

DESIGN GUIDELINES

1-A-01 Introduction

Following are guidelines for use in the design of systems subject to the Environmental Protection Rules, Chapter 1. Designers are encouraged to use equally or more effective technologies or practices in the design of systems under these guidelines. The Agency may approve different designs that are based on current technology and that have been demonstrated as effective. The Agency may approve a demonstration project designed to test a different design. The designer must support any request for a different approach. Depending on the degree of difference from the guidelines, approval may be conditioned upon periodic inspections to determine that the project is functioning as designed. Any design for a project where a municipality will ultimately be responsible for the operation and maintenance of the project shall include municipal acceptance of the system. While there are no specific technical requirements for any particular design detail, the Secretary will not approve any design that is not based on accepted scientific and engineering principles, except for a demonstration project.

Note: Although these guidelines have been subject to review and comment in a rulemaking process, they remain merely guidelines, not binding rules, in order to allow for flexibility in the design of those aspects of sewers, sewage collection systems and lift stations that are addressed in this appendix.

1-A-02 Building Sewers

The building sewer is that part of the drainage system extending from a building drain to a public sewer, private sewer, septic tank system, or other treatment system. A sewer serving one building will be considered a building sewer. All other sewers will be considered a collection sewer.

- (a) **Materials:** The building sewer shall be constructed in a manner that will prevent leaking, breaking or clogging. Acceptable materials for the sewer are rubber-ring-jointed or cast iron (CI) sewer service pipe. Other materials may be proposed for acceptance by the Secretary.
- (b) **Sizing & Slope:** Building sewers shall be sized based on procedures outlined under 1-A-02. Minimum building sewer size is 4 inches and minimum slope is 1/4 inch per foot.
- (c) **Connection to a collection sewer:** Building sewers discharging to a collection sewer shall be connected through a manhole constructed in accordance with 1-A-03(1) or with a wye fitting so as to direct flow and minimize in-line turbulence.
- (d) **Cleanouts:** Cleanouts shall be provided at each horizontal change in direction of the building sewer greater than 45 degrees and at intervals of not more than 100 feet. Building sewer changes in direction that exceed 45 degrees should be made with two 45 degree ells or long sweep fittings. Manholes are acceptable in lieu of cleanouts. Where building sewers to be installed at a depth of less than 3 feet under driveways are anticipated, extra heavy cast iron or other high strength pipe acceptable to the Secretary shall be required.

- (e) Leakage: Building sewers shall meet the leakage standards prescribed in Section 1-A-03(k).

1-A-03 Sewer Collection Systems

- (a) A sewer collection system is that system of sewers that transport wastewater from building sewers to the wastewater treatment/disposal system.
- (b) No connections of roof drains, area drains, foundation drains, cellar drains or other clean water sources or any storm drains will be allowed to building or collection sewers.
- (c) Building and collection sewers carrying raw or untreated wastewater shall be sized as follows:
 - (1) Collection sewers shall be a minimum of 6” diameter.
 - (2) The flow rate to be used in sizing the sewer shall be based on the full occupancy design flows for the facilities connected as derived from §1-503
 - (3) times the following factors.
 - (A) For design flows less than 10,000 gpd, a factor of 5.
 - (B) For design flows over 10,000 gpd, a factor derived from Table 1-A-1

TABLE 1-A-1
Peaking Factors

<u>Design Flow</u>	<u>Peaking Factor</u>
10,000 gpd	4.2
100,000 gpd	3.2
500,000 gpd	3.2
1, 000, 000 gpd	3.0

- (4) Sewers shall be sized for the above derived flow rate to provide a minimum velocity of 2 feet per second when flowing full using the Kutter formula or other acceptable formulae and friction coefficients appropriate for the pipe materials proposed, considering surface deterioration over the expected useful life of the pipe.
- (d) Depth: In general, sewers should be sufficiently deep to receive sewage from basements and to prevent freezing. A bury depth of at least four feet should be maintained. This depth should be increased to at least five feet in areas to be plowed during winter months. When these depths cannot be maintained without significant

expense, the designer may propose less depths with mitigating measures to protect the sewer.

- (e) Slope, Velocity: All sewers shall be designed and constructed to provide mean velocities, when flowing full, of not less than 2.0 feet per second. Regardless of the formula used or friction factors used in the design of the sewers, all sewers shall be installed with at least the slopes shown in Table 1-A-2

TABLE 1-A-2
Minimum Slopes

<u>Pipe Size (inches)</u>	<u>Slope (feet/100 feet)</u>
6"	0.60
8"	0.40
10"	0.28
12"	0.22
15"	0.15

Sewers shall be laid with uniform slope and straight alignment between manholes. Where velocities greater than 15 feet per second are attained, special provisions shall be made to protect against displacement by erosion and shock.

