Flood Impact Analysis and Stormwater Management
Jasper Hill Subdivision
Jasper Hill Road, Holliston, MA

October 2, 2023

Prepared for:

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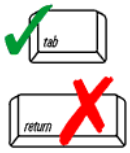
Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

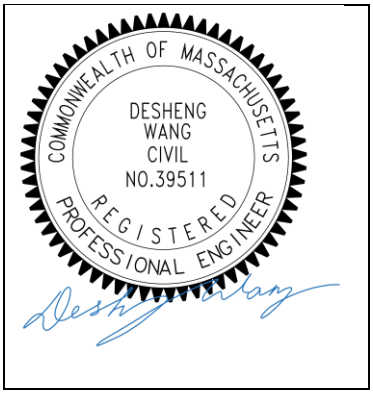
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



10/2/2023
Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☒ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☒ Minimizing disturbance to existing trees and shrubs

☒ LID Site Design Credit Requested:

- ☒ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☒ Use of "country drainage" versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☒ Grass Channel

☐ Green Roof

☒ Other (describe): Clustered development with open space

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

N/A subsurface discharge without overflow

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

☒ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm. **N/A no discharge at all to downgradient off site from the project area.**

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☒ Simple Dynamic ☐ Dynamic Field[1] confirmed the infiltration rate

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

N/A ☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

N/A ☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

☐ Site is comprised solely of C and D soils and/or bedrock at the land surface

☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000

☐ Solid Waste Landfill pursuant to 310 CMR 19.000

☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

N/A ☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

☒ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☒ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☒ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☒ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☒ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

☒ The ½" or 1" Water Quality Volume or

☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs) N/A

☒ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Infiltration basin

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable N/A Meet new project requirement to meet all performance standards

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☒ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☐ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☒ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Illicit Discharge Compliance Statement

Responsibility:

The owner is responsible for ultimate compliance with all provisions of the Massachusetts Stormwater Management Standards/ Policy, the USEPA NPDES Construction General Permit and responsible for identifying and eliminating illicit discharges (as defined by the USEPA[1])

Owner name/address/contact phone:

J. Dennis Morgan
Jasper Hill Realty Trust, LLC
340 Winter St.
Framingham, MA 01702
617-571-7744

To the best of my knowledge, the attached plans, computations and specifications meet the requirements of Standard 10 of the Massachusetts Stormwater Regulations (Handbook) regarding illicit discharges to the stormwater management system and that no known illicit discharges exist on the site.

Included with this statement are site plans, drawn to the scale, that identify the location of systems for conveying stormwater on the site and show that these systems do not allow the entry of any illicit discharges into the stormwater management system. The plans also show any systems for conveying wastewater and/ or groundwater on the site and show that there are no connections between the stormwater and wastewater systems.

J. Dennis Morgan Title

10/2/2023
Date

[1] Illicit Discharge Detection and Elimination – A Guidance Manual 2004

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1.0 Introduction

A 4-lot open space residential subdivision is proposed on a parcel off Jasper Hill Road in Holliston, MA. The site is in Agricultural-Residential Dist. B, identified on town Assessor's Map 8 Block 5 Lot 16. The property contains 6.57 acres (286,020 sq. ft.) land with 3.84 acres (167,073 sq. ft., 58.41%) set aside as an open space parcel. In 1876, 0.69 acres of land was carved out for the construction of an existing single-family residence and 1.5 story barn. Both structures will be demolished. The land is currently oak-pine woods. It is bordered by residential housing to the east, open space forest to the south and west, and wetland and town land to the northwest and north. The site has very permeable sandy soils, with over 90 percent being hydrological class A soil. In regard to surface hydrology, the site drains from north to south and southeast. See Figure 1 for USGS site locus map and Figure 2 for NRCS soil map. The proposed development will create 0.797 acres (about 13.2 percent) of impervious areas of road, driveway and walk to houses. and employ LID including country style road with crushed stone roadside aprons, grass swale and recharge basins. The proposed develop area will be surrounded by open space wooded area. Given the parcel will be accessed through the Town Hall parking lot, an upgrade of the parking lot drainage system is also incorporated into the plan to mitigate the existing impact to the maximum practicable extent.

Table 1. Summary of Land Area Break

	Lots	Open	Rd ROW	Total
Area, sf	105,562	167073	13385	286,020
Area, ac	2.42	3.84	0.31	6.57
% of total	36.91%	58.41%	4.68%	100.00%

The property is shaped irregularly. No stormwater management system existed on site for existing conditions. The runoff mostly drains from north to south and southeast to the town drainage system in Jasper Hill Road, which will be one of the design control points. The other control points are located downgradient along the south and east property lines. The proposed drainage system will be designed to mimic the existing surface drainage pattern and scattered throughout the site.

Table 1b. Land use break down in the watershed

	Area	(Acres)	Impervious area (ac)		
Land uses	Existing	Proposed	Existing	Proposed	Increment
Roof	0.072	0.230	0.072	0.230	0.157
Pave	0.614	0.948	0.614	0.948	0.334
Pervious	8.026	7.535			
Total	8.713	8.713	0.687	1.178	0.491
Imperviousness (%)			7.88	13.52	

Upon request of project proponent, J Dennis Morgan of Jasper Hill Realty Trust, LLC, Creative Land & Water Engineering, LLC (CLAWE) devised the flood control and stormwater management plan for the site to satisfy the requirements of the ten DEP stormwater management standards and Holliston bylaw and regulations. This report presents the results.

2.0 Flood Condition Analyses and Flood Control

There are no flood control or stormwater management structures under the existing conditions at the project site. Based on the drainage pattern and site conditions, four (4) control points for flood control calculations are chosen to make sure not increase in flood peaks and volumes to the offsite concerning areas:

The following is a summary of the existing and proposed land uses within the study area. See Appendix B Table B.1 for details.

Table 1c. Land use table

Condition	Land Use	Area		
		Total	HSG A	HSG D
		acre	acre	acre
Existing (Total)	Roof	0.07	0.07	0.00
	Drive/Park	0.61	0.61	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.22	0.22	0.00
	Woods	7.80	7.21	0.59
	Total	8.71	8.12	0.59
Proposed (Total)	Roof	0.23	0.23	0.00
	Drive/Park	0.91	0.91	0.00
	Walk/Patio/etc.	0.04	0.04	0.00
	Lawn	2.56	2.56	0.00
	Woods	4.98	4.39	0.59
	Total	8.71	8.12	0.59

The NRCS soil survey map (Figure 2) indicates the soils of the site are Narragansett soils (HSG A). A total of eight (19) deep hole soil test pits were excavated on the site to collect groundwater and soil permeability data for the stormwater management and septic system design (see site plan for locations) Our field soil testing showed the soil is gravely medium loamy sand to medium sand, well drained Hydrologic Class A soils in overall site with estimated high groundwater depth 6-10 ft. All percolation rates were calculated to be under 10 mpi (see soil logs for details). Four constant head permeability tests were conducted in the proposed roadway infiltration trench area to determine the infiltration rates. The infiltration rate is tested consistent with the soil texture of Rawl's table in the MA Stormwater Management Handbook, which will be used for the design. Detailed soil log can be found in Appendix D.

For the proposed conditions, flood control will be achieved by series of roadside swale and four infiltration basins: one inside of the cul-del-sac and four along the common drive and roadway. Pretreatments include deep roadside swales, dee sump catch basin with oil/grit trap. See plan for locations. The drainage divides and details of the infiltration basins and their storage information can be found in Figures 3 to 9. More details of the design features can be found on the engineering plan by Creative Land & Water Engineering, LLC dated August 30, 2023.

The flood conditions under both existing and proposed conditions are summarized in Table 2. Detailed data and calculations area presented in Appendices A and B.

As indicated in Tables 2 and 3, the results of flood control are satisfactory.

Table 2a. Summary of Peak Runoffs Leaving the Project Site

Sub-watershed		Peak Runoffs (cfs)					Runoff Volume (ac-ft)				
		2-year	10-year	25-year	50-year	100-year	2-year	10-year	25-year	50-year	100-year
Existing-	AE1, AE2 (CP1)	0.780	1.690	2.300	2.760	3.27	0.070	0.140	0.230	0.320	0.430
	BE (CP2)	0.200	0.310	0.380	0.500	0.83	0.020	0.040	0.060	0.080	0.110
	CE (CP2)	0.000	0.000	0.010	0.020	0.07	0.000	0.000	0.000	0.010	0.020
	DE1, DE2 (CP4)	1.810	2.820	3.460	3.930	4.54	0.180	0.290	0.390	0.470	0.570
Proposed- with flood control	AP1, AP2 (CP1)	0.780	1.690	2.300	2.760	3.27	0.070	0.140	0.220	0.290	0.38
	BP (CP2)	0.000	0.000	0.020	0.070	0.18	0.000	0.000	0.010	0.020	0.04
	CP (CP3)	0.000	0.000	0.010	0.020	0.07	0.000	0.000	0.000	0.010	0.01
	D1P, D2P,D3P,D4P, D5P, DPb (CP4)	0.800	1.540	2.210	3.250	4.36	0.080	0.170	0.240	0.310	0.42

Table 2b. Summary runoff peak and volume change

Control Point	Change in Peak Runoffs (%)					Change in Runoff Volume (%)				
	2-year	10-year	25-year	50-yar	100-year	2-year	10-year	25-year	50-yar	100-year
Cntrlp1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.3%	-9.4%	-11.6%
Cntrlp2	-100.0%	-100.0%	-94.7%	-86.0%	-78.3%	-100.0%	-100.0%	-83.3%	-75.0%	-63.6%
Cntrlp3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-50.0%
Cntrlp4	-55.8%	-45.4%	-36.1%	-17.3%	-4.0%	-55.6%	-41.4%	-38.5%	-34.0%	-26.3%
Mini	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-11.6%
Max	-100.0%	-100.0%	-94.7%	-86.0%	-78.3%	-100.0%	-100.0%	-83.3%	-75.0%	-63.6%

Table 3. Summary of Peak Elevations

Basin	2-yr	10-yr	25-yr	50-yr	100-yr
Basin D1	262.140	262.840	263.510	263.770	263.930
Basin D2	256.960	258.880	260.690	261.280	261.580
Basin D3	242.010	242.270	242.540	242.790	243.080
Basin D4	232.080	232.390	232.920	233.330	233.580
Basin D5	220.210	220.750	221.130	221.350	**221.540**

Table 4. Summary of Basin Recharge

Basin	Recharge	Vol, ac-ft	Vol. cf
Basin D1	rech 1	0.09	3920.4
Basin D2	rech 2	0.2	8712
Basin D3	rech 3	0.05	2178
Basin D4	rech 4	0.1	4356
Basin D5	rech 5	0.07	3049.2

3.0 Stormwater Management

This section demonstrates that the drainage design satisfies all ten DEP stormwater management standards.

Standard #1: Untreated Stormwater

No untreated stormwater from the proposed project area will be discharged to downgradient areas for the proposed conditions. Runoff from paved areas will be adequately treated before overflowing to downgradient area. The treatment train includes deep sump catchbasins equipped with oil traps, roadside stone apron and swale, and infiltration basins. LID uses driveway side stone apron, grass swale and infiltration combination to minimize flow and erosion. The infiltration basins are designed to infiltration runoff far exceeding DEP requirement that scattered fairly uniformly throughout the site.

Standard #2: Post-Development Peak Discharge Rates

Stormwater controls have been designed for 2, 10, 25, 50, and 100-year storms according to both state and the Town Holliston regulations. The post-development peak discharge rates and volumes with flood control do not exceed pre-development rates on the site at the downgradient discharge points. See Tables 2a and 2b for details.

Standard #3: Recharge to Groundwater

The soils on the site are hydrologic class A soils based NRCS soil map and *in-situ* soil evaluations. The required infiltration will be 0.6 inches of runoff per storm from increased impervious areas in HSG A soil and 0.25 inches in HSG C soil. Given the total impervious area of **1.178 acre (HSG A**), the required recharge volume is calculated as 2565 ft^3. The recharge basins as designed has a total static storage of capacity of 5257 ft^3 more than double of the required and satisfies Standard 3. The system much more recharge and water quality volume with infiltration. See following tables for details.

Hydrological soil group	A soil	B Soil	C Soil	D Soil	Total	
DEP required GW recharge (in):	0.6	0.35	0.25	0.1		
Impervious area (acres):	1.178	0.000	0.000	0.000	1.18	acres
DEP required GW recharge volume:	2564.89				**2564.89**	cu. ft

Infiltration time (hrs): 6	Basin D1	Basin D2	Basin D3	Basin D4	Basin D5	Total
At el. (out INV) (ft):	261	261	243	233	221	
Static Storage volume (cu.ft):		2790	622	804	854	**5257.00**
Infil. rate (cfs):	8.30E-02	0.205	0.19546	0.25365	0.149	
Infiltration volume (cu.ft):	1792.8	4428	4221.936	5478.84	3218.4	**19139.98**
Total volume (cu ft) :	1979.8	7218	4843.936	6282.84	4072.4	**24396.98**

Standard # 4: Water Quality

(a) Water Quality Volume. 0.5" water quality rule applies to this site. The water quality treatment volume for runoff from paved roadway is pretreated catch basin and then to distribution manhole for large flow bypass, and first flush to oil/grit separator, and the infiltration trench. The storage volume in the system is more than 24396 ft^3, much larger than the required 2137 ft^3 based on 1/2-inch rule over total impervious area. The driveway runoff will be shed off to grassed channel/swale as LID that will credit for satisfactory water quality.

Site Conditions	Water quality rule	0.5	inches
	Impervious area	WQV req.	WQV provided
	acres	cu. ft	cu. ft
existing	0.687	none	none
Proposed	1.178	2137.4063	24396.976

(b) TSS Removal. The BMPs used for the proposed project to enhance water quality include: deep sump catch basins with oil trap, roadside stone apron and swale to treat the first flush and improve the TSS removal rate, and an infiltration trench for the roadway. Driveway side grass swale and infiltration basins. Therefore, based on the large recharge of runoff and sediment settling dynamics analysis, the TSS removal rate for the paved area could reach 96%. The overall TSS removal rate will be 90% conservatively according to, the DEP stormwater management handbook guidelines. Using the DEP pre-determined TSS removal credit, the system will have 44% pretreatment TSS removal prior going to the infiltration trench and the overall TSS removal rate will be 80% as allowed for infiltration basins. See the attached calculation sheets in Appendix C for details.

Standard # 5: Higher Potential Pollutant Loads

The proposed land use will not have higher potential pollutant loads. Given the large volume for stormwater treatment, the site should have a lower pollutant load compared with the existing conditions. See Appendix C for details. Oil traps will be added to the on-site catch basin.

Standard #6: Protection of Critical Areas

The site will be service by public water and onsite septic systems. It does not contain or in the vicinity of any of the critical resource areas as listed below:

- Surface drinking water supplies, certified vernal pools, Areas of Critical Environmental Concern;
- Shellfish growing areas;
- Public swimming beaches;
- Cold water fisheries.

The proposed stormwater management facilities will promote groundwater recharge and mimic existing water treatment quality.

Standard #7: Redevelopment Projects

The proposed project is a partial redevelopment but was designed as a full new project. The proposed stormwater management will meet all ten DEP stormwater standards (2008). As proposed, the project will provide better water quality and mitigated flood impact to downgradient resource area.

Standard #8: Erosion/Sediment Control

Staked wattles and silt fences will be installed at the downgradient limit of work before any excavation starts. Six-inch thick of 3”-4” crushed trap rocks should be spread at the entrance of the proposed roadway to the project site to prevent mud from escaping the site during construction. Any sediment tracked to the town parking lot and Jasper Hill Road should be swept promptly. See details in the plans and Appendix E.

Standard #9: Long-term Operation/Maintenance Plan

See Appendix E for details.

Standard #10: Illicit Discharges

There are no existing illicit discharges into stormwater system and there will be no illicit discharges under 310 CMR 10.04 will be allowed for proposed conditions. This is emphasized in the Operation and Maintenance Plan and the Illicit Discharge Statement signed by the project proponent.

3.1 Groundwater Mounding Analysis

Due to the restriction of the land grading, five infiltration basins only have 2 ft separation from the estimated seasonal high groundwater except for Basin 5. As required by the DEP stormwater management handbook, Vol. 3 Ch. 1. P 28, groundwater mounding analysis using Hantush Method is conducted to show that the trenches will be dewatered within 72 hours. The recharge volume for a 100-year storm is used to conduct the mounding analysis. The analysis showed that the mounding height after three days will be 0.53 ft, 0.45 ft, 0.18 ft, 0.34 ft, and 0.27 ft for Basin 1, 2, 3, 4, and 5, respectively. The mounding analysis is summarized in Table 4. Detailed mounding analysis is presented in Appendix G.

Table 4. Summary of Groundwater Mounding Analysis

Parameters	Stormwater - 100 Year					Note
Recharge area	Basin D1	Basin D2	Basin D3	Basin D4	Basin D5	All Basins will be dewatered in less than three days.
Dimension, Length, ft	58.73	38.53	29.36	40.40	40.47	
Dimension, Width, ft	18	35	18	19	21	
Area, sq. ft	1057.17	1348.40	528.47	767.65	849.89	
Recharge Vol. Cu ft (per day or event)	3920.4	8712	2178	4356	3049.2	
Duration, day	1	1	1	1	1	
Recharge rate, cu ft/day/sq. ft	3.71	6.46	4.12	5.67	3.59	
Dewater time, day	3	3	3	3	3	
GW Separation, ft	2	2	2	2	4	
Distance to wetland, ft	138	51	51	60	87	
Maximum mounding height, ft	3.35	6.03	2.67	3.74	2.4	
Estimated effective Max MH, ft	**2.27**	**2.806**	**2.134**	**2.348**	**2.4**	
Impact mounding height by other systems, ft	**0**	**0**	**0**	**0**	**0**	
Combined Mound height, ft	**3.35**	**6.03**	**2.67**	**3.74**	**2.4**	
3-day residual height, ft	**0.53**	**0.45**	**0.18**	**0.34**	**0.27**	
5-day residual height, ft	**0.29**	**0.17**	**0.06**	**0.13**	**0.12**	
Estimated effective 3d MH, ft	**0.53**	**2.32**	**0.18**	**0.34**	**0.27**	
Estimated effective 5d MH, ft	**0.29**	**0.17**	**0.27**	**0.26**	**0.26**	
Bottom of Basin, ft	**260**	**258**	**242**	**232**	**220**	
Top of stones, ft						
EHGW, ft	258	256	240	230	216	
	average					
Bottom aquifer, ft	**244**	**236**	**224**	**212**	**196**	
3 day elevation, ft	**258.53**	**256.45**	**240.18**	**230.34**	**216.27**	
Flood routing elev, ft	263.930	261.580	243.080	233.580	221.540	
Top of grade, ft	264.5	262.5	244.5	234.5	222.5	
Aquafer depth, ft	14	20	16	18	20	
Hydraulic Conductivity, ft/day	16.42	16.42	16.42	16.42	16.42	

* mounded water tables for stormwater management area are at 3-day.

4.0 Summary

Flood control and stormwater management have been designed with LID and the latest stormwater BMPs techniques. The design satisfies all ten stormwater management standards as required in the MA DEP Stormwater Management Regulation and Holliston by-law. Here are some of the highlights:

- Proposed peak flows and runoff volumes for 2-year to 100-year storm events will not exceed the existing conditions.
- The system mimics natural hydrological patterns by using LID development.
- Overall Total suspended solids (TSS) removal rate will be 90% per DEP SWMH pre-determined value for the BMP structures and will likely higher based on our design analysis based on larger water quality volume and settlement hydrodynamics, which can reach 96% ;
- The capacity for water quality treatment and groundwater recharge exceeds DEP requirements.
- Groundwater Mounding analysis has been conducted to show that the infiltration basins will be dewater within 72 hours.

Figures

Figure 1: Site Locus
Figure 2: NRCS Soil Map
Figure 3: Drainage Divide- Existing Conditions
Figure 4: Drainage Divide- Proposed Conditions

Figure 5: Storage Indication Table _ Basin D1
Figure 6: Storage Indication Table _ Basin D2
Figure 7: Storage Indication Table _ Basin D3
Figure 8: Storage Indication Table _ Basin D4
Figure 9: Storage Indication Table _ Basin D5

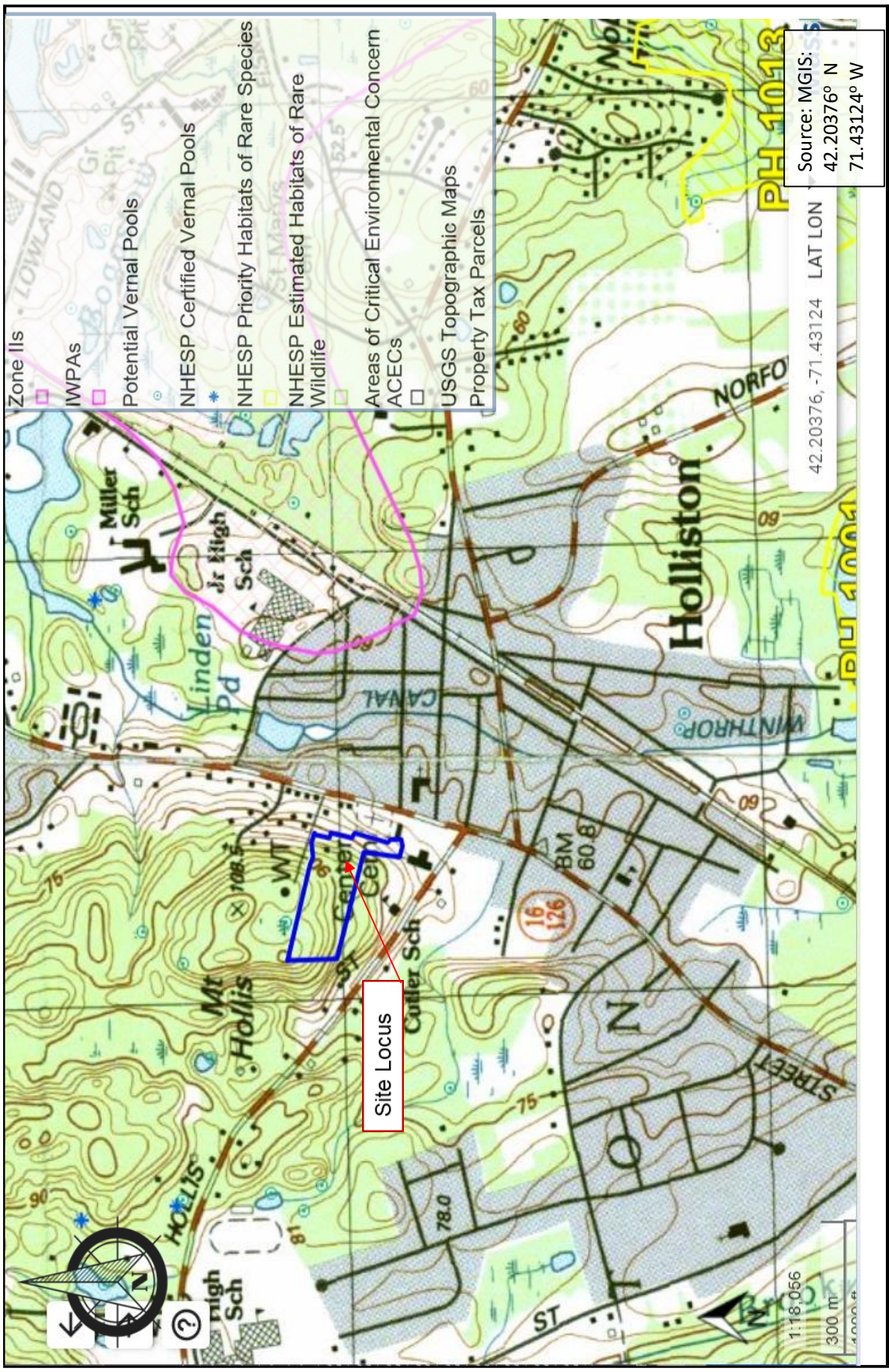
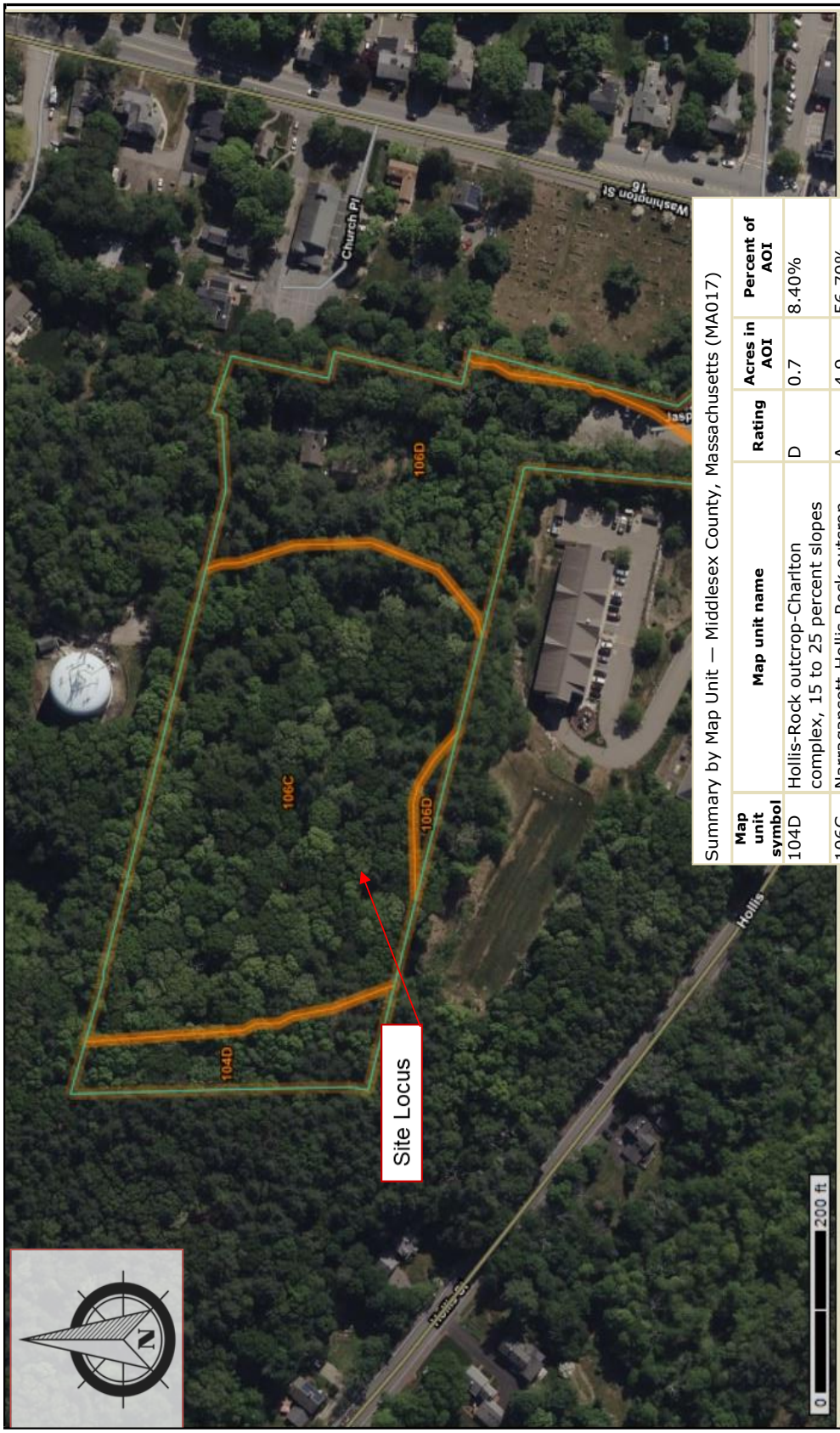


