



CLARK REGIONAL
WASTEWATER DISTRICT

DESIGN MANUAL 2010

CLARK REGIONAL WASTEWATER DISTRICT DESIGN MANUAL

INCLUDING:

DESIGN CRITERIA

CONSTRUCTION SPECIFICATIONS

STANDARD DRAWINGS



Adopted by the Clark Regional Wastewater District Board of Commissioners

By Resolution Number **1532**

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TABLE OF CONTENTS

FOR THE

CLARK REGIONAL WASTEWATER DISTRICT

DESIGN CRITERIA

CHAPTER C1 SEWERS.....	1
C1-1 GENERAL REQUIREMENTS	1
C1-1.1 Approvals	1
C1-1.2 Ownership	1
C1-1.3 Design	1
C1-1.3.1 "To and Through Policy"	1
C1-1.3.2 General	2
C1-1.3.3 Approval of Alternate Materials or Methods.....	3
C1-1.3.4 Specialty Designs	3
C1-1.3.5 Plans, Profiles and Record Drawings	3
C1-1.5 Siting Considerations	8
C1-2 INDUSTRIAL AND COMMERCIAL PRETREATMENT	9
C1-3 GRAVITY SYSTEMS DESIGN CONSIDERATIONS	9
C1-3.1 Definitions	9
C1-3.2 Design Period.....	10
C1-3.2.1 Service Laterals.....	10
C1-3.2.2 Collection Sewers.....	10
C1-3.2.3 Trunk and Interceptor Sewers	11
C1-3.3 Design Basis	11
C1-3.3.1 Design for Average Daily Flow	11
C1-3.3.2 Peak Flow.....	12
C1-3.3.3 Infiltration/Inflow	12
C1-3.4 Design Factors	12
C1-4 GRAVITY SEWER DESIGN AND CONSTRUCTION DETAILS	13
C1-4.1 Minimum Size.....	13
C1-4.2 Depth.....	13
C1-4.2.1 Minimum Depth	13
C1-4.3 Roughness Coefficient	13
C1-4.4 Slope (Minimum Velocity).....	14
C1-4.5 Alignment	14
C1-4.6 Increasing Size.....	15
C1-4.7 High-Velocity Protection	15
C1-4.8 Material	15
C1-4.9 Joints.....	15
C1-4.10 Flushing.....	15
C1-5 TESTING.....	15
C1-6 MANHOLES, MONITORING MANHOLES, CLEANOUTS, GREASE INTERCEPTORS, GREASE TRAPS AND OIL- WATER SEPARATORS	15
C1-6.1 Location and Miscellaneous Requirements.....	15
C1-6.2 Connections	17
C1-6.3 Diameter.....	17
C1-6.4 Flow Channels	17
C1-6.5 Watertightness	18
C1-6.7 Frames, Covers, and Steps.....	18
C1-6.8 Liners	18
C1-6.9 Manhole Testing.....	18
C1-6.10 Grease Interceptors.....	18
C1-7 DELETED	18

C1-8 DELETED	18
C1-9 SPECIAL REQUIREMENTS.....	19
C1-9.1 Required Separation between Potable Water Lines, Reclaimed Water Lines, and/or Sanitary Sewers (Rev. 10/2006)	19
C1-9.1.1 Horizontal and Vertical Separation (Parallel).....	19
C1-9.1.2 Unusual Conditions (Parallel)	20
C1-9.1.3 Vertical Separation (Perpendicular).....	20
C1-9.1.4 Unusual Conditions (Perpendicular).....	21
C1-9.2 Pumpout Facilities at Marinas	21
C1-9.3 Stream Crossing	22
C1-9.4 Inverted Siphons	22
C1-9.5 Required Separation from Water Supply Wells	22
C1-9.6 Odor Control.....	22
C1-9.7 Corrosion Control	23
C1-9.8 Trenchless Technologies	23
C1-9.9 Pipe Casing.....	23
C1-10 ALTERNATIVE SYSTEMS	23
C1-10.1 Grinder Pump, Septic Tank Effluent Pump, and Septic Tank Effluent Filter/Small Diameter Gravity Systems	24
C1-10.1.1 Application.....	24
C1-10.1.2 Design Considerations	24
C1-10.1.3 Hydraulic Grade line/Pipeline Sizing	25
C1-10.1.4 Minimum Velocity	25
C1-10.1.5 Pump Selection STEP/GP.....	26
C1-10.1.6 Tank/Vessel Type and Sizing.....	26
C1-10.2 System Components.....	28
C1-10.2.1 Pipeline.....	28
C1-10.2.2 Pump or SDG Assembly.....	29
C1-10.3 Vacuum Sewer System.....	30
C1-10.4.5 Easements for Municipalities.....	30
C1-10.4.6 Replacement Parts.....	30
C1-10.5 Alternative Systems-Grinder systems	30
C1-10.5.1 Application.....	30
C1-10.5.1.1 Plans, Profiles, Construction Notes and Record Drawings.....	31
C1-10.5.5 Pump Selection Grinder pumps.....	31
C1-10.5.6 Tank/Vessel Type and Sizing.....	32
C1-10.5.7. System Components.....	32
C1-10.5.7.1 Pipeline.....	32
C1-10.5.7.2 Pump Assembly.....	32
C1-10.5.8 Force Mains.....	33
C1-10.5.8.1 Construction Methods and Materials	33
C1-10.5.8.2 Pressure Tests	33
C1-10.6 Alternative Systems – STEP systems	33
C1-10.6.1 Application.....	33
C1-10.6.1.1 Plans, Profiles, Construction Notes and Record Drawings.....	33
C1-10.6.5 Pump Selection STEP.....	34
C1-10.6.6 Tank/Vessel Type and Sizing.....	35
C1-10.6.8 Force Mains.....	35
C1-10.6.8.1 Construction Methods and Materials	35
C1-10.6.9 Pressure Tests	36
C1-11 REFERENCES.....	36
CHAPTER C2 SEWAGE PUMP STATIONS	37
C2-1 GENERAL REQUIREMENTS.....	37
C2-1.1 Location, Site Selection, and Site Layout.....	37
C2-1.1.1 Location and Site Selection	37
C2-1.1.2 Flood Protection	37
C2-1.1.3 Access for Maintenance Vehicles.....	37
C2-1.1.4 Fire Protection.....	38
C2-1.1.5 Site Piping Layout	38

C2-1.1.6 Other Site Design Factors	38
C2-1.1.11 Plans, Profiles, Cross-Sections, Details, Construction Notes and Record Drawings.....	38
C2-1.2 Design Flow Rates, Hydraulics, and Number of Pump Units	41
C2-1.2.1 Design Flow Rates	41
C2-1.2.2 System Hydraulics.....	41
C2-1.2.3 Number of Pumps	41
C2-1.2.4 Pump Selection	42
C2-1.2.5 Wetwells.....	42
C2-1.3 Grit, Grease, and Clogging Protection.....	43
C2-1.4 Flow Measurement.....	43
C2-1.5 Surge Analysis	43
C2-1.5.1 General	43
C2-1.5.2 Surge Modeling	44
C2-1.5.3 Surge Protection Facilities.....	44
C2-1.6 Odor and Noise Control.....	44
C2-1.6.1 Odor Control.....	45
C2-1.6.2 Noise Control.....	45
C2-1.7 Operations and Maintenance	45
C2-1.8 Reliability.....	46
C2-1.8.1 Objective	46
C2-1.8.2 Equipment Redundancy	46
C2-1.8.3 Emergency Power	47
C2-1.8.4 Bypass Capability	47
C2-1.8.5 Overflow Storage Capability.....	48
C2-1.8.6 Alarms and Telemetry	48
C2-2 SPECIAL DESIGN DETAILS (SEE PUMP STATION SECTION)	48
C2-2.1 General	48
C2-2.1.1 Electrical Design.....	48
C2-2.1.2 Water Supply	49
C2-2.1.3 Corrosion Control	49
C2-2.1.4 Temperature and Ventilation	49
C2-2.1.5 Equipment Removal and Replacement	49
C2-2.1.6 Accessibility.....	50
C2-2.1.7 Valves and Piping.....	50
C2-2.2 Wetwell/Drywell Pump Stations.....	50
C2-2.3 Suction Lift Pump Stations	50
C2-2.4 Submersible Pump Stations	51
C2-2.5 Vertical Solids Handling Line Shaft Pumps	51
C2-3 FORCE MAINS	51
C2-3.0 <i>Plans, Profiles, Construction Notes, Profiles and Record Drawings</i>	51
C2-3.1 <i>Size and Alignment</i>	55
C2-3.2 <i>Velocity</i>	55
C2-3.3 <i>Force main Appurtenances</i>	56
C2-3.3A Pressure Cleanouts	56
C2-3.3B Locator Stations	56
C2-3.3C Air / Vacuum Valves (AVV), Vacuum Release Valves, Combination Valves	56
C2-3.4 Blow-Offs.....	56
C2-3.5 Termination	56
C2-3.6 Construction Methods and Materials	56
C2-3.7 Pressure Tests	57
C2-3.8 Connections	57
C2-3.9 Surge Control.....	57
C2-3.10 Thrust Restraint.....	57
C2-3.11 Pig Launching/Retrieval Facilities	57
C2-4 REFERENCES	58

APPENDIX “A” - Construction Specifications

APPENDIX “B” - Standard Drawings

**DESIGN CRITERIA
For The
CLARK REGIONAL WASTEWATER DISTRICT
(AMENDMENTS TO WASHINGTON DEPARTMENT OF ECOLOGY
CRITERIA FOR SEWER WORKS DESIGN)**

Adopted April 13, 2010

Shawn G. Moore, P. E.

The Clark Regional Wastewater District Design Criteria consists of the August 2008 Criteria for Sewage Works Design of the State of Washington Department of Ecology (Orange Book) Chapters C1 Sewers and C2 Sewage Pump Stations amended and supplemented as follows (amendments to the Orange Book are *italicized*, and revisions in the 2010 update are **bolded**):

Chapter C1 Sewers

This chapter covers the design, construction, operation and maintenance of gravity and low-pressure sewers and manholes. The requirements apply equally to sewer systems that are privately owned as well as publicly owned sewer systems. Also included in this chapter is a section on various types of alternative systems for conveyance of wastewater to a centralized location or wastewater facility.

C1-1 GENERAL REQUIREMENTS

C1-1.1 Approvals

Designs of new sewer systems or extensions of existing systems must provide for:

- Adequately processing the added hydraulic and organic load; or
- *The District shall approve project plans and materials*

See Chapter G1 for additional information on approvals.

C1-1.2 Ownership

The District is the owner of all public sanitary sewer facilities within the District.

C1-1.3 Design

Sewer systems shall be designed and constructed to achieve total containment of sanitary wastes and maximum exclusion of infiltration and inflow (I/I). No new combined sewers will be approved.

C1-1.3.1 "To and Through Policy"

- A. *Within Right-of-Way. Where the service parcels will be served by a collection line in right-of-way abutting the service parcels, the owner shall construct the collection line across the entire length of the abutting right-of-way; provided, that the owners of the last three parcels that can be served by such collection line,*

as determined by the District Engineer, shall construct collection lines of three equal lengths, as determined by the District Engineer; and provided further, that the owners of the last two parcels that can be served by such collection line, as determined by the District Engineer, shall construct collection lines of two equal lengths, as determined by the District Engineer.

- B. *Within Service Parcels.* Except as provided in subsection E of this section, the owner, when constructing the collection line within the service parcels, shall construct extensions of the collection line and provide easements to serve adjacent parcels that can be served by the collection line.
- C. *To Sewer Corridor.* When constructing the collection line, and its extensions if any, in accordance with subsections A and B of this section, the owner shall extend the collection line, and its extensions if any, to the sewer corridor of any additional right-of-way that abuts the service parcels and connects with the abutting right-of-way in which the collection line is located. The sewer corridor shall be seven feet south or west of the centerline of the right-of-way, as applicable.
- D. *Determination of Adjacent Service.* The District Engineer shall determine whether an adjacent parcel can be served by the collection line in the service parcels, considering the District's comprehensive plan, the topography in the vicinity, the pattern of development in the vicinity, and the existing and proposed sanitary sewer systems and lines that are not contained in the District's comprehensive plan.
- E. *Single-Family Residence.* Where (1) the collection line for the service parcels provides sewer service to a single-family residence or residences, (2) the service parcels can be further subdivided or developed under zoning regulations and (3) the adjacent parcel can be served by the collection line, the owner may extend the collection line through fifty percent of the service parcels and provide an easement to the adjacent parcel, in a location and size as determined by the District Engineer. Upon approval of a preliminary plat or issuance of a development permit, the owner shall construct the collection line in the easement.
- F. *Location of Lines and Easements.* The District Engineer shall determine the locations and types of collection lines and the locations and sizes of easements, and may require review of the collection line installation.
- G. *Finality of Decision.* The decisions of the District Engineer pursuant to this section shall be final.

C1-1.3.2 General

The purpose of the Design **Criteria** is to provide Engineers with the District's minimum standards for sanitary sewer design. The Design **Criteria** is not intended to cover all possible situations or conditions.

All engineers doing work within the Clark Regional Wastewater District on any projects, private or public, are required to have a current adopted copy of the Clark Regional Wastewater District **Design Criteria, Construction Specifications** and Standard Drawings **and shall comply with these documents.**

The Design **Criteria** shall be used for the design of public and private sanitary sewers.

Plan approval by the District consists of compliance with the Design **Criteria and Standard Specifications.** The Design Engineer is responsible for accuracy, errors or omissions on the Plans, Profiles and other documents relating to the specific project.

Sanitary sewers shall be extended and installed in accordance with Section **5.04.090** of the District's Code.

Sanitary sewer systems shall be designed to:

- A. *Achieve total containment of sanitary waste; and*
- B. *Exclude infiltration and inflow; and*
- C. *Prevent exfiltration of sewage into the surrounding soil and groundwater; and*
- D. *Not have any combined storm and sanitary sewers; and*
- E. *Be consistent with the District's Amended Comprehensive General Sewer Plan; and*
- F. *Be consistent with Washington Department of Ecology standards; and*
- G. *Be of adequate size to carry the expected flow within the design life; and*
- H. *Be designed at sufficient depth to serve adjacent properties; and*
- I. *Be able to resist all external loads that will be imposed; and*
- J. *Be of materials resistant to both corrosion and erosion caused by sanitary sewage; and*
- K. *Be economical to build and maintain.*

C1-1.3.3 Approval of Alternate Materials or Methods

Any alternate material or method will be considered for approval on the basis of the objectives in Chapter C1-1.3.2 General and C1-3.3 Design Basis. The Design Engineer shall make application to the District in writing citing specific details of why the alternate material and/or method is required for the proposed development and how it meets those objectives. Approval by the District will be in writing and the District's decision will be final.

C1-1.3.4 Specialty Designs

*The following are considered examples of specialty designs not covered in the Design **Criteria** and individual submittals must be provided to the District for approval:*

- A. *Inverted siphons*
- B. *Relining of existing sewers*
- C. *Pipe bursting **and other trenchless technologies***
- D. *Internal sealing of existing sewers*
- E. *Treatment plants*
- F. *Outfall sewers*
- G. *Energy dissipaters*
- H. *Flow regulating devices*
- I. *Flow measurement devices*
- J. *New technology*
- K. Drop manholes**
- L. Poured in place manholes**
- M. Curved line installations**
- N. Pipe slopes at less than minimum design requirements**

C1-1.3.5 Plans, Profiles and Record Drawings

- A. *General.*
 - 1. *Design Engineer shall call for pre-design locates from the NW Utility Notification Center at 1-800-424-5555. Design Engineer or Surveyor is responsible for field verification of location and elevations of facilities.*

2. *Two sets of plans, profiles, details and grading plans will be submitted to the District for each review of all new or extended sanitary sewers.*
 3. *Storm sewer plans and profiles must be included with the sanitary sewer plans and profiles for District review. Water distribution plans must be included with the sanitary sewer plans.*
 4. *After District approval of plans, profiles and details, the Design Engineer shall submit one (1) complete set of Plans and four (4) partial sets at least five (5) working days prior to the preconstruction conference. The partial sets shall include the signed coversheet, sanitary plans and profiles, and sanitary notes and detail sheets. The complete Plans shall also include all other road, storm, water and grading plans for the work.*
 5. *For projects that are the subject of a site plan or land division approved by Clark County or a City with land use authority, the approval of plans and specifications is valid for the period of the original site plan / land division approval. Projects that are not the subject of other site plan / land division approvals will expire in accordance with the terms and conditions of the developer extension agreement. Plans that have expired may be submitted for re-approval; but are subject to additional review and fees.*
 6. *Text size shall be a minimum of 0.08".*
- B. *Engineering Drawings - Plans. Plan sheets for sanitary sewer lines shall be drawn in ink and contain at least the following information:*
1. *A suitable title sheet with the name, address, telephone fax numbers, and email address of the owner, developer (including contact name) and the Design Engineer; scale; north arrow; vicinity map; section, township and range; sheet index; revision box; bench mark(s) based on Clark County Datum; date; drawing number; the Design Engineer's Professional Civil Engineers State of Washington seal signed with date of signature; and a District signature block per District Standard Drawings. Applicable sheets shall include a legend with symbols and abbreviations and general notes generic to all construction.*
 2. **District Standard Construction Notes** (See Standard Drawing) and Specifications shall be included in the plans for sanitary sewer construction. **These are standard Construction Notes. Special designs, installations or conditions may require additional Construction Notes.**
 3. *Horizontal dimensions from right-of-way, centerline of road, easement lines or property lines and other utilities or structures.*
 4. *Subtitles on each sheet describing the contents.*
 5. *Adjacent streets, property lines, tax lot numbers and serial numbers.*
 6. *All existing survey monumentation within 100 feet of the project limits shall be shown.*
 7. *All existing and proposed easements shall be shown with dimensions.*
 8. *District Standard Drawings that apply to the project.*
 9. *All sanitary sewer lines shall be clearly identified as public or private. All private sanitary sewer lines **and easements** shall be labeled as "Private".*
 10. *Conditional serviceability within any project resulting from varying topography or depth of line noted on the plans. Examples of conditional serviceability include:*
 - a. *Shallow side sewers with a lot sloping downward from the lateral in which case a minimum finished floor elevation shall be shown on the plans; or*
 - b. *Side sewers that cannot serve basements in which case a statement shall be shown on the plans that basements cannot be served; or*

