LIFT STATION
DESIGN & CONSTRUCTION
GUIDELINES

PLANTS AND MAJOR PROJECTS

July 2026

Introduction

The San Antonio Water System (SAWS) Lift Station Design and Construction Guidelines document establishes comprehensive guidelines for the planning, design, and construction of sanitary sewer lift stations and associated force mains within the SAWS service area. These guidelines are intended to ensure that all lift stations are reliable, efficient, safe, and environmentally sustainable, while minimizing operational and maintenance costs over their lifecycle. They apply to any consultant, developer, or entity proposing to construct or modify a public lift station, as required by the current SAWS Utility Service Regulations (USR) and applicable Texas Commission on Environmental Quality (TCEQ) rules.

Purpose: The primary purpose of this document is to provide uniform criteria that promote consistency in lift station development, facilitate compliance with regulatory requirements, and support SAWS' mission to deliver high-quality wastewater services. By adhering to these guidelines, lift stations will be designed to handle current and future wastewater flows at build-out densities, incorporate advanced technologies for odor control and emergency provisions, and integrate safety and security measures to protect personnel and the public.

Scope: This document covers all aspects of lift station design and construction, including but not limited to:

- Site selection and economic analysis comparing lift stations to gravity mains.
- Wet well sizing, materials, and aeration systems.
- Pumping equipment, piping, valves, and force mains.
- Electrical systems, controls, instrumentation, and Supervisory Control and Data Acquisition (SCADA).
- Emergency backup provisions, safety requirements, and submittal processes.

These guidelines are applicable to new lift stations. Where conflicts arise between these guidelines and external regulations (e.g., TCEQ Chapters 217 and 213, NFPA National Electrical Code, OSHA, or City of San Antonio standards), the more stringent requirements shall prevail.

Audience: This document is primarily for use by professional engineers, consultants, developers, contractors, and SAWS staff involved in the design, review, construction, and inspection of lift stations. All designs must be prepared under the supervision of a Texas Licensed Professional Engineer, with documentation signed, sealed, and dated accordingly.

Key Assumptions and Compliance: Designs shall consider ultimate watershed build-out, incorporating Equivalent Dwelling Units (EDU) from SAWS Water and Sewer Commitments. Flow calculations must align with TCEQ Chapter 217 and SAWS EDU Calculation Sheets. Lift stations are submersible type by default, with alternatives evaluated on a case-by-case basis. All facilities must be located outside of the 100-year flood events, including wave action, and designed to prevent sewage bypassing.

These guidelines reference specific editions of codes and regulations (e.g., 2015 TCEQ Chapter 217, 2017 NFPA NEC), but users should apply the latest editions where applicable.

SAWS reserves the right to update these guidelines administratively or through Board approval to reflect technological advancements, regulatory changes, or operational needs.

Revision History: This version is effective as of July 2026. For the most current updates, refer to the SAWS website (www.saws.org) or contact SAWS Plants and Major Projects at 2800 U.S. Hwy. 281 North, San Antonio, TX 78212.

By following these guidelines, SAWS aims to build resilient infrastructure that supports sustainable growth in the San Antonio region while protecting public health and the environment.

<u>**TABLE OF CONTENTS**</u>

Section A. General Requirements

1. As required by the current version of the San Antonio Water System Utility Service Regulations (USR) and the latest TCEQ requirements, and where there is a discrepancy, use the more stringent requirement. A present value analysis comparing the cost of constructing the sanitary sewer gravity mains option with the cost of constructing the lift station/force main system, plus ten years of operating cost alternative.

   a. The analysis must compare the cost of constructing a sanitary sewer gravity main option and the cost of constructing a lift station alternative, including the applicable lift station maintenance fee in effect for a 10 year period. The analysis must include the cost of all off-site easements required for all options evaluated.

   b. Lift stations will be considered a viable option only if the cost analysis shows that the total cost of the gravity option is more than three (3) times the total cost of the lift station alternative. Lift stations will not be allowed where an acceptable gravity option exists.

   c. This document, as well as the accompanying drawings and details shall be fully applicable to any new lift station or alteration to an existing lift station that is proposed by a developer or by a consultant hired by a developer in connection with a new development.

      1). Definition of Alteration

         i Replacement of an existing lift station.

         ii To modify an existing lift station in a way that changes any of the following:

            - The capacity.
            - The process.
            - The mode of operation.
            - The site layout.
            - A design parameter.
            - A major design assumption.

2. The engineering report shall address whether it is expected that the lift station may be expanded in the future, and the design engineer shall ensure adequate space is provided to accommodate installation of future equipment and structures, and ease of operation, access, and maintenance. The expanded facility layout will be shown in the engineering report. The force main, wet well, and yard piping shall be designed for the ultimate build-out capacity of the sewershed unless otherwise approved by SAWS. Planned phased expansions shall be incorporated into the ultimate design where applicable.

a. The lift station design shall consider both the total number of acres and total number of Equivalent Dwelling Units (EDU) to be developed, as stated in the Water and Sewer Commitment submitted to SAWS.

b. The lift station flow load shall be determined in accordance with the current applicable rules of the Texas Commission on Environmental Quality (TCEQ) Chapter 217 "Design Criteria for Domestic Wastewater Systems", and in accordance with the current Infrastructure Planning Equivalent Dwelling Unit (EDU) Calculation Sheet of the San Antonio Water System. When a conflict between SAWS and TCEQ criteria exists, the most stringent criteria shall be used.

3. All sanitary sewer lift stations shall be of the submersible type. Suction lift self-primer and package type lift stations will not be permitted.

4. All lift stations shall be designed to meet the requirements of this document.

   a. And also meet or exceed the requirements of:

      1). TCEQ Chapter 217, Subchapter C, current version (Conventional Collection Systems).

      2). TCEQ Subchapter 213 current version, Subchapters A and B (for lift station over Edwards Aquifer Recharge, Transition, or Contributing Zones).

      3). CPS Energy Standards current version.

      4). NFPA 70 National Electrical Code (NEC) current version.

      5). Occupational Safety and Health Administration (OSHA) current version, and contemporary industry practices.

      6). COSA Standards current version.

   b. When these Lift Station Guidelines are in conflict with any standards, rules and regulations from the entities listed above, the stringent requirement shall apply.

   c. <u>A lift station application shall include final construction plans, a design engineering report, a complete set of technical specifications, a geotechnical report, and a physical radio path study.</u> All design documentation shall be signed, sealed, and dated by the corresponding Texas Licensed Professional Engineers of the various disciplines involved in the design.

   d. The lift station site layout shall show the proposed contour lines elevations with maximum interval of 10 feet inside and outside the site. See SAWS Lift Station Drawings for reference.

5. All lift stations shall be located <u>in a dedicated right-of-way or permanent easement</u>, and be designed and constructed to ensure that sewage spills do not occur.

6. The firm pumping capacity of all lift stations shall be such that the expected peak wet weather flow can be pumped out to its desired destination. Firm pumping capacity is

defined as the lift station's total maximum pumping capacity with the largest pumping unit out of service. See TABLE 2.

a. The design Firm Pumping Capacity shall be at least 1.3 times greater than the design Peak Wet Weather Flow for conventional non-clog type pumps and 1.1 times greater for self- cleaning type pumps and grinder type pumps.

7. Lift Station site requirements.

a. The lift station site shall be located outside of the 100-year flood event including wave action and must remain fully operational and accessible during such event.

1). Provide a letter dated, signed and sealed by a Texas Professional Engineer certifying the site is protected from such an event. Attach FEMA or San Antonio River Authority floodplain maps clearly showing the floodplain elevation used in the lift station design.

b. Lift station site shall be protected from storm runoff entering the lift station site.

1). Lift station site pavement shall be graded in a manner to allow storm water to drain away from lift station site and to prevent puddling and accumulation of sediments within the site.

2). When lift station is in direct path of off-site storm runoff, the lift station site must be graded and include swales to divert runoff around and past the lift station. Swales must be located outside the fence. and along the edges of the access road.

c. Lift station site layout must be designed using AutoTURN or similar software to provide safe clearances for unimpeded maintenance operations and maneuvering of tractor with 6,000-gallon tanker trailer for pump-and-haul emergency operations.

d. The area surrounding the lift station components including, but not limited to, the wet well slab, valve slab, generator, electric service rack, electrical rooms, and tower shall be spaced in a manner to permit safe turn around and maneuvering of heavy equipment and maintenance vehicles.

e. The lift station site shall be designed to allow maintenance vehicles to have direct unobstructed access to the wet well, discharge header, manhole, electric service rack, electrical building, generator, and tower.

f. Lift station site must be selected in a manner that trees remain outside the fence with a minimum clearance as determine by the arborist authority or 10 feet away from the fence, whichever is greater.

g. Lift stations must be designed with a wet well aeration system to prevent the lift station and force main from becoming an odor nuisance.

1). Lift station site shall also be selected considering the direction of the prevailing wind throughout the year. The prevailing wind passing through the lift station shall not blow odors directly towards adjacent residential and commercial lots.

2). The prevailing wind shall also be considered for locating the service pole, electrical rack, canopy, electrical building, generator and tower in order to prevent wet well gases from blowing directly and creating a corrosion problem.

3). In San Antonio area, the prevailing wind comes from south to southeast most of the year.

h. The lift station site shall have the electric service rack and canopy oriented in a manner that the front door of electrical enclosures face either north or south. The length of the rack and canopy along with the sides of the electrical enclosures are oriented east to west. See Lift Station Drawings for reference

8. **Access Road Design in Residential or Commercial Developments:** The lift station shall have an access road <u>located in a dedicated right-of-way or permanent easement</u>.

a. Lift station access roads shall be dedicated for SAWS exclusive use to assure unobstructed accessibility to the lift station at all times.

b. The access road paved surface shall have a minimum straight road width of 16 feet, 90-Degree intersection to make a corner without driving over curbs/unpaved area, the receiving road must have a pavement width of at least 24 feet, and curb radii of at least 45 feet to keep the tanker from tracking onto the unpaved area. The access road paved surface shall be designed to support the load of SAWS heavy maintenance vehicles such as a loaded tractor with 6,000-gallon tanker trailer and 2,500-gallon loaded sewer cleaning trucks.

1). The asphalt pavement shall meet the vehicle load according to AASHTO HS 20-44 standard.

2). Crushed stone roads, flexible base roads or similar unpaved roads are prohibited.

c. The access road surface shall be designed to be at least 6-inches above the water level caused by a 25-year, 24-hour rainfall event.

d. The design of the access road shall include plan, section and profile sheets of the access road, drainage pipes, and details.

e. The access road must be designed using AutoTURN or similar software to verify vertical crest or sag curves vehicle undercarriage clearance. The access road must be designed to drain water away from the paved surface, prevent erosion of adjacent soil, and prevent accumulation of water and sediment within the road and along the sides of the road.

1). When the runoff path crosses the access road, the design engineer must design a water crossing under the access road to allow proper draining without impacting the access road. The water crossing shall be designed to safely support the loads imposed by a tractor with 6,000-gallon tanker trailer full of water.

f. Length of access road, measured from lift station access gate to the public road, shall be at least 25 feet long.

g. Inside the boundary of a proposed development, the lift station access road shall minimize turns and achieve the straightest possible alignment, and be configured to preclude the public from blocking SAWS access to the lift station.

1). If a straight access road cannot be provided, the design of the access road must include provisions to allow accessibility and safe turning, including safe turn-around means for tractor with 6,000-gallon tanker trailer.

i The turnaround shall meet the same requirements for the access road.

h. Access Road shall be designed to prevent any possible interference with, but not limited to vehicles, landscape, dumpsters, curbs, posts, bollards, fences, parking stalls, striping, and above grade appurtenances, etc.

9. Provide access gates that cover covers the width of the access road.

a. Access gates must comply with the current version of SAWS Security Standards.

b. The distance between the lift station access gate and the Right-Of-Way shall comply with City of San Antonio Development Services Information Bulletin 223 Commercial Fences latest edition. If outside COSA limits, access gate and fence setbacks (throat length) must be long enough to completely store tractor with 6,000-gallon tanker trailer entirely off the right-of-way to prevent queueing.

c. Lift stations with relatively long access roads must include pole gates at the entrance of the access road, and such pole gates shall be installed in a manner to allow SAWS maintenance vehicles to park on the driveway for opening/closing the pole gates without blocking the Right-Of-Way.

d. Turnarounds may be required for lift stations constructed along heavily traveled streets.

10. The lift station must be protected from intrusion of unauthorized individuals. Security fence must be provided in compliance with the current SAWS Security Standards.

11. Design concrete slabs and wet wells to counteract buoyancy force and provide supporting design calculations. The concrete slabs of top of wet well, electrical rack, tower foundation and generator shall be 3 to 6 inches higher than the lift station adjacent finished asphalt pavement.

12. The lift station site must be completely paved. The pavement can be either concrete or asphalt meeting the ASSHTO HS 20-44 vehicle loading, and the design shall be prepared by a Texas Professional Engineer.

a. Design engineer must coordinate with the local stormwater management authority to determine if the lift station site pavement can be impervious or if needs to be pervious.

b. The pavement design must be prepared to withstand the loading exerted by a 55 foot, 18 wheeler, and 80,000 pound tanker truck moving, standing and maneuvering over the pavement.

c. The pavement shall be shaped to the lines, grades, and typical sections that are on the approved construction plans.

13. Provide a ¾-inch minimum freeze proof water service with hose bib vacuum breaker attached to the hose connection.

    a. Locate within 20 feet of the wet well center and 1-foot separation from lift station fence.

14. Provide a galvanized steel supported canopy over electrical service rack that will provide a minimum 7.0 feet vertical clearance, and 5.0 feet front span and 3.5 feet back span horizontal and 3 feet horizontal side span on each side.

    a. Design engineer shall perform soil, foundation and structural analysis to properly design the canopy and electric rack foundation to ensure the canopy structure will withstand wind gusts of up to 115 miles per hour for 3 seconds.

    b. The canopy detail shown in the standard drawings is provided for illustration purposes only.

    c. A Climate Controlled Electric Building must be provided for all lift stations in which the Peak Wet Weather Flow is greater than 1,200 gallons per minute.

15. All lift stations must be designed with a wet well aeration system.

    a. Design engineer shall coordinate with aerator manufacturer to design and size the aerator system properly.

