Final Design Report

May 20, 2021

Evaluating Stormwater Best Management Practices

Portsmouth, NH

Team 15

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Introduction

The city of Portsmouth has 76 stormwater Best Management Practices (BMPs) currently installed to aid in satisfying the requirements of the MS4 permit. According to the city's MS4 general permit for stormwater discharge, these BMPs are designed to remove 80% of the average annual Total Suspended Solids (TSS) load and 50% of both the average annual Total Nitrogen (TN) and Total Phosphorus loads prior to discharging into the Great Bay. The MS4 permit, along with a Great Bay Total Nitrogen General Permit (signed November 24, 2020), are in place to reduce the nutrient load, with an emphasis on nitrogen load, entering the Great Bay, thereby reducing the effects of excess nutrient loading. The communities involved, one of which is Portsmouth, can either reduce their total nitrogen load discharging from their wastewater treatment plants to 3 mg/L, or they can reduce the total nitrogen load from non-point sources, the vast majority being stormwater, by 45% over a 23-year period. It is known that an emphasis will be placed on nutrient reduction entering the Great Bay in the future, so Portsmouth has opted to focus on stormwater discharge now, knowing they will have to do so in the future regardless.

Project team members, through the project manager, will coordinate with the Department of Public Works to evaluate the efficiency of the currently installed BMPs. BMPs will be examined based on their existing conditions, land use, soil types, BMP type, size (design storage volume), drainage area, hydrologic conditions (soil type), and other factors. Information gathered throughout this process will be documented using the pollutant tracking and accounting project application, PTAP. All necessary data collected and calculated will be entered into PTAP for each BMP, and PTAP will utilize that input data to quantify pollutant removals. This pollutant removal will be compared back to existing conditions in 2010 to determine how far along the City of Portsmouth is in the 45% reduction of their nitrogen load from non-point sources (stormwater).

Project team 15 will evaluate the 11 BMPs owned by the city of Portsmouth (public sites) initially, then shift to privately owned sites. When all public sites and six private sites (17 total sites) are fully completed, the project team will compare the associated tradeoffs for each BMP type that was analyzed. Based on the data entered into the Pollutant Tracking and Accountability Program application (PTAP), pollutant removal will be quantified for each system. This data will be utilized to determine the City of Portsmouth's progress in the reduction of pollutant load, specifically nitrogen load, entering the Great Bay for the purpose of the two permits listed above. BMPs will then be recommended to Portsmouth's Department of Public Works based on whether the project is private or public, space availability, cost, pollutant removal efficiency, and other factors for future development. These recommendations will allow future and existing sites to utilize the optimal stormwater BMP's for removing TSS, total nitrogen and total phosphorus from their site, and keep them on pace for the requirements of the Great Bay Total Nitrogen General Permit.

Scope of Work

Project Team 15 met with the project sponsor (Jamie McCarty) and the two faculty advisors (Dr. Erin Bell and Dr. James Houle) to start the project. Project Sponsor Jamie McCarty gave further details for a more complete understanding of this project. The entire team gained an understanding of project goals, schedule, expectations, and responsibilities at the conclusion of this meeting. Bi-weekly meetings were scheduled with the project sponsor to provide updates on the work completed during the previous two-week period and ideas were shared for what work would be accomplished in the next two-week period. Faculty advisors are encouraged to come to these meetings, but are not required. Progress reports detailing the work completed in the previous two-week period and the work planned for the next two-week period are emailed to the project sponsor and faculty advisors prior to the bi-weekly meetings. A record of all project-related communication was kept by the project team including recordings of the bi-weekly meetings, progress reports, and email correspondence.

The schedule for this project was developed using information from the initial project meeting. The schedule includes all the goals for this project, the time-frame for which Team 15 expects to work on and complete each task as well as a critical path. The critical path defines the tasks that are the most important for this project to ensure the deliverables will be completed by their due dates. It also defines the tasks that can’t be started until the previous task is completed.

One of the tasks included in the critical path is data collection. Data collection for this project depended on what data needs to be entered into the software for this project, the Pollutant Tracking and Accountability Program, or PTAP for short. Data was collected for each representative Best Management Practice example and entered into PTAP. PTAP utilizes that data and quantifies the pollutant removal efficiency for that system. To utilize the PTAP system, each team member created a personal account.

Data collection for this project consists of collecting site-specific data for each BMP. The following parameters are required for PTAP entry: The design storage volume, or the physical storage capacity of the system to hold water, of the system, the type of BMP, the area that drains to the system as well as the percentage of that area that is impervious, the design storm depth based on a one-inch storm event, and the infiltration rate of the soils for the site. An inventory of all BMPs installed in Portsmouth since 2010 and their respective construction drawings were provided from the project sponsor. City infrastructure drawings were available in the Plan Room archives in the Portsmouth Town Hall. The provided construction drawings were used to calculate design storage volumes (DSVs) for each site. The drainage area and the percent impervious cover was measured using Google Earth Pro or the drainage analysis if provided. Priority was placed on BMPs with the most available data to the team as this allowed team members to familiarize themselves with the data collection process. While data may be given for more than the 20 to 30 sites, some necessary data is missing. As a result, these systems were excluded to limit assumptions and focus on the quality of work. Site visits were conducted to gain a better understanding of the systems in place as well as to collect additional data when necessary.

BMP evaluations were conducted to determine the working condition of each site. These sites were evaluated on a four-point scale. These evaluations and BMP conditions were important to factor into the removal efficiency of each system when data was analyzed from PTAP.

Upon the completion of data collection and calculation for a given BMP, that data will be entered into PTAP. For each entry, a project name and geographical information is added to make each entry more identifiable. If a system is added along with new construction, then the land use conversion table in PTAP is needed. This table factors in the existing conditions prior to construction as well as the future conditions post-construction. If a system was added to a site with no other changes to the site, then the land use conversion table in PTAP is not to be used.

Once all necessary data was entered into PTAP for a given system, PTAP quantified the removal of pollutants, like TSS, total nitrogen, and total phosphorus, based on pre-BMP installation and current conditions. This resulted in the difference for pollutant loads based on 2010 conditions compared to current day conditions. After all of the BMPs were entered, the quantification of the City of Portsmouth's nitrogen load reduction via non-point sources was completed. The effectiveness of each BMP was also quantified using the data from PTAP to determine which BMPs are most effective at removing TSS, nitrogen, and phosphorus. Based on the team's findings, the team will make recommendations to the City of Portsmouth for future BMP installations. These recommendations will be based on if the site is public or private, BMP performance, available space, among other site characteristics.

Project Schedule

The schedule shows the proposed tasks that the team will complete throughout each semester. Each task is listed with a duration, start date and end date, allowing each team member to monitor upcoming tasks and complete them by their end date. The schedule is divided into two sections: Fall Semester (9/21/20 - 12/31/20) and Spring Semester (12/21/20 - 5/6/20).

The critical path and key tasks for the fall semester were as follows; the kickoff meeting, creation of project schedule and Gantt chart, creating a list of BMPs to be evaluated, site visits, and data collection for each of the systems. Data collection began with gathering all the background information for each site. The data was then analyzed and used to calculate unknowns about each system.

