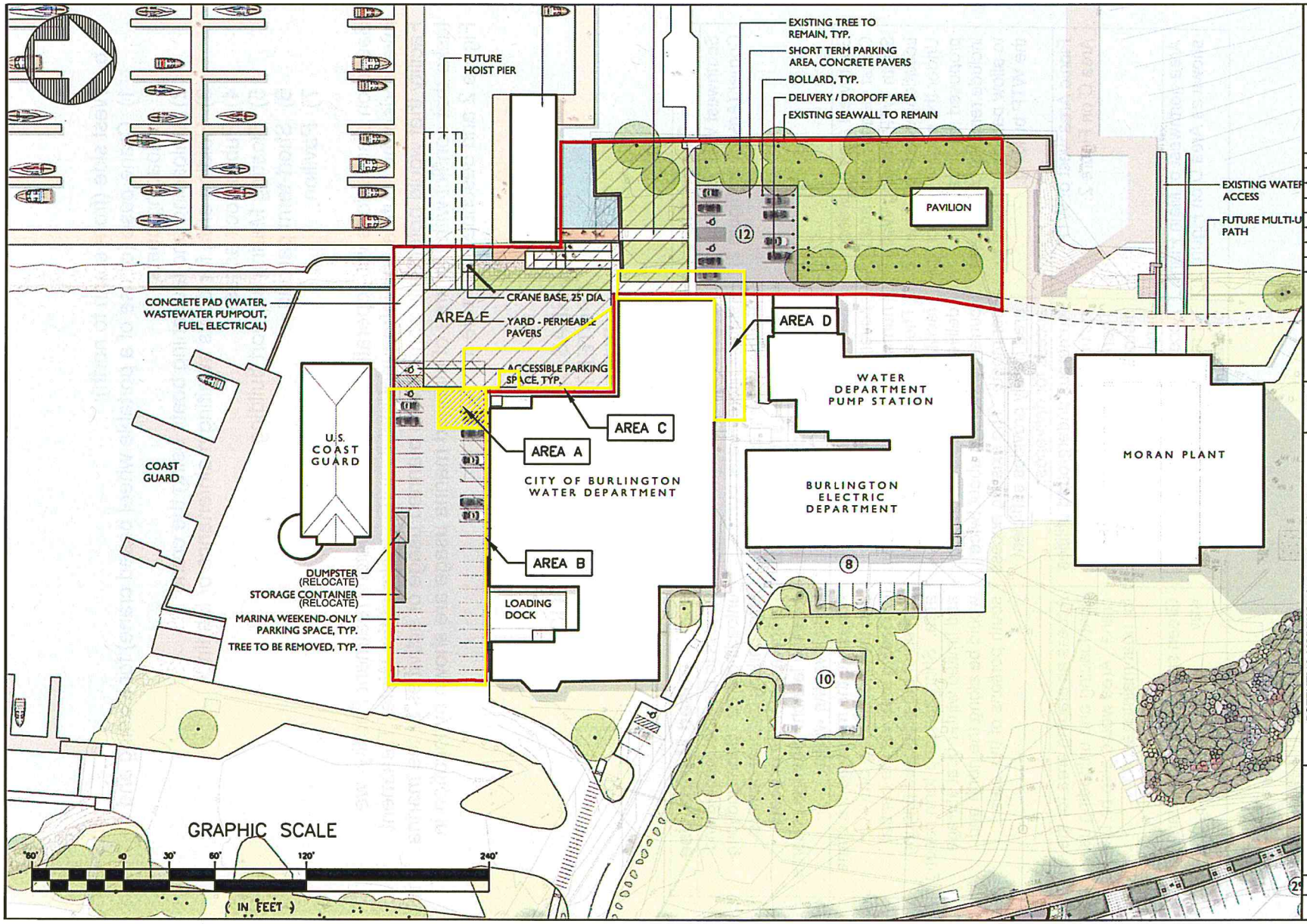
SHEET 1 OF 1

b. West side (from south to north):
   1) Crane base (or use of a portable wheel based crane) for loading and unloading boats
   2) Unloading and launching boats using the crane
   3) Holding area for boats awaiting maintenance or loading
   4) Public dock access
   5) Floating Marina support building
   6) Short-term parking
   7) Pavilion

Based on discussions with operational staff at the Water Treatment Facility, we inventoried the routine and infrequent maintenance tasks at the Water Treatment Facility that would potentially conflict with planned usage or activities at the marina. The tasks that conflict with the area of planned marina usage are shown by location in Figure 2 and described in Table 1.

TABLE 1
AREAS OF POTENTIAL CONFLICT
POTENTIAL MARINA PROJECT
BURLINGTON, VERMONT
JULY 1, 2015

Area Description	WTP Use	Proposed Marina Use
Southwest WTP Building Corner (Area A on Figure 2).	Crane location to remove/install stage 1 filtered water pumps. Estimated frequency is twice every ten years for about half a day (remove and then reinstall a month later).	Access to the boat loading and unloading area. Short and long-term parking for boat owners. Temporary storage of boats awaiting launch. Storage of some boats over the winter.
Southwest area between Coast Guard Fence and South WTP Building Wall Location Area B on Figure 2. Under the marina project, the proposed modifications include removal of the berm to allow parking adjacent to the WTP building.	Berm at South Wall provides cover and protection of numerous underground utilities. The existing access area facilitates bulk tank chemical deliveries. These deliveries currently average about twice per month. The existing access area barely provides sufficient access for deliveries.	Access to the maintenance crane and the boat loading and unloading area via the central portion of the proposed parking area. Short and long-term parking and limited winter boat storage would be along the north and south portions of this area.
Picnic Area west of WTP Area C on Figure 2.	Numerous underground utilities including a flow meter vault. There are several large diameter pipes with shallow bury depth in this area.	Access as staging area for the boat loading and unloading using crane. Area would also be used for boat maintenance.
Area northwest of Main Plant shown as Area D on Figure 2	Access for large vacuum truck for removal and/or replacement of sand media.	Green space and pedestrian walk way.



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POTENTIAL NORTHERN MARINA PROJECT

FIGURE 2
AREAS OF CONFLICT

BURLINGTON, VERMONT

FIG 2

DWG. NO. turning radius.dwg

SHEET 1 OF 1

As described in Table 1, there are some usage conflicts in the southern and western areas as follows:

A. Area A. Under the marina project, a portion of this area would be used for parking and for loading and unloading boats using a permanent or portable crane. This proposed use would at very infrequent time's conflict with the required maintenance procedure of removing or reinstalling filtered water pumps that are removed through roof hatches in the roof using a crane. The need would not be predictable but is likely not immediate since there are three pumps and only one pump is required to meet typically daily demand. Removal of a pump could be scheduled a week or so after the need arises. The procedure would take about four hours for mobilization, pump removal (or installation), and demobilization and is estimated to occur about three times every ten years based on the life of such mechanical systems. Potential mitigation measures would include:
    1. Notification of marina staff by WTP staff of the need for a portable crane at the location shown to remove or install the pump/motor. Marina staff would convey the need to set up a crane to remove the pump/motor and barricade the area to prevent parking or storage by uninformed individuals. However, since some vehicle owners may likely be out of touch for over a week, it seems beneficial that the marina owners would require vehicle keys be left with the marina management for such a situation.
B. Area B. Under the marina project, long-term parking and winter boat storage along the south wall of the Water Treatment Facility and the northern fence of the Coast Guard complex would restrict bulk delivery of chemicals to the WTP. Potential mitigation measures could include:
    1. Eliminate winter boat storage in this area. In addition to restricting access for bulk delivery, winter boat storage would hamper effective snow removal.
    2. Utilize the area for parking for WTP employees only and open areas formerly used by WTP staff for Marina customers. WTP administrative officials would have control of employee parking and could coordinate temporary restrictions for bulk deliveries.
    3. Require valet parking where the marina manager would have access to all vehicles in long-term parking. The vehicles would be removed and returned as required to facilitate bulk deliveries. Based on the current chemical delivery frequency of once every two weeks, coordinating and accomplishing vehicle relocations would appear to be onerous. In addition, if the delivery frequency increases due to enhanced coagulation or ozonation, it appears the frequent vehicle relocation concept would not be viable.
    4. Although not discussed with the City Fire Chief, it is likely that long-term parking directly adjacent to the south wall of the water treatment building would unduly restrict access for emergency vehicles and would not be endorsed as a viable concept.

2. Potential improvements due to future regulations:

The need to construct additional facilities to meet increasingly stringent standards is perhaps the most significant issue of concern when considering the potential marina project. Once the real estate surrounding the facility is lost to the marina project, it will set increased constraints for potential future projects, which have not yet been defined. Transferring partially treated water to a remote location for additional treatment due to such land constraints and back to the existing plant for additional unit operations is expensive on both a capital cost and annual cost basis.

The Water Treatment Facility for the City of Burlington withdraws and treats water from Lake Champlain to meet all current state and federal water quality standards. Currently, the facility produces water in conformance with these parameters. Water quality standards are set by the Environmental Protection Agency (EPA) and are constantly evolving. In fact, EPA is charged with setting maximum contaminant levels (MCL's) for new contaminants on a continuing basis. Twenty years ago few waterworks professionals could have predicted the extensive set of regulations now governing the production and treatment of drinking water.

The historical growth and severity of Federal regulations allows one to confidently predict that water quality standards will be even more stringent in future decades. As one would expect, equipment and tankage needed to comply with the more stringent quality standards will create the need for more expansive and more complex facilities. These new and enhanced unit operations will typically require more space to house and support these facilities. Although less so in most Vermont communities, growth due to population increases will further create a demand for larger water treatment facilities.

Offsetting the trend for larger more expansive facilities is the exponential rate of growth in technology in the water treatment industry as well as in related disciplines such as electrical, instrumentation, and mechanical systems. The WTP in Burlington is an example of a facility benefitting from such technological advances. Prior to the upgrade project in 1981, Burlington used conventional water treatment facilities, which required separate unit operations for rapid mix, slow mix (or flocculation), sedimentation, filtration, and disinfection. A significant innovation in water treatment in the late 1970's was the development of a combination flocculation and sedimentation basin. This innovation was the main objective of the 1981 filter plant renovation project in Burlington. This use of a single basin for flocculation and sedimentation was referred to as a solids contact clarifier. This multipurpose tank allowed for a 50% reduction in floor space when compared to the older "conventional" treatment technology. This multiuse basin which was further enhanced with baffles and plate settlers to allows increased application rates to allow twice the water through as compared to the original solids contact clarifier resulting in another 50% reduction in floor space for treating the same flow. In 1981 Burlington officials pursued this alternative and constructed this pretreatment unit operation with a product known as a "super-pulsator".

Innovation continued exponentially after the Burlington upgrade project was completed. Adsorber clarifiers allowed much better pretreatment clarification with only 40% of the area previously required for a "super-pulsator". Dissolved Air Floatation methods of pretreatment reduce space requirements even further. On high quality sources of supply such as Lake Champlain, membrane alternatives now allow for superior water treatment without the use of any pretreatment basins. Future innovations may yet reduce requirements for buildings and infrastructure to even greater degrees.

Operationally, better operators, better blended coagulants, new coagulant aids, advanced feed pumps, more reliable analyzers and the use of supervisory control and data acquisition (SCADA) systems allow consistent production of high quality drinking water at higher application rates (and much reduced floor space requirements).

The need for larger facilities to meet increasingly stringent water quality regulations versus the advances in technology which allow water works professionals to do more with less is the backdrop for this evaluation.

Current and Anticipated Future Regulations:

There are primarily three sets of regulations that set water quality standards for Burlington and all other surface water treatment facilities nationally. These regulations or "Rules" include:

- Stage 1 Disinfectants and Disinfection Byproducts Rule (S1D/DBPR).
- Stage 2 Disinfectants and Disinfection Byproducts Rule (S2D/DBPR).
- Long-term 2 Enhanced Surface Water Treatment Rules (LT2ESWTR).