Sewers on 20 percent slopes or greater shall be anchored securely with concrete anchors or equal, spaced as follows:

- (1) not over 36 feet center to center on grades 20 percent and up to 35 percent;
 - (2) not over 24 feet center to center on grades 35 percent and up to 50 percent;
and
 - (3) not over 16 feet center to center on grades 50 percent and over.
- (f) When a smaller sewer joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation.
 - (g) Sewer extensions should be designed for projected design flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension. The Agency may require a schedule for future downstream sewer relief.
 - (h) Materials: Generally, rubber-ring-jointed PVC, AC or ductile iron (DI) gravity sewer pipe of the proper class is acceptable. Other materials may be approved by the Secretary .
 - (1) Sewer joints shall be designed to minimize infiltration and to prevent the entrance of roots throughout the life of the system.
 - (2) All sewers shall be designed to prevent damage from superimposed loads. Proper allowance loads on the sewer shall be made because of the width and

depth of trench. Where necessary to withstand extraordinary superimposed loading, special bedding, concrete cradle or special construction may be used.

- (i) Trenching: Ledge, rock, boulders, and large stones shall be removed to provide a minimum clearance of four inches below and on each side of all pipe(s).
- (j) Bedding:
 - (1) Bedding classes A, B, or C, as described in American Society for Testing and Materials (ASTM) C12-77 or Water Pollution Control Federation Manual of Practice (WPCF MOP) No. 9* shall be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load.

*Note: WPCF MOP No. 9 is a joint publication with the American Society of Civil Engineers (ASCE) which lists it as "Manuals and Reports on ENGINEERING PRACTICE No. 39." See Appendix 5-A for the address of the ASCE.
 - (2) Bedding classes I, II, or III, as described in ASTM 0232174(80) shall be used for all flexible pipe provided the proper strength is used with the specified bedding to support the anticipated load.
 - (3) Backfill shall be of a suitable material removed from excavation except where other material is specified. Debris, frozen material, large clods or stones, organic matter, or other unstable materials shall not be used for backfill within two feet of the top of the pipe.
- (k) Leakage Tests: When tested, the leakage inward and outward of a gravity sewer including manholes shall not exceed 200 gallons per inch of pipe diameter per mile per day. Upon completion of construction, a sewer line shall be tested in accordance with one of the following procedures:
 - (1) Water testing
 - (A) Plug or cap all service laterals, stubs, and fittings. Place adequate bracing to withstand thrust forces.
 - (B) A tapped plumber's plug should be inserted in the downstream manhole inlet sewer. The water supply connection is made at this point, but never directly from a public water supply system or hydrant unless a backflow preventer is used.
 - (C) A stand pipe is tightly connected at the upstream end of the sewer. The height of the stand pipe shall be at least two feet higher than any point in the sewer or two feet higher than the highest known ground water table, whichever is higher. A manhole may be used as a stand pipe .
 - (D) Water is added at the downstream connection in order to avoid trapping air bubbles or pockets. The line shall be filled to the elevation designated in the stand pipe.

- (E) Allow the line to stand with water for at least a two hour stabilization period or such shorter period as may be required to achieve stabilized readings of water loss over three consecutive 15 minute periods. This allows air to escape and absorption to take place.
 - (F) Fill the sewer line to the reference mark and continue the test for at least one hour. Maintain the minimum head throughout the test, adding any volume of water required and including that volume in the leakage.
 - (G) Convert the leakage to the units specified.
- (2) Air testing
- (A) Procedures
 - (i) Determine the test time for the section of line to be tested using Table 1-A-3 or 1-A-4 or the formulas in Chart I.
 - (ii) Plug all openings in the test section.
 - (iii) Add air until the internal pressure of the line is raised to approximately 4.0 pounds/square inch (psi) greater than the average pressure of any ground water. After this pressure is reached, allow the pressure to stabilize. The pressure will normally drop as the air temperature stabilizes. This usually takes 2 to 5 minutes depending on the pipe size. The pressure may be reduced to 3.5 psi before starting the test.
 - (iv) When the pressure has stabilized and is at or above the starting test pressure of 3.5 psi above the pipe, start the test. If the pressure drops more than 1.0 psi during the test time, the line is presumed to have failed the test. If a 1.0 psi drop does not occur within the test time, the line has passed the test.
 - (B) Test time
 - (i) Table 1-A-3 shows the required test time, T, in minutes/100 feet of pipe for each nominal pipe size. Test times are for a 1.0 psi pressure drop from 3.5 to 2.5 psi. Table 1-A-3 has been established using the formulas contained in chart 1.
 - (ii) If the section of line to be tested includes more than one pipe size, calculate the test time for each size and add the test times to arrive at the total test time for the section.
 - (iii) It is not necessary to hold the test for the whole period when it is clearly evident that the rate of air loss is less than the allowable.

