SITE CHARACTERIZATION AND DESIGN OF On-Site Septic Systems

M. S. Bedinger, J. S. Fleming, and A. I. Johnson, editors

ASTM

STP 1324

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ASTM Publication Code Number (PCN):
04-013240-38

ASTM
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

Printed in the U.S.A.

Library of Congress Cataloging-in-Publication Data

Site characterization and design of on-site septic systems/M. S.
Bedinger, J. S. Fleming, and A. I. Johnson, editors.
(STP; 1324)
"ASTM publication code number (PCN): 04-013240-38."
Includes bibliographical references and index.
ISBN 0-8031-2420-1
1. Septic tanks. I. Bedinger, M. S. II. Fleming, J. S., 1962- .
III. Johnson, A. I. (Arnold Ivan), 1919- . IV. Series: ASTM
special technical publication: 1324.
TD778.S54 1997
628'.742-DC21 97-40555
CIP

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The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution of time and effort on behalf of ASTM.

Printed in Fredericksburg, VA
November 1997

Overview

It is estimated that 25% of the U.S. population use septic systems for treatment and disposal of their household sewage. The on-site septic system technology is undergoing dramatic changes and advances with increased effort and thought being placed on the effective and economical design of on-site systems. ASTM Committee D18 on Soil and Rock has for many years been concerned about the quality and quantity of the ground water or of any other fluids contained in or moving through soil and rock voids. The initiation in 1991 of Section D18.01.06 on On-Site Waste Treatment and Disposal is a continuation of the recognition by ASTM for the need to establish industry consensus standards concerning the design and operation of on-site waste systems.

In accordance with the objectives of ASTM Subcommittee D18.01 on Surface and Subsurface Characterization and in cooperation with the U.S. Environmental Protection Agency (EPA) and the National Onsite Wastewater Recycling Association (NOWRA) a one-and-one-half-day symposium on on-site septic systems was held in New Orleans, Louisiana on 16 and 17 Jan. 1997. This ASTM publication presents papers from this symposium. The symposium consisted of three half-day sessions. The subjects of the sessions were Septic System Operation and Evaluation, Septic System Site Characterization and Design, and Alternative Systems and Component Design.

The opening paper of the symposium (not in this volume) by **Johnson and Bedinger** presented an overview of the activities and scope of work completed and in progress by Section D18.01.06. The title and scope of the three standards completed by Section D18.01.06 are given in Appendix A. Appendix B is a list of terms defined in the three standards. Appendix C is a list of ASTM standards related to on-site septic system components, design of systems, or standards useful for characterization of sites for septic systems. These appendices can be found at the end of this Overview.

Septic System Operation and Evaluation

A comprehensive inspection procedure for evaluation of septic systems in Minnesota was reviewed in the paper by **Frekot and Elvebak.** Distribution box performance was evaluated by **Gross, Peetz, Hearne, and Rutledge** to show that they are ineffective for distributing wastewater equally along the soil absorption trenches, even with dosing and with flow equalization products in use. The infiltration of wastewater from drainfields was shown to be significantly reduced by reduced soil hydraulic conductivity by the introduction of high sodium detergents used in the home by **Patterson.**

An evaluation of pressurized distribution systems in Maryland led to recommended procedures for increased maintenance and inspection and revision in design of the systems as reported by **Glotfelty, Hammerlund, and Prager.** The use of low-pressure distribution systems were used to provide even distribution of septic tank effluent in septic filter fields. The study by **Gross, Rutledge, Wolf, and Bomblat** found that a simple pump timer and counter provide information for maintenance of the pressurized laterals.

Surface irrigation by applying wastewater to agricultural and nonagricultural lands has proved to be a viable option to surface water discharge and subsurface disposal. **Woody, Rubin, and Frederick** report that successful system operation hinges on accurate soil and site investigations, suitable agronomic receiver sites, proper design of wastewater treatment methods and components, and an understanding of disposal methods. **Owens, Rutledge, Roark, Gross, Wolf, and McNew** conducted research to determine the hydraulic performance of a serially flooded filter field with time, finding that hydraulic failure of the soil did not occur, but that blockage formed in the pipes in the trenches.