The key tasks and critical path for the spring semester began with updating the scope of work, completing the remaining data collection, creating an assumptions document, performing calculations, and entering the information into PTAP. Site visits were also done to visually assess the condition of several systems. The BMP data is being processed in PTAP by the project sponsor, and the results will be analyzed by the team shortly. Finally, the design report will be updated, and the project will be presented at the ACEC and the URC.

Introduction to PTAP & Relevance to the Project

The Pollutant Tracking and Accounting Project (PTAP) application was created by the Stormwater Center at the University of New Hampshire and NHDES. It was designed to track the removal of nonpoint source (NPS) pollution as stormwater runoff within the Great Bay watershed. The water quality in the Great Bay area has been declining as a result of NPS pollution such as septic system byproducts, fertilizers, and air pollutants carried by stormwater runoff. Impervious cover in the area has exacerbated this process by allowing stormwater to flow further and pick up more pollutants before entering the watershed. In response, Great Bay municipalities have been subjected to regulations such as Administrative Orders of Consent and MS4 stormwater permits. To meet these requirements, the city of Portsmouth must remove 80% of their average annual Total Suspended Solids (TSS) and 50% of both the average annual Total Nitrogen (TN) and Total Phosphorus (TP) loads being generated in their stormwater discharge.

For this project, PTAP was used to determine the removal efficiency of each BMP system being evaluated. The Portsmouth Department of Public Works will be able to use PTAP as a storage and evaluation system for these BMPs. This information will be helpful when the city is considering new BMP installations, or when they need to provide the EPA with data on current BMP installations. To use PTAP, team members entered parameters such as the BMP type, design storage volume, soils data, land use, and drainage area into the database. Existing conditions were utilized when there was a land-use change. For example, if a BMP system was added to a site along with new construction, then existing conditions prior to the construction are necessary, as well as the future conditions post-BMP installation. The existing and future conditions are entered into the land use conversion table in PTAP. In contrast, if there was no new construction or alterations to the site other than the addition of a BMP, then only future conditions post-BMP installation were necessary and the land use conversion table did not to be used. As these systems were entered into PTAP, they were stored in the database. The PTAP submissions made by team 15 are listed as “pending” until a PTAP administrator reviews the submission and approves it. In this case, project sponsor James McCarty is the Portsmouth PTAP administrator. Upon approval, the systems remain stored in the PTAP database and results for each system become available. The calculator in PTAP quantifies the removal efficiency of each system based on the data entered. The PTAP system assumes that the BMPs are being maintained properly and working as designed as if they are brand new.

BMP Evaluations

BMP evaluations were conducted on each system to evaluate the condition. These sites were evaluated on a four-point scale. The following are the four visual criteria that were considered for evaluation: Can water enter and exit the system, does the system appear to be operating as designed, is there a noticeable buildup of debris, vegetation, sediment, trash, etc., and is there any noticeable damage to the system. After examining the site and making observations on these criteria, they were either deemed “pass” or “fail”. A system operating correctly for all four of these criteria is given a score of four. It is important to note that the criteria don’t carry the same weight. For example, if water doesn’t enter or exit a system, the system isn’t operating as designed and isn’t treating any of the stormwater. In contrast, if the system has excess vegetation or trash but passes the other three criteria, the system is still operating as designed, but likely with less efficiency. These evaluations of BMP conditions were important to factor into the removal efficiency of each system when data was analyzed from PTAP.

Data Collection and Entry

Data was collected in a variety of ways using many different resources made available. Site plans, existing conditions, and as-built documents were provided by the Project Sponsor, James McCarty. These documents were crucial in calculating the design storage volumes of each system. There were different calculations used to calculate the design storage volume for each type of system; these equations were provided by the UNH stormwater center. Web Soil Survey was utilized to acquire the soil types for each system. Google Earth Pro was the primary resource to delineate drainage areas and the percentage of impervious cover. NH Granit was used occasionally if the system was implemented between 2010 and 2015. The drainage analysis was infrequently provided which included the drainage area and percentage of impervious cover. When system dimensions were unavailable, the dimensions were measured by printing out the plans and physically measuring them with an engineering scale. Portsmouth MapGeo was used to find the map number, block number, lot number, parcel ID, property owner, and development type of each system. One problem encountered with data collection was that many site plans did not have enough information to accurately measure the dimensions of the system. Several were missing the inlet and outlet elevation as well as the slope of the system.

Assumptions were made when applicable so the project team could enter the system into PTAP. Typically, these assumptions were based on a standard system design found in the UNH Stormwater database. Systems that required many assumptions were excluded due to the preservation of data quality. In total, data collection for each system consisted of the type of BMP, hydrologic soil group, post-installation drainage area and percent impervious cover, design storage volume, design storm depth based on a one-inch storm, and the infiltration rate for each system. Some systems required more data (the systems that required the land use conversion table), but these were the typical values entered for each BMP.

To enter the systems into PTAP, the first step was to fill out identifiable information for the site. This information included the project name, map number, block number, lot number, parcel ID, property owner, site address, and type of development. To begin entering data, it is important to understand the BMP installation history. Mentioned above, it is critical to understand if the system was installed along with other construction and land changes, or if just the system was added with no land changes. If the BMP was installed along with land changes, the next step was to fill out the land use conversion table. To do this, the acreage of each soil type on site prior to installation was entered. The land use type, acreage of impervious surfaces pre- and post-installation was also added, completing the land use conversion table. Next, the impervious surface management table was filled out. To do this, the type of BMP, design storage volume, impervious drainage area, design storm depth based on a one-inch storm, and infiltration rate was added to the table. Lastly, the “save” button is pressed which saves the entry and adds it into the PTAP database as a pending submittal. If there were several BMPs used to treat the same site, the total impervious cover for the site was calculated and divided based on the design storage volume of each BMP. In this case, a second row can be added to the impervious surface management table. Table 1 depicts which types of BMPs and how many of each type were entered into PTAP. Any assumptions made throughout this process were listed in an assumptions sheet for each system. An example of the assumptions made for a porous pavement system can be seen in Appendix III: Figure 21 of this report. A sample design storage volume and design storm depth calculation can be seen in Appendix IV. All of this information was entered into PTAP as shown in Appendix 1: Figures 4 and 5.

Table 1: List of BMPs entered into PTAP

Public Sector	List of BMPs	Private Sector
0	Gravel Wetland	0
0	Extended Dry Detention Pond	1
0	Grass Swale with Detention	0
4	Biofiltration (RG, TF, PB)	0
0	Infiltration Trench	0
2	Sand Filter	5
1	Enhanced Biofiltration with ISR	0
2	Porous Pavement	0
2	Infiltration/Surface Infiltration	0
0	Wet Ponds	0
11	Total	6

Evaluation Time Spent per System

The amount of time required to completely collect the data and enter it into PTAP varied based on a few factors. Site plans were provided to the team without identifying the type and number of BMPs present at each site. As a result, team members thoroughly looked through every plan to ensure every BMP present was identified. The longer the site plan, the more time spent thoroughly checking it. The next factor was the quality of the plans provided. Some plans included a drainage analysis which listed the design storage volume, drainage area, percent impervious cover, or a combination of the three. An example of a system with a provided drainage analysis was Hodgdon. If they weren't provided, the design storage volume needed to be calculated using site plans and cross sections, which took approximately an hour to two hours for each system. The drainage area was then found using Google Earth Pro to delineate the area and the provided plans to map out the catch basins that drained to the system. Assumptions were made on drainage area because surveying the area was out of the scope of this project. This took approximately 15 minutes to half an hour for each system. The design storm depth took about five minutes to calculate. Soil information was found using Web Soil Survey which took approximately 15 minutes. Lastly, basic site information regarding ownership, lot numbers, and parcel IDs were found using Portsmouth MapGeo, which took about 15 minutes as well. The overall time varied drastically depending on the factors listed above. For example, a site like Hodgdon which included a drainage analysis took roughly one hour to enter into PTAP. A system that didn't include a drainage analysis took roughly two to three hours because the calculation of the design storage volume and delineation of the drainage area took the most time by far.

