Report of the

TECHNICAL ADVISORY COMMITTEE
To the
Agency of Natural Resources
For the review of
On-Site Wastewater Technology

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Introduction

Vermont has been considering a thorough review and updating of its Environmental Protection Rules, especially pertaining to on-site wastewater treatment and disposal, for a long time. There have been several committees, studies, and public meetings, and numerous versions of legislation pertaining to this topic over nearly 10 years.

In March 2001, a Technical Advisory Committee was formed by the Commissioner to assist the Agency of Natural Resources (ANR) in the development of new Rules, which are intended to become a "statewide" standard, replacing numerous former rules in use by individual communities. As part of these changes and upgrades, there has been the plan to eliminate the 30-year old "10-acre exemption", which allows sites to be developed without following State standards, in many towns. The following is the Report of the Committee's findings and recommendations.

Model Framework

The Technical Advisory Committee decided at the first meeting that a basic framework was needed to guide the Committee and the ANR in future directions of regulatory structure and wastewater management for Vermont. It was also agreed that the Model should apply to conventional as well as innovative/alternative systems.

The Model Framework refers to the National Onsite Wastewater Recycling Association (NOWRA) model that promotes the necessary infrastructure for on-site wastewater solutions. It is intended as a policy guide to achieve sustainable development while protecting human health and environmental quality. Specifically, the framework is guidance for management and oversight of small-scale wastewater regulations including new technologies. The framework has eight key components, all based on performance. They are:

1. Performance requirements to protect groundwater, surface water and drinking water (Rules)
2. Wastewater system management (O&M)
3. Compliance monitoring and enforcement
4. Technical requirements/options for site evaluation, design, construction, and operation
5. Continuing education/training for all practitioners, regulators, and owners
6. Certification/licensing for all practitioners
7. Ongoing program review
8. Funding program for replacement of failed/substandard disposal systems and/or water supplies (grants, low interest loans, deferred repayment)

Practitioners are site evaluators, designers, installers, pumpers, inspectors, and O&M operators.

Following several revisions, the adopted version was written using the NOWRA Model, but was adapted for Vermont's needs. A full copy of the document, titled "Framework for Unsewered Wastewater Infrastructure", dated May 29, 2001, is included in the Appendix.

The Agency of Natural Resources, in consultation with the Committee, has used the Framework document in its deliberations on the new Rules.

Performance vs. Prescriptive Standards

Prescriptive standards set forth "step by step" design criteria that are to be implemented for permit acquisition. If followed in detail, a permit should be obtained. Prescriptive standards allow for little to no design deviation. Nearly every disposal system looks and acts the same, for similar conditions.

A performance standard sets forth "goals and objectives" that must be met to protect the public health and environment, and to acquire a permit. Performance standards leave the specific engineering issues for the design professional to consider.

A frequent complaint of the existing Environmental Protection Rules is the regulations do not allow for flexibility, one design fits all and if it does not fit, the owner and designer have few choices to solve the problem creatively.

With performance standards, the designer would evaluate site characteristics and the objectives of the regulations. Based on this assessment, a design that meets the goals and objectives of the regulations would be prepared. This would be accomplished without adhering to specific regulatory standards. This allows the design professional to find creative solutions allowing optimum utilization of an individual parcel of land.

From a regulatory perspective, the prescriptive standard is easiest to administer. All wastewater disposal designs of a certain type have a distinct similarity. This should allow for a quick, expedient and efficient review, on the basis that the designer and reviewer have agreed on a design concept at the time of site and soils investigations.

The review and approval of a performance-based design requires a depth of knowledge equal to or greater than that of the design professional. Furthermore, this type of design may require a prolonged review duration as the regulator becomes familiar with the engineering principles that apply, especially for newer and untested designs.

Section §1-309 through 1-312 "Innovative/Alternative Systems and Products" of the draft Rules provide for performance based designs. These sections establish criteria for "General," "Pilot" and "Experimental" systems. The Rules provide for an "Application Process for Innovative/Alternative Systems and Products" and establish a maximum number of systems that may be approved under the duration of the Rules.

The Committee has discussed this approach and concurs that more "marginal" sites require more detailed and sophisticated methods, which may also allow for new technological solutions.

Viral and Other Pathogens

The Committee and ANR believe the movement of viruses and other pathogens beyond the immediate vicinity of the soil-based disposal system to be an important issue and concern for establishing design and review criteria.

In evaluating the isolation distances needed between the bottom of a septic effluent disposal system and the high seasonal water table, including any water table mounding, several literature sources were reviewed.

Environmental Engineering and Sanitation, 4th ed. by Joseph Salvato in Table 1-8 shows that Hepatitis A and Poliovirus can remain viable in four-degree centigrade mineral water exceeding one year.

Removal of MS2 Coliphage by Standard Septic Tank-Leach Trench Septic Systems presents a summary of that and other studies which indicate much uncertainty regarding viral removal in disposal systems based on variability of viral, septic treatment system, and soil types. "Virus removal in soils is inversely related to the hydraulic loading rate. Thus, any distance-to-groundwater credits awarded an alternative technology should not be coupled with concurrent allowances for reduced leachfield size, since reduced size translates to a higher hydraulic loading rate." They concluded that more research was needed.

Virus Transport by Rose, Griffin, and Nicosia presented research which indicated that the maximum long-term removal obtained in leaching trenches with two feet of unsaturated soil was 2.6-log removal of a bacteriophage tracer used as a surrogate for viral contaminants. The article also states that a 7-log removal should be achieved to protect drinking water.

Pathogen Fate in Wastewater Soil Absorption Systems as Affected by Effluent Quality and Soil Clogging Genesis by Van Cuyk and Siegrist indicates that although design practices have evolved to handle hydraulic loading issues, there is still a need to understand the fate and transport of pathogenic bacteria and viruses beneath the drain field and in the subsurface aquifer.

