



Minimum Design Criteria for the Permitting of Pump Stations and Force Mains

Adopted by the Division of Water Quality on June 1, 2000

Purpose of this Document

This document sets forth minimum design criteria for the fast-track permitting of wastewater pump station and force main systems in the State of North Carolina. This document was developed by the Non-Discharge Permitting Unit, one of the two entities within the North Carolina Department of Environment and Natural Resources delegated to issue construction and operational permits for wastewater collection/conveyance facilities, in conjunction with peer reviewers from across the State.

The goals of this document are as follows:

- ✓ To provide better water quality protection by refocusing time and human resources on compliance of as-built facilities.
- ✓ To provide better customer service.
- ✓ To detail the fast-track permitting process and associated procedures for the construction and operation of pump station and force main systems.
- ✓ To present a set of minimum design criteria that can be used in conjunction with a fast-track permitting process for pump station and force main systems.
- ✓ To ensure consistent adherence to very specific minimum design and construction standards for a large majority of the pump station and force main systems permitted annually that could be permitted under the fast-track permitting process.

This document is intended to be used as design criteria for permitting pump station and force main systems without staff review and does not represent a set of rules or regulations formally adopted into the North Carolina Administrative Code. Complete adherence to all of the minimum design criteria is only required when applying for a permit under the fast-track permitting process or when applying for a “fast-track” permit from a local authority delegated to issue permits for pump station and force main systems in accordance with 15A NCAC 2T .0305. The requirements and procedures for the fast-track permitting process are described in full detail in Section 1.00 of this document.

It should be noted that these design criteria are minimum in nature only. Specifically, this document presents baseline, fundamental design and construction requirements necessary for pump station and force main systems such that a full technical review of the design documents prior to permitting can be waived in favor of an actual on-site inspection and review of the construction record documents. This being true, exceeding the requirements of the minimum design criteria is not only allowed, but also strongly encouraged when and where deemed necessary by the applicant and/or the North Carolina-licensed Professional Engineer certifying the design. On the other hand, non-compliance with the minimum design criteria without prior approval is a very serious offense. Applicants and North Carolina-licensed Professional Engineers preparing, certifying, and submitting permit application packages for consideration under the fast-track permitting process are forewarned that ignorance of the contents of this minimum design criteria document will not be considered a valid excuse for erroneous or false certifications. Appropriate actions will be taken against either or both parties accordingly.

A document such as this cannot provide guidance for every set of project conditions. Therefore, in some situations, complete adherence to the minimum design criteria is simply not possible or does not represent the best engineering design. The option of submitting a permit application package for consideration under the full review permitting process is still available in such cases and may even be required in others. Under the full review permitting process, a technical review will be performed on the design documents before a permit is issued so that unique design situations and engineering may be presented, discussed, and evaluated before construction occurs. The most recent version of the application form entitled Pump Stations, Force Mains, and Gravity Sewers (PSFMGSA 03/08) should be used in preparing permit application packages for submission under the full review process.

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Adoption

I, Kerr T. Stevens, do hereby approve this document entitled “Minimum Design Criteria for the Fast-Track Permitting of Pump Stations and Force Mains” and authorize its adoption into use by the Division of Water Quality, effective immediately.

Signed: _____ Original Signed By Kerr T. Stevens
Kerr T. Stevens, Director

This the first day of June, 2000.

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1.00 General

1.01 Application and Procedures

- A. In accordance with North Carolina General Statute (NCGS) §143-215.1.(a), no person shall construct, alter, extend, change, or operate any sewer system within the State of North Carolina without first obtaining a permit from the Environmental Management Commission (EMC).
1. Permitting for sewer systems in general and for pump stations and force mains specifically is administered by the Division of Water Quality (Division), Water Quality Section, Non-Discharge Permitting Unit; the Division's Construction Grants and Loans Section; or other authority delegated by the EMC to permit sewer systems locally in accordance with 15A NCAC 2T .0300. This Division is located administratively within the North Carolina Department of Environment and Natural Resources (Department).
 2. Requirements for permit application package preparation and submission are outlined in 15A NCAC 2T .0304.
 - a. 15A NCAC 2T .0305 presents design criteria for pump stations and force mains that are intended to be minimum requirements only. The application of standard design practices, good engineering judgement, and/or more stringent or conservative design criteria is highly encouraged when and where applicable and as deemed necessary.
 - b. These minimum design criteria shall be used in conjunction with the most recent amendment of the document entitled "Gravity Sewer Minimum Design Criteria," when specific projects involve both pump station/force main and gravity sewer systems.
 - c. As with the gravity sewer minimum design criteria, these minimum design criteria shall be used as a supplement to 15A NCAC 2T .0305 and, therefore, shall not be used in lieu of these regulations.
- B. An expedited (fast-track) permitting process for projects involving pump stations and force mains is available to applicants. This document describes specific procedures for obtaining a permit from the Division alone. Therefore, the applicant should verify the availability and applicability of a local program that is delegated by the EMC to issue permits to construct and operate pump station and force main systems, and contact the local permitting authority for permit application instructions accordingly.
1. The fast-track permitting process is only available for those projects that are designed in accordance with and meet or exceed all of the requirements of this minimum design criteria document. Other exclusions may also apply (see Section 1.04).
 2. Under the fast-track permitting process, Division staff do not complete a technical review of design documents. Rather, the responsibility for compliance with the minimum design criteria, the regulations, as well as the conditions of the permit prior to and during construction and commissioning lies with the applicant and the North Carolina-licensed Professional Engineer (PE).
- C. To apply for a permit for construction and operation of a project involving pump stations and force mains under the fast-track permitting process, a completed application form, any supporting documentation, as well as the required application fee shall be submitted to the Division for review.

1. The most recent version of the application form entitled Fast-Track Application for Gravity Sewers, Pump Stations, and Force Mains (FTA) shall be filled out in complete accordance with all applicable instructions.
 2. Both the applicant and the PE shall provide a certification that states that the application has been reviewed by them and is accurate and complete to the best of their knowledge. [Note: Any person who knowingly makes any false statement, representation, or certification in any application shall be guilty of a Class 2 misdemeanor which may include a fine not to exceed \$10,000 as well as civil penalties up to \$25,000 per violation, in accordance with NCGS §143-215.6A and NCGS §143-215.6B.]
 3. Any PE who erroneously or falsely certifies application packages shall be subject to referral to the North Carolina Board of Examiners for Engineers and Surveyors for disciplinary action and shall be subject to withdrawal of submission privileges under the fast-track permitting process.
- D. Following construction of the permitted facilities, the applicant shall submit to the Division one copy of a certificate of completion, utilizing the appropriate page of the issued permit, that has been fully-executed by a PE; the construction record drawings; the engineering calculations; and any other documentation requested to ascertain compliance with the most recent amendment of 15A NCAC 2T .0300 and these minimum design criteria to the Division.
1. Permitted facilities shall not be placed into active service until the Division receives the certificate of completion and other supporting documentation from the applicant.
 2. Receipt of certification acknowledgment from the Division shall not constitute an approval of the as-built facilities. The Division shall, upon review of the submitted documentation, retain the right to request additional information, initiate enforcement actions, direct the applicant to cease operation of the permitted facilities, and/or begin a permit rescission process, if it is discovered that the permitted facilities do not meet the requirements of the minimum design criteria document or 15A NCAC 2T .0305.
 3. Any PE who erroneously or falsely certifies permitted facilities as being in complete compliance with the minimum design criteria document and 15A NCAC 2T .0305 shall be subject to referral to the North Carolina Board of Examiners for Engineers and Surveyors for disciplinary action. Any PE who violates certification requirements shall be subject to withdrawal of submission privileges under the fast-track permitting process.

1.02 Other Permits

- A. The issued permit shall not preclude the applicant from ensuring compliance with any and all statutes, rules, regulations, or ordinances that may be imposed by other government agencies (local, state, and federal) who have jurisdiction.
- B. Of specific significance to pump stations and force mains shall be the following:
 1. A sedimentation and erosion control plan shall be approved by the appropriate office of the Department's Division of Land Resources or other delegated local authority if construction of the pump station and force main disturbs one or more acres of land or smaller threshold as specified by any applicable local rules. Construction of the permitted facilities shall be strictly forbidden until this approval is received.

