The University of Iowa
IOWA INITIATIVE
FOR SUSTAINABLE COMMUNITIES

Lake Delhi
Decentralized Wastewater Treatment Alternatives

Jason Ruffatti
Esteban Londono
Brian Cummings
Kelly Wollner

Class led by: Professor Tim Mattes
Course Name: Environmental Engineering Design | College of Engineering
Project Lead: Dennis Lyons, Delaware County Sanitarian
Fall Semester 2017

In partnership with
East Central Intergovernmental Association

A PROGRAM OF
The University of Iowa Office of Outreach & Engagement
OUTREACH.UIOWA.EDU
outreach-engagement@uiowa.edu 319.335.0684

This project was supported by the Iowa Initiative for Sustainable Communities (IISC), a program of the Provost's Office of Outreach and Engagement at the University of Iowa that partners with rural and urban communities across the state to develop projects that university students and faculty complete through research and course-work. Through supporting these projects, the IISC pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

This publication may be available in alternative formats upon request.

Iowa Initiative for Sustainable Communities
Provost's Office of Outreach and Engagement
The University of Iowa
111 Jessup Hall
Iowa City, IA, 52241
Email: iisc@uiowa.edu
Website: http://iisc.uiowa.edu/

Final Report:
Lake Delhi Wastewater Treatment

Jason Ruffatti, Brian Cummings, Esteban Londono, and Kelly Wollner
Team Rustic State Warriors
University of Iowa, Environmental Engineering Design
December 5, 2017

Table of Contents

Table of Figures

Table of Tables

Introduction

Executive Summary

In this report, design alternatives were considered for the creation of decentralized wastewater treatment facilities for the community of Lake Delhi, Iowa. The community was recently flooded in 2010, prompting the construction of the new dam under the condition that insufficient wastewater treatment in the surrounding community be addressed. For that reason, Team Rustic State Warriors have been instructed to examine three sites with little to no access to wastewater treatment. The locations each contain unique difficulties not typical of normal wastewater treatment. Due to topographical, economic, and legal constraints, the design alternatives have been limited to small decentralized systems. Also, Lake Delhi officials have stated that the homeowner demographic will be changing because the lake has returned to its original condition prior to the flood. Since the population of full-time homeowners is expected to increase, design alternative selection was adjusted to compensate for the change. Homeowner agreement and cooperation for unified systems were considered as well. Included in the report is background information on the current treatment, potential site locations for treatment systems, as well as a comprehensive analysis of treatment alternatives using decision matrices. Among the decision matrices criteria include effectiveness, cost, operation and maintenance requirements, footprint, design longevity, and installation feasibility. Final alternatives selection were made for each site. Also, cost analysis estimations were calculated on a per homeowner basis, with costs ranging from $10,900 to $34,000 per homeowner.

Background and Design Objectives

Lake Delhi, located in Delaware County, IA is ranked one of the most unsewered communities in the state of Iowa. There are a number of unincorporated areas near Lake Delhi that lack adequate wastewater treatment systems, Team Rustic State Warriors will be focusing on three of them.

In 2007, the Eastern Iowa Regional Utility Service Systems (EIRUSS) contracted with Garden & Associates to prepare a facility plan. The EIRUSS concluded that two or three centralized systems should be constructed. With controlled discharge lagoons located on the hills above the lake, wastewater would be pumped to the top of the hills and run to the treatment plants. The project had an estimated cost of $15 million but no funding source was available. Due to funding constraints, centralized systems have been ultimately ruled out as a feasible solution for this area.

In 2010, the Lake Delhi levee was breached and the State of Iowa provided funding to build a dam with the condition that the wastewater issues in the Lake Delhi area be addressed. As a result, the Delaware County Health Department has been working with the property owners in the area to resolve the wastewater issues. The objective of the design report is to provide feasible, economical, and Iowa Department of Natural Resources approved decentralized wastewater treatment for all of the residences in the Lake Delhi area.

Figure 1. "Site A", five vacation cabins located on 229th Ave Delhi, IA[7].

The first site, "Site A", consists of five vacation cabins on 229th Ave, Delhi shown in Figure 1. These five homes do not have Iowa Department of Natural Resources (IDNR) approved wastewater treatment systems which are preferred by Delaware County. One of the homes outside of Site A on the right edge of Figure 1 marked with a red rectangle has a $10,000, 1500-gallon AdvanTex wastewater treatment system which is IDNR approved and will be discussed in greater detail later on in this report. Because Lake Delhi's waters have recovered since the levee breach of 2010, the vacation cabins in Site A will be receiving more activity from their owners in the coming years. One of the main challenges of Site A is the placement of the new wastewater treatment systems. As shown in Figure 2 below, the topography of Site A presents a unique problem for design of decentralized systems. Resident responsiveness is also an issue due to the infrequent use of the vacation homes. If the residents can agree to it, they could hook into the same treatment system.

Figure 2. Shows topographical contours of "Site A" on 229th Ave Delhi, IA[7].