Results

Once all 17 systems were entered into PTAP, the program reported the total weight of suspended solids, phosphorous, and nitrogen removed in pounds per year. The results can be seen in Table 2 below. The program also reported the total impervious cover managed by each BMP type that was entered. This impervious cover breakdown can be seen in Figure 1 below.

Table 2: Total Contaminant Removals for All 17 BMPs

Pollutant Type	Total Suspended Solids	Total Phosphorus	Total Nitrogen
Nutrient Removal (lb./year)	13,728	34	263

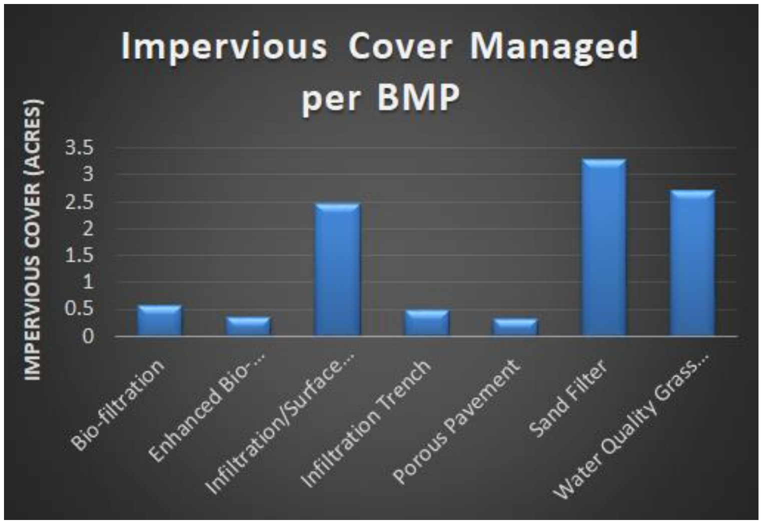


Figure 1: Impervious Cover Managed per BMP Type

Currently, the city of Portsmouth is discharging 128.9 pounds of nitrogen per day into the Great Bay via non-point source pollution. The Great Bay General Permit states that this value must decrease by 14.2 pounds per day (11%) to reach their five-year goal. Based on the results from PTAP, the 17 systems analyzed for this project are removing .7 pounds of nitrogen per day. Extrapolating this number to all 76 systems results in a reduction of 3.2 pounds of nitrogen per day, which is 22.5% of Portsmouth's 11% reduction goal over five years. This proves that adding all 76 systems into PTAP is worthwhile to achieve the nitrogen removal credit to satisfy the Great Bay General Permit. The required 11% reduction value and the extrapolated removal value for all 76 systems can be seen in Figure 2 below.

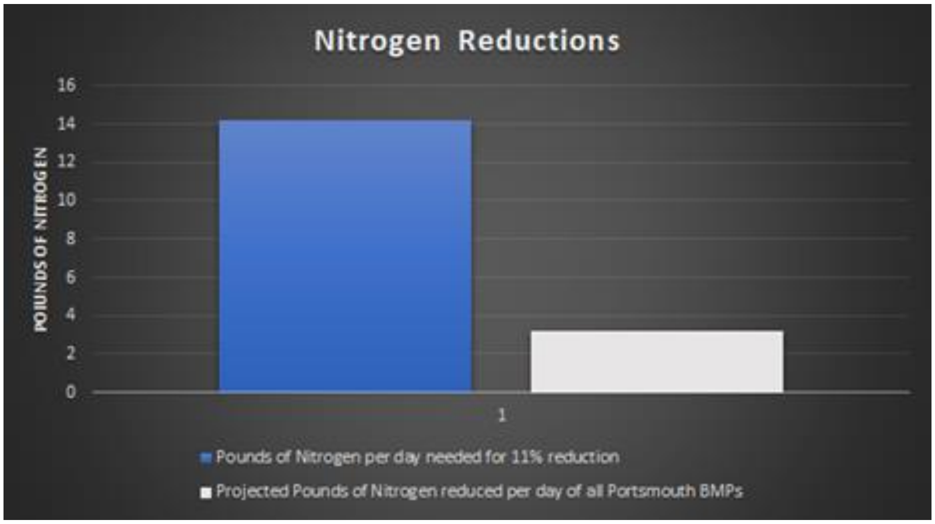


Figure 2: Portsmouth's 11% Nitrogen Goal vs. Projected Nitrogen Removal of All BMPs

Additionally, a cost assessment was conducted to determine if it is cheaper to enter BMPs into PTAP to receive nitrogen removal credit when compared to wastewater treatment plants. The city of Portsmouth has hired an intern for the summer of 2021 to input the remaining Portsmouth BMPs into PTAP. This is expected to cost Portsmouth \$20 per hour. Based on this project, it takes an average of approximately three hours to collect the necessary data and completely input a BMP into PTAP. For the 17 systems examined in this project, 1,300 pounds of nitrogen is removed over the course of the next five years, or an average of 15 pounds of nitrogen removed per year per system. This was incorporated with the cost of the intern and the time it takes to completely enter a new system into PTAP, which resulted in a cost per pound of nitrogen removed. This value came out to be \$4 per pound of nitrogen removed. This value was compared to the cost to remove a pound of nitrogen in the Portsmouth Wastewater Treatment Plant, which is roughly \$80 per pound of nitrogen removed. This proves that it is cheaper to enter currently installed BMPs into PTAP to work toward the desired nitrogen removal standards.

Recommendations

Based on the results from PTAP and independent research, it is recommended to install gravel wetlands, bioretention systems, and infiltration systems for the future. This was determined based on removal efficiency alone, but many factors can determine which system is installed, including available space, cost, and required maintenance. This was determined with a rather small sample size of BMPs, only 22% of currently installed BMPs in Portsmouth. Also, 11 out of the 17 systems analyzed were publicly owned by the city of Portsmouth, while a majority of the remaining systems are privately owned. Therefore, it is recommended that the remaining systems are analyzed and added into PTAP so a larger sample size is achieved. This will give the City of Portsmouth a more complete understanding as to how the types of BMPs perform.