2. The design and construction of the pump station and force main shall be such that they are in complete compliance with all applicable river basin rules, as established in the most recent amendment of 15A NCAC 2B .0200 “Classifications and Water Quality Standards Applicable to Surface Water and Wetlands of North Carolina.”
3. Applicable wetlands-related permits such as a Nationwide 12 permit, an individual 404 permit, or any applicable 401 certifications shall be requested, obtained, and adhered to for pump stations and force mains that impact or cross wetlands or any other surface water.
4. In accordance with 15A NCAC 2H .0100 “Stormwater Management,” a stormwater management plan for pump stations and force mains may be required for submission and approval. The applicant shall contact the appropriate regional office for applicability and specific requirements.

1.03 References and Documentation

- A. When standards are referred to in this minimum design criteria document, the most recent version or amendment shall be applicable.
 1. Pump stations, force mains, and all related appurtenances shall be manufactured, designed, constructed, and tested in accordance with accepted standards, good engineering practice, and in complete compliance with 15A NCAC 2T .0300 as well as these minimum design criteria.
 2. Several specific standards and practices are referenced in these minimum design criteria. The following acronyms shall be used when referring to these standards and practices for purpose of enhancing the clarity of this document:
 - a. American Concrete Institute (ACI).
 - b. American National Standards Institute, Inc. (ANSI)
 - c. American Petroleum Institute (API).
 - d. American Society for Testing and Materials (ASTM).
 - e. Federal Emergency Management Agency (FEMA).
 - f. Hydraulic Institute (HI).
 - g. National Electrical Manufacturers Association (NEMA).
 - h. National Fire Protection Association (NFPA).
 - i. Occupational Safety and Health Administration (OSHA).
 - j. Plastics Pipe Institute (PPI).
 - k. Underwriters Laboratories, Inc. (UL).
- B. Compliance with referenced standards, 15A NCAC 2T .0300, these minimum design criteria, and the issued permit shall be documented by the applicant. If requested by the Division, the applicant shall be prepared to supply such documentation. Such documentation shall include, but shall not be limited to the following:
 1. Engineering calculations that have been signed, sealed, and dated by a PE. Such calculations shall include, at a minimum, the following items:
 - a. Total dynamic head calculations for all applicable pumping situations.
 - b. System curve/pump curve analysis used to determine pump selection and operational point.

- c. Pump station cycle and pump run times, including an evaluation of any depressed sections of the force main to determine if the pump station is capable of completely flushing the force main section being evaluated in a single pumping cycle.
 - d. Pump station flotation/buoyancy.
 - e. Available emergency storage capacities at average and peak wastewater flows for pump stations that have not been connected to multiple power sources as provided for in Section 5.04B.1. or Section 5.04.B.2.
 - f. Minimum velocity within the force main.
 - g. Maximum detention times within the pump station and force main.
 - h. Downstream sewer evaluation demonstrating that the pump station discharge will not overload the receiving sewer line:
 - i. In situations where the pump station discharges into a gravity sewer, the downstream gravity sewer shall be evaluated based on peak flow from the proposed project as well as peak flows already tributary to the downstream gravity sewer.
 - ii. In situations where the pump station discharges into another pump station, the downstream pump station shall be evaluated to verify its ability to convey peak flows from the proposed project as well as peak flows already tributary to the downstream pump station.
 - iii. In situations where the pump station discharges into a force main, the downstream force main shall be evaluated on peak flows from the proposed project as well as peak flows already tributary to the downstream force main. The ability of each pump station tributary to the downstream force main to pump against additional head created by greater flows through the force main shall also be evaluated. An evaluation of the discharge point of the downstream force main as described in Section 1.03B.1.h.i. or Section 1.03B.1.h.ii. shall also be performed.
2. Construction record drawings that have been signed, sealed, and dated by a PE. Such drawings shall include, but shall not be limited to the following:
 - a. Plan and profile views of the force main as installed as well as its proximity to other utilities and natural resources. The locations of specific force main materials as well as any valves and other force main appurtenances shall be indicated.
 - b. Construction record detail drawings of the pump station.
 3. Documentation that the required quality assurance/control tests, as described in Section 6.00, were performed.
 4. Proof that operation and maintenance (O&M) manuals, as described in Section 6.01, have been supplied to the applicant following construction and commissioning of the pump station/force main system.

1.04 Exclusions

- A. The following types of projects involving pump stations and force mains shall be deemed permitted:
 - 1. A building sewer, defined in 15A NCAC 2T .0303(1) and documented by the local building inspector to be in compliance with the North Carolina State Plumbing Code, that involves a sewage ejector or pump station, which serves a single building with the sole purpose of conveying wastewater from that building into a gravity sewer that runs on or adjacent to the building's property.
 - 2. A pump station, documented by the local building inspector to be in compliance with the North Carolina State Plumbing Code, that serves a single building whose force main crosses property lines or runs along right-of-way and has no other pump station connections. The force main, however, shall require a permit as stipulated in 15A NCAC 2T .0300.
 - 3. Operations that involve the routine maintenance, replacement, or rehabilitation of existing pump stations and/or force mains in accordance with 15A NCAC 2T .0303(4).
- B. The following types of projects involving pump stations and force mains shall not be submitted for review under the pump station/force main fast-track permitting process:
 - 1. Pump station and force main projects that require an environmental assessment in accordance with 15A NCAC 1C .0100 "State Environmental Protection Act."
 - 2. Pump station and force main projects that do not meet any part of this minimum design criteria document.
 - 3. Pump station and force main projects that involve a variance from the requirements of 15A NCAC 2T .0300.
 - 4. Pressure sewer systems utilizing septic tank-effluent pumps (STEPS) or grinder pumps.
 - 5. Vacuum sewer systems.
 - 6. Gravity sewer systems.
- C. Projects that involve both gravity sewer and pump station/force main systems may be submitted simultaneously for permit issuance under the fast-track permitting process using the most recent version of the application form entitled Fast-Track Application for Gravity Sewer, Pump Station, and Force Main Systems (FTA).

2.00 Pump Design

2.01 General Requirements

- A. Only pumps designed and manufactured for use in conveying raw, unscreened wastewater shall be acceptable.
- B. Pump selection shall consider the duty requirements as well as the physical and chemical characteristics of the wastewater being conveyed. Materials used in pump construction shall also be suitable for the physical and chemical characteristics of the wastewater being conveyed.
- C. Pump stations conveying residential, commercial, institutional, or industrial domestic wastewater shall be provided with pumps that are suitable for continuous duty in conveying raw, unscreened wastewater.
 - 1. Pumps shall be capable of handling a three-inch solid and any trash or stringy material that can pass through a four-inch hose unless a mechanical means of solids reduction is installed at the pump station.

- a. Pumps shall be made non-clog either by passing solids, trash, and stringy material through a non-clog- or vortex-type impeller or by grinding, chopping, or cutting them prior to passing them through the impeller. Impellers shall have blades that are generally forward rounded or otherwise configured to avoid catching solids, trash, and stringy material.
 - b. Acceptable mechanical means of solids reduction shall include mechanical bar screens, communitors, dimmunitors, or other similar devices. The use of a manual bar screen or trash basket at the pump station shall not be sufficient to apply this exception.
2. Pump suction and discharge openings shall be no less than four inches in diameter unless the pump is capable of grinding, chopping, or cutting solids or a mechanical means of reducing the size of a three-inch solid and any trash or stringy material that can pass through a four-inch hose is installed at the pump station.
 3. Pumps shall be designed for continuous duty pumping of raw, unscreened wastewater. Pumps shall be adequately protected from damage due to failure conditions specific to the selected pump type and pump station configuration.

