COST ANALYSIS REPORT

COST ANALYSIS FOR WESTERN WASHINGTON LID REQUIREMENTS AND BEST MANAGEMENT PRACTICES

Prepared for
Washington State Department of Ecology

Prepared by
City of Puyallup
Washington Stormwater Center
Herrera Environmental Consultants, Inc.

HERRERA

This project was funded by a Washington State Department of Ecology Municipal Stormwater Grant of Regional or Statewide Significance

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Prepared for:

DEPARTMENT OF ECOLOGY
State of Washington

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PREFACE

This project was led by the City of Puyallup with assistance provided by the Washington Stormwater Center and Herrera Environmental Consultants. It was funded by a Washington State Department of Ecology Municipal Stormwater Grant of Regional or Statewide Significance. This report provides information on the comparative cost of implementing the minimum stormwater control requirements for new development as set forth by the Washington State Department of Ecology (Ecology) in its *2012 Stormwater Management Manual for Western Washington* (Ecology 2012) as compared with the previously published 2005 manual (Ecology 2005), hereafter referred to as the 2012 manual and 2005 manual respectively. This cost analysis covers the minimum stormwater control requirements for new development, and includes provisions for the following elements:

- Construction stormwater pollution prevention
- Permanent facilities for onsite stormwater management
- Permanent stormwater facilities for flow control and treatment
- Operations and maintenance
- Design

We based this cost analysis on 14 scenarios prepared to illustrate the expected stormwater management costs for realistic development scenarios.

The 2012 manual includes requirements for low impact development (LID) stormwater management techniques. Typically, designers distribute LID facilities throughout a site, and thereby may reduce the costs for storm drainage conveyance, replace traditional landscaping costs, and/or alter the costs of roadway, driveway, and sidewalk surfacing. As a result, this cost analysis also addresses costs for non-stormwater elements of development sites, such as surfacing, as well as stormwater conveyance. For example, for some 2005 manual scenarios the cost estimates presented in this report include traditional pavement in order to provide an equivalent comparison to the 2012 manual scenario with pervious pavement. However, in cases where conveyance or surfacing elements are equal for all scenarios within a development example (e.g., pavement is the same across all small commercial scenarios under 2005 and 2012 requirements), those elements have not been included in the cost estimates for that development example.

The cost estimates for satisfying Ecology's 2005 and 2012 minimum requirements provided in this report are approximate, and are applicable within the context of the hypothetical sites for which they were developed. Individual site conditions, selected components of stormwater control plans, costs of easements or land, costs of engineering and construction services, and many other factors can vary considerably throughout western Washington and from project to project. Some projects will have costs associated with construction of stormwater management facilities that are not captured in this analysis, such as traffic control costs, additional property costs (such as appraisal or survey), and mitigation costs for impacts to environmentally sensitive areas that occur in relation to placement of stormwater management facilities. Therefore, for a new development of comparable size to the hypothetical sites presented and discussed in this report, the cost of satisfying Ecology's minimum requirements may differ from the costs provided in this analysis.

This analysis does not address the costs that stormwater professionals (design engineers, architects, developers, and development reviewers) may incur in learning the updated requirements, and preparing the resultant technical documentation that will likely require greater detail. In addition, implementation of the stormwater management requirements set forth in the 2012 manual may vary between jurisdictions, and this study does not attempt to quantify that potential variability or the additional effort jurisdictions may incur during review of more complicated stormwater plan submittals. However, in some instances this report notes where and why costs may be higher or lower depending on actual site conditions or how a jurisdiction implements the new regulations.

This report also compares costs associated with stormwater management requirements from the 1992 *Stormwater Management Manual for the Puget Sound Basin* (1992 manual) (Ecology 1992) and the *2001 Stormwater Management Manual for Western Washington* (2001 manual) (Ecology 2001) with those of the 2005 and 2012 manuals. The comparisons to those earlier stormwater cost studies are somewhat limited; however, because the cost analysis reports prepared in conjunction with those manuals (Herrera 1993, 2001) focused more on the cost of centralized stormwater best management practices. Furthermore, they did not include the cost for other site development components such as stormwater conveyance or roadway surfacing, which are necessary to make comparisons to scenarios that include LID Best Management Practices (BMPs).

INTRODUCTION

Purpose of This Report

This report provides information on the cost of stormwater control measures required for single-family residential and commercial developments in western Washington based on the minimum requirements set forth by the Washington State Department of Ecology (Ecology) in the *2005 Stormwater Management Manual for Western Washington* (Ecology 2005) as compared with the revised 2012 *Stormwater Management Manual for Western Washington* (Ecology 2012). Hereafter, we refer to these as the 2005 manual and 2012 manual, respectively. Both manuals describe the stormwater management requirements applicable to various development and redevelopment scenarios, including many types of development other than single-family residential and commercial land use. This report presents an evaluation of stormwater management costs for new development under the 2005 manual and 2012 manual requirements, and includes costs for stormwater management on a residential site using low impact development (LID) principles (i.e., principles that go beyond the stormwater manual requirements for BMP selection and design). This study also examines the implications that infiltration rates have on cost by examining two soil types (outwash and till) for each example site.

An additional objective of this study is to compare the 2005 and 2012 cost estimates with the similar cost estimates prepared in association with the 1992 *Stormwater Management Manual for the Puget Sound Basin* (1992 manual) (Ecology 1992) and the *2001 Stormwater Management Manual for Western Washington* (2001 manual) (Ecology 2001), which is part of the reason why we analyzed residential, small commercial, and large commercial site examples.

This report discusses the expected stormwater management costs for 14 example development scenarios. The reader should use the information as a general guide to understand the cost implications for their specific project of interest.

Organization of the Report

This report includes an introduction, a discussion of the example sites and associated hypothetical stormwater management plans, and a summary of stormwater management cost estimates. The introduction provides the regulatory context for the analysis, lists the general assumptions made for each example site and development scenario, and describes the methods for modeling stormwater runoff characteristics and estimating costs for each scenario. The example site and stormwater management chapter includes a subsection for each development type analyzed. Each subsection describes the assumptions, methods, and resulting cost estimates for design, temporary erosion and sediment control (TESC), permanent stormwater best management practices (BMPs, and operations and maintenance (O&M). The summary chapter provides a total cost estimate for each scenario, and describes causes of cost variation between the 2012, 2005, and 2001 manual requirements for each site. Appendix A provides detailed planning and design assumptions for each scenario. Appendix B contains an itemized cost estimate for each development type along with the unit costs used in this analysis. Appendix C describes the stormwater runoff modeling methods in detail.

Scenario Definitions

This report analyzes 14 scenarios comprised of three hypothetical new development examples and two soil types, and presents the associated cost estimates for compliance with the 2005 and 2012 manual requirements (see Table 1). The three hypothetical new development examples evaluated are:

- 10-acre single-family residential development
- 1-acre commercial development
- 10-acre commercial development

We assumed that all minimum requirements from both the 2005 and 2012 manuals apply to all three of these sites and that all three constitute new development. This means that each example development project:

- Has less than 35 percent existing hard surface coverage before development (triggering the new development requirements for all regulatory settings)
- Results in 5,000 square feet or greater of new and replaced hard surface, or the project converts 0.75 acres or more of vegetation to lawn or landscaped area

Additionally, the analysis considers the impact that specific soil types have on how to manage stormwater, and thus the associated costs, by addressing outwash and till soils separately for each hypothetical site.

We analyzed four scenarios for each development example based on the two manuals (2005 and 2012) and the two soil types. An additional two scenarios are analyzed for the single-family residential development type that incorporate LID principles, such as smaller lot sizes and fewer parking stalls, into the layout of the development. Table 1 describes the specific parameters of the 14 scenarios for the cost estimates we provide.

This report also builds on two prior stormwater management cost analyses performed for Ecology in 1993 and 2001. The *Cost Analysis, Minimum Requirements for Stormwater Management in New Development and Redevelopments* (Herrera 1993) was prepared in conjunction with the *Stormwater Management Manual for the Puget Sound Basin* (Ecology 1992). The *Cost Analysis, Washington State Department of Ecology 2001 Minimum Requirements for Stormwater Management in Western Washington* (Herrera 2001) was prepared in conjunction with the *2001 Stormwater Management Manual for Western Washington* (Ecology 2001). The analysis in this report uses the same site development examples from the 1993 and 2001 reports. The analysis assesses the costs associated with the 2005 manual, as well as the costs associated with the guidance provided in the 2012 manual. Where applicable, this report refers to the 1993 and 2001 cost analysis reports to enable comparison of the differences in stormwater management costs between the older and newer requirements for the same site conditions.

Table 1. Cost Analysis Scenarios.

Scenario No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Development Type	Single-Family Residential (SFR) Subdivision						Small Commercial				Large Commercial			
Regulatory Standard	2005		2012		2012 with LID principles		2005		2012		2005		2012	
Soils	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till

An important difference between this report and the 1993 and 2001 reports is the incorporation of LID requirements. The 1993 and 2001 analyses were focused on centralized stormwater BMP costs (such as for ponds and large vaults), and intentionally did not include costs for site development elements related to stormwater management such as curbing, catch basins, conveyance pipes, and road surfacing. However, because LID BMPs are dispersed across the site, and include elements such as road surfacing, we revised the example sites from the 2001 analysis so that the resulting analysis will reflect how the use of LID BMPs may affect other project elements and associated costs. For example, use of LID BMPs can reduce the cost of stormwater conveyance piping or increase the cost of road surfacing. Thus, this analysis captures those effects.

Regulatory Requirements and Assumptions

In accordance with the National Pollutant Discharge Elimination System (NPDES) Phase I and II Municipal Stormwater Permits (Permits) in western Washington, all Phase I and II jurisdictions were required to implement the 2005 manual minimum requirements. They are also required to implement the minimum requirements of the 2012 manual by December 31, 2016, for Phase II jurisdictions and June 30, 2015, for Phase I jurisdictions (see the Permits for exempt jurisdictions and specific adoptions and implementation dates). This section summarizes the significant changes to the minimum requirements since 2001 and describes the assumptions underlying the development examples.

Changes to Minimum Requirements

Ecology's stormwater management requirements in western Washington have changed substantially since 2001. Ecology details the updated minimum requirements in its 2005 and 2012 manuals (Ecology 2005, 2012). We provide a summary below:

1. **Preparation of Stormwater Site Plans –** All projects are to prepare a stormwater site plan for local government review.

   Significant Change: The 2012 manual has added the requirement to minimize impervious surfaces to the extent possible and use site-appropriate development principles to retain native vegetation and minimize impervious surfaces to the extent feasible.

2. **Construction Stormwater Pollution Prevention (SWPP) –** All new development and redevelopment projects must address all requirements for preventing construction stormwater pollution found in the manual.

   Significant Changes:

   - The 2012 manual includes a new 13th Element to protect low impact development BMPs, and covers installation of additional erosion and sediment controls during construction for bioretention facilities, rain gardens, and permeable pavements.
   - Requirements for a Certified Erosion and Sediment Control Lead are more specific.

3. **Source control of pollution –** All projects must apply all known, available, and reasonable source control BMPs.

   Significant Change: There is one new source control BMP described in the 2012 manual compared to the 2005 and 2001 manuals.

4. **Preservation of natural drainage systems and outfalls –** Maintain natural drainage patterns, and discharge runoff from the site at the natural location, to the maximum extent practicable.

   No Significant Changes.

5. **Onsite stormwater management –** Projects are to employ stormwater BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent practicable without causing flooding or erosion impacts.

   Significant Change: The 2012 manual includes a new LID Performance Standard, which requires post-developed runoff discharge durations to match pre-developed durations for the range of pre-developed discharge rates from 8 percent of the 2-year peak flow to 50 percent of the 2-year peak flow. The designer may opt to select the first feasible BMP from an ordered list of BMPs for the design surface, or the designer may choose to demonstrate conformance with the LID Performance Standard through modeling the alternative design. In addition, the 2012 manual has new infeasibility criteria for each BMP.

6. **Runoff treatment –** Projects that meet specific thresholds must construct and maintain stormwater treatment facilities sized to treat the water quality design storm volume or water quality design flow rate.

   No Significant Changes.

7. **Flow control –** Projects that meet specific thresholds must construct and maintain flow control facilities to reduce the impacts of increased stormwater runoff from new impervious surfaces and land cover conversions. Specifically, post-developed runoff discharge durations shall match pre-developed durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. LID BMPs can be used to meet these requirements.

   No Significant Changes.

8. **Wetlands protection –** If site runoff discharges to a wetland, the discharge characteristics must maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated wetland uses unless the designer completes an assessment consistent with specific criteria referenced in both manuals.

   Significant Change: Ecology replaced the *Guidelines for Wetlands when Managing Stormwater* in the 2012 Manual with new guide sheets and revised wetland hydrologic analysis guidelines.

9. **Operation and maintenance –** An O&M manual that is consistent with local government standards is required for all proposed stormwater facilities and BMPs used to meet minimum requirements #6, #7, and #8. It must also address onsite stormwater management BMPs when they contribute to meeting these same minimum requirements. The O&M manual must identify the party (or parties) responsible for O&M activities and should include maintenance instructions.

Basin/watershed planning was part of Minimum Requirement #9 in the 2001 and 2005 manuals but is not present in the 2012 manual minimum requirements. However, basin/watershed planning has no impact on the example development sites in this study. See the 2001 cost analysis (Herrera 2001) for significant changes between the 1993 manual and the 2001 manual.

This study focuses on the costs associated with five of the minimum requirements (MR):

MR #2. Construction Stormwater Pollution Prevention

MR #5. Onsite Stormwater Management

MR #6. Runoff Treatment

MR #7. Flow Control

MR #9. Operation and Maintenance

Construction Stormwater Pollution Prevention

The 2005 and 2012 manuals require preparation of a Stormwater Pollution Prevention Plan (SWPPP) (Minimum Requirement #2) to guide selection and implementation of a variety of BMPs during construction. This requirement applies to all new development and redevelopment projects that add or replace 2,000 square feet or more of hard surface, or clear more than 7,000 square feet of land area, as is applicable for each of the three example sites included in this report. The 2005 and 2012 manuals both require 12 distinct elements to provide effective construction stormwater pollution prevention. The 2012 manual includes an additional 13th element in the construction SWPPP requirements to protect low impact development BMPs. A development project is required to implement BMPs for whichever of the SWPPP elements are applicable to the project site, to document the rationale for BMP selection, and document why BMPs are not necessary for other elements, as may be the case due to site-specific conditions. For each of the 14 scenarios listed in Table 1, we selected appropriate construction BMPs to address the SWPPP requirements listed below:

1. Mark clearing limits
2. Establish construction access
3. Control flow rates
4. Install sediment controls
5. Stabilize soils

6. Protect slopes
7. Protect drain inlets
8. Stabilize channels and outlets
9. Control pollutants
10. Control dewatering
11. Maintain BMPs
12. Manage the project
13. Protect LID BMPs (only in 2012 manual)

Onsite Stormwater Management

2005 Manual

The 2005 manual requires projects to employ stormwater management BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible without causing flooding or erosion impacts. The manual's requirements are minimal and relate mostly to requiring compost amendment for lawn and landscaped areas and trenches to manage roof runoff.

2012 Manual

The 2012 manual includes a new LID performance standard for onsite stormwater management that applies to all new hard surfaces. New development projects triggering all minimum requirements) must satisfy the LID performance standard and Post-Construction Soil Quality and Depth BMP, or select the first feasible BMP from List #2: Onsite Stormwater Management BMPs for Sites Triggering Minimum Requirements #1 though #9 (List #2) in the manual. The example development projects included in this cost analysis trigger all nine minimum requirements and therefore List #2 applies in order to meet the LID performance standard. If a BMP selected from List #2 would exceed the performance standard, we reduced the BMP size to the minimum size necessary to meet the standard. In some cases, the sizes of the BMPs increased slightly in order to address runoff treatment or flow control minimum requirements in addition to the onsite stormwater management requirement.

Runoff Treatment and Flow Control

The runoff treatment and flow control requirements are not significantly different between the 2001 manual and the 2005 or 2012 manuals. Under all stormwater manuals, the onsite stormwater management BMPs can help meet runoff treatment and flow control requirements. Thus, the more stringent 2012 onsite stormwater management requirements could result in smaller runoff treatment and flow control facilities in the 2012 scenarios. We made the following runoff treatment assumptions for pollutant generating surfaces for the three example development sites:

Oil Control

- **Single-Family Residential**: does not apply
- **Small Commercial**: applies to all pollutant generating hard surfaces (PGHS) (assumes site is classified as high use)
- **Large Commercial**: does not apply (assumes site is not classified as high use)

Phosphorus Treatment

- Does not apply to any example development site

Basic Treatment

- **Single-Family Residential**: applies to PGHS (all driving surfaces), lawns, and landscaping
- **Small Commercial**: Met through enhanced treatment requirements
- **Large Commercial**: Met through enhanced treatment requirements

Enhanced Treatment

- **Single-Family Residential**: does not apply
- **Small and Large Commercial**: applies to PGHS (all driving surfaces) and lawns and landscaping

Operations and Maintenance

The 2001, 2005, and 2012 manuals identify facility-specific maintenance actions that are required as identified through inspection. These maintenance actions have generally remained consistent across all three manuals. However, the Phase I and Phase II Municipal Stormwater Permits for 2013 through 2018 include new provisions that municipalities must adopt and implement to ensure proper operation and maintenance of LID BMPs. In both permits, municipal permittees bear long-term inspection responsibility for – as well as responsibility to ensure proper maintenance of – "stormwater treatment and flow control BMPs/facilities." The permits distinguish between LID BMPs based on the permit requirements. Stormwater treatment and flow control BMPs/facilities include bioretention, vegetated roofs, and permeable pavements that help meet permit Minimum Requirement #6 (treatment), #7 (flow control), or both. The permit requirements for traditional stormwater treatment and flow control BMPs/facilities, such as ponds, are more extensive and include, for example, long-term inspection and maintenance obligations that do not apply to LID BMPs.

Municipalities are obligated to inspect all BMPs upon completion of construction to ensure proper installation or retention of pre-developed site features. Municipalities do not have long-term inspection obligations concerning LID BMPs that fall outside the stormwater manual definition of Stormwater Treatment and Flow Control BMPs/Facilities. This includes Downspout Dispersion (BMP T5.10A), Downspout Full Infiltration (BMP T5.10B), Concentrated Flow Dispersion (BMP T5.11), Sheet Flow Dispersion (BMP T5.12), Soil Quality and Depth

(BMP T5.13), Rain Gardens (BMP T5.14A) and Tree Retention and Tree Planting (BMP T5.16). However, all BMPs, including those implemented to meet Minimum Requirement #5 (onsite stormwater management), are subject to maintenance requirements as adopted by local governments. Local governments are to establish mechanisms to ensure appropriate legal documents identify LID BMPs and provide maintenance instructions for all properties.

Jurisdictions are obligated to inspect all BMPs upon completion of construction to ensure proper installation or retention of pre-developed site features. Although it is not a permit requirement, Ecology encourages local governments to share the maintenance guidance for these BMPs with homeowners and commercial property owners.

Finally, Ecology is currently developing detailed guidance on maintenance standards for LID BMPs to assist local governments in meeting these new permit obligations. This guidance will describe procedures, equipment, materials, legal documents, and staffing that may be required to meet the inspection and maintenance responsibilities for LID BMPs.

Study Assumptions

Several assumptions were made for each example development type because actual site conditions for implementing stormwater controls vary considerably across western Washington, application of the 2005 and 2012 stormwater manual requirements may vary from jurisdiction to jurisdiction, and the approaches taken by developers may vary widely. The assumptions described below served as guidelines for evaluating the suite of example developments.

Beyond meeting all the minimum requirements, assumptions were necessary in order to develop realistic scenarios for the cost analysis and to ensure:

- The assumed site conditions are realistic for site conditions commonly found in western Washington.
- The development scenarios are realistic from the perspective of the developer community.
- Implementation of the 2005 and 2012 manuals accurately reflects the practices of western Washington jurisdictions.

The assumptions presented in this report were largely derived based on a series of meetings and phone calls involving representatives from Ecology, the Washington Stormwater Center, the City of Puyallup, Herrera Environmental Consultants, Inc., and members of a Technical Review Committee (TRC).

Technical Review Committee Process

We requested participation in the TRC from western Washington jurisdictions and developer associations to obtain information on how jurisdictions anticipate implementing the 2012 manual requirements, and to obtain the developer's perspective for each scenario. We identified potential TRC members based on a review of comments submitted to Ecology regarding the NPDES permit reissuance and the draft 2012 manual. Jurisdictions and development associations were contacted seeking members to participate in the TRC based on three goals:

- Members need to provide thoughtful comments related to the cost of the permit and 2012 manual requirements.
- Members reflect a geographic distribution that is representative of western Washington.
- Members have been involved in the evolution of regional stormwater management guidance or have extensive experience implementing development projects in accordance with that guidance.

The TRC is comprised of the following members (also identified in the acknowledgements at the beginning of this report): Chris May (Kitsap County), Dawn Anderson (Pierce County), Mark Palmer (City of Puyallup), Tracy Tackett (City of Seattle), Merle Ash (representative for Master Builders Association of King and Snohomish Counties and works for Land Technologies, Inc.), Art Castle (Building Industry Association of Washington), and Eric Golemo (representative for Clark County and works for SGA Engineering, PLLC).

The TRC provided comments on the assumptions via in-person meetings, emails, and conference calls as follows:

- Conference call on December 10, 2012
- Email comments received between January 1 and January 11, 2013
- In person meeting on January 25, 2013
- In person meeting on February 8, 2013

The TRC also provided comments on the draft project report.

The TRC engagement process was an important element in this analysis, particularly for guiding the assumptions described below, because assumptions could vary widely based on a particular jurisdiction's implementation of stormwater management requirements or decisions made by developers as they seek to satisfy the regulations.

Site Conditions

General assumptions for all three development site examples and the scenarios that include runoff infiltration are:

- The infiltration rate in till soils is 0.3 inch per hour and meets site suitability criteria (SSC) for infiltration facilities found in Section 3.3.7 of Volume III of the 2005 and 2012 manuals, particularly SSC 6 Soil Physical and Chemical Suitability for Treatment.
- The infiltration rate for outwash soils is 6 inches per hour and does not meet SSC 6 Soil Physical and Chemical Suitability for Treatment, but meets other SSC criteria for infiltration facilities.

- Adequate depth to groundwater is present for infiltration at all sites.
- Any infiltrating BMPs on outwash soils that receive untreated stormwater from PGHS will include soil amendments to meet soil suitability criteria for infiltration.
- Permeable pavement (BMP T5.15) is feasible for PGHS on outwash soils with a 6-inch sand treatment layer.
- Subsurface infiltration of runoff from non-pollutant generating hard surfaces (NPGHS) and properly treated PGHS below impervious parking is feasible.
- Downspout Full infiltration Systems (i.e., BMP T5.10A in 2012 manual; Downspout Infiltration Systems in 2005 manual) is infeasible on till soils.

Design (Long-Term) Infiltration Rates

- **Permeable Pavement Facilities:**
    - Correction factors (CF) based on Table 3.4.2 in Volume III of the 2012 stormwater manual are assumed to be:
        - Site variability and number of locations tested, CF_v = 0.67
        - Quality of pavement aggregate base material, CF_m = 0.95
        - Permeable pavement correction factor, $CF = CF_v * CF_m = 0.64$
    - Design infiltration rate, till = 0.19 inch per hour (i.e., 0.3 inch per hour * 0.64)
    - Design infiltration rate, outwash = 3.84 inches per hour (i.e., 6 inches per hour * 0.64)
- **Bioretention Facilities:**
    - Bioretention soil mix uncorrected infiltration rate = 6 inches per hour
    - Apply correction factor of 0.25 if the contributing area exceeds any of the following criteria or if the contributing area is comprised of multiple land cover types that in combination justifies a correction factor of 0.25 (based on professional judgment):
        - 10,000 square feet of impervious surface
        - 5,000 square feet of PGHS
        - 0.75 acre of native vegetation converted to lawn/landscaping
        - 2.5 acres of native vegetation converted to pasture

      Otherwise apply a correction factor of 0.5.
    - Design infiltration rate, exceeding threshold = 1.5 inches per hour
    - Design infiltration rate, below threshold = 3 inches per hour

- Subgrade Soils Underlying Bioretention
  - Correction factors based on Table 3.4.1 in Volume III of the 2012 stormwater manual:
    - Site variability and number of locations tested, CF_v = 0.67
    - Degree of influent control to prevent siltation and bio-buildup, CF_m = 1 (no correction factor required)
  - Design infiltration rate, till = 0.20 inch per hour (i.e., 0.3 inch per hour * 0.67)
  - Design infiltration rate, outwash = 4.02 inches per hour (i.e., 6 inches per hour * 0.67)
- **All Other Infiltrating Facilities:**
  - Correction factors (CF) based on Table 3.3.1 in Volume III of the 2012 stormwater manual:
    - Site variability and number of locations tested, CF_v = 0.67
    - Test method, CF_t = 1.0 (NA)
    - Degree of influent control to prevent siltation and bio-buildup, CF_m = 0.9
    - Infiltrating facility correction factor, $CF = CF_v * CF_t * CF_m = 0.60$
  - Design infiltration rate, till = 0.18 inch per hour (i.e., 0.3 inch per hour * 0.60)
  - Design infiltration rate, outwash = 3.6 inches per hour (i.e., 6 inches per hour * 0.60)

Development Example Characteristics

We provide a summary of assumptions for each development example below, and more detailed information on these assumptions in Appendix A.

Typical land values used in this analysis are $150,000 for single-family lots (based on TRC input) and $1,000,000 per acre for commercial properties (based on review of commercial land value in Seattle, Kitsap County, and Puyallup using data available on tax assessor websites).

Single-Family Residential without LID Principles

TRC assisted with developing typical home and lot size assumptions. For the single-family residential development that does not include LID principles, residential street width is 50 feet (two travel lanes, two sidewalks and a parking lane), and average lot size is approximately 7,600 square feet (see Appendix A). We assumed each dwelling unit has 200 square feet of open space.

Single-Family Residential with LID Principles

For the single-family residential development that includes LID principles, we assumed a smaller average lot size of 5,000 square feet, and the right of way (ROW) width is 37 feet (two travel lanes, one sidewalk, and parking bulbs within the planting strip). Two hundred square feet of open space per development unit, and space conserved through smaller lots will be available for additional units, open space, or environmental conservation at the developer's discretion.

Small Commercial

We assumed that the small commercial development is a high-use site, and therefore requires oil control facilities. Full dispersion is infeasible and the cost of ROW improvements is not included in this analysis.

Large Commercial

A large commercial site is not high use and will not require oil control. Full dispersion is infeasible and the cost of ROW improvements is not included in this analysis.

Implementation of Regulatory Requirements

We made several assumptions for each example development site in order to trigger all nine minimum requirements. The assumption that each example development site has less than 35 percent existing hard surface coverage triggered new development requirements. For each of the three example sites it was also assumed that the project would result in 5,000 square feet or greater of new plus replaced hard surface and/or the project would convert 0.75 acre or more of vegetation to lawn or landscaped area. All minimum requirements (1 through 9) therefore apply to the new and replaced hard surfaces and to the land disturbed for all three hypothetical sites.

Assumptions regarding onsite stormwater management for each site reflect realistic and generic site characteristics. We assumed that downspout infiltration is only applicable on outwash soils, which are classified as medium sand, and therefore infiltration trenches are required to be 30 linear feet long for each 1,000 square feet of contributing roof area. We also assumed that 50 feet of vegetated flow path is not available on the single-family residential development site for downspout dispersion, therefore that development example requires a dispersion trench or perforated stub out.

Assumptions Based on TRC Input

The TRC provided input on general assumptions such as lot layout, residential development density, residential street ROW width, building areas, parking areas and stall size, and setback requirements (see Appendix A). Specific attention from the TRC was required for the assumptions listed below to ensure each cost analysis scenario is representative of anticipated future implementation of the 2012 manual requirements by a wide range of jurisdictions as well as a common type of new development anticipated in western Washington.

Miscellaneous Assumptions

- The invert elevation of small municipal separate storm sewer systems (MS4s) is 4 feet below ground surface.
- For the large and small commercial site examples, the designer will select whether to use aboveground facilities (e.g., ponds) or whether to use below ground facilities (e.g., vaults) based on which approach is more cost effective.
- We used proprietary stormwater BMPs for this analysis where they are most cost effective. Generic BMP names, identified in the text and figures, illustrate where these BMPs are incorporated. Each cost estimate identifies the proprietary BMP that are included.

Permeable Pavement Feasibility

- Permeable pavement is feasible for PGHS on sites with outwash soils that do not meet the physical and chemical soil properties for treatment as long as a 6-inch sand treatment layer is installed below the pavement. We examined installing a treatment soil layer between the native soil and the permeable pavement for the large commercial development site in outwash soils and not for the residential or small commercial site scenarios in outwash soils.
- All permeable pavement in roadways on sites with till soils includes an overflow below the pavement of the roadway (not the sidewalk), and above the storage reservoir. The overflow is installed at the downstream end of the system.

Residential Subdivision

- Roadway width will accommodate parking on one side of the street only for both the 2005 and 2012 manual requirements without LID principles.
- Assume all treatment and flow control for private properties is handled on the private parcel or at a designated, centralized facility location, and facilities along the edge of the ROW manage runoff from the ROW only (except runoff from driveways). We sized all LID BMPs in the ROW based on tributary area in the ROW and included flow from private parcels.
- Stormwater management facilities may be installed in the front or rear yards on private parcels at the designer’s discretion.
- Assume that designers will configure a dispersion trench or perforated stub-out for roof downspouts depending on individual lot configuration (i.e., splash blocks are not feasible due to limited lot size and the available length of surface flow paths within the lot).

Residential Subdivision with LID Principles

- Assume BMPs are feasible in both the rear and front yards. Depending on the final typical single-family residential parcel layout, BMPs should be sited where most suitable and cost-effective.

- Assume all treatment and flow control for private properties is handled on site or at a designated, centralized facility location and facilities along the edge of the ROW manage runoff from the ROW only (except runoff from driveways).
- Assume two exterior parking spaces onsite plus one shared space per four dwelling units for guest parking.
- Hold the number of lots constant and reduce the average lot size to 5,000 square feet (3,500 square foot minimum). We note if additional space becomes available in the text of this report and assume that the additional space is available for other lots, open space, or for conservation of environmental resources, but do not quantify the value of those uses in this report.
- Assume these sites use the same BMPs implemented on the sites without LID principles.
- Assume that designers will configure a dispersion trench or perforated stub-out for roof downspouts depending on individual lot configuration (i.e., splash blocks are not feasible due to limited lot size and the length of surface flow paths within the lot).
- Assume spread footing foundations instead of minimal excavation foundations.

Designer Assumptions

Designers also made assumptions during the course of the analysis based on engineering judgment and evaluation of each scenario.

Pavement Sections

We compared the cost of permeable pavement to the cost of traditional pavement in the single-family residential and the large commercial scenarios in order to evaluate the stormwater management cost associated with requirements to use permeable pavement. Pavement costs were not included in the four small commercial site scenarios because the paving type is the same across all scenarios. We used the pavement sections listed in Table 2 in this analysis.

Because Washington Department of Transportation (WSDOT) permeable pavement design guidance does not incorporate a sand treatment layer, the pavement section for permeable asphalt driving surfaces on outwash soils was developed based on calculations performed according to the AASHTO Guide for Design of Pavement Structures (AASHTO 1993).

We also assumed that all permeable asphalt installations include a 2-inch-thick gravel-leveling course above the gravel reservoir course. All pavement sections for driving surfaces were checked to ensure they met structural design criteria (AASHTO 1993) before they were incorporated into this analysis. In some cases, developers may choose to use thinner or thicker pavement sections based on their judgment or site conditions. However, by using pavement sections that are similarly conservative across all scenarios, the resulting costs for this analysis are comparable within the analysis.

Operations and Maintenance Assumptions

Maintenance of permanent stormwater management BMPs occurs routinely on a scheduled basis for the life of the facilities. Inspections are required to determine maintenance needs and the 2005 and 2012 manuals identify the necessary facility-specific maintenance activities. Based on these requirements, we used the following assumptions to develop O&M costs across all cost analysis scenarios as applicable:

- **Bioretention (BMP T7.30)**: The following maintenance activities are required for bioretention systems:
  - Watering
  - Sediment removal from overflow
  - Vegetation management including replanting, removal of diseased or dead plants, pruning, weed removal, and mowing
  - Mulching
  - Pest control

  For this analysis, we assumed that performance of these activities occurs annually.

- **Wet ponds (BMP T10.10)**: Vegetation trimming in wet ponds occurs to keep the pond free of leaves and to maintain the aesthetic appearance of the site. Slope areas that have become bare are revegetated, and regrading of eroded areas occurs prior to revegetation. On a less frequent basis, removal of sediment accumulations in the wet pond occurs. For this analysis, we assumed that that vegetation management will occur annually and sediment removal will occur on a 15-year cycle.

- **Combined Detention and Wetpool (BMP T10.40)**: Removal of dead vegetation periodically occurs from combined detention and wetpools to prevent export of pollutants, especially nutrients. On a less frequent basis, removal of sediment accumulated in the forebay of a combined detention and wetpool occurs. For this analysis, we assumed that vegetation management occurs annually and sediment removal occurs on a 15-year cycle.

- **Stormwater Treatment Planter Vault**: Replacement of mulch on the surface of the planter vault occurs periodically to maintain the water quality treatment performance of the system. On a less frequent basis, complete replacement of the filter media within the planter vault must occur. For this analysis, we assumed that the mulch replacement occurs twice per year and filter media replacement occurs on a 10-year cycle.

- **Infiltration basin (BMP T7.10)**: Mowing of infiltration basins occurs periodically while sediment removal and reseeding is required on a less frequent basis. For this analysis, we assumed that mowing occurs twice per year and sediment removal and reseeding occurs on a 15-year cycle.

Table 2. Pavement Section Assumptions.

Soil	Use	Layer 1		Layer 2		Layer 3		Layer 4		Basis of Section
		Name	Thickness	Name	Thickness	Name	Thickness	Name	Thickness	
Traditional Pavement for Driving Surfaces										
All	Residential Road	Hot Mix Asphalt (HMA)	0.35 feet	Crushed Surfacing Base Course (CSBC)	0.50 feet					Based on pavement section design performed per AASHTO Guide for Design of Pavement Structures 1993 [a,b]. Designed to have similar structural number to permeable pavement roadway sections.
All	Parking Lot	HMA	0.35 feet	CSBC	0.50 feet					WSDOT[c] Pavement Policy. Section 5.2.4. Car parking
All	Driveway	HMA	0.35 feet	CSBC	0.50 feet					WSDOT Pavement Policy. Section 5.2.4. Car parking
Permeable Pavement for Driving Surfaces										
Outwash	Parking Lot	Pervious HMA	0.35 feet	Gravel Leveling Course	0.17 feet	Gravel Reservoir Course	0.00 feet	Sand Treatment Layer	0.50 feet	Based on pavement section design performed per AASHTO Guide for Design of Pavement Structures 1993 [a]
Till	Parking Lot	Pervious HMA	0.35 feet	Gravel Leveling Course	0.17 feet	Gravel Reservoir Course	0.33 feet	Sand Treatment Layer	0.00 feet	WSDOT Pavement Policy. Section 5.4.4. Car Parking
Till	Driveway	Pervious Concrete	0.67 feet	Gravel Leveling Course	0.00 feet	Gravel Reservoir Course	0.5 feet	Sand Treatment Layer	0.00 feet	WSDOT Pavement Policy. Section 5.4.4. Car Parking
Till	Residential Road	Pervious HMA	0.50 feet	Gravel Leveling Course	0.17 feet	Gravel Reservoir Course	0.33 feet	Sand Treatment Layer	0.00 feet	WSDOT Pavement Policy. Section 5.4.4. Light Vehicle Access
Sidewalks										
All	Sidewalk	Cement Concrete	0.33 feet							WSDOT Std. Plan F-30.10-01
All	Sidewalk	Pervious Concrete	0.35 feet	Permeable Gravel Base	0.35 feet					WSDOT Pavement Policy. Section 5.4.4. Pedestrian Sidewalks and Trails

Notes:

[a] Table 4.7 on p. II-80 Flexible pavement design catalog for low volume roads: recommended range of structural number for six US climatic regions. Seventy-five percent reliability, Climate Region 2, good soils, low traffic. CBR of 20 for sand. CBR of 70 for gravel bases.

[b] WSDOT Pavement Policy Table 5.1 stipulates 0.5' thickness of pervious HMA for roads with less than 5,000,000 equivalent single axle loads.

[c] WSDOT = Washington State Department of Transportation

- **Detention tanks**: Removal of accumulated sediments in detention tanks with a vactor truck occurs periodically. For this analysis, we assumed that this activity occurs on a 2-year cycle.

- **Infiltration trench (BMP T7.20)**: Removal of accumulated sediments and debris in infiltration trenches on commercial properties occurs periodically. A vactor truck removes sediments and debris from the upstream catch basins (i.e., sediment trap). For this analysis, we assumed that this activity occurs on a 2-year cycle.

- **Catch basins**: A vactor truck periodically removes accumulated sediments and debris in catch basins. For this analysis, we assumed that this activity occurs on a 2-year cycle in scenarios for small and large commercial development that includes catch basins. In scenarios for residential development that include catch basins, we assumed this activity occurs on a 2-year cycle.

- **Permeable sidewalks (BMP T5.15)**: Vactor truck mounted vacuum equipment periodically removes sediment from permeable sidewalks to prevent clogging. For this analysis, we assumed that this activity occurs on a 5-year cycle.

- **Permeable pavement (BMP T5.15)**: A regenerative street sweeper periodically removes sediment, debris, trash, and vegetation from permeable pavement surfaces to prevent clogging. For this analysis, we assumed that this activity occurs twice per year.

- **Impermeable pavement**: A regenerative street sweeper periodically removes sediment, debris, trash, and vegetation from impermeable surfaces using to maintain aesthetic appearance. For this analysis, we assumed that this activity occurs twice per year.

This cost analysis does not address the cost for residential parcel owners to clean out the sumps of residential catch basins incorporated in infiltration trenches or the cost of pavement repair, rehabilitation, or replacement.

Other BMP Design Assumptions

Conceptual design of all BMPs incorporated in the cost estimates are in accordance with the 2005 and 2012 manuals. Design assumptions documented in this report are not inclusive; however, Appendix C provides all scenario specific design elements. We provide a summary of some BMP design elements below.

Methods of Analysis

Modeling Methods

We used MGSFlood Version 4.31 to perform conceptual sizing of stormwater management facilities for this analysis. MGSFlood is a continuous simulation hydrologic model that simulates rainfall runoff based on land use, soils, and vegetation. Modeling was conducted to appropriately size BMPs for each site, soil type (till and outwash), and performance standard (forest flow duration and water quality treatment standards) included in this analysis. MGSFlood was also used to evaluate the prescriptive performance of LID BMPs implemented to satisfy Minimum Requirement #5 (on-site stormwater management), where applicable.

We sized infiltration (e.g., bioretention, permeable pavement) and detention (e.g., vault) facilities to meet Ecology's minimum requirement for flow control assuming a pre-developed forest land cover (referred to in this document as the forest duration standard). This standard requires matching peak flow rates and flow durations from half of the 2-year to the 50-year recurrence interval flows to a pre-developed forest condition (on till or outwash soil). Depending on which minimum requirements were triggered for a particular example development site (single-family residential, small commercial, and large commercial) or surfacing type (non-PGHS roofs or sidewalks, PGHS driveways or roads, and PGPS lawn and landscaping), facilities were also sized to achieve the Ecology water quality treatment standard (i.e., infiltrate or detain the 91st percentile, 24-hour runoff volume).

Conceptual sizing of temporary stormwater facilities used MGSFlood hydrologic model results. Conceptual design of TESC elements used the peak flow for the 2-year, 24-hour runoff event in accordance with the design requirements in the 2005 and 2012 manuals. For sediment pond sizing, we used the post-developed peak runoff rate for this event.

Detailed modeling methods, including precipitation and evaporation data selection, and BMP-specific assumptions are described in Appendix C.

Cost Estimating Methods

The cost estimate for each site includes the costs for construction stormwater pollution prevention, permanent stormwater BMPs, design, and O&M. All cost estimates incorporate scenario-specific understanding of plausible construction contractor staging, access, requirements, and constraints that would affect the cost for the project. We developed itemized construction cost estimates for TESC and permanent stormwater BMPs for each scenario based upon sound engineering practice and quantity calculations that are specific to each BMP in each scenario, and assuming that all items are constructed per the WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction* and standard design practices. We developed line item unit costs for this analysis based on a review of bid tabulations (tabs) for recent projects throughout western Washington. We used "bottom-up" cost estimates and vendor quotes to supplement data from bid tabs. Appendix B provides supporting documentation for the unit costs.

Because available bid tab data is skewed towards public sector projects that are subject to a variety of laws and regulations that tend to increase construction costs compared to private sector projects, the unit costs used in this analysis may be slightly higher than would be experienced for private development. This may result in higher estimated stormwater management costs per acre of development than many projects will experience, but is not expected to affect the comparison between scenarios for a given example development site under varied soil and regulatory conditions. In other words, the resulting costs may be slightly high for each scenario, but we expect the relative percent difference between scenarios to be the same.

Construction Stormwater Pollution Prevention Cost Estimating

The 2005 and 2012 manuals require implementation of TESC elements in accordance with the stormwater pollution prevention plan (SWPPP). A TESC plan was prepared for each site as the basis for the cost estimate. An itemized cost estimate was prepared that addresses all TESC items required for the site. Several TESC items are unique to the 2012 manual scenarios:

- Phased excavation to protect permeable pavement subgrade and bioretention facilities was estimated to cost $10 per cubic yard to account for the additional difficulty and smaller quantity

- The 2012 manual has more requirements for the certified erosion and sediment control lead (CESCL). Estimated the additional cost as 10 percent of the daily cost to have a CESCL onsite for 2012 scenarios.

Any additional effort to prepare the SWPPP document is incidental to the cost to prepare the design for stormwater BMPs, including costs to develop a generic SWPPP that would be implemented by the developer of each residential parcel.

Design Cost Estimating

We defined design cost estimates for this evaluation for each scenario individually. Design cost elements include:

- Design analyses culminating in preparation of the Stormwater Site Plan

- Engineering design plans and specifications suitable for construction

- Geotechnical and hydrogeological evaluation

We defined geotechnical analysis assumptions for each site based on stormwater manual requirements and professional judgment. Included were quantities of large scale Pilot Infiltration Tests (PITs), small scale PITs, and length of field exploration at each site. The tests are in accordance with the requirements in the stormwater manual and each PIT included a grain size analysis and evaluation of cation exchange capacity (CEC). Associated Earth Sciences, Inc. (Curtis Koger, personal communication on June 4, 2013) provided unit costs information, which helped inform the geotechnical evaluation costs and assume easy site access, a flat site, and that a hydrant would be available to provide water. The need for geotechnical borings was equal for scenarios within each hypothetical development site, so boring costs are not included in the design cost estimates.

For the residential development site scenarios, we applied design costs for BMPs on residential lots and those in the right of way, including centralized facilities. We estimated design for residential infiltration trenches, dispersion trenches, and soil quality and depth to cost $500 per lot, and the design for residential bioretention and soil quality and depth to cost $1,000 per lot. Both costs would be in addition to the costs for landscape design without stormwater BMPs. We assumed that the 2012 residential scenarios would conduct three test pits and three PITs, and the 2005 scenarios would conduct one test pit and one PIT.

For stormwater management in the right of way, we assumed design of bioretention facilities requires a greater level of effort than design of centralized facilities managing an equivalent drainage area. However, as bioretention design becomes more standardized, bioretention design costs and centralized system design costs may become more similar. In addition, for all scenarios examined in this analysis, we assumed that the bioretention planting design would substitute for landscape planting design that would otherwise apply, resulting in proportionally less of a cost increase in planting design for bioretention scenarios compared to centralized stormwater facility scenarios. Operation and maintenance manual development costs were incidental to other design costs.

Operations and Maintenance Cost Estimating

Where possible, we derived cost assumptions related to O&M activities for permanent stormwater management from the following existing sources:

- **Puget Sound Stormwater BMP Cost Database (Herrera 2012a)**: this document compiles detailed cost information on BMPs, including O&M, to support regional modeling efforts using the System for Urban Stormwater Treatment and Analysis INtegration (SUSTAIN) model. We obtained this cost information from the following sources: internet research; survey responses; bid tabs, and targeted phone calls and e-mail requests to local jurisdictions that have recently constructed projects with stormwater BMP components.

- **Case Study for Applying SUSTAIN to a Small Watershed in the Puget Lowland (Herrera 2012b)**: this document summarizes results from a case study to explore the capabilities and limitations of the SUSTAIN model as a prioritization tool for considering stormwater management strategies in an urban basin. During the development of this case study, we further refined and improved cost information from the Puget Sound Stormwater BMP Cost Database (Herrera 2012a).

- **Preliminary LID Maintenance Equipment, Skills, and Staffing Recommendations (Herrera 2012c)**: Ecology is currently developing a manual that identifies O&M requirements for LID BMPs. To support the development of this document, we performed a targeted survey of jurisdictions, contractors, landscapers, and vendors to obtain information on maintenance equipment, skills, staffing requirements, and costs for specific LID BMPs.

- **City of Lynnwood Operations and Maintenance Staffing and Equipment (Herrera 2008)**: to support an update to its Surface Water Management Comprehensive Plan, the City of Lynnwood performed an evaluation of its stormwater O&M requirements including labor costs, equipment rates, maintenance frequencies, daily production, and crew configurations.