Figure 1: USGS Locus Map

Project: Jasper Hill Estates
52 Jasper Hill Road
Holliston, MA

Prepared by: Creative Land & Water Engineering, LLC
Environmenal Scientists and Engineers
P.O.Box 584 - Southborough - MA - 01772
774-454-0266 http://claweng.com



Summary by Map Unit — Middlesex County, Massachusetts (MA017)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
104D	Hollis-Rock outcrop-Charlton complex, 15 to 25 percent slopes	D	0.7	8.40%
106C	Narragansett-Hollis-Rock outcrop complex, 3 to 15 percent slopes	A	4.9	56.70%
106D	Narragansett-Hollis-Rock outcrop complex, 15 to 25 percent slopes	A	2.8	31.90%
415C	Narragansett silt loam, 8 to 15 percent slopes	A	0.3	3.00%
Totals for Area of Interest			**8.6**	**100.00%**

Source: MGIS:
42.20376° N
71.43124° W

Figure 2: NRCS Soil Map

Project: Jasper Hill Estates
52 Jasper Hill Road
Holliston, MA

Prepared by: Creative Land & Water Engineering, LLC
Environmenal Scientists and Engineers
P.O.Box 584 - Southborough - MA - 01772
774-454-0266 http://claweng.com

Existing:

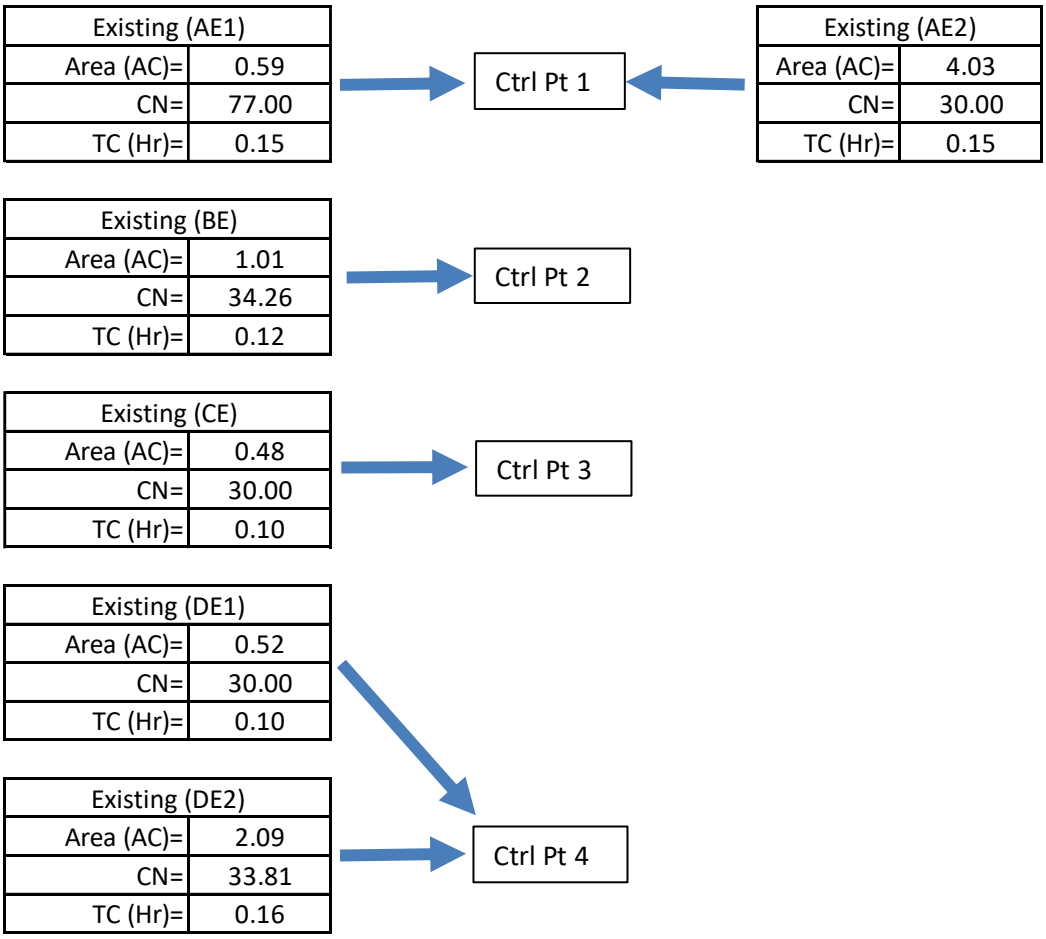


Figure 3: Watershed divide: Existing Condition, See site plan for details.

Proposed:

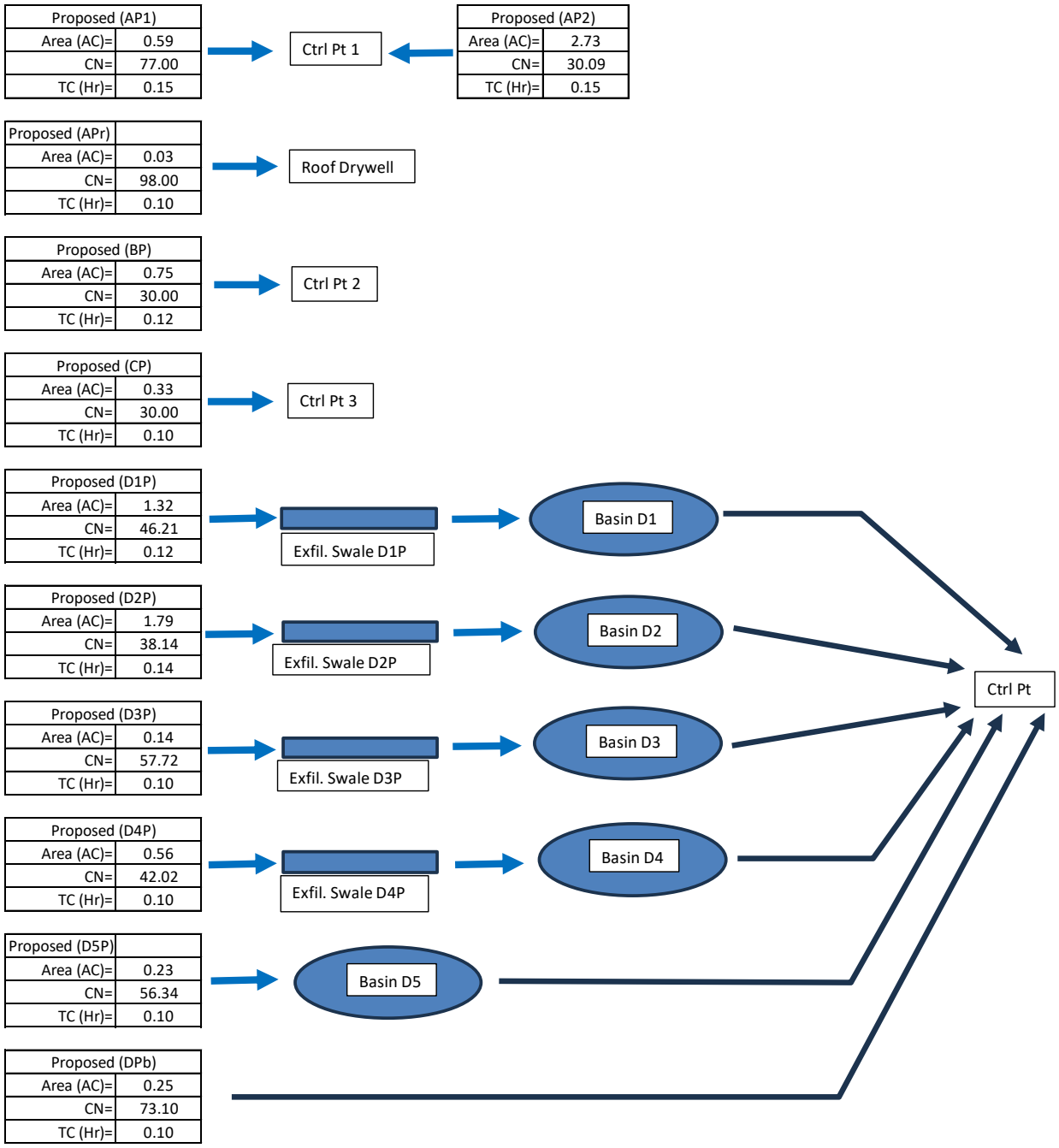


Figure 4: Watershed divide: Proposed Condition, See site plan for details.

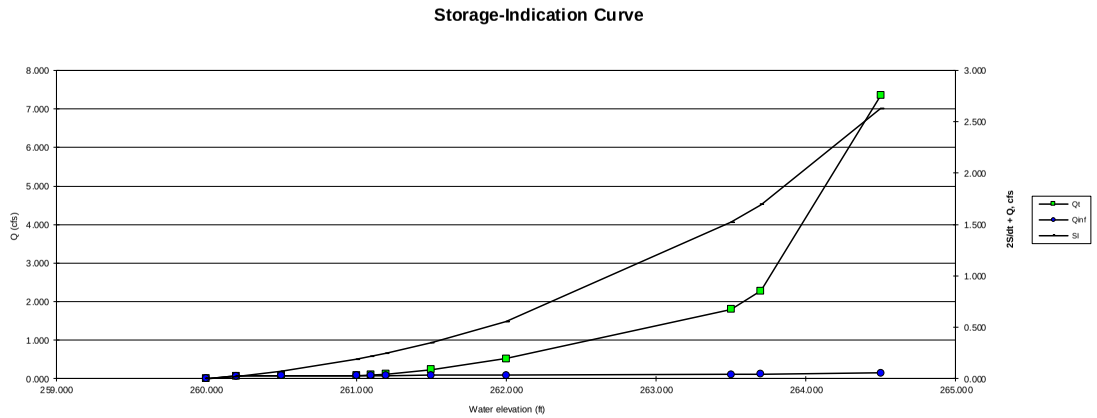
dsw

Outflow Analysis and Storage Indication

Basin D1

Location:	52 Jasper Hill Road Holliston, MA			By:	dsw	Date:	8/10/2023
				Chkd:		Date:	09/14/23
				Job No.:	J136-3	Sheet:	1 of 4
100-year elevation, ft	263.93			100-year flood storage, ac-ft:	0.0450	Area (sf):	1057.17
dt (sec.)	60			Upper perimeter (ft):		Lower perimeter (ft):	
Broad-crested weir width (ft):	0.5	Rawls	yes	Upper Permeability (ft/s):	5.58E-05	Slope (H:V):	3.00
Broad-crested weir length (ft):	1.5	Emergency BCW length (ft):	5	Lower permeability(ft/s):	5.58E-05	Inf. safety factor:	1
Weir crest elevation (ft):	263.5	Weir crest elevation (ft):	300	Total infil. depth (ft):	4.5	Starting INV (ft):	260
Pipe 1 Dia. (ft)	1.5			Pipe 2 Dia. (ft)	1	Slot width (in.):	1.5
Pipe 1 INV (ft):	300			Pipe 2 INV (ft):	256.5	Slot INV (ft):	261
				EHGW (ft):			

Elevation ft	Total Q cfs	2S/dt + Q cfs	Qinf cfs	Inf head ft	Head 1 ft	Qpipe 1 cfs	Head 2 ft	Qpipe 2 cfs	Head, weir-e ft	Qweir-e cfs	Head, weir-p ft	Qweir-p cfs	Head-slot ft	Qslot cfs	Pond area sq. ft	Storage 1000 cu. ft	Dewater hrs.
260.000	0.000	0.000	0.000	0.000	0.000	0.000	3.500	8.858	0.000	0.000	0.000	0.000	0.000	0.000	97	0.000	0.000
260.200	0.074	0.840	0.074	0.200	0.000	0.000	3.700	9.191	0.000	0.000	0.000	0.000	0.000	0.000	134	0.023	0.172
260.500	0.077	2.443	0.077	0.500	0.000	0.000	4.000	9.666	0.000	0.000	0.000	0.000	0.000	0.000	188	0.071	0.347
261.000	0.083	6.314	0.083	1.000	0.000	0.000	4.500	10.403	0.000	0.000	0.000	0.000	0.000	0.000	279	0.187	0.750
261.100	0.097	7.288	0.084	1.100	0.000	0.000	4.600	10.544	0.000	0.000	0.000	0.000	0.050	0.013	297	0.216	0.839
261.200	0.123	8.334	0.085	1.200	0.000	0.000	4.700	10.682	0.000	0.000	0.000	0.000	0.100	0.038	315	0.246	0.917
261.500	0.238	11.870	0.088	1.500	0.000	0.000	5.000	11.086	0.000	0.000	0.000	0.000	0.250	0.150	370	0.349	1.075
262.000	0.518	19.055	0.093	2.000	0.000	0.000	5.500	11.724	0.000	0.000	0.000	0.000	0.500	0.426	461	0.556	1.227
263.500	1.796	52.466	0.114	3.500	0.000	0.000	7.000	13.436	0.000	0.000	0.000	0.000	1.250	1.682	844	1.520	1.458
263.700	2.283	58.748	0.117	3.700	0.000	0.000	7.200	13.646	0.200	0.354	0.000	0.000	1.450	1.812	895	1.694	1.482
264.500	7.347	94.893	0.148	4.500	0.000	0.000	8.000	14.454	1.000	4.941	0.000	0.000	2.250	2.257	1459	2.626	1.536



elev ft	Stor ac-ft	Dis cfs	infil cfs
260.000	0.00000	0.000	0.000
260.200	0.00053	0.074	0.074
260.500	0.00163	0.077	0.077
261.000	0.00429	0.083	0.083
261.100	0.00495	0.097	0.084
261.200	0.00566	0.123	0.085
261.500	0.00801	0.238	0.088
262.000	0.01277	0.518	0.093
263.500	0.03490	1.796	0.114
263.700	0.03889	2.283	0.117
264.500	0.06029	7.347	0.148
0.000	0.000	0.000	0.000

Figure : Rating Curve and Storage-Indication Curve

Outflow Structure Analysis - Slotted Weir Version 1.2 (c) Designed and Maintained by Desheng Wang, Ph.D., P.E., Creative Land & Water Engineering, LLC.

Figure 5: Storage Indication Table _ Basin D1

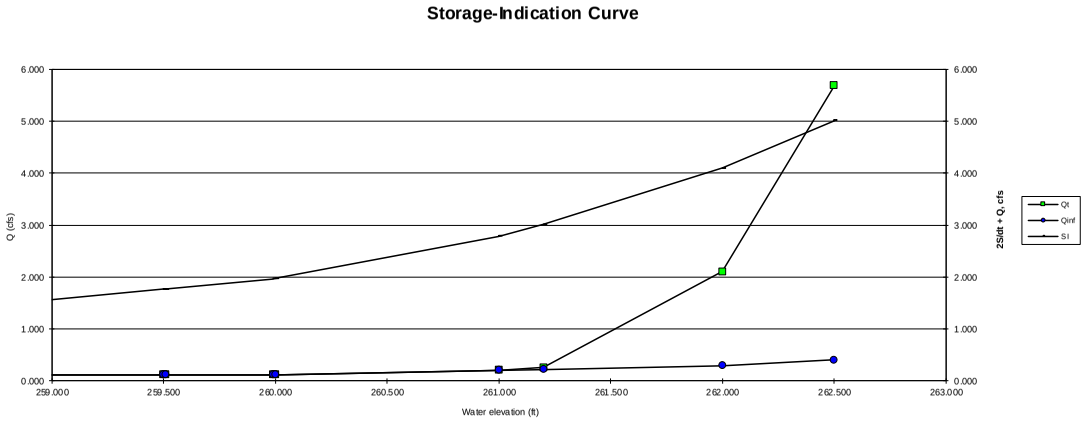
dsw

Outflow Analysis and Storage Indication

Basin D2

Location:	52 Jasper Hill Road Holliston, MA			By:	dsw	Date:	8/10/2023
				Chkd:		Date:	
				Job No.:	J136-3	Sheet:	2 of 5
100-year elevation, ft	261.58			100-year flood storage, ac-ft:	0.0810	Area (sf):	1348.40
dt (sec.)	60			Upper perimeter (ft):		Lower perimeter (ft):	
Broad-crested weir width (ft):	0.5	Rawls	yes	Upper Permeability (ft/s):	0.000191	Slope (H:V):	3.00
Broad-crested weir length (ft):	1.5	Emergency BCW length (ft):	5	Lower permeability(ft/s):	0.000191	Inf. safety factor:	1
Weir crest elevation (ft):	261.5	Weir crest elevation (ft):	300	Total infil. depth (ft):	2	Starting INV (ft):	260
Pipe 1 Dia. (ft)	1.5			Pipe 2 Dia. (ft)	1	Slot width (in.):	1.5
Pipe 1 INV (ft):	300			Pipe 2 INV (ft):	256.5	Slot INV (ft):	261
				EHGW (ft):	253		

Elevation ft	Total Q cfs	2S/dt + Q cfs	Qinf cfs	Inf head ft	Head 1 ft	Qpipe 1 cfs	Head 2 ft	Qpipe 2 cfs	Head, weir-e ft	Qweir-e cfs	Head, weir-p ft	Qweir-p cfs	Head-slot ft	Qslot cfs	Pond area sq. ft	Storage 1000 cu. ft	Dewater hrs.	storage ac-ft
255.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	256.00	0.000	0.000	0
255.500	0.123	4.390	0.123	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	256.04	0.128	0.580	0.00294
255.510	0.123	4.500	0.123	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	409.68	0.131	0.588	0.00301
259.500	0.123	58.990	0.123	0.000	0.000	0.000	3.000	7.959	0.000	0.000	0.000	0.000	0.000	0.000	409.72	1.766	4.293	0.04054
259.510	0.123	59.126	0.123	0.000	0.000	0.000	3.010	7.978	0.000	0.000	0.000	0.000	0.000	0.000	409.76	1.770	4.302	0.04064
259.990	0.123	65.684	0.123	0.000	0.000	0.000	3.490	8.841	0.000	0.000	0.000	0.000	0.000	0.000	410.00	1.967	4.748	0.04515
260.000	0.123	65.850	0.123	0.000	0.000	0.000	3.500	8.858	0.000	0.000	0.000	0.000	0.000	0.000	590.00	1.972	4.759	0.04527
261.000	0.205	93.205	0.205	1.000	0.000	0.000	4.500	10.403	0.000	0.000	0.000	0.000	0.000	0.000	1070.00	2.790	6.146	0.06405
261.200	0.261	100.713	0.223	1.200	0.000	0.000	4.700	10.682	0.000	0.000	0.000	0.000	0.100	0.038	1166.00	3.014	6.412	0.06918
262.000	2.108	138.652	0.297	2.000	0.000	0.000	5.500	11.724	0.500	1.551	0.000	0.000	0.750	0.261	1550.00	4.096	6.666	0.09404
262.500	5.685	172.743	0.407	2.500	0.000	0.000	6.000	12.324	1.000	4.941	0.000	0.000	1.250	0.336	2127.00	5.012	6.731	0.11505



elev ft	Stor ac-ft	Dis cfs	infil cfs
255.000	0.00000	0.000000	0.000000
255.500	0.00294	0.122538	0.122538
255.510	0.00301	0.122557	0.122557
259.500	0.04054	0.122576	0.122576
259.510	0.04064	0.122595	0.122595
259.990	0.04515	0.122710	0.122710
260.000	0.04527	0.122901	0.122901
261.000	0.06405	0.204836	0.204836
261.200	0.06918	0.261279	0.223213
262.000	0.09404	2.108351	0.296725
262.500	0.11505	5.684853	0.407183
0.000	0.000	0.000	0.000000

Figure : Rating Curve and Storage-Indication Curve

Outflow Structure Analysis - Slotted Weir Version 1.2 (c) Designed and Maintained by Desheng Wang, Ph.D., P.E., Creative Land & Water Engineering, LLC.

Figure 6: Storage Indication Table _ Basin D2

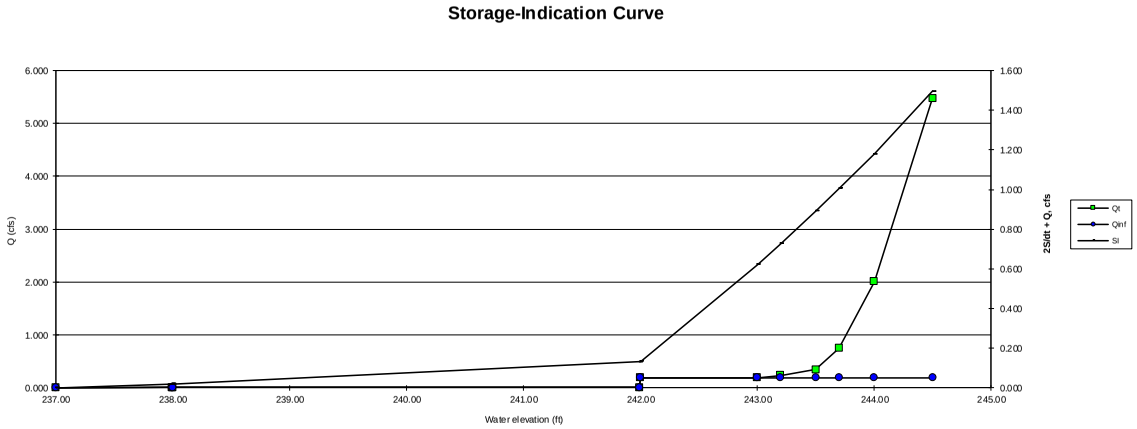
dsw

Outflow Analysis and Storage Indication

Basin D3

Location:	52 Jasper Hill Road Holliston, MA			By:	dsw	Date:	8/10/2023
				Chkd:		Date:	
				Job No.:	J136-3	Sheet:	3 of 5
100-year elevation, ft	243.08			100-year flood storage, ac-ft:	0.0153	Area (sf):	528.47
dt (sec.)	60			Upper perimeter (ft):		Lower perimeter (ft):	
Broad-crested weir width (ft):	0.5	Rawls	yes	Upper Permeability (ft/s):	0.0001914	Slope (H:V):	3.00
Broad-crested weir length (ft):	1.5	Emergency BCW length (ft):	5	Lower permeability(ft/s):	0.0001914	Inf. safety factor:	1
Weir crest elevation (ft):	243.5	Weir crest elevation (ft):	300	Total infil. depth (ft):	2	Starting INV (ft):	242
Pipe 1 Dia. (ft)	1.5			Pipe 2 Dia. (ft)	1	Slot width (in.):	1.5
Pipe 1 INV (ft):	300			Pipe 2 INV (ft):	239.5	Slot INV (ft):	243
				EHGW (ft):			

Elevation ft	Total Q cfs	2S/dt + Q cfs	Qinf cfs	Inf head ft	Head 1 ft	Qpipe 1 cfs	Head 2 ft	Qpipe 2 cfs	Head, weir-e ft	Qweir-e cfs	Head, weir-p ft	Qweir-p cfs	Head-slot ft	Qslot cfs	Pond area sq. ft	Storage 1000 cu. ft	Dewater hrs.
237.00	0.000	0.000	0.00000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.10	0.000	0.000
237.99	0.010	0.673	0.00964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.14	0.020	1.148
238.00	0.010	0.681	0.00966	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.71	0.020	1.155
241.99	0.010	4.370	0.00968	0.000	0.000	0.000	2.490	6.916	0.000	0.000	0.000	0.000	0.000	0.000	27.75	0.131	4.335
242.00	0.195	4.622	0.19526	0.000	0.000	0.000	2.500	6.938	0.000	0.000	0.000	0.000	0.000	0.000	456.00	0.133	4.340
243.000	0.195	20.927	0.19546	1.000	0.000	0.000	3.500	8.858	0.000	0.000	0.000	0.000	0.000	0.000	523.10	0.622	5.036
243.200	0.234	24.498	0.19565	1.200	0.000	0.000	3.700	9.191	0.000	0.000	0.000	0.000	0.100	0.038	536.52	0.728	5.173
243.500	0.346	30.076	0.19584	1.500	0.000	0.000	4.000	9.666	0.000	0.000	0.000	0.000	0.250	0.150	556.65	0.892	5.330
243.700	0.752	34.237	0.19603	1.700	0.000	0.000	4.200	9.968	0.200	0.354	0.000	0.000	0.450	0.202	570.07	1.005	5.387
244.000	2.008	41.294	0.19622	2.000	0.000	0.000	4.500	10.403	0.500	1.551	0.000	0.000	0.750	0.261	590.20	1.179	5.422
244.500	5.474	55.327	0.19641	2.500	0.000	0.000	5.000	11.086	1.000	4.941	0.000	0.000	1.250	0.336	678.80	1.496	5.446



elev ft	Stor ac-ft	Dis cfs	infil cfs
237.000000	0.000000	0.000000	0.000000
237.990000	0.000457	0.009637	0.009637
238.000000	0.000463	0.009656	0.009656
241.990000	0.003003	0.009675	0.009675
242.000000	0.003048	0.195264	0.195264
243.000000	0.014278	0.195455	0.195455
243.200000	0.016711	0.233712	0.195647
243.500000	0.020475	0.346306	0.195838
243.700000	0.023061	0.751801	0.196030
244.000000	0.027057	2.007848	0.196221
244.500000	0.034334	5.474083	0.196413
0.000	0.000	0.000	0.000

Figure : Rating Curve and Storage-Indication Curve

Outflow Structure Analysis - Slotted Weir Version 1.2 (c) Designed and Maintained by Desheng Wang, Ph.D., P.E., Creative Land & Water Engineering, LLC.