2.02 Number and Capacity

- A. Pump stations shall be provided with the number and capacity of pumps that is stipulated in 15A NCAC 2T .0305(h)(1)(A).
 1. Multiple pumps shall be used such that the pump station is capable of conveying the peak hourly wastewater flow to its desired outfall location with the largest single pump out of service.
 - a. In duplex pump stations, the pumps shall be of the same capacity.
 - b. If pumps in series are required to meet capacity or total dynamic head requirement, each set of pumps in series shall be viewed as a single pumping unit.
 - c. Priming pumps as well as any other auxiliary system that is required for pump functionality shall also be provided in multiple numbers.
 2. Determination of pump capacity shall be based on wastewater flows expected to become tributary to the pump station for the entire project/development at build out. For regional pump stations, pump capacity shall be based on wastewater flows expected to become tributary from the entire service area over the life of the pump station.
 - a. Interim sizing of pumps and associated pump stations shall be allowable; however, it shall only be used to meet requirements as set forth in 15A NCAC 2T .0305(h) or the minimum design criteria contained in this document and not for economic purposes.
 - b. A conspicuous statement that specifies the initial service capacity shall be provided on the drawings for projects that are approved for an interim condition. Additional wastewater flows (i.e., those in excess of that approved for the interim condition) shall not be made tributary to the pump station until a request for permit modification is submitted to and approved by the Division, the pumps and associated pump station are upgraded, and the required certificate of completion and other supporting documentation are received by the Division.
 3. The minimum allowable design daily wastewater flow to the pump station shall be determined in accordance with 15A NCAC 2T .0114.

- a. Where a pump station is designed to serve a developed service area, historical potable water use or wastewater flow generation data may be used to determine design daily wastewater flows.
 - b. Where a pump station is designed to serve a broad service area for which specific development is not known, design daily wastewater flows may be established based on historical data for the broad service area or established long-range wastewater planning criteria.
4. The selected peak hourly wastewater flow to the pump station shall be appropriate for the service area as well as the associated wastewater generation patterns and population being served by the pump station. The Division recommends that the minimum peak hourly wastewater flow to the pump station be calculated using the design daily wastewater flow in conjunction with a peaking factor determined from the following equation:

$PF = \frac{Q_{phf}}{Q_{ddf}} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}}$	<i>PF = peaking factor</i> <i>Q_{phf} = peak hourly flow (gallons per day)</i> <i>Q_{ddf} = design daily flow (gallons per day)</i> <i>P = service population (thousands)</i>
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- a. The above equation yields a peaking factor that is intended to cover normal infiltration and inflow for well-maintained sewer systems and/or those built with modern materials and construction methods. Consideration shall be given to applying higher peaking factors for special conditions such as pump stations serving older collection systems, those serving collection systems located in areas with high actual groundwater tables, those serving areas that have combined sewer systems, etc. Infiltration and inflow allowances shall be incorporated using actual flow data whenever possible.
 - b. Peaking factors for pump stations conveying industrial or other process wastewater shall be determined based on actual operating conditions of the facility; however, in no case shall the peaking factor be less than the minimum set forth in Section 2.02A.4.c.
 - c. In no case shall a peaking factor less than 2.5 be used to calculate peak hourly wastewater flows for any pump station.
- B. Pump capacity shall also be based upon the need to maintain a minimum velocity of two feet per second in the force main.

2.03 Selection Methodology

- A. Pump selection shall be based on a hydraulic analysis of the system through which the wastewater is to be conveyed.
 - 1. The design operating point(s) of the pump(s) shall be determined using a pump curve-system curve analysis. Pumps shall be selected such that the pumps shall be capable of pumping the required capacity, as described in Section 2.02, for all total dynamic head requirements developed by the system for the lifetime of the pump station.

- a. A system curve, plotting total dynamic head versus capacity, shall be developed for all operating conditions that may be imposed on the system. Total dynamic head requirements for the system shall be calculated as the total of the following individual components:
 - i. Static head requirements of the system, including that associated with both the suction and discharge sides of the pumps, shall be evaluated. In addition to calculating static head with the discharge elevation of the force main, any intermediate high points in the force main that would have an effect on the total dynamic head requirements of the pump shall be analyzed.
 - ii. Friction head requirements of the system, including that associated with both the suction and discharge sides of the pumps, shall be evaluated. The friction head shall be calculated using the Hazen-Williams formula:

$$h_f = L \left(\frac{10.44Q^{1.85}}{C^{1.85} D^{4.87}} \right)$$

h_f = friction head for pipe segment evaluated (feet)
L = length of pipe segment evaluated (feet)
Q = pumping rate (gallons per minute)
C = Hazen-Williams coefficient
D = diameter of pipe segment evaluated (inches)

All operating conditions shall be evaluated including, but shall not be limited to, multiple pump operation within the subject force main, simultaneous pump station operation for common force main situations, as well as the possibility for gravity flow conditions in force main segments with extreme negative slopes that may not flow full.

- iii. Head derived from any minor losses of the system, including that associated with the both the suction side and discharge side of the pump, shall be evaluated. Such minor losses shall include head derived from valves and other fittings such as tees, bends, angles, etc.
 - iv. If applicable, the pressure head at the junction of the existing force main shall also be evaluated for its effect on the total dynamic head requirements of the system. The evaluation shall take into account the effects of simultaneous pump station operation as well as multiple pump operation in other pump stations.
- a. System curves shall be generated and evaluated not only for present day conditions, but also for those conditions that may exist over the expected lifetime of the pump station.
 - i. The Hazen-Williams friction coefficient, C, appropriate for the force main pipe material and age of the force main shall be used.
 - ii. The following maximum values shall be allowable for C:

Pipe Type	Initial Service C	End-of-Service C
DI	125	100
PVC	140	120
HDPE	140	120

- iii. Friction head and minor losses associated with the system shall be evaluated at both the initial service condition and the end-of-service condition.
 - c. The design operating point(s) shall be defined as the intersection of the pump curve and the calculated system curve(s).
- 2. Pumps shall be selected such that all design operating points are on the pump curve as supplied by the pump manufacturer. In addition, pumps shall be selected such that the net positive suction head available (NPSH_A) shall be greater than the net positive suction head required for the pump (NPSH_R) at each of the design operating points.
- 3. Pumps shall be selected such that the pumps will not cavitate at any of the design operating points. Pumps that operate within the unstable portion of the pump curve under any of the expected design conditions shall not be allowed. Freewheeling (i.e., operating at pump run-out) or deadheading (i.e., operating at pump shut-off) of pumps shall not be allowed.
- 4. To the greatest extent possible, pumps shall be selected such that their operating efficiency is maximized during all hydraulic conditions that may exist over the expected lifetime of the pump station.
- B. Consideration shall be given to minimizing motor speeds during the pump selection process.
- C. The horsepower rating of each pump motor shall be at least 1.15 times that required by the pump when operating at all design operating conditions.

2.04 Cycle and Pump Run Times

- A. Constant speed pumps shall be cycled such that the number of starts are minimized and resting times are maximized to avoid overheating and overstressing of the pump motor.
 - 1. Automatic pump alternation shall be provided.
 - 2. Pumps shall be designed to operate between two and eight times per hour at design daily flow, whenever practicable (see Section 2.04A.2.b.).
 - a. The following equation shall be used to determine the active storage volume in the pump station (i.e., the volume between the pump-on and all pump-off elevations) required to elicit the required pump cycle time:

$$V = TQ_{ddf} \left(1 - \frac{Q_{ddf}}{Q} \right)$$

V = active volume within the pump station (gallons)
T = allowable cycle time between starts (minutes)
Q_{ddf} = design daily flow to pump station (gallons per minute)
Q = pumping rate of a single pump (gallons per minute)

- b. If the wastewater generation patterns are such that less than two pumping cycles per hour will occur at design daily flow or if the pump station is intended to provide equalization of hydraulic surges, measures to control odor and corrosion shall be employed when resultant detention times cause septic conditions. These measures shall take into consideration protection of the pump station, the force main, the outfall sewer, any related appurtenances, as well as the surrounding area.
 - B. Consideration shall be given to using variable speed pumps for main pump stations or those pump stations that discharge directly into a wastewater treatment facility.
 - C. Pump run times shall be such that excessive wear of the pumps does not occur.
 - 1. At design daily flow, adequate time shall be provided to allow a constant speed pump to “ramp up” to full speed before the pumping cycle ends.

2. Pump run times at design daily flow shall not be less than or greater than those recommended by the pump manufacturer.