Summary

<u>Activities to Date</u>

During the fall of 2020, the project team held biweekly meetings with James McCarty, the project sponsor, to gather information and update him on progress being made. The team also met with their faculty advisor, Dr. James Houle, to learn more about PTAP and how to evaluate stormwater BMPs. Using information gathered through these meetings, a scope of work for the project and a schedule for the duration of the project were created. The team searched through public and private sector site plans to find BMPs for evaluation, then collected drainage and land use information on a few of these BMPs. A list of the BMPs found was compiled, as well as the amount of information available for each system. Team members calculated design storage volumes for the BMPs with the necessary information available and sent a request to the project sponsor for more information on the systems without enough information available. In early November, the team met with their project sponsor and other DPW employees to visit some of the sites in Portsmouth and see how these systems operate. The team finished the fall semester by giving a presentation on the project's progress to the faculty advisor, project sponsor and other UNH faculty members in early December.

The focus of the first semester was data collection and gaining an understanding on the number of BMPs the project team could feasibly enter into PTAP given the available data. In the spring semester, the project team has entered 17 systems into the PTAP database. Eleven of the systems are publicly owned by Portsmouth and seven of them are privately owned. All possible public sites were entered because the Portsmouth DPW was most interested in the systems within their jurisdiction. The privately owned BMPs were selected because they had the most accessible information and the most complete site plans. The project team has continued their bi-weekly meetings with the project sponsor, and has met with the faculty advisor on several occasions.

To ensure that the results of the PTAP analysis for each system are accurate, the project team created a stormwater BMP inspection checklist. The checklist contained four visual inspection criteria, which allowed the team to evaluate whether or not the systems were functioning properly. The team used these checklists to visually evaluate all 17 systems that were put into PTAP. If the system passed, it was assumed to be fully functional and operating as designed. Examples of these checklists can be found in Appendix 1: Figures 6 to 20.

On April 14, the team gave a presentation on the project to the American Council of Engineering Companies (ACEC) conference.

The PTAP results were acquired and the team manipulated the data to come to a few conclusions. The first conclusion was that the 17 systems entered into PTAP removed 13,728 pounds of total suspended solids (TSS) per year, 34 pounds of total phosphorus (TP) per year, and 263 pounds of total nitrogen (TN) per year. The second conclusion was if the results of the 17 systems were extrapolated to all 76 systems installed in Portsmouth, that would result in a removal of 3.2 pounds of total nitrogen per day. This would put Portsmouth at 22.5% of the 11% reduction goal required in the next five years. Third, the team concluded that it costs about $4 to remove one pound of nitrogen for the method utilized in this project. This was compared to the cost of removing one pound of nitrogen from the wastewater treatment system, which is about $80 per pound. This signifies that it is worth it for Portsmouth to spend the time to enter all the BMP systems into PTAP to receive credit for the Great Bay General Permit. Recommendations were made to the city of Portsmouth to guide decisions on future installations of BMPs.

The team created and submitted a poster, as well as presented the entirety of this project and its findings to the Undergraduate Research Conference.

Tasks to Be Completed

Portsmouth has hired an intern to continue the work from where the team left off. The remaining BMPs are to be entered into PTAP to receive nitrogen removal credit for the Great Bay General permit.

Challenges

Obstacles the team has encountered have been largely related to the availability of the site plans and drainage analysis reports. This was an issue with the public sector BMPs specifically, with not enough data being available to accurately calculate the design storage volumes for many systems. Many systems were missing cross sectional views and drainage analysis reports which are necessary for calculating the design storage volumes. This issue was remedied for private sites using Portsmouth viewpoint. Viewpoint is a data base that lists all permits for a project. The team has been able to access more plans for private sites, filling in the missing data needed to calculate design storage volumes. The team overcame this with the public sites by using cross sections of BMP design standards provided by the UNH stormwater center. This allowed the team to fill in the missing information gaps for many of the public sites. Learning to read site construction plans was an issue at first, but the team quickly enhanced their ability to read site plans and is no longer issue now.

Another large challenge was time management. Choosing specific sites and types of BMPs led to dead-ends in analysis when not enough information was available to adequately input data into the software. This occurred rather frequently, leaving the team with a lot of half-finished analysis. It was a challenge to grasp which sites would be feasible to gather further information and determine the process for acquiring that information. This involved waiting for the sponsor to potentially provide additional plans, finding it on alternative databases, or making assumptions about the site based on educated guesses.

References

Bioretention - xpdrainage 2019.1 Help Documentation. (2019). Retrieved December 15, 2020, from https://help.innovyze.com/display/XDH2019V1/Bioretention

City of Portsmouth. (n.d.). MapGeo. Retrieved from https://www.cityofportsmouth.com/public-works/engineering-gis/mapgeo

NH Granit. (n.d.). NH Coastal Watershed Pollutant Load Analysis ("Hot Spot Mapping Project"). Retrieved from https://www.granit.unh.edu/Projects/Details?project_id=464

NRCS. (2019, July). Web Soil Survey. Retrieved February, 2021, from https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

OpenGov. (n.d.). Retrieved December 15, 2020, from https://portsmouthnh.viewpointcloud.com/

Porous Pavement – xpdrainage 2020.1 Help Documentation. (2020). Retrieved December 15, 2020, from https://help.innovyze.com/display/infodrainage2020v1/Porous+Paving

PTAPP. (n.d.). Retrieved December 15, 2020, from https://ptapp.unh.edu/

University of New Hampshire. (2021). Stormwater Center. Retrieved from https://www.unh.edu/unhsc/

US EPA. (2020, November 24). NPDES GENERAL PERMIT: NHG58A000. *Final National Pollutant Discharge Elimination System*. Retrieved February, 2021, from https://www3.epa.gov/region1/npdes/gbtn/nhg58a000-gbtn-gp.pdf

Cobb, Michael. “EPA's Draft of the Great Bay Total Nitrogen General Permit.” EPA, 8 May 2020, from http://files.cityofportsmouth.com/files/ww/GBTN05.08.2020.pdf

Appendix

I. Figures

ID	Task Name	Duration	Start	Finish
1	kickoff Meeting	1 day	Mon 9/21/20	Mon 9/21/20
2	Scope of Work	5 days	Mon 9/21/20	Fri 9/25/20
3	Schedule/Gantt Chart	15 days	Mon 9/21/20	Fri 10/9/20
4	Create Account For PTAP	1 day	Mon 9/21/20	Mon 9/21/20
5	Professor Houle Meeting: Intro to PTAP	1 day	Fri 10/2/20	Fri 10/2/20
6	Bi-Weekly Meeting: #1	1 day	Mon 10/5/20	Mon 10/5/20
7	Create List of BMPs being investigated	11 days	Mon 10/5/20	Sun 10/18/20
8	Learn Process of Obtaining Data for Entry into PTAP	16 days	Mon 10/5/20	Sun 10/25/20
9	Bi-Weekly Progress Report	1 day	Fri 10/9/20	Fri 10/9/20
10	Bi-Weekly Meeting: #2	1 day	Mon 10/19/20	Mon 10/19/20
11	Data Collection & BMP Entry (1-3)	54 days	Mon 10/19/20	Thu 12/31/20
12	Professor Houle PTAP Meeting #2	1 day	Wed 10/21/20	Wed 10/21/20
13	Bi-Weekly Progress Report	1 day	Fri 10/23/20	Fri 10/23/20
14	Preliminary Design Report	36 days	Fri 10/30/20	Fri 12/18/20
15	Bi-Weekly Meeting: #3	1 day	Mon 11/2/20	Mon 11/2/20
16	Bi-Weekly Progress Report	1 day	Fri 11/6/20	Fri 11/6/20
17	Site Visit	1 day	Mon 11/16/20	Mon 11/16/20
18	Bi-Weekly Meeting: #4	1 day	Mon 11/16/20	Mon 11/16/20
19	Bi-Weekly Progress Report	1 day	Fri 11/20/20	Fri 11/20/20
20	Bi-Weekly Meeting: #5	1 day	Mon 11/30/20	Mon 11/30/20
21	Bi-Weekly Progress Report	1 day	Fri 12/4/20	Fri 12/4/20
22	Design Presentation	1 day	Mon 12/7/20	Mon 12/7/20
23	Bi-Weekly Meeting: #6	1 day	Mon 12/14/20	Mon 12/14/20
24	Bi-Weekly Progress Report	1 day	Fri 12/18/20	Fri 12/18/20

