TECHNICAL MEMORANDUM

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FROM:	Kristen Cope, PE Devan Ruiz, PE, PMP
SUBJECT:	Custer Road Site – Chloramine Residual System Evaluation
PROJECT:	PRP24435 – Custer Road 6.0 MG Ground Storage Tank Project
DATE:	December 11, 2024
CC:	Alexis Walker

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

1.00 INTRODUCTION

The Town of Prosper (Town) receives water from the North Texas Municipal Water District (NTMWD) through a single entry-point located on the eastern side of town at their Custer Road Site. The Custer Road Site currently houses two ground storage tanks (GSTs), one 3-million gallon (MG) and one 5-MG, an existing pump station, the Custer Road Pump Station (CRPS), and the Lower Pressure Plane Pump Station (LPPPS) that is currently in construction. The CRPS currently provides water to the Town's Upper Pressure Plane as well as the Lower Pressure Plane through a pressure reducing valve. Due to continued growth within the Lower Pressure Plane, Freese and Nichols, Inc. (FNI) previously designed the LPPPS to meet demands in the Lower Pressure Plane. This project includes the design of an additional 6-MG GST at the Custer Road Site. The three GSTs will serve as storage for both the CRPS and the LPPPS.

Because the Town has a single entry-point, water age increases and chloramine residuals decline at areas of the system farther away from the entry-point. To better understand the Town's options for chloramine management within the system, FNI was tasked with evaluating different approaches for chloramine residual control including the following:

- Inspecting existing chloramine booster system to understand what may be re-used
- Assessing chloramine boosting locations within the Town's distribution system
- Comparing different options for chlorination and injection at the selected boosting location
- Evaluating costs for the chloramine management system

The purpose of this technical memorandum is to identify the technologies, components, and conceptual costs associated with a chloramine residual control system at the Town's Custer Road Site.

2.00 EXISTING CHLORAMINE BOOSTING SYSTEM

The CRPS has an existing chloramine system that has fallen out of use. This system includes a sodium hypochlorite bulk tank, a liquid ammonium sulfate (LAS) bulk tank, two sodium hypochlorite metering pumps and associated piping, two LAS metering pumps and associated piping, and two chlorine residual analyzers. FNI performed a site visit to assess the system on September 4, 2024, and a description of the system components are described below.

2.01 BULK SODIUM HYPOCHLORITE TANK AND CONTAINMENT

The sodium hypochlorite storage and containment area was originally designed to accommodate one 5,400-gallon bulk tank with a diameter of 11’-11” and a straight side shell height of 7’-9.5”. The sodium hypochlorite bulk tank is a non-insulated double-wall, high density polyethylene (HDPE) tank in an indoor containment area. The system has been out of service for multiple years; however, the tank still contains sodium hypochlorite. This tank was purchased from the Poly Processing Company, and according to their product information, these tanks typically have a life span of approximately 10 plus years, with 15 to 20 years of service being possible. This tank is approaching 20 years of service, which is beyond the anticipated end of its useful life. Based on the age of the tank, FNI recommends that the tank be replaced.

The concrete containment area itself appears to be in good condition based on this preliminary assessment. The finished floor of the containment area is at the same grade as the remainder of the building, and the top of the wall is approximately 4’-2” above the finished floor with a chemical resistant coating on the concrete inside the containment area. The walls are approximately 8” thick, and the tank pad within the containment area is 2’-0” tall and 13’-0” in diameter. Pictures of the tank and containment area are provided in **Figure 2-1** and **Figure 2-2**. The net containment volume is 7,345 gallons which allows for six inches of freeboard in the event of a tank failure.

Figure 2-1: Bulk Sodium Hypochlorite Tank

Figure 2-2: Bulk Sodium Hypochlorite Containment Area

There is a 12’-0” by 12’-0” roll-up door allowing access to the Chemical Room within the CRPS where the sodium hypochlorite tank and containment area is located. However, based on the diameter size of the existing tank, this tank will need to be dismantled to remove it from the building through the roll-up door. It is not recommended to remove a portion of the roof to remove the tank or install a new tank as it will be expensive and affect the wall stability of the building. Reusing the existing containment area is possible by demolishing and replacing the west containment wall located nearest the roll-up door. The tank pad can be resized if needed to accommodate a new tank, and the containment area can be re-coated prior to installation of the new tank. The west wall of the containment area would be installed after the new tank is in place.

2.02 BULK LAS TANK AND CONTAINMENT

The LAS storage and containment area was originally designed to store one 6,150-gallon bulk tank with a diameter of 10’-2” and a straight side shell height of 10’-5”. The LAS tank is a non-insulated single-wall, HDPE tank in an outdoor containment area. Like the sodium hypochlorite tank, the LAS tank been out of service for multiple years but still contains LAS. This tank was also purchased from the Poly Processing Company, and at nearly 20 years of service, the tank is at the end of its useful life. FNI recommends that this tank be replaced.

The concrete containment area itself appears to need some repair based on this preliminary assessment. The finished floor of the containment area is at the same grade as the CRPS building, and the top of the wall is approximately 4’-2” above the finished floor with a chemical resistant coating on the concrete inside the containment area. The walls are approximately 8” thick, and the tank pad within the containment area is 2’-0” tall and 12’-0” in diameter. Pictures of the tank and containment area are provided in **Figure 2-3**. The net containment volume is 7,380 gallons which allows for six inches of freeboard in the event of a tank failure.

Figure 2-3: Bulk LAS Tank and Containment Area

The LAS tank and containment area is located outdoors which will ease the removal of the existing tank. Reusing the existing containment area will be possible after making needed repairs within the containment area. The tank pad can be resized if needed to accommodate a new tank, and the containment area can be re-coated prior to installation of the new tank.

2.03 CHEMICAL METERING PUMPS

The sodium hypochlorite and LAS systems are not currently in use, but each system was designed with a duty and stand-by diaphragm metering pump. The sodium hypochlorite system metering pumps are from the ProMinent® Sigma Series, and the LAS pumps are from the ProMinent® gamma Series. The injection locations for sodium hypochlorite are within the same chemical injection manhole on the 30” suction line of the CRPS pumps. The existing sodium hypochlorite and LAS chemical feed pumps and associated piping are shown in **Figure 2-4**.

The metering pumps are not on factory-built skids, which can make following and understanding the piping system more difficult when operating. Diaphragm pumps are also used for both systems, and this type of pump is prone to vapor lock with sodium hypochlorite. Additionally, the pumps, piping, and associated equipment are not maintained regularly since the system is not in use. Based on the current condition and age of the system, FNI recommends that these chemical metering pumps be replaced.

