Form 2

OSE/PE Report For:

☒ Construction Permit ☐ Repair Permit ☐ Voluntary Upgrade Permit ☐ Certification Letter ☐ Subdivision Approval

Property Location:

911 Address: 5055 Walnut Level Road City: Crozet

Lot ________ Section ________ Subdivision ________

GPIN or Tax Map # 14-10, 14-10Axx, 14-10 C, 14-10F, 14-3A, 14-3b Health Dept ID # ________

Latitude ________ Longitude ________

Applicant or Client Mailing Address:

Name: Innisfee, Inc.

Street: 5505 Walnut Level Road

City: Crozet State VA Zip Code 22932

Prepared by:

OSE Name ________ License # ________

Address ________

City ________ State ________ Zip Code

PE Name David J. Maciolek License # 0402043224

Address 3452 Bleak House Rd.

City Earlysville State VA Zip Code 22936

Date of Report 23 Mar. 2023 Date of Revision #1 ________

OSE/PE Job # ________ Date of Revision #2 ________

Contents/Index of this report (e.g., Site Evaluation Summary, Soil Profile Descriptions, Site Sketch, Abbreviated Design, etc.)

OSE/PE Cover Page
AOSS Construction Permit Application
AOSS Engineering Report, 14 Aug. 2024
Appendix A - Flow & Load calculations
Appendix B - Process Design Calculations
Appendix C- Collection System Design
Appendix D. Drainfield Calc's Appendix E. Soils Info.
Attachment 1 - Construction Documents

Certification Statement

I hereby certify that the evaluations and/or designs contained herein were conducted in accordance with the *applicable provisions of the* Sewage Handling and Disposal Regulations (12 VAC5-610), the Private Well Regulations (12 VAC5-630), *the* Regulations for Alternative Onsite Sewage Systems (12VAC5-613) and all other applicable laws, regulations and policies implemented by the Virginia Department of Health. I further certify that I currently possess any professional license required by the laws and regulations of the Commonwealth that have been duly issued by the applicable agency charged with licensure to perform the work contained herein. The potential for both conventional and alternative onsite sewage systems has been discussed with the owner/applicant.

☐ The work attached to this cover page has been conducted under an exemption to the practice of engineering, specifically the exemption in Code of Virginia Section 54.1-402.A.11

I recommend that a (select one): construction permit ☒ certification letter ☐ subdivision approval ☐ be (select one) Issued ☐
repair permit ☐ voluntary upgrade ☐ Denied ☐

OSE/PE Signature [signature] Date 14 Aug. 2024

Commonwealth of Virginia

Application for: ☑Sewage System ☐Water Supply

VDH Use only
Health Department ID# ____________
Due Date ______________________

Owner Innisfree, Inc. — Phone Office: (434)823-5400

Mailing Address 5505 Walnut Level Road — Phone ______
Crozet, VA 22932 — Fax (434)823-5027

Agent David Maciolek, P.E. Aqua Nova Engineering, PLC — Phone 434-249-4497

Mailing Address 3452 Bleak House Rd. — Phone ______
Earlysville, VA 22936 — Fax ______

Site Address 5055 Walnut Level Road
Crozet, VA 22932 — Email David@AquaNovaEngineering.com

Directions to Property: From Emmet St,. WNW 2.3 mi. on Barracks Rd. Contin. NW 9 mi. on Garth Rd (State Rte 601), NNW 4 mi. on State Rte 810. Straight onto Walnut Level, 1.5 mi.

Subdivision ______ Section ______ Block ______ Lot ______

Tax Map 14-10, 14-10Axx, 14-10 C, 14-10F, Other Property Identification TMP 14-3A& B Dimension/Acreage of Property 232 +/- ac

Sewage System

Type of Approval: Applicants for new construction are advised to apply for a certification letter to determine if land is suitable for a sewage system and to apply for a construction permit (valid for 18 months) **only when ready to build**.

☐Certification Letter ☒ Construction Permit ☐ Voluntary Upgrade ☐ Repair Permit

Proposed Use:

Single Family Home (**Number of Bedrooms** ____) Multi-Family Dwelling (**Total Number of Bedrooms** ____)

Other (describe) Community Including: 16 Residences Office, Work shops and Community Center

Basement?☐Yes☒No Walk-out Basement?☐Yes☒No Fixtures in Basement☐Yes☒No

Conditional permit desired?☐Yes☒No If yes, which conditions do you want?

☐Reduced water flow ☐ Limited Occupancy ☐Intermittent or seasonal use ☐ Temporary use not to exceed 1 year

Do you wish to apply for a betterment loan eligibility letter?☐Yes☒No *There is a $50 fee for determination of eligibility.

Water Supply

Will the water supply be☐Public or☒Private? Is the water supply☒Existing or☐Proposed?

If proposed, is this a replacement well?☐Yes ☒No If yes, will the old well be abandoned? ☐Yes ☒No

Will any buildings within 50’ of the proposed well be termite treated? ☐Yes ☒No

All Applicants

Is this a private sector OSE/PE application? ☒Yes ☐No If yes, is the OSE/PE package attached? ☒Yes ☐No

Is this property indeed to serve as your (owners) principal place of residence? ☐Yes ☒No

In order for VDH to process your application for a sewage system you must attached a plat of the property and a site sketch. For water supplies, a plat of the property is recommended and a site sketch is required. The site sketch should show your property lines, actual and/or proposed buildings and the desired location of your well and/or sewage system. When the site evaluation is conducted the property lines, building location and the proposed well and sewage sites must be clearly marked and the property sufficiently visible to see the topography.

I give permission to the Virginia Department of Health to enter onto the property described during normal business hours for the purpose of processing this application and to perform quality assurance checks of evaluations and designs certified by a private sector Onsite Soil Evaluator or Professional Engineer as necessary until the sewage disposal system and/or private water supply has been constructed and approved.

Signature of Owner/ Agent — Date 14 Aug. 2024

This form contains personal information subject to disclosure under the Freedom of Information Act. Revised 12/1/2014

Innisfree Village

Alternative On-site Sewage System

ENGINEERING REPORT

14 August 2024

COMMONWEALTH OF VIRGINIA
14 Aug. 2024
DAVID J. MACIOLEK
Lic No. 043224
PROFESSIONAL ENGINEER

This Alternative Onsite Sewage System (AOSS) design is submitted under the provisions of Section 32.1-163.6 of the Virginia Administrative Code and to the engineer's knowledge, complies with the requirements therein.

Aqua Nova Engineering, PLC
3452 Bleak House Rd.
Earlysville VA 22936
Tel. 434-249-4497

Table of Contents

Overview 1
  Engineering Project History 1
Design Criteria 2
  Wastewater Sources, Flows and Characteristics 2
Onsite Sewage System Overview 4
New Collection system 4
Centralized Treatment 7
  Overview 7
  Effluent Total Nitrogen Requirements 7
  Primary Treatment and Flow Equalization 8
  Secondary treatment 8
  Alkalinity Addition 10
  Tertiary Treatment 10
System Control Panel 12
Centralized Effluent Dispersal 12
  General Soils Evaluations 12
  Drainfield Soils Evaluations 12
  Design Hydraulic Application Rates 14
  Drainfield Design 15
  Low Pressure Dosing System Details 17
  Controls System and Remote Access 18
  Hydraulic Controls and Overflows 18
REFERENCES 18

List of Tables

Table 1. Project Information and Projected Wastewater Flow 1
Table 2. Sewage Generation Rate by Source 2
Table 3. Water Usage - Residential Buildings with Flow Meters (a) 3
Table 4. AOSS System – Final Design Influent and Effluent Parameters 4
Table 5. Sewer Design Summary 6
Table 6. Nitrogen Dilution Model Summary 7
Table 7. Drainfield Subareas Soil Texture and Ksat Results 14
Table 8. Primary Drainfield Design – Characteristics and Capacity 16
Table 9. Reserve Drainfield Design – Characteristics and Capacity 17

List of Appendices

Appendix A	Design Flow and Loading Calculations Flow Equalization Volume Calculations Detailed Water Use Data
Appendix B	AdvanTex Treatment System Design Calculations Stage Three Treatment Biofilter calculations Total Nitrogen Dilution Model Results
Appendix C	Sewer System Design Calculations
Appendix D	LPD Dispersal System Design LPD Detail Calculations (Using OSI Pump Select calculation tool) Groundwater Mounding Model Results
Appendix E	Soils Evaluation Data- Soil Profile Descriptions and Ksat Testing Results Summary Ksat Testing Field Data

Overview

The purpose of this document is to present the design criteria and design information for wastewater treatment and disposal for the alternative onsite sewage system (AOSS) to manage sewage for Innisfree Village (Innisfree). Innisfree is a residential community for adults with mental disabilities located in western Albemarle County, north of Crozet, VA. Sewage from buildings at Innisfree Village (Innisfree) is currently managed using conventional onsite sewage systems (COSS) consisting of septic tanks with gravity drainfields.

The Project Purposes are summarized below:

- Replace most of the existing COSS's with a centralized wastewater collection treatment and disposal system permitted as an Alternative Onsite Sewage System (AOSS) through the Virginia Department of Health (VDH). This will provide reliable long-term management of the sewage from the residences and other important buildings.
- Disperse highly treated effluent in a drainfield that is downgradient from the cluster of gardens and drinking water wells in the upper Village area.
- Remove trace organic compounds and nitrogen from the effluent before discharge to the soils to protect the groundwater resources.

Table 1. Project Information and Projected Wastewater Flow

Project Information	
Owner Contact:	Aurore Hutter Innisfree Village, Inc.
Project Location:	**5505 Walnut Level Road Crozet, VA 22932**
Wastewater Source, Flows and Disposal/Re-use	
Wastewater Source:	Residential Buildings, Community Center Office and Workshop Buildings
Design Flow (Peak Effluent)	5,500 GPD
Disposal:	Low pressure dosed dispersal trench system consisting of three Cells

Engineering Project History

An evaluation of the overall water and sewer systems was performed by Inboden Environmental Services, Inc. (IES) in 2021. The conclusion of this evaluation was that a centralized sewer system should be installed to replace the COSS serving most buildings. IES prepared a Preliminary Engineering Report (PER) and submitted a draft version to Ryder Bunce of VDH in Sep. 2022. IES engineering staff had a Preliminary Engineering Conference with Mr. Bunce and Josh Kirtley of VDH. A final version of the PER was submitted in Dec. 2022.

Aqua Nova Engineering took over the project in December 2023. Representatives from VDH, including Mr. Bunce, Mr. Kitley and Steve Thomas reviewed the soils in the proposed dispersal area in February 2024. Subsequently, Aqua Nova performed further soils evaluations to define the variation in soil characteristics and hydraulic conductivity within the area proposed for the primary dispersal field.

DESIGN CRITERIA

Wastewater Sources, Flows and Characteristics

There are twenty-one separate buildings that will be connected to the AOSS. Table A-1 (Appendix A) lists the buildings, information about occupancy and estimated wastewater flows for each building. Also, the existing COSS that serves each building is listed in Table A-1. A summary of design wastewater generation rates by source is presented in Table 2.

Table 2. Sewage Generation Rate by Source

Source	**No. of Buildings**	**Occupancy Persons** (a)	**Flow,** gpd/pers (b)	**Peak Design Flow**, gpd	**Notes**
Residences	17 (80 bedrooms)	86	50	4,300	Most bedrooms are single occupancy
Workstation/ Workshop	2	42	3	126	Workers are residents & staff (c)
Office	1 (d)	10	15	150	Occupied Mon.-Fri.
Farm Bldg	1	15	7	105	Normal occupancy. is 4 persons (e)
Community Center	1	75	10	750	Typ. use lunch only for resid.
Future Residence (f)	1	5	50	250	
TOTAL Peak Flow				**5,681**	

(a) Maximum occupancy.
(b) Flow estimated in gallons per person per day
(c) Workstations used by residents and resident staff, up to 3 shifts/day of 7-person teams. Ea. Shift is 2-hours.
(d) Office and one of the workshops are in a single building but usage is estimated separately.
(e) Normal occupancy is four persons for the day shift. Occasionally up to 15 people attend a short meeting.
(f) Proposed future residence with five, 1-person bedrooms.

Residential Sewer Flow Estimate

Sewage flows for residences are based on measured water use for three buildings over a period of 11 months. The buildings were chosen to represent a range of usage types and locations. Amity is a larger building in the center of Innisfree and is has extra day use. Meadow is a medium sized residence on the edge of the core area. Trillium is a smaller residence located the at distant, uphill end of the Village; it is the northwest most residence.

A summary of residence measured water use is presented Table 3. The complete water use data is presented in Tables A-6, A-7, and A-8 of Appendix A. Note that the AOSS has seven-day flow equalization, so daily flow variation will be averaged over a week. Because of this, Aqua Nova allowed Innisfree to monitor water usage weekly after some daily usage had been recorded.

Table 3. Water Usage - Residential Buildings with Flow Meters (a)

Building Information		Average Daily Use		Maximum Daily Use gpd/person (c)	Note
Name	Residents (b)	Per building, gpd	Per Person, gpd/pers.		
Amity	8	255.9	33.9	55.8 (d)	(c) (d)
Meadow	8	221.0	27.8	43.1	(c)
Trillium	6	110.1	22.5	49.9	(c)
Combined Average (e)		195.6	**28.1**	49.6	

(a) Water use measured with dedicated water meter from 28 July 2023 to 05 July 2024.
(b) Typical number of residents. Actual occupancy is used to compute per person water usage.
(c) Maximum daily per person water usage observed in period.
(d) Amity maximum value likely due to timing of meter readings; the two day average was 39.5 gpd.
(e) Average value for the residences listed.

Water use for the three monitored residential buildings had a combined average of 28.1 gpd per person. To be conservative, Aqua Nova chose a design flow rate of 50 gpd per person for the AOSS design. This is about 1.8 times the combined average personal use. Because sewage flow from all buildings will be combined in the AOSS Primary & Flow Eq. Tanks, the combined numbers are appropriate for the AOSS design. The chosen per capita design flow of 50 gpd also corresponds to the combined average of the maximum daily water usage.

Design Wastewater Characteristics

The wastewater is predominantly residential sewage. A smaller amount is generated by office and workshops. The Community Center is used for resident and staff lunches only 5 days per week with an occasional small event on the other days. Aqua Nova used the type of occupancy/usage to estimate loading rates for BOD, TKN and other parameters. Overall design parameters for the new AOSS are summarized in Table 4 with detailed calculations presented in Tables A-3 and A-4 in Appendix A

Detailed flow and loading calculations are presented in Appendix A, Tables A-2 through A-4, and accompanying notes. Note that Aqua Nova used a safety factor in developing the design influent load for BOD and TKN listed in Table 2 so these values are higher than would be computed from values listed in Attachment A and Table 2.

Table 4. AOSS System – Final Design Influent and Effluent Parameters

Parameter	Raw Sewage (computed) [(a)]	Primary Effluent [(b)]	Design Influent [(c)]	Design Effluent [(d)]
Flow, gal/day	5,681 -Peak	5,681 -Peak	**5,450** Equalized	**5,450** Equalized
BOD_5, mg/L [(e)] [lb/d]	617 [29.1]	430 [19.9]	420 [**19.1**]	<10 [0.45]
TSS, mg/L [lb/d]	617 [26.1]	247 [11.7]	253 [**11.2**]	<10 [0.45]
TKN as N [(e)], mg/L [lb/d]	98 [4.6]	93 [4.4]	93 [**4.2**]	<2 [0.09]
Total Nitrogen, mg/L as N [lb/d]	96 [4.6]	93 [4.4]	93 [4.2]	</=12 [0.45]
Total Phosphorus, mg/L	NA	NA	NA	NA
Alkalinity, as $CaCO_3$, mg/L	250-400	250-400	400	NA
pH – standard units	350-400	350-400	6.5-8.5	NA

(a) Design parameters for sewage flow INTO the septic tanks. See Tables A-2 & A-3, Appendix A.
(b) Computed effluent from septic tanks with effluent filters. See Table A-4, Appendix A.
(c) Values used for design of Treatment and Disposal System. Flow Eq. reduces load from primary effluent.
(d) Design effluent to disposal system based on TL-3 effluent and required nitrogen removal.
(e) BOD5 = Carbonaceous 5-day Biochemical Oxygen Demand. TKN = Total Kjeldahl Nitrogen (organic N plus ammonia). TKN and Total nitrogen are concentrations and loadings are as N.
(f) Alkalinity based on estimated source water measurement plus typical addition due to human use, Table 4-15, Crites and Tchobanoglous, (1998). Alkalinity addition may be required for complete nitrification.

ONSITE SEWAGE SYSTEM OVERVIEW

The sewage system will collect wastewater from Innisfree buildings, treat it, and disperse large effluent in a low-pressure dosed drainfield. This Alternative Onsite Sewage System (AOSS) has three main components, (1) collection (2) treatment (3) dispersal that are described in this section. Because all building sewage flows to existing, functional septic tanks, the effluent from existing septic tanks is collected rather than building sewage. The proposed collection and treatment system layouts are shown in the construction drawing Attachment 1 to this report. High-quality effluent from the treatment system is pumped to a pressure-dosed drainfield system located in an area below the Farm Building and Northeast Barn along the Conservation Easement as shown in the Construction Drawing set and further described in the Dispersal Area subsection.

NEW COLLECTION SYSTEM

Septic tank effluent from regularly occupied buildings will be collected for the new Centralized AOSS using a Septic Tank Effluent Pump (STEP) and Septic Tank Effluent Gravity (STEG) collection system. The following buildings have low use and are not connected due to minimal sewage generation: Violet (garden shed), Cabana, and Pool House; septic effluent from these buildings will continue to flow to their respective existing drainfields.

Existing Septic Tanks

Existing septic tanks for the connected buildings will remain in service to provide cost effective primary treatment. All septic tanks will be retrofitted with a septic-tank effluent filter located in an access riser. The existing pipes leading from the existing septic tanks will be intercepted between the septic tank and drainfield and will either flow into pump stations or into a gravity sewer system.

STEP/STEG Sewer

The overall collection system collects settled sewage from building septic tanks and is essentially a gravity collection main with sub-mains and laterals connecting to it from buildings or groups of buildings. The sewer system layout and details are shown in the Construction Drawings, Sheets 4 through 9. Table 5 summarizes the applicable regulatory requirements and the design approach to comply with each requirement.

Table C-1 in Appendix C summarizes calculations for the gravity sewer main, including slope, length and flow. Existing gravity laterals are sufficiently sized and will not be changed except to add cleanouts. Due to the low flow rates and general downhill trend from pump stations to the gravity sewer main, STEP transport pipes will 1.5 inch diameter and will be routed as necessary to avoid buildings, roads, and buried utilities as much as possible.

There are four septic tank effluent pump stations. Each pump station will be equipped with two septic effluent pumps and a control panel with an alarm to warn of high water levels or pump faults. One of the pump stations is existing. Pump station calculations are included in Appendix C, Tables C-2 through C-4.

Existing D-Boxes and Drainfields

Once the treatment system is completed and ready for commissioning, the pipes from septic tanks to the existing drainfields will be capped after connecting the outlet to the STEP/STEG sewer. Existing distribution boxes (D-Box) and septic drainfields will be left in place. Certain drainfields will be preserved as replacement disposal areas for the new main dispersal area. These drainfields are identified in the Effluent Dispersal Section.

The drainfields in the upper and central part of the Village will not be used again in the future due to potential for contamination of gardens and groundwater. Most other drainfields will also be permanently abandoned due to age, size and location. If the D-Box is found in the process of excavating the new collection system, it be will be removed or filled gravel and the inlets & outlets will be capped.

After the Treatment System and Disposal system are completed and tested, the individual septic tanks will be connected to the main sewer system. After the connection to the main sewer, COSS abandonment applications will be submitted to the VDH with requisite documentation.

Table 5. Sewer Design Summary

Regulation Section	Design Approach and Notes
9VAC25-790-310. Design factors	The STEP pump stations are equipped with duplex pumps for redundancy and can pump at around 25 GPM. The working volume of the pump stations will store any excess flow. The gravity sewer main sizing calculations are included in Appendix C, Table C-1. The sizing is based on peak instantaneous flow (including the flow from STEP pumps and one future planned residence) to ensure that the pipe is never more than 70% full. The sewer sizing is all designed to carry over the required minimum design flows for laterals, submains, and mains.
9VAC25-790-320. Design details	The STEG elements of collection system all will carry settled sewage in 3"-6" pipe which is larger than the minimum required of 1.5" pipe. Gravity sewers will be run in Sch. 40 PVC or SDR-35 PVC pipe with sewer fittings. The specified minimum cover over the gravity sewer pipes is 1 foot which will be sufficient to prevent icing given the insulating properties of PVC and the slugs of pumped wastewater that will be regularly flushing through the main. The calculations in Appendix C, Table C-1 show the flow velocity based on the slope and a Manning's n of 0.011 which is typical for a PVC pipe coated in scum. Larger solids deposits will not occur, because the system received settled and screened sewage.
9VAC25-790-330. Construction details	We have specified low-pressure air testing for the gravity sewer piping. Detail 9-2 on Sheet 9 of the plans shows the standard rigid piping backfill detail.
9VAC25-790-350 Manholes	Cleanouts will be used for the settled sewage gravity collection piping. There are not locations where four or more settled sewage collection pipes intersect. Cleanouts will be located at most every 200 feet and before any junction or bend larger than 30 degrees.
9VAC25-790-360. Water quality and public health and welfare protection.	New sewer pipes will not be installed in the same trench as water pipe nor installed within 10 feet existing water pipes when running parallel. Details 7-1 and 7-2 on Sheet 7 of the plans show how utility crossings including potable water pipe crossings will be handled.
9VAC25-790-390. Reliability	Innisfree Village has backup power for residential building and well water systems. This allows building residents to conduct water using activities during a power outage. Any STEP pumps will be connected to the buildings backup power supply to prevent a back-up or overflow of the septic effluent pumping system.
9VAC25-790-430. Alternatives	All sewage will pass through existing upgraded or new septic tanks with 1/16" effluent filters and into the STEP pump stations which will have duplex pumps, a control panel with float switches and alarm.
9VAC25-790-440. Force mains	The septic tank effluent pumping systems will discharge into pressure laterals and a forcemain with a diameter of 1.5". The pumping rate is around 25 GPM which equates to a velocity of about 4.5 ft/s. STEP sewer pipes will connect to the gravity collection main with a terminal flushing connection and isolation valves followed by a wye into the gravity main. Pressure testing to 150% of design pressure has been specified. Pipe will be HDPE installed per manufacturer's instructions. Flushing connections will be provided at regular intervals to allow for inspection.

CENTRALIZED TREATMENT

Overview

The centralized AOSS includes an advanced treatment system. The collected septic effluent will be treated in a multi-step biological treatment process. The high-quality effluent will then be dispersed in a controlled manner to a subsurface dispersal system described in the subsequent section. The centralized treatment system will meet project goals stated in the Overview Section. As stated therein, TOrC reduction is a goal, though not required by Virginia regulations.

The Design Effluent characteristics are listed in shown Table 4. The effluent BOD and TSS will meet Treatment Level 3 (TL-3) as listed in the Virginia Department of Health (VDH) regulations. The treatment will remove more than 50% of the influent nitrogen as part of the requirements for an AOSS. For this project, Innisfree has additional criteria for the treatment system performance and design. Additional project goals include removing a significant amount of TOrCs and dispersing very high-quality effluent to preserve soil absorption capacity.

Effluent Total Nitrogen Requirements

The Innisfree AOSS will meet the requirements of 5 mg/L of total nitrogen (TN) at the project boundary through nitrogen removal in the treatment system and some dilution from rainfall in the Nitrogen Dilution Management Area (NDMA) shown on Sheet 23. Due to the location of the dispersal area and surrounding topography the NDMA is relatively small at about 298,000 sq. ft (6.84 acres) so the treatment system effluent must have relatively low TN to meet the boundary limits. A summary of the inputs and calculations of the effluent Total Nitrogen Dilution Model developed by Aqua Nova Engineering is presented in Table 7. The full calculation summary is in Appendix B, Table B-2 Nitrogen Dilution Calculations.