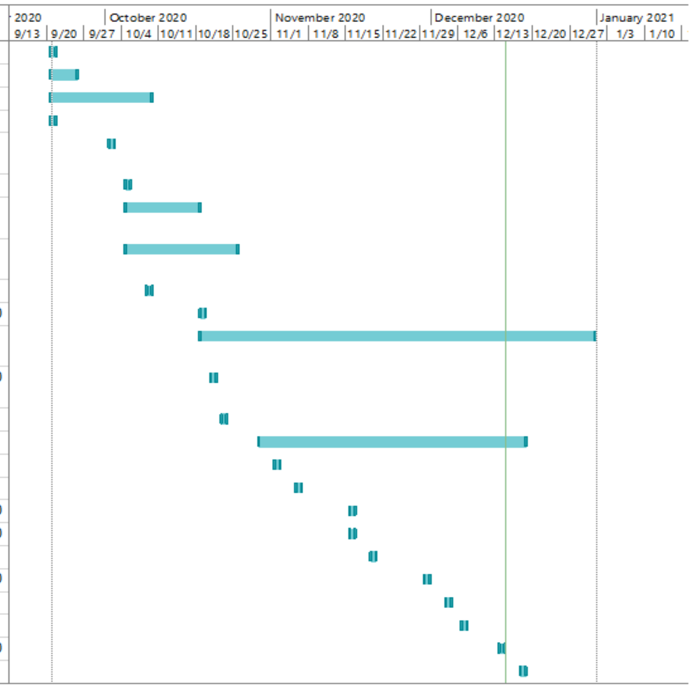


Figure 3: Fall Semester Schedule and Gantt Chart

ID	Task Name	Duration	Start	Finish
1	Updated Scope of Work	31 days	Mon 12/21/20	Mon 2/1/21
2	Remaining Data Collection & Entering	76 days	Mon 12/21/20	Sun 4/4/21
3	Bi-Weekly Meeting: #7	1 day	Mon 2/1/21	Mon 2/1/21
4	Updated Design Reports	45 days	Tue 2/2/21	Mon 4/5/21
5	Bi-Weekly Progress Report: #7	1 day	Fri 2/5/21	Fri 2/5/21
6	Bi-Weekly Meeting: #8	1 day	Mon 2/15/21	Mon 2/15/21
7	Bi-Weekly Progress Report: #8	1 day	Fri 2/19/21	Fri 2/19/21
8	Bi-Weekly Meeting: #9	1 day	Mon 3/1/21	Mon 3/1/21
9	Bi-Weekly Progress Report: #9	1 day	Fri 3/5/21	Fri 3/5/21
10	Bi-Weekly Meeting: #10	1 day	Mon 3/15/21	Mon 3/15/21
11	Bi-Weekly Progress Report: #10	1 day	Fri 3/19/21	Fri 3/19/21
12	Bi-Weekly Meeting: #11	1 day	Mon 3/29/21	Mon 3/29/21
13	Bi-Weekly Progress Report: #11	1 day	Fri 4/2/21	Fri 4/2/21
14	Undergraduate Research Conference	10 days	Tue 4/6/21	Sun 4/18/21
15	Bi-Weekly Meeting: #12	1 day	Mon 4/12/21	Mon 4/12/21
16	Bi-Weekly Progress Report: #12	1 day	Fri 4/16/21	Fri 4/16/21
17	Final Report / Panel Presentation	14 days	Mon 4/19/21	Thu 5/6/21
18	Bi-Weekly Meeting: #13	1 day	Mon 4/26/21	Mon 4/26/21
19	Bi-Weekly Progress Report: #13	1 day	Fri 4/30/21	Fri 4/30/21