- c. *Minimum finished floor when topography indicates end of side sewer invert is less than three (3) feet below the lowest elevation on a given lot or on flag lots where long runs of private side sewers are required to reach the building site.*
11. *All existing manholes and cleanouts shall be labeled with the District assigned identifier number. All appurtenances shall be numbered and stationed to facilitate checking the plans with the profiles. Stationing will be based on road stationing with the exception of side sewers (see 11 below). The first downstream manhole shall be shown as "Existing." The identifier (numbering system) for all other appurtenances shall be consecutive along the main run of the sanitary sewer. All branch line manholes and appurtenances shall be identified with consecutive numbering systems beginning with the mainline manhole (alpha, numeric, alphanumeric) and progressing in a logical order.*
 12. *All side sewers shall be stationed upstream from the nearest downstream manhole. Depths and lengths shall be shown at the end of each side sewer. Residential side sewers shall not be connected to cleanouts. When practical, side sewers will be at a right angle from the mainline at the center of the lot. Side sewers shall be located a minimum of five (5) feet from the property line. It is recommended that a side sewer table be shown on the plans indicating the station, length, invert elevation, depth and type of pipe material. If required, minimum finished floor elevations will be shown on the individual lots and/or in the side sewer table.*
 13. *Location of watercourses, wells, septic systems, stream and railroad crossings, water mains, gas mains, culverts, telephone, underground power, cable television and other utilities or structures based on best available information and field locates. Field locates for designs are available through the NW Utility Notification Center at 1-800-424-5555.*
 14. *All existing gravel or hard surface paving including widths and distances from existing right of way, easement or property line.*
 15. *Existing contours for the proposed development extending at least 100 feet outside of the proposed development along existing, proposed or future roads. If site grading is anticipated, a final site contour map shall be provided. Contour interval shall not be greater than two (2) feet in elevation except in steep terrain where contours are not easily distinguished at two (2) foot intervals.*
 16. *Plans shall be drafted at a scale that will be legible when the plans are reduced fifty (50) percent. If the entire project cannot be shown on one (1) sheet, a key map must be provided noting the sheet where each individual segment of the plan is located. Where multiple sheets are used for plans and profiles, match lines will be shown. Where multiple sheets are used for plans, a master utility plan will be provided.*
 17. *Sheet size shall be 24" x 36" or 22" x 34".*
 18. *For commercial projects: contours; pipe type, size and slopes; monitoring manholes; grease interceptors (if required) and oil-water separators (if required) must be shown. If private sewer mains are required, all requirements of public sanitary sewer plans and profiles must be met. If only an individual building side sewer is required, a plan and profile or the invert and rim elevations of all sewer appurtenances must be provided. Mechanical and/or plumbing plans, flow calculations and a pretreatment survey (with District fee) must be submitted for review with the plans.*
 19. *All new easements shall:*
 - a. *Be a minimum of fifteen (15) feet in width for sanitary sewers eight (8) feet or less in depth. The width of the easement shall increase by two (2) feet for every one (1) foot in depth beyond eight (8) feet.*
 - b. *Have the sewer pipe centered in the easement.*
 - c. *Be located on a single lot.*

- d. *Have legal description(s) submitted to the District in writing with a map in addition to platted easement(s). The District will complete the document and record the easement at the County.*
 - e. *Wider easements may be required for larger pipe installations or unusual site conditions.*
20. *Length, pipe size and type of material for all sanitary sewers. (e.g., 400 LF, 8" PVC)*
21. *Locations and elevations of existing septic tanks and drain fields and finished floor elevations for the existing building main floor and, if present, basement.*
22. *Project phasing shall be shown. If the project is phased, each individual phase must be submitted for separate approval.*
- C. *Engineering Drawings - Profiles. Profile sheets for sanitary sewer lines shall be drawn in ink and contain at least the following information:*
- 1. *Location of manholes and other appurtenances numbered and stationed as shown on the plans. Each manhole and appurtenance shall show rim elevation and invert elevation(s). Invert elevation(s) shall be specified as inlet (i.e. in), outlet (i.e. out) or knockout (K.O.) elevation and indicate the outlet line direction from the manhole and the inlet line(s) direction to the manhole. (E.g. N, E or NW).*
 - 2. *Profiles of existing and proposed ground surface or road finished grade and sanitary sewer invert(s).*
 - 3. *Sanitary sewer size, type of material, slope, length from centerline of manhole or cleanout to centerline of manhole or cleanout, and backfill.*
 - 4. *Suitable title block, scale, dates, drawing number, and the Design Engineer's name, address, telephone number and their Professional Civil Engineer's State of Washington signed seal.*
 - 5. *Limits of existing or proposed gravel and hard surface paving.*
 - 6. *Profiles shall be drafted to a vertical scale at one-tenth (1/10) of the horizontal scale unless steep terrain exists.*
 - 7. *All storm drains, storm water quality facilities, storm drain detention and/or retention ponds, water or utility crossings of sanitary sewers shall be shown with elevations and vertical clearances. Profiles of any storm, water or other utility facilities located within right of way or any easements.*
 - 8. *All side sewers shall be shown and stationed upstream from the nearest downstream manhole with lot number or serial number, station and invert elevation **at the end of lateral.***
- D. *Engineering Drawings - Construction Notes. All project plans for gravity sewer systems shall contain at least the following:*
- 1. *All sanitary sewer construction will conform to the current adopted **Construction Specifications of the District.***
 - 2. *All work in Clark County right-of-way will conform to the requirements of the Clark County utility permit or District requirements, whichever is more restrictive.*
 - 3. *Contractor shall contact the NW Utility Notification Center at 1-800-424-5555 at least two (2) working days before but not more than (10) ten working days before the start of construction of the work **and shall comply with State requirements for utility locating.***
 - 4. ***All survey monumentation shall be protected from damage unless otherwise permitted by the Washington State Department of Natural Resources.***
 - 5. *A preconstruction conference shall be held prior to the start of construction of the Work.*

6. Gravity sanitary sewer pipe materials for lines six (6) inches inside diameter and larger shall be:
 - a. AWWA C-900 or C-905, SDR 18 PVC pipe at depths of cover from three (3) feet to less than five (5) feet in a vehicle-traveled area; or
 - b. PVC pipe at depths of cover of five (5.0) feet to depths of cover of twenty (20.0) feet; or
 - c. AWWA C-900 or C-905, SDR 18 PVC or Class 50 ductile iron pipe at depths of cover greater than 20.0'.
7. Gravity sanitary sewer pipe materials for lines four (4) inches inside diameter and smaller shall be:
 - a. AWWA C-900 or C-905, SDR 18 PVC pipe at depths of cover from three (3) feet to less than five (5) feet in a vehicle traveled area; or
 - b. Schedule 40 ABS or Schedule 40 Solvent Joint PVC at depths of cover from three (3) feet to less than five (5) feet in non-vehicle traveled areas; or
 - c. Schedule 40 ABS or Schedule 40 Solvent Joint PVC at depths of cover of five (5) feet or more.
8. Backfill for all sanitary sewer pipe and side sewers shall be as required by the Clark County utility permit, **City permit, applicable RR permit**, WSDOT Utility franchise or the District which ever is more stringent.
9. Bedding for all sanitary sewer pipe and side sewers in the pipe zone shall be per Construction Specification, **Section 9-03.12(3) Gravel Backfill for Pipe Zone Bedding. Compaction from the spring line of the pipe through the bedding area shall be at 90% of the maximum density for the material as established by Section 2-03.3(14) D.**
10. Connections for side sewers (laterals) shall be:
 - a. Wyes for new sanitary sewers.
 - b. District installed taps for existing sanitary sewers. Note: A "Request for Tap" form must be completed by the contractor, and a two (2) working day notice be given to the District to allow the tap to be scheduled.
11. The ends of side sewers (laterals) shall be:
 - a. Back-filled only after District inspection and approval and the Design Engineer or surveyor has obtained record drawing information.
 - b. Marked with a 2"x4"x10' wrapped with toning wire and at a 90-degree angle from the end of the lateral. The marker will extend at least three (3) feet above the finished ground surface.

Two (2) feet of each end of the 2"x4"x10' shall be painted green. If the 2"x4" is not ten (10) feet long, the contractor will mark the actual length on the 2"x4" within six (6) inches of the top and on both sides.
12. All manholes shall be externally sealed.
13. **Manholes shall not have edges of manhole casting and cover within three (3) feet of the curb gutter. Where determined by the District, inflow dishes shall be installed on manholes.**
14. All testing shall be in accordance with the District's Construction Specifications.
 - a. At the preconstruction conference, the contractor must state if they intend to use an approved private television inspection subcontractor or the District.
15. The Design Engineer or surveyor shall submit pre-paving record drawings prior to testing.

16. *All existing septic tanks shall be decommissioned in accordance with **Clark County Public Health** and District requirements.*
 17. *Record Drawings shall be submitted to the District prior to final acceptance.*
 18. ***All lateral lines shall be installed with toning wire. Toning wire shall be installed on mains where shown on the plans.***
 19. ***All clean outs shall have the invert elevation verified prior to backfilling.***
- E. *Engineering Drawings - Record Drawing Plans and Profiles. Record drawings for Plan and Profile sheets for sanitary sewer lines shall:*
1. *Be legible and complete plans including all road, storm drainage, water supply and grading plans for the work.*
 2. *Be completed by the Design Engineer and submitted to the District prior to project acceptance by the District.*
 3. *Be submitted in electronic form as a "PDF" file on a compact disk or other approved electronic submittal media and a complete paper copy.*
 4. *Be the approved engineering drawings with the design date marked out and the Record Drawing date shown adjacent to design date.*
 5. *Show all final rim and invert elevations and stations of manholes, cleanouts, stub outs and laterals.*
 6. *Show all changes made to pipe material.*
 7. *Show all final pipe slopes, length of pipe, finished grade, etc.*
 8. *Show the distance from the back of curb to the end of the side sewer, depth, station and distance to the end of the lateral from the sanitary sewer line.*
 9. *Be clearly marked "record drawings", dated with the Design Engineer's Professional Civil Engineer's State of Washington signed seal.*
 10. *Become the permanent property of the District.*

C1-1.5 Siting Considerations

New sanitary sewers shall serve within the basin specified by the District Comprehensive General Sewer Plan unless otherwise approved by the District in writing.

Providing gravity flow shall be the primary consideration in siting sanitary sewage facilities.

Siting of public sanitary sewer mains, manholes, side sewers and appurtenances shall be restricted to public right-of-way or easements. The District preference is to locate sanitary sewer facilities in public right-of-ways. Sanitary sewers shall be located either seven (7) feet south or west of centerline of public right-of-way unless otherwise approved in writing by the District.

Sewer systems shall be accessible by District maintenance personnel for periodic inspection, cleaning, and repair. Access to the system components shall be provided by an all-weather roadway, twelve (12) feet in width, paved with either asphaltic concrete or concrete and designed to support an H-20 highway loading. Clark County standard cross-section for a public residential road is the minimum requirement.

Lines designed within or adjacent to wetland areas shall require the installation of clay dams/cut off walls to prevent the potential draining/exfiltration of the wetlands.

Where lines will be located outside of right-of-way, consideration should be given to the placement of sewer lines within the corridors proposed for use in the regional trail network as proposed by the local park jurisdiction. Where such opportunities exist, coordination between sewer line construction and trail construction should be pursued.

C1-2 INDUSTRIAL AND COMMERCIAL PRETREATMENT

Pretreatment of sanitary sewer discharges may be required for those users who do not conform to the standards established by the federal, state and local authorities as required by the Clean Water Act and the General Pretreatment Regulations. No user shall introduce or cause to be introduced into the waste stream any pollutant or wastewater which causes pass-through or interference problems.

C1-3 GRAVITY SYSTEMS DESIGN CONSIDERATIONS

All gravity system sewers must be designed to be consistent with the approved general sewer plan.

C1-3.1 Definitions

Building

A building is a structure built, erected and framed of component structural parts designed for the housing, shelter, enclosure or support of persons, animals, or property of any kind.

Construction Specifications

*The Standard Specifications for Road, Bridge and Municipal Construction of the Washington State Department of Transportation and the American Public Works Association, 2008 edition, as amended by the Clark Regional Wastewater District **General Special Provisions** and the Clark Regional Wastewater District Standard Construction Drawings all as adopted by the District Board of Commissioners.*

Owner

The private landowner or authorized representative proposing to develop property.

Design Engineer

A professional engineer registered in the State of Washington retained by the Owner to design the work.

Private Side Sewer (also a Building Sewer or Private Sewer Lateral)

The building sewer is that part of the horizontal piping of a sewage system which extends from the building drain (plumbing) and which receives the discharge of the building drain two (2) feet outside the building and conveys it to a public sewer or public side sewer.

Plans or plans and profiles

*Where the word "Plans" is used, it is in reference to plans and profiles prepared by the **Design Engineer** and approved by the District.*

*Where "plans", "profiles" or "**plans and profiles**" are used, it is in reference to plans or profiles prepared by the **Design Engineer** which are under review and not yet approved by the District.*

Side Sewer or Lateral (See also Definitions and Terms section)

- A. Private Side Sewer (also a Building Sewer or Private Sewer Lateral)
The building sewer is that part of the horizontal piping of a sewage system which extends from the building drain (plumbing) and which receives the discharge of the building drain two (2) feet outside the building and conveys it to a public sewer or public side sewer.
- B. Public Side Sewer
A public (District) side sewer that extends from a District main sanitary sewer line to:
 1. *The edge of right of way; or*
 2. *Six (6) feet beyond the edge of the public right of way into an adjacent public utility easement, or*
 3. *The edge of a public sanitary sewer easement.*

Main or trunk

*A sewer that receives flow from one or more mains **and may have direct lateral connections.***

Interceptor

A sewer that receives flow from a number of main or trunk sewers, force mains, etc. **and generally has no direct lateral connections.**

C1-3.2 Design Period

C1-3.2.1 Service Laterals

Service laterals shall be designed for the ultimate development of the parcel being served.

The minimum requirements for public and private side sewers are as follows:

- A. All single family public and private side sewers shall:
 1. *Be four (4) inches in diameter; and*
 2. *Be at a minimum slope of two (2) percent.*
 3. *Under unusual circumstances, the District may approve up to two (2) single-family residential units to be connected to a single four (4) inch public sewer line. The Design Engineer must apply in writing in accordance with Section C1-1.3.3 Approval of Alternate Materials or Methods **and receive approval before construction.***
- B. All multifamily residential public and private side sewers shall:
 1. *Be minimum of six (6) inches in diameter; and*
 2. *Be at a minimum slope of one (1) percent to the building cleanout.*
 3. *Under unusual circumstances, as determined by the Engineer, the District may approve up to two (2) multi-family residential units to be connected to a single four (4) inch public **side** sewer. The Engineer must apply in writing in accordance with Section C1-1.3.3 Approval of Alternate Materials or Methods.*
- C. All commercial public side sewers shall:
 1. *Be a minimum of six (6) inches in diameter, unless the Design Engineer shows that a four (4) inch lateral is adequate for the anticipated use **and flow**; and*
 2. *Be at a minimum slope of one (1) percent for six (6) inch diameter pipe or two (2) percent for four (4) inch diameter pipe;*
 - a. *To the monitoring manhole if the monitoring manhole is within ten (10) feet of the public right of way or public sewer easement; or*
 - b. *If the monitoring manhole is greater than ten (10) feet from the public right of way or public sewer easement, a public cleanout will be placed at the public right of way or public sewer easement; and*
 - c. *At the building cleanout, a transition in sewer pipe diameter may be made.*
 - d. *If the private side sewer is larger than six (6) inches in diameter, the public side sewer will match the size of the private side sewer.*
- D. All commercial private side sewers shall:
 1. *Transition to the public side sewer at the monitoring manhole or public cleanout as noted above.*

C1-3.2.2 Collection Sewers

Collection sewers shall be designed for the ultimate development of the tributary areas.

C1-3.2.3 Trunk and Interceptor Sewers

Selection of the design period for trunk and interceptor sewers should be based on an evaluation of economic, functional and other considerations. Some of the factors that should be considered in the evaluation are:

- Possible solids deposition, odor and pipe corrosion that might occur at initial flows.
- Population and economic growth projections and the accuracy of the projections.
- Comparative costs of staged construction alternatives.
- Effect of sewer sizing on land use and development.

C1-3.3 Design Basis

Sewer systems shall be designed on the basis of per capita flows for the design period in conjunction with a peaking factor, or approved alternative methods. Design calculations for trunk and interceptor sewers shall be submitted to the **District** for approval. Larger systems should have hydraulic modeling performed. Replacement mains or rehabilitation of existing mains shall be designed on the basis of measured flows with projections for the design period as applicable. Documentation shall be submitted for approval of the authorized entity and/or Ecology. Documentation of the alternative method shall be provided upon request.

C1-3.3.1 Design for Average Daily Flow

Design flows shall be determined by consideration of the following factors:

- A. *Drainage basin area to be served based on the District's **Comprehensive** General Sewer Plan.*
- B. *Population within the area to be served (both present and future) based on the District's **Comprehensive** General Sewer Plan.*
- C. *Land use within the area to be served based on Clark County's Comprehensive Plan.*
- D. *Per capita sewage flow per Table C1-3 Design Factors.*
- E. *Commercial, industrial or institutional users to be served.*
- F. *Infiltration allowance per Table C1-3 Design Factors.*

In the absence of flow data or other reliable information, the design factors from Table C1-3 shall be used. Appropriate peaking ratios shall be applied to determine flows.

*As a minimum, design calculations shall include estimates of peak hourly, average maximum and minimum daily flows (where applicable). The submission of design calculations shall not ordinarily be required for residential developments, but **the Design** Engineer should be prepared to substantiate pipe sizes, layout, population estimates, land uses or other design assumptions as may be requested by the District. Design calculations will be required for all commercial and industrial development.*

Type of Use	Average Flow	Peak Flow (1)
<i>Residential</i>	<i>65 gpcpd (3)</i>	<i>2.5 to 4.0 (2)</i>
<i>Commercial</i>	<i>650 gpapd (4)</i>	<i>1.5 to 4.0</i>
<i>Industrial</i>	<i>Individual Review</i>	<i>Individual Review</i>
<i>Infiltration and Storm Water Inflow</i>	<i>550 gpapd (4)</i>	<i>N/A</i>
<i>(1) Shall be determined using General Sewer Plan Figure C1-1, Peaking Flow Factor</i>		
<i>(2) Currently 3.0</i>		
<i>(3) Gallons per capita per day</i>		
<i>(4) Gallons per acre per day</i>		

Table C1-3 Design Factors

New sewer systems may be designed by methods other than on the basis of per capita flow rates. Alternative methods may include the use of per capita flow rates based on water consumption records, actual measured flows for the agency, or other methods. Documentation of the alternative method used shall be provided to **the District** for review and approval.

C1-3.3.2 Peak Flow

Sanitary sewers shall be designed to carry at least the peak hourly flow when operating at capacity. Peak hourly flow shall be the design average daily flow in conjunction with a peaking factor in the District General Sewer Plan, Figure C1-1, Peaking Flow Factor. The peaking factor shall not be less than 3.0 for subdivisions and as calculated for all other uses.

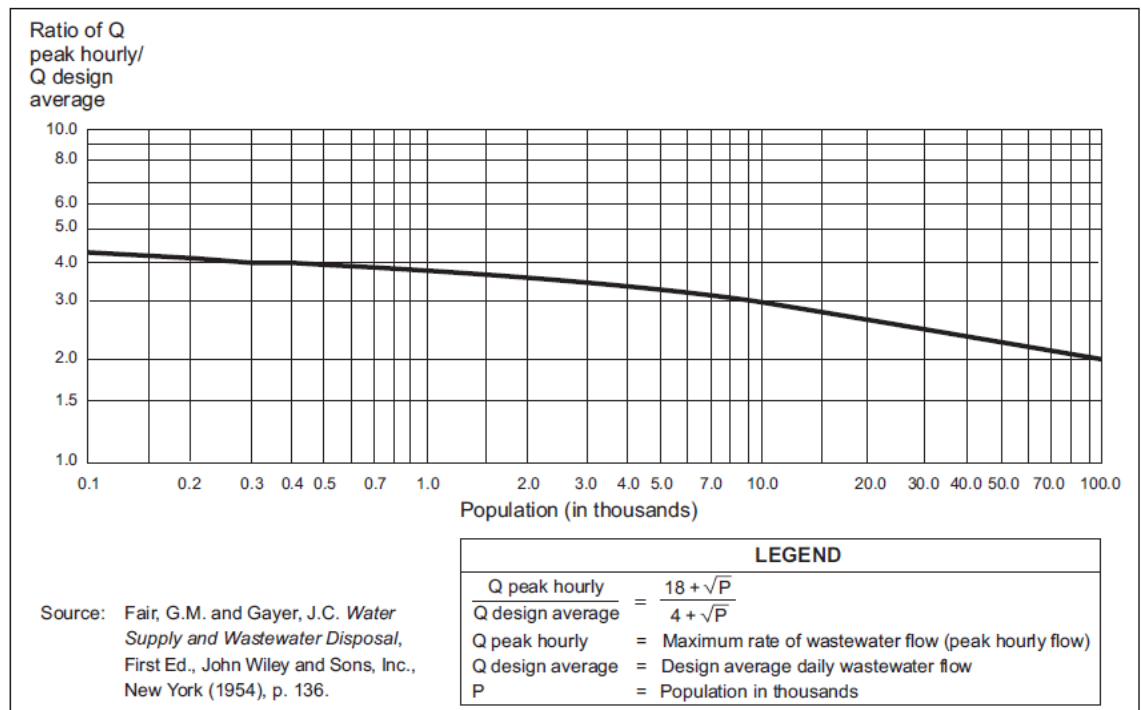


Figure C1-1. Ratio of Peak Hourly Flow to Design Average Flow

C1-3.3.3 Infiltration/Inflow

Infiltration and Inflow shall be as specified in Table C1-3.