Table 6. Nitrogen Dilution Model Summary

Parameter	Value
Flow, gal/day (a)	**5,762**
Days/year of Discharge	365
Effluent Total Nitrogen, mg/L (b) With Soil DN Factor (0.10), mg/L (c)	14.0 11.7
Total Dilution Area, sq. ft [acres]	298,000 [6.84]
Rainfall, inches/yr	44
Average Rainfall infiltration (d)	40%
Average Annual TN at project boundary, mg/L	4.94

(a) Design hydraulic loading capacity of drainfield = Equalized flow times factor of 1.05.
(b) Design final effluent from treatment system
(c) Assumed value for relatively steep area with full grass / meadow plant cover.
(d) Assumed value for relatively steep area with full grass / meadow plant cover.

Primary Treatment and Flow Equalization

At Innisfree, septic tanks connected to the buildings provide initial primary treatment, removing most solids, settleable and floating waste components. The septic tank effluent from all connected buildings will discharge into a primary settling and filter tank located at the main treatment system. This tank has dual effluent filters and will remove any residual solids or oil/grease that may have escaped the building septic tanks. This will minimize trash and other constituents that could negatively impact the rest of the treatment process.

Effluent from the primary screening process will be overflow into The Flow Equalization tank that is sized to equalize flow over seven days. This attenuates daily peak flows and higher flows from weekdays and or events. Duplex pumps in the Flow Eq. Tank are activated by the control panel in timed doses to deliver a relatively steady flow to the Secondary Treatment system. In the event of very high levels in the Eq. Tank there is a gravity overflow pipe into the Pre-Anoxic Bioreactor tank.

Because sewage flows may be at design levels during power outage events, Innisfree has decided that the treatment and disposal system will be on automatic backup power from a generator. The generator will automatically come on during a power outage to maintain wastewater system operation.

Secondary treatment

The purpose of secondary treatment is to reduce BOD and TSS to TL-3 levels or below. Also, the secondary treatment system will remove significant nitrogen. For this system, high quality secondary effluent is also necessary for the third stage of treatment (Tertiary Treatment). The secondary treatment process is described below.

Secondary treatment will utilize a biological, fixed-film process with a pre-anoxic denitrification reactor. The aerobic fixed film process is the AdvanTex system by Orenco. This proprietary trickling filter system relies microbial communities attached textile strips to treat the wastewater. The wastewater is pumped into a system of sprayers that distribute it over the textile array. This oxygenates the wastewater and brings the wastewater in contact with the microorganisms that convert the waste compounds to benign products and some microbial biomass.

The proposed design includes two stages of recirculating, trickling biofilters to provide a high level of treatment and ensure complete conversion of ammonia to nitrate (nitrification). Nitrified process water is recirculated to an anoxic reactor located downstream of the Flow Equalization Tank which will provide biological denitrification and reduce the incoming BOD somewhat. The secondary effluent will have low BOD, TSS and nitrogen and will receive further treatment in the Tertiary Treatment system.

The secondary treatment process may also provide reduction in certain trace organic compounds. The AdvanTex process appears to have good removal rates for certain TOrCs based on initial literature review. The AdvanTex treatment stage will be followed by tertiary treatment for polishing and additional removal of TOrCs.

Pre-Anoxic Reactor

The Pre-anoxic Reactor receives Eq. Tank effluent and recycled flow from the Stage 2 AdvanTex system for biological nitrogen removal. The Pre-anoxic Reactor tank has nominal a volume of 2,000 gallons and will provides about 2.9 hours residence time for the design flow with a 200% recycle rate. The septic effluent pumped in from the Eq. Tank will be anaerobic and high in BOD. The process water pumped back from the AdvanTex system will have significant amounts of nitrate which is used by bacteria to oxidize some of the incoming BOD. The recycle flow will be aerobic so recirculation rates will be controlled to prevent aerobic conditions in the Pre-anoxic Reactor.

The Controller activates pump P10 in the Stage 2 AdvanTex Recirculation Tank to move nitrified process water through the Control Building, where alkalinity can be added as necessary, to the Pre-anoxic Reactor. A propeller mixer will mix the tank contents without adding further oxygen. The Pre-Anoxic tank overflows to the Stage 1 AdvanTex Recirculation Tank #1.

AdvanTex System Design

The AdvanTex system will have two stages each with a recirculation tank and dedicated pumps to dose the textile media. The AdvanTex system was designed in accordance with loading and performance criteria provided by Orenco. The design calculations are presented in Table B-1 in Appendix B., and the system is summarized below.

1. Stage 1: AdvanTex System. From the Anoxic Reactor, receives controlled doses from Equalization Tank.
    a. 6,000-gallon recirculation volume consisting of two 3,000 gal. tanks bottom connected. Recirc. Tank 1 volume is about 1.1 times the Equalized Design flow.
    b. FIVE AdvanTex AX-100 pods (#1-#5), based on BOD mass loading rate.
    c. Each pod is dosed by a dedicated pump (P3-P7).
    d. Drains from the AX-100 pods go to a recirculating splitter valve, RSV1.
    e. RSV1 directs flow back into the Stage 1 recirc. Tank or forward to the Stage 2 Recirc. tank, depending on the level in the Stage 1 Recirc. Tank.
2. Stage 2: AdvanTex receives Stage 1 effluent from RSV1.
    a. Provides further BOD removal and nitrification.
    b. 3,000-gallon recirculation tank with duplex pumps (P8 and P9)
    c. ONE AX-100 pod based on hydraulic loading, dosed by P8 / P9.
    d. AX-100 pod # 6 drains to RSV2 which either directs flow back into the Stage 2 Recirc Tank or forward to the Stage 3 treatment, depending on the level in the Stage 2 Recirc. Tank.

3. AdvanTex ventilation. The AdvanTex units are provided with passive ventilation to provide oxygen to the biofilms in the AX pods. This has been proven effective at supplying sufficient oxygen for BOD removal and nitrification.
4. Controls System. – the overall system Control Panel will control the AdvanTex dosing pumps. This Control Panel will have user set timing for the AdvanTex dosing to allow operators to adjust dosing timing and rest duration.

Alkalinity Addition

Alkalinity will be added as needed to the recycle pipe to the Pre-Anoxic by a chemical dosing pump (MP2) located in the Control Building and actuated by the Control Panel. The system will include a 50 gal drum for sodium carbonate solution. Operators will need to periodically check pH and alkalinity and adjust the dosing settings to insure adequate alkalinity for complete nitrification.

Tertiary Treatment

A tertiary treatment system will be included in order to provide further and final treatment. This system is designed to:

- Produce very high-quality effluent that maximizes dispersal soils longevity and
- Reduce TOrCs that may contaminate the environment.
- Provide final nitrogen removal to meet design effluent requirements

Aqua Nova selected a dual-media packed bed reactor for TOrC/nitrogen removal that consists of an unsaturated wood chip layer underlain by a saturated rock-sulfur layer. Effluent from the lower layer flows into a moving bed biofilm reactor (MBBR) followed by a settling tank with an effluent filter to capture residual suspended solids.

<u>Design of the Woodchip + Rock/sulfur Biofilter</u>

This biofilter is surfaced dosed and has three main layers. The top layer is wood chips that will remain unsaturated which favors removal mechanisms for TOrCs. The rock-sulfur layer receives effluent draining through the woodchip layer and provides further denitrification and removal of excess BOD potentially leaching from the woodchip layer. The biofilter details and design criteria are outlined below.

- Lined basin with a media bed area of 320 square feet. This bed area will be covered by a roof structure to prevent rainfall entering the system and minimize plant growth in the woodchip bed.
- Top layer: 24 inches deep. Blend of 85-90% wood chips with 10-15% activated carbon.
    - The design areal loading rate is 18 gpd/sq. ft. based on research references.
    - Surface dosed via distribution laterals with holes and flow spreading devices
- Second Layer: 9 inch deep plenum of rain-tank matrix boxes
- Bottom layer of drainage rock with sulfur pellets for anoxic denitrification
    - Design loading rate is 10 gpd/cu.ft. based on research references
    - Sulfur provides terminal electron acceptors in the denitrification process

- Sulfur pellets can be added to the Second layer through pipe ports
- Collection piping in the bottom layer directs flow out to an effluent/ recirculation basin.

Woodchip + Rock/sulfur Treatment Mechanisms

The upper layer will have hardwood chips to support a community of fungal and organisms. The activated carbon in this layer will adsorb TOrCs so that the fungal/microbial matrix can metabolize these compounds. Eventually the wood chips will break down and need to be replaced. This layer can be removed with a sewer vacuum truck and/or careful use of a loader with hand shoveling. The removed material will be composted. The composting process will break down residual TOrCs.

The middle layer is rain-tank matrix boxes installed contiguously to form a 9 inch tall "plenum" zone resting on the bottom rock layer. This plenum zone allows for flow redistribution and a series of dosing ports allows sulfur to be added when necessary to the plenum where it will wash down into the rock layer.

The lower layer will be crushed rock with a nominal 1" size. Elemental Sulfur pellets will be added to the top of this layer during commissioning. The sulfur is slowly oxidized in the process of denitrification so this effluent will have sulfate and potentially sulfides.

Final Polishing Reactor

The final polishing moving bed biofilm (MBBR) reactor is designed to remove excess BOD and oxidize sulfides to avoid malodorous effluent. A significant amount of BOD can leach out of the wood chip layer when biofilter is started up and for up to 12 months after. This BOD may not be removed in the anoxic rock/sulfur layer. Also, effluent from rock/sulfur bed may have significant amounts of sulfides. An aerobic MBBR will remove the residual BOD and oxidize any sulfides. The details and design criteria of the MBBR and settling tank are outlined below.

MBBR

- 2,500 gallon Precast concrete tank with biofilm carriers (media)
- Aeration and mixing provided by a removable, coarse bubble diffuser system
- Air provided by a linear piston air pump supplying 10-12 SCFM.
- The reactor is sized for 100 mg/L of influent BOD with effluent < 5mg/L.
- The surface area loading rate for the carriers of 1.4 g/d per m^2 of protected carrier surface area (Reference maximum value is 5 g/d per m^2).
- Carrier volume will be $2m^3$ or about $70ft^3$. This represents about 20% of the reactor water volume to allow good circulation. (Max. recomm. fill is 35% of reactor vol.)

Settling Tank

- 1,100 gallon compartment in the Effluent Pump Tank
- Min. residence time of 4 hours at design flow.
- Septic Tank Effluent filter (Polylok PL-625) to prevent solids carryover
- Accumulated sludge will be periodically pumped to the septic tank or hauled off site for disposal.

SYSTEM CONTROL PANEL

The AOSS will be controlled by the central control panel based on programmable logic controllers with a touch screen operator interface. The Control Panel will control all the devices in the treatment system as well as effluent dispersal. The HMI will allow operators to review system status and data and easily change settings for controlled devices. An internet connection to the Control Panel will allow remote access for (1) broadcasting alarms and (2) monitoring and control.

The control panel will be located in the Control Building along with the main electrical panel. Most devices will be powered directly from the Control Panel with built in overload protection. Hand/Off/Auto switches will be provided for critical components to allow for manual operation and testing.

CENTRALIZED EFFLUENT DISPERSAL

The effluent will be pumped from the Effluent Tank to a low pressure-dosed lateral drainfield located about 1,200 ft away to the north northeast. Because of the size of the drainfield and variation in soil qualities in the area, Aqua Nova designed three discrete drainfields each with a low-pressure dosed lateral system. This is described further in the following subsection.

General Soils Evaluations

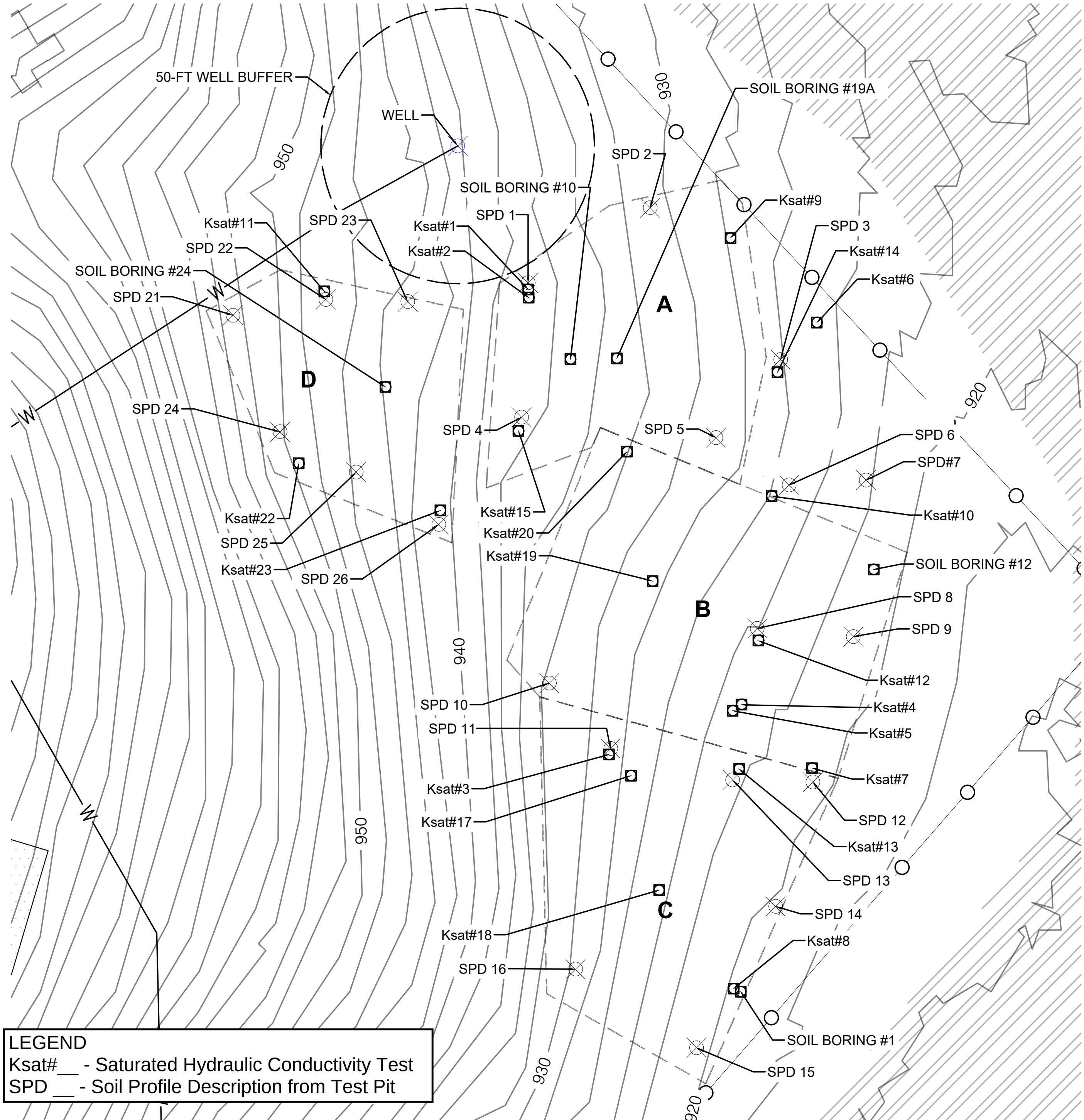
Aqua Nova engineers (while working at IES) directed HydroGeo Environmental, LLC (HydroGeo) to evaluate soils at Innisfree to identify areas suitable for disposal of the effluent from a centralized treatment system. After extensive initial evaluations in 2022 and 2023, we identified an area of suitable soils at the base of a slope below the “plateau” on which Innisfree is constructed.

On 06 Feb. 2024, representatives of VDH met with Aqua Nova and HydroGeo to review soils evaluations in the main proposed drainfield area. The findings from that review indicated that the soils evaluations in the PER were not entirely correct and the “Percolation Rates” had been overestimated.

After the VDH review, Aqua Nova and HydroGeo prepared additional soil profile descriptions and saturated hydraulic conductivity (Ksat) test to develop design hydraulic application rate for the different soils zones within the proposed drainfield area. The drainfield area has denser soils in the center section with more favorable soils on the side areas. Aqua Nova developed a drainfield design as described below with calculation details in Appendix D.

Drainfield Soils Evaluations

Based on the results of all the drainfield evaluations, Aqua Nova developed a drainfield design of four zones within the proposed drainfield area, identified as Sub-areas or Cells A-D. The Cells and locations of evaluations are presented Figure 1. A summary of soil characteristics and saturated hydraulic conductivity tests (Ksat) results for the drainfield subareas are presented in Table 6. Drainfield Design soils evaluation information is presented in Appendix E, this includes Table E-1 with eh soil profile descriptions and Ksat value summaries. The full field data for the Ksat tests is also included in Appendix E.



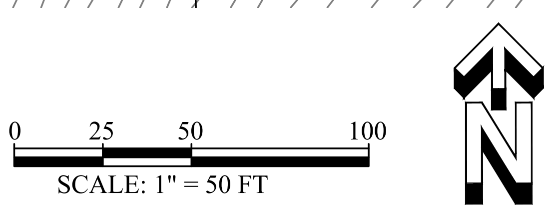


Figure 1 - Drainfield Area with Cells (Sub-Areas) and Testing Locations

NOTES
1. CONTOUR INTERVAL IS 2 FT.
2. SOIL CHARACTERIZATION WAS CONDUCTED FEBRUARY 2022 TO MARCH 2024 BY HYDROGEO ENVIRONMENTAL & AQUA NOVA ENGINEERING.

Design Hydraulic Application Rates

Based on the soils evaluations, field observations and Ksat testing results, Aqua Nova developed "Estimated perc rates" and design hydraulic loading rates for the different drainfield sub-areas. The information used to develop these values is summarized below by Sub-Area or Cell. The main soil features, and hydraulic conductivity of the Cells are summarized in Table 7. The "25% GM Ksat" value in Table 7 is derived by dividing the geometric mean of cell Ksat data by 4.

Table 7. Drainfield Subareas Soil Texture and Ksat Results

	Design		Ksat Evaluations (a)		Hydraulic Conductivity (a)		
Sub-area (b)	Trench bottom, in. (c)	Soil texture (d)	Number of Tests (e)	Depth of Test, in. (f)	Geometric Mean, cm/d	25% GM Value, cm/d (g)	Geo-mean x 0.10 (h), gpd/ft^2
A	18-20	Clay Loam	Less Deep -4	30-32	44.1	11	1.08
			Deeper- 2	53-58	33.1		
B	18-20	Clay Loam and Clay	Less Deep -5	24-32	24.3	6.1	0.60
			Deeper -1	45	10		
C	18-20	Clay Loam & Clay	Less Deep -5	24-32 58	38.1	9.5	0.94
			Deeper -1	58	2.5		
D	18-24	Clay Loam and Clay	Less Deep -2	30-32	55.9	14	1.4
			Deeper -1	44	76.0		

(a) Saturated, clean water, hydraulic conductivity measurements using Johnson Permeameter.
(b) Designated Cell (sub-area) of larger proposed drainfield area. See Figure 1.
(c) Depth of trench bottom below surface.
(d) Most common soil textures for strata at trench bottom (18 inches) and 18 inches below.
(e) Number of separate Ksat tests run for listed depth range.
(f) Depth from surface to bottom of permeameter.
(g) Value for developing hydraulic loading rates from VA regs, equal to geometric mean times 0.25.
(h) Geometric mean divided by 10 (x 0.10) converted to gpd/ft^2.

Drainfield Cell (Subarea) A -Design Hydraulic Loading Rate

Drainfield Cell A generally had clay loam soils from 6 to18 inches and for at least 18 inches below that. The exception is SPD 5 located south of the lowest trench closer to the heavier soils in Cell B. The majority of that trench and the rest of Cell A have clay loam soils. The Ksat results range from 12 to 110 cm/d with geometric mean of 44.1. One fourth of the geometric mean is 11 cm/d. This value and the soil textures justify the overall Estimated Percolation rate of 55 MPI with associated hydraulic loading rate of 0.94 gpd/ft^2. Note that Ksat geometric divided by 10 is equal to 1.08 gpd/ft^2 and the proposed rate is less than that.

Drainfield Cell (Sub-area) B -Design Hydraulic Loading Rate

Drainfield Cell B generally had clay soils at the trench bottom depth, and for at least 18 inches below the trench bottom depth. About half the SPDs have clay loam soils in that same depth range. The SPDs with clay soils show good structure that will allow decent hydraulic conductivity. The Ksat data results ranged from 5 cm/d to 120 cm/d with geometric mean of 44.1. One fourth of the geometric mean is 6.1 cm/d. The soil structure and Ksat data support the Estimated Percolation Rate of 90 MPI with associated hydraulic loading rate of 0.50 gpd/ft^2. The geometric mean of Ksat values divided by 10 is equal to 0.60 gpd/ft^2 and the proposed HLR is slightly less than that at 0.56 gpd/ft^2.

Drainfield Cell (Sub-area) C -Design Hydraulic Loading Rate

Cell C had a mixture of loam and clay loam from about 6 to 19 inches. For at least 18 inches below the trench bottom depth, the soils were clay loam and clay. The SPDs with clay soils had structure that will allow decent hydraulic conductivity. The four Ksat tests conducted from 28 to 30 inches below grade have a range of 32 to 42 cm/d with a geometric mean of 38 cm/d. One fourth of that is 9.5 cm/d, which along with soil type, support an Estimated Percolation rate of 65 MPI and a design application rate of 0.83 gpd/ft^2. The geometric mean of Ksat values divided by 10 is equal to 0.94 gpd/ft^2 and the proposed HLR of 0.83 gpd/ft^2 is less than that.

Drainfield Design

Using the geometry of the sub areas, Aqua Nova developed a trench layout for each subarea and calculated the hydraulic capacity of each sub-area. The characteristics and capacity of the sub-fields in the Primary Dispersal is shown in Table 8. Table D-1 in Appendix D contains more detail on the drainfield design. The overall capacity of the drainfield is somewhat higher than the Equalized Design flow, i.e., design effluent flow.

Note that sub-area D is located uphill of sub-area A. Sub-area D will not be used as part of the Primary Drainfield but will be used for part of the reserve area. Therefore, it is not shown in Table 7.

Primary Drainfield System Design Details

The primary drainfield will consist of Sub-areas A, B and C as listed in Table 6. specific details are shown on the construction drawings and are summarized below.

- Low-pressure dosed trenches, three feet wide, using EZ-Flow gravelless modules.
- 11 Zones -flow controlled by solenoid valves and flow balancing valves
- Lateral lengths vary from 75 to 100 ft. Each lateral has a flow balancing valve.

The multiple zones within each drainfield will facilitate effective dosing of the effluent. Low pressure dosing calculations for each drainfield sub-area are presented in Appendix D, including details of each LPD system matched with effluent (P13 & P14) pump curves

Table 8. Primary Drainfield Design – Characteristics and Capacity

Cell or Sub-area (a)	Estimated Percolation Rate, MPI (b)	HLR gpd/ft2 (c)	Dispersal Trench Physical & Design Information				
			Number of Trenches (d)	Width ft	Length ft	Absorb. Area, ft2 (e)	Hydraulic Capacity gpd (e)
A	60	0.94	9	3	75	2,205	1,904
B	90	0.58	12	3	85	3,060	1,714
C	65	0.83	8	3	100	2,400	1,992
TOTAL						**7,485**	**5,609**

(a) Designated sub-area of larger proposed drainfield area as shown in Figure 1 and listed Table 7.
(b) "Percolation Rate" defined in VA regulations, estimated from soil profile descriptions and Ksat results.
(c) Hydraulic loading rate from 12VAC5-610-950, Table 5, based on Percolation Rate and Ksat results for application of TL-3 effluent with LPD loading. See explanation in subsections below
(d) Design number of trenches in dispersal field at 9 ft on center.
(e) Total trench bottom area for absorption of applied effluent.
(f) Total amount of effluent that can be applied to sub-area on a daily basis.

Reserve Drainfield Area

Because this AOSS is replacing existing COSS systems and is essentially a repair, a reserve drainfield area is NOT required by VA regulations. However, Aqua Nova believes it is prudent to propose a reserve drainfield system design. The proposed approach uses multiple drainfield areas: Sub-Area D of the new drainfield area and some existing drainfields for specific buildings. The characteristics of the areas to be used for Reserve Drainfield are listed in Table 9. The existing drainfields would need to be retrofitted with pressure dosing to provide the design application rate. The proposed reserve drainfield area specifics are listed in Table D-2 in Appendix D.