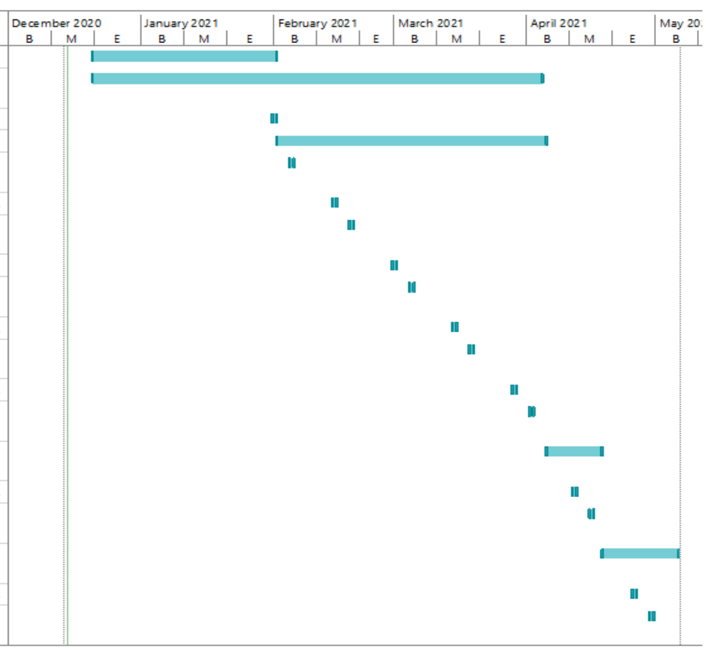


Figure 4: Spring Semester Schedule and Gantt Chart

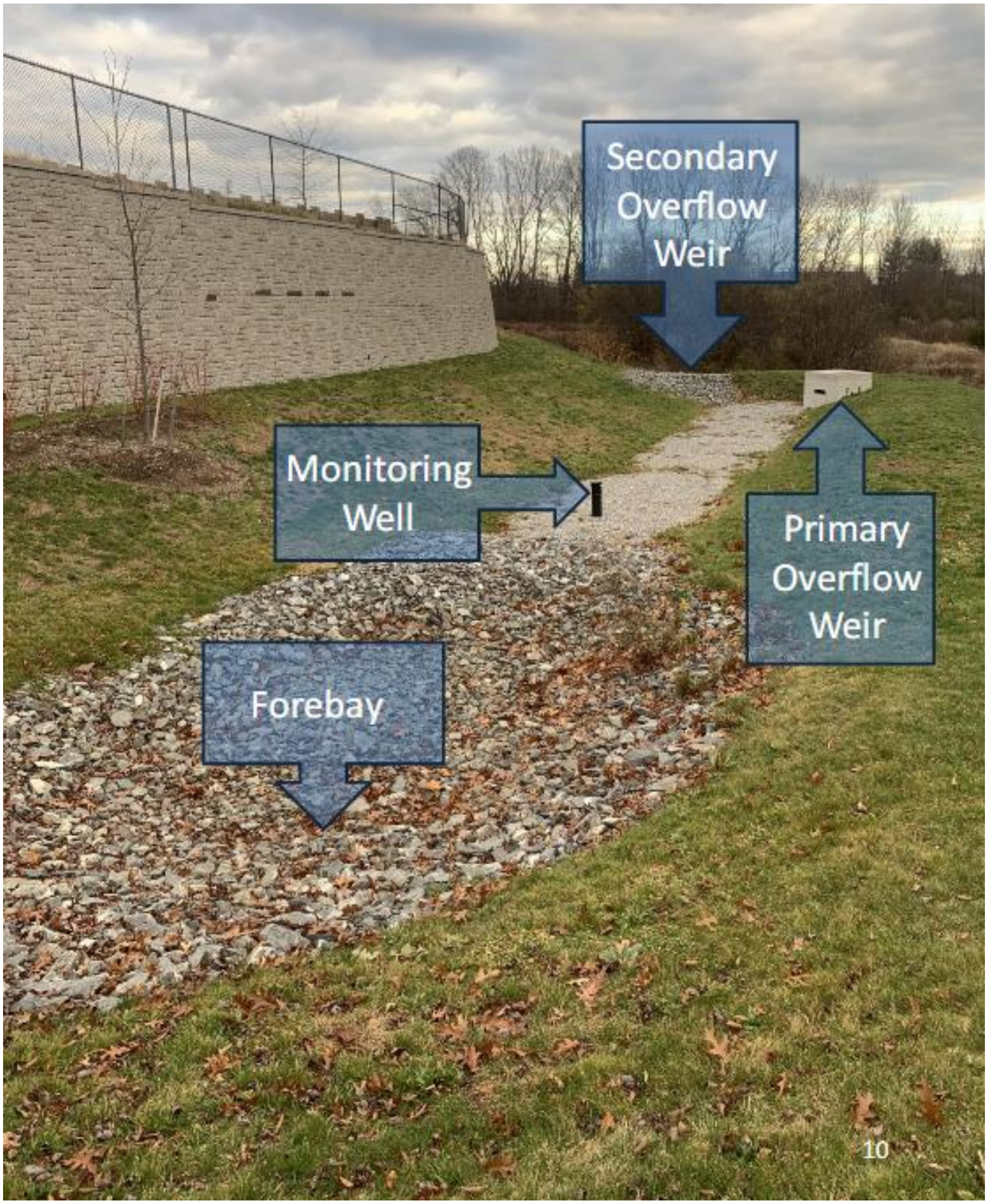


Figure 5: Sample BMP – Sand Filter: Portsmouth, NH

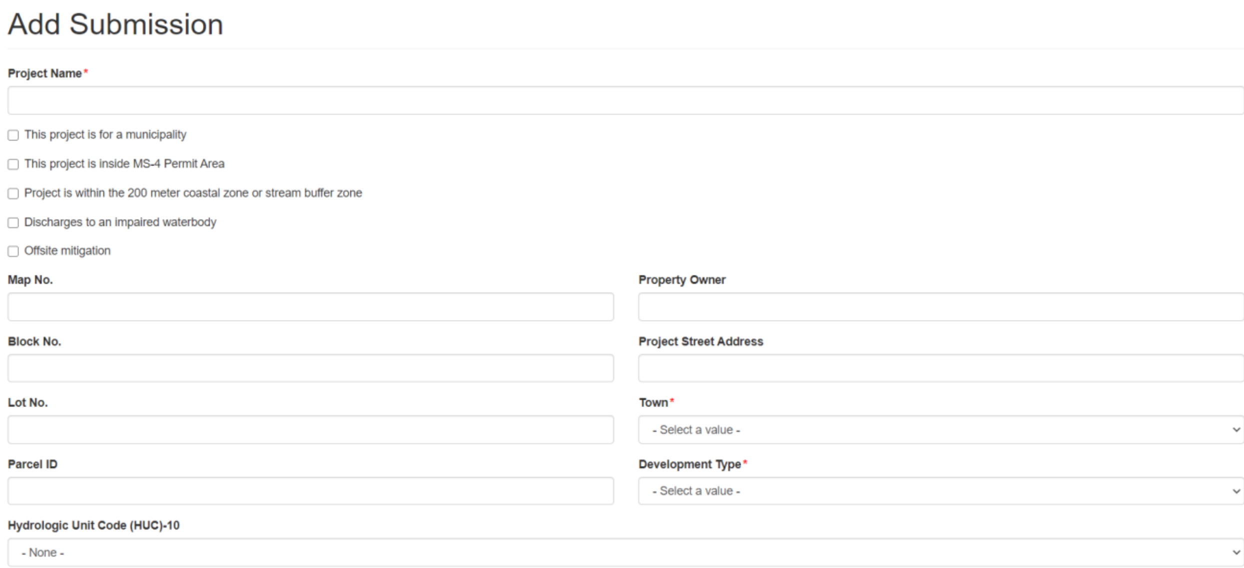


Figure 6: PTAP Data Entry

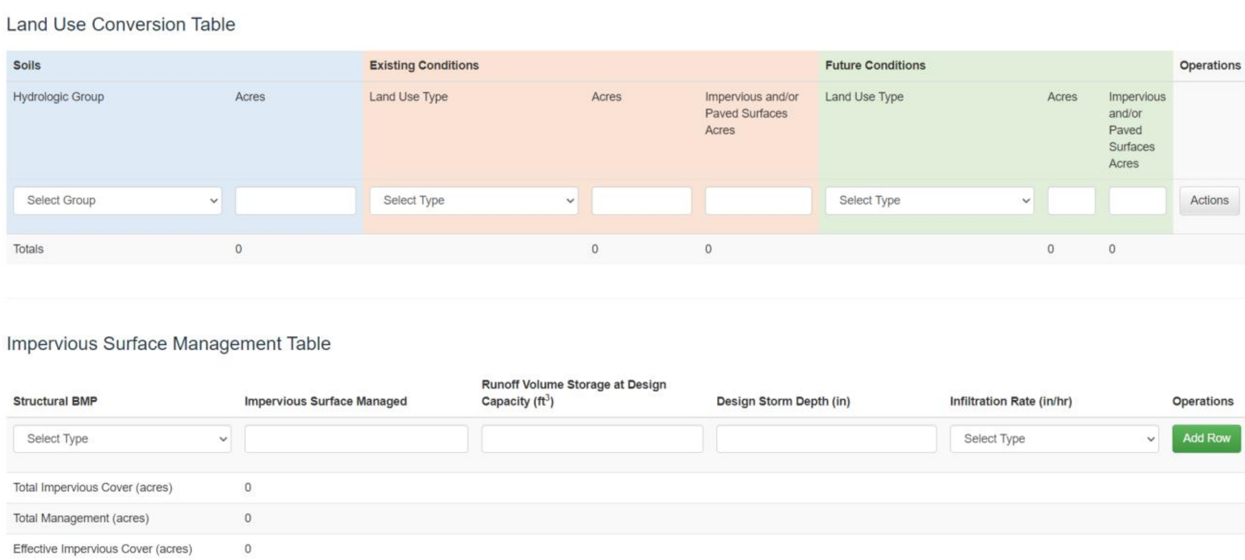


Figure 7: PTAP Data Entry Continued

II. Inspection Checklists

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type:

Location:

Date:

Weather:

Year Installed:

Visual Indicators

Pass	Fail	
☐	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☐	☐	System Operability: Does the system appear to be operating as designed?
☐	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☐	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: __________

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 8: Example BMP Inspection Checklist

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sand Filter

Location: 67,73, & 121 Corporate Drive – Sand Filter A

Date: 4/9/21

Weather: Sunny

Year Installed: 2018

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 9: Inspection Checklist - 67, 73, & 121 Corporate Drive, Sand Filter A

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sand Filter

Location: 67,73, & 121 Corporate Drive – Sand Filter B

Date: 4/9/21

Weather: Sunny

Year Installed: 2018

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 10: Inspection Checklist - 67, 73, & 121 Corporate Drive, Sand Filter B

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sand Filter

Location: 67,73, & 121 Corporate Drive – Sand Filter C

Date: 4/9/21

Weather: Sunny

Year Installed: 2018

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 11: Inspection Checklist - 67, 73, & 121 Corporate Drive, Sand Filter C

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sand Filter

Location: 67,73, & 121 Corporate Drive – Sand Filter D

Date: 4/9/21

Weather: Sunny

Year Installed: 2018

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 12: Inspection Checklist - 67, 73, & 121 Corporate Drive, Sand Filter D

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sand Filter

Location: 67, 73, & 121 Corporate Drive – Sand Filter E

Date: 4/9/21

Weather: Sunny

Year Installed: 2018

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 13: Inspection Checklist - 67, 73, & 121 Corporate Drive, Sand Filter E

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Detention Pond

Location: 85 New Hampshire Avenue

Date: 4/9/21

Weather: Sunny

Year Installed: 2015

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 14: Inspection Checklist - 85 New Hampshire Avenue, Detention Pond

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Detention Pond

Location: 160 Corporate Drive

Date: 4/9/21

Weather: Sunny

Year Installed: 2017

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 15: Inspection Checklist - 160 Corporate Drive, Detention Pond

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Two Bioretention systems

Location: Hodgdon Ave

Date: 4/9/21

Weather: Sunny

Year Installed: 2012

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21_____

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 16: Inspection Checklist - Hodgdon Avenue, Bioretention Systems

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Porous Pavement

Location: Sagamore Ave

Date: 4/9/21

Weather: Sunny

Year Installed: 2014

Visual Indicators

Pass	Fail	
☐	☒	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☐	☒	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:___________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: ___________

Comments:____
____
____
____

Figure 17: Inspection Checklist - Sagamore Avenue, Porous Pavement

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sand Filter

Location: State Street – Sand Filter

Date: 4/9/21

Weather: Sunny

Year Installed: 2012

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☐	☒	System Operability: Does the system appear to be operating as designed?
☐	☒	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____The sand Bed appears to be clogged and water is just flowing into the system over the overflow weir and out of the system.

Figure 18: Inspection Checklist - State Street, Sand Filter

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sand Filter

Location: Sagamore Bridge

Date: 4/9/21

Weather: Sunny

Year Installed: 2014

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ____4/9/21______

Date of Next Inspection: __________

Comments:____
____
____
____

Figure 19: Inspection Checklist - Sagamore Bridge, Sand Filter

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Bio-retention

Location: Sanderson

Date: 4/3/21

Weather: Sunny

Year Installed: 2018

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:___________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ___4/3/21_______

Date of Next Inspection: ___________

Comments: Good condition

Figure 20: Inspection Checklist - Sanderson Drive, Bioretention System

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Sub-surface Infiltration / Porous Pavement

Location: Plains Park

Date: 4/3/21

Weather: Sunny

Year Installed: 2012

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ___4/3/21_______

Date of Next Inspection: __________

Comments: Good condition

Figure 21: Inspection Checklist - Plains Park, Subsurface Infiltration and Porous Pavement

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Infiltration Basin

Location: Laurel Court

Date: 4/3/21

Weather: Sunny

Year Installed: 2013

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☒	☐	System Operability: Does the system appear to be operating as designed?
☒	☐	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ___4/3/21_______

Date of Next Inspection: __________

Comments:____Good condition – water ponding in the middle basin. Trees and brush beginning to reach a significant growth from the media.

Figure 22: Inspection Checklist - Laurel Court, Infiltration Basin

Team 15

Stormwater BMP Inspection Checklist

General Site Information

Stormwater BMP Type: Bio-retention

Location: State Street

Date: 4/3/21

Weather: Sunny

Year Installed: 2012

Visual Indicators

Pass	Fail	
☒	☐	Inlet/Outlet conditions: Can water enter and exit the system?
☐	☒	System Operability: Does the system appear to be operating as designed?
☐	☒	Inorganic/Organic Material Build-up: Is there Noticeable build-up of debris, sediment, trash, vegetation etc.?
☒	☐	System Integrity: Do system slopes look stable, is there notable damage in the system?

Frequency - How often is the system being Checked/Maintained?

Bi-weekly	Monthly	Quarterly	Bi- Annually	Annually	Other:__________
☐	☐	☐	☐	☐	☐

Date of Last Inspection: ___4/3/21_______

Date of Next Inspection: __________

Comments: Significant mounding of mulch and organic matter over the top of the media. Runoff appears to still be entering the system but may be running off to the sides due to the height difference from the pavement.

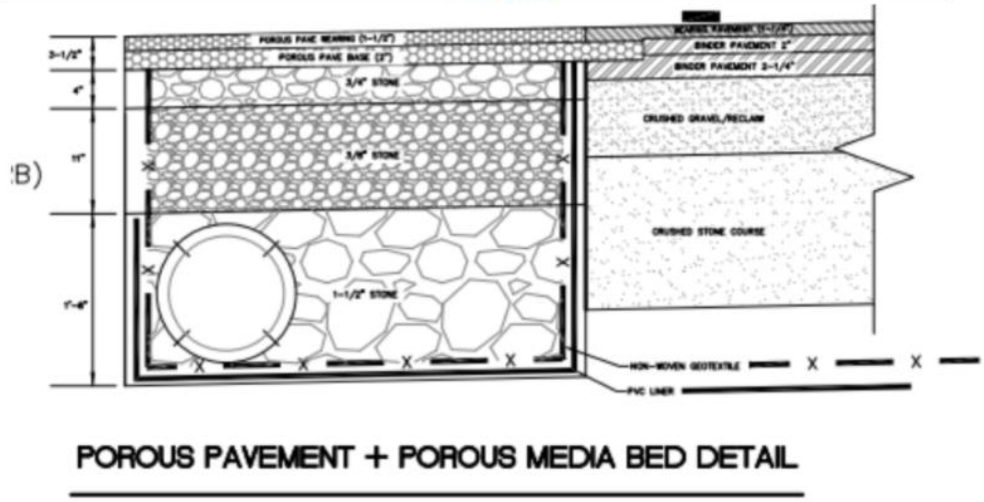
Figure 23: Inspection Checklist - State Street, Bioretention System

