APPENDIX A

Primary Treatment Units – Septic Tanks For Small Community Systems

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I. INTRODUCTION

A. Scope

This Appendix is intended to be used in conjunction with the design of alternative wastewater treatment systems as identified in the Iowa Department of Natural Resources (DNR) Treatment Design Manuals for small communities. The appendix was written to qualify and quantify the treatment processes, performance expectations, design criteria and operation and maintenance requirements of septic tank treatment units as components of an alternative wastewater treatment system. This Appendix provides design guidance and information regarding the potential discharge capabilities of the specific unit herein identified. The Appendix has been prepared using the following assumptions:

- Treatment of Domestic Waste Only;
- Design influent BOD of 250 mg/L;
- Design influent TKN of 40 mg/L;
- Design Hydraulic Loadings of 100 gpcpd
- Design Population Equivalents:
  - 25 people
  - 100 people
  - 250 people

For wastewater discharges from schools or commercial establishments, the design will need to take into account the amount and quality of wastewater being discharged, and determine if additional primary treatment, such as grease traps, are need before discharging the effluent to a secondary treatment or effluent dispersal system.

This appendix is to be used by Owners, Consulting Engineers, DNR Review Engineers and associated DNR personnel, as well as Funding source personnel to provide a common minimum threshold for design of primary treatment units.

II. PROCESS DESCRIPTION AND PERFORMANCE

A. Wastewater Source

The qualitative characteristics of wastewater generated by residential sources can be distinguished by their physical, chemical, and biological composition. Wastewater flow and the type of waste generated affect wastewater quality. Concentrations of typical pollutants in raw residential wastewaters are shown in the following table.

Table 2-1
Typical Raw Residential Wastewater Quality

Constituent	Mass Loading Grams/person/day	Concentration
5-day biological oxygen demand (BOD_5)	35-65	155 – 286 mg/l
Total suspended solids (TSS)	35-75	155 – 330 mg/l
Chemical oxygen demand (COD)	115-150	150 – 660 mg/l
Total nitrogen (TN)	6-17	26 – 75 mg/l
Ammonia (NH_4-N)	1-3	4 – 13 mg/l
Nitrites and nitrates (NO_3-N)	<1	<1 mg/l
Total phosphorus (TP)	1-2	6 – 12 mg/l
Fats, Oil & Grease (FOG)	12-18	70 – 105 mg/l
Total Coliform (TC)	-	$10^8 – 10^{10}$ cfu/100ml
Fecal Coliforms (FC)	-	$10^6 – 10^8$ cfu/100ml

(USEPA, 2002)

B. Septic Tanks

A septic tank is used to remove solids from the wastewater by settling and flotation. To a lesser degree, reducing influent TSS and BOD is needed prior to discharge to the treatment/dispersal component. For clusters of homes and small communities, a large multi-compartment tank can serve as a septic tank.

The goal of primary treatment is to reduce TSS to levels that will not cause fouling of the secondary treatment or final dispersal component. TSS removal in excess of 50% are typical, and have been found to be a sufficient level of primary treatment for successful soil dispersal components.

A secondary goal is to achieve some initial BOD reduction. The performance expectation for individual home septic tanks as well as community septic tanks is discussed in the following sub-sections.

Ammonia nitrogen will pass through septic tanks unchanged due to the lack of oxygen in the anaerobic environment. Organic nitrogen will continue its transformation to ammonia nitrogen as organic solids break down, so an increase in ammonia nitrogen concentration is not unusual. For this reason, total Kjeldahl nitrogen (the sum of the organic and ammonia forms of nitrogen) is a better indicator of the nitrogen content of raw wastewater.

The removal efficiency of a septic tank is related less to the size of the tank than to the available capacity for solids to settle. If a tank is properly maintained, performance should not vary significantly with respect to tank size. A smaller tank however, will require more frequent pumping, which increases the likelihood of solids pass-through due to missed or delayed tank pumping. Operational and monitoring concerns for this component are covered in Section V. of this appendix.