16. The service pole shall be located within the lift station site in a location where the electric service line, both overhead and underground, do not cut cross through the lift station site.

    a. Design engineer must coordinate with the electric utility company during the early planning stage to determine the location where the electric power will be brought to the lift station in order to design the lift station site configuration.

    b. Service pole must be located at least 40 feet away from the SCADA tower foundation structure and be kept 5 feet away from the fence.

17. Submittals and O&M Manuals.

    a. Design Engineer shall be responsible for reviewing and approving submittals only if they comply with the approved plans and specifications.

        1). Provide electronic copies (in pdf format) of approved submittals related to all mechanical, electrical, instrumentation and control equipment.

    b. Design Engineer shall provide electronic copies of approved Operation and

Maintenance Manuals of all mechanical, electrical and instrumentation and control equipment.

c. Operation and Maintenance Manuals shall detail the following, but not limited to, technical data, characteristic curves, technical specifications, part description, exploded view of all parts, installation instructions, operation, maintenance and troubleshooting instructions of electrical, mechanical and instrumentation components, wiring schematics of power, control and communication of all panels and devices.

End of Section A

Section B. Wet Well Design

1. Design engineer must size the wet well in a manner to accommodate the submersible pumping equipment, level sensor, discharge piping, aeration system ejectors, vent, and access hatch; but in no case shall be smaller than 6 feet in diameter.

    a. The distance between the bottom of the wet well and the invert of the incoming pipe shall be between 5 and 7 feet.

    1). Distances greater than 7 feet shall be evaluated and approved on a case-by-case basis only for lift stations with 3 pumps and more.

    b. Lift stations shall have a wet well maximum depth of 25 feet.

    1). Deeper wet wells will be evaluated on a case-by-case basis and be approved only when the design engineer demonstrates valid justification.

    c. Only one incoming sewer pipe shall be permitted to tie into a wet well.

    1). When two or more gravity mains are required to connect to a lift station, the incoming sewer mains shall connect in a manhole located outside of the lift station site, and located at least 20 feet away from the lift station fence.

    d. Sizing of wet wells shall consider the following, but not be limited to:

    1). Emergency storage volume.

    2). Adequate submergence and spacing for submersible pumps.

    3). Unobstructed projection of level transducer radar beam, projected through entire wet well depth.

    4). Adequate submergence and spacing for aerator odor control system.

    5). Pump operating levels, wet well level alarms, and pump cycling times.

    6). Distance between gravity invert and wet well bottom.

    e. Maximum diameter of fiberglass wet wells is 16 feet.

    f. For wet wells diameters greater than 16 feet, a lined monolithic concrete wet well shall be provided.

    1). Monolithic concrete wet wells shall be permitted to have a rectangular cross section.

2. The Design Engineer must be responsible to design a wet well that minimizes odor generation potential.

    a. An aeration system shall be provided for all wet wells. The aeration system must be designed to operate continuously.

b. The design engineer must determine if a supplemental odor control system is required in addition to the aeration system.

c. See aeration system requirements at the end of this Section.

3. The wet well floor shall be sloped towards the pump intakes and have a smooth finish in order to prevent accumulation of sediments.

   a. Wet wells with internal divisions to separate the pumps must be designed to prevent accumulation of sediments and to be capable of isolating each pump chamber.

   b. Include anti-vortex baffling on all lift stations with greater than 3 MGD (2,083 gpm) Peak Wet Weather Flow.

4. The design engineer must evaluate and incorporate a method to counteract the buoyancy force of both fiberglass and concrete wet wells.

   a. The thickness of the bottom slab shall be determined by the Design Engineer based in the structural analysis, the geotechnical data report, input from the Geotechnical Engineer, and recommendation from the Structural Engineer, but the thickness shall not be less than 12 inches.

   b. The design of the top slab shall also consider the size and configuration of embedded electrical conduits, air distribution lines of aeration system, the access hatch(es) and the guiderail system to assure structural integrity. In no case the thickness of the wet well top slab shall be less than 12 inches.

5. When a concrete wet well is required, the construction shall include a full monolithic concrete structure and base. Separate top slab shall be permitted. Precast concrete wet wells are prohibited.

   a. Design engineer shall evaluate the required thicknesses of wet well walls to assure structural integrity, avoid buoyant related movement and prevent leakage.

   b. A wet well must be enclosed by watertight and gas tight walls.

   c. A penetration through a wall of a wet well must be gas tight.

   d. A wet well must not contain equipment requiring regular or routine inspection or maintenance, unless inspection and maintenance can be done without a person entering the wet well.

   e. Design engineer shall analyze and determine the minimum concrete strength required for the monolithic wet well.

6. Line all internal concrete surfaces of wet wells in strict compliance with SAWS Standard Specification Item No. 852 Sanitary Sewer Manholes. Stand Alone Coating: Kerneos - SewperCoat 2000 HS & PG. Raven - 405 Series High Build Epoxy Liner. Approved only with Additional Epoxy Top coat: Permaform - CR-9000. Strong-Seal - MS-2C. Standard

Cement Material Inc. - Reliner. Quadex - Aluminaliner. Sprayroq - Spraywall (only on wet wells in rock or karst areas certified to be free of any groundwater)

7. Soil stabilization and compaction around wet well and underneath bottom slab shall be determined by the Design Engineer based on the geotechnical data report and the recommendation of the Geotechnical Engineer and Structural Engineer to prevent future shifting.

8. Use 16 mesh Stainless Steel 316 screens on passive ventilation, gooseneck type, to prevent the entry of birds or insects into wet well.

    a. Screening shall be installed in a manner that allows for future replacement.

    b. Mechanical and electrical equipment in the wet well comply with the requirements of NFPA Class 1, Division 1 construction type.

    c. Size the passive ventilation to vent at a rate equal to the maximum pumping rate of the station and not exceed 600 fpm through the vent pipe.

    d. Wet Well vent pipe shall be made of stainless steel 316, and must be placed in a location that does not interfere with the working area around the wet well access hatch. Design engineer must evaluate the size and number of vents required, but in no case the vent pipe shall be smaller than indicated in TABLE 1.

TABLE 1
WET WELL PASSIVE VENT SIZING TABLE

Wet Well Diameter	Vent Size
6 or 8 feet	4-inch
10 or 12 feet	6-inch
14 to 16 feet	8-inch
> 16 feet	Design Engineer must determine

9. Dry wells and vaults are not permitted.

10. Provide hoisting equipment, or access for hoisting equipment, for removal of pumps, motors, valves, etc.

    a. Design Engineer will determine if hoisting equipment is included in the design.

11. All accessory hardware in wet well including but not limited to chains, cables, bolts, nuts, fasteners, brackets, anchor bolts, washers, cable grip holders and pump guide rails, shall be of stainless steel 316.

12. Fiberglass wet wells must comply with SAWS standard specification Item 853 Sanitary Sewer Fiber Reinforced Polyester (FRP) Manholes and Structures.

a. Fiberglass wet wells must have a closed bottom and closed top with cut openings for access hatches, vent and pipes. Open bottom and open top fiberglass wet wells are not allowed.

13. Wet Well Testing.

a. An exfiltration test must be performed immediately after the wet well has been backfilled and compacted.

b. The test shall be performed by plugging the gravity invert and filling up the wet well with water to 1-foot below the top slab.

c. Once the wet well is filled, it must be left for stabilization for 48 hours minimum prior to beginning the exfiltration test.

d. After the stabilization period, the wet well must be checked and refilled up to 1-foot below the top slab and then begin the test.

e. The exfiltration test shall be done for two hours minimum, and no water may be added to the wet well during the test period.

f. The exfiltration test measures the amount of water required to raise the wet well level back to the mark at the end of the test period.

g. The maximum allowable water loss to pass the test is determined by the following equation:

$$\text{Water Loss (gallons)} = 0.0142tDh$$

Where:
t = test time period (2 hours)
D = wet well diameter (in feet)
h = water level depth within wet well (in feet)

h. If the exfiltration test fails, the Contractor must implement all the necessary corrective actions to reduce the exfiltration.

i. Once the repairs are completed the test shall be repeated. The test will pass when the exfiltration is equal or less than the allowable water loss.

j. SAWS Inspector, Contractor and Design Engineer shall be present for the exfiltration test.

14. Aeration System Requirements

a. The aerator system shall be sized by the design engineer and shall consider the wet well size, depth, operating levels, inflow variation and cycling time from the initial development to the ultimate built-out.

1). Aeration system shall be capable of preventing the generation of odors, and also dissolve fats, oils and grease.

b. Shall have no moving parts inside the wet well, shall be non-corrosive for the municipal wastewater and raw sewage application media, and shall not utilize any electricity within the wet well.

c. The complete aerator system shall be installed in a manner to avoid obstruction with conduits, cables, pumps, lifting chains, float switches and level detection system.

d. Blower can be installed over the wet well top slab as shown in the drawings.

e. An isolation ball valve of stainless steel 316 shall be installed at the blower discharge header for each aerator installed within the wet well.

f. Blower shall be driven by a three phase induction motor that operates at the voltage system indicated on the design; however, the motor shall be multi voltage rated suitable to operate at 208-Vac, 230-Vac and 460-Vac.

g. One blower control panel must be provided for each blower motor installed. The blower control panel must be located at the service rack and shall comply with the requirements of the Electrical Equipment Section and the standard drawings. If an electrical building is provided, then the blower control panel(s) must be located inside the electrical building.

h. Blower and motor unit enclosure.

   1). Blower enclosure shall be provided with full opening to allow free flow through for adequate air circulation to avoid overheating of the blower, motor and discharge header.

   2). Air intake shall be located in a manner that wet well gases are not drawn into the blower.

i. Air ejector.

   1). The air ejector shall be constructed of HDPE body with a 10 pound stainless steel 316 weight.

   2). The minimum wet well level shall be determined by the Design Engineer for proper performance of the air ejectors.

j. Main air distribution line.

   1). The design engineer must evaluate the required inner diameter of the main air distribution line to minimize pressure loss and to assure even air distribution among all branch lines, but in no case the main air distribution line shall be smaller than 2-inch.

   2). Main air distribution lines, valves and fittings shall be stainless steel type 316.

      i Union type fittings must be provided to disconnect the blower from the main distribution line and isolation valves.

3). To avoid a tripping hazard, the air distribution line shall be embedded in wet well top slab and shall terminate next to wet well access hatch(es) or next to dedicated penetration sleeves with heavy duty polyethylene cover.

k. Air ejector branch line.

1). The design engineer must evaluate the required inner diameter of the air ejector branch line to minimize pressure loss and assure proper air supply to ejector, but in no case shall the ejector branch line be smaller than 1-inch.

2). Air ejector branch lines, valves and fittings shall be stainless steel type 316.

3). Each air ejector branch line shall be branched from the main air distribution line. The air ejector branch line shall be embedded in the wet well top slab and penetrate to terminate at wet well access hatches and dedicated sleeved penetrations.

4). One isolation valve for each air branch line shall be provided for each air ejector and must be located inside the access hatch and inside the dedicated sleeve penetration.

l. Air ejector supply hose inside the wet well.

1). The design engineer must evaluate the required diameter of each air supply hose to minimize pressure loss, but in no case shall it be smaller than 1-inch.

2). The hose shall be made of material that resists the environment conditions inside a sanitary sewer wet well.

3). Shall be provided with Cam-Lock quick connectors made of stainless steel 316 and connect to the branch isolation valve.

4). The air supply hoses for each air ejector shall have the same length and no bending.

5). Each hose shall be supported with a cable grip made of stainless steel 316.

End of Section B

Section C. Pumping Equipment Design

1. Design Engineer must evaluate different pumps, impellers and piping sizes, including sizes of discharge and force main piping, in order to achieve the pump operating criteria and maximum efficiency.

    a. Energy consumption calculations included in the engineering report shall demonstrate the proposed combination of pump/force main is the most efficient option.

2. Provide the required number of pumps, and adequate controls to alternate all pumps. See TABLE 2 for minimum number of pumps required.

3. All pumps shall be electric, explosion proof, centrifugal, submersible type, self-cleaning, non- clogging units approved for use within Class I Division 1 hazardous locations.

4. Lift station environment.

    a. The nature of the wastewater pumped by lift stations consists of unscreened raw wastewater and sewage containing high concentration of incompressible solid trash and fibrous debris.

5. Submersible pumps must consist of centrifugal type pumps, guide rail system and discharge base.

    a. The submersible pumping unit shall be capable of continuous submergence under wastewater without the loss of watertight integrity to a depth of 65 feet.

    b. Every component of the guide system, including all fasteners, shall be made of stainless steel 316.

    c. The connection between pump and discharge base must be a leak free joint by the pump own weight in a cantilever effect. Bolted or similar connections that require man entrance to the wet well for removal of pump is not permitted.

    d. Mechanical Seals shall consist of two totally independent seal assemblies operating in an oil chamber between pump volute and motor to provide seal lubrication and cooling.

        1). The oil shall be a white paraffin based oil meeting the standards of FDA 172.87B.

        2). Seal faces shall be resistant to corrosion and wear.

    e. The motors must be designed with an integral closed-loop cooling system to allow normal operation of the lift station while the motors are totally submerged, partially submerged and totally exposed to air.

        1). The motors shall be suitable for continuous operation and be inverter-duty rated, suitable to be operated with soft starters and variable frequency drives.

2). Oil filled motors are not allowed.

f. Power cable shall meet the requirements of NEC and shall have a sufficient length to reach to the wet well junction box without splices. Power cable must have a slack of 5 to 10 feet.

1). The outer jacket of the power cable shall be designed to resist oil, sewage gases and sun resistant.

2). Power cable must be adjusted in a manner to avoid at the pump connection. Cable slack must be organized in a manner that does not interfere with wet well level sensing devices.

g. Submersible pumps shall be provided with internal sensors installed by original pump manufacturer to provide protection against motor over temperature and seal leakage.

1). Pump manufacturers must provide pump protection relays to connect the sensors and allow the pump controls to trip. See drawings.

6. To avoid pump cavitation, the selected submersible pumps shall have NPSHre as low as possible, but in no case shall be greater than 24 feet for any of the design duty points.

