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Decentralized Wastewater Treatment Options for I-89, Exit 17

Town of Colchester, Vermont

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EXECUTIVE SUMMARY

A decentralized wastewater treatment options study was conducted for the planned Growth Center at Interstate 89 Exit 17 in the Town of Colchester. The Colchester Department of Planning and Zoning requested the study utilizing a United States Environmental Protection Agency (USEPA) grant. The study determines the most cost effective and appropriate decentralized wastewater treatment options that enable the maximum desired buildout of the area while protecting public health and the environment.

The I-89 Exit 17 area was designated as an area for future development (a “Growth Center”) by the Town of Colchester in its 1996 Master Plan, and is located on I-89 just south of the Colchester / Milton town line. Three separate studies have been conducted in this area over the last 12 years that investigated various methods of wastewater disposal. Generally, the recommended wastewater management strategies previously evaluated for the I-89 Exit 17 area were to: (1) construct a new municipal sewer collection system discharging to a treatment facility in the Town of Milton; (2) construct a new municipal sewer collection system with a treatment facility in Colchester on the lower Lamoille River; or (3) construct a new municipal sewer collection system with a new treatment facility and indirect discharge with spray fields. Although the Town of Milton is planning to extend municipal sewer to the Catamount Industrial Park near Exit 17, there are currently no plans to extend municipal sewer beyond the Milton town line.

Decentralized wastewater management utilizes a combination of individual and cluster wastewater treatment, coupled with soil-based disposal systems, to serve residential, and commercial uses. In the Exit 17 Growth Center, this means that existing onsite wastewater systems would continue to operate if functioning properly. Adding pre-treatment to these systems can bring substandard systems into compliance with minimum design requirements, and in some cases, can increase a previously permitted system’s capacity (potentially doubling the capacity). Increases in wastewater disposal system capacity using existing systems will allow for growth on some properties. Some areas of existing development, such as the Jasper Mine Road area, contain silty soils with shallow groundwater. These systems have limited onsite capacity, and would be better served by an offsite cluster system. New development, where soils and site conditions are favorable, can utilize onsite capacity, and potentially serve growth on nearby properties. New development where soils and site conditions are unfavorable can also be served by off-site cluster systems.

A buildout analysis was performed to determine future land use of buildable land in the study area based on zoning regulations. The analysis was developed with input from the Town Planner and Planning Commission, utilizing a Geographic Information System (GIS) database. Scenarios were developed for a combination of growth options, including all residential, all commercial, using maximum Planned Use Development (PUD) rules, and mixed uses. Modifying properties that can or have reached maximum buildout potential, have adequate onsite wastewater capacity, or where the owner quantified the maximum number of units they expect to develop, refined the analysis.

The buildout results indicate that approximately 1,000 residential and commercial units may be developed in this Growth Center. These units would produce wastewater flows of approximately 225,000 to 250,000 gallons per day (gpd).

A public meeting was conducted on November 28, 2001 to introduce the study and to request permission to conduct preliminary soils testing (including hydrogeological site capacity tests) for potential cluster sites on private properties where permission is granted. Six property owners agreed to meet, and backhoe soils test pits and hydrogeologic tests were completed on three potential cluster sites, including two sites in the southeastern portion of the study area, and one located to the north of Mayo Road in Milton. The results of the testing showed potential for a small cluster system (under 6,500 gpd) on the Ricker property, a small cluster system (under 2,000 gpd) on the Rubman property, and for a large cluster system (80,000 gpd) on the Rowley sand pit property on the West Milton Road in Milton. The sand pit site may have significant additional capacity, pending additional deep soil borings, archaeological review, and surface water evaluations. The two small cluster systems may serve development in the southeast portion of the study area along Route 7, while the large cluster site may serve the central portion of the study area.

Wastewater treatment can occur either onsite prior to pumping to a cluster disposal system, or can occur in a centralized location. The onsite treatment may be in the form of conventional septic tanks and individual pre-treatment systems. Conceptual designs for a collection system to serve a large cluster system were completed. The collection area includes the Jasper Mine Road area and continues across the interstate interchange along U.S. Route 2, to the intersection of Routes 2 and 7. Collection system options evaluated included conventional gravity sewer lines and low-pressure sewer pipes. The low-pressure sewer system is less costly and is the preferred option.

The second treatment option studied is a centralized treatment system located in the study area, which would then pump to a cluster disposal system such as the Rowley sand pit. Treatment standards increase with wastewater design flows over 50,000 gpd, meaning that tertiary treatment of the wastewater is required. For this project, where existing flows are limited and designs are mostly based on serving future needs, a phased approach to construction of the collection system, treatment system and disposal system makes sense. The first phase of this project may be to construct a treatment system to meet the needs of up to 80,000 gpd flows, choosing a type of treatment system that includes recycling or reuse options and can expand to higher flows up to 200,000 gpd. This will save on initial startup costs, and may match the development community's timing needs.

The large cluster disposal system option at the Rowley sand pit includes a pressure sewer pipe along the interstate 89 corridor from Exit 17 to the Rowley site. Three disposal system fields were identified in the preliminary round of hydrogeological investigation, with potential for additional expansion. The initial soil test pits and hydraulic conductivity tests indicate good potential for a large cluster system on this site. However, silty soils were encountered in parts of the sand pit, indicating a need for deep soil borings to clarify site capacity estimates. Resolution of permitting and political issues, along with property owner negotiations for using any or all of the cluster sites, will be necessary for the successful development of the recommended wastewater disposal options.

It is important to note that there are other properties in Colchester and Milton within the same distance range as the Rowley sand pit that may also contain adequate capacity for large cluster systems. In particular, there are areas in the northern section of the study area and to the west closer to Lake Champlain that were not tested during this study but that may be worth considering.

The next steps for pursuing decentralized wastewater solutions for the Growth Center at Exit 17 are for the Town and Planning Commission to:

1. Begin discussions with the potential cluster system owners (Rowley and Ricker), to consider the use of their properties for cluster wastewater disposal systems under municipal management and/or ownership.
2. Conduct additional site investigations on the Rowley and Ricker properties; pursue other environmental, engineering, and permitting issues identified for each of the cluster sites.
3. Continue to contact private property owners where suitable soils exist, to see if additional cluster system sites or spray disposal sites may be available in or near the study area.
4. Investigate the use of subsurface drip irrigation in areas such as highway right-of-ways as an additional means of increasing disposal capacity in the study area.
5. Formulate and distribute a property owner survey / questionnaire.
6. Consider the form of municipal or other management entity responsible for operating and maintaining a decentralized wastewater disposal system or systems in the Exit 17 study area.
7. Identify the preferred funding and operating options for the project; consider a private/public partnership with some of the major landowners in the study area to participate in the financing and development of the wastewater utility.

1. INTRODUCTION

The Town of Colchester's Department of Planning and Zoning received a United States Environmental Protection Agency (USEPA) grant to conduct a decentralized wastewater option study supporting the identified Growth Center around Interstate 89 (I-89) Exit 17 in the northern section of Colchester. The purpose of this study is to determine the most cost effective and appropriate decentralized wastewater treatment options for the land near Exit 17 that enable the maximum desired buildout of the area while protecting public health and the environment. Stone Environmental, Inc. (SEI) of Montpelier, Vermont, and Forcier Aldrich and Associates Inc. (FA&A) of Essex Junction, Vermont were hired to conduct this study.

1.1. What is Decentralized Wastewater Treatment?

Decentralized wastewater treatment systems, commonly called "septic systems," treat sewage from homes and businesses that are not connected to a central wastewater collection and treatment facilities that discharge into surface waters. Decentralized systems include conventional septic systems, cluster systems (conventional systems that collect wastewater from a number of homes and businesses), and "alternative" wastewater treatment technologies like trickling filters, textile filters, or recirculating sand filters. Advanced systems are generally installed at sites where soil-based disposal systems cannot be used because of inadequate soils, excessive slopes, high seasonal ground water tables, or other factors. These systems can also be used to increase the flow capacity of a wastewater disposal system. In a 1997 report to Congress, the U.S. Environmental Protection Agency (EPA) concluded that "adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas" such as the State of Vermont.

The decentralized approach to wastewater management includes:

- Maximizing the use of existing onsite systems, particularly where soil conditions are favorable, including adding pre-treatment to increase capacity;
- Minimizing wastewater flows by requiring the use of low flow fixtures
- Considering ways to separate waste streams
- Considering requirements on reuse of treated water
- Providing offsite disposal where needed, through the use of one or more cluster system sites
- Considering the use of different types of individual or cluster treatment systems to allow smaller disposal areas or higher application rates
- Locating and testing potential cluster sites to determine capacity prior to onset of development
- Considering different types of dispersal technologies (conventional trenches and beds, gravelless trenches, drip irrigation, spray irrigation)

- Considering long-term management requirements

1.2. Public Information Meeting

A public information meeting was held on November 28, 2001 to explain the goals of this project and to solicit permission to conduct hydrogeological investigations for potential cluster system sites. A one-page handout was distributed to meeting attendees and to the local newspapers. Five property owners in the area gave permission for site investigation, and one owner requested a meeting to discuss the project. Meetings were held with all six property owners, and three sites were selected for further investigation. The results of the field investigations are summarized in Section 5.

1.3. Previous Studies

Several studies concerning the Exit 17 area were completed in the past 12 years that examined various centralized wastewater treatment options. Following is a brief synopsis of these studies, with summaries of their recommendations.

1.3.1. "Exit 17 Wastewater Planning Study: Colchester & Milton, Vermont" prepared by Lamoureux & Stone Consulting Engineers, Inc. dated November 1991

This study evaluated wastewater collection, treatment and disposal alternatives for the I-89 Exit 17 designated Growth Center. Three alternatives were evaluated including:

1. Tertiary wastewater treatment at a new facility constructed within or adjacent to the study area with discharge to the Lamoille River below Peterson Dam.
2. Pumping wastewater to an upgraded Milton wastewater treatment facility (WWTF) providing tertiary treatment with discharge at the existing outfall above Peterson Dam.
3. Secondary treatment at a new facility near the study area with a land-based on-site system for final disposal of treated effluent.

"The Vermont Agency of Natural Resources (ANR) had serious reservations about any additional assimilitive capacity being available in the lower Lamoille River (upstream of the Peterson impoundment)"; in fact they cautioned that the results of further studies might in fact show that the existing discharge loadings exceeded the allowable ultimate oxygen demana (UOD) limitations.

Lamoureux & Stone reported "A discharge below Peterson Dam would essentially be a discharge to Lake Champlain which ANR felt would be difficult to permit. The permit process would require extensive study in that section of the Lamoille

River and could take up to five years. Such a permit would likely be opposed by groups protecting Lake Champlain or using this section of the River. Given this assessment by the ANR, no additional effort was put into exploring alternative discharge points below Peterson Dam." Follow-up communications with the ANR indicated that this assumption was incorrect. The lower Lamoille River (below Peterson impoundment) does have adequate assimilative capacity to accommodate a new secondary wastewater treatment facility to serve Colchester. Peter Laflamme, P.E. of the Vermont Department of Environmental Conservation (DEC), Water Quality Division, indicated that an assimilative capacity study would not be required at this location for a new treatment facility with design flows in the range of 0.2 mgd. However, the Town would need to establish a waste management zone up to one mile downstream of the proposed WWTF. This process involves a detailed use assessment along the river to insure the new treatment facility would not impact existing contact recreational activities along this stretch of the river.

Land-based wastewater disposal was considered as an alternative. The most suitable site (based on soil morphology and site features) was located within the existing Catamount Industrial Park in Milton. This alternative was eliminated however, because "Use of this area for land-based disposal of 365,000 gpd of wastewater would not be compatible with its current use."

No other suitable sites with sufficient land area were identified within the existing study area that could be used for onsite disposal for 365,000 gpd of wastewater.

One area with suitable soils and area was identified outside the study area on the existing Robinson Farm property. The cost of the treatment facility alone was estimated at $2,300,000 and the additional cost of gravity sewers, pumping stations and associated appurtenances was expected to be significantly higher than the cost of the other alternatives. Therefore, this alternative was eliminated from further consideration.

1.3.1.1. Recommendations

This study included the following recommendations:

- Construct a centralized sewage collection system and upgrade the existing Milton secondary wastewater treatment facility in three phases to accommodate an ultimate design wastewater flow from the study area of 0.72 mgd.
- Construct a collection system consisting of 15,200 linear feet (lf) of gravity sewer, 17,000 lf of forcemain and six municipal wastewater pumping stations.

- Bond for a total project cost of $6,662,500 to cover work in all three proposed phases (Colchester's share was estimated at $3,800,000).
- Assuming the Towns of Colchester and Milton were able to obtain 0% financing for the entire project with a 20-year repayment schedule, total annual costs, including $250,000/yr operation and maintenance (O&M) cost, were estimated to be $576,000.
- Operation costs should be shared based on projected wastewater flow with Milton's share equal to 53% ($303,300/year) and Colchester's share equal to 47% ($273,300/year).
- Assuming a typical residential use of 100 gpcd and 2.7 people per household; one equivalent residential user would utilize an average of 270 gallon per day. For an increase in capacity of 0.495 million gallons per day (mgd) (0.720 mgd - 0.225 mgd), this would equate to approximately 1833 Equivalent Residential Users (ERUs) for a total annual cost of $576,600, each ERU on the new system would be asessed a user fee of $315.00 annually. However, initial year costs could be as much as $630/ERU, depending on the timing of development and the rate that new users are incorporated into the system.

1.3.2. "Town of Colchester Wastewater Master Planning Part II: Town-Wide Wastewater Facility Planning Update" prepared by Forcier Aldrich & Associates dated September 1997

1.3.2.1. Wastewater Management Unit Delineation, WWMU#10:

WWMU #10 encompasses the land area adjacent to I-89 which was designated as a Commercial Growth Center in the Colchester Master Plan. Other features of lands within this unit include:

1. Proposed high density residential, commercial, and industrial area located adjacent to the I-89 Exit 17 interchange.
2. Current use is primarily agricultural, low-density residential or adjacent forest land.
3. Some sites have limited capacity for onsite wastewater disposal due to shallow depth to bedrock, unfavorable soil characteristics, high seasonal groundwater tables, steep slopes, or proximity to surface water.
4. A municipal water transmission main line passes through the WWMU to serve the Town of Milton; however less than 20% of the entire land area is currently served by municipal water supply. Potable water for most existing dwellings and facilities is provided via individual drilled wells.

5. Existing dwellings currently utilize conventional subsurface or mound wastewater systems for treatment and disposal of domestic wastewater.
6. Existing wastewater disposal systems are privately owned. Many of the existing dwellings are served by onsite disposal systems, which are in excess of 20 years age.

Typically, development in the area is restricted by the limited capacity for onsite wastewater disposal due to shallow depth to bedrock, unfavorable soil characteristics, high seasonal groundwater tables, steep slopes, or proximity to surface water.

Existing dwellings currently utilize conventional subsurface or mound wastewater systems for treatment and disposal of domestic wastewater with a majority of the systems being constructed in the mid 1970's. Like other areas in the Town, these systems are technically approaching the end of their design life and may need to be reconstructed in the next 5 to 10 years. However, insufficient suitable land area is available for construction of subsurface or mound onsite wastewater disposal systems to serve the proposed level of future commercial and industrial development.

1.3.2.2. Wastewater Infrastructure Alternatives

The following wastewater infrastructure alternatives were evaluated for this WWMU #10:

No. 1: Centralized Collection with Treatment at WWTF
No. 2: Centralized Collection with Treatment at New WWTF and Direct Discharge
No. 3: Centralized Collection with Treatment at New WWTF and Indirect Discharge

1.3.2.3. Conclusions

The DEC Water Quality Division and Wastewater Management Division have tentatively reviewed the possibility of constructing a new wastewater treatment facility on the Lower Lamoille River. They concluded that there is adequate assimilative capacity in this reach of the river to accept flow from a new 0.250 mgd capacity wastewater treatment facility. They also stated that an assimilative capacity analysis will not be required for such a facility. However, the Town would still be required to go through the procedure of establishing a new wastewater management zone. The Town of Milton responded favorably to an initial inquiry regarding the possibility of accepting wastewater from the Town of Colchester's Wastewater Management Unit (WWMU) #10 for the I-89 Exit 17 area. Since they had not yet completed a Facilities Planning effort for expansion of the existing wastewater treatment facility (WWTF), they were not able to provide a specific rate structure or user fee at this time.

1.3.2.4. Recommendations

The recommended wastewater management strategy for WWMU #10 in the I-89 Exit 17 area is to construct a new municipal sewer collection system and treatment facility on the lower Lamoille River.

Although pumping raw wastewater to the Milton wastewater treatment plant (which is proposed for upgrade in the next 5 years) appeared to be more economical for the short-term, construction of a new Colchester-owned treatment works on the lower Lamoille River was determined to be the lowest cost alternative based on a twenty year life cycle cost analysis. The analysis was based on estimated debt service and annual O&M costs at the soon-to-be-upgraded Milton WWTF. Therefore, prior to further study, the Town should obtain a better estimate of what the actual wastewater fees will be.

If the secondary analysis continues to indicate that Colchester would be better served by their own treatment works, the Town needs to develop a financing plan to fund the proposed improvements. Since there is little or no existing development currently, the Town will need to develop a financial plan to determine how annual debt payments and initial year O&M costs will be funded (just until a viable group of users can be established in the area).

Possible options for consideration include:

1. Applying for Community Development Block Grants through the Vermont Agency of Commerce and Community Development with the intention of creating new jobs.
2. Establishing of a Special Assessment District to begin to acquire capital for construction of the improvements.
3. Contact the Town of Milton to determine if they are interested in pumping wastewater generated at the Catamount Industrial Park into Colchester's new system. The additional users would make the entire system more affordable for all.

1.3.3. "Town of Milton Facilities Planning Report for Wastewater Pollution Control and Plant Expansion" prepared by Webster-Martin dated June 1998.

Extension of the Town of Milton wastewater service area to the Colchester Town line affords the opportunity to provide a regional option for sewering the Exit 17 area of I-89. A 1991 study of Exit 17 showed that the most feasible means of providing wastewater services to the area is by a collection system discharging to the Town of Milton. Correspondence dated November 14, 1997 from the Town of Colchester Selectboard Chair indicated a continued interest in exploring this option.

Potential flow contributions from the Colchester Exit 17 area were estimated in 1991 to range from 224,000 gpd to 434,700 gpd, depending upon the intensity of development. For planning purposes, an initial allocation for Colchester was suggested at 240,000 gpd. In a “Town-Wide Wastewater Facility Planning Update” completed for the Town of Colchester by Forcier Aldrich & Associates, dated September 13, 1997, flows for Exit 17 were projected to be 200,000 gpd. For planning purposes, this study assumed a Colchester contribution of 250,000 gpd.

In the absence of a definitive determination of the assimilative capacity of the Lamoille River at the point of the Town’s discharge, the addition of the roughly 250,000 gpd wastewater flow from Colchester Exit 17 would require a tertiary filtration process to achieve effluent limitations.

1.3.3.1. Recommendations

The following items were included in the recommendations from the Webster-Martin report, but not very specific to Colchester.

1. Based in part upon facility planning investigations and an analysis of alternatives, a direct discharge of future wastewater flows at the location of the present plant outfall is recommended.
    - Fine rotary screening
    - Sequential batch reactor (SBR) activated sludge process
    - Sodium hypochlorite disinfection
    - Aerobic stabilization
    - Centrifuge dewatering

2. An application should be filed with the Wastewater Management Division for a National Pollutant Discharge Elimination System (NPDES) Direct Discharge Permit and establishment fo a preliminary waste management zone for a 1.0 mgd facility.
3. Improvements are recommended to be funded in part by grants obtained from the federal EPA, the ANR for sludge and septage treatment, and from

zero interest State Revolving loan funds. Costs should be recovered by connection and user fees.

4. Supplemental revenue from the Town property tax should be provided to stabilize user rates through the initial years of the project.
5. Eligibility determinations for grant funding may be subject to changes enacted by the legislature. To demonstrate public support for the project, the Town should warn for a bond vote on the total project cost, subject to a reduction from available grant funds, for the purpose of constructing all improvements.
6. Should *E. coli* effluent requirements be changed from an instantaneous maximum to a geometric mean, consideration should be given to utilization of ultraviolet disinfection processes.

As an update, the final design was completed to 90% and submitted to the State for review in November 1999. The design is based on an SBR treatment facility with a capacity of 1.0 mgd, expandable to 1.25 mgd. The Town received an amended NPDES Discharge Permit for the expanded facility on October 26, 2000.

1.3.3.2. Recent Updates

A discussion with Ted Nelson, the Town Manager from the Town of Milton was recently conducted to update the following:

The Town of Milton recently submitted the Act 250 application for the expansion of the wastewater treatment facility to 1.0 mgd and extend municipal sewer to the Catamount Industrial Park.

The Selectboard from the Town of Colchester and Town of Milton recently met in September 2002 and agreed that there are currently no plans to extend municipal sewer to or beyond the Milton town line in the Exit 17 area.

2. STUDY AREA DESCRIPTION

The I-89 Exit 17 area was designated as an area for future development (a "Growth Center") by the Town of Colchester in its 1996 Master Plan, and is located on I-89 just south of the Colchester/Milton town line. The study area is bounded on the north by the Colchester/Milton town line; on the east by Coon Hill Road and Sweeney Road; on the south by parcel boundaries approximately 1 mile south of Roosevelt Highway (Route 2); and on the west by parcel boundaries approximately 1.5 miles west of I-89. Figure 1, the Study Area Site Plan, is an orthophoto with the study area boundaries highlighted. Information about individual parcels in the study area is included in Table 1.

The part of the Exit 17 study area located east of I-89 is gently rolling land, with steep-sided valleys bordering brooks and small streams (natural features will be discussed in greater detail in Section 2.1). At the present time, development in this area is fairly light. There is a small industrial park developing north of the US-2/7 intersection on Brentwood Road, two gas stations at the US-2/7 intersection, and two small motel/apartment buildings just inside the southern boundary of the study area on Route 2/7. There are also a few individual residences and businesses scattered along Route 2/7. Coon Hill Road and Sweeney Roads border the eastern edge of the study area. This area contains scattered residences with a combination of individual onsite systems and a small cluster system.

The area located west of I-89 and south of Route 2 is hilly, partially open land, with significant steep slopes and exposed bedrock, and is basically undeveloped. North of Route 2, the land is largely flat with several significant wet areas, particularly near the Jasper Mine Road-Mayo Road intersection. The area between Route 2 and Jasper Mine Road accommodates several commercial and light industrial buildings. From the Jasper Mine Road-Mayo Road intersection northward, development includes several individual residences and an 18-lot subdivision on Chimney Hill Road at the northern edge of the study area.

Some of the larger parcels which are currently developed, or which have permits and have current wastewater capacity approvals are described in more detail in Section 3.2. An understanding of the natural features and current zoning conditions within the study area, as described in the following sections, will allow for a more robust characterization of current and future needs for wastewater disposal.

2.1. Natural Resources

Natural features can pose both opportunities for and limits to the construction and successful operation of decentralized wastewater disposal systems. These features, such as topography, surface waters, and soils, are described below with particular attention to their impact on the potential for onsite wastewater disposal in the Exit 17 Growth Center. Figure 2 identifies environmental sensitivities within the study area.

2.1.1. Topography

The topography of the study area consists mostly of gently rolling hills. Generally, elevations range from 100 to 400 feet above mean sea level (AMSL). The highest elevation in the study area is an unnamed hill in the southwest corner of the study area at approximately 400 feet AMSL. The lowest elevation of approximately 100 feet AMSL occurs where Malletts Brook flows into a wetland, just west of Niquette Bay Road and along the southern boundary of the study area. In the southern and eastern parts of the study area, land surfaces with a slope of greater than 25 percent are somewhat common, constituting 17 percent of the study area.

2.1.2. Surface Water

Streams, brooks, and wetlands make up the surface waters of the study area. Locations of all surface water bodies are shown on Figure 2. There are two small watersheds in the study area, where surface water flow is generally in slow moving wetlands and brooks that meander through the valleys. East of Route 7, Allen Brook flows generally southward toward Malletts Bay. West of Route 7, a number of unnamed streams flow south or southeast towards wetlands that discharge to the Malletts Bay portion of Lake Champlain.

2.1.3. Soils

There is a wide range of soil types in the Exit 17 study area. Soils vary based on geologic material, slope, hydrology, human disturbance, and other factors. The best generalized source of soils data for this area is the Soil Survey Report of Chittenden County prepared by the Natural Resource Conservation Service (NRCS). The NRCS data was derived by mapping the landscape with spot field checks to arrive at an approximate level of resolution of 3 acres, with acknowledged inclusions of other soils. This report describes the soil series, or groups of soils with common properties, found in the study area.

For the purposes of this assessment, we are primarily concerned with the properties of the soils that determine suitability for the siting of onsite septic systems: depth to seasonal high groundwater, depth to bedrock, and slope. NRCS ranked the soil series for septic suitability based on the 1996 version of the Vermont Environmental Protection Rules (EPRs), and they are currently revising the suitability rankings based on the new EPRs released in August 2002. Table 2 lists the soil series found within the study area, as well as information about the seasonal high groundwater table, depth to bedrock or bedrock outcrops, and a ranking of the soils' suitability for wastewater disposal. Figure 3 shows the soils in the study area and vicinity as ranked by NRCS for septic suitability. Much of the study area west of Route 7 is ranked as "Not Suited", meaning that site conditions are largely unfavorable for onsite wastewater disposal. Fifty-eight percent of the land in the study area is ranked as "Not Suited". There are also several areas that are ranked by NRCS as "Conventional/Soil Replacement", meaning that site conditions are favorable for the construction of standard wastewater disposal systems. These favorable areas cover 12% of the study area and are primarily located parallel to and just east of Route 7. There are also large areas of suitable soils located along the northern border of the study area and extending north into the Town of Milton.

2.2. Water Supplies

Currently, many properties in the study area are served by individual onsite well water supplies. Onsite wells can limit onsite wastewater capacity because of the required protective setbacks between water supply wells and wastewater disposal systems. Municipal water in the study area is limited to a 16" water transmission main which follows along Route 7 from Colchester Village to Milton. This existing transmission main is the primary water supply for Milton and is owned and maintained by Champlain Water District. Colchester Fire District No. 3 serves existing customers from the transmission main in the area of Exit 17. Any future extensions of municipal water in the Exit 17 area would be within the Fire District No. 3 boundaries. Expansion of the existing distribution system will be necessary in this area to serve the Growth Center. This study did not include a review of water supply capacities to serve additional growth. Water main extensions may aid in providing additional available wastewater capacity where suitable soils are found.

2.3. Zoning Districts

The general purpose of the zoning districts in the Exit 17 Growth Center is to focus and encourage mixed-use development, including residential and commercial buildings, while conserving important vistas and open space. Several different types of zoning districts lie within the study area, and are shown in Figure 4. The areas immediately north and south of the Route 2/Route 7 intersection and eight parcels located along Route 2 West are zoned as the General Development 4-Commercial Overlay District (GD-4C). This district is meant to contain commercial, small-scale retail, and other local-scale, high-traffic businesses at the core of the Exit 17 growth area. Most of the remaining area east of I-89 is zoned as General Development 4 (GD-4); a range of residential and low-traffic commercial or appropriate industrial development is envisioned for this district. The only exceptions to this are located in the southeastern part of the study area. Several parcels in this area are zoned as a Low Density Rural Residential District (RR), a designation that provides a balance between open land and residential development. A few parcels in the southeast part of the study area are also zoned Government-Owned (GOV); this zoning also occurs as right-of-ways immediately adjacent to I-89 and Routes 2 and 7.

The area west of I-89, aside from the area zoned GD-4C, is primarily a mix of GD-4 and Agricultural / Open Land (AGR)—a designation meant to preserve open land from suburban development. Parcels in this area zoned GD-4 are located south of Route 2 to the

Niquette Bay Road intersection, in the area bounded by Jasper Mine Road on the north side and by Route 2 to the south, and at the southwest corner of the Route 2 / Raymond Road intersection. A single parcel at the northwest corner of the Route 2 / Raymond Road intersection is zoned as General Development (GD-1), providing for residential or appropriate commercial/light industrial development. There is also a long, narrow strip of land located along the west side of I-89 near the northern border of the study area that is zoned Commercial (COM), which is intended to serve the needs of scattered residential development by providing an area with a variety of retail, personal, and professional uses.

3. BUILDOUT ANALYSIS

A buildout analysis is a process used to determine future land use of buildable land in a specified area based on existing zoning regulations. The buildout analysis conducted for the study area is based upon information available in existing Geographic Information System (GIS) databases, supplemental information that is added to these databases by SEI staff, and certain assumptions that are based upon the community's existing regulations and development patterns. Environmental setbacks to surface waters and steep slopes were included in the buildout analyses. The results of this analysis enabled us to forecast the total wastewater flows needed to meet the development anticipated from a buildout condition. Existing development uses were not excluded in the full buildout analysis.

3.1. Full Buildout Analysis

Based on meetings with the town staff and planning commission, we conducted five build-out scenarios using alternative concepts permissible under the town’s zoning regulations. Appendix A contains the detailed methodology and operations used in conducting this analysis. Table 3 contains the interpretations by zone used in our analysis and the results of our initial analysis. The five scenarios chosen were as follows:

1. All land in zones where residential is allowed were built out as residential.
2. All land in zoning districts allowing commercial development was built out as commercial.
3. All land in zoning districts where Planned Unit Developments (PUD) is allowed were built out either full residential or commercial based on what was allowed in the district.
4. All land in zoning districts where PUD’s are allowed were built out with a 50 percent of area as PUD in a 75 percent residential/25 percent commercial mix. The remaining area was built out according to the limits of the zoning district.
5. All land in zoning districts where PUDs are allowed were built out without any PUDs with 75 percent of area as Residential and 25 percent Commercial buildout.

The combined Scenarios 1 and 2 resulted in the largest buildout numbers with 2,099 residential units and 717 commercial structures. The more realistic Scenario 4 resulted in a buildout of 1,813 residential and 111 commercial units. The results of this analysis were presented to the Planning Commission and Steering Committee on December 7, 2001.

3.2. Refinement Process for Buildout Analysis

The full buildout analysis included all properties without regard to existing development, future needs of owners, or existing permit information. It was decided that more realistic analyses could be developed by removing some properties with adequate wastewater disposal capacity or by limiting buildout units to the future desires of some landowners. Most properties with existing development remain in the buildout analysis due to time constraints and the potential that some of the properties would be better served with offsite capacity if it is available in the future.

Meetings were held with three property owners in the study area to discuss their development goals and site conditions. Permit information was used on other properties to make a determination of whether or not offsite capacity was needed for the property. Following are brief descriptions of the meetings and the basis for changing the status of certain properties in the refined buildout analysis (see Table 4).

3.2.1. Willard Properties

Mary Clark of SEI held a meeting on May 1, 2002 with Mr. Phil George, and several phone and e-mail discussions were held with Mr. Richard Feeley, the co-owners of a 90-acre parcel in the southeast quadrant of the study area. Over the past several years, the owners conducted soil and site investigations on the property and identified one small area that appeared suitable for a small wastewater disposal system (approximately 1,500 gallons per day capacity, including increases for advanced treatment). The owners are interested in developing this property and envision the eventual construction of up to 300 housing units. We included this number as the cap for buildout on this property. Additional soil testing was not planned during this project, since adequate investigations were conducted on the property in the past.