TABLE 1-A-3 MINIMUM TEST TIME FOR VARIOUS PIPE SIZES

Nominal Pipe Size in inches	T (time) min/100 ft.	Nominal Pipe Size in inches	T (time) min/100 ft.
3	0.2	21	3.0
4	0.3	24	3.6
6	0.7	27	4.2
8	1.2	30	4.8
10	1.5	33	5.4
12	1.8	36	6.0
15	2.1	39	6.6
18	2.4	42	7.3

CHART I

FORMULAS AND ALLOWABLE AIR LOSS STANDARDS

Calculate the required test time at a given allowable air loss as follows:

$$T = (K) \times \frac{(D)^2(L)}{(Q)}$$

Calculate air loss with a timed pressure drop as follows:

$$Q = (K) \times \frac{(D)^2(L)}{(T)}$$

Symbols:

D = nominal size, in.

K = 0.534×10^{-6} for S.I. units

K = 0.371×10^{-3} for inch-pound units

L = length of line of one pipe size, ft.

Q = air loss, ft³/min.

T = time for pressure to drop 1.0 psi, min

(C) An appropriate allowable air loss, Q, in cubic feet per minute, has been established for each nominal pipe size. Based on field experience, the Q value that has been selected will enable detection of any significant leak. Table 1-A-4 lists the Q established for each pipe size.

TABLE 1-A-4 ALLOWABLE AIR LOSS FOR VARIOUS PIPE SIZES

Nominal Pipe Size in Inches	Q, ft ³ /min	Nominal Pipe Size in Inches	Q, ft ³ /min
3	2	21	5.5
4	2	24	6
6	2	27	6.5
8	2	30	7
10	2.5	33	7.5
12	3	36	8
15	4	39	8.5
18	5	42	9

For further information regarding the Air Testing procedures, refer to ASTM Standard C828-80.

(l) Manholes

- (1) Location: Manholes shall be installed at the end of each line, at all changes in grade, size or alignment, at all intersections, and at distances not greater than 300 feet unless the designer justifies a greater spacing.
- (2) Drop Type: A drop pipe should be provided for a sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert should be filleted to prevent deposition of solids.

Drop manholes should be constructed with an outside drop connection. Inside drop connections (when necessary) shall be secured to the interior wall of the manhole and provide access for cleaning. Where inside drops are used, the manhole diameter shall be increased to allow adequate access.

Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection shall be encased in concrete and supported by the manhole base.

- (3) Diameter: The minimum diameter of manholes shall be 48 inches; large diameters are preferred for connection to large diameter sewers. A minimum access diameter of 22 inches shall be provided.
- (4) Flow Channel: Flow channels shall be provided in the base of all manholes and the flow channel through manholes should be made to conform in shape and slope to that of the sewers.
- (5) Manholes shall be of the pre-cast concrete or poured-in place concrete type. Manholes shall be waterproofed on the exterior.
- (6) Inlet and outlet pipes shall be joined to the manhole with a rubber-gasketed flexible watertight connection that allows differential settlement of the pipe and manhole wall to take place.

Grouting is not an acceptable connection. All manhole connections, including building sewers, shall be constructed to this standard.

- (7) Watertight manhole covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Locked manhole covers may be desirable in isolated easement locations where vandalism may be a problem.
- (8) All manholes shall be tested for leakage. Leakage testing of gravity sewers utilizing the water testing procedures takes into account the leakage from one manhole in the test section. Otherwise, manholes shall be tested for leakage in accordance with the following procedure:

After the manhole has been assembled in place, all lifting holes and exterior joints shall be filled and pointed with non-shrinking mortar. All pipes and other openings into the manhole shall be suitably plugged and the plugs placed to prevent blowout.