7. Pump required ability to resist clogging.

a. Due to the strict water conservation programs followed by SAWS customers, the concentration of Total Suspended Solids (TSS), solid trash and fibrous debris is higher than the average. Special considerations shall therefore be given to this condition to ensure that the lift station pumps do not become prone to clogging.

b. Pumps used for lift station service shall be capable of self-cleaning and maintaining the impeller and volute clean without the need for pulling the pumps for manual cleaning.

c. Minimum incompressible sphere passing capacity for conventional non-clog pumps (when approved by SAWS on a case-by-case basis) shall be as indicated in TABLE 2. Pumps that meet the minimum sphere passing but the impeller clog frequently in the lift station environment specified herein, shall not be permitted.

1). Other types of pumps such as chopper, semi-chopper, vortex and grinders shall be evaluated and approved by SAWS on a case-by-case basis.

d. Pumps shall have no less than 3-inch volute intake and discharge diameter.

1). The use of smaller openings shall be evaluated and approved by SAWS on a case-by-case basis, depending on hydraulic conditions.

TABLE 2
MINIMUM NUMBER OF PUMPS REQUIRED

Peak Wet Weather Flow	Minimum Number of Pumps	Minimum Sphere Pass
500 gpm or less	● 2 Pumps: 1 Lead, 1 Standby	3-inch
Between 501 and 1500 gpm	▲ 3 Pumps: 1 Lead, 1 Lag, 1 Standby	4-inch
Over 1501 gpm	▲ 4 Pumps: 1 Lead, 2 Lag, 1 Standby	5-inch

NOTES: All pumps including Standby must alternate constantly.
- ● Lead Pump must shall meet the firm pumping capacity requirement.
- ▲ Lead Pump with Lag(s) Pump(s) must comply meet the firm pumping capacity requirement.
- ▲ When the lead pump is operating alone, it must discharge more than the average daily flow.

8. Lift stations designed with self-priming type pumps are not permitted. Package type lift stations are not permitted.

9. Pumps shall be capable of operating at any point along its performance curve without overloading the motor.

   a. Submit pump head capacity and system curves to SAWS, along with the lift station plans and engineering calculations.

   b. Pump duty point for nominal design flow shall be within 70% and 120% range of pump's flow at Best Efficiency Point (B.E.P). This condition shall be satisfied for at least one and two pumps in operation. Points outside this range will be evaluated by SAWS and may be approved based upon special hydraulic conditions.

      1). For lift stations with two pumps installed, in which the duty point with one pump running is less than the minimum 70%, an additional standby pump must be installed. The additional standby pump shall alternate with the other pumps in a Lead-Lag pump control algorithm.

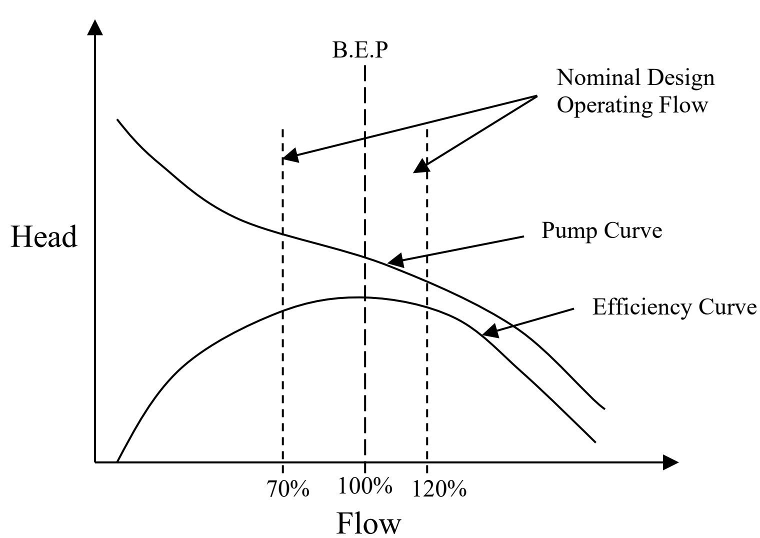

FIGURE 1:
PUMP DUTY POINT BETWEEN 70% and 120% RANGE OF FLOW AT B.E.P.

10. Based on wet well average daily flow, the pumping capacity of the lead pump, the wet well average cycle time shall not be less than those shown in TABLE 3.

TABLE 3
MINIMUM WET WELL OPERATING LEVEL CYCLING TIME

Pump Horsepower	Minimum Wet Well Cycling
Less than 50	10 minutes, with 3 minutes of run time
Between 50 and 100	17 minutes, with 5 minutes of run time
Over 100	25 minutes, with 7 minutes of run time

a. SAWS TABLE 3 must be primarily used for wet well cycling using the following equations:

1). $T_{Cy} = T_F + T_E$

2). $T_F = \frac{V}{Q_i}$

3). $T_E = \frac{V}{Q_o - Q_i}$

4). Where:

i T_{Cy} = Wet well cycling time (minutes)

ii T_F = Wet well fill time (minutes) is the time that takes the wet well level to rise from All Pumps Off to Lead Pump On

iii T_E = Wet well empty time (minutes) is the time that the lead pump takes to draw the wet well level from Lead Pump On back to All Pumps Off

iv V = wet well active volume (gallons), determined by wet well internal cross section and the difference between Lead Pump On and All Pumps Off levels

v Q_i = Average daily flow into wet well (gallons per minute)

vi Q_o = Pumped flow with lead pump running only (gallons per minute)

b. Verify the minimum pump cycle times as required by TCEQ by the following equation:

1). $V = \frac{TxQ}{4x7.48}$

2). Where:

i V = Active Volume (cubic feet)

ii Q = Pump capacity (gallons per minute)

iii T = Minimum pump cycle time (minutes)

- 6 minutes for pumps < 50-HP
- 10 minutes for pumps 50 to 100-HP
- 15 minutes for pumps >100-HP

iv 7.48 = Conversion factor (gallons per cubic foot)

11. Use the active volume calculated by TCEQ equation and compare cycling results SAWS TABLE 3 equations. Modify the design to assure compliance with both SAWS and TCEQ.

12. All lift stations shall operate based on the level in the wet well.

    a. Locate wet well level control devices as indicated in Drawings.

    b. Level control device and backup float switches shall be fully accessible without personnel entering the wet well, and shall not interfere when removing pumps.

13. Pump location within wet wells.

    a. Locate pumps in a manner that wet well gravity inflow do not pour directly over a pump.

    b. Pump discharge bases, guide rail system, access hatches and discharge pipe penetrations must be designed in a manner to assure vertical alignment.

End of Section C

Section D. Station Piping

1. Lift station piping, flanges and fittings located inside the lift station (except the force main) shall be made of ductile iron.

    a. Pipe must meet SAWS material specification for ductile iron pipe.

    b. End connections shall be flanged in compliance with ANSI/AWWA C115/A21.15.

        1). Bolt set shall consist of bolt and nut, and shall include flat and pressure washer on each side. All bolt sets shall be made of stainless steel 316.

        2). The rated working pressure of flanges must be greater than the working pressure of the pipe.

    c. Design Engineer must evaluate the possibility to substitute ductile iron with stainless steel 316 based on best engineering practices.

2. Interior lining of ductile iron pipe and fittings for corrosion protection.

    a. Ductile iron pipe must be lined according to SAWS Material Specifications for Sewer Ductile Iron Pipe and Fittings with Calcium Aluminate Mortar Lining.

3. All exposed pipe, valves, and fittings located outside the wet well shall be installed with 100% solids epoxy coating system with a top coat system of urethane, suitable for the sewer environment.

    a. Prior to application, prepare surfaces in accordance with manufacturer's instructions. Any reference to cleaning in the manufacturer's instructions shall be understood to refer to the applicable SSPC specifications.

    b. Thickness, mixing and application shall be in accordance with manufacturer instructions. Apply finish coat in accordance with the color-coding set forth in TABLE 4, below.

    c. Approved manufacturers are Tnemec, Carboline, Sherwin-Williams, PPG, and M.A.B. Paints.

4. All pump discharge pipe and fittings located within wet well, except SS316 and PVC, must be installed with a 100% solids coal tar epoxy coating system.

    a. Thickness, mixing and application shall be in accordance with manufacturer's instructions.

    b. Prior to application, prepare surfaces in accordance with manufacturer's instructions. Any reference to cleaning in the manufacturer's instructions shall be understood to refer to the applicable SSPC specifications.

    c. Approved manufacturers are Tnemec, Carboline, Sherwin-Williams, PPG, and M.A.B. Paints.

5. Discharge piping and related pipe supports must be spaced in a manner that pumps discharge bases, discharge piping, guiderails, pipe supports, and pump cables do not interference with the level sensing devices.

   a. Pipe reducers, when required, shall be installed 3 feet after the pump discharge base, and they shall be of the eccentric type.

   b. Pipe increasers/reducers installed at discharge header shall be of the concentric type.

   c. Two 45º degree bends shall be installed to offset the discharge lines away from the access hatch. These bends shall be located within the wet well and shall be located 4 feet above the wet well bottom.

   d. Discharge piping penetrating through top concrete slab shall connect to a flanged 90º bend via a restrained flange adapter.

      1). The restrained flanged adapter shall be for sanitary sewer application

      2). All fasteners shall be made of stainless steel 316. Each bolt set shall consist of bolt and nut, and each shall be provided with flat and pressure washers.

6. The design shall evaluate surge effects under worst possible pumping condition and provide protection if necessary.

   a. When the design engineer determines a surge relief valve is recommended, the design must include a pressure relief valve assembly.

   b. Surge relief flow shall be contained back in the wet well.

   c. Surge relief valve assembly shall be located in common discharge header and before the force main pressure gauge and pressure transmitter piping assembly.

7. Provide stainless steel type 316 adjustable pipe supports to support lift station piping as indicated in Standard Drawings, and as deem necessary.

8. Discharge lines shall penetrate through the wet well top slab. The penetrations shall be sealed using link seals rated for sewer service.

   a. All metallic parts of the link seals shall be made of stainless steel type 316.

9. At least a 3 foot horizontal spool pipe shall be provided between the wet well penetration bends and the check valve.

   a. For 8-inch check valves and larger, consult with check valve manufacturer for the required distance.

10. Each individual pump discharge line shall be provided with a pressure gauge assembly.

    a. The location of these pressure gauge assemblies shall be 1 foot before the check valve.

b. Pressure gauge assembly shall match the requirements of the Force Main Pressure Gauge assembly indicated below in this Section.

11. Size the discharge line of each pump to maintain flow velocity between 8.0 and 11.0 feet per second (or as recommended by the check valve manufacturer) when one pump is running to provide good check valve flushing velocity and to prevent slamming of the check valve when pumps are controlled across-the-line.

    a. This discharge line shall consist of the pipe segment between the pump discharge base and the common header.

12. Use 45º bends at discharge header to direct the piping underground and redirect horizontally to connect to HDPE force main underground.

    a. An isolation gate valve located above ground and installed before the 45º bends shall be installed to provide force main isolation means.

13. For lift stations requiring dual force mains, the common header pipe shall be split using a true wye.

    a. Spool pipe pieces and 45º bends shall be used to align for parallel force main installation separated 3 feet horizontally.

        1). The 3 feet separation shall be the physical internal separation between the force main pipes.

    b. Use 45º bends to direct the piping underground and to connect to HDPE force mains underground.

        1). Isolation gate valves shall be installed before the 45º bends to provide independent isolation means for each force main.

14. Pump discharge pipe and common discharge header pipe shall be installed 3 feet above concrete slab, measured from slab surface to center of the pipe.

15. Force main pressure gauge and transmitter piping assembly.

    a. A flanged spool pipe 5-foot long shall be provided for installation of pressure gauge and pressure transmitter assembly.

    b. The force main pressure gauge and transmitter piping assembly shall be located into the common discharge header.

        1). When surge relief valves are required, the surge relief valve shall be located immediately after all the pump discharge lines have merged into the common discharge header, then the force main pressure gauge and transmitter piping assembly shall be installed downstream.

    c. Instrument tap connections for pressure gauge and pressure transmitter shall be separated 1 foot, and both tap connections shall be centered on the spool piece.

d. Clamp saddles shall be installed at each tap connection. All clamp saddles components and related fasteners shall be made of stainless steel type 316.

   1). The rated pressure of the whole saddle clamp assembly shall match the rated working pressure of the process piping.

   2). Minimum diameter of tap shall be 2-inch, shall be standard treaded and shall be female type.

e. All piping nipples used shall be standard threaded male type, shall be made of stainless steel type 316, and be rated for no less than 250-psi.

f. Each connection tap shall be provided with a main valve for isolation means.

g. Force main pressure gauge assembly.

   1). Force main pressure gauge assembly shall be provided with a diaphragm seal as a single calibrated unit.

h. Force main pressure transmitter assembly.

   1). Force main pressure transmitter assembly shall be provided with a diaphragm seal as a single calibrated unit.

   2). A ½-inch calibration tee shall be installed between the force main pressure transmitter assembly and the main isolation valve.

      i The calibration tee shall be provided with a test connection port with valves to isolate the assembly from the process line when calibrating and servicing.

16. Emergency bypass pumping assembly.

   a. An emergency bypass pumping assembly shall be installed at the downstream end of the common discharge header and before the force main isolation valve, and before the dual force main splitting wye for lift stations with two force mains. The emergency bypass pumping assembly must be provided with an isolation gate valve upstream to allow isolation of the common discharge header and the pump discharge lines.

   b. The emergency bypass pumping assembly shall consist of a branch wye (or tee if approved by SAWS) connected in line with common discharge header.

   c. The branch shall be oriented to pump towards the flow direction of the common header.

   d. An isolation gate valve and a check valve shall be installed onto the branch wye. The gate valve shall be located between the check valve and the branch wye to provide isolation means to service the check valve.

   e. A blind flange shall be used to seal the check valve entrance flange.

f. The check valve shall be oriented to allow flow to be pumped into the common header.

g. The size of the emergency bypass pumping assembly shall depend on the firm pumping capacity of the lift station.