The second site, "Site B", shown in Figure 3, consists of approximately 30 manufactured homes with 6 current full time residents. Full time residency is expected to increase because of the improved condition of Lake Delhi. Delaware County estimates that two-thirds of the 30 homes have an IDNR approved wastewater treatment system in place such as the AdvanTex system mentioned above.

Figure 3. “Site B”, 30 mostly trailer homes located on 260th St Delhi, IA with community water well shown in the red box[7].

A small amount of the remaining third of homes have holding tanks in place, several of which are located near the community well shown in the red box in Figure 3. Site B has a relatively mild slope when compared to Site A shown by Figure 4. One of the main challenges associated with Site B is the strategic placement of treatment systems used by multiple homes. The second challenge is avoiding contamination of the community water well shown in the red box.

Figure 4. Shows topographical contours of "Site B" located on 260th St Delhi, IA[7].

The third site to be known as "Site C", shown in Figure 5 below, consists of 25-30 homes in which roughly one-third do not have proper wastewater treatment systems. In the 2010 flood, a small bar located within the red square in Figure 5 was destroyed. A $40,000 septic system that could handle roughly 8 homes for wastewater treatment remains, but the current owner of the septic system is unresponsive to efforts of communication.

Figure 5. "Site C" or "Camp-O", 25-30 homes located off the entrance of 218th Ave Delhi, IA with location of existing $40,000 septic system shown in the red box[7].

In issue with Site C is designing treatment systems in which several residences can connect and treat their wastewater. The availability of the existing $40,000 septic system also remains an issue when determining an appropriate design for the area. The slope of Site C is advantageous for inexpensive gravity draining to systems near the lake shown in Figure 6.

Figure 6. Shows topographical contours of "Site C" located on 218th Ave Delhi, IA[7].

Current Treatment

Current treatment will be addressed on an individual site basis. The current state of wastewater treatment in the three sites vary widely and are often unknown. All current treatment information was provided by associates at Delaware County. Necessary assumptions will be made about households whose current wastewater treatment systems are unknown.

<u>Site A: Current Treatment:</u>

Site A consists of five vacation cabins on 229th Ave Delhi, IA. Five of the homes on 229th Ave do not have IDNR approved water treatment. Many of these homes have concrete or plastic septic systems in place though the quality and condition of these systems is unknown. For the sake of our design we will assume that pre-existing septic tanks with proper operating information are in useful condition

Figure 7 shows the five Site A homes that do not have proper wastewater treatment. All of the homes have pre-existing cement or plastic septic tanks besides 26507. These septic tanks are not currently IDNR approved and will either have to be replaced or connected to proper treatment equipment.

Figure 7. Five Site A homes on 229th Ave Delhi, IA[7].

<u>Site B: Current Treatment:</u>

Site B is located on 260th St Delhi, IA. Five homes on Site B are deemed to have non-IDNR approved treatment systems which consist of old septic tanks that lack operational information and no current wastewater treatment information. The homes in question in Site B are marked in red in Figure 8.

Figure 8. Five Site B homes on 260th St Delhi, IA[7].

Site C: Current Treatment:

Site C consists of 25-30 homes located off the entrance of 218th Ave Delhi, IA. Six homes in Site C are deemed to have non-IDNR approved treatment systems which consist of old septic tanks that lack operational information (Figure 9).

Figure 9. Six Site C homes located off the entrance of 218th Ave Delhi, IA[7].

Feasible Treatment Sites

Feasible treatment sites were determined based on topographical, construction, and cost constraints. IDNR standards rule 567-69.21(455B) states that decentralized wastewater treatment systems should be sized based on an average dry weather flow of 150 gal/d-capita[5]. The wastewater flow in the homes on Sites A, B, and C will be calculated based on a 150 gal/d-capita basis.

Site A: Feasible Treatment Sites:

A feasible location for a treatment filter, in the blue box shown in Figure 10 below, is located on home number 26527's property. Wastewater could be pumped from all five homes to the filter which would be gravity discharged after filtration. This location is feasible because it is located on a higher elevation than the six homes to allow for gravity effluent discharge. The estimated wastewater flow for these homes was calculated to be 1650 gpd based on 11 total bedrooms.

Figure 10. Site A with feasible treatment location in the blue box[7].

Site B: Feasible Treatment Sites:

Similar to Site A, Site B has challenging topography and densely packed homes that make finding feasible treatment locations a challenge. Of the five homes located in Site B, four currently have septic systems that do not meet the IDNR wastewater effluent standards and one that has no known treatment system. The main challenge with Site B, is that the homes are located on leased land, and make it difficult to find property information. House numbers

22243, 26098, 26090, and 26123 have two bedrooms while house number 26133 only has one bedroom[7]. Assuming that these homes will have a peak in occupancy during summer months, each home was assumed to have three bedrooms, and the total wastewater flow per household would be 450 gpd.