C1-3.4 Design Factors

The design engineer shall utilize current design criteria. At a minimum, the design of gravity sanitary sewers will include the following:

- Peak sewage flows from residential, commercial, institutional and industrial sources.
- I/I.
- Topography and depth of excavation.
- Treatment plant location.
- Soils conditions.
- Flow impacts from upstream pump stations, if applicable.
- Maintenance.
- Existing sewers.

- Existing and future surface improvements.
- Controlling service connection elevations.
- Flow from existing combined systems, if applicable.
- Potential surcharge in downstream sewers.

C1-4 GRAVITY SEWER DESIGN AND CONSTRUCTION DETAILS

All side sewer laterals installed (both public and private) shall include the installation of toning wire with appropriate locate access points.

C1-4.1 Minimum Size

No sewer shall be less than 8 inches in diameter except that, in special cases, 6-inch diameter sewer lines may be approved by **the District** if the 6-inch lines meet the following criteria:

- The probable maximum number of services will not exceed 30 persons. (For this purpose, compute on the basis of not less than three persons per residence.)
- Running lengths of 6-inch pipe shall not exceed 150 feet **without approval of the District.**
- A manhole shall be provided where the 6-inch pipe connects to an 8-inch or larger line. This does not include a 6-inch side sewer.
- A manhole or cleanout shall be provided at the end of the 6-inch line.
- No extension of the 6-inch line will be possible at a later date.
- The minimum slope allowable for 6-inch lines will be 1.0 feet per 100 feet.
- *Six (6) inch pipe used in collection systems shall conform to the Construction Specifications Section 7-17.2 Materials.*
- The design is subject to all other design requirements as noted in this chapter.

C1-4.2 Depth

C1-4.2.1 Minimum Depth

Sanitary sewers shall:

- Generally have a minimum depth of cover of eight (8) feet; and*
- Unless approved in writing by the District, shall not have a depth of cover less than three (3) feet when subject to vehicular traffic; and*
- Be deep enough to prevent freezing and physical damage; and*
- Be designed at an elevation that is sufficient to serve the limits of the service basin; and***
- Be of sufficient depth to serve existing and proposed basements*

Public side sewers shall:

- Have a depth of cover of at least six (6) feet at the property line unless such is precluded by the depth of the sanitary sewer main; and*
- Where physically possible, serve all existing and proposed buildings, including basements, by gravity.*

C1-4.3 Roughness Coefficient

An “n” value of 0.013 shall be used in Manning’s formula for the design of all sewer facilities (regardless of pipe material) except inverted siphons, where an “n” value of up to 0.015 can be used.

C1-4.4 Slope (Minimum Velocity)

All sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than 2.0 fps. Self-cleaning velocity shall be provided and demonstrated by the **Design** Engineer to the **District** to accept the problem caused by a lack of sufficient flow.

Table C1-1 lists the minimum slopes that should be provided; however, slopes greater than those listed in this table are desirable under low-flow conditions.

Sewer Size (inches)	Minimum Slope (feet per 100 feet)
8	0.45
10	0.28
12	0.22
14	0.17
15	0.15
16	0.14
18	0.12
21	0.10
24	0.08
27	0.07
30	0.06
36	0.05

Table C1-1. Minimum Slope of Sewers, by Size (Assuming Full Flow)

Sewers shall be laid with uniform slope between manholes.

Sewers on a 20-percent slope or greater shall be anchored securely with concrete anchors or their equal. Suggested minimum anchorage spacing is as follows:

- Not over 36 feet center-to-center on grades of 20 percent and up to 35 percent.
- Not over 24 feet center-to-center on grades of 35 percent and up to 50 percent.
- Not over 16 feet center-to-center on grades of 50 percent and more.

C1-4.5 Alignment

Gravity sanitary sewer lines shall be designed with a straight alignment between manholes. As a general rule, horizontal and vertical curves in gravity sewers are not acceptable.

*In cases where justification can be demonstrated, the District may consider limited use of curved sanitary sewer lines. The **Design** Engineer must submit a report documenting the justifications for utilizing a curved alignment. As a minimum, the District shall require:*

- A slope greater than the minimum slope for the size of the pipe; and*
- Manhole spacing of less than 400 feet; and*
- A radii of curvature that will not cause joint widening and will maintain water tightness; and*
- The location of curved sewers, length of curve, degree of curve (or radius), and stationing of curve points clearly labeled on the plans and profiles; and*
- The radius of curvature shall not exceed the manufacturer's specification; and*
- The owner or contractor shall provide personnel under the direct supervision of the Design Engineer to continuously monitor installation of the curved sewer; and*
- A pipe manufacturer's representative to be on the site during the installation; and*
- Certification by the Design Engineer that the line was installed in accordance with the **Plans**.*
- Continuous toning wire and appropriate locate access points shall be installed for use by the District.***

C1-4.6 Increasing Size

Where a smaller sewer joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. *Where a smaller pipe joins a larger pipe, the crowns of both sewers will be at the same elevation or as approved by the District. Pipeline sizes shall only be changed at a manhole.*

C1-4.7 High-Velocity Protection

Where velocities greater than 15 fps are expected, special provision shall be made to protect against internal erosion or displacement by shock.

C1-4.8 Material

All material for sewers will meet the requirements of the Design Criteria and Section 7-17.2 Materials of the Construction Specifications.

The installation and type of mainline pipe used shall be in accordance with the following requirements:

- A. *ASTM D 3034 SDR 35 PVC pipe may be installed at depths of cover from five (5.0) feet to a depth of cover of twenty (20.0) feet, using **Construction Specification, Section 9-03.12(3) Gravel Backfill for Pipe Zone Bedding** in the pipe zone.*
- B. *AWWA C-900 or C-905, SDR 18 PVC pipe may be installed at depths of cover greater than three (3.0) feet, using **Construction Specification, Section 9-03.12(3) Gravel Backfill for Pipe Zone Bedding** in the pipe zone.*
- C. *Standard Thickness Class 50 ductile iron pipe may be installed at depths of cover greater than 20.0' using **Construction Specification, Section 9-03.12(3) Gravel Backfill for Pipe Zone Bedding** in the pipe zone.*
- D. *Other pipe materials (i.e. HDPE, Profile Wall or Concrete) may be considered by the District in accordance with C1-1.3.3 Approval of Alternate Materials or Methods.*

All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer because of the width and depth of a trench should be made. When standard-strength sewer pipe is not sufficient, the additional strength needed may be obtained by using extra-strength pipe or by special construction, such as improving bedding conditions or encasing the pipe in concrete.

C1-4.9 Joints

The method of making joints and the materials used shall be included in the specifications **and approved by the District.**

C1-4.10 Flushing

Flushing shall be in accordance with the Construction Specifications Section 7-17.3(1) Protection of Existing Sewerage Facilities.

C1-5 TESTING

Testing shall be in accordance with the Construction Specifications Section 7-17.3(2) A General.

C1-6 MANHOLES, Monitoring Manholes, Cleanouts, Grease Interceptors, Grease Traps and Oil-Water Separators

C1-6.1 Location and Miscellaneous Requirements

Manholes (except as noted under cleanouts) shall:

- A. *Not have edges of manhole casting and cover within three (3) feet of the curb storm drainage gutter.*

- B. *Be installed at the end of each line with eight (8) inch inner diameter or greater; and*
- C. *Be installed at all changes in **slope**, pipe size, or pipe alignment; and*
- D. *Be installed at all pipe intersections and at distances not greater than 400 feet; or*
- E. *Be installed at distances not greater than 500 feet for sanitary sewers with thirty six (36) inch or larger inner diameter; and*
- F. *Not have lines entering that are adverse to the flow through the manhole. The minimum angle for a line through a manhole in any one direction shall be ninety (90) degrees; and*
- G. **Shall have two-tenths (0.20) of a foot drop from the inlet sewer pipe to the outlet sewer pipe; and**
- H. **Have inflow dishes installed in areas of I/I concern as determined by the District.**

Monitoring Manholes:

- A. *Shall be installed at all commercial and industrial buildings that have other than domestic sewage in accordance with the District industrial pre-treatment requirements and for all shell or speculative buildings where tenants have not been determined; and*
- B. *Shall be a standard forty eight (48) inch pre-cast manhole per Standard Drawings; and*
- C. *Shall not be less than four (4) feet in depth; and*
- D. *Shall be a Type 3 shallow manhole per Standard Drawings between three (3) and five (5) feet in depth; and*
- E. *Shall have the steps aligned over the inlet sewer line; and*
- F. *May be substituted for the District cleanout if within ten (10) feet of the normal location of the District cleanout. In this situation, the sanitary sewer shall meet District standards from the monitoring manhole to the public side sewer; and*
- G. *Shall have two-tenths (0.20) of a foot drop from the inlet sewer pipe to the outlet sewer pipe; and*
- H. *Shall have a minimum of three (3) feet of pipe on the inlet and outlet side of the manhole aligned with the manhole channel to provide laminar flow for flow monitoring; and*
- I. **Have inflow dishes installed in areas of I/I concern as determined by the District.**

Cleanouts may:

- A. *Be used instead of manholes at the end of lines six (6) inches or eight (8) inches inner diameter and not more than 150 feet long; and*
- B. *Be used instead of manholes at the end of lines eight (8) inches inner diameter or larger not more than 250 feet long provided the line is intended to be extended in the future.*

Grease Interceptors shall:

- A. *Meet or exceed the requirements of the Uniform Plumbing Code Sections 209.0, 210.0 and 1009.0 through 1015.5, and have a minimum volume of 1,000 gallons; and*
- B. *Conform to Standard Drawing and District Pretreatment requirements ; and*
- C. *Not be placed within ten (10) feet of a drive-in window or in a drive-in lane; and*
- D. *Not be placed within fifteen (15) feet of a building entrance or exit; and*
- E. *Not be placed in a **standard parking stall**, and*
- F. **Meet the flow sizing criteria listed in C1-6.10, and**
- G. **Shall not accept flow from sanitary facilities, dishwashers or garbage disposals.**

Grease Traps May be used in lieu of a grease interceptor if;

- A. The District approves the use in writing; and*
- B. The food preparation area does not utilize a Type 1 commercial exhaust hood; and*
- C. The grease trap meets all the requirements of the Uniform Plumbing Code Sections 210.0, and 1009.0 through 1015.5.*

Oil-Water Separators shall:

- A. Meet or exceed the requirements of the Uniform Plumbing Code Section 211.0, 1009.0 through 1009.7, and 1017.0 through 1017.2; and*
- B. Conform to District Pretreatment requirements*
- C. Not be placed within ten (10) feet of a drive-through window or in a drive-through lane; and*
- D. Not be placed within fifteen (15) feet of a building entrance or exit; and*
- E. Not be placed in a standard parking stall.*

C1-6.2 Connections

The ends of all pipes shall be trimmed flush with the inside walls of the manhole. Flexible pipes connecting to sanitary sewer manholes shall be provided with an entry coupling or gasket. No pipe joint in flexible pipe shall be placed within 10 feet of the manhole.

Rigid pipes connected to the sanitary sewer manhole shall be provided with a flexible joint at a distance from the face of the manhole of not more than 1.5 times the nominal pipe diameter or 18 inches, whichever is greater. For precast concrete manholes, the cut through the manhole wall and steel mesh shall be **constructed with a coring saw sized to meet the flexible boot requirement for the pipe size, producing a non-leaking connection.**

The District normally does not allow the use of drop manholes. The District will consider a written request from the Design Engineer and evaluate the request in accordance with the Design Criteria section C1-1.3.3 Approval of Alternate Materials or Methods.

C1-6.3 Diameter

The minimum inside diameter of manholes shall be 48 inches. For incoming pipe larger than 24 inches in diameter, the manhole diameter should be 54 inches or greater. Manholes are mandatory when connecting significant industries to the system and should be of adequate size to provide for monitoring and sampling equipment.

C1-6.4 Flow Channels

Flow channels in manholes shall be shaped and sloped to provide a smooth transition between the inlet and outlet sewer lines and minimize turbulence. The channels and manholes shall conform accurately to the sewer grade. Channeling height shall be to the springline of the sewer or above. Benches shall be sloped from the manhole wall toward the channel to prevent accumulation of solids.

*The elevation difference from the inlet pipe through the manhole to the outlet pipe shall be a minimum of two-tenths (0.20) of a foot and a maximum of four-tenths (0.40) of a foot. Under unusual conditions, the District may allow a one-tenth (0.10) of a foot drop through a manhole when requested by the **Design Engineer** in writing outlining the reasons for the request.*

The District will respond in writing and the District's decision will be final. The bench shall be sloped at two (2) percent from the inside wall of the manhole to the channel.

The District will allow the direct connection of laterals into manholes provided:

- It is a terminus manhole; and***
- No more than 5 laterals are connected into a single manhole; and***

- **The elevation difference from the inlet pipe through the manhole to the outlet pipe shall be a minimum of three-tenths (0.30) of a foot and a maximum of five-tenths (0.50) of a foot.**

C1-6.5 Watertightness

Watertight manhole covers shall be used wherever the manhole tops may be flooded. Joints between precast manhole units shall have rubber gaskets or be provided with positive self-sealing mastic. Care should be exercised during the handling of the precast units to avoid disturbing or damaging the gasket and to attain proper alignment of the joints. **Additional gaskets (1 for every 2 watertight lids) shall be provided to the District by the installer.**

*All sewer line connections to existing and new manholes shall conform to the **Construction Specifications Section 7-05.3(3) Connections to Existing Manholes.***

*All manholes in areas of high groundwater shall conform to the **Construction Specifications Sections 7-05.3 Construction Requirements and 7-05.3(1) Adjusting Manholes and Catchbasins to Grade.***

C1-6.7 Frames, Covers, and Steps

*All manhole covers and frames shall conform to the **Construction Specifications Section 9-05.15(1) Manhole Ring and Cover** and District Standard Drawings. All manhole steps will conform to District Standard Drawings.*

C1-6.8 Liners

Corrosion resistant coatings should be considered for adverse environmental conditions. Structural linings should be considered for manhole rehabilitation and for reduction of I/I. **If required, Raven 405 blue or gray epoxy coating, or equivalent, shall be installed at a minimum thickness of 120 mil (dry).**

C1-6.9 Manhole Testing

*Manhole testing shall conform to the **Construction Specifications Section 7-05.3(5) Vacuum Test for Manholes.***

Grease Interceptors and Oil/Water Separators shall be exfiltration tested in accordance with the Construction Specifications.

C1-6.10 Grease Interceptors

Sizing for grease interceptors shall comply with the following formula:

$$V = R \times S \times F, \text{ where}$$

V = Minimum volume

R = Retention time (30 minutes minimum)

S = Storage Factor = 1.25

F = maximum flow rate in gpm

C1-7 DELETED

C1-8 DELETED

C1-9 SPECIAL REQUIREMENTS

C1-9.1 Required Separation between Potable Water Lines, Reclaimed Water Lines, and/or Sanitary Sewers (Rev. 10/2006)

The minimum separation requirements established in this section apply to all gravity and pressure sewers of 24-inch diameter or less. Larger sewers may create special hazards because of flow volumes and joint types, and generally require additional separation. The special construction requirements given below are for the normal conditions found with sewage and water systems. Requirements that are more stringent may also be necessary in areas of high ground water, unstable soil conditions or other geotechnical constraints. Any site conditions not conforming to conditions described in this section will require assessment and approval of the appropriate state and local agencies.

C1-9.1.1 Horizontal and Vertical Separation (Parallel)

A minimum horizontal separation of 10 feet between sanitary sewers, reclaimed water lines, and any existing potable water lines, and a minimum vertical separation of 18 inches between the bottom of the water line and the crown of the sewer shall be maintained. The distance shall be measured edge to edge (i.e., from the outer diameter of the pipes.) See Figure C1-2.

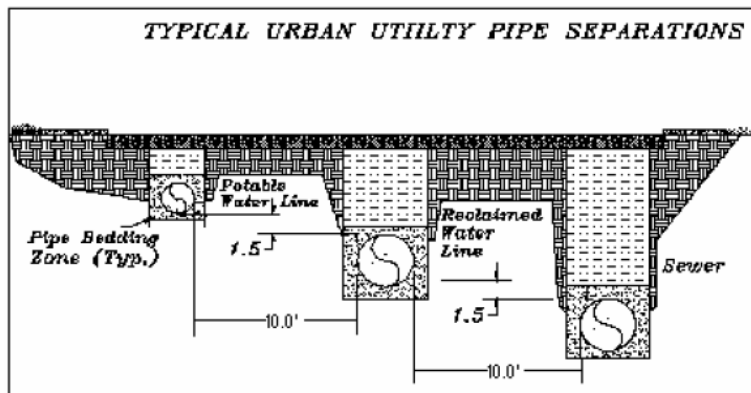


Figure C1-2 Required Separation between Potable Water Lines, Reclaimed Water Lines, and Sanitary Sewers, Parallel Construction

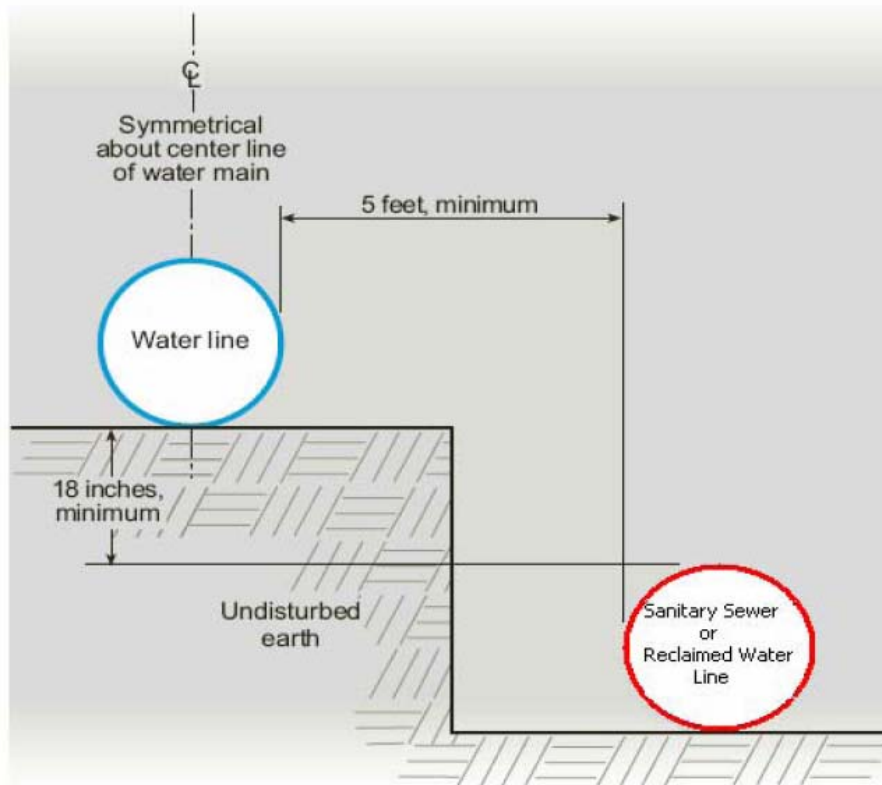


Figure C1-3 Required Separation between Water Lines and Sanitary Sewers, Unusual Conditions Parallel Construction

C1-9.1.2 Unusual Conditions (Parallel)

When local conditions prevent the separations described above, a sewer may be laid closer than 10 feet horizontally or 18 inches vertically to a water line or reclaimed water line, provided the guidelines below are followed:

- It is laid in a separate trench from the water line.
- When the vertical separation cannot be obtained, the sewer shall be constructed of materials and joints that are equivalent to water main standards of construction and shall be pressure tested to ensure water tightness (see C2-3.6) prior to backfilling. Adequate restraint should be provided to allow testing to occur.
- If sewers must be located in the same trench as a potable water line, special construction and mitigation is required. Both water lines and sewer lines shall be constructed with a casing pipe of pressure-rated pipe material designed to withstand a minimum static pressure of 150 psi.
- The water line shall be placed on a bench of undisturbed earth with the bottom of the water pipe at least 18 inches above the crown of the sewer, and shall have at least 5 feet of horizontal separation at all times. Additional mitigation efforts, such as impermeable barriers, may be required by the appropriate state and local agencies. See Figure C1-3.