3.00 Pump Station Design

3.01 General Requirements

- A. Pump stations shall be designed to achieve total containment of the influent wastewater prior to being conveyed through the force main.
- B. Pump stations shall be designed such that infiltration and inflow is minimized

3.02 Site Selection

- A. Location and Access
 1. Pump stations shall be located and designed to minimize the development of nuisance conditions (i.e., noise, odor, etc.) in the surrounding area.
 2. Pump station sites shall be accessible by an all-weather roadway
 - a. The roadway shall be provided from a hard surface road.
 - b. Wherever practicable, no portion of the roadway shall be located below the 100-year flood elevation as identified on the most recent FEMA Flood Insurance Rate map when available or as established through appropriate modeling techniques.
 - c. The roadway shall be designed to accommodate the largest vehicle expected to service the pump station. In no case shall the roadway be less than 12 feet in width. Roadway widths may be reduced in order to mitigate wetland impacts.
 - d. At a minimum, the roadway shall be constructed from a six-inch layer of compacted aggregate base course (ABC) stone. In no case shall uncompacted gravel or stone material be allowed for roadway construction.
- B. Security
 1. Access to the pump station structures as well as all associated equipment and appurtenances shall be restricted in accordance with 15A NCAC 2T .0305(h)(4).
 - a. All ports of entry into pump station structures shall be locked.
 - b. Fencing provided around pump station structures shall be of sufficient height and material to deter entry. Locked gates, a minimum of 12-feet wide, shall be provided in the fence to allow vehicular access by operation and maintenance staff. Consideration shall be given to complying with the requirements in Section 3.02B.1.c. as well.
 - c. If neither a building nor fencing is provided to protect pump station structures, all access hatches to the wet well, dry well, and other pump station structures shall be padlocked. In addition, padlocked and deadfront-type control and electrical panels shall be provided.
 2. The pump station shall be provided with adequate outdoor and indoor lighting to facilitate normal and emergency operation and maintenance activities during daylight and non-daylight hours.
 3. Safety placards for all pump station structures and equipment, as required by OSHA, shall be provided and be readily visible.

3.03 *Structural Design*

A. Materials of Construction

1. Pump station structures shall be designed and built in complete compliance with all applicable state, local, and federal codes as well as any applicable OSHA standards.
2. Material selection for pump station structures shall be based on installation and operating factors including, but not limited to, the following:
 - a. Physical, chemical, and biological wastewater characteristics.
 - b. Corrosive gas production.
 - c. Soil characteristics.
 - d. Groundwater presence.
3. Pump station structures shall be completely separated unless made completely watertight and gas-tight.
4. Pump station structures shall be adequately protected to minimize damage from vehicular traffic.

B. Buoyancy Protection

1. Below-ground pump station structures shall be protected from the buoyant forces of groundwater.
2. Buoyancy protection shall be demonstrated through the use of flotation calculations.
 - a. Flotation calculations shall be performed on below-ground pump station structures using the assumption that the elevation of the groundwater table is equivalent to the ground elevation.
 - b. Flotation calculations shall not add the weight of the pumps, internal piping and appurtenances, or wastewater present in the pump station, including the wastewater below the all pumps-off activation level, into the downward forces used to counteract buoyancy.
 - c. The use of the saturated weight of any soil above the extended footing of the pump station structure shall be allowed in the flotation calculations.
3. Flotation calculations shall show that the design of the below-ground pump station structures will be protected from buoyancy with a factor of safety that is equal to or greater than one.

C. Flood Resistance

1. Pump station structures as well as all associated equipment and appurtenances shall be protected from the 100-year flood, in accordance with 15A NCAC 2T .0305(e).
 - a. Such protection measures shall ensure that the pump station shall remain fully functional, operational, and free from physical damage during a 100-year flood.
 - b. The pump station shall be protected from inundation of floodwaters by elevating structures at least two-feet above the 100-year flood elevation. An alternate design shall include providing all pump station structures with watertight ports of entry as well as electrical, instrumentation/control, and ventilation systems that are elevated at least two-feet above the 100-year flood elevations.

2. The 100-year flood elevation shall be that as identified on the most recent FEMA Flood Insurance Rate map when available or as established through appropriate modeling techniques.

D. Solids Collection

1. Wet wells shall be designed to minimize pump or pump suction piping operational problems resulting from the accumulation of solids and grit material within the wet well.
 - a. Acceptable designs include the use of fillets and sloped wet well floors alone or in conjunction with a hopper bottom.
 - b. The design of fillets and slopes shall be such that solids are effectively moved toward the pump or pump suction piping.
2. No projections within the wet well which would allow deposition of solids under normal operating conditions shall be allowed.

E. Depth

1. Pump Submergence Depth
 - a. Sufficient submergence of the pump or pump suction piping shall be provided to prevent the occurrence of vortexing within the wet well
 - b. In no case shall the all pumps-off activation level be less than the minimum level required for successful pump operation, as recommended by the pump manufacturer.
2. The wet well shall be provided with a depth as required to maintain the active storage volume as required in Section 2.04A.2.a.
3. The wet well shall be provided with a depth as required to maintain the emergency storage volume as required in Section 5.04B.3 and Section 5.04B.4.

3.04 Piping and Valves

A. Suction and Discharge Piping Configurations

1. Each pump shall be provided with separate suction and discharge piping systems.
 - a. Pump suction and discharge piping shall be no less than four inches in diameter unless the pump is capable of grinding, chopping, or cutting solids or a mechanical means of reducing the size of a three-inch solid and any trash or stringy material that can pass through a four-inch hose is installed in the pump station. Acceptable mechanical means of solids reduction shall be as defined in Section 2.01C.1.b.
 - b. The ultimate pump suction and discharge piping sized shall be selected such that a velocity of between two and eight feet per second is effected.
2. The suction and discharge piping systems shall be provided with sufficient valves to effect proper operation and maintenance of the pump station during both normal and emergency conditions.
 - a. Selected valves shall be suitable for use with raw, unscreened wastewater and shall be of a design suitable for its function, its installation location, as well as the normal and maximum operating pressures expected at the pump station.
 - i. A full-closing shut-off valve shall be provided on the discharge piping of each pump and on the suction piping of each dry well pump.

- ii. A check valve shall be provided on the discharge piping of each pump, between the pump and the shut-off valve. Check valves shall be placed in the horizontal position unless the valve is of a ball check-type.
 - b. All valves shall be located such that they are readily accessible. The Division recommends that valves be placed either in the dry well or in a separate valve vault. If valves are to be installed in a wet well, at a minimum, the shut-off valve shall be provided with an extension handle such that entry into the wet well is not required to operate this valve.
- B. Pipe Connections
 - 1. Flexible pipe joints shall be used on pipes between the pump station structures to allow for differential settlement without compromising the integrity of the overall pump station.
 - 2. Pipe inlets and outlets of pump station structures shall be made watertight.
 - 3. Existing pump station structures shall be core drilled or saw-cut when connections are made through the structure wall. In no case shall penetrations into pump station structures be made by hammering.
- C. Water Service
 - 1. Wherever practicable or required by the design, potable or reclaimed water service shall be provided to the pump station.
 - 2. Cross-connection control for potable water services shall be provided in accordance with 15A NCAC 18C .0406(b). Cross-connection control for reclaimed water services shall be provided in accordance with 15A NCAC 2T .0909(f).
- D. Pig Launching/Retrieval Stations
 - 1. When pig launching and retrieval stations are made part of the pump station, their design shall be such that they may be isolated from the force main.
 - 2. The design of the pig retrieval station shall be such that accumulated material dislodged from the force main may be properly removed and disposed.

3.05 Appurtenances

- A. Consideration shall be given to protecting pump station structures and equipment from physical damage or clogging from solid material normally present in wastewater through the use of screening and other solids reducing equipment.
- B. Pump Removal Methods/Equipment
 - 1. Provisions shall be so that the largest piece of equipment installed at the pump station may be removed. Such provision may include supplying of hoisting equipment and/or designing sufficient clearance around the pump station for mobile hoisting equipment access.
 - 2. Pump station structures shall be provided with access hatches, doors, sky lights, etc. of sufficient size such that the largest piece of equipment may be removed without damaging the integrity of the structural design.
 - 3. Pump stations utilizing submersible pumps installed in wet wells shall be provided with a system that allows for the removal and installation of the pumps without requiring entry into the wet well.
 - a. Each pump shall be provided with a guide rail or cable system and a lift-out chain or cable.