A feasible location for a treatment filter or system for house number 22243 would be on their own property, shown in blue in Figure 11 below. The waste water from this home would gravity feed to its own system. The estimated flow of waste water from this home is 450 gpd based on our assumption.

House numbers 26133 and 26123 could share a treatment system, although 26123 may need to pump their waste depending on the final location and depth of the system. The combined flow of the two houses is 900 gpd based off the assumption of these two properties having three bedrooms each.

Houses 26090 and 26098 could also combine and share a treatment system similar to houses 26133 and 26123. They have the same flow rate of 900 gpd, but both houses should be able to utilize gravity flow to the alternative.

Figure 11. Site B with feasible treatment locations in the blue boxes[7].

Site C: Feasible Treatment Sites:

The main challenge for Site C, shown in Figure 12 below, was deciding on which homes could be grouped together to treat wastewater in the same system. Residences 25852 and 25863 were determined to be close enough to be grouped into one treatment system. The system would be located just below home 25863 shown below. The system would experience an estimated wastewater flow of roughly 600 gpd.

A group system was deemed feasible for homes 21661 and 21666. The system would be located in between the two properties, as shown in Figure 12 below, and would experience an estimated wastewater flow of 600 gpd.

Home 21650 has a small area above the home to fit a wastewater treatment system capable of 150 gpd.

Lastly, home 21630 has land within its respective property to house another small 150 gpd wastewater treatment system.

Figure 12. Site C with feasible treatment locations in the blue boxes[7].

Selection Criteria for Treatment Alternatives

Selection for which system to place in each location was based on six factors. In order to select which system was best for the locations stated, a decision matrix was created to compare the treatment systems. Included in this decision matrix is: effectiveness, cost, operation and maintenance requirements, footprint, design longevity, and installation feasibility. Each system was ranked between 1 and 5 for each location. The lower the overall total of the design matrix the better the system.

Decision Matrix

Effectiveness: Effluent from these systems meet the requirements seen below in Table 1 which are the IDNR NPDES General Permit No. 4 requirements. The system meets the flow requirements. On the decision matrix scale, highly effectiveness is designated with 1 and low effectiveness is 5.

Table 1. IDNR NPDES General Permit No.4 effluent requirements[5].

Effluents Discharging To	E. coli cfu/100 mL	$CBOD_5$ mg/L	TSS mg/L
Class "A1", "A3" waters	235	25	25
Class "A2" waters	2880	25	25

Cost: Capital cost and the cost of operation and maintenance. On the decision matrix scale, low cost is designated with 1 and high cost is given as a 5.

O&M Requirements: Operation and Maintenance requirements include how frequent the system will need maintenance. On the decision matrix scale low, infrequent maintenance is designated with 1 and high, frequent maintenance is given as a 5.

Footprint: Footprint of the treatment system. This includes the physical area required for the system. A large part deals with the topography of the site location and how much area is near the homes to be able to install a system. On the decision matrix scale, small and geographically available footprint is designated with 1 and large and geographically unacceptable is given as a 5.

Design Longevity: Design longevity considers the life time of the treatment system. On the decision matrix scale, long design life is designated with 1 and short design life is given as a 5.

Installation Feasibility: Installation of these systems needs to be considered since many of the area are either on slopes or have smaller areas to work with between homes. On the decision matrix scale, installation that is feasible is designated with 1 and installation that is unfeasible is given as a 5.

Treatment Alternatives

The three treatment alternatives suggested consist of the Orenco AdvanTex systems, Premier Tech Eco Flow Coco filters, and for worst case scenarios, standard sewage holding tanks that require intermittent pumping. It is important to notice that these three treatment alternatives will not be applied to all three sites in the same way because each site presents its own design challenges. The three treatment alternatives are preferred treatment methods of the IDNR as well as the representatives of Delaware County.

Alternative 1: Orenco AdvanTex Filter Systems

AdvanTex septic/filter systems come in a variety of models and sizes ranging from models that can handle 500 gpd to 15,000 gpd of domestic wastewater. These systems can also be duplicated and run in parallel to accommodate adverse flow conditions. The AdvanTex systems generally consist of a septic tank, AdvanTex filter comprised of textile media, and an effluent pump all shown in Figure 13 below.