Each manhole shall be checked for exfiltration by filling with water to the top of the cone section. A stabilization period of one hour shall be provided to allow for absorption. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and the measuring time of at least six hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone measuring the volume of water added.

This amount shall be converted to a 24-hour rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed one gallon per vertical foot for a 24 hour period for exfiltration and there shall be no visible infiltration.

- (9) Location of Sewers on Streams
 - (A) Cover Depth: The top of all sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the stream bed to protect the sewer line. In general, the following cover requirements must be met:
 - (i) One foot of cover is required where the sewer is located in rock;
 - (ii) Three feet of cover is required in other material. In major streams, more than three feet of cover may be required; and
 - (iii) In paved stream channels, the top of the sewer line should be placed below the bottom of the channel pavement.
 - (B) Horizontal Location: Sewers located along streams shall be located outside of the stream bed and sufficiently removed therefrom to provide for future possible stream widening, minimize pollution by siltation during construction, and allow future access for repair and maintenance of sewers.

- (C) Structures: The sewer, manholes, gate boxes, or other structures shall be located so they do not interfere with the free discharge of flood flows of the stream. No manholes or other access structures shall be located within the normal flow channel of the stream.
 - (D) Alignment: Sewer crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade. Sewer systems shall be designed to minimize the number of stream crossings.
 - (E) Construction - Materials: Sewers entering or crossing streams shall be constructed of cast or ductile iron pipe with mechanical joints and they shall be constructed so they will remain watertight and free from changes in alignment or grade. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel, or other materials that will not cause siltation.
- (10) Aerial Crossings: Support shall be provided for all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning and settlement.

Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided between above-ground and below-ground sewers.

For aerial stream crossings, the impact of flood waters and debris shall be considered. The bottom of pipe should be placed no lower than the elevation of the fifty (50) year flood.

(11) Water Line Separation

- (A) Horizontal Separation: Sewers shall be laid at least ten feet horizontally from any existing or proposed water main. The distance shall be measured edge to edge.

Where impossible or impracticable, due to ledge, boulders or other unusual conditions, to maintain the ten foot sewer - water pipe horizontal separation between sewer and water lines, the water line may be in a separate trench or on an undisturbed earth shelf in the sewer trench provided that the bottom of the water line is at least 18 inches above the top of the sewer. Wherever impossible or impractical to maintain the 18 inch vertical separation, the sewer line shall be constructed to normal water line standards and pressure tested to 50 psi for 15 minutes prior to backfilling. No leakage shall be allowed for this test.

- (B) Crossings: Sewers crossing water mains shall be laid beneath the water main with at least 18 inches vertical clearance between the outside of the sewer and the outside of the water main. When it is impossible to maintain the 18" vertical separation; 1) the crossing

shall be arranged so that one full length of sewer is centered above or below the water line with sewer joints as far as possible from water joints; 2) the sewer pipe must be constructed to water main standards for a minimum distance of 20 feet either side of the crossing or a total of three pipe lengths, whichever is greater; 3) the section constructed to water main standards must be pressure tested to maintain 50 psi for 15 minutes without leakage prior to backfilling beyond one foot above the pipe to assure water tightness; 4) where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to prevent damage to the water main.

1-A-04 Sewage Lift Stations

- (a) **Flooding:** Sewage pumping station structures and electrical and mechanical equipment shall be protected from physical damage from the one hundred (100) year flood. Sewage pumping stations should remain fully operational and accessible during the twenty-five (25) year flood.
- (b) **Equipment Removal:** Provision shall be made to facilitate removal of pumps, motors, and other mechanical and electrical equipment.
- (c) **Pump Removal:** Submersible pumps shall be readily removable and replaceable without dewatering the wet well or disconnecting any piping in the wet well.
- (d) **Construction:** Submersible pumps and motors shall be designed specifically for raw sewage use, including totally submerged operation during a portion of each pumping cycle.
- (e) **Pumping Units:** Lift stations receiving an average daily flow of less than 2,000 gal/day may be equipped with a single pumping unit, provided that replacement pumps are readily available, and one day's emergency storage is provided above the alarm level in the wet well. All other lift stations shall contain alternating duplex pumping units with each unit capable of pumping the maximum flow the station is expected to receive.
- (f) **Pump Openings:** For pumps handling raw sewage, except where grinder pumps are used, pumps shall be capable of passing spheres of at least three inches in diameter, and pump suction and discharge piping should normally be at least four inches in diameter. Pumps handling only settled wastewater shall be capable of passing 1½" spheres. However, the Agency will entertain proposals for smaller pumps where the engineer can demonstrate that such pumps are satisfactory for the particular wastewater to be pumped, based on actual operating experience.
- (g) **Priming:** Generally, the pump shall be so placed that, under normal operating conditions, it will operate under a positive suction head.
- (h) **Electrical Equipment:** Electrical systems and components (e.g., motors, lights, cables, conduits, switchboxes, control circuits; etc.) in raw sewage wet wells, or in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present shall comply with the National Electrical Code R, 1981 Edition, requirements for Class I, Group D, Division 1 locations. In addition,