Figure 7: Storage Indication Table _ Basin D3

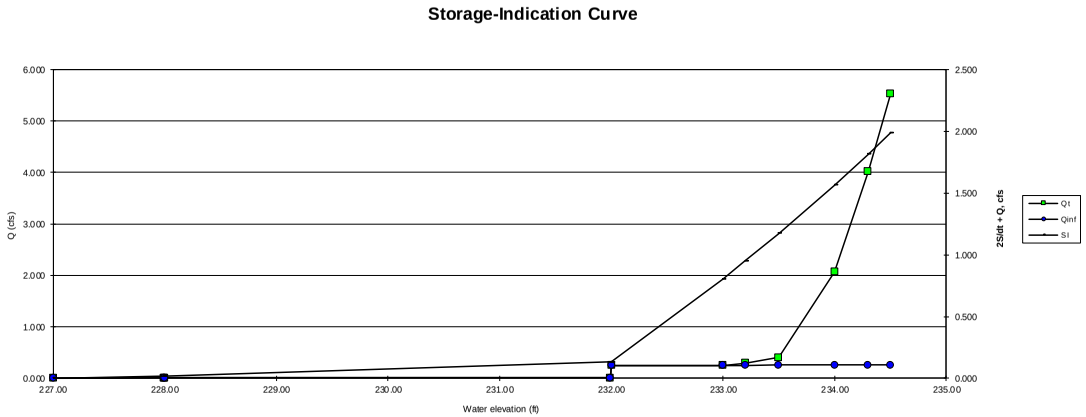
dsw

Outflow Analysis and Storage Indication

Basin D4

Location:	52 Jasper Hill Road Holliston, MA			By:	dsw	Date:	8/10/2023
				Chkd:		Date:	
				Job No.:	J136-3	Sheet:	4 of 5
100-year elevation, ft	233.58			100-year flood storage, ac-ft:	0.0284	Area (sf):	767.65
dt (sec.)	60			Upper perimeter (ft):		Lower perimeter (ft):	
Broad-crested weir width (ft):	0.5	Rawls	yes	Upper Permeability (ft/s):	0.0001914	Slope (H:V):	3.00
Broad-crested weir length (ft):	1.5	Emergency BCW length (ft):	5	Lower permeability(ft/s):	0.0001914	Inf. safety factor:	1
Weir crest elevation (ft):	233.5	Weir crest elevation (ft):	300	Total infil. depth (ft):	2	Starting INV (ft):	232
Pipe 1 Dia. (ft)	1.5			Pipe 2 Dia. (ft)	1	Slot width (in.):	1.5
Pipe 1 INV (ft):	300			Pipe 2 INV (ft):	300	Slot INV (ft):	233
				EHGW (ft):			

Elevation ft	Total Q cfs	2S/dt + Q cfs	Qinf cfs	Inf head ft	Head 1 ft	Qpipe 1 cfs	Head 2 ft	Qpipe 2 cfs	Head, weir-e ft	Qweir-e cfs	Head, weir-p ft	Qweir-p cfs	Head-slot ft	Qslot cfs	Pond area sq. ft	Storage 1000 cu. ft	Dewater hrs.	storage ac-ft
227.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.10	0.000	0.000	0
227.99	0.010	0.673	0.00964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.14	0.020	1.148	0.00046
228.00	0.010	0.681	0.00966	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.71	0.020	1.155	0.00046
231.99	0.010	4.370	0.00968	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.75	0.131	4.335	0.003
232.000	0.253	4.700	0.25269	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	626.40	0.133	4.340	0.00306
233.000	0.254	27.055	0.25365	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	715.80	0.804	5.076	0.01846
233.200	0.293	31.925	0.25461	1.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.038	733.68	0.949	5.224	0.02179
233.500	0.406	39.509	0.25557	1.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.150	760.50	1.173	5.402	0.02693
234.000	2.068	54.217	0.25652	2.000	0.000	0.000	0.000	0.000	0.500	1.551	0.000	0.000	0.750	0.261	805.20	1.564	5.490	0.03592
234.300	4.021	64.477	0.25748	2.300	0.000	0.000	0.000	0.000	0.800	3.455	0.000	0.000	1.050	0.308	856.68	1.814	5.512	0.04164
234.500	5.536	71.818	0.25844	2.500	0.000	0.000	0.000	0.000	1.000	4.941	0.000	0.000	1.250	0.336	891.00	1.988	5.523	0.04565



elev ft	Stor ac-ft	Dis cfs	infil cfs
227.0000	0.000000	0.000000	0.000000
227.9900	0.000457	0.009637	0.009637
228.0000	0.000463	0.009656	0.009656
231.9900	0.003003	0.009675	0.009675
232.0000	0.003063	0.252694	0.252694
233.0000	0.018458	0.253652	0.253652
233.2000	0.021785	0.292675	0.254609
233.5000	0.026930	0.406034	0.255566
234.0000	0.035915	2.068150	0.256523
234.3000	0.041637	4.020720	0.257480
234.5000	0.045649	5.536108	0.258438
0.000	0.000	0.000	0.000

Figure : Rating Curve and Storage-Indication Curve

Outflow Structure Analysis - Slotted Weir Version 1.2 (c) Designed and Maintained by Desheng Wang, Ph.D., P.E., Creative Land & Water Engineering, LLC.

Figure 8: Storage Indication Table _ Basin D4

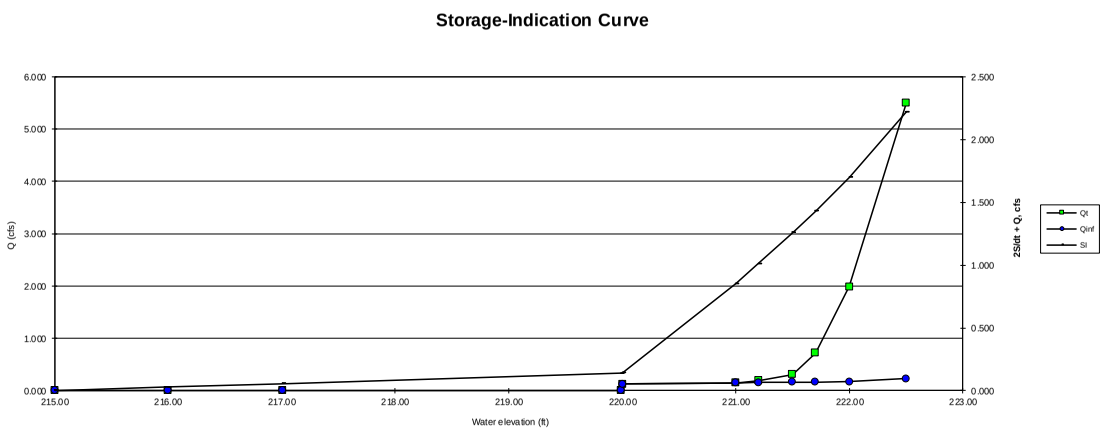
dsw

Outflow Analysis and Storage Indication

Basin D5

Location:	52 Jasper Hill Road Holliston, MA			By:	dsw	Date:	8/10/2023
				Chkd:		Date:	
				Job No.:	J136-3	Sheet:	5 of 5
100-year elevation, ft	221.54			100-year flood storage, ac-ft:	0.0297	Area (sf):	849.89
dt (sec.)	60			Upper perimeter (ft):		Lower perimeter (ft):	
Broad-crested weir width (ft):	0.5	Rawls	yes	Upper Permeability (ft/s):	0.0001914	Slope (H:V):	3.00
Broad-crested weir length (ft):	1.5	Emergency BCW length (ft):	5	Lower permeability(ft/s):	0.0001914	Inf. safety factor:	1
Weir crest elevation (ft):	221.5	Weir crest elevation (ft):	300	Total infil. depth (ft):	2	Starting INV (ft):	220
Pipe 1 Dia. (ft)	1.5			Pipe 2 Dia. (ft)	1	Slot width (in.):	1.5
Pipe 1 INV (ft):	300			Pipe 2 INV (ft):	300	Slot INV (ft):	221
				EHGW (ft):			

Elevation ft	Total Q cfs	2S/dt + Q cfs	Qinf cfs	Inf head ft	Head 1 ft	Qpipe 1 cfs	Head 2 ft	Qpipe 2 cfs	Head, weir-e ft	Qweir-e cfs	Head, weir-p ft	Qweir-p cfs	Head-slot ft	Qslot cfs	Pond area sq. ft	Storage 1000 cu. ft	Dewater hrs.
215.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.63	0.000	0.000
216.00	0.005	0.927	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.67	0.028	2.900
217.01	0.005	1.859	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.71	0.056	4.365
219.99	0.005	4.614	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.75	0.138	8.690
220.00	0.124	4.823	0.124	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	648.00	0.141	8.701
221.000	0.149	28.599	0.149	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	779.10	0.854	10.150
221.200	0.192	33.924	0.154	1.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.038	805.32	1.012	10.408
221.500	0.312	42.293	0.162	1.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.150	844.65	1.259	10.681
221.700	0.722	48.421	0.167	1.700	0.000	0.000	0.000	0.000	0.200	0.354	0.000	0.000	0.450	0.202	870.87	1.431	10.773
222.000	1.986	58.589	0.174	2.000	0.000	0.000	0.000	0.000	0.500	1.551	0.000	0.000	0.750	0.261	910.20	1.698	10.827
222.500	5.506	79.562	0.228	2.500	0.000	0.000	0.000	0.000	1.000	4.941	0.000	0.000	1.250	0.336	1190.40	2.222	10.866



elev ft	Stor ac-ft	Dis cfs	infil cfs
215.000	0.00000	0.000000	0.000000
216.000	0.00063	0.005297	0.005297
217.010	0.00128	0.005305	0.005305
219.990	0.00317	0.005313	0.005313
220.000	0.00324	0.124050	0.124050
221.000	0.01959	0.149147	0.149147
221.200	0.02323	0.192232	0.154167
221.500	0.02891	0.312164	0.161696
221.700	0.03285	0.722487	0.166715
222.000	0.03898	1.985871	0.174244
222.500	0.05100	5.505555	0.227884
0.000	0.000	0.000000	0.000000

Figure : Rating Curve and Storage-Indication Curve

Outflow Structure Analysis - Slotted Weir Version 1.2 (c) Designed and Maintained by Desheng Wang, Ph.D., P.E., Creative Land & Water Engineering, LLC.

Figure 9: Storage Indication Table _ Basin D5

Appendix A: HYDROLOGICAL ANALYSIS AND ROAD DRAINAGE CALCULATIONS

Computer Model HEC-HMS was used for the calculations of peak flow, unit hydrograph. The input data are summarized in Table A-1.

Table A-1. Summary of input Parameters

Sub-watershed	Area (Acre)	Area(Mi²)	CN	Imp.(%)	I	TC (Hr)	Lag (Min.)
AE1	0.59	0.00092	77.00	0.00	0.597	0.15	5.42
AE2	4.03	0.00630	30.00	0.00	4.667	0.15	5.42
Existing (BE)	1.01	0.00157	34.26	6.77	3.837	0.12	4.29
Existing (CE)	0.48	0.00074	30.00	0.00	4.667	0.10	3.70
Existing (DE1)	0.52	0.00081	96.03	97.10	0.083	0.10	3.60
Existing (DE2)	2.09	0.00327	33.81	5.46	3.916	0.16	5.67
Total	8.71	0.01361					
AP1	0.59	0.00092	77.00	0.00	0.597	0.15	5.50
AP2	2.73	0.00427	30.09	0.35	4.647	0.15	5.50
Proposed (APr)	0.03	0.00004	98.00	100.00	0.041	0.10	3.60
Proposed (BP)	0.75	0.00117	30.00	0.00	4.667	0.12	4.29
Proposed (CP)	0.33	0.00051	30.00	0.00	4.667	0.10	3.60
Proposed (D1P)	1.32	0.00206	46.21	28.04	2.328	0.12	4.26
Proposed (D2P)	1.79	0.00280	38.14	14.06	3.243	0.14	5.00
Proposed (D3P)	0.14	0.00022	57.72	52.29	1.465	0.10	3.60
Proposed (D4P)	0.56	0.00088	42.02	22.68	2.759	0.10	3.60
Proposed (D5P)	0.23	0.00036	56.34	49.70	1.550	0.10	3.60
Proposed (DPb)	0.25	0.00039	73.10	81.32	0.736	0.10	3.60
Total	8.71	0.01361					

Meteorological Model	Method: SCS Hypothetical Storm	
	Storm Selection: Type III	
	1" Storm Event (Inch):	1
	2-Year 24-Hour Rainfall Depth (Inch):	3.37
	10-Year 24-Hour Rainfall Depth (Inch):	5.26
	25-Year 24-Hour Rainfall Depth (Inch):	6.44
	50-Year 24-Hour Rainfall Depth (Inch):	7.32
	100-Year 24-Hour Rainfall Depth (Inch):	8.27

Creative Land & Water Engineering, LLC Environmental Scientists and Engineers P.O. Box 584 - Southborough - MA - 01772 774-454-0266 www.claweng.com			**Subject:**	SCS Modified Soil Cover Complex Method	
			Project:	52 Jasper Hill Rd	
			Location:	52 Jasper Hill Rd	
			Job No.:	J136-3	
Sub-Basin:	AE1	Analysis By:	FA	Date:	7/27/2023
Condition:	Existing	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.00	0.00
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	39	0.00	0.00
2	Woods	A	30	0.00	0.00
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.59	45.33
5					
6					
7					
8					
			Total :	0.59	45.33
			Average CN:		77.00
			Imperviousness (%):		**0.00**

Sub-Basin:	AE2	Analysis By:	FA	Date:	7/27/2023
Condition:	Existing	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27

Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.00	0.00
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	39	0.00	0.00
2	Woods	A	30	4.03	120.89
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	4.03	120.89
			Average CN:		30.00
			Imperviousness (%):		**0.00**

Sub-Basin:	BE	Analysis By:	FA	Date:	7/27/2023
Condition:	Existing	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.02	2.01
2	Drive/Park	A	83	0.05	3.94
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	39	0.04	1.61
2	Woods	A	30	0.90	26.89
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	1.01	34.45
			Average CN:		34.26
			Imperviousness (%):		**6.77**

Sub-Basin:	CE	Analysis By:	FA	Date:	7/27/2023
Condition:	Existing	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.00	0.00
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	39	0.00	0.00
2	Woods	A	30	0.48	14.29
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.48	14.29
			Average CN:		30.00
			Imperviousness (%):		**0.00**

Sub-Basin:	DE1	Analysis By:	FA	Date:	7/27/2023
Condition:	Existing	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.03	3.28
2	Drive/Park	A	98	0.47	46.15
3	Walk/Patio/ Etc	A	98	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	39	0.00	0.00
2	Woods	A	30	0.02	0.45
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.52	49.89
			Average CN:		96.03
			Imperviousness (%):		**97.10**

Sub-Basin:	DE2	Analysis By:	FA	Date:	7/27/2023
Condition:	Existing	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.02	1.80
2	Drive/Park	A	83	0.09	7.77
3	Walk/Patio/ Etc	A	83	0.00	0.20
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	39	0.18	7.06
2	Woods	A	30	1.80	53.93
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	2.09	70.76
			Average CN:		33.81
			Imperviousness (%):		**5.46**

Creative Land & Water Engineering, LLC Environmental Scientists and Engineers P.O. Box 584 - Southborough - MA - 01772 774-454-0266 www.claweng.com		**Subject:**	SCS Modified Soil Cover Complex Method
		Project:	52 Jasper Hill Rd
		Location:	52 Jasper Hill Rd
		Job No.:	J136-3

Sub-Basin:	AP1	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	

Storm Frequency:	2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):	3.37	5.26	6.44	8.27

Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.00	0.00
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.00	0.00
2	Woods	A	30	0.00	0.00
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.59	45.33
5					
6					
7					
8					
			Total :	0.59	45.33
			Average CN:		77.00
			Imperviousness (%):		**0.00**

Sub-Basin:	AP2	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.00	0.38
3	Walk/Patio/ Etc	A	30	0.01	0.15
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.54	16.23
2	Woods	A	30	2.18	65.49
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	2.73	82.25
			Average CN:		30.09
			Imperviousness (%):		**0.35**

Sub-Basin:	APr	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.03	2.81
2	Drive/Park	A	83	0.00	0.00
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.00	0.00
2	Woods	A	30	0.00	0.00
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.03	2.81
			Average CN:		98.00
			Imperviousness (%):		**100.00**

Sub-Basin:	BP	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.00	0.00
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.12	3.72
2	Woods	A	30	0.62	18.69
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.75	22.41
			Average CN:		30.00
			Imperviousness (%):		**0.00**

Sub-Basin:	CP	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.00	0.00
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.04	1.15
2	Woods	A	30	0.29	8.61
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.33	9.76
			Average CN:		30.00
			Imperviousness (%):		**0.00**

Sub-Basin:	D1P	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.12	11.58
2	Drive/Park	A	83	0.23	19.19
3	Walk/Patio/ Etc	A	83	0.02	1.62
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.81	24.23
2	Woods	A	30	0.14	4.17
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	1.32	60.79
			Average CN:		46.21
			Imperviousness (%):		**28.04**

Sub-Basin:	D2P	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.08	8.12
2	Drive/Park	A	83	0.15	12.85
3	Walk/Patio/ Etc	A	83	0.01	1.19
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.68	20.53
2	Woods	A	30	0.86	25.68
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	1.79	68.38
			Average CN:		38.14
			Imperviousness (%):		**14.06**

Sub-Basin:	D3P	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.07	6.03
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.07	1.99
2	Woods	A	30	0.00	0.00
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.14	8.01
			Average CN:		57.72
			Imperviousness (%):		**52.29**

Sub-Basin:	D4P	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.13	10.57
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.19	5.57
2	Woods	A	30	0.25	7.45
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.56	23.59
			Average CN:		42.02
			Imperviousness (%):		**22.68**

Sub-Basin:	D5P	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.11	9.45
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.06	1.84
2	Woods	A	30	0.05	1.62
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.23	12.90
			Average CN:		56.34
			Imperviousness (%):		**49.70**

Sub-Basin:	DPb	Analysis By:	FA	Date:	7/27/2023
Condition:	Proposed	Checked By:		Date:	
Storm Frequency:		2-Year	10-Year	25-Year	100-Year
24-hour rainfall (in):		3.37	5.26	6.44	8.27
Impervious Area:	Land Use	Soil Group	CN	Area (acres)	Area x CN
1	Roof	A	98	0.00	0.00
2	Drive/Park	A	83	0.20	16.98
3	Walk/Patio/ Etc	A	83	0.00	0.00
4	Roof	D	98	0.00	0.00
5	Drive/Park	D	93	0.00	0.00
6	Walk/Patio/ Etc	D	93	0.00	0.00
Pervious area:					
1	Lawn	A	30	0.05	1.41
2	Woods	A	30	0.00	0.00
3	Lawn	D	80	0.00	0.00
4	Woods	D	77	0.00	0.00
5					
6					
7					
8					
			Total :	0.25	18.39
			Average CN:		73.10
			Imperviousness (%):		**81.32**

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: AE **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.15 through subarea
0.15 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0722				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.1199	0		=	0.120

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			559.97		
9. Watercourse slope, s	Ft./Ft.			0.1007		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	5.077		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0306	=	0.031

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.035	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.15

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: BE **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.12 through subarea
0.12 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0950				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.1074	0		=	0.107

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			315.52		
9. Watercourse slope, s	Ft./Ft.			0.2156		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	7.430		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0118	=	0.012

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.035	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.12

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: CE **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.10 through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.1276				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.0954	0		=	0.095

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			172.80		
9. Watercourse slope, s	Ft./Ft.			0.1670		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	6.538		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0073	=	0.007

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.035	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.10

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: DE1 **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.03 through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Pave				
2. Manning's Roughness Coef., n (Table 3-1).....		0.011				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0230				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.0107	0		=	0.011

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)		597		Woods		
8. Flow length, L	Ft.	538.53		0.00		
9. Watercourse slope, s	Ft./Ft.	0.1170		0.2341		
10. Average velocity, V (figure 3-1)	Ft./S	6.951	0.000	7.742		
11. Tt = L/3600V Computer Tt	Hr.	0.0215	0.0000	0.0000	=	0.022

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)		Lawn				
13. Flow length, L	Ft.	0.00				
14. Watercourse slope, s	Ft./Ft.	0.0402				
15. Average velocity, V (figure 3-1)	Ft./S	3.206097383	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.035	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)		Hour			=	0.03

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: DE **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.16 through subarea
0.16 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0716				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.1203	0		=	0.120

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)		Paved		Woods		
8. Flow length, L	Ft.	538.53		189.71		
9. Watercourse slope, s	Ft./Ft.	0.1138		0.2341		
10. Average velocity, V (figure 3-1)	Ft./S	6.853	0.000	7.742		
11. Tt = L/3600V Computer Tt	Hr.	0.0218	0.0000	0.0068	=	0.029

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)		Lawn				
13. Flow length, L	Ft.	99.62				
14. Watercourse slope, s	Ft./Ft.	0.0402				
15. Average velocity, V (figure 3-1)	Ft./S	3.206097383	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.009	0.000	0.000	=	0.009

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.035	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.16

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: AP **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.15 through subarea
0.15 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0722				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.1199	0		=	0.120

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			489.78		
9. Watercourse slope, s	Ft./Ft.			0.0784		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	4.479		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0304	=	0.030

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)		Lawn	Lawn			
13. Flow length, L	Ft.	57.03	5.11			
14. Watercourse slope, s	Ft./Ft.	0.1753	0.3914			
15. Average velocity, V (figure 3-1)	Ft./S	6.699899633	10.00977995	0		
16. Tt = L/3600V Computer Tt	Hr.	0.002	0.000	0.000	=	0.003

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.	1.00				
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0.25	0	0		
19. Channel slope, s	Ft./Ft.	42.64				
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	351.02	0.00	0		
22. Flow length, L	Ft.	0.0704				
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.15

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: APr (Drywell) **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.					
4. Two-yr 24-hr rainfall, P2.....	In.	1.005541093				
5. Land slope, s	Ft./Ft.					
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.		0		=	

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)						
8. Flow length, L	Ft.					
9. Watercourse slope, s	Ft./Ft.					
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	0.000		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0000	=	0.000

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.035	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: BP **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.12 through subarea
0.12 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0950				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.1074	0		=	0.107

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			315.52		
9. Watercourse slope, s	Ft./Ft.			0.2156		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	7.430		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0118	=	0.012

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.12

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: CP **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.08 through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.2044				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.0791	0		=	0.079

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			46.57		
9. Watercourse slope, s	Ft./Ft.			0.2530		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	8.047		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0016	=	0.002

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)						
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.		0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.08

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: D1P **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.12 through subarea
0.12 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Grass - Dense Grasses				
2. Manning's Roughness Coef., n (Table 3-1).....		0.24				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0404				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.1005	0		=	0.100

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)		Paved		Lawn		
8. Flow length, L	Ft.	12.45		12.57		
9. Watercourse slope, s	Ft./Ft.	0.1044		0.1257		
10. Average velocity, V (figure 3-1)	Ft./S	6.566	0.000	5.673		
11. Tt = L/3600V Computer Tt	Hr.	0.0005	0.0000	0.0006	=	0.001

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)		Swale				
25. Bottom width, B.....	ft	2.000				
26. Side slope (H:V).....		2				
27. Design depth, D	ft	0.500				
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.354	0.000	0.000		
29. Channel slope, s	Ft./Ft.	0.0997				
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	9.419	0.000	0.000		
32. Flow length, L	Ft.	564.67	0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.017	0.000	0.000	=	0.017
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)		Hour			=	0.12

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: D2P **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.14 through subarea
0.14 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0716				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.1203	0		=	0.120

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			184.47		
9. Watercourse slope, s	Ft./Ft.			0.2468		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	7.948		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0064	=	0.006

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)		Lawn				
13. Flow length, L	Ft.	63.59				
14. Watercourse slope, s	Ft./Ft.	0.0142				
15. Average velocity, V (figure 3-1)	Ft./S	1.903473456	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.009	0.000	0.000	=	0.009

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.	1.00				
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0.25	0	0		
19. Channel slope, s	Ft./Ft.	0.0174				
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	7.08	0.00	0		
22. Flow length, L	Ft.	43.20				
23. Tt = L/3600V Computer Tt	Hr.	0.002	0.000	0.000	=	0.002

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)		Swale				
25. Bottom width, B.....	ft	2.000				
26. Side slope (H:V).....		2				
27. Design depth, D	ft	0.500				
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.354	0.000	0.000		
29. Channel slope, s	Ft./Ft.	0.2144				
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	13.812	0.000	0.000		
32. Flow length, L	Ft.	62.97	0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.001	0.000	0.000	=	0.001
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.14

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: D3P **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.09 through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Grass - Dense Grasses				
2. Manning's Roughness Coef., n (Table 3-1).....		0.24				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.0568				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.0877	0		=	0.088

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Lawn		
8. Flow length, L	Ft.			30.03		
9. Watercourse slope, s	Ft./Ft.			0.1052		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	5.190		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0016	=	0.002

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)		Swale				
25. Bottom width, B.....	ft	2.000				
26. Side slope (H:V).....		2				
27. Design depth, D	ft	0.500				
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.354	0.000	0.000		
29. Channel slope, s	Ft./Ft.	0.1112				
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	9.949	0.000	0.000		
32. Flow length, L	Ft.	125.86	0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.004	0.000	0.000	=	0.004
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.09

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: D4P **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.09 through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Woods - Light Underbrush				
2. Manning's Roughness Coef., n (Table 3-1).....		0.4				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.1812				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.0830	0		=	0.083

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Woods		
8. Flow length, L	Ft.			45.60		
9. Watercourse slope, s	Ft./Ft.			0.1522		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	6.242		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0020	=	0.002

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)		Lawn				
13. Flow length, L	Ft.	35.90				
14. Watercourse slope, s	Ft./Ft.	0.2786				
15. Average velocity, V (figure 3-1)	Ft./S	8.444477024	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.001	0.000	0.000	=	0.001

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)		Swale				
25. Bottom width, B.....	ft	2.000				
26. Side slope (H:V).....		2				
27. Design depth, D	ft	0.500				
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.354	0.000	0.000		
29. Channel slope, s	Ft./Ft.	0.0923				
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	9.064	0.000	0.000		
32. Flow length, L	Ft.	194.97	0.00	0.00		
33. Tt = L/3600V Computer Tt	Hr.	0.006	0.000	0.000	=	0.006
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.09

Creative Land & Water Engineering, LLC **Environmental Scientists and Engineers** **P.O. Box 584 - Southborough - MA - 01772** **774-454-0266 www.claweng.com**	**Subject:**	**Time of Concentration (Tc) or Travel Timel (Tt)**		
	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: D5P **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.06 through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Grass - Dense Grasses				
2. Manning's Roughness Coef., n (Table 3-1).....		0.24				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.1440				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.0604	0		=	0.060

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)				Lawn		
8. Flow length, L	Ft.			44.09		
9. Watercourse slope, s	Ft./Ft.			0.1202		
10. Average velocity, V (figure 3-1)	Ft./S	0.000	0.000	5.547		
11. Tt = L/3600V Computer Tt	Hr.	0.0000	0.0000	0.0022	=	0.002

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)		Swale				
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.					
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.06

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	Project:	Jasper Hill Rd	**Job No.:**	J136-3
	Location:	52 Jasper Hill Rd, Holliston, MA		

Sub-Basin: DPb **Analysis By:** FA Date 7/28/2023
Condition: Proposed **Checked By:** Date
Time (Hrs): 0.05 through subarea
0.10 to be used
Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to TC Only)						
1. Surface description (Table 3-1).....		Paved - Asphalt				
2. Manning's Roughness Coef., n (Table 3-1).....		0.11				
3. Flow length, L (total L <= 300 ft).....	Ft.	50.00				
4. Two-yr 24-hr rainfall, P2.....	In.	3.37				
5. Land slope, s	Ft./Ft.	0.1024				
6. Tt = 0.007 (nL)^0.8/P2^0.5 s^0.4 Compute Tt	Hr.	0.0371	0		=	0.037

Shallow Concentrated Flow		Reach 1 - Paved	Reach 2 - Paved	Reach 3 - Unpaved		
7. Surface description (Lawn, Woods, ETC)		Paved				
8. Flow length, L	Ft.	210.62				
9. Watercourse slope, s	Ft./Ft.	0.1143				
10. Average velocity, V (figure 3-1)	Ft./S	6.871	0.000	0.000		
11. Tt = L/3600V Computer Tt	Hr.	0.0085	0.0000	0.0000	=	0.009

Shallow Concentrated Flow		Reach 4 - Unpaved	Reach 5 - Unpaved	Reach 6 - Unpaved		
12. Surface description (Lawn, Woods, ETC)						
13. Flow length, L	Ft.					
14. Watercourse slope, s	Ft./Ft.					
15. Average velocity, V (figure 3-1)	Ft./S	0	0	0		
16. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Pipe		Reach 1	Reach 2	Reach 3		
17. Diameter, D	Ft.					
18. Hydraulic radius, r=a/Pw Computer r	Ft.	0	0	0		
19. Channel slope, s	Ft./Ft.					
20. Manning's roughness coeff., n		0.011	0.011	0.011		
21. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.00	0.00	0		
22. Flow length, L	Ft.					
23. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000

Channel flow - Open Trapezoid		Reach 1	Reach 2	Reach 3		
24. Surface description (Lawn, Woods, ETC)		Swale				
25. Bottom width, B.....	ft					
26. Side slope (H:V).....						
27. Design depth, D	ft					
28. Hydraulic radius, r=a/Pw Computer r	Ft.	0.000	0.000	0.000		
29. Channel slope, s	Ft./Ft.					
30. Manning's roughness coeff. for channels, n		0.025	0.025	0.025		
31. V = 1.49 r^(2/3) s^(1/2) / n Compute V	Ft/S	0.000	0.000	0.000		
32. Flow length, L	Ft.					
33. Tt = L/3600V Computer Tt	Hr.	0.000	0.000	0.000	=	0.000
34. Watershed or subarea Tc or Tt (add Tr in steps 6, 11, 16, 23, and 33)			Hour		=	0.05

Appendix B: FLOOD ROUTING CALCULATIONS FOR STORAGE AREAS

On the following pages, are the results of flood routing calculations by Storage-Indication method. We prefer this classical technique to the short cut methods because the assumptions for the short cut methods are often violated in real drainage areas.