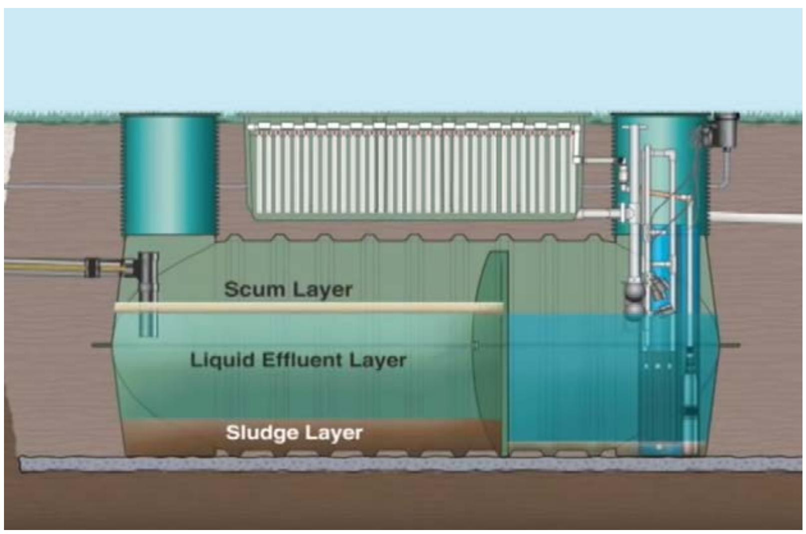

Figure 13. Shows a schematic of an AdvanTex septic/filter system[2].

The septic tank, which can be provided by Orenco, is made of fiberglass or septic tanks from other sources can be used. It allows the influent wastewater (shown on left side of Figure 13) to separate into sludge, scum, and liquid effluent layers. The liquid effluent layer is then filtered through baffle holes and pumped through the filter located above the tank in Figure 13. AdvanTex filters are comprised of a proprietary textile material that allows the wastewater to percolate through it during treatment. After filtration the effluent is discharged at an appropriate rate into the drainage field. Figure 14 provides a three-dimensional view of how an AdvanTex system sits in the ground.

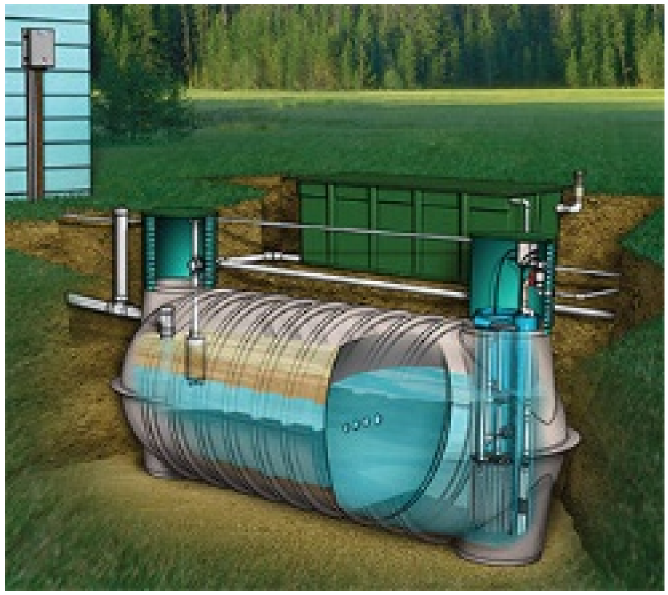

Figure 14. Three-dimensional graphic of AdvanTex septic/filter system[2].

Of the three alternative treatment systems to be discussed the AdvanTex septic/filter systems provide the highest quality wastewater treatment but are the most expensive design alternative. Table 2 below shows the average performance of various AdvanTex systems operating at different flow conditions with the data being produced from third party testing sources.

Table 2. Average performance of AdvanTex systems operating at varying flow conditions[2].

System	Orenco AdvanTex Treatment Systems					
Wastewater Contaminant	$CBOD_5$	TSS	Fecal Coliform	Total Nitrogen	NH_3	Total Phosphorus
Average % Reduction	97	97	98	71	97	28
Meet Effluent Standards?	Yes	Yes	Yes	-	-	-

Table 2 shows that AdvanTex systems more than follow the default effluent guidelines for domestic wastewater treatment in the state of Iowa. The three main AdvanTex models that are in consideration for the three sites are the AX20, AX100, and the AX-Max. The AX20 can handle wastewater flows of 500 gpd and is primarily used for single home applications. The AX100 system can handle up to 5000 gpd and is primarily used for manufactured home parks like that in Site B. The AX-Max system can handle up to 15000 gpd and is primarily used for community applications like that in Site C.

The AdvanTex systems are the logical choice in terms of effluent water quality and low operation and maintenance costs, but they do pose the largest financial burden on homeowners in terms of capital costs than the other treatment alternatives. Several AdvanTex systems are currently in use in the three Lake Delhi sites discussed previously.

Alternative 2: Premier Tech Ecoflo Coco Septic/Filter Systems

The Premier Tech Ecoflo Coco septic/filter systems come in a variety of sizes to accommodate a variety of flow conditions. The Ecoflo systems work very similar to the AdvanTex systems. Influent wastewater is pumped through a septic tank provided by Premier Tech or currently in place and is separated into sludge, scum, and liquid effluent layers. The liquid effluent is then brought to the Ecoflo biofilter shown in Figure 15 below where it drips through filter media. The filter media is comprised of 100% organic peat and coconut husk fragments which make the Ecoflo systems environmentally friendly. Ecoflo filters can be attached to already existing septic tanks.