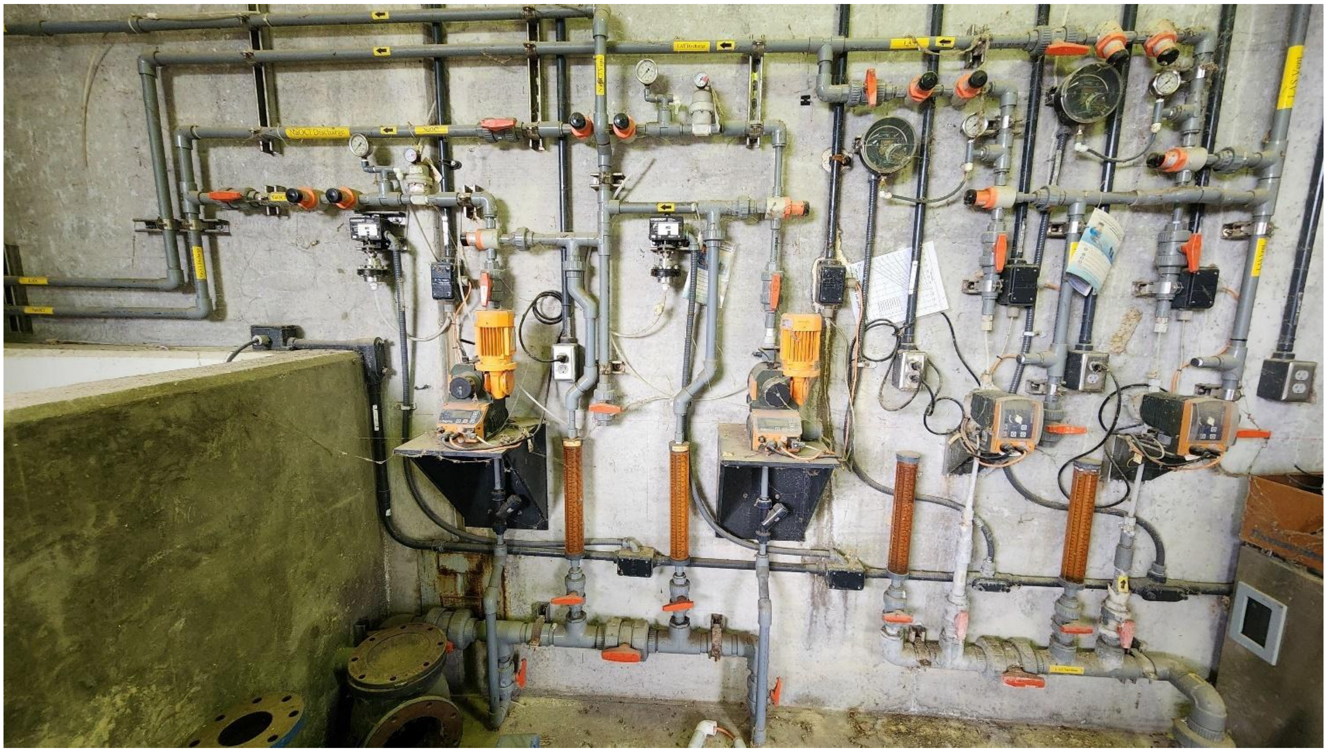


Figure 2-4: Sodium Hypochlorite and LAS Metering Pumps

2.04 CHLORINE ANALYZERS

There are two existing ProMinent® DULCOMETER controllers for chlorine analyzers within the Chemical Room of the CRPS. The units were labeled for the suction and discharge side of CRPS pumps, but they did not appear to be connected to an analyzer or in use. As the Town is interested in a residual control system to monitor chloramines, these controllers will not be re-used. A picture of the controllers is provided in **Figure 2-5**.

Figure 2-5: Chlorine Analyzer Controllers

3.00 CHLORAMINE BOOSTING LOCATION

In addition to the Custer Road Site, the Town of Prosper has three elevated storage tanks (ESTs) located across the Town. As part of this study, FNI evaluated whether the Custer Road Site or one of the other storage sites would be the best location for a Residual Control System to improve chloramine residuals within the distribution system.

The Town provided chloramine residual sample data from their nitrification action plan (NAP) taken at various locations within their system, as well as at the ESTs. Upon review of the data and discussion with the Town's operation staff on September 6, 2024, the Custer Road Site was selected as the optimal location for the residual control system.

This site was selected because it provides the Town with the ability to boost the chloramine residual throughout the distribution system as all water entering the Town passes through the Custer Road Site. This will help increase the chloramine residual at all the ESTs through one chemical storage and feed system, as opposed to having individual storage and feed systems at each EST. By centralizing the residual system at the Custer Road Site, the Town will be able to monitor and improve the residual as it is received from the NTMWD. Additionally, the storage capacity at the Custer Road Site is increasing, and having the ability to maintain a consistent, high residual in their stored water gives operators more flexibility in how the overall system and ETSs are operated.

4.00 REGULATORY REQUIREMENTS

The TCEQ has established chemical storage and feed systems requirements for water treatment systems. The relevant sections of the 30 Texas Administrative Code (TAC) are listed below:

- §290.42(e)(3)(A): Disinfection equipment shall have a capacity at least 50% greater than the highest expected dosage to be applied at any time. It shall be capable of satisfactory operation under every prevailing hydraulic condition.
- §290.42(e)(7)(C)(ii): Sampling taps must be provided at locations that allow for chlorine and ammonia to be added to the water to form monochloramine as the primary chloramine species. These locations must be listed in the system's monitoring plan as described in §290.121 of this title (relating to Monitoring Plans). Sample taps must be provided as follows: (ii) between the addition of the chloramine chemicals at chloramination facilities submitted for plan review after December 31, 2015. For these facilities, an installation without this sample tap may be approved if an acceptable technical reason is described in the plan review documents. Technical reasons, such as disinfection byproduct control, must be supported by bench scale sampling results. Other technical reasons, such as membrane integrity, must be supported by documentation.
- §290.42(f)(1)(A): Bulk storage facilities at the plant shall be adequate to store at least a 15-day supply of all chemicals needed to comply with minimum treatment technique and maximum contaminant level (MCL) requirements. The capacity of these bulk storage facilities shall be based on the design capacity of the treatment plant. However, the executive director may require a larger stock of chemicals based on local resupply ability.
- §290.42(f)(1)(B): Day tanks shall be provided to minimize the possibility of severely overfeeding liquid chemicals from bulk storage facilities. Day tanks will not be required if adequate process control instrumentation and procedures are employed to prevent chemical overfeed incidents.

- §290.42(f)(1)(C): Every chemical bulk storage facility and day tank shall have a label that identifies the facility's or tank's contents and a device that indicates the amount of chemical remaining in the facility or tank.
- §290.42(f)(1)(E)(ii)(I – II): Containment facilities for a single container or for multiple interconnected containers must be large enough to hold the maximum amount of chemical that can be stored with a minimum freeboard of six vertical inches or to hold 110% of the total volume of the container(s), whichever is less. Common containment for multiple containers that are not interconnected must be large enough to hold the volume of the largest container with a minimum freeboard of six vertical inches or to hold 110% of the total volume of the container(s), whichever is less.
- §290.42(f)(2)(A): Each chemical feeder that is needed to comply with a treatment technique or MCL requirement shall have a standby or reserve unit. Common standby feeders are permissible, but generally, more than one standby feeder must be provided due to the incompatibility of chemicals or the state in which they are being fed (solid, liquid, or gas).
- §290.42(f)(2)(B): Chemical feed equipment shall be sized to provide proper dosage under all operating conditions.
- §290.42(f)(2)(B)(i – ii): Devices designed for determining the chemical feed rate shall be provided for all chemical feeders. The capacity of the chemical feeders shall be such that accurate control of the dosage can be achieved at the full range of feed rates expected to occur at the facility.
- §290.42(f)(2)(C – D): Chemical feeders, valves, and piping must be compatible with the chemical being fed. Chemical feed systems shall be designed to minimize the possibility of leaks and spills and provide protection against backpressure and siphoning.

5.00 CUSTER ROAD SITE FLOWS AND DOSING

All water entering the Town flows through the Custer Road Site and will be pumped through either the CRPS or the LPPPS currently under construction. The design flows used for chemical system sizing are based on the recommendations identified by FNI in the August 2017 *Town of Prosper Water System CIP Updates Technical Memorandum*. **Table 5-1** provides the initial firm pumping capacity based on 2028 demands and the buildout firm pumping capacity for the CRPS and the LPPPS, and **Table 5-2** provides the flows used for the basis of design storage and feed calculations.

Table 5-1: Initial and Buildout Firm Pumping Capacity for the CRPS and LPPS

Firm Pumping Capacity	Flow (MGD)	
	CRPS | LPPS	Custer Road Site Total
Initial Capacity	25 | 26	51
Buildout Capacity	25 | 40	65

Table 5-2: Basis of Design Flows

Custer Road Site Total	Flow (MGD)	
	Initial	Buildout
Minimum[1]	5.1	6.5
Average[2]	26	33
Maximum	51	65

Chlorine and ammonia dosing estimates were developed based on total chlorine residual data entering the Custer Road Site from March 2022 to August 2024. Based on discussion with the Town, staff would like to maintain a consistent total chlorine residual of 3.5 milligrams per liter (mg/L) at the Custer Road Site. Using the incoming chlorine residual data and the desired chloramine residual, the estimated dosages used for the chemical system basis of design at the Custer Road Site are provided in **Table 5-3**. Chlorine (Cl_2) dosages were determined based on the minimum, average, and maximum residuals coming in (i.e., for the lowest residual entering the Custer Road Site, the highest amount of chlorine would be dosed to raise the residual to 3.5 mg/L). For the ammonia (NH_3) dosages, we used the chlorine-to-ammonia-nitrogen (Cl_2:NH_3-N) mass ratio of 4.8:1, which is the ideal ratio to form monochloramine.