The S1D/DBR sets maximum residual disinfectant levels (MRDL's) for chemical disinfectants, as well as maximum contaminant levels (MCL's) for disinfection byproducts (DBP's). These values are shown in Table 2.

TABLE 2
MAXIMUM LEVELS FOR DISINFECTANTS AND DISINFECTION BYPRODUCTS
STAGE 1 DISINFECTANTS AND DISINFECTION BYPRODUCTS RULE
BURLINGTON, VERMONT
JUNE 30, 2015

Disinfectant Residual	MRDL (mg/L)	Compliance Based On
Chlorine	4.0 (as Cl_2)	Annual Average
Chloramine	4.0 (as Cl_2)	Annual Average
Chlorine Dioxide	0.8 (as Clo_2)	Daily Samples
Disinfection Byproducts	**MCL (mg/L)**	**Compliance Based On**
Total Trihalomethanes (TTHM)	0.08	Annual Average
Haloacetic Acids (HAA_5)	0.06	Annual Average
Chlorite	1	Monthly Average
Bromate	0.01	Annual Average

Notes:
1. MRDL indicates Maximum Residual Disinfectant Level.
2. MCL indicates Maximum Contaminant level.

Based on data collected at distribution system monitoring sites, a running annual average (RAA) is calculated to determine compliance. Under the S1D/DBPR all sites could be averaged for compliance.

One of the greatest challenges for public community water systems, including Burlington, has been compliance with the MCL's for THM's and HAA_5's as set in the S1D/DBPR. Vermont systems treating surface water with typical total organic carbon (TOC) concentrations found in upland ponds and lakes that also use chlorine as a primary disinfectant are prone to DBP concentrations above 60 parts per billion (ppb) and 80 ppb for HAA's and THM's especially in the late summer and early fall when the organic levels are highest. Also, systems using free chlorine as a secondary disinfectant with geographically expansive water distribution systems with long detention times, such as Burlington, are especially challenged.

Also regulated under the S1D/DBR is the amount of total organic carbon (TOC) that is required to be removed. The amount removed depends on the source water TOC and the alkalinity of the source water. The removal of TOC usually reduces the potential production of DBP's. Required removal percentages of TOC are shown in Table 3.

TABLE 3
REQUIRED REMOVAL OF TOTAL ORGANIC CARBON
BURLINGTON, VERMONT
JUNE 30, 2015

Source Water Total Organic Carbon (TOC) (mg/L)	Source Water Alkalinity (mg/L as $CaCo_3$)		
	0-60	>60-120	>120
>2.0-4.0	35.0%	25.0%	15.0%
>4.0-8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

TOC sampling and analysis in Burlington indicates that the existing facility is in compliance with the above TOC removal criteria.

The Stage 2 Disinfectants and Disinfection Byproducts Rule (S2D/DBR) continues to build on the goals and procedures set forth in the S1D/DBPR. The MCL's for TTHM and HAA_5 remain the same as levels set forth in the S1D/DBP Rule at 80 ppm for TTHM and 60 ppb for HAA_5. However, compliance has changed from using the system-wide running annual average (RAA) to a locational running annual average (LRAA) at specific locations in the distribution system based on distribution system analysis. The sampling locations were selected at sites known to have the highest TMH and/or HAA levels. DBP compliance at specific system locations is the most significant and challenging issue brought forth in the S2D/DBR

Although DBP's are the focus of the S2D/DBP Rule, the microbial constituents are the focus of the Long-term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). Since Cryptosporidium oocysts are very resistant to inactivation using free chlorine, this pathogen is a target of this Rule. Cryptosporidium is a protozoan pathogen of the Phylum Apicomplexa and causes a diarrheal illness called cryptosporidiosis. Other apicomplexan pathogens include the malaria parasite Plasmodium, and Toxoplasma, the causative agent of toxoplasmosis. Unlike Plasmodium, which transmits via a mosquito vector, Cryptosporidium does not utilize an insect vector and is capable of completing its life cycle within a single host, resulting in oocyst stages which are excreted in feces and are capable of transmission to a new host.

The LT2ESWTR set a maximum contaminant level goal (MCLG) of zero for Cryptosporidium, and requires that systems utilizing filters provide at least a 2-log (99.0%) removal. The Rule also provides new maximum levels for combined filter turbidity as well as requirements for continuous turbidity monitoring of individual filters. Future regulations will target watersheds that may have susceptibility for large numbers of Cryptosporidium and will likely require more than 99% removal for this chlorine resistant pathogen.

As part of the LT2ESWTR, public water systems must execute a disinfection profiling and benchmarking program. Systems that produce finished water with TTHM or HAA_5 levels below 0.064 mg/L or 0.048 mg/L (respectively), or systems which plan to modify their disinfection technique previously approved are required to create a disinfection profile and benchmark. The purpose of the disinfection profiling and benchmarking program is to ensure that any changes made to a disinfection regime to meet the S2D/DBP regulations will not adversely affect the ability to control microbial pathogens as required under the LT2ESWTR.

As the TTHM and HAA_5 levels in Burlington are at times both above the 0.064 ms/l and 0.048 mg/l levels, a disinfection profile will be required prior to making any modifications to the current disinfection scheme.

The profile described in the LT2ESWTR is a log of daily monitoring of the log inactivation for viruses. The benchmark is then computed from the daily values and is described as the average of the lowest monthly inactivation values. The plant operator maintains this log of chlorine residual and concentration-time (CT) values provided.

The Surface Water Treatment Rule (SWTR), which preceded the LT2ESWTR, was promulgated in 1984. Under this Rule, concentration-time (CT) tables were developed to assure adequate disinfectant contact time prior to the first customer. This early Rule and the related guidance manuals set minimum concentration-time requirements (CT_R) for various inactivation goals based on both *Giardia Lamblia* and virus for different disinfectants.

In the SWTR, surface water treatment facilities are required (in addition to other requirements) to remove or inactivate 99.9% of the *giardia* cysts (or a three log removal/inactivation). Properly operated surface water treatment facilities for the type of direct filtration plant used in Burlington are assumed to remove 99% of the *giardia* cysts. This leaves another 90% (one log) of the remaining *giardia* cysts to be inactivated by disinfection.

Reaching an effective balance between the LT2ESWTR and the S2D/DBPR is referred to as simultaneous compliance and has created a significant challenge for water treatment operators across the country.

In addition to DBP issues, other potential water quality issues loom on the horizon. These issues may include removal requirements for pharmaceuticals, manganese, and new microbial, inorganic, and synthetic organic contaminants. Currently there are numerous potential contaminants monitored under the unregulated contaminant monitoring rule. It is likely that some of these contaminants will someday be regulated with MCL's set at very low levels which may or may not require additional unit operations for Burlington. Cyanobacteria and Cyanotoxins (better known as blue-green algae) are listed on EPA's Candidate Contaminant List. Many other countries (including Canada) have developed regulations for these contaminants based on the World Health

Organization provisional guideline for drinking water of 1.0 ppb. Unfortunately, many typical unit operations are not effective for removing these toxins. In fact peroxidation with chemicals such as potassium permanganate should be avoided to prevent lyses of cells. However, enhanced coagulation is effective in removal of most of the intracellular toxins. In addition, GAC have been found to be very effective for removal of these toxins. Ozone has been found to be very effective in oxidizing extracellular toxins.

In discussions with Ray Solomon, the potential future regulations that appear to be factors for Burlington in the next decade include limits on chlorate and strontium. However, he feels that as long as the hypochlorite solution remains "fresh", neither parameter should be an issue for Burlington. Ray underscored that the primary factor for Burlington for the next decade will be compliance with current and anticipated modifications of the Stage 2 Disinfectants/Disinfection Byproduct Rule.

Burlington's Existing Water Treatment System:

The Water Treatment Facility in Burlington obtains raw water from Lake Champlain, which is the sole source of supply for Burlington and their consecutive systems. There are emergency interconnections with other systems, but these connections are not capable of meeting all system demands and the Burlington Water Treatment Facility is required to meet customer demands.

Water is withdrawn from an intake screen located on the lake bottom about 4,000 feet into the lake at depth of about 40 feet. Raw water is withdrawn from the intake through a 30-inch diameter ductile iron ball and socket pipe water main laid along the lake bottom. There are several raw water sampling lines and chemical feed lines located within the raw water pipe terminating within the intake pipe near the intake screen.

The intake pipe is inspected from time to time using divers. The latest inspection completed in 2005 shows the exterior of the intake pipe completely encased with zebra mussels. Photos obtained by the divers indicate that there has been erosion of the lake bottom material under the pipe leaving the length of pipe segments only supported by the bell of the pipe. These photos attest the strong currents inside the breakwater even at the lake bottom. This situation also leaves the pipe susceptible to being "hooked" by an anchor, which depending on the surface conditions and boat size, could cause displacement of the intake pipe. However, we view this potential issue to be less significant due to the properties of ductile iron pipe material, the joint configuration allowing for watertight conditions even when displaced up to 15 degrees, and the long length of intake pipe. The submerged weight of the intake line is about 4.9 tons per 100 feet. The raw water sample lines and pretreatment lines are well protected within the intake pipe and are not susceptible to damage due to improper anchoring.

Raw water is drawn into the intake screen and potassium permanganate is added to control zebra mussels. The treated raw water is pulled through the intake line and into

the raw water pump station located to the north of the Water Treatment Facility and west of the Burlington Electric Department building. A powdered activated carbon (PAC) feed system is located within the raw water pump station for use during infrequent occasions when lampricide is fed into some river inlets to the lake.

Raw water passes through the raw water pumps and into the Water Treatment Facility building and coagulants are fed at the premix basin. The facility uses low feed rates of aluminum sulfate (alum) as the primary coagulant and feeds a cationic polymer as a coagulant aid. The coagulated water passes through one of the two "super-pulsator" basins (the baffles, plate settlers, and vacuum pulsator have since been removed). The water receives no treatment within this basin with the exception of contact time for coagulation and some flocculation. The coagulated water then normally passes onto a traveling bridge filter commonly referred to as an automatic backwash (ABW) filter. At this time, the ABW filter is being rebuilt and has been bypassed and coagulated water is pumped directly to the mono-media sand filters. This method of treatment will continue until the ABW filter is placed back on line, which is scheduled for late July.

After the ABW filter, the filtered water is re-pumped and also receives additional alum and polymer and passes onto mono-media rapid sand filters for final filtration. After this second stage filtration, sodium hypochlorite is then added into the filtered water for primary disinfection.

The chlorinated water then passes through two baffled 170,000 gallon clearwells in series. After CT requirements are achieved, finished water is withdrawn using high head pumps and transferred into the distribution system.

System Demand:

Total system demand (monthly averages) for the past three years (2010 to 2014) varied between 3.4 million gallons per day (mgd) and 4.8 mgd. The average day demand for the period was about 4.11 mgd and the general trend shows decreasing system demand with time of about 140,000 gallons per year. Based on this trend, we do not anticipate significant increased demand due to growth.

The maximum day demand is 7.5 mgd and the treatment plant can produce 10 mgd on a consistent basis, which demonstrates adequate treatment capacity to meet current maximum day demand.

Vermont Engineering Feasibility Study for DBP Reduction:

In late 2009, as a result of the imminent promulgation of Stage 2 Disinfectants and Disinfection Byproducts Rule and due to intense public concerns over the conversion from free chorine to monochloramine at Champlain Water District, the State of Vermont contracted with AECOM to complete a feasibility study for ten Vermont systems facing compliance issues under the S1D/DBP Rule. Potential process enhancements were

evaluated in a *March 2010 Engineering Feasibility Study on the Costs of Treatment Options for Reducing Disinfection Byproducts in Public Drinking Water Systems* for the Vermont Department of Environmental Conservation (DEC). Burlington was one of ten systems evaluated for potential improvements to comply with Stage 2 Disinfectants Disinfection Byproducts regulations.