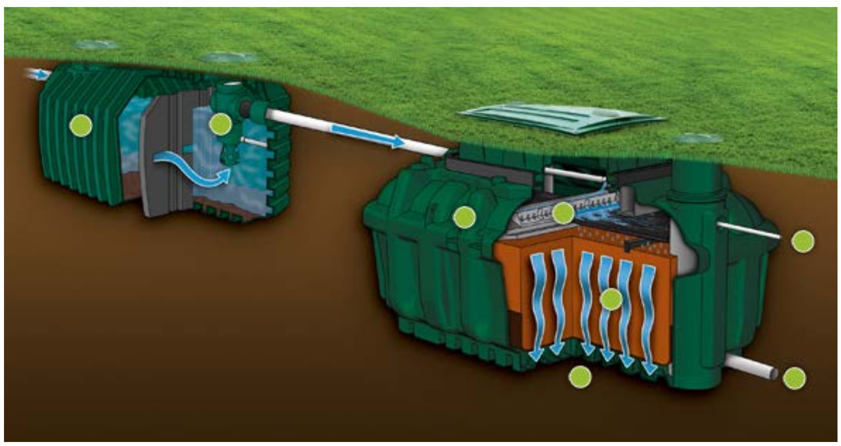

Figure 15. Schematic of Premier Tech Ecoflo Coco septic/filter system[3].

Table 3 below shows the average performance of various Premier Tech Ecoflo systems in terms of wastewater contaminant removal with data from third party testing sources. The Ecoflo systems, while they do not remove contaminants as efficiently as the AdvanTex systems, exceed the default effluent guidelines for domestic wastewater treatment in the state of Iowa.

Table 3. Average performance of Premier Tech Ecoflo systems[3].

System	Premier Tech Ecoflo Treatment System					
Wastewater Contaminant	$CBOD_5$	TSS	Fecal Coliform	Total Nitrogen	NH_3	Total Phosphorus
Average % Reduction	96	95	97	62	N/A	10
Meet Effluent Standards?	Yes	Yes	Yes	-	-	-

The key difference between the Premier Tech Ecoflo and the AdvanTex systems is that the Ecoflo systems require no effluent pump to distribute water from the septic tank to the coco filter, instead the Ecoflo systems utilize a passive distribution system that requires no energy saving the homeowner on operation and maintenance costs. The Ecoflo systems are available in gravity and pump effluent discharge configurations based on elevation conditions. Premier Tech Ecoflo systems have a lower capital cost than the AdvanTex systems and some residents in the three Lake Delhi sites currently own and operate Ecoflo systems.

Alternative 3: Holding Tanks

Standard holding tanks are suggested for worst case scenarios where no feasible installation locations for the above two alternatives can be found. Holding tanks can be made of high density plastics, concrete, and metal. Holding tanks require close monitoring and service to pump the sewage out of the tanks for treatment when necessary, which can possibly offset the relatively low capital cost of installing a conventional wastewater holding tank. The size of a holding tank is dependent on the homeowner. The homeowners should consider the flow and how often they want to pump the tank out. The recommendation of pumping for year around homes are to be pumped out twice a year. If the home is a vacation home the tank should be pumped out once a year at the end of the summer. Holding tanks can often present issues when neglected because they can potentially degrade and leach wastewater into well water sources, like the issue that is presented in Site B. This can be avoided by making sure the tank is stable and is maintained. Holding tanks are suggested to be pumped every year to protect the tank and to not over fill the tank.

Table 4. Minimum Capacity of a holding tank according to the Iowa DNR standards[5].

Number of bedrooms	Minimum Capacity
Up to and including 3- bedroom homes	1,250 gal.
4-bedroom homes	1,500 gal.
5-bedroom homes	1,750 gal.
6-bedroom homes	2,000 gals.

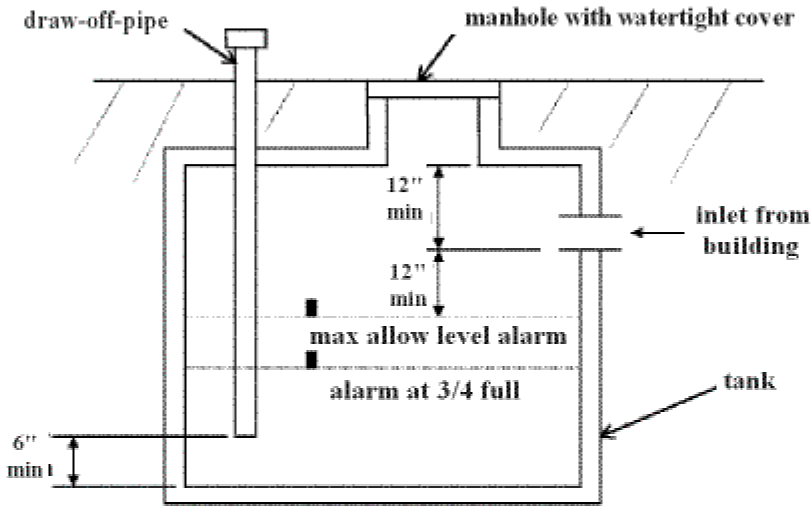

Figure 16. Cross section of a wastewater holding tank[4].