3.2.2. O'Brien Brothers Agency Inc.

A meeting was held on April 30, 2002, with Mary Clark of SEI, Mr. Patrick O'Brien, Mr. O'Brien senior, and their engineering consultant, Michael Burke, P.E., with Krebs & Lansing Consulting Engineers Inc. We discussed their large parcel, which is located on the east side of U.S Route 7 and west of Coon Hill Road. They conducted soils investigations and groundwater monitoring to determine their site capacity. They asked some questions regarding the study conducting additional site investigations, and later decided not to have any testing onsite. They did indicate, however, that they felt that there was adequate wastewater disposal capacity on their property for what they wanted to develop. Based on this indication, the property was removed from the refined buildout analysis.

3.2.3. *Carl Laroe*

Mary Clark held a meeting with Mr. Laroe on May 23, 2002 at his property near the southeast end of the study area on U.S. Route 7. Mr. Laroe owns a property containing two existing buildings for a total of 11 residential units. There are existing onsite septic systems serving each of the buildings. We obtained a copy from the town's sewage permit files of a site plan with soil test pit logs when the septic systems were replaced in 1993. Mr. Laroe is interested in further developing this property if additional wastewater capacity becomes available. A relatively limited area is available for testing. After walking the site and reviewing the soils maps, we believe that there may be some limited additional onsite capacity for expansions. Another consideration for this property might be to add advanced treatment to the existing systems, potentially doubling the system capacities. This option may only be valid if the existing system currently meets the state design requirements, was not a "best fix" upgrade to a pre-existing system, and that a fully complying replacement area is identified for both systems. Since the site has limited potential for a cluster system, we did not conduct any soils investigations. This property was included in the refined buildout analysis.

Mr. Laroe also owns some commercial properties on Jasper Mine Road in the northwestern portion of the study area. These properties contain commercial storage, warehouse, and light industrial uses presently, and there is very limited onsite capacity for wastewater systems in this area. There are several small wetland areas that significantly limit development potential. There is an interest (and potential need) for offsite wastewater capacity in the Jasper Mine Road area.

3.2.4. *Permit Research & Regulator Meetings*

Discussions and a meeting was held with Mary Clark of SEI, the Regional Engineer, and two Assistant Regional Engineers in the Essex Junction Regional Office regarding soils, site conditions, and existing permit information for properties in and around the study area. Larger development permits were researched to evaluate possible need for off-site wastewater flows, as well as for areas with good potential for cluster system sites.

Two meetings were held with Mary Clark of SEI, Wayne Elliott, P.E., of FA&A, and Mr. John Akielasczek of the Indirect Discharge Permit Section of the Vermont Department of Environmental Conservation. The first meeting was held to discuss existing permits and potential large cluster system sites, and a second meeting was convened later in the study to discuss a specific cluster site.

The Town Sewage Officer, Mr. Gerry Kittle, was also interviewed by Mary Clark and town permit files were reviewed for existing information in the study area.

3.2.5. Brentwood Park

There is an existing eight commercial/light industrial lot subdivision off of U.S. Route 7 in the northeast portion of the study area. This subdivision had previously received state and town approvals for 37 residential lots, including 11 duplexes, with a combination of individual onsite and cluster wastewater systems (Woodbridge Estates). Many of the lots are not currently developed. Based on the permit evidence, the property is capable of being developed with approved onsite capacity. This property also serves the existing Arbortech landscaping property across U.S. Route 7 and the gas station at the U.S. Route 2 intersection. Thus, these properties were removed from the refined buildout analysis.

3.2.6. Arbor Gardens Apartments

Arbor Gardens Apartments is part of a new development that recently received a state Indirect Discharge Permit (ID-9-0276) for Mr. Jay Wiley, Arbortech Inc., and Mr. Robert Marcellino, Homestead Design Inc., with a total design flow of 12,960 gallons per day. The initial approval is for the construction of 37 residential units. Future planned development includes a restaurant and additional residential units. The recent changes to the Environmental Protection Rules regarding residential flow calculations, and draft Indirect Discharge Rule changes, may provide additional capacity beyond their current future plans. Based on the approved onsite wastewater for this property, it was removed from the refined buildout analysis.

3.2.7. Chimney Hills Subdivision

There is an existing 16-lot residential subdivision at the northern edge of the study area east of Mayo Road. These lots contain constructed residences with individual onsite wastewater systems. There may be a few undeveloped lots at the end of Chimney Hill Road, but most of the properties are developed and landscaped, and additional subdivision of these properties seems unlikely. The soils in this area are well-drained sands, which could allow increases in development without needing offsite capacity. This subdivision was removed from the refined buildout analysis.

3.2.8. Vermont Agency of Transportation

The Vermont Agency of Transportation owns a parcel on U.S. Route 7 in the northern portion of the study area. This property recently received approval for the construction of offices and warehouse buildings. There is an approved onsite wastewater system serving the new construction; thus, the parcel was removed from the refined buildout analysis.

3.3. Refined Buildout Analysis Results

Following a review of already developed and/or permitted properties, and meetings with several large landowners described above, we performed a refined GIS buildout analysis.

Table 4 identifies six properties removed from the buildout analysis due to existing or permitted development uses, one property with future onsite capacity for its development needs, and set limits on two large properties based on the owners' estimate of the maximum number of units they wish to pursue. Additional information on these properties is described in Section 3.2 above. The refined build-out results are presented in Table 3. The change in the number of units was dramatic. In most scenarios, the refined buildout resulted in approximately 1,000 units. The only exception to this was the all-commercial buildout scenario, which resulted in a buildout of approximately 160 units. There was an average reduction in residential units of 45 percent and an average reduction of commercial units of about 75 percent.

4. DESIGN CRITERIA

Design criteria for onsite wastewater systems are contained in three different sets of regulations: The Town Sewage Ordinance, which references the requirements in the Environmental Protection Rules (EPRs), the EPRs, and the Indirect Discharge Rules (IDRs). Following is a summary of important rule requirements and how they relate to this decentralized wastewater project. The latest versions of the EPRs and the IDRs were used to estimate wastewater flows from the study area based on the results of the buildout analysis discussed in Section 3.

4.1. Environmental Protection Rules

The latest revisions to the EPRs became effective on August 16, 2002. These rules apply to decentralized wastewater disposal systems with design flows of less than 6,500 gallons per day (gpd) and to sewer connections for any design flow. Important changes were made in many areas of the EPRs, including those in planning and municipal requirements for use of the Rules and those in minimum site conditions, design criteria, and the use of alternative technologies in Vermont. A summary of these changes may be found in Table 5.

4.1.1. Summary of Changes Impacting Development

The change in the new EPRs most likely to impact current and future development is the elimination of the "10-acre loophole". Under the new regulations, owners of subdivided parcels covering 10 or more acres now must obtain a wastewater system permit prior to the construction of any improvements. A three-tiered approach for determining minimum site conditions was developed that allows for the improvement of lots with as little as 18" of natural soil to bedrock (the previous limit was 24") and as much as 30 percent slope with adequate hydrogeological analysis. The three approaches are described in detail in Table 5. However, the Enhanced Prescriptive and Performance-based approaches defined under the new Rules can only be used in towns with zoning bylaws and a confirmed planning process under 24 V.S.A. §4350.

Other important changes to general design standards and design flow calculations include the following:

- Septic tanks require an effluent filter and at-grade access.
- Distribution boxes with adjustable flow equalization devices are required for absorption trench and bed systems.
- Holding tanks have been added as a best fix for existing projects. Holding tanks are not allowed for new projects except for some publically owned buildings with design flows of 600 gpd or less.
- Pressure distribution requirements have been revised to allow for smaller holes in the distribution pipe and to require a larger number of holes for better distribution.
- A filtrate disposal system is allowed for use with advanced treatment systems other than sand filters.
- Drywells are not permitted for new systems.
- The design guidelines for sewer lines allow new approaches including: effluent sewers, small diameter force mains, vacuum sewers, and other technologies.
- Design flows were revised as follows:
    - Flows per bedroom reduced from 150 to 140 gpd.
    - Further flow reduction allowed after 3 bedrooms.
    - Minimum design requirement of 3 bedrooms.
    - Flow reduction for campgrounds open more than 7 months per year.
    - The 10% reduction for low flow fixtures was eliminated.

4.1.2. Advanced Treatment System Options

Under the new EPRs, a process was developed for evaluating and approving alternative wastewater treatment and disposal technologies for use in Vermont. Several technologies have already been approved under this process, in addition to the intermittent and recirculating sand filter technologies already approved in the 1996 EPRs. Alternative wastewater treatment technologies approved using this process include peat filters and textile filters. The State approvals for these technologies to date are listed in the References section of this report.

4.1.3. Dispersal System Options

Many options are available for the dispersal of treated wastewater from decentralized systems under the EPRs. Leach trenches or seepage beds are commonly utilized under favorable site conditions (those having percolation rates of between 1 and 60 minutes per inch and adequate depths to seasonal high groundwater levels and bedrock). At-grade and mound dispersal systems are generally used where minimum site conditions are met, but the site conditions are not favorable enough for the design of subsurface systems. Finally, filtrate effluent disposal systems may be used when secondary treatment is a component of the wastewater system. Any of the previously discussed soil-based dispersal systems are permissible; further, loading rates may be increased and vertical separation distances from bedrock and seasonal high water tables may be reduced if the treated effluent meets certain standards.

Spray dispersal (disposing of treated wastewater into native soil by surface application, using sprinklers) may also be used under the EPRs for systems with design flows of up to 6499 gpd. A continuous impeding layer beneath more permeable soils must underlie a successful spray dispersal site, and the treated wastewater must be chlorinated before dispersal.

4.2. Indirect Discharge Rules

Since January 1990, cluster wastewater treatment systems with design flows of 6500 gpd or greater are regulated under Chapter 14 of the EPRs, commonly known as the Indirect Discharge Rules or IDRs. The IDRs are used to permit septic tanks and leachfields, and also treatment plants and spray disposal systems, all of which use soil as part of the wastewater treatment process. Following primary and/or secondary treatment, the soil provides final effluent polishing and renovation before it reaches groundwater and, eventually, surface water. This is in contrast to direct discharge systems, which may discharge through a pipe directly to surface waters. The 1996 IDRs are still in effect, although they are in the process of being revised by the State. New IDRs will likely be approved sometime during the spring of 2003.

4.2.1. Summary of Permit Requirements

Any cluster wastewater treatment system constructed in the Exit 17 study area to support development will be considered a "System with New Indirect Discharge". If wastewater dispersal sites with design flows of greater than 6500 gpd are located near Allen Brook, the Lamoille River, or other surface waters, they may be considered "Systems with New Indirect Discharges to Class B Waters" under the IDRs. These systems are required to obtain an indirect discharge permit before construction begins. In order for a permit to be issued, the Town of Colchester must demonstrate that the new discharge:

- will not significantly alter the aquatic biota of the receiving waters;
- will not pose more than a negligible risk to public health;
- will be consistent with existing and potential beneficial uses of the waters; and
- will not violate Water Quality Standards.

The Town must also document compliance with the Aquatic Permitting Criteria, the Reliability Permitting Criteria, and the Public Health Protection Criteria as stated in the IDRs before a permit will be issued. The larger a proposed cluster system is, the more likely it is to trigger additional hydrogeological and biological testing and monitoring requirements. Permits issued under the IDRs typically include effluent monitoring and downgradient groundwater monitoring requirements.

4.2.2. Draft Rule Potential Changes & Impacts

The draft IDRs represent the first significant revision to the rules since their inception in 1990. A minor revision was made in February 1996 to provide requirements for the repair or replacement of failed systems. The current revisions are based on a review of the data collected on indirect discharge systems and are also meant to streamline the premitting process and to increase latitude to permittees in the operation of their systems. Following is a brief description of some key changes.

A General Permit is proposed for systems with design flows of 15,000 gpd or less and that do not require a certified operator to manage the system. This change streamlines the permitting process without any loss of oversight, because the General Permit still requires annual inspections and reporting of system failures.

Significant changes are proposed to the Aquatic Permitting Criteria. Sampling for nutrient parameters (total dissolved phosporus and nitrate-nitrite nitrogen) will still be required, but sampling for other parameters that did not often appear in groundwater near permitted systems (such as total chlorine, biological oxygen demand, and total kjeldahl nitrogen) will no longer be required. Changes have been made to the methods by which an applicant may demonstrate compliance with the Aquatic Permitting Criteria. A new method (the Dilution Method) has been added, and the applicability of the Treatment Index and Modified Site Specific Methods has been expanded to include more potential projects. These alternatives to the more complex and costly Site Specific Method provide a range of options for projects with smaller design flows that do not appear to have the potential for significant environmental impact.

Several important changes will be made to the technical design standards in the IDRs. The standards for the design of intermittent and recirculating sand filters have been changed to more closely match the standards set forth in the EPRs. A new section has been added to clarify requirements for reclaimed water use (including requirements for chlorination and ultraviolet (UV) disinfection, and the possibility for approval of other disinfection systems). Proposed changes specific to spray disposal systems include increases in the allowable sprayfield application rates based on the level of treatment used (up to 4 inches per week for tertiary treated effluent), and a reduction in the amount of required storage from 45 days of design sewage flow to 30 days of design sewage flow. Storage may also now be built in phases, and guidelines are given for when additional storage must be constructed.

Finally, the Experimental Systems section of the current IDRs has been expanded to include sections for both experimental treatment and experimental disposal systems. For experimental disposal systems, the applicant must be able to construct a fully complying disposal system if the experimental system does not meet its performance expectations. One consideration under this section might be to consider subsurface drip disposal in areas with sandy soils, such as along the I-89 right-of-way.

4.3. Wastewater Flow Projections

Wastewater flows were projected for the study area using the build-out analysis options and results developed in Section 3. The Vermont Environmental Protection Rules (EPRs), effective August 16, 2002, were used to estimate flows for the various development options within the Exit 17 study area.

The following assumptions were made in developing the flows:

- The residential units are defined as multiple dwellings and the flows per unit are estimated at 224 gpd (2 bedrooms X 2 persons/bedroom X 70 gpd per person per day X 80 percent).
- The commercial units are estimated at 360 gpd per unit (450 gpd per unit X 80 percent). The specific type of commercial use is not defined at this preliminary stage.
- An allowance for infiltration is not included in the projected flows.
- The 80 percent flow reduction incorporated into the projected flows applies only to projects connected to a wastewater system with a design capacity of 50,000 gpd or greater.

4.3.1. Entire Study Area

Five different buildout options were identified in the initial stage of the buildout analysis that included all possible development in the entire study area. Wastewater flows were projected for each of these options, and are summarized in Table 6. The projected flows range from 258,120 to 470,176 gpd. The highest projected flow is for the all-residential buildout option at 470,176 gpd and the lowest projected flow is for the all-commercial buildout option at 258,120 gpd.

4.3.2. *Refined Flow Projections*

Five different build-out options were also identified for the refined buildout analysis that included specific requirements for further development identified within the study area, and wastewater flows were projected for each option. Flow projections based on the refined buildout analysis are summarized in Table 7. The highest projected flow is for the all-residential buildout option at 247,072 gpd and the lowest projected flow is for the all-commercial buildout option at 58,320 gpd. Based on the potential build-out options for Exit 17 as identified in Section 3, projected wastewater flows are expected to be between 225,000 and 250,000 gpd.

4.4. Water Recycling and Reuse

Water reuse has become a common approach in many locations, especially in areas where potable water is in short supply. However, techniques for water reuse can be applied in areas where wastewater disposal capacity is limited. Killington Ski Area has used a recycling system for several years to supplement their limited wastewater disposal capacity. Treated effluent from the wastewater treatment facility is chlorinated and pumped to a nonpotable water distribution system. During the ski season, this system provides for nonpotable water demands at several of the lodges. This recycling system has the capability to provide 40 to 80% of a facility's total water usage, significantly reducing the potable water usage and wastewater disposal needs for this service area. If the Exit 17 project included reuse requirements and technologies to support those requirements, and if 30% of the design flows were reused, this would reduce the maximum wastewater flows from 250,000 gpd to 175,000 gpd.

In the draft version of the Indirect Discharge Rules, treatment requirements were added for reclaimed water use. Effluent reuse is allowed, but is subject to review and approval by the State. For effluent reuse in buildings, a tertiary level of treatment is required. The tertiary treatment requirements include disinfection and maintaining a residual chlorine concentration.

4.5. Projected Versus Metered Flows

For new projects, the design criteria in the EPR's must be used to develop the design flows. Typically, these design flows are conservative and actual metered flows are found to be considerably smaller than the design flows. Once the project is constructed and flows are metered for at least a year, the design flows can be compared to the actual metered flows. This approach requires the project to be fully built-out, so that all of the uses are representative of the design flow conditions. If the actual metered flows are less than the design flows, this data can be used as a basis for adding new connections as long the original treatment and disposal capacity are not exceeded. If the difference between projected and metered flows is 10%, this would reduce the needed site capacity by 25,000 gpd. When this reduction is added to that for water recycling, the reduced site capacity necessary may be as low as150,000 gpd.

5. HYDROGEOLOGICAL INVESTIGATIONS

Soil backhoe test pits and hydrogeological hydraulic conductivity tests were carried out on three properties. Two properties, located in the southeastern area of the study area, had areas identified as suitable for small cluster systems, and one property located approximately one mile north of the study area in the Town of Milton has potential for a large cluster system. Descriptions of the sites, the test results, and the next steps in utilizing the potential sites are given in the following sections.

5.1. Ricker Property Site Investigation

The property, located at 5956 Roosevelt Highway, is approximately 5.0 acres in size with an existing single family residence and three outbuildings. The site is a gently sloping terrace with a steep bank along the eastern and northeastern edge of the terrace down to Allen Brook, approximately 40 feet below the top of the terrace. The site contains scattered evergreen and deciduous trees. According to the Soil Survey of Chittenden County, Vermont (USDA-SCS, 1969), well-drained Adams sands underlie much of the property; however, the area along the northern property boundary is mapped as very fine sandy loam to silt loam underlain by clay. There is an existing onsite sewage disposal system near the garage currently serving the house. The property's water comes from a municipal water main running along Route 7.

Our analysis is based on backhoe test pits excavated on June 10, 2002 and described by Mary Clark, Amy Macrellis, and Bruce Douglas of SEI; hydraulic conductivity testing conducted by Amy Macrellis and Michael Pottinger of SEI on June 10, 2002; and the site plan by Dwight M. Baker titled, "O'Brien Brothers Agency 2 Lot Subdivision of Howard Farm, Colchester, Vermont" and dated April 26, 1990. The test pits were not located by topographic survey. James Ricker was also present at the June 10, 2002 site visit.

5.1.1. Backhoe Test Pits

Test pits were conducted in the terrace area to the north and east of the existing residence. Six test pits, JRi-TP1 through JRi-TP6, were excavated between 8.0 and 10.5 feet deep with a backhoe provided by the Town of Colchester. The test pit logs are attached as Appendix B, and approximate locations are shown on the site plan.

The six test pits revealed a great deal of variability in the soils on this property. Test pits JRi-TP1 and JRi-TP2 are located near the eastern edge of the terrace area (see site plan). Test pit JRi-TP1 consisted of predominantly medium sand, with a mixed medium sand and silt loam layer at 4.8-5.6 feet bgs. Test pit JRi-TP2 consisted of medium sand with some loamy fine sand. The other four test pits located on the terrace to the north and west of JRi-TP1 and 2, consisted of complex layers of medium to fine sands, sandy loams, and silt loams, with mottles present between 1.7 and 3.7 feet bgs. No groundwater or bedrock was encountered in any of the test pits. However, given the complex stratigraphy and possible shallow estimated depths to seasonal high groundwater indicated by mottling in test pits JRi-TP3, TP4, TP5, and TP6, no wastewater disposal system is proposed over most of the terrace area. Groundwater monitoring could be conducted in the spring in order to determine actual saturated conditions, but the permeability of the soils may be too slow to use.

The best possible option for a cluster wastewater disposal on this property is in the areas of test pits JRi-TP1 and TP2, parallel to the bank located near the eastern edge of the property. After accounting for a 25-foot setback from the edge of the bank, a rectangular area approximately 55 feet wide by 155 feet long (8525 ft2) is potentially available for wastewater disposal. This area may be decreased slightly if additional setbacks from buildings are required. The disposal area may also be increased, however, if it is extended beneath one or more of the barns or if more suitable soils are found extending to the north of the currently recommended disposal area. Hydraulic conductivity tests were performed in the two test pits in this area.

5.1.2. Hydraulic Conductivity Testing

Hydraulic conductivity (K) testing was performed at test pits JRi-TP1 and JRi-TP2 using the "Well Pump-in Technique" (detailed method available upon request). A 20-inch long piece of 4-inch diameter PVC was screened with filter fabric and installed in a test hole carefully excavated with a hand auger. A calibrated 5-gallon bucket was used for water storage in the pump-in test. The bottom of the test hole for JRi-TP2 was located below the bottom of the B horizon at approximately 3 feet below ground surface (bgs), while the test hole for JRi-TP1 was located at the ground surface. Four to nine runs were conducted at each location to establish consistent run times. Data regarding run times and volumes pumped was collected in the field, and data analysis was performed off site. The average flow rate from the last run of each test was used to calculate the K for each test hole. The geometric mean hydraulic conductivity was calculated using hydraulic conductivities for both test pits. See Appendix B for data and analysis.

Calculated K values, based on the last run of each test, ranged from 14 feet per day (ft/day) at JRi-TP1 to 22 ft/day at JRi-TP2. See Appendix 2 for calculation of the K values. The geometric mean was determined to be 18 ft/day, a value that agrees reasonably well with values published in the literature for well-sorted sands.

5.1.3. Capacity Analysis

In order to estimate the hydraulic capacity of the recommended cluster disposal site, we used a conservative method called Darcy's Law. This formula is represented as Q = KiA where

Q = design flow (gallons/day)(gpd)

K = hydraulic conductivity (ft./day)

i = hydraulic gradient (slope of water table)

A = transmitting soil cross-sectional area (square feet) = D x L where

D = transmitting soil thickness (depth to impeding layer or water table, minus the required separation depth, minus the system depth) (feet)

L = length of the disposal system (feet)

We used this formula to develop a range of hydraulic capacity estimates, given different assumptions as described below. The full calculations are included in Appendix B.

Assumptions:

1. Seepage bed or trench bottom is 0.5 feet below ground for first 2 scenarios, and 2 feet below ground for last two where a greater depth to groundwater table is assumed.
2. Required separation between bottom of trench/bed and induced groundwater table is 3 feet for a conventional system.
3. Hydraulic conductivity K = 18 feet/day (geometric mean of the two field tests).
4. Hydraulic gradient i = 3.0% estimated as similar to ground surface from USGS topographic map at 2.0%, plus groundwater mounding beneath the disposal field will slightly increase the hydraulic gradient This may be very conservative, given the evidence of a seasonal high groundwater table in some of the test pits upgradient of this area as being as shallow as 1.7 feet below ground, resulting in a slope of approximately 8.0%).
5. Results are limited to and by the depths and locations of the backhoe test pits.

Scenario Number	*Depth to Limiting Layer*	**Site Capacity (gpd)**
1	4.8 feet (if limiting layer in JRi-TP1 is extensive across system area)	1,100
2	10 feet (if limiting layer is at bottom of JRi-TP2)	5,500
3*	20 feet (if limiting layer is halfway down hill)	13,000
4*	40 feet (if limiting layer is at bottom of hill)	30,000

* Hypothetical scenario; requires additional field testing to verify

Based on our calculations, the available capacity for wastewater disposal in this area is between 1,100 gpd and 5,500 gpd. However, as shown in the hypothetical Scenarios 3 and 4, the site's capacity could increase twofold to greater than fourfold if additional testing confirmed significantly greater depths to seasonal high groundwater or a limiting layer.

5.2. Rubman Property Site Investigation

The property consists of approximately 114 acres of undeveloped land located in the southeast corner of the I-89 Exit 17 interchange, with its easterly boundary along U.S. Route 7 and part of the southerly boundary along Grandview Road. There is an old barn foundation located in the southeastern portion of the property. The land is a mix of open rolling hills currently used for haying, and woods along a drainage corridor near the center of the property. According to the Soil Survey of Chittenden County, Vermont (USDA-SCS, 1969), the soils on this site are a mixture of compact silt loams with a very shallow seasonal high groundwater table (typically around 12 inches below ground) in the fields, with more permeable soils but shallow bedrock in the wooded areas. An area of Adams sands, which are typically deep well-drained soils suitable for subsurface systems, is identified on the soil maps in the area of the barn site and just to the south. We focused our testing on this potentially suitable area.

Our analysis is based on backhoe test pits excavated on June 10, 2002 and described by Amy Macrellis and Bruce Douglas of SEI and the site plan by Dufresne-Henry, Inc. titled "Plot Plan", originally included in a report to Mr. Carl Grassetti dated September 18, 1986. The 1986 Dufresne-Henry report primarily describes property on the east side of Route 7, although mention is made of testing on the west side, with little capacity for siting a sewage disposal system. No previous test pit logs or site descriptions were located, although verbal reports from Mr. Ernest Christianson, Regional Engineer for the Vermont Department of Environmental Conservation indicated that test pits were excavated on this property.

5.2.1. Backhoe Test Pits

Five test pits in the southeastern portion of the property, JRu-TP1 through JRu-TP5, were excavated between 3.3 and 13.0 feet deep with a backhoe provided by the Town of Colchester. The test pit logs are attached as Appendix C, and locations are approximated on the site plan. The test pits were not located by topographic survey. The test pits revealed a great deal of variability in the local soils. Test pit JRu-TP1 consisted of fine sands and fine sandy loams, with silt loam layers at 1.6-3.4 feet below ground surface (bgs) and at 6.7-9.0 feet bgs. Test pit JRu-TP3 also consisted of fine sands and fine sandy loams, with thicker silt loam layers at 1.8-2.9 feet bgs and 5.5-13.0 feet bgs. The other three test pits consisted of a fine sandy loam to silt loam topsoil underlain by silt loams or clays that generally showed mottling within a foot of the ground surface. Additional auger holes were excavated at various areas throughout the property, but they all contained silt loam soils with mottling within one foot of the surface. No groundwater or bedrock was encountered in any of the test pits.

Given the relatively impermeable soils and possible shallow estimated depths to seasonal high groundwater indicated by mottling in test pits JRu-TP2, 4, and 5, the best possible options for wastewater disposal on this property are in the areas of test pits JRu-TP1 and 3, parallel to Routes 2 and 7 and located near the southeastern portion of the property. A rectangular area approximately 50 feet wide by 150 feet long (7500 ft2) was measured in the field as being potentially available for a cluster wastewater disposal system.

5.2.2. Hydraulic Conductivity

Hydraulic conductivity tests were not conducted on this property. The average hydraulic conductivity of the soils in JRu-TP1 and 3 was estimated to be 2-10 feet/day, based on ranges published in the literature and the results of tests in sandier soils across Route 7 from this site.

5.2.3. Capacity Analysis

In order to estimate the hydraulic capacity of the recommended cluster disposal site, we used a conservative method called Darcy's Law. This formula is represented as $Q = KiA$ where

- Q = design flow (gallons/day)(gpd)
- K = hydraulic conductivity (ft./day)
- i = hydraulic gradient (slope of water table)
- A = transmitting soil cross-sectional area (square feet) = $D \times L$ where
  - D = transmitting soil thickness (depth to impeding layer or water table, minus the required separation depth, minus the system depth) (feet)
  - L = length of the disposal system (feet)

We used this formula to develop a range of hydraulic capacity estimates, given different assumptions as described below. The full calculations are included in Appendix C.

Assumptions:

1. Seepage bed or trench bottom is 0.5 feet below ground.
2. Required separation between bottom of trench/bed and induced groundwater table is 3 feet for a conventional system.
3. Hydraulic conductivity K = 10 feet/day.

4. Hydraulic gradient i = 2.0% (estimated as similar to ground surface from USGS topographic map).
5. Results are limited to and by the depths and locations of the backhoe test pits.

Scenario Number	Depth to Limiting Layer	Separation distance to groundwater (feet)	Site Capacity (gallons/day)
1	5.5 feet (if layer in JRu-TP3 is continuous across system area)	3 feet Prescriptive	450
2	5.5 feet	1.5 feet Filtrate System	790
3	6.7 feet (if layer in JRu-TP1 is continuous across system area)	3 feet Prescriptive	720
4	6.7 feet	1.5 feet Filtrate System	1,100

When we estimate design flows using Darcy's Law, we find low design flows for this site. The Vermont Environmental Protection Rules (EPRs) do not require a hydrogeological analysis when design flows for a system are limited to less than 2,000 gpd.

5.3. Rowley Property Site Investigation

The site, located along the east side of the West Milton Road, is part of a large parcel of property with agricultural and open land in the low lands near the road, and a wooded high terrace along the eastern edge of the property, which abuts Interstate I-89. The top of the terrace is open land currently being used as a sand extraction pit, operating as "Milton Sand and Gravel" under an existing Act 250 Land Use Permit (#4CO534 and amendments). The sand extraction has been in operation since 1982. The active portion of the sand pit is approximately 11 acres in size, with some additional acreage currently set aside at the southern end of the terrace as an archaeological buffer. The sides of the terrace are quite steep and mostly covered with coniferous trees.

Our analysis is based on backhoe test pits excavated on June 11, 2002 and described by Mary Clark and Carl Etnier of SEI; hydraulic conductivity testing conducted by Amy Macrellis and Jeannie Sargent of SEI on June 11, 2002; and the site plan by Krebs and Lansing Consulting Engineers Inc. titled: "Overall Plan, Milton Sand and Gravel", dated April 15, 2002. Scott Allard was also present at the June 11, 2002 site visit. Additional site visits were made with Kevin Camara and Wayne Elliott, P.E., of Forcier Aldrich & Associates Inc. Two meetings were also held with Mr. John Akielasczek of the Indirect Discharge Permit program.

According to the Soil Survey of Chittenden County, Vermont (USDA-SCS, 1969), the terrace area consists of well-drained Adams sands that also appear to extend to the north and south of the tested area. The lower field area to the west of the ridge is mapped as Hadley very fine sandy loams (frequently flooded) and Limerick silt loams. A large portion of the lower field has been identified as within the 100-year flood zone of the Lamoille River on the site plan by Krebs & Lansing Consulting Engineers Inc. The ridge is approximately 3,000 feet east of the Lamoille River at an approximate elevation of 220 feet above mean sea level (AMSL).

There is an unnamed intermittent stream that flows around the southern end of the ridge, meandering to the Lamoille River to the west of the site. At this point, it is unclear whether this small stream or the Lamoille River would be considered the “receiving stream” for a wastewater disposal system on this site under the Indirect Discharge Rules (IDRs). If the Lamoille River is the receiving water, background water chemistry tests may be needed. Mass balance calculations can then be used to show that under worst-case conditions, the river will not be affected by a wastewater disposal system on this site. If the small stream is found to be the “receiving stream”, the State will require s more detailed evaluation and monitoring to ensure that the stream is not impacted by a large cluster disposal system. This is an important ruling that the Vermont Department of Environmental Conservation (DEC) can make in the spring if requested. Mr. Steve Fiske at the DEC can be contacted and asked to conduct this survey.

5.3.1. Backhoe Test Pits

Three general areas were tested in the area of the sand pit. Area 1 is at the southern end of the sand pit, beyond a long very narrow portion of the ridge. Area 2 is in the middle area, and Area 3 is at the northern portion of the active pit. A total of eight test pits, JR-TP1 through JR-TP8, were excavated between 7.0 and 11.5 feet deep with a backhoe provided by the Town of Colchester. The test pit logs are attached as Appendix D, and locations are noted on the site plan. The test pits were not located by topographic survey. The test pits revealed that the local soils are somewhat more variable than indicated by the soils survey map. Although medium and coarse sands were encountered in many of the pits, some test pits contained layers of silty soils, particularly those excavated in Area 3. No groundwater or bedrock was encountered in any of the test pits.