Computer models used by AECOM indicated that it was likely that, at some point in the future, Burlington would have to reduce disinfection byproducts (DBP's) to meet regulations and these models indicated that there was only a limited potential benefit using existing control systems operationally available at the facility such as powdered activated carbon, reduced CT, and lower finished water chlorine concentrations with new chlorine booster stations constructed in the distribution system. In this 2010 report, several alternatives were developed for Burlington to control DBP's including:

- Conversion of the Super-pulsator to a Dissolved Air Floatation (DAF) unit for increased total organic carbon (TOC) removal using enhanced coagulation.
- Conversion from using free chorine as a secondary disinfectant to using monochloramine as the secondary disinfectant.
- Potential use of ultraviolet light units for primary disinfection.

Based on our analysis, the conversion of one of the Super-pulsator units to DAF units and the use of UV disinfection would likely not require additional space beyond the current roof lines. In addition, chemical tanks and feed equipment necessary for conversion from free chlorine to monochloramine for secondary disinfection could be provided without any expansion beyond the current roof lines.

One unit operation that was not projected for use at Burlington in the 2010 report was Granular Activated Carbon (GAC) contactors. These units would require substantial space for the units themselves, as well as space for the potential transfer pumping systems. In addition there would be space needed on site for bulk handling operations when adding, removing, or replacing GAC. This bulk handling operation is required on about an annual basis.

Based on analysis of current and potential future regulations and analysis of the treatment facility and the raw water quality, we feel that it is most probable that Burlington will have to implement measures to reduce disinfection byproducts to meet either current Stage 2 Disinfectant/Disinfection Byproduct Rule requirements or future reduced and expanded requirements for DBP removal. In addition, based on the single relatively shallow intake, we feel it is possible that although Burlington does not currently experience any taste and odor events, such episodes may occur in the future due to increased algal events.

In review of the 2010 Feasibility Study for Burlington and our analysis of future treatment requirements, we agree that there is little benefit to be obtained via

operational practices that have not already been implemented. Pre-chlorination prior to stage 2 filtration has already been discontinued and has had a beneficial effect on reducing DPB's. The alternative of using the powdered activated carbon feeder at rates less than 25 ppm would likely not have a significant beneficial effect and at rates over 25 ppm would be problematic for direct filtration. Finally reducing the clearwell level to reduce retention time during the warmer months (when precursors are highest) would also likely not achieve significant benefits.

We agree that the most applicable additional unit operations needed to reduce DBP's that should be considered include the following:

1. Conversion from free chlorine to monochloramine for secondary disinfection.
2. Conversion of the Super-pulsator to a dissolved air floatation unit for use with enhanced coagulation to remove additional precursors. Converting to DAF would allow the State of Vermont to credit the facility with pretreatment and solids removal prior to filtration and allow a 2.5 log removal credit rather than the current 2.0 removal credit. This would reduce the inactivation requirement to 0.5 logs rather than the 1.0 log inactivation requirement currently in effect for the direct filtration mode of operation.
3. Eliminating free chlorine as a primary disinfectant. In the 2010 Feasibility Study, ultraviolet light was recommended for consideration and we feel that the recent research indicating significantly higher doses for viral inactivation limits the effectiveness of ultraviolet light for primary disinfection, unless a very high dosage is provided for at a significant annual cost for electricity. Using both ultraviolet and free chlorine to achieve adequate viral inactivation would appear to threaten or defeat the goal of reducing chlorine related byproducts. However, we do feel it is likely that converting from free chlorine to ozone would have advantages that would favor its use. For instance, using side stream ozonation for primary disinfection. The raw water could also be pre-ozonated near the intake stream for possible taste and odor control without forming chlorinated byproducts. The potassium permanganate feed system could be eliminated. The ozonated raw water would convert much of the Natural Organic Matter (NOM) to Biodegradable Organic Carbon (BDOC). This BDOC should be removed during treatment to prevent potential for regrowth in the distribution system. The traveling bridge filter could act as a biological filter to accomplish this goal using GAC media. According to tracer studies, the baffled clearwells provide adequate detention time at current free chlorine residuals to meet CT requirements. However, during cold temperatures, the CT provided is not significantly above the CT required. If future requirements increase the minimum log inactivation, additional clearwell volume would likely be required for primary disinfection using chlorine. However, additional clearwell volume would not be required using ozone for primary disinfection, which is about ten times more

effective than free chlorine for pathogen inactivation. Under the alternative of using ozone for primary disinfection, secondary disinfection would be achieved using monochloramine, which is manufactured on site using sodium hypochlorite and liquid ammonium sulfate.

Based on our analysis, we feel that it is most likely that Burlington may have to implement measures that will require capital improvements to control disinfection byproducts using one or more of the following concepts listed in order of lifecycle cost:

- Conversion from free chlorine to monochloramine for secondary disinfection.
- Conversion of the Super-pulsator to a dissolved air floatation (DAF) unit for use with enhanced coagulation to remove additional precursors.
- Conversion from free chlorine as a primary disinfectant to ozone.

Technically if DBP sampling and analysis signaled the need to reduce DBP concentrations to comply with the Rule, it would seem logical to follow the mitigation steps in the order as listed above. For instance, the initial step would be converting from free chlorine to monochloramine for secondary disinfection. If DBP concentrations did not drop sufficiently, officials would proceed with the second step of implementing enhanced coagulation using DAF. Finally if Federal regulations set lower levels of chlorinated byproducts or raw water characteristics change and precursors increase to problematic levels even after steps 1 and 2, Burlington officials would continue to step 3, converting from free chlorine for primary disinfection to ozone.

Although monochloramine has been used in many parts of the country in some cases for almost a century, there was substantial concern raised when nearby Champlain Water District converted from free chlorine to monochloramine about a decade ago. However, due to the successful experience at CWD, this phobia toward use of monochloramine as a secondary disinfectant may have diminished. Under the Vermont Water Supply Rule, there are only two alternatives for secondary disinfection including:

- Free chlorine, which is known to cause increased regulated byproducts
- Monochloramine, which has little effect for increased regulated byproducts

Loss of one of these two alternative disinfectants would severely restrict Burlington's ability to comply with existing and future regulations.

Burlington officials support open public discussion of alternate disinfection alternatives and would place significant weight on customer preference in any decision for consideration of alternate disinfection measures. Should monochloramine not be embraced by the customer base, it would likely be excluded as an alternative for secondary disinfection and continued use of free chlorine would be required even though it would increase regulated DBP's. If monochloramine is excluded for secondary disinfection, the alternatives available to Burlington become much more expensive and would include:

- Conversion of one of the the Super-pulsator basins to a dissolved air floatation (DAF) unit for use with enhanced coagulation to remove additional precursors.
- Use of Granular Activated Carbon (GAC) contactors to remove precursors from the stage two filtered water prior to primary and secondary disinfection using chlorine.

Ozone would remain as an available alternative for both pre-ozonation of raw water followed by conversion of the traveling bridge filter for use as a biologically active filter, and for primary disinfection. However, using ozone for primary disinfection seems to be of limited benefit if free chlorine is used for secondary disinfection in the distribution system.

Based on this discussion, Burlington should develop concept plans and contingency procedures for implementing improvements and modifications to proceed with any of the alternates indicted above. Until a master plan is developed to formalize future improvements, Burlington should not limit the available area around the facility so as to eliminate design and construction alternatives for implementing these alternatives. The probable alternatives to comply with current and future regulations include:

1. Conversion from free chlorine to monochloramine for secondary disinfection.
2. Conversion of the Super-pulsator to a dissolved air floatation (DAF) unit for use with enhanced coagulation to remove additional precursors.
3. Conversion from free chlorine as a primary disinfectant to ozone.
4. Use of Granular Activated Carbon (GAC) contactors to remove precursors from the stage two filtered water prior to primary disinfection using chlorine.

We have completed an analysis of the implementation of these alternatives and noted any effects related to the potential marina project.

Probable Alternatives to Comply with Future Regulations:

As described previously, although it is assured that future regulations will be more stringent, one cannot accurately predict the extent and the implementation schedule for these regulations. Therefore it would be prudent to provide for as much flexibility as possible in protecting options yet to be defined. We describe the concepts and characteristics for implementing the four most probable process improvements likely needed to comply with future regulations.

Conversion from free chlorine to monochloramine for secondary disinfection:

This improvement is relatively straightforward to implement. After primary disinfection using free chlorine, additional chemical feed points would be added prior to the finished water pumps to combine sodium hypochlorite and ammonium sulfate at the correct feed rates to produce monochloramine. Sample lines would be provided to insure the correct monochloramine residual enters the distribution system.

An additional chemical would be needed to generate the monochloramine and there are several options available to obtain a source of ammonia. In this case, liquid ammonium sulfate is the safest choice and is the most easily handled. This chemical would be delivered by tanker trucks and stored in a bulk tank similar to alum and sodium hypochlorite, which is currently delivered and stored in a similar manner.

The concept plan would be as shown in Figure 3.

Since there is sufficient space for the bulk tank, day tank, and feed pumps within the existing chemical feed area, the only adverse effects imposed by the marina project, would be the following issues:

- Constricted access during delivery and installation of an ammonium sulfate bulk tank and feed system.
- More frequent bulk tank deliveries and continued conflict with vehicles parked on the south side.

<u>Conversion of one of the Super-Pulsator units for use as a dissolved air floatation (DAF) unit for enhanced coagulation to remove additional precursors.</u>

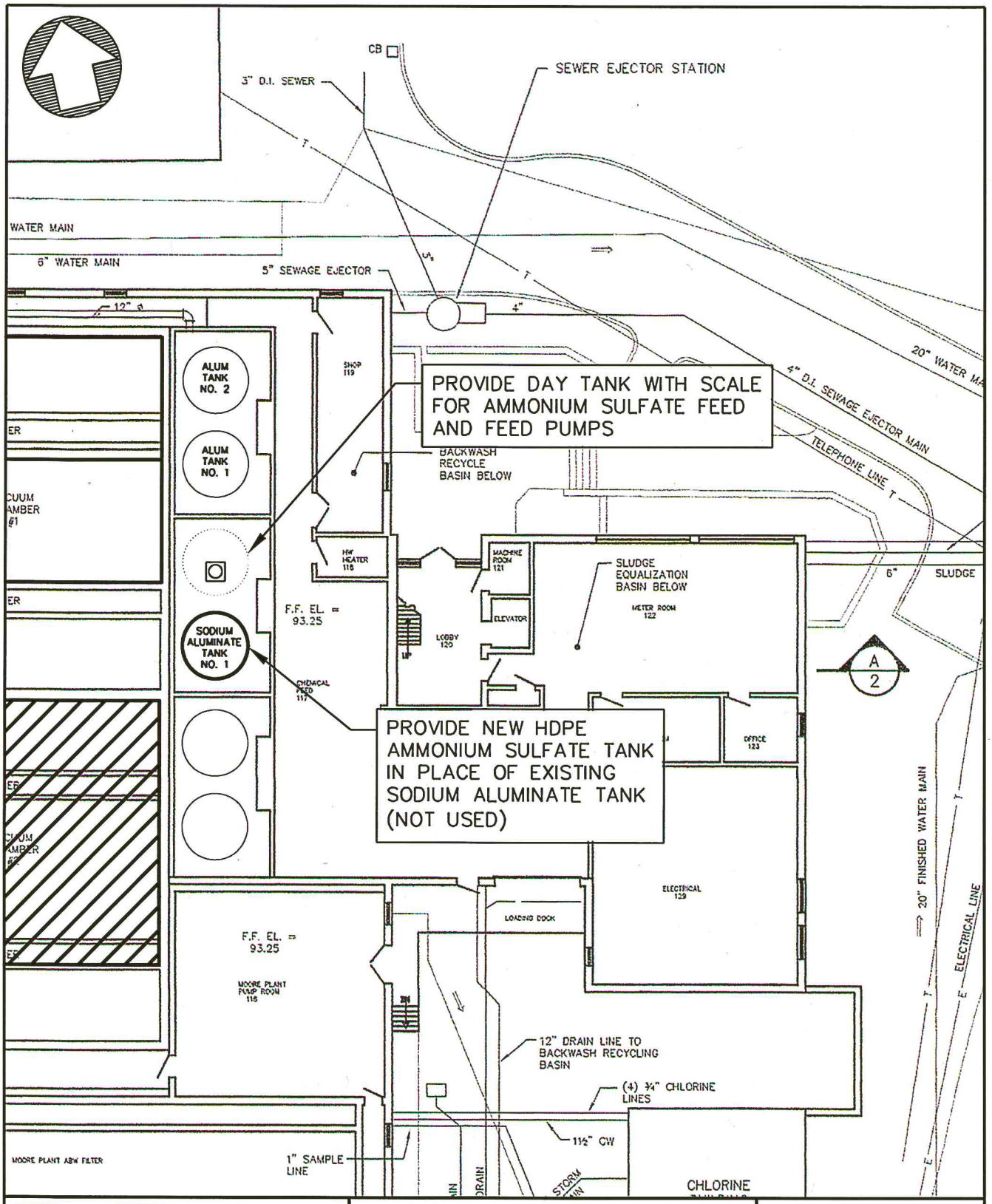
This alternative would be implemented to allow enhanced coagulation using substantially more coagulants to combine with natural organic matter and precursors to be removed in the DAF unit and in the filters prior to chlorination.