- b. Both the guide rail/cable system and the lift-out chain/cable shall be capable of withstanding the forces required to disengage the pump from the wet well.
 - c. Both the guide rail/cable system and the lift-out chain/cable shall be manufactured of stainless steel, aluminum, plastic, fiberglass, or other corrosion-resistant material. Under no circumstances shall steel or galvanized steel be used.
- C. Access Equipment
 - 1. Each pump station structure shall be designed such that access to perform routine and emergency operation and maintenance is easy, unobstructed, and safe.
 - 2. Each pump station structure shall be provided with a separate means of access. Under no circumstance shall access to the wet well be provided through a dry well.
 - 3. Steps, ladders, stairs, landings, hatches, and other means of access shall conform to OSHA standards as well as all applicable local and state building codes regarding design characteristics.
- D. Ventilation Equipment
 - 1. Pump stations shall be adequately vented in accordance with 15A NCAC 2T .0305(h)(3) as well as in complete compliance with all applicable local and state building codes as well as OSHA and NFPA standards.
 - 2. At a minimum, pump station wet wells shall be provided with a gooseneck-type vent. Active ventilation units shall also be acceptable.
 - a. Vents shall be constructed of sturdy material that is resistant to ultraviolet light and adequately supported to withstand damage during normal and emergency operation and maintenance.
 - b. Vent elevations shall be a minimum of two feet above the 100-year flood elevation as identified on the most recent FEMA map when available or as established through appropriate modeling techniques.
 - c. Vents shall be provided with an insect/bird screen of stainless steel, aluminum, corrosion-resistant material. Under no circumstances shall steel or galvanized steel be used.
 - 3. Dry wells or other enclosed pump station structures into which routine operator entry is required shall either have a positive-pressure ventilation system that meets, at a minimum, the requirements of NFPA 820 "Standard for Fire Protection in Wastewater Treatment and Collection Facilities.". Consideration shall be given to installing sensor and alarm systems to detect the accumulation of dangerous levels of hazardous gases.
- E. Other Equipment
 - 1. Consideration shall be given to controlling the pump station temperature and humidity to a level appropriate for reliable operation of the electrical and instrumentation/control systems.
 - 2. Pump station structures other than the wet well shall be provided with a means to remove accumulated water and wastewater from the structure. All floor and walkway surfaces shall be sloped such that water and wastewater drains to the removal area under the influence of gravity. Acceptable removal means include the following:
 - a. An appropriately-sized drainage pipe.

- i. The drainage pipe shall convey accumulated water and wastewater to the wet well or other available entry point into the wastewater collection system. Under no circumstances shall the drainage pipe convey accumulated water and wastewater to daylight, into a surface water, or into the ground.
 - ii. The discharge of the drainage pipe shall be higher than the high-water alarm activation level in the wet well or the maximum water level expected at the other available entry point into the wastewater collection system.
 - iii. The drainage pipe shall be provided with device to prevent backflow of wastewater and gases from the wet well into the structure.
- b. A sump pump system that is capable of automatic and manual operation.
 - i. The sump pump shall be provided with three automatic operating levels: all pumps-off, pump-on, and high-water alarm.
 - ii. The discharge of the sump pump shall be designed to convey accumulated water and wastewater to the wet well or other available entry point into the wastewater collection system. Under no circumstances shall the sump pump discharge convey accumulated water and wastewater to daylight, into a surface water, or into the ground.
 - iii. The discharge of the sump pump shall be higher than the high-water alarm activation level in the wet well or the maximum water level expected at the other available entry point into the wastewater collection system.
 - iv. The discharge piping of the sump pump shall be provided with an appropriate check valve and shut-off valve to prevent back flow of wastewater from the wet well into the structure and to facilitate removal of the sump pump.

4.00 Force Main Design

4.01 Material

- A. Pipe material and specifications shall be selected based on the installation and operating conditions of the force main following installation. Such factors shall include, but shall not be limited to:
 - 1. Installation depth and overburden pressure.
 - 2. Soil conditions and groundwater presence.
 - 3. Corrosion resistance from both external and internal sources.
 - 4. Strength required to withstand internal pressures expected during normal operation as well as those resulting from hydraulic surges and water hammer.
- B. Force mains shall be constructed of one of the following types of pipe:
 - 1. Ductile iron (DI)
 - a. DI pipe shall conform to ANSI/AWWA C151/A21.51 “Ductile Iron Pipe, Centrifugally Cast in Metal Molds for Water or Other Liquids.”

- b. The thickness and pressure class of DI pipe required for the installation and operating conditions during the expected service life of the force main shall be determined in accordance with ANSI/AWWA C150/A21.50 “Thickness Design of Ductile Iron Pipe.”
 - c. Fittings for DI pipe shall conform to ANSI/AWWA C110/A21.10 “Ductile-Iron and Gray-Iron Fittings, 3 In. through 48 In. for Water and Other Liquids” or ANSI/AWWA C153/A21.53 “Ductile Iron Compact Fittings, 3 In. through 24 In. and 54 In. through 66 In., for Water Service.”
 - d. Force mains of DI pipe shall have mechanical or gasketed push-on type joints. If exposed, force mains of DI pipe shall have flanged joints. Restrained joint DI pipe may be used for anchoring purposes as described in Section 4.03C.
 - i. Gaskets shall be manufactured of vulcanized natural or synthetic rubber in accordance with ANSI/AWWA C111/A21.11 “Rubber Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings.”
 - ii. Flanged DI pipe shall conform to ANSI/AWWA C115/A21.15 “Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges.
 - e. Consideration shall be given to the existence of or the potential for development of corrosive environments within and outside the force main shall be performed. Sources of corrosion may include: acidic soils, septic wastewater, and air entrainment within the force main. Where corrosion is deemed to be a serious problem, DI pipe shall be provided with cathodic protection or an internal/external encasement, lining, or coating appropriate for the pipe material and situation. Such encasements, linings, and coatings shall be manufactured or applied in accordance with the appropriate ANSI and AWWA standards.
2. Polyvinyl chloride (PVC)
- a. PVC material used in the manufacture of PVC pipe shall conform to ASTM D1784 “Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.”
 - b. PVC pipe shall conform to ASTM D1785 “Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, 120” or to ASTM D2241 “Poly(Vinyl Chloride) (PVC) (SDR-PR).”
 - c. The thickness and pressure class of PVC pipe required for the installation and operating conditions during the expected service life of the force main shall be determined in accordance with AWWA C900 “Poly(Vinyl Chloride) (PVC) Pressure Pipe, 4 In. through 12 In., for Water” or AWWA C905 “Poly(Vinyl Chloride) (PVC) Water Transmission Pipe, Nominal Diameters 14 In. through 36 In.”
 - d. Force mains of PVC pipe shall have gasketed push-on type joints. Gaskets shall be manufactured of elastomeric material in accordance with ASTM F477 “Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.”

- e. Mechanical joint DI pipe fittings conforming to ANSI/AWWA C110/A21.10 or gasketed PVC fittings shall be used for force mains four inches in diameter and larger. Solvent-welded or gasketed fittings may be used for smaller diameter force mains.
3. High-Density Polyethylene Pipe (HDPE)
- a. HDPE pipe shall be produced from a high molecular weight, high density, polyethylene resin, meeting the requirements of ASTM D3350 “Standard Specification for Polyethylene (PE) Plastic Pipe and Fitting Materials.” Resin material shall be listed by PPI in the name of the manufacturer and shall be based on testing in accordance with ASTM D2837 “Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe.”
 - b. HDPE pipe shall conform to ASTM D3035 “Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter” or ASTM F714 “D3035 “Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.”
 - c. The thickness and pressure class of HDPE pipe required for the installation and operating conditions during the expected service life of the force main shall be determined in accordance with AWWA C906 “Polyethylene (PE) Pressure Pipe and Fittings, 4 In. through 63 In., for Water Distribution.”
 - d. Fittings for HDPE pipe shall conform to ASTM D3261 “Standard Specification for Butt Fusion of Polyethylene (PE) Plastic Fittings for PE Plastic Pipe and Tubing ” and shall be manufactured by injection molding, a combination of extrusion and machining, or fabrication from HDPE pipe material.
 - e. Force mains of HDPE pipe shall be joined by the thermal butt fusion process and shall be performed in accordance with ASTM A2657 “Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings” and the manufacturer’s recommendations during installation.
4. All pipe used for force main construction shall be labeled or otherwise identified as conveying wastewater.