Septic System Site Characterization and Design

The Massachusetts soil evaluator program is discussed by **Veneman and Fletcher** that is designed to meet the new on-site sewage regulations requiring training and examination of soil evaluators. **Winkler and Feiden** present a pressure system design spreadsheet that enables designers to configure asymmetrical systems with up to 26 laterals and 50 orifices per lateral. Output from the spreadsheet includes system discharge, head losses for the delivery pipe, manifold, laterals, lateral segments, and total system losses, pump capability, and system configuration details. Codes governing the design of individual sewage septic systems were developed under the assumption that systems were to be placed in natural soils. In their paper, **Wespetal and Schirmers** describe the problems associated with disturbed soils, the methods of proper field identification, how to quantify the extent of disturbance, and provide design options to overcome these limitations.

A study by **Townshend** showed that manmade materials can be used effectively to produce high-quality effluent in an experimental installation using biotextile and geodrain materials in separate recirculating nitrification-denitrification filters and polishing filters. Methods for measuring saturated hydraulic conductivity of soils in the vadose are reviewed and compared with the constant-head well permeameter method by **Amoozegar. Hart** proposed that both infiltrative capacity of the soil and the evaporative capacity of the climate be combined in design to minimize the drainfield size. In their paper, **Rutledge, Owens, Goff, Gross, Brumbelow, and Wolf** provide an alternative procedure for design of systems in which effluent loading is limited by the crust which forms at the gravel-soil interface.

An empirical procedure for analysis of mounding in the vadose zone in the evaluation of the viability of large septic systems is given by **Amoozegar and Martin. Townshend, Jowett, LeCraw, Waller, Paloheimo, Ives, Russell, and Liefhebber** report on the design of self-contained water supply, water treatment, and water reuse facilities for two adjoining houses built on small unserviced lots to demonstrate the feasibility of being completely "unplugged" from public hydro, sewer, and water supply.

Alternative Systems and Component Design

Discussing a standard modular design, **Ball and Denn** show that the recirculating sand filter is a successful wastewater treatment system for producers of small to medium (500 to 1 000 000 gal/day) wastewater flows. In their paper, **Burnell and McOmber** summarize a study to determine the suitability of used tires as a substitute for drainfield aggregate in standard sewage disposal systems and as a substitute for gravelless domed chamber systems. The study showed evidence of leaching of iron, zinc, and sulfate from used tie chips, but gravelless domed chambers using half ties appears to be more promising.

Bounds estimates that more than 45% of ultimate treatment can be accomplished in the septic tank in discussing the properties of an efficient septic tank as the primary treatment component for an on-site wastewater collection and treatment system. **Nichols, Wolf, Gross, and Rutledge** evaluated the renovation of chemical and biological components of septic tank effluent in a newly constructed stratified sand filter. The study concluded that a sand filter can be used to renovate septic tank effluent when soils are not conducive to the use of traditional leach fields.

Dix and May review the field performance of chamber leaching systems and report that several field studies support the performance claim for chamber systems. **Jowett** reports on a new type of free-draining biofilter to treat domestic septic tank effluent. **Tyre and Dennis** relate alternative design for wastewater treatment for a subdivision in an area of high watertable.

The evaporative capacity of the climate is used in the system described by **Church** in the area east of the Front Range in Colorado. The drip irrigation system of Church uses a treatment and dispersal system with multiple low-pressure drainfields lines, with provision for periods of nonuse and recovery of selected drainfield lines.

APPENDIX A

Three ASTM standard practices have been prepared by Section D18.21.01.06 on Treatment and Disposal of On-Site Waste. These standards are ASTM Practice for Surface Site Characterization for On-Site Septic Systems (D 5879-95), ASTM Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems (D 5921-96), and ASTM Practice for Preliminary Sizing and Delineation of Soil Absorption Field Areas for On-Site Septic Systems (D 5925-96).

D 5879-95
Practice for Surface Site Characterization for On-Site Septic Systems

1. Scope

1.1 This practice covers procedures for the characterization of surface conditions at a site for evaluating suitability for an on-site septic system for disposal and treatment of wastewater. This practice provides a method for identifying potentially suitable areas for soil absorption of septic tank wastewater.

1.2 This practice can be used at any site where on-site treatment of residential and non-hazardous commercial wastewaters using septic tanks and natural soils or constructed filter beds is required or an option under consideration. This practice may also be useful when constructed wetlands are used as an alternative wastewater treatment method.