Onsite Sewage Disposal System Research In Florida is a work that summarizes viral survival and retention in soils. Table 4.5.1 indicates that in saturated soils viruses survive the longest and are the least retained by the soil, while dry soils are the opposite, with least survivability and greatest retention of the viruses. Changing soil moisture conditions may release viruses that are initially retained into the groundwater where their survivability increases.

Most notable was the general absence of viral information regarding their transport and fate in the subsurface environment directly below the disposal system in the saturated aquifer.

The Committee reviewed these findings, as limited and non-conclusive as they are, and also considered the following:

- The Vermont Health Department typically records about one to two dozen cases of Hepatitis A annually, and attributes about 88% to groundwater sources. (There is no indication of the type or suitability of the soil-based wastewater disposal systems in these cases.)
- Allowing of "offsets" in design standards, i.e. provide increased isolation distances to water supplies in cases where increased hydraulic loading rates are proposed.
- Continued support for the "two-year travel time" requirement between potential sources of contamination and drinking water supplies.
- Provision for increased protection for wells, such as increased casing length and casing grouting.
- Review of disinfection of wastewater as a means of protection; the Committee agreed this is not an appropriate method for single-family homes, or other small systems.

In conclusion, based on review of the studies and other States' rules, viral and other pathogen transport in the groundwater remains a concern, but there is insufficient basis to significantly alter Vermont's approach at this time. Ongoing review is warranted, and future Rule revisions should continue to consider this issue.

Soil Suitability for Soil Absorption Systems

Soils can be an effective medium for treatment and dispersal of septic tank effluent or on-site wastewater treatment system effluent in soil absorption systems. Characterization of soil suitability and capacity to accept wastewater are important aspects of on-site system site evaluation. The soil suitability for onsite soil absorption systems is generally characterized by depth to seasonal high groundwater, depth to low permeability soils, and depth to bedrock. The capacity of the soils to absorb septic tank effluent or treated wastewater is described by the long-term acceptance rate (LTAR) of the soil, normally estimated using either a percolation test or an evaluation of soil morphology. Soil volume utilization is the synthesis of soil characteristics and system design to maximize treatment and dispersion of effluent into the environment.

Fluctuating soil moisture conditions result in variation in environmental conditions for bacteria whose biologic processes result in reduction and oxidation of minerals in soil. These processes are most likely to be observable in Vermont soils by the reduction and oxidation of iron and manganese. Under reducing conditions, iron and manganese are generally more soluble and can migrate through the soils. The absence of iron and manganese is likely to be characterized by lower chroma soils. Under oxidizing conditions, these minerals are generally precipitated and are deposited on soil particle as higher chroma soil colors. The color of the soil is altered by the mobilization and precipitation of these soils. These redoximorphic features, commonly referred to as mottles, in the soil require a trained eye to detect and interpret the meaning of soil color. Groundwater levels in Vermont typically peak late winter and spring. Mottles are appropriate tools for estimating the height to which the water table may rise, as long as they are interpreted in the context of the entire soil profile, the topographic setting of the site and an understanding of the local soil chemistry, soil temperature fluctuations, surficial geology, and site hydrogeology.

Low permeability soils are detected by either soil morphology and field tests of soils ability to transmit water. Percolation tests have traditionally been used to determine the minimum rate that a soil can accept water for a soil absorption system. Soil morphology, or the physical features of the soil profile, can be used to determine the minimum soil conditions for wastewater system design (Tyler and Kuns, 2000). Typically soils with very firm, extremely firm moist consistency or very hard or hard dry consistency are not suitable for soil absorption systems. Similarly, soils with a high clay or silt content, cement soil horizons, and/or platy structure may be unsuitable for on-site systems. These soils may form the hydraulic bottom of the natural soil component of a soil absorption system.

Depth to bedrock is typically quite straightforward to estimate, with the exception of bedrock that can be readily dug with an excavator. A notable example of diggable soils can be found in the Waits River Formation in northeastern Vermont. This geological formation is often weathered in place and can be readily excavated immediately below the soil overburden. In the case of bedrock that can be excavated, the interconnection of bedrock fractures needs to be considered when defining the depth of competent or relatively difficult to excavate bedrock.

The LTAR of a soil is the steady state rate at which soil can accept effluent through an organic layer, or biomat, at the interface of the wastewater distribution system and the receiving soil. The buildup of the biomat is dependent on the quality of the effluent, the soil morphology and the separation to restrictive horizons, such as the water table, low permeability layers, and in some cases, higher permeability soils or bedrock. Percolation tests have been used to estimate the LTAR, based on empirical tests conducted in the 1920s. Research in the past 40 years has repeatedly indicated that percolation tests results are quite variable, depending on who is conducting the tests, the soil profile, the soil moisture conditions at the time of the test and other factors. Soil morphology, specifically soil texture, soil structure and soil consistence, can be used to estimate the LTAR in a more consistent and repeatable fashion that is not subject to the variability of the percolation test. The Vermont Indirect Discharge Rules have a soil morphology method for sizing soil absorption systems. Similarly, the State of Maine has been using soil morphology for sizing septic systems since 1974 and the states of Washington, Oregon, Idaho and many others have abandoned the percolation test. Tyler and Kuhns (2000) illustrate a method for using soil morphology for sizing soil absorption systems for treated and untreated septic tank effluent. Training and certification of the field specialists to use soil morphology to estimate LTAR is imperative.

The effectiveness of soils to treat and transmit water is only as good as the effectiveness of the distribution system. Soil volume utilization has been coined by researchers (Seigrist et al, 2000) to quantify how well effluent is distributed to take advantage of contact with soil particles under the lowest soil matrix potential (soil-water pore pressure). Soil matrix potential is correlated with soil moisture content for different soil types (USEPA, 1978). For a given soil type, the lower the matrix potential, the lower the saturation of the soil and the more tortuous the flow path of the soil-water/effluent. The more tortuous flow path at a low hydraulic loading rate results in more time for die-off of microorganisms. Soil volume utilization can be controlled by both the configuration of the distribution system and the dosing of the effluent. Generally, more frequent dosing of smaller volumes of effluent evenly spread over the infiltrative surface will distribute effluent more effectively than larger widely spaced flow-based doses.