4.02 Diameter

- A. The pipe diameter of the force main shall be larger than the diameter of the maximum solid size that is passed by pumps present in the pump station.
 - 1. A minimum four-inch force main shall be used unless the force main is served by pumps capable of grinding, chopping, or cutting solids or a mechanical means of reducing the size of a three-inch solid and any trash or stringy material that can pass through a four-inch hose is installed in the pump station. Acceptable mechanical means of solids reduction shall be as defined in Section 2.01C.1.b.

4.03 Velocity

- A. Wastewater velocity occurring in a force main shall be calculated using the continuity equation:

$v = \frac{0.409Q}{D^2}$	<p><i>v</i> = velocity (feet per second) <i>Q</i> = pumping rate of single pump (gallons per minute) <i>D</i> = diameter of pipe segment evaluated (inches)</p>
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- B. A self-cleansing velocity of at least two feet per second shall be provided throughout the length of the force main.
 - 1. Consideration shall be given to preventing or alleviating the accumulation of solids in the force main by providing one or more of the following:
 - a. The ability to provide velocities of between three and five feet per second during a cleaning event that are suitable to resuspend any solids that may have settled out.
 - b. Drain or blow-off valves provided at all low points in the force main. Such valves shall either be connected to an available entry point into the wastewater collection system, provided with a connection for a vacuum pumper truck, and designed with some other method to prevent an intentional discharge of wastewater during their operation.
 - c. Flushing ports along the length of the force main as well as a water supply of sufficient quantity and pressure. Such ports shall either be connected to an available entry point into the wastewater collection system, provided with a connection for a vacuum pumper truck, and designed with some other method to prevent an intentional discharge of wastewater during their operation.
 - d. Pigging device launching and retrieval stations of a size sufficient to clean the inside diameter of the force main.
 - 2. Compliance with Section 4.03B.1. shall also be required when engineering calculations determine that depressed sections of the force main will not be completely flushed in a single pumping cycle.
- C. Anchorage
 - 1. Force mains shall be adequately anchored to resist thrusts that may develop at bends, tees, plugs, and at any other location where a change in flow direction occurs.
 - a. Such anchoring shall be provided through the use of concrete thrust blocking or restrained joint pipe.
 - i. Concrete thrust blocks shall be located between the fitting to be anchored and undisturbed soil material. Appropriate thrust reaction block bearing areas shall be calculated based not only on the maximum expected force but also on the soil material. Concrete thrust blocks shall have a minimum compressive strength of 2,000 pounds per square inch.
 - ii. Self-restrained joints or joints restrained with tie rods and clamps shall both be acceptable. In both cases, component parts shall either be manufactured of corrosion-resistant materials or coated liberally with a corrosion-retarding product.
 - b. Anchoring devices shall be designed to withstand force main pressures of at least 25 percent greater than the maximum pump shut-off head plus an allowance for water hammer and an appropriate factor of safety.

4.04 *Surge and Water Hammer*

- A. Consideration shall be given to analyzing force mains in conjunction with their associated pump stations with respect to the development of hydraulic transients.

- B. Force main design shall be such that active devices for control of transient hydraulic conditions are minimized to the greatest extent possible. However, if this is not feasible, the following shall be acceptable control strategies:
1. Variable-speed pumps or constant-speed pumps in combination with control valves that open and close slowly.
 2. Providing air scouring velocities in the force main.
 3. Construction of the force main using a higher-strength pipe.
 4. Vacuum relief valves in accordance with Section 4.05A.
 5. Specialized control and/or release valves and other devices designed to prevent transient pressures from reaching levels that could damage the pump station and force main systems.

4.05 Appurtenances

- A. Air Release and Vacuum Relief Valves
1. The route of the force main shall be such that the number of air release and vacuum relief valves are minimized to the greatest extent possible.
 2. In accordance with 15A NCAC 2T .0305(h)(5), an air release valve shall be provided at all high points to prevent air locking of the force main. The Division has interpreted this regulation as requiring an air release valve at locations where the distance between the low point and high point in the force main exceeds 10 vertical feet.
 - a. Automatic or manual air release valves shall be acceptable.
 - b. Consideration shall be given to using manual air release valves in lieu of automatic air release valves or providing automatic air release valves with flood protection in areas within the 100-year floodplain or any where flooding is anticipated to occur.
 - c. Automatic air valves shall be of the quick-opening, slow-closing type to prevent the development of hydraulic surge conditions.
 3. Consideration shall be given to locating vacuum relief valves at locations along the force main where sub-atmospheric pressures or column separation may occur.

4.06 Installation

- A. Joints and Bedding
1. Force mains shall be installed such that pipe and joint deflection is minimized.
 - a. Force mains of DI pipe shall be installed in accordance with AWWA C600 "Installation of Ductile Iron Water Mains and Their Appurtenances."
 - b. Force mains of PVC pipe shall be installed in accordance with AWWA C605 "Installation of Underground Installation of Polyvinyl Chloride (PVC) Pipe and Fittings for Water."
 - c. Force mains of HDPE pipe shall be installed as described in Section 4.01B.3.e. Contractors shall be fully-trained and qualified by the manufacturer to install HDPE pipe.
 2. Continuous and uniform bedding, hunching, and backfill that is appropriate for the soil type and pipe material shall be provided in the force main trench.

B. Burial

1. A minimum burial depth of three feet as measured from the crown of the pipe to the ground surface shall be provided throughout the length of the force main in accordance with 15A NCAC 2T .0305(f). Consideration shall be given to utilizing a greater burial depth in locations where the frost depth exceeds three feet.
2. In the event that the appropriate installation depth cannot be met by the design, the force main shall be constructed of ferrous pipe or provided with a ferrous pipe encasement in accordance with 15A NCAC 2H .0305(g)(4).

C. Separations

1. Minimum separations between pump stations/force mains and natural features, other utilities, etc. shall be maintained in accordance with 15A NCAC 2T .0305(f).
2. Stream Crossings
 - a. Force mains shall be routed such that the number of stream crossings is minimized. When a stream crossing is required by the design, the crossing shall be as nearly perpendicular to the stream flow as possible.
 - b. DI pipe with joints equivalent to water main standards or a watertight ferrous encasement pipe shall be used to construct force mains that cross streams. The DI or encasement pipe shall be extended horizontally for a length equal to that required by 15A NCAC 2T .0305(f) either side of the stream.
 - c. Force main bedding, haunching, and backfill shall be appropriate for the installation location and pipe material. However, the ability of the bedding and backfill material to readily erode, cause siltation, damage the force main during installation, and corrode the force main after installation shall also be considered.
 - d. Only DI with flanged joints, used in conjunction with adequate supports, shall be used for aerial stream crossings.
 - i. Supports for aerial stream crossings shall be designed to prevent frost heave, overturning, and settlement.
 - ii. The force man shall be adequately protected from freezing and heaving.
 - iii. The impact of floodwaters and debris shall be considered during the design of aerial crossings. The bottom of the force main pips shall be placed no lower than the elevation of the 25-year flood stage of the stream.
3. In the event that the appropriate separation cannot be met by the design, the force main shall be constructed of ferrous pipe material with joints equivalent to water main standards or provided with a watertight, ferrous pipe encasement. However, force mains shall not be closer than 25 feet from a private water supply well or 50 feet from a public water supply well, even if ferrous pipe material with joints equivalent to water main standards is used.

5.00 Electrical and Instrumentation/Control Systems Design

5.01 General Requirements

- A. Electrical systems for pump stations shall be designed and installed in strict conformance with NFPA 70 “National Electric Code,” ANSI, as well as all applicable federal, state, and local codes.
 - 1. In general, electrical and instrumentation/control systems and components shall be protected against corrosive conditions.
 - 2. If located in a wet well or other location where explosive or flammable gases may concentrate, electrical and instrumentation/control systems and components shall meet the requirements for a Class I, Group D, Division 1 location.
- B. Each pump and motor unit shall be provided with a separate electrical supply, motor starter, alarm sensors, as well as electrical and instrumentation/control systems and components.
 - 1. Electrical and instrumentation/control systems and components shall be located such that they may be disconnected from outside a wet well.
 - 2. Cables and conduits shall be provided with seals that are both water-tight and gas-tight, shall be protected from corrosion, and shall allow separate strain relief.
- C. The main power feed to all pump stations shall be equipped with an above-grade, fused disconnect switch.