equipment located in the wet well shall be suitable for use under corrosive conditions. Each flexible cable shall be provided with watertight seal and separate strain relief. A fused disconnect switch located above ground shall be provided for all pumping stations. When such equipment is exposed to weather, it shall meet or exceed the requirements of weatherproof equipment as specified by the National Electrical Manufacturers Association (NEMA). Standard 3R shall be used as a minimum and is specified in Publication #250-1979, "Enclosures for Electrical Equipment - 1,000 Volt Maximum." See Appendix 5-A for the address.

- (i) Intake: Each pump should have an individual intake. Wet well design should be such as to avoid turbulence near the intake. Intake piping should be as straight and short as possible. Where turned-down bellmouth inlets or submersible pumps are used the bottom of the inlets should be placed a sufficient distance above the wet well floor to minimize inlet head losses, but close enough to the wet well floor to assure inlet velocities sufficient to prevent solids deposition.
- (j) Pumping Rates: The pumps selected shall be capable of providing the following pumping rates:
 - (1) The minimum pumping rate shall not be less than 5 gallons per minute
 - (2) For average daily flows less than 10,000 gallons per day, the maximum rate shall be 5 times the average design flow.
 - (3) For average design flows greater than 10,000 gallons per day, the maximum flow rate shall be determined by multiplying the average design flow by the appropriate peaking factor from Table 1-A-1 (Peaking Factors) (page 132).
- (k) Pump controls
 - (1) Location: The pump control system shall be located away from the turbulence of incoming flow and pump suction.
 - (2) Setting: The '2nd pump-on' level and 'alarm-on' level shall be at the same elevation.
- (l) Valves
 - (1) Suction Line: Suitable shutoff valves shall be placed on the suction line of each pump except on submersible pumps.
 - (2) Discharge Line: Suitable shutoff and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the shutoff valve and the pump. Check valves shall be suitable for the material being handled. Valves shall be capable of withstanding normal pressure and water hammer.
 - (3) Location: Valves may be located in wet wells only where single pump units are allowed. On all duplex unit pumping stations, the valves shall be in a separate valve pit adjacent to the wet well. This valve pit shall also contain a valved connection to allow the use of a portable pump for lift station bypassing during emergency conditions. The valve pit shall be provided with

a drain to the wet well. An effective method of preventing sewage from entering the pit during surcharged wet well conditions shall be provided.

(m) Wet Wells

- (1) Size: For lift stations handling raw sewage and receiving more than 20,000 gallons per day average design flow, the size of the wet well shall be such that with any combination of inflow and pumping the cycle of operation of each pump will not be less than 5 minutes and the retention time in the wet well should not be more than 30 minutes at average design flow. For raw sewage lift stations receiving less than 20,000 gallons per day, the retention time in the wet well will not be more than 30 minutes at average design flow. These requirements do not apply for lift stations handling only settled wastewater.

Emergency storage or emergency power must be provided at all lift stations for power outage. Storage should be provided above the high water alarm level of the wet well, in the wet well or in an adjacent tank. The volume of storage should equal the design wastewater flow for a period in excess of the longest power outage in the last five years that would have affected the proposed site, or four hours, based on a 16 hour delivery rate, whichever is greater.

The emergency storage volume may overflow into the connecting sewer lines providing that the sewage does not back up into building basements or fixtures, back up into septic tanks or over top manholes or the wet well.

Emergency storage will be a minimum of one day of wastewater design flow for all lift stations with a single pump.

- (2) Floor slope: For all raw wastewater pump stations except submersible pump types, the wet well floor shall have a minimum slope of one to one to the hopper bottom. The horizontal area of the hopper bottom shall be not greater than necessary for proper installation and function of the inlet.

(3) Ventilation

(A) Dry Wells: Ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least six complete air changes per hour, if intermittent, at least 30 complete air changes per hour.