References:

Seigrist, R.L.; Tyler, E.J.; Jenssen, P.D.; 2000; Design and Performance of Onsite Wastewater Soil Absorption Systems; in *National Research Needs Conference Draft Proceedings: Risk-based Decision Making for Onsite Wastewater Treatment.* May 19-20, 2000, St. Louis, Missouri.

Tyler, E.J. and Kuns, L.; 2000; Hydraulic Loading Rates for Onsite Wastewater Systems in Lake County Ohio; in Proceedings of National Onsite Wastewater Recycling Association Annual Conference, Grand Rapids, Michigan.

United States Environmental Protection Agency, 1978; *Management of Small Waste Flows*; Small Scale Waste Management Project, University of Wisconsin Madison.

Minimum Depth to Groundwater Criteria for Siting Soil Absorption Systems

Background

The objective of this section is to establish recommendations for minimum siting criteria for soil absorption systems. This issue is approached from a hydrogeological perspective with consideration of the climate, soils and development patterns in Vermont. A key question is: “Is it possible to determine whether a site meets these criteria without a detailed hydrogeological investigation for less than 1,000 gallon per day (gpd) systems?” This question is addressed by developing linear loading rates: flow of wastewater (gpd) per unit distance of system length (feet).

Vermont’s current minimum siting conditions are:

1. In-ground system: 42 inches to seasonal high water table with no geometric limitations on linear loading rate
2. At-grade system: 36 inches to seasonal high water table; limitation of 6-foot width and 1 gpsfd/linear foot (lf) provides geometric limitation on linear loading rate of 6 gpd/lf.
3. Mound system: 24 inches to seasonal high water table plus 12 inches at toe; 2:1 length to width ratio provides geometric limitation to minimize the linear loading rate
4. Sand filter systems: 18 inches to mounded seasonal high groundwater plus 12 inches at toe. Default linear loading rate: 4.5 gpd/lf

How will minimum conditions for determining the hydrogeologic suitability for on-site soil absorption systems be set? There is a need to predict the impact of artificial recharge on the water table, which produces a condition commonly called groundwater mounding. The rate of natural groundwater recharge in Vermont varies widely from site to site, season to season and year to year. When snowmelt and spring rain recharges the groundwater, the water table rises. When plants are taking up the rainfall in the summer, the water table drops. Therefore, the seasonal high groundwater levels in any one year typically occur in the spring. This is the groundwater level that should be used as a baseline for determining apparent hydrogeologic capacity of a site.

Previous Approaches

The predecessor of the current Vermont Technical Advisory Committee considered this issue in 1997 and looked at hydrogeologic conditions for on-site systems, based on the experience of consulting hydrogeologists and the hydraulic conductivity (ability of soil to transmit water). The 1997 analysis resulted in the following recommendations for minimum siting conditions:

1. A minimum ground surface slope of 3%;
2. A minimum depth from ground surface to seasonal high ground water of 12 inches or the thickness of the topsoil (A) horizon plus 12 inches, whichever is greater; site must be drainable to 18 inches.
3. A minimum of 18 inches of soil with a percolation rate faster than 120 minutes per inch;
4. A maximum linear loading rate of 2 gpd/lf;
5. A minimum of 2 feet of naturally occurring soil over bedrock; and
6. The above siting conditions must occur under the entire system and extend at least 25 feet down hill of the system.

Using this as a reference point, three other approaches that are either proposed or in regulation in Connecticut, Nova Scotia and Lake County, Ohio were evaluated by members of the Vermont Technical Advisory Committee in 2001:

- The Connecticut approach sets the length of a system along topographic contours and incorporates three variables:
  - Hydraulic factor (based on water table gradient and depth to restrictive layer)
  - Flow Factor (based on design flow)
  - Percolation Factor (based on perc rate)
- The range of resulting lengths of soil absorption systems, serving a three-bedroom home for the shallowest depth to restrictive layer allowed are 26 feet (15% gradient and less than 5 minutes per inch perc rate) to 360 feet (1% gradient and 60 minutes per inch perc rate). These standards assume no surfacing of effluent.
- Nova Scotia utilizes a nomograph that incorporates gradient, hydraulic conductivity (estimated by soil texture or measured) and design flow. The resulting systems are on the order of tens of feet to 500 foot-long systems. These standards assume surfacing may occur.
- The proposed method for Lake County, Ohio is based on a detailed evaluation of soils and measurement of hydraulic gradient. The numbers result in system lengths ranging from 40 to 200 feet long for a typical three-bedroom house. The method accepts the possibility that seasonal surfacing may occur.

A starting assumption proposes to decrease the minimum requirement to six inches of separation between ground surface and the mounded water table. This is a "bare bones" minimum. In finer-textured soils, the toe of soil absorption systems will be at or near saturation during seasonal high water table conditions due to capillary nature of the small pore spaces in silty and clayey soils with this thickness of freeboard.

What methods are used to determine the minimum siting conditions?

1. **Is there a simple and defendable way to predict groundwater mounding? *Darcy's Law***

   Darcy's Law is briefly described below.

   Darcy's law: $Q/7.48 = KIA$

   Q = design flow (gpd)
   K = hydraulic conductivity (feet/day)
   I = hydraulic gradient (dimensionless)
   A = transmitting soil cross-sectional area (depth (minus the freeboard) to water table (D) times the length of soil absorption system (L)) (square feet)

   To apply Darcy's law to determine a linear loading rate this equation is converted to the following equation:

Solving for A: A = Q/7.48KI

Solving for system length: DL = Q/7.48KI can be converted to L = Q/7.48KID

Hydraulic conductivity is the variable in Darcy's law with the greatest variability. It is normally measured in the field or laboratory using standard hydrogeologic methods. There has been a great deal of hydrogeologic data collected by consulting hydrogeologists in Vermont over the last 20 years (Vermont Sewage Advisory Committee, 1997). Table 1 was developed and uses Tyler and Kuns' soil description methods, which require description of soil texture, structure and consistence and experience with typical approximate hydraulic conductivity found in Vermont soils.