The computation is carried out by HEC-HMS.

Table B.1. Detailed land uses in each subwatershed

Sub-watershed	Land Use	Area		
		Total	HSG A	HSG D
		acre	acre	acre
Existing (Total)	Roof	0.07	0.07	0.00
	Drive/Park	0.61	0.61	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.22	0.22	0.00
	Woods	7.21	7.21	0.00
	Total	8.12	8.12	0.00
Existing (AE1)	Roof	0.00	0.00	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.00	0.00	0.00
	Woods	0.59	0.00	0.59
	Total	0.59	0.00	0.59
Existing (AE2)	Roof	0.00	0.00	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.00	0.00	0.00
	Woods	4.03	4.03	0.00
	Total	4.03	4.03	0.00
Existing (BE)	Roof	0.02	0.02	0.00
	Drive/Park	0.05	0.05	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.04	0.04	0.00
	Woods	0.90	0.90	0.00
	Total	1.01	1.01	0.00
Existing (CE)	Roof	0.00	0.00	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.00	0.00	0.00

	Woods	0.48	0.48	0.00
	Total	0.48	0.48	0.00

Existing (DE1)	Roof	0.03	0.03	0.00
	Drive/Park	0.47	0.47	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.00	0.00	0.00
	Woods	0.02	0.02	0.00
	Total	0.52	0.52	0.00

Existing (DE2)	Roof	0.02	0.02	0.00
	Drive/Park	0.09	0.09	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.18	0.18	0.00
	Woods	1.80	1.80	0.00
	Total	2.09	2.09	0.00

Condition	Land Use	Area		
		Total	HSG A	HSG D
		acre	acre	acre
Proposed (Total)	Roof	0.23	0.23	0.00
	Drive/Park	0.91	0.91	0.00
	Walk/Patio/etc.	0.04	0.04	0.00
	Lawn	2.56	2.56	0.00
	Woods	4.39	4.39	0.00
	Total	8.12	8.12	0.00

Proposed (AP1)	Roof	0.00	0.00	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.00	0.00	0.00
	Woods	0.59	0.00	0.59
	Total	0.59	0.00	0.59

Proposed (AP2)	Roof	0.00	0.00	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.01	0.01	0.00
	Lawn	0.54	0.54	0.00
	Woods	2.18	2.18	0.00
	Total	2.73	2.73	0.00

Proposed (APr)	Roof	0.03	0.03	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.00	0.00	0.00
	Woods	0.00	0.00	0.00
	Total	0.03	0.03	0.00

Proposed (BP)	Roof	0.00	0.00	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.12	0.12	0.00
	Woods	0.62	0.62	0.00
	Total	0.75	0.75	0.00

Proposed (CP)	Roof	0.00	0.00	0.00
	Drive/Park	0.00	0.00	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.04	0.04	0.00
	Woods	0.29	0.29	0.00
	Total	0.33	0.33	0.00

Proposed (D1P)	Roof	0.12	0.12	0.00
	Drive/Park	0.23	0.23	0.00
	Walk/Patio/etc.	0.02	0.02	0.00
	Lawn	0.81	0.81	0.00
	Woods	0.14	0.14	0.00
	Total	1.32	1.32	0.00

Proposed (D2P)	Roof	0.08	0.08	0.00
	Drive/Park	0.15	0.15	0.00
	Walk/Patio/etc.	0.01	0.01	0.00
	Lawn	0.68	0.68	0.00
	Woods	0.86	0.86	0.00
	Total	1.79	1.79	0.00

Proposed (D3P)	Roof	0.00	0.00	0.00
	Drive/Park	0.07	0.07	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.07	0.07	0.00
	Woods	0.00	0.00	0.00
	Total	0.14	0.14	0.00

Proposed (D4P)	Roof	0.00	0.00	0.00
	Drive/Park	0.13	0.13	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.19	0.19	0.00
	Woods	0.25	0.25	0.00
	Total	0.56	0.56	0.00
Proposed (D5P)	Roof	0.00	0.00	0.00
	Drive/Park	0.11	0.11	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.06	0.06	0.00

	Woods	0.05	0.05	0.00
	Total	0.23	0.23	0.00

Proposed (DPb)	Roof	0.00	0.00	0.00
	Drive/Park	0.20	0.20	0.00
	Walk/Patio/etc.	0.00	0.00	0.00
	Lawn	0.05	0.05	0.00
	Woods	0.00	0.00	0.00
	Total	0.25	0.25	0.00

Table 2B. Summary of Peak Runoffs Leaving the Project Site

Sub-watershed		*Peak Runoffs (cfs)*					*Runoff Volume (ac-ft)*				
		2-year	*10-year*	*25-year*	*50-year*	*100-year*	*2-year*	*10-year*	*25-year*	*50-year*	*100-year*
Existing-	*AE1, AE2 (CP1)*	0.780	1.690	2.300	2.760	3.27	0.070	0.140	0.230	0.320	0.430
	BE (CP2)	0.200	0.310	0.380	0.500	0.83	0.020	0.040	0.060	0.080	0.110
	CE (CP2)	0.000	0.000	0.010	0.020	0.07	0.000	0.000	0.000	0.010	0.020
	DE1, DE2 (CP4)	1.810	2.820	3.460	3.930	4.54	0.180	0.290	0.390	0.470	0.570
Proposed- with flood control	*AP1, AP2 (CP1)*	0.780	1.690	2.300	2.760	3.27	0.070	0.140	0.220	0.290	0.38
	BP (CP2)	0.000	0.000	0.020	0.070	0.18	0.000	0.000	0.010	0.020	0.04
	CP (CP3)	0.000	0.000	0.010	0.020	0.07	0.000	0.000	0.000	0.010	0.01
	D1P, D2P,D3P,D4P, D5P, DPb (CP4)	0.800	1.540	2.210	3.250	4.36	0.080	0.170	0.240	0.310	0.42

Table B2b Summary runoff peak and volume change

Control Point	*Change in Peak Runoffs (%)*					*Change in Runoff Volume (%)*				
	2-year	*10-year*	*25-year*	*50-yar*	*100-year*	*2-year*	*10-year*	*25-year*	*50-yar*	*100-year*
Cntrlp1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.3%	-9.4%	-11.6%
Cntrlp2	-100.0%	-100.0%	-94.7%	-86.0%	-78.3%	-100.0%	-100.0%	-83.3%	-75.0%	-63.6%
Cntrlp3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-50.0%
Cntrlp4	-55.8%	-45.4%	-36.1%	-17.3%	-4.0%	-55.6%	-41.4%	-38.5%	-34.0%	-26.3%
Mini	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-11.6%
Max	-100.0%	-100.0%	-94.7%	-86.0%	-78.3%	-100.0%	-100.0%	-83.3%	-75.0%	-63.6%

Table B3. Summary of Peak Elevations

Basin	*2-yr*	*10-yr*	*25-yr*	*50-yr*	*100-yr*
Basin D1	262.140	262.840	263.510	263.770	263.930
Basin D2	256.960	258.880	260.690	261.280	261.580
Basin D3	242.010	242.270	242.540	242.790	243.080
Basin D4	232.080	232.390	232.920	233.330	233.580
Basin D5	220.210	220.750	221.130	221.350	**221.540**

Table B4. Summary of Basin Recharge

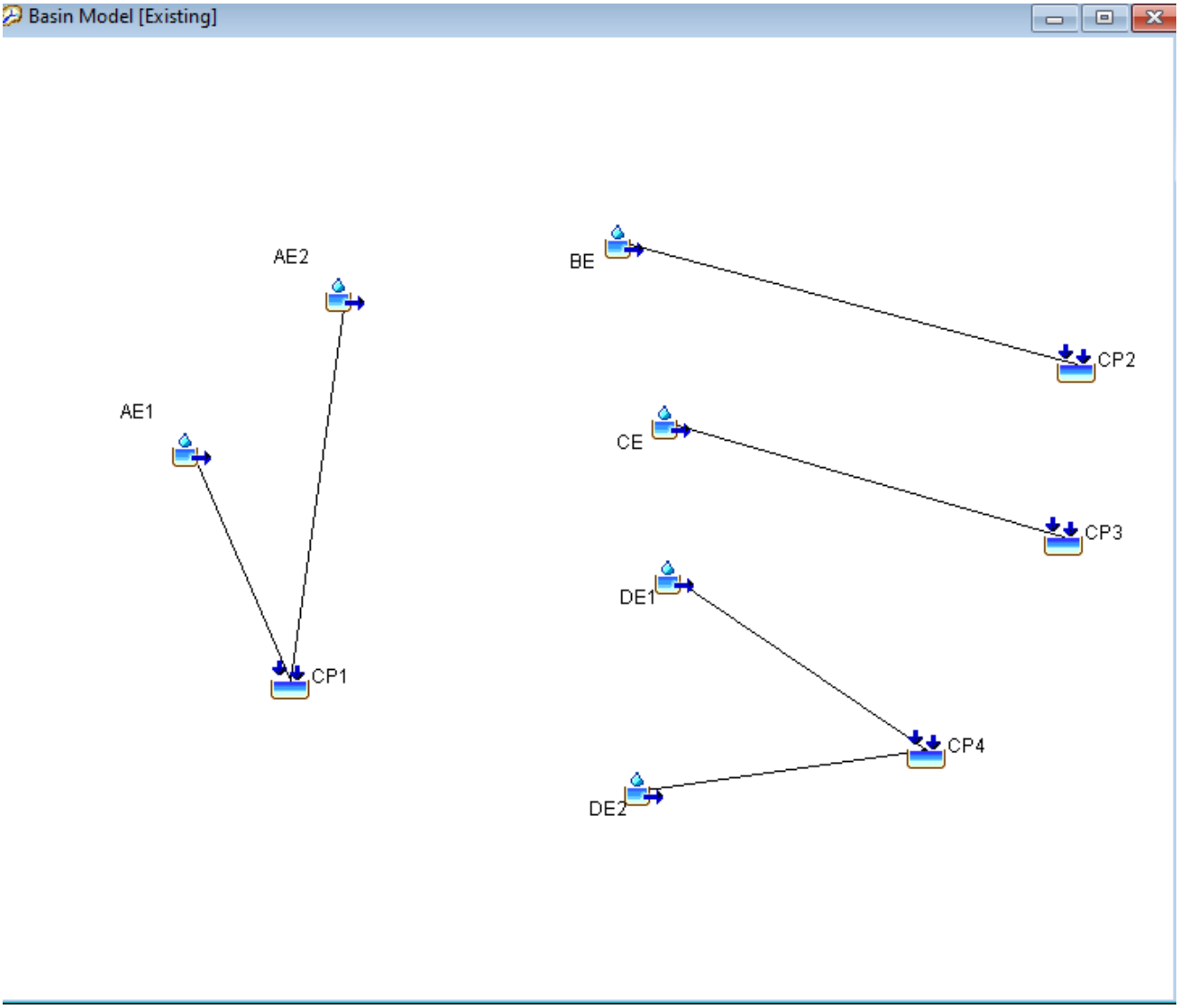
Basin	Recharge	Vol, ac-ft	Vol. cf
Basin D1	rech 1	0.09	3920.4
Basin D2	rech 2	0.2	8712
Basin D3	rech 3	0.05	2178
Basin D4	rech 4	0.1	4356
Basin D5	rech 5	0.07	3049.2
Total			22215.6

The detailed computer outputs are available as the following:

HEC HMS Global Summary Table

Existing		Peak, cfs					Vol, ac-ft				
		2-yr	10-yr	25-yr	50-yr	100-yr	2-yr	10-yr	25-yr	50-yr	100-yr
	Area, sq mi										
AE1	0.00092	0.78	1.69	2.3	2.76	3.26	0.07	0.14	0.19	0.23	0.27
AE2	0.0063	0	0.01	0.07	0.16	0.61	0	0	0.04	0.09	0.16
BE	0.00157	0.2	0.31	0.38	0.5	0.83	0.02	0.04	0.06	0.08	0.11
CE	0.00074	0	0	0.01	0.02	0.07	0	0	0	0.01	0.02
CP1	0.00722	0.78	1.69	2.3	2.76	3.27	0.07	0.14	0.23	0.32	0.43
CP2	0.00157	0.2	0.31	0.38	0.5	0.83	0.02	0.04	0.06	0.08	0.11
CP3	0.00074	0	0	0.01	0.02	0.07	0	0	0	0.01	0.02
CP4	0.00408	1.81	2.82	3.46	3.93	4.54	0.18	0.29	0.39	0.47	0.57
DE1	0.00081	1.56	2.43	2.98	3.39	3.82	0.15	0.23	0.28	0.32	0.36
DE2	0.00327	0.29	0.46	0.56	0.73	1.23	0.03	0.06	0.11	0.15	0.21

Proposed		Peak, cfs					Vol, ac-ft				
		2-yr	10-yr	25-yr	50-yr	100-yr	2-yr	10-yr	25-yr	50-yr	100-yr
Hyd. Elem.	Area, sq. mi										
AP1	0.00092	0.78	1.69	2.3	2.76	3.26	0.07	0.14	0.19	0.23	0.27
AP2	0.00427	0	0.01	0.05	0.12	0.42	0	0	0.03	0.06	0.11
BP	0.00117	0	0	0.02	0.07	0.18	0	0	0.01	0.02	0.04
BSN1	0.00206	0.64	1.23	1.82	2.75	3.76	0.06	0.13	0.19	0.24	0.3
BSN2	0.0028	0.12	0.12	0.18	0.46	1.14	0.04	0.09	0.14	0.19	0.25
BSN3	0.00022	0.2	0.2	0.2	0.2	0.21	0.01	0.02	0.03	0.04	0.05
BSN4	0.00088	0.25	0.25	0.25	0.34	0.67	0.02	0.05	0.07	0.09	0.12
BSN5	0.00036	0.13	0.14	0.18	0.25	0.39	0.02	0.04	0.05	0.06	0.08
CP	0.00051	0	0	0.01	0.02	0.07	0	0	0	0.01	0.01
CP1	0.00519	0.78	1.69	2.3	2.76	3.27	0.07	0.14	0.22	0.29	0.38
CP2	0.00117	0	0	0.02	0.07	0.18	0	0	0.01	0.02	0.04
CP3	0.00051	0	0	0.01	0.02	0.07	0	0	0	0.01	0.01
CP4	0.00671	0.8	1.54	2.21	3.25	4.36	0.08	0.17	0.24	0.31	0.42
div 1	0.00206	0.54	1.13	1.71	2.63	3.64	0.02	0.07	0.11	0.16	0.21
div2	0.0028	0	0	0	0.23	0.88	0	0	0	0.01	0.05
div3	0.00022	0	0	0	0	0.01	0	0	0	0	0
div4	0.00088	0	0	0	0.09	0.41	0	0	0	0	0.01
div5	0.00036	0	0	0.03	0.09	0.23	0	0	0	0	0.01
DPb	0.00039	0.66	1.08	1.34	1.54	1.75	0.06	0.1	0.12	0.14	0.16
D1P	0.00206	1.09	1.95	2.85	3.59	4.44	0.11	0.21	0.28	0.34	0.41
D2p	0.0028	0.73	1.14	1.54	2.17	2.99	0.07	0.14	0.2	0.26	0.33
D3p	0.00022	0.23	0.43	0.56	0.66	0.77	0.02	0.04	0.05	0.06	0.07
D4p	0.00088	0.38	0.61	0.92	1.2	1.52	0.04	0.07	0.1	0.12	0.15
D5p	0.00036	0.36	0.66	0.88	1.04	1.22	0.04	0.06	0.08	0.09	0.11
Reach-1a	0.00206	1	1.85	2.74	3.47	4.31	0.06	0.13	0.19	0.24	0.3
Reach-1b	0.00206	0.54	1.13	1.71	2.63	3.64	0.02	0.07	0.11	0.16	0.21
Reach-2a	0.0028	0.68	1.08	1.48	2.11	2.92	0.04	0.09	0.14	0.19	0.25
Reach-2b	0.0028	0	0	0	0.23	0.88	0	0	0	0.01	0.05
Reach-3a	0.00022	0.21	0.41	0.54	0.64	0.75	0.01	0.02	0.03	0.04	0.05
Reach-3b	0.00022	0	0	0	0	0.01	0	0	0	0	0
Reach-4a	0.00088	0.36	0.58	0.89	1.16	1.49	0.02	0.05	0.07	0.09	0.12
Reach-4b	0.00088	0	0	0	0	0	0	0	0	0	0
Reach-5a	0.00036	0.33	0.64	0.85	1.01	1.19	0.02	0.04	0.05	0.06	0.08
Reach-5b	0.00036	0	0	0	0	0	0	0	0	0	0
rech 1	0	0.09	0.1	0.11	0.12	0.13	0.04	0.06	0.07	0.08	0.09
rech 2	0	0.12	0.12	0.18	0.23	0.26	0.04	0.09	0.14	0.18	0.2
rech 3	0	0.2	0.2	0.2	0.2	0.2	0.01	0.02	0.03	0.04	0.05
rech 4	0	0.25	0.25	0.25	0.26	0.26	0.02	0.05	0.07	0.09	0.1
rech 5	0	0.13	0.14	0.15	0.16	0.16	0.02	0.04	0.05	0.06	0.07



Detailed computer output reports are listed below and available upon request:

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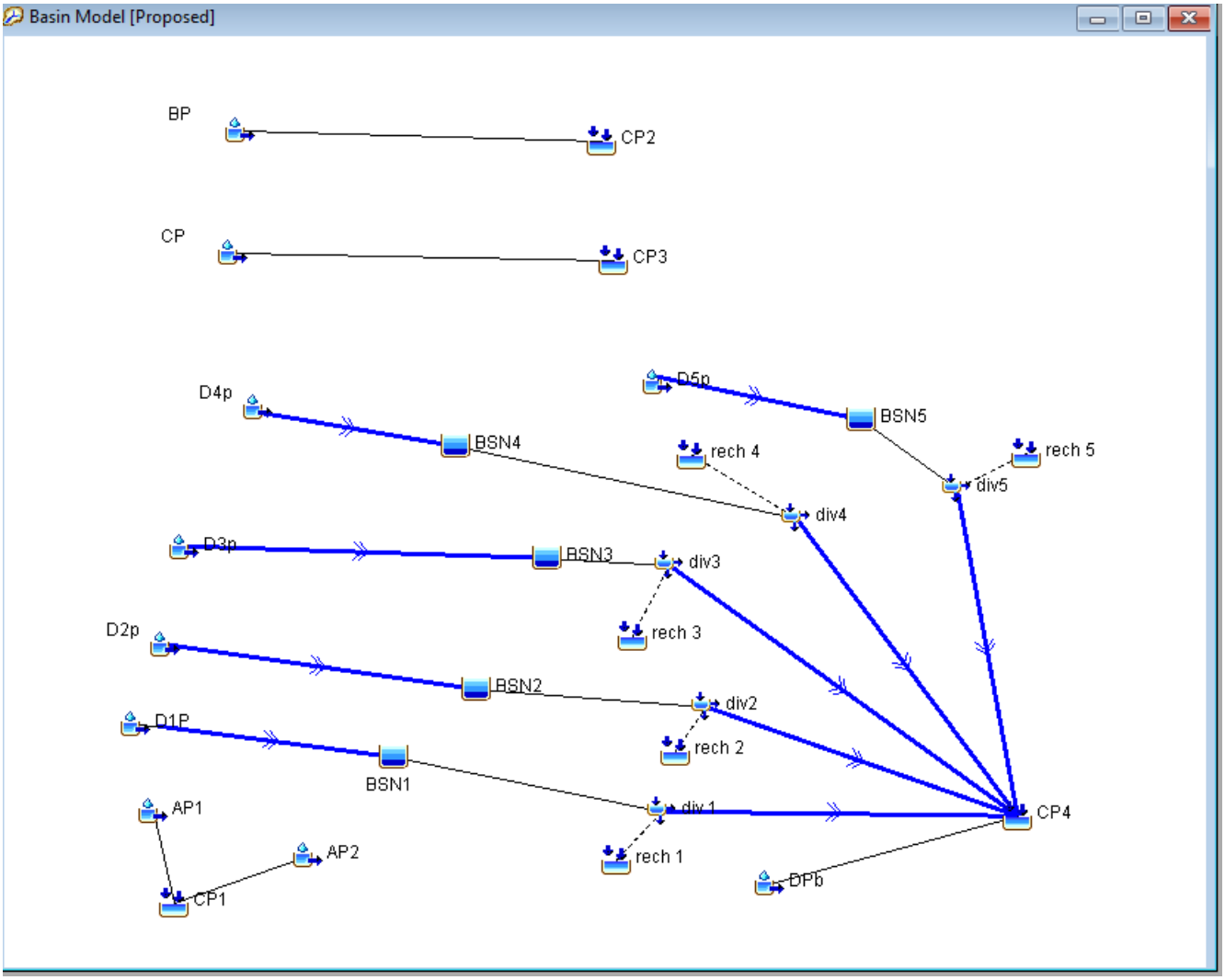
hg ex 10yr.html		9/19/2023 11:09 P...	Microsoft Edg...	1,493 KB
hg ex 25yr.html		9/19/2023 11:06 P...	Microsoft Edg...	1,511 KB
hg ex 100yr.html		9/18/2023 10:53 P...	Microsoft Edg...	1,797 KB



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hg pr 100yr.html		10/3/2023 10:47 A...	Microsoft Edg...	5,412 KB

Appendix C: CALCULATIONS OF STORMWATER QUALITY CONTROL[1]

1. Infiltration Pond

In current Best Management Practices, extended infiltration ponds are one of the most widely used methods. We have used the most recent studies (Schueler 1987, 1992, Urbonas and Stahre 1993) on stormwater quality control by extended infiltration ponds (EDP) to calculate nutrient load. The results are used as a basis for the designs of sediment forebays and water treatment pools. Information on pollutant concentration from runoff (EPA 1983) is used. Pollutant loads from predevelopment and postdevelopment are calculated and compared. Removal efficiency is calculated based on long-term average results from typical basins, U.S. EPA (1986), and adapted to reflect modifications of Walker (1986) and short term dynamic effect. A generalized formula is provided in the following (Wang and Carr 1996):

$$Pr = Prmax(1 - \frac{1}{1 + Vi^{np}}) .\text{fr} \qquad (1)$$

in which, Pr = pollutant removal rate (%);

Prmax = maximum pollutant removal rate (%);
Vi = ratio of designed water treatment volume to the runoff volume from mean storm (about 0.5 inches rainfall);
np = power coefficient, 1.4 is used in this study.
fr = residence time coefficient to reflect the dynamic effect.

$$fr = 1 - [1 + \frac{V_s t}{nh}]^{-n} \qquad (2)$$

where, n = turbulence or short circuiting constant (Fair and Geyer 1954), n = 1 for poor performance, n = 3 for good performance, n >5 for very good, and n = 4 for ideal performance;
Vs = effective settling velocity, ft/hr.
t = residence time, hr;
h = average depth of the pond, ft.

Some Prmax values for some pollutants are summarized here:

Pollutant	Prmax (%)
TSS	100
BOD, COD, Zn,Cu	45
TP	70
TN	50
Pb	95

These removal rates do not include the effect of swales or sediment sumps in catch basins. Removal

[1] Water Quality Module of Stormwater Analysis Version 1.0 © 1996, by Desheng Wang, Ph.D., P.E.,

rates of trace metals can be different due to the form of the metal. The particulate forms of metals are easy to remove. The soluble forms of metals are usually more difficult to remove. However, significant parts of soluble metals appear to adsorb to sediment particles and settle out of the water column. 60% removal rate was estimated in a case when 80% of zinc is in soluble form (Schueler 1987). The following table shows the removal rates of selected pollutants for a typical extended infiltration pond with a water treatment volume of 2.5 times the average runoff volume.

Table A.1: Fact Sheet of Standard Extended Infiltration Ponds (SEDP) (Schueler 1987, 1992)

Contaminant	Removal Efficiency (%)	Remarks
TSS	78	Total suspended solids
TN	41	Total nitrogen
TP	51	Total phosphorus
BOD	40	Biological oxygen demand
COD	40	Chemical oxygen demand
Pb	72	Lead
Zn	40	Zinc
Cu	40	Copper
HCs	60	Hydrocarbons*
Bact	70	Bacteria*

* Based on field studies by EPA (1981), Grizzard et al. (1986).

The SEDP requires that a pond volume equal the runoff volume of a rainfall event with exceedance frequency 90%.

The summary of calculations is presented below.

Standard Pond Volume (Treatment Volume, in acre-ft) (Schueler 1987, 1992):

$$Vp=[(P)(Pj)(Rv)/12]A \qquad (3)$$

Total Pollutant Load in lbs:

$$L=[(P)(Pj)(Rv)/12](A)\ (C)\ (2.72) \qquad (4)$$

where, P=Rainfall depth (inches); Pj=correction factor, equals the accumulative frequency of rainfall events; Rv=runoff coefficient, =0.05 + 0.009I; I= Imperviousness (%); A = watershed area (Acre); L= pollutant load (lbs); C = pollutant concentration (mg/l).

Sediment forebay is designed to hold 5 years accumulation of TSS. Once a year or once every two

years cleanup of the forebay is recommended. In addition, 24 hrs or longer infiltration time is recommended to achieve predicted removal rate (Schueler 1987, Urbonas and Stahre 1993). Most coarse particles are supposed to be trapped by sediment forebay. For a given site condition, the area of the forebay can be determined by the following equation which was derived by the Washington State Department of Ecology from the Camp-Hazen equation (Washington State Department of Ecology, 1992 and Chen, 1975):

$$A_s = -(\frac{Q_o}{\omega}) * Ln(1-E) \qquad (5),$$

where:

A_s = sediment forebay or basin surface area (ft^2);

E = target removal efficiency of suspended solids;

ω = particle settling velocity; for target particle size (silt) use settling velocity = 0.0004 ft/sec for a site with imperviousness larger or equal to 75% and 0.0003 ft/sec for imperviousness < 75%;

Q_o = rate of outflow form the basin; which is equal to the water quality volume divided by the infiltration time (t_d).

Besides the above mentioned pollutants, it has been reported that an order of magnitude reduction in bacterial counts after 32 hours of infiltration occurs (Whipple and Hunter 1981). Also, about 60 - 70% removal of hydrocarbons was reported over the same interval.

In addition to the pond attenuation abilites, marshes are used to provide extra treatment and purification for the water passing through them. Tables A.2 and A.3 provide average removal rates for selected pollutants from typical marshes.

Table A.2 Uptake Potentials of Cattail (Typha latifolia) Marshes (Chan et al 1982)

Contaminant	Uptake (lbs/acre/yr)
TP	9.7 to 358.7
TN	456.3 to 2340.7
Cu	0.32
Zn	0.53
Mn	12.16

Table A.3 Uptake Potentials and Removal Rate of Free Water Surface Marshes (Reed 1990)

Contaminant	Uptake (lbs/acre/yr)	Removal Rate (%)
TSS	125 to 49,508	61 to 95
TP	19.2 to 400.6	31 to 80
TN	215 to 430.6	43 to 93
BOD	220 to 20,764	49 to 95

2. Catch Basins

Catch basins are to be equipped with sediment sumps and oil/grease traps. Regularly maintained and cleaned catch basins can remove significant amounts of pollutants. Table A.4 presents an average removal rate of selected pollutants from catch basin sumps (Aronson et al 1983).