Table 5-3: Chlorine and Ammonia Design Dosages

Criteria	Total Chlorine Residual Entering the Custer Road Site (mg/L as Cl_2)	Chlorine Dosage Needed to Raise Chloramine Residual to 3.5 mg/L (mg/L as Cl_2)	Ammonia Dosage Needed for a 5:1 Ratio of Cl_2:NH_3-N (mg/L as NH_3-N)
Minimum Dosage	3.4[3]	0.1	0.02
Average Dosage	2.9	0.6	0.12
Maximum Dosage	1.0	2.5	0.52
Maximum Dosage + 50%[4]	-	3.8	0.78

6.00 CHLORAMINE BOOSTER SYSTEM COMPONENTS

The Custer Road Site chloramine booster system will include the following major components:

- Chemical system including chlorine and ammonia storage, feed, and injection equipment
- Tank mixers to improve water quality in the GSTs

[1] The minimum flow is assumed to be 10 percent of the total Custer Road Site capacity.
[2] The average flow was assumed to be 50 percent of the total Custer Road Site capacity.
[3] The 95th percentile value of the chlorine residual data was used in lieu of the maximum to determine the minimum dose of chlorine needed to raise the chloramine residual to 3.5 mg/L. This approach is taken since the actual maximum chlorine residual was greater than the target residual of 3.5 mg/L and no additional chlorine would be needed.
[4] The maximum plus 50 percent is to satisfy the TCEQ design criteria associated with disinfection systems.

- Residual control system(s) which uses a programmable logic controller (PLC) to monitor water quality data and automatically increase or decrease the rate of chemical injection

Additional information on any of these components and any alternatives is provided below.

6.01 CHEMICAL INJECTION ALTERNATIVES

Two options were evaluated for chemical injection at the Custer Road Site: (A) in-line chemical injection or (B) in-tank chemical injection.

A. In-Line Chemical Injection

The CRPS was originally designed on the use of in-line chemical injection for chlorine and ammonia injection, which the Town has had difficulties with in the past and does not currently operate. The injection point for the CRPS is on the 30” suction header prior to the CRPS pumps, and it would be in approximately the same location if in-line injection is utilized for the new booster system. With the addition of the LPPPS to the Custer Road Site, there would be a second injection point on the suction header of the LPPPS pumps. The feed system would be designed with two duty (one for each injection location) pumps for each chemical, and one stand-by pump for each chemical that could be used for either injection location. New injection and sample quills would be installed for all injection and sample locations. A conceptual in-pipe residual control system process diagram for each pump station is provided in **Figure 6-1**.

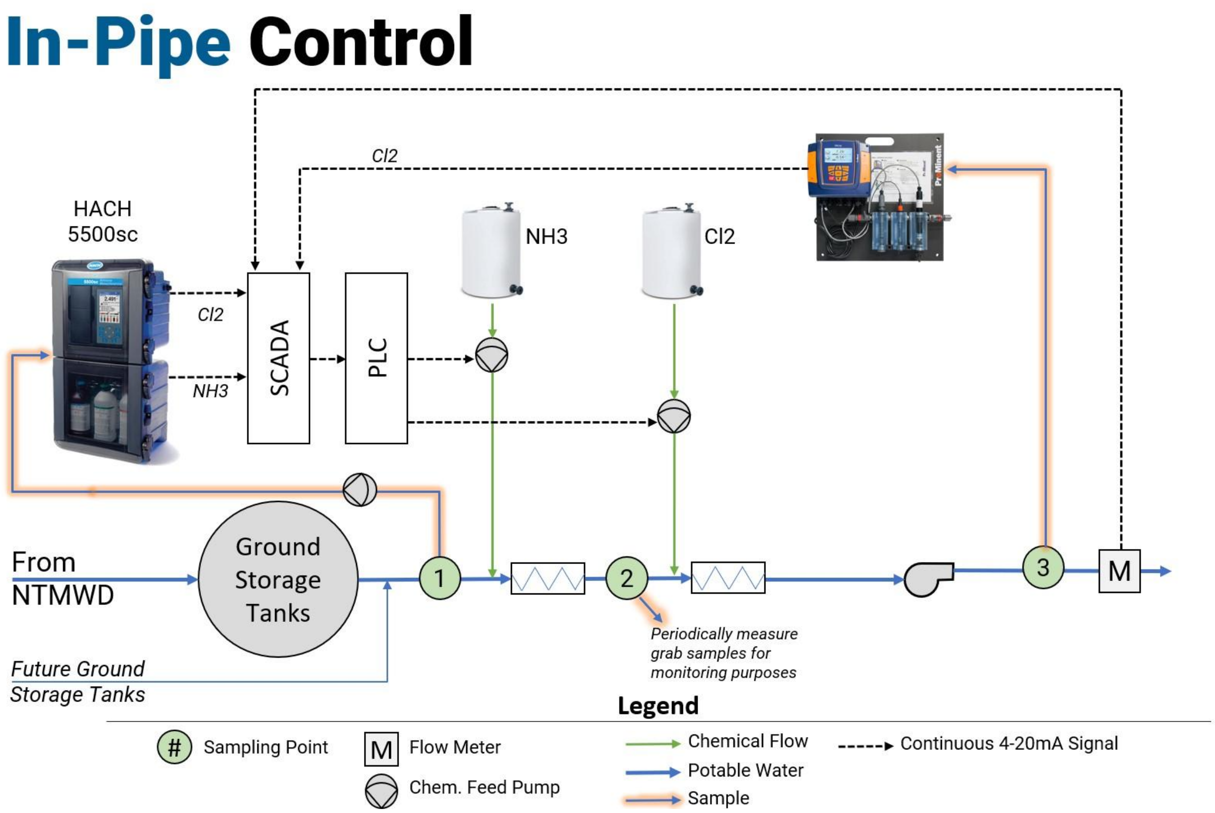


Figure 6-1: In-Line Chemical Injection Residual Control System for Each Pump Station

While this type of system can be successfully utilized for residual control, there are possible downsides, primarily related to mixing. Without good mixing at the injection locations, it can be difficult for the chlorine and ammonia to fully mix and form monochloramine. In-line mixers can be added to help with mixing, but there is limited space to add two inline mixers between the pump stations and the last ground storage tanks on each suction header. If good mixing is not achieved, other species of chloramines (di- and tri-chloramine) may be formed, and there is also a possibility that a higher concentration of chemical could reach a pump.

Because the Town already expressed interest in adding mixers to the GSTs to improve water quality, the in-tank option will provide better mixing and residual control at the Custer Road Site, and in-line injection was not further investigated for costs or a layout.

B. In-Tank Chemical Injection

In-tank chemical injection with a mixer is the optimal option to maintain good water quality with a consistent chloramine residual. It also simplifies the residual control system as there is only one sample point feeding back to the chemical dosing system where chlorine is added and trimmed by adding ammonia as needed to maintain monochloramine formation. The Custer Road Site will have up to four GSTs, and each one would have its own residual control system as well as three duty pumps for each chemical with space for a future fourth duty pump when the last tank is installed. There would also be an additional installed stand-by pump for each chemical that can be used for any of the GSTs. New chemical and sample pipes would be run to each of the GSTs. A conceptual in-tank residual control system process flow diagram for each GST is shown in **Figure 6-2**.