This alternative would be much more mechanically complex as compared to using monochloramines as in addition to structural improvements within the former super-pulsator the following support systems are required:

- Air compressors are required for injecting air into the coagulated water.
- Recycle pumps for injecting supersaturated water into the coagulated water.
- Floc concentrators and control valves and piping to convey the floc removed to the waste holding tank; perhaps from an average of twice per month to twice per week.

Since these modifications are internal to the existing facility, the only adverse effects posed by the marina project are as follows:

- Constricting the available staging areas available to the Contractor during construction.
- More frequent bulk deliveries of alum and polymer and continued conflict with vehicles parked on the south side of the facility.



FILE: S:\Transfers\burlington harbor marina\FIGURE 3.dwg Jul 01, 2015 - 4:51pm

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FIGURE NO 3

CONCEPT PLAN
SECONDARY DISINFECTION
USING MONOCHLORAMINE

BURLINGTON, VERMONT

PROJECT NO.	000000
PROJECT MJR.	RED
SCALE	AS SHOWN
DATE	JULY 2015
DRAWING NO.	FIGURE 3.dwg

Conversion from free chlorine to ozone as a primary disinfectant:

This alternative would entail several systems to complete a working ozonation system. Ozone would need to be generated from a source of oxygen. We have opted to consider liquid oxygen at this concept stage as the mechanical systems necessary to obtain dry oxygen from the air are complex, inefficient, and operationally intensive. The oxygen gas would be stored in two pressurized bulk tanks located somewhere outside the facility with access available for bulk gas delivery. Based on a monthly refill, two 2,000 gallon liquid oxygen tanks would be required. These tanks would need to be accessible for deliveries with large (55 foot) tanker trucks.

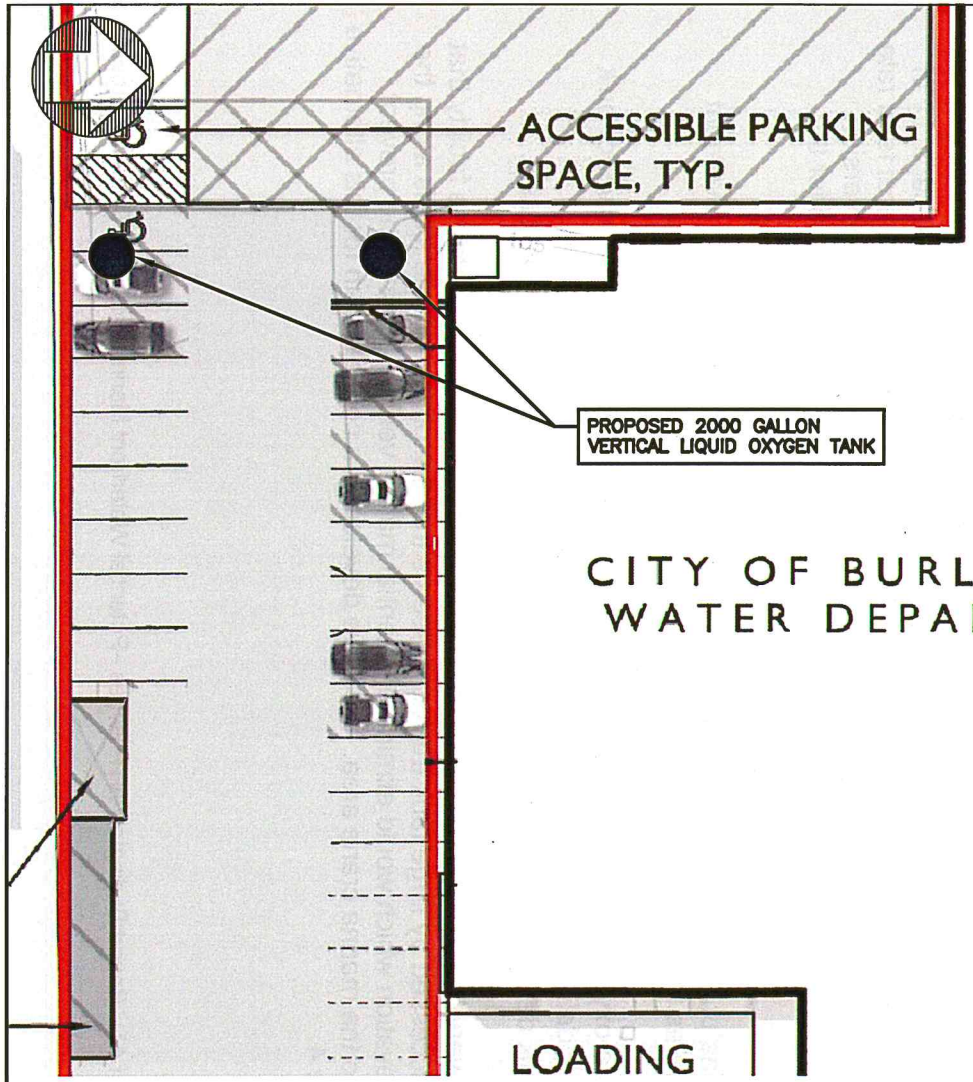
An ozone generator system would be required to manufacture ozone from the pure oxygen for use at the facility. This generator would have a significant electrical load that would likely require modifications and upgrades to the primary electrical service, standby generators, a transfer switch, and distribution wiring.

A side stream process pumping system would be required to convey process water though an eductor to mix ozone into the feed water. The ozonated water would then pass through a degas vessel and the heavily ozonated water would pass into the process stream. A positive method to trap excess ozone and for ozone destruction would be required prior to atmospheric discharge. If the ozone is used both on raw water and filtered water, care must be taken to protect the interior treatment building spaces from ozone gas by trapping, collecting, and destroying the gas prior to discharge. Based on a maximum combined ozone dose (both pre-oxidation and primary disinfection) of 2.0 mg/l at 7 mgd, the ozone system would need a capacity of about 117 pounds per day. However, based on historical demand, the typical feed rate for ozone would be about 67 pounds per day. However, due to ozone conversion inefficiency, about 700 pounds per day of liquid oxygen gas would be used for the process.

The marina project would have some adverse effects on this process improvement alternative as follows:

- The oxygen tanks would need to be positioned at a location conducive for bulk gas delivery and be fenced to prevent unauthorized access.
- Bulk delivery to the oxygen tanks would be required on a monthly basis.

There is very little land available for storage of liquid oxygen adjacent to the facility that can be accessed by large tank trucks. It seems that the only available site is along the south elevation which would eliminate potential marina vehicle parking and prevent access to the marina crane area. We have developed a concept plan for this alternative in Figure 4.



GRAPHIC SCALE

20' 0 10' 20' 40' 80'

(IN FEET)

CHART INDUSTRIES
VERTICAL BULK STORAGE TANK
NOT TO SCALE

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Project #	000000
Project Mgr.	RED
Design	NAME
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Checked by	R.E. DUFRESNE
Date	JUNE 29, 2015
Scale	AS SHOWN
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POTENTIAL NORTHERN MARINA PROJECT

FIGURE 4
LIQUID OXYGEN STORAGE TANK
SCHEMATIC PLAN

BURLINGTON, VERMONT

FIG 4

DWG. NO. turning radius.dwg

SHEET 1 OF 1

Use of Granular Activated Carbon (GAC) contactors to remove precursors from the stage two filtered water prior to primary disinfection using chlorine:

The existing process architecture provides a significant opportunity for additional unit operations without geographical expansion at the facility. The duplex Super-pulsator units not being used provide opportunities to meet the challenges of the future more stringent regulations. As indicated previously, the efficiency of the DAF process allows superior floc removal using only one of the pulsator units. The other unit could be converted into four GAC contactor filter units for precursor reduction prior to primary disinfection. Although the floor space and allowable height provided makes this alternative feasible, there would be significant demolition required. In addition, there would be structural and process improvements required to implement such an alternative. However, importantly GAC contactor units could be implemented at the Burlington Water Treatment Facility without a roof line addition.

Under this concept, filtered water (post second stage filtration) would be collected and pumped to GAC contactors to reduce any remaining precursors prior to primary disinfection using free chlorine. The concept would entail triplex pumps and four open concrete contactor tanks with sufficient GAC to provide for 20 minutes of empty bed contact time. The design concept could be to treat average day demand (about 4 mgd) which would normally provide high quality water with little potential to form DBP's. During demands of greater than average day, the contact time with the GAC would be reduced but would still provide for precursor adsorption such that the finished water would be well below current Federal limits for DBP's.

The concept for this alternative is shown in Figure 5.

3. Chemical Deliveries:

Chemicals are required for water treatment and are delivered using various size trucks depending on the specific chemical. Chemical use is recorded daily and the need for chemical delivery is predictable and can be forecast weeks in advance. Delivery companies are less reliable in that the driver can typically name the day of delivery but not the hour. Drivers would not be able to "wait while we move the cars" due to their delivery schedules. With the exception of powered activated carbon, all deliveries are made at the loading dock area. The chemicals used at the facility and the delivery trucks are described in Table 4.