1. Individual (STEP/STEG Systems)

In a collection system in which septic tanks are provided at each individual home, primary treatment occurs before the wastewater enters the collection system. A system in which septic tank effluent flows into the collection system by gravity is known as a Septic Tank Effluent Gravity (STEG) system. Those systems which require the septic tank effluent to be pumped into the collection system are referred to as Septic Tank Effluent Pump (STEP) system. These collection systems benefit the community by allowing for the use of smaller diameter pipes, fewer manholes, and less reliance on minimum slopes. These benefits can result in a lower cost collection system, and are made possible by the removal of heavy solids at the source, thereby minimizing concerns about solids settling out in the collection system and creating blockages.

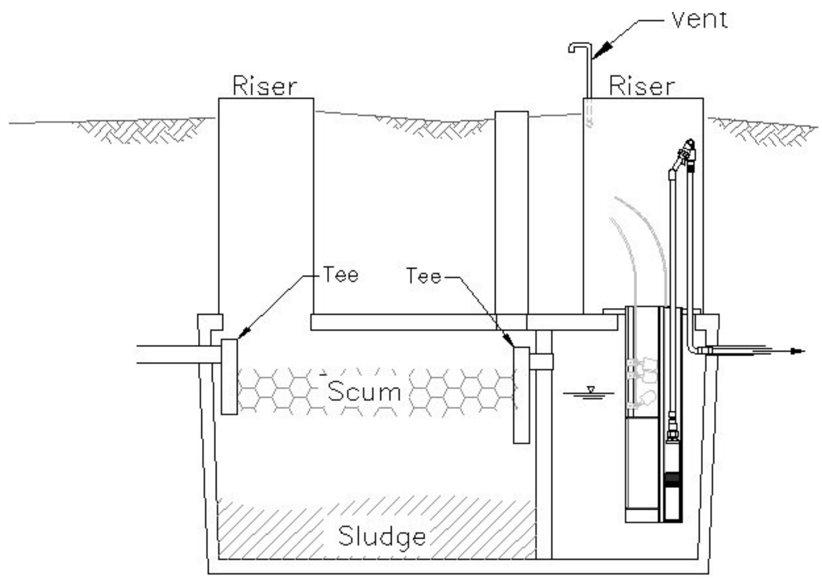

Figure 2-1 STEP - Septic Tank Pump Cross Section

Septic tank effluent systems, which require a pump to reach the collection system, are referred to as STEP (Fig. 2-1) systems, and those that rely solely on gravity are called STEG (Fig. 2-2) systems.

STEP/STEG systems typically achieve higher levels of BOD reduction than community septic tanks. BOD removal rates of more than 50% can result, typically reducing influent BOD concentrations to the treatment/dispersal component to less than 125 mg/l.

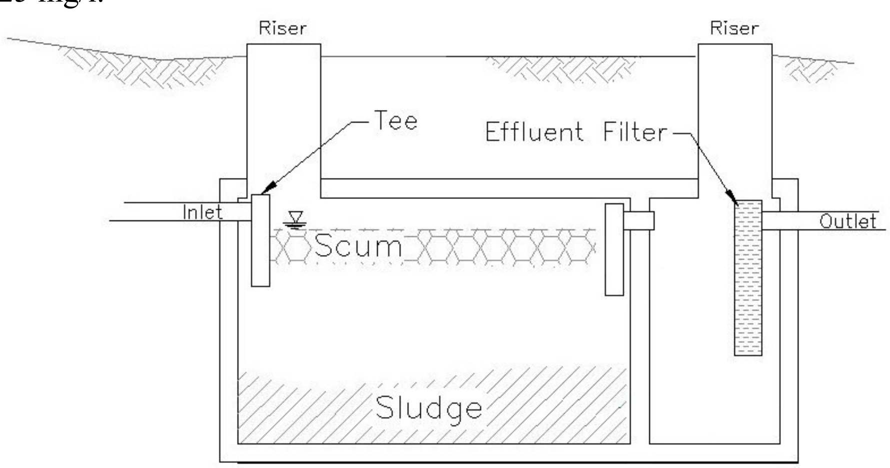

Figure 2-2 STEG - Septic Tank Cross Section

A study of individual home septic tanks (Bounds, 1994) found that individual home septic tanks without effluent screens reduced BOD and TSS by an average of 58% and 75%, respectively. In municipal STEP systems where effluent screens are used, these removal efficiencies increased to 64% for BOD and 91% for TSS.