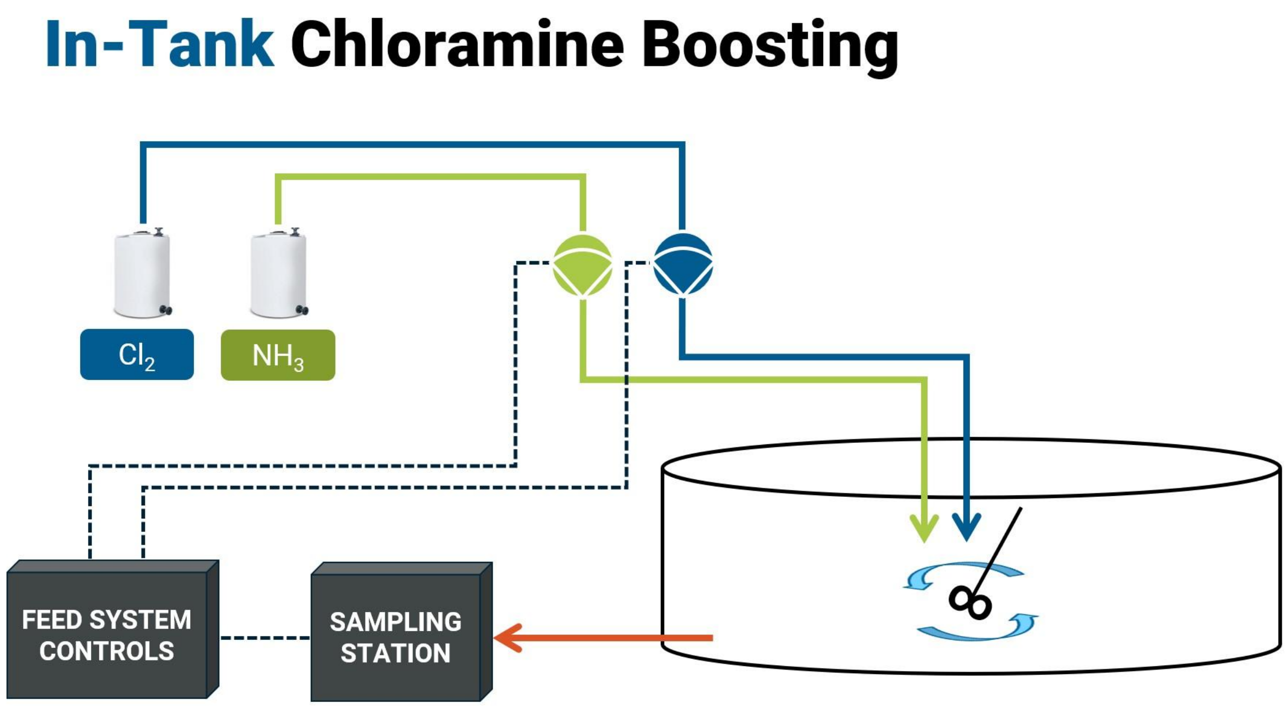


Figure 6-2: In-Tank Chemical Injection Residual Control System

In-tank chemical injection of chlorine and ammonia has been successfully utilized at pump stations throughout Texas; however, an exception request will still be needed to 30 TAC §290.42(e)(7)(C)(ii), which requires intermediate sample taps between injection points of chloramine chemicals. This will be a straightforward exception request, but the standard TCEQ review period is 100-days. To avoid a slowdown to final design and construction, this exception request can be submitted as soon as the Town agrees to move forward with the in-tank injection option and associated mixing equipment and residual control system. Additional information on the cost and layout of the system are provided in **Section 7.00** below.

6.02 CHLORINE SYSTEM ALTERNATIVES

There are three primary options used for chlorination systems that were evaluated as part of this study:

A. Chlorine Gas – Compressed liquid chlorine is delivered to the site in pressurized containers for storage and feed.
B. On-Site Sodium Hypochlorite Generation (OHSG) – Sodium hypochlorite is generated on-site at a concentration of 0.8-percent for storage and chemical feed using a salt delivered to the site.
C. Bulk Sodium Hypochlorite – Sodium hypochlorite is delivered to the site in bulk at a concentration of 12.5-percent for storage and feed.

A. Chlorine Gas

Chlorination using chlorine gas is still a common practice in Texas; however, many public water systems are choosing to move toward sodium hypochlorite as an inherently safer alternative to chlorine gas. While chlorine gas is effective for disinfection, it poses an exposure risk to personnel in the event of a leak as well as to the community during transport of the chemicals to the facility for storage. Due to these risks and discussion with the Town, chlorine gas was not further investigated for costs or a system layout.

B. On-Site Sodium Hypochlorite Generation (OSHG)

The OSHG process consists of a brine solution being passed through an electrolytic cell where a current is applied to convert the brine to a dilute, low-strength sodium hypochlorite solution (approximately 0.8-percent, or 0.067 pounds of available chlorine per gallon). At the Custer Road Site, the process would begin with solar salt delivered to a salt/brine storage tank using semi-trucks capable of delivering 22 to 24 tons per load, where it would be discharged by truck mounted blowers into the tank. Softened water is required for the process, and a dedicated water softener system would be used to form the brine solution, while a second water softener system would be dedicated to the sodium hypochlorite generator. To form the brine solution, softened water is discharged into the brine tank where the water level is maintained automatically in the brine maker to create a reservoir of 30-percent brine solution. The brine solution is diluted to 3-percent using softened water passed through a water chiller from the generator water softeners before the brine solution enters the electrolytic cells. The diluted brine solution then passes across electrodes powered by a low-voltage direct current and forms a low-strength solution of 0.8-percent sodium hypochlorite. The equation for the generation is as follows:

$$\underset{(solar\ salt)}{NaCl} + \underset{(water)}{H_2O} = \underset{(sodium\ hypochlorite)}{NaOCl} + \underset{(hydrogen\ gas)}{H_2}$$

The dilute sodium hypochlorite solution will be stored in a sodium hypochlorite bulk tank and pumped to the desired injection points at the GSTs using metering pumps. Hydrogen gas, the by-product of on-site sodium hypochlorite generation, is vented to the atmosphere using blowers. The generation process requires approximately 2.5 to 3.5 pounds of salt, 1.8 to 2.4 kWh of electricity, and 14 to 17 gallons of water to generate 14 to 17 gallons of 0.8-percent sodium hypochlorite product. Fifteen gallons of 0.8-percent sodium hypochlorite is equivalent to approximately 1.0 pound of chlorine gas. The advantages of this low concentration solution are that it is safer to handle than 12.5-percent, and it will not degrade in concentration as quickly as a higher concentration solution.

In addition to the primary materials (solar salt, softened water, and electricity) required by the process, dilute hydrochloric acid (5-10-percent) or citric acid is required for periodic cleaning of the electrolytic cell assemblies. Typically, cells are cleaned in place utilizing a portable cleaning cart and recirculation pump. Cleaning frequency varies based upon the local water supply characteristics but typically ranges between three and six months.

To comply with TCEQ requirements for backup chlorination units, either a secondary sodium hypochlorite generator would be required, or the Town would need to be prepared to order 12.5-percent sodium hypochlorite if the generator is out of service. Purchasing 12.5-percent leads to an issue with pump turndown ratios as the pumps sized for 0.8-percent will be too large, so a separate set of feed pumps would be required. Alternatively, a dilution panel could be used to dilute the sodium hypochlorite when it is delivered, but dilution of one 4,600-gallon bulk delivery of 12.5-percent to 0.8-percent would require over 70,000 gallons of water and more storage than would be reasonable to provide. Additionally, to meet the 15-day storage requirement for a 0.8-percent sodium hypochlorite solution, over 50,000 gallons of storage. Instead, the brine tank would be sized to store over 15 days' worth of salt (a minimum of 7 tons) to be used to form the sodium hypochlorite solution, and a 7,700-gallon tank would be provided for approximately two days of 0.8-percent sodium hypochlorite storage.

These systems are considered a safer alternative to chlorine gas, and because the sodium hypochlorite produced is very dilute, a spill of the 0.8-percent solution would be less hazardous than a spill of 12.5-sodium hypochlorite. However, hydrogen gas is produced as a by-product of the process, and the systems must be maintained to ensure the hydrogen blowers are functioning to avoid any hydrogen entrapment in the building or in the storage tank. While hydrogen is a non-toxic substance, it is flammable and must be vented.

Based on FNI's experience with these systems, there is a heavy maintenance requirement, and the equipment and infrastructure needed for these systems can make them cost prohibitive. A larger chemical storage and equipment area is needed for these systems as the pumps required are larger, either a second generator or second set of metering pumps is required, a minimum of two bulk tanks are needed (one brine tank and one dilute sodium hypochlorite tank), and there is more ancillary equipment required for the system including water softeners, blowers, and a water chiller. Based on the operational and maintenance challenges associated with an OSHG system, this option is not recommended for the Custer Road Site. As this option is not recommended, OSHG was not further investigated for a full opinion of probable construction cost (OPCC) or a system layout, but based on discussion with the manufacturer's representative, a single generator of the size needed for this system with the associated transformer rectifier, control panel, blowers, and water softeners would cost approximately $710,000. This cost does not include storage tanks for sodium hypochlorite or the salt/brine solution, a water chiller, pumps for sodium hypochlorite, or any modifications to buildings or new containment areas.

C. Bulk Sodium Hypochlorite

Sodium hypochlorite purchased in bulk at a concentration of 12.5-percent is an inherently safer chemical to handle than chlorine gas. While it is more hazardous than the 0.8-percent sodium hypochlorite solution, the system can be designed with several safety features to minimize hazards to operation and maintenance staff through alarms and safety equipment such as personal protective equipment (PPE) lockers and maintaining showers/eyewash stations inside and outside the containment area where exposure to sodium hypochlorite is possible. It is commonly used throughout Texas and is a straightforward process for operators with lower maintenance requirements than an OSHG system. Based on FNI's experience with other chloramine booster systems, bulk sodium hypochlorite is the recommended option for the Custer Road Site.