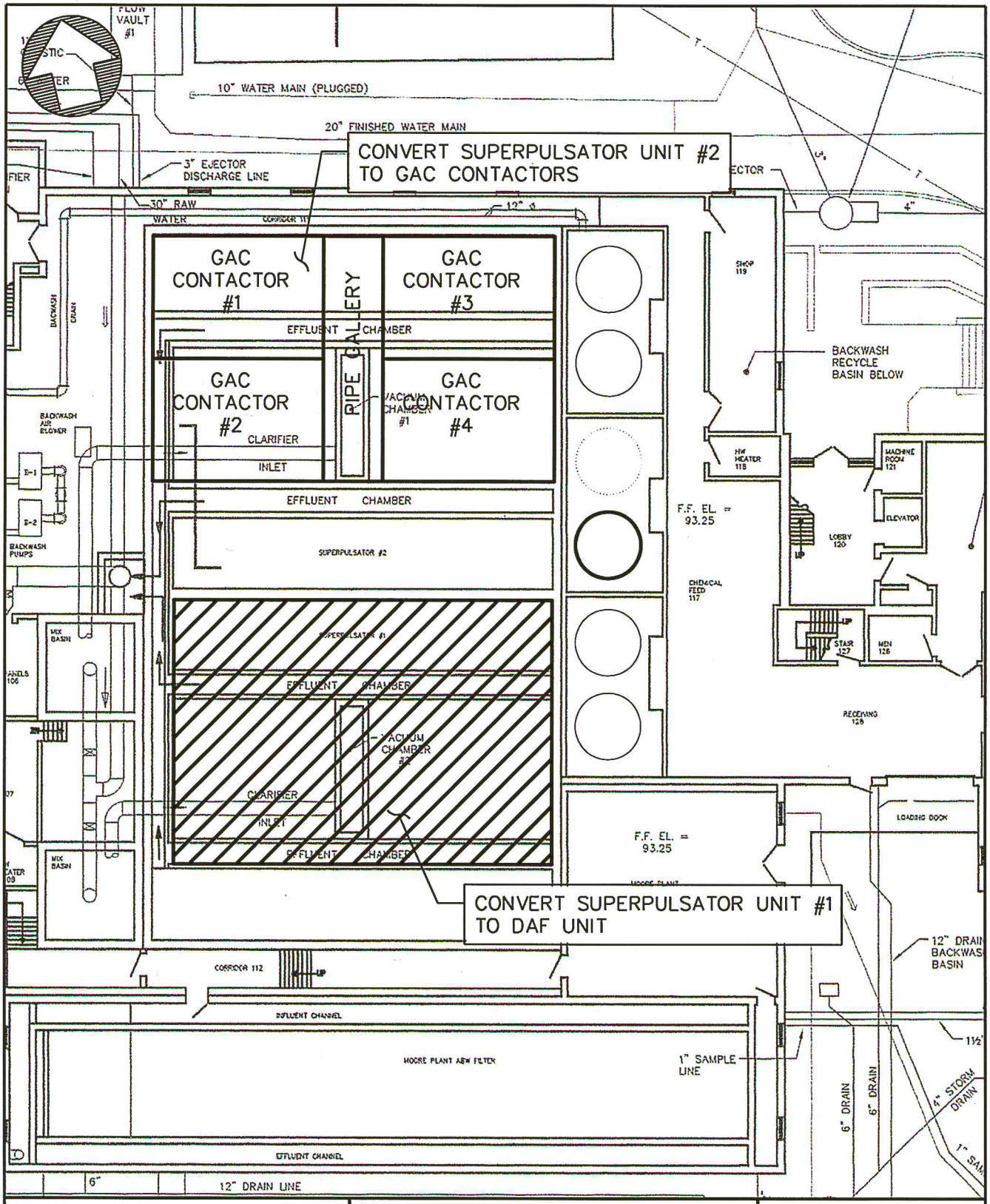

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FIGURE NO 5

SUPERPULSATOR CONVERSION SCHEMATIC PLAN

BURLINGTON, VERMONT

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TABLE 4
EXISTING CHEMICAL FEED DELIVERIES
POTENTIAL MARINA PROJECT
BURLINGTON, VERMONT
JULY 1, 2015

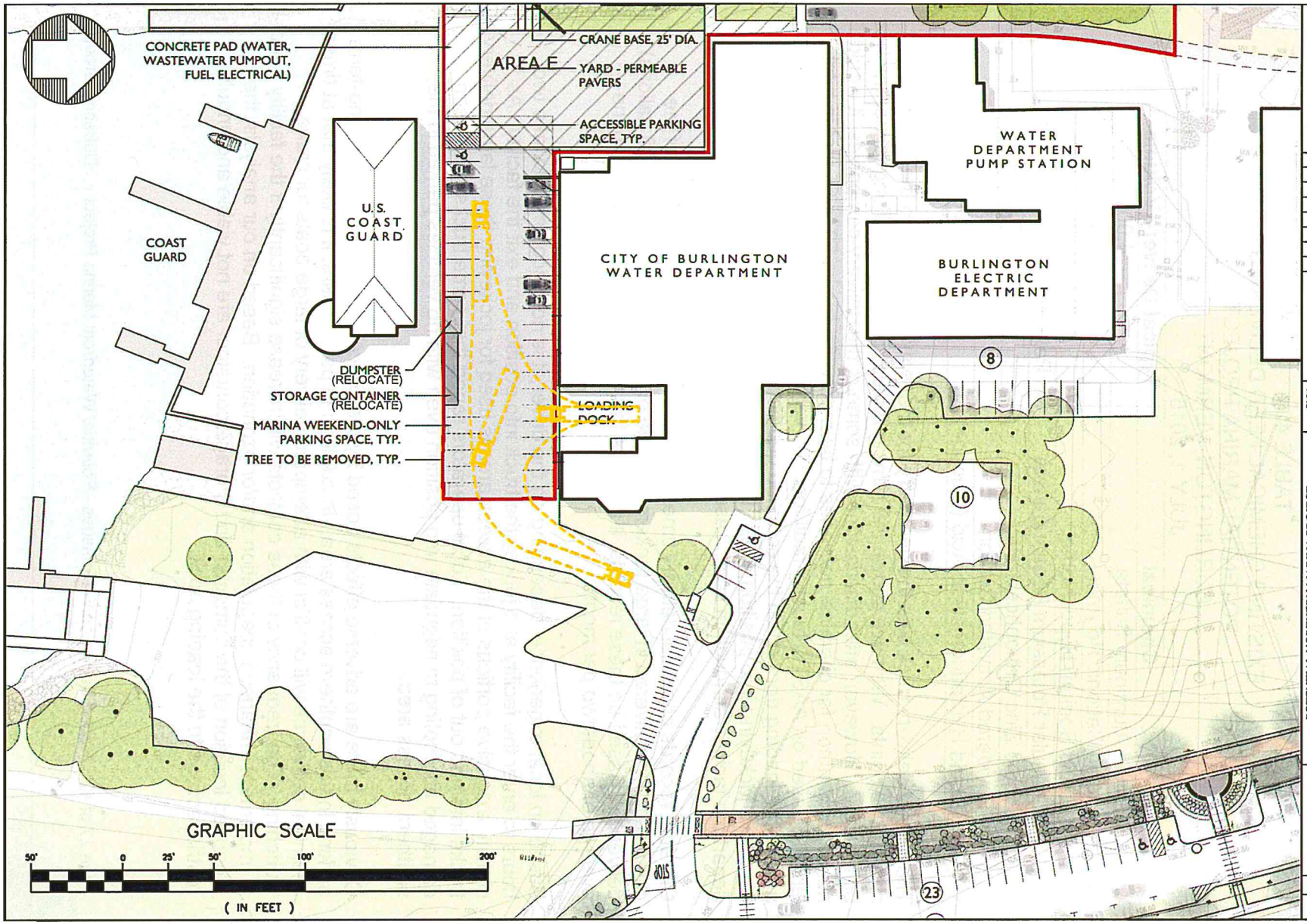
Chemical	Typical Delivery Volume
Liquid Aluminum Sulfate	4,000 gallons
Liquid Cationic Polymer	4,000 gallons
Liquid Sodium Hypochlorite	4,000 to 5,000 gallons
Granular Potassium Permanganate	Pallets of five gallon pails
Liquid Zinc Orthophosphate	4,000 gallons
Powdered Activated Carbon	Large Bags
Liquid Hydrofluorosilicic Acid (Fluoride)	2,000 gallons

The largest delivery truck sets the geometry for the required access to the loading dock and bulk fill points. We have shown the turning radius for the 55 foot long tanker truck on Figure 6. However, after discussions with some of the delivery companies, it would not be uncommon for chemical deliveries to be made with trucks 59 to 65 feet in total length. Based on AASTO turning radii for such vehicles, it does not appear possible to access the loading dock given the confined geometry at the facility. However, after extensive jockeying into position, these trucks have not failed to make a delivery and depart the facility; although in some cases it takes hours to jockey into position.

City staff records chemical delivery times and dates and as indicated most of the chemicals are delivered in large tankers capable of "full load" (4,000 to 5,000 gallons) deliveries. Based on these records, it appears the City receives deliveries on the average of about two per month.

Based on local experience, depending on the driver, it is not uncommon to take two hours to enter the facility and jockey the truck into position and exit the facility. As shown, extensive portions of the access area is used for jockeying these large delivery trucks into and out of position. Local operators report that some trucks have been damaged attempting to negotiate into position even with no vehicles parked in the southern access area.

Obviously there are adverse effects posed by the concept of double headed long-term parking in this southern access area. In addition to parked cars, it is likely that at times chemical deliveries will conflict with attempted delivery of large boats for crane launching. The frequency of these conflicts will increase significantly if the facility needs to implement enhanced coagulation and/or ozonation. Based on our analysis, the proposed location of the dumpster and storage container are not viable and unduly restrict access to the loading dock.



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POTENTIAL NORTHERN MARINA PROJECT

FIGURE 6
AREA REQUIRED FOR CHEMICAL DELIVERIES

BURLINGTON, VERMONT

FIG 6

DWG. NO. turning radius.dwg

SHEET 1 OF 1

Potential mitigation measures would include:

- Exclude marina client parking in this southern area. The area could be expanded for additional parking for WTP personnel only.
- Insure that marina personal have keys to all vehicles and sufficient staff to jockey cars out of the area during marina delivery.
- Relocate the chemical fill stations and loading dock to another location.

Reserving this southerly area for WTP personnel parking may free up other areas where WTP staff is currently parking for use by marina clientele. Conceivably the operational manager at the WTP would have control over delivery times and can control the schedule for vehicle removal to facilitate chemical delivery truck access. This appears to be a viable mitigation measure with the exception of conflicts with boat launching activities. The aspect of a two to four hour delay would not be acceptable to either the boat owners or the chemical delivery drivers. In addition, it appears unlikely to expect this area be cleared of all vehicles once every other week and perhaps twice per week in the future.

Allowing long-term parking for marina clientele so long as marina staff has keys to all vehicles and sufficient staff to jockey cars around on the surface appears viable. However, it is likely that some marina clientele vehicles will not have keys and such vehicles would require towing. Unless the communication is very good, it is likely that the chemical delivery truck will pull into the Coast Guard drive and the access will have vehicles and/or boat trailers waiting to be moved. At that point the truck will have difficulty in parking so as not to conflict with vehicle removal and access to the Coast Guard complex. We don't consider this alternative to be viable.

The last mitigation measure would be to relocate the chemical fill stations to other areas. In addition to the loading dock where pallets of some chemicals are received, there are two chemical fill stations that facilitate delivery of bulk liquid chemicals. One of the stations, located on the southern side of the loading dock, has multiple connection points to receive coagulants and conditioning chemicals. The second point is located southeast of the loading dock on the wall of the sodium hypochlorite feed building. Based on our field observations and discussions with operational staff, these stations could be relocated within certain distance and geometric constraints. The sodium hypochlorite feed point could easily be relocated to the eastern side of the chlorine feed building. Using this concept, delivery trucks would not have to enter the southern access area and make deliveries on the western side of the Coast Guard access drive as shown in Figure 7. However, the trucks would either need to back in or back out unless turn around access is negotiated with the State of Vermont and/or the Coast Guard. The bulk chemical fill station could be relocated to allow access from Penny Lane along the northern elevation. Again, trucks would need to back in or back out and perhaps use the state boat launch for a turn around. In order for this alternative to be viable, all parties should recognize that Penny Lane could be restricted to one very narrow lane for hours at times as chemical deliveries are made. The potential relocation of the chemical feed lines are shown in Figure 8. We estimate the cost to relocate the two chemical fill stations at $40,000.