The holding tanks prices were estimated using a precast concrete structure from Shea Concrete Products[6]. The annual operation and maintenance costs and the installation costs were estimated as an average in Iowa.

Decision Matrix

Decision matrices were developed based on site circumstances and alternative favorability. Tables 5, 6, and 7 are 20-year lifecycle cost estimates of the three design alternatives mentioned above.

Table 5. Cost analysis for AdvanTex wastewater treatment systems provided by manufacturer.

System Requirements	Equipment Selection	Capital Cost	Annual O&M Cost	Installation Cost	Total 20-year Lifecycle Cost
1650 gpd Peak Flow	(2) AX20, Duplex PF5007	$ 24,739.00	$ 2,358.77	$ 22,265.00	**$ 94,179.40**
600 gpd Peak Flow	(1) AX25RT, Duplex PF3005	$ 5,787.33	$ 1,960.59	$ 14,208.50	**$ 69,207.63**

Table 6. Cost analysis for Premier Tech wastewater treatment systems provided by manufacturer.

System Requirements	Equipment Selection	Capital Cost	Annual O&M Cost	Installation Cost	Total 20-year Lifecycle Cost
900 gpd Peak Flow	(1) 900 gpd units	$ 8,400.00	$ 750.00	$ 7,560.00	**$ 30,960.00**
600 gpd peak flow	(1) 600 gpd units	$ 5,600.00	$ 560.00	$ 5,040.00	**$ 21,840.00**

Table 7. Cost analysis for holding tank wastewater treatment systems.

System Requirements	Equipment Selection	Capital Cost	Annual O&M Cost	Installation Cost	Total 20-year Lifecycle Cost
1250 gallons	(2) Septic Tank 1250 gallon	$ 1,235.00	$ 525.00	$ 5,023.00	**$ 16,758.00**
1500 gallons	(1) Septic Tank 1500 gallon	$ 1,520.00	$ 525.00	$ 5,023.00	**$ 17,043.00**

Drip field design calculations for all three sites can be found in tables A1, A2, and A3 in the Appendix. Soil type was assumed to be "lilah sandy loam" with a percolation rate of 16-30 min/in and a design loading rate (DLR) of 0.9 gpd/ft^2 in reference to IDNR 567-69.12(455B).

The final recommendations will not include drip field designs and costs because the systems that will be recommended (AdvanTex and/or PremierTech) are able to treat strong domestic wastewater to levels below the IDNR NPDES General Permit No.4 effluent requirements in Table 1. These septic systems will discharge into primary contact recreational use waters, or Class "A1" waters which are defined in IDNR Environmental Protection Chapter 69 as "waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing, and water contact recreational canoeing" [5]. Additionally, IDNR 567-69.4(455B) states "All discharges from private sewage disposal systems which are discharged into, or have the potential to reach, any designated waters of the state or subsurface drainage tile shall be treated in a manner that will conform with the requirements of NPDES General Permit No. 4 issued by the department of natural resources, as referenced in 567—Chapter 64. Prior to the use of any system discharging to designated waters of the state or a subsurface drainage tile, a Notice of Intent to be covered by NPDES General Permit No. 4 shall be submitted to the department. Systems covered by this permit must meet all applicable requirements listed in the permit, including effluent sampling and monitoring."

Site A: Final Recommendations

Due to the topography and location of Site A, our preliminary recommendation is to install an AdvanTex system shown in our decision matrix, Table 8, below. The AdvanTex filtration system would need to be able to treat 1650 gpd of standard domestic wastewater to meet the IDNR wastewater effluent standards.

Table 8. Decision matrix for five homes on Site A.

Site A-26527	AdvanTex	Eco-flow	holding tank
Effectiveness	1	2	5
Cost	4	3	2
O&M Requirements	3	2	4
Footprint	3	3	4
Design longevity	1	2	2
Installation Feasibility	1	2	4
Total	**13**	14	21

Referring to Table 5 above, this recommended 1650 gpd AdvanTex system has a total 20-year lifecycle cost of $94,179.40. This cost could be split between the five homes sharing the system leaving an individual cost of $18,835.88 per homeowner. This cost seems very reasonable for a 20-year design life. Grinder pumps will be required to convey wastewater from each home located at a lower elevation than our recommended system location. Because of the multiple homes being services on this site, the AdvanTex system was deemed more effective and feasible. This is the only site that is plausible to fit a drip field, which would require an area 1834 ft^2 and regrading of the area from a 35% slope to below a 25% slope as required the IDNR. Adding a drip field was deemed too costly and would add roughly another $10,000 to the total cost. This system will directly discharge into Lake Delhi.