Where cost information for a specific O&M activity was not available from these sources, we used bottom-up cost estimates and vendor quotes to derive representative values. In all cases, O&M costs were assessed as a present value (2013 dollars), assuming a 30-year facility lifecycle, and that construction cost inflation rates are equal to interest rates for future years. Table 3 summarizes the O&M cost estimates derived from this process.

Table 3. Cost Assumptions for Permanent Stormwater Management BMP Operations and Maintenance.

BMP	Activities	Base Cost	Frequency	Present Value 30-year Life Cycle Cost [a]	Source
Bioretention (BMP T7.13)	Watering, sediment removal from overflow, vegetation management, mulching; and pest control	Early: $1.47/SF Mature: $0.70/SF	Annual	$21.84/SF	Herrera 2012b
Wet Pond (BMP T10.10)	Routine vegetation management	0.17/SF	Annual	$9.01/SF	Herrera 2012b
	Sediment removal including haul, planting with shrubs and seeding mix, site restoration	$2.08/SF	15-year cycle		
Combined Detention and Wetpool (BMP T10.40)	Routine vegetation management	0.17/SF	Annual	$9.01/SF	Herrera 2012b
	Forebay sediment removal including haul, planting with shrubs and seeding mix, site restoration	$2.08/SF	15-year cycle		
Stormwater Treatment Planter Vault	Replace mulch, water	$300/PV	Twice per year	$27,903/PV	Vendor quote
	Replace media	$3,500/PV	10-year cycle		
Infiltration Basin (BMP T7.10)	Mowing	$0.05/SF	Twice per year	$3.36/SF	Bottom up estimate
	Sediment removal, repair, tilling, reseeding	$0.23/SF	15-year cycle		
Detention Tank	Sediment removal from sediment trap with vactor truck	$177.58/DT	2-year cycle	$2,662/DT	Herrera 2008
Infiltration Trench [b] (BMP T7.20)	Sediment removal from sediment trap with vactor truck	$177.58/IT	2-year cycle	$2,662/IT	Herrera 2008
Catch Basin	Sediment removal with vactor truck	$88.79/CB	2-year cycle for commercial	$1,331/CB for commercial	Herrera 2008
			2-year cycle for residential	$1,331/CB for residential	
Permeable Sidewalk (BMP T5.15)	Sediment removal using vactor truck mounted vacuum equipment	$3.06/SF	5-year cycle for residential	$15.30/SF	Herrera 2013

Table 3 (continued). Cost Assumptions for Permanent Stormwater Management BMP Operations and Maintenance.					
BMP	**Activities**	**Base Cost**	**Frequency**	**Present Value 30-year Life Cycle Cost [a]**	**Source**
Permeable Pavement (BMP T5.15)	Regenerative Vacuum sweeping	$0.02/SF	Twice per year	$1.16 SF	Herrera 2012a
Impermeable Pavement	Regenerative Vacuum sweeping	$0.02/SF	Twice per year	$1.16 SF	Herrera 2012a

[a] O&M costs were assessed as a present value (2013 dollars), assuming a 30-year facility lifecycle and that the inflation rate is offset by the interest rate.

[b] Cost provided is for infiltration trenches at commercial sites. Costs are not included for operation and maintenance of catch basins upstream of residential infiltration trenches.

SF: square foot

PV: planter vault

IB: infiltration basin

DT: detention tank

IT: infiltration trench

CB: catch basin

SAMPLE SITES AND STORMWATER MANAGEMENT

This section describes stormwater management for the three hypothetical development sites, and provides details of corresponding construction stormwater pollution prevention, onsite stormwater management, runoff treatment and flow control, O&M, and design. We developed conceptual designs and costs that satisfy the minimum requirements outlined in the 2005 and 2012 manual for all 14 scenarios.

Single-Family Residential Development - Scenarios 1 to 6

The single-family residential development is a 10-acre single-family residential development. We evaluated two site plans for residential development. The first incorporates typical planning and layout principles as shown in Figure 1 and Figure 2. The second site plan incorporates LID principles including smaller lot sizes and a narrower ROW as shown in Figure 3 and Figure 4.

Both site plans include 44 lots and two entrances to the development from the main arterial street. The site plan without LID principles includes a 50-foot wide ROW, and lots ranging between 6,924 square feet to 11,300 square feet. The site plan with LID principles includes a 37-foot wide ROW and lots ranging between 3,600 square feet to 7,706 square feet. With the smaller lots, an area of 184,084 square feet is left undeveloped which can be used for additional units, open space, or environmental conservation at the developer's discretion. We did not analyze the cost of stormwater management for the open space.

The pre-development characteristics of the site are common to both site plans with and without LID principles. We assumed a forested site prior to development. The topography of the site in its undeveloped state averages 2 percent grade, and causes runoff to flow to the lower left corner via a few defined drainage courses. These drainage courses are not streams and provide negligible ecological benefits. The development plan does not include extensive re-grading of the slopes on the site. Drainage will therefore proceed in the same general direction after development. It is assumed that after development, any treated runoff from the site that does not infiltrate into the soil will be conveyed downstream of the site to a stream (see below for treatment plans).

The topographic layout of the residential development is conducive to stormwater runon from adjacent land, and through-flow in the main drainage course. We assumed a decision to minimize the size (and cost) of TESC facilities and of permanent stormwater management facilities by separating the offsite runon from the onsite drainage. For the purposes of this analysis, the designer would include one or more culverts and/or intercepting ditches (or similarly effective diversion/conveyance facilities) to convey those flows around the site. Because these provisions are necessary due to hypothetical site conditions for all sites, costs are not included for them.

We assumed that construction would require 12 months of site work to complete all site plans. In addition, the contractor would grade the site, providing basic infrastructure and utilities, and leave individual building sites for future contractors. However, construction costs are included in this analysis for stormwater BMPs on each residential lot. In addition, construction would continue through the rainy season, and implementation of additional grading and erosion controls would occur during winter months as needed.

Construction Stormwater Pollution Prevention

Six scenarios are included for the single-family residential example based on two soil types (outwash or till), and three regulatory requirement scenarios that are consistent with requirements provided by the 2005 manual, 2012 manual, and 2012 manual when using LID principles. We provide a TESC plan for each scenario. Figure 5 displays the TESC plan for scenarios 1 and 2. The 2005 manual TESC BMPs are the same for outwash and till soils, except for the size of the temporary sediment pond. The TESC BMPs for Scenario 3 are the same as those for Scenario 5, and likewise for scenarios 4 and 6; therefore, TESC plans are only provided for scenarios 3 and 4. Figure 6 outlines the TESC plan for Scenario 3 and includes the sediment pond size for Scenario 5. Figure 7 outlines the TESC plan for Scenario 4 and includes the sediment pond size for Scenario 6. Other BMPs would also be smaller for scenarios 5 and 6 because the site is smaller.

Maintenance of the erosion and sediment control BMPs is a key component of construction stormwater pollution prevention at each site. We assumed that routine BMP maintenance checks would occur once weekly and after runoff-producing storm events during the dry season, and daily during the wet season to ensure that BMPs continue to function effectively. Inspection of sediment ponds would occur periodically to check for sediment buildup, especially following storms. Excess sediment accumulation would be removed from the pond, and disposed of off the site or spread in a controlled location on the site. Replacement and relocation of mulch used to cover stripped site areas would occur as needed, as portions of the site are permanently stabilized. Sediment tracked offsite onto neighboring streets would be swept and collected as necessary.

2005 Manual

To control transport of sediments off the site and to protect downstream properties and waterways during construction for all site plans, a combination of BMPs would be used including fenced clearing limits, stabilized site roads, storm drain inlet protection on the adjacent street, temporary ground cover in disturbed areas, stabilized conveyance ditches, silt fencing, and a temporary sediment pond. To satisfy the minimum requirements, these BMPs would be in place prior to beginning construction activities on the individual lots. We assumed that dewatering would not be required at this site.

The BMPs for each site plan are nearly the same for outwash (Type A and B) soils and till (Type C) soils. We include a temporary sediment pond in all site plans; however, the size of the pond differs based on the soil type and the size of each site. We sized temporary sediment ponds in accordance with the 2005 manual, and Table 4 lists the resulting pond sizes. Silt fencing is included in the cost estimates for all temporary sediment ponds as a divider to enhance the removal of suspended sediments.

Table 4. Temporary Sediment Pond Volume.						
Scenario No.	**1**	**2**	**3**	**4**	**5**	**6**
Development Type	SFR Subdivision					
Standard	2005		2012		2012 with LID Principles	
Soils	Outwash	Till	Outwash	Till	Outwash	Till
Construction Stormwater Pollution Prevention	246 cubic yards (CY)	538 CY	246 CY	538 CY	124 CY	453 CY

Seeding of the construction site would occur under all of these scenarios immediately after grading to stabilize the soil until all the individual parcels are developed, and permanently stabilized. Temporary conveyance channels lined with suitable geotextiles or organic blankets would convey all site runoff to the sediment pond. The site would have a construction entrance stabilized with 100 linear feet of quarry spalls, and crushed rock to stabilize construction roads on the site and one main parking/staging area. High visibility fence would be placed along a portion of the edge of the construction boundary to limit vehicle access to the stabilized construction entrance. Silt fence would be placed along the perimeter of the southern edge of the site to capture sediment transported from the construction area.

During the rainy season, greater attention to soil stabilization is necessary to prevent erosion on disturbed ground, particularly in Type C soils. Mulch would be applied extensively to areas of exposed soil during winter months of construction. Additionally, greater attention to sediment pond maintenance, street sweeping, vehicle tire washing, and replacement of storm drain inlet protection devices is required. Paving of sidewalks and streets would permanently stabilize disturbed areas prior to construction on individual lots. Following construction of homes on the site, planting of lawns and landscaping would incorporate Soil Quality and Depth (BMP T5.13).

2012 Manual

The TESC plans to meet the 2012 manual requirements include additional erosion and sediment controls to protect LID BMPs during construction. Installation of permeable pavement would occur last after all grading and utility construction is complete, and all disturbed areas are temporarily stabilized with seeding. Six inches of native soil (above finished subgrade elevation) would remain in place in all areas that will have permeable surfacing. Removal of 6 inches of native soil would occur immediately before installation of the base material and the permeable surfacing. Construction on individual lots requires additional BMPs to prevent sediment from tracking to the permeable surface. The cost estimates for these sites include additional straw wattles at the perimeter of each lot and a small stabilized construction entrance at each lot.

Excavation of the bottom of each bioretention facility would occur after the entire site has been stabilized to protect the permanent bioretention cells. This would remove any construction phase sediment buildup from the temporary drainage channels, which will become the permanent bioretention cells.

Costs for Construction Stormwater Pollution Prevention

The estimated TESC costs are higher for the 2012 scenarios due to costs associated with having a stabilized construction entrance at each lot, protection of the permeable pavement base, protection of bioretention cells during construction, and slightly higher CESCL costs. The scenarios with till soils have higher costs than those with outwash soils associated with the larger sediment pond (Table 5). The estimated TESC costs for scenarios 5 and 6 are lower than for scenarios 3 and 4 because less material is required for the smaller sites with LID Principles.

Table 5. Construction Stormwater Pollution Prevention Costs for Single-family Residential Scenarios.

Scenario No.	1	2	3	4	5	6
Development Type	SFR Subdivision					
Standard	2005		2012		2012 with LID Principles	
Soils	Outwash	Till	Outwash	Till	Outwash	Till
Construction Stormwater Pollution Prevention	$95,000	$104,000	$125,000	$156,000	$91,000	$111,000

Permanent Stormwater Management

We evaluated each single-family residential scenario in accordance with the applicable regulatory standards and the related assumptions to determine which permanent stormwater management BMPs would be required. Figures 8 through 11 illustrate the stormwater management BMPs we selected for each site, and the conceptual flow path between land cover types and BMPs.

Onsite Stormwater Management Measures (Minimum Requirement #5)

2005 Manual

Under the 2005 manual, onsite stormwater management for residential parcels uses the following BMPs, as shown in Figures 12 through 15:

- **Scenario 1 – Outwash:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from all lawn and landscape
  - Downspout infiltration trenches to manage roof runoff
- **Scenario 2 – Till:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from lawn and landscape
  - Downspout dispersion trenches to manage roof runoff

No onsite stormwater management BMPs are required for surfaces in the ROW under the 2005 manual. Runoff treatment and flow control BMPs described in the next section manage the remainder of runoff from the site.

2012 Manual

Under the 2012 manual, onsite stormwater management for residential parcels and in the ROW uses the following BMPs in accordance with List #2, as shown in Figures 16 through 19:

- **Scenario 3 – Outwash:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from lawn and landscape
  - Full infiltration trenches (BMP T5.10A) to manage roof runoff
  - Bioretention (BMP T7.30) to manage roadway runoff
  - Permeable pavement (BMP T5.15) sidewalks (permeable base thickness of 0.35 feet)
- **Scenario 4 – Till:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from lawn and landscape
  - Bioretention (BMP T7.30) to manage roof runoff
  - Permeable pavement (BMP T5.15) driveways (permeable base thickness of 0.7 feet)
  - Permeable pavement (BMP T5.15) sidewalks (permeable base thickness of 0.7 feet)
  - Permeable pavement (BMP T5.15) roadways (permeable base thickness of 1.1 feet)

For Scenario 3, we sized bioretention in the ROW to meet minimum requirements #6 and #7 for only the roadway surface (not private parcel runoff) because, under the assumptions of this analysis, ROW BMPs are not permitted to manage runoff from parcel-based development. Therefore, centralized runoff treatment and flow control BMPs are still required at the downstream end of the development to manage excess runoff from the lawn, landscaping, and driveway, as described in the next section.

For Scenario 4, we sized bioretention to receive only roof runoff.

For both scenarios 3 and 4, the bioretention could be eliminated and the flow durations would still meet the LID Performance Standard. The cost implications are discussed later in this section.

2012 Manual with LID Principles

Scenarios 5 and 6, which included LID principles, have all the same BMPs as scenarios 3 and 4 but with reduced ROW area and lot sizes. See Figures 20 through 23 for illustrations of the different scale of BMPs on these sites.

Runoff Treatment and Flow Control Measures (Minimum Requirement #6 and #7)

2005 Manual

Under the 2005 manual, implementation of runoff treatment and flow control for the residential development uses the following BMPs, as shown in Figures 12 through 15:

- **Scenario 1 – Outwash:**
  - Wet pond (BMP T10.10) for runoff treatment
  - Infiltration Basin (BMP T7.10) for flow control
- **Scenario 2 – Till:**
  - Combined detention and wetpool (BMP T10.40) for runoff treatment and flow control

2012 Manual

Under the 2012 manual, implementation of runoff treatment and flow control for the residential development uses the following BMPs, as shown in Figures 16 through 19:

- **Scenario 3 – Outwash:**
  - Wet pond (BMP T10.10) for runoff treatment
  - Infiltration Basin (BMP T7.10) for flow control
- **Scenario 4 – Till:**
  - Combined detention and wetpool (BMP T10.40) for runoff treatment and flow control

2012 Manual with LID Principles

Scenarios 5 and 6, which included LID principles, have all the same BMPs as scenarios 3 and 4 but with reduced ROW area and lot sizes. See Figures 20 through 23 for illustrations of the different scale of BMPs on these sites.

Costs for Permanent Stormwater Management

The LID BMPs used for scenarios 3 and 4 result in higher onsite stormwater management costs for these sites relative to scenarios 1 and 2 (Table 6). The smaller lots for scenarios 5 and 6 make onsite stormwater management for these scenarios the lowest. Use of permeable pavement in Scenario 4 produces the highest onsite stormwater management cost for that scenario.

The LID BMPs implemented in scenarios 3 and 4 reduce the size of runoff treatment and flow control BMPs for those scenarios, resulting in lower runoff treatment and flow control costs compared to scenarios 1 and 2. Though Scenario 3 requires smaller centralized facilities than Scenario 4, the estimated runoff treatment and flow control costs for Scenario 4 are lower than Scenario 3 because the permeable pavement in Scenario 4 makes a conveyance system unnecessary.The runoff treatment and flow control BMP costs for Scenario 6 is slightly lower than for Scenario 4 because the reduced impervious surface further reduces the need for centralized stormwater management. The runoff treatment and flow control BMP costs for Scenario 5 is slightly higher than for Scenario 3 because more drainage structures are required for Scenario 5 and because the excavation performed for the Scenario 3 sediment pond eliminates the need for additional excavation for the infiltration basin.

Table 6. Onsite Stormwater Management Costs for Single-family Residential Scenarios.

Scenario No.	**1**	**2**	**3**	**4**	**5**	**6**
Development Type	SFR Subdivision					
Standard	2005		2012		2012 with LID Principles	
Soils	Outwash	Till	Outwash	Till	Outwash	Till
Onsite Stormwater Management	$990,000	$988,000	$1,114,000	$1,174,000	$751,000	$804,000
Runoff Treatment and Flow Control	$170,000	$174,000	$121,000	$87,000	$124,000	$73,000
Total Permanent Stormwater Management Costs	$1,160,000	$1,162,000	$1,235,000	$1,261,000	$875,000	$877,000

The total cost estimated for permanent stormwater management BMPs is higher for scenarios 3 and 4 than for scenarios 1 and 2. The costs for scenarios 5 and 6 are lower compared to scenarios 1 and 2 due to the reduced size of the development. If bioretention on private parcels is removed from scenarios 4 and 6, the LID Performance Standard would still be met and the estimated permanent stormwater management costs for those scenarios would be reduced to $1,198,000 and $795,000, respectively, making the cost for Scenario 4 only 4 percent greater than Scenario 2.

Appendix B provides more detailed cost breakdowns for the permanent stormwater management costs associated with each of these scenarios.

Design

2005 Manual

The design effort for the 2005 manual scenarios includes design of infiltration trenches, dispersion trenches, soil quality and depth for each residential lot, and design of each centralized runoff treatment and flow control facility. Design work for these scenarios also includes soil quality and depth for onsite stormwater management in the planting strip and preparing design details for drainage conveyance systems in the right of way. The estimated design cost for centralized facilities, and drainage conveyance for both the outwash and till scenarios is $45,000, assuming nine design plan sheets are prepared for the conveyance, permanent stormwater management, and planting. These sheets include the following:

- General notes sheet
- Three drainage plan and detail sheets, including traditional pavement and sidewalk sections
- Two runoff treatment and flow control plan and details sheet
- Two planting plan sheets
- One planting schedule and details sheet

The subtotal cost for design of infiltration trenches, dispersion trenches, and soil quality and depth on the individual lots is estimated to be $21,000 for the outwash scenario, and $20,000 for the till scenario for 42 lots and 40 lots, respectively.

The geotechnical evaluation for Scenario 1 includes one large scale PIT and 2 days of field exploration (20- and 10-foot deep test pits) to determine infiltration rates for the infiltration facility and infiltration trenches, at a total estimated cost of $13,000. The geotechnical evaluation for Scenario 2 includes one large scale PIT and 1 day of field exploration (20-foot deep test pits) to infiltration rates for the detention facility, at a total estimated cost of $9,000.

Scenario 1 Total Design Cost: $79,000

Scenario 2 Total Design Cost: $74,000

2012 Manual

The design effort for the 2012 manual scenarios is more complex than the 2005 scenarios due to incorporation of LID BMPs for onsite stormwater management.

Scenario 3 - Outwash

Design of stormwater facilities in the right of way in this scenario includes bioretention and soil quality and depth within the planting strip, permeable sidewalks for onsite stormwater management, and centralized facilities for runoff treatment and flow control. The onsite stormwater management design costs will make the drainage plan sheets slightly more complicated than in the 2005 manual scenarios. We assumed that an additional design plan sheet is required for bioretention details, and the planting plans and schedules will be more complex than in the 2005 manual scenarios. The estimate for right of way design is $55,000 for nine design plan sheets:

- General notes sheet
- Three drainage plan sheets, including traditional pavement and sidewalk sections
- Bioretention details sheet
- Two runoff treatment and flow control plan and details sheet
- Three planting plan sheets

- One planting schedule and details sheet

The estimated subtotal cost for design of infiltration trenches, and soil quality and depth for onsite stormwater management on the residential lots is $21,500 for 43 lots.

The geotechnical evaluation for Scenario 3 includes one large scale PIT and several test pits (20-foot deep) to determine infiltration rates for the infiltration facility and seven small scale PITs to evaluate suitability for infiltration trenches and bioretention facilities at a total estimated cost of $50,000.

Scenario 3 Total Design Cost: $126,000

Scenario 4 - Till

Design of stormwater facilities in the right of way in this scenario includes soil quality and depth within the planting strip, permeable sidewalks, and permeable pavement roadway for onsite stormwater management. The design effort also includes centralized facilities for runoff treatment and flow control. Inclusion of permeable pavement in the development plans will make the design more complicated than in the 2005 scenarios. We assumed that an additional design plan sheet is required for permeable pavement, internal check dam, and overflow details, and that the planting plans and schedules will be more complex than in the 2005 manual scenarios. The estimated right of way design cost is $45,000 for nine design plan sheets:

- General notes sheet
- Two drainage plan sheets, including permeable pavement, overflow pipe, and sidewalk sections
- Permeable pavement internal check dam and overflow details sheet
- Two runoff treatment and flow control plan and details sheet
- Two planting plan sheets
- One planting schedule and details sheet

The estimated subtotal cost for design of bioretention and soil quality and depth for onsite stormwater management on the residential lots is $41,000 for a total of 41 lots.

The geotechnical evaluation for Scenario 4 includes one large scale PIT and several test pits (20 feet deep) to determine infiltration rates at the detention facility and seven small scale PITs to evaluate suitability for bioretention facilities at a total cost of $50,000.

Scenario 4 Total Design Cost: $136,000.

2012 Manual with LID Principles

Though the stormwater management BMPs are smaller in the 2012 manual scenario with LID principles (scenarios 5 and 6), we expect the level of effort for design to be equivalent for scenarios without LID principles due to the challenges of designing to accommodate site spatial constraints with smaller lots. The geotechnical evaluation would only include five small scale PITs (instead of seven), reducing the estimated geotechnical investigation cost to $38,000 each.

Scenario 5 Design Cost: $114,000.

Scenario 6 Design Cost: $124,000.

Comparison of Estimated Design Costs for Different Scenarios

The estimated design cost for both 2012 manual scenarios is higher than the estimated design costs for the 2005 manual scenarios. This is because design of onsite stormwater management BMPs on the residential lots and in the public right of way (2012 manual) is likely to require additional detail in the design plans compared to design of the centralized infiltration and detention system (2005 manual) (Table 7). We also included more PITs in the 2012 manual scenarios, further raising the design cost estimates for those scenarios.

Table 7. Estimated Design Costs for Single Family Residential Scenarios.

Scenario No.	1	2	3	4	5	6
Development Type	SFR Subdivision					
Standard	2005		2012		2012 with LID Principles	
Soils	Outwash	Till	Outwash	Till	Outwash	Till
Design	$79,000	$74,000	$126,000	$136,000	$114,000	$124,000

For the site scenarios in till soils, estimates of design costs are approximately 65 to 85 percent higher under the 2012 manual requirements (scenarios 3 and 5) than under the 2005 manual requirements (Scenario 1).

For the site scenarios in outwash soils, estimated design costs are approximately 45 to 60 percent higher under the 2012 manual requirements (scenarios 4 and 6) than under the 2005 manual requirements (Scenario 2).

Some designers working under the 2005 manual requirements may opt to determine infiltration rates based on soil characterization only, without PITs. This would reduce geotechnical investigation costs, but may also lead to higher correction factors for infiltration system design and thus reduced design infiltration rates that increase the facility size, and increase permanent stormwater management costs accordingly.

We assumed that scenarios 4 and 6 would have one less sheet for drainage plans and details because conveyance design is not necessary in these scenarios due to permeable pavement. In addition, for scenarios 3 through 6, if the LID BMP sizes were increased to provide runoff treatment and flow control for private property runoff, centralized facilities could be eliminated, along with the associated design costs, and more parcels could be developed into homes.

Operation and Maintenance

2005 Manual

Under the 2005 manual, the following O&M activities are required for the permanent stormwater management BMPs in the residential development scenarios:

- **Scenario 1 – Outwash:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Regenerative vacuum sweeping of impermeable pavement streets and parking twice per year
  - Catch basin sediment removal on a 5-year cycle
  - Vegetation management in the wet pond (BMP T10.10) on an annual cycle and sediment removal on a 15-year cycle
  - Mowing in the infiltration basin (BMP T7.10) twice per year and sediment removal on a 15-year cycle
- **Scenario 2 – Till:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Regenerative vacuum sweeping of impermeable pavement streets and parking twice per year
  - Catch basin sediment removal on a 5-year cycle
  - Vegetation management in the combined detention and wetpool (BMP T10.40) on an annual cycle and sediment removal on a 15-year cycle

2012 Manual

Under the 2012 manual, the following O&M activities are required for the permanent stormwater management BMPs in the residential development scenarios:

- **Scenario 3 – Outwash:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Sediment removal from permeable sidewalks (BMP T5.15) on a 5-year cycle using vactor truck mounted vacuum equipment
  - Catch basin sediment removal on a 5-year cycle
  - Annual sediment removal, vegetation management, mulching, and pest control in bioretention facilities (BMP T7.30)

- Vegetation management in the wet pond (BMP T10.10) on an annual cycle and sediment removal on a 15-year cycle
- Mowing in the infiltration basin (BMP T7.10) twice per year and sediment removal on a 15-year cycle

- **Scenario 4 – Till:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Regenerative vacuum sweeping of permeable pavement streets and parking (BMP T5.15) twice per year
  - Sediment removal from permeable sidewalks (BMP T5.15) on a 5-year cycle using vactor truck mounted vacuum equipment
  - Catch basin sediment removal on a 5-year cycle
  - Annual sediment removal, vegetation management, mulching, and pest control in bioretention facilities (BMP T7.30)
  - Vegetation management in the combined detention and wetpool (BMP T10.40) on an annual cycle and sediment removal on a 15-year cycle

2012 Manual with LID Principles

Scenarios 5 and 6, which included LID principles, require all the same O&M activities as scenarios 3 and 4 with the exception that sediment removal from permeable sidewalks (BMP T5.15) would also need to occur on a 5-year cycle for Scenario 5.

Cost for Operation and Maintenance

As shown in Table 8, estimated O&M costs for the 2012 scenarios (scenarios 3 and 4) are approximately 2.5 to 3.5 times greater than for the 2005 scenarios (scenarios 1 and 2) because of the additional costs for cleaning permeable sidewalks and the additional cost of maintaining bioretention facilities for scenarios 3 and 4. However, scenarios 1 and 2 would incur O&M costs for the lawn and landscape that occupies the same footprint as the bioretention facilities, which are not included in this analysis.

Table 8. Operation and Maintenance Costs for Single-family Residential Scenarios.

Scenario No.	1	2	3	4	5	6
Development Type	SFR Subdivision					
Standard	2005		2012		2012 with LID Principles	
Soils	Outwash	Till	Outwash	Till	Outwash	Till
Operation and Maintenance (30-years)	$149,000	$306,000	$536,000	$744,000	$347,000	$523,000

O&M costs for scenarios 5 and 6, which included LID principles, are estimated to be lower relative to scenarios 3 and 4 because there is less area requiring maintenance. Appendix B provides more detailed cost breakdowns for the O&M activities associated with each of these scenarios.

Small Commercial Development - Scenarios 7 to 10

Site 2 is a 1-acre commercial development assumed as a typical restaurant with drive-through. Figure 24 shows the layout of the small commercial development as planned for development. There are two entrances to the site; however, only one is for construction access.

The developed site would have underground storm sewer pipes to convey runoff to the permanent stormwater control facilities. It is assumed that some mechanism is provided to divert offsite runoff around the site (such as that mentioned for the residential site), the costs of which are not included in this analysis. We also assumed that developed site runoff that is not infiltrated is discharged to an offsite storm sewer, eventually reaching a stream.

This relatively flat site drains from the upper right to the lower left (when viewing Figure 24) in its undeveloped state, with the potential for stormwater runon from adjacent land. Because extensive grading of the site would not occur, post-development drainage would flow in the same direction.

Construction Stormwater Pollution Prevention

This section describes the construction stormwater pollution prevention measures implemented for a 1-acre commercial site under the 2005 and 2012 manual requirements covering both outwash and till soils, including the primary differences between the requirements and the resultant TESC measures.

We analyzed four scenarios for the small commercial site for two soil types and two regulatory requirement manuals. The TESC plan is very similar for all scenarios. Figure 25 shows the TESC plan for scenarios 11 and 12, in accordance with the 2005 manual. Figure 26 shows the TESC plan for scenarios 13 and 14, in accordance with the 2012 manual.

Maintenance of the erosion and sediment control BMPs is a key component of the construction SWPPP. We assumed that routine BMP maintenance checks would occur once weekly and after runoff-producing storm events during the dry season, or daily during the wet season to ensure that BMPs continue to function effectively. Inspection of silt fencing would occur periodically, especially following storms, to determine if there are needed repairs or replacement sections. Replacement and relocation of mulch used to cover stripped site areas would occur as portions of the site are permanently stabilized. Sediment tracked offsite onto neighboring streets would be swept and collected as necessary.

2005 Manual

We assumed that exterior construction would take 2 months to complete. Several BMPs are necessary to control site runoff and erosion during the construction phase of the small commercial site. A combination of TESC BMPs would control transport of sediment off site, and protect downstream properties and waterways during construction, including:

- Intercepting swales with check dams
- Small sediment pond
- Stabilized construction entrance and equipment parking area
- Mulch application to bare areas
- Storm drain inlet protection on the adjacent street
- Silt fencing on the downslope perimeter

These BMPs would be in place prior to construction activities in order to satisfy the minimum requirements. Figure 25 shows the locations of the erosion and sediment control BMPs selected for the small commercial development site. The BMPs are almost all the same for both outwash soils (suitable for infiltration) and till soils (unsuitable for infiltration). The size of the temporary sediment pond differs for the two soil types because of the effect soil type has on runoff peak flows and volumes. Figure 25 indicates the sediment pond size corresponding to till soils and outwash soils; the till soils require a larger pond.

Due to the relatively short time frame for construction, it is assumed that cleaning of the catch basins on the adjacent street would not be necessary following construction, and that the small sediment pond would not require sediment cleanout prior to its removal. Implementation of other BMPs such as vehicle tire washing, watering of dusty areas, and street sweeping would occur during construction as needed.

The intercepting swales along the edges of the site would convey almost all of the construction site runoff to the sediment pond. The sediment pond would contain a silt fence divider to enhance trapping of suspended sediments. Silt fencing would contain sediments on the site periphery that may be present in runoff that does not reach the interceptor swales. Quarry spalls would be used to stabilize the construction entrance. Mulch would be applied as needed to areas of exposed soil during construction. We assumed that two catch basins on the adjacent street would require inlet protection.

2012 Manual

The 2012 manual requires additional protection for permanent LID BMPs (SWPPP element #13). This would include protecting the bioretention cells for all soil types. Excavation of bioretention subgrade would occur after the majority of site construction and development is complete to protect the permanent bioretention. Silt fencing and additional interceptor swales would protect the infiltration trenches during construction.

Costs for Construction Stormwater Pollution Prevention

The estimated TESC costs are slightly higher for scenarios 9 and 10 compared to scenarios 7 and 8 due to the additional cost for protection of bioretention facilities during construction (Table 9).

Table 9. Construction Stormwater Pollution Prevention Costs for Small Commercial Development.				
Scenario No.	**7**	**8**	**9**	**10**
Development Type	Small Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Construction Stormwater Pollution Prevention	$17,000	$18,000	$18,000	$19,000

Permanent Stormwater Management

Each scenario was evaluated to determine which permanent stormwater management BMPs would be required in accordance with the applicable regulatory standards and relevant assumptions. Figures 27 through 30 illustrate the stormwater management BMPs selected for each small commercial development scenario and the conceptual flow paths between land cover types and BMPs. Because the small commercial development is a high-use site, permeable pavement is infeasible and thus the cost of pavement is not included in the cost estimates.

Onsite Stormwater Management Measures (Minimum Requirement #5)

2005 Manual

Under the 2005 manual, onsite stormwater management at the small commercial development uses the following BMPs, as shown in Figures 31 and 32:

- **Scenario 7 - Outwash:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from landscaped areas
  - Downspout Infiltration Trenches to manage roof runoff
- **Scenario 8 - Till:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from landscaped areas

2012 Manual

Under the 2012 manual, onsite stormwater management at the small commercial development uses the following BMPs, as shown in Figures 33 and 34:

- **Scenario 9 - Outwash:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from lawn and landscaped areas
  - Downspout Infiltration Trenches (Full Infiltration BMP T5.10A) to manage roof runoff
  - Bioretention (BMP T7.30) to manage parking lot runoff

- **Scenario 10 – Till:**
  - Bioretention (BMP T7.30) to manage parking lot runoff
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from lawn and landscaped areas

For Scenario 9, we sized the bioretention to meet minimum requirements #5, #6, and #7 for the small commercial site, eliminating the need for a centralized runoff treatment and flow control BMP. For Scenario 10, we sized the bioretention to meet only minimum requirements #5 and #6 because lower infiltration rates on till soils would limit the feasibility of upsizing the facility to meet minimum requirement #7.

Runoff Treatment and Flow Control Measures (Minimum Requirements #6 and #7)

2005 Manual

Under the 2005 manual, runoff treatment and flow control at the small commercial development could be accomplished with the following BMPs, as shown in Figures 31 and 32:

- **Scenario 7 – Outwash:**
  - Stormwater Treatment Planter Vault for runoff treatment
  - Infiltration Trench (BMPT7.20) for flow control
- **Scenario 8 – Till:**
  - Stormwater Treatment Planter Vault for runoff treatment
  - Detention Tank for flow control.

We selected the Stormwater Treatment Planter Vault as an economical option to meet MR #6 while staying within the vertical constraints of the site (i.e., invert of the MS4 is assumed to be 4 feet below ground surface). The detention tank was selected as an economical option for flow control with limited live storage depth and to match assumptions from the 2001 cost study.

2012 Manual

Under the 2012 manual, runoff treatment and flow control at the small commercial development could use the following BMPs, as shown in Figures 33 and 34:

- **Scenario 9 – Outwash:**
  - Bioretention (BMP T7.30) for runoff treatment and flow control
  - No centralized facility required for this scenario
- **Scenario 10 – Till:**

- Bioretention (BMP T7.30) with an underdrain for runoff treatment (only the downstream cells included an underdrain)
- Detention Tank for flow control

Costs for Permanent Stormwater Management

The permanent stormwater management costs estimated for scenarios 9 and 10 are 27 percent and 3 percent lower than the costs for scenarios 7 and 8, respectively (Table 10). The estimated cost for bioretention in Scenario 9 is roughly the same as the cost for stormwater treatment planter vaults in Scenario 7, so the elimination of the centralized infiltration system from Scenario 9 accounts for most of the cost difference. The remaining difference is due to reduced cost for drainage conveyance. The estimated total cost for Scenario 10 is slightly lower than that for Scenario 8 because the use of bioretention for onsite stormwater management and runoff treatment also results in some infiltration, which reduces the size of the detention facility relative to Scenario 8. Appendix B provides more detailed cost breakdowns for the permanent stormwater management costs associated with each of these scenarios.

Table 10. Permanent Stormwater Management Costs for Small Commercial Development.

Scenario No.	7	8	9	10
Development Type	Small Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Onsite Stormwater Management	$64,000	$34,000	$126,000	$110,000
Runoff Treatment and Flow Control	$109,000	$177,000	$0	$95,000
Total Permanent Stormwater Management Costs	$173,000	$211,000	$126,000	$205,000

Design

2005 Manual

Design effort for the 2005 manual scenarios includes design of runoff treatment, detention and infiltration systems, including infiltration trenches to manage roof runoff. Design work for these scenarios also includes drainage conveyance system details and profiles. The estimated design cost for both the outwash and till scenarios is $20,000 and includes four design plan sheets.

- General notes sheet
- Drainage plan sheet, including runoff treatment and detention/infiltration system layouts
- Runoff treatment and detention/infiltration system cross-sections and details sheet
- Drainage conveyance details and profile sheet, including infiltration trenches for roof runoff

The geotechnical evaluation for scenarios 7 and 8 include one large scale PIT and 1 day of field exploration (20-foot deep test pits) to evaluate infiltration rates at the flow control facilities, at a total estimated cost of $9,000 per scenario.

Scenarios 7 and 8 Design Cost: $29,000

2012 Manual

Design effort for the 2012 manual scenarios includes bioretention instead of detention and infiltration systems. The estimated design cost for the outwash and till scenarios is $20,000 and includes four design plan sheets:

- General notes sheet
- Drainage plan sheet, including conveyance details and profile
- Bioretention sheet with details and planting plan
- Planting schedule and planting details

The design effort for the till soil scenario (Scenario 10) is estimated to cost an additional $5,000 ($25,000 total) due to an additional plan sheet for detention/infiltration system cross sections and details.

The geotechnical evaluation for Scenario 9 includes one small scale PIT and 1 day of field exploration (10-foot deep test pits) to evaluate infiltration rates at the bioretention facility, at a total estimated cost of $9,000. The geotechnical evaluation for Scenario 10 includes one large scale PIT, one small scale PIT, and 1 day of field exploration (20- and 10-foot deep test pits) to evaluate infiltration rates at the detention and bioretention facilities, at a total estimated cost of $15,000.

Scenario 9 Design Cost: $34,000

Scenario 10 Design Cost: $40,000

Comparison of Estimated Design Costs for Different Scenarios

The estimated design cost for the small commercial development site in the 2012 manual scenarios is higher than for the 2005 manual scenarios (Table 11) due to the additional cost for design of bioretention facilities and additional geotechnical investigation costs (Scenario 10 only). Some designers working under the 2005 manual requirements may opt to determine infiltration rates based on soil characterization alone, without PITs. This would reduce geotechnical investigation costs slightly, but may also lead to higher correction factors for infiltration system design and thus reduced design infiltration rates that increase the facility size and increase permanent stormwater management costs accordingly.

Table 11. Design Costs for Small Commercial Development.				
Scenario No.	**7**	**8**	**9**	**10**
Development Type	Small Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Design	$29,000	$29,000	$34,000	$40,000

Operation and Maintenance

2005 Manual

Under the 2005 manual, the following O&M activities are required for the permanent stormwater management BMPs in the small commercial development scenarios:

- **Scenario 7 – Outwash:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Catch basin sediment removal on a 2-year cycle
  - Stormwater treatment planter vault mulch replacement twice per year, and media replacement on a 15-year cycle
  - Infiltration trench (BMP T7.20) sediment trap cleanout on a 2-year cycle
- **Scenario 8 – Till:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Catch basin sediment removal on a 2-year cycle
  - Stormwater treatment planter vault mulch replacement twice per year, and media replacement on a 15-year cycle
  - Detention tank sediment removal on a 2-year cycle

2012 Manual

Under the 2012 manual, the following O&M activities are required for the permanent stormwater management BMPs in the small commercial development scenarios:

- **Scenario 9 – Outwash:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Catch basin sediment removal on a 2-year cycle

- Annual sediment removal, vegetation management, mulching, and pest control in bioretention facilities (BMP T7.13)

- **Scenario 10 – Till:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Catch basin sediment removal on a 2-year cycle
  - Annual sediment removal, vegetation management, mulching, and pest control in bioretention facilities (BMP T7.13)
  - Detention tank sediment removal on a 2-year cycle

Cost for Operation and Maintenance

As shown in Table 12, the estimated O&M costs for the 2012 scenarios (scenarios 9 and 10) are about 45 percent lower than the 2005 scenarios (scenarios 7 and 8) due to higher costs for maintaining the stormwater treatment planter boxes in the 2005 scenarios. In comparison, the bioretention facilities used in the 2012 scenarios (scenarios 9 and 10) would be generally less expensive to maintain than the stormwater treatment planter boxes. Because the bioretention facilities can occupy landscaped area that would otherwise require periodic maintenance, the relative costs for scenarios 9 and 10 shown in Table 12 would be reduced further if these land costs were included in this analysis. Appendix B provides more detailed cost breakdowns for the O&M activities associated with each of these scenarios.

Table 12. Operation and Maintenance Costs for Small Commercial Development.

Scenario No.	7	8	9	10
Development Type	Small Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Operation and Maintenance (30 years)	$178,000	$173,000	$77,000	$82,000

Large Commercial Development - Scenarios 11 to14

The large commercial development is a 10-acre site consisting of a retail shopping center and parking lot. Figure 35 shows the layout of the planned development. The topography of this site in its undeveloped condition causes drainage to flow from the top of the lot to the bottom; there are several defined drainage courses not classified as streams or sensitive areas. Extensive grading of this site would occur to construct the large building and parking lot. Stormwater runon and through-flow in the drainage courses would occur unless there are diversions. We assumed that diversion trenches ring the site on the upslope sides to convey runon and through-flow around the site to the downstream conveyance system.

The costs of providing diversion trenches and constructing retaining walls, or similarly effective slope stabilization measures near the site border, are not included in this analysis because their necessity is consistent across all scenarios.

Construction Stormwater Pollution Prevention

We developed four scenarios for the large commercial development for two soil types and the 2005 and 2012 manuals. Figure 36 shows the TESC plan for scenarios 11 and 12 in accordance with the 2005 manual. Figure 37 shows the TESC plan for scenarios 13 and 14 in accordance with the 2012 manual.

Maintenance of the erosion and sediment control BMPs is a key component of the construction SWPPP. We assumed that routine BMP maintenance checks would occur once weekly and after runoff-producing storm events during the dry season, and daily during the wet season to ensure that BMPs continue to function effectively. Excess sediment accumulation would be removed from the pond, and disposed off site or spread in a controlled location on the site. Inspection of silt fencing would occur periodically, especially following storms, to determine if there are needed repairs or replacement of fabric sections. Replacement and relocation of mulch used to cover stripped site areas would occur, along with permanent stabilization of the site. Sediment tracked offsite onto neighboring streets would be swept and collected as necessary.

2005 Manual

The BMPs are almost all the same for outwash (Type A and B) and till (Type C) soils. The differences assumed for BMP applications with Type A soils include reduced size of the temporary sediment pond, reduced extent of street sweeping, and reduced extent of offsite catch basin cleaning. Therefore, the cost estimate for the construction SWPPP associated with outwash soils reflects slightly reduced BMP applications.

The lined drainage channels would convey site runoff to the sediment pond. Suitable geotextiles or organic blankets would line these channels to prevent erosion. Silt fencing would be installed along the edges of the site boundary to prevent sediment discharge.

The sediment pond size indicated on Figure 36 uses the 2-year peak runoff flow from the developed site with till soils. Silt fencing would provide a divider within the temporary sediment pond to enhance the removal of suspended sediments. Quarry spalls would stabilize the site entrance. Crushed rock would be used to stabilize construction roads on the site, and one main parking area under the 2005 scenarios (scenarios 11 and 12).

Areas of exposed soil would be treated with mulch applied extensively during staged construction. Silt fencing would be used to contain sediments on the site periphery that may be present in runoff that does not reach the drainage channels. We assumed that three catch basins on the adjacent streets would require inlet protection. Implementation of other BMPs such as vehicle tire washing and spraying of dusty areas would occur during construction as needed.

2012 Manual

The 2012 manual requires additional protection for permanent LID BMPs (SWPPP element #13). For the large commercial development, this would include protecting the infiltration trenches for outwash soils, the detention pond for till soils, and permeable pavement base for all soil types. Silt fencing and interceptor swales would protect the excavation of the infiltration trench during construction. Installation of permeable pavement would occur last, after all grading and utility construction is complete, and all disturbed areas are temporarily stabilized. Six inches of native soil (above finished subgrade elevation) would be left in place in all areas that will have permeable surfacing. Removal of 6 inches of native soil would occur immediately before installation of the base material and the permeable surfacing. The estimated additional cost for this out-of-phase construction is $10 per cubic yard to account for the additional difficulty and smaller quantity.

Costs for Construction Stormwater Pollution Prevention

The estimated TESC costs are higher for the 2012 scenario due to costs associated with protection of permeable pavement base and slightly higher CESCL costs (Table 13). The scenarios with till soils have higher estimated costs than those with outwash soils, associated with the larger sediment pond. The estimated TESC cost is lowest for Scenario 11 because the sediment pond is smallest and the pavement subgrade does not need protection during construction.

Table 13. Construction Stormwater Pollution Prevention Costs for Large Commercial Development.

Scenario No.	11	12	13	14
Development Type	Large Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Construction Stormwater Pollution Prevention	$146,000	$156,000	$203,000	$226,000

Permanent Stormwater Management

We evaluated each scenario to determine which permanent stormwater management BMPs would be required in accordance with the applicable regulatory standards, and the relevant assumptions. Figures 38 through 41 illustrate the stormwater management BMPs selected for each site and the conceptual flow path between land cover types and BMP.

Onsite Stormwater Management Measures (Minimum Requirement #5)

2005 Manual

Under the 2005 manual, onsite stormwater management on a large commercial development could use the following BMPs, as shown in Figures 42 and 43:

- **Scenario 11 – Outwash:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from lawn and landscape
  - Downspout Infiltration Trench under parking to manage roof and sidewalk runoff

- **Scenario 12 – Till:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from landscape

2012 Manual

Under the 2012 manual, onsite stormwater management on large commercial parcels and in the ROW could use the following BMPs, as shown in Figures 44 and 45:

- **Scenario 13 – Outwash:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from landscaped areas
  - Full Infiltration (BMP T5.10A) under parking to manage roof runoff
  - Permeable Pavement (BMP T5.15) to manage parking lot runoff (permeable base thickness of 0.7 feet)
- **Scenario 14 – Till:**
  - Soil Quality and Depth (BMP T5.13) to reduce runoff from landscaped areas
  - Infiltration Trench (BMP T5.15) under parking to manage roof runoff
  - Permeable Pavement (BMP T5.15) to manage parking lot runoff (permeable base thickness of 1.5 feet)

For scenarios 13 and 14, the downspouts would discharge directly onto the permeable pavement and we sized the gravel reservoir for the parking lot to meet minimum requirements #5, #6, and #7, thus eliminating the need for centralized stormwater BMPs. Both scenarios include a loading dock, which included the same pavement section as the remainder of the parking lot. In some cases a thicker pavement section, impervious hot mix asphalt, or Portland cement concrete may be required for the loading dock, which could increase the cost slightly relative to the results presented herein. Some designers may also choose to route the roof runoff directly into the permeable pavement base using perforated pipe, increasing the construction costs slightly when compared to roof downspouts that discharge onto the surface of the permeable pavement.