5.3.1.1. Area 1

In the southern area of the sand pit (Area 1), test pits JR-TP5 and JR-TP7 were predominantly sands with a few silty layers at varying depths. Test pit JR-TP6 was predominantly sand, but showed a few fine, distinct mottles from the ground surface to approximately 5 feet below ground surface (bgs). The sand pit operator has indicated that they are extracting “coarse mound sand” from this area of the pit. To date, this area appears to have the most consistently good soils for a disposal system at the current level of the pit.

There is an area just south of Area 1 that is currently set aside as an archaeological buffer. This area is partially open and contains small diameter trees and shrubs. The soils in the area are mapped as Adams sands. Further investigation into whether there are any archaeological artifacts in this area may be necessary before it can be considered for use as a cluster system site. However, after viewing the bank cut along the edge of this area, it is our opinion that the additional capacity may be worth the cost of additional archaeological and site investigations.

5.3.1.2. Area 2

In Area 2, test pit JR-TP4 consisted of coarse sand with a single clay layer located approximately 2.5 feet bgs. This area is at a higher elevation than Area 3, but could be expanded if material were removed to a similar level as Area 3. This area may also expand to the east near several piles of fill material.

5.3.1.3. Area 3

In Area 3, test pit JR-TP1 consisted of predominantly medium sand, with a few relatively thin bands of loamy fine sand. The other two test pits in the northern area of the sand pit, however, were predominantly clays with a few thin layers of fine sand. This area appears limited for wastewater disposal at the current level of the pit. However, this area is approximately 40 feet higher than the bottom of the hill. If suitable soils are encountered over a large enough area, and contain a significant depth of medium and coarse sands, the overlying materials may be removed. There is also a large area to the north of the current sand pit operation that may significantly expand the cluster site area from what is currently tested and shown.

One test pit was excavated at the bottom of the rise leading into the sand pit below Area 3. JR-TP8 consisted of interlayered sands and silts. Although there were signs of a seasonal high groundwater table, no groundwater was encountered to the depth of the test pit.

5.3.2. Hydraulic Conductivity Testing

Four hydraulic conductivity (K) tests were performed in the three areas, at test pits JR-TP1, 4, 6, and 7 using the “Well Pump-in Technique” (detailed method available upon request). These tests were conducted in the soil layers anticipated to receive wastewater flows. A 20 inch long piece of 4-inch diameter PVC was screened with filter fabric and installed in a test hole carefully excavated with a hand auger. A calibrated 5-gallon bucket was used for water storage during the pump-in test. Three to four runs were conducted at each location to establish consistent run times. Data regarding run times and volumes pumped was collected in the field, and data analysis was performed off site. The average flow rate from the last run of each test was used to calculate the K for each test hole. The geometric mean hydraulic conductivity was calculated using hydraulic conductivities for all four test pits. See Appendix D for data and analysis.

Calculated K values, based on the last run of each test, ranged from 22 feet per day (ft/day) at JR-TP7 to 77 ft/day at JR-TP6. Although the hydraulic conductivity tests were taken in different areas and at different elevations, there was sufficient similarity between the tested horizons to enable us to use a geometric mean to aggregate the test results for this prelimianry analysis. The geometric mean was determined to be 39 ft/day, a value that agrees well with values published in the literature for well-sorted sands.

5.3.3. Capacity Analysis

In order to estimate the hydraulic capacity of the recommended cluster disposal sites, we used a conservative method called Darcy's Law.
This formula is represented as Q = KiA where,

- Q = design flow (gallons/day)(gpd)
- K = hydraulic conductivity (ft./day)
- i = hydraulic gradient (slope of water table)
- A = transmitting soil cross-sectional area (square feet) = D x L where
  - D = transmitting soil thickness (depth to impeding layer or water table, minus the required separation depth, minus the system depth) (feet)
  - L = length of the disposal system (feet)

We used this formula to develop a range of hydraulic capacity estimates for the three areas, given different assumptions as described below. The full calculations are included in Appendix D.
Assumptions:

1. Trench bottom is 0.5 feet below ground for current scenarios, and 2 feet below ground for scenarios where a greater depth to groundwater table is assumed.
2. Required separation between bottom of trench and induced groundwater table is 3 feet for a conventional system.
3. Average hydraulic conductivity K = 39 feet/day (geometric mean of the four field tests).

4. Hydraulic gradient i = 3.0% estimated as similar to ground surface from the USGS topographic map and the site plan at 2.0%; groundwater mounding beneath the disposal field will also slightly increase the hydraulic gradient.
5. Results are limited to and by the depths and locations of the backhoe test pits.

Area Number	Capacity given current limitations (gallons/day)	Capacity given 20 feet of suitable soils* (gallons/day)	Capacity given expanded areas or where groundwater may flow in more than 1 direction* (gallons/day)
1	10,300	33,000	66,000
2	10,200	24,000	47,000
3	6,300	21,000	39,000
Total	**26,800**	**78,000**	**152,000**
* Hypothetical scenario; requires additional field testing to verify			

Based on our calculations, the total available capacity for wastewater disposal across the sand pit given current conditions is approximately 26,800 gpd. However, as shown in the two hypothetical scenarios, the site's capacity could increase twofold to greater than sixfold if additional testing confirmed significantly greater depths to seasonal high groundwater or a limiting layer.

6. DESIGN OPTIONS FOR CLUSTER SITES

6.1. Ricker Property Treatment and Disposal System

The results of the hydrogeological investigation identified the best possible location on this property for wastewater disposal to be in the vicinity of the existing barns. An area approximately 8,525 square feet (sq. ft.) (55 ft. X 155 ft.) was determined to be available for wastewater disposal as shown on Figure 5. To estimate the hydraulic capacity of this area, the preliminary layout assumed the entire disposal area was designed as absorption trenches. The loading rate for this area was estimated to be 1.13 gallons per square foot per day (gal/sf/day) based on the results of the hydrogeological investigation.

A preliminary layout using absorption trenches was prepared and included reserving space for a 100% replacement area. The primary disposal area would be approximately 55 ft. X 75 ft. and consist of four-foot wide absorption trenches. This defined area was utilized to provide the maximum disposal capacity allowable under the Small Scale Environmental Protection Rules. Depending on the level of treatment provided prior to the disposal area, this area can provide a disposal capacity up to 6,499 gpd as summarized in Table 8. This wastewater treatment and subsurface disposal system has the capability to support up to 24 residential units or a combination of residential/commercial uses.

For septic tank effluent, an estimated capacity up to 2,500 gpd is available based on the estimated loading rate. If tertiary treatment is provided, the loading rate can be increased up to 2 times, therefore the disposal capacity can be increased up to 5,000 gpd. An increase of the depth of stone under the trenches to 24 inches allows an additional increase of 66 percent which provides a disposal capacity up to 6,499 gpd. Once the capacity reaches 6,500 gpd, the Indirect Discharge Rules (IDRs) apply. Under these rules, a credit for the increased depth of stone is not provided, therefore the disposal capacity of this area is limited by the requirements under the EPRs which cannot exceed design flows of 6,499 gpd.

The objective of this study is to maximize the capacity using land based treatment, so further definition of this cluster system is based on a disposal system with treatment that can provide the 6,499 gpd of capacity. Sand filters or innovative/alternative systems can provide effluent treatment. The State approved five types of innovative/alternative systems for use with subsurface wastewater disposal systems and several other systems are currently under review. A system offered by Orenco Systems called the "Advantex Treatment System" was approved in March 2001 and has been used at several installations throughout the State. This treatment system was selected as the baseline for this property to develop the preliminary design criteria and estimated costs since it provides the following benefits:

- Approved State I/A treatment technology.
- Existing systems have been in operation in the State providing historical data on performance, reliability, and operations.
- Local representative provides ongoing technical support and warranty service.
- The filter system is modular and can be easily expanded.
- Supplied as a pre-manufactured package.
- Low routine maintenance and power costs.
- Control system has remote telemetry capability.
- Manufacturer provides a 3-year warranty.

A schematic of the typical treatment system is provided on Figure 6 and consists of the following elements:

- Two 3,500 gallon septic tanks with effluent filters.
- Recirculation/blend tank containing pump and recirculation equipment.
- Textile filters.
- Dosing pump station with forcemain to disposal area.
- Control system.

The subsurface disposal system consists of the following elements:

- Distribution assembly
- Primary disposal area (4,125 sq. ft.) with seven (7) absorption trenches, each 4 feet wide.
- Defined replacement area (4,125 sq. ft).

6.1.1. Estimated Costs

An estimated construction cost was prepared for the installation of the treatment system and subsurface disposal system. The construction cost estimated doesn't include the collection system since the specific needs will be dependent on the site development. A detailed breakdown of the estimated cost of $152,000 is provided in Table 9 based on an Engineering News Record (ENR) 6600 for November 2002.

A first year operation and maintenance cost was developed for the new treatment and disposal system. Responsibility for operation of the system still has to be determined, but could be either the landowner, Town, or other public entity. The annual operation and maintenance cost is estimated at $13,350 as summarized in Table 10. The following assumptions were made in estimating the operation and maintenance costs:

- The system is operating at a design capacity up to 6,499 gpd.
- A system operator provides daily monitoring and maintenance at an average of 1 hour per day.
- Annual pumping of the septic tanks is required.

6.1.2. Next Steps

There are several steps to be taken in finalizing this potential cluster system site, keeping in mind that additional testing may increase or decrease the preliminary hydrogeologic capacities developed during this study.

1. We recommend that additional backhoe soils testing be conducted to identify the extent of suitable soils for wastewater disposal. These tests will also help determine whether there are any continuous or thick silt layers that need to be considered in the system layout and depth.
2. Conduct percolation tests and a topographic survey of the site. Surveying the bank slope is important in determining where the slope may be greater than 30 percent for setback determinations.
3. If there appears to be significant potential for a system with flows of 6,500 gpd or greater, conduct soil borings and install groundwater monitoring wells to determine the groundwater depth, direction of groundwater flow, and the potential for seeps on the bank and groundwater mounding.
4. Determine the system capacity and which set of rules (EPRs or IDRs) to follow for future steps.

5. An additional consideration for increased wastewater flows is to have discussions with the adjacent property owner to the south of this site. There is potential for added capacity on the site if the 25-foot setback to the side property line could be waived with an easement, or if the abutting owner was interested in conducting soils testing on their property to determine additional capacity along the same terrace as on this property.

6.2. Rubman Property

The results of the hydrogeological investigation identified the best possible location on this property for wastewater disposal to be at the southwest corner of the property adjacent to Route 7. An area approximately 7,500 sq. ft. (50 ft. X 150 ft.) was determined to be available for wastewater disposal as shown on Figure 5. To estimate the hydraulic capacity of this area, the preliminary layout assumed the entire disposal area was designed as absorption trenches. The loading rate for this area was estimated to be 0.73 gal/sf/day based on the hydrogeological investigation.

A preliminary layout using absorption trenches was prepared and included reserving space for a 100% replacement area. The primary disposal area would be approximately 50 ft. X 70 ft. and consist of four-foot wide absorption trenches. This defined area was utilized to provide the maximum disposal capacity allowable under the Small Scale Environmental Protection Rules.

For septic tank effluent, an estimated capacity up to 1,300 gpd is available based on the initial loading rate as summarized in Table 11. If treatment is provided, the loading rate can be increased up to two times, therefore the disposal capacity can be increased up to 2,600 gpd. An increase of the depth of stone under the trenches to 24 inches allows an additional increase of 66 percent, providing a disposal capacity of up to 4,000 gpd.

6.2.1. Next Steps

There are several steps to be taken in finalizing this potential cluster system site, keeping in mind that additional testing may increase or decrease the preliminary hydrogeologic capacities developed during this study.

1. We recommend that additional backhoe test pits be conducted in the cluster site area to better define the limits of suitable soils.
2. Based on the results of the additional test pits, the area may require groundwater monitoring through a spring as outlined in the Vermont Environmental Protection Rules §1-507. This may allow for increasing the available area if there are signs of a seasonal high groundwater table, but the actual groundwater table is lower. Groundwater monitoring pipes can be installed during the excavation of additional test pits.

3. A subsurface curtain drain may also be installed along Route 7 to try to lower the groundwater table. Springtime monitoring may be needed to confirm the results.
4. Hydraulic conductivity tests or other hydrogeological tests may be conducted in the future, if the results of the soils and monitoring are favorable for a larger system.
5. Percolation tests and a topographic survey are needed to finalize the system layout and design criteria.

6.3. Rowley Sand Pit Cluster Options

6.3.1. Disposal Capacity, Phase 1

The results of the hydrogeological investigation identified three (3) initial locations on the Rowley sand pit property for wastewater disposal under Phase I as listed below. The approximate location of each disposal area is shown on Figures 7 and 9.

- Disposal Area No. 1: The southerly disposal area is approximately 45,000 sq. ft. (150 ft. X 300 ft.).
- Disposal Area No. 2: The middle disposal area is approximately 18,000 sq. ft. (100 ft. X 180 ft.).
- Disposal Area No. 3: The northerly disposal area is approximately 18,400 sq. ft. (80 ft. X 230 ft.).

To estimate the hydraulic capacity of each area, the preliminary layouts assumed the entire area was designed as absorption trenches. The maximum loading rate for this area was estimated to be 0.9 gal/sf/day based on the results of the hydrogeological investigation.

A preliminary layout using absorption trenches was prepared and includes the replacement areas. Under the Indirect Discharge Rules, both the primary and replacement areas must be constructed. This defined area was utilized to provide the maximum disposal capacity allowable under the State IDR’s. Depending on the level of treatment provided prior to the disposal area, the identified areas have the ability to provide a disposal capacity up to 80,000 gpd as summarized in Table 12. This subsurface wastewater system has the capability to support up to 358 residential units or a combination of residential/commercial uses.

For septic tank effluent, a combined estimated capacity up to 16,000 gpd is available based on the initial loading rate. If secondary plus treatment is provided, the loading rate can be increased up to three times, therefore the disposal capacity can be increased to 48,000 gpd. Addition of tertiary treatment allows an increase in the loading rate up to five times for a disposal capacity of up to 80,000 gpd.

6.3.2. Disposal Capacity, Phase II

During the performing of the hydrogeological investigations, general areas of the site were tested to identify potential disposal areas. The majority of this area is mapped as Adams sands. Additional investigations performed of other suitable areas of the site may indicate additional disposal areas. For example, a southerly area of the pit has been set aside due to potential archeological issues, but an archeological investigation has not been conducted. If this investigation was performed and was cleared, this area could be used. Conceptual layouts were performed of the sand pit, and identified up to four additional disposal areas. If the site investigations for these areas prove favorable and construction can be sequenced with the sand pit operation, significant additional disposal capacity may be developed. Preliminary layouts indicate that up to an additional 115,000 gpd of disposal capacity may be available in future phases with tertiary treatment.

6.3.3. Collection, Treatment, And Disposal Options: Onsite Treatment, Phase I (48,000 gpd)

An initial design capacity of 48,000 gpd was developed for this option based on the predicted disposal capacity of the Rowley sand pit if secondary plus treatment is provided. This approach to serve the future wastewater needs for the Exit 17 area consists of the following major components:

- Onsite treatment systems
- Low pressure sewer system
- Effluent pumping station and force main
- Subsurface disposal system at Rowley sand pit

Individual treatment systems will be located on each lot to provide a secondary plus level of treatment. The capacity of each system will be determined by the wastewater flow needs as each lot is developed. The treatment system could be a textile filter, sand filter, or other type of innovative/alternative systems. The State has approved five types innovative/alternative systems for use with subsurface wastewater disposal systems and several other systems are currently under review.

A schematic of the typical on-site treatment system is provided on Figure 8 and consists of the following elements:

- Septic tank(s) with effluent filters.
- Recirculation/blend tank containing pump and recirculation equipment.
- Textile filters.

- Dosing pump station with forcemain to low pressure sewer system.
- Control system.

A new low-pressure sewer system serves the Exit 17 area as shown on Figure 7. New low-pressure sewers will be provided along Route 2, Route 7, and Jasper Mine Road to provide service for the initial phase of the project. Effluent from each lot will be pumped directly to the low-pressure sewer system. All of the flow collected in this area will be transported to the new effluent pumping station located adjacent to the Interstate 89 south off ramp.

The effluent pumping station will consist of a wet well with submersible pumps. Effluent will be pumped in a new 6-inch force main north along Interstate 89 to the Rowley sand pit for distribution and disposal.

At the Rowley sand pit, the effluent will be temporarily stored in a distribution structure containing dosing pumps. Repumping at the structure will be performed to dose and evenly distribute the flow to each of the three primary disposal areas. Each disposal area will consist of individual 5,000 gpd fields operated as a pressure distribution system due to the length of distribution piping.

Advantages:

- Small diameter pressure sewer systems significantly reduce initial capital costs compared to conventional gravity sewers.
- Low-pressure sewer systems do not need to be installed to accurate line and grade.
- Decentralized treatment is provided, thereby reducing the initial capital cost for the treatment facilities.
- The Town or public entity would be responsible for operation and maintenance of the low-pressure sewer system, effluent pumping station and disposal area.
- Sludge wasting and disposal for each treatment system can be the responsibility of each lot owner.
- The effluent pumping station and force main can be constructed to handle future phases.
- The Rowley sand pit site has potential for additional disposal capacity under future phases.
- Alternate disposal sites can be used and may be either subsurface dispersal areas or spray fields.

Disadvantages:

- Maximum wastewater flow is limited by the small diameter of the various forcemains.
- Effluent pumps are required at each lot to discharge to the low-pressure sewer.
- This approach is limited to a capacity less than 50,000 gpd unless tertiary treatment and disinfection is added as required by the IDRs. The onsite treatment systems only provide a secondary plus level of treatment.
- Single responsibility is not provided for operation of the treatment systems, unless the Town or public entity takes responsibility for management of the onsite treatment systems.
- Addition of disinfection is required to implement the reclaimed water use.
- The disposal system will serve the Town of Colchester Exit 17 service area, but the site is located in the Town of Milton.
- Extensive groundwater and surface water monitoring is required of the land based disposal area.

6.3.3.1. Land Requirements

Low Pressure Sewer System: The new pipelines will be constructed within the Town right-of-way on Jasper Mine Road to minimize the need for permanent easements. An easement will be required from the Vermont Agency of Transportation (VTrans) for the new pipelines located within the State right-of-way along Route 2 and 7.

Effluent Pumping Station: Purchase of property will be required for access and siting of the new effluent pumping station.

Effluent Force Main: An easement will be required from Vtrans to construct the new effluent force main in the Interstate 89 right-of-way.

Disposal System: Purchase of a portion of the Rowley property will be required for the subsurface wastewater disposal system located off Mayo Road in the Town of Milton.

6.3.3.2. List of Permits/Approvals

Indirect Discharge Permit: A new Indirect Discharge Permit will be required from the Agency of Natural Resources, Wastewater Management Division, for the wastewater disposal system.

Act 250: A determination will be required from the District #4 coordinator regarding the need for an Act 250 Land Use permit. If the impacted project area exceeds 10 acres, a permit will likely be required.

Vtrans: A permit will be required for the new pipelines located with the Route 2, Route 7, and Interstate 89 right-of-way.

Town of Colchester: Site plan approval will be required from the Development Review Board for the new effluent pumping station.

Wetlands: Any work performed crossing wetlands or within the 50-foot buffer will require a Conditional Use Determination from the State Water Quality Division.

Archeological Assessment: As a minimum, a Phase IA investigation will be required of the work areas to determine if there will be any impacts of sensitive areas. Depending on the findings, additional Phase IB investigation may be required.

6.3.3.3. Estimated Costs

An estimated construction cost was prepared for the new low-pressure sewer system, effluent pumping and force main, and disposal system. A detailed breakdown of the estimated cost of $1,540,000 is provided in Table 13 for Phase I based on an ENR 6600 for November 2002. This construction cost estimate excludes the individual on-site treatment systems and effluent pumping stations. For a typical 5,000 gpd treatment system, the estimated construction cost will range from $90,000 to $110,000.

A first year operation and maintenance cost was developed for the collection, effluent pumping system, and disposal system. Responsibility for operation of the system will likely be either the Town, or other public entity. The annual operation and maintenance is estimated at $46,500 as summarized in Table 14. The following assumptions were made in estimating the operation and maintenance costs:

- The system is operating at a design capacity up to 48,000 gpd.
- A system operator provides daily monitoring and maintenance at an average of two hours per day, five days per week.
- Monitoring of the groundwater and surface waters will be required at the disposal area to comply with the Indirect Discharge Permit.

6.3.4. Collection, Treatment, And Disposal Options: Onsite Treatment - Phase II (80,000 gpd)

The disposal area at the Rowley sand pit has been projected to have an initial disposal capacity up to 80,000 gpd with the addition of tertiary treatment. Under Phase I, only secondary plus treatment is planned, limiting the capacity to 48,000 gpd. In accordance with the IDRs, addition of a tertiary level of treatment and disinfection is required once the capacity exceeds 50,000 gpd. To utilize the additional 32,000 gpd of capacity at the disposal site, addition of tertiary treatment is proposed under Phase II of this option. The facilities would be added adjacent to the effluent pumping station and would include the following elements:

- Influent pumping and wet well
- Chemical feed system
- Cloth media filters and backwash system
- Ultraviolet disinfection system
- Sludge storage tank
- Emergency power

Addition of the tertiary treatment and disinfection also provides the ability to reuse the treated effluent for reclaimed water use. The level of treatment provided allows the effluent to be used to supply the nonpotable water needs for the surrounding service area.

The estimated construction cost for the listed facilities with maximum wastewater flows of 80,000 gpd under Phase II is $900,000 to $1,000,000 based on an ENR 6600 for November 2002. Addition of these facilities will increase the operation and maintenance costs for the system approximately $60,000 per year.

6.3.5. Collection, Treatment, And Disposal Options: Centralized Treatment

An initial design capacity of 80,000 gpd was developed for this option based on the preliminary disposal capacity of the Rowley sand pit. This approach to serve the future wastewater needs for the Exit 17 area consists of the following major components:

- Sewer collection system
- Tertiary treatment facility
- Effluent pumping station and force main
- Subsurface disposal system at Rowley sand pit

A new conventional sewer collection system serves the Exit 17 area as shown on Figure 9. New gravity sewers will be provided along Route 2, Route 7, and Jasper Mine Road to provide service for the initial phase of the project. A wastewater pump station located at the low point at the intersection of Jasper Mine Road and Mayo Road will pump the flow in a force main east toward the gravity sewers near Interstate 89. A second wastewater pump station located on the east side of

Interstate 89 will pump the flow collected in this area in a forcemain to the gravity sewers located west of the interstate. All of the flow collected in this area will be transported to the new wastewater treatment facility located adjacent to the Interstate 89 south off ramp.

The new wastewater treatment facility will be accessed from Jasper Mine Road. The treatment facility will provide a tertiary level of treatment using the ultrafiltration membrane treatment system and a schematic of the process is shown on Figure 10. The facility will include the following elements:

- Headworks
- Flow equalization and influent pumping
- Ultrafiltration membrane treatment system
- Ultraviolet disinfection system
- Sludge holding tanks
- Control Building
- Emergency power

The treatment process consists of a suspended growth biological reactor integrated with an ultrafiltration membrane system. This ultrafiltration system replaces the solids separation function of secondary clarifiers and cloth media filters in a conventional activated sludge system. For municipal applications, the ultrafilter is a hollow fiber membrane, which has a 0.1-micron pore size that ensures no particulate matter is discharged in the effluent. This treatment system is readily adaptable for denitrification, where total nitrogen removal is required. An upstream anoxic zone is incorporated into the tank design. Phosphorus removal is easily achieved through the addition of metal salts, such as alum to the raw wastewater. The soluble phosphorus is precipitated and is removed with the waste activated sludge since it is unable to pass through the membranes. This type of process is ideally suited to water recharge and reuse and has the capability of producing an effluent with drinking water quality with the addition of reverse osmosis.

Treated water will be discharged to a new effluent pumping station located adjacent to the treatment facility. The pump station will consist of a wet well with submersible pumps. Effluent will be pumped in a new 6-inch force main north along Interstate 89 to the Rowley sand pit for disposal.

At the Rowley sand pit, the effluent will be temporarily stored in a distribution structure containing dosing pumps. Repumping at the structure will be performed to dose and evenly distribute the flow to each of the three disposal areas. Each disposal area will consist of individual 5,000 gpd fields operated as a pressure distribution system due to the length of distribution piping.

Advantages:

- Manholes are provided at frequent intervals in the sewer system for ready access to inspect and maintain the sewers.
- Additional services or lateral connections can be made easily at any time in the future as need arises.
- The treatment facility provides a level of tertiary treatment and disinfection to comply with the requirements of the IDRs for disposal capacities greater than 50,000 gpd.
- The ultrafiltration membrane treatment process provides a level of tertiary treatment within a single bioreactor. The system is provided on skid-mounted units for ease of installation.
- Centralized treatment is provided, so that the system can be controlled and monitored by a single operator to ensure compliance with the Indirect Discharge Permit.
- The new treatment facility can be constructed for future expandability so that additional membrane cassettes can be installed if additional disposal capacity is developed.
- The treatment facility provides a level of tertiary treatment and disinfection, so recycle of the treated water for reclaimed water uses can be implemented.
- Effluent pumping will be located adjacent to the treatment facility for ease of operation and monitoring.
- The effluent pumping station and force main can be constructed to handle future phases.
- The Rowley sand pit has potential for additional disposal capacity under future phases.
- Alternate disposal sites can be used and may be either subsurface dispersal areas or spray fields.

Disadvantages:

- Gravity sewer installations are typically 50 to 60 percent more expensive to construct than a comparable sewer forcemain.
- Pipe sizes for the conventional sewers are typically larger than a comparable low-pressure sewer system.
- Pipelines must be installed at an accurate line and grade to maintain gravity flow.

- Significant capital investment is required to provide pump stations at the low points in the sewer system to lift the flow to the high points.
- Pumping to the sewer system may be required from some of the lots at lower ground elevations.
- Preliminary treatment is provided at the treatment facility for proper removal and disposal of large debris.
- Sludge wasting and disposal off-site will be required for the new treatment facility.
- Generating adequate wastewater flow in the early years will be difficult and will not provide adequate revenue to operate the new treatment facility.
- Additional Town staff will be required to operate and maintain the new sewer collection system, treatment facility, and disposal system.

6.3.5.1. Land Requirements

Sewer Collection System: The new pipelines will be constructed within the Town right-of-way on Jasper Mine Road to minimize the need for permanent easements. An easement will be required from VTrans for the new pipelines located within the State right-of-way along Route 2 and 7.

Wastewater Treatment Facility: Purchase of property will be required for access and siting of the new wastewater treatment and effluent pumping station.

Effluent Force Main: An easement will be required from Vtrans to construct the new effluent force main in the Interstate 89 right-of-way.

Disposal System: Purchase of a portion of the Rowley property will be required for the subsurface wastewater disposal system located off Mayo Road in the Town of Milton.

6.3.5.2. List of Permits/Approvals

Indirect Discharge Permit: A new Indirect Discharge Permit will be required from the Agency of Natural Resources, Wastewater Management Division, for the wastewater treatment facility and disposal system.

Act 250: A determination will be required from the District #4 coordinator regarding the need for an Act 250 Land Use permit. If the impacted project area exceeds 10 acres, a permit will likely be required.

VTrans: A permit will be required for the new pipelines located with the Route 2, Route 7, and Interstate 89 right-of-way.

Town of Colchester: Site plan approval will be required from the Development Review Board for the new wastewater treatment facility.

Wetlands: Any work performed crossing wetlands or within the 50-foot buffer will require a Conditional Use Determination from the State Water Quality Division.

Archeological Assessment: As a minimum, a Phase IA investigation will be required of the work areas to determine if there will be any impacts of sensitive areas. Depending on the findings, additional phased investigations may be required.

6.3.5.3. Estimated Costs

An estimated construction cost was prepared for the new collection system, wastewater treatment facility, effluent pumping and force main, and disposal system. A detailed breakdown of the estimated cost of $4,265,000 is provided in Table 15 based on an ENR 6600 for November 2002.

A first year operation and maintenance cost was developed for the new collection, treatment, and disposal system. Responsibility for operation of the system will likely be either the Town, or other public entity. The annual operation and maintenance cost is estimated at $120,000 as summarized in Table 16. The following assumptions were made in estimating the operation and maintenance costs:

- The system is operating at a design capacity up to 80,000 gpd.
- A system operator provides daily monitoring and maintenance at an average of four hours per day, seven days per week.
- Annual pumping of the flow equalization tanks is required.
- Monitoring of the groundwater and surface waters will be required at the disposal area to comply with the IDP.

6.3.6. Next Steps

There are several steps to be taken in finalizing this potential cluster system site, keeping in mind that additional testing may increase or decrease the preliminary hydrogeologic capacities developed during this study.

1. Contact Mr. Steve Fiske of Vermont DEC this spring to request his determination on whether the unnamed stream or the Lamoille River is considered the receiving waters for this site. Once this evaluation is completed, a plan can be formed for providing necessary information regarding in-stream receiving water quality and for compliance with the Aquatic Permitting Criteria. In general, if the Lamoille River is determined to be the receiving stream, the Aquatic Permitting Criteria will be easier to meet than if the unnamed stream

does contain biological life and habitats that need to be protected from impacts related to wastewater disposal.

2. Hire an archaeologist to evaluate the area currently set aside as potentially containing artifacts and determine whether there are indeed artifacts in the area and what type of protection is needed. If the archaeologist determines that there are no significant artifacts, it may be worthwhile to amend the current Act 250 Land Use Permit to allow use of this area. The Vermont Division of Historic Preservation should be involved with the consultant's determination and in agreement with the findings. We had a conversation with Mr. Scott Dillon of the Department of Historic Preservation (DHP) on January 7, 2003. He did not think that an archaeologist ever evaluated the site. However, since the site had potential archaeological importance, it was decided to set up a buffer and not disturb the area until after a review was completed and the site cleared by DHP. At this time, a Phase 1A study would be needed, with additional evaluations performed if findings warrant.
3. Currently there is an Act 250 Land Use Permit for the sand pit operation. An Act 250 permit amendment would be needed for approval of this site as a cluster wastewater disposal system. The Act 250 District Coordinator, Ms. Stephanie Hesson, should be contacted regarding the proposed change in use and when permit amendments will be needed. They also may be involved with approving any monitoring well installation and should be contacted prior to any drilling.
4. Begin discussions with the Town of Milton Board of Selectmen and Planning Department regarding piping to and use of the sand pit as a disposal system site.
5. Meet with State personnel (VTrans) regarding the feasibility of using the I-89 corridor for the force main piping.
6. Conduct a series of deep soil borings throughout the sand pit site to a depth of 60-100 feet (into the groundwater table and to bedrock or to refusal). A hydrogeologist should log the soil borings, and monitoring wells should be installed into the groundwater table. The monitoring wells can then be used to determine the depth and flow direction of the groundwater under this site, and to determine the hydraulic conductivity of the saturated layer. We also suggest that additional backhoe test pits could be conducted, particularly in the northern area beyond the current limits of the sand pit operation. Use of this area for wastewater disposal could significantly increase the site's capacity. Prior to installing the monitoring wells, the Act 250 coordinator should be contacted regarding the need for a permit amendment for this work. Based on a letter and site plan describing the proposed work, Ms. Hesson will issue a determination as to whether an amendment application is needed. Mr. John Akielaszek should also review and approve the workplan prior to proceeding.
7. Evaluate the topographic survey information completed to date by Krebs and Lansing Consulting Engineers Inc., and conduct additional survey work

regarding identifying the unnamed stream's location, nearby water supply wells, and monitoring well elevations. Identify all drinking water supply wells within 1,000 feet of the site. Depending on the water supply wells' location, type, and depth, monitoring of the wells may be necessary to determine whether a hydraulic connection exists between the well and the groundwater beneath the proposed disposal sites. Identify any groundwater seeps on the sides of the terrace around the sand pit.