1.3 This practice should be used in conjunction with Practices D 5921 and D 5925.

D 5921-96
Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems

1. Scope

1.1 This practice covers procedures for the characterization of subsurface soil conditions at a site as part of the process for evaluating suitability for an on-site septic system. This practice provides a method for determining the usable unsaturated soil depth for septic tank effluent to infiltrate for treatment and disposal.

1.2 This practice describes a procedure for classifying soil by field observable characteristics within the United States Department of Agriculture, Soil Conservation Service (SCS) classification system.[2] The SCS classification system is defined in Refs (**1–4**),[3] not in this practice. This practice is based on visual examination and manual tests that can be performed in the field. This practice is intended to provide information about soil characteristics in terms that are in common use by soil scientists, public health sanitarians, geologists, and engineers currently involved in the evaluation of soil conditions for septic systems.

1.3 This procedure can be augmented by Test Method D 422, when verification or comparison of field techniques is required. Other standard test methods that may be used to augment this practice include: Test Methods D 2325, D 3152, D 5093, D 3385, and D 2434.

1.4 This practice is not intended to replace Practice D 2488 which can be used in conjunction with this practice if construction engineering interpretations of soil properties are required.

1.5 This practice should be used in conjunction with D 5879 to determine a recommended field area for an on-site septic system. Where applicable regulations define loading rates-based soil characteristics, this practice, in conjunction with D 5925, can be used to determine septic tank effluent application rates to the soil.

1.6 This practice should be used to complement standard practices developed at state and local levels to characterize soil for on-site septic systems.

1.7 The values stated in SI units are to be regarded as the standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

D 5925-96

Practice for Preliminary Sizing and Delineation of Soil Absorption Field Areas for On-Site Septic Systems

1. Scope

1.1 This practice covers procedures for estimating the dimensions and marking the boundaries of a soil absorption area for an on-site septic system involving residential-strength wastewater. It can also be used to estimate the dimensions of commercial on-site septic systems where wastewater strengths are similar to residential wastewater.

1.2 This practice can also be used for marking the boundaries of the area for a septic system constructed filter bed.

1.3 This practice can be used at any site where a potentially suitable or recommended field area has been identified in accordance with Practices D 5879 and D 5921.

1.4 Non-metric units remain the common practice in design and installation of on-site waste disposal systems, and are used in this practice. Use of SI units given in parentheses is encouraged, if acceptable to the appropriate permitting agency.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

APPENDIX B

Terminology

The following terms have been defined for use as specifically related to on-site septic systems in ASTM standards D 5879, D 5921, and D 5925.

clinometer—an instrument for measuring inclination, as in topographic slope.

constructed filter bed—a material, usually of a sandy texture, placed above or in an excavated portion of the natural soil for filtration and purification of wastewater from an on-site septic system.

limiting depth—for the purpose of determining suitability for on-site septic systems, the depth at which the flow of water, air, or the downward growth of plant roots is restricted.

mottle—spots or blotches of different colors or shades of color interspersed with the dominant color (**5**). In SCS (**3**) practice mottles associated with wetness in the soil are called redox concentrations or redox depletions.

on-site septic system—any wastewater treatment and disposal system that uses a septic tank or functionally equivalent device for collecting waste solids and treats wastewater using natural soils, or constructed filter beds with disposal of the treated wastewater into the natural soil.

pocket penetrometer—a hand operated calibrated spring instrument used to measure resistance of the soil to compressive force.

potentially suitable field area—the portions of a site that remain after observing limiting surface features such as excessive slope, unsuitable landscape position, proximity to water supplies, and applicable setbacks have been excluded.

recommended field area—the portion of the potentially suitable field area at a site that has been determined to be most suitable as a septic tank soil absorption field or filter bed based on surface and subsurface observations.

soil absorption area—an area of natural soil used for filtration and purification of wastewater from an on-site septic system.

soil absorption field area—an area that includes soil absorption trenches and any soil barriers between the trenches. Also called a *leachfield.*

soil absorption trench—an excavated trench, usually 1.5 to 3 ft wide that receives wastewater for treatment. Also called a *lateral* or *leachline.*

unsaturated—soil water condition at which the void spaces that are able to be filled are less than full.

vertical separation—the depth of unsaturated, native, undisturbed soil between and bottom of the disposal component of the septic system and the limiting depth.