Innisfree will be directed to survey the existing drainfields to be used for reserve and create a plan to preserve these areas in perpetuity. This plan will include specific language in the Innisfree planning documents that preserves these areas and access to them.

Table 9. Reserve Drainfield Design – Characteristics and Capacity

			Dispersal Trench Physical & Design Information				
Sub-area /Cell (a)	Perc. Rate, MPI (b)	HLR gpd/ft2 (c)	Number of Trenches (d)	Width ft	Length ft	Absorb. Area, ft2 (e)	Hydraulic Capacity gpd (f)
D (*)	50	1.0	10	2	65	1,300	1,300
Comm. Cntr. (**)	115	0.35	12	3	85	9,600	3,360
Redstar (**)	100	0.46	8	3	100	1,500	690
Office	100	0.46	4	3	80	960	442
TOTAL						7,485	**5,792**

(a) Drainfield Cell D, defined in Fig. 1. is new. Other areas are existing drainfields.
(b) "Percolation Rate" from soils evaluations OR existing COSS permits.
(c) Hydraulic loading rate from percolation rate with TL-3 effluent & LPD dosing (12VAC5-610-950, Table 5.5).
(d) Design number of trenches in dispersal field at 8 ft on-center for Area D and 9 ft on-center for other areas.
(e) Total trench bottom area for absorption of applied effluent.
(f) Total amount of TL-3 effluent that can be applied to sub-area on a daily basis.

Groundwater Mounding Analysis

A groundwater mounding evaluation was performed using the spreadsheet model, from Khan et. Al, 1976, provided by VDH. This model was used to evaluate the potential for mounding of effluent underneath the drainfield areas. A separate spreadsheet model was developed for each drainfield Cell (A-C) because each sub-area had different soils and Ksat values. Drainfield cells A-C are aligned along the contours and general slope is perpendicular to the trenches of the three drainfields so the infiltration of adjacent drainfields should not affect each other. Results of this model are included in Appendix D after Table D-1.

The model inputs assumed conservative hydraulic conductivity or permeability values. The vadose zone (K1) permeability was assumed to be only 25% of the median Ksat Value for a given drainfield. The Restrictive Layer permeability (K2) was set at 25% of K1. The notes section of each mounding model explains that model input values in detail. Even with these very low permeability values, the model predicts no mounding at the design application rates.

Low Pressure Dosing System Details

Effluent from the final settling and filtration tank will flow into a 1,100-gallon nominal volume effluent pump tank. Duplex effluent pumps will pump effluent to the LPD drainfields via an approximately 1,500 ft long transfer pipe. This transfer pipe passes through two flow meters, one located near the treatment system and another at the drainfield area to allow for monitoring of flow, leak detection, and drainfield balancing. A manifold splits flow between the three drainfield Cells (A-C) with manual valves on each for control and balancing to each Cell. Each drainfield sub area has a dedicated zone valve array with manual balancing valves and zone solenoid valves.

The effluent pumps will be programmed to time-dose the drainfield with each dose cycling through the zone valves one at a time. The flow meters will totalize flow to each drainfield zone to allow the operator to more accurately balance flow to each zone in the long term and detect problems with solenoid valves. The solenoid valves will be controlled and powered via a relay panel located near the drainfield to allow manual operation and troubleshooting.

Detailed information about the pump sizing and LPD system including lateral lengths, orifice size and spacing, and headloss are included in Appendix D as Figures D-1, D-2, and D-3. Details on the LPD system's construction can also be found on Sheet 21 of the plans.

Controls System and Remote Access

The entire wastewater treatment and disposal system operation will be fully automated through the Wastewater Controller which includes a Programmable Logic Controller (PLC) with graphic viewing through a smartphone or personal computer. Based on programmed logic, operator input and multiple sensors, the PLC activates all pumps, actuated valves and blowers. The phone/ computer interface allows easy operator control and input. A secure network connection allows remote monitoring and control of the system for designated operators through the internet. This network connection also allows alarms to be sent to designated operators through email.

Hydraulic Controls and Overflows

Water level sensors (float switch assemblies) located in most tanks or basins in the treatment process sense low, normal and high water levels. Flow meters in the system measure flow into the treatment system and disposal area. Water levels, flow rates and pumps' operational status are monitored by the Wastewater Controller at all times. High water levels will be logged in the Controller and flagged for operator review. Critical high water conditions will trigger an alarm that will be broadcast to designated operations staff.

If water reaches a critical level in the Stage 2 Recirc tank, the Eq. Tank pumps will be disabled and an alarm created. These safeguards prevent spills of untreated wastewater from the wastewater system.

REFERENCES

1. Crites, R. and Tchobanoglous, G., 1998. Small and Decentralized Wastewater Management Systems. McGraw- Hill.
2. McQuarrie, J. and Boltz, P., 2011. Moving Bed Biofilm Reactor Technology, Process Applications, Design and Performance, Water Environment Research, Vol. 83, No. 6.
3. Tchobanoglous, G., and Burton, F., 1991. Wastewater Engineering – Treatment Re-use and Disposal, Metcalf and Eddy, 3rd Edition, McGraw- Hill.
4. Water Environment Federation, 2010. Biofilm Reactors - WEF MOP 35. McGraw-Hill.

Appendix A

Flow and Loading Calculations

- **Design Flow and Loading Calculations**
- **Flow Equalization Volume Calculations**
- **Detailed Water Use Data**

Appendix A - Design Wastewater Flow and Characteristics

Project Name:	**Innisfree Village - Alternative Onsite Sewage System**	Updated:	8/14/2024
Scenario:	All Regularly occupied or used buildings	By:	D. Maciolek
		Checked:	8/14/2024
		By:	C. Hammond

Table A-1. EXISTING Buildings, Occupancy and Sewage System Information

Building	Address (a)		Bed-rooms	Typical Residents	Max Occupancy	Unit flows (gpd/person)	Design flow (gpd)	Septic System	Septic Tank Size (gal.)	# tanks (b)	
Trillium	5700	Innisfree Ln.	5	5		50	250	Individual	1,000-1,500	1	
Halcyon	5696	Innisfree Ln.	7	7		50	350	Individual	1,500	1	
Oakwood	5670	Innisfree Ln.	3	3		50	150	Individual	1,000	1	(b)
Upper Residences Subtotal	***3***		***15***	***15***			***750***			**3**	
Kenmare	5638	Innisfree Ln.	7	7		50	350	Individual			(e)
Laurel (New) Part 1	5616	Innisfree Ln.	8	8		50	400	Laurel 1 (1/3)	1,250	1	(b)
Laurel (New) Part 2		Innisfree Ln.	Incl. in Laurel Part 1					Laurel 2 (2/3)	1,250	1	(b)
Garden Cottage		Innisfree Ln.	1	2		50	100	Old Laurel Drainfield	750-1,000	1	
Oz 2 (downstairs)	5566	Innisfree Ln.	2	2		50	100	Individual	750	1	
Oz 1 (upstairs)	5566	Innisfree Ln.	1	2		50	100	Individual	750	1	(b)
Dogwood	5542	Innisfree Ln.	8	8		50	400	Individual	1,500	1	(b)
Sunflower	5540	Innisfree Ln.	8	9		50	450	Individual	1,000-1,500	1	
Windsong	5525	Innisfree Ln.	4	4		50	200	Individual	1,000	1	(b)
Meadow	5514	Innisfree Ln.	8	8		50	400	Individual	1,500	1	(b)
Amity and Harmony	5495	Innisfree Ln.	9	9		50	450	Amity/Harmony Mult	1,500	1	
Echo	5480	Walnut Level	2	2		50	100	Echo/Walnut Level	Shared w/ Walnut Level		
Walnut Level	5474	Walnut Level	4	4		50	200	Echo/Walnut Level	900	1	(b)
Bittersweet	5490	Walnut Level	3	6		50	300	Bittersweet/Swallowt	1,000	1	(b)
Lower Residences Subtotal			***80***	***86***			***3,550***				
Swallowtail -garden wkstn (g)	5484	Walnut Level			21	3	63	Bittersweet/Swallowt	Shared w/ Bittersweet		(b)
Wrkstn at Office Bldg. (g,h)	5466	Innisfree Ln.			21	3	63	Individual	1,000	1	(b)
Farm Building (Redstar), Day use + occasional meeting	5501	Walnut Level			15	7	105	Farm Bldg. Individual	1,000	1	(d)
Office Bldg. Staff (h)	5466	Innisfree Ln.			10	15	150	Individual	1,000	1	(b)
Office & Workshop Subtotal					***57***		***381***				
Community Center (h)	5483	Innisfree Ln.	N/A		75	10	750	Individual	2,000	2	(b)
OVERALL TOTAL				101			**5,431**			**45541**	

(a) Building number and street address. All are listed as Crozet, VA 22932
(b) Based on VDH permits currently available.
(c) Based on permits from VDH, or where no permit is available, from 2017 "Preliminary Engineering Report" by C. F. Greenberg . Field verify as necessary.
(d) Septic system record is unclear.
(e) Operation Permit was obtained from Health Department
(f) Information is from the septic permit for Community Center (5483 Innisfree Ln.) Need to confirm all information for this well
(g) Workstation Buildings are used by up to 3 shifts of seven-person teams, each there for 2 hours max. Flow is assumed as 1 toilet use + misc.
(h) Office and Workstation Buildings are joined. Office staff is listed separately from worstation staff.
(i) Buildings are not residences and have only occasional use.

Aqua Nova Engineering, PLC
Tel. 434- 249-4497

Appendix A - Design Wastewater Flow and Characteristics

Project Name: **Innisfree Village - Alternative Onsite Sewage System**
Updated: **8/8/2024** By: D. Maciolek

Table A-2. Sewage Flow Estimated from Buildings Connected to AOSS (a)

Area or Source	Unit	Number of Units	Unit flow, gpd	Source flow, gpd	Check (Table A-1)	
Residential Buildings (b)	Resident	86	50	4,300	4,300	gpd
Workstation and Wrkshps	Users	42	3	126	126	gpd
Office Building	Staff	10	15	150	150	
Redstar Farm Bldg	Users	15	7	105	105	gpd
Community Center	Occupants	75	10	750	750	
Future additional residence (d)	Person	5	50	250		gpd
	Total Peak Wastewater Flow			**5,681**		gpd

(a) Regularly occupied buildings including residences, offices, workshops & Comm. Cntr. NO pool & Cabana
(b) Current Residential Buildings per Table A-1.
(c) Farm building used for egg processing. Day use only; typical use is 3-5 employees with occas. meetings.
(d) Potential future expansion under consideration by Innisfree.

Table A-3. Waste Loading (Raw Sewage) Resulting Concentrations

Source or Area	Unit	Number of Units	Ref. Value Daily Load, lb/d			Load per unit lb/d Design Value						Source Total Loading, lb/d		
			BOD/TSS	**TKN**		**BOD**		**TSS**		**TKN**		**BOD**	**TSS**	**TKN**
Existing Residents	Persons	101	0.200	0.029	(a) (b)	0.20		0.20		0.03		20.20	20.20	2.93
Office and Workstations	Users	57	0.03-0.07	0.010	(a) (d)	0.03		0.03		0.01		1.71	1.71	0.57
Community Center	Users	75	0.040	0.006	(e)	0.04		0.04		0.01		3.00	3.00	0.44
Future expansion	Persons	5	0.200	0.029	(a) (b)	0.20		0.20		0.03		1.00	1.00	0.17
											Total Load	**25.9**	**25.9**	**4.1**
						Combined Concentration at Peak Flow, mg/L						**547**	**547**	**87**

(a) Reference value for BOD and TSS daily mass load from VA Regs (Reference 1), Table 5.1. Residents = "Dwelling"
(b) Values for TKN are the typical per capita values for individuals per Wastewater Engineering text. See note (c)
(c) Based on "Quantity of Waste Discharged by individuals on a dry weight basis, Typical without ground up kitchen waste", Metcalf and Eddy (Ref. 2), Table 3-12, p.
(d) Values for TKN are the 1/3 of the per captia values for individuals for 8 hour shift. See note (c)
(e) Short term visit and/or lunch. Values for BOD are 1/5 of per capita values per note (a) andfor TKN are 1/5 values per note C.

References

1. Commonwealth of Virginia, Adiministrative Code, 12VAC5-610-670.
2. Tchobanoglous, Burton and Stensel [Metcalf and Eddy], 2002, Wastewater Engineering, fourth ed., McGraw Hill, Inc.
3. Crites and Tchobanoglous, 1998, Small and Decentralized Wastewater Management Systems, McGraw Hill, Inc.

Appendix A - Design Wastewater Flow and Characteristics

Project Name: **Innisfree Village - Alternative Onsite Sewage System**
Updated: **8/8/2024** By: D. Maciolek

Table A-4. Design Criteria -Wastewater Treatment and Disposal (a)

		Primary Effl. Calculated Values (b)				Design For Treatment (c)					
	Computed	Treatment	Flow (gpd)	5,681		Flow (gpd)	5,500	Design Effluent			
	Load d)	Reduction	Load	Equiv.		Load	Equiv.	Avg. Conc.	Load	Removal	
Parameter	lb/d	% (d)	**lb/d**	Conc., mg/L		**lb/d**	Conc., mg/L	mg/L	lb/d	% (f)	Max. (f)
BOD	25.9	**32%**	17.6	371.9		17.1	**372**	**7**	0.32	**98%**	**10**
TSS	25.9	**60%**	10.4	218.7		10.0	**219**	**7**	0.32	**97%**	**10**
TKN	4.1	**5%**	3.9	82.2		3.8	**82**	**2**	0.09	**98%**	**2**
Nitrate	0.0		0.0	0.0		0.0	**0**	**8**			**12**
Total Nitrogen	4.1	**5%**	3.9	82.2		3.8	**82**	**10**	0.46	**88%**	**14**
TP (a)	0.0		0.0	0.0		NA	**NA**	**NA**		**-**	
E. Coli, MPN/100 mL		NA				NA	**NA**	**NA**		**-**	
Min. Temperature, °F		NA				60	**NA**	**NA**			
Temperature, °C		NA				15.6	**NA**	**NA**			

(a) Flow, loading and resulting concentrations for design of biological treamten system, secondary clarifier and disposal system.
(b) Estimated flow and calculated load after reduction in primary treatment System and resulting concentration.
(c) Equalized flow and load for design of tratment systems..
(e) Estimated percent reduction in Primary Treatment, i.e., septic tanks with effluent filters.
(f) Percent removal based on influent to secondary treatment

Appendix A - Flow Equalization Calculations

Project Name: **Innisfree Village - Alternative Onsite Sewage System**
Updated by: *DJM* 8/14/2024

Peak Daily Flow (gpd), from Table A-2. 5,681

Table A-5. Equalization Volume & Average Flow

Projected Flow Pattern				Discharge & Vol. in Tank, gal.	
Day Of week	**Flow Adjustment (a)** gpd	Reason	Daily Flow, gpd (b)	DAILY Discharge (c)	Volume in Tank (d)
Monday	0		5,681	5500	281
Tuesday	0		5,681	5500	462
Wednesday	-750	No Comm. Cntr	4,931	5500	0
Thursday	0		5,681	5500	181
Friday	0		5,681	5500	362
Saturday	-213	No Work or Office	5,468	5500	330
Sunday	-1026	No office or Comm. Cntr	4,655	5500	0
TOTAL			**37,778**	**38,500**	
Daily Discharge (Equalized over 7 days) (e)			**5,397**	**5,500**	
Calculated Required Equalization Volume (f)				462	gal.
Selected Equalization volume (g)				**2,000**	gal.

(a) Reduction in flow on gived day for reason(s) listed
(b) Flow for day based on peak flow less reductions listed.
(c) Design Discharge to treatment and disposal system
(d) Water volume in Equalization Tank (at midnight) = Start Vol. + Daily Flow - Daily Discharge.
(e) First value is average of all days flow. Second value is DESIGN flow to treatment and dispersal system.
(f) Maximum value of "Volume in Tank".
(g) Working volume above pump minimum submergence and allowing for alarm volume (high water).

Project Name	Innisfree Wastewater Upgrades
Updated:	8/12/2024
By:	DJM

Table A-6. Detailed Water Meter Data for Amity Residential Building

Date	Day of Wk	# Persons in House	Meter Reading	Daily use (gal)	GPD per person
7/28/2023	Fri		270107.3		
7/29/2023	Sat	7	270339.4	232.1	33.2
7/30/2023	Sun	7	270557.8	218.4	31.2
7/31/2023	Mon	7	270748.5	190.7	27.2
8/1/2023	Tue	8	270988.6	240.1	30.0
8/2/2023	Wed	8	271251	262.4	32.8
8/4/2023	Fri	9	271867	308.0	34.2
8/5/2023	Sat	9	272201.3	334.3	37.1
8/6/2023	Sun	9	272472.8	271.5	30.2
8/7/2023	Mon	9	272600.3	127.5	14.2
8/8/2023	Tue	11	273063.5	463.2	42.1
8/15/2023	Tue	10	275110	292.4	29.2
8/22/2023	Tue	8	276870	251.4	31.4
8/29/2023	Tue	8	278556	240.9	30.1
8/31/2023	Thu	7	279036.8	240.4	34.3
9/1/2023	Fri	8	279358	321.2	40.2
9/2/2023	Sat	6	279589.6	231.6	38.6
9/3/2023	Sun	6	279808	218.4	36.4
9/4/2023	Mon	6	279932.9	124.9	20.8
9/5/2023	Tue	8	280278.5	345.6	43.2
9/6/2023	Wed	6	280450	171.5	28.6
9/7/2023	Thu	6	280718.6	268.6	44.8
9/8/2023	Fri	6	280947.3	228.7	38.1
9/9/2023	Sat	6	281234.8	287.5	47.9
9/10/2023	Sun	6	281475	240.2	40.0
9/11/2023	Mon	7	281638.2	163.2	23.3
9/12/2023	Tue	7	282028.1	389.9	**55.7**
9/13/2023	Wed	7	282283.6	255.5	36.5
9/14/2023	Thu	7	282458.2	174.6	24.9
9/15/2023	Fri	7	282699.3	241.1	34.4
9/16/2023	Sat	7	282897.2	197.9	28.3
9/17/2023	Sun	7	283080.4	183.2	26.2
9/18/2023	Mon	7	283279.8	199.4	28.5
9/19/2023	Tue	7	283565.9	286.1	40.9
9/20/2023	Wed	7	283834.9	269.0	38.4
9/21/2023	Thu	7	284015.9	181.0	25.9
9/22/2023	Fri	7	284203.8	187.9	26.8
9/23/2023	Sat	7	284471.7	267.9	38.3
9/24/2023	Sun	7	284738.3	266.6	38.1
9/25/2023	Mon	7	284978.4	240.1	34.3
9/26/2023	Tue	7	285157.6	179.2	25.6

Project Name	Innisfree Wastewater Upgrades	
	Updated:	8/12/2024
	By:	DJM

Table A-6. Detailed Water Meter Data for Amity Residential Building, contin.

Date	Day of Wk	# Persons in House	Meter Reading	Daily use (gal)	GPD per person
9/27/2023	Wed	7	285458.6	301.0	43.0
9/28/2023	Thu	7	285598.2	139.6	19.9
9/29/2023	Fri	8	285820.8	222.6	27.8
9/30/2023	Sat	8	286175.7	354.9	44.4
10/1/2023	Sun	8	286301.8	126.1	15.8
10/2/2023	Mon	8	286466.4	164.6	20.6
10/3/2023	Tue	8	286765.7	299.3	37.4
10/4/2023	Wed	8	287282.7	517.0	**64.6**
10/5/2023	Thu	8	287434.2	151.5	18.9
10/6/2023	Fri	8	287730.3	296.1	37.0
10/9/2023	Mon	8	288524.6	264.8	33.1
10/10/2023	Tue	8	288887.7	363.1	45.4
10/11/2023	Wed	8	289130	242.3	30.3
10/12/2023	Thu	8	289315.8	185.8	23.2
10/13/2023	Fri	8	289537.6	221.8	27.7
10/14/2023	Sat	8	289809.4	271.8	34.0
10/15/2023	Sun	8	289974.2	164.8	20.6
10/16/2023	Mon	8	290236.7	262.5	32.8
1/5/2024	Fri	8	321851.4	390.3	48.8
1/26/2024	Fri	8	327780	282.3	35.3
2/2/2024	Fri	8	329726.5	278.1	34.8
2/9/2024	Fri	8	331788.4	294.6	36.8
2/16/2024	Fri	8	334267	354.1	44.3
2/22/2024	Thu	8	336262.3	332.5	41.6
3/1/2024	Fri	8	338394	266.5	33.3
3/15/2024	Fri	7	342173.9	270.0	38.6
3/22/2024	Fri	8	344222.9	292.7	36.6
3/29/2024	Fri	8	346297.6	296.4	37.0
4/5/2024	Fri	8	348080	254.6	31.8
4/12/2024	Fri	8	349960.4	268.6	33.6
4/19/2024	Fri	8	351869.5	272.7	34.1
4/26/2024	Fri	8	353767.8	271.2	33.9
5/3/2024	Fri	8	355550.7	254.7	31.8
5/10/2024	Fri	8	357150	228.5	28.6
5/17/2024	Fri	8	358595.8	206.5	25.8
5/24/2024	Fri	8	361718.3	446.1	**55.8**
5/31/2024	Fri	8	363592.7	267.8	33.5
6/7/2024	Fri	8	365346.1	250.5	31.3
6/14/2024	Fri	8	367038.5	241.8	30.2
6/21/2024	Fri	8	368829.8	255.9	32.0
6/28/2024	Fri	8	370819.4	284.2	35.5
7/5/2024	Fri	8	372753	276.2	34.5

Project Name **Innisfree Wastewater Upgrades**

Updated:	8/12/2024
By:	DJM

Table A-7. Detailed Water Meter Data for Meadow Residential Building

Date	Day of Wk	# Persons in House	Meter Reading	Daily use (gal)	GPD per person
7/20/2023	Thu		0		
7/21/2023	Fri	8	248	248.0	31.0
7/24/2023	Mon	8	1001	251.0	31.4
7/25/2023	Tue	8	1244.5	243.5	30.4
7/26/2023	Wed	8	1541	296.5	37.1
7/27/2023	Thu	8	1748.5	207.5	25.9
7/28/2023	Fri	8	2009	260.5	32.6
7/29/2023	Sat	8	2244.3	235.3	29.4
7/30/2023	Sun	8	2464.4	220.1	27.5
7/31/2023	Mon	7	2686	221.6	31.7
8/1/2023	Tue	8	3018	332.0	41.5
8/8/2023	Tue	8	4600.6	226.1	28.3
8/15/2023	Tue	8	6116	216.5	27.1
10/12/2023	Thu	7	6160.9		
10/13/2023	Fri	8	6317.4	156.5	19.6
10/14/2023	Sat	8	6499.2	181.8	22.7
10/15/2023	Sun	8	6697.3	198.1	24.8
10/16/2023	Mon	8	7042.1	344.8	43.1
1/5/2024	Fri	8	24152.6	211.2	26.4
1/26/2024	Fri	8	29210.5	240.9	30.1
2/2/2024	Fri	8	30989.3	254.1	31.8
2/16/2024	Fri	8	34315.7	237.6	29.7
2/22/2024	Thu	8	35881	260.9	32.6
3/15/2024	Fri	8	40687.4	218.5	27.3
3/22/2024	Fri	8	42105.6	202.6	25.3
3/29/2024	Fri	8	43553.7	206.9	25.9
4/5/2024	Fri	8	45082	218.3	27.3
4/12/2024	Fri	8	46430	192.6	24.1
4/19/2024	Fri	8	47690.3	180.0	22.5
4/26/2024	Fri	8	49167.8	211.1	26.4
5/3/2024	Fri	8	50551.6	197.7	24.7
5/10/2024	Fri	8	51934.4	197.5	24.7
5/17/2024	Fri	8	53290.2	193.7	24.2
5/24/2024	Fri	8	54559.2	181.3	22.7
5/31/2024	Fri	8	55959	200.0	25.0
6/7/2024	Fri	8	57369.1	201.4	25.2
6/14/2024	Fri	8	58938.6	224.2	28.0
6/21/2024	Fri	8	60405.6	209.6	26.2
6/28/2024	Fri	8	61726.9	188.8	23.6
7/5/2024	Fri	7	62627.5	128.7	18.4

Aqua Nova Engineering, PLC.
434-249-4497
File: Water Meters readings 2023-2024 w_analysis, Sheet: Meadow

Project Name	Innisfree Wastewater Upgrades
Updated:	8/12/2024
By:	DJM

Table A-8. Detailed Water Meter Data for Trillium Residential Building

Date	Day of Wk	# Persons in House	Meter Reading	Daily use (gal)	GPD per person
7/20/2023	Thu		0		
7/21/2023	Fri	6	167	167.0	27.8
7/24/2023	Mon	5	493	108.7	21.7
7/25/2023	Tue	5	588	95.0	19.0
7/26/2023	Wed	5	684	96.0	19.2
7/27/2023	Thu	5	799.5	115.5	23.1
7/28/2023	Fri	5	944.5	145.0	29.0
7/29/2023	Sat	5	1133	188.5	37.7
7/30/2023	Sun	5	1283.7	150.7	30.1
7/31/2023	Mon	5	1378.5	94.8	19.0
8/1/2023	Tue	5	1518	139.5	27.9
8/8/2023	Tue	5	2489	138.7	27.7
8/15/2023	Tue	5	3301.2	116.0	23.2
8/22/2023	Tue	5	4144	120.4	24.1
8/29/2023	Tue	3	4739.4	85.1	28.4
8/31/2023	Thu	4	4923.2	91.9	23.0
9/1/2023	Fri	4	5019.8	96.6	24.2
9/2/2023	Sat	4	5189.4	169.6	42.4
9/3/2023	Sun	3	5255.9	66.5	22.2
9/4/2023	Mon	3	5324.9	69.0	23.0
9/5/2023	Tue	3	5381	56.1	18.7
9/6/2023	Wed	3	5460	79.0	26.3
9/7/2023	Thu	3	5577.7	117.7	39.2
9/8/2023	Fri	3	5689	111.3	37.1
9/9/2023	Sat	3	5838.7	149.7	49.9
9/10/2023	Sun	3	5924.2	85.5	28.5
9/11/2023	Mon	3	5992.9	68.7	22.9
9/12/2023	Tue	5	6144.8	151.9	30.4
9/13/2023	Wed	5	6246.4	101.6	20.3
9/14/2023	Thu	5	6333.8	87.4	17.5
9/15/2023	Fri	5	6448.2	114.4	22.9
9/16/2023	Sat	4	6569.6	121.4	30.4
9/17/2023	Sun	4	6721.4	151.8	37.9
9/18/2023	Mon	5	6854.1	132.7	26.5
9/19/2023	Tue	5	6995.4	141.3	28.3
9/20/2023	Wed	5	7080.5	85.1	17.0
9/21/2023	Thu	6	7151.8	71.3	11.9
9/22/2023	Fri	5	7289.3	137.5	27.5
9/23/2023	Sat	5	7464.5	175.2	35.0
9/24/2023	Sun	4	7550.7	86.2	21.6
9/25/2023	Mon	4	7589	38.3	9.6

Project Name	Innisfree Wastewater Upgrades	
	Updated:	8/12/2024
	By:	DJM

Table A-8. Detailed Water Meter Data for Trillium Residential Building, contin.