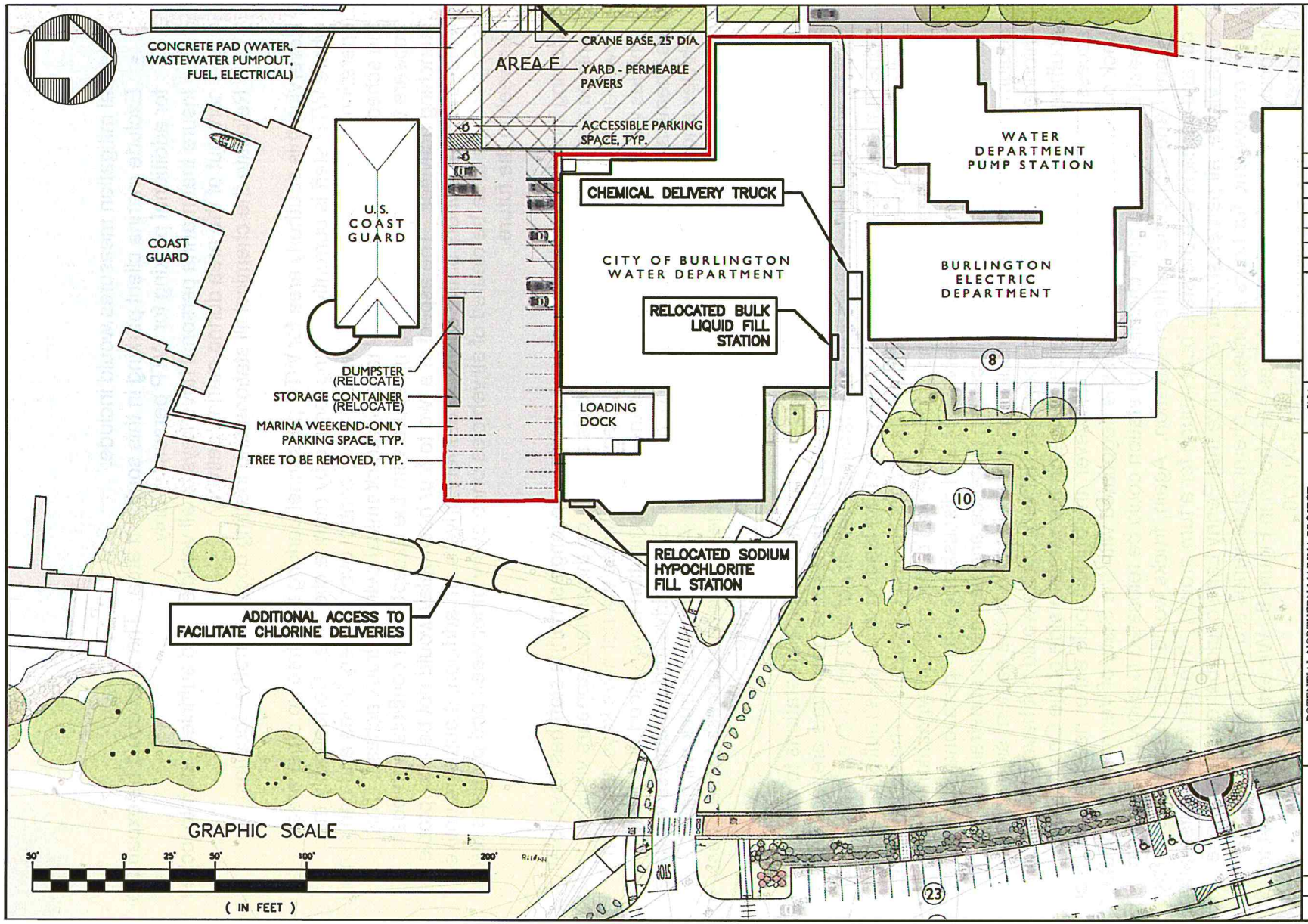

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FIGURE 7
ALTERNATIVE BULK LIQUID FILL POINTS RELOCATION

BURLINGTON, VERMONT

FIG 7

DWG. NO. turning radius.dwg

SHEET 1 OF 1

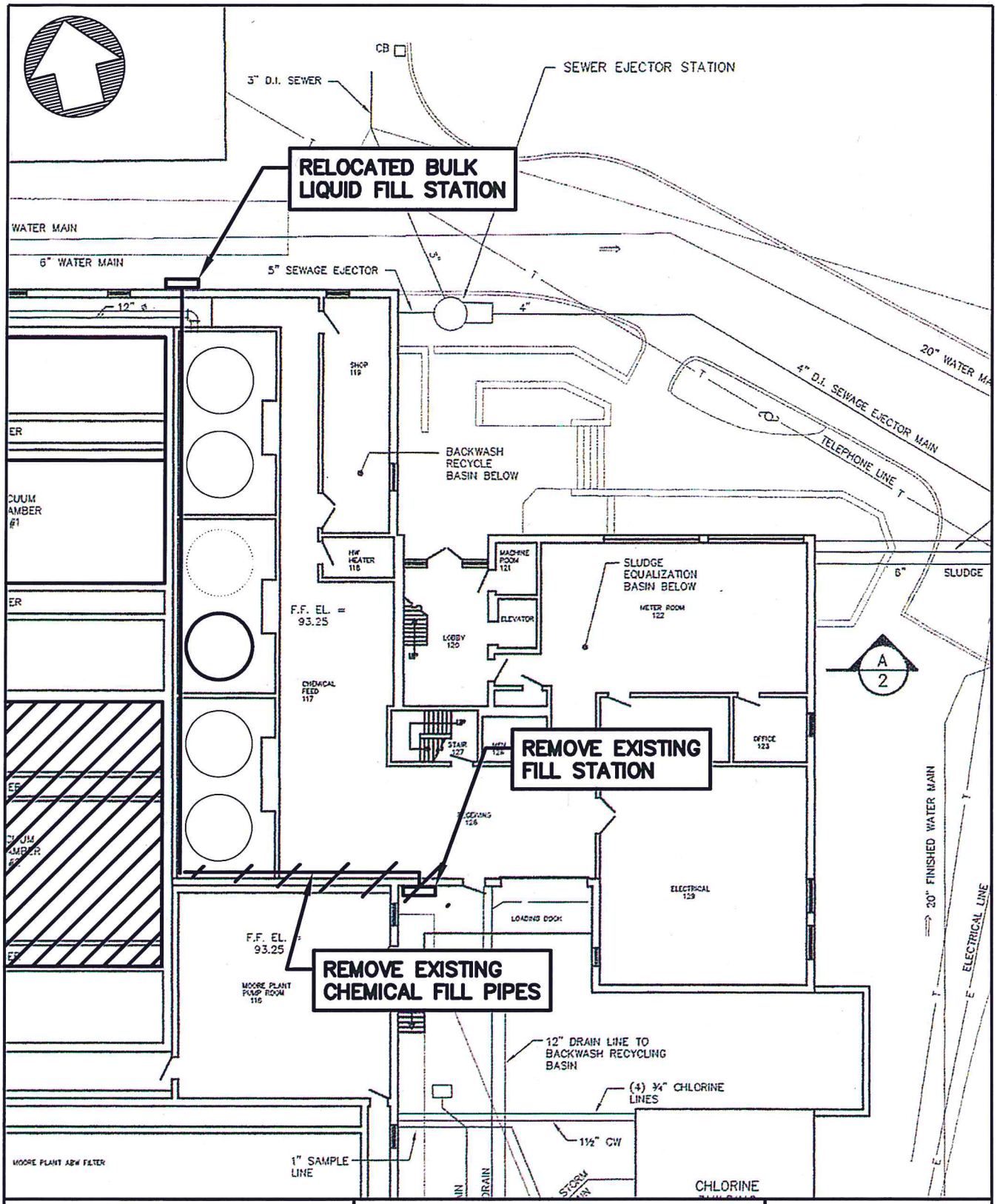

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FIGURE NO 8

CONCEPT PLAN
FILL STATION RELOCATION

BURLINGTON, VERMONT

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SCALE AS SHOWN
DATE JULY 2015
DRAWING NO. FIGURE 3.dwg

FILE: W:\CADD Files\Burlington VT\burlington harbor marina\FIGURE 3.dwg Jul 07, 2015 - 4:16pm

In addition to chemical deliveries, equipment and supplies arrive at the facility at the loading dock in large delivery trucks. Pallets of paper supplies and dry chemicals such as potassium permanganate arrive at the facility and are hoisted to the upper levels using the hydraulic ramp hoist. These trucks can be even larger than the chemical delivery trucks. Relocation of the chemical feel stations does not negate the need to maintain access to the loading dock.

4. Intake pipe protection:

This concern focuses on the raw water intake system to ascertain the potential for disruption caused by issues at the marina due to increased boat traffic and possible damage due to anchoring.

Based on the existing information, there are three raw water intake pipes that allow water to be withdrawn well out into the lake and convey the water into the Water Treatment Facility. There are two 24-inch diameter intake pipes that are not utilized and could not be easily called into service as they have been out of service for decades. It is likely that these two intake pipes would require mechanical cleaning and perhaps new intake screens prior to returning to service. Using these pipes in the future is unlikely. The other intake pipe is the only active intake to the facility.

This pipe is a 30-inch diameter ball and socket joint ductile iron pipe with high density polyethylene pipes for sampling, zebra mussel control, and peroxidation inside the 30-inch diameter pipe. The intake pipe is connected to an intake screen located far out into the lake and is not a factor in consideration of the effects of a marina project.

The 30-inch diameter intake pipe is inspected from time to time using divers. The latest inspection indicates the exterior of the intake pipe is heavily coated with zebra mussels but in good condition. The intake screen and supports appears in good condition with zebra mussel attachment prevented by the type of screen material used. The interior of the pipe is protected from veliger attachment with an internal potassium permanganate feed system. The divers report that currents between the shore and breakwater have undermined the pipe and the pipe is supported in some areas only at the bell joints with the barrel of the pipe left unsupported.

The 30-inch ductile iron pipe is one of the most durable piping systems available today. The pipe is assembled without bolts and the ball and socket design allows deflection up to 15 degrees without damage or leakage. The pipe is many times assembled on shore and dragged into place for installation without damage.

In this case, there are three potential concerns including:

- Possible damage by impact such as an anchor in freefall.
- Possible damage from an anchor "hooking" the pipe and the force of holding the boat transferred to the pipe. This could be significant if the boater was trying to free the boat anchor without knowledge of the situation.

- A large boat sinking atop the intake pipe at a location where the pipe barrel is not well supported.

Obviously the potential impact from a freefalling anchor would depend on the size of the anchor and its velocity when hitting the pipe. However, in discussions with officials from the Ductile Iron Pipe Research Association (DIPRA), it is extremely unlikely that the velocity would be high enough to damage the pipe. These officials are continuing with this investigation and have not yet reached a conclusion at the time of this draft.

The potential aspect of "hooking the pipe" with the anchor and pulling the pipe seems to be possible for large boats/anchors with the undermining of the bottom material from below the pipe. Based on pictures and video, it appears the gap below the pipe is 6 inches to a foot in some areas. If the boat were large enough and the current or motor force was strong enough, the pipe could be deflected. A 60 foot boat in a 60 knot wind would generate about 4 tons of force. "Power setting the anchor with a 500 hp boat would develop about 5 tons of force. However, the type of joint and the long length of pipe would quickly develop significant opposing force to counter the pull of the anchor and craft. For instance, if the anchor caught on a section of pipe and exerted sufficient force to deflect and slightly dislodge two lengths (19.5 feet per length) of pipe, the joint attachment would maintain continuity and engage more pipe. If 200 feet of pipe were engaged, the submerged weight of the pipe would be about 10 tons or more than sufficient to resist the load caused by the anchor attachment or the anchor power set. Our opinion is there would not be potential for adverse effects by "hooking the pipe" during anchoring.

The third potential issue is for a large boat that sinks directly atop the pipe. In this case, there is more potential for damage as sections of pipe are only supported at the joints. However, in our opinion, the bottom is sufficiently unstable that the weight of the boat would cause the pipe to sink into the bottom rather than create shear stress on a particular point and we do not view this to be a significant issue.