Table 1. Hydraulic Loading Method for Detailed Soil Descriptions in Vermont

				Hydraulic Loading Rate (gpd/square foot)							
				(Sorted by hydraulic gradient and % ground surface slope range as noted)							
Soil Texture[1]	**Soil Structure[2]**		**K[3]**	0.01	0.03	0.05	0.07	0.09	0.125	0.175	0.25
	Shape	Grade	(ft/day)	0-2%	2.1-4%	4.1-6%	6.1-8%	8.1-10%	10.1-15%	15.1-20%	20.1-30%
Coarse Sand, Sand,		0SG	100	7.5	22.4	37.4	52.4	67.3	93.5	130.9	187.0
Loamy Coarse Sand, Loamy Sand											
Fine Sand, Very Fine Sand,	--	0SG	50	3.7	11.2	18.7	26.2	33.7	46.8	65.5	93.5
Loamy Fine Sand, Loamy Very Fine Sand											
Coarse Sandy Loam, Loamy Sand											
	--	0M	50	3.7	11.2	18.7	26.2	33.7	46.8	65.5	93.5
	PL	1	25	1.9	5.6	9.4	13.1	16.8	23.4	32.7	46.8
	PL	2,3	25	1.9	5.6	9.4	13.1	16.8	23.4	32.7	46.8
	PR/BK/GR	1	40	3.0	9.0	15.0	20.9	26.9	37.4	52.4	74.8
	PR/BK/GR	2,3	50	3.7	11.2	18.7	26.2	33.7	46.8	65.5	93.5
Fine Sandy Loam, Very Fine Sandy Loam	--	0M	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
	PL	1,2,3	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
	PR/BK/GR	1	20	1.5	4.5	7.5	10.5	13.5	18.7	26.2	37.4
	PR/BK/GR	2,3	30	2.2	6.7	11.2	15.7	20.2	28.1	39.3	56.1
				Hydraulic Loading Rate (gpd/square foot)							
				(Sorted by hydraulic gradient and % ground surface slope range as noted)							
Soil Texture[1]	**Soil Structure[2]**		**K[3]**	0.01	0.03	0.05	0.07	0.09	0.125	0.175	0.25
	Shape	Grade	(ft/day)	0-2%	2.1-4%	4.1-6%	6.1-8%	8.1-10%	10.1-15%	15.1-20%	20.1-30%
Loam	--	0M	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
	PL	1,2,3	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
	PR/BK/GR	1	15	1.1	3.4	5.6	7.9	10.1	14.0	19.6	28.1
	PR/BK/GR	2,3	20	1.5	4.5	7.5	10.5	13.5	18.7	26.2	37.4

Silt Loam	--	0M	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
	PL	1,2,3	5	0.4	1.1	1.9	2.6	3.4	4.7	6.5	9.4
	PR/BK/GR	1	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
	PR/BK/GR	2,3	20	1.5	4.5	7.5	10.5	13.5	18.7	26.2	37.4
Sandy Clay Loam, Clay Loam, Silty Clay Loam	--	0M	5	0.4	1.1	1.9	2.6	3.4	4.7	6.5	9.4
	PL	1,2,3	5	0.4	1.1	1.9	2.6	3.4	4.7	6.5	9.4
	PR/BK/GR	1	8	0.6	1.8	3.0	4.2	5.4	7.5	10.5	15.0
	PR/BK/GR	2,3	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
Sandy Clay, Clay, Silty Clay	--	0M	3	0.2	0.7	1.1	1.6	2.0	2.8	3.9	5.6
	PL	1,2,3	3	0.2	0.7	1.1	1.6	2.0	2.8	3.9	5.6
	PR/BK/GR	1	5	0.4	1.1	1.9	2.6	3.4	4.7	6.5	9.4
	PR/BK/GR	2,3	10	0.7	2.2	3.7	5.2	6.7	9.4	13.1	18.7
Note: 1. Soil texture and structure columns are based on Tyler and Kuns (2000).											
2. Structure Abbreviations: Shapes: PL = platy; BK = blocky; PR = prismatic; GR = granular											
Grade: 0 = structureless; SG = single grain; M = massive; 1 = weak; 2 = moderate; 3 = strong											
3. K = hydraulic conductivity (estimated)											

2. **Can we develop a method to determine the linear loading rate for combinations of gradient and hydraulic conductivity?** ***Yes***

   The recommended approach is to use the linear loading rate times the design flow of the project to calculate the length of the system perpendicular to the apparent groundwater flow direction if there is one foot of transmitting soil thickness available. If there is more or less thickness of transmitting soil thickness available then the linear loading rate should be multiplied by the proportion of the actual soil thickness (in feet) to one foot.

3. **Which field techniques for soil evaluation/description are required to estimate hydraulic conductivity?** ***Soil morphology: Texture, structure and consistence***

   Table 2 was developed to simplify the soil morphology characterization using only texture to estimate hydraulic conductivity. The use of Table 2 should only be a temporary measure until soil absorption systems are routinely sized based on soil morphology including texture, structure and consistence.