2. Community Septic Tanks

Where a STEP/STEG system is not present or feasible, sewage from a conventional gravity sewer system must at a minimum be pre-settled prior to discharge to the final dispersal component. The simplest means of TSS removal is to allow settling in a large, community septic tank (Fig. 2-3).

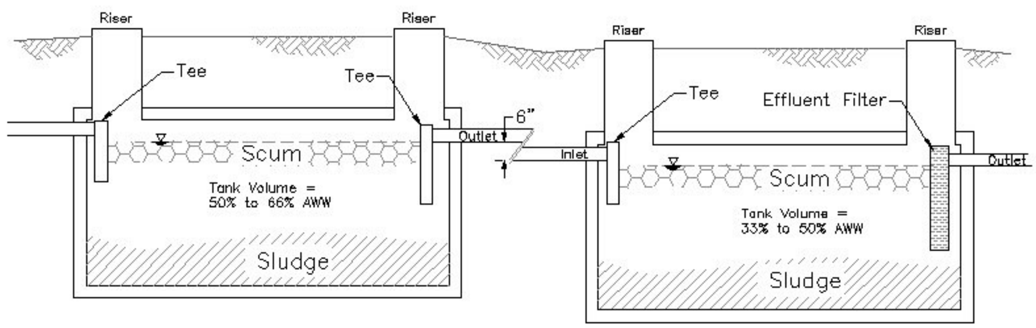

Figure 2-3 Community Septic Tank Cross Section

Community septic tanks shall be sized for a minimum of a two-day detention time for gravity collection systems, based on the design flow. Community tanks that receive wastewater from a low-pressure collection system in which 10% or more of the users utilize grinder pumps shall be sized for a minimum of three days detention time.

Tanks are commonly sized for a two to three-year pumping interval but pumping should be based on inspection and measurement of the sludge and scum depths. A study of community scale septic tanks by the authors revealed a much lower level of BOD removal as compared to individual septic tanks. This finding is consistent with a study (Bounds, 1997) in which found that septic tanks require about three years to establish sufficient volatile organic acid concentrations to allow digestion to occur. This suggests that too frequent pumping will negatively impact BOD removal. See Section V. for additional information regarding sludge removal and management.

C. Effluent screens

It is important that the solids are retained in the septic tank and not released to the treatment and dispersal component. Excessive discharge of solids to downstream components can result in increased maintenance of dosing components and plugging and/or loss of efficiency in treatment and dispersal of the normal liquid flow.

Effluent screens vary in size and shape, surface areas and mesh sizes. A typical installation is shown in Fig. 2-4. Gravity flow screens generally consist of a screening element located in a canister. They have surface areas upon which solids collect or possibly become re-entrained in the septic tank liquid. These surfaces likely are attachment sites for microbial growth.

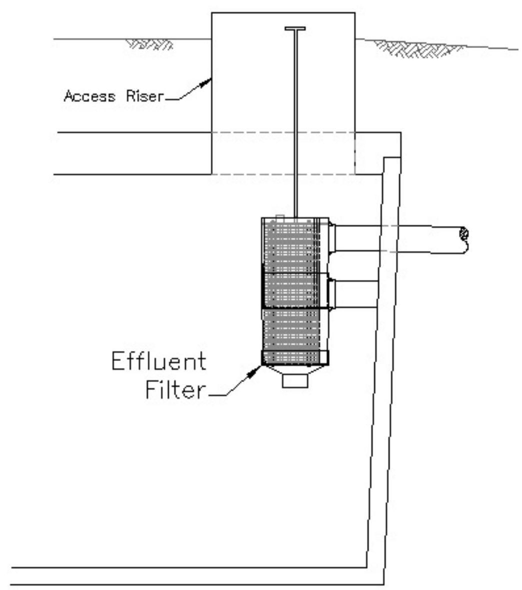

Figure 2-4 Typical Effluent screen Installation

Effluent screens are located in the most downstream chamber or tank in a series. This screen should be installed on the final outlet of the septic tank to provide efficient solids removal and longest possible periods between maintenance events. Effluent screens require periodic maintenance so access to the screen through a surface riser is an essential part of any tank equipped with an effluent screen.