8. Once the two steps identified above are completed, the hydrogeologist can then determine the approximate depth and layout of a disposal system, and can identify any additional testing needed to further characterize the site. For example, if the soils are much more favorable for wastewater disposal at an elevation starting ten feet below the current level of the pit, material may need to be removed before further testing can be conducted.
9. Phasing considerations – If significant amounts of material need to be removed over portions of the sand pit in order to use it for wastewater disposal, phasing the extraction process and the IDR permit approval process may be the best way to proceed. This may allow for continued extraction of materials over portions of the pit. For example, if the initial system is approved for 50,000 gpd, the system could later be approved for a higher application rate under the experimental approval section of the IDRs, so that groundwater monitoring can be initiated to determine whether performance objectives have been achieved.

6.4. Spray Disposal Systems

In the draft version of the Indirect Discharge Rules, significant changes are made to the spray disposal requirements. The changes were discussed in Section 4 and are summarized as follows:

- Increases the allowable application rate based on the level of treatment used. The maximum rate would be 4 inches per week for tertiary treated effluent.
- Reduces the amount of storage required from 45 to 30 days of design flows, and allows construction of the storage in phases.
- If the effluent sprayed meets the *E. coli* water quality standard, chlorination of the effluent is not required prior to spraying.

The "Town of Colchester Wastewater Master Planning Part II: Town-Wide Wastewater Facility Planning Update" completed in September 1997 assessed potential wastewater options for the Exit 17 area. This service area was designated as Wastewater Management Unit #10 in the study. Under Alternative #10-3, a centralized collection system with treatment and indirect discharge were evaluated. At the time of the study, this approach was the least favorable option for the Exit 17 area. However, both of the other options considered are not workable at this time, therefore this indirect discharge option should be reconsidered. This approach assumed extension of an effluent force main west along Route 2 to a spray site located south of the Lamoille River near Clay Point Road. As a disposal option, this approach becomes significantly more favorable due to the changes in the Indirect Discharge Rules. This spray disposal field can be developed as a future phase and used to supplement the subsurface disposal fields at the Rowley property. In combination, these land based disposal sites have the ability to provide the entire wastewater disposal needs for the Exit 17 service area.

7. RECOMMENDED OPTION – CONCEPTUAL PLAN

The recommended option for decentralized wastewater management in the Exit 17 Growth Center includes onsite secondary treatment of effluent, followed by effluent pumping and tertiary treatment and disinfection at a centralized site. After tertiary treatment and disinfection, some of the effluent will be recycled through an effluent reuse pumping and distribution system, while the rest will be returned to the subsurface through various disposal methods. Specific details of the recommended option are discussed in this section, as well as potential options for achieving full buildout within the study area and for financing and managing the wastewater treatment, reuse, and dispersal systems.

7.1. Phasing Recommendations

Phase 1 of the recommended option includes wastewater flows of up to 120,500 gpd. This option includes construction of the Onsite Treatment Phase II option for the Rowley sand pit with design flows of 80,000 gpd (Section 6.3.4) and the construction of the Ricker Property Treatment and Disposal System option with design flows of 6,499 gpd (Section 6.1). In order to benefit from the full wastewater flows afforded by this option, an effluent reuse pumping and distribution system must reuse at least 30% of the treated effluent. This reuse essentially adds 34,000 gpd of available capacity to the recommended Phase 1. In order for the recommended option to support wastewater flows of 120,500 gpd, the effluent reuse system should be included in any new development within the Growth Center.

Assuming that 120,500 gpd of wastewater capacity is available during Phase 1, as many as 570 residential units could be built within the study area. Figure 11 shows how this new development might be constructed under a buildout scenario where all land in zoning districts where PUDs are allowed was built out with 50% of available area as PUD in a 75% residential/25% commercial mix (Scenario 4 from Section 3.1).

Phase 2 of the recommended option includes wastewater flows of up to 225,000 gpd. This phase primarily consists of the development of additional capacity at the Rowley sand pit cluster site as discussed in Section 6.3.2. Other potential options for the dispersal of expanded wastewater flows include expansion of the Ricker cluster site as discussed in Section 6.1.2, and the addition of a spray disposal site as discussed in Section 6.4.

Although the recommended option as described above only provides a path to potential wastewater design flows of up to 225,000 gpd, it is almost certainly possible to provide adequate capacity for the maximum wastewater flows of 250,000 gpd calculated for the study area in Section 4.3.2. If the constructed wastewater disposal system includes reuse of 30% of the wastewater as described in Phase 1 of the recommended option, the flows needed are reduced to 175,000 gpd. Once the system has been in operation for 1 year, metered wastewater flows may be used instead of projected flows to determine additional available capacity. This usually results in an additional 10% reduction in needed wastewater flows. Thus, to support the maximum buildout in the study area, the actual needed wastewater flows may be as low as 150,000 gpd—a figure well within the flows provided by the recommended option.

7.2. Project Financing

The costs of implementing the recommended option include both initial construction, administrative, legal, and enginering costs and ongoing operation and maintenance after the system is built. Potential funding sources may include several of the following:

- State revolving loans
- State grants
- Federal loan or grant programs
- Loans from banks
- Cash on hand
- Property Assessments
- Cost sharing with major users

The State of Vermont offers several different types of loan and grant funding sources on similar projects for planning, design, and construction. An interest-free loan with a two percent administrative fee for 100 percent of the eligible costs is authorized under 24 V.S.A. Chapter 120 for all projects with bond votes after July 1, 1999, and is drawn from the Environmental Protection Agency revolving fund (SRF). The Vermont DEC can assist in determining eligibility of cost in regard to loans or grants. Local funds or a separate loan can be used to cover noneligible costs. Land purchases, easements, and related engineering and legal fees are not typically eligible for reimbursement under the SRF program.

The Vermont Community Development Program (VCDP) provides implementation grants to address local needs and priorities in the areas of housing, economic development, public facilities and public services for persons of lower income. Vermont cities, towns, and incorporated villages chartered to function as general-purpose units of local government are eligible to apply for grants under this program. The VCDP is funded by federal Community Development Block Grant (CDBG) funds that are administered by the State. Funded activities must meet at least one national objective and at least one state objective.

USDA Rural Development offers loan and grant programs to public bodies or non-profit associations serving a community with a population of 10,000 or less. Applicants must also show that they are unable to afford commercial credit. Funds can be used to develop or improve water and wastewater systems, including solid waste disposal and storm drainage. Eligible costs include funds for engineering, construction, legal costs, land and rights, interim financing interest and equipment. Rural Development can make an eligibility determination based on a written request that includes the project's scope and approach.

Since many of the new units that may be developed in the Exit 17 Growth Center will be located on a few large parcels in the study area, some form of public/private partnership or other form of cost sharing between the Town and the major potential developers who will use the new system may be of particular interest to Colchester.

7.3. Management Structures

Continued operation, maintenance, and management of the wastewater disposal solution constructed in the Exit 17 study area could take any one of many forms. The management structure could follow one of the one of the five "model programs" suggested in the draft EPA Guidelines for Management of Onsite/Decentralized Wastewater Systems (US EPA, 2000). These model programs range from system inventory and awareness of maintenance needs (Level 1) to ownership and management of all system components by a utility such as a town, county, or special wastewater management district (Level 5). Many communities choose an approach that lies between these two extremes. For instance, the Town might choose to keep the onsite components of the recommended option (septic tanks and piping up to the service connection) under individual ownership, with the remaining components (effluent piping, pump stations, treatment units, and disposal fields) owned and managed by the Town. Additionally, as now is the case with roads within PUDs, developers might construct portions of the effluent collection system to the Town's standards, then turn those portions of the system over to the Town for management.

7.4. Next Steps

The following are suggestions for the next steps that the Town of Colchester should take towards the completion of a decentralized wastewater management program for the Exit 17 Growth Center.

1. Begin discussions with the potential cluster system owners (Rowley and Ricker), to consider the use of their properties for cluster wastewater disposal systems under municipal management and/or ownership. Develop option agreements for purchases or use of properties including negotiated purchase prices and conditions of purchase (including additional testing discussed under Step 2).

2. Conduct additional site investigations on the Rowley (Section 6.3.6) and Ricker (Section 6.1.2) properties; pursue other environmental, engineering, and permitting issues identified for each of the cluster sites.
3. Continue to contact private property owners where suitable soils exist, to see if additional cluster system sites or spray disposal sites may be available in or near the study area.
4. Investigate the use of subsurface drip irrigation as a pilot experimental system along the Interstate 89 right-of-way as an additional means of increasing disposal capacity in the study area.
5. Formulate and distribute a property owner survey / questionnaire.
6. Consider the form of municipal or other management entity responsible for operating and maintaining a decentralized wastewater disposal system or systems in the Exit 17 study area.
7. Identify the preferred funding and operating options for the project; consider a private/public partnership with some of the major landowners in the study area to participate in the financing and development of the wastewater utility.
8. Assess the expansion of municipal water lines with Colchester Fire District #3.

8. REFERENCES

1. Barnstable County Department of Health and Environment, "The Second Compendium of Information on Alternative Onsite Septic System Technology in Massachusetts," A Special Issue of Environment Cape Cod Journal, June 2001.
2. Forcier Aldrich & Associates, "Town of Colchester Wastewater Master Planning Part II: Town-Wide Wastewater Facility Planning Update", September 1997.
3. Lamoureux & Stone Consulting Engineers, Inc., "Exit 17 Wastewater Planning Study: Colchester & Milton, Vermont", November 1991.
4. National Onsite Water Recycling Association (NOWRA), "NOWRA 2002 Annual Conference and Exposition, Protecting Water Quality On Site, Proceedings, 2002.
5. State of Vermont Department of Highways Geologic Section, Materials Division, "Survey of Highway Construction Materials in the Town of Milton, Chittenden County, Vermont," December 1961.
6. State of Vermont, "Environmental Protection Rules, Chapter 1, Wastewater System and Potable Water Supply Rules," Effective August 16, 2002.
7. State of Vermont, "Indirect Discharge Rules, Chapter 14: Environmental Protection Rules," Effective February 29, 1996.
8. State of Vermont, "Indirect Discharge Rules, Chapter 14," Draft: September 2002 Version.
9. State of Vermont, "Innovative/Alternative System Approval #2001-01," Advantex™ Treatment System, Expiration date: September 15, 2003
10. State of Vermont, "Innovative/Alternative System Approval for General Use #2002-02," Premier Tech Ecoflo® Peat Filter Treatment System, Expiration date: April 30, 2004
11. State of Vermont, "Innovative/Alternative System Approval for General Use #2002-03," SeptiTech® Residential Series and Commercial Series Recirculating Trickling Filter Treatment System, Expiration date: November 1, 2004.
12. United States Department of Agriculture Soil Conservation Service, "Soil Survey of Chittenden County, Vermont," Reissued January 1989.
13. United States Office of Water, Office of Research and Development, and Environmental Protection Agency, "Onsite Wastewater Treatment Systems Manual," EPA/625/R-00/008, February 2002.
14. Webster-Martin, "Town of Milton Facilities Planning Report for Wastewater Pollution Control and Plant Expansion", June 1998.
15. West Virginia University, National Small Flows Clearinghouse, "Wastewater Products Catalog" and web site review, 2002.

TABLE 1: STUDY AREA DESCRIPTION

Map/Lot	Property Location	Owner Name(s)	Parcel Size (acres)
17-3-8	BRENTWOOD DR	CHIMNEY CORNERS CORPORATION	4
17-3-2	BRENTWOOD DR	CHAIKIN JOSHUA	1
17-3	BRENTWOOD DR	CHIMNEY CORNERS CORPORATION	3
17-3-4	BRENTWOOD DR	CHIMNEY CORNERS CORPORATION	6
17-3-5	BRENTWOOD DR	CHIMNEY CORNERS CORPORATION	6
17-3-6	BRENTWOOD DR	CHIMNEY CORNERS CORPORATION	3
17-3-3	BRENTWOOD DR	CHIMNEY CORNERS CORPORATION	6
17-3-1	63 BRENTWOOD DR	RUSSELL PROPERTIES LLC	3
17-3-7	156 BRENTWOOD DR	CHIMNEY CORNERS CORPORATION	4
17-43	18 CHIMNEY HILL DR	KLEIN RONALD L & KLEIN BARBARA T	12
17-36	50 CHIMNEY HILL DR	PAPARO ENRICO J & PAPARO LAUREN K	0
17-17	67 CHIMNEY HILL DR	BRADLEY DONALD L JR & BRADLEY JUDITH ANNE	1
17-50	95 CHIMNEY HILL DR	BRAMLEY ROBERT S & BRAMLEY DONNA M	0
17-37	104 CHIMNEY HILL DR	BLACKETOR PAUL G & BLACKETOR SANDRA M	0
17-49	121 CHIMNEY HILL DR	ZENO MICHAEL & ZENO DARLENE S	1
17-38	134 CHIMNEY HILL DR	HAMILTON RICHARD A & HAMILTON JUDITH R	0
17-39	156 CHIMNEY HILL DR	MODICA DAVID & MODICA JEANNIE	1
17-48	157 CHIMNEY HILL DR	SMITH BENJAMIN & TOUNTAS-SMITH LESLIE ELIZABETH	1
17-47	183 CHIMNEY HILL DR	WRIGHT RICHARD H & WRIGHT LYNN A	1

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TABLE 1: STUDY AREA DESCRIPTION (continued)

Map/Lot	Property Location	Owner Name(s)	Parcel Size (acres)
17-40	184 CHIMNEY HILL DR	ROYER RICHARD L	1
17-46	211 CHIMNEY HILL DR	SMITH PATRICIA M & SMITH HERBERT S TRUSTEE	1
17-41	236 CHIMNEY HILL DR	MEEKINS ROBERT E & MEEKINS MARSHA S	1
17-45	237 CHIMNEY HILL DR	OHLER JEFFREY N & OHLER KATHRYN L	1
17-44	267 CHIMNEY HILL DR	ZIDOVSKY ALEX P & JARVIS PAMELA	1
17-42	284 CHIMNEY HILL DR	FOSTER DAVID & FOSTER LYNN C	11
14-8	COON HILL RD	LEITNER DAVID W & LEITNER LINDA	4
14-14-1	49 COON HILL RD	GREGOIRE PAULA	5
14-14	55 COON HILL RD	DACRES ALLEN M	5
17-1	98 COON HILL RD	OBRIEN BROS AGENCY INC	115
14-14-2	269 COON HILL RD	GOODRICH DAVID J & GOODRICH LOUISE	5
14-13	317 COON HILL RD	DAIGLE JAMES & DAIGLE CAROL	1
14-11	445 COON HILL RD	CHAPIN DARYL J	19
14-10	527 COON HILL RD	HARTMAN SUSAN A	32
14-9	573 COON HILL RD	HARBISON JOHN S & PILCHER SUSAN L	6
17-21	29 CORTLAND LANE	GINGRAS MICHAEL J	1
17-21-2	47 CORTLAND LANE	HEBERT A DANIEL & HEBERT SUSAN Y	1
17-21-3	63 CORTLAND LANE	RYAN SEAN C	1
14-26-1	181 GRANDVIEW RD	MEILLEUR ANDREW R & MEILLEUR CORINNE H	1

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TABLE 1: STUDY AREA DESCRIPTION (continued)

Map/Lot	Property Location	Owner Name(s)	Parcel Size (acres)
17-31-7	JASPER MINE RD	GARDNER CONSTRUCTION INC	0
17-24	JASPER MINE RD	COLCHESTER TOWN OF	0
17-12	2 JASPER MINE RD	KELLY JOHN D & KELLY PAMELA A	10
17-12-1	8 JASPER MINE RD	BEAUREGARD REALTY PARTNERSHIP	18
17-12-2	12 JASPER MINE RD	BEAUREGARD ROBERT G & BEAUREGARD HELEN E	2
17-15	17 JASPER MINE RD	MARCOTTE KARL ET AL	0
16-8	25 JASPER MINE RD	HANDY INVESTMENT GROUP	2
17-20-1	29 JASPER MINE RD	LAROE CARL	1
17-16	34 JASPER MINE RD	PRINCE RONALD E & PRINCE JOANN M	10
17-31-5	45 JASPER MINE RD	SCHWANS SALES ENTERPRISES INC	3
17-30	49 JASPER MINE RD	ABBOTT SHERWOOD W & ABBOTT BEATRICE	1
17-31-8	57 JASPER MINE RD	ACTION INDUSTRIES LLC	0
17-18	124 JASPER MINE RD	BAXTER GILBERT A	1
17-19	151 JASPER MINE RD	G R ENTERPRISE INC	1
17-22	204 JASPER MINE RD	BROWN LAWRENCE P P & BROWN SANDRA L	2
17-23	214 JASPER MINE RD	MOREHOUSE BERTHA	0
17-31	257 JASPER MINE RD	GR ENTERPRISES INC	2
17-31-1	271 JASPER MINE RD	MARCHESSAULT ARTHUR A & MARCHESSAULT RITA	1
17-31-3	359 JASPER MINE RD	ACTION INDUSTRIES LLC	5

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TABLE 1: STUDY AREA DESCRIPTION (continued)

Map/Lot	Property Location	Owner Name(s)	Parcel Size (acres)
17-28	414 JASPER MINE RD	PIDGEON LEO H & PIDGEON JOYCE M	2
17-29	468 JASPER MINE RD	ABBOTT SHERWOOD W & ABBOTT BEATRICE	2
17-32-1	494 JASPER MINE RD	GREIG DOUGLAS C & GREIG ALICE M	2
17-32	628 JASPER MINE RD	ESPINOLA CELESTINO & ESPINOLA DONNA	6
16-10	723 JASPER MINE RD	PATTERSON JAMES E	1
16-11	751 JASPER MINE RD	MORIN JAY	0
17-31-6	17 LEE COURT	ACTION INDUSTRIES LLC	1
17-31-4	70 LEE CT	NEWTON GEORGE & NEWTON JOANNE	3
17-26-3	25 MAYO RD	MAYO DOUGLAS A	24
17-26-4	31 MAYO RD	MAYO LEE E & MAYO ALICE M	23
17-26	33 MAYO RD	MAYO LEE E & DOUGLAS A	1
17-25	90 MAYO RD	SCHUMACHER PAUL R & JERTSON JILL E	8
17-27	93 MAYO RD	ARKILLS JAMES W & ARKILLS JANET M	4
17-33	138 MAYO RD	STEWART ROBERT D & SPIES ALLYSON A	3
17-25-1	190 MAYO RD	HAMMER JERAMY A & HAMMER GARY G	1
17-25-2	200 MAYO RD	BEEDE SUSAN M & CIFRIAN DANIEL A	1
17-26-2	243 MAYO RD	MAYO DOUGLAS A	1
17-35	256 MAYO RD	GOLDFIELD JEFFREY J & GOLDFIELD M PAMELA	5
17-34	258 MAYO RD	ROE MICHAEL W & ROE CHERYL A	18

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TABLE 1: STUDY AREA DESCRIPTION (continued)

Map/Lot	Property Location	Owner Name(s)	Parcel Size (acres)
17-25-3	328 MAYO RD	MARTEL WILFRED & MARTEL CAROLYN J	1
17-25-4	354 MAYO RD	BARTON JEFFREY P & BARTON JOANNE M	0
17-26-1	395 MAYO RD	MAYO LEE E & MAYO ALICE M	2
17-25-5	414 MAYO RD	BARNES JOAQUINA R & BARNES JOEL T & TINA L	0
17-26-5	335 MAYO ROAD	MAYO STEPHEN P & MAYO TRACY H	1
17-13-1	NIQUETTE BAY RD	WILLARD PROPERTIES OF BURLINGT	65
17-15-1	NIQUETTE BAY RD	MARCOTTE KARL ET AL & C/O FLOYD MARCOTTE	7
17-14	246 NIQUETTE BAY RD	SONNTAG PAUL & SONNTAG KIM M	18
16-10-1	114 RAYMOND RD	ROCHELEAU DAVID P & ROCHELEAU KATHY J	4
16-7	135 RAYMOND RD	HENNIG ALEXANDER & HENNIG ANDREA	1
16-6	170 RAYMOND RD	PITTS GREGORY A	2
14-30	ROOSEVELT HWY	HANDY MOUNTAHA	1
17-5	ROOSEVELT HWY	QUIGLEY MICHAEL M & QUIGLEY EILEEN F	7
17-6	ROOSEVELT HWY	CD CAIRNS IRREVOCABLE TRUST PARTNERSHIP	14
14-22	ROOSEVELT HWY	WICHMANN MARY ANN & LEBLANC FREDERICK	120
17-7	ROOSEVELT HWY	LAKE CHAMPLAIN TRANS CO	1
14-26-2	ROOSEVELT HWY	LAKE CHAMPLAIN BASIN SCIENCE CTR	148
14-27	ROOSEVELT HWY	RUBMAN JEFFREY W & RUBMAN CLAIRE J	114
14-26	577 ROOSEVELT HWY	ROWLEY J M CORPORATION	18

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TABLE 1: STUDY AREA DESCRIPTION (continued)

Map/Lot	Property Location	Owner Name(s)	Parcel Size (acres)
14-32	602 ROOSEVELT HWY	OBRIEN BROTHERS AGENCY INC	58
14-24	5744 ROOSEVELT HWY	REICHARD H CLINTON & REICHARD CAROL J	1
14-23	5779 ROOSEVELT HWY	GUYETTE JON & GUYETTE JAY E	1
14-25	5819 ROOSEVELT HWY	CAX LLC	1
14-28	5912 ROOSEVELT HWY	LUEDEKE SALLY J	5
14-31	5956 ROOSEVELT HWY	RICKER JAMES R	5
14-29	6068 ROOSEVELT HWY	WORTHEN GILBERT & WORTHEN LISA	0
17-31-2	ROUTE 2	FORMAN HAROLD C & FORMAN RITA M	67
17-20	ROUTE 2	GEAKE HAZEL	10
17-10	ROUTE 2	BUSHEY EUNICE EXECUTRIX & BUSHEY KERMIT H REVOCABLE TRUST	4
17-11	ROUTE 2	RUBMAN JEFFREY W & RUBMAN CLAIRE J	4
17-13	ROUTE 2	WILLARD PROPERTIES	24
17-4-3	US ROUTE 7	ARBOR ONE L.P. & C/O HDI REAL ESTATE INC	0
17-9	77 US ROUTE 7	SISTERS & BROTHERS INVST GROUP & C/O HANDY'S TEXACO	2
17-4-2	120 US ROUTE 7	ARBOR ONE L.P. & C/O EP MANAGEMENT CORP	16
17-4	210 US ROUTE 7	ARBORTECH INC	18
17-4-1	400 US ROUTE 7	VERMONT STATE OF & DEPT OF ST BLDGS & GEN SERVICE	6
17-2	431 US ROUTE 7	MUZZY BRIAN S & MUZZY NANCY A	1

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Source: Colchester Assessor Data
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Date/Init: 12/23/02, bp; rev 01/03/03 anm

TABLE 2

NRCS SOILS CHARACTERISTICS WITHIN THE STUDY AREA

Name	Depth to Seasonal High Groundwater Table (feet)		Depth to Bedrock (inch)		Total Acres	Percent	Septic Suitability
	Shallow	Deep	Shallow	Deep			
AdA-ADAMS AND WINDSOR LOAMY SANDS, 0 TO 5 PERCENT SLOPES	6	6	60	60	92	8.5	1
AdB-ADAMS AND WINDSOR LOAMY SANDS, 5 TO 12 PERCENT SLOPES	6	6	60	60	13	1.2	1
AdE-ADAMS AND WINDSOR LOAMY SANDS, 30 TO 60 PERCENT SLOPES	6	6	60	60	29	2.6	1 b
An-ALLUVIAL LAND	Not Rated	Not Rated	Not Rated	Not Rated	11	1.0	7
BlA-BELGRADE AND ELDRIDGE SOILS, 0 TO 3 PERCENT SLOPES	1	3.5	60	60	21	1.9	4
CaC-CABOT STONY SILT LOAM, 3 TO 15 PERCENT SLOPES	0	2	60	60	5	0.5	6
Cv-COVINGTON SILTY CLAY	0.5	1	60	60	9	0.9	6
DdA-DUANE AND DEERFIELD SOILS, 0 TO 5 PERCENT SLOPES	1.5	3	60	60	12	1.1	4
DdB-DUANE AND DEERFIELD SOILS, 5 TO 12 PERCENT SLOPES	1.5	3	60	60	2	0.2	4
EwA-ENOSBURG AND WHATELY SOILS, 0 TO 3 PERCENT SLOPES	0	1.5	60	60	8	0.7	6
FaC-FARMINGTON EXTREMELY ROCKY LOAM, 5 TO 20 PERCENT SLOPES	6	6	10	20	123	11.3	6
FaE-FARMINGTON EXTREMELY ROCKY LOAM, 20 TO 60 PERCENT SLOPES	6	6	10	20	79	7.2	6
FsB-FARMINGTON-STOCKBRIDGE ROCKY LOAMS, 5 TO 12 PERCENT SLOPES	6	6	10	60	13	1.2	5 a
FsC-FARMINGTON-STOCKBRIDGE ROCKY LOAMS, 12 TO 20 PERCENT SLOPES	6	6	10	60	4	0.4	5 a
Gp-NO DATA	0	0	0	0	0	0.0	
HlB-HARTLAND VERY FINE SANDY LOAM, 2 TO 6 PERCENT SLOPES	6	6	60	60	16	1.5	3
HnA-HINESBURG FINE SANDY LOAM, 0 TO 3 PERCENT SLOPES	1.5	2.5	60	60	21	1.9	4
HnB-HINESBURG FINE SANDY LOAM, 3 TO 8 PERCENT SLOPES	1.5	2.5	60	60	24	2.2	4
HnD-HINESBURG FINE SANDY LOAM, 15 TO 25 PERCENT SLOPES	1.5	2.5	60	60	5	0.4	4 c

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Sources: National Resource Conservation Service (NRCS); Study Area - SEI.

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TABLE 2 (continued)
NRCS SOILS CHARACTERISTICS WITHIN THE STUDY AREA

Name	Depth to Seasonal High Groundwater Table (feet)		Depth to Bedrock (inch)		Total		Septic
	Shallow	Deep	Shallow	Deep	Acres	Percent	Suitability
HnE-HINESBURG FINE SANDY LOAM, 25 TO 60 PERCENT SLOPES	1.5	2.5	60	60	2	0.2	6
Le-LIMERICK SILT LOAM	0	1.5	60	60	16	1.5	6
Lh-LIVINGSTON CLAY	0	1	60	60	1	0.1	6
LmB-LYMAN-MARLOW ROCKY LOAMS, 5 TO 12 PERCENT SLOPES	2	6	10	60	2	0.1	5 a
LyD-LYMAN-MARLOW VERY ROCKY LOAMS, 5 TO 30 PERCENT SLOPES	2	6	10	60	33	3.0	5 a,c
MuD-MUNSON AND BELGRADE SILT LOAMS, 12 TO 25 PERCENT SLOPES	0.5	2	60	60	55	5.1	4 c
MyB-MUNSON AND RAYNHAM SILT LOAMS, 2 TO 6 PERCENT SLOPES	0	2	60	60	158	14.5	6
MyC-MUNSON AND RAYNHAM SILT LOAMS, 6 TO 12 PERCENT SLOPES	0	2	60	60	109	10.0	6
Rk-ROCK LAND	6	6	0	0	37	3.4	7
ScA-SCANTIC SILT LOAM, 0 TO 2 PERCENT SLOPES	0	1	60	60	111	10.2	6
ScB-SCANTIC SILT LOAM, 2 TO 6 PERCENT SLOPES	0	1	60	60	10	0.9	6
Sd-SCARBORO LOAM	-1	1	60	60	2	0.2	6
TeE-TERRACE ESCARPMENTS, SILTY AND CLAYEY	Not Rated	Not Rated	Not Rated	Not Rated	67	6.2	7

FA&A *Forcier, Aldrich, Associates, Inc.* STONE ENVIRONMENTAL INC.