Table 2. Proposed Vermont Hydraulic Loading Method for General Soil Descriptions

Draft October 9, 2001

Hydraulic Loading Rate (gpd/square foot)
(column headings denote gradient used in calculation and slope range)

Soil Texture	**0.01**	**0.03**	**0.05**	**0.07**	**0.09**	**0.125**	**0.175**
	0-2%	**2.1-4%**	**4.1-6%**	**6.1-8%**	**8.1-10%**	**10.1-15%**	**15.1-20%**
Coarse sand, Sand, Loamy Coarse Sand and Loamy Sand	7.5	22.4	37.4	52.4	67.3	93.5	130.9
Fine Sand, Very Fine Sand, Loamy Fine Sand,	3.74	11.22	18.7	26.18	33.66	46.8	65.5

Loamy Very Fine Sand							
Coarse Sandy Loam and Loamy Sand	3.74	11.22	18.7	26.18	33.66	46.8	65.5
Fine Sandy Loam Very Fine Sandy Loam	1.496	4.488	7.48	10.472	13.464	18.7	26.18
Loam	1.1	3.4	5.6	7.9	10.1	14.0	19.6
Silt Loam	0.7	2.2	3.7	5.2	6.7	9.4	13.1
Silty Clay Loam, Clay Loam, Sandy Clay Loam	0.4	1.1	1.9	2.6	3.4	4.7	6.5
Silty Clay, Clay, Sandy Clay	0.2	0.7	1.1	1.6	2.0	2.8	3.9

Notes: 1. These are selected rows from the detailed method denoted by "x"
2. Shaded areas are linear loading rates that are generally not recommended

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This approach will result in system lengths from 10 to 600 feet long for typical three-bedroom house design flow of 405 gpd.

The following recommendations are made regarding siting of disposal systems. For additional information regarding limitations based on specific treatment levels, see Table 2 on page 19.

1. Retain current siting conditions as defaults not requiring hydrogeologic analyses or investigations for systems with less than 1,000 gpd design flow.
2. Minimum vertical separation to seasonal high groundwater should be 12 inches (drainable to 18 inches), or the thickness of the A horizon plus four inches, whichever is greater.
3. Minimum freeboard for groundwater mounding analyses for systems less than 1,000 gpd should be six inches.
4. The recommended minimum length of the system should be calculated by the available thickness of unsaturated material, estimated hydraulic conductivity based on soil morphology; ground surface slope (or hydraulic gradient, if available); and the wastewater design flow for the project.
5. Actual measurements of hydraulic conductivity in the field can be used to provide more accurate analyses.

The Committee discussed these topics on numerous occasions and supports the advice of the hydrogeologic subcommittee. In addition, there was discussion about the elimination of the percolation test, after practitioners are comfortable with soils identification methods. Further, it was recognized that as safety factors are reduced, there is greater need for increased training, licensing, system management and regulatory oversight.

References

1. Vermont Department of Environmental Conservation, Wastewater Management Division, 1997. Progress Report of the Technical Committee – Concepts for Changes to the Technical Standards Proposed for Inclusion in Phase II Rules.

2. Connecticut Department of Health, 2000, Public Health Code, Regulations and Technical Standards for Subsurface Sewage Disposal Systems.
3. Waller, D. 1986, Nova Scotia On-site System Siting Criteria.
4. Tyler and Kuns, 2000, Designing with Soil: Development and Use of a Wastewater Hydraulic Linear and Infiltration Loading Rate Table, National Onsite Wastewater Recycling Association Conference Proceedings, Grand Rapids, Michigan.

Design Flows

Background

Current Vermont Environmental Protection Rules (Appendix 1-7A) provide for the required wastewater flows from all types of establishments normally expected in project designs. Generally, the unit flow requirements are based on a flow stated in "Gallons/Person/Day", and are in conformance with similar published standards of other states and regions.

There has been a provision for a design "credit" of a 10% reduction from the stated flows for projects using fixtures of a "low flow" design, especially toilets, showerheads and faucets. The current rules also allow a 20% reduction in flow values for any project connected to a municipal system, recognizing that a) average actual flows are usually less than those stated in the table, and b) the municipal system can accommodate occasional peaks better than an individual on-site system.

The Committee supports most of the flow values for commercial and non-residential uses, as in the present rules. There is concern, however, that the flow requirements for residential uses are exceedingly conservative, especially for "community" systems serving multiple units. The current residential standard is 150 gpd per bedroom, assuming double occupancy at 75 gpd per person. The only credit, when using an on-site system, is the 10% credit for low flow fixtures.

The Committee also agrees that the average Vermont residence includes about 2.5 to 2.7 persons, depending on location, and not the six persons normally designed for in a three-bedroom dwelling. It is recognized that some dwellings have a high occupancy, but as a group or community grows, the design value can be reduced; it is our goal to develop a flow basis that more accurately reflects reality.

Safety Factors and Published Information

The design flow values contained in rules of other New England states are consistent with Vermont Rules. However, Maine uses a value of 90 gpd per bedroom, acknowledging that the average bedroom does not have two occupants.

A recent EPA Draft "Onsite Wastewater Treatment Systems Design Manual" also confirms that a closer estimate of actual population served is appropriate. The Manual also references studies which show that average daily residential wastewater flow is 68.6 gpd per person, also indicating that rural dwellings on private wells use less than that. Data collected during engineering evaluations for Vermont communities supports this information. In that same EPA Draft, there is reference to a 1999 study by Mayer et al. that shows that out of a sample of 1,188 residences, the range of daily flow is 57.1 to 83.5 gpd. The EPA Draft also indicates that when more than 10 units are served, the effects of averaging can be more predictable.

There is also a trend in Vermont that many residences are more than three bedrooms, even though family size is not increasing, resulting in oversized wastewater treatment/disposal systems.

Elimination of the "low-flow" credit is recommended; all modern fixtures manufactured for sale in the United States meet this standard, and the public has acclimated to water conservation over the past 20 years.