(B) Wet Wells: For lift stations receiving less than 20,000 gallons per day design flow gravity ventilation is acceptable. For flows greater than 20,000 gallons per day design flow, forced ventilation shall be used. Forced ventilation may be either intermittent or continuous. Ventilation, if continuous, shall be capable of providing at least 12 complete air changes per hour, if intermittent, at least 30 complete air

changes per hour. Air changes shall be forced into the wet well rather than exhausted from the wet well.

- (n) Alarm Systems: Alarm systems shall be provided for pumping stations. The alarm shall be activated in cases of pump failure, use of the lag pump, high water in wet well, or other evidence of pump station malfunction. Audio and visual alarms shall be provided. Alarms shall be located in a normally frequented area.

1-A-05 Force Mains

- (a) Velocity: The force main shall be sized to maintain a minimum hydraulic velocity of 2 feet per second with one pump on. The minimum force main size shall be 1 ½ inch diameter.
- (b) Air Relief Valve: An automatic air relief valve shall be placed at high points in the force main to prevent air locking.
- (c) Termination: Force mains should enter the gravity sewer system at a point not more than 2 feet above the flow line of the receiving manhole
- (d) Design Pressure: Force mains and fittings, including reaction blocking, shall be designed to withstand normal pressure and pressure surges (water hammer).
- (e) Design Friction Losses: Friction losses in force mains shall be based on the Hazen-Williams formula or other acceptable method. Selected friction factors shall be representative of pipe materials selected, considering surface deterioration over the expected useful life of the pipe.

Hazen-Williams Formula

$$V = 1.32 C R^{.63} S^{.54}$$

R is the hydraulic radius

S is the slope of the energy grade line

C is the coefficient of roughness

- (f) Separation from Water Mains: There shall be a minimum 10-foot horizontal separation between water mains and force mains. A minimum 18 inch vertical separation between the outside pipe surfaces shall be maintained where force mains cross water mains. Force mains shall cross water mains at or near right angles with one full length of water pipe centered on the force main so both end joints are at maximum separation from the force main. Special structural support for the water main and the force main may be required.
- (g) Pressure Test: Upon completion of construction of a force main the line shall be pressure and leakage tested. All newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure of at least 1.5 x the highest working pressure in the section in accordance with the following procedure:

- (1) Test pressures shall:

- (A) not be less than 50 psi at the highest point along the test section.
 - (B) not exceed pipe or thrust restraint design pressures.
 - (C) be of at least 2 hour duration.
 - (D) not vary by more than 5 psi.
 - (E) not exceed twice the rated pressure of the valves when the pressure boundary of the test section includes closed gate valves.
- (2) Pressurization. Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to test gauge, shall be applied by means of a pump connected to the pipe.
 - (3) Air Removal. Before applying the specified test pressure, air shall be expelled completely from the pipe and valves.
 - (4) Examination. All exposed pipe, fittings, valves, and joints shall be examined carefully during the test. Any damaged or defective pipe, fittings, or valves, that are discovered following the pressure test shall be repaired or replaced with sound material and the test shall be repeated.
- (h) Leakage Test
- (1) A leakage test shall be conducted concurrently with the pressure test.
 - (2) Leakage Defined. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled.
 - (3) Allowable Leakage. No pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = \frac{(N)(D) \times \sqrt{P}}{7400}$$

L is the allowable leakage, in gallons per hour
 N is the number of joints in the length of pipeline tested
 D is the nominal diameter of the pipe, in inches
 P is the average test pressure during the leakage test, in pounds per square inch gage.