Runoff Treatment and Flow Control Measures (Minimum Requirements #6 and #7)

2005 Manual

Under the 2005 manual, runoff treatment and flow control at large commercial parcels and in the ROW uses the following BMPs, as shown in Figures 42 and 43:

- **Scenario 11 – Outwash:**
  - Stormwater Treatment Planter Vault for runoff treatment
  - Infiltration Trench (BMP T7.20) for flow control

- **Scenario 12 – Till:**
  - Stormwater Treatment Planter Vault for runoff treatment
  - Detention Tank for flow control

For Scenario 12, we assumed the detention tank to be perforated, and therefore there would be additional storage in the aggregate backfill surrounding the perforated detention tanks, thus reducing the size and cost of these systems. Both scenarios include infiltration.

2012 Manual

For scenarios 13 and 14, we sized permeable pavement parking areas to meet minimum requirements #5, #6, and #7, thus eliminating the need for a centralized flow control and runoff treatment facility. Scenario 14 does incur a small cost for perforated underdrain pipe to convey any overflow from within the permeable pavement base to the MS4.

Costs for Permanent Stormwater Management

Permanent stormwater management for both 2012 scenarios costs significantly less due to the use of permeable pavement for most stormwater management on the site (Table 14). Appendix B provides more detailed cost breakdowns for the permanent stormwater management costs associated with each of these scenarios.

Table 14 Permanent Stormwater Management Costs for Large Commercial Development.

Scenario No.	11	12	13	14
Development Type	Small Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Onsite Stormwater Management	$1,438,000	$1,248,000	$1,578,000	$1,963,000
Runoff Treatment and Flow Control	$ 667,000	$1,689,000	$ 0	$ 0
Total Permanent Stormwater Management Costs	$2,105,000	$2,937,000	$1,578,000	$1,963,000

Design

2005 Manual

Design effort for the 2005 manual scenarios would include design of runoff treatment, detention, and infiltration systems, including infiltration trenches to manage roof runoff. Design work would also include drainage conveyance system details and profiles. The estimated design cost for both the outwash and till scenarios is $30,000 and includes six design plan sheets:

- General notes sheet
- Drainage plan sheet

- Detention/infiltration system plan and details sheet
- Pavement section infiltration trenches for roof runoff, and runoff treatment details sheet
- Two drainage conveyance details and profiles sheets

The geotechnical evaluations for scenarios 11 and 12 include three large scale PITs and two days of field exploration (20-foot deep test pits) to evaluate infiltration rates at the flow control facilities, at a total estimated cost of $22,000 per scenario.

Scenarios 11 and 12 Design Cost: $52,000

2012 Manual

Design effort for the 2012 manual scenarios would include permeable pavement instead of the runoff treatment, detention, and infiltration systems that are included in the 2005 manual scenarios. The cost for permeable pavement analysis and design is typically slightly higher than for design of conventional (impermeable) pavement. However, there are no design costs for runoff treatment or flow control systems in these scenarios. The design of permeable pavement on outwash soil (Scenario 13) includes details and specifications for a sand treatment layer in the pavement section that are not included for the design on till soils. The design for the site with till soils (Scenario 14) includes an overflow system to prevent any excess runoff from bubbling out of the downstream edge of the pavement subbase. The treatment soil and overflow system design costs are offsetting and thus the cost for the outwash and till scenarios is estimated to be $15,000, encompassed in three design plan sheets:

- General notes sheet, including sand treatment layer specifications (outwash site only)
- Drainage plan sheet, including layout of check dams within the permeable pavement
- Drainage and pavement details sheet, including pavement sections and overflow details (till site only)

The geotechnical evaluations for scenarios 9 and 10 include five small scale PITs and 2 days of field exploration (10-foot deep test pits) to evaluate infiltration rates for the permeable pavement, at a total estimated cost of $32,000 per scenario.

Scenarios 13 and 14 Design Cost: $47,000

Comparison of Estimated Design Costs for Different Scenarios

The estimated design cost for both 2012 manual scenarios is approximately 10 percent lower than the 2005 manual scenarios because design of runoff treatment and flow control facilities and storm drains to convey site runoff to them would require more effort than design of permeable pavement (Table 15). However, the cost for geotechnical analysis to determine infiltration rates for the 2012 manual scenarios is higher. We assumed that the soil boring and other geotechnical analysis conducted to support design of the building foundation in the 2005 and 2012 manual scenarios would provide all information needed for design of the traditional pavement and pervious pavement sections. Additional geotechnical investigations are required for stormwater infiltration purposes as noted in the assumptions described above. As noted in the introduction, geotechnical borings are not included in the cost estimates for design work. Some designers working under the 2005 manual requirements may opt to determine infiltration rates based on soil characterization only, without PITs. This would reduce geotechnical investigation costs, but may also lead to higher correction factors for infiltration system design, and thus reduced design infiltration rates that increase the facility size and increase permanent stormwater management costs accordingly.

Table 15. Design Costs for Large Commercial Development.

Scenario No.	11	12	13	14
Development Type	Large Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Design	$52,000	$52,000	$47,000	$47,000

Operation and Maintenance

2005 Manual

Under the 2005 manual, the following O&M activities are required for the permanent stormwater management BMPs in the large commercial development scenarios:

- **Scenario 11 – Outwash:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Regenerative vacuum sweeping of impermeable pavement streets and parking twice per year
  - Catch basin sediment removal on a 2-year cycle
  - Stormwater treatment planter vault mulch replacement twice per year and media replacement on a 15-year cycle.
  - Infiltration trench (BMP T7.20) sediment trap cleanout on a 2-year cycle
- **Scenario 12 – Till:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Regenerative vacuum sweeping of impermeable pavement streets and parking twice per year
  - Catch basin sediment removal on a 2-year cycle

- Stormwater treatment planter vault mulch replacement twice per year and media replacement on a 15-year cycle.
- Detention tank sediment removal on a 2-year cycle

2012 Manual

Under the 2012 manual, the following O&M activities are required for the permanent stormwater management BMPs in the large commercial development scenarios:

- **Scenario 13 – Outwash:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Regenerative vacuum sweeping of permeable pavement streets and parking (BMP T5.15) twice per year
- **Scenario 14 – Till:**
  - Monthly mowing and weeding of landscaped areas to maintain soil quality and depth (BMP T5.13)
  - Catch basin sediment removal on a 2-year cycle
  - Regenerative vacuum sweeping of permeable pavement streets and parking (BMP T5.15) twice per year

Cost for Operation and Maintenance

As shown in Table 16, estimated O&M costs for the 2005 scenarios (scenarios 11 and 12) are roughly four to five times greater than those for the 2012 scenarios (scenarios 13 and 14) due to higher costs for maintaining the stormwater treatment planter boxes. Permeable pavement replaces these systems in the 2012 scenarios, and is less expensive to maintain. Appendix B provides more detailed cost breakdowns for the O&M activities associated with each of these scenarios.

Table 16. Operation and Maintenance Costs for Large Commercial Development.

Scenario No.	**7**	**8**	**9**	**10**
Development Type	Large Commercial			
Standard	2005		2012	
Soils	Outwash	Till	Outwash	Till
Operation and Maintenance (30-years)	$1,317,000	$1,707,000	$340,000	$341,000

SUMMARY OF STORMWATER SITE PLAN COSTS

Total Stormwater Control Costs

Table 17, Figure 46, and Figure 47 display a summary of the total stormwater control costs estimated for all 14 scenarios.

Single-Family Residential

The total of stormwater management costs for Scenario 3 is 20 percent higher than for Scenario 1 (costs are the same without O&M costs). The largest contributor to additional cost for Scenario 3 is O&M for permeable sidewalks and bioretention.

The total of stormwater management costs for Scenario 4 (which uses permeable pavement extensively) is 24 percent higher than for Scenario 2 (4 percent without O&M costs). Though the runoff treatment and flow control cost for Scenario 4 is half as much as for Scenario 2, the other cost components are all greater for Scenario 4 than Scenario 2. The largest contributor to additional cost for Scenario 4 is O&M for permeable sidewalks and bioretention.

The smaller lot sizes and reduced roadway width in scenarios 5 and 6 reduce the cost of stormwater management by 8 to 27 percent when compared to scenarios 1 and 2, depending on whether O&M is included.

The designs for scenarios 3 through 6 used List #2 from the 2012 Manual in order to demonstrate the LID BMP types, sizes, and costs that would result from the application of this list on residential parcels. For scenarios 4 and 6, the resultant combination of BMPs over-performs with regard to LID performance standards. Elimination of bioretention from the design would still meet the LID performance standard, and the combined detention and wetpool facility would not need to be larger. Eliminating bioretention construction and maintenance costs from scenarios 4 and 6 would reduce the estimated total cost by $285,000 and $251,000, respectively; and would result in total costs for those scenarios that are 9 percent greater and 25 percent lower relative to those estimated for Scenario 2. For scenarios 4 and 6, a thicker permeable pavement base course could also meet all stormwater requirements for the development (i.e., the LID performance standard, and requirements for runoff treatment and flow control); however, assumptions of this analysis prohibited ROW BMPs from managing private parcel runoff.

Small Commercial

The total estimated stormwater management cost for Scenario 9 is 36 percent lower than for Scenario 7 because bioretention is capable of meeting minimum requirements #5, #6, and #7 on outwash soils. In Scenario 9, elimination of the centralized treatment and flow control facilities significantly reduces the total cost for construction as well as long-term operations and maintenance.

The total estimated stormwater management cost for Scenario 10 is 20 percent lower than for Scenario 8. However, most of the cost savings is due to the reduced long term O&M cost for bioretention used in Scenario 10 relative to stormwater treatment planter vaults used in Scenario 8. Use of bioretention in Scenario 10 also reduced the amount of landscaped area relative to Scenario 8; however, landscape maintenance costs are not included in this analysis. Without O&M costs, the estimated Scenario 10 cost is 2 percent more than Scenario 8.

Large Commercial

The total estimated stormwater management cost for Scenario 13 is 40 percent lower than Scenario 11 because permeable pavement is capable of meeting minimum requirements #5, #6, and #7 on outwash soils, and the conveyance system is eliminated. The elimination of the runoff treatment and flow control components more than offsets the slightly higher permeable pavement surfacing costs and thicker pavement base course in Scenario 13. The elimination of runoff treatment and flow control also significantly reduces the total cost for long term O&M. If O&M is ignored, the estimated total cost saving is reduced to 21 percent.

The total estimated stormwater management cost for Scenario 14 is 47 percent lower than Scenario 12 because permeable pavement is capable of meeting minimum requirements #5, #6, and #7 on till soils, and most of the conveyance system is eliminated in Scenario 14. The elimination of the runoff treatment and flow control components more than offsets the slightly higher permeable pavement surfacing costs and significantly thicker pavement base course in Scenario 14. The elimination of runoff treatment and flow control BMPs also significantly reduces the total cost for long term O&M. If O&M is ignored, the estimated total cost saving is reduced to 29 percent.

Site Condition Assumptions and Design Decisions Affecting Cost

Stormwater Management in the Right of Way

Based on recommendations from the TRC, we did not size BMPs in the right of way to manage runoff from the residential parcels because jurisdictions limit use of the right of way space to management of right of way runoff. However, elimination of this restriction would allow expansion of bioretention facilities (scenarios 3 and 5) and thicker permeable pavement base course (scenarios 4 and 6) to meet minimum requirements #6 and #7 for the entire development. This would eliminate the cost for centralized stormwater management systems in all 2012 scenarios and make one more developable parcel available in scenarios 3 and 5, and three more developable parcels available in scenarios 4 and 6.

Unit Costs

We used standardized unit costs in this analysis in order to ensure consistency across the 14 scenarios. We derived the unit costs primarily through analysis of bid tabulations for relevant local projects (see Appendix C). Specifically, we selected local projects with stormwater elements (e.g., conveyance, runoff treatment, flow control, bioretention, and permeable pavement) incorporated their associated costs into this analysis. However, many factors can affect unit costs for individual sites, especially quantity of work required.

Table 17. Summary Costs for 14 Cost Analysis Scenarios.

Scenario	**Scenario No.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	Development Type	SFR Subdivision						Small Commercial				Large Commercial			
	Standard	2005		2012		2012 with LID Principles		2005		2012		2005		2012	
	Soils	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till	Outwash	Till
Component Costs	Construction Stormwater Pollution Prevention	$95,000	$104,000	$125,000	$156,000	$91,000	$111,000	$17,000	$18,000	$18,000	$19,000	$146,000	$156,000	$203,000	$226,000
	Onsite Stormwater Management	$990,000	$988,000	$1,114,000	$1,174,000	$751,000	$804,000	$64,000	$34,000	$126,000	$110,000	$1,438,000	$1,248,000	$1,578,000	$1,963,000
	Runoff Treatment and Flow Control	$170,000	$174,000	$121,000	$87,000	$124,000	$73,000	$109,000	$177,000	$0	$95,000	$667,000	$1,689,000	$0	$0
	Design	$79,000	$74,000	$126,000	$136,000	$114,000	$124,000	$29,000	$29,000	$34,000	$40,000	$52,000	$52,000	$47,000	$47,000
	Operation and Maintenance (30-years) [a]	$149,000	$306,000	$536,000	$744,000	$347,000	$523,000	$178,000	$173,000	$77,000	$82,000	$1,317,000	$1,707,000	$340,000	$341,000
Number of Parcels		42	40	43	41	43	41	NA	NA	NA	NA	NA	NA	NA	NA
Value of Land Lost [b]		$150,000	$450,000	NA	$300,000	NA	$300,000	NA	NA	NA	NA	NA	NA	NA	NA
Total Cost without O&M [c]		$1,484,000	$1,790,000	$1,486,000	$1,853,000	$1,080,000	$1,412,000	$219,000	$258,000	$178,000	$264,000	$2,303,000	$3,145,000	$1,828,000	$2,236,000
Total Cost [c]		$1,633,000	$2,096,000	$2,022,000	$2,597,000	$1,427,000	$1,935,000	$397,000	$431,000	$255,000	$346,000	$3,620,000	$4,852,000	$2,168,000	$2,577,000
Percent change relative to 2005 scenarios, without O&M				0%	4%	-27%	-21%			-19%	2%			-21%	-29%
Percent change relative to 2005 scenarios, total cost				24%	24%	-13%	-8%			-36%	-20%			-40%	-47%

Notes:

[a] Calculated as the sum of maintenance for the next 30 years assuming cost inflation would be the same as the interest rate.

[b] Residential parcel values were estimated at $150,000 per parcel based on input from the TRC. Assumes a maximum of 43 parcels developed (highest number of developable parcels for any scenario).

[c] Includes value of land lost.

The quantity of work for each item varies across the scenarios and thus the unit costs incorporated in this analysis may be slightly low for scenarios or BMPs that incorporate high quantities and high for scenarios or BMPs that incorporate low quantities.

Depth of Municipal Separate Storm Sewer System

The depth of the MS4 limited the effectiveness and feasibility of some BMPs. For this study, the MS4 was assumed to be 4 feet below ground surface based on recommendations from the TRC, which limited pond depths and the depths of infiltration facilities. This limitation makes the footprint of centralized flow control BMPs larger than it would be in cases with a deeper MS4. With a deeper MS4, the pond footprint in some of the residential scenarios may also be smaller, and thus stormwater facilities would consume less developable land, reducing the net cost of stormwater management. A deeper MS4 may also help make surface facilities cost effective at large commercial sites, though only when combined with lower land values than were assumed in this analysis.

Pavement Structural Section for Roadway

The permeable asphalt structural roadway sections assumed in this analysis were designed with a minimum of 6 inches of asphalt and 6 inches of rock base according to the WSDOT pavement policy. In order to reduce the construction costs, designers may choose to reduce the asphalt thickness and increase the base thickness, while keeping the same structural number for the pavement section. A 4-inch asphalt layer will require a 22-inch base layer to provide the same structural number on till soil with very poor drainage and moisture levels within the pavement structure that approach saturation for more than 25 percent of the time. This approach (4 inches of asphalt and 22 inches of base) reduces the cost per square foot by 1 percent relative to the cost for scenarios 4 and 6, partly because scenarios 4 and 6 require a 13-inch-thick base in order to meet flow control requirements.

The base thickness is heavily dependent on the quality of drainage and the percent of time the pavement structure will be saturated. In cases with fair drainage (water removed within one week) and saturation within the pavement structure less than 5 percent of the time, only 9 inches of base material will be required with a 4-inch asphalt layer (reduced from 22 inches as noted above) and the cost of the roadway section would be 30 percent less expensive than the section assumed in scenarios 4 and 6. In addition, the WSDOT asphalt pavement policy produces a conservative structural number and some designers may opt to reduce costs by specifying a less resilient pavement section, which would also reduce the pavement construction costs, but could affect the cost of pavement repair or rehabilitation.

Land Value

Land value assumptions for this analysis have some impact on the resultant total costs, as well as on BMP selection.

For the residential scenarios with LID Principles (scenarios 5 and 6), the analysis did not account for the value of land that was left undeveloped by the denser development. The analysis also did not discount the value of each lot due to the reduced parcel size.

For the commercial property scenarios, land was valued at $1,000,000 per acre, and underground flow control facilities included. In situations with much lower land values, surface ponds for infiltration and detention may be more cost effective.

Operation and Maintenance Costs

This analysis considers operation and maintenance costs for a 30-year life cycle. The costs for maintenance are significant for all BMP relative to the cost of construction. In scenarios 2 through 6, 9, and 10, bioretention replaces traditional lawn and landscape; however, lawn and landscape maintenance costs are not included in this analysis. This causes the relative costs of scenarios with bioretention to be high relative to scenarios without bioretention (i.e., 2005 scenarios and large commercial 2012 scenarios.

Similarly, many public and commercial property owners sweep their paved surfaces on a regular basis. If a regenerative air sweeper is used for sweeping, then permeable pavement would not require additional maintenance above and beyond typical sweeping. However, the long-term maintenance needs of pervious pavement are not fully understood. For cases where permeable pavement deteriorates and requires replacement sooner than traditional pavement or requires a periodic deep cleaning, the operations and maintenance cost would be higher than those shown in this analysis.

Considering many jurisdictions are only beginning to conduct maintenance of LID BMPs, the unit costs incorporated into this analysis should be revisited after more maintenance cost information becomes available in the region. For example the cost of cleaning porous concrete surfaces may change over time as supply and demand of these new services grow. In particular, the permeable sidewalk O&M unit cost used in this study assumes that vactor truck mounted equipment will be used to clean the sidewalk; however, less expensive maintenance methods may be developed in the future.

Stormwater Requirements and Resultant BMPs Having Greatest Cost Impact

2005 Manual

Construction Stormwater Pollution Prevention

For the 2005 manual scenarios, the most costly TESC BMPs relate to stabilizing and maintaining the site, including establishing a stabilized construction entrance and construction road, as well as temporary stabilization of the site with mulching and seeding during construction. Other large component costs include requirements to have a CESCL onsite, stockpile extra materials onsite, and perform regular maintenance on TESC BMPs.

Permanent Stormwater Management Facilities

For all 2005 manual scenarios, the most expensive BMPs are the centralized stormwater management BMPs:

- Wet ponds
- Stormwater treatment planter vaults
- Infiltration basins
- Combined detention and wet pool facilities
- Infiltration trenches
- Infiltration tanks

The cost of developable land lost to centralized facilities is significant in comparison to any other individual BMP on the residential scenarios.

Design

For all 2005 manual scenarios, the most expensive design elements are sizing and providing plans and details for the centralized stormwater management facilities.

Operations and Maintenance

The O&M costs for lawn and landscape soil quality were not included in this analysis, but have the potential to exceed other stormwater BMP O&M costs for all 2005 manual scenarios. The residential scenarios in particular would have much higher O&M costs if lawn and landscape O&M were included; scenarios 1 and 2 would include over 4.5 acres of lawn and landscape O&M. The costs for maintenance of the stormwater treatment planter vaults and pavement are major O&M costs for the commercial scenarios.

2012 Manual with and without LID Principles

Construction Stormwater Pollution Prevention

For most 2012 manual scenarios, the most costly TESC BMPs are the same as with the 2005 manual scenarios. All 2012 scenarios include additional costs for phased excavation to protect the subgrade below LID BMPs and some additional straw wattles and construction entrances used to protect permeable pavement in the residential scenarios. The phased excavation is a significant TESC cost for scenarios 13 and 14, making up about 25 percent of the total estimated TESC costs for those scenarios.

Permanent Stormwater Management Facilities

Scenarios 3 through 6 all have significant costs for centralized runoff treatment and flow control facilities. If the right of way were available for management of stormwater from private parcels, then the cost of centralized stormwater management could be reduced or eliminated. The cost of developable land lost to centralized facilities is significant in comparison to any other individual BMP on the residential scenarios.

For Scenario 9, bioretention is the most significant cost for permanent stormwater management because it is sized to meet minimum requirements #5, #6, and #7. For

Scenario 10, the estimated bioretention cost is nearly as high, but a detention tank is still required to meet Minimum Requirement #7.

For the large commercial scenarios, the primary stormwater management cost is permeable pavement, which is sized to meet minimum requirements #5, #6, and #7.

Design

For scenarios 3, 5, 9, and 10, the cost of bioretention adds a significant component to the design costs. In addition, the 2012 scenarios incur higher geotechnical investigation costs for more detailed evaluation of infiltration potential and soil characteristics over a wider area of the site. Scenarios 13 and 14 have significant saving in design effort and cost because centralized facility design is not required.

Operations and Maintenance

The O&M costs for lawn and landscape soil quality were not included in this analysis, but have the potential to exceed other stormwater BMP O&M costs for all 2012 manual scenarios. The residential scenarios in particular would have much higher O&M costs if lawn and landscape O&M were included; scenarios 3 and 4 would include over 4.5 acres of lawn and landscape O&M and scenarios 5 and 6 would include over 2.5 acres of lawn and landscape O&M. Pervious sidewalk maintenance is also a significant cost element for the 2012 residential scenarios. The O&M costs for bioretention is a major cost element for the small commercial scenarios. Permeable pavement O&M costs are significant for the large commercial scenarios.

Development Examples for Future Analysis

Though we have only evaluated 14 scenarios, this analysis has shown that LID BMPs have the potential to reduce the size of centralized runoff treatment and flow control facilities, or potentially eliminate the need for centralized facilities. Below we describe several common development types that could be considered for future analysis. LID BMPs may have a similar cost effect in these development types; however, the BMPs triggered in other scenarios will vary, and LID BMP feasibility may be more limited in other scenarios.

Parcel Redevelopment

Stormwater management approaches at redevelopment sites may vary from the approaches included in this analysis. In cases where the redevelopment only triggers minimum requirements #1 through #5 (e.g., projects with 2,000 to 4,999 square feet of new hard surface, projects with greater than 5,000 square feet of replaced hard surface and less than 50 percent increase in value of site improvements [e.g., buildings]), onsite stormwater management BMPs would be the only permanent stormwater BMPs required. Under the 2005 manual, the BMP options would be the same as for new development. Under the 2012 manual, the BMPs would either be selected from List #1 (instead of List #2) or need to meet the LID performance standard. In cases where the redevelopment triggers all minimum requirements (e.g., greater than 5,000 square feet of new hard surface, greater than 50 percent increase in value of site improvements [e.g., buildings]), the permanent stormwater management BMPs may be the same as those incorporated in this analysis. In redevelopment scenarios, site features such as soil compaction, fill, existing hard surface, and existing utilities may affect BMP selection or increase the cost of BMP construction.

Ultra-Urban Parcel Redevelopment

Stormwater management approaches at ultra-urban redevelopment sites may vary significantly from the approaches included in this analysis. Different BMPs, such as green roofs and cisterns may be selected for management of roof runoff, and would be a significant cost element in scenarios where the building footprint occupies a large percentage of the parcel. LID BMPs may also take a different form, such as bioretention planters with vertical sidewalls and decorative pervious surfacing as a hardscape design element.

Transportation

Scenarios 1 through 6 of this analysis incorporate stormwater management BMPs for residential streets; however, this study does not address road widening or development of new arterial roads and highways. Transportation projects generally require stormwater BMPs that fit the linear nature of the projects. For road widening, the extent of stormwater management will be affected by the intensity of development surrounding the existing road. Roads that are widened into existing pervious surfaces may trigger runoff treatment and flow control, while roads that are widened into existing hard surfaces may only trigger runoff treatment. In both cases, onsite stormwater management would be triggered. Under the 2005 manual there are very little onsite stormwater management requirements, while under the 2012 manual, LID feasibility must be considered. In some cases, the type of road or the nature of surrounding development may make LID BMPs infeasible.

Comparisons of Costs with the Former Minimum Requirements

Table 18 compares the estimated costs of stormwater management from this analysis with the results of previous analyses related to the 1992 and 2001 manual requirements. Comparison between analyses is complicated due to the incorporation of LID BMPs and inclusion of some non-stormwater elements, such as surfacing, into the analysis presented in this report. In addition, the previous analyses present annual maintenance costs, while this analysis presents present value of O&M costs assuming a 30-year life cycle (much higher O&M cost). Therefore, Table 18 presents costs from this analysis without O&M included in order to make the comparison more reasonable. For the 2005 and 2012 scenarios, we also subtracted the costs for traditional pavement from the cost totals to yield costs that are more comparable to the previous analyses.

Table 18. Comparison of Stormwater Management Costs with Previous Analyses.

	Total Stormwater Management Costs		
	10-acre Residential	1-acre Commercial	10-acre Commercial
1992, Outwash[a]	$448,000	$134,000	$ 544,000
1992, Till[a]	$343,000	$ 66,000	$ 416,000
2001, Outwash[a]	$384,000	$448,000	$ 512,000
2001, Till[a]	$368,000	$913,000	$ 785,000
2005, Outwash[b]	$342,000 [c]	$149,000 [d]	$ 957,000 [e]
2005, Till[b]	$348,000 [c]	$188,000 [d]	$1,800,000 [e]
2012, Outwash[b]	$494,000 [c]	$108,000 [d]	$ 482,000 [e]
2012, Till[b]	$561,000 [c]	$194,000 [d]	$ 890,000 [e]

[a] Cost escalated from previous analyses assuming 4 percent per year inflation.

[b] Operation and maintenance costs not included.

[c] $992,368 subtracted from costs in Table 17 to remove the costs for traditional pavement (road, driveway aprons, sidewalk), conveyance, and soil quality and depth, which were not included in the previous analyses.

[d] $70,226 subtracted from costs in Table 17 to remove the costs for landscaping and conveyance, which were not included in the previous analyses.

[e] $1,345,838 subtracted from costs in Table 17 to remove the costs for traditional pavement, landscaping, and conveyance.

Single-Family Residential

We subtracted the cost for traditional pavement (road, driveway aprons, and sidewalk), conveyance, soil quality and depth, and costs for lost land value from the 2005 and 2012 scenarios, because these costs were not included in the previous analyses. The resulting cost estimates for the 2005 scenarios are similar to the results from the 1992 and 2001 analyses. The costs for the 2012 scenarios are significantly higher than under the previous analyses due to the addition of LID BMPs and because the benefits of increased developable parcels that result from LID implementation are not incorporated into the comparison.

Small Commercial

For the small commercial development example, the cost of stormwater management per the 2005 and 2012 manuals is lower than with the 2001 manual. Several factors contribute to the lower cost estimates:

- We assumed a higher infiltration rate for the outwash scenarios (3.6 inches per hour in this analysis vs. 1 inch per hour for the 1992 and 2001 analyses).
- We assumed an infiltration rate of 0.18 inches per hour for centralized detention facilities in this analysis while no infiltration was assumed for till scenarios in the 1992 and 2001 analyses.
- The cost estimate for this analysis includes no contingency. A contingency of 25 percent of the construction subtotal was used in the 2001 analysis.

- Design costs were estimated to be lower for this analysis based on an estimate of the specific design needs for the project. Estimated engineering and permitting fees are 30 percent of the total construction cost for the 2001 analysis.

Large Commercial

The estimated costs of the 2005 scenarios are significantly higher than the estimated costs for all other scenarios because the limited MS4 depth that we assumed, coupled with assumed land value, required the use of stormwater treatment planter vaults and underground flow control facilities, while the 2001 and 1992 scenarios both assumed only ponds for stormwater management. However, if the 2001 and 1992 analysis had accounted for the reduction in developable land that resulted from surface stormwater facilities, the net cost for stormwater management would have been significantly higher in those analyses. The costs for the 2012 scenarios are comparable to the costs from the previous analyses because use of permeable pavement meets minimum requirements #5, #6, and #7.

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FIGURES

Gross Lot Area:	10 acres 435,600 sf
Public streets/ROW area:	92,617 sf
Net Developable Area:	336,574 sf
Net Developable Acreage:	7.73
Allowed Density per zoning:	5.73 DU/acre
Maximum Density:	44 units
Lot Area Range:	6,924 sf to 11,300 sf
ROW Width:	50 ft

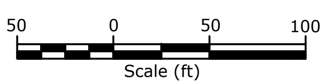


Figure 1. Scenario 1 to 4. Single-Family Residential Development Plan without LID Principles

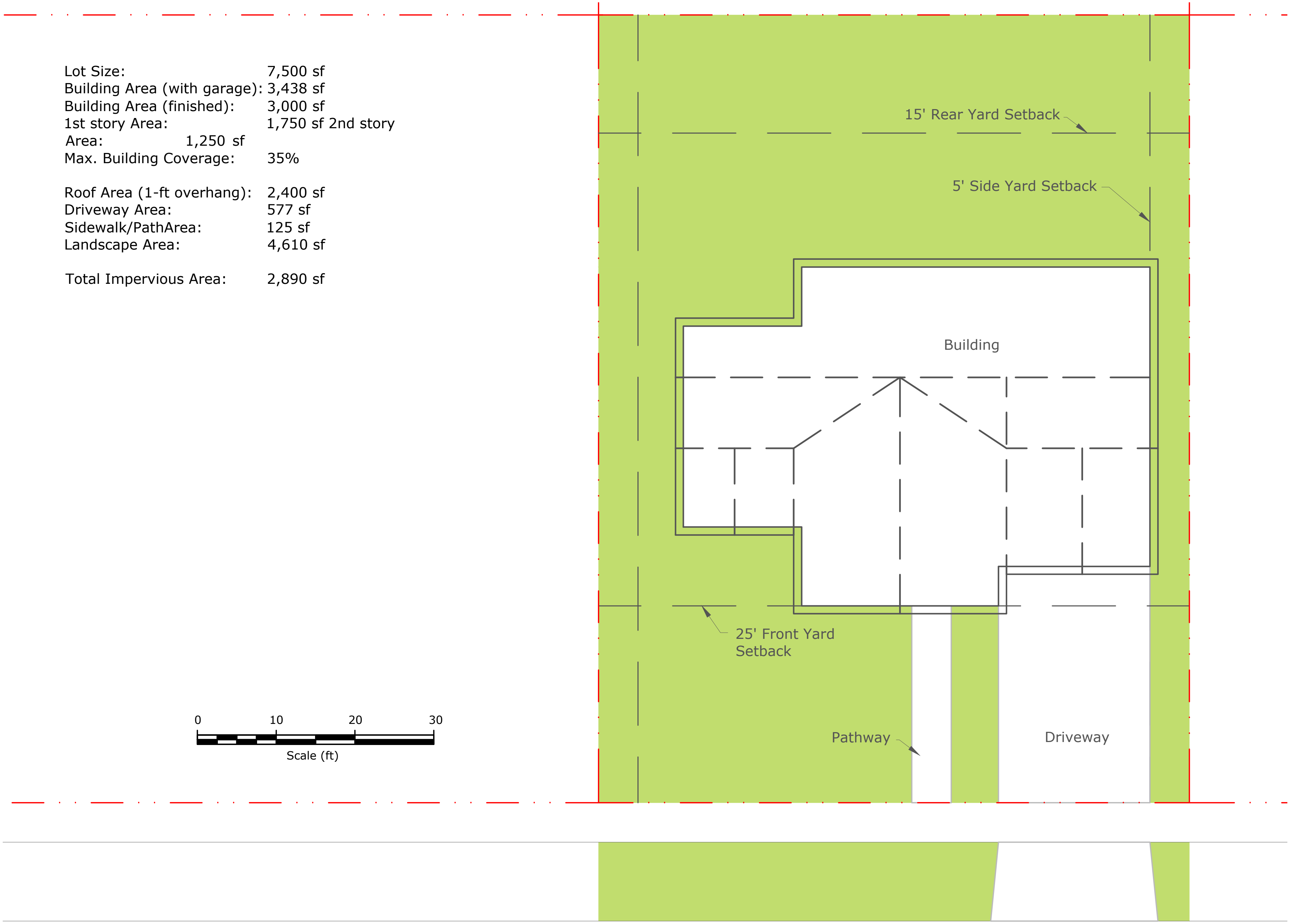


Figure 2. Scenario 1 to 4. Typical Single-Family Residential Parcel Plan without LID Principles

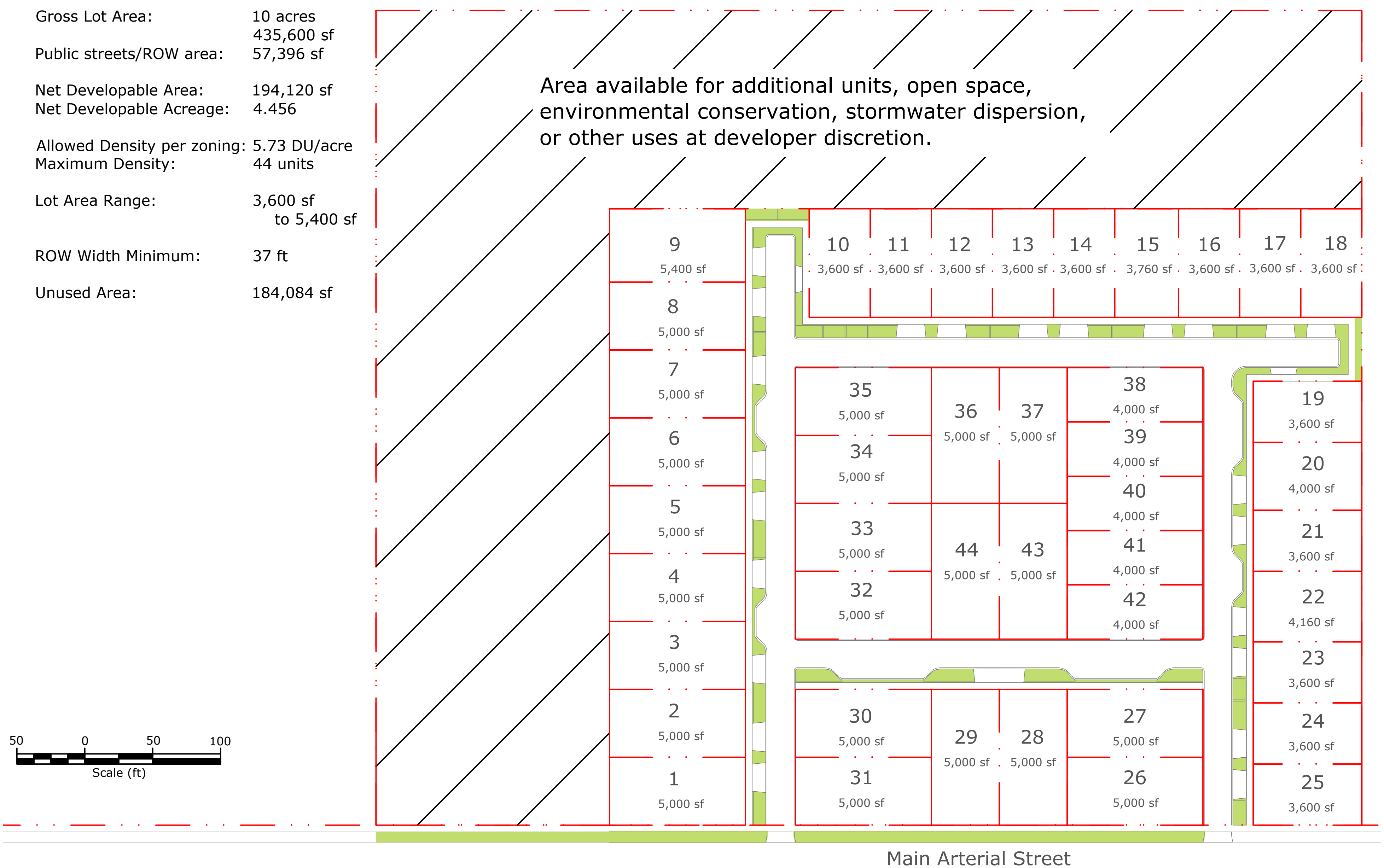


Figure 3. Scenario 5 and 6. Single-Family Residential Development Plan with LID Principles

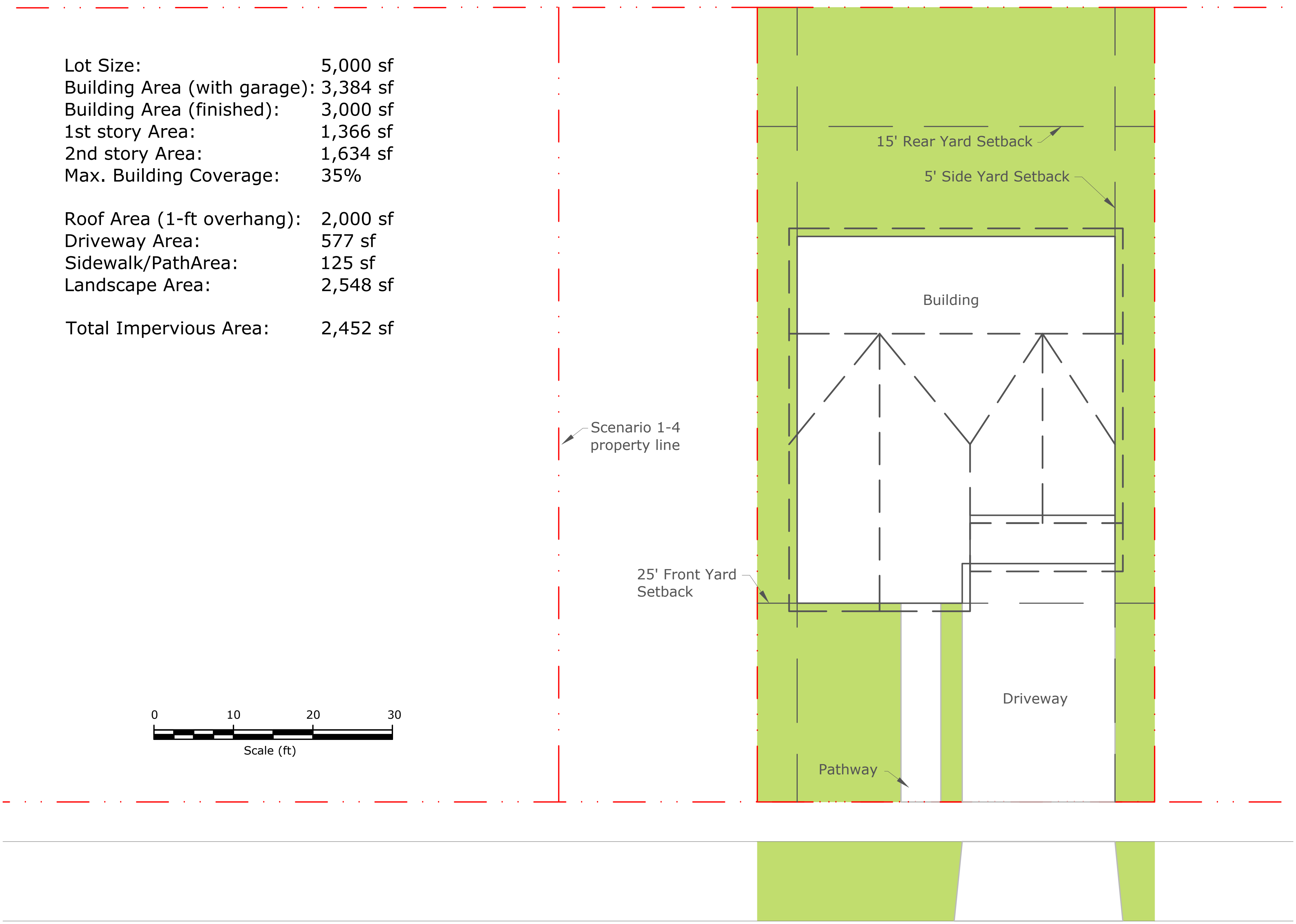


Figure 4. Scenario 5 and 6. Typical Single-Family Residential Parcel Plan with LID Principles

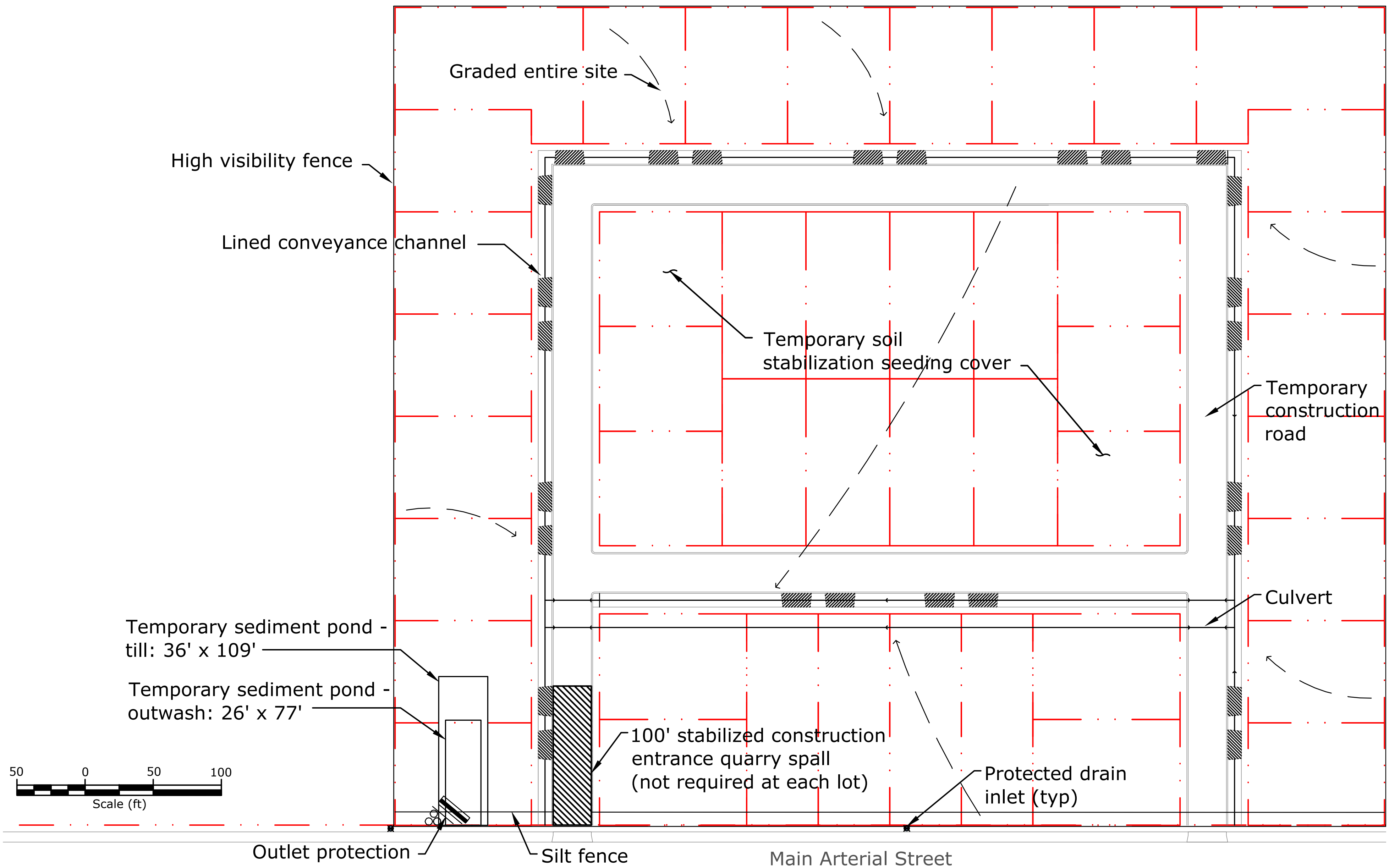


Figure 5. Scenario 1 and 2. Temporary Erosion and Sediment Control Plan - Single-Family Residential Development, 2005 Requirements