APPENDIX C

ASTM Standards Related to On-Site Septic Systems

Many ASTM standards have application to site and soils characterization and evaluation with respect to design of on-site septic systems. In addition, many ASTM standards are related to on-site system components and materials used in construction and the procedures related to the use of these components and materials. A list of ASTM standards with titles are given below.

Standards Related to Site and Materials Characterization, Tests and Evaluation

D 420-93	Guide to Site Characterization for Engineering, Design, and Construction Purposes
D 5879-95	Practice for Surface Site Characterization for On-Site Septic Systems
D 5921-96	Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems
D 5925-96	Practice for Preliminary Sizing and Delineation of Soil Absorption Field Areas for On-Site Septic Systems
D 1452-80 (1995)	Practice for Soil Investigation and Sampling by Auger Borings
D 3385-94	Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer
D 5093-90	Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring

D 2487-93	Test Methods for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D 2488-93	Practice for Description and Identification of Soils (Visual-Manual Procedure)
D 5434-93	Guide for Field Logging of Subsurface Explorations of Soil and Rock
D 4700-91	Guide for Soil Sampling from the Vadose Zone
D 5126-90	Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone
D 5911-96	Practice for Minimum Set of Data Elements to Identify a Soil Sampling
D 5092-90 (1995)	Practices for Design and Installation of Ground Water Monitoring Wells in Aquifers

Standards Related to On-Site Systems Components, Materials, and Construction Procedures

C 33-93	Specification for Concrete Aggregates
C 913-96	Specification for Precast Concrete Water and Wastewater Structures
C 1227-96	Specification for Precast Concrete Septic Tanks
D 1785-96a$^{\epsilon 1}$	Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
D 2241-96a	Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
D 2729-96	Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
D 5101-96	Test Method for Measuring the Soil-Geotextile System Clogging Potential (By the Gradient Ratio)
E 1609-94	Guide for Development and Implementation of a Pollution Prevention Program
D 2321-89 (1995)	Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
D 2564-96a	Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings
D 2855-96	Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
D 3083-89	Specification for Flexible Poly(Vinyl Chloride) Plastic Sheeting for Pond, Canal, and Reservoir Lining
D 4551-96	Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
D 449-89 (1994)$^{\epsilon 1}$	Specification for Asphalt Used in Dampproofing and Waterproofing
D 645-92	Test method for Thickness of Paper and Paperboard
D 1668-95	Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing

Contents

Septic System Operation and Evaluation

Lori L.C. Frekot[1] and Melonie L. Elvebak[2]

INSPECTION MANUAL FOR EXISTING SEPTIC SYSTEMS

REFERENCE: Frekot, L. L. C. and Elvebak, M. L., **"Inspection Manual for Existing Septic Systems,"** Site Characterization and Design of On-Site Septic Systems, ASTM STP 1324, M. S. Bedinger, J. S. Fleming, and A. I. Johnson, Eds., American Society for Testing and Materials, 1997.

ABSTRACT: In response to the demand for uniform inspections and conformity of existing Individual Sewage Treatment Systems (ISTS) across the state, the Minnesota Pollution Control Agency (MPCA) is developing a manual addressing the need for inspection procedures for existing ISTS. In this effort, the MPCA has done thorough research, formed advisory committees, and tested all the different procedures for inspecting existing ISTS. The manual is to be used as an educational tool to complete a comprehensive inspection of an existing ISTS on a property.

The manual will be used by individual sewage treatment system professionals and local unit of government employees to systematically investigate ISTS to determine which systems meet current Minnesota state standards. It was created to be user-friendly and comprehensive, with sections appropriate for copying and use directly in the field. The manual includes the definition of failing systems according to Minnesota Rule, Chapter 7080, and provides a methodology for inspecting ISTS. It also describes the available equipment used to investigate systems, dye tracer use, safety, a protocol for public involvement and recordkeeping.