The characteristics of 12.5-percent sodium hypochlorite are shown in **Table 6-1**. The sodium hypochlorite storage and feed systems will be sized based on the capacity and required chlorine dosages described in **Table 5-2** and **Table 5-3**, respectively. The anticipated sodium hypochlorite daily usage for the expected doses and flows is summarized in **Table 6-2**.

Table 6-1: Sodium Hypochlorite Parameters

Parameter	Value
Chemical Formula	NaOCl (Sodium Hypochlorite)
Appearance	Clear or green to yellow, liquid with a chlorine (bleach) odor
Concentration	12.5% purchased (chemical concentration may vary from 10% to 15.6%)
pH	12 – 14 SU[5]
Specific Gravity	1.20 – 1.40
Freezing Point	20°F

Table 6-2: Sodium Hypochlorite (12.5-percent Solution) Daily Usage

Sodium Hypochlorite Dose (mg/L as Cl_2)	Sodium Hypochlorite Usage (gpd[6])			
	Initial Minimum Flow (5.1 MGD)	Initial Average Flow (26 MGD)	Initial Maximum Flow (51 MGD)	Buildout Maximum Flow (65 MGD)
Minimum (0.1)	3.56	17.8	35.6	45.4
Average (0.6)	20.7	103	207	264
Maximum (2.5)	89.1	446	891	1,136
Maximum + 50% (3.8)	134	668	1,337	1,704

[5] SU – standard units
[6] gpd – gallons per day

The TCEQ requires that liquid chemical storage facilities be sized to supply 15 days of storage, at a minimum, based on the maximum facility capacity and average dose. For the Custer Road Site, the maximum facility capacity was assumed to be the site's initial 2028 firm capacity of the CRPS and LPPPS combined, which is a total of 51 MGD. At an average dosage of 0.6 mg/L (as Cl_2), it is expected that approximately 207 gpd of sodium hypochlorite will be used. Based on the 15-day storage requirement, approximately 3,105 gallons of sodium hypochlorite solution will be required. At the buildout firm capacity of both pump stations, 65 MGD, approximately 264 gpd will be used and 3,960 gallons of sodium hypochlorite will be required at the Custer Road Site.

It should be noted that sodium hypochlorite degrades over time, especially when exposed to heat or sunlight. As hypochlorite degrades, the free available chlorine (FAC) decreases, requiring more sodium hypochlorite to achieve the same chlorine dose. To mitigate this issue, the existing chemical room at the CRPS will be re-used to store a new sodium hypochlorite storage tank. The degradation of sodium hypochlorite by ultraviolet light and heat will be mitigated significantly by providing an enclosed and conditioned space for the storage tank and containment facilities.

To allow the Town to accommodate a full delivery of sodium hypochlorite, while still being able to fit through the 12' by 12' roll-up door of the chemical room, a minimum tank size of 5,100-gallon polyethylene tank is recommended. A full truck load is approximately 4,500 to 5,000 gallons, and the Town will not have as much flexibility to schedule deliveries as the tank level will have to be lowered to 100 to 600 gallons to accept the truck load. At the average dosage and average flow rate, 103 gallons of sodium hypochlorite will be used per day, so this still provides the Town with approximately 1 to 6 days to prepare to get a delivery scheduled. The chemical manufacturer will have a maximum delivery amount that will help the Town narrow down the level the tank will need to be lowered to in order to accept a delivery. While a larger tank would provide more flexibility, this size tank at 10'-2" in diameter and 10'-6.5" tall will fit through the existing overhead door without requiring additional modifications. FNI did discuss modifying the door opening, but because the walls of the building are pre-cast panels, there were concerns that this could have negative structural impacts. Removal of the roof to install a larger tank is also not recommended because it may have a negative effect on the wall stability of the building. The possibility of tilting a tank to fit it through the door was discussed with both internal and external construction experts, and due to the size and weight of the tank, they could not guarantee a tank larger than the door opening could be installed in the room without causing damage to the tank.

This 5,100-gallon tank will meet the 15-day storage requirement for both the current capacity and the future buildout maximum capacity. The estimated storage duration for the 5,100-gallon tank at various flows and doses is summarized in **Table 6-3**. The design storage duration is circled in green.

Table 6-3: Sodium Hypochlorite Bulk Storage Duration

Sodium Hypochlorite Dose (mg/L as Cl_2)	12.5-percent Sodium Hypochlorite Bulk Storage 1 Tank: 5,100-gallon Total Storage Capacity Storage Duration (Days)			
	Initial Minimum Flow (5.1 MGD)	Initial Average Flow (26 MGD)	Initial Maximum Flow (51 MGD)	Buildout Maximum Flow (65 MGD)
Minimum (0.1)	1,430	286	143	112
Average (0.6)	247	49.3	24.7	19.4
Maximum (2.5)	57.2	11.4	5.72	4.49
Maximum + 50% (3.8)	38.1	7.63	3.81	2.99

The sodium hypochlorite containment area within the CRPS chemical room will meet the TCEQ's bulk storage containment requirements by providing more than six inches of freeboard and will contain over 110 percent of the total volume of the tank.

The sodium hypochlorite storage system will not utilize a day tank. Instead, process control instrumentation and procedures will be used to minimize the potential of overfeeding sodium hypochlorite from the bulk tank in accordance with TCEQ requirements.

The sodium hypochlorite feed system will include chemical feed pumps. One of the challenges of sodium hypochlorite is off gassing. While improvements to diaphragm pumps have been made to help overcome this challenge, diaphragm pumps can experience vapor locking, where gas bubbles become trapped in the diaphragm assembly and restrict pump capacity. Peristaltic (tube) pumps handle hypochlorite and any off gassing with little to no issue. The new sodium hypochlorite feed pumps will be peristaltic-style pumps.

The new sodium hypochlorite feed pumps will be in on a wall of the existing chemical feed room, similar to the existing system and separated from the bulk storage area by the 4'-2" containment wall. The sodium hypochlorite pumps, piping, valves, and accessories will be furnished on wall-mounted skids. The pre-assembled skids allow the units to be leak tested at the assembly facility before shipment, leaving the general contractor to mount the skids and install the necessary piping and wiring to each skid.

To provide in-tank chemical injection, one duty pump skid will be provided for each GST and one stand-by pump skid will be provided to inject at any of the GSTs. The initial build out will include three duty pumps and one stand-by pump with space reserved for a future fourth duty pump skid for the last GST anticipated to be installed at the Custer Road Site.

The sodium hypochlorite feed pumps will be sized for the full range of operational scenarios from the minimum flow (5.1 MGD) and minimum dose (0.1 mg/L as Cl2) to the anticipated maximum buildout capacity (65 MGD) and a dosage 50 percent greater than the maximum dose in accordance with TCEQ regulations (3.8 mg/L as Cl2). This results in a sodium hypochlorite usage range of 0.14 gallons per hour (gph) to 74.5 gph. **Table 6-4** summarizes the potential pump speeds for a single type of pump that may be included in the project.

Table 6-4: Sodium Hypochlorite Pump Speeds for Full Range of Custer Road Capacities

Manufacturer and Model Information	Watson Marlow Qdos H-FLO (ReNu 300 SEBS Tubing)
Available Speeds, rpm	0.1 – 186
Available Flows, gph	0.032 – 79.36
Project Flows, gph Min | Design (Average) | Buildout Max	0.14 | 4.31 | 74.5
Project Speeds, rpm Min | Design (Average) | Buildout Max	0.33 | 10.1 | 175

Costs and layouts for the proposed bulk sodium hypochlorite system are provided in **Section 7.00**.

6.03 AMMONIA SYSTEM

The ammonia system will be based on the use of LAS. The characteristics of LAS are shown in **Table 6-5**. The LAS storage and feed systems will be sized based on the capacity and required ammonia dosages described in in **Table 5-2** and **Table 5-3**, respectively. The anticipated LAS daily usage for the expected doses and flows is summarized in **Table 6-6**.