Date	Day of Wk	# Persons in House	Meter Reading	Daily use (gal)	GPD per person
9/26/2023	Tue	4	7705.7	116.7	29.2
9/27/2023	Wed	4	7779.3	73.6	18.4
9/28/2023	Thu	4	7860	80.7	20.2
9/29/2023	Fri	5	7946.4	86.4	17.3
9/30/2023	Sat	5	8058.2	111.8	22.4
10/1/2023	Sun	5	8112.4	54.2	10.8
10/2/2023	Mon	5	8189.7	77.3	15.5
10/3/2023	Tue	6	8332.8	143.1	23.8
10/4/2023	Wed	6	8535.8	203.0	33.8
10/5/2023	Thu	6	8680	144.2	24.0
10/6/2023	Fri	6	8813.4	133.4	22.2
10/9/2023	Mon	6	9219	135.2	22.5
10/10/2023	Tue	6	9351.5	132.5	22.1
10/11/2023	Wed	6	9465.4	113.9	19.0
10/12/2023	Thu	6	9573.4	108.0	18.0
10/13/2023	Fri	6	9754.4	181.0	30.2
10/14/2023	Sat	6	9900.7	146.3	24.4
10/15/2023	Sun	6	10018.8	118.1	19.7
10/16/2023	Mon	6	10087	68.2	11.4
1/5/2024	Fri	6	17156.3	87.3	14.5
1/26/2024	Fri	6	19700	121.1	20.2
2/2/2024	Fri	6	20471	110.1	18.4
2/9/2024	Fri	5	21283.6	116.1	23.2
2/16/2024	Fri	5	21948	94.9	19.0
2/22/2024	Thu	5	22554.7	101.1	20.2
3/1/2024	Fri	5	23025.4	58.8	11.8
3/15/2024	Fri	6	24231	86.1	14.4
3/22/2024	Fri	6	24970	105.6	17.6
3/29/2024	Fri	6	25632.6	94.7	15.8
4/5/2024	Fri	6	26339.7	101.0	16.8
4/12/2024	Fri	6	27044.8	100.7	16.8
4/19/2024	Fri	6	27566.3	74.5	12.4
4/26/2024	Fri	6	28291.1	103.5	17.3
5/3/2024	Fri	6	28824.8	76.2	12.7
5/10/2024	Fri	6	29546.4	103.1	17.2
5/17/2024	Fri	6	30256.9	101.5	16.9
5/24/2024	Fri	6	31073	116.6	19.4
5/31/2024	Fri	6	31652	82.7	13.8
6/7/2024	Fri	6	32205.9	79.1	13.2
6/14/2024	Fri	6	32765.9	80.0	13.3
6/21/2024	Fri	6	33422	93.7	15.6
6/28/2024	Fri	6	34886	209.1	34.9
7/5/2024	Fri	6	35522.8	91.0	15.2

Appendix B

- **AdvanTex System Design Calculations**
- **Stage Three Treatment Biofilter calculations**
- **Nitrogen Dilution Calculations**

Appendix B - Wastewater Treatment Design

Project Name:	Innisfree Village - Alternative Onsite Sewage System		
Updated:	8/1/2024	By:	D. Maciolek

Design input
Important output

Table B-1 Orenco AdvanTex® System Design (a)

Design Parameter	Septic Effluent Loading Value (c)	Unit	Stage 1 Advantex (b) Loading Rate (d)	Stage 1 AX area required ft^2 (e)	Stage 1 Effluent Load (e)	Stage 1 Estimated Effluent Conc. (f)	Stage 2 Advantex (b) Loading Rate (d)	Stage 2 AX area required ft^2 (e)	Stage 2 Estimated Effluent Conc. (f)
Flow- Average	5,500	gpd	25	220	N/A	NA	75	73.3	N/A
Flow - Peak (limit)	9,000	gpd	50	180	N/A	NA	125	72.0	N/A
BOD - average	17.1	lb/d	0.04	426.4	1.3	27.9	0.02	64.0	5.6
BOD - Peak	22.2	lb/d	0.08	277.2	1.7	22.2	0.04	41.6	4.4
TKN/TN- Average	3.8	lb/d	0.014	269.3	0.4	8.2	0.007	53.9	0.8
TKN/TN- Peak	4.9	lb/d	0.02	245.0	0.5	10.7	0.01	49.0	1.1
			Minimum area required (sq. ft.)	426.4		Minimum area required (sq. ft.)		73.3	

Advantex Module Requirements AX design:	Textile plan area per module, sq. ft.		Stage 1 No. of Modules	Stage 1 Plan Area, sq.ft.	Stage 1 Safety Factor (g)	Stage 2	Stage 2 Textile Plan Area, sq.ft.	Stage 2 Safety Factor (g)
AX100	100		5	500	74%	1	100	27%
AX 20	20	N.A.		0			0	

(a) Design of biological treamtment using Orenco Systems AdvanTex® textile trickling filter system.
(b) Each stage consisits of AdvanTex pods and dedicated recirculation tank.
(c) Design Flow and Loading criteria from Tables A-4.
(d) Recommended loading rates from Orenco Systems, Inc. 2017 Design/Engineering Binder.
(e) Computed required area of Advantex AX unit . Actual area is determined by the number and size of AX units.
(d) Estimated effluent load based on expected reduction in Stage 1 system.
(f) Concentration equivalent computed from effluent load and flow.
(g) Additional textile plan area provided compared to required computed area = (Provided Area - Required Area/Required Area) x %

Appendix B - Wastewater Treatment Design

Project Name:	**Innisfree Village - Alternative Onsite Sewage System**		
Updated:	8/14/2024	By:	D. Maciolek

Design input
Important output

Table B-3. TOrC Removal Wetland

Flow	5,681	gpd			
Areal loading rate	18	gpd/sqft	(based on Ref 1)		
Media depth	24	inches			
Wetland Surface Area	320	sq. ft.			
Volume	640	cu. ft.			
Media:					
Biochar	15%	96	cu. ft.	4	cu. yd.
Hardwood chips	85%	544	cu. ft.	20	cu. yd.

Ref 1: Evaluation of pilot-scale biochar-amended woodchip bioreactors to remove nitrate, metals, and trace organic contaminants from urban stormwater runoff. Ashoori et. al. 20. Water Research
Volume 154, 1 May 2019, Pages 1-11

Table B-4. - Nitrogen Removal Wetland

Flow	**5,681**	gpd		
Volumetric loading rate	10.0	gpd/cu.ft. (based on Ref 2)		
Washed stone Vol.	568	cu. ft.		
Stone Surface Area	376	sq. ft.		
Min. Stone Layer Depth	1.5	ft		
Nitrate concentration reduction	30	mg/L		
Bio-Avail. Fraction of elemental sulfur	0.85			
Required Sulfur/nitrate	1			
Required Elemental Sulfur Dose	125	kg/yr	277	lbs/yr

Ref 2:

Aqua Nova Engineering, PLC
Tel. 434- 249-4497

Appendix C

- **Sewer System Design Calculations**

Appendix C - Sewer Collection System Calculations

Project Name: **Innisfree Wastewater Upgrades**
Design Aspect: **Collection System Calculations**

Updated:	8/7/2024	Reviewed	8/12/2024
By:	CBH	By:	DJM

Table C-1. Septic Tank Effluent Gravity Collection System Calculations -PEAK FLOW (a)

Manning's "n" Coefficient for PVC coated in sewer scum: 0.011

Segment name (b)	Elevation Difference ft (c)	Slope (c)	Min. Pipe inside diameter, in.	Pipe length, ft	Grav. Velocity, ft/s	Max. Gravity flow, gpm (d)	feeding into Seg. from grav. Connect. (e)	Gravity flow per person, gpm (f)	Gravity flow (gpm)	Pumped flow (gpm)	Estimated peak flow (gpm)	Max.% Pipe fill	Notes
Kenmare to Laurel	-24	-5.5%	3.042	433	5.07	115	7	2	14	25	39	34%	(g)
Laurel to Windsong	-27	-4.3%	3.975	625	5.35	207	13	2	26	0	65	31%	
Windsong to Amity	-12	-3.2%	3.975	375	4.60	178	12	2	24	25	114	64%	
Amity to Community Cntr	-13	-3.0%	5.915	433	5.81	498	9	2	18	0	132	27%	
Community Cntr to Office	-10	-4.2%	5.915	236	6.90	591	74	0.5	37	0	169	29%	(h)
Office to Red Star pump	-9	-3.0%	5.915	305	5.76	494	31	0.5	15.5	0	184.5	37%	(i)
Redstar to Bittersweet	-2	-2.2%	5.915	91	4.97	426	0	2	0	28	212.5	50%	
Bittersweet to Walnut Lvl	-8	-2.1%	5.915	385	4.84	385	6	2	12	0	224.5	54%	
Walnut Lvl to WWTS	-5	-3.3%	5.915	153	6.06	385	6	2	12	1	237.5	46%	

(a) Gravity sewer "Main" that starts where pumped effluent from Trilliium, Halcyon & Oakwood combines with flow from Kenmare and becomes gravity sewer.
(b) Segment start and end points are named for nearest building septic effluent pipe connection. WWTS is the wastewater treatment system.
(c) Negative indicates elevation drop from start to end. Calculated slope is the min. over entire length of segment. Slope to be constant between cleanouts.
(d) Peak instantanous gravity flow rate from septic tanks is assumed to be attenuated by the septic tank.
(e) Residents or users in buildings with sewer connecting to sewer main segment by gravity flow lateral.
(f) Peak instantanous gravity flow rate from septic tanks is assumed to be attenuated by the septic tank.
(g) Pumped flow for this segment is a combination of STEP Pump Station 1 (SPS1) and STEP Pump Station 2 (SPS2) running at the same time.
(h) Maximum community center occupancy. Due to lighter use patterns the GPM instantnous flow per person is reduced.
(i) Maximum office and workshop personnel. Due to lighter use patterns, the GPM instantnous flow per person is reduced.

Appendix C - Sewer Collection System Calculations

Project Name:	**Innisfree Village Wastewater System Ugrade**
Pumps and Piping	**SPS1-Duplex Septic Effluent pumps - to Sewer Main**
Updated:	7/31/2024
By:	CBH

Desired Pump Flow	Avg.
gallons per minute	18.0

Simplex Pump (No Manifold) Parameter	Pump Outlet to Transfer	Transfer* pipe length
Pipe length, ft	8	1130
Pipe diam., inside (in)	1.533	1.533
Hazen-Williams Coeff., C	120	120

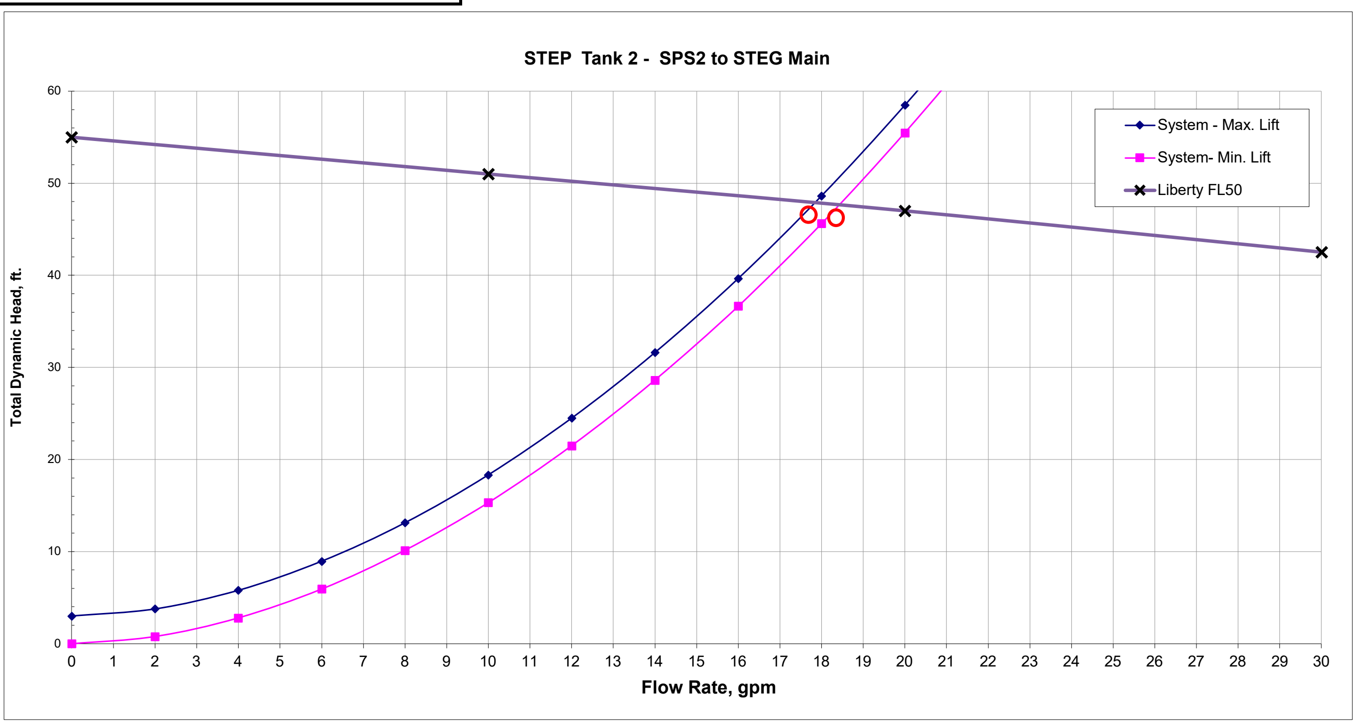
* Piping from pump basin to discharge point

Pump Lift			*Additional Head, ft	
SPS1 to SPS2	Min. lift, ft	0	MIN.	0
PS 1 to Eq. tank	Max. lift, ft	3	Max.	0

Minor Losses		Number of fittings		
Type	K	Pump Outlet to Trnsfer**	Transfer piping	Transfer to discharge
Entrance to manifold	0.5	0		
Ball Valve - fully open	0.1	1		
Gate Valve - half open	13		0	
Check Valve	2.5	1	0	
Tee - line flow	0.6		0	
Tee - branch flow	1.6	1		
90° Elbow - regular	1.0	3	1.0	
45° Elbow - med. rad	0.25		0	
Open pipe disch.	1.0		1.0	
Flow Meter - insertion	8		0	
Sum of K values		7.2	2.0	0.0

System Curve - Head Loss Calculations

		Water Velocity in:		Dynamic Losses, ft				Total Head	
		Outlet	Transfer	Pump to Transfer		Transfer Pipe to Disch			
gpm	cfs	Velocity, ft/s	Velocity, ft/s	Minor Losses	Pipe Friction	Minor Losses	Pipe Friction	Min. lift	Max. lift
0	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.0	3.0
2	0.00	0.3	0.3	0.01	0.01	0.00	0.75	0.8	3.8
4	0.01	0.7	0.7	0.05	0.02	0.02	2.71	2.8	5.8
6	0.01	1.0	1.0	0.12	0.04	0.03	5.74	5.9	8.9
8	0.02	1.4	1.4	0.22	0.07	0.06	9.78	10.1	13.1
10	0.02	1.7	1.7	0.34	0.10	0.09	14.78	15.3	18.3
12	0.03	2.1	2.1	0.49	0.15	0.14	20.72	21.5	24.5
14	0.03	2.4	2.4	0.66	0.20	0.18	27.57	28.6	31.6
16	0.04	2.8	2.8	0.86	0.25	0.24	35.30	36.7	39.7
18	0.04	3.1	3.1	1.09	0.31	0.30	43.91	45.6	48.6
20	0.04	3.5	3.5	1.35	0.38	0.38	53.37	55.5	58.5
22	0.05	3.8	3.8	1.63	0.45	0.45	63.67	66.2	69.2
24	0.05	4.2	4.2	1.95	0.53	0.54	74.80	77.8	80.8
26	0.06	4.5	4.5	2.28	0.61	0.63	86.76	90.3	93.3
28	0.06	4.9	4.9	2.65	0.70	0.74	99.52	103.6	106.6
30	0.07	5.2	5.2	3.04	0.80	0.84	113.08	117.8	120.8
32	0.07	5.6	5.6	3.46	0.90	0.96	127.44	132.8	135.8
34	0.08	5.9	5.9	3.90	1.01	1.08	142.59	148.6	151.6
36	0.08	6.3	6.3	4.38	1.12	1.22	158.51	165.2	168.2
38	0.08	6.6	6.6	4.88	1.24	1.35	175.20	182.7	185.7



Appendix C - Sewer Collection System Calculations

Project Name: Innisfree Village Wastewater System Ugrade

Pumps and Piping **SPS1-Duplex Septic Effluent pumps - to Sewer Main**

Updated: 7/31/2024

By: CBH

Desired Pump Flow	Avg.
gallons per minute	23.0

Simplex Pump (No Manifold) Parameter	Pump Outlet to Transfer	Transfer* pipe length
Pipe length, ft	8	680
Pipe diam., inside (in)	1.533	1.533
Hazen-Williams Coeff., C	120	120

* Piping from pump basin to discharge point

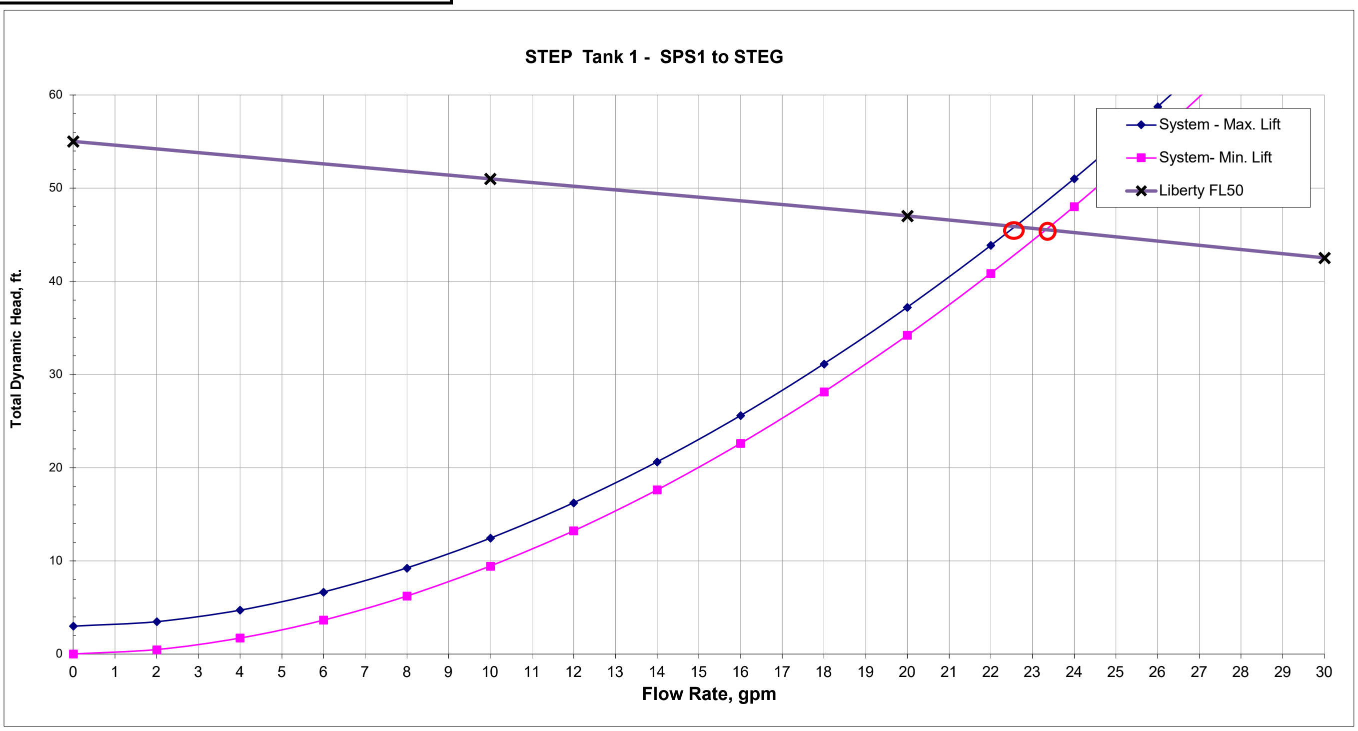
Pump Lift ***Additional Head, ft**

SPS1 to SPS2	Min. lift, ft	0	MIN.	0
PS 1 to Eq. tank	Max. lift, ft	3	Max.	0

Minor Losses		Number of fittings		
Type	K	Pump Outlet to Trnsfer**	Transfer piping	Transfer to discharge
Entrance to manifold	0.5	0		
Ball Valve - fully open	0.1	1		
Gate Valve - half open	13		0	
Check Valve	2.5	1	0	
Tee - line flow	0.6		0	
Tee - branch flow	1.6	1		
90° Elbow - regular	1.0	3	1.0	
45° Elbow - med. rad	0.25		0	
Open pipe disch.	1.0		1.0	
Flow Meter - insertion	8		0	
Sum of K values		**7.2**	**2.0**	**0.0**