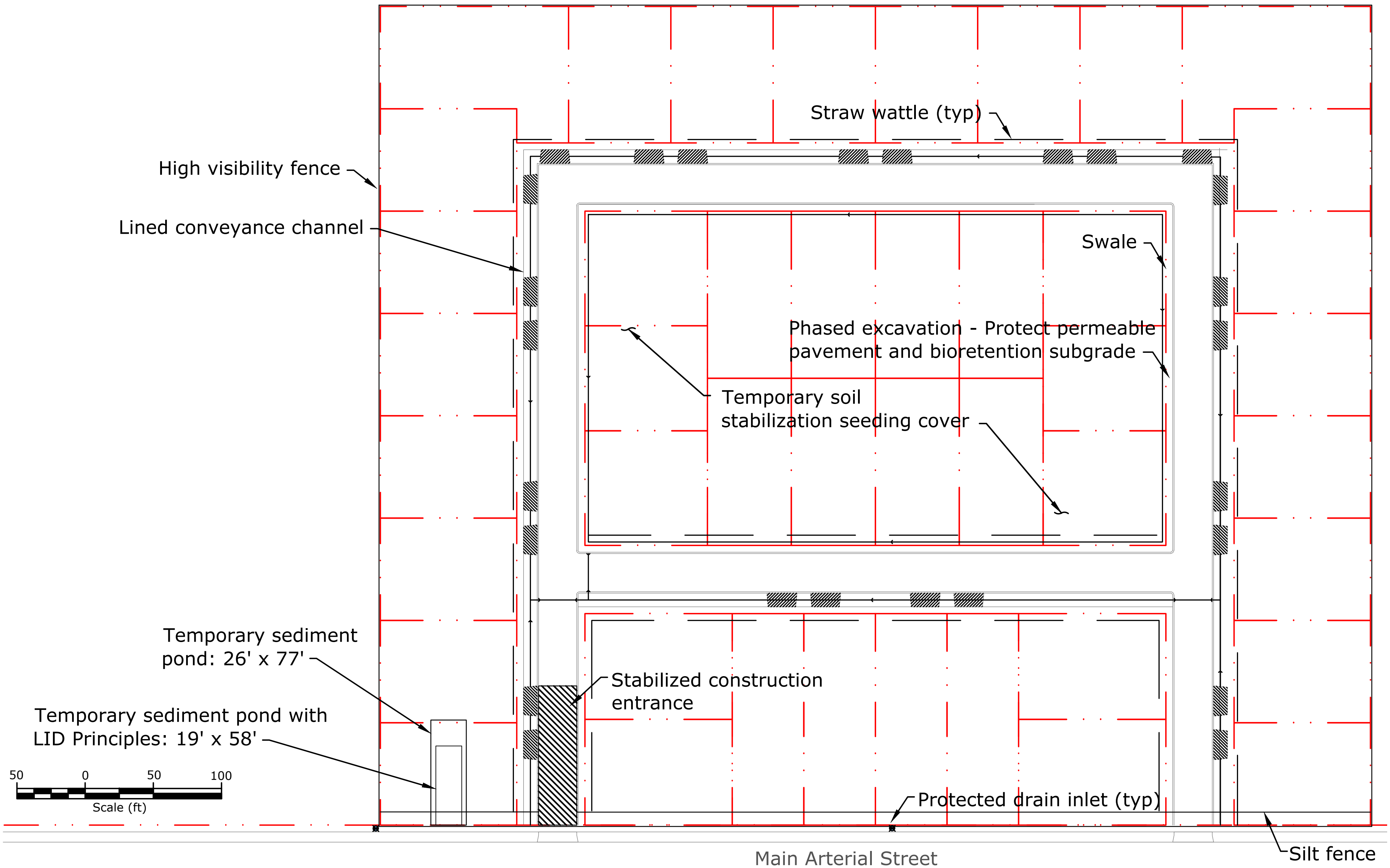


Figure 6. Scenario 3 and 5. Temporary Erosion and Sediment Control Plan - Single-Family Residential Development, 2012 Requirements, Outwash

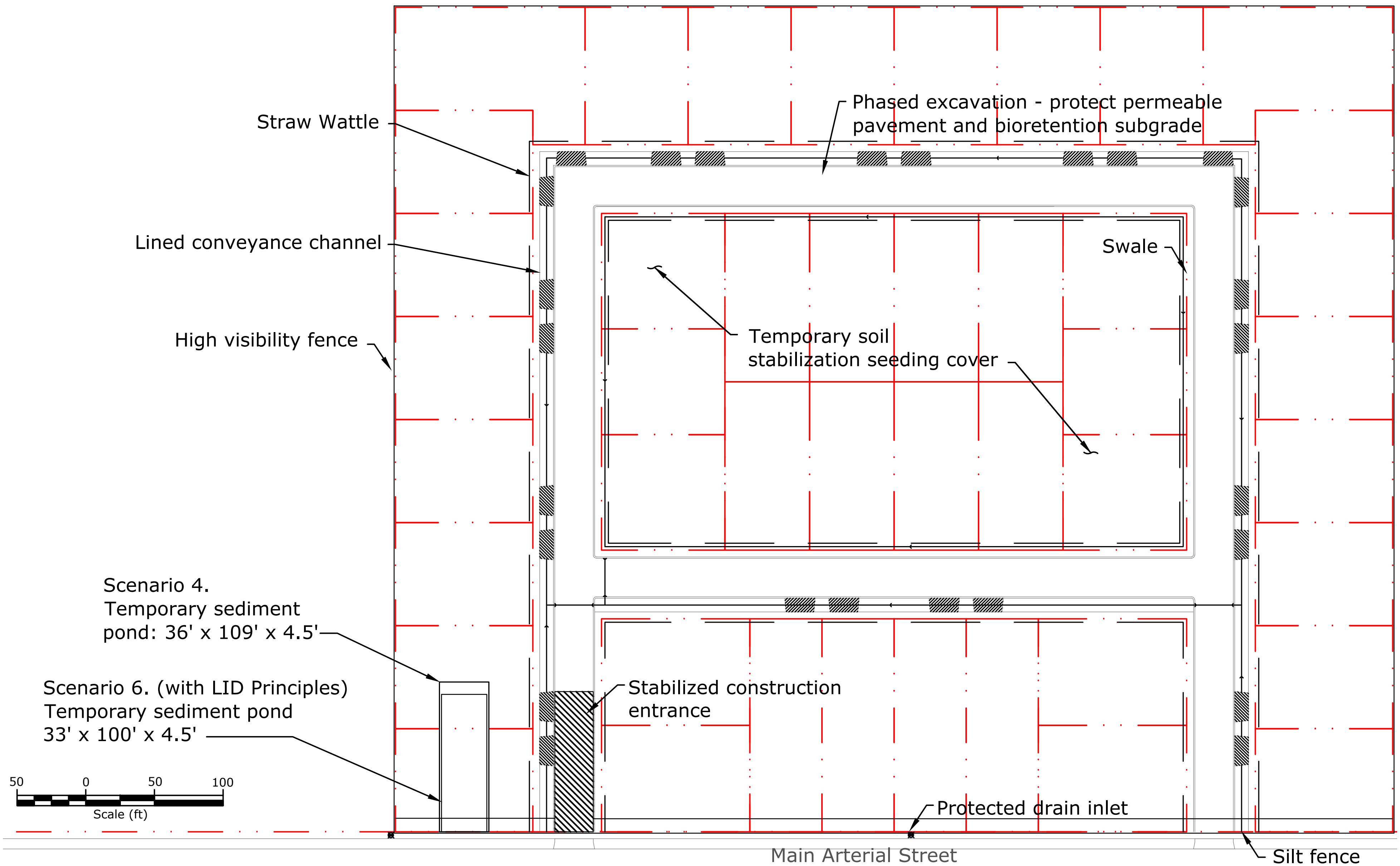


Figure 7. Scenario 4 and 6. Temporary Erosion and Sediment Control Plan - Single-Family Residential Development, 2012 Requirements, Till

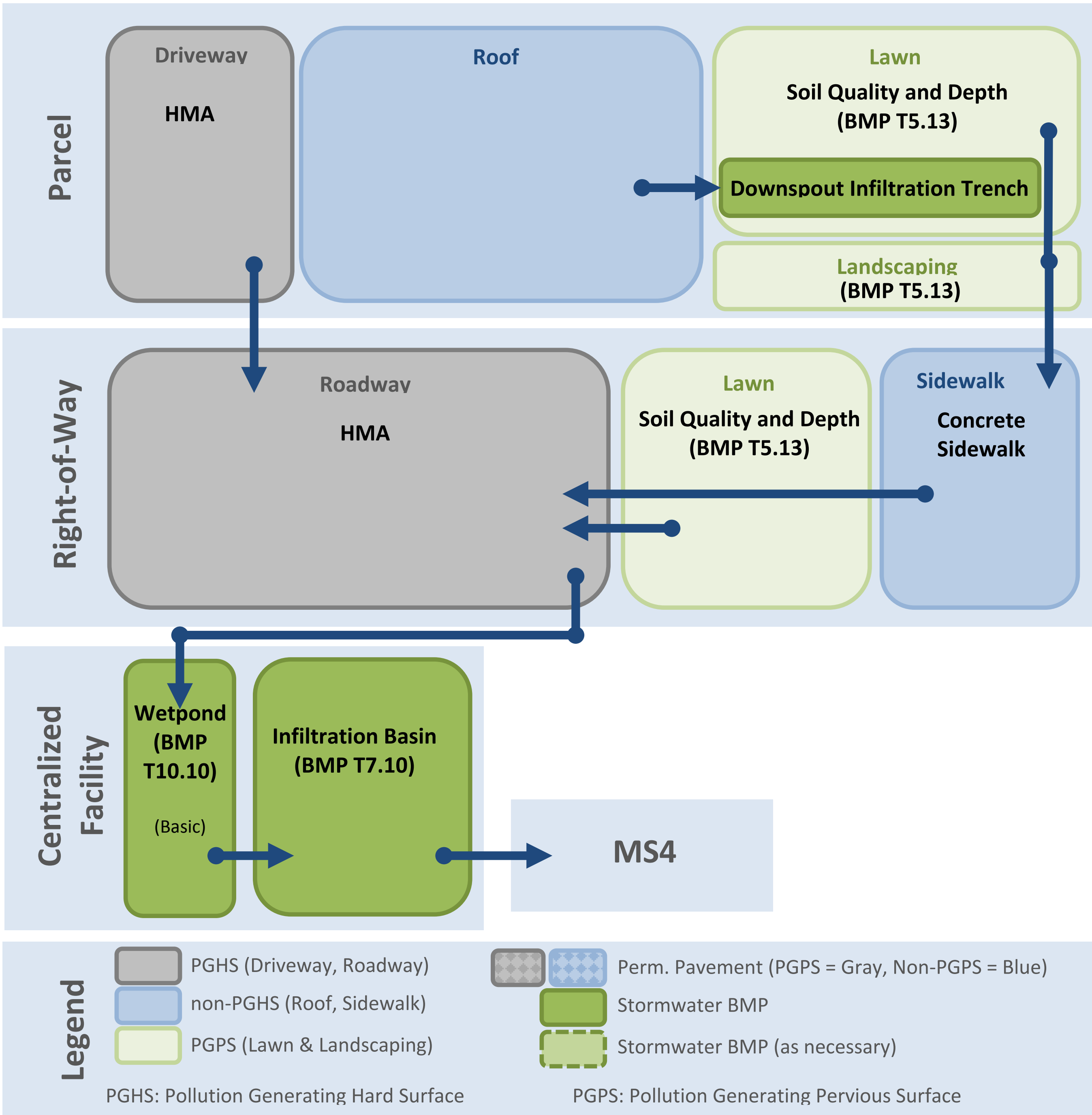


Figure 8. Scenario 1. Permanent Stormwater Management BMPs, Single-Family Residential Development, 2005, Outwash

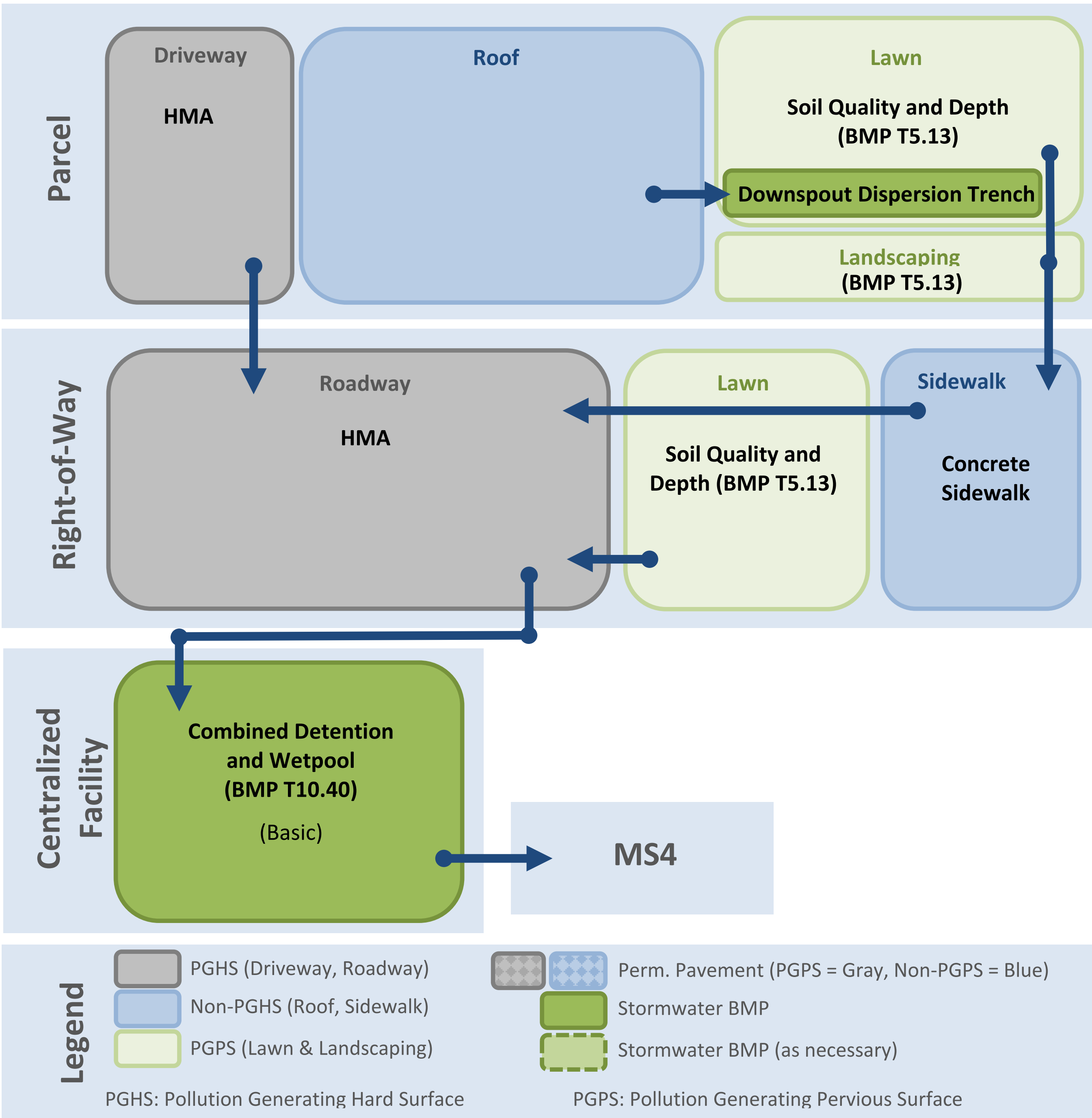


Figure 9. Scenario 2. Permanent Stormwater Management BMPs, Single-Family Residential Development, 2005, Till

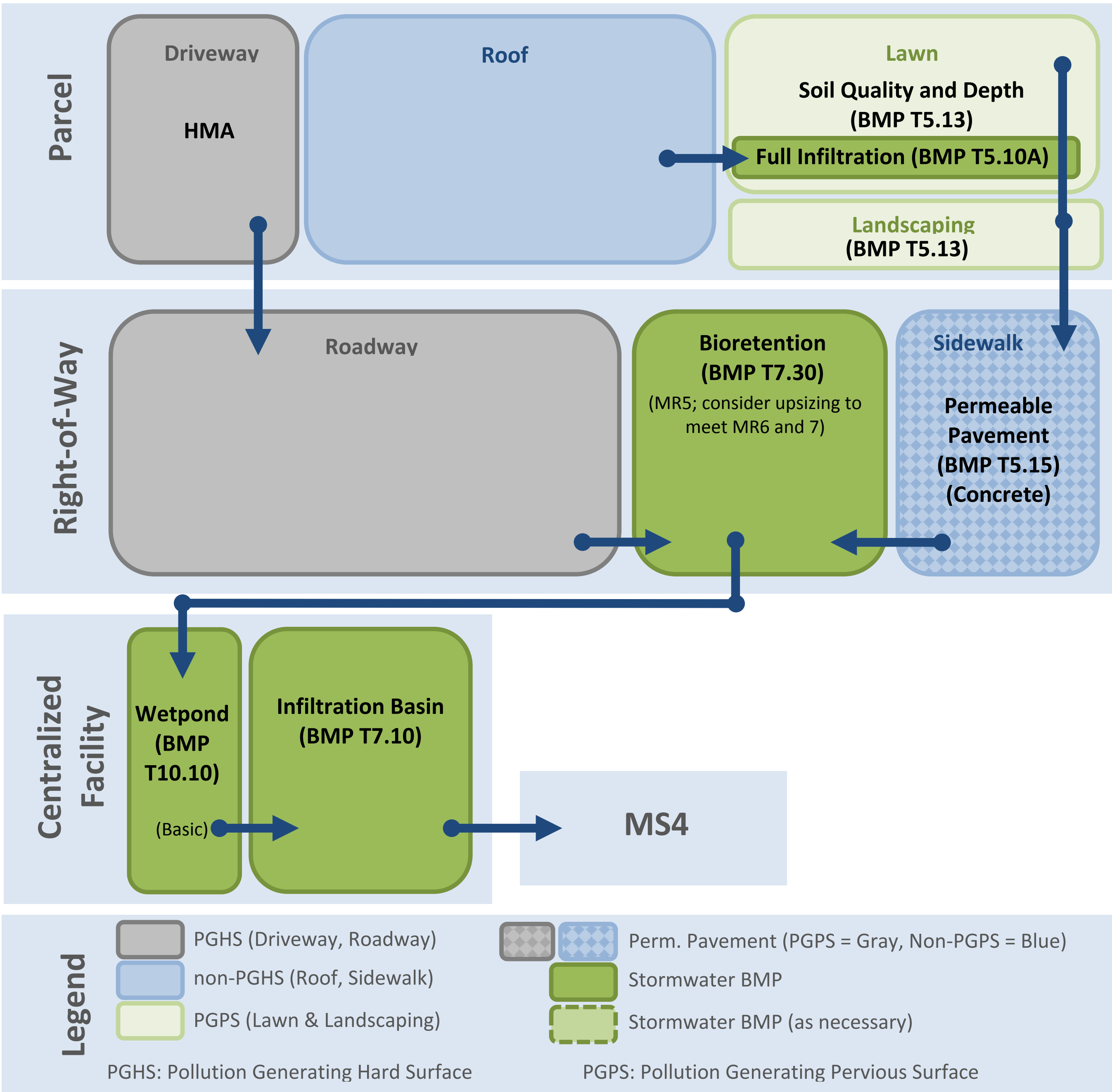


Figure 10. Scenario 3 and 5. Permanent Stormwater Management BMPs, Single-Family Residential Development, 2012, Outwash

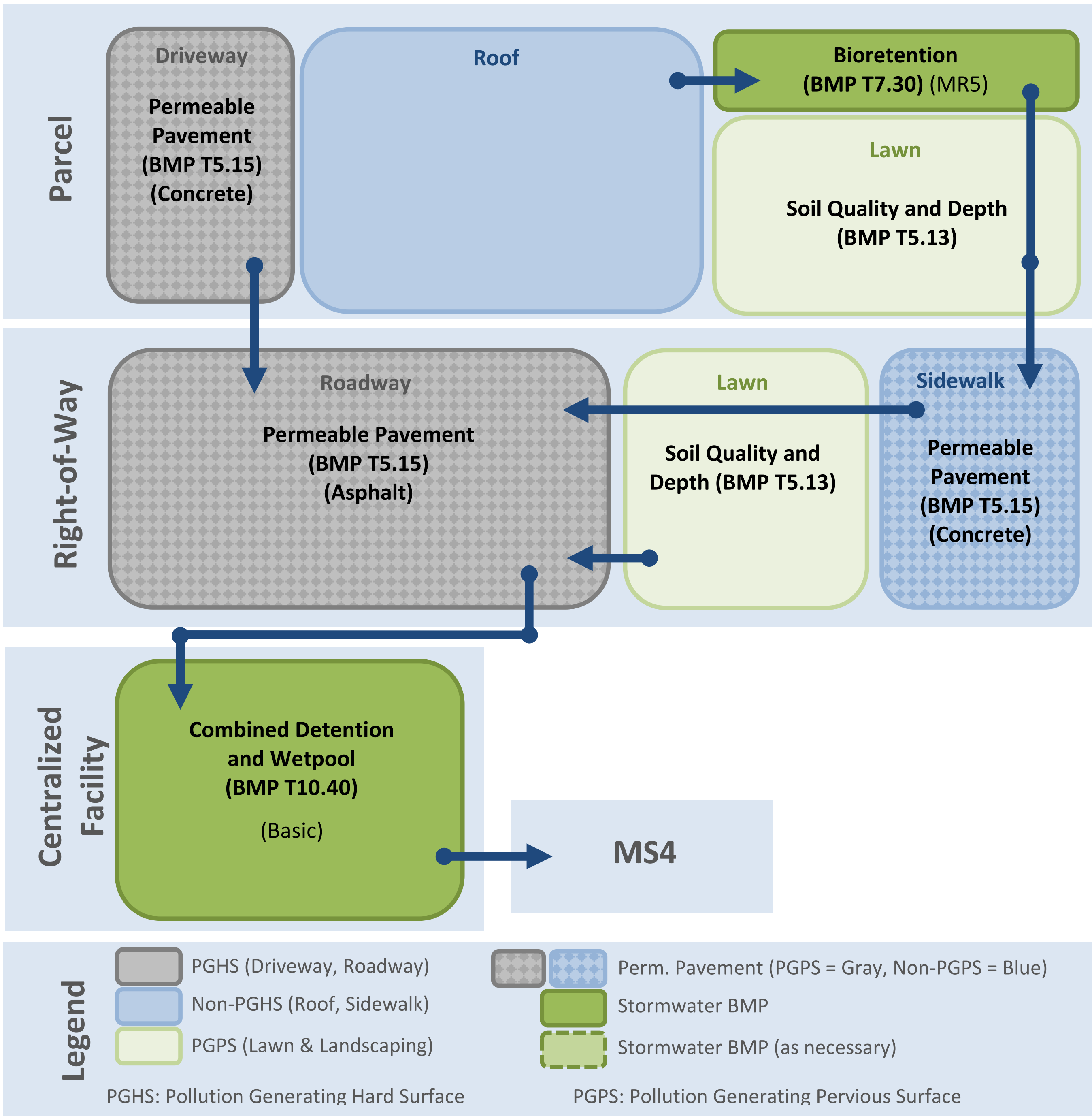


Figure 11. Scenario 4 and 6. Permanent Stormwater Management BMPs, Single-Family Residential Development, 2012, Till

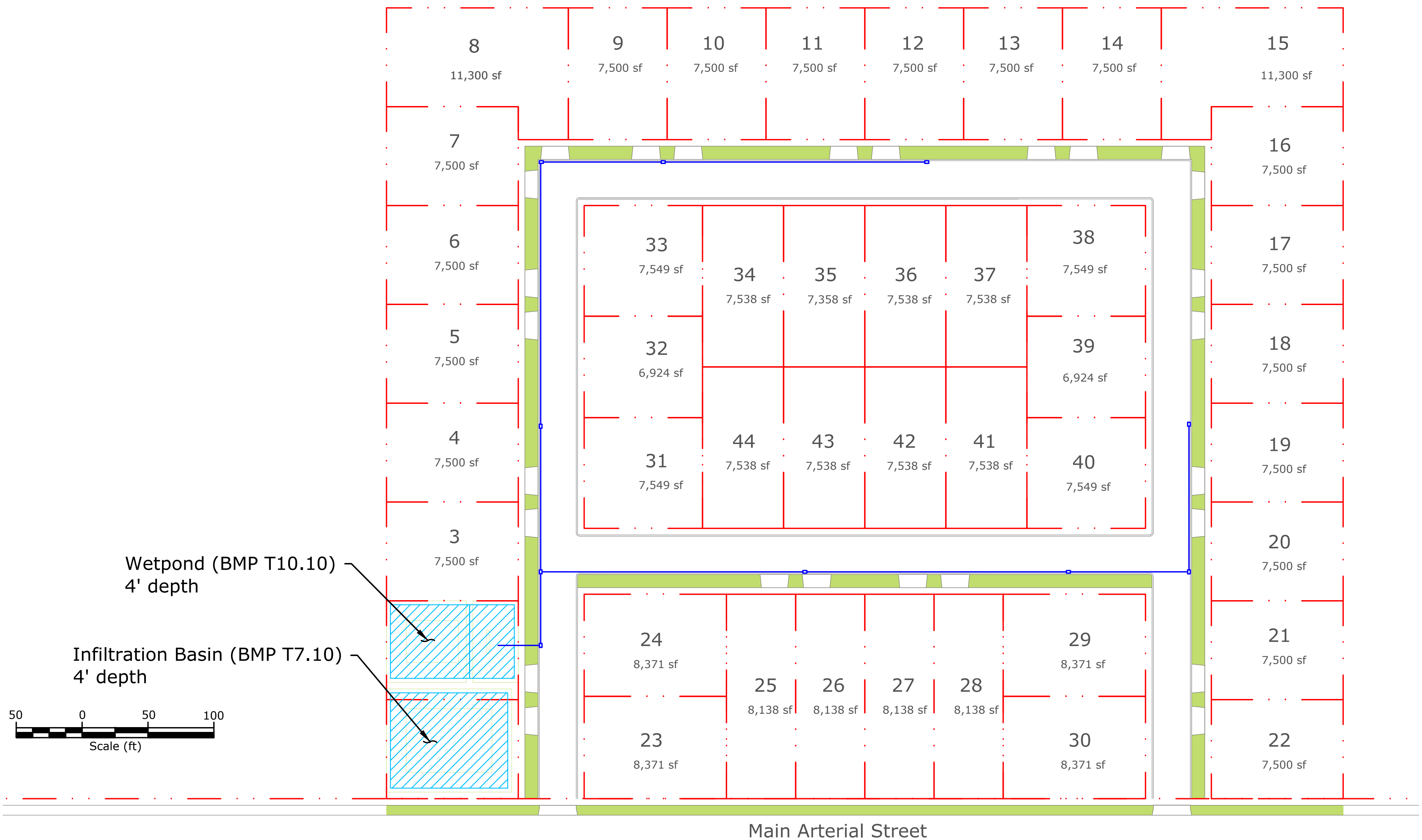


Figure 12. Scenario 1. Permanent Stormwater Site Plan – Typical Single-Family Residential Development, 2005 Requirements, Outwash Soils

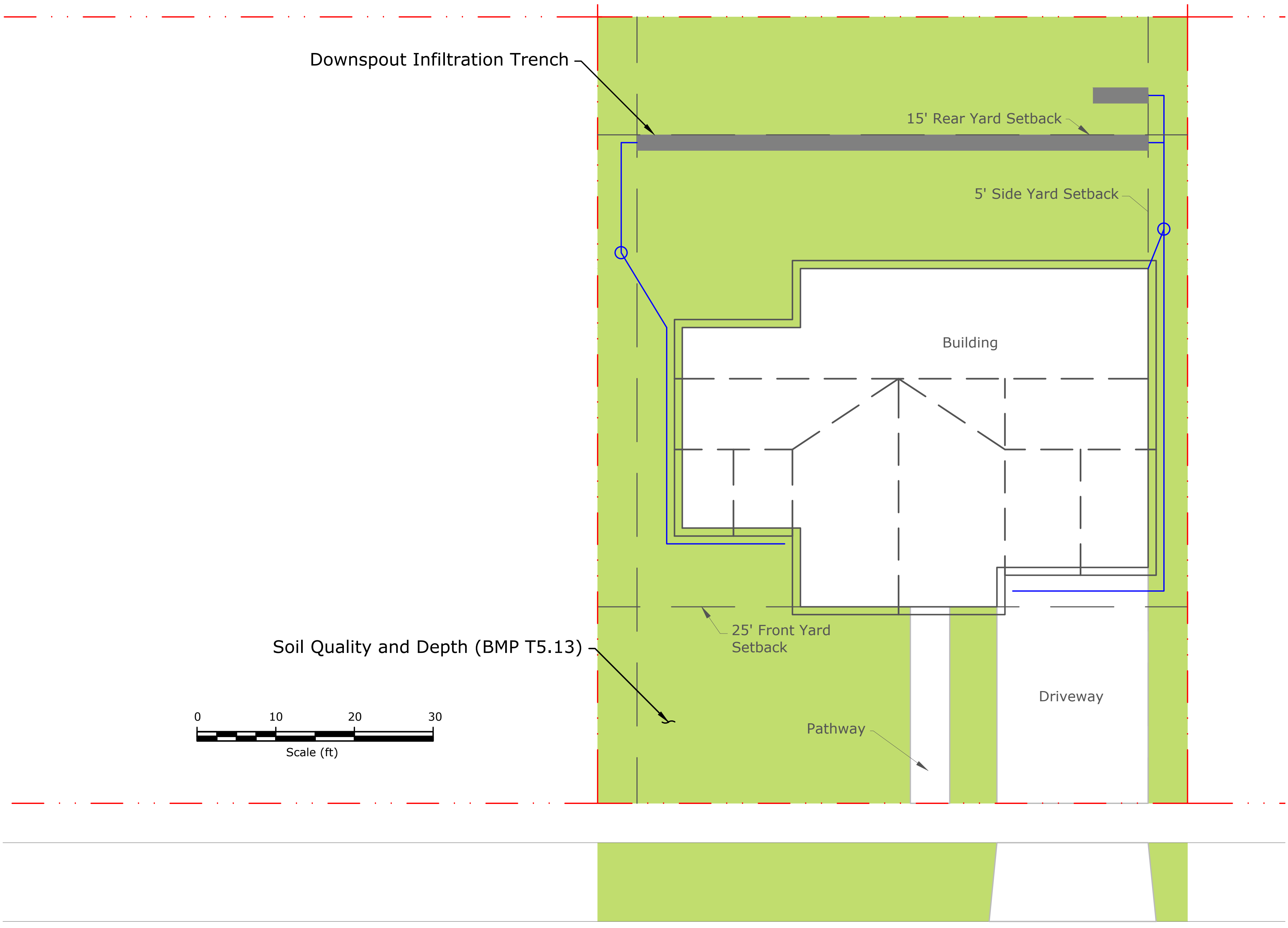


Figure 13. Scenario 1. Permanent Stormwater Site Plan – Typical Single-Family Residential Parcel, 2005 Requirements, Outwash Soils

Figure 14. Scenario 2. Permanent Stormwater Site Plan – Typical Single-Family Residential Development, 2005 Requirements, Till Soils

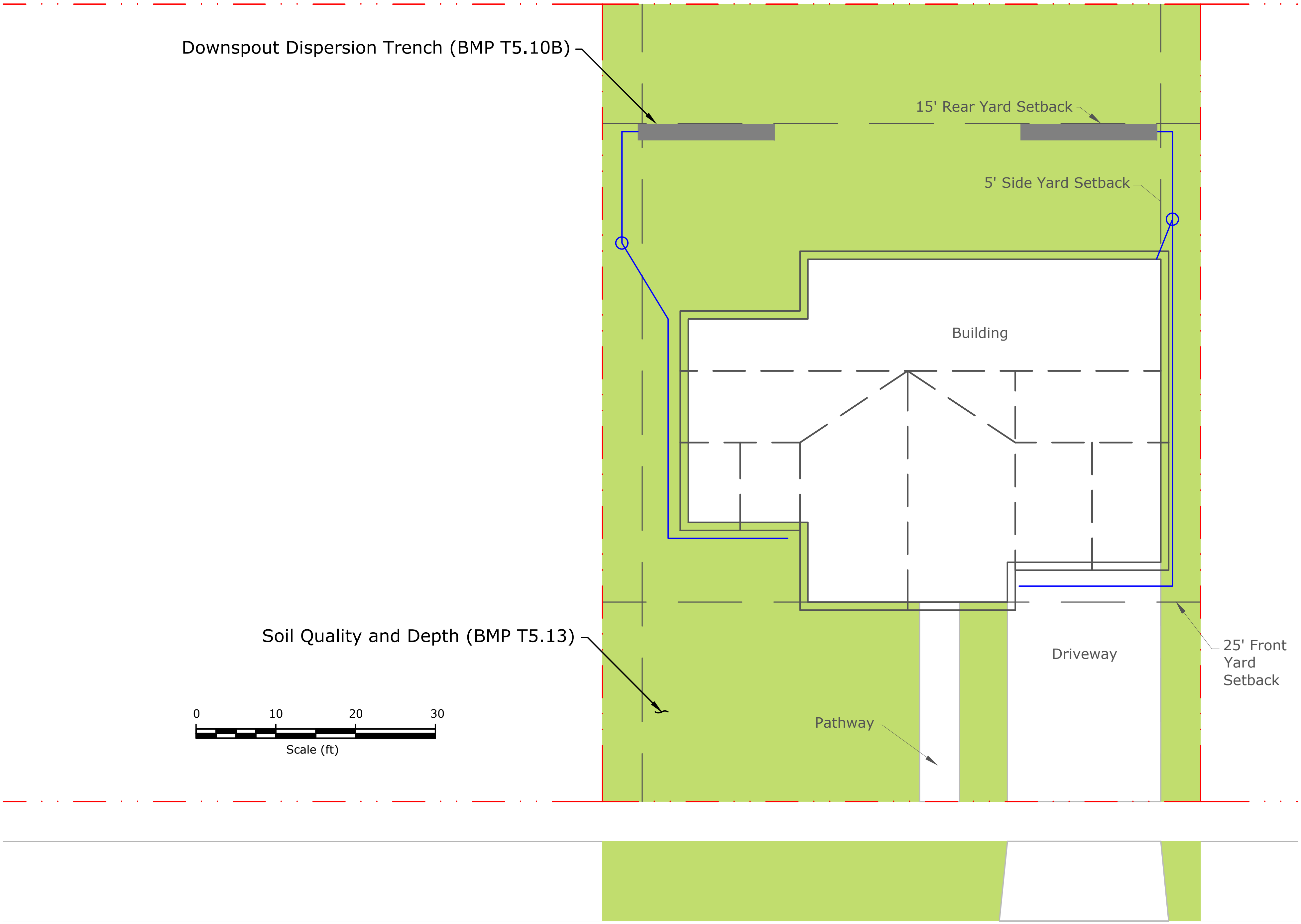


Figure 15. Scenario 2. Permanent Stormwater Site Plan - Single-Family Residential Parcel, 2005 Requirements, Till Soils

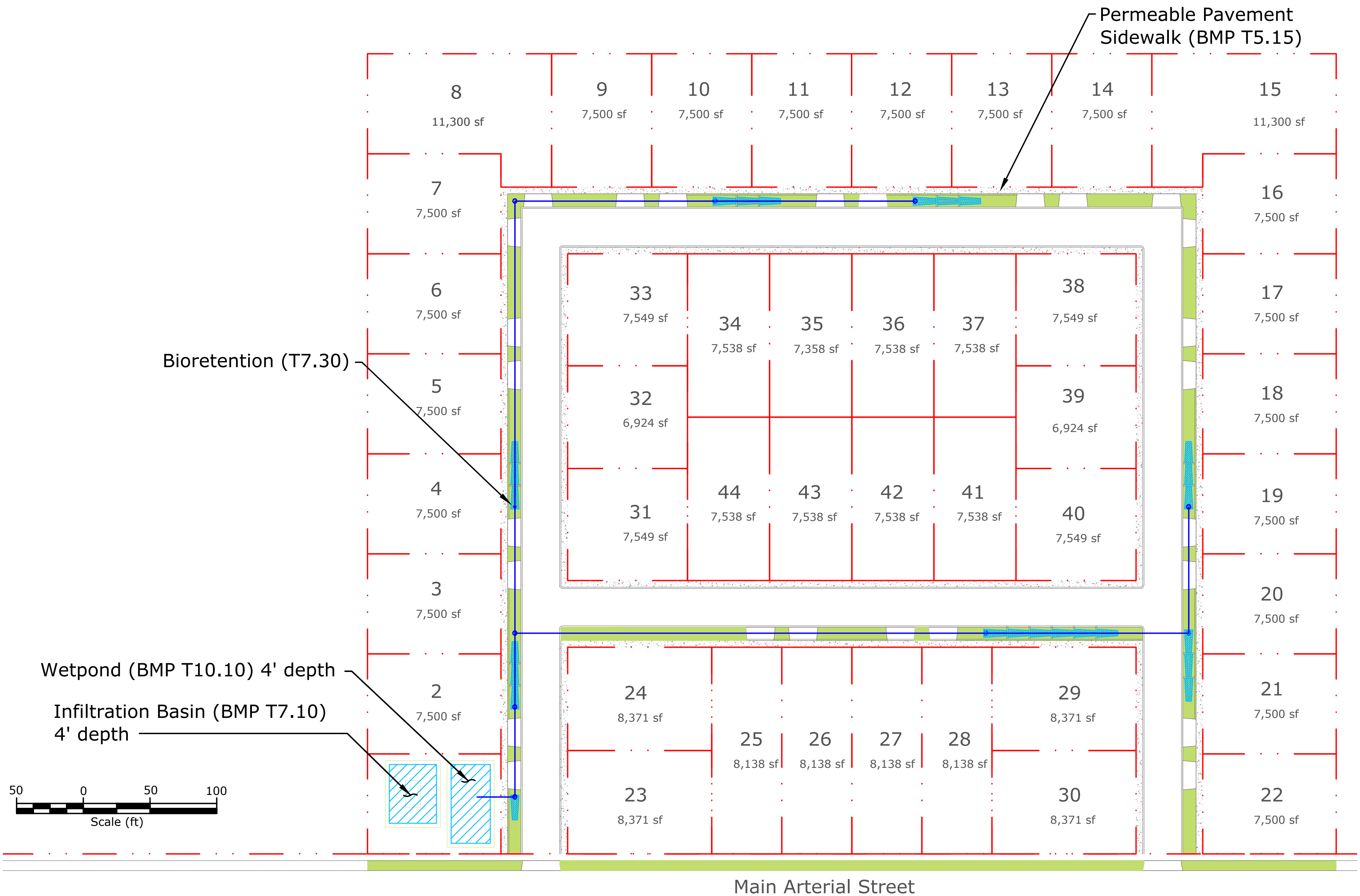


Figure 16. Scenario 3. Permanent Stormwater Site Plan - Typical Single-Family Residential Development, 2012 Requirements, Outwash Soils

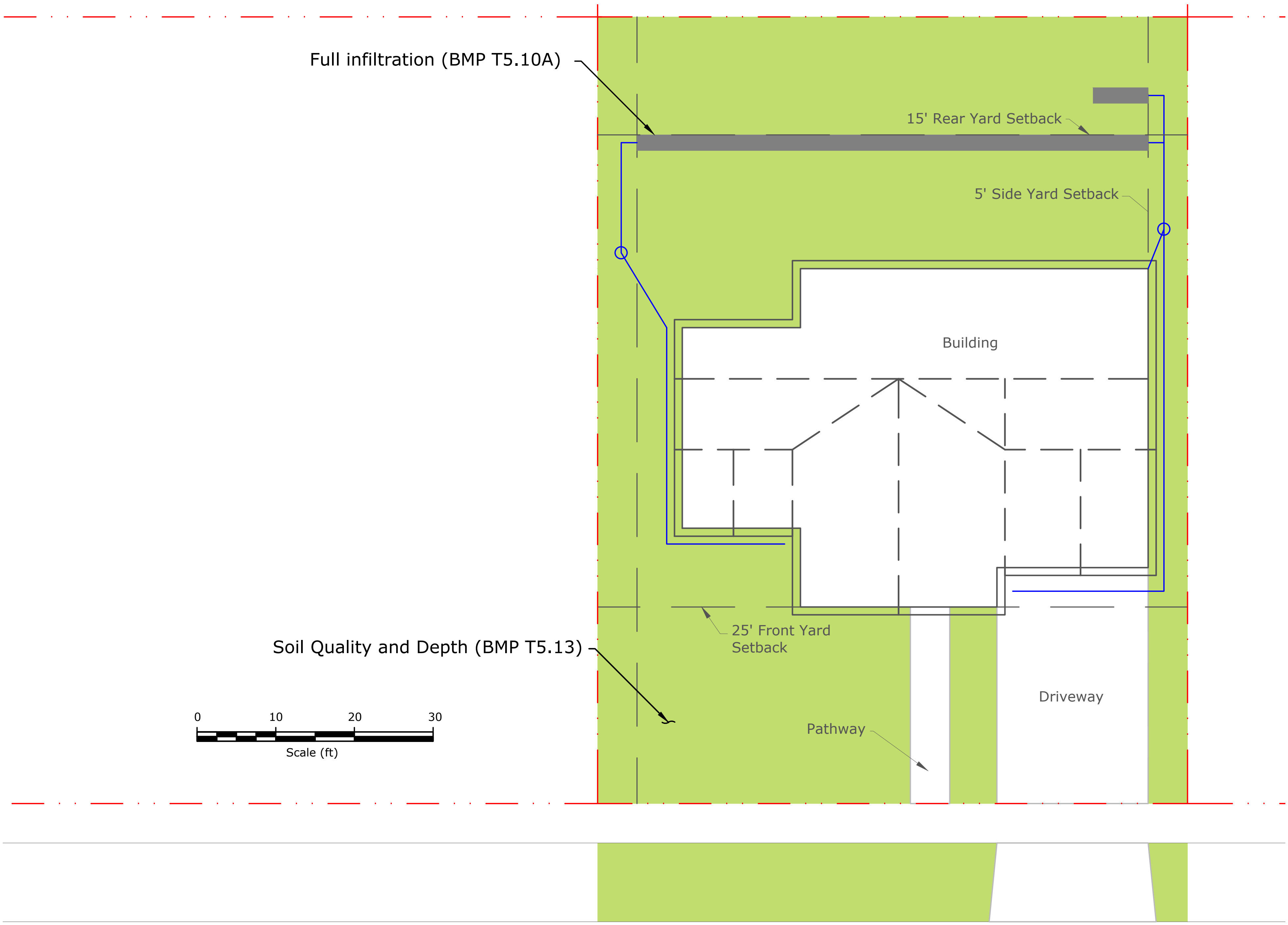


Figure 17. Scenario 3. Permanent Stormwater Site Plan - Typical Single-Family Residential Parcel, 2012 Requirements, Outwash Soils

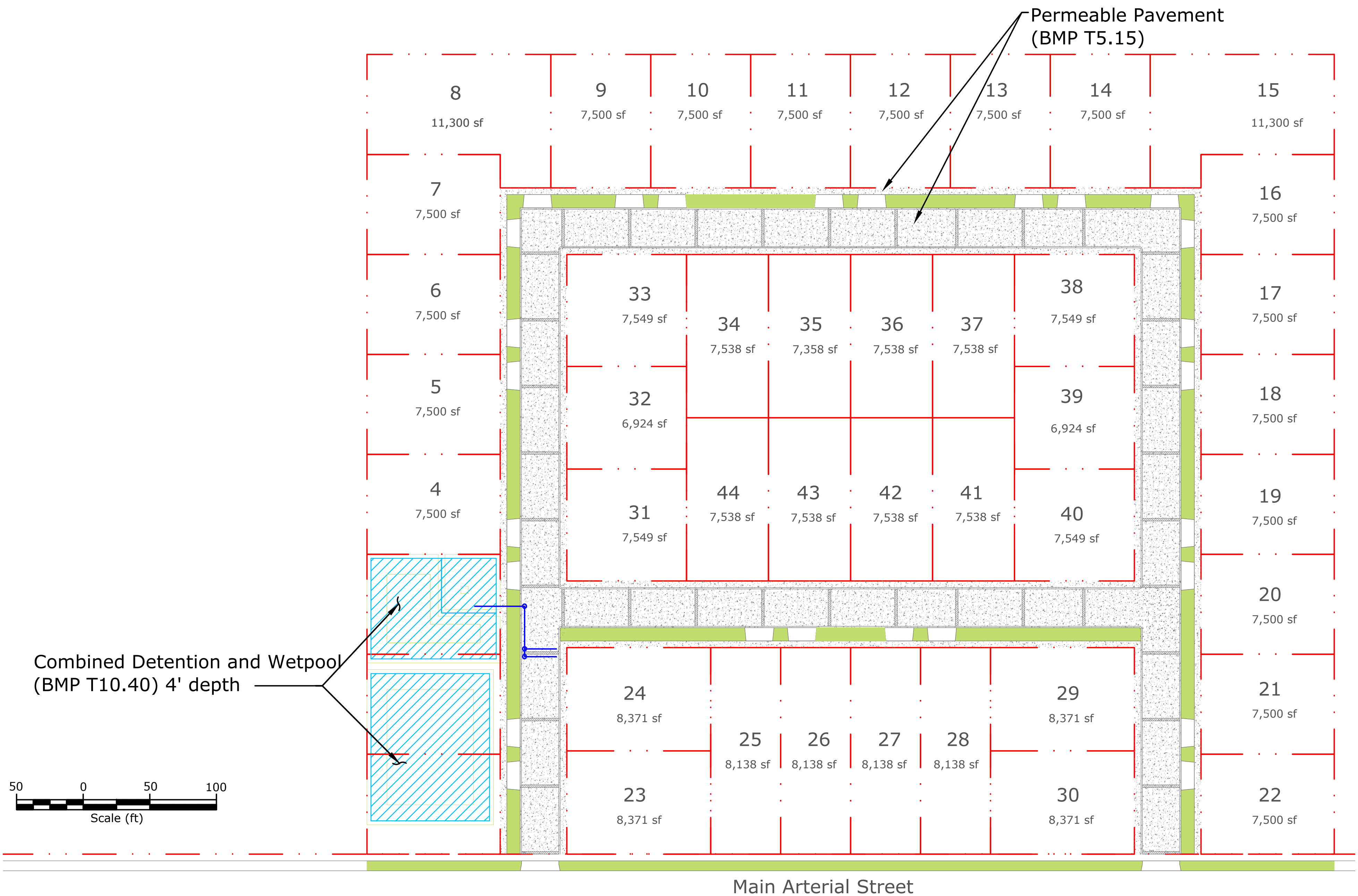


Figure 18. Scenario 4. Permanent Stormwater Site Plan - Typical Single-Family Residential Development, 2012 Requirements, Till Soils