Proposed Residential Design Flows

Following are proposed standards for computing residential design flows, as contained in the current Draft of Proposed Rules (Oct. 16,2001):

- Design flows shall be based on 70 gallons/person/day;
- The first three bedrooms of a residence assume two persons each, then one person per bedroom over three, except for rental or high occupancy properties;
- Minimum flows for subdivided lots shall assume three bedrooms;
- For projects with a wastewater system serving more than four units, a graduated design flow reduction will be allowed, continuing to reduce up to 20 units;
- Wastewater systems serving over 20 units will be based on a minimum flow of 245 gallons/day/unit (compared to 405 gallons/day/unit at present);
- Single family units connected to a municipal system may use a design flow of 210 gallons/day/unit; and
- There will not be any "low flow credit" for water-saving plumbing for these residential uses.

Proposed Commercial and Institutional Flows

There are suggested revisions to the current design values in the EPA Rules, which could apply in Vermont. Considering the other changes in siting criteria, and performance standards, the Committee recommends avoiding other reductions and modifications in the unit loadings for non-residential uses at this time. Future Rule changes should consider additional changes, based on practitioner and regulatory experience.

Other Considerations

The municipal connection adjustment to 80% of the computed flow value for non-residential uses should be retained. The reductions shown above, even with the adjustment, will still likely be conservative for effects on a municipal system.

Provision for the infiltration allowance, as in the current rules, must still be added to compute the total flow from the project.

A provision for "metered flow" design for community systems, generally above 2,500 gpd, is recommended. Conditions for a metered flow design would include a provision that meter records are kept, with a minimum of daily readings, and the project owner retains a qualified manager to monitor the system. A reasonable basis must be established for computing the "maximum daily flow", out of the records, plus an allowance for reserve capacity, to account for possible future changes in property uses.

The Committee reviewed these concepts at several meetings, and developed general consensus with ANR as to the approach on flow reduction for multiple units served. Related topics included limiting the maximum loading rates to disposal fields to 1.0 gallons/day/square foot, use of flow equalization for certain projects having high peak loadings, and establishing good operating and management practices, all as an offset to reduced design flows. Consideration should also be given to the potential for high strength waste, which may result in a reduced allowable application rate in the disposal system.

Pretreatment

Pretreatment is an important component of on-site wastewater treatment and disposal. For on-site systems pretreatment occurs in a septic tank where differential settling and other processes result in a reduction in wastewater strength for effluent passing through the tank. In properly sized septic tanks significant reductions in biochemical oxygen demand (BOD), total suspended solids (TSS) and oil and grease (O&G) can be expected.

The use of effluent filters can improve the effectiveness of the septic tank as well as protect the discharge of untreated solids from the septic tank. The table below provides typical data on the expected effluent wastewater characteristics from a residential septic tank with and without an effluent filter.

	Concentration, mg/l				
		Without effluent filter		With effluent filter	
Constituent	Typical mixed influent value	Range	Typical	Range	Typical
BOD5	450	150-250	180	100-140	130
TSS	503	40-140	80	20-55	30
O&G	164	20-50	25	10-20	15

Adapted from Crites & Tchobanoglous (1998)

Typically septic tanks are made from concrete, fiberglass or polyethylene. A septic tank must be *watertight* and *structurally sound* to function properly. Failure of a septic tank can result in increased risk to the environment and public health; additionally it can cause premature failure of downstream treatment and disposal components.

Vermont's current minimum septic tank size is 1,000 gallons. For a flow of 6,500 gpd a tank of at least 6,000 gallons would be required. It is recommended that the minimum tank size for any project be 1,500 gallons and that the tank volume be at least two times the daily design flow of the project. This improves the effectiveness of the treatment process and the required pump out frequency of the septic tank. For a household with six persons the typical pump out frequency is increased from two to six years when the tank size is enlarged from 1,000 to 1,500 gallons (Bounds, 1994).

For operation and maintenance of septic tanks it is recommended that tanks be inspected at least every three years and pumped as necessary.

The Committee had the following recommendations with respect to pretreatment:

- All septic tanks should be watertight and structurally sound. Watertight testing should be preformed to insure watertightness.
- All septic tanks should have watertight access at grade to facilitate the inspection and maintenance.
- All septic tanks should be equipped with an effluent filter.
- Sizing of septic tanks:
  - Minimum 1,500 gallons
  - At least twice the daily design volume
  - When used with an in-tank pumping system the <u>minimum</u> liquid volume should be twice the daily design flow

- Facilities with "commercial" kitchens should have a properly sized external grease interceptor for kitchen waste plumbing prior to the septic tank. It is recognized that this may conflict with the Vermont Plumbing Rules; however, this requirement is important for any soil-based disposal system
- Use of garbage grinders is discouraged, especially for wastewater treated by a septic tank, due to increased (and unnecessary) organic and solids loading.

Treatment Level

The use of performance standards is an approach that allows for the management of risk to public health and the environment associated with on-site wastewater treatment and reuse. It is reuse because all of the wastewater we introduce into the environment returns to the hydrologic cycle, which includes all surface, ground and atmospheric waters of the planet. Performance standards can be set to provide protection based on the receiving environment.

Using treatment levels, corollary values for soil loading, isolation distances, and inspection and monitoring frequency can be developed. The following tables are examples of treatment levels and associated requirements. They also define potential treatment levels and some recommended standards to use when dealing with the specific treatment level.

Table 1 – Treatment Level Requirements

	Treatment Level	**BOD5**	**TSS**	**Nutrient Reduction**	**Disinfection**
T1	High Strength Septic Tank Effluent	>250	>150	No	No
T2	Domestic Strength Septic Tank Effluent	≤250	<150	No	No
T3	Secondary Treatment	30	30	No	No
T4	Advanced Wastewater Treatment	10	10	No	No
T5N	Advanced Wastewater Treatment + Nitrogen	20	20	Yes – Nitrogen	No
T5P	Advanced Wastewater Treatment + Phosphorus	20	20	Yes – Phosphorus	No
T6	Advanced Wastewater Treatment + Disinfection	10	5	No	Yes

Table 2 – Recommended Standards

Treatment Level	**Application Rate Factor***	**Vertical Separation induced WT/ Ledge**	**O & M Requirement****	**Comments**
T1	0.5	36 in. / 48 in.	Annual	Requires lower loading rate due to solids loading
T2	1.0	36 in. / 48 in.	Every 3-5 years	Represents typical domestic strength
T3	3.0	18 in. / 24 in.	Annual	
T4	5.0	12 in. / 12 in.	Semi-annual	Higher application rates require pressure distribution.
T5N	3.0	18 in. / 24 in.	Semi-annual	To be used for nutrient sensitive areas.
T5P	3.0	18 in. / 24 in.	Semi-annual	To be used for nutrient sensitive areas.
T6	5.0	0 in. / 0 in.	Continuous	24-7 monitoring through remote telemetry.