Sources: National Resource Conservation Service (NRCS); Study Area - SEI.
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TABLE 3: BUILD-OUT ANALYSIS -- SUMMARY OF RESULTS

Zoning District	Land in Study Area	All Residential		All Commercial Units		Max PUD Residential		Max PUD Commercial		50% PUD 75% Residential		50% PUD 25% Commercial		No PUD, 75% Residential		No PUD, 25% Commercial	
	(Acres)	Initial	Refined	Initial	Refined	Initial	Refined	Initial	Refined	Initial	Refined	Initial	Refined	Initial	Refined	Initial	Refined
AGR	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COM	2	0	0	3	3	0	0	3	3	0	0	3	3	0	0	0	0
GD1	1	5	5	2	2	5	5	2	2	5	5	2	2	4	4	0	0
GD4	354	1,545	661	579	60	1,466	653	29	3	1,312	637	87	9	1,158	621	144	15
GD4C	81	354	261	133	97	336	247	6	4	301	221	19	14	266	195	33	24
GOV	108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R1	174	189	170	0	0	189	170	0	0	189	170	0	0	142	128	0	0
RR	29	6	6	0	0	6	6	0	0	6	6	0	0	4	4	0	0
Total Buildout	**762**	**2,099**	**1,103**	**717**	**162**	**2,002**	**1,081**	**40**	**12**	**1,813**	**1,039**	**111**	**28**	**1,574**	**952**	**177**	**39**

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Source: SEI database Buildout.mdb

Notes: All buildout analysis results are reported in numbers of buildable units

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10/23/02 DJH, rev 12/13/02 ANM

CRITERIA USED FOR CALCULATING BUILD-OUT FOR EACH STUDY AREA ZONING DISTRICT

ZONE	RESIDENTIAL CRITERIA	COMMERCIAL CRITERIA
AGR	minimum lot size for duplex = 25 acres	no commercial units
COM	no residential units	minimum lot size for commercial use = 20,000 sq ft
GD1	minimum lot size for duplex = 7,500 sq ft	minimum lot size for commercial use = 20,000 sq ft
GD4	minimum lot size for duplex = 7,500 sq ft	minimum lot size for commercial use = 20,000 sq ft
GD4C	minimum lot size for duplex = 7,500 sq ft	minimum lot size for commercial use = 20,000 sq ft
GOV	no residential units (roadways)	no commercial units (roadways)
R1	minimum lot size for duplex = 0.6887 acres (30,000 sq ft)	no commercial units
RR	minimum lot size for duplex = 3.5 acres	no commercial units

Source: Town of Colchester Zoning Regulations

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10/23/02 DJH, rev 11/04/02 ANM

TABLE 4: BASIS FOR REFINEMENT OF BUILDOUT ANALYSIS

Development/Owner Name	Existing Land Use	Future Land Use	Wastewater System Type	Status
Chimney Hill Road Subdivision	16 Residential lots	no change	Individual Onsite	Permitted/Constructed
Willard Properties	Open	<=300 resid. units	Approx. 2,000 gpd capacity onsite	Limited onsite, proposed for offsite
Brentwood Park Subdivision	Industrial/Comm. lots	no change	Individual/Cluster onsite	Permitted/Being Constructed
Service Station Lot	Service Station	no change	Connecting To Brentwood Park	Permitted/Constructed
Jeffrey Rubman Property	Open	<=200 residential units	Approx. 4,000 gpd capacity onsite	Limited onsite, proposed for offsite
State of Vermont AOT Lot	Storage/office Buildings	no change	Individual onsite	Permitted/Constructed
Jay Wiley Arbortech Lot	Commercial Unit - Landscaping business	no change	Connecting To Brentwood Park	Permitted/Constructed
Jay Wiley Arbor Gardens	37 Residential Apartments	additional units, restaurant	Onsite cluster	Permitted/Under Construction
O'Brien Brothers Agency	Open	Residential/commercial units	Indiv./Cluster onsite	Proposed/Have onsite capacity

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Source: Meetings with landowners; State of Vermont permit files; Town of Colchester permit files

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Table 5: Summary of Requirements Under the 2002 EPRs

Planning / Municipal Requirements	
Before 7/1/2007	Municipalities may choose to adopt either the "new" Rules or the Small Scale Wastewater Treatment and Disposal Rules (August 8, 1996). Municipalities may not adopt or amend a sewage ordinance or a zoning bylaw that imposes criteria more stringent than the rules on which they are based All ordinances / amendments must be reviewed / approved in writing by the Secretary Enhanced Prescriptive and Performance-based approaches cannot be used on lots subdivided after 6/14/02 UNLESS: * Municipality has a planning process confirmed under 24 V.S.A. §4350 * Municipality has zoning bylaws Enhanced Prescriptive and Performance-based approaches may be used on lots greater than 10 acres created between 6/13 and 11/1/02 without meeting planning and zoning prerequisites
After 6/30/2007	Existing ordinances establishing technical standards for potable water supplies and wastewater systems are superceded by criteria of the "new" rules and the Vermont Water Supply Rules Municipalities may continue to have ordinances and zoning bylaws regulating water supplies and wastewater systems only: * To eliminate permit exemptions contained in the "new" Rules * To establish requirements for the processing of permits consistent with the "new" Rules

Site Conditions	Prescriptive	Enhanced Prescriptive	Performance-based
Soil Conditions	24" natural soil to seasonal high groundwater table	12" (or A horizon + 4") natural soil to seasonal high groundwater table; less than 18" to eshgw must lower water table	Maintain 6" unsaturated soil above effluent plume (desktop or on-site hydrogeologic analysis required)
	24" to impermeable soil 24" natural soil to ledge / bedrock Perc rate = 120 min/in or less	18" to impermeable soil 18" natural soil to ledge / bedrock Perc rate = 120 min/in or less	18" natural soil to ledge / bedrock
Slope Conditions	Maximum slope = 30% for lots created before 6/14/02	Slope is at least 3% but not more than 30% (for lots created before 6/14/02) or 20% (for lots created after 6/14/02)	Maximum slope = 20% for lots created after 6/14/02
	Maximum slope = 20% for lots created after 6/14/02; Slope shall never exceed 30%	Linear loading rate not greater than 2 gal/day/ft	Maximum slope for other lots = 30% unless specific approval granted (includes replacement systems); special conditions for system on greater than 30% slope
Other Conditions		Approvable conditions continue at least 25' downhill from system toe	

Table 5: Summary of Requirements Under the 2002 EPRs

System Design (Absorption Trenches)	3' separation to seasonal high groundwater table or impervious soil 4' separation to ledge / bedrock Perc rate must be between 4 and 60 min/in Maximum loading rate = 1.5 gal/day/sqft Maximum slope = 30% (except under performance-based standard) Maximum width = 48" Maximum depth = 36" Absorption trenches on slope must be parallel to ground contours At least 4' of undisturbed soil between trenches; trenches shall be at least 6' on center Trench cover = 6-12" permeable soil (uppermost 2-4" = topsoil) Area reductions may be allowed where depth of crushed stone exceeds 12" depth below distribution pipe (see table p. 88)

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Source: Vermont Environmental Protection Rules, Chapter 1, Wastewater System and Potable Water Supply Rules, effective August 16, 2002

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int: 10/09/02 anm; rev: 01/14/02 anm

Table 6
Wastewater Flow Projections - Entire Study Area

	Total Flow (gpd)				
Zoning District	All Residential	All Commercial	Max PUD Residential Max PUD Commercial	50% PUD Residential 50% PUD Commercial	No PUD, 75% Residential No PUD, 25% Commercial
AGR	0	0	0	0	0
COM	0	1,080	1,080	1,080	0
GD1	1,120	720	1,840	1,840	896
GD4	346,080	208,440	338,824	325,208	311,232
GD4C	79,296	47,880	77,424	74,264	71,464
GOV	0	0	0	0	0
R1	42,336	0	42,336	42,336	31,808
RR	1,344	0	1,344	1,344	896
Projected Total Flows	470,176	258,120	462,848	446,072	416,296

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Notes:

1. The estimated wastewater flows were developed using the Environmental Protection Rules, Subchapter 5, Design Flows, effective August 16, 2002.
2. Estimated flows for residential units are based on the following: (2 bedrooms X 2 persons/bedroom X 70 gpd per person per day X 80% =224 gpd).
3. Estimated flows for commercial units are based on the following: (450 gpd per lot X 80% = 360 gpd).
4. An allowance for infiltration is not included in the projected flows.
5. The 80% flow reduction is incorporated into the projected flows which applies to projects to be connected to a wastewater system with a design capacity of 50,000 gpd or greater.

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Table 7
Wastewater Flow Projections - Refined Results

	Total Flow (gpd)				
Zoning District	All Residential	All Commercial	Max PUD Residential Max PUD Commercial	50% PUD Residential 50% PUD Commercial	No PUD, 75% Residential No PUD, 25% Commercial
AGR	0	0	0	0	0
COM	0	1,080	1,080	1,080	0
GD1	1,120	720	1,840	1,840	896
GD4	148,064	21,600	147,352	145,928	144,504
GD4C	58,464	34,920	56,768	54,544	52,320
GOV	0	0	0	0	0
R1	38,080	0	38,080	38,080	28,672
RR	1,344	0	1,344	1,344	896
Projected Total Flows	247,072	58,320	246,464	242,816	227,288

FA&A *Forcier, Aldrich, & Associates Inc.* STONE ENVIRONMENTAL, INC.

Notes:

1. The estimated wastewater flows were developed using the Environmental Protection Rules, Subchapter 5, Design
2. Estimated flows for residential units are based on the following: (2 bedrooms X 2 persons/bedroom X 70 gpd per
3. Estimated flows for commercial units are based on the following: (450 gpd per lot X 80% = 360 gpd).
4. An allowance for infiltration is not included in the projected flows.
5. The 80% flow reduction is incorporated into the projected flows which applies to projects to be connected to a

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Table 8
Ricker Cluster Site Disposal Capacity

Level of Treatment	Disposal Capacity (gpd)
Domestic Wastewater	2,500
With Effluent Treatment	5,000
With Effluent Treatment and 24" Depth of Stone	6,499

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Notes:
1. The capacities are based on the disposal area and loading rates developed by SEI.
2. The disposal capacities are based on a preliminary layout using absorption trenches and a replacement area of similar size.
3. The capacities were developed using the EPR's effective August 16, 2002.
4. Capacities exceeding 6,500 gpd require compliance with the Indirect Discharge Rules.

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Table 9
Ricker Cluster Estimated Construction Cost

Item Description	Estimated Construction Cost (ENR 6600)
General Requirements	$12,000
Sitework/Yard Piping	$15,000
Septic Tanks	$20,000
Treatment System (2)	$60,000
Dosing Pump Station and Force Main	$25,000
Disposal System	$20,000
Estimated Total (3)	$152,000

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Notes:
1. The estimated construction cost is based on a system with a disposal capacity of up to 6,499 gpd.
2. The treatment system cost is based on an Advantex Treatment System.
3. The estimated construction cost above doesn't include a 10% construction contigency.
4. ENR 6600 = November 2002.

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Table 10
Ricker Cluster Estimated First Year O&M Costs

Item Description	Initial Year
Labor (1)	$6,000
Benefits (2)	$2,400
Utilities	$750
Septic Tank Pumping	$2,000
Sampling and Monitoring	$1,200
Miscellaneous Repairs	$1,000
Depreciation	$0
Estimated Total	$13,350

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Notes:
1. The labor is based on an average of 1 hour per day at 7 days per week.
2. The benefits are based on 40% of the labor costs.

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int: 01/09/02 we; rev: 01/13/02 anm

Table 11
Rubman Cluster Site Disposal Capacity

Level of Treatment	Disposal Capacity (gpd)
Domestic Wastewater	1,300
With Effluent Treatment	2,600
With Effluent Treatment and 24" Depth of	4,000

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Notes:
1. The capacities are based on the disposal area and loading rates developed by SEI.
2. The disposal capacities are based on a preliminary layout using absorption trenches and a replacement area of similar size.
3. The capacities were developed using the EPRs effective August 16, 2002.

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Table 12
Rowley Sand Pit Disposal Capacity

Level of Treatment	Disposal Capacity (gpd)
Septic Tank Effluent	16,000
With Effluent Treatment - Secondary +	48,000
With Effluent Treatment - Tertiary	80,000

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Notes:
1. The capacities are based on the disposal area and loading rates developed by SEI.
2. The disposal capacities are based on a preliminary layout using absorption trenches.
3. Capacities exceeding 6,500 gpd require compliance with the Indirect Discharge Rules.
4. Disposal capacities ranging from 30,001 to 50,000 gpd require secondary+ level of treatment prior to disposal.
5. Disposal capacities exceeding 50,000 gpd require tertiary treatment prior to disposal.

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Table 13
Rowley Sand Pit Cluster with Onsite Treatment Option -
Phase I Estimated Construction Cost

Item Description	Estimated Construction Cost (ENR 6600)
Sewer Collection System	$350,000
Onsite Treatment Systems (1)	$0
Effluent Pumping System	$640,000
Dispersal System	$550,000
Estimated Total (2)	$1,540,000

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Notes:
1. The sewer collection system is based on the low pressure sewer system.
2. The estimated construction cost doesn't include the onsite treatment systems and pump stations.
3. The estimated construction cost above doesn't include a 10% construction contigency.
4. ENR 6600 = November 2002.
5. A detailed breakdown of construction costs for each project element is provided in Appendix C.

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Table 14
Rowley Sand Pit Cluster with Onsite Treatment
Phase I Estimated First Year O&M Costs

Item Description	Initial Year
Labor (1)	$9,600
Benefits (2)	$3,900
Utilities	$5,000
Chemicals	$500
Maintenance	$2,500
Miscellaneous Repairs	$2,500
Sludge Disposal	$1,500
Lab Service/Monitoring	$12,000
Capital Replacement	$2,500
Administration	$2,500
Insurance	$1,000
Professional Services	$1,000
Annual Operating Fee	$2,000
Depreciation	$0
Estimated Total	$46,500

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Notes:

1. The labor is based on an average of 2 hours per day at 5 days per week.
2. The benefits are based on 40% of the labor costs.

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Table 15
Rowley Sand Pit Cluster - Centralized Treatment Option
Estimated Construction Cost

Item Description	Estimated Construction Cost (ENR 6600)
Sewer Collection System	$1,150,000
Tertiary Treatment System (2)	
General Requirements (8%)	$150,000
Sitework/Yard Piping	$100,000
Preliminary Treatment	$175,000
Flow Equalization	$125,000
Treatment System	$800,000
UV Disinfection System	$125,000
Sludge Holding Tanks	$100,000
Control Building	$200,000
Emergency Generator	$75,000
Misc. Equipment	$75,000
Effluent Pumping System	$640,000
Dispersal System	$550,000
Estimated Total (3)	$4,265,000

FA&A *Forcier, Aldrich, & Associates Inc.* STONE ENVIRONMENTAL, INC.

Notes:

1. The sewer collection system is based on the conventional system with gravity sewers and pump stations.
2. The estimated construction cost for the treatment system is based on an ultrafiltration membrane system.
3. The estimated construction cost above doesn't include a 10% construction contigency.
4. ENR 6600 = November 2002.
5. A detailed breakdown of the construction cost for each project element is provided in Appendix ??.

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Table 16

Rowley Sand Pit Cluster - Centralized Treatment Option

Estimated First Year O&M Costs

Item Description	Initial Year
Labor [1]	$26,500
Benefits [2]	$10,500
Utilities	$17,500
Chemicals	$2,500
Maintenance	$5,000
Miscellaneous Repairs	$5,000
Sludge Disposal	$16,000
Lab Service/Monitoring	$20,000
Capital Replacement	$5,000
Administration	$5,000
Insurance	$2,500
Professional Services	$2,500
Annual Operating Fee	$2,000
Depreciation	$0
Estimated Total	$120,000

FA&A *Forcier, Aldrich, & Associates Inc.* STONE ENVIRONMENTAL, INC.

Notes:

1. The labor is based on an average of 4 hours per day at 7 days per week.
2. The benefits are based on 40% of the labor costs.

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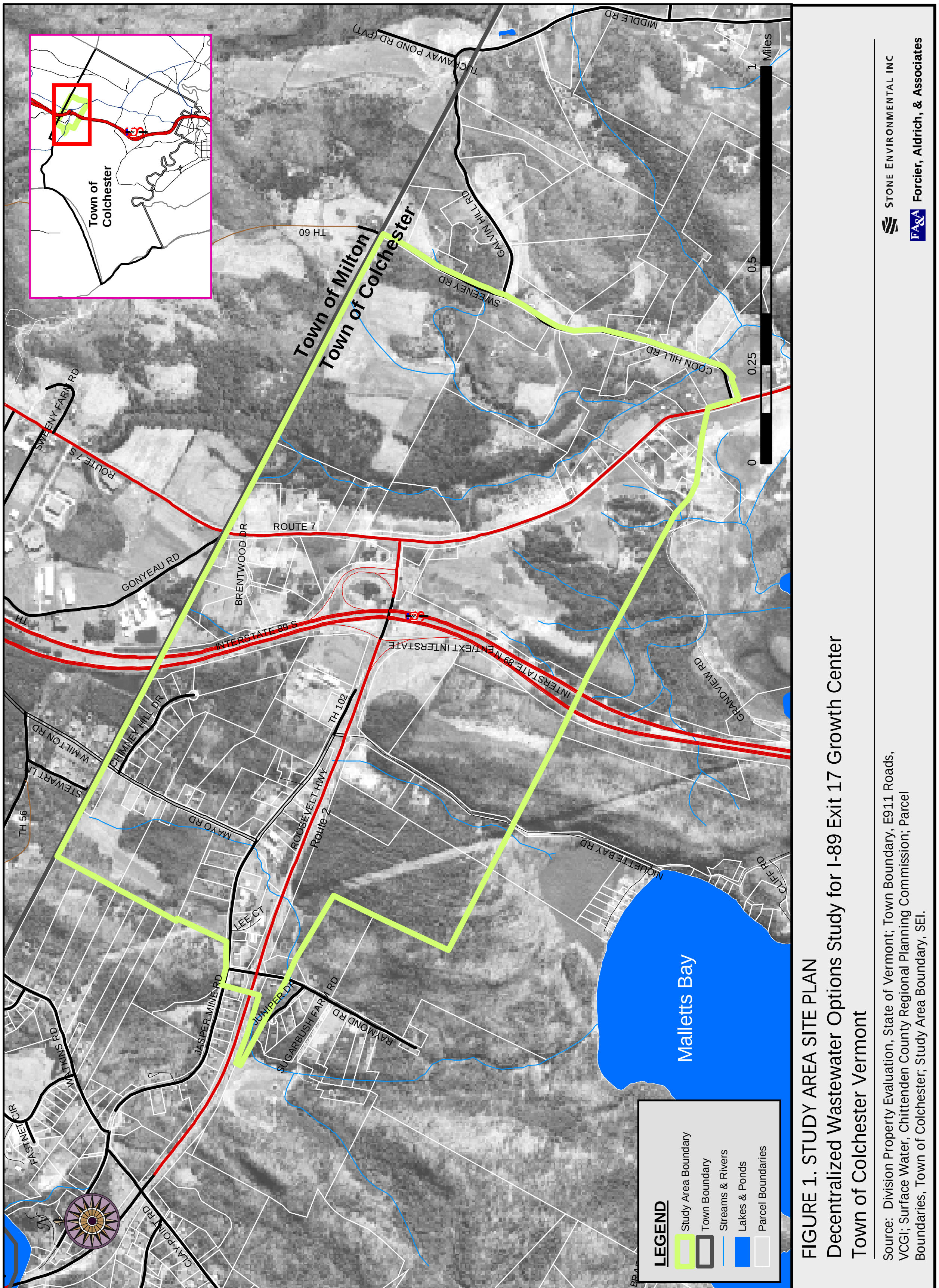

FIGURE 1. STUDY AREA SITE PLAN
Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center
Town of Colchester Vermont

Source: Division Property Evaluation, State of Vermont; Town Boundary, E911 Roads, VCGI; Surface Water, Chittenden County Regional Planning Commission; Parcel Boundaries, Town of Colchester; Study Area Boundary, SEI.

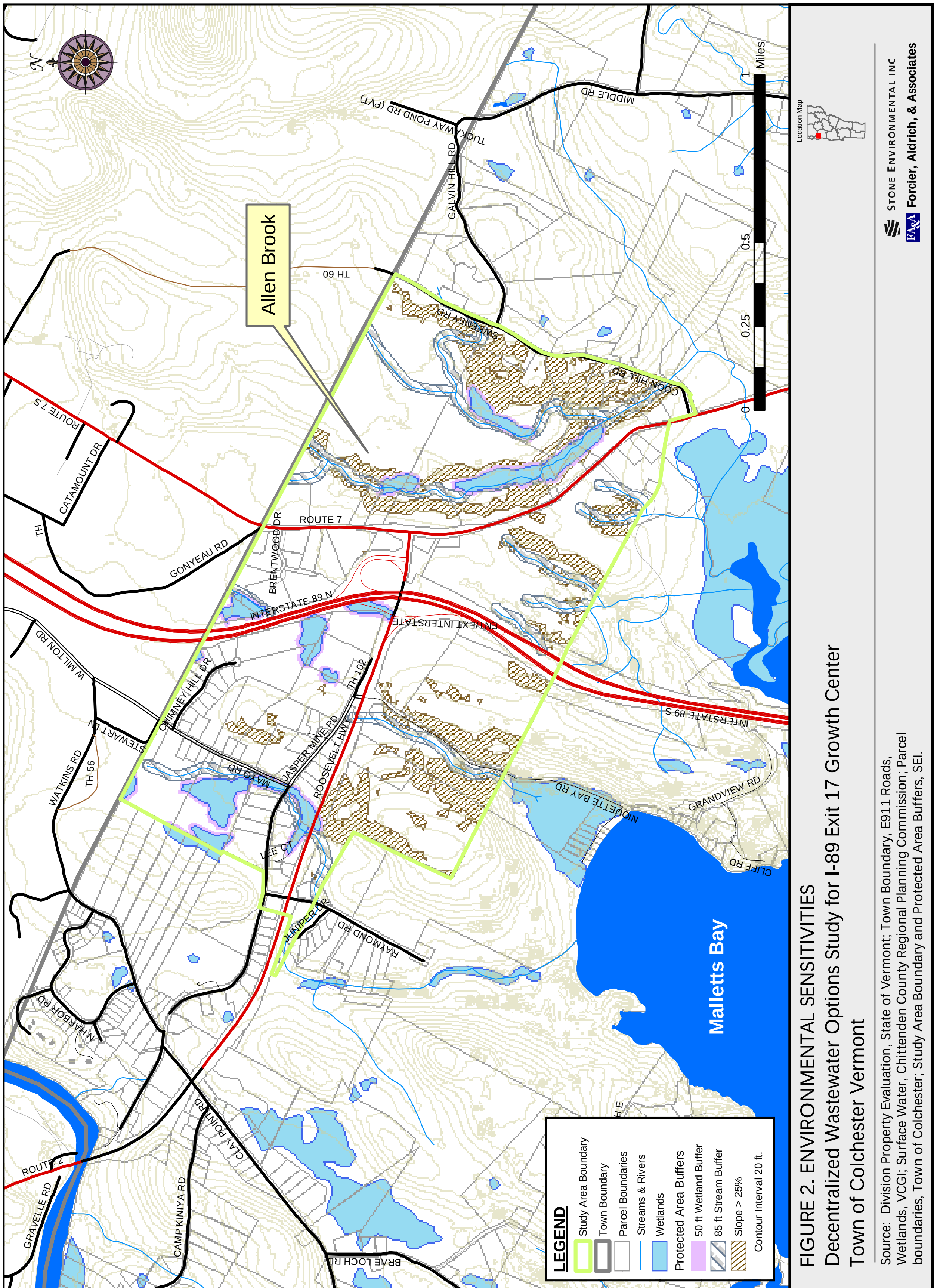

FIGURE 2. ENVIRONMENTAL SENSITIVITIES
Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center
Town of Colchester Vermont

Source: Division Property Evaluation, State of Vermont; Town Boundary, E911 Roads, Wetlands, VCGI; Surface Water, Chittenden County Regional Planning Commission; Parcel boundaries, Town of Colchester; Study Area Boundary and Protected Area Buffers, SEI.

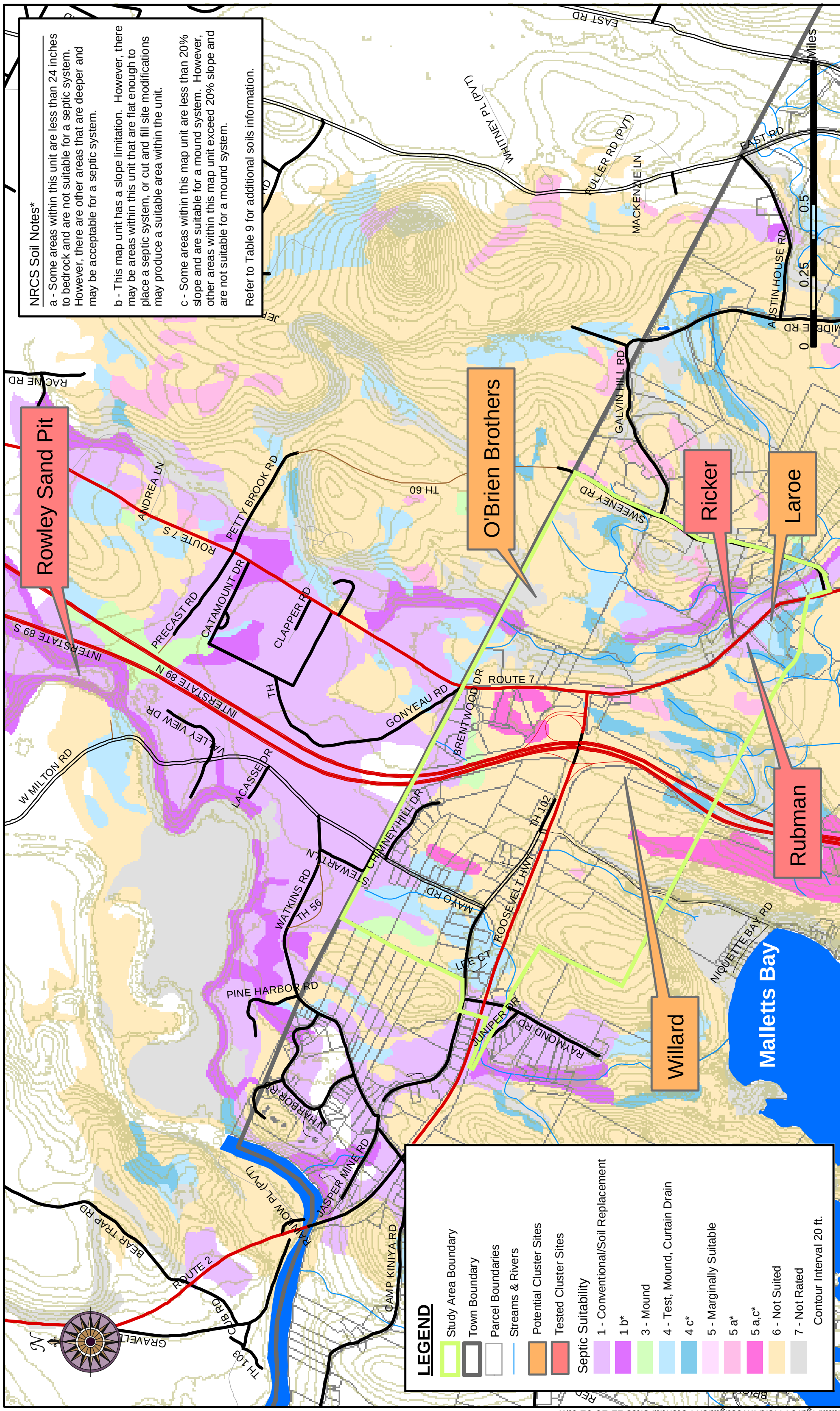

FIGURE 3. SOIL SUITABILITY AND POTENTIAL CLUSTER SITES
Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center
Town of Colchester, Vermont

Source: Division Property Evaluation, State of Vermont; Town Boundary, E911 Roads, VCGI; Surface Water and Zoning, Chittenden County Regional Planning Commission; Parcel Boundaries, Town of Colchester; Study Area Boundary and Protected Area Buffers, SEI; Septic Suitibility, NRCS.

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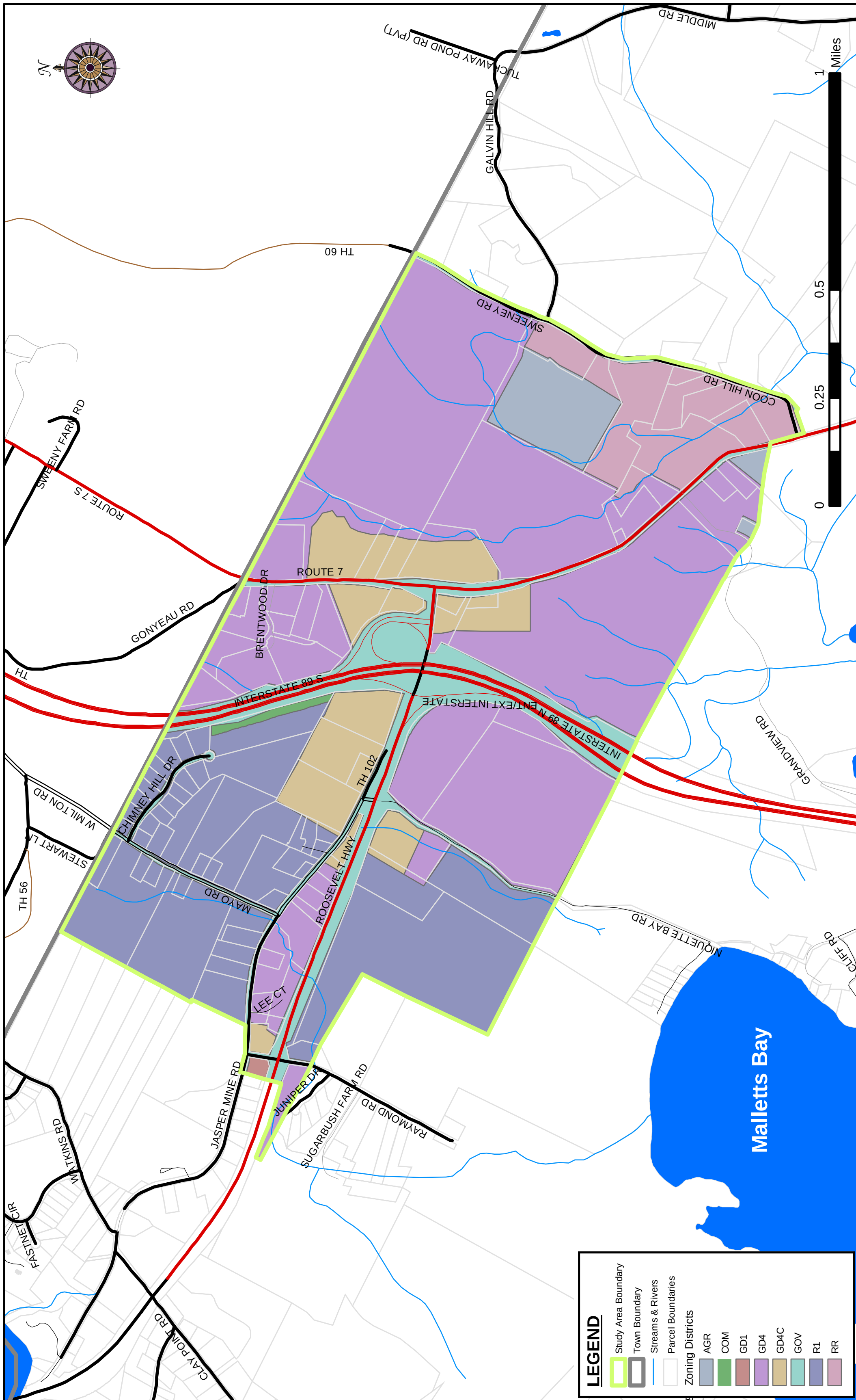


FIGURE 4. STUDY AREA ZONING DISTRICTS

Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center

Town of Colchester Vermont

Source: division Property Evaluations, State of Vermont; town Boundary, E911 Roads, VCGI; Surface Water and Zoning, Chittenden County Regional Planning Commission; Parcel Boundaries, Town of colchester; Study Area Boundary, SEI.