III. Example Assumptions Document

Sagamore Avenue:

Porous Pavement:

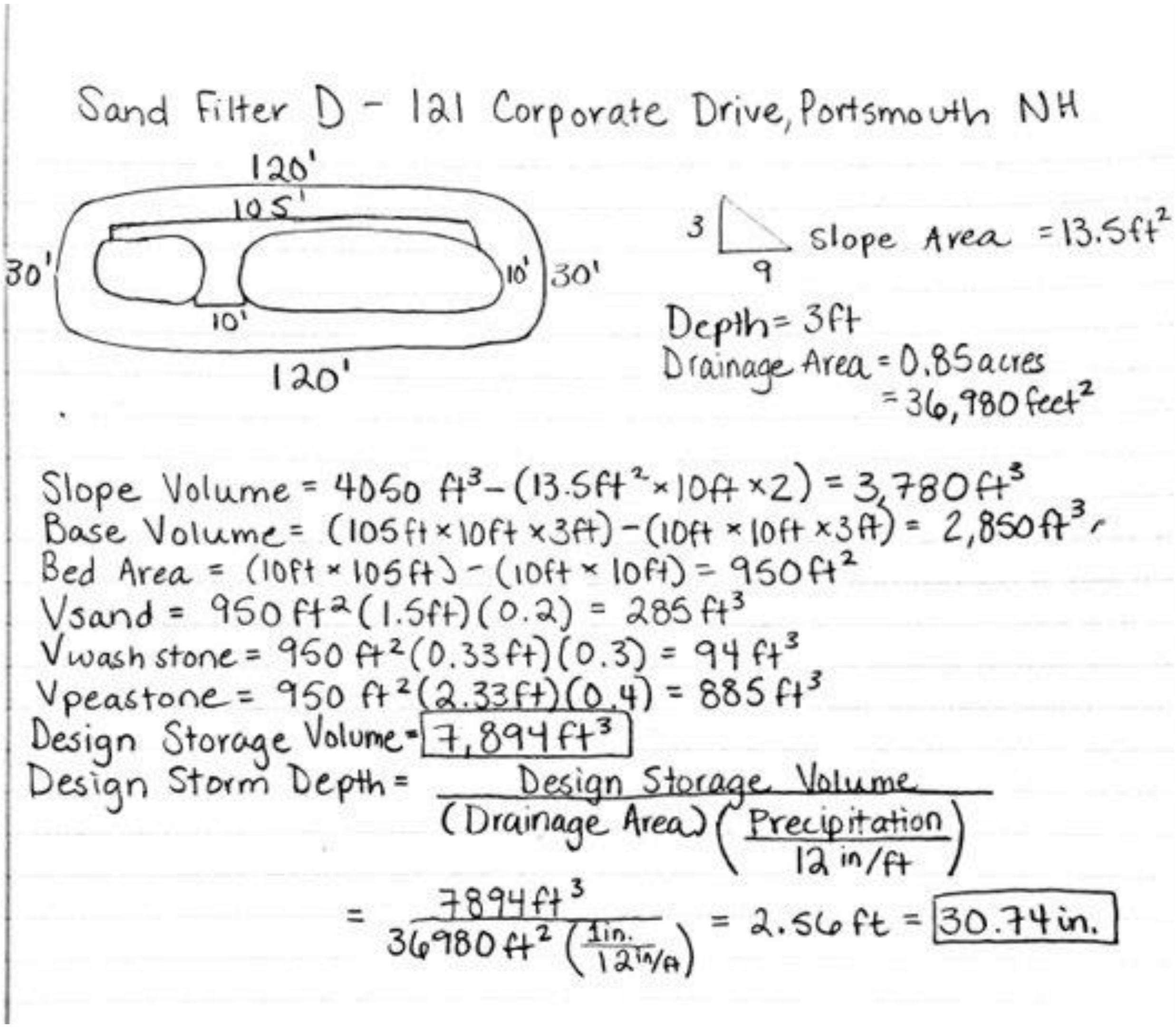
$(L*W*D_{stone}*n_{stone})$



- DSV:
  - Where it was Found: Plans Provided by Jamie McCarty: 901 Sagamore Avenue As-Builts 2017-10-17a.pdf. 12.5' width of porous pavement for a length 75' added to a 4' width for 900 feet. This surface area multiplied by a depth of 3' A surface area of 17,600 feet and a depth of 1.67 feet of stone was used. There is an underdrain throughout the entire length of the porous pavement, and the volume of the pipe was subtracted from the volume of the porous pavement and stone. Plans were printed out and an engineering scale was used to get dimensions of the porous pavement.
  - Assumptions: Assume a porosity of .35 and assume the underdrain pipe diameter is 1.2 feet for the full length of 950 feet.
- Drainage Area
  - Where it was Found: AutoCAD drawing. From the centerline (crown) of Sagamore Avenue measured to the outer edge of the porous pavement shoulder along the length of road that the porous pavement was installed.
  - Assumptions: The porous pavement itself is considered part of the impervious drainage area
- Soil Type
  - Where it was Found: Web Soil Survey
  - Assumptions: None
- Impervious Cover
  - Where it was Found: The entire drainage area is impervious.
  - Assumptions: None

Figure 24: Sagamore Avenue Assumption Document

IV. Sample DSV and Storm Depth Calculation



Sand Filter D – 121 Corporate Drive, Portsmouth NH

Slope Area $= 13.5 ft^2$

Depth $= 3 ft$

Drainage Area $= 0.85$ acres $= 36{,}980$ feet^2

Slope Volume $= 4050\ ft^3 - (13.5 ft^2 \times 10 ft \times 2) = 3{,}780 ft^3$

Base Volume $= (105 ft \times 10 ft \times 3 ft) - (10 ft \times 10 ft \times 3 ft) = 2{,}850 ft^3$

Bed Area $= (10 ft \times 105 ft) - (10 ft \times 10 ft) = 950 ft^2$

$V_{sand} = 950 ft^2 (1.5 ft)(0.2) = 285 ft^3$

$V_{wash\ stone} = 950 ft^2 (0.33 ft)(0.3) = 94 ft^3$

$V_{peastone} = 950 ft^2 (2.33 ft)(0.4) = 885 ft^3$

Design Storage Volume $= \boxed{7{,}894 ft^3}$

$$\text{Design Storm Depth} = \frac{\text{Design Storage Volume}}{(\text{Drainage Area})\left(\frac{\text{Precipitation}}{12\ in/ft}\right)}$$

$$= \frac{7894 ft^3}{36980 ft^2 \left(\frac{1 in.}{12 in/ft}\right)} = 2.56 ft = \boxed{30.74 in.}$$

Figure 25: Sample Calculations for DSV and Storm Depth