TABLE 4
SAN ANTONIO WATER SYSTEM LIFT STATION COLOR CODES

TYPES OF EQUIPMENT	COLOR
1. Pump Suction Piping (if required)	Gray – Pantone Number 431 U
2. Header and Force Main Piping	Gray – Pantone Number 431 U
3. Pump/Motors and Mounts (if apply)	Gray – Pantone Number 431 U
4. Potable Water Line	Avalon Blue – Pantone Number 558 C
5. Compressed Air Line (where used)	Green – Pantone Number 349
6. Power Conduit	Orange – Pantone Number 166
7. Control/Instrumentation Conduit	Yellow – Pantone Number 109
8. Recycled water pipe	Purple – Pantone Number 521 C

End of Section D

Section E. Station Valves

1. Gate Valves.

    a. Install a gate valve on the upstream side of the check valve for each pump discharge line and on each force main to isolate the station from the force main.

    b. Gate valves shall be chained and locked to prevent operation by an unauthorized person. Chains must be made of stainless steel 316 and shall allow for installation of a padlock.

    c. Shall be suitable for use in unscreened raw sewage and wastewater application.

    d. Shall be resilient wedge, flanged joints, conforming to the applicable requirements of ANSI/AWWA C515, and shall be handled and installed in accordance with the recommendations of the manufacturer.

    e. Internal parts shall be capable of being serviced without removing the valve from the process pipe.

    f. Minimum rated working pressure for all sizes shall be 250-psi, or 100-psi above operating pressure at Firm Pumping Capacity, whichever is greater.

    g. Process connection shall be flanged in compliance with ANSI/AWWA C110/A21.10 (ASME B16.1 Class 125).

        1). Bolt and nut set shall include flat and pressure washer on each side. All bolt sets shall be made of stainless steel 316.

    h. Approved manufacturers are Mueller, Kennedy, and American Flow Control.

2. Check Valves.

    a. Shall be suitable for unscreened raw sewage and wastewater application.

    b. A flanged check valve shall be installed on the discharge side of each pump and on emergency by-pass pumping assembly, followed by a full-closing isolation gate valve.

    c. Shall provide clear unobstructed opening waterway when disc is in fully open position.

        1). Check valves installed inside of a wet well shall be prohibited.

    d. Check valves shall be sized to assure they will not slam during pump starting, operating and stopping. The valve sizing shall also allow full opening to maintain full port open for passage of solid trash and fibrous debris.

    e. Check valves shall be swing type with an external lever and weight.

f. Approved check valve manufacturers are Kennedy, Mueller, and American Flow Control.

3. Butterfly valves, tilting disc check valves, or other valves utilizing a tilting disc in the flow line shall be strictly prohibited.

4. Combination Air and Vacuum Release Valves.

   a. The combination air and vacuum release valves shall combine an air and vacuum component and an air release component in a single body.

   b. The air and vacuum release valve shall be specifically designed to operate with liquids carrying solid particles such as municipal wastewater and raw sewage.

      1). The combination air and vacuum release valve shall discharge air and gases at high flow rate during the filling or charging of the system, and shall admit air at high flow rate into the system during draining and at water column separation, and it shall release at low flow rate accumulated air or gases from the system while it operating under pressure.

      2). High velocity air flow shall not cause the float to seal the discharge orifice.

   c. Shall be mounted on common header and all high points along force mains.

   d. Shall be sized for intended system hydraulics, with related sizing calculations included in engineering report.

   e. Shall be rated for raw sewage application, have a minimum 2-inch inlet and $1^1/_2$-inch outlet, and be provided with flush ports.

      1). Minimum rated working pressure shall be equal or greater than the force main rated pressure.

      2). Rated working ambient temperature shall be 60-ºC.

   f. The air release pipe to convey the exhausted air or gas shall be determined by the design engineer, and it shall be installed in a manner that doesn't represent a tripping hazard, and it shall be solidly fastened; unless embedded in concrete slab, and shall discharge into wet well.

      1). Liquid shall not accumulate within air release pipe.

   g. Approved manufacturer is A.R.I Model D-020 or equivalent.

5. Surge Relief Valves

   a. The design engineer must be responsible to size the surge relief valve..

   b. It shall be rated for municipal raw unscreened wastewater and sewage service, and it shall have isolation gate valve on the inlet side.

c. End process connections shall be ANSI/AWWA C110/A21.10 (ASME B16.1 Class 125) flanged.

   1). Bolt and nut set shall include flat and pressure washer on each side. All bolt sets shall be made of stainless steel 316.

d. Minimum rated working pressure for all sizes shall be 160-psi, or 50-psi above operating pressure at Firm Pumping Capacity, whichever is greater.

e. Opening setting shall not exceed 5 psi above normal operating pressure of the system measured at the discharge header when firm pumping capacity flow is being pumped.

f. Shall be of the long radius 90º elbow.

g. Surge relief pipe shall be routed back to the wet well.

h. Engineering report must include analysis and reference information showing how the valve was selected and sized.

   1). When the analysis shows dangerous surge pressure at firm pumping capacity, a surge relief valve will be included in the design in addition to the soft starters.

i. Testing of surge relief valves.

   1). During the lift station startup and testing, the surge relief valve shall be tested and adjusted as needed to assure the surge relief valve opens fully at the proper setting and closes completely when all pumps are off.

   2). The lubrication system shall be checked.

End of Section E

Section F. Force Main

1. Minimum force main size shall be 4-inch (except for grinder pumps).

    a. Force mains smaller than 4 inch will be evaluated by SAWS and may be approved in writing on a case-by-case basis, provided the pumps are of the grinder type.

2. Flow velocity within force mains.

    a. Size force mains so that flow velocity is between 3.0 and 3.5 feet per second with the lead pump operating only.

        1). Velocities slightly above 3.0 feet per second are recommended.

    b. Flow velocity shall not exceed 4.8 feet per second with two pumps operating in parallel at firm pumping capacity.

    c. Flow velocity shall not exceed 6.0 feet per second with three pumps operating in parallel at firm pumping capacity.

    d. For lift stations with three or more pumps, flow velocity may be as low as 2.5 feet per second with one pump in operation, but when two pumps operate in parallel, a flow velocity equal to, or greater than 5.0 feet per second must be generated in the force main at least twice a day.

    e. A force main with a velocity greater than 6.0 feet per second can withstand the high and low negative surge pressures in the event of sudden pump failure.

3. Separation of force mains from water pipes.

    a. When a force main is installed parallel to a water pipe or when it crosses a water pipe, the force main shall be installed below the water pipes.

    b. A separation distance between a force main and any water supply pipe must meet the minimum separation requirements established in TCEQ article 217.53(d).

4. Metallic detector tape must be laid in the same trench as the force main.

    a. The detector tape must be located above and parallel to the force main.

    b. The detector tape must bear the label "PRESSURIZED WASTEWATER" continuously repeated in at least 1.5-inch letters.

5. The force main design must provide plan and profile.

6. Force mains shall transition into a gravity line at a manhole.

    a. Force main termination at a manhole must be designed in a manner that transitions to gravity flow without splashing.

7. Dual Force Mains

a. All lift stations located over Edwards Aquifer Recharge and Contributing Zones shall be designed with double containment force mains/dual force mains.

b. All dual force mains shall be designed to provide full redundancy.

c. Lift Stations over the Edwards Aquifer Transition Zone will be evaluated by SAWS on a case-by-case basis to determine if dual force main will be required.

d. Lift Stations located outside Edwards Aquifer Recharge, Contributing and Transition Zones.

   1). Lift stations located outside the Edwards Aquifer Recharge, Contributing and Transition Zones with either Peak Wet Weather Flow of 1,200 gallons per minute or greater shall be provided with dual force mains.

   2). Force main lengths of 5,000 feet or greater shall be provided with dual force mains.

e. Dual force mains shall be connected (above ground) to a common header through a true wye fitting, and an isolation gate valve shall be provided for each force main immediately after the wye.

f. The clearance between the two force mains shall be 3 feet minimum as measured between the external pipe surfaces.

g. When steel casings are required, each force main shall be installed in a dedicated steel casing.

8. Force main detention time.

   a. A force main average flush time analysis must be included in the engineering report.

   b. Average flush time shall not exceed 180 minutes.

9. Protection against pressurized air pockets and vacuum effects.

   a. Force main design shall minimize the number of peaks and valleys along the force main profile to limit the accumulation of gases.

10. Force main isolation valves

    a. Each force main shall have an isolation valve installed before the force main discharge manhole to facilitate force main testing.

    b. Subsequent isolation valves shall be installed spaced at no more than 2,000 feet intervals as measured from the discharge manhole towards the lift station.

    c. Isolation valves shall be buried.

       1). Force main isolation valves shall be of the plug type, rated for sanitary sewer application.

2). Isolation valve shall be provided with valve box and cover, with the word "SEWER" cast on the cover.

  i Plug valves shall open left (counterclockwise).

  ii A rising stem shall be provided to have the operating nut just under the valve box cover.

  iii Open-Close indication shall be provided and be visible when opening the valve box cover.

3). Plug valves shall be provided with gear box to minimize the operating torque.

  i Gear box shall be suitable for direct buried installation and be corrosion and leak resistant. The Gear box shall be maintenance free type, which means factory filled with grease and hermetically sealed.

11. Force main material

    a. Force mains must comply with SAWS Material Specification for High Density Polyethylene Pipe (HDPE).

    b. Pressure class shall not be less than 150-psi.

    c. The HDPE pipe must be ductile iron pipe size (DIPS).

    d. Pipe joints and fittings must be butt-fused.

12. Force main testing.

    a. Design engineer must include specifications for testing of force mains.

13. Surge analysis and control

    a. Provide effective surge control measures to minimize surge pressure due to water hammer effect and to reduce force main stress and fatigue due to pressure changes due to cycling of the pumps under firm pumping capacity condition.

    b. Provide a water hammer analysis to determine the surge pressure when operating ay firm pumping capacity. If the difference between the surge pressure and the operating pressure is greater than 50-psi, a surge relief valve shall be included in the design.

14. Fatigue Life. Provide the design engineering report calculations that show the strength of the force main pipe at the end of 50-year design life. The calculations must consider the fluctuations between pressurized and depressurized operating state.

End of Section F

Section G. Electrical Building

1. General

   a. The design of the electrical building shall be determined by the design engineer with SAWS' approval.

   b. The electrical building must be installed within the lift station fence. The lift station site layout shall be designed in a manner that the prevailing wind blows wet well gases away from the building.

   c. The building shall be watertight and shall be sealed in a manner to avoid entrance of wet well gases inside the building.

   d. Structural engineer shall be responsible for the design of the building foundation in coordination with the electrical engineer and civil engineer.

   e. The internal length and width shall be coordinated with the electrical engineer considering the enclosures and equipment to be installed inside.

   f. The design loads shall be in compliance with the local requirements of the IBC, including loads imposed by wall mounted enclosures and equipment.

   g. Interior side of doors shall be provided with panic exit bar opening. Doors shall open towards outside of the building.

   h. Doors shall be provided and sized as required for personnel egress and to allow all equipment and enclosures contained inside the building to pass through fully upright.

   i. The electrical building shall have dual climate control units and must provide both heating and cooling.

      1). The climate control units shall consist of ductless split system with a minimum SEER of 16. Wall mount units are not permitted. Approved manufacturers are Innovent, Xetex, Trane, Carrier and York.

      2). Compressors shall be mounted on concrete pads adjacent to the electric building.

      3). Voltage system for climate control units shall be the same as the voltage system of the lift station electric service.

      4). The design engineer shall be responsible for performing a heat load analysis to properly determine the cooling and heating capacity of the HVAC units.

   j. HVAC and dust filtering equipment shall be located in a manner that do not interfere with any electrical enclosure, wiring system and dedicated electrical working spaces.

   k. The roof shall have 1-inch pitch minimum to the foot. Rain gutters shall be included to capture and drain rain water to grade level. Drain gutters shall not be placed near the doors.

l. External color finish shall be earth tones. Example CMU colors Apache Brown and Gold Canyon. Mortar color shall be Austin Tan S Grout. Joint Sealant color shall be Sandalwood Beige. Provide physical samples for the split-face CMU veneer for SAWS review and approval.

End of Section G

Section H. Electrical Equipment

1. General:

   a. SAWS typical lift stations have an electrical connected load of less than 300 kVA and the minimum requirements shown here will need to be adjusted accordingly for lift stations of higher electrical connected load. SAWS has made an attempt to review these standard requirements for accuracy, however, the Design Engineer remains responsible for the lift station design. The Design Engineer shall tailor the concepts shown in this guideline and on the lift station drawings to the specific lift station application under design. Design Engineer to coordinate all requirements with SAWS, incorporate SAWS requests, and anticipate multiple reviews of interim design progress submittals.

   b. Minimum SAWS general requirements for major equipment and material for Lift Station applications are listed hereinafter. The listing provided does not constitute complete specifications needed for the project, pre-approval of specific manufacturers, or an exhaustive list of all of SAWS requirements. The Design Engineer is to coordinate requirements with SAWS for each project on a case-by-case basis.

   c. The Design Engineer shall review NFPA requirements and assign area classifications appropriate to each area of the lift station project site. The Design Engineer shall select equipment ratings accordingly. All electrical equipment installed shall comply with NFPA 820 requirements and the latest version of the NFPA 70 National Electrical Code (NEC) requirements. All outdoor or wet well located electrical equipment shall be suitable for use in a corrosive environment.

   d. As a minimum, all free standing equipment shall be mounted on a 4-inch tall concrete housekeeping pad. All electrical equipment shall have proper clearances per NEC, but in no case shall be less than those specified in Section K Emergency Provisions.

   e. Transfer switches, motor starters, control panels, dry type transformers, power distribution panelboards, load centers and SCADA panel shall be installed as shown in the Drawings. For electric buildings the configuration may be different, but the dedicated working spaces and clearances shall be maintained.

   f. Provide free standing and rack mounted equipment as required. Equipment mounting rack shall be constructed of type 316 stainless steel strut, 1-5/8” minimum, mounted on a minimum 4-inch diameter and ½-inch thick hot dip galvanized structural steel tube. See mounting rack layout and structural details on the Drawings. Approved manufacturers: UNISTRUT, ABB, Eaton or approved equal. Touch up with cold galvanizing compound any scratches where coatings are applied. Close all exposed tube ends with proper size PVC plug caps. Do not use the electrical service pole as support of the electric rack and canopy, unless permitted by the electric utility company. Typically, a small rack is permitted to be supported to the service pole to install the service disconnect switches, meter and main SPD.

   g. A climate controlled electric building shall be required for all lift stations in which the Peak Wet Weather Flow is greater than 1200 gpm. For lift stations that require soft starters, regardless of the Peak Wet Weather Flow, the design engineer shall evaluate if an electrical building is more cost effective than the canopy.

h. Provide type 316 stainless steel corrosion resistant mounting hardware.

i. Refer to the Drawings for additional requirements.