Table A.4 Average Removal Rates of Catch Basins for Selected Contaminants

Contaminant	Average Removal Rate (%)
TSS	58
TN	17
P	4
TM	50

* P = Phosphates; TM = Total metals.

References:

[1] Aronson, G. L., et al. (1983). "*Evaluation of Catchbasin Performance for Urban Stormwater Pollution Control*," Municipal Environmental Research Laboratory, Office of Research and Development, U.S. EPA. EPA-600/2-83-043.

[2] Reed, S. C. (1990). "*Natural Systems for Wastewater Treatment - Manual of Practice FD-16,"* Water Pollution Control Federation.

[3] Shueler, T. (1987) *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Dept. of Environmental Programs, Metropolitan Washington Council of Governments, Washington D. C.

[4] Shueler, T. (1992) *Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetland Systems in the Mid-Atlantic Region*, Anacostia Restoration Team, Dept. of Environmental Programs, Metropolitan Washington Council of Governments, Washington D. C.

[5] Urbonas, Ben, and Stahre, Peter (1993) *Stormwater --Best Management Practices and Infiltration for Water Quality, Drainage, and CSO Management*, PTR Prentice Hall, Englewood Cliffs, New Jersey.

[6] Walker, W. (1986). "*Phosphorus Removal by Urban Runoff Infiltration Basins,"* Presented at Lake and Reservoir Management Conference: Influence on Nonpoint Source Pollutants. North American Lake Management Society, Portland, Oregon, November 5-8, 1986.

[7] Wang, D. S., and Carr, B. J. (1996). "Pollutant Removal Rates for Stormwater Infiltration Ponds," Proceedings of 1996 AIH Conference, Boston.

[8] Claytor, R. A., and Schueler, T. T. (1996) *Design of Stormwater Filtering Systems*, the Center for Watershed Protection, Silver Spring, MD 20910.

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Subject: Groundwater Recharge
Water Quality Calcs.
52 Jasper Hill Road
Location: Holliston

revision by:
By: dsw
Chkd:
Job No.: J136-3

Date: 10/2/2023
Date:
Date:
Sheet: 1

Rev.

1. Land Use Break Down

	Subbasin	Land Uses (Acres) Existing	Proposed	Existing	Proposed	Increment
1	Roof	0.072	0.230	0.072	0.230	0.157
2	Pave	0.614	0.948	0.614	0.948	0.334
3	Pervious	8.026	7.535			
	Total	8.713	8.713	0.687	1.178	0.491
	Imperviousness (%)			7.88	13.52	

2. Groundwater Recharge

Dry wells (2)

Infiltration time (hrs): 6
Diameter (ft): 6 width (ft): Depth (ft): 6 Pipe dia. (in):
Storage volume (cu.ft):
Infil. rate (cfs):
Infiltration volume (cu.ft): 0
Total volume (cu ft) : 0

Impervious area (acres):	A soil	B Soil	C Soil	D Soil	Total			
					0 acres		Provided	
DEP required GW recharge volume:					**0** cu. ft	larger than	**0** cu. ft	OK!

Crushed Gravel

		Basins						
Infiltration time (hrs):	6	Basin D1	Basin D2	Basin D3	Basin D4	Basin D5	Total	
At el. (out INV) (ft):		261	261	243	233	221		
Static Storage volume (cu.ft):		187.00	2790	622	804	854	**5257.00**	
Infil. rate (cfs):		8.30E-02	0.205	0.19546	0.25365	0.149		
Infiltration volume (cu.ft):		1792.8	4428	4221.936	5478.84	3218.4	**19139.98**	
Total volume (cu ft) :		1979.8	7218	4843.936	6282.84	4072.4	**24396.98**	
Hydrological soil group	A soil (0.6)	B Soil (0.:	C Soil	D Soil	Total			
DEP required GW recharge (in):	0.6	0.35	0.25	0.1				
Impervious area (acres):	1.178	0.000	0.000	0.000	1.18 acres		Provided	
DEP required GW recharge volume:	2564.89				**2564.89** cu. ft	less than	**24396.976** cu. ft	OK!

Infiltration trenches:

		Trench						
Infiltration time (hrs):	6	Trench 1	Trench 2	Trench 3	Trench 4	Trench 5	Trench 6	Total
Depth (ft):								
Storage volume (cu.ft):								**0**
Infil. rate (cfs):								
Infiltration volume (cu.ft):		0	0	0	0	0	0	**0**
Total volume (cu ft) :		0	0	0	0	0	0	**0**
Impervious area (acres):	A soil	B Soil	C Soil	D Soil	Total			
					0.000 acres		Provided	
DEP required GW recharge volume:					**0** cu. ft	less than	**0** cu. ft	OK!

An Average Storm Event Runoff:

Precipitation (in): 0.7
Total Impervious area (acres): 1.18
Runoff Volume (cu. ft): **2992.37** This is a conservative average groundwater recharge volume for a average rain event.
Total infiltration capacity(cu.ft): 24396.98 larger than 2992.3688 cu. ft OK !

Conclusion 1: Therefore, the pratical average groundwater recharge compensation will be **2992.3688** cu.ft. larger than **2564.89** cu.ft as DEP required.

3. Average Site TSS Removal Rate

	Subbasin	Area (acres)	TSS removal (%)	A x TSS	
1	*Basin D1*	1.318	90	118.656	mixed
2	*Basin D2*	1.792	90	161.28	mixed
3	*Basin D3*	0.141	90	12.672	mixed
4	*Basin D4*	0.563	90	50.688	mixed
5	*Basin D5*	0.230	90	20.736	mixed
	Total	4.045		364.032	

Total average removal rate 90.00 %

Conclusion 2: The average total suspended solid removal rate is 90.00 % better than existing conditions

4. Water Quality Volume

Water quality rule 0.5 inches

Site Conditions	Impervious area acres	WQV req. cu. ft	WQV provided cu. ft	
existing	0.687	none	none	
Proposed	1.178	2137.4063	24396.976	OK!

Conclusion 3: Therefore, the total stormwater quality volume for proposed condition will be **24396.976** cu.ft. larger than **2137.4063** cu.ft as DEP required.

DSW (c) 6/6/1999, 2023

TSS Removal Calcualtion Worksheet

					Revised:		
Project:	Jasper Hill Estates		Designed by:	dsw	Date:	2-Oct-23	Sheet: 1 of 2
Location:	52 Jasper Hill Road	Holliston	chkd by:		Date:		Job: J136-2
	Basin 1-5		revision:		Date:		

A	B	C	D	E
BMP*	TSS Removal Rate	Starting TSS	Amount Removed (BxC)	Remaining Load (C - D)
Grass channel	0.5	1	0.5	0.5
IB	0.8	0.5	0.4	0.1

Total TSS Removal= 0.90

* WQS = water quality swale; WQI = water Qality inlet; EDB = extended detention basin.
DSCB = deep sump catch basin; SW = sweeping; DW=drywell; IT = infiltration trench.
FB = sediment Forebay; CW = constructed wetland, RB = retention basin, WB = wet basin
IB = Infiltration Basin, GC = grass channels
Reference: MADEP (2008) Stormwater Management, Volume I & II.

TSS Removal Calcualtion Worksheet

					Revised:			
Project:	Jasper Hill Estates		Designed by:	dsw	Date:	2-Oct-23	Sheet:	1 of 2
Location:	52 Jasper Hill Road	Holliston	chkd by:		Date:		Job:	J136-2
	Basin 1-5		revision:		Date:			

A	B	C	D	E
BMP*	TSS Removal Rate	Starting TSS	Amount Removed (BxC)	Remaining Load (C - D)
Grass channel	0.5	1	0.5	0.5
IB	0.8	0.5	0.4	0.1

Total TSS Removal= 0.90

* WQS = water quality swale; WQI = water Qality inlet; EDB = extended detention basin.
DSCB = deep sump catch basin; SW = sweeping; DW=drywell; IT = infiltration trench.
FB = sediment Forebay; CW = constructed wetland, RB = retention basin, WB = wet basin
IB = Infiltration Basin, GC = grass channels
Reference: MADEP (2008) Stormwater Management, Volume I & II.

CALCULATIONS OF STORMWATER QUALITY CONTROL

						revision:	
Project:	Jasper Hill Estates	Street:	Jasper Hill Road	User:	dsw	Date:	2-Oct-23
Site:	52 Jasper Hill Road	Town:	Holliston			Job:	J136-3
County:	Middlesex	State:	MA	Check:		Sheet:	1 of 1

Input Report:

P=Rainfall depth (inches): Pj=Correction factor: 0.9000

Event	1.250	C=Concentration (mg/l):					
Annual	45.000		Resid. (R)	Comm. (C)	Nonurban (N)	Constr. (S)	User define(U)
I=Imperviousness (%):		TSS	101.0000	69.0000	70.0000	10000.0000	505.0000
Pre-Development	7.883	TN	1.9000	1.1800	0.9650		9.5000
Post-Development	13.516	TP	0.3830	0.2010	0.1210		1.9150
Watershed condition:		BOD	10.0000	9.3000	9.0000		50.0000
Pre-Development	R	COD	73.0000	57.0000	40.0000		365.0000
Post-Development	R	Pb	0.1440	0.1040	0.0300		0.7200
A=Watershed area (Acres):		Zn	0.1350	0.2260	0.1950		0.6750
Pre-Development	8.713	Cu	0.0330	0.0290	0.0300		0.1650
Post-Development	8.713						

Designed Pond:

Volume (ac-ft)	0.560	Mean depth (ft):	7.500
Area (Acres)	0.104	Eff. sett. vel. (ft/hr):	1.600
Residence Time (hrs)	72.000	Turbulence factor:	5.000
Forebay Trap Efficiciency (%)	25.000		

Output Report:

	Predevelopment	Postdevelopment
Site Condition:	Residential	Residential
Rv=	0.121	0.17
Standard Vp (Ac-ft):	0.099	0.14
Effective treatment ratio:		9.99
Min. Sediment Forebay (cu. ft):		414.66
Sediment Forebay area (sq. ft.)	1000.000	1000.00
Sediment forebay depth (ft)	2.000	2.00
Residence time coef.:		1.00

	Predevelopment	Postdevelopment		Removal efficiency (%)	Conc. (mg/l)
Annual Nutrients (lbs/yr):		Before treated	After treatment	Predicted *	Predicated
TSS	977.062	1386.598	54.373	96.079	3.961
TN	18.380	26.085	13.554	48.039	0.987
TP	3.705	5.258	1.722	67.255	0.125
BOD	96.739	137.287	77.930	43.235	5.676
COD	706.193	1002.195	568.892	43.235	41.438
Pb	1.393	1.977	0.172	91.275	0.013
Zn	1.306	1.853	1.052	43.235	0.077
Cu	0.319	0.453	0.257	43.235	0.019

*After average results from U.S. EPA (1986), and adapted to reflect modifications of Walker (1986).

Nutrient Removal by Plant Uptake**

Contaminant	Uptake (lbs/acre/yr)		Ave uptake (lbs/yr)	Ave. removal (%)	Reference Total Removal (%)
TSS	125 to 49508		2591.604	78.000	99.137
TN	215 to 430.6		33.710	68.000	83.373
TP	19.2 to 400.6		21.920	55.500	85.429
BOD	220 to 20764		1095.687	72.000	84.106

* *After average results from Reed (1990).

Water Quality Module of Stormwater Analysis Version 1.3 (c) by Desheng Wang, Ph.D., P.E., 1998, Carr Research Laboratory, Inc., 251 West Central Street, D-36, Natick, MA 01760

APPENDIX D: INFILTRATION CALCULATIONS
by Desheng Wang, Ph.D., P.E., © 2000

This appendix presents the calculation method for an infiltration rate. The whole method includes: effective infiltration area, infiltration rate, and water quality benefit. It is noted that infiltration facilities should only be used in very permeable soils.

1.0 Effective Infiltration Area

To keep an infiltration facility functioning, the most important thing is to prevent sediment from entering the effective infiltration area. It is recommended that storm runoff be pretreated by sediment sumps before be discharged to the infiltration facility. If a basin does become severely clogged, partial or complete replacement of the structure may be required [1]. It is recommended that for an infiltration facility such as an infiltration basin/trench, only the sides of the basin/trench should be used as the effective infiltration area. The reason for this is that the bottom eventually is sealed by the accumulation of sediments. For a recharge galley or infiltration basin/trench filled with crushed stone, the bottom area can be counted as part of the effective area, providing there is a sump with access for sediment removal.

2.0 Design of the Basin/trench

There are two aspects to consider in the design of an infiltration basin/trench: one is the function in reducing runoff peak flow; the other is stormwater quality control. Water quality control is controlled by the volume of the basin/trench. The peak flow is controlled by the infiltration rate of the basin/trench. The infiltration rate of a basin/trench is determined by the on-site soil condition and the size of the basin/trench.

2.1 Volume of the Basin/trench

To maximize the pollutant attenuation, the volume of the infiltration basin/trench can be designed as large as possible. However, studies (Griffin et al., 1980; MD WRA, 1986) showed that a great port of pollutant loads is delivered during the early part of storms or the first flush of the storm. The first flush storm is the runoff due to the first half of an inch of rain. To store this part of runoff is the key to achieve better stormwater quality. Two basic rules are commonly used to determine the basin/trench volume for water quality benefit. The first rule is to size the basin/trench storage volume as 0.5 inches of runoff volume per impervious acre in the contributing watershed (MD WPA, 1986), using

$$V = 0.5 * A * Imp$$

where, V = Volume of the porous of the basin/trench (ac-in);
A = Watershed area (acre);

Imp = fraction of site imperviousness.

The second rule is to size the basin/trench so that it is capable of storing runoff produced from a one

$$V = 1.0\, R_v\, A$$

inch storm over the contributing watershed (Schueler 1987), using

where, R_v = Runoff coefficient, R_v=0.05+0.009 (I); I = the percent of site imperviousness.

The expected pollutant removal rate for a basin/trench with this design volume is presented in the following table.

Table A.1: Estimated Long-term Pollutant Removal Rate (%) for Full Exfiltration Basin (Shueler 1987)

Pollutant	Removal Rate	
	Rule 1	**Rule 2**
Sediment	75%	90%
Total Phosphorus	50-55%	60-70%
Total Nitrogen	45-55%	55-60%
Trace Metals	75-80%	85-90%
BOD	70%	80%
Bacteria	75%	90%

If catch basins are all equipped with sediment sumps, the final pollutant removal rates are expected higher for both rules. Table A.2 presents average removal rates for selected pollutants from catch basin sumps (Aronson et al 1983).

Table A.4 Average Removal Rates of Catch Basins for Selected Contaminants

Contaminant	Average Removal Rate (%)
TSS	58
TN	17
P	4
TM	50

* P = Phosphates; TM = Total metals.

2.2 Infiltration Rate

It is important to know that there is an unsaturated zone underneath an infiltration basin/trench. However, it is not necessary to have this zone for infiltration to take place. In case of on-site sewage disposal design, this unsaturated zone is important for bio-treatment of waste water. In general, a 2 to 5 ft. separation from the water table to the bottom of the basin/trench is recommended or required by state regulations (Finnemore, 1993). It is not necessary to have such a zone for a stormwater recharge basin/trench. The calculation method here is based on the permeability test which can be used for both saturated infiltration flow and flow penetration into the water table [4].

One of the most common on-site constant head test [4] uses the following formula to calculate soil

$$k = \frac{Q}{5.5rH}$$

permeability:
where, k = permeability,
Q = constant rate of flow into the test hole,
r = internal radius of casing, and
H = differential head of water.

This formula requires that the aquifer thickness underneath the pipe should be larger than 10r. From this formula, we can conclude that for a given soil condition, the infiltration rate will be proportional to the free water depth in the basin/trench. The most effective depth of free water in the basins/trenches was found to be four feet. Significantly lesser or greater depths resulted in reduced rates of infiltration, the former because of inadequate entrance head and the latter because of increasing weight-compaction of the soil (Baumann, 1965). Based on this formula, we can calculate the infiltration rate through bottom surface Q_1 can be calculated in the following ways.

For a circular surface:

$$Q_1 = 5.5\ rHk$$

For a rectangular surface with width B and length L, the above formula can be modified to account for the change in shape (Wang 1999):

$$Q_1 = 3.50\ kHB(0.5 + L/2B)$$

The infiltration rate through side surface Q_2 is calculated by Darcy's formula assuming the hydraulic gradient equals 1.0 [3] and assuming that the recharge galley does not penetrate the water table.

$$Q_2 = k\ A_s$$

Where, A_s = side surface area of the basin/trench, = $2BrH$ for a circular section; = $2(B+L)H$ for a rectangular section.

The total infiltration rate is the summation of rates through bottom surface and side surfaces:

$$Q = Q_1 + Q_2$$

3.0 Overflow Structure

Overflow structures should be installed at the end of the recharge basins/trenches. Typical overflow structures are weirs. It is recommended that the overflow water leaves as sheet flow to the downgradient area to avoid possible erosion. Wells of small diameters should also be installed in the ends of each for dual purposes of (a) measurement of the distance to and sampling of ground water and (b) aiding in the expulsion of air as the mound rises. Trapped air may cause slow infiltration, especially when there is a large separation between the basin/trench and the normal water table.

4.0 Summary

This appendix presents the design method of an infiltration basin/trench. The design criteria include water flood control and water quality management. For a given hydrological condition (runoff hydrograph), the size of the basin/trench can be easily determined by the formulas given in this appendix. A computer program is designed to carry out the computations. Flood routing can be further applied to a determined larger flood when overflows may occur.

References:

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[2] Shueler, T. (1992) *Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetland Systems in the Mid-Atlantic Region*, Anacostia Restoration Team, Dept. of Environmental Programs, Metropolitan Washington Council of Governments, Washington D. C.

[3] Urbonas, Ben, and Stahre, Peter (1993) *Stormwater --Best Management Practices and Infiltration for Water Quality, Drainage, and CSO Management*, PTR Prentice Hall, Englewood Cliffs, New Jersey.

[4] U.S. D. I. (1974) *Earth Manual - A Water Resources Technical Publication*, Washington, D.C.

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[9] Hantush, M. S. (1967) "Growth and Decay of Groundwater-Mounds in Response to Uniform Percolation," *Water Resources Research*, Vol. 3, No. 1, First Quarter, 1967, 227-234.

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[11] Baumann, P. (1965) "Technical Development in Ground Water Recharge," *Advances in Hydroscience*, Vol. 2, New York, Academic Press, 209-279.

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On May 15, 16, and 19, we evaluated eight (19) soil test pits: 15 for septic system and 4 for stormwater management system design, and conduct ten percolation testing and 4 permeability testing in representative test pits to guide the design locations of stormwater infiltration systems and septic system design. We also checked a dozen existing monitoring pipes on site, which were all dry at the time of our testing. The testing confirmed NRCS soil rating well. See the following summary table for a general site soil condition. Based on the percolation testing, the average infiltration rate exceeds 12 in/hour. Therefore, 8.27 in/hour will be used per MASWMHK Rawl's table.

Summary of Soil Evaluation

Summary of Soil testing							
52 Jasper Hill Road, Holliston, MA							
Soil Evaluator:	Desheng Wang		Witnessed by:	Scott Moles			
Test pit	Approx G.S. Elev, ft	Date	Soil texture	EHGW, ft	GW, elev., f	Percolation rate, mpi	Note
DHTP 1-1	310.5	5/17/2023	L.S.	8	302.5	3	
DHTP1-2	308.2	5/17/2023	L.S-M.S.	9	299.2	3	
DHTP1-3	312.4	5/17/2023	L.S.	6	306.4	-	Deep Hole Only
DHTP 2-1	296.3	5/16/2023	L.S.	8	288.3	3	
DHTP 2-2	293.1	5/16/2023	M.L.S.	7	286.1	5	
DHTP 2-3	294.3	5/16/2023	L.S.	7	287.3	-	Deep Hole Only
DHTP 3-1N	302.63	5/19/2023	M.L.S.	7	295.63	2	
DHTP 3-2N	301.45	5/19/2023	L.S.	7	294.45	<2	
DHTP 3-3N	297.26	5/19/2023	L.S.	8	289.26	-	Deep Hole Only
DHTP 4-1	280.4	5/15/2023	M.L.S.	7	273.4	9	
DHTP 4-2	277.2	5/15/2023	M.L.S-M.S.	9	268.2	<2	
DHTP 4-3	276.6	5/15/2023	L.S.	8	268.6	-	Deep Hole Only
TP-1	268.2	5/15/2023	F.S.-Co.M.S.	9	259.2	-	Stormwater
TP-2	281.0	5/17/2023	M.S.	8	273	-	Stormwater
TP-8	253.5	5/15/2023	Co.M.S.	10	243.5	-	Stormwater
TP-10	298.26	5/17/2023	M.L.S.-M.S.	7	291.26	-	Stormwater
OD #52-2 (MW-21)	293.53	10/13/2004	L.S.	3	290.53	8	By Ralph Wegener
#55-5 (MW-21)	294.94	10/13/2004	S/L.S.	4.5	290.44	2	By Ralph Wegener
GML#7		-	-	-	-	-	By Others. No Record

Creative Land & Water Engineering, LLC
Environmental Science and Resource Management
P.O. Box 584, Southborough, MA 01772
Tel: (508)281-1694 Fax: (508)281-1694

Subject:	Permeability Test	Tested:	FA	Date:	5/15/2023
	52 Jasper Hill Rd	**Calc.:**	BW	**Date:**	5/18/2023
	Holliston, MA	**Chk.:**		**Date:**	
	Email: deshengw@yahoo.com	**Job No.:**	J136-3	**Sheet:**	1 of 4

Site Condition

Hole #:	STW 1		
Soil:	F.S. - Co.M.S	Landform:	
Depth to Bed Rock (ft):		Position:	See Plan
Depth to GW (ft):	9		
Casing Dia., 2r, (in):	6	Casing height (ft):	3.12
Depth to the bottom (ft):	4	Exposed casing (ft):	1.1

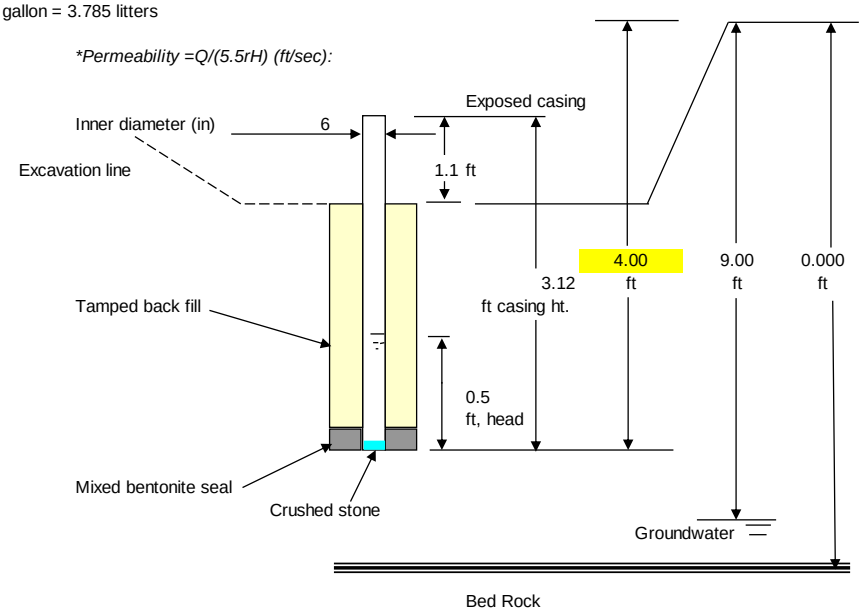
Summary of Constant Head Test (Method E-18, USDI)

Standard Temperature for Permeability Calculation (oC): 20 (68 F)

Test #	Time sec	Head ft	Volume gallon	Temp. oC	Correct. Ceof.	Permeability (ft/sec)* Field	Standard
1	88.15	0.500	0.066	12.00	1.2270	1.4571E-04	1.7879E-04
2	81.15	0.500	0.066	12.00	1.2270	1.5827E-04	1.9421E-04
3	92.94	0.500	0.066	12.00	1.2270	1.3820E-04	1.6957E-04
4	85.36	0.500	0.066	12.00	1.2270	1.5047E-04	1.8463E-04
5	89.79	0.500	0.066	12.00	1.2270	1.4304E-04	1.7552E-04
6	95.06	0.500	0.066	12.00	1.2270	1.3511E-04	1.6579E-04
7	88.69	0.500	0.066	12.00	1.2270	1.4482E-04	1.7770E-04
8	84.32	0.500	0.066	12.00	1.2270	1.5232E-04	1.8691E-04
9	92.58	0.500	0.066	12.00	1.2270	1.3873E-04	1.7023E-04
10	88.82	0.500	0.066	12.00	1.2270	1.4461E-04	1.7744E-04

1 gallon = 3.785 litters

**Permeability =Q/(5.5rH) (ft/sec):*



Permeability Rate at 95% Confidence Level			degree of freedom	$t_{0.05}$
No. of tests, n:		10	1	6.314
Degree of freedon, n-1:		9	2	2.920
Mean permeability (ft/sec), m:		1.78E-04	3	2.353
Probability, α:		0.050	4	2.132
Standard deviation (ft/sec), σ:		8.65E-06	5	2.015
t distribution, α=	0.05:	1.833113	6	1.943
Permeability at confidence level:	**95%:**	**0.000173**	7	1.895
(Half rate in/hr):		3.74	8	1.860

Permeability Calculation V1.1 method 1, by Desheng Wang, Ph.D., P.E, Creative Land & Water Engineering, LLC., Southborough, MA

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Environmental Science and Resource Management
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Tel: (508)281-1694 Fax: (508)281-1694

Subject:	Permeability Test	Tested:	DSW	Date:	5/17/2023
	52 Jasper Hill Rd	**Calc.:**	BW	**Date:**	5/18/2023
	Holliston, MA	**Chk.:**		**Date:**	
	Email: deshengw@yahoo.com	**Job No.:**	J136-3	**Sheet:**	2 of 4

Site Condition

Hole #:	STW 2		
Soil:	M.S.	Landform:	
Depth to Bed Rock (ft):		Position:	See Plan
Depth to GW (ft):	8		
Casing Dia., 2r, (in):	6	Casing height (ft):	3.12
Depth to the bottom (ft):	4.42	Exposed casing (ft):	0.7

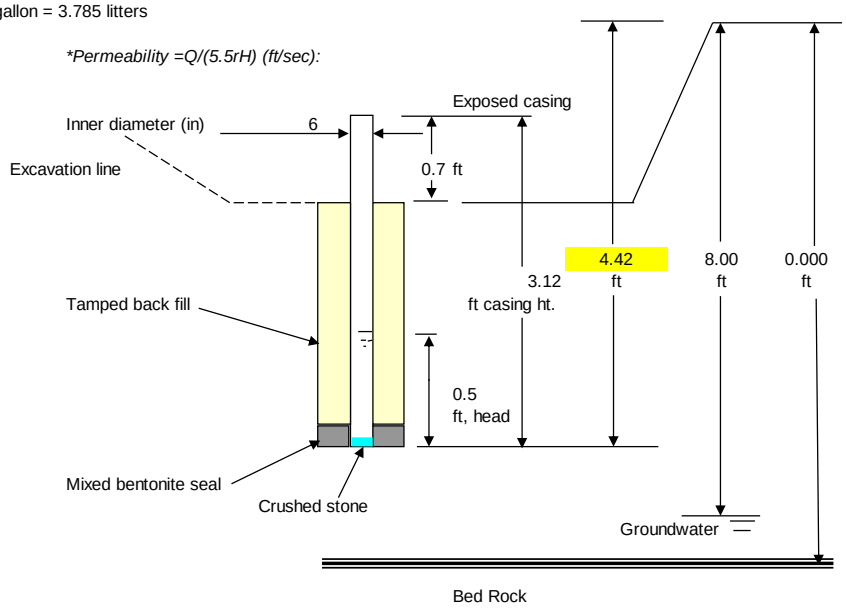
Summary of Constant Head Test (Method E-18, USDI)