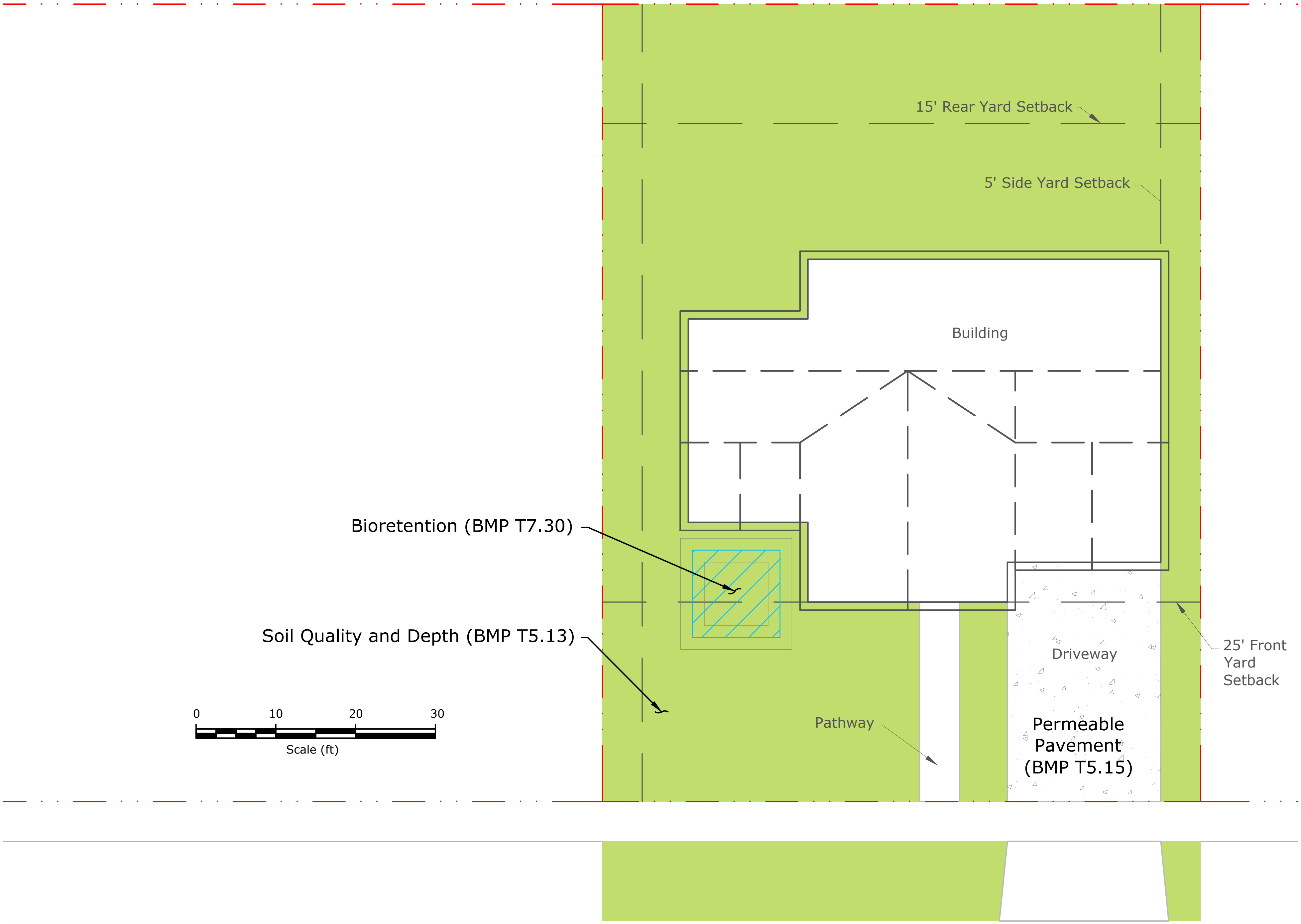


Figure 19. Scenario 4. Permanent Stormwater Site Plan - Typical Single-Family Residential Parcel, 2012 Requirements, Till Soils

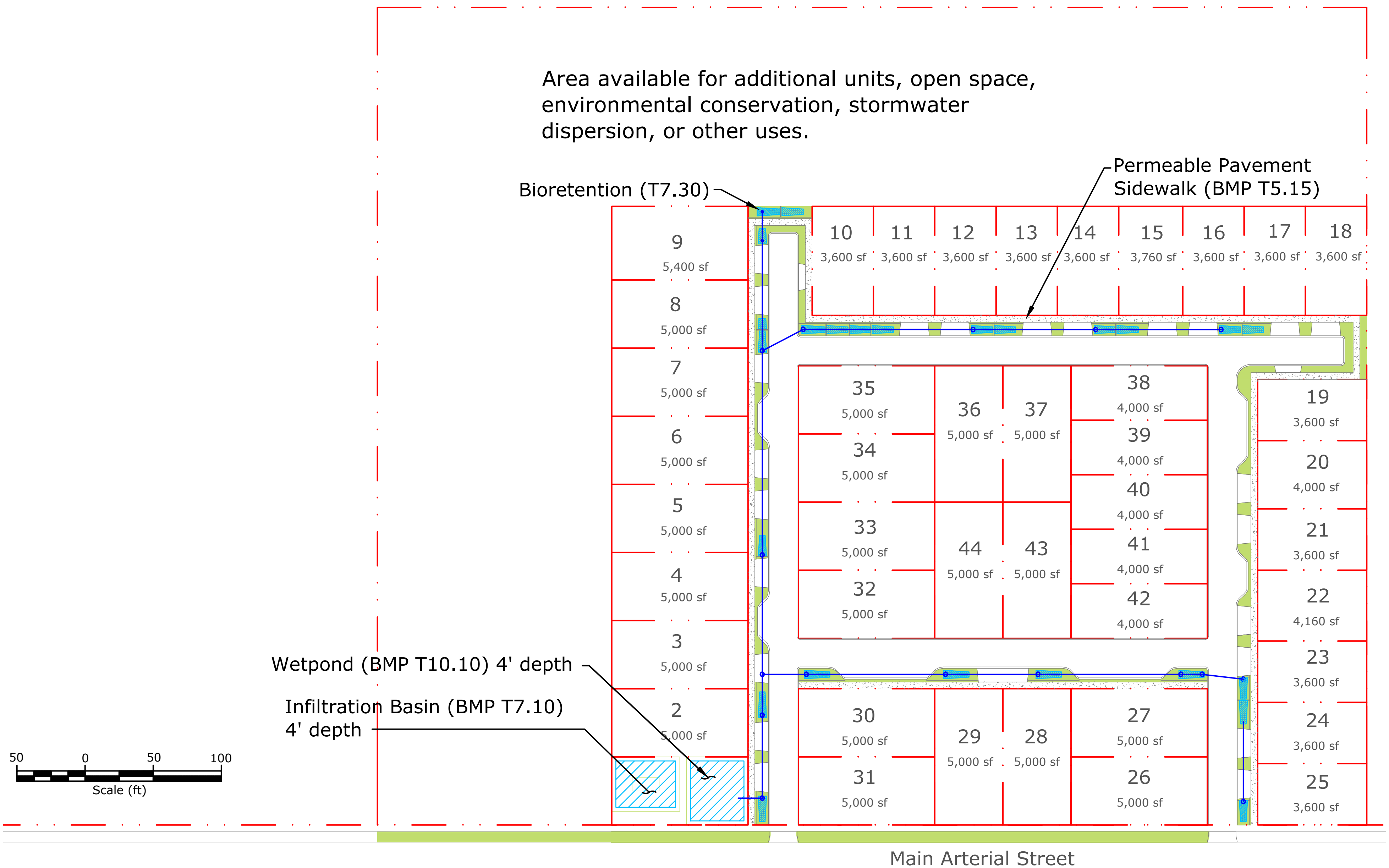


Figure 20. Scenario 5. Permanent Stormwater Site Plan - Typical Single-Family Residential Development, 2012 Requirements with LID Principles, Outwash Soils

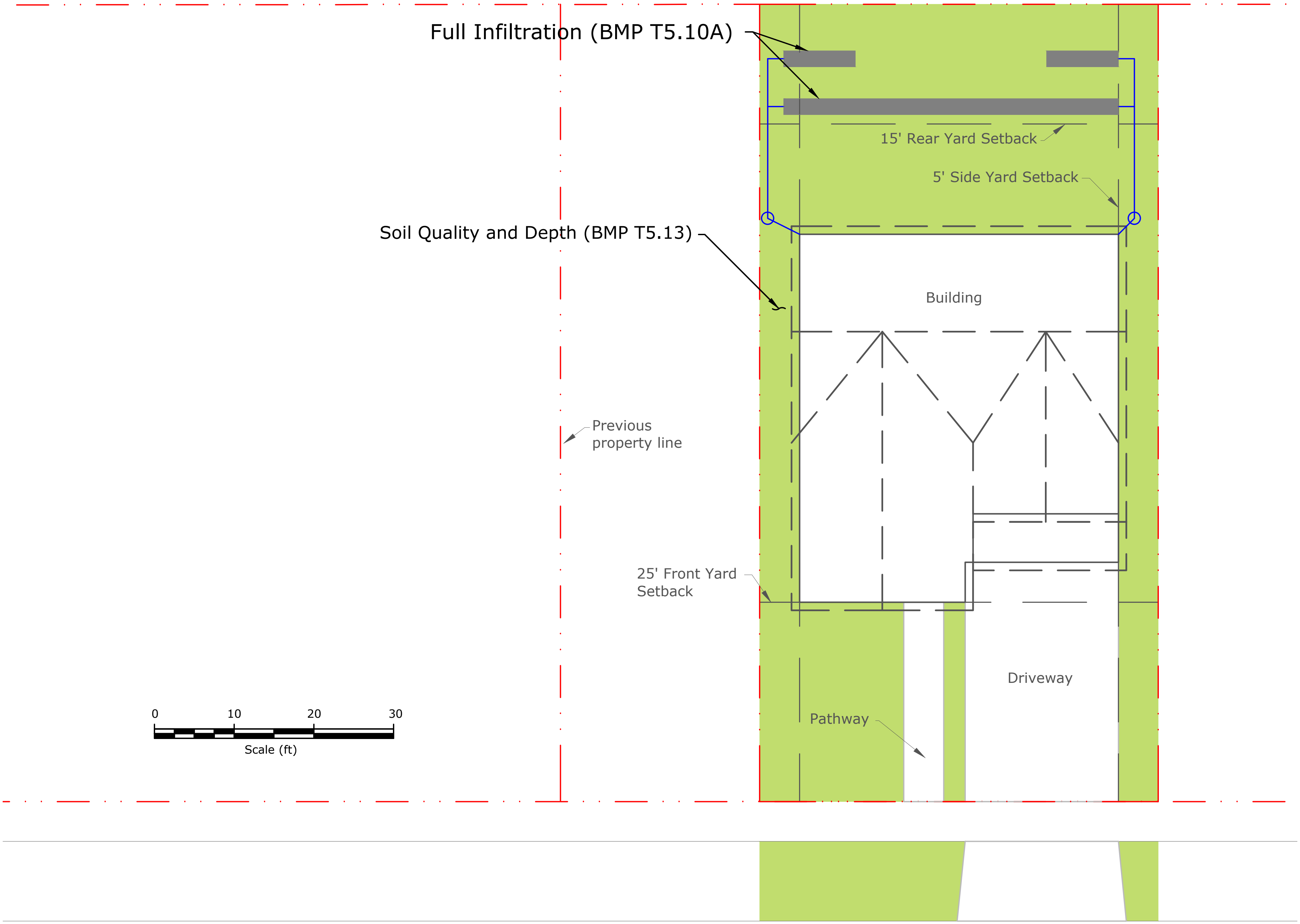


Figure 21. Scenario 5. Permanent Stormwater Site Plan - Typical Single-Family Residential Parcel, 2012 Requirements with LID Principles, Outwash Soils

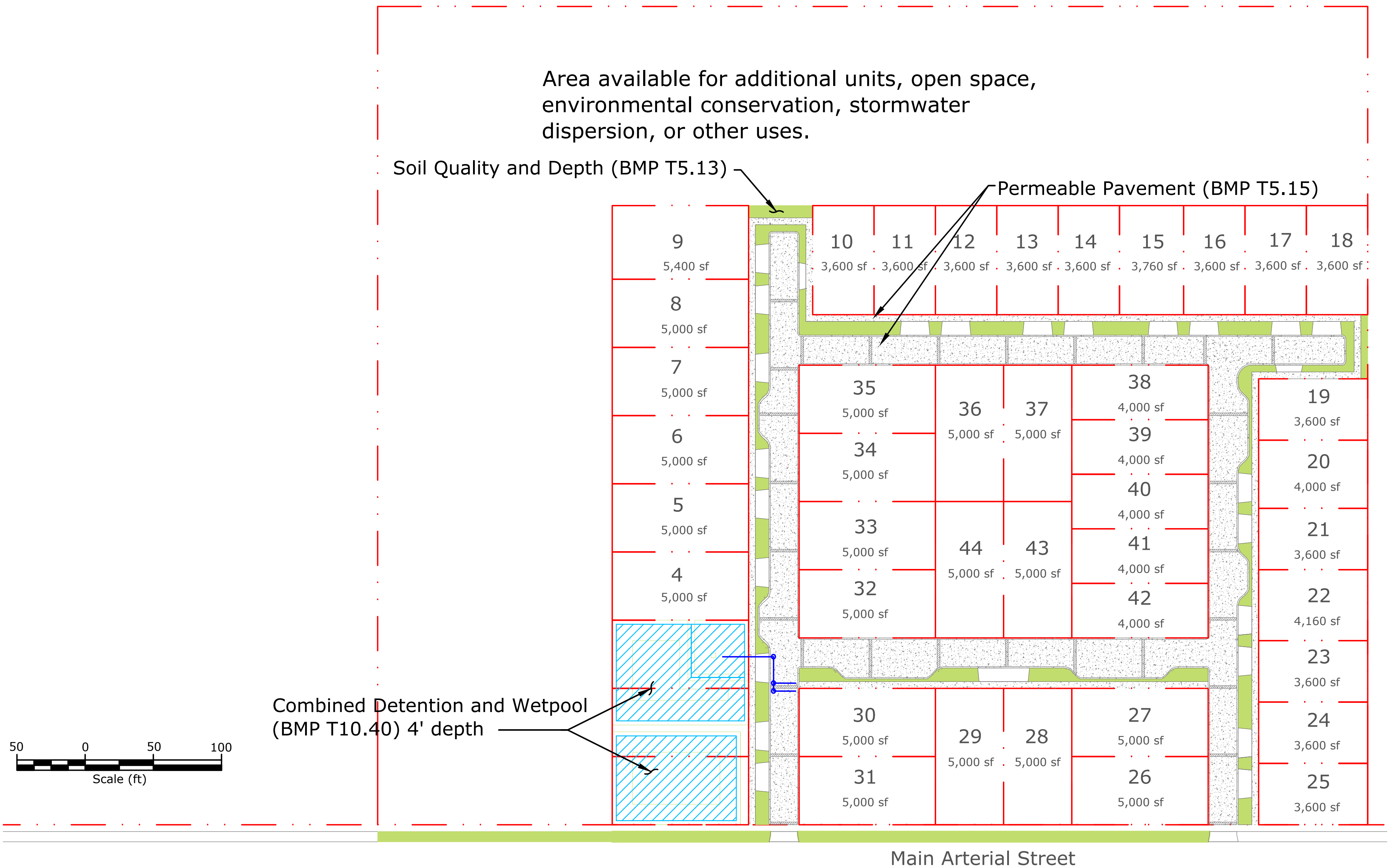


Figure 22. Scenario 6. Permanent Stormwater Site Plan - Typical Single-Family Residential Development, 2012 Requirements with LID Principles, Till Soils

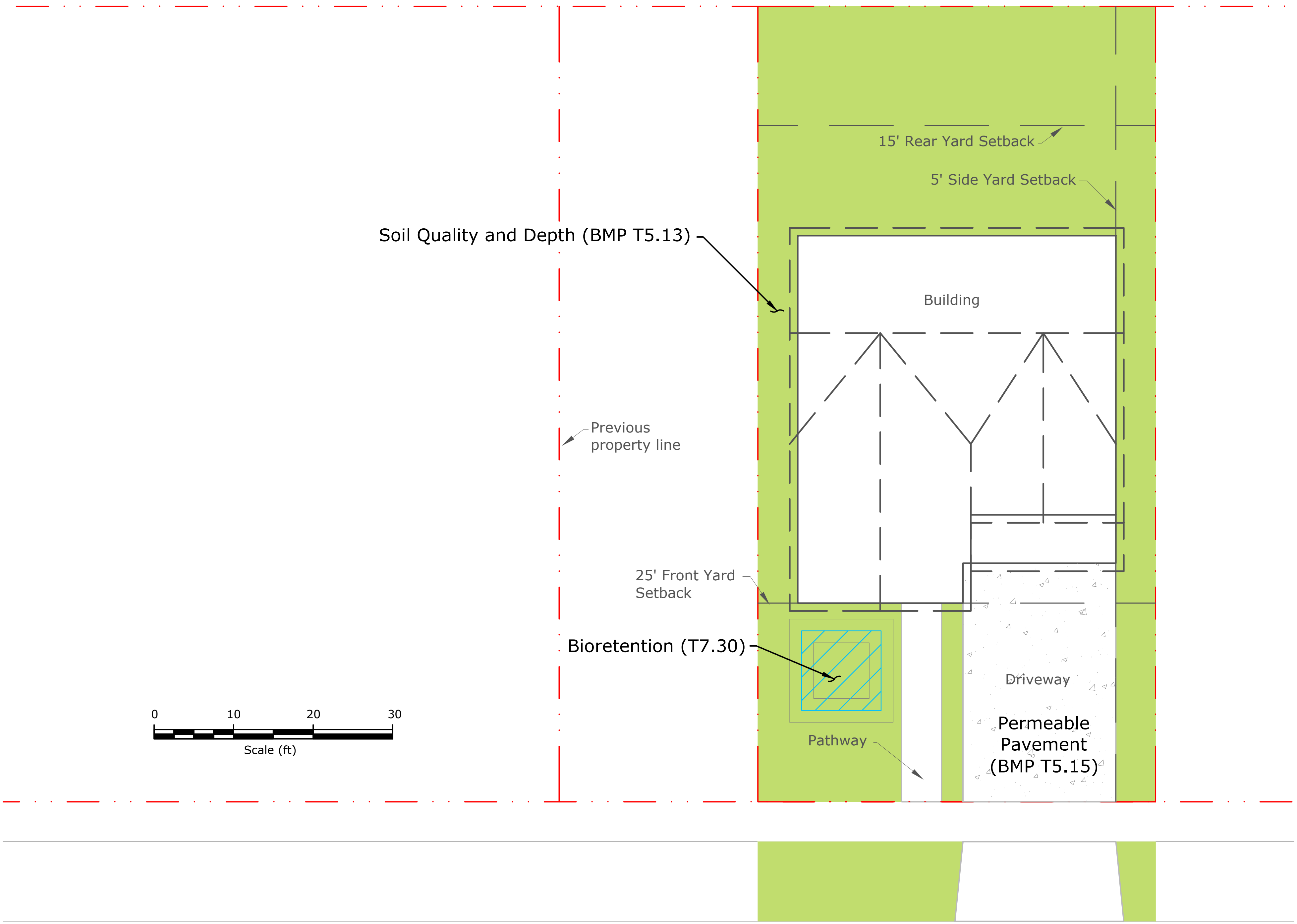
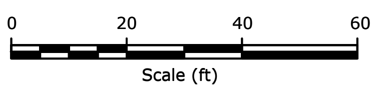


Figure 23. Scenario 6. Permanent Stormwater Site Plan - Typical Single-Family Residential Parcel, 2012 Requirements with LID Principles, Till Soils

Gross Lot Area:	1 acre 43,560 sf
Building Area:	5,000 sf
Required Parking:	50 spaces
Provided Parking:	59 spaces
Required Drive-in Queing:	10 spaces
Roof Area:	5,000 sf
Road Area:	29,740 sf
Sidewalk/Path Area:	775 sf
Landscape Area:	8,045 sf
Total Impervious Surface Area:	35,515 sf



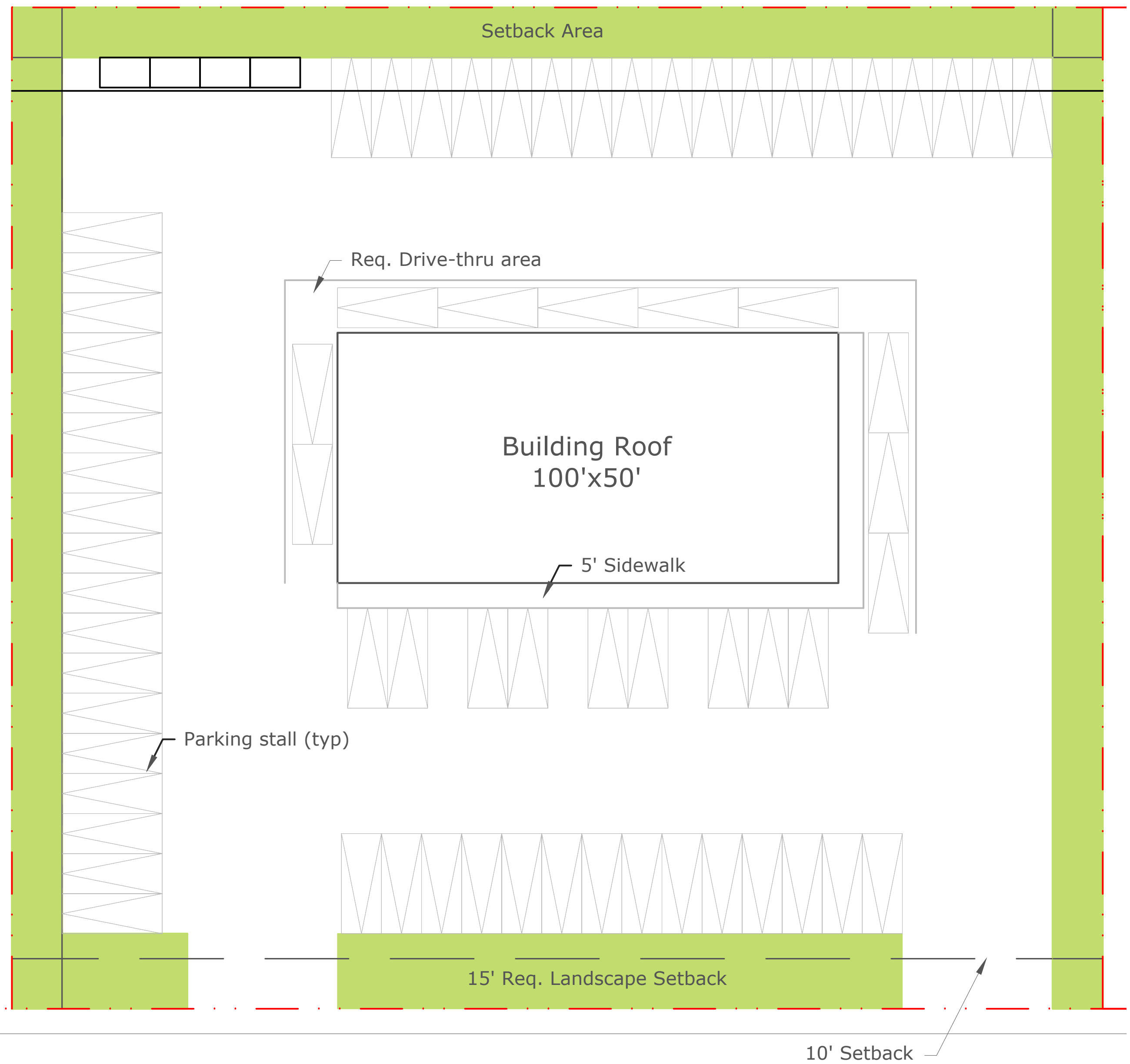


Figure 24. Scenario 7 to 10. Small Commercial Development Plan

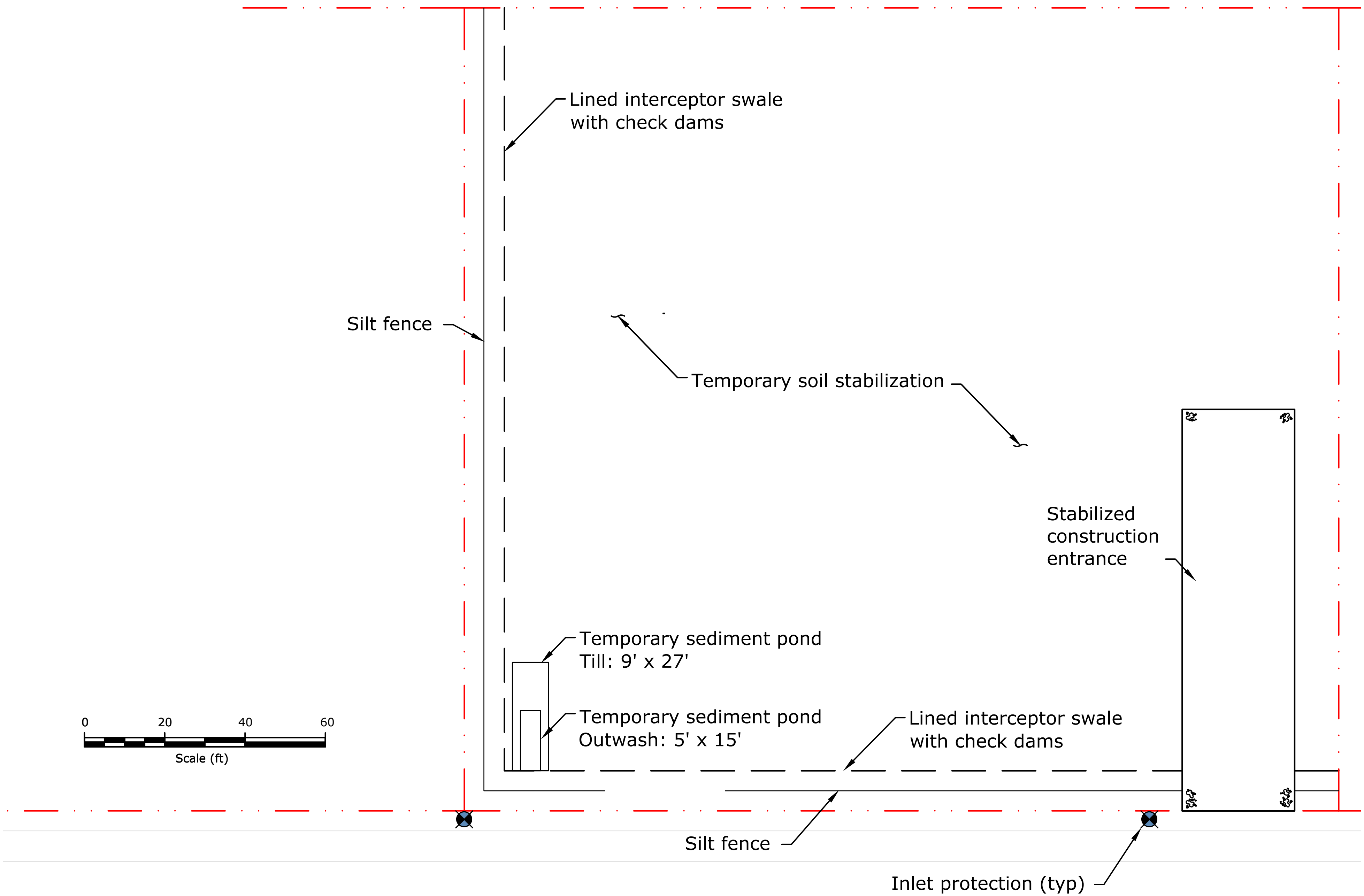


Figure 25. Scenario 7 and 8. Temporary Erosion and Sediment Control Plan – Small Commercial Development Plan, 2005 Requirements

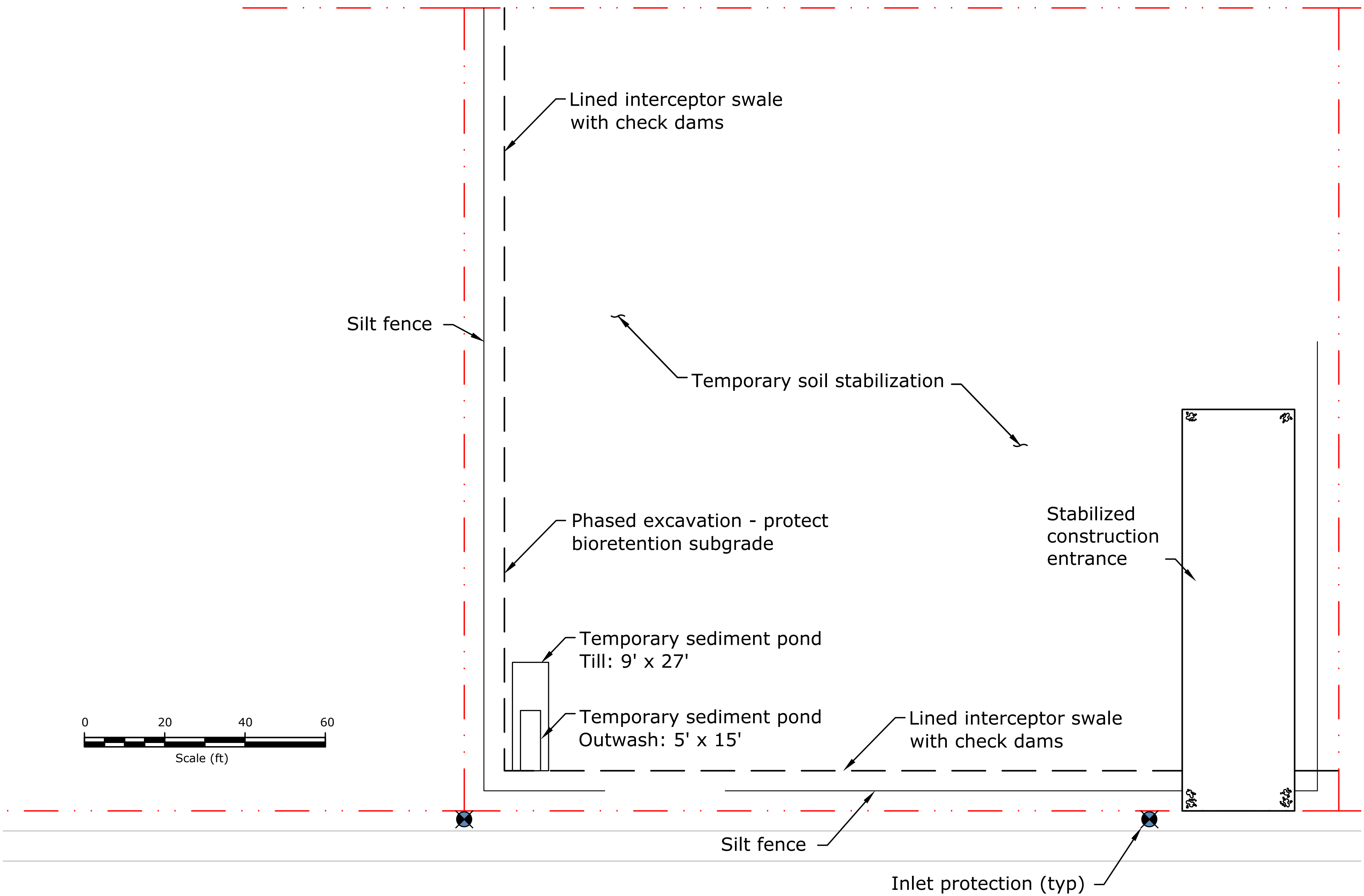


Figure 26. Scenario 9 and 10. Temporary Erosion and Sediment Control Plan – Small Commercial Development Plan, 2012 Requirements

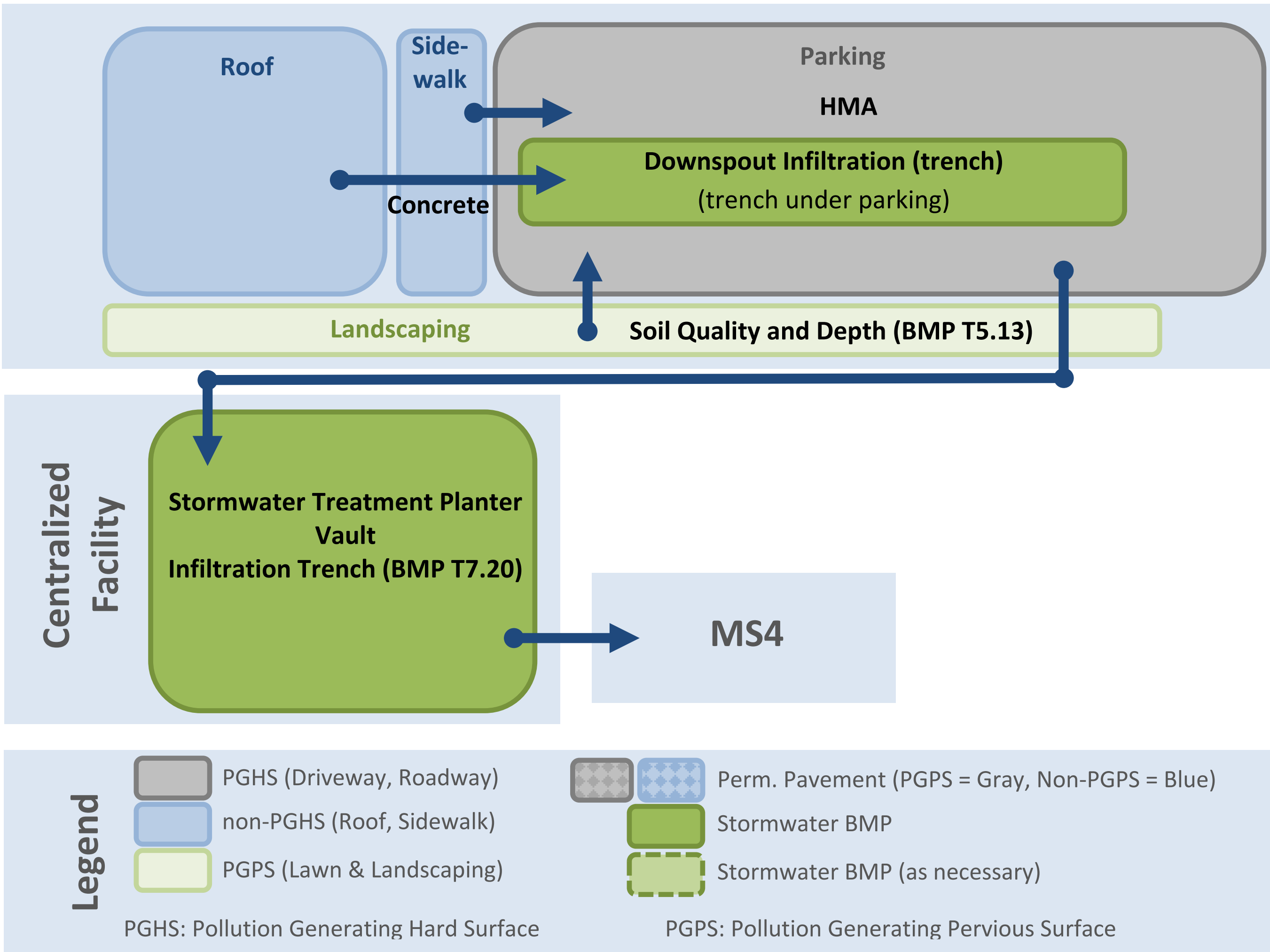


Figure 27. Scenario 7. Permanent Stormwater Management BMPs, Small Commercial Development, 2005, Outwash

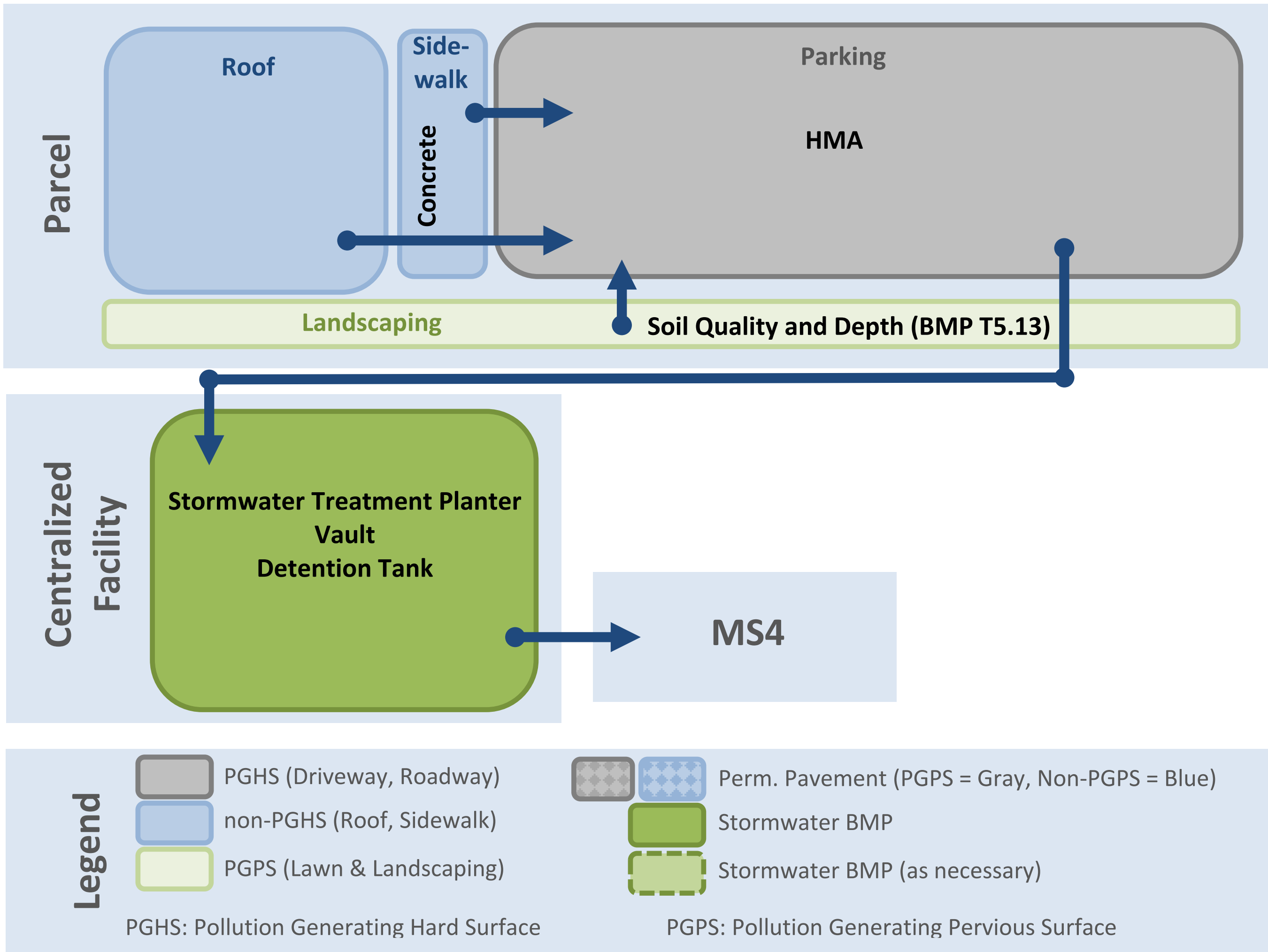


Figure 28. Scenario 8. Permanent Stormwater Management BMPs, Small Commercial Development, 2005, Till

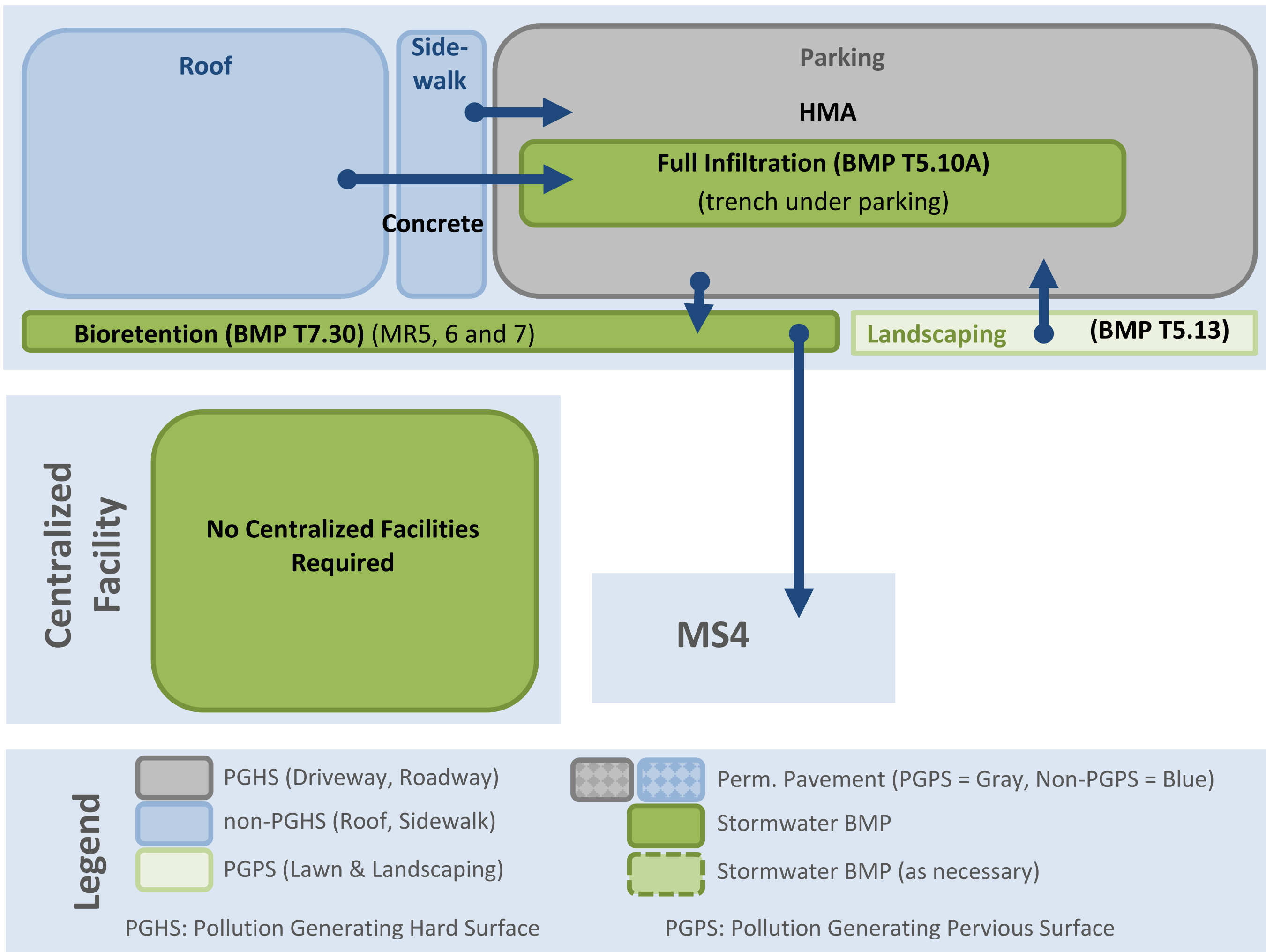


Figure 29. Scenario 9. Permanent Stormwater Management BMPs, Small Commercial Development, 2012, Outwash

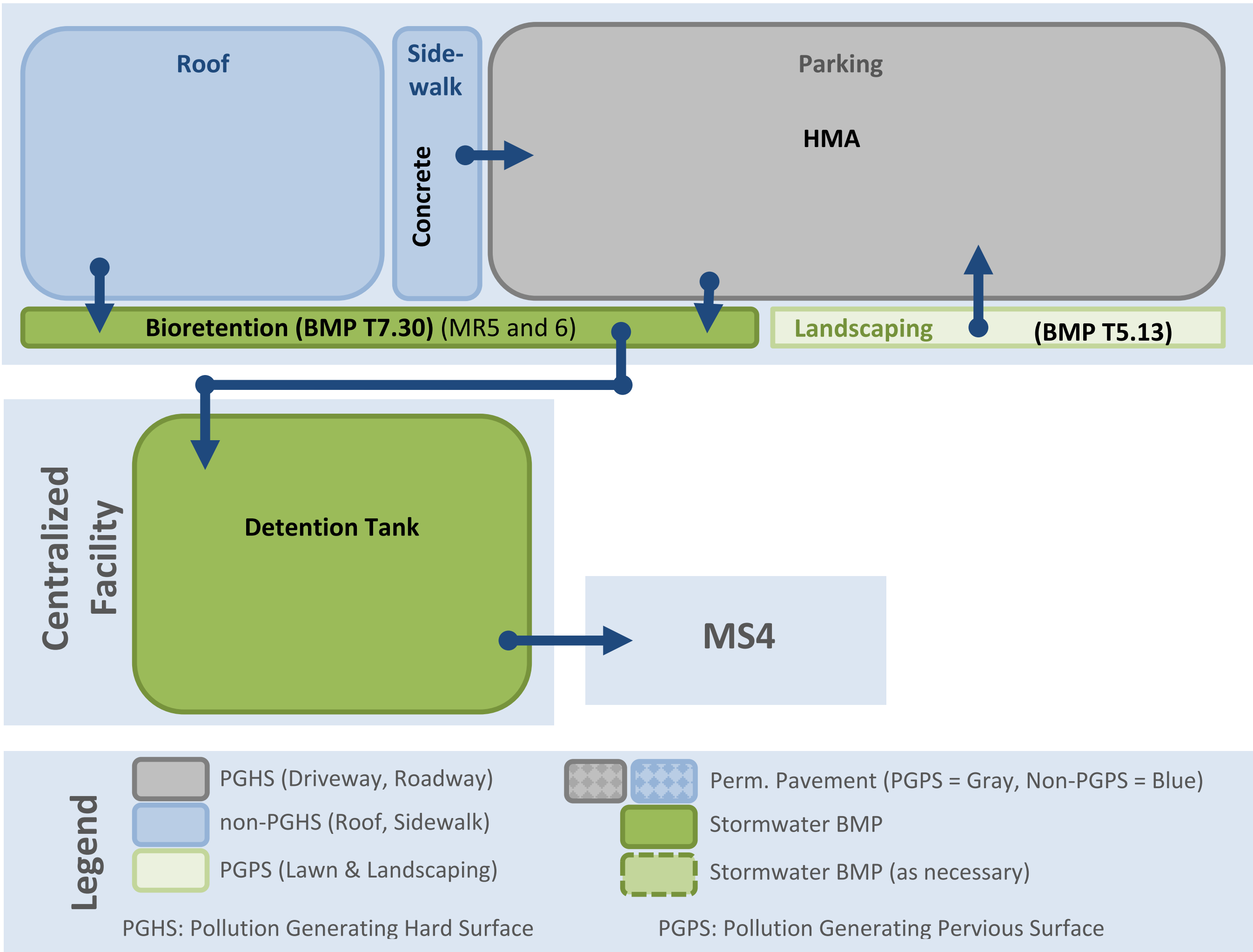


Figure 30. Scenario 10. Permanent Stormwater Management BMPs, Small Commercial Development, 2012, Till