Location Map

STONE ENVIRONMENTAL INC

Forcier, Aldrich, & Associates

O:\Proj-01\1240-W-Colc-Exit17\Gisdata\Figure 2-StudyAreaZoningDistricts.mxd 10-3-02 caw

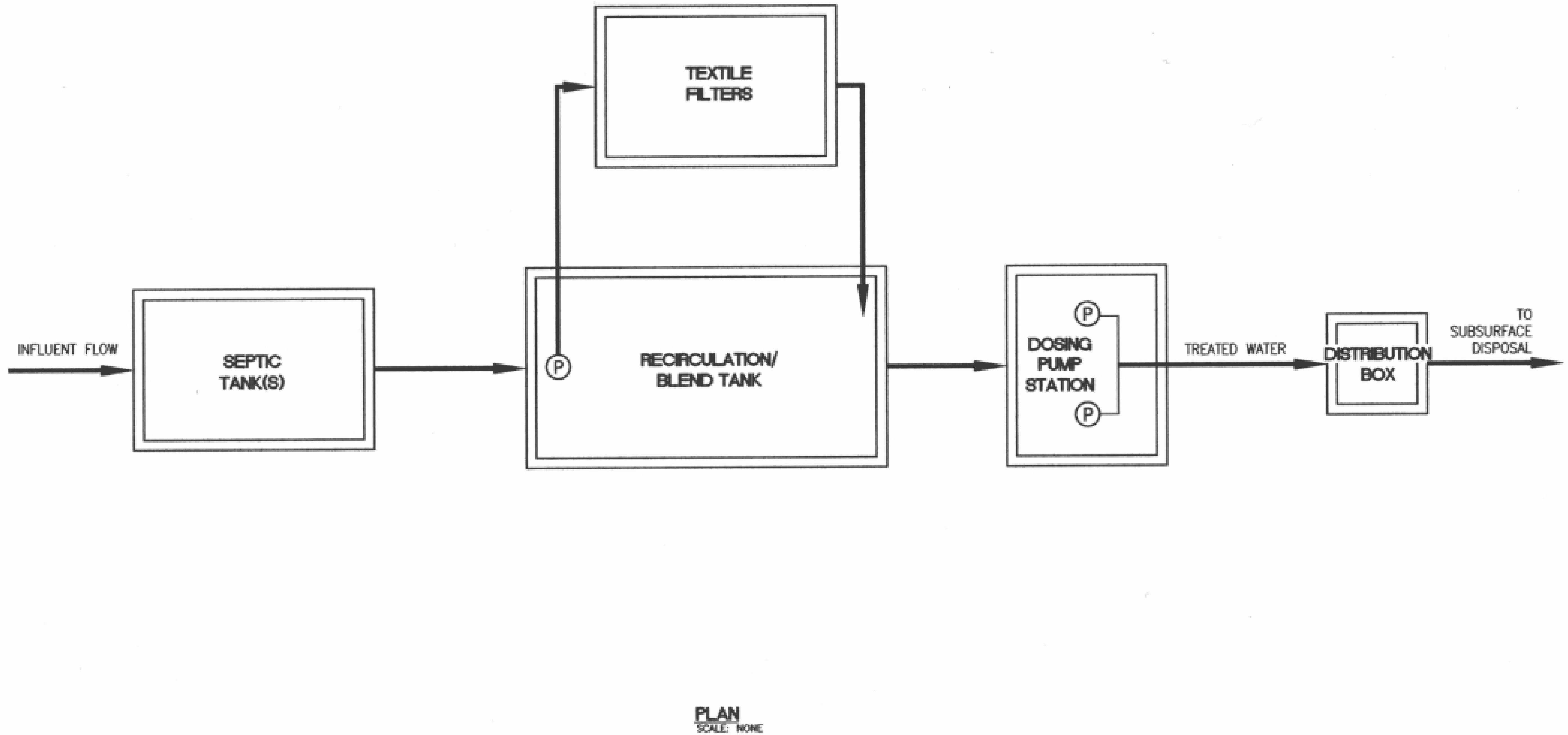
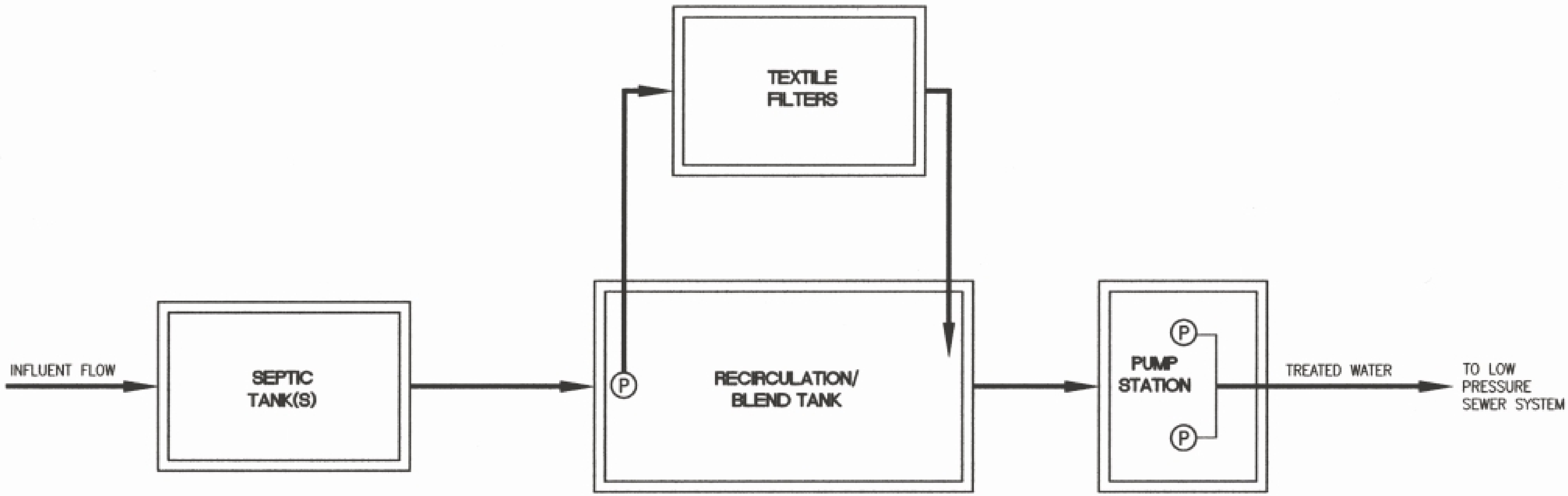


FIGURE 6 - CLUSTER TREATMENT SYSTEM SCHEMATIC

Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center
Town of Colchester, Vermont

STONE ENVIRONMENTAL INC
FORCIER ALDRICH & ASSOCIATES, INC.



PLAN
SCALE: NONE

FIGURE 8 - TYPICAL ON-SITE TREATMENT SYSTEM SCHEMATIC-PHASE I

Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center
Town of Colchester, Vermont

STONE ENVIRONMENTAL INC

FORCIER ALDRICH & ASSOCIATES, INC.

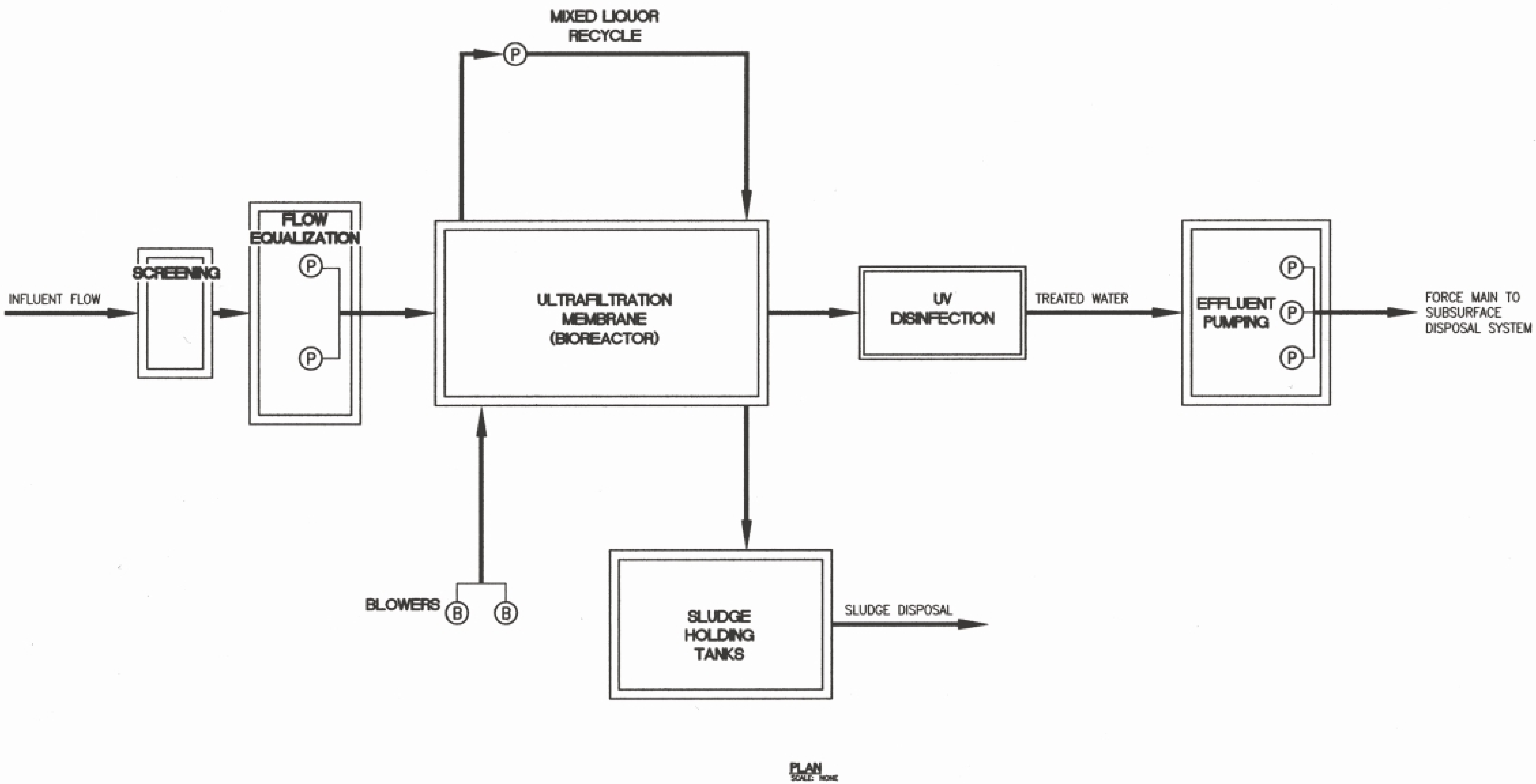
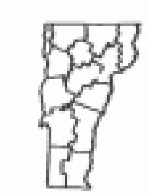


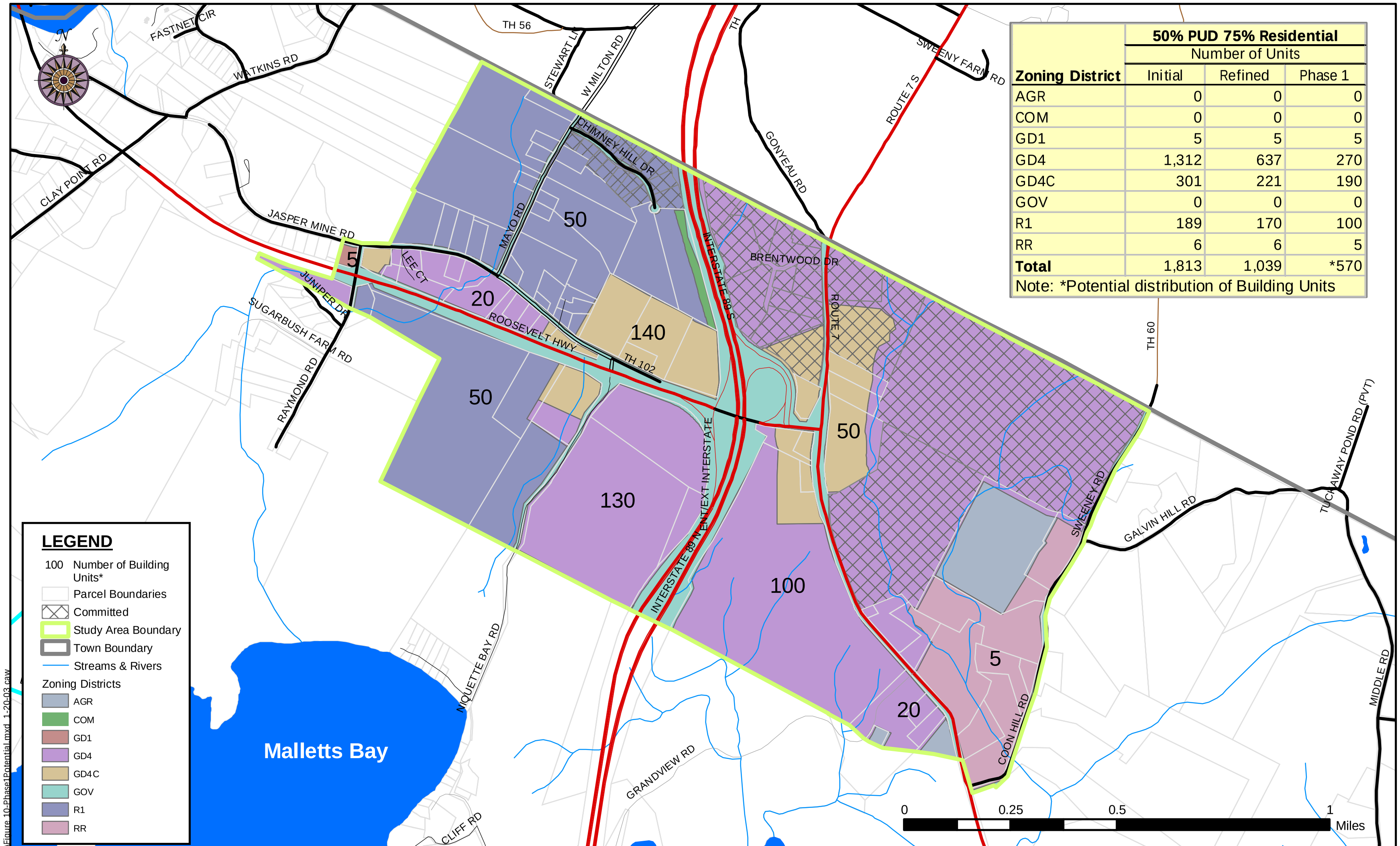
FIGURE 10 - CENTRALIZED TREATMENT SYSTEM SCHEMATIC

Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center
Town of Colchester, Vermont



STONE ENVIRONMENTAL INC

FORCIER ALDRICH & ASSOCIATES, INC.



Zoning District	50% PUD 75% Residential Number of Units Initial	Refined	Phase 1
AGR	0	0	0
COM	0	0	0
GD1	5	5	5
GD4	1,312	637	270
GD4C	301	221	190
GOV	0	0	0
R1	189	170	100
RR	6	6	5
Total	1,813	1,039	*570

Note: *Potential distribution of Building Units

FIGURE 11. PHASE 1 POTENTIAL GROWTH USING 50% PUD AND CONTAINING 75% RESIDENTIAL
Decentralized Wastewater Options Study for I-89 Exit 17 Growth Center
Town of Colchester Vermont

Source: Division Property Evaluations, State of Vermont; Town Boundary, E911 Roads, VCGI; Surface Water and Zoning, Chittenden County Regional Planning Commission; Parcel Boundaries, Town of Colchester; Study Area Boundary, SEI.

O:\Proj-01\1240-W-Colc-Exit17\Gisdata\Figure 10-Phase1Potential.mxd 1-20-03 caw

APPENDIX A: DETAILED METHODOLOGY FOR BUILDOUT ANALYSIS

APPPENDIX A: DETAILED METHODOLOGY FOR DETERMINATION OF BUILDOUT IN STUDY AREA

I Data Preprocessing

All data layers created were stored at *O:\Proj-01\1240-W-Colc-Exit17\Gisdata* (further noted as ~\).

a. Study Area
The Study area boundary was determined by SEI from the EXIT 17 Growth Study maps and saved as ~*\Gisdata\SEI_LAYERS*\studyarea-sei.shp. *Note: The study area divides some parcels and does not always follow parcel boundaries.*

b. GD4 and GD4C Zones
The new Zones GD4 and GD4C had to be incorporated into the Zoning layer. This was done using the following steps:

1. GIS layers for GD4 and GD4C were obtained from the town (data located at ~\exit17\) and "Unioned" using the Geoprocessing Wizard in ArcMap.
2. Unioned the old Zoning coverage (~\zn97) with the new layer created in Step 1(GD4 and GD4C districts).
3. Added two new fields to the attribute table called NEWZONE and DESCRIP and populated the new fields with data in the ABBREV and DISTRICT fields and then modify the GD4 and GD4C polygons to have the appropriate NEWZONE and DESCRIP for those zones (i.e. GD4 – General Development GD-4; GD4C – General Development-Commercial District GD-4C). Fixed any code errors on sliver polygons and saved as ~*\SEI_LAYERS*\NewZones_Colchester.shp
4. Intersected the Zoning layer (from the previous step) with the Study area boundary *(~\Gisdata\SEI_LAYERS*\studyarea-sei.shp).
5. Fixed any code errors on sliver polygons and Dissolved on the NEWZONE field to create ~*\SEI_LAYERS*\NewZones_studyarea.shp
6. Deleted any unnecessary fields from NewZones_studyarea.shp and added fields AREA and AREA_AC and populated them appropriately.

c. Parcels & Zones
It was then necessary to determine which zone the parcels were located in. This was done using the following steps:

1. Intersected the Zoning shapfile created in the previous step with the Parcel coverage (~*\Parcel01*\parcel_poly). The new file was saved as ~\parcels_studyarea.shp.
2. Added the fields AREA_PIECE and PIECE_AC and then populated them with the area of each polygon in sq meters and acres respectively.

II Protected Areas

It was important to exclude all Protected Areas from the buildout calculations. Protected areas include all streams, wetlands, and areas with a slope greater than or equal to 25%. According to the Zoning regulations, there must be an 85 ft buffer around streams, as well as a 50 ft buffer around NWI wetlands.
Note: The streams and wetlands layers buffered were supplied by the town of Colchester (data obtained from VCGI). The streams layer was digitized from the 1:24K topographic maps and was considered the best stream coverage available at this time.

1. Opened the streams layer (~\surfacewater) and applied an 85 ft buffer using the Buffer Wizard in ArcMap. Added a field called BufferCode and populated the table with WP (for watercourse protection).
2. Opened the wetlands layer (~\nwi_wet) and applied a 50 ft buffer. Added a field called BufferCode and populated the table with W/F (for wetland/floodplain).
3. Clipped the wetlands layer to the Study area boundary.
4. The buffer layers created in Step 1 and Step 2 were then merged with the clipped wetlands layer in Step 3. Those records with no Buffercode were then changed to W/F since they represented Wetlands polygons.
5. The slope grid (~\SlopeGrid) was also supplied by the town of Colchester and after close consideration was determined to show values in Percent, not degrees. The Raster calculator was used to create a grid showing only areas with a slope greater than or equal to 25%, i.e., SetNull([slopegrid] < 25, 1) .
6. This raster layer was then converted to features and clipped to the Study area boundary.
7. The clipped Slope shapefile from the previous step was then merged with the Stream and Wetland buffers file from Step 4. All records with no Buffercode were changed to "Slope" since they were features from the slope layer. This file was called ~*Temp*\Str_Wet_Slp_merge.shp
8. Unioned the Str_Wet_Slp_merge.shp file with the Parcel layer (parcels_studyarea.shp) to form ~*SEI_LAYERS*\parcels_withProtectedLand.shp. Then recalculated the area in the AREA_PIECES and PIECES_AC fields.
9. parcels_withProtectedLand.dbf was then imported into the *O:\Proj-01\1240-W-Colc-Exit17\Database\buildout.mdb* and a query was created to show all land except Protected land (qryParcels_minus_ProtectedLands) – that is, those records with no BufferCode.

```
SELECT parcels_withProtectedLand.MAP_LOT, parcels_withProtectedLand.NEWZONE,
parcels_withProtectedLand.PIECE_AC
FROM parcels_withProtectedLand
WHERE (((parcels_withProtectedLand.BUFFERCODE) Is Null));
```

III Number of Residential Units

The number of Residential units was calculated by dividing the *area* of the zone in each parcel by the minimum lot size requirement for a duplex in that zone. (*Note: Duplex was used since it would allow for the maximum buildout)*. Also, subtracted 25% of the area for buildout of roadways.

Criteria for each Zone:

GOV – no residential units (roadways)
R1 - minimum lot size for duplex = 0.6887 acres (30,000 sq ft)
RR – minimum lot size for duplex = 3.5 acres
AGR – minimum lot size for duplex = 25 acres
COM – no residential units
GD1 – minimum lot size for duplex = 0.172 acres (7,500 sq ft)
GD4 - minimum lot size for duplex = 0.172 acres (7,500 sq ft)
GD4C – minimum lot size for duplex = 0.172 acres (7,500 sq ft)

The following statement was used in MS Access to calculate the number of residential units for each zone:

ResUnt:
((IIf([NEWZONE]="GOV",0,IIf([NEWZONE]="R1",[PIECE_AC]*0.75/0.6887,IIf([NEWZONE]="RR",[PIECE_AC]*0.75/3.5,IIf([NEWZONE]="GD1",[PIECE_AC]*0.75/0.172,IIf([NEWZONE]="AGR",[PIECE_AC]*0.75/25,IIf([NEWZONE]="COM",0,IIf([NEWZONE]="GD4" Or [NEWZONE]="GD4C",[PIECE_AC]*0.75/0.172))))))))

IV Number of Commercial Units

The number of Commercial units was calculated by dividing the area of the zone in each parcel by the minimum lot size requirement for a commercial building in that Zone. Also, subtracted 25% of the area for buildout of roadways.

Criteria for each Zone:

- **GOV –** no commercial units (roadways)
- **R1** - no commercial units
- **RR** – no commercial units
- **AGR** – no commercial units
- **GD1** – minimum lot size for commercial use = 0.459 acres (20,000 sq ft)
- **COM** – minimum lot size for commercial use = 0.459 acres (20,000 sq ft)
- **GD4** - minimum lot size for commercial use = 0.459 acres (20,000 sq ft)
- **GD4C** – minimum lot size for commercial use = 0.459 acres (20,000 sq ft)

The following statement was used in Access to calculate the number of commercial units for each zone:

CommUnt:
(IIf([NEWZONE]="GOV",0,IIf([NEWZONE]="R1",0,IIf([NEWZONE]="RR",0,IIf([NEWZONE]="GD1",[PIECE_AC]*0.75/0.459,IIf([NEWZONE]="AGR",0,IIf([NEWZONE]="COM",[PIECE_AC]*0.75/0.459,IIf([NEWZONE]="GD4" Or [NEWZONE]="GD4C",[PIECE_AC]*0.75/0.459))))))))

So together, the query looked like this:

```
SELECT qryParcels_minus_ProtectedLand.MAP_LOT, qryParcels_minus_ProtectedLand.PIECE_AC,
qryParcels_minus_ProtectedLand.NEWZONE,
((IIf([NEWZONE]="GOV",0,IIf([NEWZONE]="R1",[PIECE_AC]*0.75/0.6887,IIf([NEWZONE]="RR",[
PIECE_AC]*0.75/3.5,IIf([NEWZONE]="GD1",[PIECE_AC]*0.75/0.172,IIf([NEWZONE]="AGR",[PIEC
E_AC]*0.75/25,IIf([NEWZONE]="COM",0,IIf([NEWZONE]="GD4" Or
[NEWZONE]="GD4C",[PIECE_AC]*0.75/0.172)))))))) AS ResUnt,
(IIf([NEWZONE]="GOV",0,IIf([NEWZONE]="R1",0,IIf([NEWZONE]="RR",0,IIf([NEWZONE]="GD
1",[PIECE_AC]*0.75/0.459,IIf([NEWZONE]="AGR",0,IIf([NEWZONE]="COM",[PIECE_AC]*0.75/0.45
9,IIf([NEWZONE]="GD4" Or [NEWZONE]="GD4C",[PIECE_AC]*0.75/0.459)))))))) AS CommUnt
FROM qryParcels_minus_ProtectedLand;
```

V Buildout Scenarios

A. Maximum PUD buildout:

For a PUD, the GD4 and GD4C zones can have commercial use if there are at least 50 Residential Units within the PUD. To determine the number of Residential and Commercial uses on parcels in these zones, we first had to determine the area needed for 50 residential and 1 commercial use. Since the minimum lot size for a residential unit in these zones is 0.172 acres and the minimum lot size for a commercial unit is 0.459 acres, the total area for 50 residential and 1 commercial unit would be 9.059 acres. So the total area of these zones (minus 25% for buildout of roads) was divided by 9.059 to determine the area for the PUD. Then this number was multiplied by 50 to determine the new number of residential units and multiplied by one to determine the number of commercial units. All other zones would have the same number of residential and commercial units as calculated in the previous section. The query below (qryRes&CommUnts_maxPUD), shows how the new number of residential and commercial units for the GD4 and GD4C zones was calculated in Access:

```
SELECT [qryNumRes&CommUnts].NEWZONE, Sum([qryNumRes&CommUnts].PIECE_AC)
AS SumOfPIECE_AC, Sum([qryNumRes&CommUnts].ResUnt) AS SumOfResUnt,
Sum([qryNumRes&CommUnts].CommUnt) AS SumOfCommUnt, Sum(IIf([NEWZONE]="GD4"
Or [NEWZONE]="GD4C",[PIECE_AC]*0.75/9.059,0)) AS PUD, Int(IIf([NEWZONE]="GD4"
Or [NEWZONE]="GD4C",[PUD]*50,Sum([ResUnt]))) AS New_Res,
Int(IIf([NEWZONE]="GD4" Or [NEWZONE]="GD4C",[PUD]*1,Sum([CommUnt]))) AS
New_Comm
FROM [qryNumRes&CommUnts]
GROUP BY [qryNumRes&CommUnts].NEWZONE;
```

Note: GD1 shows maximum buildout as both Residential and Commercial (not a mix between the two).

Results:

NEWZONE	SumOfPIECE_AC	SumOfResUnt	SumOfCommUnt	PUD	New_Res	New_Comm
AGR	10.746467	0.32239401	0		0	0
COM	2.312054	0	3.7778660130719		0	3
GD1	1.36151	5.93681686046512	2.22468954248366		5	2
GD4	354.386259	1545.28892005813	579.062514705881	29.3398492383263	1466	29
GD4C	81.399726	354.940665697673	133.006088235293	6.73913174743352	336	6
GOV	108.224105	0	0		0	0
R1	174.10104	189.597473500798	0		189	0
RR	29.141416	6.24458914285714	0		6	0

B. Half PUD with 75% Residential & 25% commercial mix on remaining land:

This scenario assumes that only *half* the number of PUDs calculated above are possible and that the remaining land will be built out as 75% Residential and 25% commercial. The following query was created to determine the number of residential and commercial units (qryRes&CommUnts_halfPUD&75-25mix):

```
SELECT [qryNumRes&CommUnts].NEWZONE, Sum([qryNumRes&CommUnts].PIECE_AC) AS
SumOfPIECE_AC, Sum([qryNumRes&CommUnts].ResUnt) AS SumOfResUnt,
Sum([qryNumRes&CommUnts].CommUnt) AS SumOfCommUnt, Sum(IIf([NEWZONE]="GD4" Or
[NEWZONE]="GD4C",([PIECE_AC]/9.059)/2,0)) AS PUD, Int(IIf([NEWZONE]="GD4" Or
[NEWZONE]="GD4C",((Sum([PIECE_AC])-
([PUD]*9.059))*(0.75*0.75/0.172))+[PUD]*50,Sum([ResUnt]))) AS New_Res,
Int(IIf([NEWZONE]="GD4" Or [NEWZONE]="GD4C",((Sum([PIECE_AC])-
([PUD]*9.059))*(0.75*0.25/0.459))+[PUD]*1,Sum([CommUnt]))) AS New_Comm
FROM [qryNumRes&CommUnts]
GROUP BY [qryNumRes&CommUnts].NEWZONE;
```

Results:

NEWZONE	SumOfPIECE_AC	SumOfResUnt	SumOfCommUnt	PUD	New_Res	New_Comm
AGR	10.746467	0.32239401	0	0	0	0
COM	2.312054	0	3.7778660130719	0	0	3
GD1	1.36151	5.93681686046512	2.22468954248366	0	5	2

NEWZONE	SumOfPIECE_AC	SumOfResUnt	SumOfCommUnt	PUD	New_Res	New_Comm
GD4	354.386259	1545.28892005813	579.062514705882	19.5598994922182	1557	91
GD4C	81.399726	354.940665697673	133.006088235293	4.49275449828898	357	21
GOV	108.224105	0	0	0	0	0
R1	174.10104	189.597473500798	0	0	189	0
RR	29.141416	6.24458914285714	0	0	6	0

C. No PUDs with 75% Residential & 25% Commercial mix on all buildable land:

This scenario assumes that there will be *no* PUDs and that the entire area will be built out as 75% Residential and 25% commercial. The following query was created to determine the number of residential and commercial units (qryRes&CommUnts_NoPUD&75-25mix):

```
SELECT qryParcels_minus_ProtectedLand.NEWZONE,
Sum(qryParcels_minus_ProtectedLand.PIECE_AC) AS SumOfPIECE_AC,
Int(((IIf([NEWZONE]="GOV",0,IIf([NEWZONE]="R1",Sum([PIECE_AC])*0.75*0.75/0.6887,IIf([NEWZ
ONE]="RR",Sum([PIECE_AC])*0.75*0.75/3.5,IIf([NEWZONE]="GD1",Sum([PIECE_AC])*0.75*0.75/0.1
72,IIf([NEWZONE]="AGR",Sum([PIECE_AC])*0.75*0.75/25,IIf([NEWZONE]="COM",0,IIf([NEWZON
E]="GD4" Or [NEWZONE]="GD4C",Sum([PIECE_AC])*0.75*0.75/0.172))))))))) AS New_ResUnt,
Int((IIf([NEWZONE]="GOV",0,IIf([NEWZONE]="R1",0,IIf([NEWZONE]="RR",0,IIf([NEWZONE]="
GD1",Sum([PIECE_AC])*0.25*0.75/0.459,IIf([NEWZONE]="AGR",0,IIf([NEWZONE]="COM",Sum([PI
ECE_AC])*0.25*0.75/0.459,IIf([NEWZONE]="GD4" Or
[NEWZONE]="GD4C",Sum([PIECE_AC])*0.25*0.75/0.459))))))))) AS New_CommUnt
FROM qryParcels_minus_ProtectedLand
GROUP BY qryParcels_minus_ProtectedLand.NEWZONE;
```

Results:

NEWZONE	SumOfPIECE_AC	New_ResUnt	New_CommUnt
AGR	10.746467	0	0
COM	2.312054	0	0
GD1	1.36151	4	0
GD4	354.386259	1158	144
GD4C	81.399726	266	33
GOV	108.224105	0	0
R1	174.10104	142	0
RR	29.141416	4	0

Comparison of Scenarios:

For comparison purposes, the following query was created to show the results of all buildout scenarios (qryAllRes&CommMixes):

```
SELECT [qryRes&CommUnts_halfPUD&75-25mix].NEWZONE, [qryRes&CommUnts_halfPUD&75-
25mix].SumOfPIECE_AC AS Area, Int([qryRes&CommUnts_halfPUD&75-25mix]![SumOfResUnt]) AS
All_Res, Int([qryRes&CommUnts_halfPUD&75-25mix]![SumOfCommUnt]) AS All_Comm,
```

```
[qryRes&CommUnts_maxPUD].New_Res AS MaxPUDRes, [qryRes&CommUnts_maxPUD].New_Comm AS
MaxPUDComm, [qryRes&CommUnts_halfPUD&75-25mix].New_Res AS HalfPUDRes75,
[qryRes&CommUnts_halfPUD&75-25mix].New_Comm AS HalfPUDComm25,
[qryRes&CommUnts_NoPUD&75-25mix].New_ResUnt AS NoPUDRes75,
[qryRes&CommUnts_NoPUD&75-25mix].New_CommUnt AS NoPUDComm25
FROM ([qryRes&CommUnts_halfPUD&75-25mix] INNER JOIN [qryRes&CommUnts_maxPUD] ON
[qryRes&CommUnts_halfPUD&75-25mix].NEWZONE = [qryRes&CommUnts_maxPUD].NEWZONE)
INNER JOIN [qryRes&CommUnts_NoPUD&75-25mix] ON [qryRes&CommUnts_maxPUD].NEWZONE
= [qryRes&CommUnts_NoPUD&75-25mix].NEWZONE;
```

Results:

NEWZONE	Area	All_Res	All_Comm	MaxPUD Res	MaxPUD Comm	HalfPUD Res75	HalfPUD Comm25	NoPUDRes75	NoPUDComm25
AGR	10.746467	0	0	0	0	0	0	0	0
COM	2.312054	0	3	0	3	0	3	0	0
GD1	1.36151	5	2	5	2	5	2	4	0
GD4	354.386259	1545	579	1466	29	1557	91	1158	144
GD4C	81.399726	354	133	336	6	357	21	266	33
GOV	108.224105	0	0	0	0	0	0	0	0
R1	174.10104	189	0	189	0	189	0	142	0
RR	29.141416	6	0	6	0	6	0	4	0

Parcels to be Excluded In Refined Analysis:

After further discussions with landowners, several properties were excluded from the analysis:

1. State of Vermont AOT property U.S. Route 7 (already developed)
2. Jay Wiley Property including Arbor Gardens (recently permitted to max)
3. O'Brien Brothers Realty Property (verbally indicated they have needed capacity for their property)
4. Brentwood Park including gas station on NW corner Route 2/7 (formerly a residential subdivision, max. permit developed)
5. Chimney Hill Subdivision (residential subdivision, built-out, could convert on-site)

These properties were excluded by first adding a field called ELIM to the attribute table of *parcels_withProtectedLand.shp*. The properties were then selected and the ELIM field was populated with "Yes" for these parcels. The attribute table was then imported into the database and the query *qryParcels_minus_ProtectedLand* was modified to exclude all records with ELIM = "Yes" as well as all Protected Land.