5.02 Enclosures

- A. Enclosures for electrical and control components for the pump station shall be located outside of the wet well and in a location such that they are readily accessible, ensure maximum electrical and personnel safety, and are protected from damage due to vehicular traffic and flooding.
- B. Enclosures shall have a NEMA-rating that is appropriate for the installation location at the pump station.
 - 1. If not housed, enclosures shall have a minimum NEMA 3R rating. NEMA 4X enclosures shall be used in locations where the potential for flooding and the development and accumulation of corrosive gases exist. However, the Division recommends the use of NEMA 4X enclosures for all outdoor installations.
 - 2. Enclosures shall be protected by a conduit seal or other appropriate sealing method that meets the requirements of NFPA 70 to protect the wet well atmosphere from gaining access to the enclosure. This seal shall be located such that it will not be disturbed during routine operation and maintenance functions at the wet well for a Class I, Division 2 location.
- C. All enclosures as well as all switches and indicator lights, whether mounted on an inner door or face of the enclosure, shall be provided with a label that conforms to UL descriptions and procedures.
- D. The applicant’s lock-out/tag-out procedures shall be considered in the design of all enclosures to be installed at the pump station.

5.03 Instrumentation and Controls

- A. Wastewater Level Sensing Equipment
 - 1. Pump station cycles, as described in Section 2.04A.2., shall be controlled through the use of wastewater level sensing equipment in the wet well.

2. At a minimum, wastewater levels within the wet well shall be detected through the use of sealed mercury-type float switches. In the event that an alternate method of level detection (i.e., bubble tube, ultrasonic meter, etc.) is used, a float switch at the high-water alarm level shall be installed as a back-up.
3. Wastewater level sensing equipment shall be used to indicate the following levels and operate the pump station correspondingly: all pumps off, lead pump on, lag pump on, and high-water alarm.
4. Wastewater level sensing equipment shall be located so as not to be affected by flows entering the wet well or the turbulence created by the suction of the pump.

B. Components

1. The pump station shall be equipped with sufficient instrumentation/control systems and components to monitor and control key operating conditions.
2. At a minimum, the following systems and components shall be provided for the pump station:
 - a. Pump Station Function
 - i. Each pump installed at the pump station shall be provided with a “Hand-Off-Auto” selector switch so that the operational mode of the pump may be selected.
 - ii. Each pump installed at the pump station shall have a pump run timer that is capable of keeping a cumulative log of the operational time of each pump.
 - b. Sufficient indicator lights shall be used to demonstrate the operational status of the pump station. The indication lights shall be specific to the condition detected. At a minimum, indicator lights shall be provided for each pump to indicate a pump on condition and a pump alarm/failure condition.
 - c. Weather-proof audible and visual alarms that are external to any structure or enclosure shall be provided at the pump station in accordance with 15A NCAC 2T .0305(h)(1)(F). In the event of a power loss at the pump station or a failure of the automatically-activated stand-by power generation source, the alarm system shall be operated from a battery back-up power source. This battery back-up power source shall be provided with continuous charge. At a minimum, the following conditions shall be monitored by the system, and each shall cause activation of the audible and visual alarms:
 - i. Pump failure.
 - ii. Wastewater level sensing failure (if applicable).
 - iii. High-water in the wet well.
 - iii. High-water level in the dry well sump (if applicable).
 - iv. Loss of telemetry transmission line (if applicable).
 - v. Loss of power supply.
 - vi. Automatically-activated stand-by power generation source failure (if applicable).

- d. The Division highly recommends that a telemetry system be installed at all pump stations, regardless of the reliability method employed in the pump station design as stipulated by Section 5.04. 15A NCAC 2T .0305(h)(1)(E) requires that pump stations not connected to a telemetry system be inspected at least three times per week until July 1, 2000; thereafter, such pump stations shall be inspected daily, as defined in 15A NCAC 2B .0503(5), until July 1, 2001; and thereafter, such pump stations shall be inspected every day. Pump stations that are connected to a telemetry system shall be inspected once per week.
 - i. The telemetry system shall contact personnel capable of initiating a response to a pump station alarm condition 24 hours per day, 365 days per year.
 - ii. In the event of a power supply loss at the pump station or a failure of the automatically-activated stand-by power generation source, the telemetry system shall be operated from a battery back-up power source. This battery back-up power source shall be provided with continuous charge.
 - iii. The Division highly recommends that the telemetry system alert for all of the alarm conditions designed into the pump station instrumentation/control system. However, at a minimum, the telemetry system shall be activated for any of the following alarm conditions: high-water in the wet well, pump failure, loss of power supply, and automatically-activated stand-by power generation source failure (if applicable).
- e. Appurtenances
 - i. Sufficient 110-volt electrical receptacles shall be provided to facilitate maintenance at the pump station. If located in an outdoor area, the receptacles shall be of the ground fault interruptible type and shall be protected from the weather elements.
 - ii. If reliability for the pump station is based on a contingency plan that involves portable power generation units (see Section 5.04B.3.), the pump station shall be provided with a quick connection receptacle that mates with the pigtail of the applicant's unit that will be utilized at the pump station. This receptacle shall facilitate easy installation and start-up of the unit in the event of a power supply failure. The quick connection receptacle shall be located outside of any enclosure and shall be protected from the weather elements.

5.04 Reliability

- A. Pump station reliability shall be in accordance with 15A NCAC 2T .0305(h)(1) and shall be considered a key, integral part of the overall pump station design.
- B. One of the following reliability options shall be incorporated into the pump station design:
 - 1. The pump station shall be connected to multiple power sources.
 - a. A multiple power source shall be defined as a completely separate power feeder line(s) connected to the pump station from a substation or transformer that is independent from the primary feeder.

- b. Each separate substation or transformer and associated transmission lines shall be capable of starting and operating the pump station at its rated capacity.
- 2. The pump station shall be connected to an automatically-activated stand-by power generation source with automatic reset.
 - a. The generation unit shall be capable of powering the pump motors' starting current, electrical systems, instrumentation/controls and alarm systems, and other auxiliary equipment as may be necessary to provide for the safe and effective operation of the pump station.
 - i. The generation unit shall have the appropriate power rating to start and continuously operate under all connected loads.
 - ii. The generation unit shall be provided with special sequencing controls to delay lead and lag pump starts unless the generating unit has the capacity to start all pumps simultaneously while the auxiliary equipment is operating.
 - b. The generation unit shall be protected from operating conditions that would result in damage.
 - i. The generation unit shall be capable of shutting down and activating the audible and visual alarms and telemetry (if applicable) if a damaging operating condition develops.
 - ii. The generation unit shall be protected from damage when restoration of the power supply occurs.
 - c. The generating unit shall be located in a building structure or otherwise protected from the weather elements. The generating unit shall be adequately ventilated.
 - d. The generation unit shall be provided with on-site fuel storage. The volume of on-site fuel storage shall be determined from a number of considerations; however, in no case shall the fuel storage be less than that needed to operate the generating unit for 12 continuous hours.
- 3. The applicant shall have a sufficient number of portable power generation units or portable, independently-powered pumping units and personnel available for distribution and operation of these units.
 - a. A portable power generation unit shall be sized such that it meets or exceeds the electrical requirements of each of the pump stations that the unit is intended to serve. Likewise, a portable, independently-powered pumping unit shall be sized to meet or exceed the operating conditions of each of the pump stations that the unit is intended to serve.
 - b. If the applicant's contingency plan is based on utilizing portable power generation units, the pump station shall be provided with a manual transfer switch, portable generator quick-connection receptacle, a telemetry system with a battery back-up capable of contacting the applicant when the power supply is not available, and sufficient storage capacity in the pump station wet well above the pump-on activation level to hold the wastewater expected to become tributary to the pump station over the period of time during which detection of the power supply failure and transportation and connection of the portable power generation unit occurs.