System Curve - Head Loss Calculations

		Water Velocity in:		Dynamic Losses, ft				Total Head	
		Outlet	Transfer	Pump to Transfer		Transfer Pipe to Disch			
gpm	cfs	Velocity, ft/s	Velocity, ft/s	Minor Losses	Pipe Friction	Minor Losses	Pipe Friction	Min. lift	Max. lift
0	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.0	3.0
2	0.00	0.3	0.3	0.01	0.01	0.00	0.45	0.5	3.5
4	0.01	0.7	0.7	0.05	0.02	0.02	1.63	1.7	4.7
6	0.01	1.0	1.0	0.12	0.04	0.03	3.45	3.7	6.7
8	0.02	1.4	1.4	0.22	0.07	0.06	5.88	6.2	9.2
10	0.02	1.7	1.7	0.34	0.10	0.09	8.90	9.4	12.4
12	0.03	2.1	2.1	0.49	0.15	0.14	12.47	13.2	16.2
14	0.03	2.4	2.4	0.66	0.20	0.18	16.59	17.6	20.6
16	0.04	2.8	2.8	0.86	0.25	0.24	21.24	22.6	25.6
18	0.04	3.1	3.1	1.09	0.31	0.30	26.42	28.1	31.1
20	0.04	3.5	3.5	1.35	0.38	0.38	32.12	34.2	37.2
22	0.05	3.8	3.8	1.63	0.45	0.45	38.32	40.9	43.9
24	0.05	4.2	4.2	1.95	0.53	0.54	45.01	48.0	51.0
26	0.06	4.5	4.5	2.28	0.61	0.63	52.21	55.7	58.7
28	0.06	4.9	4.9	2.65	0.70	0.74	59.89	64.0	67.0
30	0.07	5.2	5.2	3.04	0.80	0.84	68.05	72.7	75.7
32	0.07	5.6	5.6	3.46	0.90	0.96	76.69	82.0	85.0
34	0.08	5.9	5.9	3.90	1.01	1.08	85.80	91.8	94.8
36	0.08	6.3	6.3	4.38	1.12	1.22	95.38	102.1	105.1
38	0.08	6.6	6.6	4.88	1.24	1.35	105.43	112.9	115.9



Appendix C - Sewer Collection System Calculations

Project Name: **Innisfree Village Wastewater System Ugrade**

Pumps and Piping **SPS4 Duplex Effluent Pumps to Sewer Main**

Updated:	7/31/2024
By:	CBH

Desired Pump Flow	Avg.
gallons per minute	28.0

Simplex Pump (No Manifold) Parameter	Pump Outlet to Transfer	Transfer* pipe length
Pipe length, ft	8	430
Pipe diam., inside (in)	1.533	1.533
Hazen-Williams Coeff., C	120	120

* Piping from pump basin to discharge point

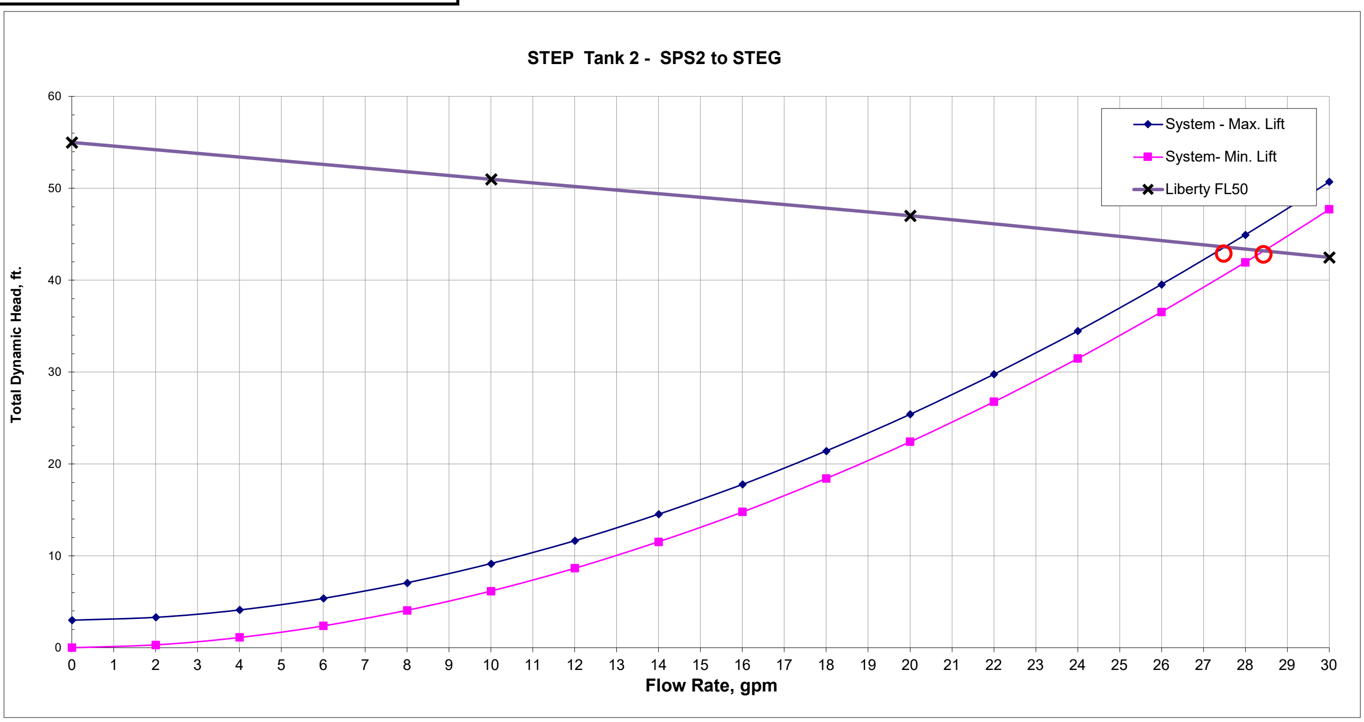
Pump Lift

				*Additional Head, ft
SPS1 to SPS2	Min. lift, ft	0	MIN.	0
PS 1 to Eq. tank	Max. lift, ft	3	Max.	0

Minor Losses		**Number of fittings**		
Type	K	Pump Outlet to Trnsfer**	Transfer piping	Transfer to discharge
Entrance to manifold	0.5	0		
Ball Valve - fully open	0.1	1		
Gate Valve - half open	13		0	
Check Valve	2.5	1	0	
Tee - line flow	0.6		0	
Tee - branch flow	1.6	1		
90° Elbow - regular	1.0	3	1.0	
45° Elbow - med. rad	0.25		0	
Open pipe disch.	1.0		1.0	
Flow Meter - insertion	8		0	
Sum of K values		**7.2**	**2.0**	**0.0**

System Curve - Head Loss Calculations

		Water Velocity in:		Dynamic Losses, ft				Total Head	
		Outlet	**Transfer**	Pump to Transfer		Transfer Pipe to Disch			
gpm	cfs	Velocity, ft/s	Velocity, ft/s	Minor Losses	Pipe Friction	Minor Losses	Pipe Friction	Min. lift	Max. lift
0	0.00	0.0	0.0	0.00	0.00	0.00	0.00	**0.0**	**3.0**
2	0.00	0.3	0.3	0.01	0.01	0.00	0.29	**0.3**	**3.3**
4	0.01	0.7	0.7	0.05	0.02	0.02	1.03	**1.1**	**4.1**
6	0.01	1.0	1.0	0.12	0.04	0.03	2.18	**2.4**	**5.4**
8	0.02	1.4	1.4	0.22	0.07	0.06	3.72	**4.1**	**7.1**
10	0.02	1.7	1.7	0.34	0.10	0.09	5.63	**6.2**	**9.2**
12	0.03	2.1	2.1	0.49	0.15	0.14	7.89	**8.7**	**11.7**
14	0.03	2.4	2.4	0.66	0.20	0.18	10.49	**11.5**	**14.5**
16	0.04	2.8	2.8	0.86	0.25	0.24	13.43	**14.8**	**17.8**
18	0.04	3.1	3.1	1.09	0.31	0.30	16.71	**18.4**	**21.4**
20	0.04	3.5	3.5	1.35	0.38	0.38	20.31	**22.4**	**25.4**
22	0.05	3.8	3.8	1.63	0.45	0.45	24.23	**26.8**	**29.8**
24	0.05	4.2	4.2	1.95	0.53	0.54	28.47	**31.5**	**34.5**
26	0.06	4.5	4.5	2.28	0.61	0.63	33.01	**36.5**	**39.5**
28	0.06	4.9	4.9	2.65	0.70	0.74	37.87	**42.0**	**45.0**
30	0.07	5.2	5.2	3.04	0.80	0.84	43.03	**47.7**	**50.7**
32	0.07	5.6	5.6	3.46	0.90	0.96	48.50	**53.8**	**56.8**
34	0.08	5.9	5.9	3.90	1.01	1.08	54.26	**60.3**	**63.3**
36	0.08	6.3	6.3	4.38	1.12	1.22	60.32	**67.0**	**70.0**
38	0.08	6.6	6.6	4.88	1.24	1.35	66.67	**74.1**	**77.1**



Appendix D

- **Drainfield Design Calculations- Area and Trench Design**
- **LPD Detail Calculations (Using OSI calculation tool)**
- **Groundwater Mounding Model Results**

Appendix D - Effluent Dispersal System Design and Configuration

Project:	**Innisfree Village - Combined Sewage AOSS**		
Scenario:	**Residences, Office, Workshops and Community Center**		
Updated:	**5/6/2024**	By:	*David Maciolek*
Checked	**8/12/2024**	By:	*CBH*

Table D-1. Primary Effluent Dispersal Area - LPD Trenches

Design Flow to Mass Drainfield, gpd			5,500	equalized flow from table A-2, Flow Equalization Calcluations							
Field Area	Estimated Perc. Rate (a) mpi	Loading Rate **TL3** Effluent gpd/ft²	Area & Dimens. for Absorbtion Trenches				Field (d) Absorption Capacity, gpd	Distance Trench CLs ft (e)	Approx. Field Area ft²	Effluent Flow Alloc. (f)
			Width ft	Design Length, ft	Number of Trenches	Adsorp. Area (c), ft²				
A	60	0.94	**3**	75	9	2,025	1,904	9	5,175	33%
B	85	0.61	**3**	85	12	3,060	1,867	9	8,160	32%
C	65	0.83	**3**	100	8	2,400	1,992	9	6,000	35%
TOTAL						7,485	**5,762**			100%

(a) Design Percolation Rate developed from soil profile descriptions and Ksat results.
(b) Per Virginia Sewage Handling and Disposal Regulations, 12VAC5-610-950, Table 5.5.
(c) Adsoprtion area is total trench bottom area.
(d) Maximum effluent application capacity equal to Absorption area times Loading Rate (hydraulic loading rate).
(e) Distance between trench centers. Three times trench width for slopes <20% ,Sewage Handling and Disposal Regulations, 12VAC 5-610, Section 950, F., page 96.
(f) Effective percent of total flow allocated to drainfield area listed.

Table D-2. Reserve Dispersal Area - LPD Trenches

Design Flow to Mass Drainfield, gpd			5,500	equalized flow from table A-2, Flow Equalization Calcluations						
Field Area	Estimated Perc. Rate (a) mpi	Loading Rate **TL3** Effluent gpd/ft² (b)	Area & Dimens. for Absorbtion Trenches				Field (c) Absorption Capacity, gpd	Distance Trench CLs ft (d)	Approx Field Area ft²	Note
			Width ft	Design Length, ft	Number of Trenches	Adsorp. Area (c), ft²				
D- new	50	1.00	**2**	65	10	1,300	1,300	**6**	3,380	Area downhill of barn uphill of Farm Well
Comm. Cntr	115	0.35	**3**	100	32	9,600	3,360	9	27,600	Existing drainfield for Community Center
Farm Blg (e)	100	0.46	**3**	100	5	1,500	690	**9**	3,300	Existing drainfield constructed in 2016
TOTAL						12,400	**5,350**			

(a) Rate for Area D is from soil profile descriptions and Ksat results. Rates for Community Center and Farm Bldg are from existing COSS perr
(b) Application rate Per Virginia Sewage Handling and Disposal Regulations, 12VAC5-610-950, Table 5.5.
(c) Adsoprtion area is total trench bottom area. Adsoprtion Capacity is Adsorption area times Loading Rate (hydraulic loading rate).
(d) Distance between trench centers. Three times trench width for slopes <20% ,Sewage Handling and Disposal Regulations, 12VAC 5-610, Section 950, F., page 96.
(e) "Red Star" Farm building used for egg processing. New drainfield constructed in 2016.

Pump Selection for a Pressurized System - Multiple Family Residence Project

Innisfree Village / LPD dispersal area A

Figure D-1 - Drainfield A LPD Detailed Calculations

Parameters

Discharge Assembly Size	2.00	inches
Transport Length	1550	feet
Transport Pipe Class	40	
Transport Line Size	2.00	inches
Distributing Valve Model	None	
Max Elevation Lift	-23	feet
Manifold Length	100	feet
Manifold Pipe Class	40	
Manifold Pipe Size	2.00	inches
Number of Laterals per Cell	3	
Lateral Length	75	feet
Lateral Pipe Class	40	
Lateral Pipe Size	1.50	inches
Orifice Size	1/8	inches
Orifice Spacing	2.25	feet
Residual Head	5	feet
Flow Meter	2.0	inches
'Add-on' Friction Losses	12	feet

Calculations

Minimum Flow Rate per Orifice	0.43	gpm
Number of Orifices per Zone	102	
Total Flow Rate per Zone	44.5	gpm
Number of Laterals per Zone	3	
% Flow Differential 1st/Last Orifice	3.6	%
Transport Velocity	4.3	fps

Frictional Head Losses

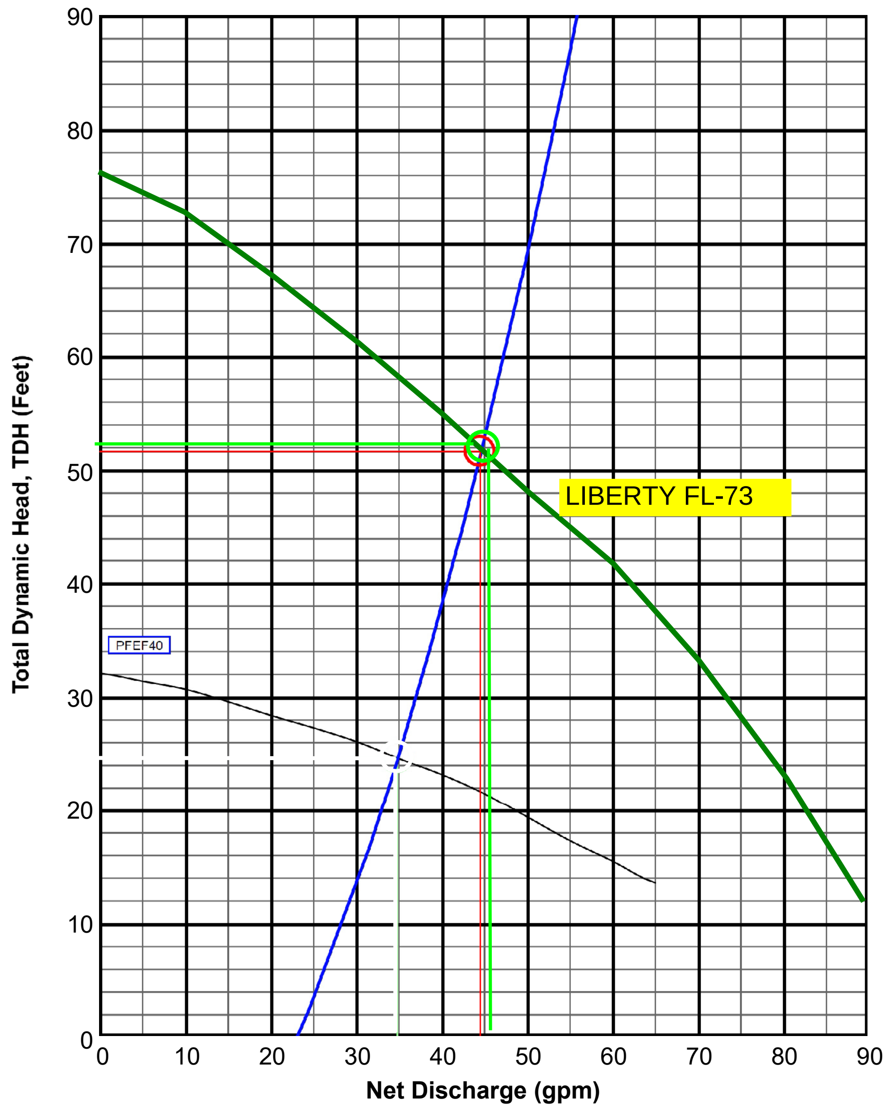
Loss through Discharge	3.9	feet
Loss in Transport	50.0	feet
Loss through Valve	0.0	feet
Loss in Manifold	0.9	feet
Loss in Laterals	0.4	feet
Loss through Flowmeter	2.3	feet
'Add-on' Friction Losses	12.0	feet

Pipe Volumes

Vol of Transport Line	270.2	gals
Vol of Manifold	17.4	gals
Vol of Laterals per Zone	23.8	gals
Total Volume	311.4	gals

Minimum Pump Requirements

Design Flow Rate	44.5	gpm
Total Dynamic Head	51.6	feet



PumpData

Liberty FL-73M-2
208V, 3 Phase,
Full Load Amps: 7.5

Legend

System Curve:
Pump Curve:
Pump Optimal Range:
Operating Point:
Design Point:

Orenco Systems
PROTECTING THE WORLD'S WATER

Appendix D

Pump Selection for a Pressurized System - Multiple Family Residence Project

Innisfree Village / LPD dispersal area B

Figure D-2 - Drainfield B LPD Detailed Calculations

Parameters

Discharge Assembly Size	2.00	inches
Transport Length	1560	feet
Transport Pipe Class	40	
Transport Line Size	2.00	inches
Distributing Valve Model	None	
Max Elevation Lift	-25	feet
Manifold Length	120	feet
Manifold Pipe Class	40	
Manifold Pipe Size	2.00	inches
Number of Laterals per Cell	3	
Lateral Length	80	feet
Lateral Pipe Class	40	
Lateral Pipe Size	1.50	inches
Orifice Size	1/8	inches
Orifice Spacing	2.5	feet
Residual Head	5	feet
Flow Meter	2.0	inches
'Add-on' Friction Losses	12	feet

Calculations

Minimum Flow Rate per Orifice	0.43	gpm
Number of Orifices per Zone	99	
Total Flow Rate per Zone	43.2	gpm
Number of Laterals per Zone	3	
% Flow Differential 1st/Last Orifice	3.6	%
Transport Velocity	4.2	fps

Frictional Head Losses

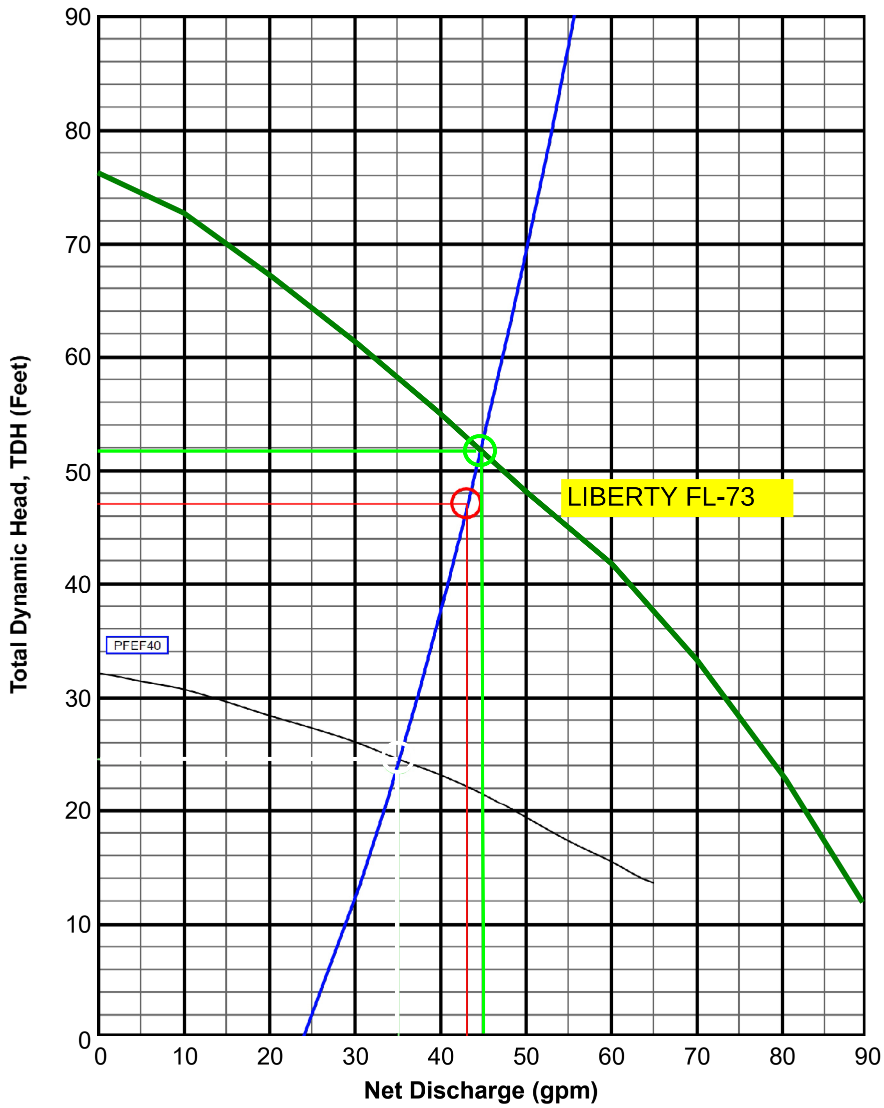
Loss through Discharge	3.7	feet
Loss in Transport	47.6	feet
Loss through Valve	0.0	feet
Loss in Manifold	1.0	feet
Loss in Laterals	0.4	feet
Loss through Flowmeter	2.2	feet
'Add-on' Friction Losses	12.0	feet

Pipe Volumes

Vol of Transport Line	271.9	gals
Vol of Manifold	20.9	gals
Vol of Laterals per Zone	25.4	gals
Total Volume	318.2	gals

Minimum Pump Requirements

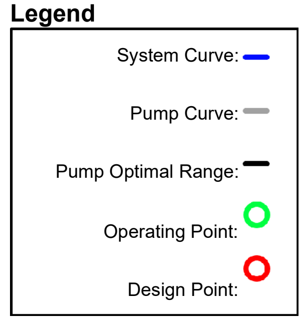
Design Flow Rate	43.2	gpm
Total Dynamic Head	47.0	feet



PumpData

Liberty FL-73M-2
208V, 3 Phase,
Full Load Amps: 7.5

Legend



Orenco Systems
PROTECTING THE WORLD'S WATER

Pump Selection for a Pressurized System - Multiple Family Residence Project

Innisfree Village / LPD dispersal area C

Figure D-3 - Drainfield C- LPD Detailed Calculations

Parameters

Discharge Assembly Size	2.00	inches
Transport Length	1665	feet
Transport Pipe Class	40	
Transport Line Size	2.00	inches
Distributing Valve Model	None	
Max Elevation Lift	-31	feet
Manifold Length	80	feet
Manifold Pipe Class	40	
Manifold Pipe Size	2.00	inches
Number of Laterals per Cell	2	
Lateral Length	99	feet
Lateral Pipe Class	40	
Lateral Pipe Size	1.50	inches
Orifice Size	1/8	inches
Orifice Spacing	2	feet
Residual Head	5	feet
Flow Meter	2.0	inches
'Add-on' Friction Losses	12	feet

Calculations

Minimum Flow Rate per Orifice	0.43	gpm
Number of Orifices per Zone	100	
Total Flow Rate per Zone	44.4	gpm
Number of Laterals per Zone	2	
% Flow Differential 1st/Last Orifice	9.5	%
Transport Velocity	4.3	fps