Exceptions:

Two properties were determined to be exceptions to the analysis:

1. Willard Properties (Map_Lots 17-13 and 17-13-1) – landowner does not want more than 300 residential units.
2. Rubman Properties (Map_Lots 14-27 and 17-11) – landowner does not want more than 200 residential units.

All queries discussed in Section V. (Buildout Scenarios) of this O&R were modified to exclude the Willard and Rubman properties. All scenarios were compared using the query *qryAllRes&CommMixes_plusExceptions*. In this query, an additional 500 residential units (200 for Rubman and 300 for Willard) were added to each scenario for the GD4 district (Note: this was the district in which the majority of the Willard and Rubman parcels fell within).

```
SELECT [qryRes&CommUnts_halfPUD&75-25mix].NEWZONE, Int(IIf([qryRes&CommUnts_halfPUD&75-
25mix]![NEWZONE]="GD4",[qryRes&CommUnts_halfPUD&75-
25mix]![SumOfResUnt]+300+200,[qryRes&CommUnts_halfPUD&75-25mix]![SumOfResUnt])) AS All_Res,
Int([qryRes&CommUnts_halfPUD&75-25mix]![SumOfCommUnt]) AS All_Comm,
IIf([qryRes&CommUnts_maxPUD]![NEWZONE]="GD4",[qryRes&CommUnts_maxPUD]![New_Res]+300+200,[qryRes
&CommUnts_maxPUD]![New_Res]) AS MaxPUDRes, [qryRes&CommUnts_maxPUD].New_Comm AS MaxPUDComm,
IIf([qryRes&CommUnts_halfPUD&75-25mix]![NEWZONE]="GD4",[qryRes&CommUnts_halfPUD&75-
25mix]![New_Res]+300+200,[qryRes&CommUnts_halfPUD&75-25mix]![New_Res]) AS HalfPUDRes75,
[qryRes&CommUnts_halfPUD&75-25mix].New_Comm AS HalfPUDComm25, IIf([qryRes&CommUnts_NoPUD&75-
25mix]![NEWZONE]="GD4",[qryRes&CommUnts_NoPUD&75-
25mix]![New_ResUnt]+300+200,[qryRes&CommUnts_NoPUD&75-25mix]![New_ResUnt]) AS NoPUDRes75,
[qryRes&CommUnts_NoPUD&75-25mix].New_CommUnt AS NoPUDComm25
FROM ([qryRes&CommUnts_halfPUD&75-25mix] INNER JOIN [qryRes&CommUnts_maxPUD] ON
[qryRes&CommUnts_halfPUD&75-25mix].NEWZONE = [qryRes&CommUnts_maxPUD].NEWZONE) INNER JOIN
[qryRes&CommUnts_NoPUD&75-25mix] ON [qryRes&CommUnts_maxPUD].NEWZONE =
[qryRes&CommUnts_NoPUD&75-25mix].NEWZONE;
```

NEW ZONE	All_Res	All_Comm	MaxPUDRes	MaxPUDComm	HalfPUDRes75	HalfPUDComm25	NoPUDRes75	NoPUDComm25
AGR	0	0	0	0	0	0	0	0
COM	0	3	0	3	0	3	0	0
GD1	5	2	5	2	5	2	4	0
GD4	661	60	653	3	663	9	621	15
GD4C	261	97	247	4	263	15	195	24
GOV	0	0	0	0	0	0	0	0
R1	170	0	170	0	170	0	128	0
RR	6	0	6	0	6	0	4	0

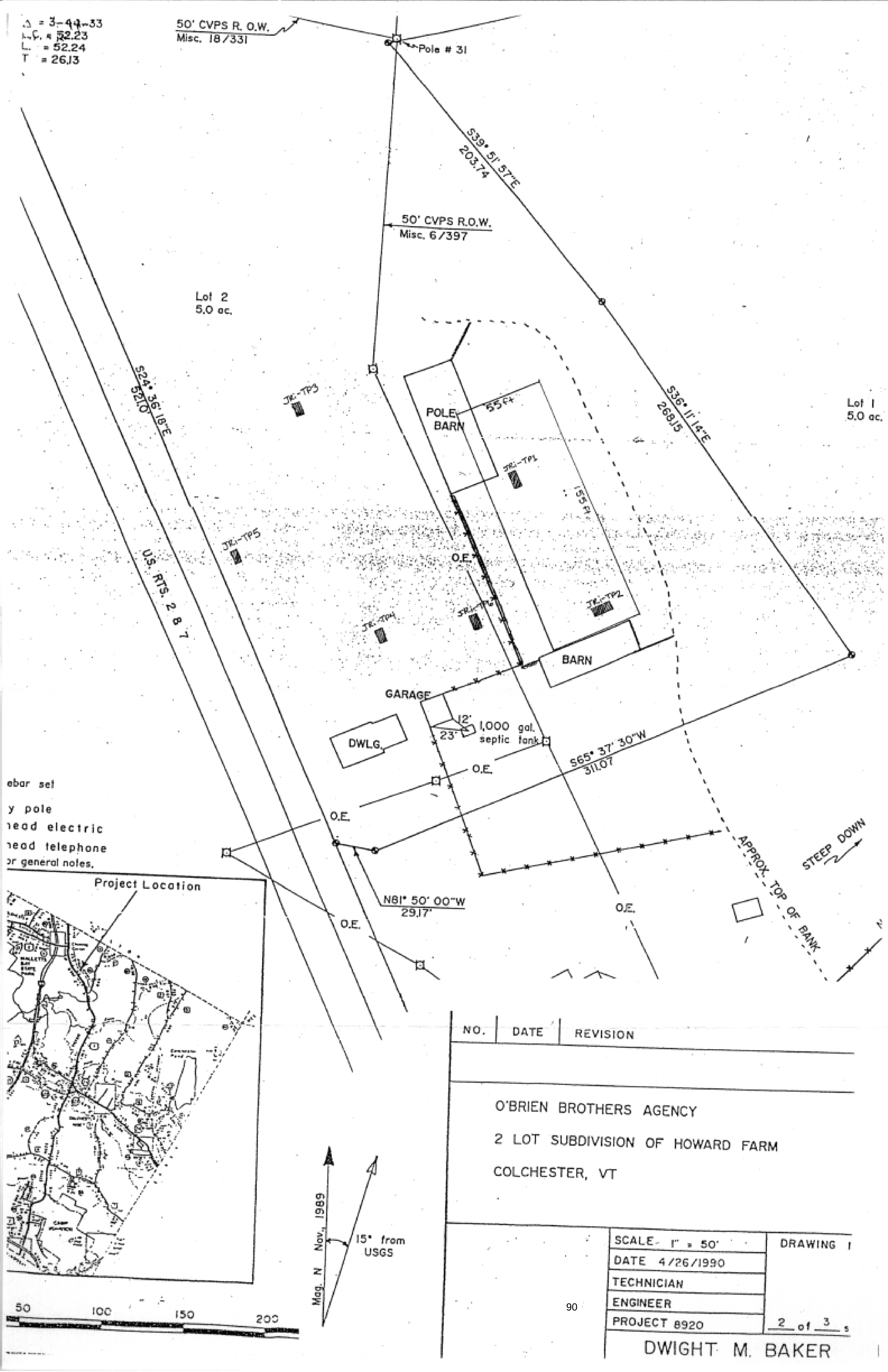
Quality Control Review

Upon QC of the results described above, an inconsistency was discovered in the "qryRes&CommUnts_halfPUD&75-25mix" calculations. The problem was that number of possible PUDs did not consider the 0.75 build factor that was used to determine the number of PUDs for the "maxPUD" case. This was corrected by calculating the number of PUDs to be equal to the half the available land for the zone multiplied by the 0.75 build factor. The total residential units was then calculated as the n number of PUDs * 50 units per PUD, plus, taking the number of residential units available on the other half of the land, multiplying by the 75% residential factor and the 0.75 build factor. The new queries created were "qryRes&CommUnts_halfPUD&75-25mixMFW" and "qryAllRes&CommMixes_plusExceptionsMFW". The final table was exported to *~1240-W-Colc-Exit17\Database\ BuildoutResultsMFW.xls*.

Refined Analysis Build-out Results:

New queries were generated to report results of the full build-out for the study area without the limitations to individual parcels described above. The query “qryRes&CommUnts_halfPUD&75-25mixFULL” was modified from “qryRes&CommUnts_halfPUD&75-25mixMFW” to include all parcels in the analysis. The query “qryRes&CommUnts_maxPUDFULL” was modified from “qryRes&CommUnts_maxPUD” to include all parcels in the analysis. The query “qryRes&CommUnts_NoPUD&75-25mixFULL” was modified from “qryRes&CommUnts_NoPUD&75-25mixFULL” to include all parcels in the analysis. Finally, the query, “qryAllRes&CommMixesFULL” was created to summarize the results of the different build-out scenarios. These results were exported to the Excel worksheet, *~/1240-W-Colc-Exit17\Database\BuildoutResultsNoLimitations.xls.*

APPENDIX B: SITE INVESTIGATION DATA, RICKER PROPERTY


Δ = 3-44-33
L.C. = 52.23
L. = 52.24
T = 26.13
50' CVPS R. O.W.
Misc. 18/331
Pole # 31
S39° 51' 57"E
203.74
50' CVPS R.O.W.
Misc. 6/397
Lot 2
5.0 ac.
Lot 1
5.0 ac.
S24° 36' 18"E
521.0
S36° 11' 14"E
268.15
POLE BARN
55 Ft
155 Ft
JRI-TP1
JRI-TP2
JRI-TP3
JRI-TP4
JRI-TP5
JRI-TP6
U.S. RTS. 2 & 7
O.E.
BARN
GARAGE
12'
23'
1,000 gal. septic tank
DWLG.
S65° 37' 30"W
311.07
N81° 50' 00"W
29.17'
APPROX. TOP OF BANK
STEEP DOWN
ebar set
y pole
head electric
head telephone
or general notes.
Project Location
Mag. N Nov., 1989
15° from USGS
50
100
150
200
NO.
DATE
REVISION
O'BRIEN BROTHERS AGENCY
2 LOT SUBDIVISION OF HOWARD FARM
COLCHESTER, VT
SCALE 1" = 50'
DATE 4/26/1990
TECHNICIAN
ENGINEER
PROJECT 8920
DRAWING
2 of 3
DWIGHT M. BAKER

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRi-TP1

Client: Town of Colchester	Date: June 10, 2002
Described By: MK Clark, Amy Macrellis Recorded By: MK Clark	Location: James Ricker, Roosevelt Highway, Colchester
Vegetation: lawn	Topographic Setting:
Slope: flat	Land Use:
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-0.7	7.5YR 3/2	---	FSL	w	sbk		m	fr	a		
0.7-4.2	2.5Y 5/4	---	MS	w	n/a		m	l			Coarser; 5.0 ft = impeding layer for hydraulic conductivity test (run at 2.0-4.0 ft)
4.2-4.8			MS								
4.8-5.6	7.5YR 3/3	m2d	SiL	w	pl		m	fr			Mixed layer; some MS also present
5.6-9.0			MS								Finer sand than above; some Fe staining

Notes: Deepened hole 5.6-9.0 ft.; did not enter below 5.6 ft.

O:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\TEST PIT log 061002.doc

Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRi-TP2

Client: Town of Colchester	Date: June 10, 2002
Described By: AM Recorded By: MKC	Location: lawn
Vegetation: lawn	Topographic Setting:
Slope: 1%	Land Use:
Aspect: east	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-1.0	7.5YR 2.5/3	---	FSL	w	sbk		m	fr			
1.0-1.4	7.5YR 5/8	---	LFS	w	---		m	fr			
1.4-2.6	10YR 4/4	---	LFS	w	l		m	l	g		
2.6-8.0	2.5Y 5/2	---	MS	w	l		m	l			Eastern end of pit some lenses slightly coarser sand (10-25% coarse)

Notes: On sides of pit, discontinuous SiL/FSL layer from mottled iron staining (4.5-5.5 ft on north, 3.9-4.6 ft on south); overexcavated to 10 ft, no limiting layer found
Bruce Douglas comment: Bottom of B horizon ~ 3 ft.; 3-6 ft. = layer for hydraulic conductivity test

O:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\TEST PIT log 061002.doc

Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRi-TP3

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM Recorded By: ANM	Location: Ricker property
Vegetation: lawn	Topographic Setting: flat
Slope: flat to 1%	Land Use: lawn
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-1.0	7.5YR 4/4	---	FSL	w	sab		m	fr			
1.0-2.1	7.5YR 5/8	---	FSL				m	fr			mottled below 16 in.
2.1-9.0	2.5Y 4/2	m1d	SiL	m	pl	m	m	vfr			Complex layer; mostly SiL with interbedded Si and S; abundant Fe staining (7.5YR 3/4 to 7.5YR 4/3) throughout

Notes:

O:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\TEST PIT log 061002.doc

Key:

Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRi-TP4

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM Recorded By: ANM, BFD	Location: Ricker property
Vegetation: grass	Topographic Setting: lawn
Slope: flat	Land Use: lawn / pumpkin patch
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0.0-0.6	7.5YR 3/3	---	FSL	w	sab		m	fr			
0.6-2.0	7.5YR 4/4	---	SiL	w	sab		m	fr			
2.0-5.0	2.5Y 5/3	m1d	SiL	w	pl		m	fr			Bands of Fe staining (7.5YR 4/3) throughout; few sand lenses toward bottom of layer
5.0-7.0	2.5Y 6/3	---	FS				m	l			very fine bands of Fe staining
7.0-9.4	2.5Y 6/3		FS				m	l			7.0-7.5 ft, 8.0-8.6 ft = Si layers with 7.5YR 4/3 m1d mottles and pronounced bands of Fe staining

Notes: Deepened hole to 10.5 ft bgs, as above with stratified FSL, LFS, and FS stratified and mottled to depth

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Key:

Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRi-TP5

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM Recorded By: ANM	Location: Ricker property
Vegetation: grass	Topographic Setting:
Slope: flat	Land Use:
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-0.6	10YR 3.4	---	FSL	--	--	--	m	l			
0.6-1.7	7.5YR 4/6	---	FSL	--	--	--	m	l			
1.7-4.3	2.5Y 4/4	m2d	FSL	w	sab		m	fr			7.5YR 4/4 ¼ in. – 1 in. bands Fe staining; mottles in this layer are at 2.4-2.6 ft
4.3-8.0	2.5Y 4/3	m2d	SiL	w	pl		m	fr			1 band of S at ~6.5 ft; heavy Fe staining interspersed in ~2 in. bands throughout
8.0-9.0	2.5Y 6/3	---	FS	--	--	--	m	l			

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRi-TP6

Client: Town of Colchester	Date: June 10, 2002
Described By: BFD Recorded By: MKC	Location: James Ricker property
Vegetation:	Topographic Setting:
Slope:	Land Use:
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-1.5	10YR 3/3		FSL	w	gr		m	vfr	a	i	
1.5-2.3	10YR 4/6		LFS	w	sbk		m	vfr	g		
2.3-3.7	5Y 5/3		MS				m	l	a	s	
3.7-5.1	2.5Y 4/3	m2d	VFSL	w	sbk		m	fr	a	s	Mottle color: 10YR 3/6
5.1-6.4	2.5Y 5/4	m1d	FS				m	l	g	s	10YR 3/4 iron band ¼ in. thick at 5.4 ft.; mottle color is 5Y 5/2
6.4-6.8	5Y 4/2	c2p	SiL	w	pl		vm	fr	a	s	somewhat firm in places; mottle colors are 10B 6/1, 10YR 4/4
6.8-8.7	2.5Y 5/3, 10YR 4/6, 10YR 3/1		MS	w	pl		m	vf	a	s	stratified – mottled in layers
8.7-9.0	2.5Y 4/3	m2p	SiL	w	pl		m	fr			Mottle colors: 10B 6/1, 7.5YR 4/6
9.0-9.3			FS								same characteristics as SiL at 8.7-9.0 ft interval

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

Auger Hole Hydraulic Conductivity Measurement

Project Title: Decentralized Wastewater Treatment Options for I-89, Exit 17
SEI Study #: 01-1240-W
Date: June 10, 2002
Sampling Personnel: ANM, MHP
Backhoe test pit #: JRi-TP1
Auger hole radius: 2 in.
Auger hole depth: 20 in.

Field Measurements:

Run	Time (t) seconds	Δ t	Volume (v) Liters	Δ v	Flow Rate (Q_e) cm^3/sec
1	0		14		
	29	29	12	2	69
2	0		14		
	107	107	12	2	19
	221	114	10	2	18
	310	89	8	2	22
3	0		14		
	72	72	12	2	28
	140	68	10	2	29
	201	61	8	2	33
	267	66	6	2	30
4	0		14		
	68	68	12	2	29
	137	69	10	2	29
	206	69	8	2	29

Calculations:

K = hydraulic conductivity (cm/sec)
L_w = wetted length of auger hole (cm)
r_w = radius of auger hole (cm)
S_i = vertical distance from bottom of auger hole to impeding layer (cm)
Q_e = equilibrium rate of water added (cm^3/sec) = average Δv/Δt for last run

$$K = \frac{3Q}{\pi L_w (3L_w + 2S_i)} \ln \frac{L_w}{r_w}$$

Assumption:
none for this test

Results:

L_w = 51 cm
r_w = 5.1 cm
S_i = 49 cm
Q_e = 29 cm^3/sec

K = 0.0050 cm/sec
14 ft/day

Path: 0:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\KTestCalcs.xls
6/13/02 ANM

STONE ENVIRONMENTAL, INC.

Auger Hole Hydraulic Conductivity Measurement

Project Title: Decentralized Wastewater Treatment Options for I-89, Exit 17
SEI Study #: 01-1240-W
Date: June 10, 2002
Sampling Personnel: ANM, MHP
Backhoe test pit #: JRi-TP2
Auger hole radius: 2 in.
Auger hole depth: 20 in.

Field Measurements (continued on following page)**:**

Run	Time (t) seconds	Δ t	Volume (v) Liters	Δ v	Flow Rate (Q_e) cm^3/sec
1	0		14		
	22	22	12	2	91
	53	31	10	2	65
	67	14	8	2	143
	92	25	6	2	80
	102	10	4	2	200
2	0		12		
	20	20	10	2	100
	34	14	8	2	143
	52	18	6	2	111
	71	19	4	2	105
3	0		10		
	15	15	8	2	133
	36	21	6	2	95
	56	20	4	2	100
4	0		14		
	21	21	12	2	95
	37	16	10	2	125
	56	19	8	2	105
	80	24	6	2	83
	99	19	4	2	105
5	0		14		
	23	23	12	2	87
	38	15	10	2	133
	62	24	8	2	83
	85	23	6	2	87
	105	20	4	2	100
6	0		10		
	21	21	8	2	95
	44	23	6	2	87
	67	23	4	2	87
7	0		14		
	23	23	12	2	87
	46	23	10	2	87
	67	21	8	2	95
	98	31	6	2	65
	127	29	4	2	69

Calculations:

K = hydraulic conductivity (cm/sec)
L_w = wetted length of auger hole (cm)
r_w = radius of auger hole (cm)
S_i = vertical distance from bottom of auger hole to impeding layer (cm)
Q_e = equilibrium rate of water added (cm^3/sec) = average Δv/Δt for last run

$$K = \frac{3Q}{\pi L_w (3L_w + 2S_i)} \ln \frac{L_w}{r_w}$$

Assumption:
none for this test

Results:

L_w = 51 cm
r_w = 5.1 cm
S_i = 98 cm
Q_e = 63 cm^3/sec

K = 0.0078 cm/sec
22 ft/day

8	0		14		
	22	22	12	2	91
	44	22	10	2	91
	64	20	8	2	100
	102	38	6	2	53
	122	20	4	2	100
9	0		14		
	32	32	12	2	63
	64	32	10	2	63
	96	32	8	2	63
	128	32	6	2	63
	160	32	4	2	63

Path: 0:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\KTestCalcs.xls STONE ENVIRONMENTAL, INC.
6/13/02 ANM

Capacity Analysis: Ricker Cluster Site, Scenario #1

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 23, 2002
Prepared by: Mary K. Clark

Darcy's Law Calculations: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = D * L = transmitting soil cross-sectional area (square ft.), where
D = depth to impeding layer or water table, minus required separation, minus system depth (ft.)
L = length of disposal system (ft.)

Assumptions:
1 System bottom is 0.5 feet below ground surface (bgs)
2 Slope, i = ground slope, estimated from USGS topographic map, plus 1% for groundwater mounding = 3%
2 Required separation distance = 3 feet
3 Hydraulic conductivity K = average of two readings = 18 feet/day
4 Impeding layer at 4.8 feet bgs is continuous across site
5 System length (L) across slope, plus width for rounded length on north end
6 Scenarios 2 & 3 are hypothetical requiring additional field testing to verify

Calculations:
K = 18 ft./day
i = 3%
L = 155 ft. + 55 ft. = 210 ft.
D = (4.8 ft. - 3.0 ft. - 0.5 ft.) = 1.3 ft.
Q = 18 ft/day x 0.03 x (210 ft x 1.3ft) x 7.48 gal/ft^3
Q = 1,100 gpd

Capacity Analysis: Ricker Cluster Site, Scenario #2

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 23, 2002
Prepared by: Mary K. Clark

Darcy's Law Calculations: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = D * L = transmitting soil cross-sectional area (square ft.), where
D = depth to impeding layer or water table, minus required separation, minus system depth (ft.)
L = length of disposal system (ft.)

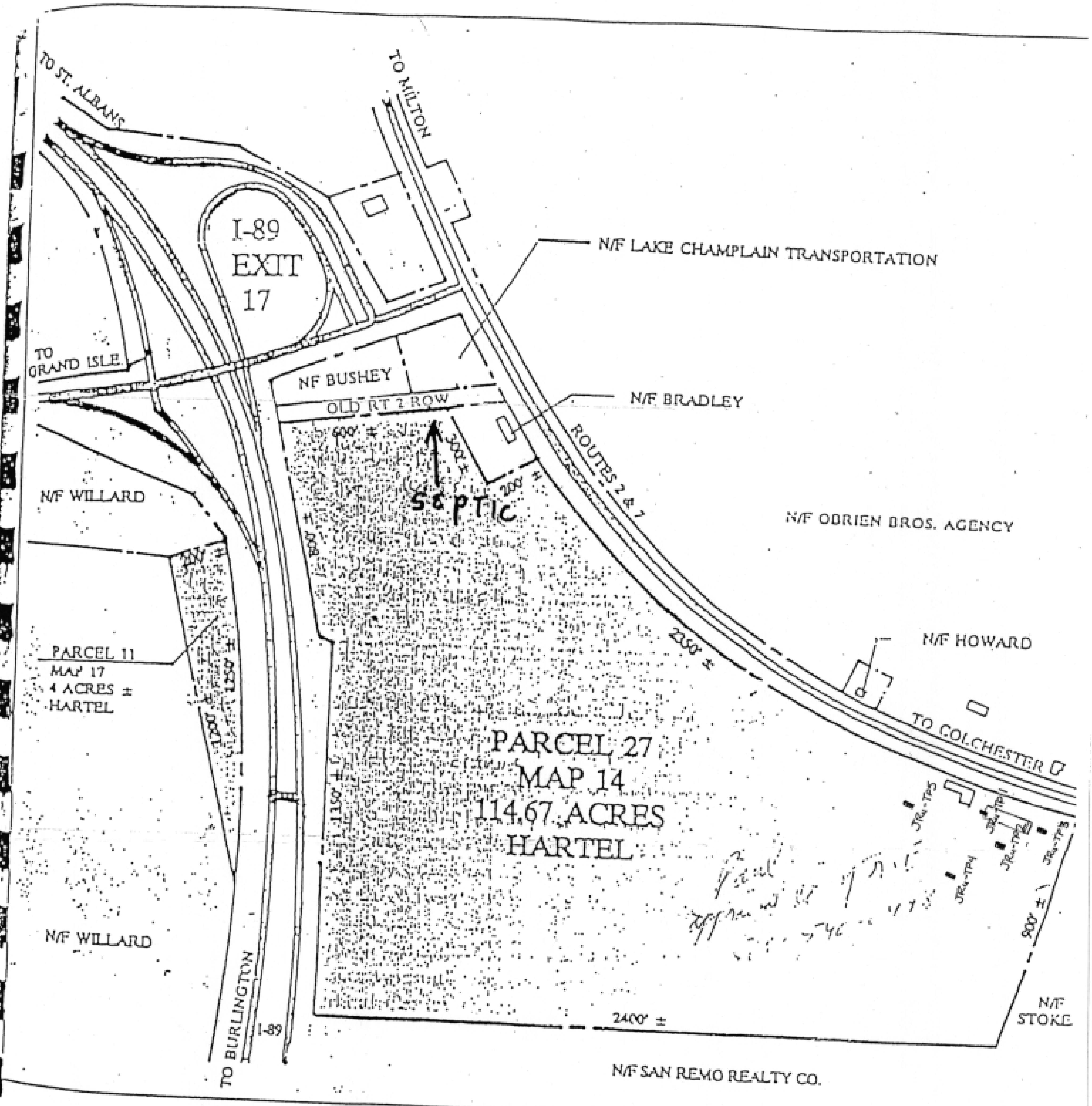
Assumptions:

1 System bottom is 0.5 feet below ground surface (bgs)
2 Slope, i = ground slope, est. USGS topo. = 2%, add 1% for flow increasing gradient
2 Required separation distance = 3 feet
3 Hydraulic conductivity K = average of two readings = 18 feet/day
4 Impeding layer at 10.0 feet bgs at bottom of test pit
5 L = system length across slope, plus width for rounded length on north end

Calculations

K = 18 ft./day
i = 3%
L = 155 ft. + 55 ft. = 210 ft.
D = (10.0 ft. - 3.0 ft. - 0.5 ft.) = 6.5 ft.
Q = 18 ft/day x 0.03 x (210 ft. x 6.5 ft.) x 7.48 gal/ft3
Q = 5,510 gpd

APPENDIX C: SITE INVESTIGATION DATA, RUBMAN PROPERTY



PLOT PLAN

1" = 400' ±

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRu-TP1

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM, BFD Recorded By: ANM	Location: Rubman property
Vegetation: grass / hay	Topographic Setting: rolling hills
Slope: 1%	Land Use: hay field
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-0.9	7.5YR 3/3	---	FSL	--	--	--	m	l			
0.9-1.6	10YR 4/6	---	FSL	--	--	--	m	l			
1.6-3.4	10YR 5/4	f1d	SiL	w	pl		m	fr			1.5 in band Fe staining (7.5YR 4/4) at 2.5 ft.; FSL 2.5 – 3.2 ft.
3.4-4.7	2.5Y 6/3	---	FS	--	--	--	m	l			¼ in. bands Fe staining (7.5YR 4/4) throughout
4.7-5.1	light olive brown		FSL								light olive brown with light brownish gray layers 1/8 in. thick; few distinct yellowish-brown mottles
5.1-6.7	2.5Y 6/3		FS	--	--	--	m	l			¼ in. bands Fe staining (7.5YR 4/4) throughout
6.7-9.0	2.5Y 5/4	m2d	SiL	w	pl		m				Fe staining throughout; few ½ in. diam. Fe concretions

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRu-TP2

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM Recorded By: ANM	Location: Rubman property
Vegetation: grass / hay	Topographic Setting: rolling hills
Slope: slight (~2%)	Land Use: hay field
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-0.4	7.5YR 4/3	---	FSL	--	--	--	m	l			many root fragments
0.4-1.3	10YR 5/4	---	FSL	w	sab		m	fr			
1.3-9.0	2.5Y 4/1	c2p	SiL	w	pl	m	m	fr			alternating Si and SiL layers; Fe staining and ½ to 1 in. diameter Fe concretions prominent

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRu-TP3

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM Recorded By: ANM	Location: Rubman property
Vegetation: hay / grass	Topographic Setting: rolling hills
Slope: flat	Land Use: hayfield
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-0.7	7.5YR 2.5/3	---	FSL	--	--	--	m	l			
0.7-1.8	10YR 4/4	---	FSL	w	sab	--	m	l			
1.8-2.9	2.5Y 5/3	f1d	SiL	w	pl	--	m	fr			
2.9-5.5	2.5Y 6/3	---	FS	--	--	--	m	l			thin bands Fe staining throughout
5.5-9.1	2.5Y 4/4	m1d	SiL	w	pl	--	m	fr			Fe staining in ½ in. bands and many ½ in. diameter Fe concretions

Notes: Overexcavated to 13 ft.; still silty to bottom of hole
Area 50 ft. wide by 150 ft. long +/-

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRu-TP4

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM Recorded By: ANM	Location: Rubman property
Vegetation: grass / hay	Topographic Setting: rolling hills
Slope: ~2%	Land Use: hay field
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-0.7	2.5Y 4/1	---	SiL	--	--	--	m	fr			
0.7-4.3	2.5Y 4/1	c1p	CL	m	pl	--	m	fi			

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JRu-TP5

Client: Town of Colchester	Date: June 10, 2002
Described By: ANM Recorded By: ANM	Location: Rubman property
Vegetation: grass / hay	Topographic Setting: rolling hills
Slope: ~2%	Land Use: hay field
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-1.0	2.5Y 4/1	---	SiL	--	--	--	m	fr			0.8 – 1.0 ft leached layer 2.5Y 5/1
1.0-3.3	2.5Y 4/1	c1p	CL	m	pl	--	m	fr			

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

Capacity Analysis: Rubman Cluster Site, Scenario #1

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 23, 2002
Prepared by: Mary K. Clark

Darcy's Law Formula: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = transmitting soil cross-sectional area (D) times length of disposal system (L) square feet, where
D = depth to impeding layer or water table, minus required separation, minus system depth

Assumptions:
1 System bottom is 0.5 feet below ground surface (bgs)
2 Slope, i = ground slope, estimated from USGS topographic map = 2%
2 Required separation distance = 3 feet
3 Hydraulic conductivity K = 10 feet/day
4 Impeding layer at 5.5 feet bgs is continuous across site
5 System length (L) across slope = 150 feet

Calculations:
K = 10 ft./day
i = 2%
L = 150 feet
D = (5.5 ft. - 3.0 ft. - 0.5 ft.) = 2.0 ft.
Q = 10 ft/day x 0.02 x (150' x 2.0') x 7.48
Q = 450 gpd

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12/23/02 MKC, rev 12/30/02 ANM
STONE ENVIRONMENTAL, INC.