C1-9.1.3 Vertical Separation (Perpendicular)

Sewer lines crossing water lines at angles including perpendicular shall be laid below the water lines to provide a separation of at least 18 inches between the invert of the water line and the crown of the sewer.

C1-9.1.4 Unusual Conditions (Perpendicular)

When local conditions prevent a vertical separation as described above, construction shall be used for crossing pipes as follows:

A. Gravity Sewers Passing Under Water Lines

All of the following shall apply to gravity sewers:

- Constructed of material described in Table C1-4. The one segment of the maximum standard length of pipe (but not less than 18 feet long) shall be used with the pipes centered to maximize joint separation.
- Standard gravity-sewer material encased in concrete or in a one quarter-inch thick continuous steel, ductile iron or pressure rated PVC pipe with a dimension ratio (DR) of 18 or less, with all voids pressure-grouted with sand-cement grout or bentonite. Commercially available pipe skids and end seals are acceptable. When using steel or ductile iron casing, design consideration for corrosion protection should be considered.
- The length of sewer pipe shall be centered at the point of crossing so that the joints will be equidistant and as far as possible from the water line. The sewer pipe shall be the longest standard length available from the manufacturer.

Table C1- 4 Recommended Pipe Material for Unusual Conditions

Type of Pipe	AWWA (ASTM) Standard		
	Pipe	Joint	Fittings
Ductile Iron	C 151 and C 104	C 111	C 110
Polyvinyl-Chloride	C 900	(D 3139 AND F 477)	C 110
Concrete Cylinder	C 303		
HDPE 3408	C 906	Fused per C 906	C 906

* Pipe spec C900 for pipe less than or equal to 12 inches in diameter; C905 for pipe greater than 12 inches in diameter.

B. Gravity Sewers Passing Over Water Lines

Water lines shall be protected by providing:

- A vertical separation of at least 18 inches between the invert of the sewer and the crown of the water line.
- Adequate structural support for the sewers to prevent excessive deflection of joints and settling on and breaking of the water lines.
- The length of sewer pipe shall be centered at the point of crossing so that the joints will be equidistant and as far a possible from the water line. The sewer pipe shall be the longest standard length available from the manufacturer.
- A water line casing equivalent to that specified in C1-9.1.4A.

C. Pressure Sewers under Water Lines

These pressure sewers shall be constructed only under water lines with ductile iron pipe or standard sewer pipe in a casing equivalent to that specified above in C1-9.1.4A for a distance of at least 10 feet on each side of the crossing.

C1-9.2 Pumpout Facilities at Marinas

Pumpout facilities and shore side facilities for disposal of sanitary wastes from boats shall be installed at marinas at the time of initial construction or expansion of facilities, when the marina is of sufficient size and design to serve boats 17 feet or larger in overall length.

The facilities shall be designed according to “Design Criteria for Pumpout Facilities at New or Expanded Marinas,” which is the criteria established by the Washington State Parks and Recreation Commission in its document, “Financial Assistance Application for Clean Vessel Funding Program.”

The requirement for construction of sewage pumpout facilities shall be specified in the Water Quality Certification for the Corps of Engineers Section 10 permit.

Each marina shall prominently display signs stating that it is illegal to discharge untreated sanitary wastes into US waters and directing boaters to the pumpout facilities.

C1-9.3 Stream Crossing

The pipe and joints shall be tested in place, exhibit zero infiltration, and be designed, constructed, and protected against anticipated hydraulic and physical, longitudinal, vertical, and horizontal loads, erosion, and impact. Sewers laid on piers across ravines or streams shall be allowed only when it can be demonstrated that no other practical alternative exists. Such sewers on piers shall be constructed in accordance with the requirements for sewers entering or crossing under streams. Construction methods and materials of construction shall be such that sewers will remain watertight and free from change in alignment or grade. *A minimum depth of cover of 5 feet for stabilized channels and 7 feet for shifting channels should be provided.*

Permits from other agencies or departments are required for work in or adjacent to waterways.

C1-9.4 Inverted Siphons

Inverted siphons shall have not less than two barrels, with a minimum pipe size of 6 inches, and shall be provided with necessary appurtenances for convenient flushing and maintenance. The manholes shall be designed to facilitate cleaning and, in general, sufficient head shall be provided and pipe sizes selected to secure velocities of at least 3 fps for average flows. A rock catcher and coarse screen should be provided to prevent plugging of the siphons. The inlet and outlet details shall be arranged so that normal flow is diverted to one barrel and so that either barrel may be removed from service for cleaning or other maintenance.

C1-9.5 Required Separation from Water Supply Wells

Sewer lines shall be placed no closer than 100 feet to any public water supply well. When constructing sewer lines in the vicinity of any water supply, contact **Clark County Public Health and the appropriate local water purveyor** for local requirements, including the use of alternative construction materials.

C1-9.6 Odor Control

Odor problems are typically related to the presence of hydrogen sulfide. Therefore, the alternatives for control of odor are usually aimed at preventing sulfide generation or at removing sulfides through chemical or biological action. Regular inspection and cleaning of existing collection systems can reduce sulfide buildup, significantly minimizing odor problems. Sealing manhole lids and their openings can be used as a temporary solution for reducing odor complaints.

Slope is the key criterion in designing a new wastewater collection system to avoid sulfide problems. Sewers designed with long runs at minimum slope are prone to sulfide generation due to long residence times, poor oxygen transfer and deposition of solids. Sulfide generation can be a problem in new sewers where actual flows are much less than design flows during the early lifetime of the system, and velocities are inadequate to maintain solids in suspension.

Current conventional design practice recommends that a minimum velocity of 2 fps be achieved regardless of pipe size to maintain a self-cleaning action in sewers. It should be noted that this is a minimum velocity and that it is desirable to have a velocity of 3 fps or more whenever practical.

If sulfide generation is anticipated to be a problem, larger pipe sizes may be selected to improve the rate of re-aeration. However, adequate scouring velocities must still be maintained if larger pipe is used.

The use of drops and falls in manholes can be used as a method of adding substantial amounts of oxygen to the wastewater.

However, drops or falls are not recommended when appreciable amounts of dissolved sulfide are present, as the turbulence will release sulfide from the stream, generating odors and potentially deteriorating the structure.

Sewer line junctions and transitions at manholes require special consideration because they offer an opportunity for both solids deposition and the release of dissolved sulfide. For aerobic wastewater, the major goal of junction design is to provide smooth transitions with minimum turbulence between incoming and outgoing lines in order to prevent eddy currents or low velocity points that will permit deposition of solids. See G2-5 for additional information on odor prevention and treatment

C1-9.7 Corrosion Control

Hydrogen sulfide may result in severe corrosion of unprotected sewer pipes made from cementitious materials and metals. The corrosion occurs when sulfuric acid is derived through the oxidation of hydrogen sulfide by bacterial action on the exposed sewer pipe wall. Various pipe materials exhibit resistance to corrosive attack from sulfuric acid but other forms of chemical corrosion should also be considered. Certain concentrated organic solvents can soften the polymeric materials in plastic pipes and in plastic joints on non-plastic pipe, but this type of damage is rare. Galvanic action is the cause of most corrosion in buried iron and steel pipe.

Where corrosion problems are the result of hydrogen sulfide action, similar actions to those taken to control odor will also have the beneficial effect of reducing corrosion. Various linings and coatings are available to protect concrete, ductile iron, steel and ABS composite pipes. External polyethylene film encasements are often used on metal pipes to impede external corrosion from galvanic action. Manholes can also be protected from corrosion by the use of lining systems.

C1-9.8 Trenchless Technologies

Trenchless techniques for new construction include: micro-tunneling, auguring or boring, pipe jacking, and other mining-type operations.

Costs, topography or other issues that may preclude traditional open-cut-and-excavation methods will most often direct the use of these techniques. See C1-8 for descriptions of techniques involving trenchless technologies applicable to sewer system rehabilitation or replacement. Some of these techniques may also be applicable for new construction.

C1-9.9 Pipe Casing

Often when a sanitary sewer is installed by boring methods, a casing pipe is inserted and the sanitary sewer pipe is placed inside. **Casing crossings will normally be required on all State Highway crossings, Railroad crossings and major arterial crossings. Casings may be required on stream crossings.** When installing pipe in a casing, the pipe must be uniformly supported **with approved spacers and end caps. The spacers will be constructed of non-decaying material, firmly connected to the pipe and spaced per manufacturer's specifications or District standards.** Generally, the annular space between the pipe and the casing is filled with **sand**, grout or controlled density fill.

All pipe casing design shall conform to the Amendments to the Construction Specifications Division 10 Jacking and Boring.

C1-10 ALTERNATIVE SYSTEMS

Alternative systems are systems which may be used as alternatives to gravity sewers when special conditions warrant the usage of these nonstandard systems.

Alternative systems for conveyance of wastewater to a centralized location or wastewater treatment facility include grinder pump (GP), septic tank effluent pump (STEP), small diameter gravity (SDG), and vacuum systems. **The following description provides general information for the design of STEP systems and GP systems. Sections C1-10.6 provides additional District specific design criteria.**

GP systems use a macerating type pump to convey sewage through small diameter pipelines to a centralized location.

Grinder pumps are also commonly used in conjunction with gravity systems where a particular structure is located below the invert of a gravity collection pipe or there is insufficient vertical drop between the structure and the gravity pipe.

STEP systems use an effluent-type pump to convey the relatively clear liquid from the center of a vessel (STEP tank) that is similar in nature to a septic tank. A STEP system is similar to a grinder system in that it conveys liquid to a common location through small diameter pipelines. The major difference is that much of the solids remain in the STEP tank and have to be removed periodically (similar to pumping a septic tank) and that the liquid conveyed in a STEP system is septic.

STEP; Commercial Duplex. The commercial pump system site will be required to be paved, fenced and gated. The site must be of sufficiently sized area to accommodate the necessary equipment for maintenance, repair and replacement. The site must have an all weather access to it capable of sustaining H-20 loads from equipment trucks as large as 40' long and 10' wide with no turns less than a 30' radius. As every application of a commercial Duplex system may have significantly different sizes and shapes the site area placement, paving, fencing, gates, access road needs will be determined through the plan review process. For this reason, the District encourages owners and their design engineers to request a predesign conference before initial plan submittal.

SDG systems, sometimes referred to as septic tank effluent filter (STEF) systems or septic tank effluent gravity systems, use gravity to convey liquid to a common location. A SDG system conveys the relatively clear liquid from the center of a vessel, similar to a septic tank.

The liquid is conveyed by gravity through a system of small diameter pipelines that are designed and sized to ensure that the hydraulic grade line is below the liquid level of the SDG tanks during peak flow. Similar to a STEP system, much of the solids remain in the tank or vessel and are periodically removed. It is common to combine STEP and SDG on a single system with the SDG units above the hydraulic grade line and the STEP units in areas that are below the peak hydraulic grade line.

C1-10.1 Grinder Pump, Septic Tank Effluent Pump, and Septic Tank Effluent Filter/Small Diameter Gravity Systems

C1-10.1.1 Application

The designer may consider alternative collection methods for a variety of different applications. An alternative method of conveyance can be used in any application but is usually selected due to the circumstances surrounding the installation. Examples of such circumstances are as follows:

- Difficult construction conditions, such as high ground water, subsurface rock removal, large amounts of street reconstruction to implement the system, undulating terrain requiring multiple pump stations for a gravity collection system, and difficult topography requiring the structures to pump to the collection line.
- Low- to moderate-density structures along the collection system route or high-density structures separated from the remainder of the collection system by long distances.
- Limited treatment plant capacity requiring I/I to be kept to a minimum.
- Low system costs for certain installations.

C1-10.1.2 Design Considerations

Design of a STEP, STEF/SDG, or GP system shall, at a minimum, incorporate the system design considerations such as determining the peak-hydraulic grade line, matching the peak-hydraulic grade line to the individual pump curve or elevation of the SDG units, sizing the holding vessel based on estimated or actual wastewater flows, and designing system appurtenances required to provide a reliable municipal system.

A. Peak Design Flows

The minimum peak flow used in the pipeline design for alternative systems shall be equal to or greater than the following:

$$Q = 15 + .5D \text{ or}$$

$$Q = 15 + .15P$$

Where:

Q = Design peak flow, gpm

D = Number of equivalent dwellings

P = Population

Peak flow is defined as an event that lasts about 15 minutes. If a dead-end reach of pipe has single or minimal users with high individual flows, the designer shall use the estimated discharge from two vessels or the combined discharge from two pumps as the minimum design flow.

B. Infiltration and Inflow Considerations

Alternative forms of collection are not meant to receive high amounts of I/I from ground water or surface water. The designer shall incorporate methods and materials in the design to eliminate sources of I/I from the system.

C1-10.1.3 Hydraulic Grade line/Pipeline Sizing

Pipelines for STEP, SDG and GP systems shall be sized to keep the peak hydraulic grade line below the critical operating elevations of the individual system. The hydraulic grade line shall be computed using common engineering fluid mechanics calculations using the Hazen Williams or Manning equation with an appropriate roughness co-efficient.

If downhill pumping cannot be avoided, the downhill pipeline shall be sized for two-phase flows (water and air). The pipeline shall be sized to allow air to transfer to properly located and sized air release assemblies.

A. SDG Hydraulic Grade line

The maximum hydraulic grade line based on peak flow (C1-10.1.2) shall be below the outlet of the SDG/STEP tank minus 2 percent fall along the service line between the tank and the collection main. The service line will include, at a minimum, a check valve to prevent surcharge of the vessel from the collection line.

B. STEP/GP Hydraulic Grade line

The maximum hydraulic grade line of the mainline, service line, and minor friction losses based on peak flow (C1-10.1.2) shall be no greater than the installed elevation of a STEP/GP pump plus 85 percent of the total available head of the pump. The designer shall also consult the manufacturer of the pump equipment to be used to determine if the individual pump criteria allows continued use at that position on the head curve. The designer shall use whichever criteria are more stringent. The service line will include a minimum of two check valves to prevent surcharge of the vessel from the collection line.

C1-10.1.4 Minimum Velocity

Minimum velocities for STEP and/or SDG pipelines are not required. STEP and/or SDG pipelines will be installed with cleanouts (pig ports) at the end of each line and at critical line size changes to necessitate cleaning. Minimum velocities for GP pipelines shall be 2 fps. GP pipelines will be installed with cleanouts (pig ports) at the end of each line and at critical line size changes to necessitate cleaning.

C1-10.1.5 Pump Selection STEP/GP

Pumps installed on a STEP or GP system shall meet the criteria for the maximum hydraulic grade line and be able to meet the pumping requirements of the structure where it is installed.

The designer shall review the system as a whole and select a type or characteristic of a pump for the entire system that has sufficient head to operate at the maximum hydraulic grade line (see C1-10.1.3). The designer may opt to include design zones within the system with different maximum hydraulic gradelines.

The pump selected (*see sections C1-10.5.5 and C1-10.6.5*) shall also be able to discharge influent peak flow (volume) without exceeding the working volume within the pump holding vessel (see C1-10.1.6). Influent peak flow (volume) will be determined by reviewing the number of fixtures within a structure or by applying a peaking factor to average daily volumes. The designer shall use a minimum of 400 percent of average daily flow for estimating peak influent volumes.

C1-10.1.6 Tank/Vessel Type and Sizing

Any vessel used for construction of a STEP, SDG or GP system shall conform to general guidelines, as follows:

- Vessels shall be constructed of a material that does not degrade from corrosion caused by the surrounding soil or the wastewater being held in the vessel.
Common materials include reinforced cement concrete, reinforced fiberglass and polyethylene.
- Vessels shall be designed to withstand the external soil loading based upon the type of soil, lateral loading due to hydrostatic water pressure and wheel loading. Vessels to be located in a traffic-bearing area shall be designed to withstand HS-20 truck loading with appropriate impact factors.
- All vessel designs will bear the stamp of an engineer licensed in the State of Washington with specific expertise in design of similar vessels certifying that the tanks will meet the loading conditions specified herein.
- The vessel, appurtenances (risers, lids, cleanouts, inspection ports, inlet and outlet piping, etc.), and the connection between the vessel and appurtenances shall be watertight. Each vessel and appurtenances once fully assembled and installed shall be tested for leakage by filling with water. The test will be witnessed by the agency operating the system or their duly authorized representatives. No vessel will be accepted if there is any noticeable leakage during the testing period.

A. Tank Configuration STEP/SDG

A vessel (tank) up to 1,500 gallons in size shall be configured in accordance with the intent of the International Association of Plumbing and Mechanical Officials (IAPMO) SPS 1-87 with the following recommendations:

- A baffle wall or compartment wall is recommended but not required for 1,000- and 1,500-gallon tanks.
- The baffle wall will be constructed with a hole or knockout at the top of the baffle wall for ventilation and multiple holes or knockouts located in the clear zone of the tank (approximately 70 percent of the liquid level of the tank). The holes or knockouts shall be of sufficient size to prevent plugging from raw sewage.

A vessel (tank) over 1,500 gallons in size shall be configured to allow solids to deposit in the tank. It is recommended that the tanks conform to the following approximate configurations:

- An approximate tank size of 3,000 gallons shall have an equivalent diameter of 6 feet.
- An approximate tank size of 6,000 gallons shall have an equivalent diameter of 8 feet. It is recommended that tank volume over 6,000 gallons be accomplished with tanks in series to facilitate tank pumping. If tanks are placed in series, a baffle wall will not be required.