Table 6-5: LAS Parameters

Parameter	Value
Chemical Formula	$(NH_4)_2SO_4$ (Ammonium Sulfate)
Appearance	Clear, Faint Yellow to Amber Liquid
Concentration	38.0 – 40.0%
pH	3 – 5 SU
Specific Gravity	1.22 – 1.23
Freezing Point	10.4°F

Table 6-6: LAS (40-percent Solution) Daily Usage

LAS Dose (mg/L as NH_3-N)	LAS Usage (gpd) Initial Minimum Flow (5.1 MGD)	Initial Average Flow (26 MGD)	Initial Maximum Flow (51 MGD)	Buildout Maximum Flow (65 MGD)
Minimum (0.02)	0.96	4.80	9.61	12.2
Average (0.12)	5.76	28.8	57.6	73.5
Maximum (0.52)	25.0	125	250	318
Maximum + 50% (0.78)	37.5	187	375	478

Like the sodium hypochlorite system, the LAS system will be sized to supply a minimum of 15 days of storage based on the maximum facility capacity and the average dose to meet TCEQ requirements. For the Custer Road Site, the maximum facility capacity was assumed to be the site's initial 2028 firm capacity of the CRPS and LPPPS combined, which is a total of 51 MGD. At an average dosage of 0.12 mg/L (as NH_3-N), it is expected that approximately 58 gpd of LAS will be used. Based on the 15-day storage requirement, approximately 870 gallons of LAS solution will be required. At the buildout firm capacity of both pump stations, 65 MGD, approximately 74 gpd will be used and 1,110 gallons of LAS will be required at the Custer Road Site.

To allow the Town to accommodate a full delivery of LAS, approximately 4,500 gallons, and to make use of the existing LAS containment area, a new 6,100-gallon polyethylene tank is recommended. This is roughly the same capacity as the existing tank, which the containment area was sized to accommodate. Once repairs are made to the existing containment area, it will meet the TCEQ's bulk storage containment requirements by providing more than six inches of freeboard and will contain over 110 percent of the total volume of the tank. This tank will also meet the 15-day storage requirement for the future buildout maximum capacity. Unlike sodium hypochlorite, LAS has a long storage life and can be stored outdoors without degradation issues. The tank will be heat traced and insulated to avoid freezing.

The estimated storage duration for the 6,100-gallon tank at various flows and doses is summarized in **Table 6-7**. The design storage duration is circled in green.

Table 6-7: LAS Bulk Storage Duration

LAS Dose (mg/L as NH_3-N)	40-percent LAS Bulk Storage 1 Tank: 6,100-gallon Total Storage Capacity Storage Duration (Days)			
	Initial Minimum Flow (5.1 MGD)	Initial Average Flow (26 MGD)	Initial Maximum Flow (51 MGD)	Buildout Maximum Flow (65 MGD)
Minimum (0.02)	6,348	1,270	635	498
Average (0.12)	1,058	212	106	83.0
Maximum (0.52)	244	48.8	24.4	19.2
Maximum + 50% (0.78)	163	32.6	16.3	12.8

The LAS storage system will not utilize a day tank. Instead, process control instrumentation and procedures will be used to minimize the potential of overfeeding LAS from the bulk tank in accordance with TCEQ requirements.

The LAS feed system will include chemical feed pumps. The new LAS feed pumps will be peristaltic-style pumps.

The new LAS feed pumps will be in on a wall of the existing chemical feed room, similar to the existing system and separated from the sodium hypochlorite bulk storage area by the 4'-2" containment wall. The LAS pumps, piping, valves, and accessories will be furnished on wall-mounted skids. The pre-assembled skids allow the units to be leak tested at the assembly facility before shipment, leaving the general contractor to mount the skids and install the necessary piping and wiring to each skid.

To provide in-tank chemical injection, one duty pump skid will be provided for each GST and one stand-by pump skid will be provided to inject at any of the GSTs. The initial build out will include three duty pumps and one stand-by pump with space reserved for a future fourth duty pump skid for the last GST anticipated to be installed at the Custer Road Site. There will be no shared pumps between the LAS system and the sodium hypochlorite system.

The LAS feed pumps will be sized for the full range of operational scenarios from the minimum flow (5.1 MGD) and minimum dose (0.02 mg/L as NH_3-N) to the anticipated maximum buildout capacity (65 MGD) and a dosage 50 percent greater than the maximum dose in accordance with TCEQ regulations (0.78 mg/L as NH_3-N). This results in an LAS usage range of 0.04 gallons per hour (gph) to 22.8 gph. **Table 6-8** summarizes the potential pump speeds for a single type of pump that may be included in the project.

Table 6-8: LAS Pump Speeds for Full Range of Custer Road Capacities

Manufacturer and Model Information	Watson Marlow Qdos 120 Universal+ (ReNu Santoprene Tubing)
Available Speeds, rpm	0.078 – 140
Available Flows, gph	0.02 – 31.7
Project Flows, gph Min | Design (Average) | Buildout Max	0.04 | 1.21 | 22.8
Project Speeds, rpm Min | Design (Average) | Buildout Max	0.18 | 5.1 | 101

Costs and layouts for the proposed bulk LAS system are provided in **Section 7.00**.

6.04 TANK MIXERS AND RESIDUAL CONTROL SYSTEM

Mixing can improve water quality in potable water storage tanks by minimizing regions of the tank that exhibit longer water ages as a result of thermal stratification or hydraulic dead spots. Two primary types of mixing systems are available for GSTs: active and passive systems. Active systems can operate continuously, or at the discretion of the operators, mixing the GST's contents using a dedicated motor/energy source that is independent of the GST's drain/filling cycle. On the other hand, passive systems operate intermittently, mixing the GST's contents using the energy generated from filling the GST. Each type of system is compared below in **Table 6-9**.

For GSTs with chemical injection as is the recommended option for the Custer Road Site, active mixing systems are preferred since they allow operators to control chloramine residuals independent of system demand. This is especially critical for situations where extended water age is common such as oversized tanks and during low demand periods. In these scenarios, active mixing systems continuously mix the tank's contents, effectively allowing for direct chemical injection into the tank regardless of whether or not water is moving in and out of the GST. For these reasons, an active mixing system is recommended for the Custer Road Site GSTs.

There are two types of active mixing systems discussed in the table below: (1) active mixing systems with submerged moving parts and (2) active mixing systems with external moving parts. The advantage of the submerged option is that they have a wet installation option that will simplify installation in the existing GSTs at the Custer Road Site, and this is the recommended option for the Town.

The number of mixers will be confirmed with the manufacturer during design, but for cost estimation purposes, it was assumed that two mixers would be installed in the 3-MG GST, and three mixers would be installed in the 5-MG and 6-MG GSTs.

Table 6-9: Comparison of GST Mixing Systems

Criteria	Active Mixing System (Submerged Moving Parts)	Active Mixing System (External Moving Parts)	Passive Mixing System
Example System Types ***Manufacturers / Model***	Submersible Propeller *PAX/PXM, Invent/Hypermix* Submersible Sheet Flow *Medora/GridBeeGS*	Large-Bubble Mixing *Enviromix, Pulsair, PHi* Pumped Recirculation *Tideflex/Active TMS, PAX/Tank Shark*	Duckbill Inlet Mixing *Tideflex/Passive TMS Landmark/HMS*
Ability to Minimize Thermal Stratification	**Yes**	**Yes**	**Yes,** during avg demands. **No** during low demands (tank turnover required to achieve good mixing).
Ability to Homogenize Water Quality in GST	**Yes**	**Yes**	**Yes,** during avg demands. **No** during low demands (tank turnover required to achieve good mixing).
Ease of Installation	**Best**. Wet install possible.	**Good**. Dry install required (not an issue for new tanks).	**Good**. Dry install required (not an issue for new tanks).
Ease of Maintenance	**Good**. Low maintenance frequency. Mixer must be removed from top of GST for maintenance.	**Better**. Low maintenance frequency. All moving parts can be located external to tank at ground level.	**Best**. No components require routine maintenance.
Ease of Equipment Repair	**Best**. Mixers can be removed and replaced from roof hatch without draining tank.	**Good**. External components can be readily accessed. Wetted components of system will require tank draining and a crane if large piping replacement is necessary.	**Good**. Wetted components of system will require tank draining and a crane if large piping replacement is necessary.
Compatible with Chemical Injection Approaches	**Yes**	**Yes**	**Yes,** for pipe injection. **No** for in-tank injection.

There are multiple options for the submerged system, but the Cleanwater1 PAX Impeller Water Mixer is recommended as the system can be installed as part of Cleanwater1's Monoclor Residual Control System (Monoclor System), which is the recommend residual control system for the Custer Road Site based on FNI's experience with systems that are installed and working at multiple sites across Texas. A simplified process and instrumentation diagram (P&ID) for a single tank is provided in **Figure 6-3**.

The Monoclor System is an integrated residual control system capable of controlling tank mixing, water quality monitoring, and dosing of chlorine and ammonia to maintain the residual specified by the Town. The system includes a Water Quality Station and Smart Controller. The Water Quality Station is made up of one (1) pH probe, one (1) oxidation reduction potential (ORP) probe, and two (2) chlorine probes that send data on the water quality within the tank to the Smart Controller. The Smart Controller uses an internal algorithm to maintain the chloramine concentration on the breakpoint curve at a 5:1 chlorine to ammonia-nitrogen level. The Smart Controller will automatically adjust the dose of chlorine or ammonia (or both) to maintain the input desired residual in each tank.