Manufacturers of the commercially available screens provide an expected time line for cleaning the screens based on wastewater strength and design daily flow rates. Because of the variable wastewater characteristics of each system, the operator will need to make adjustments to the maintenance schedule based on experience with their particular system just as they will for collection of solids in septic tanks.

D. Performance Goals and Experience

Primary treatment reduces levels of TSS to help prevent fouling of the final dispersal component. Some initial BOD reduction has been documented as well, although experience shows this is often not significant. The performance expectation for both individual and community septic tank primary treatment units is shown in Table 2-2. Where no data exists, the Iowa Design Guidelines shown in Table 2-2 for community or individual septic tanks shall be used to determine the design loading rates to secondary treatment and effluent dispersal systems. Where data exists the designer may submit it to support the use of alternate values.

Table 2-2
Septic Tank Effluent Quality

		Iowa Design Guidelines	
	Typical Literature Value*	Individual Septic Tanks	Community Septic Tanks
Constituent	Typical Concentration, mg/l		
5-day biological oxygen demand (BOD_5)	100 – 220	125	250
Total suspended solids (TSS)	20 – 55	125	125
Chemical oxygen demand ($CBOD_5$)	160 – 300		
Organic Nitrogen (ON) (as N)	20 – 40		
Total Kjeldahl Nitrogen (TKN) (as N)	50 – 90	40	40
Ammonia (NH_3-N) (as N)	30 – 50		
Nitrites & Nitrates (NO_3-N) (as N)	< 1.0		
Total Phosphorus (TP)	12 – 20		
Fats, Oil & Grease (FOG)	10 - 20		
Fecal Coliform (FC)	10^6 - 10^8 cfu/100ml		

* For residential septic tanks with an effluent screen, adapted from Crites and Tchobanoglous, 1998

III. DESIGN CRITERIA

A. Design Criteria

This manual provides design guidance for primary treatment units used in for small wastewater treatment systems. The design guidance is summarized in the following discussions, figures and tables. A design report and detailed plans must be submitted for review and approved by IDNR prior to construction.

B. Design Flow

For a system designed under these guidelines the design flow is described as the average wet weather flow (AWW) and shall be 100 gal/person/day.

AWW = no. of people x 100 gal/person/day

Table 3-1
AWW for Various Populations

Population	Flow/Person, gal.cap/day	Design Daily Flow, gpd
25	100	2,500
100	100	10,000
250	100	25,000

As with any system a careful evaluation of the wastewater source and characteristics is necessary. The designer should try to determine if there are any sources of unusual flow that may have a significant effect on the anticipated design daily flow. Some items that the designer and the owner/community should be aware of and watchful for are:

- sump pumps that may add substantial wet weather flows
- poor landscaping around access points to the collection system, which may add surface water to the system
- leaky plumbing fixtures
- condensate drains from furnaces
- water softener discharge
- commercial establishments, including schools, office and retail space, restaurants and bars,

If any of these items will pose a significant increase in expected flow rates, adjust the design daily flow accordingly.

C. Primary Treatment Component – Septic Tanks

1. Individual (STEP/STEG) Tanks

a) *Volume Sizing Requirements*

Septic tanks are sized along the same guidelines typically used for on-site disposal systems. Tanks for individual homes shall be a minimum of 1,000 gallons each, and shall typically be between 1,000 and 1,500 gallons. All tanks in a collection system should be of the same size to allow for simple record keeping and maintenance.