Standard Temperature for Permeability Calculation (oC): 20 (68 F)

Test	Time	Head	Volume	Temp.	Correct. Ceof.	Permeability (ft/sec)*	
#	sec	ft	gallon	oC		Field	Standard
1	168.03	0.500	0.066	12.00	1.2270	7.6439E-05	9.3793E-05
2	187.08	0.500	0.066	12.00	1.2270	6.8655E-05	8.4242E-05
3	181.19	0.500	0.066	12.00	1.2270	7.0887E-05	8.6981E-05
4	194.03	0.500	0.066	12.00	1.2270	6.6196E-05	8.1225E-05
5	178.98	0.500	0.066	12.00	1.2270	7.1762E-05	8.8055E-05
6	191.41	0.500	0.066	12.00	1.2270	6.7102E-05	8.2336E-05

1 gallon = 3.785 litters

**Permeability =Q/(5.5rH) (ft/sec):*



Permeability Rate at 95% Confidence Level			degree of freedom	$t_{0.05}$
No. of tests, n:		6	1	6.314
Degree of freedon, n-1:		5	2	2.920
Mean permeability (ft/sec), m:		8.61E-05	3	2.353
Probability, α:		0.050	4	2.132
Standard deviation (ft/sec), σ:		4.59E-06	5	2.015
t distribution, α= 0.05:		2.015048	6	1.943
Permeability at confidence level:	**95%:**	**8.23E-05**	7	1.895
(Half rate in/hr):		1.78	8	1.860

Permeability Calculation V1.1 method 1, by Desheng Wang, Ph.D., P.E, Creative Land & Water Engineering, LLC., Southborough, MA

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P.O. Box 584, Southborough, MA 01772
Tel: (508)281-1694 Fax: (508)281-1694

Subject:	Permeability Test	Tested:	DSW	Date:	5/15/2023
	52 Jasper Hill Rd	**Calc.:**	BW	**Date:**	5/18/2023
	Holliston, MA	**Chk.:**		**Date:**	
	Email: deshengw@yahoo.com	**Job No.:**	J136-3	**Sheet:**	3 of 4

Site Condition

Hole #:	STW 8		
Soil:	MS	Landform:	
Depth to Bed Rock (ft):		Position:	See Plan
Depth to GW (ft):	6		
Casing Dia., 2r, (in):	6	Casing height (ft):	3.12
Depth to the bottom (ft):	4	Exposed casing (ft):	1.55

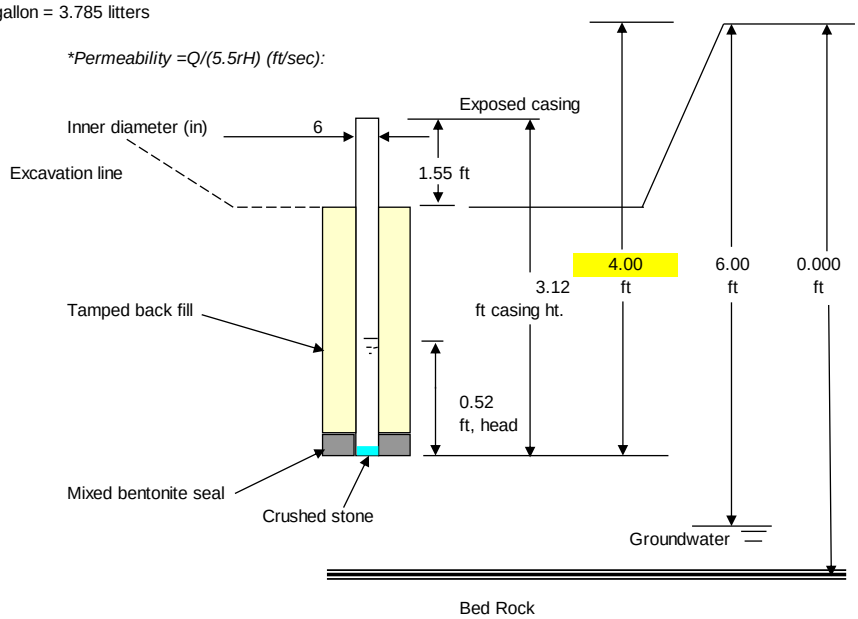
Summary of Constant Head Test (Method E-18, USDI)

Standard Temperature for Permeability Calculation (oC): 20 (68 F)

Test	Time	Head	Volume	Temp.	Correct. Ceof.	Permeability (ft/sec)*	
#	sec	ft	gallon	oC		Field	Standard
1	98.17	0.520	0.066	12.00	1.2270	1.2580E-04	1.5436E-04
2	120.92	0.520	0.066	12.00	1.2270	1.0213E-04	1.2532E-04
3	104.38	0.520	0.066	12.00	1.2270	1.1832E-04	1.4518E-04
4	107.67	0.520	0.066	12.00	1.2270	1.1470E-04	1.4074E-04
5	118.43	0.520	0.066	12.00	1.2270	1.0428E-04	1.2796E-04
6	121.11	0.520	0.066	12.00	1.2270	1.0197E-04	1.2512E-04
7	119.48	0.520	0.066	12.00	1.2270	1.0336E-04	1.2683E-04
8	126.55	0.520	0.066	12.00	1.2270	9.7590E-05	1.1975E-04

1 gallon = 3.785 litters

**Permeability =Q/(5.5rH) (ft/sec):*



Permeability Rate at 95% Confidence Level			degree of freedom	$t_{0.05}$
No. of tests, n:		8	1	6.314
Degree of freedon, n-1:		7	2	2.920
Mean permeability (ft/sec), m:		1.33E-04	3	2.353
Probability, α:		0.050	4	2.132
Standard deviation (ft/sec), σ:		1.21E-05	5	2.015
t distribution, α= 0.05:		1.894579	6	1.943
Permeability at confidence level:	**95%:**	**0.000125**	7	1.895
(Half rate in/hr):		2.70	8	1.860

Permeability Calculation V1.1 method 1, by Desheng Wang, Ph.D., P.E, Creative Land & Water Engineering, LLC., Southborough, MA

Creative Land & Water Engineering, LLC
Environmental Science and Resource Management
P.O. Box 584, Southborough, MA 01772
Tel: (508)281-1694 Fax: (508)281-1694

Subject:	Permeability Test	Tested:	DSW	Date:	5/17/2023
	52 Jasper Hill Rd	**Calc.:**	BW	**Date:**	5/18/2023
	Holliston, MA	**Chk.:**		**Date:**	
	Email: deshengw@yahoo.com	**Job No.:**	J136-3	**Sheet:**	4 of 4

Site Condition

Hole #:	STW 10		
Soil:	M.L.S.-M.S.	Landform:	
Depth to Bed Rock (ft):		Position:	See Plan
Depth to GW (ft):	7		
Casing Dia., 2r, (in):	6	Casing height (ft):	3.12
Depth to the bottom (ft):	3.92	Exposed casing (ft):	0.7

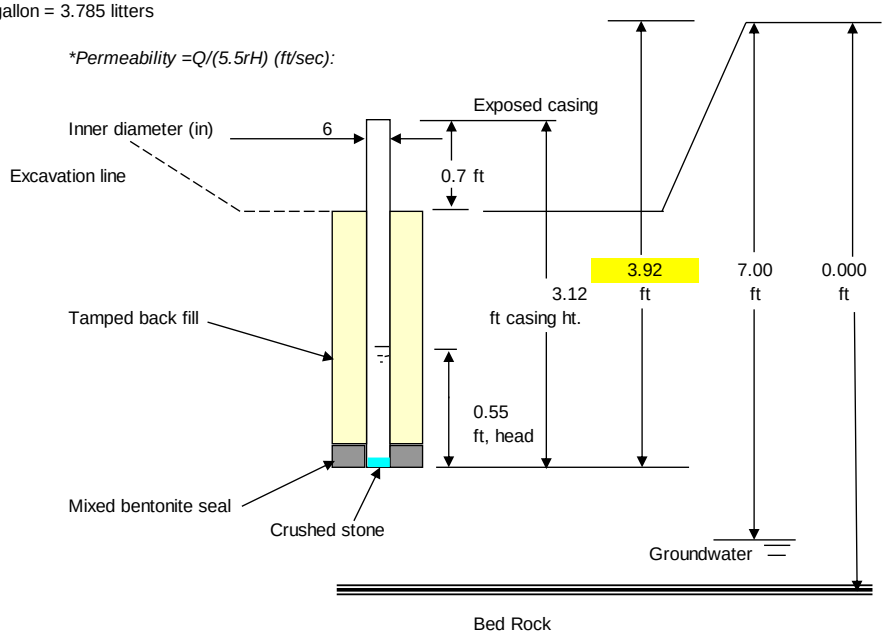
Summary of Constant Head Test (Method E-18, USDI)

Standard Temperature for Permeability Calculation (oC): 20 (68 F)

Test	Time	Head	Volume	Temp.	Correct. Ceof.	Permeability (ft/sec)*	
#	sec	ft	gallon	oC		Field	Standard
1	103.01	0.550	0.066	12.00	1.2270	1.1335E-04	1.3909E-04
2	96.91	0.550	0.066	12.00	1.2270	1.2049E-04	1.4784E-04
3	102.94	0.550	0.066	12.00	1.2270	1.1343E-04	1.3918E-04
4	118.29	0.550	0.066	12.00	1.2270	9.8710E-05	1.2112E-04
5	104.44	0.550	0.066	12.00	1.2270	1.1180E-04	1.3718E-04
6	108.62	0.550	0.066	12.00	1.2270	1.0750E-04	1.3190E-04

1 gallon = 3.785 litters

**Permeability =Q/(5.5rH) (ft/sec):*



Permeability Rate at 95% Confidence Level			degree of freedom	$t_{0.05}$
No. of tests, n:		6	1	6.314
Degree of freedon, n-1:		5	2	2.920
Mean permeability (ft/sec), m:		1.36E-04	3	2.353
Probability, α:		0.050	4	2.132
Standard deviation (ft/sec), σ:		8.94E-06	5	2.015
t distribution, α= 0.05:		2.015048	6	1.943
Permeability at confidence level:	**95%:**	**0.000129**	7	1.895
(Half rate in/hr):		2.78	8	1.860

Appendix E: OPERATION AND MAINTENANCE PLAN FOR STORMWATER BMPs

	During Construction	Post-construction
BMB Owner:	J. Dennis Morgan Morgan Jasper Hill Realty Trust, LLC 340 Winter St. Framingham, MA 01702 617-571-7744	To be determined
Party of Plan Responsibility:	J. Dennis Morgan Morgan Jasper Hill Realty Trust, LLC 340 Winter St. Framingham, MA 01702 617-571-7744	To be determined

Signature

The stormwater management system is depicted in the engineering plan by Creative Land & Water Engineering, LLC: Stormwater Management Plan, The Jasper Hill Estates, August 30, 2023

Illicit discharges into stormwater management system per 310 CMR 1.04 are perpetually prohibited and agreed to be implemented by the owner. No sewer pipes or floor drains will be connected to the drainage network. All wastewater will be connected to a dedicated private onsite septic system as approved.

Personnel Training – All contracted personnel retained for work on site will be given a copy of this Plan and will receive training in applicable practices and implementation to prevent pollutants from entering the stormwater system

The plan includes ***Housekeeping and Reporting, Routine Operation and Maintenance (long-term pollution source control, pavement sweeping, landscaping, stormwater structure) Emergency Action or Accidental Spill Plan, Mosquito Control in sumps.*** *A typical O&M recording form is also created for reference use.*

<u>Housekeeping and Reporting</u>

The property owner or designated property manager will be responsible for carrying out this operation and maintenance, i.e., long-term pollution prevention plan. All maintenance conducted shall be recorded and the records shall be kept on site for at least 3 year for auditing by approving authorities or relevant **Town officials**. See attached record forms for reference.

Routine Operation and Maintenance

Sediment and Erosion Control

1. During construction, **weekly or biweekly** inspection of erosion control straw wattles/hay bales and silt fences should be conducted by a qualified staff of the responsible party or an independent sediment and erosion control expert hired by the responsible party. Any displaced straw wattles or broken siltation fences should be restored or repaired immediately. All silt fences and straw wattles shall be installed at minimum **30 feet** from wetlands or 5 feet from the property line unless permitted by Holliston Conservation Commission.

Long-term Pollution Source Control

2. All potential pollution materials shall be stored properly inside and under cover
    a. Fuel (other than in vehicles or equipment), if any, will be stored for machinery or motor use in fire proof cabinet and inspected routinely
    b. Fertilizers, herbicides, and pesticides, if any, will be stored inside in secured cabinet or bins
    c. House cleaning chemical(s) shall be stored in secured cabinet(s)
    d. De-icing materials, if any, shall be waterproof covered, or stored inside.
    e. Snow shall be plowed and stored in vegetated area or dedicated parking spaces where runoff from snowmelt will be collected and treated by the parking lot drainage system. In case of large snow storm, excessive snow shall be trucked off site and disposed in the town snow dump.
    f. All hazardous materials (battery, light bulbs, etc.) shall be recycled or disposed in accordance with the State and Town requirements.
    g. Pet waste, if any, shall be collected and disposed properly in accordance with **Town** policy. **No pet wastes shall be dumped in the drainage system.** Residents and visitors will be encouraged to pick up after their pets with signage along lawn areas

Pavement Sweeping/General Landscape Maintenance

3. The driveway and parking lot shall be swept quarterly (by high efficiency vacuum sweeper or regenerative air sweeper) or monthly (Mechanical weeper, rotary broom), or per the Town of Holliston standard practice.
4. During growing season, the lawn and landscaping for each house will be mowed and maintained weekly or biweekly depending on the growth and weather condition. All landscape debris will be removed from lawn or landscaping and parking area and disposed of off site or used for compost.
5. The use of fertilizers shall be limited to slow-release, low nitrogen granular fertilizers.

Drainage/Stormwater Structure(s)

6. a)The catch basins and oil/grit separators, discharge level spreaders should be inspected at least four times per year and at the end of the foliage and snow removal seasons. Sediment must be removed four times a year or whenever the **depth of deposits is greater than or equal to one half the depth from the lowest pipe invert in the basin.** Catch basin sediment should be cleaned by clamshell buckets or vacuum truck. Debris over the level spreader shall be cleaned up. b) Oil/Grit separator should be inspected monthly and cleanout at least twice per year or as needed per inspection. c) All polluted water or sediments removed from the system should be disposed of in accordance with all applicable local, state and federal laws and regulations. d) The regular manholes shall be inspected annually to check if any settlement and damage for repair. All accumulated sediment and debris in the subsurface infiltration structures and level spreaders should be removed and disposed. Note and repair any erosion or low spots observed on level spreaders. **After the construction completed**, the observation port of the infiltration trenches, distribution manholes, oil/grit separators and the discharge level spreaders should also be inspected at least four times a year for the first year following the catch basin inspection schedule, which can be reduced to annual after have a

understanding of the operation condition as expected. The parking lot will be swept twice a year: one before hurricane season, the other in the spring after snowmelt, or per the **Town of Holliston** standard practice.

7. Install oil trap elbows in all deep sump catchbasins. It is recommended that the vertical length of the oil trap below the outlet invert be at least 12 inches. All catch basins shall be protected with filter fabric during construction time to prevent siltation to infiltration trenches.

Emergency Reaction or Accidental Spill Plan

In case of an accident in the parking lot or driveways, where significant gasoline or other petroleum products are released, the following procedure must be followed.

Step. 1. First of all, plug the outlet pipe from the catch basin to the manhole and the outlet pipe from the manhole to infiltration trench. Immediately notify **Holliston** Fire Department, Board of Health, Conservation Commission, and the Mass. Department of Environmental Protection (DEP). **Holliston** is in the Northeast Region of DEP, and their main office is presently at 205B Lowell Street, Wilmington, Massachusetts 01887 and their phone number is (978)694-3200.

Step 2. If any of those three agencies so direct, a clean up firm shall be immediately contacted. If the materials have remained trapped in the catch basin and manhole, then the catch basin shall be pumped out. If the volume of the spill is such that materials have flowed out of the catch basin sump or the trench, then corrective actions will be extended to the receiving **water** and beyond. For an oil release in excess of on site storage capacity, a floating boom shall be used to prevent oil release from spreading in any receiving area. For materials which are partially soluble in water, e.g., components of gasoline, then DEP or clean-up firm recommendations shall be followed. These might include, but are not limited to (1) pumping out the entire trench, (2) air stripping, or (3) excavation of an interceptor basin to allow air stripping in the downgradient soils. Since the technology of containment and control is steadily advancing, clean-up and recovery technology shall be specified on site just after the spill.

Mosquito Control in Sumps

In general, mosquito breeding occurs in standing water that lasts five days or more. The catch basin during high groundwater season may have standing water. Thus mosquito control may be needed. In case of mosquitoes breeding in the catch basin, there are many methods available to control them including biological control and chemical control. Biological controls are preferred since the biological controls specifically target mosquito larvae and are harmless to humans, unlike many chemicals even at standard does. It is not recommended any chemicals be used in the inlet box or the catch basins due to their frequent flushing and water quality issues in the receiving waters. The following is the recommended biological control.

Bacillus thuringiensis israeliensus (Bti) is an effective control for mosquitoes and flies and is widely used in various forms in U.S. This is a bacterium, which kills larvae of target insects. Commercial Bti is considered safe to add to drinking water (WRRI 1989) and is available at most hardware stores.

Cost Estimation

The cost of cleaning up each catch basin and oil/grit separator is estimated to be $100 per unit; No significant sediment is expected in the manholes and outflow control box. Checking and clean debris in the distribution manhole is the expected maintenance, which shall cost no more than $50 each time if any. The total estimated cost for each clean up is $2000 as detailed in the following:

Annual Maintenance Budget

BMPs	Cost per item	Quantity	Total
Road/Parking sweeping	**$ 200.00**	**2**	**$ 400.00**
Infiltration Basin	**$ 50.00**	**5**	**$ 250.00**
Catchbasin or drywell	**$ 100.00**	**8**	**$800.00**
Outlet control box	**$ 50.00**	**5**	**$ 250.00**
swale	**$ 50.00**	**3**	**$150.00**
Regular DMH	**$50**	**3**	**$150**
Total			**$ 2000.00**

Summary

The maintenance steps outlined above are sufficient to prevent sediment accumulation from affecting the long term performance of the BMP system. If maintenance is not conducted, then the detention basin and catch basin will be filled up with sediment, which will impede the function of stormwater treatment. Routine maintenance is the most cost-effective in the long run.

If you have any questions about the plan, please feel free to contact us.

Sincerely,

Creative Land & Water Engineering, LLC
by

Desheng Wang, Ph.D. P.E.
Senior Environmental/Hydraulic Engineer

Operation/Maintenance Form

Project Site: 52 Jasper Hill Road, Holliston, MA

Operator: **Date of O/M:**

BMPs	Location	Description of Maintenance
Road/Parking sweeping		Note sediment condition, clean as needed
Infiltration Basin		Check to see if any water in basin
Catchbasin or drywell		Check sediment depth and floating materials
Outlet control box		Check and clean debris on racks
swale		Mow regularly
Regular DMH		Check for any cover damage or paving settlement, repair as needed
Others		Any uncovered in above

Notes: 1) Sediment deposit depth and other pollutants shall be recorded in structural BMPs for record, such as, 12" of sediment is cleaned out of the Catchbasin #. 2)The O/M staff can expand the form on separate sheet for different BMPs items. 3) Inspections shall be conducted four times for the first year after construction as spelled out in the plan and can be reduced to annual after gaining understanding of the site operation conditions as expected.

References:

[1] J. McLean (1995) "Mosquitoes in Constructed Wetlands -- A Management Bugaboo," Watershed Protection Techniques, Vol. 1, No. 4, Center for Watershed Protection, 203-208.

[2] Water Resources Research Institute (1989) Report No. 247: Proceedings of Workshop on Management of Aquatic Weeds and Mosquitoes in Impoundments, March 14-15, 1989 UNC Charlotte.

[3] Mian, L. S., Mulla, M. S., and Wilson, B. A. (1986) "Studies of Potential Biological Control Agents of Immature Mosquitoes in Sewage Wastewater in Southern California," J. Am. Mosquito Control Assoc. 2(3), 329-335.

[4] MA DEP *Stormwater Management Standards - Stormwater Management Handbook*, 2008

Stormwater Pollution Prevention Plan
For Construction Activities
at
Jasper Road, Holliston, MA

October 2, 2023

Prepared for:

J. Dennis Morgan
Jasper Hill Realty Trust, LLC
340 Winter St.
Framingham, MA 01702
617-571-7744

Prepared by:

Creative Land & Water Engineering, LLC
P.O. Box 584
Southborough, MA 01772
Tel. 508-281-1694

Jasper Hill Estates, Holliston, MA
CONSTRUCTION/STORMWATER POLLUTION PREVENTION PLAN

SITE DESCRIPTION			
Project Name and Location (Latitude, Longitude, or Address)	**The Jasper Hill Estates** **Holliston, MA** **42.20376º N** **-71.43124º W**	Owner Name and Address:	J. Dennis Morgan Morgan Jasper Hill Realty Trust, LLC 340 Winter St. Framingham, MA 01702 617-571-7744
Description: (Purpose and Types of Soil Disturbing Activities)			
A 4-lot residential subdivision development on a southeasterly pitching sloped forest land. Soil disturbing activities will include installation of a stabilized construction entrance; installation of erosion control line; clearing and grubbing; stabilization of rough drive and parking lot with gravel; excavation for infiltration trenches, utilities, building foundations; construction of driveways, and buildings; grading; and preparation for final planting and seeding. The underlying subsoils are Narragansett sandy soil (hydrologic group A) in the entire site based on NRCS soil survey and on-site inspection.			
Runoff Coefficient:	The final coefficient of runoff for the site will be c = 0.30.		
Site Area:	The site is 6.57 acres. About 3.8 acres will be disturbed by construction activities.		
Sequence of Major Activities			
The order of activities will be as follows: 1. Install stabilized construction entrance. 2. Install erosion control line. 3. Clear & grub for overall site preparation 4. Excavate infiltration trenches; temporarily seed these areas 5. Excavate foundation hole and install foundations. 6. Install roadway & associated utilities (i.e. retaining walls, sewer, water, catch basins, & conveyance pipes). 7. Complete grading for driveway, parking lot; install subbase and binder in driveway and parking lot. 8. Install infiltration trenches. 9. Construct the four houses.		10. Stabilize exposed soils & stockpiles within 14 days of last construction activity in a given area. 11. Complete grading for landscape area permanently seed and plant. 12. Complete final paving. 13. Remove accumulated sediment from sediment forebay, infiltration basin, catch basins, distribution manhole 14. Clean all catch basins and install hoods. . When all construction is complete and all exposed soils are stabilized, remove erosion control line. Reseed any areas disturbed by its removal.	
Name of Receiving Waters:	**Bogastow Brook to Dirty Meadow Brook to Charles River**		

CONTROLS		
	Erosion and Sediment Controls	
Stabilization Practices		
Temporary Stabilization – Silt fence and/or straw wattles or hay bales containing no invasive plants shall be installed along the downgradient of disturbed area. Sediment basins can be installed in area of natural flow concentrates. Silt bag or equal protection measures shall be installed in catchbasins in the existing roadway receiving runoff from the project site. The soil stock piles and disturbed portions of the site where construction activity temporarily ceases for at least 21 days will be stabilized with temporary seed and mulch no later than 14 days from the last construction activity in that area. The temporary seed shall be hydroseeded or hand spread with Rye (grain) applied at the rate of 120 pounds per acre. Prior seeding, 2,000 pounds of ground agricultural limestone and 1,000 pounds of 10-10-10 fertilizer shall be applied to each acre to be stabilized. If hand spread seeding applied, each area shall be mulched with 4,000 pounds per acre of straw. The straw mulch is to be tacked into place by a disk with blades set nearly straight. Areas of the site which are to be paved will be temporarily stabilized by applying geotextile and stone sub-base until bituminous pavement can be applied. Permanent Stabilization – Disturbed portions of the site where construction activities permanently cease shall be stabilized with permanent seed no later than 14 days after the last construction activity by hydroseeding and landscaping planting and mulching.		
Structural Practices		
Flow diverting dikes, swales, and sediment basins will be installed where is needed to retain sediment on site.		
Storm Water Management		
Stormwater management will achieved by road drainage system (catchbasins, manholes, and pipes), **five** infiltration trenches with oil/grit separator or glass swale pretreatment.		
OTHER CONTROLS		
Waste Disposal:		
Waste Materials Construction debris will be stored in dumpster and disposed in accordance with applied local, state and federal regulations. **Hazardous Waste** All hazardous waste materials will be disposed of in the manner specified by local or state regulations or by the manufacturer. Site personnel will be instructed in these practices and **a dedicated personnel/General contractor** , the individual who manages day-to-day site operations, will be responsible for seeing that these practices are followed by qualified subcontractors certified by OHSA. **Sanitary Waste** All sanitary waste will be collected by the portable units and managed by certified sanitary waste management contractor.		
Offsite Vehicle Tracking:		

A stabilized construction entrance will be provided to help reduce vehicle tracking of sediments. The paved street adjacent to the site entrance will be swept daily to remove any excess mud, dirt or rock tracked from the site. Dump trucks hauling material from the construction site will be covered with a tarpaulin.

TIMING OF CONTROLS/MEASURES

As indicated in the Sequence of Major Activities. Sediment and erosion control measures and devices will be constructed prior to clearing or grading of any other portions of the site. Areas where construction activity ceases for more than 21 days will be stabilized with a temporary seed and mulch within 14 days of the last disturbance. Once construction ceases permanently in an area, it will be stabilized with permanent seed and mulch. After the entire site is stabilized, the accumulated sediment will be removed from the sediment basin/trap and all measures will be removed.

CERTIFICATION OF COMPLIANCE WITH FEDERL, STATE, AND LOCAL REGULATIONS

The storm water pollution prevention plan reflects requirements for storm water management and erosion and sediment control. To ensure compliance, this plan was prepared in accordance with the MA DEP Stormwater Management Policy and the requirements of National Pollution Discharge Elimination System (NPDES).

MAINTENANCE/INSPECTION PROCEDURES

Erosion and Sediment Control Inspection and Maintenance Practices

These are the inspection and maintenance practices that will be used to maintain erosion and sediment controls.

- Less than one half of the site will be denuded at one time.
- All control measures will be inspected at least once each week and following any storm event of 0.5 inches or greater.
- All measures will be maintained in good working order; if a repair is necessary, it will be initiated within 24 hours of report.
- Built up sediment will be removed from silt fence when it has reached one third the height of the fence.
- Silt fence will be inspected for depth of sediment, tears, to see if the fabric is securely attached to the fence posts, and to see that the fence posts are firmly in the ground.
- The sediment basin will be inspected for depth, and built up sediment will be removed when it reaches 10 percent of the design capacity or at the end of the job.
- Diversion dike will be inspected and any breaches promptly repaired.
- Temporary and permanent seeding and planting will be inspected for bare spots, washouts, and healthy growth.
- A maintenance inspection report will be made after each inspection. A copy of

the report form to be completed by the inspector is attached.

- Designated site superintendent, will select three individuals who will be responsible for inspections, maintenance and repair activities, and filling out the inspection and maintenance report.

- Personnel selected for inspection and maintenance responsibilities will receive training from the dedicated **expert consultant.** They will be trained in all the inspection and maintenance practices necessary for keeping the erosion and sediment controls used onsite in good working order.