This Smart Controller will be able to communicate to SCADA and in addition to automatically adjusting the chemical dosages, it will monitor the residual in each GST, control the tank mixer, monitor the sample pump for each GST, and monitor the bulk tank chemical levels. The default method for integrating the Smart Controller with SCADA involves Ethernet communication using Modbus TCP, but other protocols can be accommodated upon request including hardwiring signals to the SCADA Remote Terminal Unit (RTU).

Three Monoclor Systems will be installed, one for each GST, with space reserved for a fourth system when the final GST is installed at the Custer Road Site.

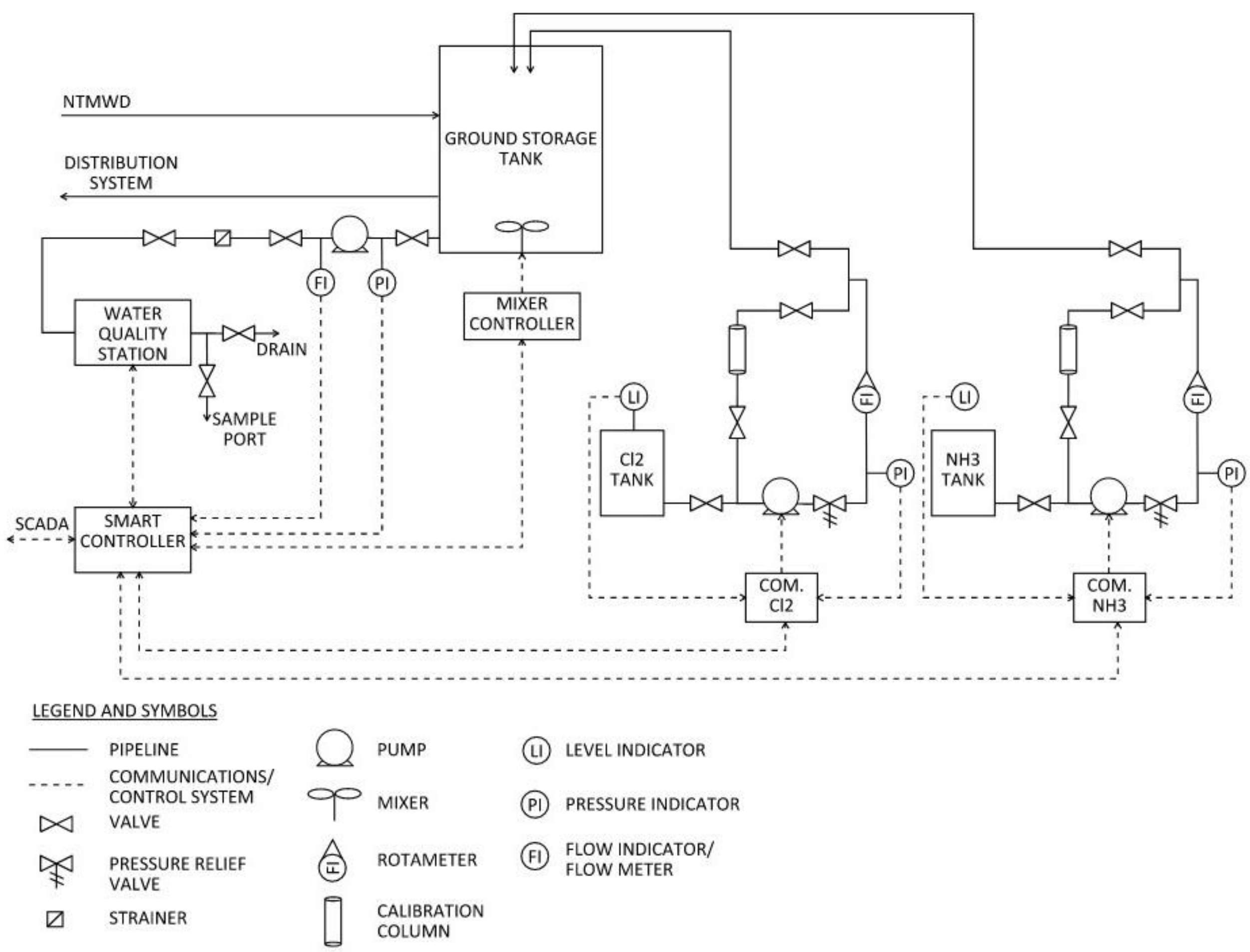


Figure 6-3: Monoclor Residual Control System P&ID

Costs and layouts for the proposed tank mixers and Monoclor System are provided in **Section 7.00**.

7.00 RESIDUAL MANAGEMENT SYSTEM PRELIMINARY LAYOUT AND COSTS

The proposed site layout for the bulk sodium hypochlorite and LAS system is provided in **Figure 7-1**. The chemical metering pumps, water quality stations, and smart controllers will be installed in the chemical room of the CRPS, and chemical feed lines will be sent to each of the GSTs. The existing GSTs will be modified to include tank mixers, and the new and future GSTs will be designed with tank mixers. A high-level opinion of probable construction cost (OPCC) is provided in **Table 7-1**, and a detailed OPCC is provided as an attachment.

Table 7-1: Bulk Sodium Hypochlorite and LAS System OPCC

Item	OPCC*
Residual Control Systems (1 per Tank)	$690,000
Tank Mixers (2 for 3 MG GST, 3 for 5 MG GST, and 3 for 6 MG GST)	$500,000
Yard Piping	$126,195
Sodium Hypochlorite Area and Chemical Room Demolition and Repairs	$39,810**
New Sodium Hypochlorite System	$303,575
LAS Area Demolition and Repairs	$21,410**
New LAS System	$300,575
Subtotal	$1,981,565
Contingency (30%), Mobilization (5%), OH&P (20%), and Escalation (4%)	$1,394,070
TOTAL OPCC (2025)	$3,375,635

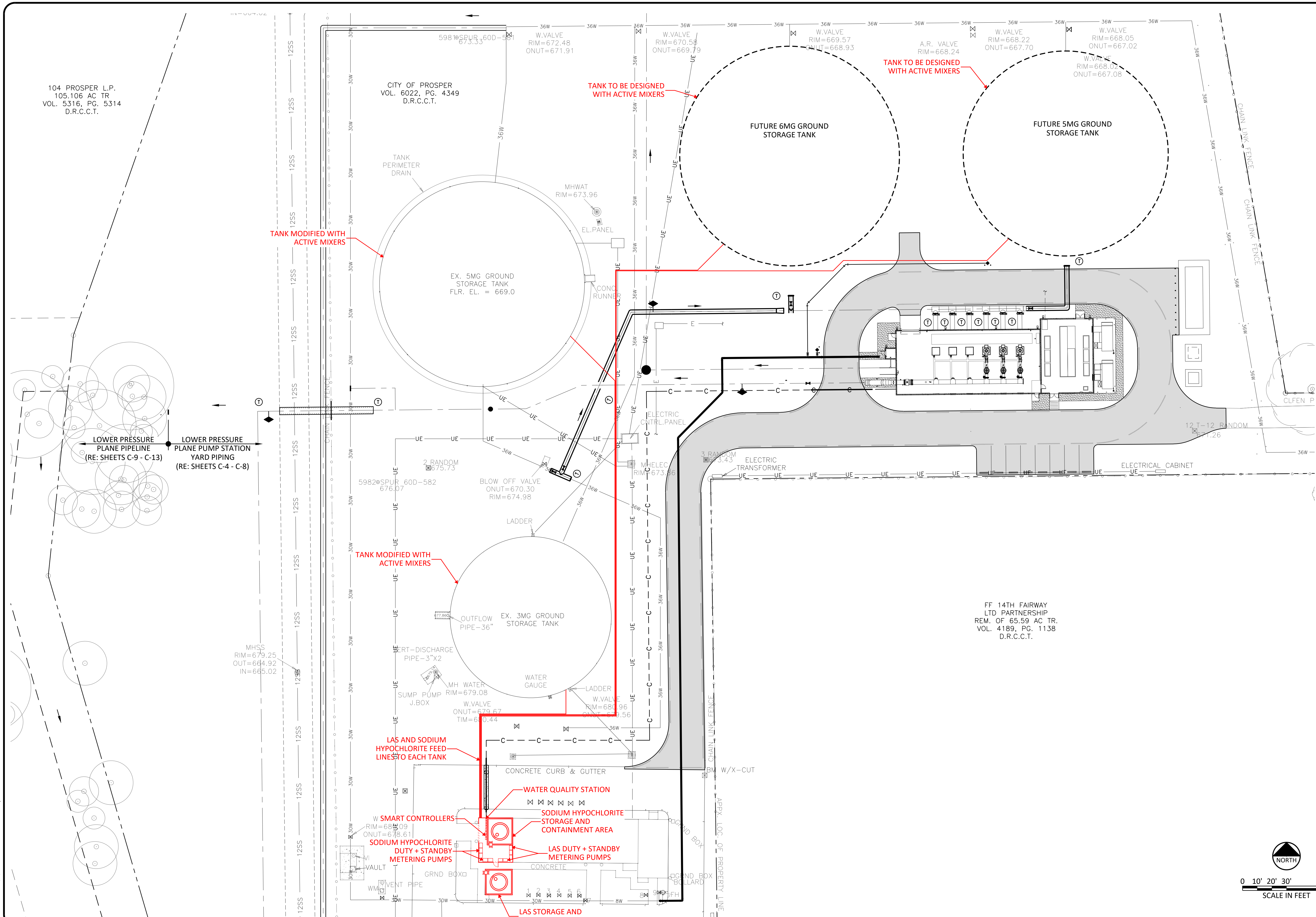
*The costs provided are only for equipment and piping for three (3) GSTs. Costs associated with the future GST pumps, piping, mixers, and residual control system are not included.
**These costs do not include disposal of sodium hypochlorite and LAS remaining in the existing tanks.