STEP/STEG tanks shall have two chambers. The primary chamber must have at least one half of the total capacity, but not more than 2/3 of the total capacity. It is recommended that the maximum allowable volume be provided in the primary chamber of the septic tank.

b) *"Stilling" Tank*

When the community chooses the option of installing individual septic tanks at each residence it is recommended that a "stilling tank" be installed at the final dispersal component site prior to the secondary treatment or dosing component. The stilling tank is the receiving vessel for the discharge from the collection system. The stilling tank can be a septic tank of adequate size to provide a buffer between the collection system and the treatment components. The purpose of this tank is to provide additional settling and to filter out particles that can be introduced into the collection system due to a pipe break, screen or baffle failure or illegal discharge into the collection system. A suggested size for this tank, based on the population served, is shown in Table 3-2. Because this is a redundant tank, which should not receive solids on a regular basis, the volume is flexible. Periodic checking of the sludge depths will be an indicator of the required pumping interval.

Table 3-2
Stilling Tank Volumes for STEP/STEG Collection Systems

Population	Size, gallons
25	1,000
100	2,500
250	3,000

2. Community Tanks

Community septic tank sizing is based on the type of collection system being used. For a gravity collection system, the volume shall be a minimum of the average wet weather flow times 2. For systems in which 10% or more of the homes being served employ grinder pumps, the minimum size of the community septic tank shall be 3 times the average wet weather design flow. For either case, additional volume, above the minimum required, will provide additional solids settling capacity and will minimize downstream impacts from variable flows. The following calculations are based on a hydraulic retention time of 2 days.

Table 3-3
Community Septic Tank Volumes for Populations

Population	Design Flow, gpcd	Gravity Collection System Septic Tank Volume, gal	Grinder Pump Collection System Septic Tank Volume, gal
25	2,500	5,000	7,500
100	10,000	20,000	30,000
250	25,000	50,000	75,000

Some manufacturers of secondary treatment components have specific requirements for the volume of the septic tank preceding their equipment. Consult with the manufacturer and if they require a different volume than the one stated above provide a statement from the manufacturer justifying the volume used in the design. The designer and owner should be aware that a reduction in septic tank volume might require more frequent pumping of the tank to remove solids.

a) *Configuration and Layout*

Whether the septic tanks are individual precast concrete, molded units or site constructed concrete, multiple tanks or chambers should be incorporated into the design to allow maximum opportunity for sludge settlement and scum retention. In system designs for 25 to 100 people, a tank configuration should include at a minimum two separate chambers or individual tank structures with the first chamber having a volume equal to 50% to 66% of the AWW.

Example: 100 people on a gravity system = 20,000 gallon of septic tank volume. The first tank or chamber will be 10,000 to 13,200 gallons and the second tank will be 6,800 to 10,000 gallons. See Fig 3-1.

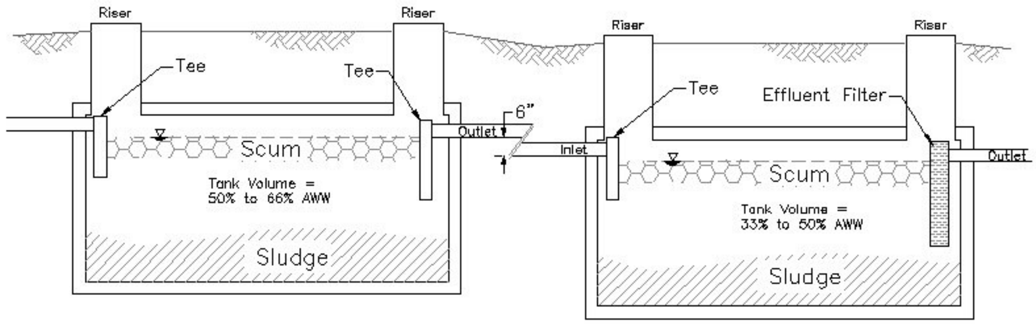

Figure 3-1 Septic Tank Configuration for Populations of 25 to 100 people

A larger first compartment will increase the interval between sludge pump outs. The second tank will receive a comparatively smaller volume of solids requiring less frequent sludge removal.

Systems with a design flow between 100 and 250 people require a minimum of three separated tanks or chambers. The first chamber or tank should be larger than the downstream tanks. The first tank volume should be equal to 40% of the design flow.