Site B: Final Recommendations

Due to home 22243's proximity to the community water well, a decision was made to go against the decision matrix, shown in Table 9 below, and recommend that a well maintained 1500 gallon holding tank be installed. A 1500 gallon holding comes with a cost of $17,043. A well maintained holding tank with a pump was recommended because an AdvanTex or Premier Tech septic systems require leaching fields which are required by the IDNR to be 50 feet away from public water wells.

Table 9. Decision matrix for home 22243 on Site B.

Site B-22243	AdvanTex	Eco-flow	holding tank
Effectiveness	1	2	5
Cost	4	3	2
O&M Requirements	3	2	4
Footprint	3	3	4
Design longevity	1	2	2
Installation Feasibility	1	2	4
Total	**13**	14	21

For homes 26123 and 26133, it was suggested one Premier Tech Ecoflo Coco filter system that can handle 900 gpd, as shown by our decision matrix shown below in Table 10, be used. Referring to Table 7 above, this recommended Ecoflo system has a total 20-year cost of $30,960, leaving a total cost of $15,480 per homeowner. An Ecoflo system is optimal for these two homes because they are located in a spot that favors gravity drainage. These two homes have limited space to install a system and Ecoflo systems are much more compact than AdvanTex systems. Drip fields were deemed not feasible because there is not enough space on the properties to accommodate the required area shown in Table A2 in the Appendix. This system will directly discharge into Lake Delhi.

Table 10. Decision matrix for homes 26123 and 26133 on Site B.

Site B-26123	AdvanTex	Eco-flow	holding tank
Effectiveness	1	2	5
Cost	4	3	2
O&M Requirements	3	2	4
Footprint	3	1	3
Design longevity	1	2	2
Installation Feasibility	2	1	3
Total	14	**11**	19

For homes numbered 26098 and 26090, it was suggested a Premier Tech Ecoflo Coco filter system, as shown by our decision matrix shown in Table 11 below, be used. The topography and location of these homes make it a better candidate for the Coco filter system based on the ability to use gravity to flow through the system. The flow from these two homes is 900 gpd, so the system would need to handle that amount of flow in the limited space that these two homes share. Referring to Table 7 above, this recommended Ecoflo system has a total 20-year cost of $30,960, leaving a total cost of $15,480 per homeowner. Due to a similar situation above, drip fields were deemed not feasible because there is not enough space on the properties to accommodate the required area shown in Table A2 in the Appendix. This system will directly discharge into Lake Delhi.

Table 11. Decision matrix for homes 26098 and 26090 on Site B.

Site B-26098	AdvanTex	Eco-flow	holding tank
Effectiveness	1	2	5
Cost	4	3	2
O&M Requirements	3	2	4
Footprint	3	1	3
Design longevity	1	2	2
Installation Feasibility	2	1	3
Total	14	**11**	19

<u>Site C: Final Recommendations</u>

For homes 25863 and 25852 in site C which are located across the street from another, it was suggested an AdvanTex treatment system capable of 600 gpd be used shown by the decision matrix in Table 12 below. Referring to Table 5 above, a 600 gpd AdvanTex system has a total 20-year cost of $69,207.63, leaving a $34,603.82 cost per homeowner. From an installation standpoint, the AdvanTex system is preferable. The AdvanTex system is optimal because home 25852 does not currently have a septic tank and AdvanTex could provide a tank. Both septic tanks could be connected to the same AdvanTex filter for cost savings. Due to close proximity to other properties drip fields were deemed not feasible to accommodate the required area shown in Table A3 in the Appendix. This system will directly discharge into Lake Delhi.

Table 12. Decision matrix for homes 25863 and 25852 on Site C.

Site C-25863	AdvanTex	Eco-flo	holding tank
Effectiveness	1	2	5
Cost	4	3	2
O&M Requirements	3	2	4
Footprint	3	3	4
Design longevity	1	2	2
Installation Feasibility	1	2	4
Total	**13**	14	21

Homes 21666 and 21661 at Site C do not currently have a wastewater treatment system on either of their properties. Based off the decision matrix, shown in Table 13 below, the preliminary recommendation would be an Ecoflo system that would be shared between them. There is little space for a larger AdvanTex system, which made Ecoflo the better alternate for the site. The Ecoflo system would need to treat a combined standard domestic waste water flow of 600 gpd from the two properties. Home 21666 will require a grinder pump. Referring to Table 6 above, the total 20-year cost for a 600 gpd Ecoflo system is $21,840, leaving a cost of

$10,920 per homeowner. Drip fields were deemed not feasible to accommodate the required area shown in Table A3 in the Appendix. This system will directly discharge into Lake Delhi.

Table 13. Decision matrix for homes 21666 and 21661 on Site C.

Site C-21666	AdvanTex	Eco-flo	holding tank
Effectiveness	1	2	5
Cost	4	3	2
O&M Requirements	3	3	4
Footprint	3	1	3
Design longevity	1	2	2
Installation Feasibility	2	2	3
Total	14	**13**	19

For home 21650 in Site C, referring to Table 14 below, it was recommended that a 1250 gallon well maintained holding tank with a pump be installed. Referring to Table 7 above, the total cost of a 1250 gallon holding tank is $16,758 which is our cheapest design alternative. A holding tank was the optimal treatment solution for this home because of the low flow and infrequent use.