*The Application Rate Factor is the multiplier to be used on the determined application rate of a given disposal system to calculate the design application rate based on treatment level.

** Operation and maintenance inspection requirements are the maximum time between inspections and may be more frequent depending on any given treatment technology based on the manufacturer's or regulatory recommendations. Other operation and maintenance may be required depending on chosen technology.

The Committee had the following recommendations with respect to use of treatment level:

- Treatment levels T1 through T4 could be incorporated in the proposed rules.
- T5N & T5P are not currently applicable to Vermont.
- T6 requires increased regulatory oversight and any use would require some form of a wastewater maintenance district or operating permit.

The proposed Rules have incorporated a modified version of the “treatment level” table shown above, using three steps of treatment. Future reviews of the Rules should consider the success of this approach, and whether it is appropriate to allow additional steps or levels.

Modified Well Isolation Distance Approach

The Committee considered a new concept, having particular applicability to the flatter, heavy soil regions of the Champlain Valley. This concept would utilize a modified well isolation distance approach which incorporates a two-year time of travel.

By using science, public health could be protected for some low permeability soil sites which are difficult or currently impossible to develop under present site requirements. This concept would provide a greater range of disposal options for clay soil sites which have traditionally been the most difficult to develop due to the current wastewater disposal requirements.

Articles published by Marylynn V. Yates, Ph.D. discussed the viability of viruses in the subsurface aquifer environment. Different pathogenic viruses are affected in this environment differently, depending upon many factors, such as pH, temperature, soil particle size, organic content, aeration, saturation, viral electrical charge potentials, among others. The basic finding was that generally within one and a half years most viruses were believed to be either inactivated (unable to be infectious) or had died off. Based on Ms. Yates work, the two-year time of travel (TOT) methodology was adopted by the Department of Health when the Drinking Water Program was within their jurisdiction. This time period was designed to take into account the expected variations in aquifer conditions, the spatial variability in soil parameters, and viability differences for differing viruses. This was a value that was also being used by some other states based on the same or similar research.

The use of this modified approach could occur where 1) the isolation distance to a seasonal high water table is less than 24", 2) it is demonstrated that the effluent plume would travel slowly enough on site such that a two-year TOT was satisfied before it moved off the property site or reached an on-site water withdrawal, and 3) the dispersed effluent would not rise to or above the ground surface at any time of the year.

This two-year TOT would provide for pathogen die-off, or inactivation, and would provide for adequate health protection through a natural means (see the discussion regarding *Viral and Other Pathogens* included elsewhere in this report). This is an important consideration since effectively it is through natural means that current wastewater disposal systems work. They make the viral environment inhospitable through oxygenation in the unsaturated zone, which allows aerobic bacteria and other microscopic organisms to "eat" pathogens, and through physical entrapment by soil grains and electro positive and negative potentials. This all reduces the numbers of infectious agents that can cause disease. The two-year TOT concept does this by introducing a time element to the equation such that no pathogens remain infectiously viable (i.e. they die of old age) if the other factors are not performing optimally.

This also would be a cost-effective means of wastewater disposal as long as adequate land area were available (off-site easements would be an option, as easements are used now to meet isolation distance requirements). Generally speaking, the isolation distance to an adjoining property would be about 50 feet for a typical clay soil site with a minimum 3% slope. Greater permeability or slope would increase this distance, as would the need to disperse the wastewater in the subsurface environment to prevent breakout to the surface prior to two years time. The concept avoids the high cost concerns of most innovative technology systems (initial purchase and installation, and ongoing operation and maintenance costs). It would allow the disposal system to be constructed and treated much like a conventional system with pressure distribution and dosing in a shallow placed situation (not necessarily a mound). Initial costs would be less than an analogous current mound system and the operation and maintenance would be similar to any current pressurized distribution system.

This concept is not applicable where ledge or bedrock are a receiving medium due to the very rapid and unpredictable nature of bedrock transport. Vertical downward permeability would have to be shown to be virtually impervious with horizontal transport being the primary means of dispersing the applied effluent, in conjunction with evaporation and plant uptake.

The disposal system size would depend highly upon the hydraulic properties of the site being able to handle the effluent without it rising to or above the ground surface at any time of the year. This would mean that systems would be required to be pressure dosed at a widely dispersed low application rate.

Since this approach was introduced near the end of the Committee's deliberations, time did not permit the full technical development of details to be incorporated into the currently proposed Rules. It is recommended that this concept be given more thorough review, with possible future inclusion in a Rule update.

Disinfection

Initial consideration of disinfection by the Committee as a means to control E-coli, viruses and pathogens was largely dismissed because of a lack of regulatory authority to assure proper operation of the disinfection system on a day by day basis, especially for single family residential units.

As the Committee worked to evaluate advanced treatment systems, the issue of disinfection resurfaced. The Committee observed examples of disinfection using ultra violet light in many failed system upgrade installations in Rhode Island. Disinfection is permitted under certain circumstances for residential and commercial facilities in Rhode Island.

While use of disinfection on a regular basis was debated extensively by the Committee, some of the members, as well as the Vermont Department of Health and the Water Supply Division are uncomfortable in relying on disinfection as a reliable means to allow reduction of the vertical separation required from the bottom of the disposal fields to the ground water table. Committee members agree that use of chlorinated compounds for disinfection of effluent into the soil, and possibly the groundwater, is inappropriate.