KEYWORDS: sewage, septic system, wastewater, on-site system, inspection

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The MPCA received monies from the U.S. Environmental Protection Agency (EPA) (Federal Emergency Management Act) in response to the spring floods of 1993. Many septic systems were inundated with water, resulting in environmental and health concerns. The *Inspection Manual for Existing Individual Sewage Treatment Systems* (Minnesota Pollution Control Agency, 1996a) was proposed and accepted as a viable document to be used by ISTS professionals for systematically investigating existing septic systems to help determine which systems have the potential for water inundation.

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The MPCA researched equipment, other state and private inspection protocols, and ISTS treatment and evaluation theories; conducted several information-gathering meetings across the state; tested all the procedures for inspecting existing ISTS described in the manual; presented proposed manual contents during the Minnesota Onsite Sewage Treatment System Workshops; and provided draft manuals to ISTS professionals for review and comment. The manual is intended to be used as an educational instrument for ISTS professionals by providing the tools and techniques for systematic investigations of existing ISTS.

PURPOSE OF MANUAL

The manual was developed for two reasons: first, to address the concerns of identifying systems susceptible to water inundation. Concerns were elevated during the 1993 floods in the Midwest. The high potential for pathogenic organisms in groundwater was the driving force. Second, manual development was fostered by the swell of interested persons entering the ISTS inspection field because of 1994 legislation. Suddenly, there was a great need for inspectors who were independent of the installer to be available to meet the new construction, replacement and existing system inspection demands.

The manual provides compliance definitions for ISTS inspectors so a standard approach is used to reasonably assure public health and the environment are protected. It also indicates the rule requirements for when an ISTS must be upgraded, repaired, replaced or abandoned. The manual provides the information and the tools needed to make such determinations.

The manual also describes ISTS inspection programs. For example, describing lakeshore survey processes versus individually-triggered inspections (such as for property transfers). It is intended to be user-friendly and comprehensive, with forms offered for copying and use directly in the field. It includes:

- professional requirements for a person who conducts existing ISTS inspections in Minnesota;
- a primer of state ISTS standards and criteria;
- administrative suggestions for public involvement;
- recordkeeping and rating systems;
- office and field procedures for inspections;
- advanced inspection techniques; and
- an annotated bibliography.

The manual is a fluid document. It will be updated as its use expands and as the MPCA receives additional comments from manual users. For now, it provides recommended procedures for conducting compliance inspections for existing ISTS. It will be used in the statewide ISTS workshops as a supplement to the University of Minnesota Extension's *Onsite Sewage Treatment Manual* (Minnesota Agricultural Extension Service, 1994). The basis for the compliance criteria can be found in Minnesota Rule, Chapter 7080, Individual Sewage Treatment Systems Standards, and is described in detail in the *Manual* (Minnesota Pollution Control Agency, 1996b).

THE MINNESOTA PERSPECTIVE

Minnesota Rule, Chapter 7080: ISTS Standards And Criteria

ISTS requirements were initially adopted in 1978. These requirements were presented as recommended site evaluation, design, installation, maintenance and use standards and criteria, to be voluntarily adopted at the local level. The rules, known as Chapter 7080, were subsequently revised in 1989 and 1996. The theories and treatment alternatives in the rules have been essentially the same since 1978; modifications have been made to include technological advancements, legislative mandates, and to clarify problems noted in the field.

In 1994, the legislature required local unit of government administrative processes and a state ISTS professional licensing program to be included in the ISTS rules. Chapter 7080 expanded its technical rules to include these two new requirements, effective in January 1996.

Local Unit Of Government Administration And Enforcement

Chapter 7080 has always been voluntarily adopted at the local level. Therefore, each local unit of government may or may not have an ordinance. Currently, 64 counties have a county-wide ISTS ordinance; 18 counties have a shoreland-area ordinance only, four counties delegate ISTS responsibilities to municipalities; and one county has no ISTS requirements. In addition, an unknown number of cities and townships have adopted ISTS ordinances. This patchwork has resulted in a variety of inspection criteria and methods across the state.

Minnesota's Geomorphic And Hydrogeologic Characteristics

As one would expect in the "land of 10,000 lakes," Minnesota has a high water table throughout the state and also has a problem with seasonal flooding, especially during spring snow-melt. These conditions are due to the geology, soils, topography, and hydrology of the state.