Frictional Head Losses

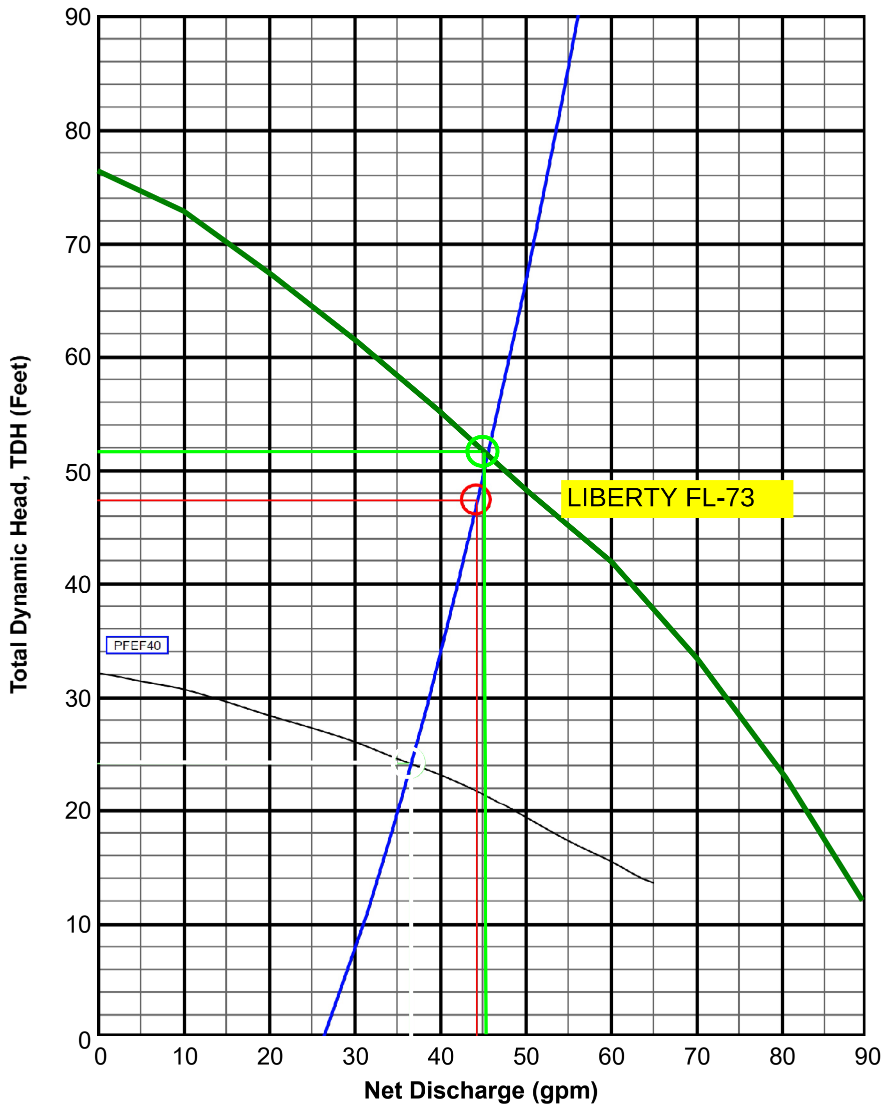
Loss through Discharge	3.9	feet
Loss in Transport	53.3	feet
Loss through Valve	0.0	feet
Loss in Manifold	0.7	feet
Loss in Laterals	1.1	feet
Loss through Flowmeter	2.3	feet
'Add-on' Friction Losses	12.0	feet

Pipe Volumes

Vol of Transport Line	290.2	gals
Vol of Manifold	13.9	gals
Vol of Laterals per Zone	20.9	gals
Total Volume	325.1	gals

Minimum Pump Requirements

Design Flow Rate	44.4	gpm
Total Dynamic Head	47.3	feet



PumpData

Liberty FL-73M-2
208V, 3 Phase,
Full Load Amps: 7.5

Legend

System Curve:
Pump Curve:
Pump Optimal Range:
Operating Point:
Design Point:

Orenco SYSTEMS
PROTECTING THE WORLD'S WATER

APPENDIX E

- **Soils Evaluation SPD and Ksat Summary**
- **Ksat Testing Data sheets**

APPENDIX E

Project: **Innisfree Village AOSS**

Updated: 8/14/2024 **By:** David Maciolek

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfield (Cell) A - North Section of Lower Area					
A	**SPD 1, Pit**	13-Oct-23	Ap	0-4	Reddish brown (5YR 4/4) LOAM; friable; granular structure; coarse quartz sands and small gravels present; abundant fine and medium roots; abundant fine and medium pore spaces; abrupt smooth boundary.
			BA	4-9	Yellowish red (5YR 4/6) CLAY LOAM; light grey coarse quartz sands present; friable; medium subangular blocky; abundant fine-med roots; trace micas present; abrupt smooth boundary.
			Bt1	9-34	Red (10R 4/6) CLAY LOAM; ~5% yellowish red (5YR 5/8) saprolitic greenstone gravels; friable and slightly loose; medium subangular blocky; abundant fine-med roots; abundant fine-med pores; abrupt smooth boundary.
			2Bt2	34-66	Red (10R 4/8) CLAY LOAM; friable; weak medium subangular blocky; olive yellow saprolitic greenstone gravels, white quartz gravels, and grey friable weathered gneiss gravels; fine roots present; fine-medium pores present; 5-10% weathered gravels; slightly hard; micaceous.
A	**SPD 2, pit**	13-Oct-23	Ap	0-4	Reddish brown (5YR 4/4) LOAM; fine subangular blocky- to granular structure; abundant fine roots; abundant fine and medium pores; trace subangular gravels; abrupt smooth boundary.
			Bt1	4-24	Red (10YR 5/8) CLAY LOAM; medium subangular blocky; 10-15% olive yellow (2.5Y 6/6) weathered greenstone and grey gneiss gravels up to 2" diameter present; loose; friable; common fine-med roots; abundant fine-med pores; abrupt smooth boundary.
			Bt2	24-64	fine roots present; fine-med pores common; clay films; ~5% weathered gravels present; subrounded coarse sands common; trace mica; abrupt smooth boundary.
A	**SPD 3, pit**	06-Feb-24	Ap	0-4	Reddish brown (5YR 4/4) CLAY LOAM; granular structure; abundant fine and medium roots; abundant fine and medium pores.
			BA	4-10	Yellowish red (5YR 4/6) CLAY LOAM; few weathered gravels; medium subangular blocky structure; loose consistency; friable; common fine and medium roots; abundant fine-med pores.
			Bt1	10-32	medium subangular blocky; slightly loose; friable; fine and medium roots common; fine-medium pores abundant; mica present; clay films; abrupt wavy boundary.
			2Bt2	32-48	Red (2.5YR 4/6) CLAY LOAM; weak medium subangular blocky structure; slightly hard; friable; roots present; pores present; micaceous

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfield Cell A -continued					
A	**SPD 4 Pit**	13-Oct-23	Ap	0-6	Reddish brown (5YR 4/4) LOAM; trace coarse quartz sands and small gravels present; fine subangular blocky- to granular structure; abundant fine roots; abundant fine and medium pores; abrupt smooth boundary.
			Bt1	6-18	Red (2.5YR 4/6) CLAY LOAM; medium subangular blocky; olive yellow (2.5Y 6/6) weathered greenstone gravels up to 2" diameter and weathered gneiss gravels present; 10-20% weathered gravel content; loose; friable; common fine roots; abundant fine-med pores; micaceous; abrupt smooth boundary.
			2Bt2	18-60	Red (2.5YR 4/6) CLAY LOAM; weak medium subangular blocky; trace olive yellow weathered greenstone and grey weathered gneiss gravels; trace subrounded coarse quartz sands; friable; fine roots common above 42" and present below that; 5-10% weathered gravels; fine-medium pores present; micaceous.
A	**SPD 5 - pit**	13-Oct-23	Ap	0-5	Reddish brown (5YR 4/4) LOAM; fine subangular blocky- to granular structure; abundant fine roots; abundant fine and medium pores; trace subangular gravels; abrupt smooth boundary.
			Bt1	5-16	Red (10YR 5/8) CLAY LOAM; medium subangular blocky; ~5% olive yellow (2.5Y 6/6) weathered greenstone and white quartz gravels present; loose; friable; abundant fine-med roots; abundant fine-med pores; abrupt smooth boundary.
			2Bt2	16-32	Red (10YR 5/8) CLAY; medium subangular blocky structure; friable; fine roots common; fine-med pores common; ~5-10% weathered gravels present; abrupt smooth boundary.
			2Bt3	32-62	Red (10YR 4/8) CLAY; friable; weak medium subangular blocky; olive yellow saprolitic greenstone gravels, white quartz gravels, and grey friable weathered
A	SB 10-Boring	2/10/2022	Ap	0-10	Reddish brown (5YR 4/4) LOAM
			Bt1	10-36	Red (2.5YR 4/6) CLAY LOAM; micaceous; subrounded gravels common
			Bt2	36-62	Red (2.5YR 4/8) SILTY CLAY LOAM; micaceous
	SB 19A-boring	4/18/2024	Ap	0-10	Strong brown (7.5YR/4/6) LOAM; granular structure; abundant roots
			1Bt1	10-30	Yellowish red (5YR 4/6) CLAY LOAM w/ coarse sands; loose and friable
			2Bt2	30-40	Yellowish red (5YR/4/6) CLAY w/ 10YR lithochr. masses; gravelly at base of horizon

A	**Sat. Hydraulic Conductivity Test Results (b)**				
	Test	Depth, in.	Rate, cm/d		
	Ksat 6	30	84		
	Ksat 9	32	34		
	Ksat 14	22	12		
	Ksat 15	32	110		
		Geometric Mean	44.1	***11.02***	*= Geometric Mean divided by 4*
		Median	59.0	***14.75***	*= Median divided by 4*
	Ksat 1	58	30.5	Note:	Performed in most restrictive horizon in Pit
	Ksat 2	53	36	Note:	Performed in most restrictive horizon in Pit
		Geometric Mean	33.1		

APPENDIX E

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfield (Cell) B - Center Section of Lower Area					
B	**SPD 6**	06-Feb-24	Ap	0-4	Reddish brown (5YR 4/4) CLAY LOAM; granular structure; abundant fine and medium roots; abundant fine and medium pores.
			Bt1	4-17	Red (2.5YR 4/6) CLAY; medium subangular blocky; olive yellow (2.5Y 6/6) weathered greenstone gravels; loose consistency: 10-20% weathered gravel content; friable; common fine and medium roots; common fine-med pores; micaceous; abrupt wavy boundary.
			2Bt	17-32	Red (2.5YR 4/8) CLAY; medium subangular blocky; slightly loose; fine and medium roots common above 42"; fine-medium pores present; micaceous; clay films.
			3Bt	32-42	Red (2.5YR 4/8) CLAY; weak medium subangular blocky structure; slightly hard; friable; no roots present; micaceous.
B	**SPD 7**	13-Oct-23	Ap	0-5	Reddish brown (5YR 4/4) LOAM; trace coarse quartz sands and small gravels present; fine subangular blocky- to granular structure; abundant fine roots; abundant fine and medium pores; abrupt smooth boundary.
			Bt1	5-22	Yellowish red (5YR 5/8) CLAY LOAM; medium subangular blocky; trace olive yellow (2.5Y 6/6) weathered greenstone gravels up to 2" diameter present; friable; common fine roots; abundant fine-med pores; abrupt smooth boundary.
			2Bt2	22-32	Red (10YR 5/8) SANDY CLAY LOAM; medium subangular blocky; friable; fine roots present; fine-med pores common; 20% grey weathered gravels with few cobbles; abrupt smooth boundary.
			2Bt3	32-64	Red (10YR 5/8) SANDY LOAM; weak medium subangular blocky; very loose; friable; fine-med pores common; 20-30% grey weathered gravels with few
B	**SPD 8**	06-Feb-24	Ap	0-4	Reddish brown (2.5YR 4/6) CLAY; coarse quartz sands; granular structure; friable; abundant fine and medium roots; abundant fine and medium pores; trace mica; smooth boundary.
			Bt1	4-17	Reddish brown (2.5YR 4/6) CLAY; coarse quartz sands; strong medium subangular blocky; loose; common fine to medium roots; common fine-medium pores; smooth boundary.
			Bt2	17-38	Red (2.5YR 4/6) CLAY; medium subangular blocky; slightly hard; medium roots common; fine-medium pores common between peds; trace mica; no redox; clay films; abrupt wavy boundary.
			2BC	32-44	Dark red (2.5YR 3/6) CLAY LOAM; weak medium subangular blocky; slightly hard; friable; trace roots; few pores; no redox.
B	**SPD 9**	15-Mar-22	Ap	0-4"	Reddish brown (5YR/4/4) SILTY CLAY LOAM; Granular structure; Abundant roots
			Bt1	4-28"	Dark red brown (5YR/3/4) CLAY LOAM; Friable; Medium subangular blocky structure; Abundant fine to medium roots
			Bt2	28-44"	Yellowish red (5YR/4/6) CLAY LOAM; Trace subrounded gravels; Medium subangular blocky structure; Fine roots common
			2BC	44-62"	Mottled CLAY LOAM; 5-10% subrounded gravels; 15% red (2.5YR/4/6) iron accumulations; Reddish brown (5YR/5/4) iron depletions; Dark reddish brown (5YR/3/3) oxide staining; Restrictive layer

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfield Cell B -continued					
B	**SPD 10**	13-Oct-23	Ap	0-6	Strong brown (7.5YR 4/6) LOAM; friable; granular structure; abundant fine roots; abundant fine and medium pore spaces; micaceous; abrupt smooth boundary.
			1Bt	6-30	Yellowish red (5YR 4/6) CLAY LOAM; medium subangular blocky; slightly loose; friable; abundant fine-med roots; abundant fine-med pores; micaceous; abrupt smooth boundary.
			2BC1	30-48	Yellowish red (5YR 4/6) CLAY LOAM; weak medium subangular blocky; friable and slightly hard; grey and dark red saprolitic gravels present; common fine-med roots; abundant pores; abrupt smooth boundary.
			2BC2	48-72	Yellowish red (5YR 4/6) CLAY LOAM; fine- to medium subangular blocky; friable and slightly hard; reddish brown (5YR 4/3) lithochromic masses (highly saprolitic subangular gravels) present; fine-med pores present; trace fine roots; micaceous.
B	**SPD 12**	13-Oct-23	Ap	0-6	Reddish brown (5YR 4/3) fine SANDY LOAM; friable; fine- to med subangular blocky; abundant fine roots; fine and medium pore spaces common; trace quartz gravels; abrupt smooth boundary.
			1Bt	6-36	Dark brown (7.5YR 3/4) LOAM; medium subangular blocky structure; loose; friable; trace olive yellow weathered greenstone gravels; common fine-med roots; common fine-med and large pores; abrupt smooth boundary.
			2B	36-64	Yellowish red (5YR 5/8) SANDY LOAM; medium subangular blocky structure; friable; loose; red clay films; abundant fine roots; abundant fine-med pores; 20-30% weathered gravels.
B	SB 12-boring	2/10/2022	Ap	0-7	Reddish brown (2.5YR 5/4) SILT LOAM
			Bt1	7-34	Red (2.5YR 4/6) SILTY CLAY LOAM
			Bt2	34-46	Yellowish red (5YR 5/8) SILTY CLAY LOAM; faint redox

Sat. Hydraulic Test	Depth, in.	Rate, cm/d		
Ksat 5	32	120		
Ksat 7	24	60.0		
Ksat 12	30	5.0		
Ksat 19	24	11.2		
Ksat 20	30	21.1		
	Geometric Mean	**24.3**	***6.1***	*= Mean divided by 4*
	Median	**21.1**	***5.3***	*= Median divided by 4*
Ksat 10	45	10.0		

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfield (Cell) C - South Section of Lower Area					
C	**SPD 11**	15-Mar-22	Ap	0-4”	Reddish brown (5YR/4/4) CLAY LOAM; Granular to medium subangular blocky structure; Abundant fine roots
			Bt1	4-22”	Yellowish red (5YR/4/6) CLAY LOAM; Medium subangular blocky structure; Abundant roots
			Bt2	22-62”	Red (2.5Y/4/6) CLAY LOAM; micaceous; Few subangular greenstone and quartz gravels; Medium subangular blocky structure; Abundant subangular coarse sands; Clay films present on faces of soil pedons; Fine and medium roots commmon
			2BC	62-80”	Mottled SANDY CLAY LOAM to SANDY CLAY; Weathered gravels present; Fine subangular blocky structure
C	**SPD 12**	13-Oct-23	Ap	0-6	Reddish brown (5YR 4/3) fine SANDY LOAM; friable; fine- to med subangular blocky; abundant fine roots; fine and medium pore spaces common; trace quartz gravels; abrupt smooth boundary.
			1Bt	6-36	Dark brown (7.5YR 3/4) LOAM; medium subangular blocky structure; loose; friable; trace olive yellow weathered greenstone gravels; common fine-med roots; common fine-med and large pores; abrupt smooth boundary.
			2B	36-64	Yellowish red (5YR 5/8) SANDY LOAM; medium subangular blocky structure; friable; loose; red clay films; abundant fine roots; abundant fine-med pores; 20-30% weathered gravels.
C	**SPD 13**	06-Feb-24	Ap	0-4	Brown (7.5YR 4/4) LOAM; granular structure; Soft consistency; abundant fine and medium roots; abundant fine and medium pore spaces; abrupt smooth boundary.
			Bt1	4-19	Yellowish red (5YR 4/6) LOAM; few subangular weathered gravels; strong medium subangular blocky structure; common fine to medium roots; fine to medium pores present; abrupt wavy boundary.
			2Bt2	19-48	Yellowish red (5YR 4/6) CLAY; few olive yellow lithochromic masses; friable and slightly loose; medium subangular blocky; fine to medium roots common; abundant fine to medium pores; trace mica; clay films present.
C	**SPD 14**	06-Feb-24	Ap	0-4	Dark brown (7.5YR 3/3) CLAY LOAM; granular structure; abundant fine and medium roots; abundant fine and medium pores; abrupt wavy boundary.
			Bt1	4-20	Brown (7.5YR 4/4) CLAY LOAM; coarse quartz sands present; strong medium subangular blocky; loose consistency; friable; abundant fine and medium roots; common fine-med pores; diffuse smooth boundary.
			Bt2	20-35	Reddish brown (5YR 4/4) CLAY; coarse quartz sands present; strong medium subangular blocky; fine and medium roots common; clay films.
			Bt3	35-48	Reddish brown (2.5YR 4/4) CLAY; (7.5YR 5/4) depletions; (2.5YR 4/6) trace halos; fine-medium pores common; fine to medium roots common; no depletions along root traces.

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfield Cell C -continued					
C	**SPD 15**	13-Oct-23	Ap	0-5	Reddish brown (5YR 4/3) fine SANDY LOAM; friable; fine- to med subangular blocky; abundant fine roots; fine and medium pore spaces common; trace quartz gravels; abrupt smooth boundary.
			Bt1	5-50	Dark brown (7.5YR 3/4) LOAM; medium subangular blocky structure; loose; friable; trace olive yellow weathered greenstone gravels; common fine-med roots; common fine-med and large pores; abrupt smooth boundary.
			2Bt2	50-66	Strong brown (7.5YR 5/6) CLAY LOAM; weak medium subangular blocky structure; friable; ~20% light brown (7.5YR 6/3) iron depletions and ~10% red (2.5YR 5/8) concentrations; no roots observed; fine-med pores present.
C	**SPD 16**	13-Oct-23	Ap	0-5	Strong brown (7.5YR 4/6) LOAM; friable and loose; granular structure; abundant fine roots; abundant fine and medium pores; micaceous; abrupt smooth boundary.
			Bt1	5-28	Yellowish red (5YR 4/6) CLAY LOAM; reddish brown (5YR 4/3) lithochromic masses; friable and slightly loose; medium subangular blocky structure; common fine roots; abundant fine and medium pore spaces; abrupt smooth boundary.
			Bt2	28-38	Red (2.5YR 4/8) CLAY LOAM; friable (dry); slightly sticky when wetted; medium subangular blocky structure; common fine roots; common fine and medium pore spaces; coarse subrounded quartz sands observed; micaceous; abrupt smooth boundary.
			2C	38-66	Yellowish red (5YR 5/8) soft gneissic saprolite; crushes to SANDY LOAM; friable and slightly loose; weak medium subangular blocky structure; olive yellow and grey lithochroimic features observed; red clay films; fine roots present; fine-med pores present; micaceous.

C	**Sat. Hydraulic Conductivity (b)**				
	Test	Depth, in.	Rate, cm/d		
	Ksat 8	30	42		
	Ksat 13	32	40		
	Ksat 17	28	32.9		
	Ksat 18	30	38.10	DESIGN Value	
		Geometric Mean	**38.1**	***9.5***	*= Geometric Mean divided by 4*
		Median	**39.1**	***9.8***	*= Median divided by 4*
	Ksat 3	58	2.5		

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfied (Cell) D - Area Uphill of Well and Cell A					
D	**SPD 21**	13-Mar-24	Ap	0-2	Red (2.5YR 3/4) CLAY LOAM; granular structure; loose; abundant fine and medium roots; abundant fine and medium pore spaces; clear smooth boundary.
			Bt1	2-12	Reddish brown (2.5YR 4/4) CLAY LOAM; few grey subrounded gravels present; strong medium subangular blocky structure; loose and friable consistency; roots and pores common; clear smooth boundary.
			2Bt2	12-37	Yellowish red (5YR 4/6) CLAY; trace black oxide staining; medium subangular blocky structure; slightly loose; roots and pores common; mica present; clay films present.
			3Bt3	37-72	Yellowish red (5YR 4/6) CLAY; common coarse sands; platy structure; hard; no roots present; trace pores; clay films present.
D	**SPD 22**	13-Mar-24	Ap	0-5	Reddish brown (5YR 4/4) LOAM; granular structure; loose consistency; roots and pores present; clear smooth boundary.
			Bt1	5-20	Reddish brown (5YR 4/4) CLAY LOAM; coarse sands present; trace black biochar; medium subangular blocky structure; loose and friable; roots and pores common; very good structure; diffuse smooth boundary.
			2Bt2	20-32	Red (2.5YR 4/6) CLAY; coarse quartz sands present; medium subangular blocky structure; slightly loose and friable; common roots; abundant pores; micaceous; diffuse smooth boundary.
			2Bt3	32-54	Red (2.5YR 4/6) CLAY; coarse quartz sands present; weak medium subangular blocky structure; slightly hard; roots and pores present; micaceous; clay films present; diffuse smooth boundary.
			Bt4	54-72	Red (2.5YR 4/6) CLAY; platy structure; hard; no roots present; few pores present; micaceous; clay films present.
D	**SPD 23**	13-Mar-24	Ap	0-4	Dark reddish brown (2.5YR 3/4) LOAM; granular structure; abundant roots.
			Bt1	4-32	Yellowish red (5YR 4/6) CLAY LOAM; grey coarse quartz sands present; medium subangular blocky structure; loose, slightly sticky; roots common; fine, medium, and large pores common; trace percentage of rock content; trace amounts of mica; diffuse wavy boundary.
			Bt2	32-50	Red (2.5YR 4/6) CLAY; approximately 5% is mixed subrounded gravels; medium subangular blocky structure; loose, slightly sticky; roots and pores common; trace amounts of mica; diffuse wavy boundary.
			2Bt3	50-72	Red (2.5YR 4/6) CLAY; white micas common; mixed subrounded gravels present; platy structure; hard, sticky; pores present; approximately 10% gravel composition; common mica flakes.
D	**SPD 24**	13-Mar-24	Ap	0-2	Reddish brown (5YR 4/4) LOAM; granular structure; loose; roots and pores present; clear smooth boundary.
			Bt1	2-10	Yellowish red (5YR 4/6) CLAY LOAM; medium subangular blocky structure; loose, friable; roots and pores abundant; trace rock percentage; diffuse smooth boundary.
			Bt2	10-50	Yellowish red (5YR 4/6) CLAY; subangular coarse sands present; medium subangular blocky structure; loose; roots and pores common; trace rock percentage; trace mica grains; moist; clear smooth boundary.
			2Bt3	50-72	Red (2.5YR 4/6) CLAY; platy structure; hard, friable; trace pores; trace mica grains.