Tanks shall have a baffle wall installed that represents two-thirds volume in the first chamber and one-third volume in the second chamber. It is recommended that the baffle wall shall be constructed as outlined above. Tanks that are over 2,500 gallons total volume shall have three access ports with a minimum diameter of 18 inches, two in the first chamber and one in the second chamber. *Multiple tanks may be used upon application to and approval of the District Engineer.*

All tanks will include an inlet tee. The bottom of the tee will be extended to 18 inches below the liquid level.

A STEP/SDG tank shall contain detention volume, working volume, and storage volume.

B. Detention Volume STEP/SDG

The detention volume or liquid volume of a STEP or SDG tank that serves a single-family home or small business shall be a minimum of 950 gallons. Detention volume is defined as the volume of liquid below the "OFF" switch (STEP) or the outlet pipe (SDG). Tanks that serve structures with higher wastewater discharge volumes shall be sized in accordance with the following equation:

$$V = 1.5Q \text{ (residential strength waste)}$$

$$V = 2.0Q \text{ (nonresidential strength waste)}$$

Where:

V = Liquid volume

Q = Peak day flow for the structure being served

The equation provides the minimum liquid volume within the STEP/SDG tank. The tank shall also contain sufficient working volume and storage volume. Liquid volume shall be approximately 65 to 75 percent of the total tank volume.

C. Working Volume STEP/GP

The working volume shall be greater than the difference between the peak influent flow and the discharge of the STEP or grinder pump over a period of time estimated to be the peak duration. Working volume is defined as the volume between the "ON" and the "OFF" switch.

D. Storage Volume

STEP, SDG and GP vessels (tanks) shall have a minimum of 24 hours of storage within the tank except as allowed (see C1-10.1.6E.2). Tanks without 24 hours of storage shall be installed with a power transfer switch with an emergency generator plug or other device for allowing emergency power connection, or shall have reserve volume provided with a separate vessel. Storage volume is defined as the volume between the "OFF" switch and the top of the tank.

E. Power Outages

1. Applicability

STEP, SDG, and GP systems installed in areas with a history of prolonged power outages may require additional storage volumes. The designer shall review historical records of the local power purveyor to determine the advisability of adding more storage.

2. Power Transfer Switch/EG Plug

Vessels without 24 hours of storage shall be provided with a power transfer switch with an emergency generator plug. The number of tanks installed with power transfer switches shall be limited to the number of tanks or vessels that can be serviced by the local agency during a power outage. The agency shall also keep power generators with the proper connection to the generator plug on hand and in good working order.

C1-10.2 System Components

C1-10.2.1 Pipeline

Generally, pipelines shall be constructed of material that is not readily subject to corrosion by raw or septic wastewater.

A. Service Line/Check Valves

Each service line between the SDG vessel, STEP, or GP pump and the collection line shall have a corporation stop valve installed at the main. In addition, a minimum of two check valves will be installed on the STEP and GP service lines, and a minimum of one check valve will be installed on the SDG service line. The check valve attached to either the STEP or GP pump counts as one of the check valves.

Service lines shall be as **further outlined in the Design Specifications.**

B. Cleanouts/Pig Ports

Cleanouts (pig ports) shall be installed at the ends of all pipelines. Cleanouts will be designed to launch a 2 lb/cu/ft polyfoam pig for scouring the pipelines. A cleanout can accept a pig that is 2 inches larger in diameter than the pipe that it is being inserted (for example, a 4-inch pig can be launched into a 2-inch pipeline). An additional pig port will be installed when the pipeline diameter exceeds the size of pig that can be launched in a cleanout (such as the transition between a 4- and 6-inch-diameter pipeline).

C. Valves

Sufficient mainline valves shall be installed at locations to isolate portions of the system and to ensure continuous operation for maintenance and repair. On straight runs of pipeline, it is recommended that valves be installed every one-thousand (1,000) feet.

D. Air Release Assemblies

In conformance with good engineering practices, air release and combination air release assemblies shall be installed in the system. Special attention shall be given to the release of air from STEP/SDG pipelines. Air evacuated in these pipelines shall be stripped of odor using activated carbon, soil filters or other odor control mechanism. The designer should take extra precaution in reducing or eliminating the amount of air being exhausted by keeping the pipeline full of liquid wherever possible.

E. Pipeline Material and Pressure Testing

Pipeline material shall be pressure rated equal to working pressure of the system. Material shall be resistant to the corrosive nature of wastewater. Common materials include PVC, polyethylene, stainless steel and epoxy-coated or lined ductile iron. Pressure testing of service lines shall be completed with the ball valve at the mainline in the closed position. Pressure testing of the mainline shall be completed with the service line corporation stop in the open position. Pressure testing shall be in compliance with pressure testing for water mains using **District** standards.

- STEP service lines shall be a minimum of one and one-quarter (1¼) inch diameter Schedule 40 PVC;
- Grinder service lines shall be a minimum of two (2) inch diameter Schedule 40 PVC

F. Discharge to a Gravity Collection System

1. Grinder Pump System

Discharge to a gravity system from a GP system can be accomplished at a manhole. Discharge in a manhole shall be accomplished by producing a laminar flow in the manhole channel.

Both types of installations assume that the GP system has sufficient internal velocity and that the raw sewage has not turned septic. If the raw sewage within the GP pipeline has turned septic, provisions shall be made to reduce or eliminate the effects of hydrogen sulfide release.

2. Corrosion Control in STEP/SDG Systems

Discharge to a gravity system from a STEP or SDG system can be accomplished by either installing a saddle on the gravity main or at a manhole. Discharge in a manhole shall be accomplished by producing a laminar flow in the manhole channel. Laminar flow shall not be accomplished using a drop manhole. Prior to discharge, the STEP/SDG effluent shall be conditioned to reduce or eliminate the effects of hydrogen sulfide release. Conditioning may include aeration or chemical addition.

3. Odor Control

Release of air at the discharge point will require odor control, which may include the use of carbon filters, soil filters or other mechanisms.

G. Discharge to a Conventional Force Main

In extraordinary circumstances, as approved by the District Engineer, a STEP or GP system may be connected to a conventional force main. The designer shall review the following issues to ensure that there will not be a negative effect on the existing system:

A. Ensure that the hydraulics or performance of either the system being connected or the existing force main pump station are not appreciably altered beyond the design parameters.

B. Ensure that the downstream facilities are protected from release of hydrogen sulfide. Protection shall consider, when applicable, impacts to treatment, corrosion and odor.

C. The system must be designed to interface with existing pump station controls.

C1-10.2.2 Pump or SDG Assembly

A. Pumps

Grinder or effluent pumps installed in a municipal system shall be UL listed for the intended application. Each pump shall be affixed with a UL tag denoting its use and shall have available for review a UL card showing the intended application.

B. Pump/Effluent Vault (Screen) STEP/SDG

Effluent pumps installed in STEP systems that are not rated to pump solids shall be protected with a screening or filtering mechanism to prevent the impeller from plugging. The screening or filtering mechanism shall be designed to provide sufficient effective screen area to prevent plugging. Solids entering the pump impeller shall be reduced to one-eighth-inch in size.

Small diameter gravity tanks will be installed with a screening or filtering mechanism at the discharge of the tank to prevent solids over one-eighth-inch in size from entering the service line and mainline. The screening or filtering mechanism shall be designed to provide sufficient effective screen area to prevent plugging.

C. Control Panel/Level Control

Each STEP and GP pump assembly shall be equipped with a pump control panel and level-sensing mechanism that is UL listed for the application.

The control panel shall include an audio and visual alarm that is activated when a high liquid level occurs within the vessel.

The audio alarm will be capable of being silenced until repair or corrections can be made.

If the system is owned and operated by a single agency, each panel will be affixed with a permanent placard with the name of the agency operating the system, the phone number of the agency, and instructions for silencing the audio alarm.

It is recommended that the control panel audio and visual alarm also be activated by low liquid levels occurring within the vessel. It is recommended that each SDG tank be equipped with an alarm panel and a level-sensing mechanism that is UL listed for the application. The alarm panel shall include an audio and visual alarm that is activated when a high liquid level occurs within the vessel. The panel shall have the same alarm and placard features as listed for the STEP and GP control panel.

D. Electrical Requirements

All electrical components of a STEP, SDG or GP system shall be in compliance with the latest version of the NEC and latest requirements of the state Labor and Industries Electrical Inspection Division.

E. Ventilation

Each vessel for a STEP, SDG or GP system shall either be vented through the structure plumbing or provided with a separate ventilation system.

C1-10.3 Vacuum Sewer System

Clark Regional Wastewater District does not allow vacuum systems within the current system.

C1-10.4.5 Easements for Municipalities

The property owner shall grant an easement to the District ***for STEP systems*** that allows, at a minimum, access onto the property to:

- Monitor and provide routine maintenance.
- Repair or replace defective components.
- Remove and replace all on-site components, if necessary.

The minimum duration of the easement shall be for the life of the system.

C1-10.4.6 Replacement Parts

The District shall keep on hand sufficient replacement parts to ensure that corrections to the system can be made in an expeditious manner.

C1-10.5 Alternative Systems-Grinder systems

Alternative systems for conveyance of wastewater to a centralized location or wastewater treatment facility include grinder pump and septic tank effluent pump (STEP systems).

This section is for grinder pump systems only and does not include gravity or force mains. For gravity main requirements see Design Criteria Chapter C1. For force main requirements see Chapter C2-3 Force Mains.

C1-10.5.1 Application

Grinder systems are the preferred/recommended alternative system inside the Urban Growth Area when alternate systems are required. Grinder systems will not be designed or installed within the urban area without written approval from the District.

The Design Criteria is primarily for single-family residential simplex grinder pump systems. All other applications will require duplex systems. The **Developer** shall retain an Engineer to design all duplex grinder pump systems.

The design of duplex systems will be in accordance with the Design Criteria and Gravity and Force Main Design Criteria Section C1-1.3.3 Approval of Alternate Materials or Methods. The **Design** Engineer's plans, profiles and specifications must be submitted to, reviewed by and approved by the District.

C1-10.5.1.1 Plans, Profiles, Construction Notes and Record Drawings

A. General

1. Plans, profiles and construction notes, and record drawings are not required for the installation of a single-family residential grinder pump system. **The requirements of the District's Standard drawings must be met.**
2. District will gather record drawing data for the installation
3. Plans, profiles and construction notes, and record drawings are required for the installation of a duplex grinder pump system.
4. If a force or gravity main extension is required, all requirements for plans, profiles, construction notes and record drawings will be required as per Design Criteria, Chapter C-1 and C-2, and Grinder Pump Design Criteria, Chapter C1-10.

C1-10.5.5 Pump Selection Grinder pumps

- A. Grinder pumps shall be in compliance with Table C1-10.5 – Approved Pumps, unless otherwise approved by the District in writing.
- B. Grinder pumps shall be cast iron submersible grinder pumps suitable for submersion in septic tank effluent.
- C. Motors shall be 240-volt, single phase with permanently split capacitor located in the motor housing.
- D. Motor casing shall be oil filled.
- E. Lower bearings shall be ball thrust bearings. Upper bearings shall be radial bearings. The pumps shall be capable of starting and running on a 20-ampere, 240-volt, single phase circuit.
- F. Motors shall be non-overloading throughout the range of the manufacturer's pump curve.
- G. Horsepower rating for the pump motors shall not exceed two and one-half (2½) horsepower. Pumps shall be compatible with the specified electrical control panel.
- H. The cable splice to the motor lead shall be watertight.
- I. Pump power cords shall use copper wire with type SO insulation and non-metallic cord grips resistant to septic tank corrosive atmospheres. The cords shall be suitable for use with two (2) – two and one-half (2½)-horsepower, 240-volt motors including locked rotor conditions.
- J. Conductor insulation shall be color coded consistently throughout the power supply system.
- K. Cord grip material manufactured of type 18-9 stainless steel shall be an approved equal to non-metallic material.

Wire Size and Color

The float control conductors from the control panel to the tank junction box shall be:

- Stranded copper #12 with THHN insulation; with
- Red insulation for OFF; and
- Blue insulation for ON; and
- Green insulation for GROUND; and
- Grey insulation for REDUNDANT OFF; and
- Yellow insulation for HIGH WATER ALARM.

All pumps shall be installed with one-half (½) inch polypropylene lifting ropes connected to 304 SS hooks at the top of the riser. The rope shall extend three (3) feet above the top of the riser.

Pump Designation (Residential)	Minimum Head @ Shutoff	Minimum Head @ 20 GPM	Required Pump
Grinder Pump	95 feet	75 feet	ABS Piranha S20/2W
Grinder Pump	94 feet	84 feet	Goulds RGS2012
Grinder Pump	160 feet	0 @ 15 gpm	Environment 2012AMGP

Table C1-10.5 – Approved Pumps

C1-10.5.6 Tank/Vessel Type and Sizing

A. Tank Configuration GP

All single-family residential grinder pump tanks shall be for a simplex installation and be installed per manufacturer’s recommendations.

The minimum size tank for grinder pump systems is 500 gallons nominal capacity and shall be concrete as manufactured by and available through D and K, Inc. Concrete Products of Vancouver, WA (360-573-4020), **or spherical HDPE pump tanks as manufactured by Norwesco** or approved equal;

C1-10.5.7. System Components

C1-10.5.7.1 Pipeline

A. Discharge to a Gravity Collection System

Grinder Pump System

Discharge to a gravity system from a grinder pump system shall be accomplished by extending a gravity lateral from the gravity sewer line to the property line and connecting the grinder pump pressure sewer service at that point. Upon approval of the District, a 2” pressure lateral may connect directly to a gravity main. See District Standard Drawings for details. The valve box shall be located within five (5) feet of the right-of-way or public easement.

C1-10.5.7.2 Pump Assembly

A. Control Panel, Safety Disconnect Panel and Level Control

All units shall be in conformance with District Standard Drawings and Construction Specifications for Grinder Pump Systems, 12-02.4.C Float Assembly and 12-02.7 Electrical.

C1-10.5.8 Force Mains

C1-10.5.8.1 Construction Methods and Materials

All pressure sewer services shall:

- A. Be designed to prevent damage from superimposed loads. Proper allowance for loads imposed on the pipe shall be calculated for the width and depth of the trench; and
- B. Be Schedule 40 PVC, ASTM D1785; and
- C. Have a minimum of three (3) feet depth of cover over the top of the pipe from finished grade or the flow line of a ditch; and
- D. Have a continuous toning wire attached to the top of the pressure sewer service, and
- E. Valve box shall generally not be located in the driveway. If located within a driveway, the valve box shall be traffic rated; and
- F. Taps will be allowed for two (2) inch pressure sewer services. All larger pressure sewer services shall be made with a tee in accordance with District Standard Drawings.
- G. **Grinder service lines shall be two (2) inches in diameter.**

C1-10.5.8.2 Pressure Tests

Pressure service lines shall be tested at 150 psi for 15 minutes with no loss of pressure.

C1-10.6 Alternative Systems – STEP systems

This section is for STEP systems only and does not include gravity or force mains. For gravity main requirements see Design Criteria Chapter C-1. For force main requirements see Chapter C-2-3 Force Mains.

C1-10.6.1 Application

With the written approval of the District, the Design Engineer may consider alternative collection methods for a variety of different applications. The Hockinson and Meadow Glade areas are STEP systems and no alternatives will be considered in these service areas. STEP systems will not be designed or installed within the urban area without written approval from the District.

The Design Criteria is primarily for single-family residential simplex STEP systems. All other applications will require duplex systems. The Owner shall retain an Engineer to design all duplex STEP pump systems. The design of duplex systems will be in accordance with the Design Criteria and Gravity and Force Main Design Criteria Section C1-1.3.3 Approval of Alternate Materials or Methods. The Design Engineer's plans, profiles and specifications must be submitted to, reviewed by, and approved by the District.

C1-10.6.1.1 Plans, Profiles, Construction Notes and Record Drawings

A. General

Plans, profiles and construction notes, and record drawings are not required for the installation of a single-family residential STEP pump system. District Standard drawing requirements shall be met.

District will gather record drawing data for the installation

Plans, profiles and construction notes, and record drawings are required for the installation of a duplex STEP pump system.

If a force main or gravity main extension is required, all requirements for plans, profiles, construction notes and record drawings will be required as per Design Criteria, Chapter C-1 or STEP Design Criteria, Chapter C1-10.

C1-10.6.5 Pump Selection STEP

All STEP systems (other than single-family residential) shall be a duplex pump system designed in accordance with the Design Criteria (See C1-3 Gravity Systems Design Consideration,

Table C1-3 Design Factors). In addition, with the exception of specific sizing for single-family residential, all other duplex systems shall meet the following requirements.

All duplex STEP systems shall have separate wiring, discharge and valve assemblies.

All duplex STEP systems shall be designed by a professional engineer. Plans and specifications shall be submitted for written approval of the District.

All STEP single-family residential pumps shall be simplex installation and meet the following requirements.

- A. STEP pumps shall be in compliance with Table C1-10.6 – Approved Pumps unless otherwise approved by the District in writing.*
- B. STEP pumps shall be cast iron submersible septic tank effluent pumps suitable for submersion in septic tank effluent.*
- C. Motors shall be 240-volt, single phase with permanently split capacitor located in the motor housing.*
- D. Motor casing shall be oil filled.*
- E. Lower bearings shall be ball thrust bearings. Upper bearings shall be radial bearings.*
- F. The pumps shall be capable of starting and running on a 20-ampere, 240-volt, single phase circuit.*
- G. Motors shall be non-overloading throughout the range of the manufacturer's pump curve.*
- H. Horsepower rating for the pump motors shall not exceed two (2) horsepower. Pumps shall be compatible with the specified electrical control panel.*
- I. The cable splice to the motor lead shall be watertight.*
- J. Pump power cords shall use copper wire with type STOW insulation. Cord grips shall be manufactured of non-metallic material or type 18-9 stainless steel resistant to septic tank corrosive atmospheres. The cords shall be suitable for use with two (2) horsepower, 240-volt motors including locked rotor conditions. Conductor insulation shall be color coded consistently throughout the power supply system.*
- K. Wire Size and Color*

The float control conductors from the control panel to the tank junction box shall be:

 - Stranded copper #12 with THWN insulation; with*
 - Red insulation for OFF; and*
 - Blue insulation for ON; and*
 - Green insulation for GROUND; and.*
 - Grey insulation for REDUNDANT OFF; and*
 - Yellow insulation for HIGH WATER ALARM.*

- L. All pumps shall be installed with one-half (½) inch polypropylene lifting ropes connected to 304 SS hooks at the top of the riser. The rope shall extend three (3) feet beyond the top of the riser.

Pump Designation (Residential)	Minimum Head @ Shutoff	Minimum Head @ 20 GPM	Required Pump
STEP- Meadow Glade Low Head	72 feet	55 feet	Gould WE10H
STEP – Meadow Glade High Head	105 feet	90 feet	Gould WE1512 HH
STEP – Hockinson	105 feet	90 feet	Gould WE1512 HH

Table C1-10.6 – Approved Pumps

C1-10.6.6 Tank/Vessel Type and Sizing

All STEP system tanks (other than single-family residential) shall be designed for a duplex pump system in accordance with the Design Criteria (See C1-3 Gravity System Design Consideration, Table C1-3, Design Factors). Duplex STEP tank systems shall be designed by a licensed Professional Engineer.