When ISTS are installed too close to the water table, are not properly maintained, or are used improperly, contamination may adversely impact surface and groundwater and has the potential to impact public health. Approximately two-thirds of Minnesotans gets their drinking water from groundwater sources, with the remaining one-third obtaining drinking water from lakes and rivers. Since a majority of Minnesotans drink from groundwater sources, it is extremely important to protect our groundwater resources.

The geology and soils vary throughout the state from bedrock to clay material, and are primarily influenced by glaciation with smaller areas of shallow, sometimes fractured, bedrock. In Minnesota, limestone, granite, sandstone, dolomite, and gabbro are some of the common types of bedrock that are specific to different regions. The soils are commonly loamy in texture but do range from clays to silts to sands. Dry, loamy soil is ideal for ISTS because the slower infiltration rate (as opposed to coarse-textured soils) and soil particle surface area provides a high degree of treatment for the wastewater.

The topography also changes across the state from prairies in the western part of the state to very hilly and rolling in south-central Minnesota. The southeastern region in the state is a karst region. The north-central to the northern part of the state is known for its lakes, bedrock outcrops and hills. These conditions influence the types of ISTS an inspector will see.

UNDERSTANDING COMPLIANCE INSPECTIONS

What Is A Compliance Inspection?

Chapter 7080 defines a compliance inspection as: "...any evaluation, investigation, inspection, or other such process to make conclusions, recommendations or statements regarding an individual sewage treatment system by conducting site investigations, gathering and reviewing information or conducting tests." This definition was selectively chosen to comprehensively include all ISTS investigations. This eliminates the problems with inspections where the system is "evaluated," not inspected; thereby, giving the consumer a false sense that the ISTS complies with state requirements. For example, it may not be clear that all state requirements have been met if a property transfer "evaluation" is conducted where a property owner interview is the only method of obtaining information.

When Are Compliance Inspections Required?

Statewide, compliance inspections must be conducted for all new construction and replacement of ISTS and when a bedroom permit or variance is requested. This is based on 1994 amendments to Minnesota Statute, Chapter 115. Also in effect statewide are the Minnesota Department of Natural

Resources' Shoreland Act and Flood Management Act, which requires compliance inspections when any type of permit or variance request is made for properties within shoreland area -- 305m (1000 ft) from a lake, pond or flowage; 91m (300 ft) from a river or stream or the landward extent of a floodplain.

Each local unit of government may require compliance inspections as determined by local ordinance. For example, inspections may occur due to complaints, sale or transfer of property, or when any building permit is requested.

Outside entities may also require compliance inspections. For example, lending institutions, mortgage companies, real estate companies, state agencies (when state funding or state permits are involved) and individual property owners may also request a compliance inspection. This has become a major influence in Minnesota and the demand for inspectors and demand for consistent methodologies and training has been intensive.

Types Of ISTS Compliance Inspections

Chapter 7080 differentiates between two types of inspections:

1. Inspections to determine whether the ISTS is failing.
2. Inspections to determine full compliance with current technical standards and criteria.

When Is An ISTS Failing?

A failing system is defined in Chapter 7080 as:

- any system that discharges untreated or partially treated sewage to the ground surface; surface water, or groundwater;
- a seepage pit, cesspool, drywell, or leaching pit;
- any system with less than 0.9 m (3 feet) of soil or sand between the system bottom and the saturated soil level or bedrock; and
- any system causing sewage backup into a dwelling or other establishment.

COMPLIANCE INSPECTION: IS THE ISTS FAILING?

The flow chart in Figure 1 illustrates the different inspection components to determine the status of the system. The boxes indicate the different components of the system being inspected. Hanging notations indicate general procedures and tools needed to investigate the different components. The difference between a failing and a full compliance inspection is the level of inspection detail performed. Full compliance inspections must be conducted for all new construction and replacement. In addition, many local governments include the criterion "not built-to-code at the time of construction" in their failing definition.

The criteria and methods in Figure 1 were placed in a specific order to reduce the amount of time needed for each inspection. The manual describes methods beginning with those that take the least amount of time to verify. Inspections to determine failure can take from one-half to three hours or more, depending on the amount of known information about the system, the time of year, and whether it is a failing or full compliance inspection. If one item on the flow chart is violated, the inspection could theoretically be over; however, it is in the consumer's and the inspector's best interest to do a reasonable verification of all parameters so the inspection is complete.