Non-Storm Water Discharges

If any of the following non-storm water discharges would occur from the site during the construction period:

- Water from water line flushing.

- Pavement wash waters (where no spills or leaks of toxic or hazardous materials have occurred).

- Uncontaminated groundwater (from dewatering excavation).

All non-storm water discharges should be directed to the sediment basin prior to discharge.

INVENTORY FOR POLLUTION PREVENTION PLAN

The materials of substances listed below are expected to be present onsite during construction:

- Concrete
- Detergents
- Paints
- Metal materials
- Tar or bituminous concrete
- Fertilizers
- Petroleum Based Products
- Cleaning Solvents
- Wood
- Masonry Block
- Roofing Shingles

SPILL PREVENTION

Material Management Practices

The following are the material management practices that will be used to reduce the risk of spills or other exposure of materials and substances to storm water runoff.

Good Housekeeping:

The following good housekeeping practices will be followed onsite during the construction project.

- Effort will be made to restock only enough product required to do the job

- All materials stored onsite will be stored in a neat, orderly manner in their appropriate containers, if possible, under a roof or other enclosure

- Products will be kept in their original containers with the original manufacturer's label
- Substances will not be mixed with one another unless recommended by the manufacturer
- Whenever possible, all of a product will be used up before disposing of the container
- Manufacturers' recommendations for proper use and disposal will be followed
- The site superintendent will inspect daily to ensure proper use and disposal of materials

Hazardous Products:

These practices are used to reduce the risks associated with hazardous materials.

- Products will be kept in original containers unless they are not re-sealable
- Original labels and material safety data will be retained; they contain important product information
- If surplus product must be disposed of, manufacturers' or local and state recommended methods for proper disposal will be followed.

Product Specific Practices

The following specific practices will be followed onsite:

Petroleum Products:

All onsite vehicles will be monitored for leaks and receive regular preventive maintenance to reduce the chance of leakage. Petroleum products will be stored in tightly sealed containers which are clearly labeled. Any asphalt substances used onsite will be applied according to the manufacturer's recommendations.

Fertilizers:

Fertilizers used will be applied only in the minimum amounts recommended by the manufacturer. Once applied, fertilizer will be worked into the soil to limit exposure to storm water. Storage will be in a covered shed. The contents of any partially used bags of fertilizer will be transferred to a sealable plastic bin to avoid spills.

Paints:

All containers will be tightly sealed and stored when not required for use. Excess paint will not be discharged to the storm sewer system but will be properly disposed of according to manufacturers' instructions or state and local regulations.

Concrete Trucks:

Concrete trucks will not be allowed to wash out or discharge surplus concrete or drum wash water without proper treatment. Capturing and filtering the rinsate will be provided

before discharge.

Spill Control Practices
In addition to the good housekeeping and material management practices discussed in the previous sections of this plan, the following practices will be followed for spill prevention and cleanup: • Manufacturers' recommended methods for spill cleanup will be clearly posted and site personnel will be made aware of the procedures and the location of the information and cleanup supplies. • Materials and equipment necessary for spill cleanup will be kept in the material storage area onsite. Equipment and materials will include but not be limited to brooms, dust pans, mops, rags, gloves, goggles, kitty litter, sand, sawdust, and plastic and metal trash containers specifically for this purpose. • All spills will be cleaned up immediately after discovery. • The spill area will be kept well ventilated and personnel will wear appropriate protective clothing to prevent injury from contact with a hazardous substance. • Spills of toxic of hazardous material will be reported to the appropriate state or local government agency, regardless of the size. • The spill prevention plan will be adjusted to include measures to prevent this type of spill from reoccurring and how to clean up the spill if there is another one. A description of the spill, what caused it, and the cleanup measures will also be included. • The site superintendent responsible for the day-to-day site operations will be the spill prevention and cleanup coordinator. He/she will designate at least three other site personnel who will receive spill prevention and cleanup training. These individuals will each become responsible for a particular phase of prevention and cleanup. The names of responsible spill personnel will be posted in the material storage area and in the office trailer onsite.

POLLUTION PREVENTION PLAN CERTIFICATION
I certify under penalty of law that this document and all attachments were prepared under

my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signed:

Desheng Wang, Ph.D., P.E.
Creative Land&Water Engineering, LLC
P.O. Box 584
Southborough, MA 01772
Tel. 508281-1694

Date:____10/2/2023

CONTRACTOR'S CERTIFICATION

I certify under penalty of law that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the storm water discharges associated with industrial activity from the construction site identified as part of this certification.

Signature	For	Responsible for
_____ J. Dennis Morgan Date:_____	J. Dennis Morgan Jasper Hill Realty Trust, LLC 340 Winter St. Framingham, MA 01702 617-571-7744	General Contractor Temporary and Permanent Stabilization Stabilized Construction Entrance, Earth Dikes, Sediment Basin

Inspection Report – Jasper Hill Estates
EPA Tracking Number:
DEP File #:

The report shall be completed Within 24 hours of completing each inspection

Purpose

This Inspection Report presents our field inspection results required in Part 4.1.7 of the CGP, and the Order of Conditions issued by Holliston Conservation Commission, MA datedxxxx. You must retain in your records copies of all inspection reports in accordance with the requirements in Part 4.1.7.3 of the 2012 CGP. These reports must be retained for at least **3 years** from the date your permit coverage expires or is terminated.

Overview of Inspection Requirements

This Construction operation is covered under the 2022 CGP and subject to the following requirements in Part 4:

Inspection Frequency *(see Part 4.1.4)*

We will conduct inspections either:

- Once every 7 calendar days; or
- Once every 14 calendar days and within 24 hours of a storm event of 0.25 inches or greater.

The inspection frequency may be increased if the site discharges to a sensitive water. See Part 4.1.3. The inspection frequency may be decreased to account for stabilized areas, or drought-stricken conditions, or for frozen conditions. See Part 4.1.4.

Areas to Be Inspected *(see Part 4.1.5)*

During each inspection, the following areas will be inspected:

- Cleared, graded, or excavated areas of the site;
- Stormwater controls (e.g., perimeter controls, sediment basins, inlets, exit points etc.) and pollution prevention practices (e.g., pollution prevention practices for vehicle fueling/maintenance and washing, construction product storage, handling, and disposal, etc.) at the site;
- Material, waste, or borrow areas covered by the permit, and equipment storage and maintenance areas;
- Areas where stormwater flows within the site;
- Stormwater discharge points; and
- Areas where stabilization has been implemented.

Inspection Checklist *(see Part 4.1.6)*

During our site inspection, we are required to check:

- Whether stormwater controls or pollution prevention practices require maintenance or corrective action, or whether new or modified controls are required;
- For the presence of conditions that could lead to spills, leaks, or other pollutant accumulations and discharges;
- Whether there are visible signs of erosion and sediment accumulation at points of discharge and to the channels and streambanks that are in the immediate vicinity of the discharge;
- If a stormwater discharge is occurring at the time of the inspection, whether there are obvious, visual signs of pollutant discharges; and
- If any permit violations have occurred on the site.

Summary of Inspection Findings

General Information (see reverse for instructions)					
Name of Project	**The Jasper Hill Estates**	**CGP Tracking No.**		**Inspection Date**	
Inspector Name, Title & Contact Information	Desheng Wang – Environmental Monitor Creative Land & Water Engineering, LLC, P.O. Box 584, Southborough, MA 01772 Tel. 774-454-0266, Email: deshengw@yahoo.com or desheng@creative-land-water-eng.com				
Present Phase of Construction					
Inspection Location (if multiple inspections are required, specify location where this inspection is being conducted)					

Inspection Frequency *(Note: you may be subject to different inspection frequencies in different areas of the site. Check all that apply.)*

Standard Frequency: ☐ Weekly ☐ Every 14 days and within 24 hours of a 0.25" rain

Increased Frequency: ☐ Every 7 days and within 24 hours of a 0.25" rain (for areas of sites discharging to sediment or nutrient-impaired waters or to waters designated as Tier 2, Tier 2.5, or Tier 3)

Reduced Frequency:
- ☐ Once per month (for stabilized areas)
- ☐ Once per month and within 24 hours of a 0.25" rain (for arid, semi-arid, or drought-stricken areas during seasonally dry periods or during drought)
- ☐ Once per month (for frozen conditions where earth-disturbing activities are being conducted)

Was this inspection triggered by a 0.25" storm event? ☐ Yes ☐ No

If yes, how did you determined whether a 0.25" storm event has occurred?

☐ Rain gauge on site ☐ Weather station representative of site. Specify weather station source:

Total rainfall amount that triggered the inspection (in inches)**:**

Unsafe Conditions for Inspection

Did you determine that any portion of your site was unsafe for inspection per CGP Part 4.1.5? ☐ Yes ☐ No

If "yes", complete the following:

- Describe the conditions that prevented you from conducting the inspection in this location:

- Location(s) where conditions were found:

Condition and Effectiveness of Erosion and Sediment (E&S) Controls (CGP Part 2.1) (see reverse for instructions)				
Type/Location of E&S Control [Add an additional sheet if necessary]	**Repairs or Other Maintenance Needed?***	**Corrective Action Required?***	**Date on Which Maintenance or Corrective Action First Identified?**	**Notes**
1. Entrance	☐Yes ☐No	☐Yes ☐No		
2. Siltfence/socks/wattles	☐Yes ☐No	☐Yes ☐No		
3. Sediment trap (stoage, overflow …)	☐Yes ☐No	☐Yes ☐No		
4. Mulch over exposed area	☐Yes ☐No	☐Yes ☐No		
5.	☐Yes ☐No	☐Yes ☐No		
6.	☐Yes ☐No	☐Yes ☐No		
7.	☐Yes ☐No	☐Yes ☐No		

8.				
9.				
10.				

*** Note:** The permit differentiates between conditions requiring repairs and maintenance, and those requiring corrective action. The permit requires maintenance in order to keep controls in effective operating condition and requires repairs if controls are not operating as intended. Corrective actions are triggered only for specific, more serious conditions, which include: 1) A required stormwater control was never installed, was installed incorrectly, or not in accordance with the requirements in Part 2 and/or 3; 2) You become aware that the stormwater controls you have installed and are maintaining are not effective enough for the discharge to meet applicable water quality standards or applicable requirements in Part 3.1; 3) One of the prohibited discharges in Part 2.3.1 is occurring or has occurred; or 4) EPA requires corrective actions as a result of a permit violation found during an inspection carried out under Part 4.2. If a condition on your site requires a corrective action, you must also fill out a corrective action form found at www.epa.gov/npdes/stormwater/swppp. See Part 5 of the permit for more information.

Condition and Effectiveness of Pollution Prevention (P2) Practices (CGP Part 2.3) (see reverse for instructions)				
Type/Location of P2 Practices [Add an additional sheet if necessary]	**Repairs or Other Maintenance Needed?***	**Corrective Action Required?***	**Date on Which Maintenance or Corrective Action First Identified?**	**Notes**
1. Storage area	☐Yes ☐No	☐Yes ☐No		
	☐Yes ☐No	☐Yes ☐No		
2. Fueling area	☐Yes ☐No	☐Yes ☐No		
3. Wash discharge area	☐Yes ☐No	☐Yes ☐No		
	☐Yes ☐No	☐Yes ☐No		
4.	☐Yes ☐No	☐Yes ☐No		
5.	☐Yes ☐No	☐Yes ☐No		
6.	☐Yes ☐No	☐Yes ☐No		
7.	☐Yes ☐No	☐Yes ☐No		
8.	☐Yes ☐No	☐Yes ☐No		
9.				
10.				

*** Note:** The permit differentiates between conditions requiring repairs and maintenance, and those requiring corrective action. The permit requires maintenance in order to keep controls in effective operating condition and requires repairs if controls are not operating as intended. Corrective actions are triggered only for specific, more serious conditions, which include: 1) A required stormwater control was never installed, was installed incorrectly, or not in accordance with the requirements in Part 2 and/or 3; 2) You become aware that the stormwater controls you have installed and are maintaining are not effective enough for the discharge to meet applicable water quality standards or applicable requirements in Part 3.1; 3) One of the prohibited discharges in Part 2.3.1 is occurring or has occurred; or 4) EPA requires corrective actions as a result of a permit violation found during an inspection carried out under Part 4.2. If a condition on your site requires a corrective action, you must also fill out a corrective action form found at www.epa.gov/npdes/stormwater/swppp. See Part 5 of the permit for more information.

Stabilization of Exposed Soil (CGP Part 2.2) (see reverse for instructions)			
Stabilization Area **[Add an additional sheet if necessary]**	**Stabilization Method**	**Have You Initiated Stabilization?**	**Notes**
1. Entrance		☐ YES ☐ NO If yes, provide date:	
2. Stormwater infiltration trenches		☐ YES ☐ NO If yes, provide date:	
3. Buffer zone		☐ YES ☐ NO If yes, provide date:	
4. Parking lot		☐ YES ☐ NO If yes, provide date:	
5.		☐ YES ☐ NO If yes, provide date:	

Description of Discharges (CGP Part 4.1.6.6) (see reverse for instructions)	
Was a stormwater discharge or other discharge occurring from any part of your site at the time of the inspection? ☐ Yes ☐ No **If "yes", provide the following information for each point of discharge:**	
Discharge Location **[Add an additional sheet if necessary]**	**Observations**
1. Sediment trap	Describe the discharge: At points of discharge and the channels and banks of surface waters in the immediate vicinity, are there any visible signs of erosion and/or sediment accumulation that can be attributed to your discharge? ☐ Yes ☐ No If yes, describe what you see, specify the location(s) where these conditions were found, and indicate whether modification, maintenance, or corrective action is needed to resolve the issue:

2. Silt fence or silt socks, straw wattles	Describe the discharge: At points of discharge and the channels and banks of surface waters in the immediate vicinity, are there any visible signs of erosion and/or sediment accumulation that can be attributed to your discharge? ☐ Yes ☐ No If yes, describe what you see, specify the location(s) where these conditions were found, and indicate whether modification, maintenance, or corrective action is needed to resolve the issue:

Contractor or Subcontractor Certification and Signature
(see reverse for instructions)

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Signature of Contractor or Subcontractor: _____ **Date:**

Printed Name and Affiliation: _____

Certification and Signature by Permittee
(see reverse for instructions)

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Signature of Permittee or "Duly Authorized Representative": _____ **Date: 8/25/2022**

Printed Name and Affiliation: **Desheng Wang, Creative Land & Water Engineering, LLC**

- The signed and dated written authorization is attached here and included in the SWPPP. A copy must be submitted to EPA, if requested.

Delegation of Authority

I, J. Dennis Morgan (name), hereby designate the person or specifically described position below to be a duly authorized representative for the purpose of overseeing compliance with environmental requirements, including the Construction General Permit, at the 52 Jasper Hill Road, Holliston, MA 01746 construction site. The designee is authorized to sign any reports, stormwater pollution prevention plans and all other documents required by the permit.

Desheng Wang, Ph.D., P.E. - Environmental Monitor
Creative Land & Water Engineering, LLC
P.O. Box 584
Southboro, MA 01772
Tel. 774-454-0266 Email: deshengw@yahoo.com

By signing this authorization, I confirm that I meet the requirements to make such a designation as set forth in Appendix I of EPA's Construction General Permit (CGP), and that the designee above meets the definition of a "duly authorized representative" as set forth in Appendix I.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: **J. Dennis Morgan**

Company: J. Dennis Morgan Morgan
Jasper Hill Realty Trust, LLC
340 Winter St.
Framingham, MA 01702
617-571-7744

Signature: _____

President

Date: **October 2, 2023**

Appendix G: Groundwater Mounding Analysis

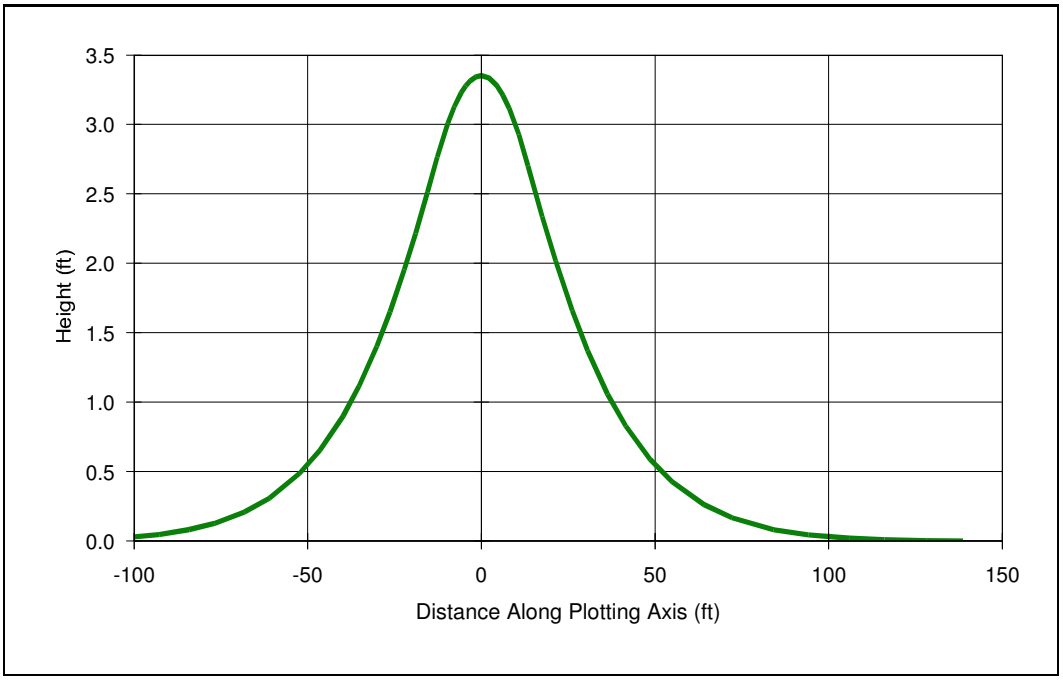
This Appendix contains the detailed groundwater mounding analysis results by Hantush method.

Table G.1. Summary of Groundwater Mounding Analysis

Parameters	Stormwater - 100 Year					Note
Recharge area	Basin D1	Basin D2	Basin D3	Basin D4	Basin D5	All Basins will be dewatered in less than three days.
Dimension, Length, ft	58.73	38.53	29.36	40.40	40.47	
Dimension, Width, ft	18	35	18	19	21	
Area, sq. ft	1057.17	1348.40	528.47	767.65	849.89	
Recharge Vol. Cu ft (per day or event)	3920.4	8712	2178	4356	3049.2	
Duration, day	1	1	1	1	1	
Recharge rate, cu ft/day/sq. ft	3.71	6.46	4.12	5.67	3.59	
Dewater time, day	3	3	3	3	3	
GW Separation, ft	2	2	2	2	4	
Distance to wetland, ft	138	51	51	60	87	
Maximum mounding height, ft	3.35	6.03	2.67	3.74	2.4	
Estimated effective Max MH, ft	**2.27**	**2.806**	**2.134**	**2.348**	**2.4**	
Impact mounding height by other systems, ft	**0**	**0**	**0**	**0**	**0**	
Combined Mound height, ft	**3.35**	**6.03**	**2.67**	**3.74**	**2.4**	
3-day residual height, ft	**0.53**	**0.45**	**0.18**	**0.34**	**0.27**	
5-day residual height, ft	**0.29**	**0.17**	**0.06**	**0.13**	**0.12**	
Estimated effective 3d MH, ft	**0.53**	**2.32**	**0.18**	**0.34**	**0.27**	
Estimated effective 5d MH, ft	**0.29**	**0.17**	**0.27**	**0.26**	**0.26**	
Bottom of Basin, ft	**260**	**258**	**242**	**232**	**220**	
Top of stones, ft						
EHGW, ft	258	256	240	230	216	
	average					
Bottom aquifer, ft	**244**	**236**	**224**	**212**	**196**	
3 day elevation, ft	**258.53**	**256.45**	**240.18**	**230.34**	**216.27**	
Flood routing elev, ft	263.930	261.580	243.080	233.580	221.540	
Top of grade, ft	264.5	262.5	244.5	234.5	222.5	
Aquafer depth, ft	14	20	16	18	20	
Hydraulic Conductivity, ft/day	16.42	16.42	16.42	16.42	16.42	

* mounded water tables for stormwater management area are at 3-day.

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D1

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:28:41 PM

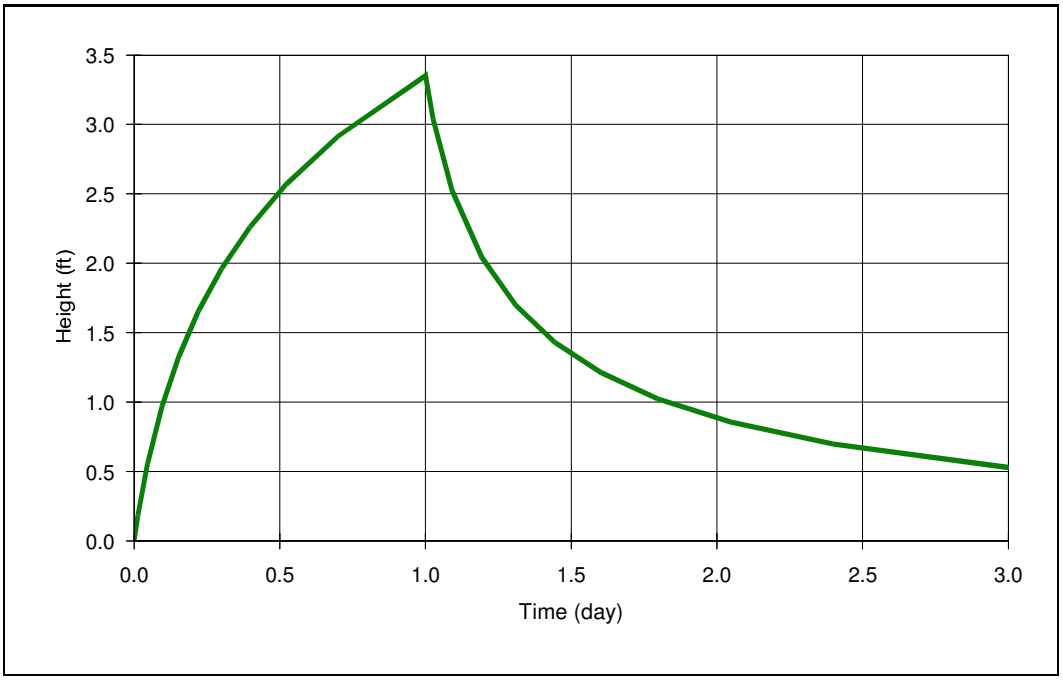
INPUT PARAMETERS

Application rate: 3.71 c.ft/day/sq. ft
Duration of application: 1 days
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 14 ft
Length of application area: 58.73 ft
Width of application area: 18 ft
Constant head boundary used at: 138 ft
Plotting axis from Y-Axis: 45 degrees
Edge of recharge area:
positive X: 9 ft
positive Y: 9 ft
Total volume applied: 3921.989 c.ft

MODEL RESULTS

X (ft)	Y (ft)	Plot Axis (ft)	Mound Height (ft)
-70.7	-70.7	-100	0.03
-59.5	-59.5	-84	0.08
-48.2	-48.2	-68	0.21
-37	-37	-52	0.49
-28.1	-28.1	-40	0.9
-21.3	-21.3	-30	1.4
-15.7	-15.7	-22	1.96
-11	-11	-15	2.51
-6.9	-6.9	-10	3.01
-4.1	-4.1	-6	3.23
-2.2	-2.2	-3	3.32
0	0	0	3.35
3.1	3.1	4	3.28
5.7	5.7	8	3.12
9.5	9.5	13	2.7
15.1	15.1	21	2.02
21.6	21.6	31	1.37
29.4	29.4	42	0.83
38.8	38.8	55	0.43
51	51	72	0.17
66.5	66.5	94	0.04
82.1	82.1	116	0.01
97.6	97.6	138	0

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D1

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:30:59 PM

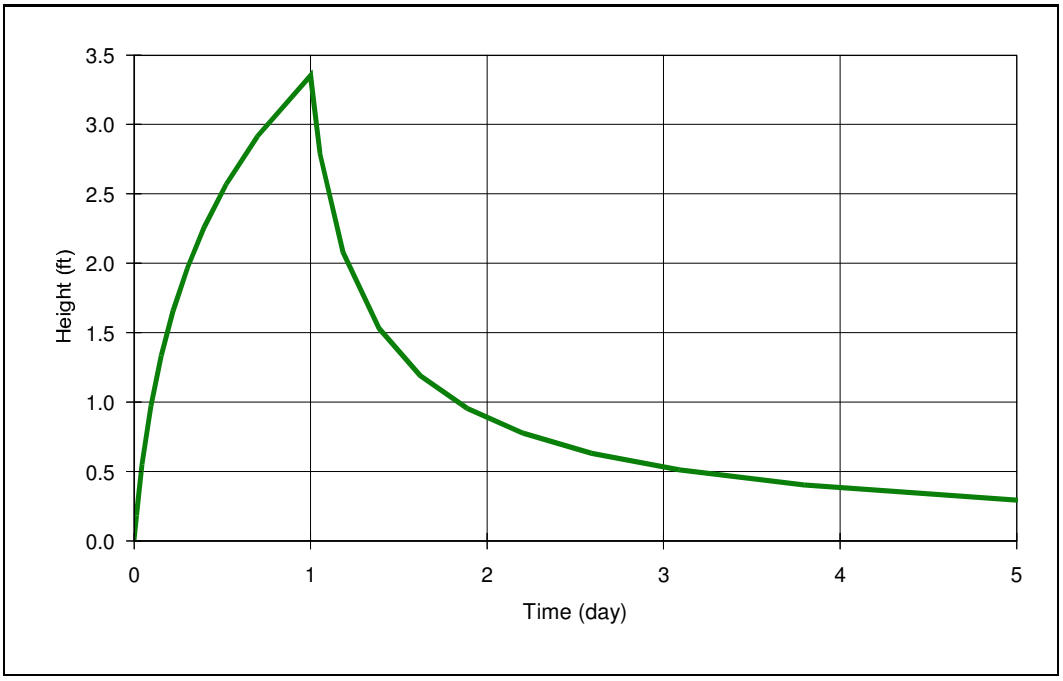
INPUT PARAMETERS

Application rate: 3.71 c.ft/day/sq. ft
Duration of application: 1 day
Total simulation time: 3 day
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 14 ft
Length of application area: 58.73 ft
Width of application area: 18 ft
Constant head boundary used at: 138 ft
Groundwater mounding @
X coordinate: 0 ft
Y coordinate: 0 ft
Total volume applied: 3921.99 cft

MODEL RESULTS

Time (day)	Mound Height (ft)
0	0
0	0.18
0	0.55
0.1	0.98
0.2	1.34
0.2	1.66
0.3	1.96
0.4	2.26
0.5	2.57
0.7	2.91
1	3.35
1	3.04
1.1	2.52
1.2	2.04
1.3	1.7
1.4	1.43
1.6	1.21
1.8	1.02
2	0.86
2.4	0.7
3	0.53