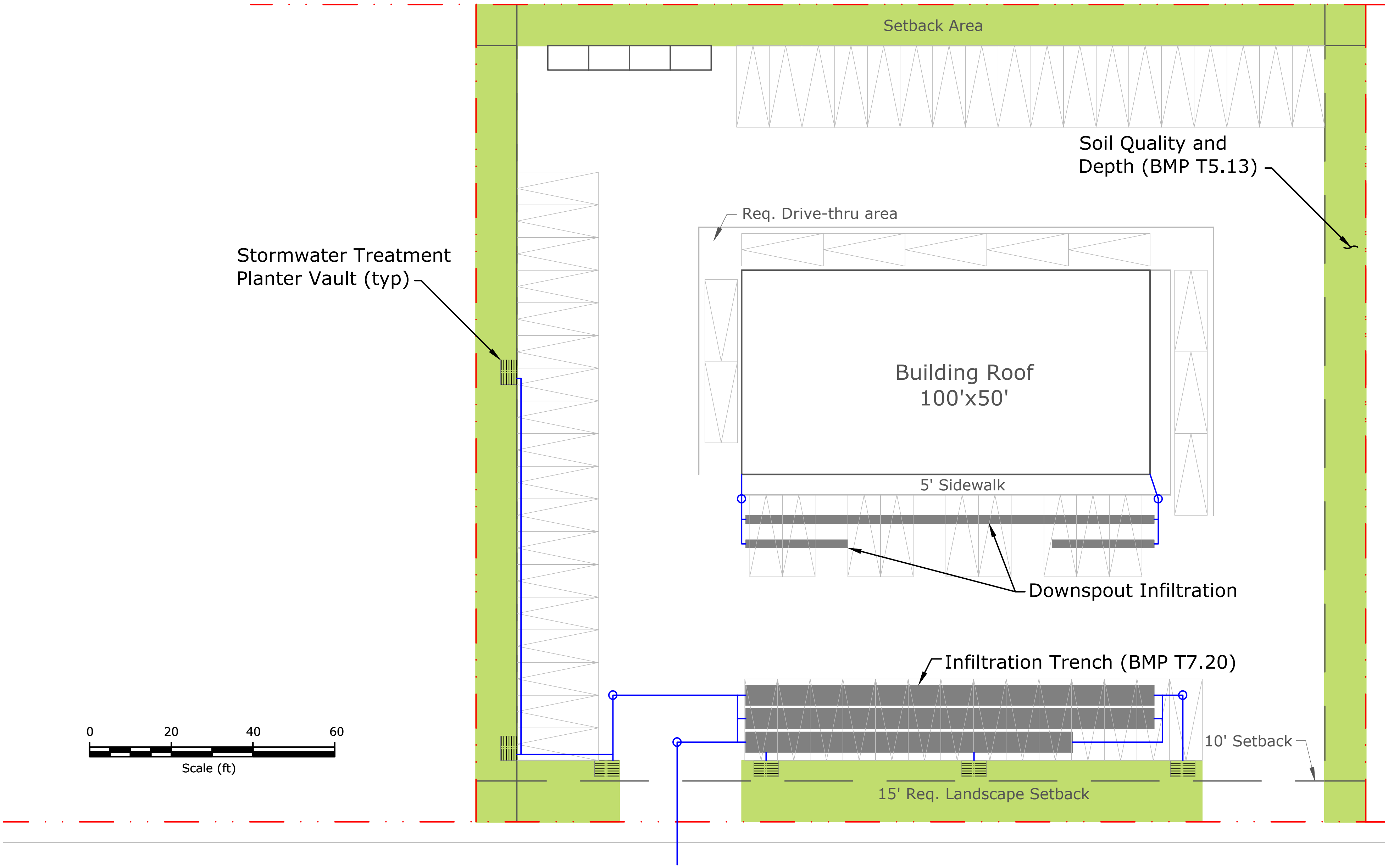


Figure 31. Scenario 7. Permanent Stormwater Site Plan – Small Commercial Development, 2005 Requirements, Outwash Soils

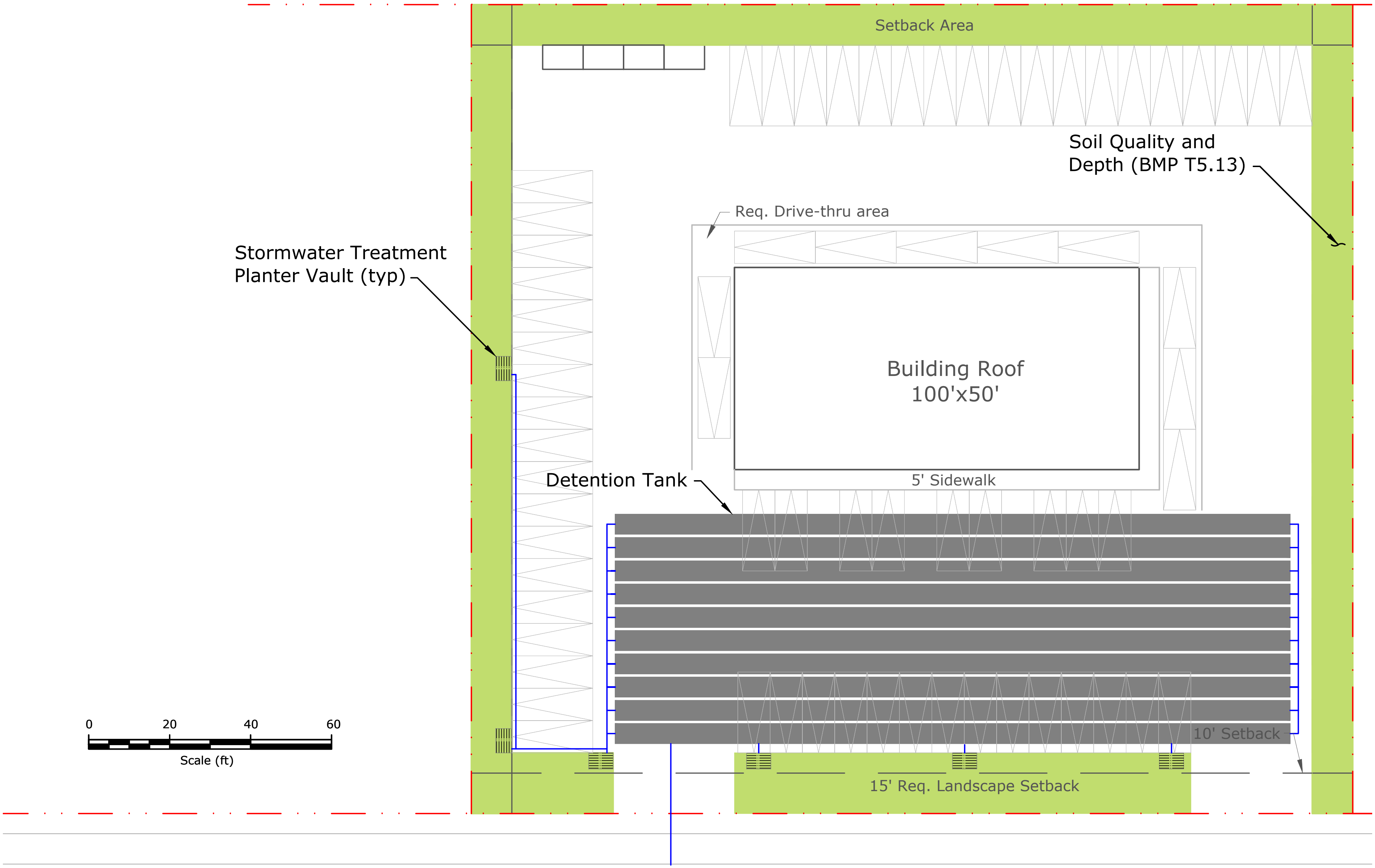


Figure 32. Scenario 8. Permanent Stormwater Site Plan – Small Commercial Development, 2005 Requirements, Till Soils

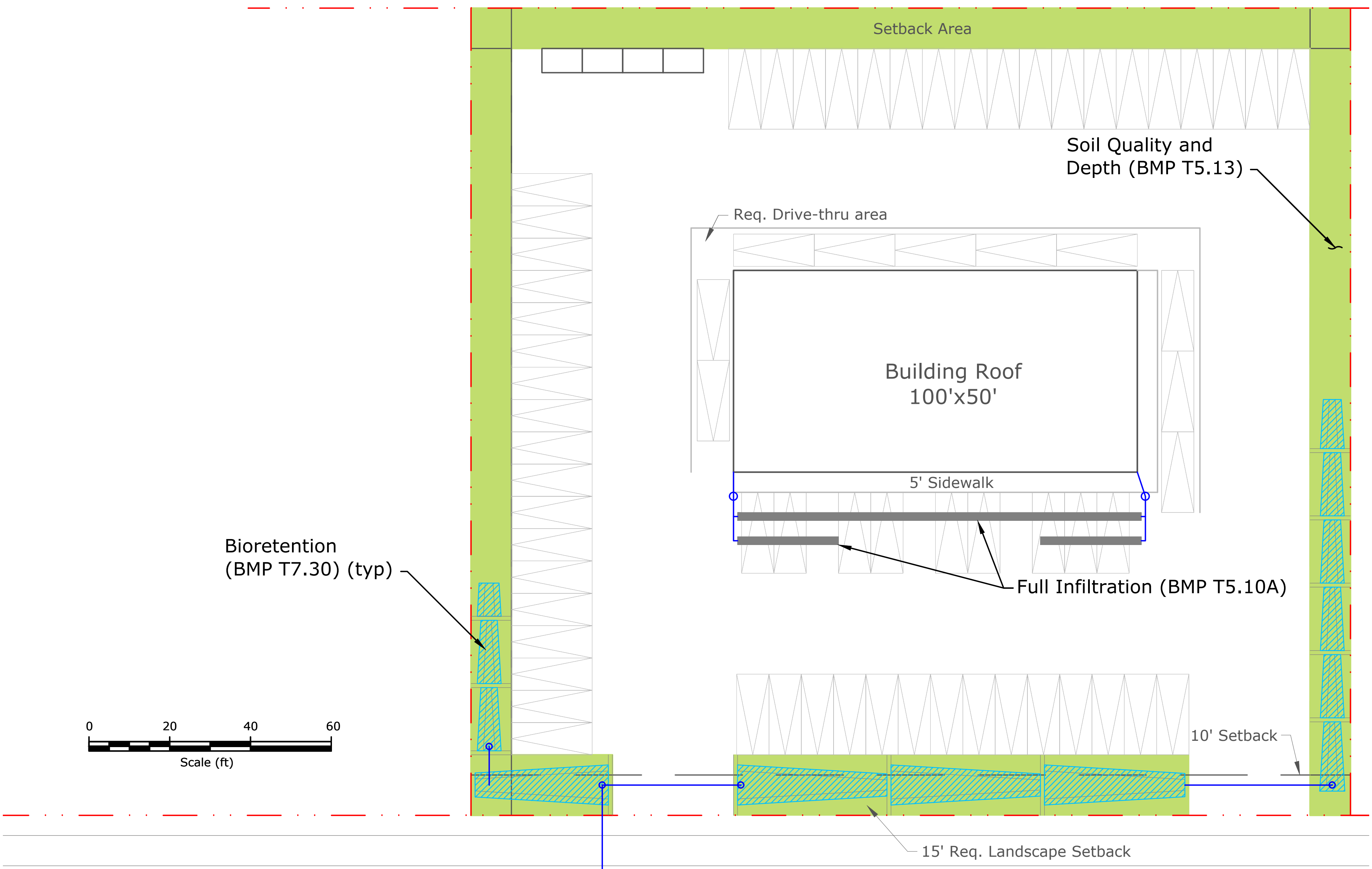


Figure 33. Scenario 9. Permanent Stormwater Site Plan – Small Commercial Development, 2012 Requirements, Outwash Soils

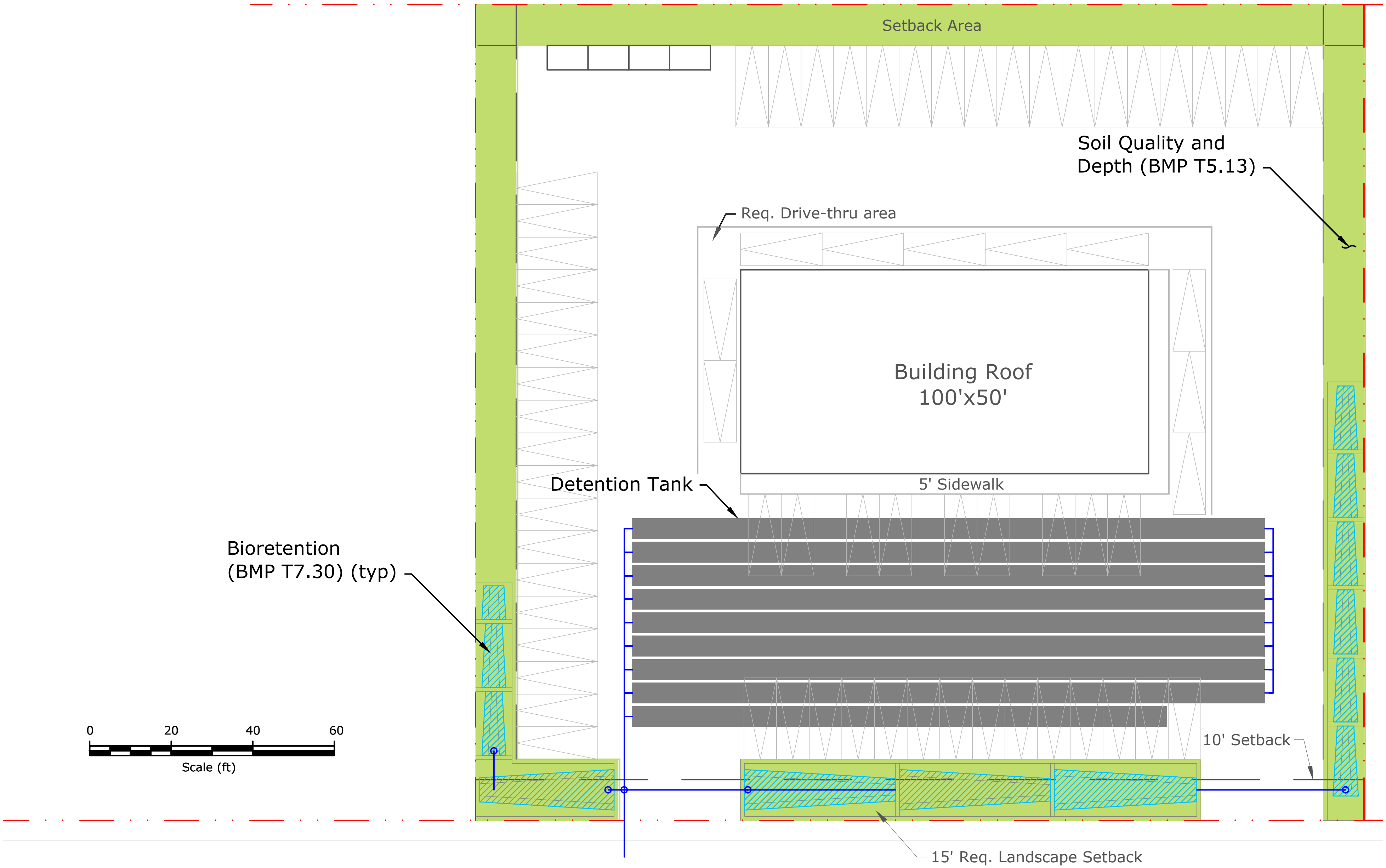


Figure 34. Scenario 10. Permanent Stormwater Site Plan – Small Commercial Development, 2012 Requirements, Till Soils

Gross Lot Area:	10 acres 435,600 sf
Building Area:	127,565 sf
Retail Commercial Area:	117,565 sf
Restaurant/Food Area:	10,000 sf
Req. Commercial Parking:	392 spaces
Req. Restaurant Parking:	100 spaces
Req. Total # Parking:	492 spaces
Provided Parking:	492 spaces
Roof Area:	127,565 sf
Road Area:	283,430 sf
Sidewalk/Path Area:	6,360 sf
Landscape Area:	18,245 sf
Total Impervious Surface Area (building included):	417,355 sf

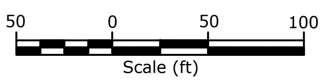


Figure 35. Scenario 11 to 14. Large Commercial Development Plan

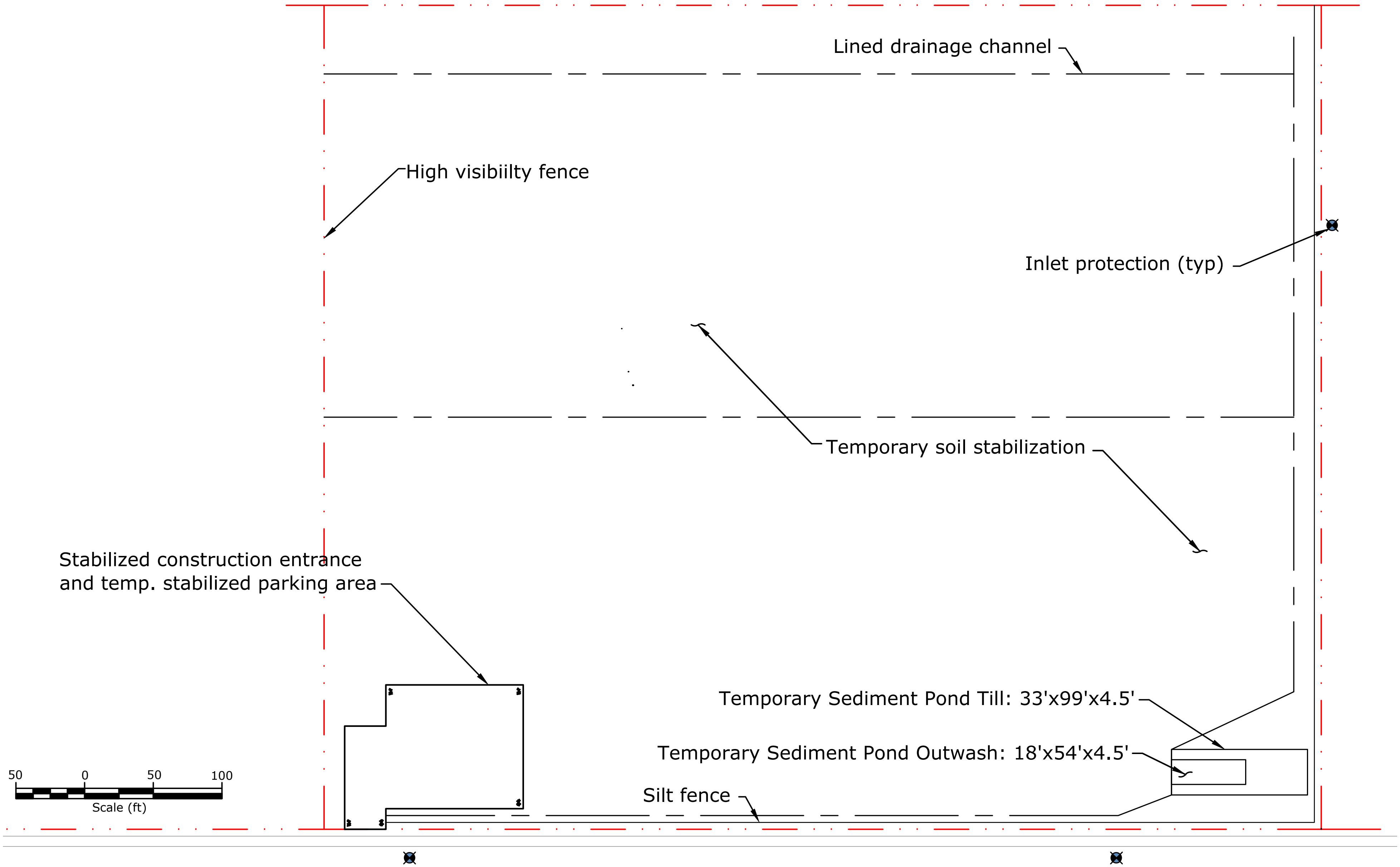


Figure 36. Scenario 11 and 12. Temporary Erosion and Sediment Control Plan – Large Commercial Development Plan, 2005 Requirements

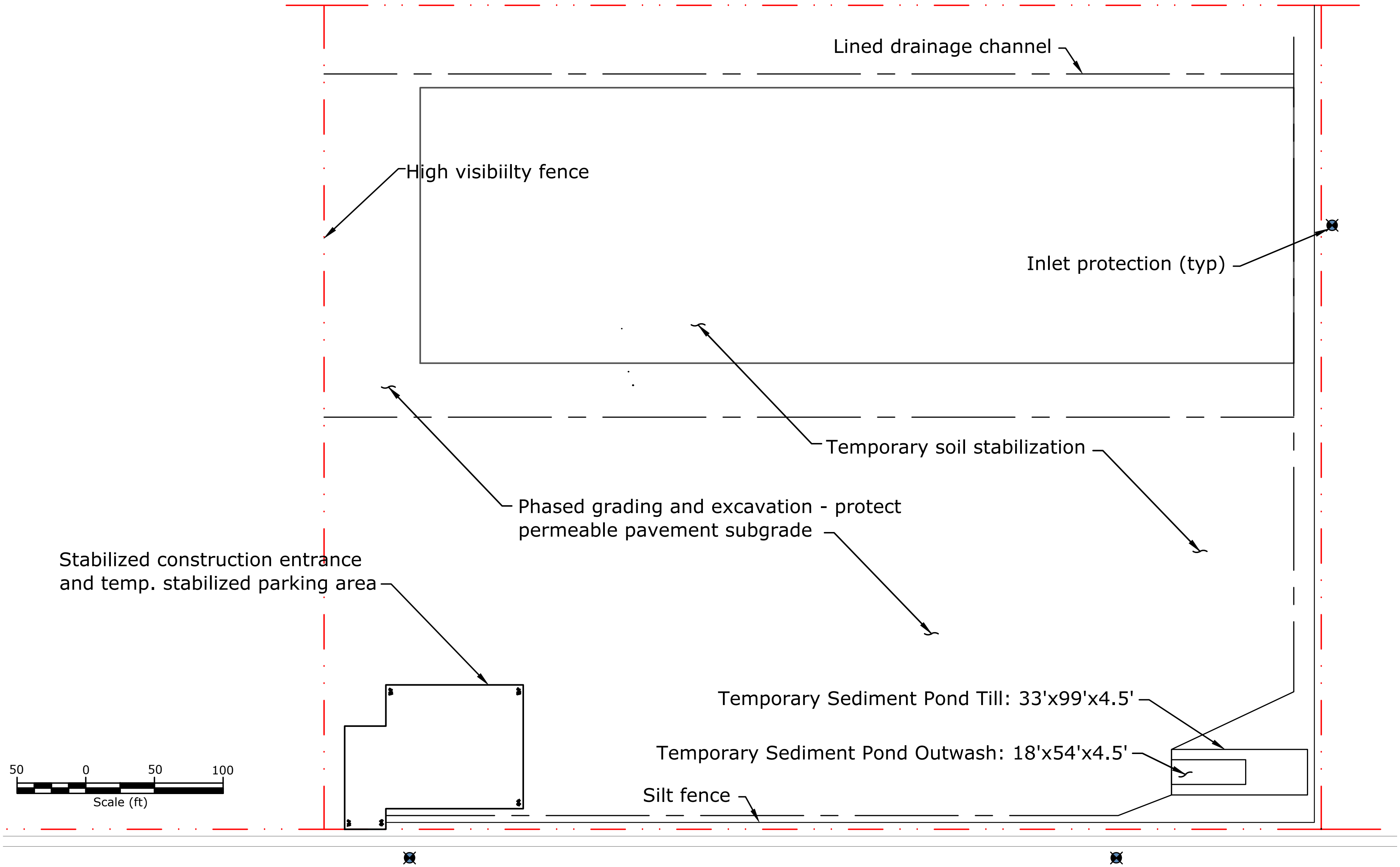


Figure 37. Scenario 13 and 14. Temporary Erosion and Sediment Control Plan – Large Commercial Development Plan, 2012 Requirements

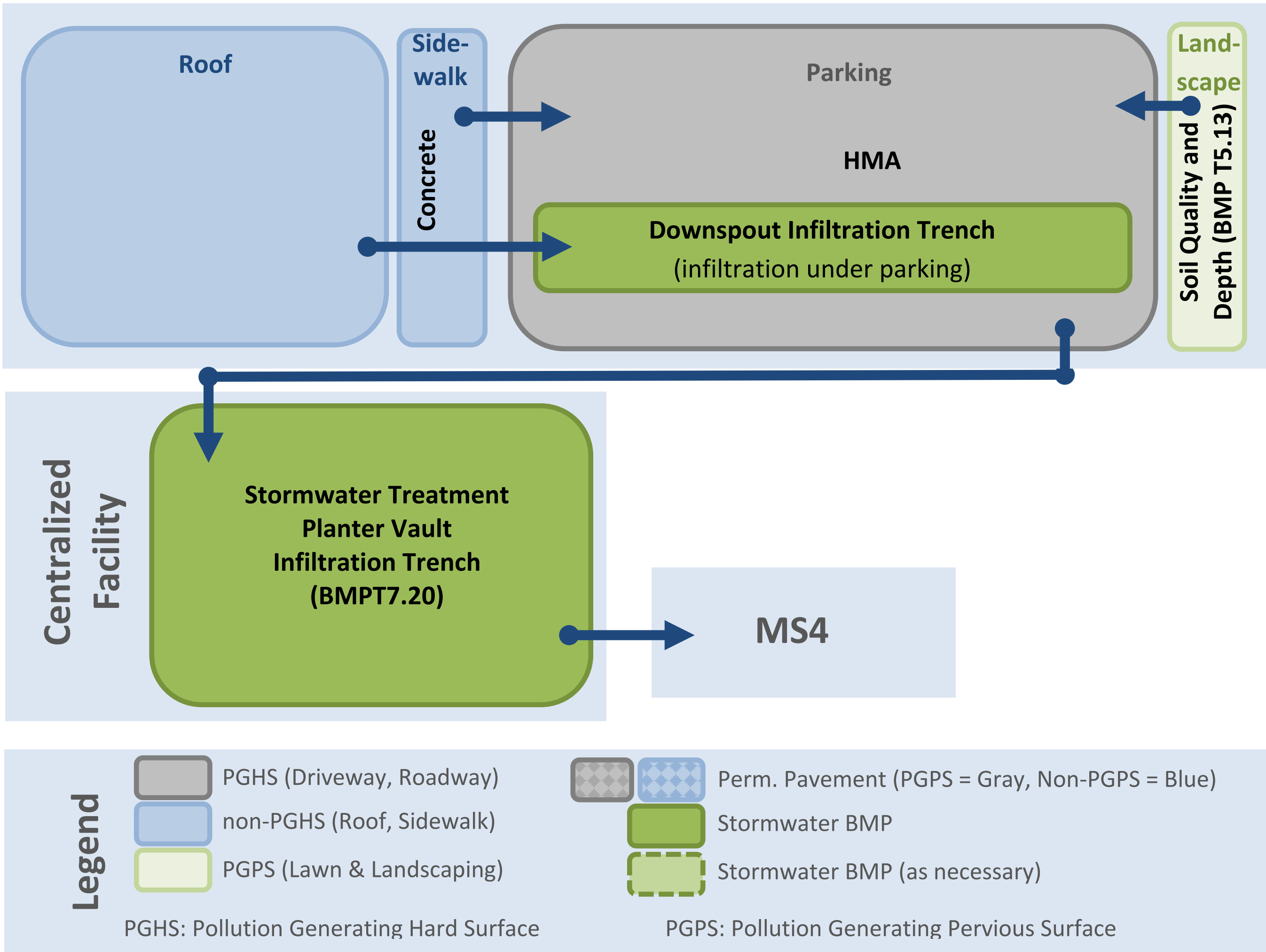


Figure 38. Scenario11. Permanent Stormwater Management BMPs, Large Commercial Development, 2005, Outwash

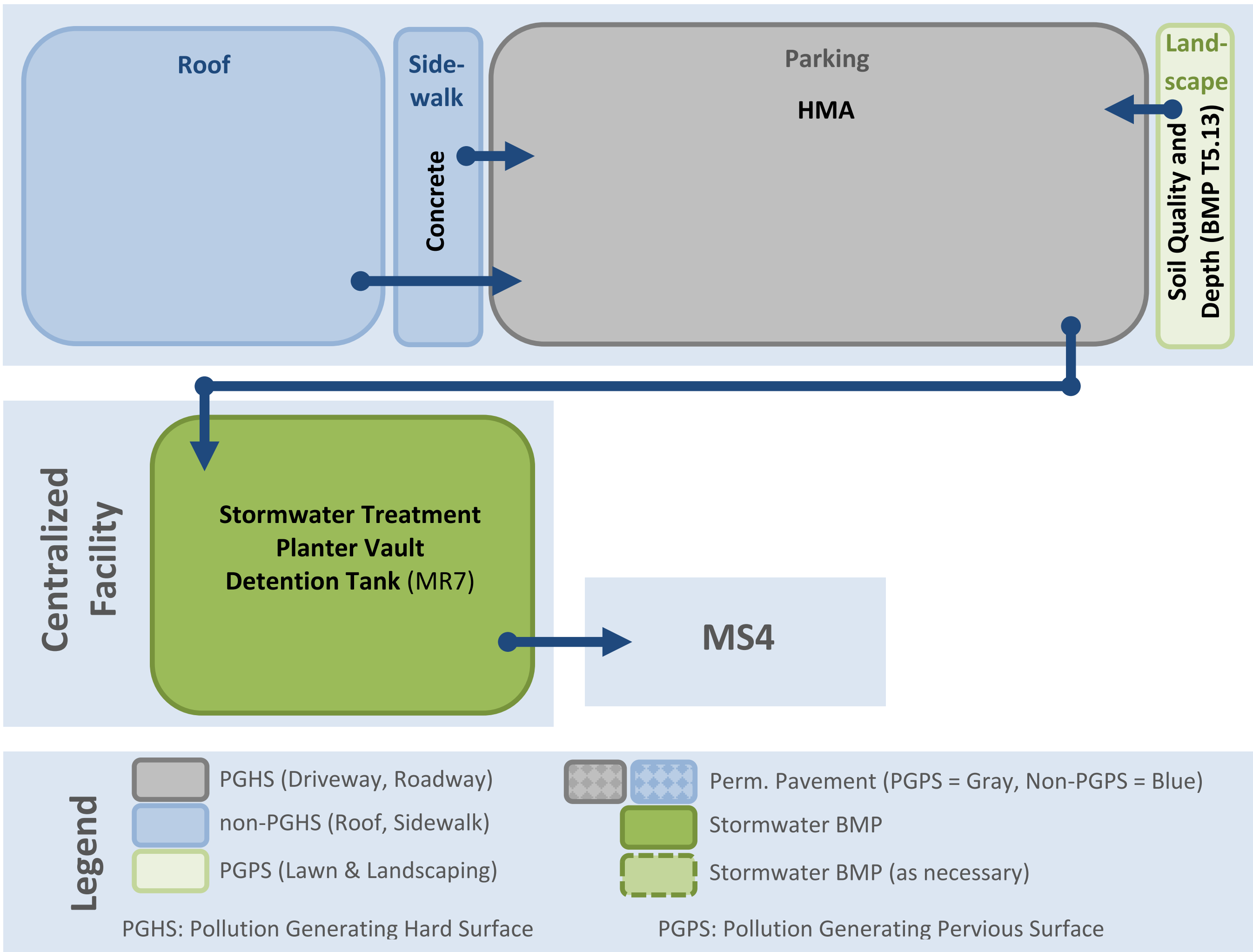


Figure 39. Scenario12. Permanent Stormwater Management BMPs, Large Commercial Development, 2005, Till

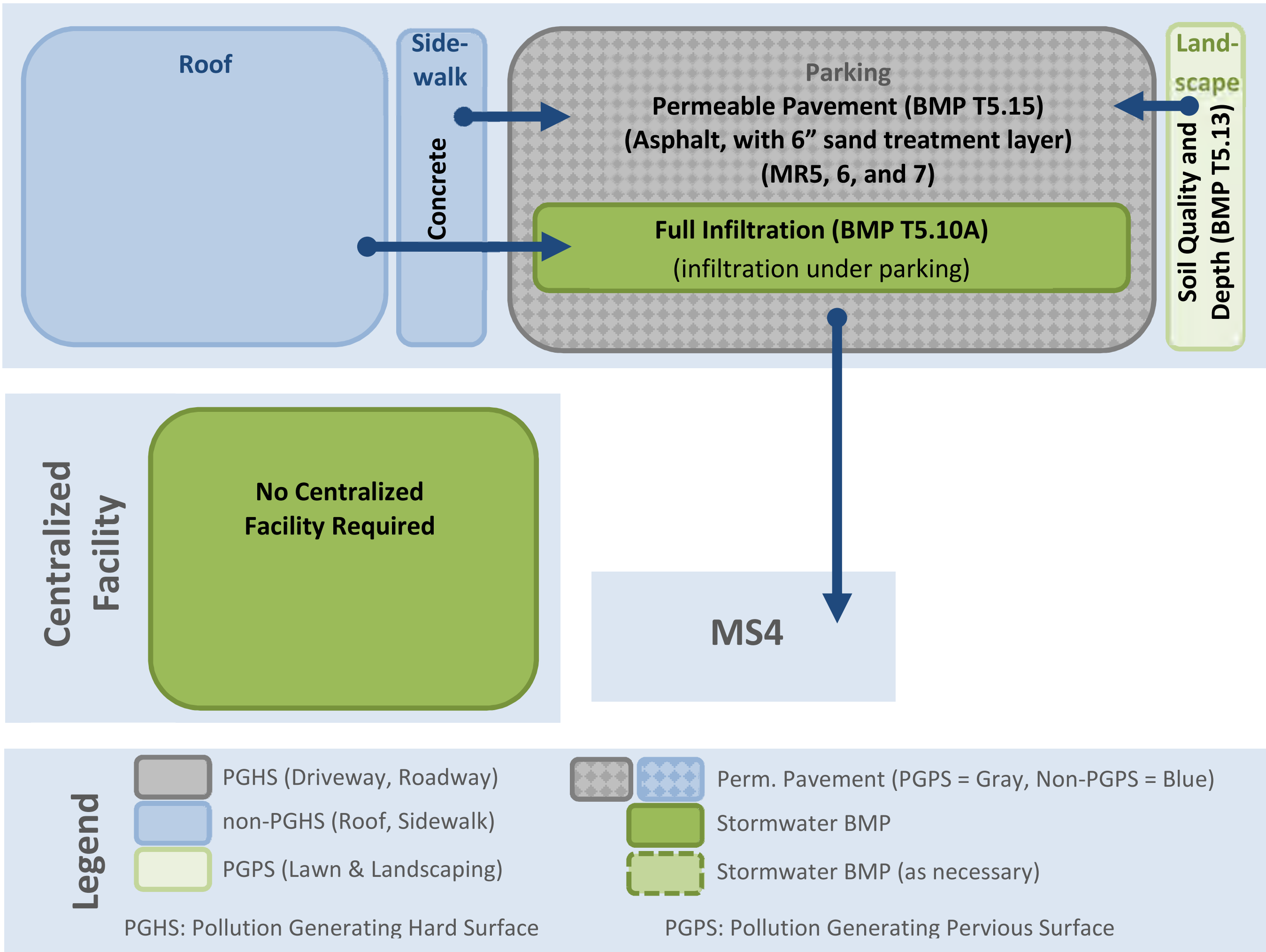


Figure 40. Scenario 13. Permanent Stormwater Management BMPs, Large Commercial Development, 2012, Outwash

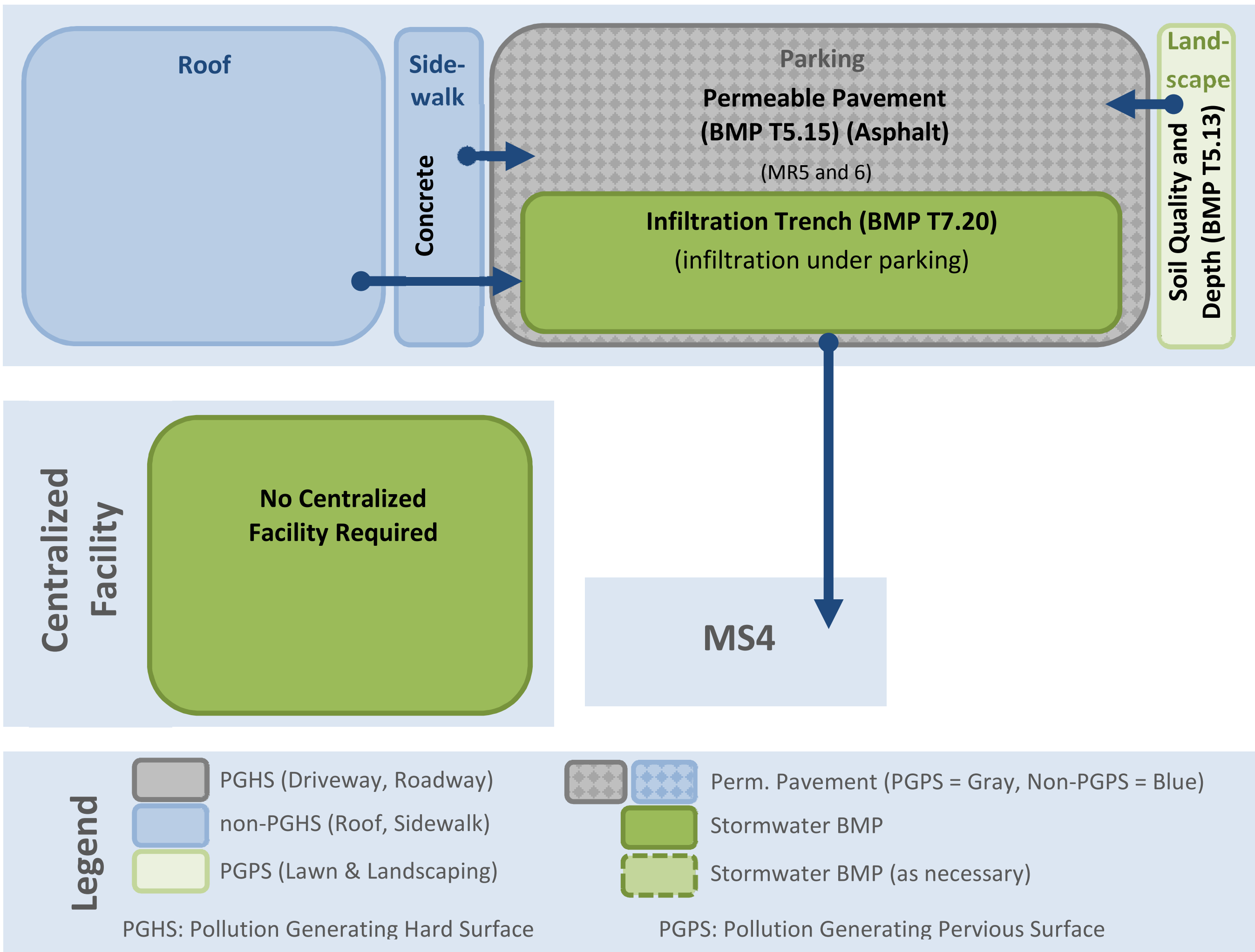


Figure 41. Scenario 14. Permanent Stormwater Management BMPs, Large Commercial Development, 2012 Till

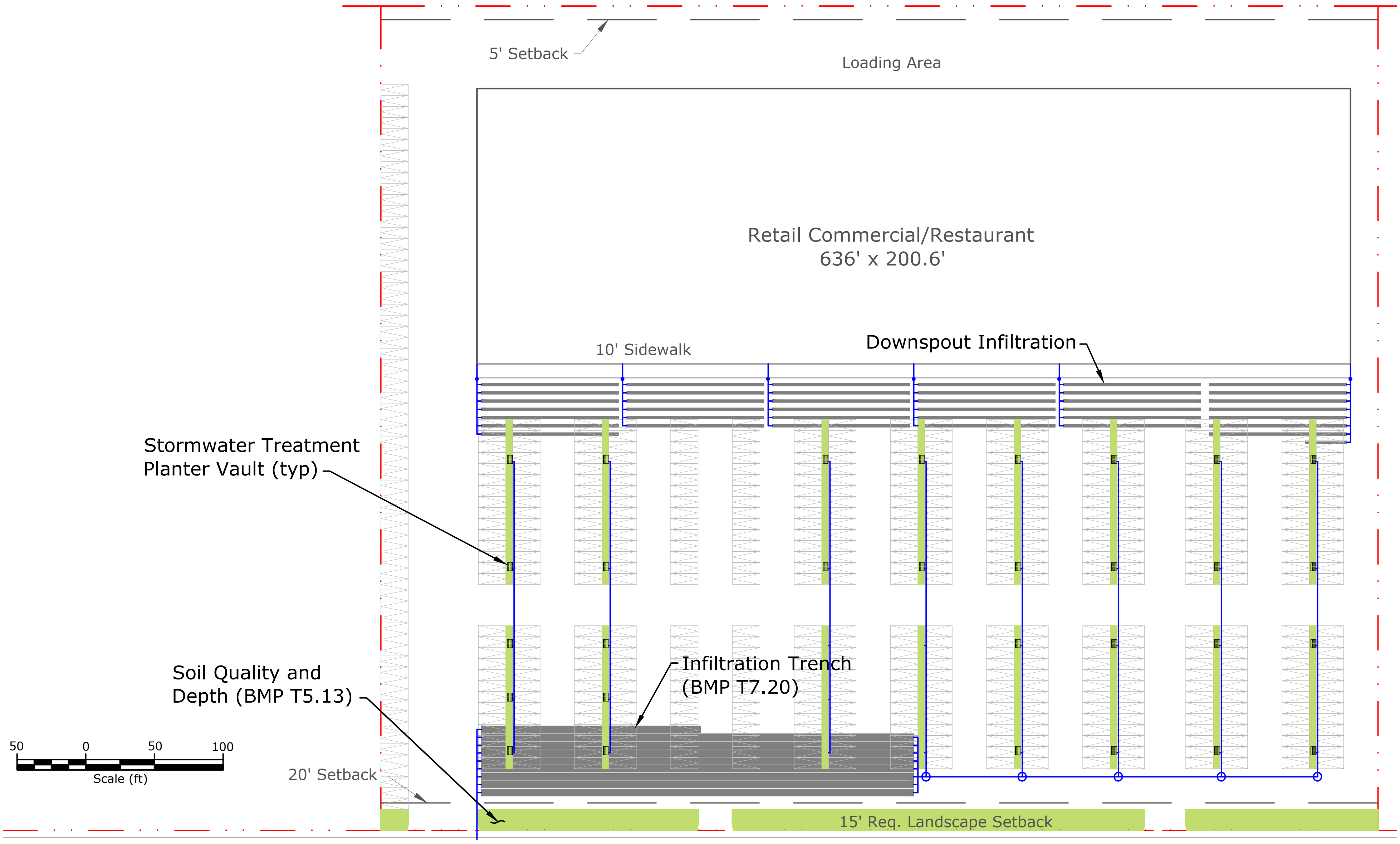


Figure 42. Scenario 11. Permanent Stormwater Site Plan – Large Commercial Development, 2005 Requirements, Outwash Soils