- c. If the applicant's contingency plan is based on utilizing portable independently-powered pumping units, the pump station shall be provided with a plugged emergency pump connection port, a telemetry system with a battery back-up capable of contacting the applicant when the power supply is not available, and sufficient storage capacity in the pump station wet well above the pump-on activation level to hold the wastewater expected to become tributary to the pump station over the period of time during which detection of the power supply failure and transportation and connection of the portable pumping unit occurs.
 - d. Pump stations that provide reliability through the use of permanent generation units used in conjunction with manual transfer switches shall meet the telemetry system and wet well storage requirements stipulated in Section 5.04B.3.
4. The applicant shall demonstrate a history of power reliability for the power supply serving the pump station.
- a. This option is available only to those pump stations whose failure would impact surface waters that are classified as C in accordance with 15A NCAC 2B .0100.
 - b. Three years worth of data from the power supplier shall be obtained and examined to determine the maximum power outage time at the pump station. Sufficient storage shall be provided in the pump station wet well above the high-water alarm level to hold the wastewater expected to become tributary to the pump station over that period of time.
 - c. Utilizing this option to demonstrate pump station reliability shall be at the applicant's own risk, and the applicant shall be aware that selection of this option does not relieve the applicant of liability or future enforcement problems should a discharge of wastewater occur at the pump station. It is very strongly recommended that, at a minimum, a telemetry system be installed at the pump station, if this reliability option is selected.

6.00 Quality Assurance and Quality Control

6.01 Operations and Maintenance (O&M) Manuals

- A. An O&M Manual shall be prepared for each pump station and shall be made available to the applicant upon start-up of the pump station/force main system.
- B. A copy of the O&M Manual shall be kept at the applicant's main office. The O&M Manual shall be kept on file for the life of the pump station and updated as required.
- C. At a minimum, O&M Manuals shall contain the following minimum information:
 - 1. Approved shop drawings, including design data for all installed equipment and each major component and a pump curve/system curve analysis showing the design operating point(s).
 - 2. Control panel wiring diagrams.
 - 3. Warranty information for all installed equipment and each major component.
 - 4. Inventory, functional descriptions, and complete operating instructions for all installed equipment and each major component.
 - 5. Instructions for start-up/shut-down as well as for calibration and adjustment of all installed equipment and each major component.

6. Recommended maintenance management system, including preventative and predictive maintenance, for all installed equipment and each major component.
7. Contingency plan and analysis of critical safety issues.
8. Contact information for local service companies as well as instructions for replacement of all installed equipment and each major component.
9. Contact information for local contractors capable of performing emergency repairs.
10. Contact information for regulatory and other agencies.

6.02 Pump Station Testing

A. Watertightness Testing

1. Wet wells and other wastewater-containing structures at the pump station shall be inspected and tested for watertightness.
2. The watertightness test for the wet well and other wastewater-containing structures at the pump station shall be completed separately and independently of the leakage test performed on the force main as required in Section 6.04D.
3. The watertightness test shall be performed in the presence of the applicant, the PE, or other authorized representative.
4. The watertightness test shall be performed in accordance with ACI 350.1R “Testing Reinforced Concrete Structures for Watertightness,” AWWA D100 “Welded Steel Tanks for Water Storage,” or the manufacturer’s recommendations. A vacuum test method in accordance with ASTM C1244 “Standard Test Method for Concrete Sewer Manholes by Negative Test Pressure (Vacuum) Test” may be used for small diameter wet wells in lieu of a hydraulic test
 - a. Unless the pump station wet well is constructed of cast-in-place concrete, testing shall not commence until the structure being tested has been fully assembled and backfilling is complete.
 - b. All inlets and outlets in the structure shall be temporarily plugged and braced or otherwise sealed prior to initiating the test.
 - c. Pump station wet wells that fail to meet the watertightness test requirements shall be inspected, made watertight, and retested until the test passage is assured.
5. The results of all watertightness testing shall be maintained by the applicant as part of the construction record documentation as stipulated in Section 1.03B.

6.03 Pump Testing

A. Factory Testing

1. All pumps shall be tested by the manufacturer in accordance with the appropriate HI standard prior to shipment for installation.
2. The results of all factory testing shall be maintained by the applicant as part of the construction record documentation as stipulated in Section 1.03B.

B. Drawdown Testing

Following installation, each pump in the pump station shall be subjected to a drawdown test or other similar testing procedure to confirm that the pump is operating at or near the required design operating point(s).

The drawdown test shall be performed in the presence of the applicant, the PE, or other authorized representative.

The results of all drawdown testing shall be maintained by the applicant as part of the construction record documentation as stipulated in Section 1.03B.

C. Witnessed Testing

1. Consideration shall be given by the applicant to require a witnessed test for large pumps, pumps in critical installations, or pump replacement/repair situations.
2. All witnessed testing shall be performed in accordance with the appropriate HI standard.
3. Witnessed testing shall be performed in the presence of the applicant, the PE, or other authorized representative.
4. The results of all witnessed testing shall be maintained by the applicant as part of the construction record documentation as stipulated in Section 1.03B.

6.04 Force Main Testing

A. General

1. Prior to testing any segment of force main, care shall be taken to prevent the pipe from moving while under pressure.
2. Temporary taps and air releases shall be permissible to facilitate testing.
3. Water used for testing force main installations shall either be disposed in a nearby sanitary sewer, as authorized by the local sewer authority, or in another location in accordance with state and federal laws and regulations.
4. All testing shall be performed in the presence of the applicant, the PE, or other authorized representative.
5. The results of all testing shall be maintained by the applicant as part of the construction record documentation as stipulated in Section 1.03B.

B. Force mains shall be installed in a manner such that pipe deflection is minimized.

C. Pressure Testing

1. A hydrostatic pressure test shall be performed on each segment of installed force main.
2. The test shall be performed after the force main has been backfilled and at least seven days following the pouring of the last thrust block.
3. The following procedures shall be followed in performing hydrostatic pressure tests on force mains:
 - a. The force main segment shall be carefully filled with water at a velocity of approximately one foot per second. Water may be introduced from either the pump station or a temporary connection made in the force main. Appropriate measures necessary to eliminate all air from the force main shall be taken during this process.
 - c. Once full of water, the force main segment shall be pressurized and allowed to stabilize at a minimum test pressure of 1.5 times the maximum design pressure of the force main pipe material.
 - d. This pressure shall be maintained for at least two consecutive hours.
 - e. If the stated pressure cannot be maintained, the applicant is responsible for assuring that the cause of test failure is determined, all necessary repairs are made, and repeating the hydrostatic pressure test until the force main segment passes.

The pressure test may be performed concurrently or separately with the leakage test as required in Section 6.04D.

D. Leakage Testing

1. A leakage test shall be performed on each segment of installed force main at the hydrostatic pressure test stipulated in Section 6.04C.
2. Leakage shall be defined as the quantity of water required to maintain a pressure within five pounds per square inch of the specified test pressure after the pipe has been filled with water and all air has been expelled.
3. Leakage shall be measured with a calibrated test meter and shall not exceed the amount given by the following formula:

$$L = \frac{SD\sqrt{P}}{133,200}$$

S = length of pipe (feet)
L = leakage (gph)
D = nominal diameter of pipe segment tested (inches)
P = test pressure (pounds per square inch)

All visible leaks shall be repaired regardless of the amount of leakage. If leakage exceeds this rate, the applicant is responsible for assuring that the cause of test failure is determined, all necessary repairs are made, and repeating the test until the force main segment passes.

4. The leakage test may be performed concurrently or separately with the leakage test stipulated in Section 6.04D.
- E. Each layer of fill or backfill over the force main shall be compacted to a density needed to accommodate the use of the force main installation area or as otherwise may be required (e.g., encroachment agreement with the North Carolina Department of Transportation, etc.).

6.05 Electrical and Instrumentation/Control System Testing

- A. The applicant shall ensure that a formal testing program of all electrical as well as instrumentation and control systems installed at the pump station is developed and performed.
- B. The program may consist of a combination of unwitnessed/witnessed factory tests, field readiness tests, and witnessed field tests. At a minimum, however, the applicant shall witness a field test of the pump station's electrical and instrumentation/control systems. The basic functions which shall be tested for operation as intended by the pump station design shall include, but shall not be limited to, the following:
 1. Pump operational functions.
 2. Level-sensing equipment.
 3. Alarm system.
 4. Telemetry system.
 5. Stand-by or emergency power system.
- C. All testing of the electrical and instrumentation/control systems shall be performed in the presence of the applicant, the PE, or other authorized representative.
- D. The results of all testing shall be maintained by the applicant as part of the construction record documentation as stipulated in Section 1.03B.