A. Tank configuration for STEP Systems

Tanks shall be a minimum 1,500 gallons nominal capacity and shall be either:

1. Fiberglass as manufactured by Fiber Septic Systems of Yakima, WA (509-965-8437); or
2. Fiberglass as manufactured by FSI of Red Bluff, California available through US Filter of Vancouver, WA (360-256-6151); or
3. Concrete as manufactured by and available through D and K, Inc. Concrete Products of Vancouver, WA (360-573-4020); and
4. All single STEP tanks shall have one (1) baffle installed that divides the volume of the STEP tank into two thirds (2/3) solids tank and one third (1/3) pump chamber by volume;
5. All multiple tank STEP systems shall be submitted for review by the District; or
6. Approved equal.

Upon installation and prior to backfilling, the tank shall be filled to a point above the riser with potable water. Concrete tanks shall be filled for a period of 24 hours to allow for absorption. Following this period, the tank shall be filled to a point above the base of the riser. There shall be no more than a one (1) inch loss of water depth over a 24-hour period.

The District shall approve all STEP tanks in writing. Contractor's submittal shall include design information and detail drawings with dimensions and specifications.

C1-10.6.8 Force Mains

C1-10.6.8.1 Construction Methods and Materials

All pressure sewer services shall:

- A. Be designed to prevent damage from superimposed loads. Proper allowance for loads imposed on the pipe shall be calculated for the width and depth of the trench; and
- B. Be Schedule 40 PVC, ASTM D1785; and
- C. Have a minimum of three (3) feet depth of cover over the top of the pipe from finished grade or the flow line of a ditch; and

- D. Have a continuous toning wire attached to the top of the pressure sewer service; and*
- E. Valve box shall generally not be located in the driveway. If located within a driveway, the valve box shall be traffic rated; and*
- F. Taps will be allowed for one and one-quarter (1¼) inch and two (2) inch pressure sewer services. All larger pressure sewer services shall be made with a tee in accordance with District Standard Drawings.*

C1-10.6.9 Pressure Tests

Pressure service lines shall be tested at 150 psi for 15 minutes with no loss of pressure.

C1-11 REFERENCES

Recommended Standards for Wastewater Facilities. (10 States Standards.) 1990 Edition.

US Environmental Protection Agency. Handbook for Sewer System Infrastructure Analysis and Rehabilitation. EPA/625/6-91/030. 1991.

Washington State Parks and Recreation Commission. Design Criteria for Pumpout Facilities at New or Expanded Marinas from Financial Assistance Application for Clean Vessel Funding Program.

Water Environment Federation and American Society of Civil Engineers. Existing Sewer Evaluation and Rehabilitation. WEF Manual of Practice FD-6 and ASCE Manual and Report on Engineering Practice No. 62, Second Edition. 1994.

Water Pollution Control Federation. Alternative Sewer Systems. 1986.

WRC, Inc. Waves Multimedia CD. Contact: 2655 Philmont Ave., Huntingdon Valley, PA 19006, (215) 938-8444). 1995.

Washington State Departments of Health and Ecology. Pipeline Separation Design and Installation Reference Guide. Publication Number 06-10-029. 2006. <http://www.ecy.wa.gov/biblio/0610029.html>

Chapter C2 Sewage Pump Stations

C2-1 GENERAL REQUIREMENTS

These Design Specifications, the Construction Specifications and Standard Drawings are typical for District sewage pump station installations. The design of each sewage pump station must be specific to the conditions and requirements of the sewage pump station being designed.

C2-1.1 Location, Site Selection, and Site Layout

All sewage pump station locations, sites and layouts are to be approved by the District in writing. All site layouts will substantially conform to the District Standard Drawings.

C2-1.1.1 Location and Site Selection

Sewage pump stations are usually located at the low point of the service area. The pump discharges to the treatment works or to a high point in the sewer system for continued conveyance by gravity. Generally, sewage pump stations should only be used when gravity flow is not possible.

There is often little choice in siting sewage pump stations. Locations should be sited as far as practical from present or proposed built-up residential areas to reduce community impacts. The amount of land area required is a direct function of the station's size and type and of the need or desire for ancillary facilities such as a maintenance building. The station should be sited to accommodate reasonable pumping head, force main length and depth of the gravity influent sewer(s). Other considerations are:

- Local land use and zoning regulations.
- Location on public right-of-ways versus private easements or site acquisition by the sewer purveyor.
- Permits (or variances) which might be required, such as grading, building, and so on.
- Availability of needed utilities, such as water, electricity and natural gas.
- Applicable noise ordinances, especially when an emergency backup generator will be present.
- Space for future expansion, especially if population growth or development in the drainage area may increase substantially.
- *Local, state and federal critical areas, regulations, permits, etc.*
- *Adjacent land uses.*

C2-1.1.2 Flood Protection

The station shall be designed to remain fully operational during the 100-year flood/wave action

C2-1.1.3 Access for Maintenance Vehicles

- Adequate access to the site is required for maintenance personnel and equipment and for visitors after construction.
- Adequate access during construction is required for construction equipment.
- Access road grade shall not exceed 15%.
- The road and parking configuration should be adequate for vehicle turnaround or allow for one-way access, minimum 40' x 12'.
- Adequate parking spaces for maintenance equipment and visitors should be provided.
- Additional easement or site acquisition may be required for the access road.

- Ingress/egress to the site near busy public right-of-ways may be affected by traffic.

C2-1.1.4 Fire Protection

- Contact the local fire jurisdiction for its requirements.
- Contact the local water purveyor to determine fire flow availability.
- Conform to the requirements of Standards for Fire Protection in Wastewater Treatment and Collection Facilities (NFPA) 820.

C2-1.1.5 Site Piping Layout

- Avoid installing buried pipes directly underneath each other, and minimize pipes crossing one another.
- Maintain appropriate minimum and/or maximum velocities in pipes.
- Provide appropriate restraint or thrust blocking for pressure pipe bends, etc.
- Conform to water purveyor's requirements for meter service, backflow prevention, etc.
- Provide potable water cross-connection protection in accordance with State DOH regulations.
- Provide flexible pipe connections to pipe penetrations through vaults and other underground structures.
- Provide a pig launch facility for the force main.
- *All site piping shall substantially conform to the District Standard Drawings.*
- *If off-site force or gravity mains are required in relation to the sewage pump station, the design and drawings will be in conformance with C1 Sewers and C2-3 Force Mains.*
- *Normally only one inlet line will be allowed into the wetwell.*

C2-1.1.6 Other Site Design Factors

- Landscaping may be required for aesthetic reasons or by local land-use agency codes. Use low-maintenance landscaping wherever possible. *Alternative landscape plans may be submitted for review and approval. Alternative plans shall be designed by a licensed landscape architect licensed in the State of Washington. The plan should be designed: in accordance with governing land use regulations, to be incorporated into the landscape pattern or theme of the project or neighboring area, to reduce or minimize maintenance, and to fit the context of the site and account for factors that will affect plant health and survivability (i.e. sun and wind exposure, soil conditions). The use of native and drought tolerant plants is encouraged.*
- Provide exterior lighting, easily accessible for manual operation, in case maintenance at night is required.
- Provide appropriate security against vandalism.
- *Provide odor control as necessary.*
- Consider intrusion telemetry alarms.

C2-1.1.11 Plans, Profiles, Cross-Sections, Details, Construction Notes and Record Drawings

A. General.

1. *Design Engineer shall call for pre-design locates from the NW Utility Notification Center at 1-800-424-5555. Design Engineer or Surveyor is responsible for field verification of location and elevations of facilities.*
2. *Two (2) sets of plans, cross sections, elevations and details will be submitted to the District for each review of all sewage pump stations.*

3. *After District approval of plans, cross sections, elevations and details, Design Engineer shall submit four (4) sets of prints of the cover sheet and sewage pump station Plans, profile(s) and details to the District at least 5 working days prior to the preconstruction conference.*
 4. *For projects that are the subject of a site plan or land division approved by Clark County or a City with land use authority, the approval of plans and specifications is valid for the period of the original site plan /land division approval.*

Projects that are not the subject of other site plan/land division approvals will expire in accordance with the terms and conditions of the developer extension agreement. Plans that have expired may be submitted for re-approval; but are subject to additional review and fees.
 5. *If off-site force or gravity mains are required in relation to the sewage pump station, the design and plans will be in conformance with C1 Sewers and C2-3 Force Mains.*
- B. *Engineering Drawings -Plans. Plan sheets for sewage pump stations shall be drawn in ink and contain at least the following information:*
1. *A suitable title sheet with the name, address, telephone, e-mail address, and FAX numbers of the Owner, Developer (including contact name) and the Design Engineer; scale; north arrow; vicinity map; section, township and range; legend including symbols and abbreviations; general notes generic to all construction; sheet index; revision box; bench mark(s) based on Clark County Datum; date; drawing number; the Design Engineer's Professional Civil Engineers State of Washington signed seal with date of signature; and District signature block per District Standard Drawings.*
 2. *Minimum Construction Notes (See E.) and Specifications shall be included on the plans sheet for sewage pump station construction.*
 3. *Horizontal dimensions from right-of-way, centerline of road, easement lines or property lines and other utilities or structures.*
 4. *Subtitles on each sheet describing the contents.*
 5. *Adjacent streets, property lines, tax lot numbers and serial numbers.*
 6. *All existing and proposed easements shall be identified with dimensions shown.*
 7. *All existing survey monumentation within 100 feet of the project limits shall be shown.*
 8. *District Standard Drawings that apply to sewage pump stations, force mains and gravity mains.*
 9. *Site and landscape plans with dimensions and finished grade elevations in substantial conformance with the District Standard Drawings.*
 10. *Each drywell, wetwell, electrical panel, valve, valve vault and other appurtenance identified to facilitate checking the cross-section and elevation views.*
 11. *Location of all critical areas including buffers, watercourses, wells, septic systems, stream and railroad crossings, water mains, gas mains, culverts, telephone, underground power, cable television and other utilities or structures based on best available information and field locates. Field locates for designs are available through the NW Utility Notification Center at 1-800-424-5555.*
 12. *All existing gravel and hard surface paving including width(s) and distance(s) from existing right of way, easement or property line*
 13. *Contours for the proposed sewage pump station site extending at least 10 feet outside of the proposed sewage pump station site. If site grading is anticipated, a final site contour map shall be provided. Contour interval shall not be greater than two (2) feet in elevation except in steep terrain where contours are not easily distinguished at two (2) foot intervals.*
 14. *Spot elevations and slopes indicating how the proposed sewage pump station site will be drained of storm water runoff.*

15. *Plans shall be drafted at a scale that will be legible when the plans are reduced fifty (50) percent. If the entire project plans cannot be shown on one (1) sheet, a key map will be provided noting the sheet that each individual section of the plans is located. Where multiple sheets are used for plans or profiles, match lines will be shown. Where multiple sheets are used for plans, a master utility plan will be provided.*
16. *Sheet size shall be 24" x 36" or 22" x 34".*
17. *Pump station sites should be a minimum of fifty (50) feet by fifty (50) feet.*
18. *The proposed sewage pump station site shall:*
 - a. *Be in the form of an easement or platted as a separate lot to be owned by the District; and*
 - b. *Have legal description(s) submitted to the District in writing with a map in addition to platted easement(s); and*
 - c. *If an easement is required, the District will complete the document and record the easement at the County.*
19. *Length, pipe-size and type of material for all on site force or gravity sanitary sewers. (e.g., 50 LF - 6" DIP)*
- C. *Engineering Drawings - Profiles. If off-site force or gravity mains are required in relation to the sewage pump station, the design and plans will be in conformance with C1 Sewers and C2-3 Force Mains.*
- D. *Engineering Drawings – Cross-Sections and Elevation Views and Details. Cross-section and elevation view and detail sheets for sewage pump stations shall be drawn in ink and contain at least the following information:*
 1. *Suitable title plate, scale, dates, drawing number, and the name, address, telephone number and the Design Engineer's Professional Civil Engineer's State of Washington signed seal.*
 2. *Plan and elevation cross-section of the drywell (if applicable), wetwell and valve vault with elevations and dimensions for each component of the system.*
 3. *Elevation view of the electrical panels with all components outlined and named and all conduit sizes and their intended use. If a permanent standby power generator (motor generator) is required by the District, show all wiring, connections and conduits.*
 4. *Profiles of existing and proposed ground surface or road finished grade.*
- E. *Engineering Drawings - Construction Notes. All plans for sewage pump stations shall contain at least the following:*
 1. *All sewage pump station construction will conform to the District adopted Specifications.*
 2. *All Work in Clark County right-of-way will conform to the requirements of the Clark County utility permit or District requirements, whichever is more restrictive.*
 3. *Contractor shall contact the NW Utility Notification Center at 1-800-424-5555 at least two (2) working days before but not more than (10) ten working days before the start of construction of the Work.*
 4. *A preconstruction conference shall be held prior to the start of construction.*
 5. *Backfill of all trenches in traveled areas (roads, driveways or parking lots) shall conform to Construction Specification, Section 9-03.14(1) Gravel Borrow, or as required by the Clark County utility permit, whichever is more restrictive. Compaction for backfill shall be at 95% of the maximum density for the material as established by SECTION 2-03.3(14)D.*
 6. *Bedding for all force mains in the pipe zone shall conform to Construction Specification 9-03.12.3 Gravel Backfill for Pipe Zone Bedding.*
 7. *All testing shall be in accordance with the District's General Special Provisions.*
 8. *Record Drawings shall be submitted to the District prior to final acceptance.*

F. *Record Drawings, plans, cross-sections and elevation views. Record drawings for plans and profile sheets for sewage pump stations shall:*

1. *Be completed by the Design Engineer or Surveyor and submitted to the District prior to project acceptance by the District.*
2. *Be submitted in electronic form as a "PDF" file on a compact disk or other approved electronic submittal media and a complete paper copy.*
3. *Be placed on the approved drawings.*
4. *Show all final elevations and measurements of the dry pit (if applicable), wetwell, valve vaults and valves and other appurtenances.*
5. *Show all changes made to pipe material, slope, length of pipe, finished grade, etc.*
6. *Be clearly marked Record Drawings, dated and with the Design Engineer's Professional Civil Engineer's State of Washington signed seal.*
7. *Be completed by the Design Engineer and submitted to the District prior to project acceptance by the District.*
8. *Become the permanent property of the District.*

C2-1.2 Design Flow Rates, Hydraulics, and Number of Pump Units

C2-1.2.1 Design Flow Rates

The firm capacity of a pump station shall be equal to or greater than the peak hourly design flow. This peak design flow should be based on projected growth in the tributary area, future improvements anticipated in the collection system, and any phased improvements planned for the pump station and force main. It should also allow for a reasonable amount of wear to pump equipment, particularly in a tributary area that is at or near build out. Because mechanical and electrical equipment is typically designed for a 20-year life, it is recommended that the peak design flow be based on a 20-year forecast or greater.

The flow rates shall be determined by C1-3.3. Design Basis as amended by the District.

In addition to establishing the peak design flow, it is also necessary to review minimum flows and determine how the station will operate under low flow conditions.

C2-1.2.2 System Hydraulics

System hydraulics should provide an optimum balance for the project's force main characteristics, pump selection, and minimum and maximum flows. The force main should be small enough in diameter to minimize solids deposition yet large enough that the total head permits a good pump selection and minimizes the requirements for surge protection facilities. Recommended sizing considerations for force mains are covered under the force main section (see C2-3). A cost-benefit analysis is often useful in selecting the best alternative.

Pump stations shall be designed to operate under the full range of projected system hydraulic conditions. Both new and old pipe conditions should be evaluated, along with the various combinations of operating pumps and minimum and maximum flows, to determine the highest head and lowest head pumping conditions. The system should be designed to prevent a pump from operating for long periods of time beyond the pump manufacturer's recommended normal operating range.

Selection of head loss coefficients for pipes and valves should be conservative to allow for installation and equipment variations and normal aging of the pumping system.

C2-1.2.3 Number of Pumps

All pump stations shall have a minimum of two (2) pumps.

The number of pumps selected shall allow the station to provide the peak design flow with the largest pump out of order. Also, the number of pumps should correlate to the wetwell size and prevent excessively short periods between pump starts. On constant speed pump stations, the number of pumps is often based on the pumping capacity required to provide a minimum scour velocity in the force main.

C2-1.2.4 Pump Selection

The District must approve all pumps in writing.

Pumps should be designed for pumping sewage and capable of passing solids at least 3 inches in diameter. Pump suction and discharge should be 4 inches or greater. Exceptions to these criteria are discussed in the sections on grinder pumps and septic tank effluent pumps (see C1-10).

C2-1.2.5 Wetwells

Sewage pump station wetwells should be designed to provide acceptable pump intake conditions, adequate volume to prevent excessive pump cycling and sufficient depth for pump control, while minimizing solids deposition. *The minimum wetwell inner diameter shall be eight (8) feet.*

For wet well and dry well installations, the sump pump from the dry pit to the wet pit shall enter the wet pit approximately three (3) feet from the bottom of the top slab and be cored and booted with a ninety (90) degree bend inside the wet pit turned downward for discharge. The sump pump shall be as specified on the Plans and the piping and fittings shall be Schedule 40 PVC.

For constant speed pumps, the minimum volume between pump on and off levels can be calculated using the following general formula:

$$V = tQ/4, \text{ where}$$

V = minimum volume (gallons)

t = minimum time between pump starts

Q = pump capacity (gallons/minute)

Recommendations for various pump intake designs can be found in the references included at the end of this chapter. At normal operating levels, the designer should consider the following recommendations:

- Reduce or eliminate the free fall of sewage into the wetwell.
- Minimize prerotation of water at the pump intake.
- Provide adequate submergence to minimize surface vortices.
- Locate the pump intakes to minimize the forming of subsurface vortices from the walls or floor.

There are exceptions, however, to these criteria. For example, a prerotation chamber can be used to swirl the water in the same direction as the pump is turning in order to reduce flow through the pump at low wetwell levels. This provides turndown ability for the pump without requiring a variable speed drive. Another exception is drawing down the water level to flush out solids buildup in the wetwell.

Wetwells should be designed to minimize solids buildup. The wetwell should be either trench or hopper style with side slopes of 45 degrees or steeper (60 degrees is preferred). Maintenance procedures should be developed to remove any solids that do build up in the wetwell. A recycle pipe can be provided to temporarily route pumpage to the bottom of the wetwell to dislodge solids. Another method is to periodically operate the wetwell below its normal level, increasing velocities and allowing the pumps to pull in deposited solids.

Wetwells shall be designed to minimize solids buildup. They shall be designed to have:

1. *A six (6) inch fillet around the base as per District Standard Drawings; or*

2. Trench or hopper style with side slopes or 45 degrees or steeper (60 degrees is preferred); or
3. A WEMCO Hidrostaal Prerostal, pre-rotation pumping system; or
4. A self-cleaning pit using the Ogee ramp; or
5. Approved equal.

In most cases, all electrical equipment in a raw sewage wetwell should meet the requirements of the NEC Area Classification as listed in NFPA 820.

Personnel entering the wetwell shall meet the requirements of current State Department of Labor and Industry confined space regulations, contained in Chapter 296-62M WAC.

C2-1.3 Grit, Grease, and Clogging Protection

If it is necessary to pump sewage prior to grit removal, the design of the wetwell should receive special attention. In particular, the discharge piping should be designed to prevent grit settling in discharge lines of pumps when not operating.

At some pump stations, it may be beneficial to use bar screens, grinders or comminutor devices. Design of bar screen facilities should include odor control and a method for handling the screening.

Grease in the flow entering sewage pump stations can present problems, both for the sewage collection pipelines (from the source to the station) and in handling or removal after flow is present in the wetwell. Grease floats on the surface of the liquid in the wetwell, and tends to cake on the walls and accumulate at the high pump start or upper level control setting. That can interfere with the pump control systems, including float switches, air bubbler controls, pressure bells (either static or encapsulated in a bulb or containment bag), and a variety of other mechanical or electrical control styles. (One control virtually free from grease-related problems is the ultrasonic level controller.)