Table E-1. Drainfield Soil Evaluation Summary

	Test No. (a)	Date	Horizon	Depth, in.	Description
Drainfied Cell D - continued					
D	**SPD 25**	13-Mar-24	Ap	0-4	Reddish brown (5YR 4/4) LOAM; granular structure; loose; roots and pores present; clear smooth boundary.
			Bt1	4-22	Yellowish red (5YR 4/6) CLAY; medium subangular blocky structure; loose; roots and pores present; trace rock percentage; trace mica grains; clear smooth boundary.
			Bt2	22-60	Yellowish red (5YR 4/6) CLAY; red clay films present; medium subangular blocky structure; very loose; roots and pores present; trace rock percentage; moist.
D	**SPD 26**	13-Mar-24	Ap	0-3	Reddish brown (5YR 4/4) LOAM; granular structure; loose; roots and pores present; clear smooth boundary.
			1Bt1	3-17	Yellowish red (5YR 4/6) CLAY; Medium subangular blocky structure; loose, friable; abundant roots; pores present; trace rock percentage; clear smooth boundary.
			2Bt2	17-58	Yellowish red (5YR 4/6) CLAY; few olive yellow lithochromic masses; medium subangular blocky structure; loose, friable; abundant roots; pores common; trace rock percentage; clay films present; moist; clear smooth boundary.
			3Bt3	58-68	Yellowish red (5YR 4/6) CLAY; micaceous; weak medium subangular blocky structure; slightly hard; no roots present.
D	**Sat. Hydraulic Conductivity (b)**				
	Test	Depth, in.	Rate, cm/d		
	Ksat 22	30	114.8		
	Ksat 23	30	27.20		
		Geometric Mean	**55.9**	***14.0***	*= Geometric mean divided by 4*
		Median	**71.0**	***17.8***	*= Median divided by 10*
	Ksat 11	44	76.0		

(a) Test Pit (pit), soil boring (SB) or Saturated Hydaulic Contductivity Test (Ksat)
(b) Saturated hydaulic contductivity test stabilized rate. Full test data is presented in Appendix E.

APPENDIX E

Constant-Head Borehole Permeameter Test		Analytical Method: Glover Solution		File Name.....: GloverRE_Template
Project Name......:	Innisfree Village	**Boring No...........:**	Ksat 1	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:	23-818	**Investigators......:**	AS, EB	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 20
Project Location..:	Crozet, VA	**Date..................:**	10/13/2023	Q: Rate of flow of water from the borehole
Boring Depth......:	45.72 **(m, cm, ft, in)**	**WCU Base Ht. h:**	10.0 **cm**	H: Constant height of water in the borehole
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	11.0 **cm**	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	21.0 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	20 **°C**	**H/r** ** **.................:**	5.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001003 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.001003 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		13:42:00								
3200	0	13:58:00	0:16:00	16.00	0.00	0.0	0.00E+00	0.0	0.00	0.00
2740	460	13:58:30	0:00:30	0.50	920.00	83.4	8.34E-03	720.5	11.82	23.64
2310	430	13:59:00	0:00:30	0.50	860.00	78.0	7.80E-03	673.5	11.05	22.10
1900	410	13:59:30	0:00:30	0.50	820.00	74.3	7.43E-03	642.2	10.53	21.07
1550	350	14:00:00	0:00:30	0.50	700.00	63.4	6.34E-03	548.2	8.99	17.99
1200	350	14:00:30	0:00:30	0.50	700.00	63.4	6.34E-03	548.2	8.99	17.99
900	300	14:01:00	0:00:30	0.50	600.00	54.4	5.44E-03	469.9	7.71	15.42
600	300	14:01:30	0:00:30	0.50	600.00	54.4	5.44E-03	469.9	7.71	15.42
350	250	14:02:00	0:00:30	0.50	500.00	45.3	4.53E-03	391.6	6.42	12.85
130	220	14:02:30	0:00:30	0.50	440.00	39.9	3.99E-03	344.6	5.65	11.31
3,200		14:04:00								
2,800	400	14:04:30	0:00:30	0.50	800.00	72.5	7.25E-03	626.5	10.28	20.55
2,420	380	14:05:00	0:00:30	0.50	760.00	68.9	6.89E-03	595.2	9.76	19.53
2,180	240	14:05:30	0:00:30	0.50	480.00	43.5	4.35E-03	375.9	6.17	12.33
1,760	420	14:06:00	0:00:30	0.50	840.00	76.1	7.61E-03	657.8	10.79	21.58
1,460	300	14:06:30	0:00:30	0.50	600.00	54.4	5.44E-03	469.9	7.71	15.42
1,200	260	14:07:00	0:00:30	0.50	520.00	47.1	4.71E-03	407.2	6.68	13.36
960	240	14:07:30	0:00:30	0.50	480.00	43.5	4.35E-03	375.9	6.17	12.33
760	200	14:08:00	0:00:30	0.50	400.00	36.3	3.63E-03	313.3	5.14	10.28
360	400	14:08	0:00:30	0.50	800.00	72.5	7.25E-03	626.5	10.28	20.55

Natural Moisture......:		**Consistency...............:**	**Enter Ksat Value:**	**250.6**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph
Struct./% Pass. #200.:		**Init. Saturation Time.:**		

Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test				Analytical Method: Glover Solution		File Name.....: GloverRE_Template
Project Name......:	Innisfree Villiage	Boring No...........:	Ksat 2	Terminology and Solution (R. E. Glover Solution)*		
Project No...........:	23-818	Investigators......:	AS, EB	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C)		20
Project Location..:	Crozet, VA	Date...................:	10/13/2023	Q: Rate of flow of water from the borehole		
Boring Depth......:	134.62 (m, cm, ft, in)	WCU Base Ht. h:	10.0 cm	H: Constant height of water in the borehole		
Boring Diameter..:	8.3 cm	WCU Susp. Ht. S:	11.0 cm	r: Radius of the cylindrical borehole		
Boring Radius r...:	4.13 cm	Const. Wtr. Ht. H:	21.0 cm	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B		
Soil/Water Tmp. T:	20 °C	H/r**.................:	5.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]		
Dyn. Visc. @ T.....:	0.001003 kg/m·s	Dyn. Visc. @ T_B.:	0.001003 kg/m·s	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]		

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
4400		14:10:00								
3250	1,150	14:31:00	0:21:00	21.00	54.76	5.0	4.96E-04	42.9	0.70	1.41
3020	230	14:36:00	0:05:00	5.00	46.00	4.2	4.17E-04	36.0	0.59	1.18
2760	260	14:41:00	0:05:00	5.00	52.00	4.7	4.71E-04	40.7	0.67	1.34
2500	260	14:46:00	0:05:00	5.00	52.00	4.7	4.71E-04	40.7	0.67	1.34
2260	240	14:51:00	0:05:00	5.00	48.00	4.4	4.35E-04	37.6	0.62	1.23
1990	270	14:56:00	0:05:00	5.00	54.00	4.9	4.89E-04	42.3	0.69	1.39
1730	260	15:01:00	0:05:00	5.00	52.00	4.7	4.71E-04	40.7	0.67	1.34
1450	280	15:06:00	0:05:00	5.00	56.00	5.1	5.08E-04	43.9	0.72	1.44
1170	280	15:11:00	0:05:00	5.00	56.00	5.1	5.08E-04	43.9	0.72	1.44
910	260	15:16:00	0:05:00	5.00	52.00	4.7	4.71E-04	40.7	0.67	1.34
620	290	15:21:00	0:05:00	5.00	58.00	5.3	5.26E-04	45.4	0.75	1.49
360	260	15:26:00	0:05:00	5.00	52.00	4.7	4.71E-04	40.7	0.67	1.34
3,250		15:29:00								
3,150	100	15:31:00	0:02:00	2.00	50.00	4.5	4.53E-04	39.2	0.64	1.28
3,050	100	15:33:00	0:02:00	2.00	50.00	4.5	4.53E-04	39.2	0.64	1.28
2,950	100	15:35:00	0:02:00	2.00	50.00	4.5	4.53E-04	39.2	0.64	1.28
2,850	100	15:37:00	0:02:00	2.00	50.00	4.5	4.53E-04	39.2	0.64	1.28

Natural Moisture......:		Consistency...............:		Enter Ksat Value:			36.0	0.668
USDA Txt./USCS Class:		Water Table Depth...:		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.				
Struct./% Pass. #200.:		Init. Saturation Time.:						

Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Constant-Head Borehole Permeameter Test		Analytical Method: Glover Solution		File Name.....: GloverRE_Template
Project Name......:	Innisfree	**Boring No...........:**	Ksat 5	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:		**Investigators......:**	ECP	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	**Date...................:**	2-22-2024	Q: Rate of flow of water from the borehole
Boring Depth......:	81.3 (m, cm, ft, in)	**WCU Base Ht. h:**	15.0 cm	H: Constant height of water in the borehole
Boring Diameter..:	8.3 cm	**WCU Susp. Ht. S:**	10.2 cm	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 cm	**Const. Wtr. Ht. H:**	25.2 cm	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	8 °C	**H/r** **.................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001386 kg/m·s	**Dyn. Visc. @ T_B.:**	0.000955 kg/m·s	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		13:40:00								
1160	2,040	13:50:00	0:10:00	10.00	204.00	20.6	2.06E-03	177.7	2.92	5.83
800	360	13:52	0:02:00	2.00	180.00	18.2	1.82E-03	156.8	2.57	5.14
440	360	13:56:00	0:04:00	4.00	90.00	9.1	9.08E-04	78.4	1.29	2.57
80	360	13:58:00	0:02:00	2.00	180.00	18.2	1.82E-03	156.8	2.57	5.14
2820		13:58:00								
2450	370	14:00:00	0:02:00	2.00	185.00	18.7	1.87E-03	161.2	2.64	5.29
2110	340	14:02:00	0:02:00	2.00	170.00	17.1	1.71E-03	148.1	2.43	4.86
1770	340	14:04:00	0:02:00	2.00	170.00	17.1	1.71E-03	148.1	2.43	4.86
1,430	340	14:06:00	0:02:00	2.00	170.00	17.1	1.71E-03	148.1	2.43	4.86
1,100	330	14:08:00	0:02:00	2.00	165.00	16.6	1.66E-03	143.8	2.36	4.72
800	300	14:10:00	0:02:00	2.00	150.00	15.1	1.51E-03	130.7	2.14	4.29
440	360	14:12:00	0:02:00	2.00	180.00	18.2	1.82E-03	156.8	2.57	5.14
80	360	14:14:00	0:02:00	2.00	180.00	18.2	1.82E-03	156.8	2.57	5.14
3,010		14:32:00								
2,680	330	14:34:00	0:02:00	2.00	165.00	16.6	1.66E-03	143.8	2.36	4.72
2,380	300	14:36:00	0:02:00	2.00	150.00	15.1	1.51E-03	130.7	2.14	4.29
2,060	320	14:38:00	0:02:00	2.00	160.00	16.1	1.61E-03	139.4	2.29	4.57
1,720	340	14:40:00	0:02:00	2.00	170.00	17.1	1.71E-03	148.1	2.43	4.86
1,030	690	14:45:00	0:05:00	5.00	138.00	13.9	1.39E-03	120.2	1.97	3.94
300	730	14:50:00	0:05:00	5.00	146.00	14.7	1.47E-03	127.2	2.09	4.17

Natural Moisture......:	**Consistency...............:**	**Enter Ksat Value:**	**120 cm/day**
USDA Txt./USCS Class:	**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph
Struct./% Pass. #200.:	**Init. Saturation Time.:**		

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

APPENDIX E

Constant-Head Borehole Permeameter Test	Analytical Method: Glover Solution	File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 6	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:		**Investigators......:**	APS	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	**Date..................:**	3-13-2024	Q: Rate of flow of water from the borehole
Boring Depth......:	81.3 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	17 **°C**	**H/r** **................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001081 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	(min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3000		9:55:00								
1730	1,270	10:05:00	0:10:00	10.00	127.00	10.0	9.99E-04	86.3	1.42	2.83
1090	640	10:10	0:05:00	5.00	128.00	10.1	1.01E-03	87.0	1.43	2.85
430	660	10:15:00	0:05:00	5.00	132.00	10.4	1.04E-03	89.7	1.47	2.94
3200		10:16:00								
2580	620	10:21:00	0:05:00	5.00	124.00	9.8	9.75E-04	84.3	1.38	2.76
1410	1,170	10:26:00	0:05:00	5.00	234.00	18.4	1.84E-03	159.0	2.61	5.22
1000	410	10:31:00	0:05:00	5.00	82.00	6.4	6.45E-04	55.7	0.91	1.83
20	980	10:36:00	0:05:00	5.00	196.00	15.4	1.54E-03	133.2	2.18	4.37
3,200		10:48:00								
2,700	500	10:50:00	0:02:00	2.00	250.00	19.7	1.97E-03	169.9	2.79	5.57
2,140	560	10:52:00	0:02:00	2.00	280.00	22.0	2.20E-03	190.3	3.12	6.24
1,580	560	10:54:00	0:02:00	2.00	280.00	22.0	2.20E-03	190.3	3.12	6.24
1,000	580	10:56:00	0:02:00	2.00	290.00	22.8	2.28E-03	197.1	3.23	6.47
420	580	10:58:00	0:02:00	2.00	290.00	22.8	2.28E-03	197.1	3.23	6.47
3,200		11:00:00								
2,620	580	11:02:00	0:02:00	2.00	290.00	22.8	2.28E-03	197.1	3.23	6.47
2,040	580	11:04:00	0:02:00	2.00	290.00	22.8	2.28E-03	197.1	3.23	6.47

Natural Moisture......:		**Consistency...............:**		**Enter Ksat Value:**	84 cm/day
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.	
Struct./% Pass. #200.:		**Init. Saturation Time.:**			

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Constant-Head Borehole Permeameter Test	Analytical Method: Glover Solution	File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 7	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:		**Investigators......:**	APS	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	**Date...................:**	3-13-2024	Q: Rate of flow of water from the borehole
Boring Depth......:	61 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	17 **°C**	**H/r** ** **.................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001081 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		12:53:00								
2050	1,150	13:03:00	0:10:00	10.00	115.00	9.0	9.04E-04	78.1	1.28	2.56
980	1,070	13:13	0:10:00	10.00	107.00	8.4	8.42E-04	72.7	1.19	2.39
3280		13:14:00								
2570	710	13:19:00	0:05:00	5.00	142.00	11.2	1.12E-03	96.5	1.58	3.17
2140	430	13:24:00	0:05:00	5.00	86.00	6.8	6.76E-04	58.4	0.96	1.92
1620	520	13:29:00	0:05:00	5.00	104.00	8.2	8.18E-04	70.7	1.16	2.32
1120	500	13:34:00	0:05:00	5.00	100.00	7.9	7.86E-04	67.9	1.11	2.23
620	500	13:39:00	0:05:00	5.00	100.00	7.9	7.86E-04	67.9	1.11	2.23
120	500	13:44:00	0:05:00	5.00	100.00	7.9	7.86E-04	67.9	1.11	2.23
3,200		13:45:00								
2,690	510	13:50:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
2,180	510	13:55:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
1,670	510	14:00:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
1,160	510	14:05:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
650	510	14:10:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
140	510	14:15:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
3,200		14:16:00								
2,690	510	14:21:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
2,180	510	14:26:00	0:05:00	5.00	102.00	8.0	8.02E-04	69.3	1.14	2.27

Natural Moisture......:	**Consistency...............:**	**Enter Ksat Value:**	**60 cm/day**
USDA Txt./USCS Class:	**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.
Struct./% Pass. #200.:	**Init. Saturation Time.:**		

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test

Analytical Method: Glover Solution

File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 8
Project No...........:		**Investigators......:**	APS
Project Location..:	Crozet, VA	**Date...................:**	3-13-2024
Boring Depth......:	76.2 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**
Soil/Water Tmp. T:	17 **°C**	**H/r**.................:**	6.1
Dyn. Visc. @ T.....:	0.001081 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**

Terminology and Solution (R. E. Glover Solution)*

- $Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
- Q: Rate of flow of water from the borehole
- H: Constant height of water in the borehole
- r: Radius of the cylindrical borehole
- V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
- $Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
- $Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
2970		14:32:00								
2630	340	14:37:00	0:05:00	5.00	68.00	5.3	5.35E-04	46.2	0.76	1.52
2310	320	14:42	0:05:00	5.00	64.00	5.0	5.03E-04	43.5	0.71	1.43
1980	330	14:47:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
1650	330	14:52:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
1330	320	14:57:00	0:05:00	5.00	64.00	5.0	5.03E-04	43.5	0.71	1.43
1000	330	15:02:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
690	310	15:07:00	0:05:00	5.00	62.00	4.9	4.88E-04	42.1	0.69	1.38
360	330	15:12:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
3,200		15:18:00								
2,840	360	15:23:00	0:05:00	5.00	72.00	5.7	5.66E-04	48.9	0.80	1.61
2,500	340	15:28:00	0:05:00	5.00	68.00	5.3	5.35E-04	46.2	0.76	1.52
2,170	330	15:33:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
1,840	330	15:38:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
1,510	330	15:43:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
1,180	330	15:48:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
850	330	15:53:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47
520	330	15:58:00	0:05:00	5.00	66.00	5.2	5.19E-04	44.8	0.74	1.47

Natural Moisture......:		**Consistency...............:**	
USDA Txt./USCS Class:		**Water Table Depth...:**	
Struct./% Pass. #200.:		**Init. Saturation Time.:**	

Enter Ksat Value: **42 cm/day**

Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test				Analytical Method: Glover Solution		File Name.....:	GloverRE_Template
Project Name......:	Innisfree	**Boring No...........:**	Ksat 9	**Terminology and Solution (R. E. Glover Solution)***			
Project No...........:		**Investigators......:**	APS	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C)			22
Project Location..:	Crozet, VA	**Date...................:**	3-13-2024	Q: Rate of flow of water from the borehole			
Boring Depth......:	81.3 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole			
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole			
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B			
Soil/Water Tmp. T:	17 **°C**	**H/r**** **.................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]			
Dyn. Visc. @ T.....:	0.001081 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]			

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	(min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3250		10:24:00								
3050	200	10:29:00	0:05:00	5.00	40.00	3.1	3.15E-04	27.2	0.45	0.89
1450	1,600	11:04	0:35:00	35.00	45.71	3.6	3.60E-04	31.1	0.51	1.02
1230	220	11:14:00	0:10:00	10.00	22.00	1.7	1.73E-04	14.9	0.25	0.49
1010	220	11:19:00	0:05:00	5.00	44.00	3.5	3.46E-04	29.9	0.49	0.98
780	230	11:24:00	0:05:00	5.00	46.00	3.6	3.62E-04	31.3	0.51	1.03
550	230	11:29:00	0:05:00	5.00	46.00	3.6	3.62E-04	31.3	0.51	1.03
320	230	11:34:00	0:05:00	5.00	46.00	3.6	3.62E-04	31.3	0.51	1.03
90	230	11:39:00	0:05:00	5.00	46.00	3.6	3.62E-04	31.3	0.51	1.03
3,200		11:34:00								
2,930	270	11:44:00	0:10:00	10.00	27.00	2.1	2.12E-04	18.3	0.30	0.60
2,680	250	11:49:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
2,430	250	11:54:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
2,180	250	11:59:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
1,930	250	12:04:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
1,680	250	12:09:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
1,430	250	12:14:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
1,180	250	12:19:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
930	250	12:24:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
680	250	12:29:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
430	250	12:34:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11
180	250	12:39:00	0:05:00	5.00	50.00	3.9	3.93E-04	34.0	0.56	1.11

Natural Moisture......:		**Consistency...............:**		**Enter Ksat Value:**	**34 cm/day**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.	
Struct./% Pass. #200.:		**Init. Saturation Time.:**			

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test				Analytical Method: Glover Solution		File Name.....: GloverRE_Template	
Project Name......:	Innisfree	**Boring No...........:**	Ksat 10	**Terminology and Solution (R. E. Glover Solution)***			
Project No...........:		**Investigators......:**	APS	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C)			22
Project Location..:	Crozet, VA	**Date...................:**	3-13-2024	Q: Rate of flow of water from the borehole			
Boring Depth......:	114.3 (m, cm, ft, in)	**WCU Base Ht. h:**	15.0 cm	H: Constant height of water in the borehole			
Boring Diameter..:	8.3 cm	**WCU Susp. Ht. S:**	10.2 cm	r: Radius of the cylindrical borehole			
Boring Radius r...:	4.13 cm	**Const. Wtr. Ht. H:**	25.2 cm	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B			
Soil/Water Tmp. T:	17 °C	**H/r ** ....:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]			
Dyn. Visc. @ T.....:	0.001081 kg/m·s	**Dyn. Visc. @ T_B.:**	0.000955 kg/m·s	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]			

VOLUME	Volume Out	TIME	Interval Elapsed Time		Flow Rate Q	$Ksat_B$ Equivalent Values				
(ml)	(ml)	(h:mm:ss A/P)	(hr:min:sec)	(min)	(ml/min)	(µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3100		11:37:00								
2970	130	11:47:00	0:10:00	10.00	13.00	1.0	1.02E-04	8.8	0.14	0.29
2780	190	11:57	0:10:00	10.00	19.00	1.5	1.49E-04	12.9	0.21	0.42
2630	150	12:07:00	0:10:00	10.00	15.00	1.2	1.18E-04	10.2	0.17	0.33
2450	180	12:17:00	0:10:00	10.00	18.00	1.4	1.42E-04	12.2	0.20	0.40
2300	150	12:27:00	0:10:00	10.00	15.00	1.2	1.18E-04	10.2	0.17	0.33
2160	140	12:37:00	0:10:00	10.00	14.00	1.1	1.10E-04	9.5	0.16	0.31
2000	160	12:47:00	0:10:00	10.00	16.00	1.3	1.26E-04	10.9	0.18	0.36
1840	160	12:57:00	0:10:00	10.00	16.00	1.3	1.26E-04	10.9	0.18	0.36
1680	160	13:07:00	0:10:00	10.00	16.00	1.3	1.26E-04	10.9	0.18	0.36
1,520	160	13:17:00	0:10:00	10.00	16.00	1.3	1.26E-04	10.9	0.18	0.36
1,360	160	13:27:00	0:10:00	10.00	16.00	1.3	1.26E-04	10.9	0.18	0.36
1,200	160	13:37:00	0:10:00	10.00	16.00	1.3	1.26E-04	10.9	0.18	0.36
1,040	160	13:47:00	0:10:00	10.00	16.00	1.3	1.26E-04	10.9	0.18	0.36

Natural Moisture......:		**Consistency...............:**	**Enter Ksat Value:** 10 cm/day
USDA Txt./USCS Class:		**Water Table Depth...:**	Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.
Struct./% Pass. #200.:		**Init. Saturation Time.:**	

Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test | Analytical Method: Glover Solution

File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 11	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:		**Investigators......:**	APS	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	**Date..................:**	3-13-2024	Q: Rate of flow of water from the borehole
Boring Depth......:	111.6 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	17 **°C**	**H/r**** **.................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001081 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	(min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		15:04:00								
2180	1,020	15:14:00	0:10:00	10.00	102.00	8.0	8.02E-04	69.3	1.14	2.27
1100	1,080	15:24	0:10:00	10.00	108.00	8.5	8.49E-04	73.4	1.20	2.41
3200		15:25:00								
2630	570	15:30:00	0:05:00	5.00	114.00	9.0	8.97E-04	77.5	1.27	2.54
2050	580	15:35:00	0:05:00	5.00	116.00	9.1	9.12E-04	78.8	1.29	2.59
1470	580	15:40:00	0:05:00	5.00	116.00	9.1	9.12E-04	78.8	1.29	2.59
910	560	15:45:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
350	560	15:50:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
3,250		15:53:00								
2,680	570	15:58:00	0:05:00	5.00	114.00	9.0	8.97E-04	77.5	1.27	2.54
2,120	560	16:03:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
1,560	560	16:08:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
1,000	560	16:13:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
440	560	16:18:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
2,660		16:25:00								
2,100	560	16:30:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
1,540	560	16:35:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
980	560	16:40:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50
420	560	16:45:00	0:05:00	5.00	112.00	8.8	8.81E-04	76.1	1.25	2.50

Natural Moisture......:		**Consistency...............:**	**Enter Ksat Value:**	**76 cm/day**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph
Struct./% Pass. #200.:		**Init. Saturation Time.:**		