Table 14. Decisions matrix for home 21650 on Site C.

Site C-21650	AdvanTex	Eco-flo	holding tank
Effectiveness	5	5	3
Cost	4	3	2
O&M Requirements	3	3	4
Footprint	5	4	3
Design longevity	1	2	2
Installation Feasibility	3	3	2
Total	21	20	**16**

For home 21630 in Site C it was recommended that a well maintained holding tank with a pump capable of handling 1250 gallons of wastewater. Referring to Table 7 above, the total cost of a 1250 gallon holding tank is $16,758 which is our cheapest design alternative. The homeowners reportedly do not visit often and this home has one bedroom. They do have an existing septic tank but it was deemed unusable because it was installed in 1962.

Table 15. Decision matrix for home 21630 on Site C.

Site C-21630	AdvanTex	Eco-flo	holding tank
Effectiveness	5	5	3
Cost	4	3	2
O&M Requirements	3	3	4
Footprint	5	4	3
Design longevity	1	2	2
Installation Feasibility	3	3	2
Total	21	20	**16**

Conclusion

In this report, three design alternatives were considered for each of the three sites examined. Orenco AdvanTex systems, Premier Tech Eco Flow Coco filters, and standard sewage holding tanks were evaluated for individual locations using decision matrices. The decision matrices included effectiveness, cost, operation and maintenance requirements, footprint, design longevity, and installation feasibility. Recommendations varied depending on the site. All recommendations and cost analysis are shown in Table 16.

Table 16. Summary of final recommendations.

	Homes	System	20-year Total Lifecycle Cost	Cost per homeowner
Site A	26507, 26511, 26527, 26535, 26539	1650 gpd Advantex System	$ 94,179.40	$ 18,835.88
Site B	26123, 26133	900 gpd PremierTech System	$ 30,960.00	$ 15,480.00
	26098, 26090	900 gpd PremierTech System	$ 30,960.00	$ 15,480.00
	22243	1500 gallon holding tank w/ pump	$ 17,043.00	$ 17,043.00
Site C	25863, 25852	600 gpd AdvanTex System	$ 69,207.63	$ 34,603.82
	21666, 21661	600 gpd PremierTech System	$ 21,840.00	$ 10,920.00
	21650	1250 gallon holding tank w/ pump	$ 16,758.00	$ 16,758.00
	21630	1250 gallon holding tank w/ pump	$ 16,758.00	$ 16,758.00

Appendix

Drip field area example calculation:

Site A

Assuming: soil is lilah sandy loam- percolation rate of 16-30min/in

$$Dlr := 0.9 \frac{gal}{day \cdot ft^2}$$

IDNR 567-69.12 (455B)

$$Q_A := 1650 \frac{gal}{day}$$

$$A_{req} := \frac{Q_A}{Dlr} = 1833.333\ ft^2$$

Table A1. Drip field design calculations for Site A.

Site A Home(s)	System	# of Bedrooms	Required Drip Field Area [ft^2]
26507, 26511, 26527, 26535, 26539	1650 gpd Advantex System	11	1834

Table A2. Drip field design calculations for Site B.

Site B Home(s)	System	# of Bedrooms	Required Drip Field Area [ft^2]
26123, 26133	900 gpd PremierTech System	6	1000
26098, 26090	900 gpd PremierTech System	6	1000

Table A3. Drip field design calculations for Site B.

Site C Home(s)	System	# of Bedrooms	Required Drip Field Area [ft^2]
25863, 25852	600 gpd AdvanTex System	4	670
21666, 21661	600 gpd PremierTech System	4	670

References

1. Metcalf & Eddy (2003). Wastewater Engineering Treatment and Reuse. New York: McGrawHill Companies, Inc.

2. "AdvanTex Performance Summary 1&2." Orenco, Orenco Systems, 3 Dec. 2012, www.orenco.com/products/treatment-systems.

3. Rubin, Robert. Field Performance Assessment of Premier Tech Ecoflo Wastewater Treatment Systems in Virginia. Field Performance Assessment of Premier Tech Ecoflo Wastewater Treatment Systems in Virginia.

4. Cross Section of a Sewage Holding Tank. Digital image. Background of the PCMA Sewage Management Program. N.p., n.d. Web.

5. "Private Septic Systems." Iowa Department of Natural Resources, Iowa Department of Natural Resources, www.iowadnr.gov/Environmental-Protection/Water-Quality/Private-Septic-Systems.

6. Shae Concrete Products, sheaconcrete.com/products/precast-concrete-residential-septic-tanks#septic-tanks.

7. Beacon - Delaware County, IA, The Schneider Corporation, beacon.schneidercorp.com/Application.aspx?AppID=72&LayerID=474&PageTypeID=2&PageID=459.