2. Power Distribution System:

a. Identify the electric utility service provider that will serve the lift station site and coordinate all aspects of the electrical service with electric utility service provider. The proposed lift station electrical system shall incorporate the features necessary to comply with the requirements of the electric utility service provider in all respects.

b. Perform the necessary motor starting transient voltage dip, generator sizing, power quality, load, short circuit, arc-flash, selective coordination, and other calculations to the level of detail required to select the proper system equipment as well as determine the ratings and sizing of the equipment, at minimum.

c. Each electric service regardless of its origin, and the lift station main power distribution system shall have the following features at minimum:

1). 480Y/277-Volt, 3-Phase, 4-Wire for connected loads of 45-kVA or greater, and 208Y/120-Volt, 3-Phase, 4-Wire if connected loads are less than 45-kVA. Lift stations with connected loads of 300 kVA and above shall require further review and coordination with SAWS and SAWS may make supplemental design requests not shown on the standard drawings that shall be incorporated.

2). Sized for the connected load of the entire lift station facility at a minimum, unless the electric utility provider requires a specific minimum size of service greater than the lift station connected load. SAWS will review and coordinate desired additional spare capacity with the Design Engineer on a case-by-case basis.

3). Request for other electrical service type shall be reviewed by SAWS and considered for approval on a case-by-case basis.

d. The generator shall employ a diesel fueled engine as prime mover. Diesel fuel tanks shall be UL listed base tanks integrated into generator unit by OEM, shall include double wall containment, and shall be sized to run the generator for at least 48 hours continuously at 100% lift station load without needing to be refueled. The generator foundation shall be steel reinforced concrete and provided with spill containment to capture any spillage (see Drawings for details). Generator shall be provided with noise control package, including sound attenuating enclosure for generator and noise control exhaust muffler package having sound attenuation performance suitable for residential applications. <u>Sound attenuation system performance shall result in measured sound levels not to exceed 72 dB @ 7 meters (23 feet), 60 Hz</u>. Perform a load analysis and transient voltage dip due to motor starting calculations with the recommended sequence of motor starting in order to know the motor running loads, the motor starting loads, and associated transient voltage dips. Such electric load calculations must be done in kVA units to account additional loads due to low power factor. The generator shall have a motor starting kVA capacity to limit the transient voltage dip to no more than 15% measured at the pump control panel terminals (refer to the Drawings) for any motor starting condition. Such generator related power system analysis must be included in the engineering report. Approved generator manufacturers are Kohler, Cummins, MTU America, Caterpillar and Generac, or SAWS-approved equal. Refer to Drawings for additional requirements.

e. Provide an electric utility service disconnecting means located near the electric utility service provider meter. The service main electrical disconnect means shall consist of a molded case service and outdoor rated circuit breaker with electronic adjustable trip settings, and must be enclosed in a NEMA 4X, Type 316 stainless steel enclosure, with pad-lockable external handle operator mechanically linked with the circuit breaker.

    1). The adjustable trip settings of the service circuit breaker must be long delay, short delay and instantaneous trip.

f. Provide a main power distribution panelboard for distribution of power for the facility, please refer to the Drawings. Panelboard shall not be incorporated into the panel enclosing the motor starters or other control panels.

    1). Provide supplemental load centers as required for 208/120V miscellaneous and auxiliary power distribution, etc. Minimum size of panelboards shall be as shown on the Drawings. Refer to the Drawings.

g. All panelboard and load center buses shall be tin-plated copper. Panelboard and load center circuit breakers shall be bolt-on type. All panelboards shall be enclosed in Nema 4X, Type 316 stainless steel enclosures. Nema 1 enclosures shall be permitted for installations inside electric buildings. Provide panelboard with hinged doors and 3-point door latches. Provide pad-locking means for circuit breaker handles.

    1). All circuit breakers installed inside main power distribution panelboards must be of the electronic trip type with adjustable settings for long delay, short delay and instantaneous trip.

h. The automatic transfer switch shall be enclosed in Nema 4X, Type 316 stainless steel enclosure with hinged outer door. Nema 1 enclosures shall be permitted if located inside the electric building. Provide automatic transfer switch with phase monitor relays wired as shown on the Drawings.

i. General lighting and power transformer shall be at least 15-kVA, 3-phase, and shall have non-ventilated Type 316 stainless steel enclosure. Nema 1 enclosures shall be permitted if located inside the electrical building. Transformer shall have copper windings and be encapsulated in epoxy resin.

j. Provide surge protective device and serve from a branch circuit breaker from the main power distribution panelboard. Surge suppressor shall be enclosed in a dedicated Nema 4X, Type 316 stainless steel enclosure and mounted immediately adjacent to the main power distribution panelboard. Nema 1 enclosure shall be permitted if installed inside the electric building.

3. Motor Starting Means:

a. Full Voltage Starters are preferred where the pumping application permits their use and the resulting transient voltage dip during motor starting complies with the electric utility service provider company's requirements as well as those of IEEE, NEMA, NEC, etc. for proper system operation.

b. Design engineer must evaluate and determine if solid state reduced voltage soft starters will be required based on hydraulic conditions, and based on motor starting requirements by the electric utility service. When soft starters are required, the following additional requirements apply:

1). Must be provided with line contactors for soft starter input line isolation as well as full voltage run mode operation, refer to the Drawings. Perform calculations of the starting current, reduced voltage and torque to ensure pumps do not stall during startup. Coordinate the results with SAWS.

2). Must be rated for operation in 40 ºC environment.

3). Soft starter shall be capable of allowing accelerating and decelerating ramps of 20 seconds without de-rating the soft starter capacity; however accelerating and decelerating ramp time must be programmable.

4). Must be suitable for use in UL 508A custom control panels.

5). Must include an internal shorting contactor to supply full voltage to the motor when the soft starter applies 100% rated voltage. The complete soft starter assembly shall be NEMA rated.

6). The soft starter shall provide all the following motor starting methods: 1) Voltage Ramp (adjustable from 15% to 100%), 2) Current Ramp (adjustable from 250% to 800%), and 3) True Torque Ramp (adjustable from 25% to 300%).

7). The soft starters shall provide all the following stopping methods: 1) Coast, 2) Voltage Ramp (adjustable from 1 to 100%), 3) True Torque Ramp (automatically adjusted when starting method is true torque).

c. All starters shall be NEMA rated. Provide NEMA rated solid state type overload relays with selectable trip class 10 and 20 and with adjustable tripping setting. Provide overload reset with extension and plastic cap on the inner panel of the motor starter panel. Refer to the Drawings for additional requirements.

d. Provide one UL 508 labeled custom pump control panel for each pump installed to enclose the pump motor starters and other hardwired control equipment for the lift station. Considerations for personnel safety, relative need for availability of lift station operation, and maintenance shall be included in the proposed design and are subject to revision by SAWS on a case-by-case basis.

e. All motor starter enclosures shall be white enameled stainless steel type 316, rated NEMA 4X, with hinged and pad-lockable outer doors with door holders. Provide supplemental hinged interior panels as required. Laminated wiring schematics shall be stored in the enclosure and be provided to SAWS electronically. Nema 1 enclosures shall be permitted for installations inside an electric building.

4. Lighting and Convenience Receptacles:

   a. Use LED fixtures for general illumination, suitably rated for the area in which they are located at minimum, supplemented with the additional requirements described hereinafter. Provide LED fixtures having 40K color temperature.

   b. Provide outdoor area lighting design featuring pole mounted fixtures with full cutoff down lighting and no up-light. Locate and select lighting fixtures such to minimize light spillage to neighboring properties. Alter fixture selection and lighting system design as required to comply with City of San Antonio Dark Sky/MLOD and other site specific lighting system requirements. Submit lighting calculations for review by SAWS.

   c. Provide general illumination of 1.0 foot-candle (average) at the lift station site. Refer to the Drawings.

   d. Provide aluminum pole mounted light fixtures and poles for outdoor area lighting. Provide poles with handholes and other means as required to facilitate wiring installation and termination. Default finish for pole mounted fixtures and poles is dark bronze. Coordinate finish with architectural requirements specific to the project and with SAWS. Design pole foundation specific to the project site. Refer to the Drawings for additional requirements.

   e. Provide task illumination underneath the electrical equipment canopy of minimum of 40 foot-candles (average). Mount light fixtures underneath the canopy. Refer to the Drawings. Light fixtures underneath the canopy shall be linear LED type fixtures rated Nema-4X with frosted acrylic lens and 40K color temperature, at minimum.

   f. Lighting fixtures shall be manually switched as well as controlled from a common photocell and motion sensor. Refer to the Drawings. Supplement lighting control as requested by SAWS and evaluated on a case-by-case basis.

   g. Light switches shall be installed in a weatherproof box.

   h. Provide 120-volt, 20-amp duplex, GFI, receptacles in weatherproof box having a clear weatherproof while-in-use cover.

5. Field Conductors: Assign field power conductor insulation colors according to TABLE 5.

TABLE 5
POWER CONDUCTOR COLOR CODE

Phase	480/277Vac	208/120Vac	24Vdc
Phase A	Purple	Black	Not applicable
Phase B	Brown	Red	Not applicable
Phase C	Yellow	Blue	Not applicable
Neutral	Gray	White	Not applicable
Ground	Green	Green	Green
DC Positive	Not applicable	Not applicable	Blue
DC Negative	Not applicable	Not applicable	White w/blue tracer

a. Field control wiring insulation color for 120Vac switched circuits shall be red. Field control wiring insulation color for 24Vdc switched circuits shall be blue. Signal wiring insulation color for 120-Vac circuits must be yellow.

b. Single conductors shall be stranded copper, rated 600V, having type XHHW-2 insulation. Sizing shall be done according to NEC requirements at minimum.

c. Minimum size of conductors

1). Design engineer shall be responsible for evaluating and sizing all conductors to be installed. NEC correction factors such as temperature, number of conductors, etc. shall be applied. Voltage drop calculations shall also be performed to limit the maximum voltage drop to within the limits established by the NEC.

2). Size of conductors shall be determined as indicated above, but they shall not be smaller than the following:

3). Minimum pump motor conductor size shall be #10-AWG.

4). Minimum general power conductor size shall be #12 AWG.

5). Minimum control wiring size shall be #14 AWG.

d. Field splices of conductors are not allowed, except for branch circuits serving lighting or convenience receptacles.

e. Field instrumentation analog signal (4-20mADC, RTD, etc.) wiring shall be multi-conductor twisted shielded cable having #16 AWG conductors and a tin-plated copper shield drain wire enclosed in an overall jacket, at minimum.

f. Submersible pump motor cables and cables for other field devices that are located in the wet well shall meet the requirements of the National Electrical Code for flexible cords in wastewater pumping stations and shall be constructed in a manner to prevent entry of moisture into the cable.

g. Provide a dedicated type 316 stainless steel strain relief cable grip accessory for each multi-conductor cable to suspend the cable from the interior of the wet well. Refer to the Drawings.

6. Raceway System

   a. Conductors shall be routed in a totally enclosed conduit based raceway system to the maximum extent practicable. Routing of power conductors dedicated to multiple pumps in a common conduit is not acceptable. Provide separate conduits for pump power conductors from those of pump instrumentation/control conductors. Contract drawings to clearly represent how conduits are routed and delineate between duct bank, exposed conduits, etc. Refer to the Drawings for additional requirements.

   b. Size all conduits in initial construction to meet ultimate needs of the lift station.

   c. All exposed conduit shall be rigid aluminum.

      1). Exception: Provide the type of conduit as required by the electric service utility provider for the electric service utility provider's service conduits.

   d. Conduit routed underground shall be grey, rigid nonmetallic conduit (RNC), schedule 40 PVC, at minimum, with the exception of stub-ups which shall be PVC coated aluminum as shown on the Drawings.

      1). Exception: Provide the type of conduit as required by the electric service utility provider for the electric service utility provider's service conduits.

   e. Route conduit such to avoid tripping hazards. Routing of exposed conduit is to be minimized where practicable for the application.

   f. Conduits routed underground shall be encased in steel reinforced concrete duct banks. Provide duct bank and trench design that incorporates the geotechnical, civil, and structural site specific conditions and resulting measures needed for longevity. Routing of duct banks shall be coordinated with the other site utilities by the Design Engineer and shall not cross above or underneath the wastewater wet wells, wastewater manholes, etc. Routing is subject to review by SAWS.

   g. Conduit may be embedded in concrete slabs under certain circumstances with specific authorization from SAWS and the structural design engineer, refer to the Drawings.

   h. Provide conduit sealing fittings where appropriate per NFPA requirements, at minimum. Provide sealant for sealing fittings appropriate for the application. Additionally, provide supplemental conduit sealing fittings to prevent the migration of corrosive gases through the conduit system between high valued equipment, evaluated by SAWS on a case-by-case basis. Please refer to the Drawings.

   i. Provide rack mount pull boxes in lieu of manholes where practicable.

   j. Provide junction boxes exterior and immediately adjacent to wet well top slab for termination of wet well located submersible pump multi-conductor cables, float switch cables, and level transmitter cable. Provide lugs as needed inside the boxes for wire termination. Junction boxes shall be oversized with spare length of submersible cables coiled inside. Provide separate junction boxes for the wiring associated with each lift pump.

k. Support channel shall be type 316 stainless steel.

7. Electrical Enclosures and Junction Boxes

a. Basic requirements for enclosures and junction boxes.

1). All electrical enclosures and junction boxes shall be NEMA 4X and be UL 508A Listed. Nema 1 enclosures shall be permitted if installed inside the electric building.

2). The material of construction shall be white enameled stainless steel 316, gauge 14. Shall be continuously welded and ground smooth.

3). All internal devices shall be fastened onto the back panel. Penetrating the body for installation of back panel shall be prohibited. Back panel shall be bonded to the body.

4). Wall mounted type shall be provided with external welded mounting brackets.

5). Conduit penetrations shall be done adequately to maintain the NEMA 4X and UL 508A rating. Only conduit penetrations on the bottom face shall be permitted.

6). All external mounting hardware shall be stainless steel type 316.

b. Special requirements for enclosures.

1). Doors shall be provided with pad lockable opening handle.

2). Dimensions shall be determined by the design engineer on a case-by-case basis.

3). Internal swing panel shall be provided for installation of selector switches, push buttons, indicating lights, etc.

4). Floor mounted enclosures the enclosure stands shall be 12 inches high.

c. Special requirements for junction boxes

1). Door shall be provided with clamp assembly on three sides of door (except on hinged side), and shall be provided with hasp and staple for pad locking.