However, the potential use of disinfection was revisited for circumstances where failed disposal systems occur and other means of treatment are not sufficient to protect groundwater quality. Under these circumstances disinfection should be allowed as a means of additional groundwater protection. Questions continue to arise with respect to permitting and regulatory authority over installed facilities, to assure that effective treatment is occurring.

The Committee discussed the appropriate utilization of disinfection for small communities where "in-fill" may be desirable. In-fill may be considered desirable as a component of "smart growth." In many instances these "in-fill" parcels are small with limited vertical separation to the seasonal high water table. While several members of the Committee felt that disinfection for small commercial and residential facilities remains viable, using appropriate O&M and management, full consensus of the concept was not accepted by the regulatory members.

The Committee advises that the use of effluent disinfection methods before discharge to a soil-based system be given further consideration, as future Rule changes are considered.

Licensed Designers and Installers

The Committee discussed at length the need for competent designers and installers of potable water supply and wastewater systems. Because the treatment of effluent in conventional systems and the disposal of effluent in all systems rely on the qualities of the available soils, it is imperative that the soils be adequately and accurately characterized. However, because a poor installation can result in the failure of an excellent design, it is important that installers be responsible for their work. In order to most effectively institute control over construction of these systems, the Committee believes that installers should be licensed. This cannot be accomplished unless statutory changes give ANR the authority to do so. Therefore this concept is not incorporated in the proposed rules.

The Committee recommends that adequate training be provided for all practitioners involved in the construction of these systems, including hydrogeologists, designers, installation contractors, and maintenance providers. System owners and operators, including individual homeowners, also require training and education, especially for the systems having more advanced technology.

Another concept that needs legislative action is the proposal by ANR to expand the size and type of system that Site Technicians are allowed to design and review from single lot residential units (600gpd) to systems with design flows of 1350 gpd, or three single-family residential units, including apartments and public buildings. The Committee briefly discussed this issue, with various members supporting different perspectives. Consensus was not reached on this topic; it is not something that the Committee needs to or can resolve. It will be addressed by the legislative review process.

Operation and Maintenance (O&M) of Wastewater Systems

The Committee's framework document, adopted by the On-Site Technical Advisory Committee and the ANR on June 19, 2001, states the following:

> *All wastewater treatment and disposal systems require operation and maintenance. With respect to conventional septic tank leachfields, such operation and maintenance should be addressed with ongoing education and training. Permits for systems of a large or more complex nature, especially those involving mechanical devices, will include conditions requiring an appropriate level of operation and maintenance. These conditions will be specific to the particular site and system and could include annual inspections, having a maintenance contract, or continuous remote monitoring. In some cases the operation and maintenance will require specialized knowledge and the permit will specify that approved individuals are required to perform the work. The permit condition will require that all information be reported to the Agency. Permits for complex systems will be operation permits that may be renewed upon a determination that the system has been, and will remain, in compliance with the Rules and permit conditions.*

Operation and maintenance issues were one of the key topics of discussion as the Committee began to consider recommending the implementation of performance based treatment levels. More advanced treatment systems increasingly rely on technological solutions to offset in-ground biological waste treatment and distribution. In addition, these systems would be allowed to operate in conditions where, in comparison to conventional systems, distances to the seasonal high groundwater table and ledge (bedrock) are reduced. Therefore, the need to ensure fail-safe operation (e.g. "24/7" monitoring) of the technology becomes more important as a means to lessen the risk of ground and/or surface water contamination and related health issues.

Given the increased importance of proper operation and maintenance, the Committee recognized the need for requiring a heightened level of operation and maintenance protocol, system redundancy and the frequency of regulatory oversight for these technologies. These administrative requirements also imply an increased need for agency staff and file space to check, maintain and enforce operational permit conditions.

The formation of municipal waste management districts and maintenance contracts with private firms will be important factors to ensure that permittees maintain proper operation and maintenance of these systems for their entire operational life. Also, applicants for permits should be required to demonstrate that they have the financial capability to ensure that the more complex systems will be properly operated and maintained.

Additionally, the Committee made the following operation and maintenance recommendations:

1. In order to lengthen the life of a leach field, water saving/low flow fixtures, appliances and water conservation practices should be utilized whenever possible. The use of garbage grinders is strongly discouraged. An even temporal distribution of flow from the building to the leach field is encouraged.
2. Use of a septic tank effluent filter is recommended. Effluent filters may be retrofitted in existing septic tanks or incorporated in new systems in order to prevent larger solids from entering the leach field. Septic tank effluent filters require regular checking/maintenance.
3. Install at-grade access for all septic tanks. This will simplify regular maintenance of the tank and effluent filter.
4. In order to gain a more even distribution of flow to the leach field, use a dosing or tipping distribution box system. To ensure even flow to the leach field, check the distribution box for levelness and proper operation when the septic tank is inspected or pumped.
5. Inspect the septic tank before pumping. This will ensure that the tank is only pumped when needed.
6. Review the current requirements on alternating leach fields. Alternation may not be wise because the bio-mat takes months to form thus giving inferior treatment in the interim.
7. Flush and perform yearly maintenance on sand filters to ensure proper operation.
8. Avoid the use of septic tank additives. These are not needed and may do harm which could cost the owner money that could be used for proper maintenance.
9. Check on-off floats in pump chambers to ensure that the proper dose is being pumped to the field, and that the alarm floats function.
10. Keep trees and brush from growing near the leach fields to prevent roots from plugging distribution lines and affecting the soil column.
11. Mark and inspect curtain drain outlets to ensure proper drainage.

Many of the above recommendations have been incorporated into the proposed Rules; the others are intended to be “advisory” at this time.

The Committee also believes there is a need for formal training of wastewater system operating personnel, and education of system owners as well.