> Example: 250 people on a gravity system = 50,000 gallons septic tank volume. Three tanks or chambers are required, sized as follows:
>
> First tank = 50,000 (40%) = 20,000 gallons
> Second & third tank = 15,000 gallons each

The first tank will receive the bulk of the solids and will need sludge removed more often than the downstream tanks. See Fig 3-2.

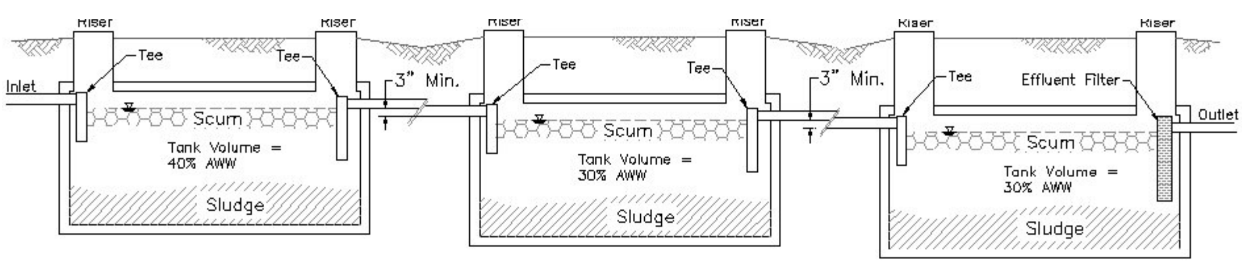

Figure 3-2 Community Septic Tank Configuration for Populations of 100 to 250 People

b) *Bypass Piping*

To facility routine maintenance, repairs or malfunctions of the septic tank component(s), bypass valves and piping should be incorporated into design. The following diagram illustrates one method of providing bypass capabilities. The designer may present alternate methods of providing this function.

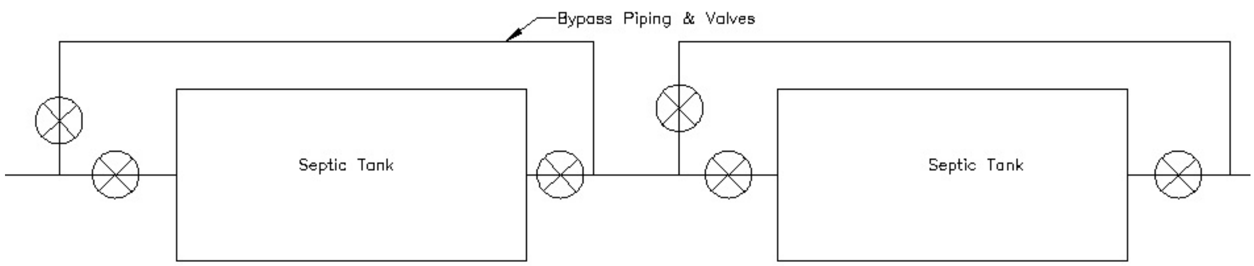

Figure 3-3 Septic Tank Bypass Piping

c) *Access Risers*

Access risers ≥ 24" in diameter are required at the inlet and outlet of each chamber/tank in the system. An access riser is also required over any device requiring periodic maintenance or monitoring such as screens, pumps, float switches, etc. The access risers over treatment devices shall be sized adequately for routine maintenance and/or removal of the item without entering the tank. Additional risers may be required in long tanks to facilitate complete solids pump out of the tank. Risers used for access to remove solids from the tank should be located at intervals no greater than 10' apart along the long axis of the tank. All risers shall terminate 4" above finish grade to prevent surface water leakage into the tank. All riser joints shall be sufficiently waterproof to prevent infiltration of ground or surface water into the tank.

d) *Lids*

All access risers shall be covered with a lid. A strong, lightweight lid constructed from fiberglass or aluminum is recommended to facilitate ease of maintenance. Access to the treatment devices within the tanks for sampling and maintenance is required much more frequently than in small system applications, light weight, easily opened lids makes this activity much easier to accomplish.