Grease can also contribute to odor in the pump station. Allowed to build up to the point of collapse from the wall or other surface, chunks of grease can clog the pump suction, restrict flow through other features such as vortex breakers and flow-directing vanes, or just increase operation or maintenance problems in the station or the force main downstream from it. Provisions to limit grease from entering the system, such as regulating the allowable fats, oils and grease by sewer ordinances, pretreatment requirements, or other ways to put the burden for grease limits on the originator, should be considered. Adequate access to the wetwell for grease removal using mechanical means, such as vactor or septic pumping-truck suction pipes or hoses, blasting using high-pressure water to loosen the material, injecting grease control chemicals by pumping, drip, shock or maintenance dosing, or hand scraping and removal methods should be provided.

C2-1.4 Flow Measurement

Suitable devices for measuring sewage flow shall be provided at pump stations. Run timers should be provided on all pumps. A wide variety of pump station level and flow control devices and instrumentation exists. Consider strategies that use instrumentation, monitoring, control or process-driven concepts to integrate flow measurement into the overall perspective of the pump station design.

With complete information at hand, or data available for computer analysis, great gains can be made in operating efficiency, maintenance prediction, budgeting, coordination of treatment processes, and other useful productivity steps. **Pressure gauges and flow meters will be installed on all pump stations.**

C2-1.5 Surge Analysis

C2-1.5.1 General

Hydraulic surges and transients (water hammer) should be considered during design of pump stations and force mains. All systems should be at least conceptually reviewed for the possibility of damaging hydraulic transients. The transients can cause vapor cavities, pipe rupture or collapse, joint weakening or separation, deterioration of pipe lining, excessive vibration, noise, deformation, or displacement, and otherwise unacceptable pressures for the system.

Possible sources of damaging conditions include closing or opening a valve, pump starts and stops, sudden power loss, rapid changes in demand, closure of an air release valve, pipe rupture and failure of surge protection facilities. Particular care should be taken in design if the expected change occurs in less than two wave periods, velocities are high (greater than 4 feet per second), the force main is long, the piping system has dead ends, or significant grade changes occur along the force main.

C2-1.5.2 Surge Modeling

If it is not possible in conceptual design or with simple manual calculations to ensure that the system is safe from excessive water hammer conditions, the system should be computer modeled. It is important that a computer modeling program is selected that suits the complexity of the project and has proven accuracy when compared to field-test results. The design methodology should include some method of checking the model results before construction. During facility startup, modeled results should be verified by gradually generating increasingly severe conditions. In this way it can be shown that the system will work as predicted prior to generating the worst-case design conditions.

C2-1.5.3 Surge Protection Facilities

There are many methods to provide surge protection, including the following:

- Open surge tanks.
- Pressurized surge tanks.
- One-way surge tanks.
- Appropriate check valve attachments.
- Pump control valves.
- Surge relief valves.
- Surge anticipator valves.
- Vacuum relief valves.
- Regulated air release valves.
- Optimizing the force main size and alignment.
- Electric soft start/stop and variable speed drives for pumps.
- Electric interlocks to prevent more than one pump from starting at the same time.
- Slow opening and closing valves.
- Increasing the polar moment of inertia of the rotating pump/motor assembly.
- Different pipe material to reduce surge forces.

Some of these techniques are not suitable for raw sewage. A combination of methods may be necessary to provide a safe operating system. Care must be taken in design so that adding a protection device does not precipitate a secondary water hammer equal to or worse than the original water hammer. Reliability of the surge protection facilities is critical. Routine inspection and maintenance must be incorporated into the design. Where appropriate, redundancy should be provided for essential pieces of equipment, such as vacuum relief valves. Adequate alarms should be provided on surge tanks and similar equipment to give operators early warnings. Consideration should be given to preventing the pumping system from operating if the surge protection facilities are not operable.

C2-1.6 Odor and Noise Control

The design of both sewage pump stations and related pipelines should incorporate planning and construction techniques that consider odor and noise-producing conditions and solutions. Gravity and pressure mains carrying wastewater to and from the station present separate problems.

The physical layout of the pump station should allow a variety of accessory systems to be applied that meet whatever odor concern is indicated, either before construction, in the planning/design phase, or after starting operation. Both the expected waste load, with associated chemical or unusual physical parameters, and the detention time and hydraulic characteristics of pipes and wetwell should be considered.

C2-1.6.1 Odor Control

Odor control is discussed in general terms in Chapter G2.

Odor Control options – The Design Engineer shall submit a report to the District detailing the need for and method of odor control.

C2-1.6.2 Noise Control

Noise control for sewage pump station design depends on location, type, and layout of the station components, and local conditions, such as zoning, property use, or other ordinances (see C2-1.1.1). Noise control systems shall comply with all local and state regulations. The regulations usually are set by local government, development covenants or simply a cooperative understanding between the station owners and adjoining properties. The WISHA standards also speak to noise and safety considerations, specifically Chapter 296-62 WAC of the General Occupational Health Standards.

The Design Engineer shall submit a report to the District detailing the need for and method of noise control.

The most significant sources of noise are emergency generators, ventilation equipment, and, in some cases, motor or pump operations. Of these, the emergency generator is most significant. The generator may be powered by a piston internal-combustion engine, fueled by gasoline, diesel, propane or natural gas, or powered by a rotary-power source, such as gas or steam turbine. These kinds of engines can produce mechanical, intake air, or exhaust stack noise, which may result in racking, pulsating, whining, humming or other noises. A variety of sound insulation schemes are used to reduce the effects of these noises, and are rated by the degree of sound reduction they can achieve. Hospital-grade silencing is recommended as the design standard. Consider manufacturers' recommendations and careful study of the rated noise production values assigned to each component of a pump station in implementing a successful noise-reduction strategy.

C2-1.7 Operations and Maintenance

The design of the pump station should take into account the safety of operations and maintenance personnel.

During the design of sewer pump stations, consideration must be given to operations and maintenance (O&M) needs. This is typically documented in an O&M manual (see REVIEW need for Section G1 G1-4.4) which conforms to the operating agency's O&M plan for the wastewater utility.

Six (6) copies of the O&M manual shall be submitted to the District and should include provisions for:

- Detailed descriptions of all operating processes.
- Design data for pumps, motors, force main, standby power, overflow point and elevation, telemetry, and sulfide control system, as applicable.
- Pump curve with computed system curve showing design operating point.
- Startup and shutdown procedures.
- Analysis of critical safety issues.
- Inventory of critical components, including nameplate data for pumps and motors, etc.
- Description of the maintenance management system, including preventative and predictive maintenance.
- Vulnerability analysis.

- Contingency plan, including redundancy considerations.
- List of affected agencies and utilities, including after-hour contacts.
- List of local contractors for emergency repairs, including after-hours contacts.
- List of vendors and manufacturers of critical system components, including after-hour contacts.
- Staff training plan.

C2-1.8 Reliability

C2-1.8.1 Objective

Sewage pump stations **shall** be designed to provide enough reliability that accidental spills of wastewater into the environment or backups of sewage into structures do not occur. All pump stations should be designed to EPA Class 1 reliability standards, unless otherwise approved by Department of Ecology. Refer to G2-8 for additional information on reliability.

Reliability is achieved by:

- Specification of quality components.
- *Proper design and planning.*
- Redundancy of key equipment items.

C2-1.8.2 Equipment Redundancy

Components of the sewage pump station that **shall** be designed with redundancy in equipment to provide capacity for peak design flows include:

- Pumps and motors.
- Motor control center components.
- Instrumentation and control for pumps and motors.
- Power supply.
- Emergency storage in lieu of permanent standby power.

Sewage pumps and motors should be selected to provide one redundant unit that matches the largest pump and motor unit in the pump station, and should handle peak design flows with one of the largest units out of service.

Each pump and motor unit should have a separate electrical supply, motor starter, motor sensor and alarm, electrical components, and instrumentation and control components. Each wetwell bay should have an instrumentation and control module for operation of the pumps and alarm conditions as designed.

Power supply to most sewage pump stations should include the primary electrical feed as well as standby power. Standby power can include permanent generators, portable generators or secondary electrical feeds from an independent power grid.

Emergency storage should be included for all sewage pump stations that rely on portable engine generators for standby power, and should be considered for remote sewage pump stations where emergency response times may be long.

At locations where severe property damage could result from sewage backups caused by a pump station failure, it is recommended that the design include a manhole with a low elevation lid or an overflow pipe in the influent gravity sewage system.

C2-1.8.3 Emergency Power

All sewage pump stations should be designed with capability for emergency power in case the primary electrical feed is out of service. A portable engine generator unit that is plugged into a pigtail at the pump station commonly provides emergency power for small pump stations. Larger pump stations should have permanent engine generator units with automatic transfer switches to transfer the electrical feed from the primary to the standby unit when a power failure is detected by the instrumentation and control system. *The District shall determine if emergency power is required and the type of emergency power.*

Determining the engine generator's size should depend upon the requirements of starting and operating the pumps at peak possible load, and all ancillary equipment in the sewage pump station that could operate during a power outage.

A. Portable Engine Generators

Portable engine generators can be used at sewage pump stations where the total electrical demand is provided for in the wetwell; however, larger portable generators can be used if an adequate transport vehicle is routinely available during a power failure. Portable engine generators should be trailer-mounted and include adequate fuel storage. A suitable towing vehicle should be available at all times. A pump station that relies on portable engine generators needs a pigtail or proper electrical connection point for the generator. Emergency generators and transfer switches must meet all state electrical standards.

Pump stations with portable engine generators shall be provided with auto transfer switch and connection for transfer of power.

Portable engine generators most commonly use gasoline engines, but are also available with diesel engines.

B. Permanent Engine Generators

Permanent engine generators are recommended for larger pump stations and permanent facilities. Automatic transfer switches provide for quick transitions to standby power when the primary power fails. Permanent engine generators commonly use gasoline, diesel or natural gas engines, depending on size.

Permanent engine generators should be located inside a building, or other weather-tight enclosure. Block heaters are recommended to ensure reliable startup in cold weather.

C. Fuel Storage

Fuel storage for both portable and permanent engine generators shall be adequate to operate the sewage pump station for a minimum of sixteen (16) continuous hours with all pumps operating simultaneously.

Above ground fuel storage is required to have liquid containment capability equal to the volume in the tank, and should be covered to prevent accumulation of precipitation. The fuel fill tube should be equipped to prevent overfilling of the tank.

New belowground fuel storage tanks will not be approved in the District.

A fuel gauge can be incorporated into the instrumentation system for remote readings of the fuel supply status.

C2-1.8.4 Bypass Capability

Pump stations shall be designed to eliminate any bypass due to power outage, mechanical failure or unusual flow regime. This is typically accomplished by some combination of the following:

- Flow storage.
- Standby electric generator.
- Portable electric generator.

- Power from two different electrical substations.
- Extra fitting on force main to allow quick connection for a portable pump.
- Design surcharge of gravity lines.

C2-1.8.5 Overflow Storage Capability

The wetwell and gravity sewer system shall have a minimum of two (2) hours peak flow detention time or a permanent standby emergency power generator (engine generator) shall be installed.

C2-1.8.6 Alarms and Telemetry

All sewage pump stations shall be equipped with sensors for key operational conditions and the alarm signals shall be connected to telemetry. The telemetry should send alarm signals to a location that is continuously monitored.

The telemetry units generally include the following:

- Radio controlled units

C2-2 SPECIAL DESIGN DETAILS (SEE PUMP STATION SECTION)

C2-2.1 General

This section describes special design details to be addressed for pump stations. *The District will determine the type of sewage pump station for each application. Generally, sewage pump stations will be either submersible (described in C2-2.4) or wetwell with a drywell (as described in C2-2.2).*

C2-2.1.1 Electrical Design

Electrical design for sewage pump stations shall conform to the National Electrical Code (NEC), National Electrical Safety Code (ANSI), and all federal, state and local codes.

Particular attention should be given during design to classifying the various enclosed spaces in the sewage pump station to ensure adequate ventilation, and using explosion-proof electrical equipment where necessary.

All electrical design shall meet the requirements of the District Design Specifications, Amendments to the Construction Specifications and Standard Drawings for sewage pump stations.

A. Instrumentation

Instrumentation at sewage pump stations should, at a minimum, include flow meters, pump run times, pressure gauges and voltage/ampere meters for the motors.

B. Alarms

Alarms at sewage pump stations should include, in generally decreasing order of importance, the following:

- High water.
- Low water.
- Power failure.
- Pump failure.
- Excessive run time.
- Surge control system failure.
- Engine generator failure.

As determined by the District Engineer:

- Fire alarm.
- Pump station intrusion.
- Drywell air quality sensors
- Sump pump alarm

C. Lighting

Sewage pump stations should include adequate lighting in all equipment areas to allow for repair and maintenance during non-daylight hours.

Automatic lights should be designed and placed to meet local and state standards.

See District design details for lighting information.

C2-2.1.2 Water Supply

When required by the District Engineer, water supply for sewage pump stations shall be provided and include a reduced pressure backflow preventer with double-check valves, with an independent relief between the valves. Cross-connection control shall meet the requirements of DOH. Refer to G2-2.2.1 for information on potable water supply connection.

C2-2.1.3 Corrosion Control

The design of the wetwell shall evaluate and compensate for the potential for hydrogen sulfide in the wetwell from sewage. If low initial flows, long travel times, or high sewage temperatures could cause significant concentrations of hydrogen sulfide, it is required that the concrete and steel structure in the wetwell be protected from corrosion. Protection can be provided with a liner or other means, such as high-rate ventilation at 30 air changes per hour with scrubbing of the exhaust through carbon canisters, or equivalent. Liners can be formed into the concrete or adhered to the concrete walls after they have cured.

C2-2.1.4 Temperature and Ventilation

Design of the sewage pump station shall also ensure that the temperature of the room (if applicable) or enclosure that the electrical and instrumentation equipment is within the equipment manufacturer's specifications on the hottest day of the year. Generally, the design of ventilation equipment should be adequate to maintain a temperature within the manufacturer's suggested operating range. The life of solid-state-based equipment, such as programmable logic controllers, variable frequency drives, telemetry equipment, and computers, will be increased if a lower maximum design temperature is used. Design of louvers for ventilating rooms that enclose engine generators should follow similar guidelines. Design of all sewage pump stations shall conform to the **Washington State Energy Code as defined in Chapter 51-11 WAC and codified in Chapter 19.27A RCW.**

C2-2.1.5 Equipment Removal and Replacement

The sewage pump station design, including doors, vaults and roof access panels, shall include the capability to remove or replace all major equipment items, including the following:

- Pumps and motors.
- Electrical panels.
- Valves.
- Surge control components.
- Engine generators.

For sewage pump stations with larger pumps and motors, permanent monorails and hoists **shall** be included with a lift rating at least equal to the largest piece of equipment. For smaller sewage pump stations, portable gantry-style hoists or truck-mounted hoists may be sufficient.

All access to sewage pump station wetwell and vault shall meet the requirements of the District Design Specifications, Amendments to the Construction Specifications and Standard Drawings.

C2-2.1.6 Accessibility

The sewage pump station site layout shall substantially conform to the District Standard Drawings and provide for easy access by maintenance vehicles to key equipment for repair, removal and replacement, including access to each piece of equipment. The sewage pump station site layout should provide for safe and convenient access by maintenance vehicles and personnel to key equipment for removal and replacement, including access to each piece of equipment listed in C2-2.1.5.

C2-2.1.7 Valves and Piping

It is necessary in all pump stations to provide a valve chamber for valves, piping, air and vacuum relief valves, and surge control components. Each pump discharge should include a check valve, an isolation valve and pressure gauge.

Sewage pump stations that discharge into long force mains in which there is high likelihood of grease buildup or where the force main will have low velocities should be equipped with valves, piping, and end cap for launching of a pig to remove buildups of undesirable materials in the force main. Pig launchers typically include three valves so that a pig launcher can be isolated from the force main.

If required by the District Engineer, a pig launcher will be included in a sewage pump station design and special care needs to be given to designing the force main terminus to include a pig catcher and the ability to remove materials driven out of the force main by the pig. See C2-3.11 for additional information about pig launching and retrieval. *All valve and piping design shall meet the requirements of the District Design Specifications, Amendments to the Construction Specifications and Standard Drawings.*

C2-2.2 Wetwell/Drywell Pump Stations

Wetwell/drywell pump stations site the pumps below grade in a drywell immediately adjacent to the wetwell. Design should incorporate the latest standards from NFPA 820, the NEC and L&I confined space regulations (Chapter 296-62 WAC, Part M). To provide an unclassified space, the facility should provide complete separation between the wetwell and drywell, meeting requirements in NFPA 820. Continuous positive pressure air ventilation from a source of clean air, with effective safeguards against failure, should be provided in the drywell, in accordance with the NEC and NFPA 820. No transfer of air should occur between classified and unclassified spaces. Air quality in the drywell space should be tested and recorded on a regular basis, in accordance with Chapter 296-62 WAC, Part M.

The drywell should be provided with at least one sump pump and a float switch alarm. Discharge should be into the wetwell or sewer pipe.

C2-2.3 Suction Lift Pump Stations

Suction lift pump stations incorporate self-priming pumps in order to locate the pumps above the water level and either eliminate or decrease the depth of the drywell. Priming tanks or vacuum priming systems are not recommended for raw, unscreened sewage on new installations. Maximum suction lift should not exceed the pump manufacturer's recommendations and should be based on a net positive suction calculation with a generous factor of safety. Typically suction lift should not exceed 15 feet.

An air release valve should be provided at the high point in the discharge piping and should vent into the wetwell above maximum water level.

Any structure housing the pumps or the motor control center should be physically separated from the wetwell and meet the requirements of NFPA 820 and NEC.

C2-2.4 Submersible Pump Stations

Submersible pump stations provide submersible pumps in the wetwell with the motor control center mounted above grade. Pumps should be readily removable and replaceable without dewatering the wetwell or requiring personnel to enter the wetwell. Check valves and isolation valves should be mounted in a separate vault outside the wetwell to facilitate access and suitable for protection against vandalism and the elements.

Control panels shall be physically separated from the wetwell, meet the requirements of the NEC, and be suitably protected from the weather, humidity, and vandalism. The pumps should be explosion-proof unless the control system can provide adequate assurance that pump motors in operation are submerged at all times. Electrical junction boxes should be easily accessible without entering the wetwell.

C2-2.5 Vertical Solids Handling Line Shaft Pumps

The District does not install Vertical Solids Handling Line Shaft pumps.