Another potential aspect of possible effects on the intake pipe by a marina project includes the anchoring system for the docks. Prior to design of the dock and anchoring system, the intake pipe should be precisely located to insure soil anchors and other attachment methods do not damage the intake pipe.

5. Utilities near the west side of the water plant near the picnic area:

In discussions with City Staff, there was concern regarding potential damage to underground utilities in the area under and adjacent to the picnic area. Under the marina project concept, the picnic structure would be removed and the area would be used for access to the maintenance and loading/unloading crane. The exiting grass and asphalt area would be replaced with porous pavers to reduce impervious area. There are several very large pipes that convey water to and from the two clearwells. There are two parallel 30-inch ductile iron treated water lines for effective inactivation of

pathogens. A 20-inch ductile iron raw water line, a 12-inch diameter drain line, a 6-inch diameter water service line, and a small diameter water service to the picnic area. Finally there is a flow control vault just west of the southwest corner of the Moore Plant. This vault was opened and observed. Although groundwater was above the level of the pipe, we noted that the vault contains an insertion flow sensor/transmitter with related electrical and instrumentation wiring. There is also an old electric heater in the vault. The vault is referenced as a flow control vault, which normally includes a flow sensor coupled with a control valve for controlling an operator set flow for coagulated water entering the ABW filter. Since the vault does not include a motorized valve it appears the flow signal is keyed with a remote control valve. As such, it is likely that that the flow meter could be relocated to another interior location and the vault be eliminated. We estimate the cost to relocate the flow meter and demolish this vault $25,000.

Based on several record drawings, there is a small on-site wastewater disposal system used to treat and dispose of wastewater from the picnic area. The on-site system is not related to the Water Treatment Facility.

The concern would be increased traffic loadings caused by transport trucks and service cranes as they traverse this area. Based on the record drawings some of these pipes have less than six feet of cover. For instance, the pipes with the shallowest amount of cover would be the two 30-inch diameter PVC treated water lines that have only 2'-8" of cover based on the record drawings. Although the constant velocity of water in the pipes is more than sufficient to prevent freezing these pipes are susceptible to damage from heavy wheel loads.

AWWA C-900 PVC pipe derives its ability to resist traffic loading from the selection and placement of the embedment material. The PVC pipes deflect and transmit forces to the surrounding material to resist vertical loading. As the criteria for transport truck loading, the portable crane size and load, and the compaction methods and material surrounding the treated water lines are not well documented, it would be wise to take action to prevent damage to these pipes that are crucial for plant operations.

Potential mitigation measures include:

- Replace the PVC pipes with ductile iron pipes.
- Excavate the PVC pipes and encase the pipes in concrete to protect the pipes and transfer vertical loads below the pipes without deflecting the pipe deflecting the pipe as shown in Figure 9.

Replacing the existing lines with ductile iron would cause significant down time at the plant during interconnections. It may also be necessary to provide a temporary above ground pipe system in service to allow sufficient space to replace the PVC lines. The cost to replace these 30-inch lines is estimated to cost $80,000.

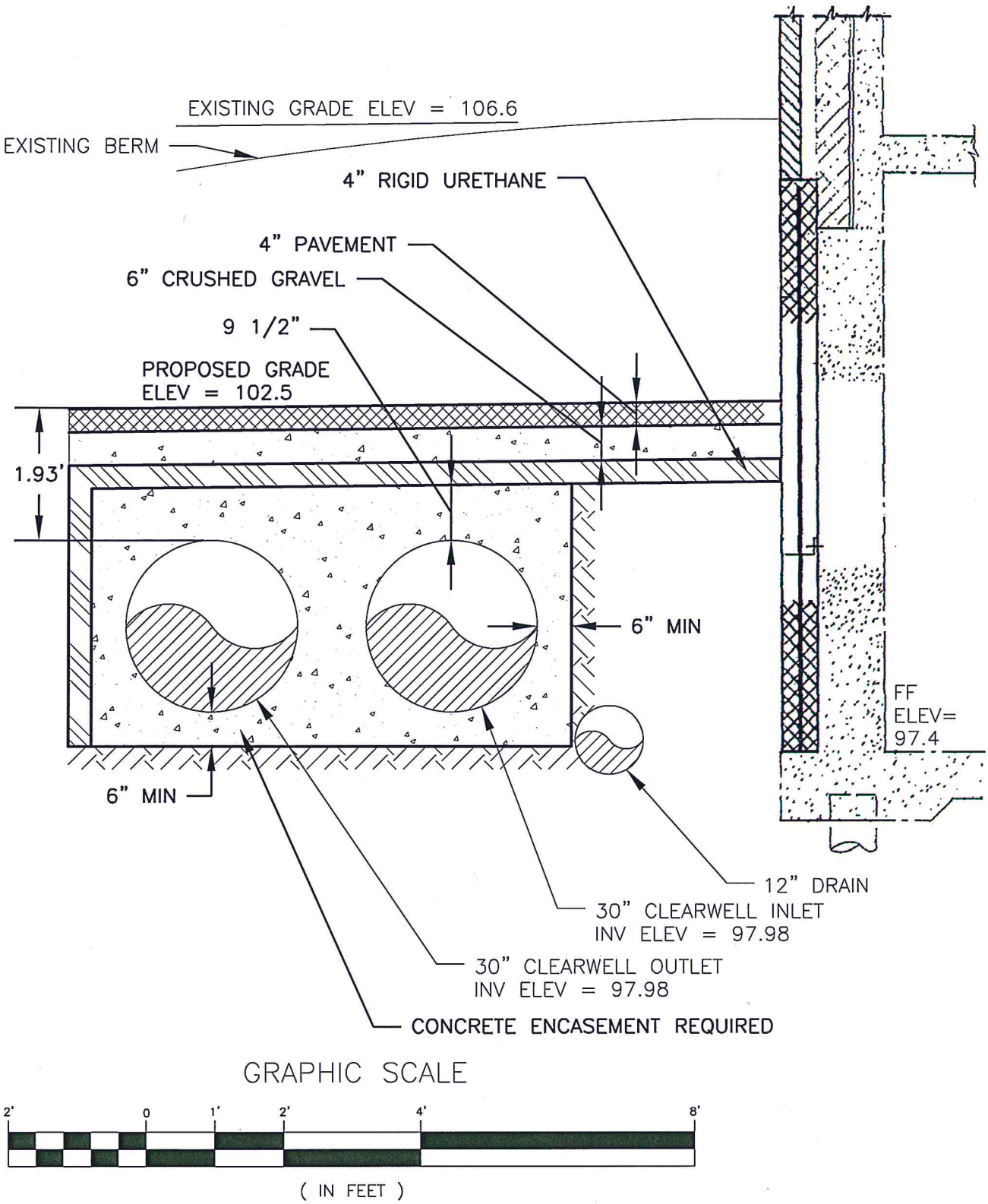

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FIGURE NO 9

WATER TREATMENT FACILITY
ALT. GRADE MODIFICATION
SOUTH ELEVATION
MARINA PROJECT

BURLINGTON, VERMONT

PROJECT NO. 000000
PROJECT MJR. RED
SCALE AS SHOWN
DATE JUNE 29, 2015
DRAWING NO. Drawing1.dwg

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The cost to excavate and provide concrete encasement for the pipes has significant advantages in that the existing pipes can be encased while in service and there would not be any downtime at the plant. Much of this work would need to be hand excavated and there are numerous crossing with other utilities that would require additional encasement to below these utilities. Based on evidence of standing water in the flow control valve vault, it is likely that dewatering will be required in some areas. The cost for the encasement is estimated at $35,000.

6. Northside water and electric utilities:

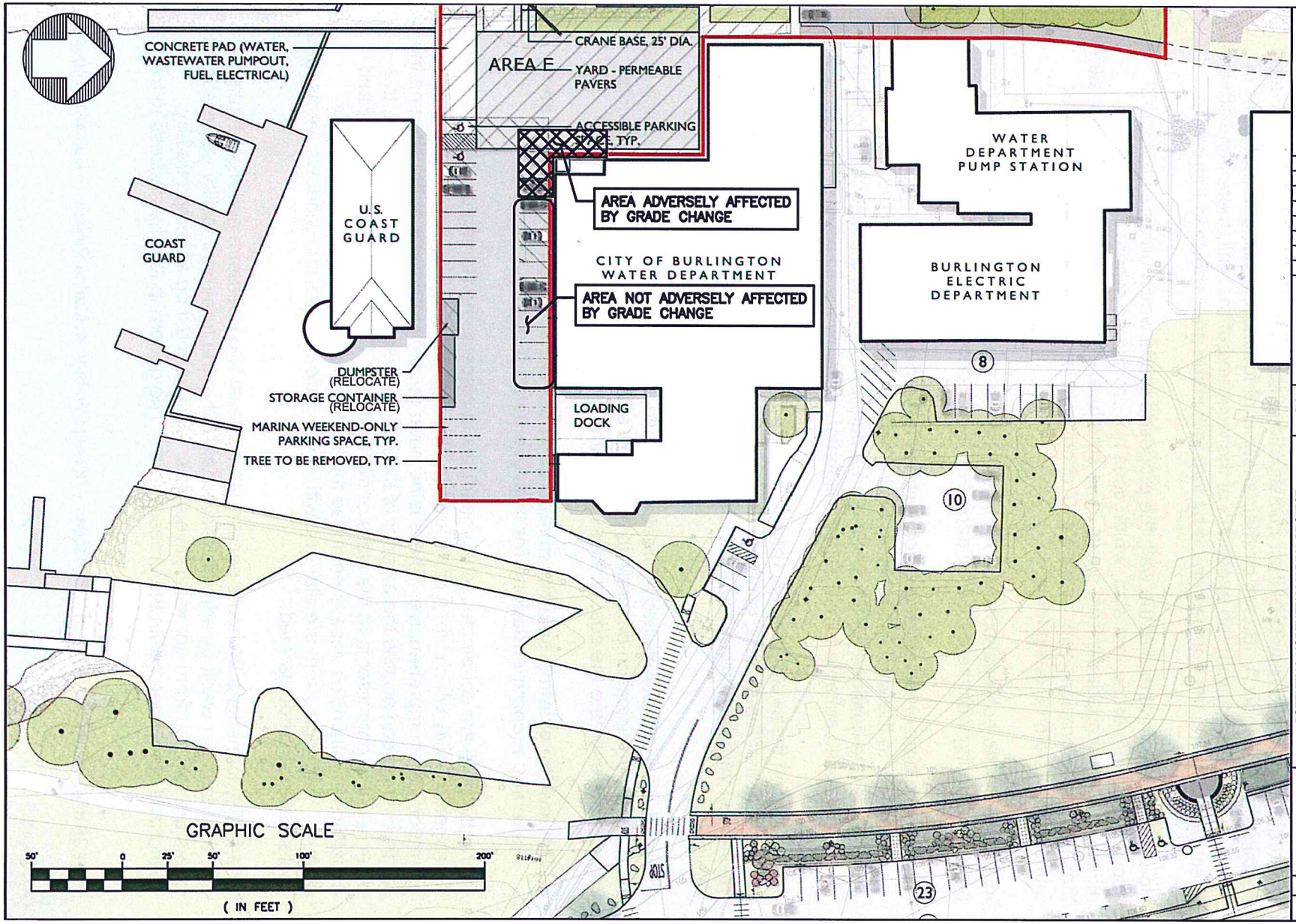
Based on the "Illustrative Plan" for the marina and as confirmed by officials representing Burlington Harbor Marina, LLC in the kickoff meeting, there are no proposed modifications planned for this alley.