Appendix 2-A
Soil Mottling

2-A-01 Soil Mottling

- (a) Mottling indicates the average seasonal high water table over many years produced by the seasonal fluctuation of the water table. The presence of mottling is a definite indication of the seasonal high water table. However, mottling does not occur in all soils. The absence of mottling does not necessarily indicate that the seasonal high water table is not a problem.
- (b) The soil mottling should be described in abundance, size, contrast, and color of the mottles in the following manner:
 - (1) Abundance. Abundance shall be described as "few" if the mottled color occupies less than 2% of the exposed surface; "common," if the mottle color occupies from 2% to 20% of the exposed surface; or "many" if the mottled color occupies more than 20% of the exposed surface.
 - (2) Size. Size refers to the length of the mottle measured along the longest dimension and shall be described as "fine" if the mottle is less than 5mm; "medium" if the mottle is from 5mm to 15mm, or "coarse" if the mottle is greater than 15mm.
 - (3) Contrast. Contrast refers to the difference in color between the soil mottle and the background color of the soil and is described as "faint" if the mottle is evident but recognizable only with close examination; "distinct" if the mottle is readily seen but not striking; or "prominent" if the mottle is obvious and one of outstanding features in the soil horizon
 - (4) Color. The color(s) of the mottle(s) shall be given.
- (c) Observed Groundwater: Groundwater shall be observed and reported at the highest level the ground water rises in the soil excavation or at the highest level of sidewall seepage in the excavation. Measurements shall be made from the ground surface. Soil above the water level in the excavation shall be checked for the presence of mottles or color patterns indicative of soil saturation.
- (d) Color Patterns Not Indicative of Seasonal High Groundwater: One-foot exception. Soil profiles that have an abrupt textural change with finer textured soils overlying more than 4 feet of unmottled, or coarse sand can have a mottled zone in the finer textured material. If the mottled zone is less than one foot thick and is immediately above the textural change, then a soil-based system may be installed in the loamy sand or coarser material below the mottled layer.

- (e) Other Color Patterns: Soil mottles can occur that are not due to zones of seasonal or periodic soil saturation. Examples of such soil conditions not limited by enumeration are:
- (1) soil mottles formed from uneven weathering of glacially deposited material. Glacially deposited material may also be naturally gray in color. This may include concretionary materials in various stages of decomposition;
 - (2) deposits of lime in a profile derived from highly calcareous parent materials;
 - (3) soil mottles that are usually vertically oriented along old or decayed root channels with dark organic stain usually present in the center of the mottled area.

3-A-01 Septic Tank Specifications and Maintenance

(a) Specifications

(1) **Materials:** Septic tanks shall be watertight, structurally sound, and constructed of materials not subject to extensive corrosion or decay. Heavy gauge steel, reinforced concrete and fiberglass are considered the normal construction materials. Steel tanks shall be continuous and watertight. Precast concrete tanks shall have a minimum wall thickness of 3 inches and shall be adequately reinforced to facilitate handling. When precast slabs are used as covers, they shall be watertight, have a thickness of at least 3 inches, and be adequately reinforced. For fiberglass tanks, the manufacturer may be required to substantiate the structural soundness of the tank by submitting an approved laboratory report, that relates to structural testing of the tank.

(2) **Tank Properties:** Adequate tank capacity is required above the liquid tank level to provide for that portion of the scum that floats above the liquid. Although some variation is to be expected, on the average, about 30 percent of the total scum will accumulate above the liquid line. In addition to the provision for scum storage, one inch is usually provided at the top of the tank to permit free passage of gas back to the inlet and house vent pipe.

For tanks having straight, vertical sides, the distance between the top of the tank and the liquid line should be equal to approximately 20% of the liquid depth. In horizontal, cylindrical tanks, an area equal to approximately 15 percent of the total circle should be provided above the liquid level.

(3) **Access to Tank:** Adequate access must be provided to each compartment of the tank for inspection and cleaning. Both the inlet and outlet devices shall be accessible. Access shall be provided to each compartment by means of either a removable cover or a manhole of at least 16 inches in diameter. Each tank shall have one manhole access to grade. Covers should be tight fitting and designed to prevent entry by children.

(4) **Inlet:** The inlet invert shall enter the tank at least 3 inches above the liquid level in the tank to allow for momentary rises in liquid level during discharges to the tank. A vented inlet tee, or baffle, shall be provided to direct the incoming wastewater downward. It shall penetrate at least 6 inches below the liquid level, but in no case shall the penetration be greater than that allowed for the outlet device.

(5) **Outlet:** It is important that the outlet device penetrate just far enough below the liquid level of the septic tank to provide a balance between sludge and scum storage volume. The outlet device retains scum in the tank, but at the same time, it limits the amount of sludge that can be accommodated without scouring, which results in sludge discharging in the effluent from the tank. The outlet device should generally extend to a distance below the surface

equal to 40 percent of the liquid depth. For horizontal, cylindrical tanks, this should be reduced to 35 percent.