C2-3 FORCE MAINS

C2-3.0 Plans, Profiles, Construction Notes, Profiles and Record Drawings

A. General.

1. *Design Engineer shall call for pre-design locates from the NW Utility Notification Center at 1-800-424-5555. Design Engineer or Surveyor is responsible for field verification of location and elevations of facilities.*
2. *Two (2) sets of plans, profiles, details and grading plans will be submitted to the District for each review of all new or extended sanitary sewers.*
3. *Storm sewer plans and profiles must be included with the sanitary sewer plans and profiles for District review. Water distribution plans must be included with the sanitary sewer plans. The water distribution profile must be shown on the sanitary sewer profile.*
4. *After District approval of plans, profiles and details, the Design Engineer shall submit one (1) complete set of Plans and four (4) partial sets at least five (5) working days prior to the preconstruction conference. The partial sets shall include the signed coversheet, sanitary plans and profiles, and sanitary notes and detail sheets. The complete Plans shall also include all other road, storm, water and grading plans for the Work.*
5. *For projects that are the subject of a site plan or land division approved by Clark County or a City with land use authority, the approval of plans and specifications is valid for the period of the original site plan /land division approval. Projects that are not the subject of other site plan/land division approvals will expire in accordance with the terms and conditions of the developer extension agreement. Plans that have expired may be submitted for re-approval; but are subject to additional review and fees.*
6. *Text size shall be a minimum of 0.08".*

B. Engineering Drawings - Plans. *Plan sheets for force mains shall be drawn in ink and contain at least the following information:*

1. *A suitable title sheet with the name, address, telephone and FAX numbers, and e-mail addresses of the Owner, Developer (including contact name) and the Design Engineer; scale; north arrow; vicinity map; section, township and range; sheet index; revision box; bench mark(s) based on Clark County Datum; date; drawing number; the Design Engineer's Professional Civil Engineers State of Washington signed seal with date of signature; and District signature block per District Standard Drawings. Applicable sheets shall include a legend with symbols and abbreviations and general notes generic to all construction.*

2. *District Standard Construction Notes (See D.) and specifications shall be included on the plan sheet for sanitary sewer construction. **These are minimum Construction Notes and special designs or conditions may require additional Construction Notes.***
3. *Horizontal dimensions from right-of-way, centerline of road, easement lines or property lines and other utilities or structures.*
4. *All existing survey monumentation within 100 feet of the project limits shall be shown.*
5. *Subtitles on each sheet describing the contents.*
6. *Adjacent streets, property lines, tax lot numbers and serial numbers.*
7. *All existing and proposed easements.*
8. *District Standard Drawings and details that apply to the project.*
9. *All force mains identified as "Public" or "Private." All private sanitary sewer lines **and easements** shall be labeled as "Private".*
10. *Each valve, air / vacuum valve, pressure cleanout, corporation stop, pressure service line, locate station and other appurtenance shall be stationed to facilitate checking the plans with profiles. Stationing shall be based on road stationing with the exception of pressure service lines [see 10 below].*
11. *Each valve, air / vacuum valve,, and pressure cleanout shall be numbered as follows. The first downstream connection of a new force main with the existing force main shall be shown as the lowest alpha, numeric or alphanumeric prefix. The prefixes shall be consecutive along the main run of the force main for each intersection or branch of force mains. All branch force main intersections and appurtenances shall be identified with consecutive prefixes from the connection of the branch sanitary sewer pressure line to the main force main.*
12. *All pressure service lines shall be stationed upstream from the nearest downstream force main intersection or main line valve.*

Depths and lengths shall be shown at the end of each pressure service line. When practical, pressure service lines shall be at a right angle from the force main and at the center of the lot. For flag lots, pressure service lines shall be located a minimum of five (5) feet from the property line.
13. *Location of watercourses, wells, septic systems, stream and railroad crossings, water mains, gas mains, culverts, telephone, underground power, cable television and other utilities or structures based on best available information and field locates. Field locates for designs are available through the NW Utility Notification Center at 1-800-424-5555.*
14. *All existing gravel and hard surface paving including width(s) and distance(s) from existing right of way, easement or property line*
15. *Existing contours for the proposed development extending at least 100 feet outside of the proposed development along existing, proposed or future roads. If site grading is anticipated, a final site contour map shall be provided. Contour interval shall not be greater than two (2) feet in elevation except in steep terrain where contours are not easily distinguished at two (2) foot intervals.*
16. *Plans shall be drafted at a scale that will be legible when the plans are reduced fifty (50) percent. If the entire project plan cannot be shown on one (1) sheet, a key map will be provided noting the sheet that each individual section of the plan is located. Where multiple sheets are used for plans and/or profiles, match lines will be shown. Where multiple sheets are used for plans, a master utility plan will be provided.*
17. *Sheet size shall be 24" x 36" or 22" x 34".*
18. *For commercial projects: contours; pipe type, size and slopes; monitoring manholes; grease interceptors (if required) and Oil-Water separators (if required) must be shown. If private force mains are required, all requirements of public force main plans and profiles must be met. If only an individual building pressure service line and/or gravity side sewer is required, a plan and profile will be provided or the invert and rim elevations of all sewer appurtenances.*

Two (2) sets of mechanical and/or plumbing plans, flow calculations and a pretreatment survey (with District fee) must be submitted for District review with the plans.

19. *All new easements shall:*
 - a. *Be a minimum of fifteen (15) feet in width for force mains eight (8) feet or less in depth. The width of the easement shall increase by two (2) feet for every one (1) foot in depth beyond eight (8) feet.*
 - b. *Have the pressure sanitary sewer pipe centered in the easement.*
 - c. *Be located on a single lot.*
 - d. *Have description(s) submitted to the District in writing with a map in addition to platted easement(s). The District will complete the document and record the easement at the County.*
 20. *Length, pipe-size and type of material for all sanitary sewers. (e.g., 400 LF, 3" Class 200 SDR 21 PVC)*
 21. *Locations and elevations of existing septic tanks and drain fields and finished floor elevations for the existing building main floor and, if present, basement.*
- C. *Engineering Drawings - Profiles. Profile sheets for sanitary sewer lines shall be drawn in ink and contain at least the following information:*
1. *Location of each valve, automatic air release valve, pressure cleanout, corporation stop, locate station and other appurtenances numbered and stationed as shown on the plans. Each valve, automatic air release valve, pressure cleanout, corporation stop, pressure service line, locate station and other appurtenances shall show finished grade elevation(s) and invert elevation(s).*
 2. *All pressure service lines shall be shown and stationed upstream from the nearest downstream pressure sanitary sewer intersection or main line valve with lot number, station and invert elevation or depth.*
 3. *Profiles of existing and proposed ground surface or road finished grade and force main invert(s) at each change in grade.*
 4. *Force main size, type of material, slope and length between force main intersections, valves, pressure cleanouts, automatic air release valves, elbows, bedding class and backfill type.*
 5. *Suitable title plate, scale, dates, drawing number, and the name, address, telephone number and the Design Engineer's Professional Civil Engineer's State of Washington signed seal.*
 6. *Limits of existing or proposed gravel and hard surface paving.*
 7. *Profiles shall be drafted to a vertical scale at one-tenth (1/10) of the horizontal scale unless steep terrain exists.*
 8. *All storm drains, storm water quality facilities, storm drain detention and/or retention ponds, water or utility crossings of sanitary sewers shall be shown with elevations and vertical clearances. Profiles of any storm, water or other utility facilities if located within ten (10) horizontal feet of existing or proposed sanitary sewers.*
 9. *All force mains shall be at a minimum depth of cover of three (3) feet.*
 10. *All force mains shall have a positive slope in order to reduce the potential for trapping air in lines. Each run of force main should maintain a consistent positive (+) or negative (-) grade.*
- D. *Engineering Drawings - Construction Notes. All project plans for force mains shall contain at least the following:*
1. *All sanitary sewer construction will conform to the current adopted Construction Specifications of the District.*
 2. *All Work in Clark County right-of-way will conform to the requirements of the Clark County utility permit or District requirements, whichever is more restrictive.*

3. Contractor shall contact the NW Utility Notification Center at 1-800-424-5555 at least two (2) working days before but not more than (10) ten working days before the start of construction of the Work.
4. A preconstruction conference shall be held prior to the start of construction of the Work which:
 - a. May be held at the construction site for single-family residences.
 - b. Shall be held in conjunction with the Clark County preconstruction conference or scheduled at the District offices for all other projects.
5. Pressure sanitary sewer pipe materials for depths of cover less than twenty (20) feet for lines two (2) inches inside diameter and larger shall be:
 - a. Ductile iron pipe (DIP), standard thickness class 50, AWWA C151; or
 - b. Polyvinyl chloride (PVC) pipe ASTM D2241, SDR 21, Class 200; or
 - c. Polyvinyl chloride (PVC) pipe AWWA C900 or AWWA C905, SDR 18; or
 - d. High density polyethylene (HDPE) pipe PE 3408, minimum SDR 17, 100 psi, ASTM D3350, PE 3454C and ASTM D-1248 type III, class C, category 5, grade P3; and
 - e. All fittings shall match the pipe material installed.
- f. Pressure sanitary sewer pipe materials for special installations (e.g., depths of cover twenty (20) feet or greater, stream crossings, suspended pipes) shall be submitted to the District Engineer for approval.
6. Pressure service line pipe for residential installations shall be:
 - a. One and one-quarter (1¼) inch diameter schedule 40 polyvinyl chloride (PVC) for STEP systems; and
 - b. Two (2) inch diameter schedule 40 polyvinyl chloride (PVC) for grinder pump systems
7. Connections for single-family residential pressure service lines shall be:
 - a. One and one-quarter (1¼) inch by main diameter self-tapping PVC full circle stainless steel saddles for STEP systems on new force mains; and
 - b. Two (2) inch by main diameter self-tapping PVC full circle stainless steel saddles for grinder pump systems on new force mains; and
 - c. The District will install taps on all existing force mains. Note: A "Request for Tap" form must be completed by the Contractor, fees paid, and a two (2) working day notice be given to the District Superintendent to allow the tap to be scheduled.
8. Backfill of all trenches in traveled areas (roads, driveways or parking lots) shall be imported granular material meeting or exceeding Standard Specification, **Section 9-03.12(3)** or as required by the Clark County utility permit, whichever is more restrictive. Compaction for backfill shall be at 95% of the maximum density for the material as established by SECTION 2-03.3(14)D.
9. Bedding for all force mains and pressure service lines in the pipe zone shall be Standard Specification, 9-03.12(3) Gravel Backfill for Pipe Zone Bedding.
10. **All force mains and pressure service lines installed (both public and private) shall include the installation of locate wire with appropriate locate access points.** A continuous toning wire shall be attached to the top of the pressure service line. The toning wire shall end in the valve box with a minimum of a two (2) foot coil of wire. The toning wire shall be tested for continuity prior to acceptance.
11. Locator tape shall be continuous three (3) inch wide green six (6) mil thick marked with three (3) inch high black letters every three (3) feet with "Warning – Buried Pressure Sewer". The locator tape shall be installed eighteen (18) inches above the force main.
12. The ends of pressure service lines shall be:

- a. *Back-filled only after District inspection and approval and after Design Engineer or Surveyor has obtained record drawing information.*
 - b. *Generally marked with a 2"x4"x6' with the toning wire from the pressure service line wrapped around the marker. The marker shall extend three (3) feet above the finished ground surface. Two (2) feet of each end of the 2"x4"x6' shall be painted green. If the 2"x4" is not six (6) feet long, Contractor will mark actual length on the 2"x4".*
13. *All testing shall be in accordance with the District's General Special Provisions.*
 14. *All existing septic tanks will be decommissioned in accordance with Clark County Public Health, Uniform Plumbing Code and District requirements.*
 15. *Record Drawings will be submitted to the District prior to approval of Sewer Permits.*
- E. *Engineering Drawings - Record Drawing Plans and Profiles. Record Drawings for plan and profile sheets for sanitary sewer lines shall:*
1. *The record drawings shall be legible and complete Plans including all road, storm drainage, water supply and grading plans for the Work.*
 2. *Be completed by the Design Engineer or Surveyor and submitted to the District prior to project acceptance by the District.*
 3. *Be submitted in electronic form as a "PDF" file on a compact disk or other approved electronic submittal media and a complete paper copy.*
 4. *Be placed on the approved engineering drawings with the design date marked out and the Record Drawing date shown adjacent to design date.*
 5. *Show all final stations of valves, air / vacuum valves, pressure cleanouts, corporation stops, pressure service line, locate stations and other appurtenances.*
 6. *Show all final elevations of valves, air / vacuum valves, pressure cleanouts, pressure service line, locate stations and other appurtenances.*
 7. *Show all changes made to pipe material, slope, length of pipe, finished grade, etc.*
 8. *Show the distance from the back of curb or, if no curb, from the corporation stop to the end of the pressure service lines, depth, station and distance to the end of the pressure service lines from the force main.*
 9. *Be clearly marked Record Drawings, dated and with the Design Engineer's Professional Civil Engineer's or Professional Land Surveyor's State of Washington signed seal.*
 10. *Become the permanent property of the District.*

C2-3.1 Size and Alignment

Except for small grinder and effluent pump installations, piping for force mains should not be less than 4 inches in diameter. As a general rule, whenever the velocity exceeds 8 fps, a larger pipe should be used.

If the Design Engineer proposes horizontal or vertical curves, the request shall be reviewed and approved by the District. If the District approves horizontal or vertical curves in writing, the radius of curvature shall not exceed the manufacturer's limits.

C2-3.2 Velocity

At pumping capacity, a minimum self-scouring velocity of 2 fps should be maintained unless flushing facilities are provided. Velocity should not exceed 8 fps. Optimum velocities for reducing maintenance costs and preventing accumulation of solids range between 3.5 and 5 fps. The Design Engineer shall submit calculations showing start-up and ultimate velocities.

C2-3.3 Force main Appurtenances

C2-3.3A Pressure Cleanouts

Pressure cleanouts shall be installed at the end of each force main. Pressure cleanouts shall comply with District Standard Drawings.

C2-3.3B Locator Stations

Locator stations shall be installed every 500 feet along the force main. Locator stations shall comply with District Standard Drawings.

C2-3.3C Air / Vacuum Valves (AVV), Vacuum Release Valves, Combination Valves

Air / vacuum valves, vacuum release valves, and combination valves shall be installed at applicable points of the force main and shall comply with District Standard Drawings.

Design Engineer shall provide design calculations for size of air / vacuum valves, vacuum release valves, and combination valves for District review and approval. Air / vacuum valves, vacuum release valves, and combination valves shall be APCO or approved equal.

C2-3.4 Blow-Offs

Deleted

C2-3.5 Termination

The force main should enter the receiving manhole with its centerline horizontal and an elevation that will ensure a smooth transition of flow to the gravity flow section.

In no case, however, should the force main enter the gravity system at a point more than 1 foot above the flow line of the receiving manhole. The design should minimize turbulence at the point of discharge.

The receiving manhole shall be coated in accordance with C1-6.8 to prevent deterioration from hydrogen sulfide or other chemicals.

C2-3.6 Construction Methods and Materials

All force mains shall:

- A. Be designed to prevent damage from superimposed loads. Proper allowance for loads imposed on the pipe shall be calculated for the width and depth of the trench; and
- B. Conform to Table C2-3; and
- C. Have a minimum of three (3) feet depth of cover over the top of the pipe from finished grade or the flow line of a ditch; and
- D. *All force mains and pressure service lines installed (both public and private) shall include the installation of locate wire with appropriate locate access points. A continuous toning wire shall be attached to the top of the pressure service line. The toning wire shall end in the valve box with a minimum of a two (2) foot coil of wire. The toning wire shall be tested for continuity prior to acceptance.*
- E. Have a continuous three (3) inch wide green six (6) mil thick locator tape marked with three (3) inch high black letters every three (3) feet with "Warning – Buried Pressure Sewer". The locator tape shall be installed eighteen (18) inches above the force main.
- F. Have a positive slope to minimize air pockets. A flat grade is not acceptable.

<u>Description</u>	<u>Technical Specification</u>
Ductile Iron Pipe (DIP)	Standard Thickness Class 50, AWWA C151
Polyvinyl Chloride Pipe (PVC)	ASTM D2241, SDR 21, Class 200
Polyvinyl Chloride Pipe (PVC)	AWWA C900 or AWWA C905, SDR 18
High Density Polyethylene Pipe (HDPE)	PE3408, Minimum SDR 17, 100 psi, ASTM D-3350, PE: 345434C & ASTM D-1248, Type III, Class C, Category 5, grade P34
Fittings	Standard Thickness Class 50, AWWA C151 Shall conform and be compatible with pipe material

Table C2-3 Approved Materials for Force mains

Materials used for force mains include ductile iron, polyethylene and polyvinyl chloride (PVC). The pipe material and interior lining should be selected to adapt to local conditions, including industrial waste and soil characteristics, exceptionally heavy external loading, internal erosion, corrosion, and similar problems. The system design and surge allowances may preclude the use of some materials.

Installation specifications should contain appropriate requirements based on the criteria, standards, and requirements established by the industry in its technical publications. Requirements should be set forth in the specifications for the pipe and methods of backfilling to preclude damage to the pipe or its joints, impede future cleaning operations, and prevent excessive side pressures that may create ovalation of the pipe, or seriously impair flow capacity.

All pipes should be designed to prevent damage from superimposed loads. Proper allowance for loads imposed on the pipe should be calculated for the width and depth of the trench.

C2-3.7 Pressure Tests

All new force mains shall be pressure tested at 150 psi in accordance with Construction Specifications Sections 7-09.3(23) Hydrostatic Pressure Test and 7-09.3(23)A Testing Extensions.

C2-3.8 Connections

In order to avoid shearing force main pipes because of differential settlement, flex couplings should be used on force main pipes between the pump station structures, such as the pump station and the valve box. Flex couplings should also be used between the final pump station structure and the force main. Couplings shall be Dresser or approved equal.

C2-3.9 Surge Control

Hydraulic surges and transients (water hammer) are dependent on a force main's size, length, profile and construction materials. Surge analysis, possible causes and types of protection facilities for transient conditions are discussed in C2-1.5. Pipe pressure tests and thrust restraint should be based on maximum transient conditions, including an appropriate margin for safety.

C2-3.10 Thrust Restraint

Thrust forces in pressurized pipelines shall be restrained or anchored to prevent excessive movement and joint separation under all projected conditions.

Thrust restraint shall be mechanically restrained joints, Megalugs, or approved equal. The Design Engineer shall submit thrust restraint calculations for review and shall callout on the plans the required length of joint restraint.

C2-3.11 Pig Launching/Retrieval Facilities

Provisions for launching and retrieving cleaning pigs should be considered in the design of a force main. See C2-2.1.7 for a discussion of when pig-launching capability is advised. Pig launching facilities may be as simple as a pipe wye or more elaborate, with a special launch chamber, bypass piping and valves. In either case, provisions should be made for attaching gauges to monitor pressure.

Retrieval facilities may also be elaborate or simple. Elaborate retrieval devices are usually mirror images of the launch device; baskets, traps, or screens placed in the receiving manhole are among the simpler retrieval methods.

C2-4 REFERENCES

American National Standard Institute/Hydraulic Institute (ANSI/HI). Centrifugal Pumps-Nomenclature, Definitions, Application and Operation. 1994.

ANSI/HI. Centrifugal and Vertical Pumps—Definitions, Application and Operation. 1998.

ANSI/HI. Vertical Pumps—Nomenclature, Definitions, Application and Operation. 1994.

Metcalf & Eddy, Inc. Wastewater Engineering—Collection and Pumping of Wastewater. Third Edition, New York, NY: McGraw-Hill, Inc., 1991.

National Fire Protection Agency (NFPA) Standard 820. Standard for Fire Protection in Wastewater Treatment and Collection Facilities. 1995.

Prosser, M.J. The Hydraulic Design of Pump Sumps and Intakes. BHRA. 1977.

Sanks, Robert L., et al. Pumping Station Design. Second Edition. Butterworth-Heinemann Publishers. 1998.

Sanks, Robert L., et. al. Improvements in Pump Intake Basin Design. EPA/600/R-95/041. 1995.

Underwriters Laboratories 1207. Sewage Pumps for Use in Hazardous (Classified) Locations. 1996.

Water Environment Federation. Design of Wastewater and Stormwater Pump Stations. Manual of Practice FD-4. 1993.