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test				Analytical Method: Glover Solution		File Name.....: GloverRE_Template			
Project Name......:	Innisfree	**Boring No...........:**	Ksat 12	**Terminology and Solution (R. E. Glover Solution)***					
Project No...........:		**Investigators......:**	ECP	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C)				22	
Project Location..:	Crozet, VA	**Date...................:**	2.22.2024	Q: Rate of flow of water from the borehole					
Boring Depth......:	76.2 (m, cm, ft, in)	**WCU Base Ht. h:**	15.0 cm	H: Constant height of water in the borehole					
Boring Diameter..:	8.3 cm	**WCU Susp. Ht. S:**	10.2 cm	r: Radius of the cylindrical borehole					
Boring Radius r...:	4.13 cm	**Const. Wtr. Ht. H:**	25.2 cm	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B					
Soil/Water Tmp. T:	8 °C	**H/r** ** ....:	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]					
Dyn. Visc. @ T.....:	0.001386 kg/m·s	**Dyn. Visc. @ T_B.:**	0.000955 kg/m·s	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]					

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		10:05:00								
3010	190	10:15:00	0:10:00	10.00	19.00	1.9	1.92E-04	16.6	0.27	0.54
2890	120	10:25	0:10:00	10.00	12.00	1.2	1.21E-04	10.5	0.17	0.34
2770	120	10:35:00	0:10:00	10.00	12.00	1.2	1.21E-04	10.5	0.17	0.34
2670	100	10:45:00	0:10:00	10.00	10.00	1.0	1.01E-04	8.7	0.14	0.29
2570	100	10:55:00	0:10:00	10.00	10.00	1.0	1.01E-04	8.7	0.14	0.29
2480	90	11:05:00	0:10:00	10.00	9.00	0.9	9.08E-05	7.8	0.13	0.26
2430	50	11:10:00	0:05:00	5.00	10.00	1.0	1.01E-04	8.7	0.14	0.29
2380	50	11:15:00	0:05:00	5.00	10.00	1.0	1.01E-04	8.7	0.14	0.29
2340	40	11:20:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,300	40	11:25:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,260	40	11:30:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,220	40	11:35:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,180	40	11:40:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,140	40	11:45:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,100	40	11:50:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,060	40	11:55:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
2,020	40	12:00:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23
1,920	100	12:15:00	0:15:00	15.00	6.67	0.7	6.72E-05	5.8	0.10	0.19
1,870	50	12:20:00	0:05:00	5.00	10.00	1.0	1.01E-04	8.7	0.14	0.29
1,840	30	12:25:00	0:05:00	5.00	6.00	0.6	6.05E-05	5.2	0.09	0.17
1,810	30	12:30:00	0:05:00	5.00	6.00	0.6	6.05E-05	5.2	0.09	0.17
1,770	40	12:35:00	0:05:00	5.00	8.00	0.8	8.07E-05	7.0	0.11	0.23

Natural Moisture......:		**Consistency...............:**	**Enter Ksat Value:**	**5 cm/day**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph
Struct./% Pass. #200.:		**Init. Saturation Time.:**		

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10 Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test		Analytical Method: Glover Solution		File Name.....: GloverRE_Template
Project Name......:	Innisfree	Boring No...........:	Ksat 13	Terminology and Solution (R. E. Glover Solution)*
Project No...........:		Investigators......:	ECP	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	Date..................:	2.22.2024	Q: Rate of flow of water from the borehole
Boring Depth......:	81.3 (m, cm, ft, in)	WCU Base Ht. h:	15.0 cm	H: Constant height of water in the borehole
Boring Diameter..:	8.3 cm	WCU Susp. Ht. S:	10.2 cm	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 cm	Const. Wtr. Ht. H:	25.2 cm	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	8 °C	H/r**.................:	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001386 kg/m·s	Dyn. Visc. @ T_B.:	0.000955 kg/m·s	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		10:12:00								
2550	650	10:22:00	0:10:00	10.00	65.00	6.6	6.55E-04	56.6	0.93	1.86
1940	610	10:32	0:10:00	10.00	61.00	6.2	6.15E-04	53.1	0.87	1.74
1400	540	10:42:00	0:10:00	10.00	54.00	5.4	5.45E-04	47.0	0.77	1.54
880	520	10:52:00	0:10:00	10.00	52.00	5.2	5.24E-04	45.3	0.74	1.49
380	500	11:02:00	0:10:00	10.00	50.00	5.0	5.04E-04	43.6	0.71	1.43
2930		11:07:00								
2690	240	11:12:00	0:05:00	5.00	48.00	4.8	4.84E-04	41.8	0.69	1.37
2440	250	11:17:00	0:05:00	5.00	50.00	5.0	5.04E-04	43.6	0.71	1.43
2,190	250	11:22:00	0:05:00	5.00	50.00	5.0	5.04E-04	43.6	0.71	1.43
1,950	240	11:27:00	0:05:00	5.00	48.00	4.8	4.84E-04	41.8	0.69	1.37
1,710	240	11:32:00	0:05:00	5.00	48.00	4.8	4.84E-04	41.8	0.69	1.37
1,470	240	11:37:00	0:05:00	5.00	48.00	4.8	4.84E-04	41.8	0.69	1.37
1,230	240	11:42:00	0:05:00	5.00	48.00	4.8	4.84E-04	41.8	0.69	1.37

Natural Moisture......:		Consistency...............:	Enter Ksat Value: 40 cm/day
USDA Txt./USCS Class:		Water Table Depth...:	Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph
Struct./% Pass. #200.:		Init. Saturation Time.:	

Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

APPENDIX E

Constant-Head Borehole Permeameter Test				Analytical Method: Glover Solution		File Name.....: GloverRE_Template	
Project Name......:	Innisfree	**Boring No...........:**	Ksat 14	**Terminology and Solution (R. E. Glover Solution)***			
Project No...........:		**Investigators......:**	ECP	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C)			22
Project Location..:	Crozet, VA	**Date...................:**	2.22.2024	Q: Rate of flow of water from the borehole			
Boring Depth......:	55.9 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole			
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole			
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B			
Soil/Water Tmp. T:	8 **°C**	**H/r** ** **.................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]			
Dyn. Visc. @ T.....:	0.001386 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]			

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		11:53:00								
3010	190	12:04:00	0:11:00	11.00	17.27	1.7	1.74E-04	15.0	0.25	0.49
2860	150	12:13	0:09:00	9.00	16.67	1.7	1.68E-04	14.5	0.24	0.48
2720	140	12:23:00	0:10:00	10.00	14.00	1.4	1.41E-04	12.2	0.20	0.40
2570	150	12:33:00	0:10:00	10.00	15.00	1.5	1.51E-04	13.1	0.21	0.43
2440	130	12:43:00	0:10:00	10.00	13.00	1.3	1.31E-04	11.3	0.19	0.37
2310	130	12:53:00	0:10:00	10.00	13.00	1.3	1.31E-04	11.3	0.19	0.37
2240	70	12:58:00	0:05:00	5.00	14.00	1.4	1.41E-04	12.2	0.20	0.40
2170	70	13:03:00	0:05:00	5.00	14.00	1.4	1.41E-04	12.2	0.20	0.40
2100	70	13:08:00	0:05:00	5.00	14.00	1.4	1.41E-04	12.2	0.20	0.40
2,030	70	13:13:00	0:05:00	5.00	14.00	1.4	1.41E-04	12.2	0.20	0.40
1,960	70	13:18:00	0:05:00	5.00	14.00	1.4	1.41E-04	12.2	0.20	0.40
1,890	70	13:23:00	0:05:00	5.00	14.00	1.4	1.41E-04	12.2	0.20	0.40

Natural Moisture......:		**Consistency...............:**		**Enter Ksat Value:**	**12 cm/day**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.	
Struct./% Pass. #200.:		**Init. Saturation Time.:**			

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test	Analytical Method: Glover Solution	File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 15	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:		**Investigators......:**	ECP	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	**Date...................:**	2.22.2024	Q: Rate of flow of water from the borehole
Boring Depth......:	81.3 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	8 **°C**	**H/r**..................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001386 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	(min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
2700		14:55:00								
2000	700	15:00:00	0:05:00	5.00	140.00	14.1	1.41E-03	122.0	2.00	4.00
1330	670	15:05	0:05:00	5.00	134.00	13.5	1.35E-03	116.7	1.92	3.83
680	650	15:10:00	0:05:00	5.00	130.00	13.1	1.31E-03	113.3	1.86	3.72
10	670	15:15:00	0:05:00	5.00	134.00	13.5	1.35E-03	116.7	1.92	3.83
2900		15:20:00								
2100	800	15:25:00	0:05:00	5.00	160.00	16.1	1.61E-03	139.4	2.29	4.57
1300	800	15:30:00	0:05:00	5.00	160.00	16.1	1.61E-03	139.4	2.29	4.57
500	800	15:35:00	0:05:00	5.00	160.00	16.1	1.61E-03	139.4	2.29	4.57
2,770		15:40:00								
1,970	800	15:45:00	0:05:00	5.00	160.00	16.1	1.61E-03	139.4	2.29	4.57
1,170	800	15:50:00	0:05:00	5.00	160.00	16.1	1.61E-03	139.4	2.29	4.57
360	810	15:55:00	0:05:00	5.00	162.00	16.3	1.63E-03	141.1	2.32	4.63
3,200		16:00:00								
2,460	740	16:05:00	0:05:00	5.00	148.00	14.9	1.49E-03	128.9	2.12	4.23
1,650	810	16:10:00	0:05:00	5.00	162.00	16.3	1.63E-03	141.1	2.32	4.63
850	800	16:15:00	0:05:00	5.00	160.00	16.1	1.61E-03	139.4	2.29	4.57

Natural Moisture......:		**Consistency...............:**	**Enter Ksat Value:** 110 cm/day
USDA Txt./USCS Class:		**Water Table Depth...:**	Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.
Struct./% Pass. #200.:		**Init. Saturation Time.:**	

* Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

APPENDIX E

Constant-Head Borehole Permeameter Test	Analytical Method: Glover Solution	File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 17	**Terminology and Solution (R. E. Glover Solution)***	
Project No...........:		**Investigators......:**	APS	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C)	22
Project Location..:	Crozet, VA	**Date...................:**	4-18-24	Q: Rate of flow of water from the borehole	
Boring Depth......:	71.12 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole	
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole	
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B	
Soil/Water Tmp. T:	15 **°C**	**H/r** ** **.................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]	
Dyn. Visc. @ T.....:	0.001139 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B= QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]	

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		10:20:00								
3010	190	10:25:00	0:05:00	5.00	38.00	3.1	3.15E-04	27.2	0.45	0.89
2830	180	10:30	0:05:00	5.00	36.00	3.0	2.98E-04	25.8	0.42	0.85
2650	180	10:35:00	0:05:00	5.00	36.00	3.0	2.98E-04	25.8	0.42	0.85
2450	200	10:40:00	0:05:00	5.00	40.00	3.3	3.31E-04	28.6	0.47	0.94
2250	200	10:45:00	0:05:00	5.00	40.00	3.3	3.31E-04	28.6	0.47	0.94
2050	200	10:50:00	0:05:00	5.00	40.00	3.3	3.31E-04	28.6	0.47	0.94
1850	200	10:55:00	0:05:00	5.00	40.00	3.3	3.31E-04	28.6	0.47	0.94
1610	240	11:00:00	0:05:00	5.00	48.00	4.0	3.98E-04	34.4	0.56	1.13
1380	230	11:05:00	0:05:00	5.00	46.00	3.8	3.81E-04	32.9	0.54	1.08
1,150	230	11:10:00	0:05:00	5.00	46.00	3.8	3.81E-04	32.9	0.54	1.08
920	230	11:15:00	0:05:00	5.00	46.00	3.8	3.81E-04	32.9	0.54	1.08
690	230	11:20:00	0:05:00	5.00	46.00	3.8	3.81E-04	32.9	0.54	1.08
460	230	11:25:00	0:05:00	5.00	46.00	3.8	3.81E-04	32.9	0.54	1.08
230	230	11:30:00	0:05:00	5.00	46.00	3.8	3.81E-04	32.9	0.54	1.08

Natural Moisture......:		**Consistency...............:**		**Enter Ksat Value:**	**32.9 cm/day**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph	
Struct./% Pass. #200.:		**Init. Saturation Time.:**			

*Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test	Analytical Method: Glover Solution	File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 18	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:		**Investigators......:**	ECP	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	**Date..................:**	4-18-24	Q: Rate of flow of water from the borehole
Boring Depth......:	76.2 (m, cm, ft, in)	**WCU Base Ht. h:**	15.0 cm	H: Constant height of water in the borehole
Boring Diameter..:	8.3 cm	**WCU Susp. Ht. S:**	10.2 cm	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 cm	**Const. Wtr. Ht. H:**	25.2 cm	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	12 °C	**H/r** ** **................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001236 kg/m·s	**Dyn. Visc. @ T_B.:**	0.000955 kg/m·s	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		10:22:00								
2960	240	10:27:00	0:05:00	5.00	48.00	4.3	4.32E-04	37.3	0.61	1.22
2760	200	10:32	0:05:00	5.00	40.00	3.6	3.60E-04	31.1	0.51	1.02
2560	200	10:37:00	0:05:00	5.00	40.00	3.6	3.60E-04	31.1	0.51	1.02
2320	240	10:42:00	0:05:00	5.00	48.00	4.3	4.32E-04	37.3	0.61	1.22
1860	460	10:52:00	0:10:00	10.00	46.00	4.1	4.14E-04	35.7	0.59	1.17
1370	490	11:02:00	0:10:00	10.00	49.00	4.4	4.41E-04	38.1	0.62	1.25
880	490	11:12:00	0:10:00	10.00	49.00	4.4	4.41E-04	38.1	0.62	1.25
390	490	11:22:00	0:10:00	10.00	49.00	4.4	4.41E-04	38.1	0.62	1.25

Natural Moisture......:		**Consistency...............:**	**Enter Ksat Value:**	**38.1 cm/day**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.
Struct./% Pass. #200.:		**Init. Saturation Time.:**		

Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Constant-Head Borehole Permeameter Test

Analytical Method: Glover Solution

File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 19
Project No...........:		**Investigators......:**	APS
Project Location..:	Crozet, VA	**Date...................:**	4-18-24
Boring Depth......:	60.96 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**
Soil/Water Tmp. T:	16 **°C**	**H/r **.................:**	6.1
Dyn. Visc. @ T.....:	0.001109 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**

Terminology and Solution (R. E. Glover Solution)*

- $Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
- Q: Rate of flow of water from the borehole
- H: Constant height of water in the borehole
- r: Radius of the cylindrical borehole
- V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
- $Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
- $Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3230		12:32:00								
3160	70	12:37:00	0:05:00	5.00	14.00	1.1	1.13E-04	9.8	0.16	0.32
3090	70	12:42	0:05:00	5.00	14.00	1.1	1.13E-04	9.8	0.16	0.32
3030	60	12:47:00	0:05:00	5.00	12.00	1.0	9.68E-05	8.4	0.14	0.27
2960	70	12:52:00	0:05:00	5.00	14.00	1.1	1.13E-04	9.8	0.16	0.32
2880	80	12:57:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37
2800	80	13:02:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37
2720	80	13:07:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37
2640	80	13:12:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37
2560	80	13:17:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37
2,480	80	13:22:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37
2,400	80	13:27:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37
2,320	80	13:32:00	0:05:00	5.00	16.00	1.3	1.29E-04	11.2	0.18	0.37

Natural Moisture......:		**Consistency...............:**	
USDA Txt./USCS Class:		**Water Table Depth...:**	
Struct./% Pass. #200.:		**Init. Saturation Time.:**	

Enter Ksat Value: **11.2 cm/day**

Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph

Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

APPENDIX E

Constant-Head Borehole Permeameter Test	Analytical Method: Glover Solution	File Name.....: GloverRE_Template

Project Name......: Innisfree	**Boring No...........:** Ksat 20	**Terminology and Solution (R. E. Glover Solution)***	
Project No...........:	**Investigators......:** ECP	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C)	22
Project Location..: Crozet, VA	**Date..................:** 4-18-24	Q: Rate of flow of water from the borehole	
Boring Depth......: 60.96 **(m, cm, ft, in)**	**WCU Base Ht. h:** 15.0 **cm**	H: Constant height of water in the borehole	
Boring Diameter..: 8.3 **cm**	**WCU Susp. Ht. S:** 10.2 **cm**	r: Radius of the cylindrical borehole	
Boring Radius r...: 4.13 **cm**	**Const. Wtr. Ht. H:** 25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B	
Soil/Water Tmp. T: 12 **°C**	**H/r**** **.................:** 6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]	
Dyn. Visc. @ T.....: 0.001236 **kg/m·s**	**Dyn. Visc. @ T_B.:** 0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]	

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		12:32:00								
3040	160	12:37:00	0:05:00	5.00	32.00	2.9	2.88E-04	24.9	0.41	0.82
2920	120	12:42	0:05:00	5.00	24.00	2.2	2.16E-04	18.6	0.31	0.61
2800	120	12:47:00	0:05:00	5.00	24.00	2.2	2.16E-04	18.6	0.31	0.61
2690	110	12:52:00	0:05:00	5.00	22.00	2.0	1.98E-04	17.1	0.28	0.56
2420	270	13:02:00	0:10:00	10.00	27.00	2.4	2.43E-04	21.0	0.34	0.69
2140	280	13:12:00	0:10:00	10.00	28.00	2.5	2.52E-04	21.8	0.36	0.71
1860	280	13:22:00	0:10:00	10.00	28.00	2.5	2.52E-04	21.8	0.36	0.71
1580	280	13:32:00	0:10:00	10.00	28.00	2.5	2.52E-04	21.8	0.36	0.71

Natural Moisture......:	**Consistency...............:**	**Enter Ksat Value:**	**21.8 cm/day**
USDA Txt./USCS Class:	**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.
Struct./% Pass. #200.:	**Init. Saturation Time.:**		

*Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

Constant-Head Borehole Permeameter Test

Analytical Method: Glover Solution

File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 22
Project No...........:		**Investigators......:**	ECP
Project Location..:	Crozet, VA	**Date..................:**	4-18-24
Boring Depth......:	76.2 (m, cm, ft, in)	**WCU Base Ht. h:**	15.0 cm
Boring Diameter..:	8.3 cm	**WCU Susp. Ht. S:**	10.2 cm
Boring Radius r...:	4.13 cm	**Const. Wtr. Ht. H:**	25.2 cm
Soil/Water Tmp. T:	13 °C	**H/r** ** **.................:**	6.1
Dyn. Visc. @ T.....:	0.001202 kg/m·s	**Dyn. Visc. @ T_B.:**	0.000955 kg/m·s

Terminology and Solution (R. E. Glover Solution)*

- $Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
- Q: Rate of flow of water from the borehole
- H: Constant height of water in the borehole
- r: Radius of the cylindrical borehole
- V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
- $Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
- $Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	(min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3200		14:27:00								
2520	680	14:32:00	0:05:00	5.00	136.00	11.9	1.19E-03	102.8	1.69	3.37
1800	720	14:37	0:05:00	5.00	144.00	12.6	1.26E-03	108.8	1.78	3.57
1100	700	14:42:00	0:05:00	5.00	140.00	12.2	1.22E-03	105.8	1.74	3.47
380	720	14:47:00	0:05:00	5.00	144.00	12.6	1.26E-03	108.8	1.78	3.57
3200		14:52:00								
2440	760	14:57:00	0:05:00	5.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
1680	760	15:02:00	0:05:00	5.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
920	760	15:07:00	0:05:00	5.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
160	760	15:12:00	0:05:00	5.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
3,200		15:17:00								
2,440	760	15:22:00	0:05:00	5.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
1,680	760	15:27:00	0:05:00	5.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
160	1,520	15:37:00	0:10:00	10.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
3,200		15:42:00								
2,440	760	15:47:00	0:05:00	5.00	152.00	13.3	1.33E-03	114.8	1.88	3.77
920	1,520	15:57:00	0:10:00	10.00	152.00	13.3	1.33E-03	114.8	1.88	3.77

Natural Moisture......:		**Consistency...............:**	
USDA Txt./USCS Class:		**Water Table Depth...:**	
Struct./% Pass. #200.:		**Init. Saturation Time.:**	

Enter Ksat Value: **114.8 cm/day**

Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.

*Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014

APPENDIX E

Constant-Head Borehole Permeameter Test	Analytical Method: Glover Solution	File Name.....: GloverRE_Template

Project Name......:	Innisfree	**Boring No...........:**	Ksat 23	**Terminology and Solution (R. E. Glover Solution)***
Project No...........:		**Investigators......:**	APS	$Ksat_B$: (Coefficient of Permeability) @ Base Tmp. T_B (°C) 22
Project Location..:	Crozet, VA	**Date...................:**	4-18-24	Q: Rate of flow of water from the borehole
Boring Depth......:	76.2 **(m, cm, ft, in)**	**WCU Base Ht. h:**	15.0 **cm**	H: Constant height of water in the borehole
Boring Diameter..:	8.3 **cm**	**WCU Susp. Ht. S:**	10.2 **cm**	r: Radius of the cylindrical borehole
Boring Radius r...:	4.13 **cm**	**Const. Wtr. Ht. H:**	25.2 **cm**	V: Dyn. Visc. of water @ Tmp. T °C/Dyn. Visc. of water @ T_B
Soil/Water Tmp. T:	17 **°C**	**H/r** **.................:**	6.1	$Ksat = Q[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Basic Glover Solution]
Dyn. Visc. @ T.....:	0.001081 **kg/m·s**	**Dyn. Visc. @ T_B.:**	0.000955 **kg/m·s**	$Ksat_B = QV[\sinh^{-1}(H/r) - (r^2/H^2+1)^{.5} + r/H]/(2\pi H^2)$ [Tmp. Correction]

VOLUME (ml)	Volume Out (ml)	TIME (h:mm:ss A/P)	Interval Elapsed Time (hr:min:sec)	Interval Elapsed Time (min)	Flow Rate Q (ml/min)	$Ksat_B$ Equivalent Values (µm/sec)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3250		13:51:00								
3160	90	13:56:00	0:05:00	5.00	18.00	1.4	1.42E-04	12.2	0.20	0.40
3020	140	14:01	0:05:00	5.00	28.00	2.2	2.20E-04	19.0	0.31	0.62
2870	150	14:06:00	0:05:00	5.00	30.00	2.4	2.36E-04	20.4	0.33	0.67
2730	140	14:11:00	0:05:00	5.00	28.00	2.2	2.20E-04	19.0	0.31	0.62
2600	130	14:16:00	0:05:00	5.00	26.00	2.0	2.04E-04	17.7	0.29	0.58
2400	200	14:21:00	0:05:00	5.00	40.00	3.1	3.15E-04	27.2	0.45	0.89
2210	190	14:26:00	0:05:00	5.00	38.00	3.0	2.99E-04	25.8	0.42	0.85
2040	170	14:31:00	0:05:00	5.00	34.00	2.7	2.67E-04	23.1	0.38	0.76
1840	200	14:36:00	0:05:00	5.00	40.00	3.1	3.15E-04	27.2	0.45	0.89
1,640	200	14:41:00	0:05:00	5.00	40.00	3.1	3.15E-04	27.2	0.45	0.89
1,440	200	14:46:00	0:05:00	5.00	40.00	3.1	3.15E-04	27.2	0.45	0.89
1,240	200	14:51:00	0:05:00	5.00	40.00	3.1	3.15E-04	27.2	0.45	0.89
1,040	200	14:56:00	0:05:00	5.00	40.00	3.1	3.15E-04	27.2	0.45	0.89

Natural Moisture......:		**Consistency...............:**	**Enter Ksat Value:**	**27.2 cm/day**
USDA Txt./USCS Class:		**Water Table Depth...:**		Notes: Test Ksat Value is determined by averaging and/or rounding the test results for the final three or four stabilized values and analyzing the Flow Rate Q vs Total Elapsed Time Graph.
Struct./% Pass. #200.:		**Init. Saturation Time.:**		

Glover, R. E. l953. Flow from a test-hole located above groundwater level. pp. 69-7l. in: Theory and Problems of Water Percolation. (C. N. Zanger. ed.). USBR. The condition for this solution exists when the distance from the bottom of the borehole to the water table or an impervious layer is at least twice the depth of the water in the well. **H/r>5 to ≥10

Johnson Permeameter, LLC Revised 1/14/2014