2). Dimensions shall be determined by the design engineer on a case-by-case basis, but in no case shall be smaller than shown on the standard drawings.

i Exception: junction boxes used for miscellaneous wiring such as receptacle outlets, lighting fixtures and snap switches shall be permitted to be rigid deep cast aluminum boxes.

3). Installation of junction boxes directly onto concrete slabs shall be prohibited.

d. Climate control requirements for enclosures located outdoors.

1). All enclosures dedicated for SCADA, level controller, and pump control with soft starters that are located outdoors shall be provided with heating and cooling climate control. Heaters shall be installed within the enclosure. Cooling units shall consist of panel mount closed loop a/c units.

2). Design engineer shall evaluate the internal and external heat loading to determine the required heating and cooling capacity of the a/c unit required to dissipate all the heating load to maintain an enclosure internal temperature of 77ºF at 50% non-condensing relative humidity while the external ambient temperature is 105ºF.

i Design of heating and cooling must avoid condensation of moisture within the enclosures.

3). The cooling unit shall be NEMA 4X, be UL Listed and be made of stainless steel 316. The cooling unit shall be for use in harsh corrosive environment.

4). A minimum clearance of 2-ft shall be provided between the a/c unit and any adjacent enclosure or device mounted on the service rack.

5). Design engineer shall evaluate the heating load required to maintain an enclosure internal temperature of 40ºF.

6). The heating unit shall be UL Listed.

7). Operating voltage system for heating and cooling units shall be 120Vac, single phase. Different voltage systems shall be evaluated on a case-by-case basis.

8. Grounding system shall have a maximum ground resistance of 5 Ohms. Provide a grounding system to achieve the grounding system resistance. Incorporate ground enhancement material as required for the site specific soil conditions. Chemical type grounding electrodes are not accepted by SAWS. Incorporate grounding system soil moisturizing means as shown on the Drawings. Incorporate grounding system test wells to facilitate testing of the grounding system.

End of Section H

Section I. Station Controls, Instrumentation and Monitoring

1. General:

    a. For the purpose of the SAWS guideline, all instrumentation and control equipment installed shall comply with NFPA820 requirements and the latest version of the NFPA 70 National Electrical Code (NEC) requirements. All outdoor or wet well located instrumentation and control equipment shall be suitable for use in a corrosive environment.

    b. Provide intrinsically safe circuits where required.

    c. Provide supplemental surge protective devices for each control panel installed.

    d. Provide an aluminum sun shield for each outdoor located transmitter.

    e. Provide type 316 stainless steel corrosion resistant mounting hardware wherever possible.

    f. Refer to the Drawings for additional requirements.

2. Overall Control and Instrumentation System Description:

    a. The proposed lift station control, instrumentation, and monitoring system shall include a hardwired interlock based control system for control of the lift pumps.

    b. The lift station shall be provided with multiple control panels to contain the respective major elements of the lift station control, instrumentation, and monitoring system. The PLC and other remote telemetry equipment will be contained in a panel referred to hereinafter as the SCADA Panel. Refer to Supervisory Control and Data Acquisition (SCADA), Section I, for additional requirements. The hardwired interlock based control system will be contained in a panel referred to hereinafter as the Level Controller Panel. Also refer to the Drawings.

    c. The lift station shall be provided with a primary and secondary wet well level measurement systems that shall each be capable of controlling the lift pumps.

        1). The location of the wet well level sensing devices must ensure that is not affected by internal equipment such as the pumps, discharge piping, support beams, guiderail, power cables, lifting cables and chains, aerator hoses and ejectors, wet well walls, gravity invert, as well as currents, rags, grease, or other floating materials.

3. Lift Station Monitoring:

    a. Wet Well Level Monitoring:

        1). Primary level monitoring system employed for monitoring the lift station wet well must consist of a radar level detection system suitable for application in corrosive sanitary sewer environment.

i The angle of the radar beam must be 4 degrees, or less, and must be vertically aligned. The signal of the radar must be analog 4 to 20-mA. Wireless connection is not required.

ii The radar instrument must be installed inside the wet well and be accessible through the pump access hatch or a dedicated access hatch.

iii The radar instrument must be mounted on a stainless steel 316 bracket. The location of the bracket must not interfere with installation and removal of equipment located inside the wet well.

iv The bracket must allow the radar instrument to be pulled without the need to remove any fasteners. When installed back on the bracket, the radar must self align vertically to the position set.

v The bracket must allow for alignment of the radar in both the horizontal and vertical plane.

2). Secondary level monitoring system employed for monitoring the lift station wet well must consist of suspended mechanical tilting float switches.

i Provide float switches for high level and to control all the pumps in a lead-lag algorithm, refer to the Drawings.

ii All float switches shall be non-mercury type. Provide floats with the contacts as required by the Drawings.

3). Wiring of the primary and secondary level detection systems must terminate in dedicated junction boxes respectively. The junction boxes must be located adjacent to the wet well as shown in the Drawings.

b. Submersible pump/motor monitoring: At minimum, provide submersible pump motor seal moisture detection, winding temperature protection, and additional protection interlocks in accordance with the pump manufacturer's recommendation.

c. Lift Station Discharge Monitoring:

1). The force main discharge pressure transmitter shall have a 150 psi gauge pressure range, but it must be capable to read the operating and surge pressures. It shall operate at 24 Vdc, 4-20 mA output, and it shall be located as shown in the Drawings. <u>It shall be provided with a glycerin filled diaphragm seal, an isolation ball valve, electric heat trace, and be wrapped in insulating material.</u> Pressure transmitter must have a LCD display and must display the measured pressure in psi. Pressure transmitter will be powered from the 24Vdc power supply located within the SCADA panel. Communication protocol must be 4 to 20-mA analog signal with HART capability.

2). Install a discharge pressure gauge rated for corrosive service that meets the following specifications: 2.5" Dial, Grade 1A, ASME B40.100, ±1% full scale accuracy, liquid filled, type 316 stainless steel bourdon tube, glass safety lens, full blowout protection, weatherproof, hermetic seal and with a standard ¼ inch

NPT. Pressure gauge shall be provided with a glycerin filled diaphragm seal, isolation ball valve, electric heat trace, and freeze protection. The installation and location of the pressure gauge shall be as indicated in the Drawings. Design engineer must evaluate and determine the pressure range of the gauge to have clear indication of the operating pressures.

3). If specifically required by SAWS, provide flow-measuring devices with instantaneous rate indicators, totalizers and recorders designed specifically for sewage force mains on the discharge side of the pump station. Flow meters shall be of the electromagnetic type and must meet the current standards of SAWS Treatment Instrumentation and Controls. Flow display to be installed at lift station level controller panel. In this case the header must provide a minimum horizontal distance of straight pipe upstream and downstream as recommended by the flow meter manufacturer.

4. Lift Station Control System:

a. Pump Control System: Lift station shall be capable of discharging all anticipated peak wet weather flow.

1). The “Lead” pump must turn on first, and if the wet well level continues to rise, the “Lag” pumps will start one by one as the level rises and reaches the respective levels. The “Lead” and “Lag” pumps will continue to operate until the “All Pumps Off” level is reached. The “lead” and “lag” pumps shall automatically alternate at the completion of each pumping cycle.

2). A hardwired pump controller shall be provided to control the lift pumps based upon the level in the wet well measured by the primary level measurement system with delay action timing for control of the lift station pumps. The controller shall also have pump lead-lag control capability and shall be mounted on a hinged swing panel inside the level controller enclosure. Acceptable level controller manufacturer is Siemens (SITRANS LT500), or SAWS approved equal.

3). A hardwired pump alternating relay shall also be provided to control the lift pumps based upon the level in the wet well measured by the secondary level measurement system with delayed action timing for control of the lift station pumps. The pump alternating relay shall also have pump lead-lag control capability and shall be installed on the back panel of the level controller enclosure. Refer to the Drawings.

4). Pump and motor protections must be active in all modes of operation, except low water cutout. The low level cutout must trip the pumps only when they operate in automatic mode. Refer to the Drawings.

5). Control logic shall prohibit parallel starting of multiple pumps at the same time.

6). Provide supplementary functionality as may be requested by SAWS on a case-by-case basis.

7). Each pump shall be provided with a dedicated pump control panel with Hand-Off-Auto selector switch, momentary action Start and Stop pushbuttons, and associated control logic to allow for continued lift station operation with one pump out of service, alternation of remaining pumps in service, and proper lockout procedures. Refer to the Drawings for additional requirements. The pump will be available for control via the start and stop pushbuttons when the selector switch is in the Hand position and shall not be affected by the low level alarm condition and by the primary and secondary level monitoring systems.

8). The primary and secondary wet well level monitoring systems must be located in a dedicated Level Controller enclosure. The level controller enclosure must have a "Primary-Both-Secondary" selector switch to choose the desired monitoring system.

9). Coordination between primary and secondary level detection systems.

i Primary level monitoring system must set the normal operating levels of all pumps and also low and high wet well level detection. The primary high wet well level must be set above all the secondary pump operating levels, but below the secondary high level detection.

ii Secondary level monitoring system must set the backup emergency operating levels for all pumps and high wet well level detection when the primary system fails. The operating levels for the secondary system must be set above the normal operating wet well level of the primary system, yet minimizing surcharge into the collection system. The secondary high level must be set above the primary high level detection.

10). Additionally for each pump, provide in addition to the aforementioned at minimum:

i Pump ON and Pump OFF indicating lights

ii Alarm indicating lights for motor overload, moisture alarm, seal leakage alarm

iii Reset pushbutton

iv An elapsed time meter on the inner panel of the pump control panel. Meters shall be five digit, indicates tenths of hours and be non-resetting. Operating power shall be 120 volt. Approved manufacturers are Cramer, Hobbs, Honeywell, and Redington.

v Refer to the Drawings for additional requirements.

b. Phase Monitor Relays

1). The voltage rating of the phase monitor relay shall be selected based on the voltage application.

2). Trip settings and delay to trip must be adjustable. Output Contacts: SPDT rated at 10 amperes @ 277 Vac, and rated for ½-HP @ 125-Vac.

3). Operating Temperature: -28 to 65-ºC (-40 to 185-ºF).

c. Control Relays

1). Contact rating shall be determined by the design engineer, but in no case shall be less than 10-A for general use.

i Special consideration shall be given to provide adequate contact rating required to switch coils of starters, contactors and similar large control devices.

2). Relay shall be designed to operate at a temperature range from -40 to +55ºC.

3). Shall be provided with pilot light to indicate when energized and mechanism for manual testing.

d. Miscellaneous:

1). A dedicated 120Vac:24Vdc power supply shall be provided inside of the level controller panel to serve the primary wet well level instrument analog loop.

2). Provide 30mm, Nema 4X rated pilot lights, selector switches, and push buttons. Pilot lights shall be push-to-test type.

3). Mount all pilot devices on the inner swing panel of the level controller panel and all the pump control panels.

e. Level controller panel requirements:

1). Provide a UL 508 labeled custom level controller panel as required to enclose the wet well level monitoring systems and all equipment comprising the hardwired control system for the lift station. Refer to the Drawings. Designs will be reviewed by SAWS and considered for approval on a case-by-case basis. Provide supplemental fixed barriers as required. Laminated wiring schematics shall be stored in the pump control panel and be provided to SAWS.

End of Section I

Section J. Supervisory Control and Data Acquisition (SCADA)

1. Include a radio path survey report in the lift station engineering report. The radio path survey shall be done preliminary using a modeling software and also a physical radio path survey. Both the report and the plans must include the NAD83 State Coordinates of the proposed lift station site.

   a. The radio path study must show a communication solution that will ensure a clear and steady quality radio signal and data transmission is achieved from the proposed lift station site to an existing SAWS network access point.

2. If a clear and steady quality radio signal and data transmission cannot be achieved between the proposed lift station and any existing SAWS network access point, evaluate existing SAWS facilities without network access points located near the proposed lift station in order to evaluate if a clear and steady quality radio signal and data transmission can be achieved.

   a. Include in the lift station engineering report a section that shows the required upgrades to the existing nearby SAWS facility in order to add a new SAWS network access point.

3. If the studies show a steady quality radio signal and data transmission cannot be achieved through any nearby existing SAWS facility, coordinate with developer to provide a new site for construction of a new network access point station in order to achieve a steady quality radio signal and data transmission from the proposed lift station to SAWS network. New network access point facility shall comply with all access and site requirements for lift station site as described in these Guidelines and drawings.

4. Computer Based Radio Path Survey Requirement for Broadband Systems.

   a. The design engineer shall prepare a computer based radio path survey report detailing the results before performing the physical radio path survey. Coordinate with SAWS Network for approved modeling software.

   b. SAWS will provide the nearest available access points to link the communication.

   c. If there are various options, the design engineer shall evaluate all options provided by SAWS.

   d. When the physical radio path survey is completed and the results differ significantly from the computer based, the design engineer shall correct the computer base survey by adjusting the heights of the obstructions along the radio path until results are reasonably close within engineering practices. The design engineer shall submit the updated computer based report, with the annexed results of the physical radio path survey.

5. Physical Radio Path Survey Testing Requirements.

   a. SAWS shall provide the test radios to be used for the physical radio path survey. SAWS shall witness the physical radio path surveys with either a network technician or an I&C technician or both, depending on the degree of the physical radio path survey.

b. It shall be the responsibility of the design engineer to plan, coordinate with SAWS and Developer, and perform all computer based and physical radio path surveys.

   1). Design engineer shall coordinate with Developer in order to provide clear and safe access to the proposed lift station site, as well as opening any private gates that may be required to cross. Failure to comply with this will result in automatic cancellation of the physical radio path survey.

c. The design engineer, or his designee shall provide the following for the physical radio path survey:

   1). Test Cabling – provide 150-LF of the CAT 6 ethernet cable. Coordinate with SAWS Network for specific requirements of the cable.

   2). Lift/bucket truck shall have the capacity to raise at least 20 vertical feet higher than the height determined by the preliminary computer-based radio path survey.

   3). Batteries/power supply needed to power up the radios

   4). Provide an engineering report with description and details about the specific physical radio path survey done, equipment used, results obtained at the various heights tested and recommendation for tower height.

6. Signals to be monitored by the SCADA system and the specific wiring order are shown in the drawings.

7. Communication Protocol Requirements.

   a. The standard communication protocol for processors, radios and access points shall be Ethernet Industrial Protocol.