(b) Maintenance

- (1) At least once a year, the depth of sludge and scum in the septic tank should be measured. The tank should be pumped if:
 - (A) the sludge is closer than twelve inches to the outlet baffle, or
 - (B) the scum layer is closer than three inches to the septic tank outlet baffle.
 - (C) Following septic tank cleaning in units over 5,000 gallons, all interior surfaces of the tank should be inspected for leaks and cracks).
- (2) At least once a year, dosing tanks and distribution boxes should be opened and settled solids removed as necessary and the dosing tank or distribution box checked for levelness.
- (3) Toxic or hazardous substances should in general not be disposed of in septic systems. These substances may pass through the system in an unaltered state and contaminate groundwater or remain in the septage and subsequently contaminate the soil or crops at the site of ultimate disposal.

Appendix 4-A Percolation Test Procedures

The following procedure is to be used for determining the percolation value required by these rules.

- (a) **Depth of Test** - Tests shall be taken entirely within the most dense, least permeable soil identified within one (1) to three (3) feet below the bottom of the infiltrative surface of the proposed leachfield.
- (b) **Type of Test Holes** - The test hole will be unlined, shaped like a vertically oriented cylinder with a diameter of 6 - 8 inches and a depth of 10 inches.
- (c) **Preparation of Test Hole** - Using a sharp instrument, carefully scrape the sidewalls of the hole to remove any smeared soil surface. This is particularly important in soils that have a significant silt or clay content. Place one (1) inch of clean crushed stone in the bottom of the hole to reduce scouring. When possible, instead of pouring water directly from a bucket into the hole, use a hose to siphon water out of a suitably located reservoir to provide a high degree of control over the rate of water entering the hole, to minimize scouring.
- (d) **Percolation Test Measurements** - To begin the test, fill the hole with water up to a level six (6) inches above the stone and allow it to drop the distance specified in the table below for seven (7) consecutive runs. After each run, bring the water up to the six (6) inch level. The time of each run, the refill time between each run, and the total elapsed time must be accurately recorded.

WATER LEVEL DROPS FOR EACH TEST RUN OF THE PERCOLATION TEST PROCEDURE

Soil Texture:	Coarse to Medium	Fine Sand to	Silts to Clay
Loam	Sand	Silt Loam	
Anticipated Percolation Rate (min/in)	1 - 10	10 - 60	60 - 120
Drop (inches)	2	1	1/2

- (e) **Determining the Percolation Rate** - The rate of drop for each run is plotted, on graph paper with logarithmic scales on both axes (log/log graph paper), against the cumulative time of the seven runs, including the refill times. The best straight line is fitted to the seven data points and extrapolated out to one (1) day (1440 minutes) of cumulative time. The rate of drop after 1440 minutes is the percolation rate.

ORGANIZATIONS THAT PUBLISH THE CODES AND MATERIAL STANDARDS
REFERRED TO IN THE GUIDELINES CONTAINED IN APPENDIX 1-A

- ASCE American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia 20191
Telephone: 800-548-2723
www.asce.org
- ASTM American Society for Testing and Materials
100 Barr Harbor Drive
West Conshohocken, Pennsylvania 19428-2959
Telephone: 610-832-9585
www.astm.org
- CISPI Cast Iron Soil Pipe Institute
5959 Shallowford Road, Suite 419
Chattanooga, Tennessee 37421
Telephone: 703-869-4617 (Northeast Regional Representative)
www.cispi.org
- NEIWPCC New England Interstate Water Pollution Control Commission
Boott Mills South
100 Foot of Johns Street
Lowell, Massachusetts 01852
www.neiwpcc.org

For copies of:
Guides for the Design of Wastewater Treatment Works, 1998 Ed.
New England Interstate Environmental Training Center
2 Fort Road
South Portland, Maine 04106
Telephone: 207-767-2539

- BOCA Building Officials Code Administrators, International
International 4051 West Flossmoor Road
Country Club Hills, Illinois 60478
Telephone: 708-799-2300
www.bocai.org

National Fire Protection Association, Inc.
1 Batterymarch Park
Quincy, Massachusetts 02269-9101
Telephone: 800-344-3555
617-770-3000
www.nfpa.org

Note: The National Electrical Code is a registered trademark of the National Fire Protection Association, Inc. of Quincy, Massachusetts

NEMA National Electrical Manufacturers Association
1300 North 17th Street
Suite 1847
Rosslyn, Virginia 22209
Telephone: 703-841-3200
www.nema.org

Publications available through Global Engineering Documents
Telephone: 800-854-7179
www.global.his.org

Health Education Services, Inc.
P.O. Box 7126
Albany, New York 12224
Telephone: 518-439-7286
www.hes.org

Source for: Recommended Standards of Sewage Works, 1990 Edition