All riser lids and hatchways shall have a label attached to them warning of the hazards of entering the tank without proper breathing equipment. The environment within the septic tank or any treatment vessel is classified as confined, hazardous space and should not be entered by anyone without proper training, equipment and support personnel on site. All lids and covers shall be equipped with a locking mechanism such as tamper proof bolts, chains & locks or internal locking devices to prevent unauthorized access.

3. Effluent screens

Effluent screens used in the septic tank component will be passive screens located on the outlet of the last tank or chamber (see Fig. 2-4). The screen should be sized for the anticipated flow and an expected maintenance schedule. Screens can be equipped with service alarms, which are activated when the screen needs cleaning. The alarm signal can be routed to an automatic alarm dialer or can be sent to a stand-alone alarm panel mounted next to the screen access riser. The need for alarms can be reduced or eliminated with frequent, regular maintenance of the screens.

Experience has shown that the biological buildup of material on an effluent screen occurs at a faster rate than is indicated in the manufacturers literature, especially in small community systems. So, while the estimates of scheduled maintenance listed in the literature can be used to compare screens, more frequent cleaning of the screen(s) should be expected. An effluent screen can be viewed as the last defensive measure prior to effluent discharge to the next downstream component in the treatment process. When choosing a screen, consideration should be given to issues such as:

- availability of maintenance personnel
- frequency of cleanings
- alarm signalization for clogging (visual, audible, route to auto dialer)
- availability of pressurized water source for screen cleaning purposes

In many cases, with a large system, multiple screens will be required. The tank design must include screen access risers or hatchways of sufficient size to remove all of the screens for cleaning or replacement. The hatchway or riser shall be a minimum of 24” in diameter or square for one (1) screen. Multiple screens will require a larger opening sized so all the screens can be removed for cleaning. Septic tanks can be constructed with multiple 24” risers or larger rectangular openings with an aluminum hatch cover. Multiple effluent screens can be configured to flow into a common manifold pipe, which in turn is connected to the outlet of the tank.

4. Buoyancy

Where high groundwater conditions are anticipated, buoyancy of the treatment tank structures shall be considered and, if necessary, adequate provisions shall be made for protection of each tank from buoyant forces of the groundwater. Light weight molded tanks are quite likely to require additional weight added to prevent floatation of the tanks during high groundwater events. The worst case should be evaluated, high groundwater events occurring simultaneously with the removal of treatment tank contents because of an emergency situation. In some cases, the additional weight of the soil on the tank may be enough, while in others the tank may need to be strapped to a concrete slab to provide ballast.

5. Site Access

An all-weather service road to the location of a community septic tank site is required to facilitate maintenance and septage pumping needs. The service road should be:

- wide enough to accommodate septage pumper trucks and maintenance repair vehicles.
- graded to accommodate occasional large vehicular traffic
- have at a minimum a crush gravel surface for ease of snow removal
- terminate within 25 feet of treatment tank to be serviced

Maintenance or repairs will sometimes require the use of a small backhoe, which is generally delivered to the site on a flat bed trailer. Depending on the local road traffic conditions, adequate turn around space or off road parking for this equipment should be considered when laying out of the treatment tank area. It is further recommended that a crushed gravel walkway, to each of the treatment tank access points, be included in the design for continuing operation and monitoring of the system components during inclement weather periods.

IV. OPERATIONAL, MONITORING AND MAINTENANCE ISSUES

In cluster or community wastewater treatment systems, there is a greater need to provide for flexibility of operation and to monitor system performance than with individual septic systems. While this poses an additional burden to both the owner-operator as well as the regulatory agency, the potential impacts to multiple homeowners and to the environment are significant enough to warrant greater oversite. The designer and owner-operator should not be led to believe that, once constructed, these small community wastewater systems can be forgotten about. Each system should be monitored so the operator can gain an understanding of the system's performance, allowing them to recognize problems as they arise and make any necessary changes to the operating or maintenance schedule.