8.00 CONCLUSIONS AND RECOMMENDATIONS

Technologies, components, and conceptual costs associated with a chloramine residual control system were evaluated for the Town of Prosper. Based on the evaluation and alternatives discussed above, the following system will be designed:

- The residual control system will be designed for the Custer Road Site.
- Bulk sodium hypochlorite will be utilized for chlorine addition with LAS for ammonia addition.
- The existing sodium hypochlorite storage room and containment area will be modified and re-used for storage of a new bulk sodium hypochlorite tank as well as feed equipment for both sodium hypochlorite and LAS.

- The existing LAS containment area will be modified and re-used for storage of a new bulk LAS tank.
- Chemical injection of sodium hypochlorite and LAS will be done individually at each GST.
- The Monoclor Residual Control System will be utilized with one system for each GST, and the systems will be integrated with PAX Impeller Water Mixers to maintain chloramine residuals in each GST. The number of mixers will be determined during detailed design.
- The Water Quality Stations and Smart Controllers associated with the Monoclor Residual Control Systems will in installed in the sodium hypochlorite storage room.



Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

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TOWN OF PROSPER, TEXAS
CUSTER ROAD SITE
CHLORAMINE RESIDUAL SYSTEM EVALUATION
CIVIL
DISINFECTION SYSTEM
PROPOSED SITE AND YARD PIPING PLAN

F&N JOB NO.	PRP19556
DATE	MAR 2024
DESIGNED	CL
DRAWN	LMR
REVISED	
CHECKED	CCB
FILE NAME	CV-PST-PL-SITE_treat use.dwg

NO.	ISSUE	BY	DATE

VERIFY SCALE
Bar is one inch on original drawing. If not one inch on this sheet, adjust scale.

SHEET FIGURE 7-1
SEQ. 24

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OPINION OF PROBABLE CONSTRUCTION COST

PROJECT NAME	Custer Road Site – Chloramine Residual System Evaluation	DATE	10/8/2024
CLIENT	Town of Prosper	GROUP	1153
% SUBMITTAL	Conceptual	PM	Devan Ruiz

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
Kristen Cope	John Rinacke	PRP24435

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Residual Control System					
1	Residual Control System - 3 (1 per tank)	3	EA	$ 230,000.00	$ 690,000
Tank Mixers					
1	3 MG GST Mixers - Assume 2 Mixers	2	EA	$ 62,500.00	$ 125,000
2	5 MG GST Mixers - Assume 3 Mixers	3	EA	$ 62,500.00	$ 187,500
3	6 MG GST Mixers - Assume 3 Mixers	3	EA	$ 62,500.00	$ 187,500
Yard Piping					
1	Trench, Excavation	604	CY	$ 35.00	$ 21,140
2	Trench, Backfill and Compaction	604	CY	$ 40.00	$ 24,160
3	1.5" DWV PVC Conduit Pipe for Sodium Hypochlorite to Each Tank	1480	LF	$ 29.00	$ 42,920
4	1.5" DWV PVC Fittings	35	EA	$ 59.56	$ 2,085
5	Sodium Hypochlorite 1/2" ID PVC Tubing to Each Tank	1630	LF	$ 2.00	$ 3,260
6	1" DWV PVC Conduit Pipe for Sodium Hypochlorite to Each Tank	1480	LF	$ 20.00	$ 29,600
7	1" DWV PVC Fittings	35	EA	$ 40.00	$ 1,400
8	LAS 1/4" ID PE Tubing to Each Tank	1630	LF	$ 1.00	$ 1,630
Sodium Hypochlorite Area and Chemical Room Demolition and Repairs					
1	Existing Sodium Hypochlorite Tank Demolition	1	EA	$ 15,000.00	$ 15,000
2	Existing Sodium Hypochlorite Pad Demolition	7	CY	$ 400.00	$ 2,800
3	Existing Sodium Hypochlorite/LAS Pumps and Piping Demolition	1	LS	$ 20,000.00	$ 20,000
4	Existing Sodium Hypochlorite Containment Area Repair	138.75	SF	$ 8.00	$ 1,110
5	Demolition of Sodium Hypochlorite Containment Area Wall	2	CY	$ 450.00	$ 900
New Sodium Hypochlorite System					
1	New Sodium Hypochlorite Containment Area Wall	2	CY	$ 1,500.00	$ 3,000
2	New Sodium Hypochlorite Tank Pad	7	CY	$ 1,350.00	$ 9,450
3	Re-Coat Sodium Hypochlorite Containment Area	555	SF	$ 75.00	$ 41,625
4	Sodium Hypochlorite Tank - HDPE	1	EA	$ 34,500.00	$ 34,500
5	Sodium Hypochlorite Pumps - 3 Duty + 1 Standby	4	EA	$ 43,750.00	$ 175,000
6	Miscellaneous Sodium Hypo Bulk Storage and Feed Area Piping	1	LS	$ 40,000.00	$ 40,000
LAS Area Demolition and Repairs					
1	Existing LAS Tank Demolition	1	EA	$ 7,500.00	$ 7,500
2	Existing LAS Pad Demolition	7	CY	$ 400.00	$ 2,800
3	Existing LAS Pumps and Piping Demolition	1	LS	$ 10,000.00	$ 10,000
4	Existing LAS Containment Area Repair	138.75	SF	$ 8.00	$ 1,110
New LAS System					
1	New LAS Tank Pad	7	CY	$ 1,350.00	$ 9,450
2	Re-Coat LAS Containment Area	555	SF	$ 75.00	$ 41,625
3	LAS Tank - HDPE	1	EA	$ 34,500.00	$ 34,500
4	LAS Pumps - 3 Duty + 1 Standby	4	EA	$ 43,750.00	$ 175,000
5	Miscellaneous LAS Bulk Storage and Feed Area Piping	1	LS	$ 40,000.00	$ 40,000
		SUBTOTAL			$ 1,981,565

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COST

PROJECT NAME	Custer Road Site – Chloramine Residual System Evaluation	DATE	10/8/2024
CLIENT	Town of Prosper	GROUP	1153
% SUBMITTAL	Conceptual	PM	Devan Ruiz

ESTIMATED BY	QC CHECKED BY	FNI PROJECT NUMBER
Kristen Cope	John Rinacke	PRP24435

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL

CONTINGENCY	30%	$	594,469
SUBTOTAL		$	2,576,034
MOBILIZATION	5%	$	128,802
SUBTOTAL		$	2,704,836
OH&P	20%	$	540,967

PROJECT TOTAL (2024 COSTS)		**$**	**3,245,803**

COST ESCALATION FACTOR	4.0%	$	129,832
PROJECT TOTAL (2025 COSTS)		**$**	**3,375,635**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

NOTES:

1 FNI OPCC classified as an AACE Class 5 Estimate with accuracy range or -30 to + 50.

2 FNI OPCC does not include costs associated with engineering fees, permits, surveying, etc.