8. Isolation relays must be installed for each digital I/O channel to separate 120-Vac circuit loops or others from 24-Vdc PLC digital I/O circuit loops.

   1). One isolation relay shall be installed and wired for each digital I/O channel installed in the SCADA enclosure, including spare channels.

   2). Isolation relays shall be single pole double throw (SPDT) and be in compliance with the relay requirements indicated in Section H Electrical Equipment.

9. Design engineer must coordinate with SAWS Network for specific requirements of the following equipment:

   a. Broadband Radios 450 Series Cambium.

      1). All lift stations shall communicate using broadband radios with redundant cellular backup for regional and critical lift stations. SAWS shall make final determination whether a lift station shall be considered critical.

b. Broadband Industrial Midspan Power Over Ethernet (POE) Power Injector.

c. CISCO Industrial Router with cellular modem and expandable modules.

d. Industrial Ethernet CISCO Switch.

e. Outdoors OSP Ethernet Cabling.

f. Surge Suppression Device for Broadband Systems.

g. Tower Enclosure for Broadband Systems.

   1). Provide Tower Enclosure NEMA Type 4 on the face of the tower approximately 4 feet.

   2). Tower Enclosure will house Grounding Busbars, Broadband dataline SPD.

   3). Bond Tower Enclosure ground busbar to tower ground ring using minimum No. 4/0 AWG Bare Tinned Copper.

   4). Bond SPD to ground busbar using minimum No. 6 AWG.

   5). All cables shall enter and exit the Tower Enclosure through the bottom of the enclosure.

10. A 4-20mA temperature transmitter must be installed within the SCADA enclosure or inside the electrical building and be wired to the PLC analog input board for internal panel or internal building temperature monitoring. Temperature transmitter must be provided with RTD sensor and transmitter. Temperature range must be 0 to 150 ºF.

11. Tower Requirements

    a. Must be of the self supported type without guy wires.

    b. Must meet the minimum height indicated by the physical radio path study, but in no case shall be less than 60 feet high.

    c. Check with FAA for any particular requirements, based on the location of the tower, and include any FAA requirements as needed.

    d. Tower shall be designed in accordance with ANSI/TIA-222-latest revision.

    e. Include tower foundation design.

    f. Tower shall be located within lift station site in a place where bucket truck has straight access. Engineer to demonstrate how the bucket truck can access the antenna.

12. SCADA Panel shall be provided with an industrial rated uninterruptible power supply of 120Vac. The power supply shall provide reliable power for a minimum of 2 hours under full load condition. Power supply shall be used exclusively for the loads located within the SCADA panel. The wet well level controller and any other load located within the

pump control panel and automatic transfer switch (if any) shall not be powered by the SCADA power supply.

a. Size the SCADA panel considering the dimensions of the UPS. The UPS must be located in a place that does not obstruct direct sight and access to wiring and devices.

b. Design engineer must coordinate with SAWS Instrumentation and Controls for current requirements for UPS.

13. Install an industrial supplemental voltage surge protector inside the SCADA panel.

14. Tower structure shall be grounded in a manner that conductive path to ground is through copper conductors. A perimeter ground must be provided and it must be bonded to the rest of the lift station grounding system. Ground resistance shall not exceed 5 Ohms.

15. Serial to Ethernet Industrial Protocol Converters.

a. When SAWS requires devices that do not provide Ethernet Industrial Protocol communication, but such devices provide Serial communication, the communication converter shall be coordinated with SAWS Instrumentation and Controls department.

16. Requirements for Programmable Logic Controller.

a. SAWS has standardized the Top End platform and programmable logic controllers with Allen Bradley. Design engineer must coordinate with SAWS Instrumentation and Controls, Telecommunications, and Instrumentation and Controls for current requirements.

17. Logic for Discrete Signals.

a. The standard logic for discrete signals shall be as follow:

1). De-energized (0) for any normal condition, and equipment at rest, and;

2). Energized (1) for any alarm condition, and equipment in operation.

b. Design wiring schematics in a manner that the same logic is maintained on each complete signal loop, from the PLC input modules, interposing relays, and the relays and dry contacts located in the field.

18. Programming.

a. SAWS will provide programming services for PLC, Top End and Radio for all lift stations; however, the design engineer shall verify.

1). Design engineer must coordinate with SAWS during the design.

2). During construction, SAWS shall be notified immediately after the SCADA panel has been delivered at the lift station site in order to allow SAWS programmers with sufficient time to perform the programming and internal testing, but the time requested by Contractor/Engineer/Developer to complete the programming by SAWS shall not be less than forty five (45) calendar days.

b. In the special case that SAWS determines the programming to be provided by the Contractor, the PLC programming shall be provided by a Process Control Systems Integrator (PCSI) and the Top End graphics shall be performed by an Application Services Provider (ASP). Both the PCSI and the ASP shall be approved by SAWS.

19. SCADA System Acceptance Testing.

a. Design engineer must adhere to SAWS procedures for Operational Readiness Test (ORT) and Functional Demonstration Test (FDT) and include these provisions in the specifications.

End of Section J

Section K. Emergency Provisions

1. Lift Stations shall be designed to ensure that no discharges of untreated wastewater will occur at the lift station, force main, and any point of the collection system upstream and downstream of the lift station due to loss of electric power or mechanical failure within the operating time frames defined in this Section. All lift stations shall be provided with service reliability based on the standard requirements hereinafter.

2. Wet Well Emergency Storage.

   a. The wet well emergency storage capacity for <u>all lift stations</u> shall be designed to provide the required emergency storage volume within the wet well, excluding the capacity of sanitary collection system upstream from the wet well.

   b. Emergency storage capacity shall be supported by engineering calculations and shall be the primary criteria to size a wet well.

   c. Wet well emergency storage design shall provide the following capacity:

      1). 60 minutes using Average Daily Flow, and 20 minutes using Peak Wet Weather Flow.

   d. For calculation purposes, the wet well emergency storage level shall begin at the "Lead Pump On" level to wet well "Spill" level elevation.

      1). Spill level elevation shall be determined by the critical structure upstream of the wet well.

         i The critical structure is typically a manhole, a siphon box, or any other structure upstream of the wet well that is part of the lift station subcatchment basin and has the lowest top elevation of the system, that when the system surcharges this critical structure will be the first to spill.

3. Emergency standby generator and automatic transfer switch shall be provided for <u>all lift stations</u>.

   a. All lift stations shall be designed with a permanently installed standby generator and automatic transfer switch.

   b. The emergency backup power generator system shall be sized to operate 100% of lift station electric loads.

4. The use of a spill containment structure as a means of providing service reliability is prohibited. Spill containment structures may be used in addition to one of the service reliability options detailed in this Section, provided accessibility, site security, odor control means and a detailed management plan for cleaning and maintaining the spill containment structure is discussed in the final engineering design report. Additionally, any spill containment structures shall be enclosed by security fenced. The security fence and access gate must comply with the current requirements of SAWS Security. Spill containment structures shall not be used to reduce other power reliability requirements in any way.

5. An audio-visual alarm system (red flashing light and horn) must be provided for all lift stations, and must be located at the level controller panel. The audiovisual alarm shall be activated only by wet well high level condition, by both the primary level detection system and secondary level detection system. The level controller panel shall be provided with pushbuttons for testing the alarms and to silence the horn.

   a. For lift station with electrical buildings, install at least two audio-visual alarms located outside the electrical building, instead of installing at the level controller panel inside the electrical building. The external audio-visual alarms must be clearly visible and audible to the public around the lift station.

6. Emergency bypass pumping assembly system shall be provided for all lift stations. The number of assemblies and size shall be determine by the Peak Wet Weather Flow, and shall consist of a horizontally aligned branch wye, isolation gate valve and swing check valve with external arm and weight ending with a blind flange. Orient the check valve to allow flow to be pumped into the header.

7. Lift stations equipped with soft starters must be provided with a parallel full voltage starter to by-pass the soft starter units when they trip. The motor control panel must be provided with a selector switch that will allow operating the motors through soft start mode or full start mode.

8. A fully automatic backup float switch control system shall be provided as a secondary level detection system to provide automatic emergency backup control if the primary level detection system fails.

9. Install cellular communication system to backup the broadband communication system.

10. Install a cellular router in all critical lift stations. SAWS will determine if the lift station is critical.

    a. The cellular router must generate at least four calls to SAWS designated personnel and must leave a recorded message associated with the alarm event.

    b. As a minimum the cellular router must monitor the following:

       1). Utility Power Loss.

       2). Generator Running.

       3). Wet Well Level High.

       4). Common Pump Fail (for each pump).

          i Pump Seal Leak, Motor High Temperature, Motor Overload, Soft Start Fail (if equipped with soft starter), and Motor Phase Loss, must be combined in a single common fail signal only for the cellular router.

End of Section K

Section L. Safety and Security Requirements

1. The lift station shall be enclosed within an intruder resistant chain link. The design of the fencing shall be in compliance with the requirements of SAWS Security Specifications.

2. Above-ground valves located inside or outside of an intruder-resistant fence must be chained and locked to prevent unauthorized operation.

3. Overhead Lines. Do not run overhead lines over lift station site. Overhead wires include, but are not limited to, primary and secondary electric lines, electric service drop, and cable and telephone lines. If a secondary overhead electric service drop is required to feed the lift station, the service pole must be located in a place where the service drop will be at least: 10 feet away from canopy, 20 feet away from wet well, header piping and generator, and 40 feet away from SCADA tower structure.

4. Electric Conduits and Piping. Eliminate tripping hazards from electric conduits and pipes across the surface of the lift station. They must be buried and embedded in concrete slabs.

5. The bottom side of junction boxes and electrical enclosures shall be installed minimum 48 inches above the finished surface which maintenance personnel will stand to perform work, provided the top side does not exceed 72 inches. Installation of junction boxes, conduit bodies and the like over the paved surfaces and concrete slabs shall be prohibited.

6. Arc Flash Analyses. Include an Arc Flash Analysis in engineering report. Reduce arc flash Hazard/Risk Rating to Category 2 if they originally are Category 3 or 4 by properly selecting protective devices and setting trip parameters properly. Electric panels must include proper warning labels. Analysis must be done using SKM or similar electrical modeling software.

7. Access Hatches. One or more lockable aluminum hatch covers with anti-slip top surface shall be installed on the wet well top slab for access to the wet well, pumps, floats, level control devices, wet well aeration system, and for general cleaning purposes. Minimum hatch internal clearance shall be 36 by 48 inches, or larger as required; providing sufficient clearance for removal of submersible pumps without interfering with electrical wiring, conduits, cable hangers, wet well aerator system, and to provide adequate working space for wet well cleaning.

   a. Access hatch covers shall be installed in a manner that are flushed with concrete slabs to prevent a tripping hazard. All covers and safety grates for pump access hatches shall open towards the discharge piping, no exceptions. The cover and safety grate for all other access hatches shall open away from the top slab area. Access hatch covers shall be provided with a lift assist mechanism made of stainless steel type 316.

   b. Hatch safety grate shall be installed to provide fall protection and shall consist of aluminum material designed to withstand a load of 300-lb per square foot. The safety grate shall be designed to have gaps of 4 to 5 inches wide to allow for wet well inspection, and shall be installed directly under the access hatch cover to provide support. Safety grates installed more than ½-inch below the concrete slab shall be prohibited.

c. Black and yellow stripes shall be painted around the access hatch using Epoxy Enamel (Tnemec, or equal) coating system. Also a "CAUTION! FALL HAZARD" sign shall be painted/stenciled on all four sides of the hatch. Coating requirements and thickness shall be in accordance with Manufacturer's recommendations.

d. When two or more access hatches are required, the design of the access hatch, safety grate and wet well top slab shall be done in a manner that only one single concrete slab opening will cover for all the required access hatches without any obstruction.

8. No fixed ladders are permitted in the wet well.

9. The tower structure shall be provided with a fall safety cable protection system.

10. Dedicated Working Space and Clearances. Dedicated working spaces and clearances shall not be permitted to overlap with fencing, concrete slabs, piping, canopy, and foundations such as for light poles and towers.

    a. Lift station site shall have an unobstructed general dedicated working space inside the fence of at least 100-ft long and 45-ft wide measured from the side where the access gate is located.

    b. Dedicated working space in front of electrical junction box shall be at least 5 feet.

    c. Dedicated working space in front of panels and equipment installed at the electric service rack under the canopy and installed inside electric buildings shall be at least 8 feet.

    d. Horizontal clearance between electrical junction boxes and wet well access hatches shall be at least 3 feet.

    e. Horizontal clearance between electrical junction boxes and wet well vents shall be 5 feet minimum.

    f. Horizontal clearance around canopy and electric building shall be at least 10 feet.

    g. Horizontal clearance between gravity mains and nearest edge of service rack slab and building foundation slab, shall be 40 feet minimum.

    h. Horizontal minimum clearance between outer diameters of pump discharge pipes shall be determined by the radar projection to the bottom of the wet well to assure unobstructed radar path, but in no case shall be less than 30 inches for wet wells up to 30-ft deep, and 36 inches for wet wells up to 40 feet deep. For deeper wet wells, design engineer must coordinate with SAWS.

    i. Dedicated working space around discharge header slab shall be at least 10 feet.

    j. Dedicated working space around wet well top slab shall be at least 15 feet.

        1). Exception: Electrical junction boxes dedicated for pumps, backup float switch and wet well level sensor shall be permitted to overlap with wet well dedicated working space, provided that do not overlap with any other dedicated working space and clearance, do not interfere with wet well accessibility for cleaning and pulling pumps, do not interfere with accessibility to emergency bypass assembly, and the junction boxes open away from the wet well.

k. Tower Clearances

1). Tower horizontal clearance shall comply with the requirements set by San Antonio UDC Section 35-385 Radio, Television Antennas, and Wireless Communication Systems, but in no case shall be less than 115% of the total tower height measured from tower center to any undeveloped residential lot to be served by the lift station and to any existing residential structure.

2). Tower shall have a minimum clearance of 15 feet within the lift station site measured from the edge of the exposed finished foundation.

3). Horizontal clearance between gravity mains and nearest edge of tower foundation shall be 40 feet minimum.

4). Tower structure shall be located at least 40 feet away from electric overhead lines and service drop.

l. Light Poles and electric service pole shall have a minimum clearance of 5 feet measured from the pole surface.

m. Dedicated working space around generator slab shall be at least 5 feet.