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D1

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:32:47 PM

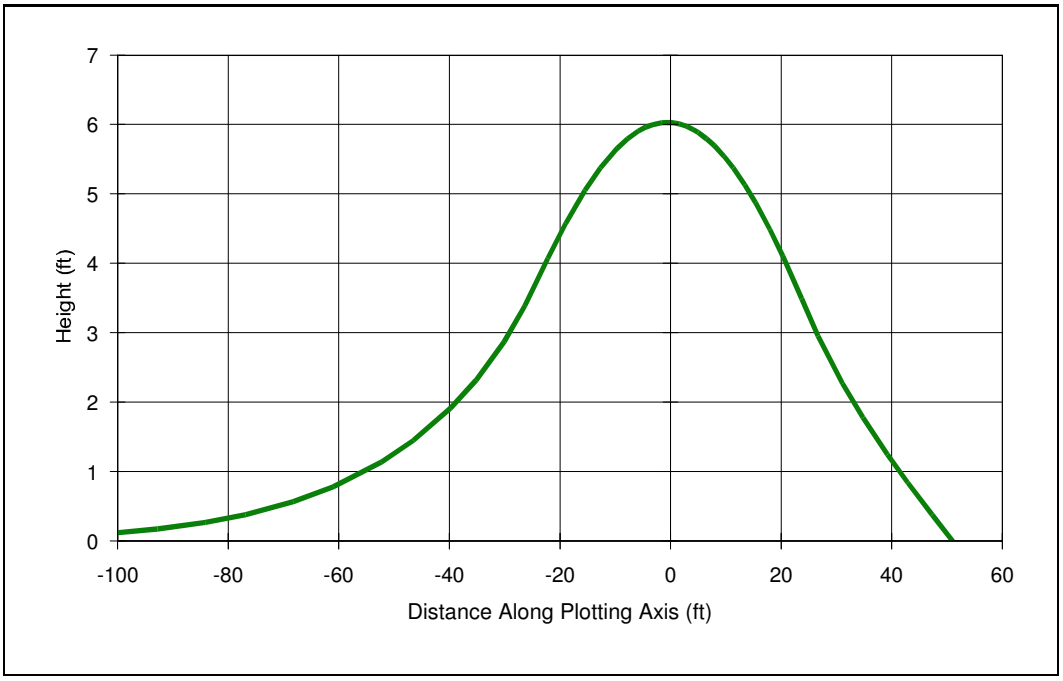
INPUT PARAMETERS

Application rate: 3.71 c.ft/day/sq. ft
Duration of application: 1 day
Total simulation time: 5 day
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 14 ft
Length of application area: 58.73 ft
Width of application area: 18 ft
Constant head boundary used at: 138 ft
Groundwater mounding @
X coordinate: 0 ft
Y coordinate: 0 ft
Total volume applied: 3921.99 cft

MODEL RESULTS

Time (day)	Mound Height (ft)
0	0
0	0.18
0	0.55
0.1	0.98
0.2	1.34
0.2	1.66
0.3	1.96
0.4	2.26
0.5	2.57
0.7	2.91
1	3.35
1.1	2.8
1.2	2.08
1.4	1.53
1.6	1.19
1.9	0.96
2.2	0.78
2.6	0.63
3.1	0.51
3.8	0.4
5	0.29

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D2

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:35:53 PM

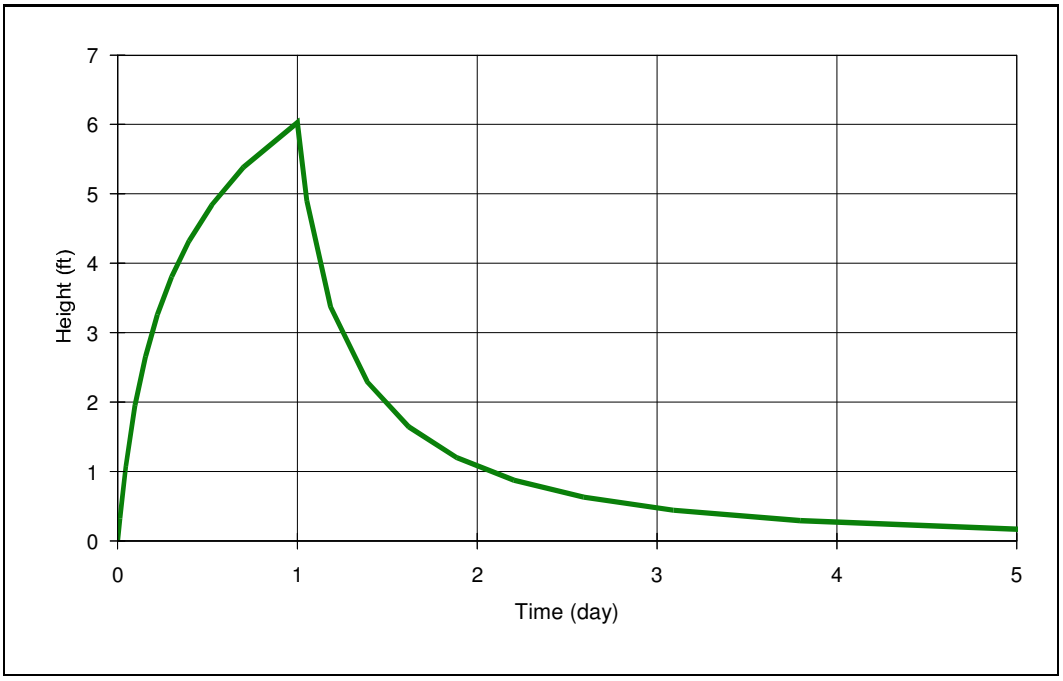
INPUT PARAMETERS

Application rate: 6.46 c.ft/day/sq. ft
Duration of application: 1 days
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 20 ft
Length of application area: 38.53 ft
Width of application area: 35 ft
Constant head boundary used at: 51 ft
Plotting axis from Y-Axis: 45 degrees
Edge of recharge area:
positive X: 17.5 ft
positive Y: 17.5 ft
Total volume applied: 8711.633 c.ft

MODEL RESULTS

X (ft)	Y (ft)	Plot Axis (ft)	Mound Height (ft)
-70.7	-70.7	-100	0.12
-59.5	-59.5	-84	0.27
-48.2	-48.2	-68	0.57
-37	-37	-52	1.14
-28.1	-28.1	-40	1.91
-21.3	-21.3	-30	2.87
-15.7	-15.7	-22	4.07
-11	-11	-15	5.05
-6.9	-6.9	-10	5.66
-4.1	-4.1	-6	5.91
-2.2	-2.2	-3	6
0	0	0	6.03
1.1	1.1	2	6.01
2.1	2.1	3	5.97
3.5	3.5	5	5.89
5.6	5.6	8	5.7
8	8	11	5.38
10.9	10.9	15	4.88
14.3	14.3	20	4.1
18.9	18.9	27	2.95
24.6	24.6	35	1.78
30.3	30.3	43	0.84
36.1	36.1	51	0

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D2

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:36:25 PM

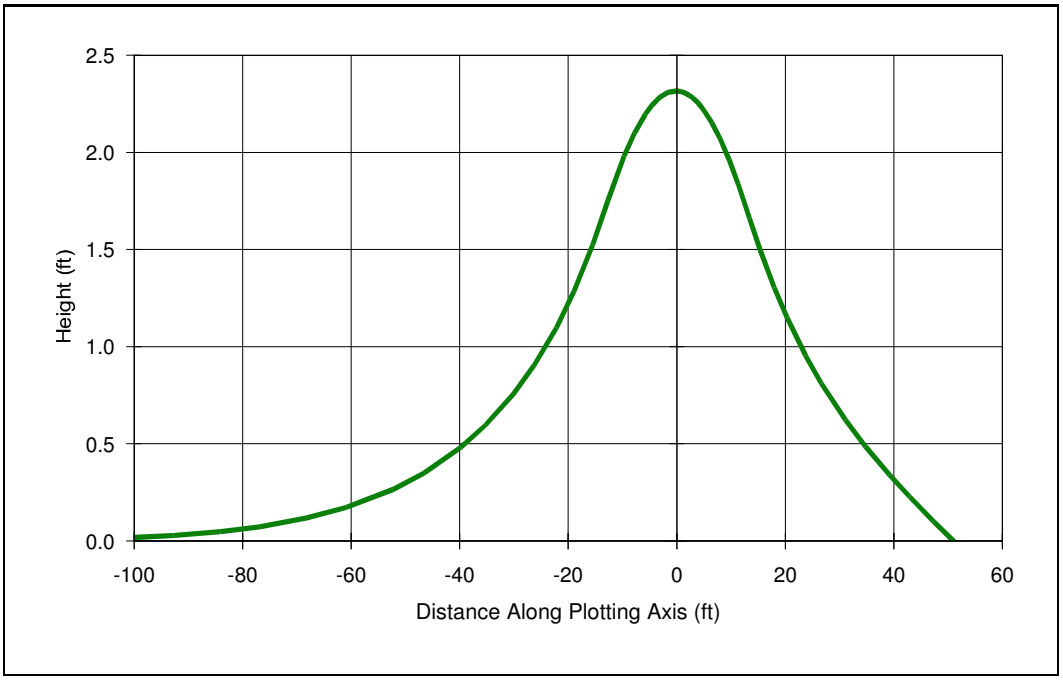
INPUT PARAMETERS

Application rate: 6.46 c.ft/day/sq. ft
Duration of application: 1 day
Total simulation time: 5 day
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 20 ft
Length of application area: 38.53 ft
Width of application area: 35 ft
Constant head boundary used at: 51 ft
Groundwater mounding @
X coordinate: 0 ft
Y coordinate: 0 ft
Total volume applied: 8711.633 cft

MODEL RESULTS

Time (day)	Mound Height (ft)
0	0
0	0.33
0	1.08
0.1	1.96
0.2	2.66
0.2	3.26
0.3	3.81
0.4	4.32
0.5	4.84
0.7	5.38
1	6.03
1.1	4.9
1.2	3.38
1.4	2.3
1.6	1.65
1.9	1.2
2.2	0.88
2.6	0.63
3.1	0.44
3.8	0.3
5	0.17

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D3

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:40:24 PM

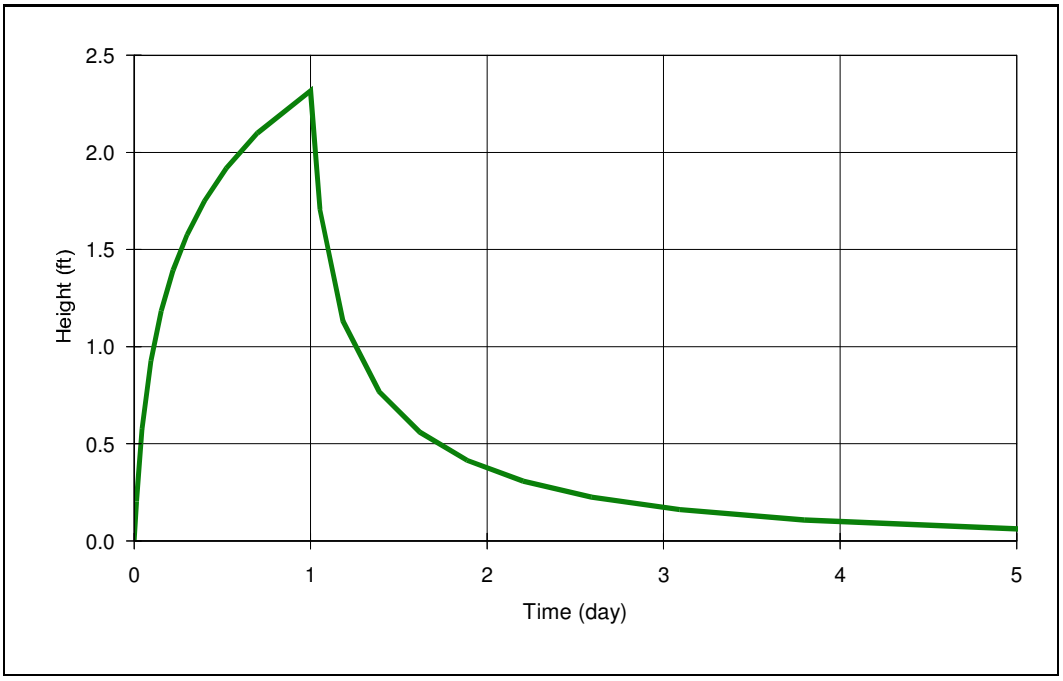
INPUT PARAMETERS

Application rate: 4.12 c.ft/day/sq. ft
Duration of application: 1 days
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 16 ft
Length of application area: 29.36 ft
Width of application area: 18 ft
Constant head boundary used at: 51 ft
Plotting axis from Y-Axis: 45 degrees
Edge of recharge area:
positive X: 9 ft
positive Y: 9 ft
Total volume applied: 2177.338 c.ft

MODEL RESULTS

X (ft)	Y (ft)	Plot Axis (ft)	Mound Height (ft)
-70.7	-70.7	-100	0.02
-59.5	-59.5	-84	0.05
-48.2	-48.2	-68	0.12
-37	-37	-52	0.26
-28.1	-28.1	-40	0.48
-21.3	-21.3	-30	0.76
-15.7	-15.7	-22	1.1
-11	-11	-15	1.52
-6.9	-6.9	-10	1.98
-4.1	-4.1	-6	2.2
-2.2	-2.2	-3	2.28
0	0	0	2.32
1.1	1.1	2	2.3
2.1	2.1	3	2.28
3.5	3.5	5	2.22
5.6	5.6	8	2.08
8	8	11	1.84
10.9	10.9	15	1.5
14.3	14.3	20	1.15
18.9	18.9	27	0.81
24.6	24.6	35	0.49
30.3	30.3	43	0.23
36.1	36.1	51	0

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D3

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:40:35 PM

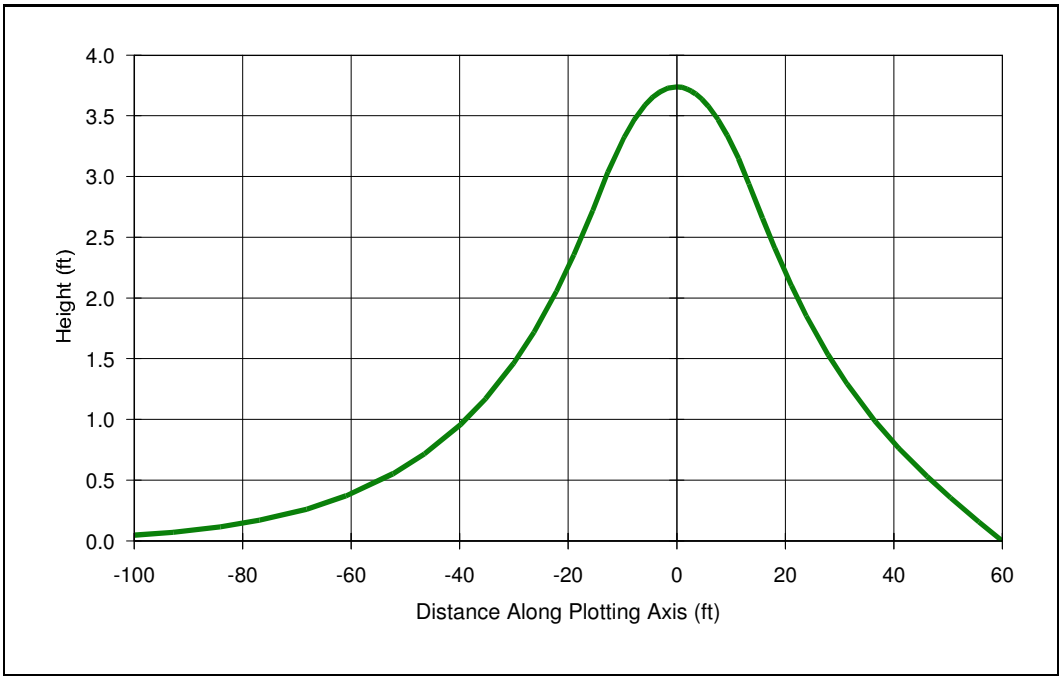
INPUT PARAMETERS

Application rate: 4.12 c.ft/day/sq. ft
Duration of application: 1 day
Total simulation time: 5 day
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 16 ft
Length of application area: 29.36 ft
Width of application area: 18 ft
Constant head boundary used at: 51 ft
Groundwater mounding @
X coordinate: 0 ft
Y coordinate: 0 ft
Total volume applied: 2177.338 cft

MODEL RESULTS

Time (day)	Mound Height (ft)
0	0
0	0.2
0	0.58
0.1	0.93
0.2	1.18
0.2	1.39
0.3	1.58
0.4	1.75
0.5	1.92
0.7	2.1
1	2.32
1.1	1.71
1.2	1.13
1.4	0.77
1.6	0.56
1.9	0.42
2.2	0.31
2.6	0.23
3.1	0.16
3.8	0.11
5	0.06

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D4

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:45:23 PM

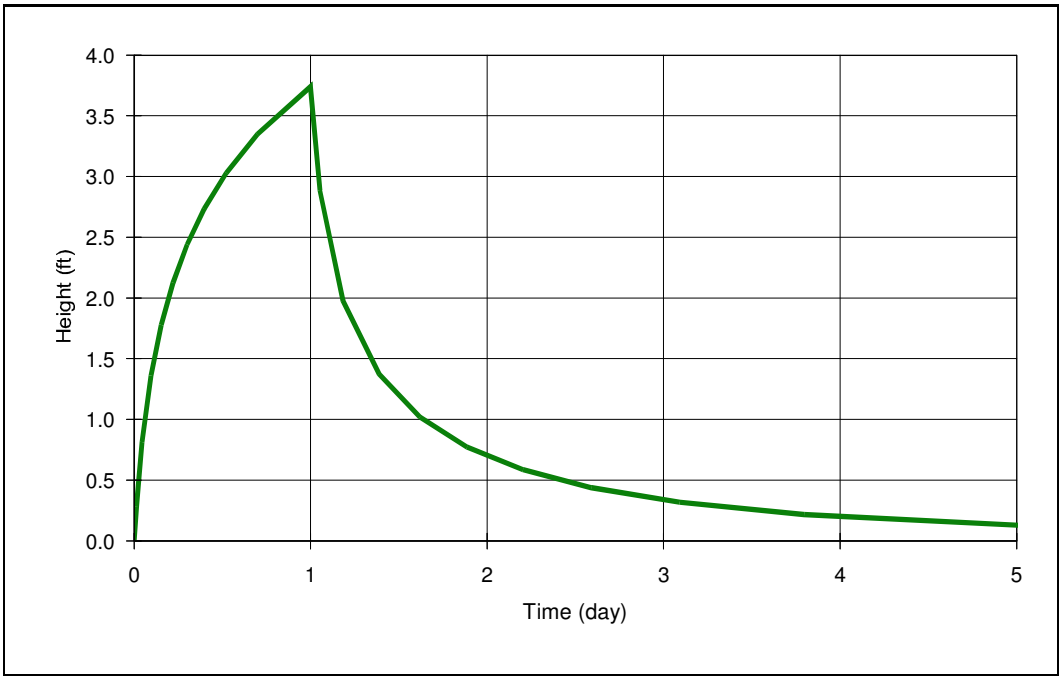
INPUT PARAMETERS

Application rate: 5.67 c.ft/day/sq. ft
Duration of application: 1 days
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 18 ft
Length of application area: 40.4 ft
Width of application area: 19 ft
Constant head boundary used at: 60 ft
Plotting axis from Y-Axis: 45 degrees
Edge of recharge area:
positive X: 9.5 ft
positive Y: 9.5 ft
Total volume applied: 4352.292 c.ft

MODEL RESULTS

X (ft)	Y (ft)	Plot Axis (ft)	Mound Height (ft)
-70.7	-70.7	-100	0.05
-59.5	-59.5	-84	0.12
-48.2	-48.2	-68	0.26
-37	-37	-52	0.55
-28.1	-28.1	-40	0.96
-21.3	-21.3	-30	1.46
-15.7	-15.7	-22	2.06
-11	-11	-15	2.72
-6.9	-6.9	-10	3.32
-4.1	-4.1	-6	3.59
-2.2	-2.2	-3	3.7
0	0	0	3.74
1.3	1.3	2	3.72
2.5	2.5	3	3.68
4.1	4.1	6	3.58
6.6	6.6	9	3.34
9.4	9.4	13	2.94
12.8	12.8	18	2.41
16.9	16.9	24	1.85
22.2	22.2	31	1.29
28.9	28.9	41	0.76
35.7	35.7	50	0.36
42.4	42.4	60	0

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D4

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:45:38 PM

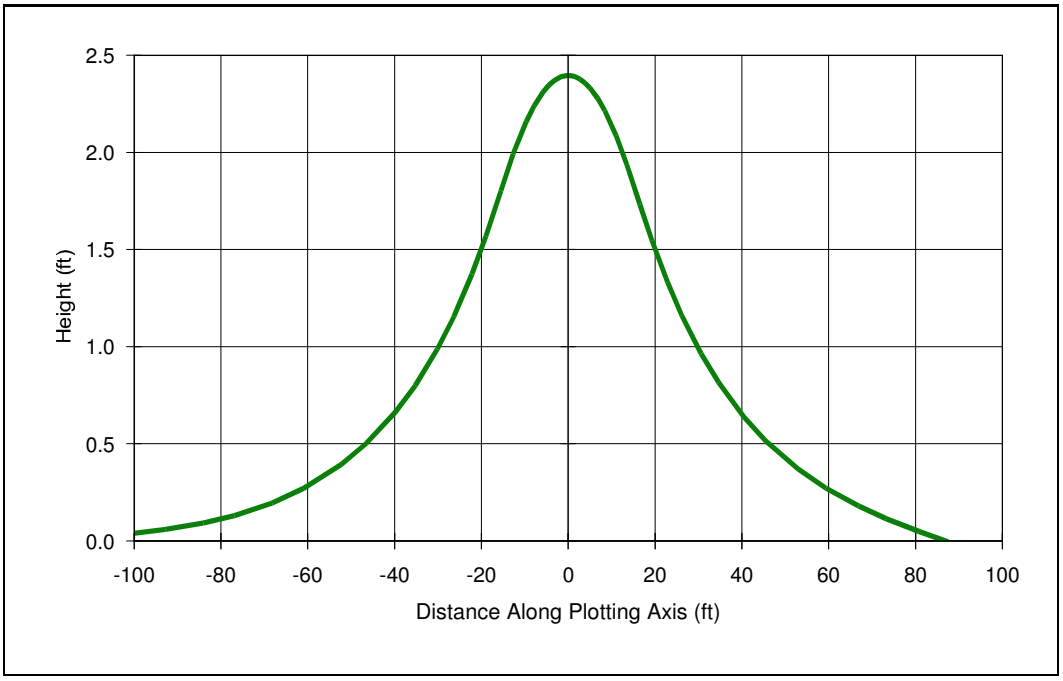
INPUT PARAMETERS

Application rate: 5.67 c.ft/day/sq. ft
Duration of application: 1 day
Total simulation time: 5 day
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 18 ft
Length of application area: 40.4 ft
Width of application area: 19 ft
Constant head boundary used at: 60 ft
Groundwater mounding @
X coordinate: 0 ft
Y coordinate: 0 ft
Total volume applied: 4352.292 cft

MODEL RESULTS

Time (day)	Mound Height (ft)
0	0
0	0.28
0	0.82
0.1	1.36
0.2	1.78
0.2	2.13
0.3	2.44
0.4	2.74
0.5	3.03
0.7	3.35
1	3.74
1.1	2.89
1.2	1.98
1.4	1.38
1.6	1.02
1.9	0.77
2.2	0.59
2.6	0.44
3.1	0.32
3.8	0.22
5	0.13

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D5

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:51:26 PM

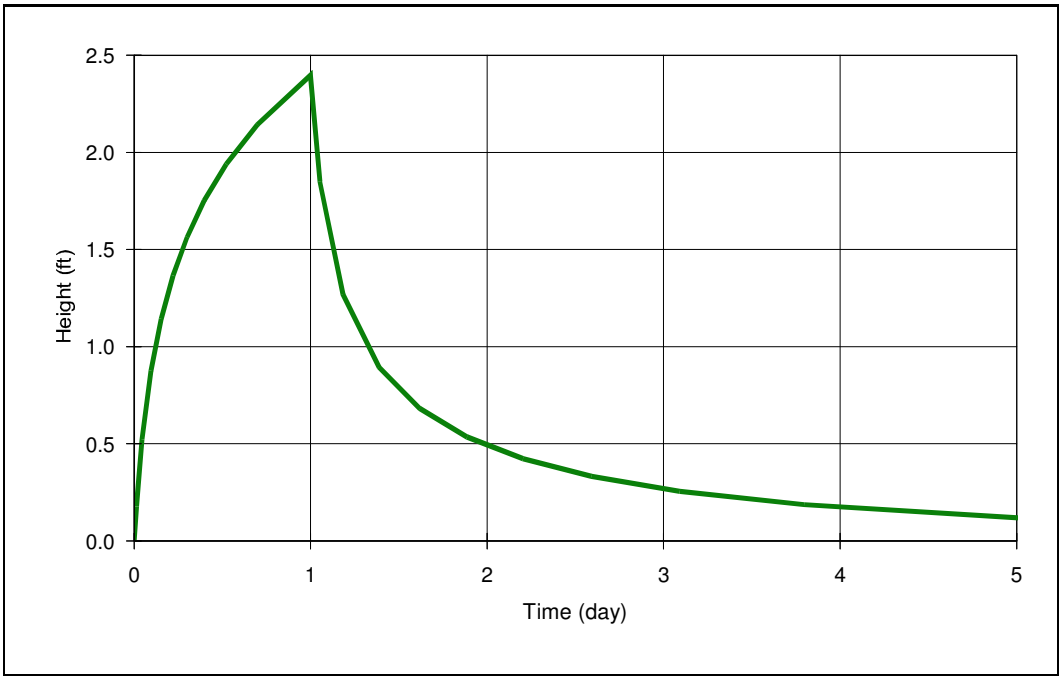
INPUT PARAMETERS

Application rate: 3.59 c.ft/day/sq. ft
Duration of application: 1 days
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 20 ft
Length of application area: 40.47 ft
Width of application area: 21 ft
Constant head boundary used at: 87 ft
Plotting axis from Y-Axis: 45 degrees
Edge of recharge area:
positive X: 10.5 ft
positive Y: 10.5 ft
Total volume applied: 3051.033 c.ft

MODEL RESULTS

X (ft)	Y (ft)	Plot Axis (ft)	Mound Height (ft)
-70.7	-70.7	-100	0.04
-59.5	-59.5	-84	0.09
-48.2	-48.2	-68	0.2
-37	-37	-52	0.39
-28.1	-28.1	-40	0.66
-21.3	-21.3	-30	0.99
-15.7	-15.7	-22	1.37
-11	-11	-15	1.8
-6.9	-6.9	-10	2.16
-4.1	-4.1	-6	2.31
-2.2	-2.2	-3	2.37
0	0	0	2.4
1.9	1.9	3	2.38
3.6	3.6	5	2.33
6	6	8	2.21
9.5	9.5	13	1.94
13.6	13.6	19	1.54
18.5	18.5	26	1.16
24.5	24.5	35	0.82
32.2	32.2	45	0.52
41.9	41.9	59	0.27
51.7	51.7	73	0.12
61.5	61.5	87	0

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Jasper hill - BASN D5

ANALYST: Desheng Wang

DATE: 9/26/2023 TIME: 1:51:42 PM

INPUT PARAMETERS

Application rate: 3.59 c.ft/day/sq. ft
Duration of application: 1 day
Total simulation time: 5 day
Fillable porosity: 0.26
Hydraulic conductivity: 16.42 ft/day
Initial saturated thickness: 20 ft
Length of application area: 40.47 ft
Width of application area: 21 ft
Constant head boundary used at: 87 ft
Groundwater mounding @
X coordinate: 0 ft
Y coordinate: 0 ft
Total volume applied: 3051.033 cft

MODEL RESULTS

Time (day)	Mound Height (ft)
0	0
0	0.18
0	0.52
0.1	0.88
0.2	1.14
0.2	1.37
0.3	1.56
0.4	1.75
0.5	1.94
0.7	2.14
1	2.4
1.1	1.85
1.2	1.27
1.4	0.9
1.6	0.68
1.9	0.54
2.2	0.42
2.6	0.33
3.1	0.26
3.8	0.19
5	0.12