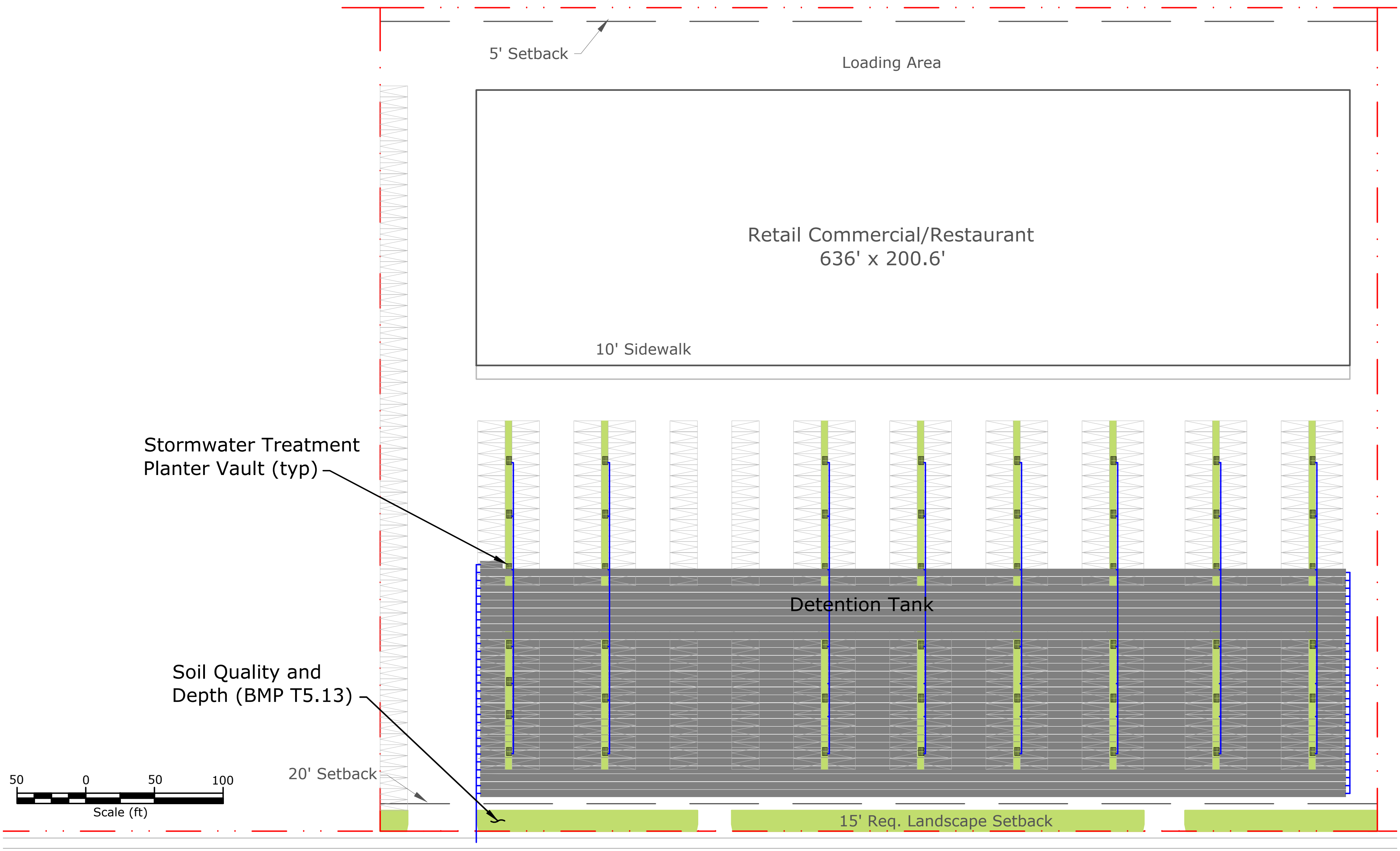


Figure 43. Scenario 12. Permanent Stormwater Site Plan – Large Commercial Development, 2005 Requirements, Till Soils

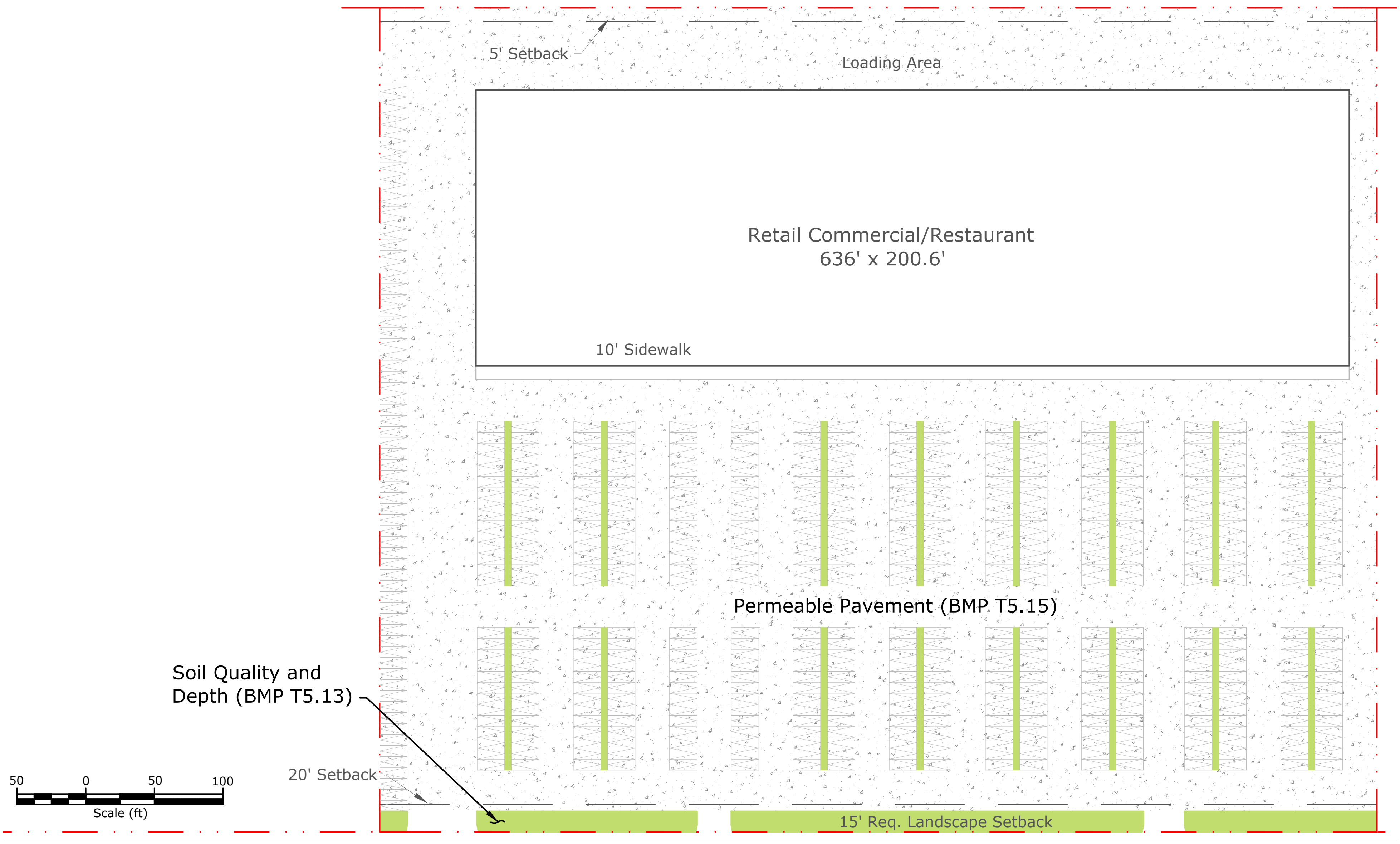


Figure 44. Scenario 13. Permanent Stormwater Site Plan – Large Commercial Development, 2012 Requirements, Outwash Soils

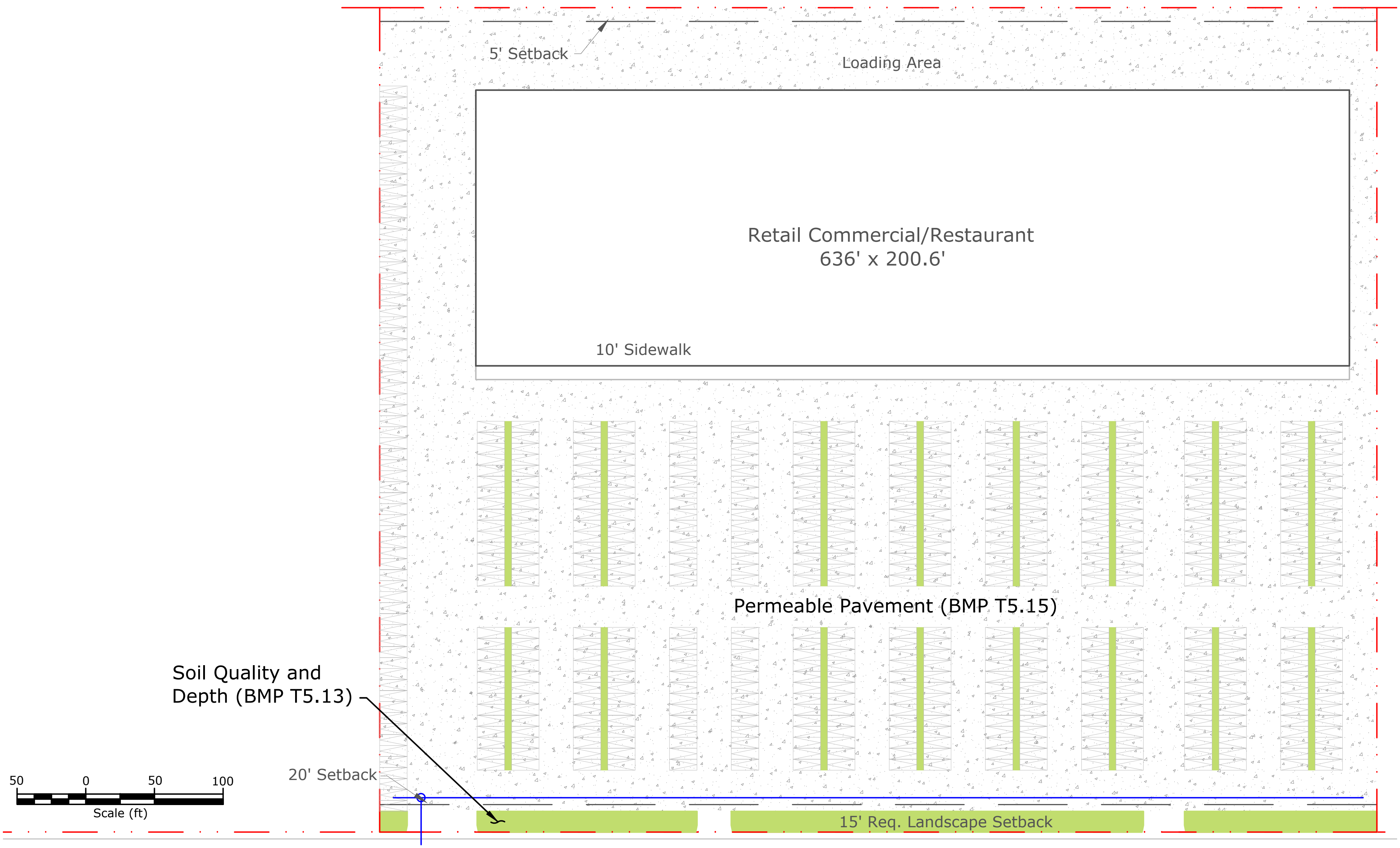


Figure 45. Scenario 14. Permanent Stormwater Site Plan – Large Commercial Development, 2012 Requirements, Till Soils

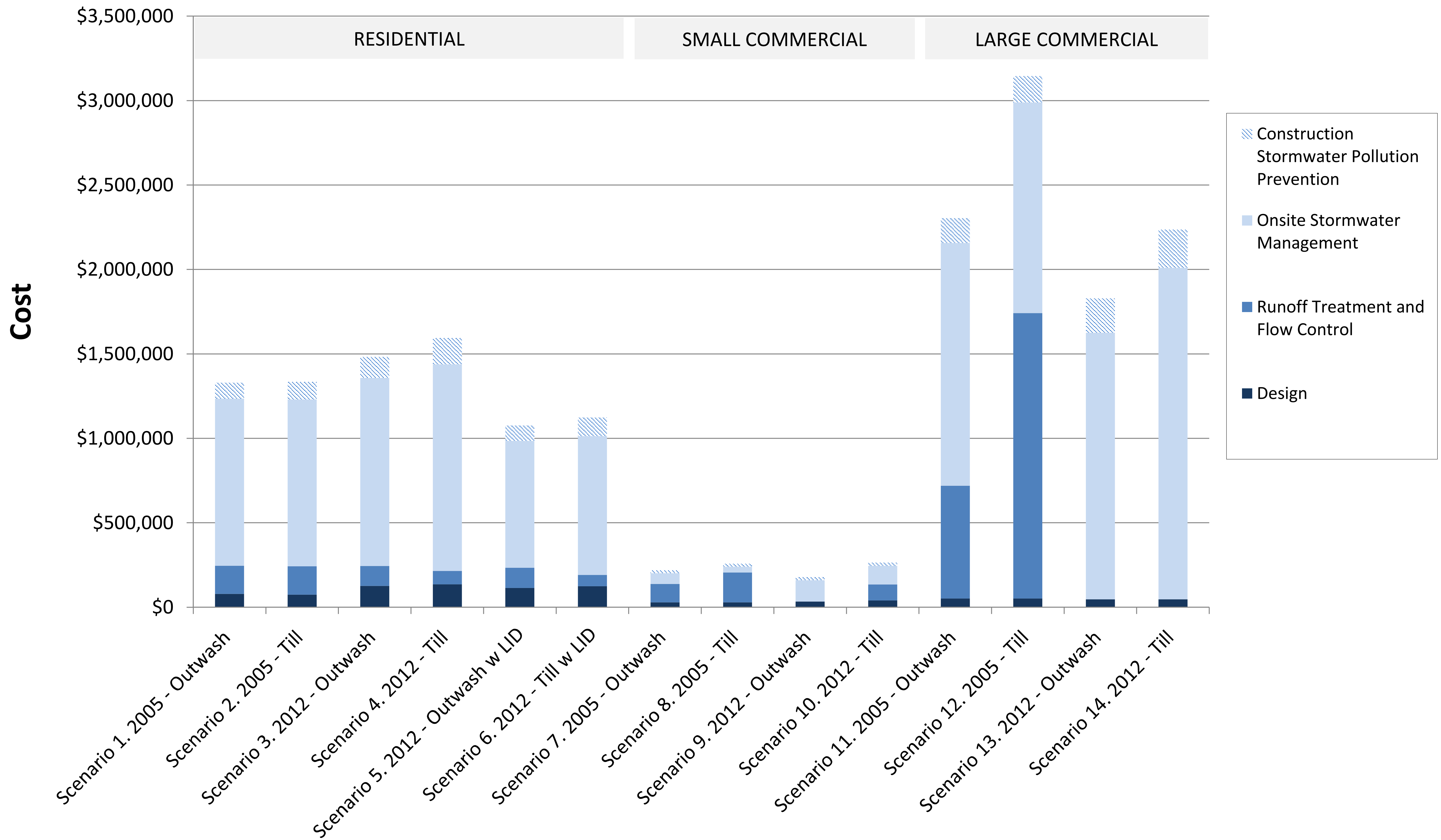


Figure 46. Stacked Bar Chart of Total Costs for All 14 Scenarios without Operation and Maintenance

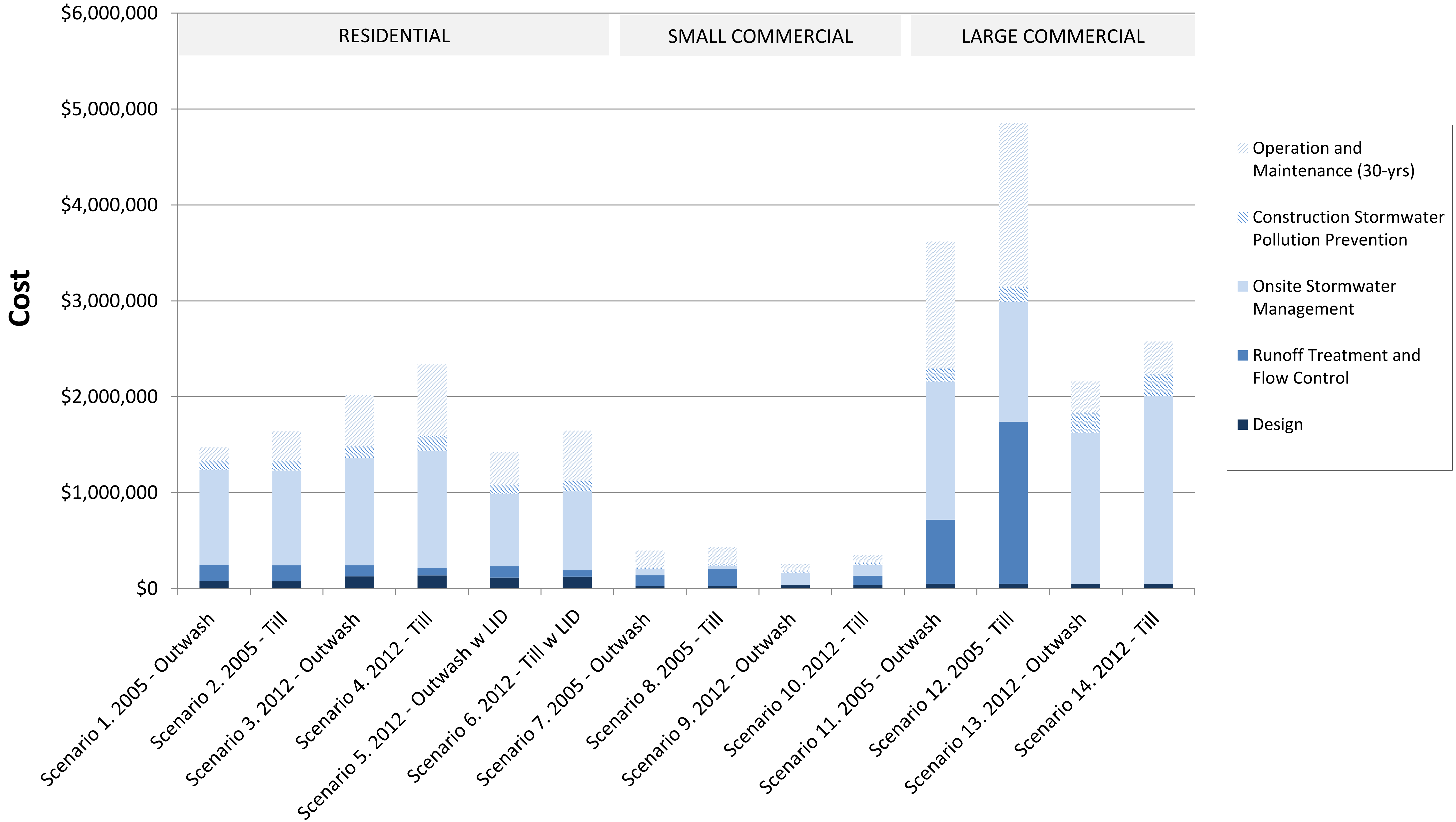


Figure 47. Stacked Bar Chart of Total Costs for All 14 Scenarios

APPENDIX A

Planning Assumptions for Example Site Layouts

Planning Assumptions for Example Site Layouts

Introduction

Tables A-1 and A-2 provide assumptions used in developing layouts for the three single-family residential subdivisions examples and the two commercial examples.

Table A-1. Planning Assumptions for Single-Family Residential Subdivision Scenarios.

Scenario	2005 Requirements; 2012 Requirements Without LID Principles	2012 With LID Principles
	Density Requirements[1]	
Zone	R-1,5.0	R-1,7.0
Min. Density (DU/acre)	4	6.93
Max. Density (DU/acre)	5.73	9.92
Average lot size (sf)[2]	7,602	5,000
	Lot Requirements	
Min. Lot Area (sf)	6,000	3,500
Average Min. Lot Width (ft)	50	45
Average Min. Lot Depth (ft)	100	80
Min. Open Space per Lot (sf)	200	200
	Setback Requirements	
Front Yard Arterial (ft)	25	25
Front Yard at Other (ft)	20	20
Side Yard (ft)	5	5
Rear Yard (ft)	15	15
Max. Building Height (ft)	35	35
	Coverage	
Max. Building Coverage	35%	40%
Exterior Parking Spaces[3]	2	2
Parking Space Size (ft)	8 x 20	8 x 20
	Right-of-way	
ROW Minimum (ft)	50	37
Street Width (ft)	28 (i.e., 2 x 10-ft travel lanes + 8-ft parking lane)	20 (i.e., 2 x 10-ft travel lanes)
Min. Sidewalk (ft)	5 x 2	5 x 1
Planting Strip (ft)[4]	5 x 2 or 1 x 10	5 x 2 or 1 x 10
Parking bulb outs	NA	1 shared space per 4 dwelling units
Curb & Gutter (ft)	1 x 2	1 x 2

Notes:

1. Density calculation based on gross area minus right-of-way and other easements.
2. Calculation based on maximum allowable density, not in municipal code.
3. Spaces in driveway apron, in addition to 2 enclosed spaces
4. Parking bulb-outs were assumed to consume space within the planting strip.

Table A-2. Planning Assumptions for Small and Large Commercial Sites.		
Scenario and Zone	**Small Commercial (Community Business)**	**Large Commercial (Commercial General)**
Zoning Requirements		
Zone	CB	CG
Min. Lot Area per Building Site (sf)	none	none
FAR	4.0	4.0
Lot Requirements		
Min. Lot Area (sf)		
Average Min. Lot Width (ft)	75	50
Average Min. Lot Depth (ft)	100	100
Coverage		
Max. Building Lot Coverage	75%	75%
Setback Requirements		
Front Yard Arterial (ft)	10	20
Side Yard (ft)	10	10
Rear Yard (ft)	10	0
Min. Landscape Setback (ft)	15	15
Base Building Height (ft)	50	20
Parking Use Requirements		
Retail commercial	NA	300 sf/space
Restaurant (on-site consumption)	100 sf/space	100 sf/space

APPENDIX B

Cost Estimating and Unit Costs

Cost Estimating and Unit Costs

Cost Estimates for Each Scenario

This appendix provides cost estimates for each scenario. The cost estimate for each site includes the costs for construction stormwater pollution prevention, permanent stormwater BMPs, design, and O&M. All cost estimates incorporate scenario specific understanding of plausible construction contractor staging, access, requirements, and constraints that would affect the cost for the project. Itemized construction cost estimates for TESC and permanent stormwater BMPs were developed for each scenario based upon sound engineering practice, and quantity calculations that are specific to each BMP in each scenario. All items are assumed to be constructed per the Washington State Department of Transportation Standard Specifications for Road, Bridge, and Municipal Construction, and standard design practices.

Unit Costs

The unit costs for all items included in the cost estimates are provided at the end of this appendix. Standardized unit costs were used in this analysis in order to ensure consistency across the 14 scenarios. The unit costs were primarily derived through analysis of bid tabulations for relevant and recent projects throughout western Washington. Specifically, local projects with stormwater elements (e.g., conveyance, runoff treatment, flow control, bioretention, permeable pavement) were selected and incorporated into this analysis.

“Bottom-up” cost estimates and vendor quotes were used to supplement data from bid tabs. Because available bid tab data is skewed towards public sector projects that are subject to a variety of laws and regulations that tend to increase construction costs compared to private sector projects, the unit costs used in this analysis may be slightly higher than would be experienced for private development. Some private sector unit costs were incorporated in this analysis to offset the influence of public sector bid tabs. The private sector unit costs were weighted equally against the public project unit costs, regardless of the number of data points available for a given item. The names of private projects included in the unit cost are blacked out as this information is considered confidential.

This historic bid-based method applies historical unit costs to quantities of work items to determine a total cost for the item. These unit cost data are adjusted to include inflation. Other factors that should be taken into account include geographic considerations, quantities, item availability, site constraints, permit conditions, and raw material costs. This analysis took into account when quantities were relatively high or low, for example splitting the unit cost of excavation into two categories for small and large quantities. The other factors that influence unit cost are assumed to impact all projects equally, such as the cost of raw materials, and therefore will not affect the comparison of scenarios.

Cost Estimates

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: **1 - Single-Family Residential Subdivision, Outwash Soils, 2005 Requirements**

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management					
Downspout Infiltration Trench/ Full Infiltration Trench (BMP T5.10B)					**$71,598**
Division 1 - General Requirements					
Mobilization			8%	$ 5,304	
Division 2- Earthwork					
Structure Excavation Class B	C.Y.	460	$ 15	$ 6,900	
Haul	C.Y.	340	$ 5	$ 1,700	
Division 4- Bases					
Gravel Backfill for Drain	C.Y.	300	$ 35	$ 10,500	
Trench Backfill	C.Y.	110	$ 12	$ 1,320	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.			$ -	
Underdrain Pipe 4"	L.F.	3,000	$ 11	$ 33,000	
NDS Basin	EA	1	$ 54	$ 54	
Piping	L.F.			$ -	
Drain Pipe 4"	L.F.	620	$ 11	$ 6,820	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	3,000	$ 2	$ 6,000	
HMA Pavement - Driveways					**$92,146**
Division 1 - General Requirements					
Mobilization			8%	$ 6,826	
Division 4- Bases					
Crushed Surfacing Base Course	TON	800	$ 30	$ 24,000	
Division 5- Surface Treatments and Pavements					
Pavement	TON	610	$ 92	$ 56,120	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	2,600	$ 2	$ 5,200	
HMA Pavement - Roadway and Apron					**$227,664**
Division 1 - General Requirements					
Mobilization			8%	$ 16,864	
Division 4- Bases					
Crushed Surfacing Base Course	TON	2,000	$ 30	$ 60,000	
Division 5- Surface Treatments and Pavements					
Pavement	TON	1,500	$ 92	$ 138,000	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	6,400	$ 2	$ 12,800	
Concrete Sidewalk					**$102,900**
Concrete sidewalk	S.Y.	2,100	$ 49	$ 102,900	
Basic Wetpond (BMP T10.10)					**$56,649**
Division 1 - General Requirements					
Mobilization			8%	$ 4,196	
Division 2- Earthwork					
Pond Excavation	C.Y.	850	$ 19	$ 16,150	
Haul	C.Y.	790	$ 5	$ 3,950	
Division 4- Bases					
Trench Backfill	C.Y.	7	$ 12	$ 89	
Crushed Surfacing	C.Y.	2	$ 30	$ 60	
Pond Embankment	C.Y.	66	$ 6	$ 396	
Piping	L.F.			$ -	
Storm Sewer Pipe 12"	L.F.	40	$ 49	$ 1,960	
Flow Control Structure	EA			$ -	
Catch Basin Type 2	EA	1	$ 3,400	$ 3,400	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$ 4,800	$ 4,800	
Stream Bed Cobbles	C.Y.	2	$ 67	$ 114	
Fencing	L.F.	480	$ 21	$ 10,080	
Impermeable Liner	S.Y.	1,700	$ 0.70	$ 1,190	
Plantings-Wetland	S.F.	4,600	$ 0.50	$ 2,300	
Mulch	C.Y.	29	$ 41	$ 1,189	
Compost	C.Y.	43	$ 38	$ 1,635	
Broad-Crested Weir/ Berm	L.F.	92	$ 56	$ 5,141	
Division 8- Miscellaneous Construction					

Infiltration Basin (BMP T7.10)							**$39,444**
Division 1 - General Requirements							
Mobilization				8%	$	2,922	
Division 2- Earthwork							
Pond Excavation	C.Y.	750	$	19	$	14,250	
Haul	C.Y.	470	$	5	$	2,350	
Division 4- Bases							
Trench Backfill	C.Y.	7	$	5	$	37	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Pond Embankment	C.Y.	140	$	6	$	840	
Piping	L.F.				$	-	
Storm Sewer Pipe 12"	L.F.	40	$	49	$	1,960	
Flow Control Structure	EA				$	-	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$	4,800	$	4,800	
Stream Bed Cobbles	C.Y.	2	$	67	$	114	
Fencing	L.F.	340	$	21	$	7,140	
Seeding and Mulching	A.C.	0.17	$	3,300	$	561	
Mulch	C.Y.	46	$	41	$	1,886	
Compost	C.Y.	68	$	38	$	2,584	
Division 8- Miscellaneous Construction							
Turf Soil Quality and Depth (BMP T5.13)							**$342,000**
Soil Quantity and Depth (BMP T5.13)	S.F.	180,000	$	1.90	$	342,000	
Landscape Soil Quality and Depth							**$153,300**
Landscape Soil Quality and Depth	S.F.	21,000	$	7.30	$	153,300	
Conveyance System							**$74,358**
Division 1 - General Requirements							
Mobilization				8%	$	5,508	
Division 2- Earthwork							
Structure Excavation Class B	C.Y.	500	$	15	$	7,500	
Haul	C.Y.	280	$	5	$	1,400	
Division 4- Bases							
Trench Backfill	C.Y.	230	$	5	$	1,150	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Piping					$	-	
Storm Sewer Pipe 8"	L.F.	1,300	$	36	$	46,800	
Catch Basin Type 1	EA	10	$	1,200	$	12,000	
Division 8- Miscellaneous Construction							
Onsite Stormwater Management Subtotal							**$989,607**
Runoff Treatment and Flow Control Subtotal							**$170,451**
Permanent Stormwater Management Subtotal							**$1,160,058**
Temporary Erosion and Sediment Control							
Division 1 - General Requirements							
Mobilization				8%	$	7,054	
Division 2- Earthwork							
Pond Excavation	C.Y.	250	$	19	$	4,750	
Haul	C.Y.	390	$	5	$	1,950	
Channel Excavation	C.Y.	150	$	15	$	2,250	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Storm Sewer Pipe 6"	L.F.	590	$	25	$	14,750	
Division 8- Miscellaneous Construction							
Seeding and Mulching	AC	8	$	3,300	$	26,400	
Riprap	C.Y.	2	$	110	$	220	
High Visibility Fencing	L.F.	180	$	10	$	1,800	
Stabilized Construction Entrance	S.Y.	330	$	19	$	6,270	
Silt Fence	L.F.	750	$	3	$	1,875	
Wheel Wash	EA	1	$	2,600	$	2,600	
Inlet Protection	EA	2	$	59	$	118	
Interceptor swale geosynthetic liner	S.Y.	910	$	3	$	2,730	
Erosion and Sediment Control (ESC) Lead	DAY	180	$	70	$	12,600	
Extra materials on hand - 5% of TESC materials	L.S.			5%	$	3,285.65	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.			10%	$	6,571.30	
Temporary Erosion and Sediment Control Subtotal							**$95,224**

Operations and Maintenance Costs								
Wet Pond	S.F.	1,100	$	9	$	9,911		
Catch Basin-Residential	EA	10	$	1,332	$	13,319		
Pavement	S.F.	99,000	$	1.16	$	114,840		
Infiltration Basin	S.F.	3,136	$	3.36	$	10,537		
Operations and Maintenance Subtotal								**$148,607**
Design Costs								
Engineering Design Plans and Specifications	LS				$	66,000		
Geotechnical and Hydrogeological	LS				$	13,000		
Design Subtotal								**$79,000**
Grand Total								**$1,482,888**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: **2 - Single-Family Residential Subdivision, Till Soils, 2005 Requirements**

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management					
Downspout Dipsersion Trench					**$78,162**
Division 1 - General Requirements					
Mobilization			8%	$ 5,790	
Division 2- Earthwork					
Structure Excavation Class B	C.Y.	330	$ 15	$ 4,950	
Haul	C.Y.	150	$ 5	$ 750	
Division 4- Bases					
Gravel Backfill for Drain	C.Y.	150	$ 35	$ 5,250	
Trench Backfill	C.Y.	170	$ 12	$ 2,040	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.			$ -	
Underdrain Pipe 4"	L.F.	1,370	$ 11	$ 15,070	
Inlet Structure	EA			$ -	
NDS Basin	EA	80	$ 54	$ 4,320	
Piping	L.F.			$ -	
Drain Pipe 4"	L.F.	1,760	$ 11	$ 19,360	
Division 8- Miscellaneous Construction					
Level Spreader Board	L.F.	1,370	$ 14	$ 19,113	
Filter Fabric/Geotextile	S.Y.	760	$ 2	$ 1,520	
HMA Pavement-Driveway					**$103,313**
Division 1 - General Requirements					
Mobilization			8%	$ 7,653	
Division 4- Bases					
Gravel Reservoir Course	TON	580	$ 25	$ 14,500	
Crushed Surfacing Base Course	TON	760	$ 30	$ 22,800	
Division 5- Surface Treatments and Pavements					
Pavement	TON	580	$ 92	$ 53,360	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	2,500	$ 2	$ 5,000	
HMA Pavement-Roadway					**$227,664**
Division 1 - General Requirements					
Mobilization			8%	$ 16,864	
Division 4- Bases					
Crushed Surfacing Base Course	TON	2,000	$ 30	$ 60,000	
Division 5- Surface Treatments and Pavements					
Pavement	TON	1,500	$ 92	$ 138,000	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	6,400	$ 2	$ 12,800	
Concrete Sidewalk					**$102,900**
Concrete sidewalk	S.Y.	2,100	$ 49	$ 102,900	

Combined Detention and Wetpool (BMP T10.40)							**$106,373**
Division 1 - General Requirements							
Mobilization				8%	$	7,423	
Division 2- Earthwork							
Pond Excavation	C.Y.	2,560	$	19	$	48,640	
Haul	C.Y.	2,420	$	5	$	12,100	
Division 4- Bases							
Trench Backfill	C.Y.	7	$	5	$	37	
Crushed Surfacing	C.Y.	12	$	30	$	360	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Pond Embankment	C.Y.	81	$	6	$	486	
Piping	L.F.				$	-	
Storm Sewer Pipe 12"	L.F.	40	$	49	$	1,960	
Flow Control Structure	EA	12			$	-	
Catch Basin Type 2	EA	1	$	3,400	$	3,400	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$	4,800	$	4,800	
Stream Bed Cobbles	C.Y.	2	$	67	$	114	
Fencing	L.F.	580	$	21	$	12,180	
Impermeable Liner	S.Y.	1,400	$	1	$	980	
Plantings-Wetland	S.F.	7,000	$	0.50	$	3,500	
Mulch	C.Y.	43	$	41	$	1,763	
Compost	C.Y.	65	$	38	$	2,470	
Broad-Crested Weir/ Berm	L.F.	110	$	56	$	6,160	
Turf Soil Quality and Depth (BMP T5.13)							**$323,000**
Soil Quantity and Depth (BMP T5.13)	S.F.	170,000	$	1.90	$	323,000	
Landscape Soil Quality and Depth							**$153,300**
Landscape Soil Quality and Depth	S.F.	21,000	$	7.30	$	153,300	
Conveyance System							**$67,662**
Division 1 - General Requirements							
Mobilization				8%	$	5,012	
Division 2- Earthwork							
Structure Excavation Class B	C.Y.	430	$	15	$	6,450	
Haul	C.Y.	230	$	5	$	1,150	
Division 4- Bases							
Trench Backfill	C.Y.	210	$	5	$	1,050	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Piping					$	-	
Storm Sewer Pipe 8"	L.F.	1,200	$	36	$	43,200	
Catch Basin Type 1	EA	9	$	1,200	$	10,800	
Division 8- Miscellaneous Construction							
Onsite Stormwater Management Subtotal							**$988,339**
Runoff Treatment and Flow Control Subtotal							**$174,035**
Permanent Stormwater Management Subtotal							**$1,162,374**
Temporary Erosion and Sediment Control							
Division 1 - General Requirements							
Mobilization				8%	$	7,676	
Division 2- Earthwork							
Pond Excavation	C.Y.	540	$	19	$	10,260	
Haul	C.Y.	680	$	5	$	3,400	
Channel Excavation	C.Y.	150	$	15	$	2,250	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Storm Sewer Pipe 6"	L.F.	590	$	25	$	14,750	
Division 8- Miscellaneous Construction							
Seeding and Mulching	AC	8	$	3,300	$	26,400	
High Visibility Fencing	L.F.	180	$	10	$	1,800	
Stabilized Construction Entrance	S.Y.	330	$	19	$	6,270	
Silt Fence	L.F.	760	$	2.50	$	1,900	
Wheel Wash	EA	1	$	2,600	$	2,600	
Inlet Protection	EA	2	$	59	$	118	
Interceptor swale geosynthetic liner	S.Y.	910	$	3	$	2,730	
Erosion and Sediment Control (ESC) Lead	DAY	180	$	70	$	12,600	
Extra materials on hand - 5% of TESC materials	L.S.			5%	$	3,623.90	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.			10%	$	7,247.80	
Temporary Erosion and Sediment Control Subtotal							**$103,626**

Operations and Maintenance Costs							
Wet Pond	S.F.	20,000	$	9	$	180,200	
Catch Basin-Residential	EA	9	$	1,332	$	11,987	
Pavement	S.F.	98,000	$	1.16	$	113,680	
Operations and Maintenance Subtotal							**$305,867**
Design Costs							
Engineering Design Plans and Specifications	LS				$	65,000	
Geotechnical and Hydrogeological	LS				$	9,000	
Design Subtotal							**$74,000**
Grand Total							**$1,645,867**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: **3 - Single-Family Residential Subdivision, Outwash Soils, 2012 Requirements**

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management					
Downspout Infiltration Trench/ Full Infiltration Trench (BMP T5.10B)					**$93,651**
Division 1 - General Requirements					
Mobilization			8%	$ 6,937	
Division 2- Earthwork					
Structure Excavation Class B	C.Y.	480	$ 15	$ 7,200	
Haul	C.Y.	370	$ 5	$ 1,850	
Division 4- Bases					
Gravel Backfill for Drain	C.Y.	300	$ 35	$ 10,500	
Trench Backfill	C.Y.	110	$ 12	$ 1,320	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.			$ -	
Underdrain Pipe 4"	L.F.	3,100	$ 11	$ 34,100	
Inlet Structure	EA			$ -	
NDS Basin	EA	86	$ 54	$ 4,644	
Piping	L.F.			$ -	
Drain Pipe 4"	L.F.	1,900	$ 11	$ 20,900	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	3,100	$ 2	$ 6,200	
Bioretention (BMP T7.30)					**$118,932**
Division 1 - General Requirements					
Mobilization			8%	$ 8,810	
Division 2- Earthwork					
Pond Excavation	C.Y.	480	$ 19	$ 9,120	
Haul	C.Y.	480	$ 5	$ 2,400	
Division 4- Bases					
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Division 8- Miscellaneous Construction					
Geotextile	S.Y.	660	$ 2	$ 1,320	
Check dam/weir	L.F.	100	$ 56	$ 5,600	
Plantings-Bioretention	S.F.	5,100	$ 5	$ 25,500	
Mulch	C.Y.	1,300	$ 41	$ 53,300	
Bioretention Soil	C.Y.	290	$ 44	$ 12,760	
Stream Bed Gravel	C.Y.	2	$ 61	$ 122	
HMA Pavement- Driveway					**$86,615**
Division 1 - General Requirements					
Mobilization			8%	$ 6,929	
Division 4- Bases					
Gravel Reservoir Course	TON	3	$ 25	$ 75	
Crushed Surfacing Base Course	TON	810	$ 30	$ 24,300	
Division 5- Surface Treatments and Pavements					
Pavement	TON	620	$ 92	$ 57,040	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	2,600	$ 2	$ 5,200	
HMA Pavement- Roadway					**$210,800**
Division 1 - General Requirements					
Mobilization			8%	$ 16,864	
Division 4- Bases					
Crushed Surfacing Base Course	TON	2,000	$ 30	$ 60,000	
Division 5- Surface Treatments and Pavements					
Pavement	TON	1,500	$ 92	$ 138,000	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	6,400	$ 2	$ 12,800	
Permeable Pavement Sidewalk (BMP T5.15) (Concrete)					**$145,130**
Division 1 - General Requirements					
Mobilization			8%	$ 10,750	
Division 4- Bases					
Gravel Reservoir Course	TON	440	$ 25	$ 11,000	
Division 5- Surface Treatments and Pavements					
Pavement	S.Y.	2,100	$ 54	$ 113,400	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe 8"	L.F.	20	$ 22	$ 440	
Division 8- Miscellaneous Construction					
Internal check dams	L.F.	1,060	$ 9	$ 9,540	

Basic Wetpond (BMP T10.10)							**$27,389**
Division 1 - General Requirements							
Mobilization				8%	$	1,904	
Division 2- Earthwork							
Pond Excavation	C.Y.	250	$	19	$	4,750	
Haul	C.Y.	200	$	5	$	1,000	
Division 4- Bases							
Trench Backfill	C.Y.	7	$	12	$	89	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Pond Embankment	C.Y.	55	$	6	$	330	
Piping	L.F.				$	-	
Storm Sewer Pipe 12"	L.F.	40	$	49	$	1,960	
Flow Control Structure	EA				$	-	
Catch Basin Type 2	EA	1	$	3,400	$	3,400	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$	4,800	$	4,800	
Stream Bed Cobbles	C.Y.	2	$	67	$	114	
Fencing	L.F.	220	$	21	$	4,620	
Impermeable Liner	S.Y.	260	$	0.70	$	182	
Plantings-Wetland	S.F.	2,300	$	0.50	$	1,150	
Mulch	C.Y.	14	$	41	$	574	
Compost	C.Y.	22	$	38	$	836	
Broad-Crested Weir/ Berm	L.F.	30	$	56	$	1,680	
Division 8- Miscellaneous Constructior							
Infiltration Basin (BMP T7.10)							**$13,365**
Division 1 - General Requirements							
Mobilization				8%	$	990	
Division 2- Earthwork							
Pond Excavation	C.Y.	-	$	19	$	-	
Haul	C.Y.	-	$	5	$	-	
Division 4- Bases							
Trench Backfill	C.Y.	7	$	5	$	37	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Pond Embankment	C.Y.	25	$	6	$	150	
Piping	L.F.				$	-	
Storm Sewer Pipe 12"	L.F.	40	$	49	$	1,960	
Flow Control Structure	EA				$	-	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$	4,800	$	4,800	
Stream Bed Cobbles	C.Y.	2	$	67	$	114	
Fencing	L.F.	180	$	21	$	3,780	
Seeding and Mulching	AC	0.05	$	3,300	$	165	
Mulch	C.Y.	13	$	41	$	533	
Compost	C.Y.	19	$	44	$	836	
Division 8- Miscellaneous Constructior							
Turf Soil Quality and Depth (BMP T5.13)							**$342,000**
Soil Quantity and Depth (BMP T5.13)	S.F.	180,000	$	1.90	$	342,000	
Landscape Soil Quality and Depth							**$116,800**
Landscape Soil Quality and Depth	S.F.	16,000	$	7.30	$	116,800	
Conveyance System							**$80,298**
Division 1 - General Requirements							
Mobilization				8%	$	5,948	
Division 2- Earthwork							
Structure Excavation Class B	C.Y.	540	$	15	$	8,100	
Haul	C.Y.	290	$	5	$	1,450	
Division 4- Bases							
Trench Backfill	C.Y.	240	$	5	$	1,200	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Piping					$	-	
Storm Sewer Pipe 8"	L.F.	1,400	$	36	$	50,400	
Catch Basin Type 1	EA	11	$	1,200	$	13,200	
Catch Basin Type 2	EA	-	$	3,400	$	-	
Onsite Stormwater Management Subtotal							**$1,113,928**
Runoff Treatment and Flow Control Subtotal							**$121,052**
Permanent Stormwater Management Subtotal							**$1,234,980**

Temporary Erosion and Sediment Control							
Division 1 - General Requirements							
Mobilization				8%	$	9,246	
Division 2- Earthwork							
Pond Excavation	C.Y.	250	$	19	$	4,750	
Haul	C.Y.	390	$	5	$	1,950	
Channel Excavation	C.Y.	150	$	15	$	2,250	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Storm Sewer Pipe 6"	L.F.	620	$	25	$	15,510	
Division 8- Miscellaneous Constructio							
Seeding and Mulching	AC	8	$	3,300	$	26,730	
High Visibility Fencing	L.F.	180	$	10	$	1,800	
Wattle	L.F.	1,800	$	3	$	5,400	
Stabilized Construction Entrance	S.Y.	930	$	19	$	17,670	
Silt Fence	L.F.	750	$	2.50	$	1,875	
Wheel Wash	EA	1	$	2,600	$	2,600	
Inlet Protection	EA	2	$	59	$	118	
Interceptor swale geosynthetic liner	S.Y.	910	$	3	$	2,730	
Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	444	$	10	$	4,444	
Erosion and Sediment Control (ESC) Lead	DAY	198	$	77	$	15,246	
Extra materials on hand - 5% of TESC materials	L.S.			5%	$	4,169.15	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.			10%	$	8,338.30	
Temporary Erosion and Sediment Control Subtotal							**$124,827**
Operations and Maintenance Costs							
Bioretention	S.F.	5,100	$	22	$	111,384	
Wet Pond	S.F.	2,340	$	9	$	21,083	
Catch Basin-Residential	EA	11	$	1,332	$	14,651	
Permeable Pavement Sidewalk-Residential	S.F.	19,000	$	15	$	290,700	
Permeable Pavement-Street and Parking	S.F.	81,000.00	$	1.20	$	97,200	
Infiltration Basin	S.F.	225	$	3.36	$	756	
Operations and Maintenance Subtotal							**$535,774**
Design Costs							
Engineering Design Plans and Specifications	LS				$	76,000	
Geotechnical and Hydrogeological	LS				$	50,000	
Design Subtotal							**$126,000**
Grand Total							**$2,021,582**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: **4 - Single-Family Residential Subdivision, Till Soils, 2012 Requirements**