However, it is important to recognize that this alleyway has extensive underground utilities and electrical conduit and is also extremely busy with vehicles accessing the waterfront. This alley provides little opportunity for service vehicles for the WTP for such tasks as media replacement and chemical deliveries unless the alleyway is closed to traffic.

7. Determine if the plans to remove an existing earthen berm on the south side of the water plant to accommodate additional parking for the proposed marina will compromise the integrity of the structure. This will most likely require a structural analysis of the wall to ensure its stability with appropriate factors of safety due to reduced support.

Officials from Burlington Harbor Marina, LLC, expressed an objective for additional vehicle parking in the area south of the Water Treatment Facility with sufficient central space to facilitate access to and from the maintenance crane as previously shown in Figure 1. Currently, this narrow paved area only allows access for maintenance tasks, limited parking for plant operational staff, and access for large trucks for chemical deliveries to the loading dock. It should be noted that the public is not prevented from parking in this area and does so without any formal organization or overview.

Because of the fixed width between the Coast Guard complex and the Water Treatment Facility, the only option that would allow double head parking would be to maximize the paved width up to about the Coast Guard security fence and to remove an existing berm and plantings along the southern Water Treatment Facility elevation. This berm extends from the loading dock access to the southwest corner of the facility. Currently this grass berm provides cover for numerous large underground utilities located along this elevation. In addition, the berm provides earthen cover to inhibit frost migration so as not to adversely affect footings.



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Project #	000000
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Design	NAME
Drawn	EAE
Checked by	R.E. DUFRESNE
Date	JUNE 29, 2015
Scale	AS SHOWN
Approved by	RED

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POTENTIAL NORTHERN MARINA PROJECT

FIGURE 10
AREAS AFFECTED BY GRADE
MODIF. & REMOVAL OF BERM

BURLINGTON, VERMONT

FIG 10

DWG. NO. turning radius.dwg

SHEET 1 OF 1

Potential adverse effects due to removal of this berm were evaluated by Engineering Ventures, PC with the results of their investigations contained in a June 26, 2015 letter contained in Appendix A. Based on their analysis of footings, walls, and mat slabs in this area indicate that with the exception of the west end of the wall, there is no adverse effect with lowering the finished grade by four feet in the area shown in Figure 10.

However, at the west end of the wall, the proposed grade would only be about 1'-3" above the bottom of the mat slab, which does not provide anywhere close to the minimum 4'-0' of adequate frost cover. The structural engineer recommends that either these areas be provided with at least 4'-0' of cover or that a shallow frost protected foundation system be designed.

In discussing the potential options for eliminating the mound and using a shallow frost protected footing with the structural engineer, he described two alternatives:

- Using horizontal rigid insulation suitable for traffic from the building wall to about six feet to the west (horizontally) to inhibit frost migration along the building.
- Excavate confined portions of the area below the footing and injecting concrete to a depth suitable to inhibit frost migration to below the fill concrete.
-

In considering these alternatives, we feel that the horizontal insulation alternative has more risk in that the existing concrete footing would allow freezing temperatures to be transmitted vertically downward and would in effect limit the effectiveness of the insulation.

As such, we feel that only two alternatives should be considered including leaving the berm in place or injection concrete to below the existing footing. Based on previous projects, we estimate the cost of excavating and injecting concrete at $100,000.

8. Review the existing security measures at the Water Treatment Facility and make any recommendations for improvements if deemed necessary.

Currently there are certain security procedures in place at the Burlington Water Treatment Facility which when compared to other similar facilities across the country are much less comprehensive. There is no outer security perimeter at the site and the public at large can access the exterior of the building without challenge. In fact, the outer security perimeter is at the walls of the building. The building architecture and construction minimizes access points as there are few windows, doors, and roof scuttles. Although doors are alarmed with contact closure alarms, windows, vents, and roof scuttles are not alarmed.

The facility is manned 24 hours per day with at least two operators and eight hours per day five days per week by administrative staff within the treatment facility. Operational areas are isolated from administrative areas. Visitors must be accompanied by authorized staff when within the process area. The general public has access to the

administrative areas during normal business hours. The administrative offices and entrances are locked at the building perimeter after business hours.

There are several closed circuit TV cameras providing digital data to a monitor in the control room. There is also a separate monitor fed by several cameras providing signals from remote sites within the distribution system. These monitors are rarely viewed. Some cameras at the plant take in internal areas and some cameras take in external areas. There are significant areas of the facility not monitored. The digital files are recorded and overwritten on a three week frequency. Basically the system would be beneficial in attempting to identify a perpetrator, but does not provide a proactive defense against a security breach. The following facility characteristics were noted in regard to security issues:

- There is no security fencing at the facility.
- There are no security measures in place at the pump station.
- There are no internal motion detectors or infrared sensors and alarms to detect and warn of unauthorized movement within the facility.
- There is no security gate at the facility and any vehicle could drive to within a few feet of the east, north, or south walls of the facility. With a four wheel drive vehicle, one could park within a few feet of the west wall of the facility.
- Traffic to and from the sailing club and public dock passes through the alleyway unrestricted anytime of the day or night.
- Public parking is not prevented along the south wall of the Moore Plant between the Coast Guard complex and the Moore Plant.
- Chemical fill line connections are not secured.
- Security doors between public space and process areas were observed to be open at times.

Based on these investigations, the facility clearly needs to implement additional security measures to protect the safety and dependability of the water supply for the City. However, the constricted site will not lend itself to normal and customary securing measures and it appears the securing perimeter will remain at the building exterior walls. Although the current situation is inadequate, the potential marina project should not adversely affect the existing condition. The potential marina project would significantly increase boat traffic near the facility as well as substantially increase both pedestrian and vehicular traffic in and around the Water Treatment Facility. This issue is not significant as there are at times numerous people using the picnic area that are allowed adjacent to the facility unchallenged. However, there is one significant issue related to the marina project that does adversely affect the security of the facility as follows:

- Long-term parking with vehicles not known by WTP staff adjacent to the south wall of the facility

Under the current parking concept, it would be acceptable for a van or small truck to access the south wall and provide an enclosure that would preclude observation of activities directly adjacent to the building perimeter. Immediately on the other side of this wall is direct access to partially treated water hours away from customers. Although it is possible for the public at large to park along the Coast Guard fence, it is not possible to park directly adjacent to the building wall. In our opinion, this would constitute an unacceptable risk to the water safety of the Water Treatment Facility.

Conclusions:

1. Some owners of vehicles left in long-term parking may not be available to move cars when needed to suite chemical deliveries.
2. Boat storage over the winter would not be acceptable due to conflicts with snow removal activities and chemical deliveries.
3. It would be more efficient if parking was restricted to WTP employees in the area south of the building as operational staff at the WTP could organize parking based on chemical deliveries.
4. It would not be efficient for marina staff to transfer vehicles in and out of the south lot to facilitate chemical deliveries even if they had keys to all vehicles.
5. Due to the frequency of chemical deliveries, it would be onerous for marina employees to transfer cars around to facilitate deliveries.
6. It is likely that marina staff would not have all keys necessary to move cars from the lot.
7. Chemical deliveries will increase in the future and increased delivery frequency would limit the viability of transferring cars in and out of the southern lot.
8. It is likely that long-term parking directly adjacent to the south wall of the water treatment facility would not be acceptable to public safety officials due to the possible need to access this area with emergency vehicles.
9. Water quality standards will be more stringent in the future.
10. Burlington will require additional and/or enhanced unit operations to meet these more stringent standards.
11. There is risk in reducing the land available for water treatment when the future needs have not been defined.
12. Transferring water to and from a remote location for treatment is more expensive than treating at one central location.
13. Technological innovations in methods to treat drinking water will reduce the area required for treatment.
14. Of all the future regulations set by EPA, control of disinfectants and disinfectant byproducts will be Burlington's most challenging standard for compliance.
15. Conversion of one of the super-pulsator units to a dissolved air floatation (DAF) unit would not require expansion beyond the current roof lines.
16. Burlington may have to address algal events or algae toxins at some point in the future.
17. Burlington has completed all available operational efficiencies and the water produced is as high a quality as can be produced at this facility using these unit operations.

18. From a technical basis, converting from free chlorine to monochloramine for secondary disinfection would be the most economical and most beneficial method to comply with future regulations.
19. Conversion of one of the super-pulsator units to a DAF unit would allow additional removal credits and reduce the inactivation requirement, both of which will reduce DBP levels.
20. Ultraviolet light could replace primary disinfection but would significantly increase electrical costs at dosages high enough to inactivate virus. In addition, it seems of limited benefit if free chorine remains as a secondary disinfectant.
21. Ozone would be beneficial as both a pre-oxidant and for use as a primary disinfectant. However, it would be necessary to use the ABW filter as a Biologically Active Filter to limit regrowth in the distribution system.
22. Burlington will need to implement capital improvement projects to control disinfection byproducts in the future.
23. If monochloramine disinfection is not a viable alternative for Burlington, the available options are more expensive and less effective for controlling regulated byproducts.
24. GAC would likely be required if monochloramines are not available as an alternative for secondary disinfection to meet future disinfection byproduct standards.
25. New processes such as MIEX should be considered and piloted as a more cost effective alternative to GAC. Both GAC and MIEX will not require additional expansion beyond the current roof lines due to use of the former super-pulsator units.
26. The benefits of ozone would be reduced if free chlorine remains as a secondary disinfectant.
27. The existing capital improvement plan addresses building and equipment upgrades but does not, and cannot, project requirements due to emerging Federal regulations. Until a master plan for future improvements is completed which defines future improvements based on these regulations, Burlington should not limit the available area around the water treatment plant.
28. Since future regulations cannot accurately be predicted, it would be prudent to maintain as much flexibility as possible in protecting options yet to be defined.
29. Conversion from free chlorine to monochloramine using ammonium sulfate will not require any additional modifications beyond the current roof lines.
30. Conversion of one of the super-pulsator units to a DAF unit will not require any modification beyond the current rooflines. Operating in an enhanced coagulation mode will reduce total organic carbon levels and precursors, but will require additional chemicals.
31. Converting from free chlorine to ozone as a primary disinfectant will require two large liquid oxygen tanks located on the western side of the southern access area east of the picnic area.
32. Conversion of one of the super-pulsator units to a GAC contactor will be feasible and provide sufficient contact time to reduce TOC levels prior to disinfection for compliance with future standards even when using free chlorine as a primary disinfectant.

33. The existing access for chemical delivery is inadequate and operates only due to the skill of delivery drivers.
34. Chemical deliveries occur on the average of about twice per month.
35. Relocation of the chemical fill stations is possible but large trucks will still have to access the loading docks.
36. Relocation of the bulk liquid fill station for sodium hypochlorite will require access to the State boat launch for turn around.
37. Relocation of the bulk liquid deliver station for process chemicals will adversely affect traffic flow in the alleyway.
38. Chemical deliveries will occur much more often in the future if process improvements are required to meet future regulations.
39. The intake pipe does not need any additional protection due to the marina project. However, after the securement method is defined, it should be reviewed to insure there are no adverse effects attributed to dock anchoring methods.
40. Some utilities on the south and west side of the Water Treatment Facility should be concrete encased to insure adequate protection from increased loading.
41. The flow control vault on the west side can be abandoned and the meter relocated.
42. Most of the berm on the southern side of the facility can be removed without adverse effects on the Water Treatment Plant building footing. However, the southwest corner must be protected from frost migration below the existing slab if the berm is removed in this area.
43. Security at the Water Treatment Facility is inadequate. The increased vehicle and pedestrian traffic due to the marina project will not degrade the current situation. However, the aspect of long-term vehicle storage for vehicles not owned or controlled by WTP operational staff directly against the building on the south side is not acceptable from a security standpoint.

We appreciate the assistance you provided during the completion of this report. Should you have any questions, please don't hesitate to contact us.

Sincerely,
DUFRESNE GROUP

Robert E. Dufresne, PE
President