Capacity Analysis: Rubman Cluster Site, Scenario #2

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 23, 2002
Prepared by: Mary K. Clark

Darcy's Law Formula: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = transmitting soil cross-sectional area (D) times length of disposal system (L) square feet, where
D = depth to impeding layer or water table, minus required separation, minus system depth

Assumptions:
1 System bottom is 0.5 feet below ground surface (bgs)
2 Slope, i = ground slope, estimated from USGS topographic map, plus 1% for groundwater mounding = 3%
2 Required separation distance = 1.5 feet for filtrate system
3 Hydraulic conductivity K = 10 feet/day
4 Impeding layer at 5.5 feet bgs is continuous across site
5 System length (L) across slope = 150 feet

Calculations:
K = 10 ft./day
i = 2%
L = 150 feet
D = (5.5 ft. - 1.5 ft. - 0.5 ft.) = 3.5 ft.
Q = 10 ft/day x 0.02 x (150' x 3.5') x 7.48
Q = 785 gpd

Capacity Analysis: Rubman Cluster Site, Scenario #3

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 23, 2002
Prepared by: Mary K. Clark

Darcy's Law Formula: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = transmitting soil cross-sectional area (D) times length of disposal system (L) square feet, where
D = depth to impeding layer or water table, minus required separation, minus system depth

Assumptions:

1 System bottom is 0.5 feet below ground surface (bgs)
2 Slope, i = ground slope, estimated from USGS topographic map = 2%
2 Required vertical separation distance = 3 feet
3 Hydraulic conductivity K = 10 feet/day
4 Impeding layer at 6.7 feet bgs is continuous across site
5 System length (L) across slope = 150 feet

Calculations:

K = 10 ft./day
i = 2%
L = 150 feet
D = (6.7 ft. - 3.0 ft. - 0.5 ft.) = 3.2 ft.
Q = 10 ft/day x 0.02 x (150' x 3.2') x 7.48
Q = 718 gpd

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STONE ENVIRONMENTAL, INC.

Capacity Analysis: Rubman Cluster Site, Scenario #4

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 23, 2002
Prepared by: Mary K. Clark

Darcy's Law Calculations: Q = KiA

Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = transmitting soil cross-sectional area (D) times length of disposal system (L) square feet, where
D = depth to impeding layer or water table, minus required separation, minus system depth

Assumptions:

1 System bottom is 0.5 feet below ground surface (bgs)
2 Slope, i = ground slope, estimated from USGS topographic map = 2%
2 Required separation distance = 1.5 feet for filtrate system
3 Hydraulic conductivity K = 10 feet/day
4 Impeding layer at 6.7 feet bgs is continuous across site
5 System length (L) across slope = 150 feet

Calculations

K = 10 ft./day
i = 2%
L = 150 feet
D = (6.7 ft. - 1.5 ft. - 0.5 ft.) = 4.7 ft.
Q = 10 ft/day x 0.02 x (150' x 4.7') x 7.48
Q = 1,054 gpd

APPENDIX D: SITE INVESTIGATION DATA, ROWLEY PROPERTY

Portion of Sand Pit to remain open for use as fine mound sand
woods
Portion of Sand Pit to Remain Active (2002-2007)
Area = 11.0 acres (area within yellow line)
JR-TP1
JR-TP2
JR-TP3
Portion of Sand Pit to be Stabilized (2002-2003)
woods
Drainage way
haul road
JR-TP4
woods
Drainage way
woods
Interstate 89 South
Drainage way
Portion of Sand Pit to remain open for use as coarse mound sand
woods
JR-TP5
JR-TP6
New Archaeological Barrier Fence (Snow fence)
JR-TP7
brush
brush
Drainage way
Design IAJ
Drawn DMR
Checked
Scale 1" = 120'
Date April 15, 2002
Project 01200
Overall Plan
Milton Sand & Gravel
West Milton Road
Milton, Vermont
KREBS & LANSING Consulting Engineers, Inc.
164 Main Street, Colchester, Vermont 05446

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP1

Client: Town of Colchester	Date: June 11, 2002
Described By: MK Clark Recorded By: Carl Etnier	Location: Rowley sand pit
Vegetation: none	Topographic Setting: sand pit
Slope: flat	Land Use: sand pit
Aspect:	Comments: Raining

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-1.2	2.5Y 5/4		MS	w	gr		m	fr			
1.2-2.0	5Y 6/1		MS	w			m	fr			
2.0-2.4	5Y 6/2		LFS	w			m	fr			
2.4-3.6	5Y 6/1		MS	w			m	l			
3.6-3.7	2.5Y 4/3	7.5YR 5/8	LFS	w			m	fr			
3.7-8.0	10YR 6/2		MS	w			m	l			

Notes:

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Key:

Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
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STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP2

Client: Town of Colchester	Date: June 11, 2002
Described By: CE Recorded By: MKC	Location: Rowley sand pit
Vegetation:	Topographic Setting: sand pit
Slope:	Land Use: sand pit
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-8.5	2.5Y 4/4	yes	C	m	pl		m	fr / fi			Mostly clay layers ; few 6 in. (at widest) sand layers

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
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Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP3

Client: Town of Colchester	Date: June 11, 2002
Described By: Mary Clark Recorded By: Carl Etnier	Location: Rowley sand pit
Vegetation: none	Topographic Setting: sand pit
Slope: flat	Land Use: sand pit
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-11.5	2.5Y 4/3		C								Clay with narrow sand layers

Notes:

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Key:

Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
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Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP4

Client: Town of Colchester	Date: June 11, 2002
Described By: Mary Clark Recorded By: Carl Etnier	Location: Rowley sand pit
Vegetation: very little	Topographic Setting: sand pit
Slope: flat	Land Use: sand pit
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-2.6	2.5Y 6/2		CoS				d	l	a	w	
2.6-3.3	2.5Y 4/3		CL	w	pl		m	fi	a	w	diving to NW; interbedded with FS; run hydraulic conductivity test below 2.5-3.8 ft. interval to avoid this layer
3.3-10.0	2.5Y 6/2		CoS				d	l	a	w	Some medium sand too

Notes:

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Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP5

Client: Town of Colchester	Date: June 11, 2002
Described By: Mary Clark Recorded By: Carl Etnier	Location: Rowley sand pit
Vegetation: none	Topographic Setting: sand pit
Slope: flat	Land Use: sand pit
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-3.3	2.5Y 6/2		CoS								Some narrow Fe and Mn bands
3.3-3.5	2.5Y 6/2		MS								Fe and Mn banding
3.5-3.6	10YR 5/8		CoS								
3.6-4.7	2.5Y 6/2		FS								
4.7-5.0	10YR 5/3							fi			Narrow layers of FS and silt
5.0-5.8	2.5Y 6/3		FS				m				
5.8-6.2	2.5Y 5/1		Si								
6.2-8.0	2.5Y 5/4		MS								

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP6

Client: Town of Colchester	Date: June 11, 2002
Described By: Mary Clark Recorded By: Carl Etnier	Location: Rowley sand pit
Vegetation: none	Topographic Setting: sand pit
Slope: flat	Land Use: sand pit
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-3.7	2.5Y 6/3	7.5YR 5/8 f1d	F-VFSL				m		a	s	thin layers of silt and VFS
3.7-4.6	2.5Y 6/1	7.5YR 5/8 f1d	FS				d		a	s	
4.6-5.2	2.5Y 6/2	7.5YR 5/8 f1d	FS				m		a	s	Lower boundary 5.4 ft on north side of pit
5.2-7.7	2.5Y 5/1		CoS				d	l	a	s	

Notes:

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Key:
Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP7

Client: Town of Colchester	Date: June 11, 2002
Described By: Mary Clark Recorded By: Carl Etnier	Location: Rowley sand pit
Vegetation:	Topographic Setting: sand pit
Slope:	Land Use: sand pit
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	**Color**	**Mottles**	**Texture**	**G**	**SH**	**S**	**Moisture**	**Consistence**	**D**	**T**	**Comments**
0-1.0											
1.0-2.0	2.5Y 4/4		CoS					l			layered
2.0-6.4	2.5Y 1/2	10YR 5/8	MS and CoS					l			bottom 6 in. mottled
6.4-7.6	2.5Y 4/2		Si and FS								Thin FS layers with many silty bands; this layer slopes up to north on west side of pit, so top of layer is at 2.0 ft.
7.6-8.2	10YR 6/3		MS								

Notes:

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Key:

Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

TEST PIT LOCATION DESCRIPTION AND LOG FORM

TEST PIT #: JR-TP8

Client: Town of Colchester	Date: June 11, 2002
Described By: Clark Recorded By: Etnier	Location: Rowley sand pit
Vegetation:	Topographic Setting: sand pit
Slope:	Land Use: sand pit
Aspect:	Comments:

				Structure					Boundary		
Depth (ft)	Color	Mottles	Texture	G	SH	S	Moisture	Consistence	D	T	Comments
0-1.1	10YR 3/2		SiL								
1.1-4.1	2.5Y 6/1		CoS								Fe and Mn banding
4.1-6.0	2.5Y 4/3		SiL								Contains FS layers
6.0-7.0	2.5Y 6/2		FS								

Notes:

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Key:

Texture: V = Very, F = Fine, Co = Coarse, S = Sand, C = Clay, L = Loam, Si = Silt, Gr = Gravelly, Cb = Cobbly, ST = Stony
Structure: Grade (G) w = weak, m = moderate
Shape (SH) gr = granular, sbk = subangular blocky, abk = angular blocky, pl = platy
Size (S) f = fine, m = medium, c = coarse, v tn = very thin, vtk = very thick
Moisture: m = moist, w = wet, d = dry
Consistence: l = loose, fr = friable, fi = firm, vfr = very friable, vfi = very firm, xfi = extremely firm
Boundary: Distinctness (D) g= gradual, a = abrupt
Topography (T) s = smooth, i = irregular, w = wavy

Color: Munsell Soil Color Chart (1994) codes refer to Hue, Value & Chroma
Mottles: Expressed as abundance/size/contrast
Abundance: f=few; m=many; c=common
Size: 1=fine; 2=medium; 3=coarse
Contrast: f=faint; d=district; p=prominent
ESHGW = estimated seasonal high groundwater table
BGS = below ground surface

STONE ENVIRONMENTAL INC

Auger Hole Hydraulic Conductivity Measurement

Project Title: Decentralized Wastewater Treatment Options for I-89, Exit 17
SEI Study #: 01-1240-W
Date: June 11, 2002
Sampling Personnel: ANM, JMS
Backhoe test pit #: JR-TP1
Auger hole radius: 2 in.
Auger hole depth: 20 in.

Field Measurements (continued on following page)**:**

Run	Time (t) seconds	Δ t	Volume (v) Liters	Δ v	Flow Rate (Q_e) cm^3/sec
1	0		10		
	17	17	8	2	118
	36	19	6	2	105
	58	22	4	2	91
2	0		14		
	21	21	12	2	95
	41	20	10	2	100
	62	21	8	2	95
	83	21	6	2	95
3	0		12		
	22	22	10	2	91
	44	22	8	2	91
	66	22	6	2	91

Calculations:

K = hydraulic conductivity (cm/sec)
L_w = wetted length of auger hole (cm)
r_w = radius of auger hole (cm)
S_i = vertical distance from bottom of auger hole to impeding layer (cm)
Q_e = equilibrium rate of water added (cm^3/sec) = average $\Delta v/\Delta t$ for last run

$$K = \frac{3Q}{\pi L_w (3L_w + 2S_i)} \ln \frac{L_w}{r_w}$$

Assumption:
Impeding layer is assumed to be at 8.0 ft (bottom of excavation)

Results:

L_w = 51 cm
r_w = 5.1 cm
S_i = 98 cm
Q_e = 91 cm^3/sec

K = 0.011 cm/sec
32 ft/day

Path: 0:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\KTestCalcs.xls
6/13/02 ANM

STONE ENVIRONMENTAL, INC.

Auger Hole Hydraulic Conductivity Measurement

Project Title: Decentralized Wastewater Treatment Options for I-89, Exit 17
SEI Study #: 01-1240-W
Date: June 11, 2002
Sampling Personnel: ANM, JMS
Backhoe test pit #: JR-TP4
Auger hole radius: 2 in.
Auger hole depth: 20 in.

Field Measurements (continued on following page)**:**

Run	Time (t) seconds	Δ t	Volume (v) Liters	Δ v	Flow Rate (Q_e) cm^3/sec
1	0		14		
	19	19	12	2	105
	37	18	10	2	111
2	0		12		
	15	15	10	2	133
	34	19	8	2	105
3	0		14		
	15	15	12	2	133
	32	17	10	2	118
	47	15	8	2	133
	61	14	6	2	143
	76	15	4	2	133
	92	16	2	2	125
	108	16	0	2	125

Calculations:

K = hydraulic conductivity (cm/sec)
L_w = wetted length of auger hole (cm)
r_w = radius of auger hole (cm)
S_i = vertical distance from bottom of auger hole to impeding layer (cm)
Q_e = equilibrium rate of water added (cm^3/sec) = average Δv/Δt for last run

$$K = \frac{Q}{2\pi L_w^2}\left(\ln\left[\frac{L_w}{r_w} + \sqrt{\left(\frac{L_w^2}{r_w^2} - 1\right)}\right] - 1\right)$$

Assumption:
Impeding layer is assumed to be at 10.0 ft (bottom of excavation)

Results:

L_w = 51 cm
r_w = 5.1 cm
S_i = 116 cm
Q_e = 130 cm^3/sec

K = 0.016 cm/sec
45 ft/day

Path: 0:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\KTestCalcs.xls
6/13/02 ANM

STONE ENVIRONMENTAL, INC.

Auger Hole Hydraulic Conductivity Measurement

Project Title: Decentralized Wastewater Treatment Options for I-89, Exit 17
SEI Study #: 01-1240-W
Date: June 11, 2002
Sampling Personnel: ANM, JMS
Backhoe test pit #: JR-TP6
Auger hole radius: 2 in.
Auger hole depth: 20 in.

Field Measurements (continued on following page)**:**

Run	Time (t) seconds	Δ t	Volume (v) Liters	Δ v	Flow Rate (Q_e) cm^3/sec
1	0		10		
	35	35	8	2	57
2	0		10	-2	
3	0	0	8		
	38	38	6	2	53
	70	32	4	2	63
4	0		10		
	19	19	8	2	105
	39	20	6	2	100
	58	19	4	2	105
	77	19	2	2	105

Calculations:

K = hydraulic conductivity (cm/sec)
L_w = wetted length of auger hole (cm)
r_w = radius of auger hole (cm)
S_i = vertical distance from bottom of auger hole to impeding layer (cm)
Q_e = equilibrium rate of water added (cm^3/sec) = average Δv/Δt for last run

$$K = \frac{3Q}{\pi L_w (3L_w + 2S_i)} \ln \frac{L_w}{r_w}$$

Assumption:
Impeding layer is assumed to be at 7.7 ft (bottom of excavation)

Results:

L_w = 51 cm
r_w = 5.1 cm
S_i = 3.0 cm
Q_e = 100 cm^3/sec

K = 0.027 cm/sec
77 ft/day

Path: 0:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\KTestCalcs.xls
6/13/02 ANM
STONE ENVIRONMENTAL, INC.

Auger Hole Hydraulic Conductivity Measurement

Project Title: Decentralized Wastewater Treatment Options for I-89, Exit 17
SEI Study #: 01-1240-W
Date: June 11, 2002
Sampling Personnel: ANM, JMS
Backhoe test pit #: JR-TP7
Auger hole radius: 2 in.
Auger hole depth: 20 in.

Field Measurements (continued on following page)**:**

Run	Time (t) seconds	Δ t	Volume (v) Liters	Δ v	Flow Rate (Q_e) cm^3/sec
1	0		10		
	31	31	8	2	65
	57	26	6	2	77
	97	40	4	2	50
2	0		10		
	36	36	8	2	56
	71	35	6	2	57
	100	29	4	2	69
3	0		14		
	32	32	12	2	63
	64	32	10	2	63
	97	33	8	2	61
	131	34	6	2	59
	162	31	4	2	65

Calculations:

K = hydraulic conductivity (cm/sec)
L_w = wetted length of auger hole (cm)
r_w = radius of auger hole (cm)
S_i = vertical distance from bottom of auger hole to impeding layer (cm)
Q_e = equilibrium rate of water added (cm^3/sec) = average Δv/Δt for last run

$$K = \frac{Q}{2\pi L_w^2}\left(\ln\left[\frac{L_w}{r_w} + \sqrt{\left(\frac{L_w^2}{r_w^2} - 1\right)}\right] - 1\right)$$

Assumption:
none for this test

Results:

L_w = 51 cm
r_w = 5.1 cm
S_i = 122 cm
Q_e = 62 cm^3/sec

K = 0.0076 cm/sec
22 ft/day

Path: 0:\Proj-01\1240-W-Colc-Exit17\SoilsTesting\KTestCalcs.xls
6/13/02 ANM

STONE ENVIRONMENTAL, INC.

Capacity Analysis: Rowley Cluster Site, Area A

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 24, 2002
Prepared by: Mary K. Clark

Darcy's Law Formula: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = D * L = transmitting soil cross-sectional area (square ft.), where
D = depth to impeding layer or water table, minus required separation, minus system depth (ft.)
L = length of disposal system (ft.)

Assumptions:
1 System bottom is 0.5 feet below ground surface (bgs) for Scenario 1, and 2.0 feet bgs for Scenarios 2 and 3
2 Required separation distance = 3 feet for standard disposal system
3 Average hydraulic conductivity K = 39 feet/day
4 Slope, i = ground slope, estimated from USGS topographic map = 3%
5 Totals are divided by 2 to account for construction of primary and replacement systems
6 Scenarios 2 and 3 are hypothetical requiring additional field testing to verify

Calculations:
Scenario 1: Capacity Given Current Site Conditions

K = 39 ft./day
i = 3%
L = 250 feet
D = (8.2 ft. - 3.0 ft. - 0.5 ft.) = 4.7 ft.
Q = 39 ft/day x 0.03 x (250' x 4.7') x 7.48
Q = 10,283 gpd

Scenario 2: Capacity Given 20 Feet of Suitable Soils Underlying Disposal Area

K = 39 ft./day
i = 3%
L = 250 feet
D = (20 ft. - 3.0 ft. - 2.0 ft.) = 15 ft.
Q = 39 ft/day x 0.03 x (250' x 15') x 7.48
Q = 32,819 gpd

Scenario 3: Capacity Given That Archaeological Buffer is Included

K = 39 ft./day
i = 3%
L = 500 feet
D = (20 ft. - 3.0 ft. - 2.0 ft.) = 15 ft.
Q = 39 ft/day x 0.03 x (500' x 15') x 7.48
Q = 65,637 gpd

Capacity Analysis: Rowley Cluster Site, Area B

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 24, 2002
Prepared by: Mary K. Clark

Darcy's Law Formula: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = D * L = transmitting soil cross-sectional area (square ft.), where
D = depth to impeding layer or water table, minus required separation, minus system depth (ft.)
L = length of disposal system (ft.)

Assumptions:
1 System bottom is 0.5 feet below ground surface (bgs) for Scenario 1, and 2.0 feet bgs for Scenarios 2 and 3
2 Required separation distance = 3 feet for standard disposal system
3 Average hydraulic conductivity K = 39 feet/day
4 Slope, i = ground slope, estimated from USGS topographic map = 3%
5 Totals are divided by 2 to account for construction of primary and replacement systems
6 Scenarios 2 and 3 are hypothetical requiring additional field testing to verify

Calculations:
Scenario 1: Capacity Given Current Site Conditions

K = 39 ft./day
i = 3%
L = 180 feet
D = (10 ft. - 3.0 ft. - 0.5 ft.) = 6.5 ft.
Q = 39 ft/day x 0.03 x (180' x 6.5') x 7.48
Q = 10,239 gpd

Scenario 2: Capacity Given 20 Feet of Suitable Soils Underlying Disposal Area

K = 39 ft./day
i = 3%
L = 180 feet
D = (20 ft. - 3.0 ft. - 2.0 ft.) = 15 ft.
Q = 39 ft/day x 0.03 x (180' x 15') x 7.48
Q = 23,629 gpd

Scenario 3: Capacity Given That Groundwater Drains East and West from Disposal Site

K = 39 ft./day
i = 3%
L = 360 feet
D = (20 ft. - 3.0 ft. - 2.0 ft.) = 15 ft.
Q = 39 ft/day x 0.03 x (360' x 15') x 7.48
Q = 47,258 gpd

Capacity Analysis: Rowley Cluster Site, Area C

Project Title: Decentralized Wastewater Treatment Options for Exit 17
SEI Study #: 01-1240-W
Date: December 24, 2002
Prepared by: Mary K. Clark

Darcy's Law Formula: Q = KiA
Q = design flow (gallons/day)
K = Hydraulic conductivity (ft./day)
i = Hydraulic gradient (slope of water table)
A = D * L = transmitting soil cross-sectional area (square ft.), where
D = depth to impeding layer or water table, minus required separation, minus system depth (ft.)
L = length of disposal system (ft.)

Assumptions:
1 System bottom is 0.5 feet below ground surface (bgs) for Scenario 1, and 2.0 feet bgs for Scenarios 2 and 3
2 Required separation distance = 3 feet for standard disposal system
3 Average hydraulic conductivity K = 39 feet/day
4 Slope, i = ground slope, estimated from USGS topographic map = 3%
5 Totals are divided by 2 to account for construction of primary and replacement systems
6 Scenarios 2 and 3 are hypothetical requiring additional field testing to verify

Calculations:
Scenario 1: Capacity Given Current Site Conditions

K = 39 ft./day
i = 3%
L = 160 feet
D = (8.0 ft. - 3.0 ft. - 0.5 ft.) = 4.5 ft.
Q = 39 ft/day x 0.03 x (160' x 4.5') x 7.48
Q = 6,301 gpd

Scenario 2: Capacity Given 20 Feet of Suitable Soils Underlying Disposal Area

K = 39 ft./day
i = 3%
L = 160 feet
D = (20 ft. - 3.0 ft. - 2.0 ft.) = 15 ft.
Q = 39 ft/day x 0.03 x (160' x 15') x 7.48
Q = 21,004 gpd

Scenario 3: Capacity Given That Additional Excavation Reveals Suitable Soils to East

K = 39 ft./day
i = 3%
L = 300 feet
D = (20 ft. - 3.0 ft. - 2.0 ft.) = 15 ft.
Q = 39 ft/day x 0.03 x (300' x 15') x 7.48
Q = 39,382 gpd

APPENDIX E: ESTIMATED CONSTRUCTION COST DETAILS

TOWN OF COLCHESTER
DECENTRALIZED WW TREATMENT OPTIONS FOR I-89 EXIT 17

EFFLUENT PUMPING SYSTEM
ESTIMATED CONSTRUCTION COST

As of 12/23/02

ITEM NO.	DESCRIPTION OF ITEM	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL ESTIMATED COST (ENR 6600)
A- SEWERS					
A- 1	12" PVC Gravity Sewer	0	L.F.	$42.00	$0.00
A- 2	10" PVC Gravity Sewer	0	L.F.	$40.00	$0.00
A- 3	8" PVC Gravity Sewer	0	L.F.	$35.00	$0.00
A- 4	6" D.I. Force Main	0	L.F.	$30.00	$0.00
A- 5	4" D.I. Force Main	8700	L.F.	$24.00	$208,800.00
B- SEWER SYSTEM APPURTENANCES					
B- 1	4' Sewer Manhole	1	Each	$2,000.00	$2,000.00
B- 2	4' Air Release/Cleanout Manhole	10	Each	$4,000.00	$40,000.00
B- 3	6" Sewer Service Connections	0	Each	$1,000.00	$0.00
B- 4	Jack & Bore Roadway Crossings	0	L.F.	$150.00	$0.00
C- EARTHWORK					
C- 1	Rock Excavation	200	C.Y.	$100.00	$20,000.00
C- 2	Boulder Excavation	100	C.Y.	$25.00	$2,500.00
C- 3	Misc., Extra & Below Grade Excavation	100	C.Y.	$15.00	$1,500.00
C- 4	Excavation & Replacement of Unsuitable Ma	200	C.Y.	$25.00	$5,000.00
D- ROAD AND DRIVE REPAIRS					
D- 1	Gravel Roads and Drives	200	L.F.	$15.00	$3,000.00
D- 2	Temp. Trench Bituminous Pavement	0	S.Y.	$12.00	$0.00
D- 3	Permanent Trench Bituminous Pavement	0	S.Y.	$25.00	$0.00
D- 4	Concrete Sidwalk Replacement	0	L.F.	$20.00	$0.00
E- INCIDENTAL WORK					
E- 1	Class "B" Concrete	10	C.Y.	$200.00	$2,000.00
E- 2	Calcium Chloride	2	TON	$600.00	$1,200.00
E- 3	Rigid Trench Insulation	250	L.F.	$5.00	$1,250.00
E- 4	Uniform Traffic Control	400	HRS	$40.00	$16,000.00
F- LUMP SUM ITEMS					
F- 1	Construction Photographs	1	L.S.	$250.00	$250.00
F- 2	Effluent Pump Station	1	L.S.	$300,000.00	$300,000.00
F- 3	Preparation of Site and Misc. Work (2.5%)	1	L.S.	$15,087.50	$15,087.50
F- 4	Bonds (2.5%)	1	L.S.	$15,464.69	$15,464.69
	TOTAL				$634,052
	USE				$640,000

NOTES:
1. ENR 6600 = November 2002

TOWN OF COLCHESTER
DECENTRALIZED WW TREATMENT OPTIONS FOR I-89 EXIT 17

LOW PRESSURE SEWER SYSTEM
ESTIMATED CONSTRUCTION COST

As of 12/23/02

ITEM NO.	DESCRIPTION OF ITEM	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL ESTIMATED COST (ENR 6600)
A- SEWERS					
A- 1	12" PVC Gravity Sewer	0	L.F.	$42.00	$0.00
A- 2	10" PVC Gravity Sewer	0	L.F.	$40.00	$0.00
A- 3	8" PVC Gravity Sewer	1250	L.F.	$36.00	$45,000.00
A- 4	6" D.I. Force Main	0	L.F.	$30.00	$0.00
A- 5	4" PVC. Force Main	4000	L.F.	$25.00	$100,000.00
A- 6	2" PVC Force Main	1000	L.F.	$15.00	$15,000.00
B- SEWER SYSTEM APPURTENANCES					
B- 1	4' Sewer Manhole	6	Each	$2,500.00	$15,000.00
B- 2	4' Air Release/Cleanout Manhole	4	Each	$4,000.00	$16,000.00
B- 3	2" Effluent Force Main Connections	24	Each	$500.00	$12,000.00
B- 4	Directional Bore Roadway Crossings	450	L.F.	$100.00	$45,000.00
C- EARTHWORK					
C- 1	Rock Excavation	200	C.Y.	$100.00	$20,000.00
C- 2	Boulder Excavation	100	C.Y.	$25.00	$2,500.00
C- 3	Misc., Extra & Below Grade Excavation	100	C.Y.	$15.00	$1,500.00
C- 4	Excavation & Replacement of Unsuitable Ma	200	C.Y.	$25.00	$5,000.00
D- ROAD AND DRIVE REPAIRS					
D- 1	Gravel Roads and Drives	1000	L.F.	$15.00	$15,000.00
D- 2	Temp. Trench Bituminous Pavement	250	S.Y.	$12.00	$3,000.00
D- 3	Permanent Trench Bituminous Pavement	500	S.Y.	$25.00	$12,500.00
D- 4	Concrete Sidewalk Replacement	0	L.F.	$20.00	$0.00
E- INCIDENTAL WORK					
E- 1	Class "B" Concrete	10	C.Y.	$200.00	$2,000.00
E- 2	Calcium Chloride	10	TON	$600.00	$6,000.00
E- 3	Rigid Trench Insulation	250	L.F.	$5.00	$1,250.00
E- 4	Uniform Traffic Control	200	HRS	$40.00	$8,000.00
F- LUMP SUM ITEMS					
F- 1	Construction Photographs	1	L.S.	$250.00	$250.00
F- 2	Preparation of Site and Misc. Work (2.5%)	1	L.S.	$8,125.00	$8,125.00
F- 3	Bonds (2.5%)	1	L.S.	$8,328.13	$8,328.13
	TOTAL				$341,453
	USE				$350,000

NOTES:
1. ENR 6600 = November 2002

TOWN OF COLCHESTER
DECENTRALIZED WW TREATMENT OPTIONS FOR I-89 EXIT 17

SEWER COLLECTION SYSTEM
ESTIMATED CONSTRUCTION COST

As of 12/23/02

ITEM NO.	DESCRIPTION OF ITEM	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL ESTIMATED COST (ENR 6600)
A- SEWERS					
A- 1	12" PVC Gravity Sewer	0	L.F.	$42.00	$0.00
A- 2	10" PVC Gravity Sewer	0	L.F.	$40.00	$0.00
A- 3	8" PVC Gravity Sewer	6400	L.F.	$35.00	$224,000.00
A- 4	6" D.I. Force Main	1650	L.F.	$30.00	$49,500.00
A- 5	4" D.I. Force Main	1900	L.F.	$24.00	$45,600.00
B- SEWER SYSTEM APPURTENANCES					
B- 1	4' Sewer Manhole	22	Each	$2,500.00	$55,000.00
B- 2	4' Air Release/Cleanout Manhole	10	Each	$4,000.00	$40,000.00
B- 3	6" Sewer Service Connections	20	Each	$1,000.00	$20,000.00
B- 4	Jack & Bore Roadway Crossings	400	L.F.	$150.00	$60,000.00
C- EARTHWORK					
C- 1	Rock Excavation	200	C.Y.	$100.00	$20,000.00
C- 2	Boulder Excavation	100	C.Y.	$25.00	$2,500.00
C- 3	Misc., Extra & Below Grade Excavation	100	C.Y.	$15.00	$1,500.00
C- 4	Excavation & Replacement of Unsuitable Ma	200	C.Y.	$25.00	$5,000.00
D- ROAD AND DRIVE REPAIRS					
D- 1	Gravel Roads and Drives	1000	L.F.	$15.00	$15,000.00
D- 2	Temp. Trench Bituminous Pavement	250	S.Y.	$12.00	$3,000.00
D- 3	Permanent Trench Bituminous Pavement	500	S.Y.	$25.00	$12,500.00
D- 4	Concrete Sidewalk Replacement	0	L.F.	$20.00	$0.00
E- INCIDENTAL WORK					
E- 1	Class "B" Concrete	10	C.Y.	$200.00	$2,000.00
E- 2	Calcium Chloride	10	TON	$600.00	$6,000.00
E- 3	Rigid Trench Insulation	250	L.F.	$5.00	$1,250.00
E- 4	Uniform Traffic Control	200	HRS	$40.00	$8,000.00
F- LUMP SUM ITEMS					
F- 1	Construction Photographs	1	L.S.	$500.00	$500.00
F- 2	Pump Station No. 1	1	L.S.	$275,000.00	$275,000.00
F- 3	Pump Station No. 2	1	L.S.	$250,000.00	$250,000.00
F- 4	Preparation of Site and Misc. Work (2.5%)	1	L.S.	$21,158.75	$21,158.75
F- 5	Bonds (2.5%)	1	L.S.	$27,937.72	$27,937.72
	TOTAL				$1,145,446
	USE				$1,150,000

NOTES:
1. ENR 6600 = November 2002