A. Operational Concerns

1. Sludge Management

Periodic measurements of the combined sludge and scum depth are required. When the combined thickness of these two items reaches 1/3 of the liquid depth in any one tank, the tank should be pumped. For individual tanks in STEG & STEP collection systems where the tank is owned and maintained by the community, sludge removal will based on periodic inspections of the tank and measurement of the sludge/scum layer. A suggested frequency of monitoring this component is shown in Table 4-1.

2. Odors

Odors associated with the septic tanks can occur because of the anoxic environment. In most cases, if the lids are kept in place properly, the strongest odors will only occur when the solids are pumped out of the tank. This should only last for the short time period when the pumping is occurring. If objectionable odors are continually present remedies such as charcoal filters and raising vent pipes higher into the air have been successful at alleviating the problem. Remotely located septic tanks will make odor issues more manageable.

Strong odors emanating from a secondary treatment unit may signal a malfunction of the unit. Odors at this device would signal a change in the wastewater to an anaerobic condition has developed due to a higher than expected wastewater strength or increased flows beyond the capacity of the unit to handle them. Further investigation of the unit by trained personnel is recommended.

3. <u>Freezing</u>

Freezing issues are not generally a problem with the septic tank but can occur if there is a large surge of clear water into the tank and/or prolonged periods of subzero weather occurs. The standard remedy for a frozen tank is to apply a temporary heat source to the tank as soon as possible such as stream or hot water and cover the frozen device with an insulating layer of straw or insulation. Resolution of a persistent freezing problem may require installation of permanent insulating blankets over tanks and pipes to provide adequate frost protection.

Table 4-1
Operation & Monitoring Schedule

System Component	Frequency								Comment
	W	M	Q	S	A	2YR	3YR	OTHER	
Primary Component									
1st Tank									
Sludge Depth					X				
Pump Contents								As needed	
2nd Tank									
Sludge Depth					X				
Pump Contents								As Needed	
3rd Tank									
Sludge Depth					X				
Pump Contents								As Needed	
Baffles (all tanks)					X				
Outlet Screen(s)		X							For community septic tanks; annually for individual septic tanks
Wastewater Sampling			X						Monthly if flow is >10,000 gpd

W - Weekly, M - Monthly, Q - Quarterly, S - Semi-Annually, A - Annually

4. <u>Structural</u>

The tank, access risers and lids should be checked routinely for structural abnormalities such as defective lids and leaking, cracked or broken or joints at pipe entry and exit points and riser sections. Inlet and outlet tees should be checked annually to insure that they are in place and not clogged with debris.

5. Effluent screen

Effluent screens should be checked on a routine basis as suggested in Table 4-1. The interval for cleaning this device should be adjusted based on the wastewater strength and characteristics of the particular system.

6. Site Maintenance

a) Mowing

Mowing around the septic tanks is recommended to provide a safe environment for maintenance activities. Mowing intervals should be based on the equipment available and the normal community requirements.

b) Site Access

In general access to the primary treatment tank area should be restricted. Trails created by either motor vehicle or foot traffic contribute to driving the frost deeper. An unsecured site increases opportunities for vandalism of the mechanical and electrical devices. Fencing of the treatment tank area may be necessary if local conditions dictate a need for increased security at the site.

7. Record Keeping

The operation, monitoring and maintenance record keeping system should include the following items:

- Solids Removal including volumes and dates
- Sludge Depth Measurements
- Effluent screen Cleaning Frequency
- Secondary Treatment Component Monitoring
- Wastewater Sampling Results

The maintenance record keeping system may be modified to best suit the needs of the facility. It is important that the system operator keeps the record system up-to-date by recording and filing in an orderly manner any information pertaining to the operation and maintenance of the facility.

Equipment maintenance records assure that information on operation and maintenance of facility equipment will be available should there be absences or changes in operations personnel. The operator should make sure that any information obtained on the equipment (either through operation, maintenance, or correspondence with equipment representatives) is recorded on equipment maintenance record cards or filed in an orderly manner. Regular review of the equipment maintenance files can alert the operator to problems, which might be developing at the facility, so that they can be corrected before costly emergency repairs are needed.

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