End of Section L

Section M. Submittal Requirements

1. An engineering design report that include construction feasibility and site analysis, a present value analysis with detailed capital and O&M cost estimate, flow development for initial and final phases of the development, wet well design, wet well detention time and force main flush time for both initial and final phases, system curves, pump curves and head calculations (Total Head including Static Head, Friction Losses, Minor Losses, NPSH, Total Suction Lift (when applicable)). Calculations and system curves at both minimum (all pumps off) and maximum (last normal operating pump on) static heads, and friction losses based on material of pipe selected, for each pump and for the combination of pumps (modified pump curves). Buoyancy calculations for the wet well in order to design a concrete slab heavy enough to keep the wet well in place. Energy consumption calculations shall be presented comparing different pumps, impellers and pipe sizes in order to select the most efficient pump. The overall layout of the development and the development master plan shall be submitted for SAWS review.

2. The engineering design report must include the following calculations, although the design engineer is not required to use the same formulas:

A. **TITLE PAGE** - Title page should include the project name, date, developer/owner's name and engineering firm preparing plans.

B. **SEWER SYSTEM INFORMATION**
1. Introduction
    a) Type, location and size of development
    b) Number of and range in size of lots or buildings to be serviced
2. Existing Sewer System
    a) Location and type of gravity system the force main will discharge into.
    b) Indicate whether the entire development will be serviced by the proposed phase or if several phases will be involved.
    c) Indicate the number of lots this phase will encompass initially and finally if future phases are to be constructed.

C. **PUMP STATION AND FORCE MAIN DESIGN CALCULATIONS**
(The following formulas are provided as <u>guidelines</u>. The design engineer can use other equivalent formulas, of preference, to achieve similar results.)

1. <u>Site Characteristics, and allowances, to Calculate Flows (Design engineer is responsible to verify the current SAWS Utility Service Regulations and comply with current criteria)</u>:
    a) Residential EDUs @ 200 gals/day per EDU
    b) Commercial SF @ 0.07 gals/day per SF
    c) Multi-family Units @ 0.50 EDUs per Unit
    d) Peaking Factor - 2.5 times the Average Daily Flow
    e) Inflow and Infiltration (I/I) Allowance of 600 GPD/acre.

2. <u>Average Dry Weather Flow (ADF)</u>: This is the flow developed without the maximum flow peaking factor.

a) ADF (GPD) = Residential (single and multi-family) + Commercial GPDs
b) ADF (GPM) = ADF (GPD) / 1440 (Min/Day)

3. Peak Dry Weather Flow (PDWF) (SAWS Utility Service Regulation 11.3.1):

   a) Peaking Factor = 2.5 for Proposed Residential Development, SAWS USR
   b) PDWF (GPD) = PF * ADF
   c) PDWF (GPM) = PF * ADF (GPM)

4. Peak Wet Weather Flow (PWWF): All lift stations shall be designed to handle the maximum peak wet weather flow for its service area.

   a) Inflow and Infiltration (I/I): Total Development Acreage * 600 GPD/acre
   b) PWF (GPD) = PDWF (GPD) + I/I (GPD)
   c) PWF (GPM) = PWF (GPD) / 1440 (Min/Day)

5. Minimum Dry Weather Flow (MDWF): This is used to determine the maximum detention time in the wet well.

   $MDWF = (0.2 * (0.0144 * ADF)^{0.198}) * ADF$

6. Minimum Pump Requirements (Peak Wet Weather Flow, PWWF):
   a) For two-pump stations, size each pump to handle PWWF.
   b) Calculate Total Dynamic Head (TDH):
      1) Static Head (Hs)
         Eh = Maximum force main elevation
         E1 = Wet well low water elevation
         Hs = Eh – E1
      2) Loss (Lf) due to friction in force main
         Length = Total equivalent length of force main and piping on station
         Lf = Length x Friction Factor
         (Use Hazen-Williams C of actual pipe material selected for friction losses)
      3) TDH = Hs + Lf
   c) Plot System Curve on Pump Curve and determine operating point to select proper pump sizes.

7. Net Positive Suction Head: For suction lift stations, compare the net positive suction head ($NPSH_R$) required by the pump with the net positive suction head available ($NPSH_A$) in the system, at the operating range. The NPSH available shall be greater than the NPSH required by at least 3 feet.

   $NPSH_A \text{ (suction lift)} = P_B + H_S - P_V - H_{fs}$

   Where;
   P_B = barometric absolute pressure in feet, available at lift station site
   H_S = minimum static suction head, in feet
   P_V = vapor pressure of liquid in feet absolute, use 1.4 feet
   H_{fs} = friction loss in suction, in feet (including entrance losses and minor losses)

8. Velocity Produced in Force Main See Section F. Design engineer shall use the internal diameter of force main pipe to compute this calculation.

9. Wet Well Emergency Storage Requirements:
   a) Required Wet Well Emergency Storage (volume between "Lead Pump On" and "Spill" elevations):

$$V = Q_i \ x \ T_{Sto}$$

   Where:
   - V is the wet well emergency storage volume, in gallons
   - Q_i is the design inflow, in gallons per minute
   - T_{Sto} is the required storage time
   - See Section B and Section J for requirements.

   b) The design engineer shall be responsible for evaluating the top elevations of the entire gravity system that will discharge into the wet well in order to identify the manhole or structure with the lowest top elevation.

10. Wet Well Working Volume.

    a) The wet well working volume shall be determined based on the required pump cycling times determined in Section C.

11. Buoyancy Checks: A buoyancy check shall be performed for the wet well to assure the wet well structure will not move after construction. Design engineer shall be responsible for the methodology used to determine this calculation.

12. Water Hammer Calculations: Calculate surge pressures and compare to the pressure rating of the force main pipe to determine the need for a surge relief valve.

$$a = \frac{4660}{\sqrt[2]{\frac{E_W \ x \ D_i}{E_P \ x \ t_P}}}$$

Where:
a = pressure wave velocity factor
E_W = water bulk modulus (300,000 psi)
D_i = force main pipe inner diameter (inches)
E_P = force main material modulus of elasticity (130,000 psi for HDPE)
T_P = force main pipe wall thickness (inches)

$$P = \frac{a \ x \ V}{2.31 \ x \ g} + operating \ pressure$$

Where:
P = water hammer pressure (psi)
a = pressure wave velocity factor

V = flow velocity in force main at firm pumping capacity (ft/s)
g = acceleration of gravity (32.2 ft/sec^2)
2.31 = conversion factor

13. Force Main Flush Time Calculations: Calculate force main average flush time.

Instructions:

1. Basic Information Required.
   1.1. Wet Well Diameter (D)
   1.2. Distance between All Pumps Off and Lead Pump On ($\Delta h_{On\text{-}Off}$)
   1.3. Wet Well Inflow (Q_i)
   1.4. Pumped Flow (Q_o)
   1.5. Force Main Length (L)

2. Basic Calculations Required
   2.1. Wet Well Filling Time (WWFT)
   The wet well filling time is the time that takes to raise the wet well level from All Pumps Off to Lead Pump On.
   2.2. Pump Running Time (PRT)
   The pump running time is the time that takes to drop the wet well level from Lead Pump On to All Pumps Off.
   2.3. Wet Well Detention Time (WWDT)
   The wet well detention time is the addition of the wet well filling time plus the pump running time.
   2.4. Flushing Cycles (FC)
   The flushing cycles are the number of cycles required to flush the force main.
   2.5. Flush Time (FT)
   The flush time is the time that takes to flush the force main completely.

3. Supplemental Formulas

   3.1. Equation 1: Wet Well Filling Time (WWFT)

$$WWFT = \frac{7.481\pi D^2 (\Delta h_{On-Off})}{4Q_i}$$

Where:
D is the Wet Well Diameter in feet.
$\Delta h_{On\text{-}Off}$ is the distance in feet between Lead Pump On and All Pumps Off.
Q_i is the wet well inflow in gal/min.

WARNING!
Use Average Daily Flow to calculate Average Wet Well Filling Time.

   3.2. Equation 2: Pump Running Time (PRT)

$$PRT = \frac{7.481\pi D^2 (\Delta h_{On-Off})}{4(Q_o - Q_i)}$$

Where:
D is the Wet Well Diameter in feet.
$\Delta h_{On\text{-}Off}$ is the distance in feet between Lead Pump On and All Pumps Off.

Q_i is the wet well inflow in gal/min.
Q_o is the pumped flow in gal/min.

WARNING!
Average Daily Flow to calculate Average Pump Running Time.

3.3. Equation 3: Wet Well Detention Time (WWDT)

$$WWDT = WWFT + PRT$$

Where:
WWFT is the wet well filling time in minutes.
PRT is the pump running time in minutes.

WARNING!
Use average wet well filling time and average pump running time to calculate average wet well detention time.

3.4. Equation 4: Flushing Cycles (FC)

$$FC = \frac{L}{60v(PRT)}$$

Where:
L is the force main total length in feet.
V is the flow velocity within the force main in ft/s.
PRT is pump running time in minutes.

WARNING!
Use average pump running time to calculate average flushing cycles.

IMPORTANT!
Normally the flushing cycles are composed by whole and decimal numbers. It is required to separate the whole part from the decimal part in order to be used in the following equation.

3.5. Equation 5: Flushing Time (FT)

$$FT = (FC_W)(WWDT) + (FC_D)(PRT)$$

Where:
FC_W is the whole part of the flushing cycles.
WWDT is the wet well filling time in minutes.
FC_D is the decimal part of the flushing cycles.
PRT is the pump running time.

WARNING!
Use average flushing cycles, average wet well detention time and average pump running time to calculate average force main flushing time.

4. Example:

A lift station with a 12-foot diameter wet well has a 3000-foot force main. The average daily flow is 150 gal/min. The distance between Lead Pump On and All Pumps Off is 2 feet. The pumps discharge 600 gal/min, and the flow velocity within the force main is 3.25 ft/s. Calculate the average force main flush time.

Procedure

Step 1: Calculate average wet well filling time with equation 1 as follows:

$$WWFT = \frac{7.481\pi(D)^2(\Delta h_{On-Off})}{4Q_i} \Rightarrow \frac{7.481\pi(12)^2(2)}{4(150)}$$

The Average Wet Well Filling Time is 11.28 minutes.

Step 2: Calculate average pump running time with equation 2 as follow:

$$PRT = \frac{7.481\pi D^2(\Delta h_{On-Off})}{4(Q_o - Q_i)} \Rightarrow \frac{7.481\pi(12)^2(2)}{4(600-150)}$$

The Average Pump Running Time is 3.76 minutes.

Step 3: Calculate average wet well detention time with equation 3 as follow:

$$WWDT = WWFT + PRT \Rightarrow 11.28 + 3.76$$

The Wet Well Average Detention Time is 15.04 minutes.

Step 4: Calculate average flushing cycles with equation 4 as follow:

$$FC = \frac{L}{60v(PRT)} \Rightarrow \frac{3000}{60(3.25)(3.76)}$$

The Average Flushing Cycles are 4.09 cycles.

Step 5: Calculate average force main flush time with equation 5 as follow:

$$FT = (FC_W)(WWDT) + (FC_D)(PRT) \Rightarrow (4)(15.04) + (0.09)(3.76)$$

The Average Force Main Flush Time is 60.49 minutes.

Step 6: Summary Table. Make a table showing all the results of the calculations as follow:

Average Flush Time Results

Wet Well Diameter	12.00	Average Wet Well Filling Time	11.28
Distance between Lead Pump On and All Pumps Off	2.00	Average Pump Running Time	3.76
Average Daily Flow	150.00	Average Wet Well Detention Time	15.04
Pumped Flow	600.00	Average Flushing Cycles	4.09
Force Main Length	3000.00	**Average Force Main Flush Time**	**60.49**
Flow Velocity Within Force Main	3.25		

3.

D. **CYCLE TIMES.** Calculate detention times (Td) for Average Daily Flow, Peak Wet Weather Flow, and Minimum Dry Weather Flow.

Td = Tf + Te

Where;

Tf = time to fill wet well in minutes = Vr / Q_i

Te = time to empty wet well in minutes = $Vr / (Q_o – Q_i)$

Vr = Required Wet Well Volume

Q_i = Wet well inflow (ADF)

Q_o = Pump capacity in gpm

1. Average Detention Time (based on Average Dry Weather Daily Flow):

   a) $Tf = Vr$ /ADF (GPM)
   b) $Te = Vr / (Q – ADF)$
   c) Td (ADF) = Tf + Te

2. Maximum Detention Time (based on Minimum Dry Weather Flow):

   a) $Tf = Vr$ /MDWF (GPM)
   b) $Te = Vr / (Q – MDWF)$
   c) Td (MDWF) = Tf + Te

3. Total Cycle Times:

E. LISTING OF RESULTS FROM THE DESIGN CALCULATIONS TO BE PRESENTED IN THE FOLLOWING ORDER:

1. Number of Lots or Buildings
2. Acreage of lift station subcatchment
3. Average Daily Flow in GPM
4. Peak Dry Weather Flow in GPM
5. Peak Wet Weather Flow in GPM
6. The Volume of the Retention Chamber
7. Static Head
8. Total Dynamic Head
9. Net Positive Suction Head Available ($NPSH_A$) from system
10. The Pump Selected including the following:
    a) Manufacturer
    b) Model
    c) Discharge Size
    d) Impeller Diameter
    e) Flow
    f) Head
    g) $NPSH_R$
    h) Break Horse Power
    i) Efficiency
11. Pump Motor Data
    a) Rated Power
    b) Efficiency
    c) Power Factor
    d) NEMA Code Letter
    e) Voltage

12. Net Positive Suction Head Required ($NPSH_R$) form pump
13. Total Detention Times for, Maximum Dry Weather Flow, and Average Dry Weather Flow
14. Total Cycle Times for, Maximum Dry Weather Flow, and Average Dry Weather Flow
    a) Number of Minutes ON (Pumping Time)
    b) Number of Minutes OFF (Fill Time)
15. Material, Class, Size, Inner Diameter, Rated Pressure and Length of Force Main
16. Flow Velocity in Force Main
17. Force Main Average Flush Time
18. Water Hammer Analysis
19. Wet well buoyancy calculations
20. Generator analysis

F. **COST EFFECTIVENESS ANALYSIS**

As required by the San Antonio Water System Utility Services Regulations.

End of Section M