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management					
Bioretention (BMP T7.30)					**$104,197**
Division 1 - General Requirements					
Mobilization			8%	$ 7,718	
Division 2- Earthwork					
Pond Excavation	C.Y.	620	$ 19	$ 11,780	
Haul	C.Y.	590	$ 5	$ 2,950	
Division 4- Bases					
Gravel Backfill for Drain	C.Y.		$ 35	$ -	
Trench Backfill	C.Y.	30	$ 12	$ 360	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Piping	L.F.			$ -	
Storm Sewer Pipe 6"	L.F.	820	$ 25	$ 20,500	
Division 8- Miscellaneous Construction					
Geotextile	S.Y.	930	$ 2	$ 1,860	
Check dam/weir	EA		$ 56	$ -	
Plantings-Bioretention	S.F.	8,300	$ 5	$ 41,500	
Mulch	C.Y.	77	$ 41	$ 3,157	
Bioretention Soil	C.Y.	310	$ 44	$ 13,640	
Stream Bed Gravel	C.Y.	12	$ 61	$ 732	
Permeable Pavement (BMP T5.15) (Concrete)- Driveway					**$99,793**
Division 1 - General Requirements					
Mobilization			8%	$ 7,392	
Division 4- Bases					
Gravel Reservoir Course	TON	1,100	$ 25	$ 27,500	
Division 5- Surface Treatments and Pavements					
Pavement	S.Y.	1,100	$ 48	$ 52,800	
Division 8- Miscellaneous Construction					
Internal check dams	L.F.	789	$ 9	$ 7,101	
Filter Fabric/Geotextile	S.Y.	2,500	$ 2	$ 5,000	
Permeable Pavement (BMP T5.15) (Asphalt)-Roadway					**$395,937**
Division 1 - General Requirements					
Mobilization			8%	$ 29,329	
Division 4- Bases					
Gravel Leveling Course	TON	670	$ 38	$ 25,460	
Gravel Reservoir Course	TON	3,600	$ 25	$ 90,000	
Sand Treatment Layer	TON		$ 27	$ -	
Division 5- Surface Treatments and Pavements					
Pavement	TON	2,100	$ 109	$ 228,900	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.			$ -	
Underdrain Pipe 4"	L.F.		$ 11	$ -	
Underdrain Pipe 8"	L.F.	40	$ 22	$ 880	
Division 8- Miscellaneous Construction					
Internal check dams	S.Y.	952	$ 9	$ 8,568	
Filter Fabric/Geotextile	S.Y.	6,400	$ 2	$ 12,800	

Permeable Pavement (BMP T5.15) (Concrete)- Sidewalk							**$156,335**
Division 1 - General Requirements							
Mobilization				8%	$	11,580	
Division 4- Bases							
Gravel Leveling Course	TON		$	38	$	-	
Gravel Reservoir Course	TON	890	$	25	$	22,250	
Sand Treatment Layer	TON		$	27	$	-	
Division 5- Surface Treatments and Pavements							
Pavement	S.Y.	2,100	$	54	$	113,400	
Division 8- Miscellaneous Construction							
Internal check dams	S.Y.	545	$	9	$	4,905	
Filter Fabric/Geotextile	S.Y.	2,100	$	2	$	4,200	
Combined Detention and Wetpool (BMP T10.40)							**$79,704**
Division 1 - General Requirements							
Mobilization				8%	$	5,904	
Division 2- Earthwork							
Pond Excavation	C.Y.	1,460	$	19	$	27,740	
Haul	C.Y.	1,020	$	5	$	5,100	
Division 4- Bases							
Trench Backfill	C.Y.	7	$	5	$	37	
Crushed Surfacing	C.Y.	12	$	30	$	360	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Pond Embankment	C.Y.	320	$	6	$	1,920	
Water Quality Berm	C.Y.		$	6	$	-	
Piping	L.F.				$	-	
Storm Sewer Pipe 12"	L.F.	40	$	49	$	1,960	
Flow Control Structure	EA				$	-	
Catch Basin Type 2	EA	1	$	3,400	$	3,400	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$	4,800	$	4,800	
Stream Bed Cobbles	C.Y.	2	$	67	$	114	
Fencing	L.F.	570	$	21	$	11,970	
Impermeable Liner	S.Y.	2,600	$	0.70	$	1,820	
Plantings-Wetland	S.F.	6,600	$	0.50	$	3,300	
Mulch	C.Y.	41	$	41	$	1,681	
Compost	C.Y.	61	$	38	$	2,318	
Broad-Crested Weir/ Berm	L.F.	130	$	56	$	7,280	
Turf Soil Quality and Depth (BMP T5.13)							**$323,000**
Soil Quantity and Depth (BMP T5.13)	S.F.	170,000	$	1.90	$	323,000	
Landscape Soil Quality and Depth							**$94,900**
Landscape Soil Quality and Depth	S.F.	13,000	$	7.30	$	94,900	
Conveyance System							**$7,223**
Division 1 - General Requirements							
Mobilization				8%	$	535	
Division 2- Earthwork							
Structure Excavation Class B	C.Y.	32	$	15	$	480	
Haul	C.Y.	20	$	5	$	100	
Division 4- Bases							
Trench Backfill	C.Y.	12	$	5	$	60	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits							
Piping					$	-	
Storm Sewer Pipe 8"	L.F.	68	$	36	$	2,448	
Catch Basin Type 1	EA	3	$	1,200	$	3,600	
Division 8- Miscellaneous Construction							
Onsite Stormwater Management Subtotal							**$1,174,162**
Runoff Treatment and Flow Control Subtotal							**$86,927**
Permanent Stormwater Management Subtotal							**$1,261,089**

Temporary Erosion and Sediment Control						
Division 1 - General Requirements						
Mobilization				8%	$ 11,546	
Division 2- Earthwork						
Pond Excavation	C.Y.	540	$	19	$ 10,260	
Haul	C.Y.	680	$	5	$ 3,400	
Channel Excavation	C.Y.	150	$	15	$ 2,250	
Division 4- Bases						
Trench Backfill	C.Y.	-	$	5	$ -	
Crushed Surfacing	C.Y.	-	$	30	$ -	
Gravel Reservoir Course	C.Y.		$	25	$ -	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
Storm Sewer Pipe 6"	L.F.	620	$	25	$ 15,510	
Division 8- Miscellaneous Construction						
Seeding and Mulching	AC	8	$	3,300	$ 26,400	
High Visibility Fencing	L.F.	180	$	10	$ 1,800	
Geotextile / Filter Fabric	S.Y.	1,400	$	2	$ 2,800	
Wattle	L.F.	1,800	$	3	$ 5,400	
Stabilized Construction Entrance	S.Y.	1,100	$	19	$ 20,900	
Silt Fence	L.F.	800	$	2.50	$ 2,000	
Wheel Wash	EA	1	$	2,600	$ 2,600	
Inlet Protection	EA	2	$	59	$ 118	
Interceptor swale geosynthetic liner	S.Y.	910	$	3	$ 2,730	
Erosion and Sediment Control (ESC) Lead	DAY	180	$	77	$ 13,860	
Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	1,987	$	10	$ 19,870	
Extra materials on hand - 5% of TESC materials	L.S.			5%	$ 4,808.41	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.			10%	$ 9,616.82	
Temporary Erosion and Sediment Control Subtotal						**$155,870**

Operations and Maintenance Costs						
Bioretention	S.F.	8,300	$	22	$ 181,272	
Wet Pond	S.F.	19,046	$	9	$ 171,604	
Detention Pond	S.F.		$	9	$ -	
Catch Basin-Residential	EA	3	$	1,332	$ 3,996	
Permeable Pavement Sidewalk-Residential	S.F.	19,000	$	15	$ 290,700	
Permeable Pavement-Street and Parking	S.F.	80,000	$	1.20	$ 96,000	
Operations and Maintenance Subtotal						**$743,572**

Design Costs						
Engineering Design Plans and Specifications	LS				$ 86,000	
Geotechnical and Hydrogeological	LS				$ 50,000	
Design Subtotal						**$136,000**
Grand Total						**$2,296,531**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: **5 - Single-Family Residential Subdivision, Outwash Soils, 2012 Requirements with LID Principles**

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management					
Downspout Infiltration Trench/ Full Infiltration Trench (BMP T5.10B)					**$83,102**
Division 1 - General Requirements					
Mobilization			8%	$ 6,156	
Division 2- Earthwork					
Structure Excavation Class B	C.Y.	410	$ 15	$ 6,150	
Haul	C.Y.	310	$ 5	$ 1,550	
Division 4- Bases					
Gravel Backfill for Drain	C.Y.	250	$ 35	$ 8,750	
Trench Backfill	C.Y.	96	$ 12	$ 1,152	
Division 5- Surface Treatments and Pavements					
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.			$ -	
Underdrain Pipe 4"	L.F.	2,600	$ 11	$ 28,600	
Inlet Structure	EA			$ -	
NDS Basin	EA	86	$ 54	$ 4,644	
Piping	L.F.			$ -	
Drain Pipe 4"	L.F.	1,900	$ 11	$ 20,900	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	2,600	$ 2	$ 5,200	
Bioretention (BMP T7.30)					**$101,991**
Division 1 - General Requirements					
Mobilization			8%	$ 7,555	
Division 2- Earthwork					
Pond Excavation	C.Y.	310	$ 19	$ 5,890	
Haul	C.Y.	310	$ 5	$ 1,550	
Division 4- Bases					
Trench Backfill	C.Y.	0	$ 12	$ 4	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Piping	L.F.			$ -	
Storm Sewer Pipe 6"	L.F.	10	$ 25	$ 250	
Outlet Structure				$ -	
Type I Catch Basin	EA	1	$ 1,200	$ 1,200	
Division 8- Miscellaneous Construction					
Geotextile	S.Y.	430	$ 2	$ 860	
Check dam/weir	EA	8	$ 56	$ 420	
Plantings-Bioretention	S.F.	4,700	$ 5	$ 23,500	
Mulch	C.Y.	1,200	$ 41	$ 49,200	
Bioretention Soil	C.Y.	260	$ 44	$ 11,440	
Stream Bed Gravel	C.Y.	2	$ 61	$ 122	
HMA Pavement - Driveway					**$81,626**
Division 1 - General Requirements					
Mobilization			8%	$ 6,046	
Division 4- Bases					
Crushed Surfacing Base Course	TON	710	$ 30	$ 21,300	
Division 5- Surface Treatments and Pavements					
Pavement	TON	540	$ 92	$ 49,680	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	2,300	$ 2	$ 4,600	
HMA Pavement - Roadway and Apron					**$148,349**
Division 1 - General Requirements					
Mobilization			8%	$ 10,989	
Division 4- Bases					
Crushed Surfacing Base Course	TON	1,300	$ 30	$ 39,000	
Division 5- Surface Treatments and Pavements					
Pavement	TON	980	$ 92	$ 90,160	
Division 8- Miscellaneous Construction					
Filter Fabric/Geotextile	S.Y.	4,100	$ 2	$ 8,200	

Permeable Pavement (BMP T5.15) (Concrete) - Sidewalk					**$65,956**
Division 1 - General Requirements					
Mobilization			8%	$ 4,886	
Division 4- Bases					
Gravel Reservoir Course	TON	204	$ 25	$ 5,100	
Division 5- Surface Treatments and Pavements					
Pavement	S.Y.	950	$ 54	$ 51,300	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.	540		$ -	
Underdrain Pipe 4"	L.F.	20	$ 11	$ 220	
Division 8- Miscellaneous Construction					
Internal check dams	S.Y.	490	$ 9	$ 4,410	
Filter Fabric/Geotextile	S.Y.	20	$ 2	$ 40	
Basic Wetpond (BMP T10.10)					**$27,523**
Division 1 - General Requirements					
Mobilization			8%	$ 2,039	
Division 2- Earthwork					
Pond Excavation	C.Y.	250	$ 19	$ 4,750	
Haul	C.Y.	200	$ 5	$ 1,000	
Division 4- Bases					
Trench Backfill	C.Y.	7	$ 12	$ 89	
Division 5- Surface Treatments and Pavements					
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Pond Embankment	C.Y.	55	$ 6	$ 330	
Piping	L.F.			$ -	
Storm Sewer Pipe 12"	L.F.	40	$ 49	$ 1,960	
Flow Control Structure	EA			$ -	
Catch Basin Type 2	EA	1	$ 3,400	$ 3,400	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$ 4,800	$ 4,800	
Stream Bed Cobbles	C.Y.	2	$ 67	$ 114	
Fencing	L.F.	220	$ 21	$ 4,620	
Impermeable Liner	S.Y.	260	$ 0.70	$ 182	
Plantings-Wetland	S.F.	2,300	$ 0.50	$ 1,150	
Mulch	C.Y.	14	$ 41	$ 574	
Compost	C.Y.	22	$ 38	$ 836	
Broad-Crested Weir/ Berm	L.F.	30	$ 56	$ 1,680	
Division 8- Miscellaneous Construction					
Infiltration Basin (BMP T7.10)					**$15,804**
Division 1 - General Requirements					
Mobilization			8%	$ 1,170.63	
Division 2- Earthwork					
Pond Excavation	C.Y.	110	$ 19	$ 2,090	
Haul	C.Y.	80	$ 5	$ 400	
Division 4- Bases					
Trench Backfill	C.Y.	7	$ 5	$ 37	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Pond Embankment	C.Y.	24	$ 6	$ 144	
Piping	L.F.			$ -	
Storm Sewer Pipe 12"	L.F.	40	$ 49	$ 1,960	
Flow Control Structure	EA			$ -	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$ 4,800	$ 4,800	
Stream Bed Cobbles	C.Y.	2	$ 67	$ 114	
Fencing	L.F.	180	$ 21	$ 3,780	
Seeding and Mulching	AC	0.04	$ 3,300	$ 132	
Mulch	C.Y.	12	$ 41	$ 492	
Compost	C.Y.	18	$ 38	$ 684	
Division 8- Miscellaneous Construction					
Turf Soil Quality and Depth (BMP T5.13)					**$182,400**
Soil Quantity and Depth (BMP T5.13)	S.F.	96,000	$ 1.90	$ 182,400	
Landscape Soil Quality and Depth					**$87,600**
Landscape Soil Quality and Depth	S.F.	12,000	$ 7.30	$ 87,600	
Conveyance System					**$80,568**
Division 1 - General Requirements					
Mobilization			8%	$ 5,968	
Division 2- Earthwork					
Structure Excavation Class B	C.Y.	490	$ 15	$ 7,350	
Haul	C.Y.	280	$ 5	$ 1,400	
Division 4- Bases					
Trench Backfill	C.Y.	210	$ 5	$ 1,050	
Division 5- Surface Treatments and Pavements					
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Piping				$ -	
Storm Sewer Pipe 8"	L.F.	1,200	$ 36	$ 43,200	
Catch Basin Type 1	EA	18	$ 1,200	$ 21,600	

Onsite Stormwater Management Subtotal						**$751,024**
Runoff Treatment and Flow Control Subtotal						**$123,895**
Permanent Stormwater Management Subtotal						**$874,919**

Temporary Erosion and Sediment Control

Division 1 - General Requirements					
Mobilization			8%	$ 6,743	
Division 2- Earthwork					
Pond Excavation	C.Y.	120	$ 19	$ 2,280	
Haul	C.Y.	220	$ 5	$ 1,100	
Channel Excavation	C.Y.	100	$ 15	$ 1,500	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Storm Sewer Pipe 6"	L.F.	480	$ 25	$ 12,000	
Division 8- Miscellaneous Construction					
Seeding and Mulching	AC	5	$ 3,300	$ 16,500	
High Visibility Fencing	L.F.	110	$ 10	$ 1,100	
Geotextile / Filter Fabric	S.Y.	300	$ 2	$ 600	
Wattle	L.F.	1,300	$ 3	$ 3,900	
Stabilized Construction Entrance	S.Y.	740	$ 19	$ 14,060	
Silt Fence	L.F.	570	$ 3	$ 1,425	
Wheel Wash	EA	1	$ 2,600	$ 2,600	
Inlet Protection	EA	2	$ 59	$ 118	
Interceptor swale geosynthetic liner	S.Y.	640	$ 3	$ 1,920	
Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	245	$ 10	$ 2,454	
Erosion and Sediment Control (ESC) Lead	DAY	180	$ 77	$ 13,860	
Extra materials on hand - 5% of TESC materials	L.S.		5%	$ 2,955.15	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.		10%	$ 5,910.30	
Temporary Erosion and Sediment Control Subtotal					**$91,025**

Operations and Maintenance Costs

Bioretention	S.F.	4,700	$ 22	$ 102,648	
Wet Pond	S.F.	2,300	$ 9	$ 20,723	
Catch Basin-Residential	EA	18	$ 1,332	$ 23,974	
Permeable Pavement Sidewalk-Residential	S.F.	8,600	$ 15	$ 131,580	
Pavement	S.F.	58,000	$ 1.16	$ 67,280	
Infiltration Basin	S.F.	196	$ 3	$ 659	
Operations and Maintenance Subtotal					**$346,863**

Design Costs

Engineering Design Plans and Specifications	LS			$ 76,000	
Geotechnical and Hydrogeological	LS			$ 38,000	
Design Subtotal					**$114,000**
Grand Total					**$1,426,807**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: 6 - Single-Family Residential Subdivision, Till Soils, 2012 Requirements with LID Principles

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management					
Bioretention (BMP T7.30)					**$94,078**
Division 1 - General Requirements					
Mobilization			8%	$ 6,969	
Division 2- Earthwork					
Pond Excavation	C.Y.	560	$ 19	$ 10,640	
Haul	C.Y.	530	$ 5	$ 2,650	
Division 4- Bases					
Trench Backfill	C.Y.	30	$ 12	$ 360	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Piping	L.F.			$ -	
Storm Sewer Pipe 6"	L.F.	820	$ 25	$ 20,500	
Division 8- Miscellaneous Construction					
Geotextile	S.Y.	800	$ 2	$ 1,600	
Plantings-Bioretention	S.F.	7,200	$ 5	$ 36,000	
Mulch	C.Y.	67	$ 41	$ 2,747	
Bioretention Soil	C.Y.	270	$ 44	$ 11,880	
Stream Bed Gravel	C.Y.	12	$ 61	$ 732	
Permeable Pavement (BMP T5.15) (Concrete)- Driveway					**$95,538**
Division 1 - General Requirements					
Mobilization			8%	$ 7,077	
Division 4- Bases					
Gravel Reservoir Course	TON	940	$ 25	$ 23,500	
Division 5- Surface Treatments and Pavements					
Pavement	S.Y.	990	$ 54	$ 53,460	
Division 8- Miscellaneous Construction					
Internal check dams	L.F.	789	$ 9	$ 7,101	
Filter Fabric/Geotextile	S.Y.	2,200	$ 2	$ 4,400	
Permeable Pavement (BMP T5.15) (Concrete)- Sidewalk					**$115,421**
Division 1 - General Requirements					
Mobilization			8%	$ 8,550	
Division 4- Bases					
Gravel Leveling Course	TON	950	$ 38	$ 36,100	
Gravel Reservoir Course	TON	410	$ 25	$ 10,250	
Division 5- Surface Treatments and Pavements					
Pavement	S.Y.	950	$ 54	$ 51,300	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.			$ -	
Underdrain Pipe 4"	L.F.	20	$ 11	$ 220	
Division 8- Miscellaneous Construction					
Internal check dams	L.F.	789	$ 9	$ 7,101	
Filter Fabric/Geotextile	S.Y.	950	$ 2	$ 1,900	
Permeable Pavement (BMP T5.15) (Asphalt)-Roadway					**$261,793**
Division 1 - General Requirements					
Mobilization			8%	$ 19,392	
Division 4- Bases					
Gravel Leveling Course	TON	430	$ 38	$ 16,340	
Gravel Reservoir Course	TON	2,300	$ 25	$ 57,500	
Division 5- Surface Treatments and Pavements					
Pavement	TON	1,400	$ 109	$ 152,600	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain Pipe	L.F.			$ -	
Underdrain Pipe 8"	L.F.	30	$ 22	$ 660	
Division 8- Miscellaneous Construction					
Internal check dams	L.F.	789	$ 9	$ 7,101	
Filter Fabric/Geotextile	S.Y.	4,100	$ 2	$ 8,200	
Division 8- Miscellaneous Construction					

Combined Detention and Wetpool (BMP T10.40)					**$65,935**
Division 1 - General Requirements					
Mobilization			8%	$ 4,884	
Division 2- Earthwork					
Pond Excavation	C.Y.	1,050	$ 19	$ 19,950	
Haul	C.Y.	850	$ 5	$ 4,250	
Division 4- Bases					
Trench Backfill	C.Y.	7	$ 5	$ 37	
Crushed Surfacing	C.Y.	12	$ 30	$ 360	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Pond Embankment	C.Y.	76	$ 6	$ 456	
Piping					
Storm Sewer Pipe 12"	L.F.	40	$ 49	$ 1,960	
Flow Control Structure					
Catch Basin Type 2	EA	1	$ 3,400	$ 3,400	
Catch Basin Type 2 with Bird Cage/ Debris Barrier	EA	1	$ 4,800	$ 4,800	
Stream Bed Cobbles	C.Y.	2	$ 67	$ 114	
Fencing	L.F.	550	$ 21	$ 11,550	
Impermeable Liner	S.Y.	2,500	$ 0.70	$ 1,750	
Plantings-Wetland	S.F.	6,200	$ 0.50	$ 3,100	
Mulch	C.Y.	38	$ 41	$ 1,558	
Compost	C.Y.	57	$ 38	$ 2,166	
Broad-Crested Weir/ Berm	L.F.	100	$ 56	$ 5,600	
Division 8- Miscellaneous Construction					
Turf Soil Quality and Depth (BMP T5.13)					**$172,900**
Soil Quantity and Depth (BMP T5.13)	S.F.	91,000	$ 1.90	$ 172,900	
Landscape Soil Quality and Depth					**$64,240**
Landscape Soil Quality and Depth	S.F.	8,800	$ 7.30	$ 64,240	
Conveyance System					**$6,567**
Division 1 - General Requirements					
Mobilization			8%	$ 486	
Division 2- Earthwork					
Structure Excavation Class B	C.Y.	25	$ 15	$ 375	
Haul	C.Y.	16	$ 5	$ 80	
Division 4- Bases					
Trench Backfill	C.Y.	9	$ 5	$ 46	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Piping				$ -	
Storm Sewer Pipe 8"	L.F.	55	$ 36	$ 1,980	
Catch Basin Type 1	EA	3	$ 1,200	$ 3,600	
Onsite Stormwater Management Subtotal					**$803,969**
Runoff Treatment and Flow Control Subtotal					**$72,502**
Permanent Stormwater Management Subtotal					**$876,472**
Temporary Erosion and Sediment Control					
Division 1 - General Requirements					
Mobilization			8%	$ 7,496	
Division 2- Earthwork					
Pond Excavation	C.Y.	450	$ 19	$ 8,550	
Haul	C.Y.	550	$ 5	$ 2,750	
Channel Excavation	C.Y.	100	$ 15	$ 1,500	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Storm Sewer Pipe 6"	L.F.	480	$ 25	$ 12,000	
Division 8- Miscellaneous Construction					
Seeding and Mulching	AC	5	$ 3,300	$ 16,500	
High Visibility Fencing	L.F.	110	$ 10	$ 1,100	
Geotextile / Filter Fabric	S.Y.	700	$ 2	$ 1,400	
Wattle	L.F.	1,300	$ 3	$ 3,900	
Stabilized Construction Entrance	S.Y.	730	$ 19	$ 13,870	
Silt Fence	L.F.	590	$ 2.50	$ 1,475	
Wheel Wash	EA	1	$ 2,600	$ 2,600	
Inlet Protection	EA	2	$ 59	$ 118	
Interceptor swale geosynthetic liner	S.Y.	640	$ 3	$ 1,920	
Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	1,342	$ 10	$ 13,417	
Erosion and Sediment Control (ESC) Lead	DAY	180	$ 70	$ 12,600	
Extra materials on hand - 5% of TESC materials	L.S.		5%	$ 3,384	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.		10%	$ 6,768	
Temporary Erosion and Sediment Control Subtotal					**$111,348**

Operations and Maintenance Costs							
Bioretention	S.F.	7,200	$	22	$	157,248	
Wet Pond	S.F.	18,000	$	9	$	162,180	
Catch Basin-Residential	EA	3	$	1,332	$	3,996	
Permeable Pavement Sidewalk-Residential	S.F.	8,600	$	15	$	131,580	
Permeable Pavement-Street and Parking	S.F.	57,000	$	1.20	$	68,400	
Operations and Maintenance Subtotal							**$523,404**
Design Costs							
Engineering Design Plans and Specifications	LS				$	86,000	
Geotechnical and Hydrogeological	LS				$	38,000	
Design Subtotal							**$124,000**
Grand Total							**$1,635,223**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: 7 - Small Commercial, Outwash Soils, 2005 Requirements

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
Downspout Infiltration Trench (BMP T5.10A)						**$5,786**
Division 1 - General Requirements						
	Mobilization			8%	$ 429	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	31	$ 15	$ 465	
	Haul	C.Y.	30	$ 5	$ 150	
Division 4- Bases						
	Gravel Backfill for Drain	C.Y.	16	$ 35	$ 560	
	Trench Backfill	C.Y.	1	$ 12	$ 12	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Underdrain Pipe	L.F.			$ -	
	Underdrain Pipe 4"	L.F.	150	$ 11	$ 1,650	
	Inlet Structure	EA			$ -	
	Type I Catch Basin	EA	1	$ 1,200	$ 1,200	
	Piping	L.F.			$ -	
	Storm Sewer Pipe 6"	L.F.	40	$ 25	$ 1,000	
Division 8- Miscellaneous Construction						
	Filter Fabric/Geotextile	S.Y.	160	$ 2	$ 320	
Filterra						**$69,719**
Division 1 - General Requirements						
	Mobilization			8%	$ 5,164	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	89	$ 15	$ 1,335	
	Haul	C.Y.	44	$ 5	$ 220	
Division 4- Bases						
	Trench Backfill	C.Y.	45	$ 12	$ 540	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping	L.F.			$ -	
	Storm Sewer Pipe 6"	L.F.	30	$ 25	$ 750	
	Filterra Unit	EA			$ -	
	4'x6' Filterra Unit	EA	6	$ 10,285	$ 61,710	
Detention Tank/ Infiltration Trench (StormChamber)						**$27,097**
Division 1 - General Requirements						
	Mobilization			8%	$2,007	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	250	$ 15	$3,750	
	Haul	C.Y.	250	$ 5	$1,250	
Division 4- Bases						
	Gravel Reservoir Course	C.Y.	60	$ 25	$1,500	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	StormChamber Units	EA	37	$ 275	$10,175	
	Catch Basin Type 2	EA		$ 3,400	$0	
	Catch Basin Type 2 with Outlet Flow Control Structure	EA	1	$ 4,300	$4,300	
	Storm Sewer Pipe 12"	L.F.	40	$ 49	$1,960	
Division 8- Miscellaneous Construction						
	Heavy duty netting	EA	1	$ 160	$160	
	Light duty stabilization netting	EA	2	$ 265	$530	
	Filter fabric	EA	1	$ 365	$365	
	Sediment traps	EA	2	$ 550	$1,100	
Landscape Soil Quality and Depth						**$58,400**
	Landscape Soil Quality and Depth	S.F.	8,000	$ 7.30	$58,400	

Conveyance System					**$11,826**
Division 1 - General Requirements					
Mobilization			8%	$876	
Division 2- Earthwork					
Structure Excavation Class B	C.Y.	80	$ 15	$ 1,200	
Haul	C.Y.	40	$ 5	$ 200	
Division 4- Bases					
Trench Backfill	C.Y.	40	$ 5	$ 200	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Piping				$ -	
Storm Sewer Pipe 6"	L.F.	230	$ 25	$ 5,750	
Catch Basin Type 1	EA	3	$ 1,200	$ 3,600	
Onsite Stormwater Management Subtotal					**$64,186**
Runoff Treatment and Flow Control Subtotal					**$108,643**
Permanent Stormwater Management Subtotal					**$172,828**
Temporary Erosion and Sediment Control					
Division 1 - General Requirements					
Mobilization			8%	$ 1,298	
Division 2- Earthwork					
Pond Excavation	C.Y.	9	$ 19	$ 175	
Haul	C.Y.	67	$ 5	$ 336	
Channel Excavation	C.Y.	58	$ 15	$ 871	
Division 8- Miscellaneous Construction					
Seeding and Mulching	AC	1	$ 800	$ 747	
Riprap	C.Y.	1	$ 140	$ 140	
High Visibility Fencing	L.F.	200	$ 10	$ 2,000	
Stabilized Construction Entrance	S.Y.	311	$ 19	$ 5,911	
Silt Fence	L.F.	455	$ 2.50	$ 1,138	
Inlet Protection	EA	2	$ 59	$ 118	
Interceptor swale geosynthetic liner	S.Y.	283	$ 3	$ 849	
Erosion and Sediment Control (ESC) Lead	DAY	30	$ 70	$ 2,100	
Extra materials on hand - 5% of TESC materials	L.S.		5%	$ 614.25	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.		10%	$ 1,228.51	
Temporary Erosion and Sediment Control Subtotal					**$17,526**
Operations and Maintenance Costs					
Catch Basin-Commercial	EA	4	$ 1,332	$ 5,327	
Detention/Infiltration Tank	EA	2	$ 2,664	$ 5,327	
Filterra	EA	6	$ 27,900	$ 167,400	
Operations and Maintenance Subtotal					**$178,055**
Design Costs					
Engineering Design Plans and Specifications	LS			$ 20,000	
Geotechnical and Hydrogeological	LS			$ 9,000	
Design Subtotal					**$29,000**
Grand Total					**$397,409**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: **8 - Small Commercial, Till Soils, 2005 Requirements**

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
Filterra						**$69,719**
Division 1 - General Requirements						
	Mobilization			8%	$5,164.40	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	89	$ 15.00	$1,335.00	
	Haul	C.Y.	44	$ 5.00	$220.00	
Division 4- Bases						
	Trench Backfill	C.Y.	45	$ 12.00	$540.00	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping	L.F.				
	Storm Sewer Pipe 6"	L.F.	30	$ 25.00	$750.00	
	Filterra Unit	EA				
	4'x6' Filterra Unit	EA	6	$ 10,285.00	$61,710.00	
Detention Tank/ Infiltration Trench (StormChamber)						**$101,952**
Division 1 - General Requirements						
	Mobilization			8%	$7,552.00	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	1,400	$ 5.00	$7,000.00	
	Haul	C.Y.	1,400	$ 5.00	$7,000.00	
Division 4- Bases						
	Gravel Reservoir Course	C.Y.	360	$ 25.00	$9,000.00	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	StormChamber Units	EA	220	$ 275.00	$60,500.00	
	Catch Basin Type 2 with Outlet Flow Control Structure	EA	1	$ 4,300.00	$4,300.00	
	Storm Sewer Pipe 12"	L.F.	40	$ 49.00	$1,960.00	
Division 8- Miscellaneous Construction						
	Heavy duty netting	EA	1	$ 160.00	$160.00	
	Light duty stabilization netting	EA	10	$ 265.00	$2,650.00	
	Filter fabric	EA	2	$ 365.00	$730.00	
	Sediment traps	EA	2	$ 550.00	$1,100.00	
Landscape Soil Quality and Depth						**$33,580**
	Landscape Soil Quality and Depth	S.F.	4,600	$ 7.30	$33,580.00	
Conveyance System						**$5,049**
Division 1 - General Requirements						
	Mobilization			8%	$374.00	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	50	$ 15.00	$750.00	
	Haul	C.Y.	20	$ 5.00	$100.00	
Division 4- Bases						
	Trench Backfill	C.Y.	20	$ 5.00	$100.00	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping					
	Storm Sewer Pipe 6"	L.F.	149	$ 25.00	$3,725.00	
Onsite Stormwater Management Subtotal						**$33,580**
Runoff Treatment and Flow Control Subtotal						**$176,720**
Permanent Stormwater Management Subtotal						**$210,300**

Temporary Erosion and Sediment Control					
Division 1 - General Requirements					
Mobilization			8%	$1,320.95	
Division 2- Earthwork					
Pond Excavation	C.Y.	20 $	19	$380	
Haul	C.Y.	80 $	5	$400	
Channel Excavation	C.Y.	60 $	15	$900	
Division 8- Miscellaneous Construction					
Seeding and Mulching	AC	1 $	800	$744	
Riprap	C.Y.	1 $	110	$110	
High Visibility Fencing	L.F.	200 $	10	$2,000	
Stabilized Construction Entrance	S.Y.	310 $	19	$5,890	
Silt Fence	L.F.	460 $	2.50	$1,150	
Inlet Protection	EA	2 $	59	$118	
Interceptor swale geosynthetic liner	S.Y.	280 $	3	$840	
Erosion and Sediment Control (ESC) Lead	DAY	30 $	70	$2,100	
Extra materials on hand - 5% of TESC materials	L.S.		5%	$627	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.		10%	$1,253	
Temporary Erosion and Sediment Control Subtotal					**$17,833**

Operations and Maintenance Costs					
Detention/Infiltration Tank	EA	2 $	2,664	$ 5,327	
Filterra	EA	6 $	27,900	$ 167,400	
Operations and Maintenance Subtotal					**$172,727**

Design Costs					
Engineering Design Plans and Specifications	LS			$ 20,000	
Geotechnical and Hydrogeological	LS			$ 9,000	
Design Subtotal					**$29,000**
Grand Total					**$429,861**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: **9 - Small Commercial, Outwash Soils, 2012 Requirements**

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
Downspout Infiltration Trench/ Full Infiltration Trench (BMP T5.10B)						**$5,786**
Division 1 - General Requirements						
	Mobilization			8%	$ 429	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	31	$ 15	$ 465	
	Haul	C.Y.	30	$ 5	$ 150	
Division 4- Bases						
	Gravel Backfill for Drain	C.Y.	16	$ 35	$ 560	
	Trench Backfill	C.Y.	1	$ 12	$ 12	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Underdrain Pipe	L.F.			$ -	
	Underdrain Pipe 4"	L.F.	150	$ 11	$ 1,650	
	Inlet Structure	EA			$ -	
	Type I Catch Basin	EA	1	$ 1,200	$ 1,200	
	Piping	L.F.			$ -	
	Storm Sewer Pipe 6"	L.F.	40	$ 25	$ 1,000	
Division 8- Miscellaneous Construction						
	Filter Fabric/Geotextile	S.Y.	160	$ 2	$ 320	
Bioretention (BMP T7.30)						**$77,436**
Division 1 - General Requirements						
	Mobilization			8%	$ 5,736	
Division 2- Earthwork						
	Pond Excavation	C.Y.	320	$ 19	$ 6,080	
	Haul	C.Y.	320	$ 5	$ 1,600	
Division 8- Miscellaneous Construction						
	Geotextile	S.Y.	380	$ 2	$ 760	
	Check dam/weir	L.F.	111	$ 56	$ 6,218	
	Plantings-Bioretention	S.F.	3,200	$ 5	$ 16,000	
	Mulch	C.Y.	790	$ 41	$ 32,390	
	Bioretention Soil	C.Y.	180	$ 44	$ 7,920	
	Stream Bed Gravel	C.Y.	12	$ 61	$ 732	
Landscape Soil Quality and Depth						**$33,580**
	Landscape Soil Quality and Depth	S.F.	4,600	$ 7.30	$ 33,580	
Conveyance System						**$9,234**
Division 1 - General Requirements						
	Mobilization			8%	$ 684	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	50	$ 15	$ 750	
	Haul	C.Y.	30	$ 5	$ 150	
Division 4- Bases						
	Trench Backfill	C.Y.	20	$ 5	$ 100	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping				$ -	
	Storm Sewer Pipe 6"	L.F.	110	$ 25	$ 2,750	
	Catch Basin Type 1	EA	4	$ 1,200	$ 4,800	
Onsite Stormwater Management Subtotal						**$126,036**
Runoff Treatment and Flow Control Subtotal						**$0**
Permanent Stormwater Management Subtotal						**$126,036**

Temporary Erosion and Sediment Control						
Division 1 - General Requirements						
Mobilization				8%	$ 1,347	
Division 2- Earthwork						
Pond Excavation	C.Y.	10	$	19	$ 190	
Haul	C.Y.	70	$	5	$ 350	
Channel Excavation	C.Y.	60	$	15	$ 900	
Division 8- Miscellaneous Construction						
Seeding and Mulching	AC	1	$	800	$ 747	
Riprap	C.Y.	1	$	110	$ 110	
High Visibility Fencing	L.F.	200	$	10	$ 2,000	
Stabilized Construction Entrance	S.Y.	310	$	19	$ 5,890	
Silt Fence	L.F.	460	$	2.50	$ 1,150	
Inlet Protection	EA	2	$	59	$ 118	
Interceptor swale geosynthetic liner	S.Y.	280	$	3	$ 840	
Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	59	$	10	$ 593	
Erosion and Sediment Control (ESC) Lead	DAY	30	$	70	$ 2,100	
Extra materials on hand - 5% of TESC materials	L.S.			5%	$ 614.76	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.			10%	$ 1,229.52	
Construction Stormwater Pollution Prevention Subtotal						**$18,179**
Operations and Maintenance Costs						
Bioretention	S.F.	3,200	$	22	$ 69,888	
Catch Basin-Commercial	EA	5	$	1,332	$ 6,659	
Operations and Maintenance Subtotal						**$76,547**
Design Costs						
Engineering Design Plans and Specifications	LS				$ 25,000	
Geotechnical and Hydrogeological	LS				$ 9,000	
Design Subtotal						**$34,000**
Grand Total						**$254,762**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: 10 - Small Commercial, Till Soils, 2012 Requirements

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Cost Estimates

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
Bioretention (BMP T7.30)						**$74,731**
Division 1 - General Requirements						
	Mobilization			8%	$ 5,536	
Division 2- Earthwork						
	Pond Excavation	C.Y.	310	$ 19	$ 5,890	
	Haul	C.Y.	310	$ 5	$ 1,550	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping	L.F.			$ -	
	Perforated Underdrain Pipe 4" PVC	L.F.	36	$ 11	$ 396	
Division 8- Miscellaneous Construction						
	Geotextile	S.Y.	390	$ 2	$ 780	
	Check dam/weir	L.F.	64	$ 56	$ 3,584	
	Plantings-Bioretention	S.F.	3,200	$ 5	$ 16,000	
	Mulch	C.Y.	800	$ 41	$ 32,800	
	Bioretention Soil	C.Y.	180	$ 44	$ 7,920	
	Stream Bed Gravel	C.Y.	5	$ 61	$ 276	
Detention Tank/ Infiltration Trench (StormChamber)						**$84,202**
Division 1 - General Requirements						
	Mobilization			8%	$ 6,237	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	1,100	$ 5	$ 5,500	
	Haul	C.Y.	1,100	$ 5	$ 5,500	
Division 4- Bases						
	Gravel Reservoir Course	C.Y.	290	$ 25	$ 7,250	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	StormChamber Units	EA	181	$ 275	$ 49,775	
	Catch Basin Type 2	EA		$ 3,400	$ -	
	Catch Basin Type 2 with Outlet Flow Control Structure	EA	1	$ 4,300	$ 4,300	
	Storm Sewer Pipe 12"	L.F.	40	$ 49	$ 1,960	
Division 8- Miscellaneous Construction						
	Heavy duty netting	EA	1	$ 160	$ 160	
	Light duty stabilization netting	EA	5	$ 265	$ 1,325	
	Filter fabric	EA	3	$ 365	$ 1,095	
	Sediment traps	EA	2	$ 550	$ 1,100	
Landscape Soil Quality and Depth						**$35,040**
	Landscape Soil Quality and Depth	S.F.	4,800	$ 7.30	$ 35,040	
Conveyance System						**$11,070**
Division 1 - General Requirements						
	Mobilization			8%	$ 820	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	50	$ 15	$ 750	
	Haul	C.Y.	30	$ 5	$ 150	
Division 4- Bases						
	Trench Backfill	C.Y.	20	$ 5	$ 100	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping				$ -	
	Storm Sewer Pipe 6"	L.F.	130	$ 25	$ 3,250	
	Catch Basin Type 1	EA	5	$ 1,200	$ 6,000	
Onsite Stormwater Management Subtotal						**$109,771**
Runoff Treatment and Flow Control Subtotal						**$95,272**
Permanent Stormwater Management Subtotal						**$205,043**

Temporary Erosion and Sediment Control							
Division 1 - General Requirements							
Mobilization				8%	$	1,387	
Division 2- Earthwork							
Pond Excavation	C.Y.	20	$	19	$	380	
Haul	C.Y.	80	$	5	$	400	
Channel Excavation	C.Y.	60	$	15	$	900	
Division 8- Miscellaneous Construction							
Seeding and Mulching	AC	1	$	800	$	744	
Riprap	C.Y.	1	$	110	$	110	
High Visibility Fencing	L.F.	200	$	10	$	2,000	
Stabilized Construction Entrance	S.Y.	311	$	19	$	5,911	
Silt Fence	L.F.	460	$	2.50	$	1,150	
Inlet Protection	EA	2	$	59	$	118	
Interceptor swale geosynthetic liner	S.Y.	280	$	3	$	840	
Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	59	$	10	$	593	
Erosion and Sediment Control (ESC) Lead	DAY	30	$	77	$	2,310	
Extra materials on hand - 5% of TESC materials	L.S.			5%	$	627.66	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.			10%	$	1,255.32	
Construction Stormwater Pollution Prevention Subtotal							**$18,726**
Operations and Maintenance Costs							
Bioretention	S.F.	3,200	$	22	$	69,888	
Catch Basin-Commercial	EA	5	$	1,332	$	6,659	
Detention/Infiltration Tank	EA	2	$	2,664	$	5,327	
Operations and Maintenance Subtotal							**$81,875**
Design Costs							
Engineering Design Plans and Specifications	LS				$	25,000	
Geotechnical and Hydrogeological	LS				$	15,000	
Design Subtotal							**$40,000**
Grand Total							**$345,644**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: 11 - Large Commercial Site, Outwash Soils, 2005 Requirements

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Engineering Estimate of Probable Construction Cost

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
Downspout Infiltration Trench/ Full Infiltration Trench (BMP T5.10B)						**$189,231**
Division 1 - General Requirements						
	Mobilization			8%	$ 14,017	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	1,500	$ 5	$ 7,500	
	Haul	C.Y.	1,400	$ 5	$ 7,000	
Division 4- Bases						
	Gravel Backfill for Drain	C.Y.	570	$ 35	$ 19,950	
	Trench Backfill	C.Y.	22	$ 12	$ 264	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Underdrain Pipe	L.F.			$ -	
	Underdrain Pipe 4"	L.F.	9,600	$ 11	$ 105,600	
	Inlet Structure	EA			$ -	
	Type I Catch Basin	EA	1	$ 1,200	$ 1,200	
	Piping	L.F.			$ -	
	Storm Sewer Pipe 6"	L.F.	580	$ 25	$ 14,500	
Division 8- Miscellaneous Construction						
	Filter Fabric/Geotextile	S.Y.	9,600	$ 2	$ 19,200	
HMA Pavement						**$1,117,584**
Division 1 - General Requirements						
	Mobilization			8%	$ 82,784	
Division 4- Bases						
	Crushed Surfacing Base Course	TON	9,700	$ 30	$ 291,000	
Division 5- Surface Treatments and Pavements						
	Pavement	TON	7,400	$ 92	$ 680,800	
Division 8- Miscellaneous Construction						
	Filter Fabric/Geotextile	S.Y.	31,500	$ 2	$ 63,000	
Filterra						**$406,112**
Division 1 - General Requirements						
	Mobilization			8%	$ 30,082	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	500	$ 15	$ 7,500	
	Haul	C.Y.	260	$ 5	$ 1,300	
Division 4- Bases						
	Trench Backfill	C.Y.	240	$ 12	$ 2,880	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping	L.F.			$ -	
	Storm Sewer Pipe 6"	L.F.	175	$ 25	$ 4,375	
	Filterra Unit	EA			$ -	
	4'x6' Filterra Unit	EA	35	$ 10,285	$ 359,975	
Detention Tank/ Infiltration Trench (StormChamber)						**$164,327**
Division 1 - General Requirements						
	Mobilization			8%	$ 12,172	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	2,200	$ 5	$ 11,000	
	Haul	C.Y.	2,200	$ 5	$ 11,000	
Division 4- Bases						
	Gravel Reservoir Course	C.Y.	570	$ 25	$ 14,250	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	StormChamber Units	EA	350	$ 275	$ 96,250	
	Catch Basin Type 2	EA	2	$ 3,400	$ 6,800	
	Catch Basin Type 2 with Outlet Flow Control Structure	EA	1	$ 4,300	$ 4,300	
	Storm Sewer Pipe 12"	L.F.	40	$ 49	$ 1,960	
Division 8- Miscellaneous Construction						
	Heavy duty netting	EA	1	$ 160	$ 160	
	Light duty stabilization netting	EA	16	$ 265	$ 4,240	
	Filter fabric	EA	3	$ 365	$ 1,095	
	Sediment traps	EA	2	$ 550	$ 1,100	
Landscape Soil Quality and Depth						**$131,400**
	Landscape Soil Quality and Depth	S.F.	18,000	$ 7.30	$ 131,400	

Conveyance System								**$96,854**
Division 1 - General Requirements								
Mobilization				8%	$	7,174		
Division 2- Earthwork								
Structure Excavation Class B	C.Y.	790	$	5	$	3,950		
Haul	C.Y.	420	$	5	$	2,100		
Division 4- Bases								
Trench Backfill	C.Y.	370	$	5	$	1,850		
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits								
Piping					$	-		
Storm Sewer Pipe 8"	L.F.	2,105	$	36	$	75,780		
Catch Basin Type 1	EA	5	$	1,200	$	6,000		
Onsite Stormwater Management Subtotal								**$1,438,215**
Runoff Treatment and Flow Control Subtotal								**$667,294**
Permanent Stormwater Management Subtotal								**$2,105,509**
Temporary Erosion and Sediment Control								
Division 1 - General Requirements								
Mobilization				8%	$	10,794		
Division 2- Earthwork								
Pond Excavation	C.Y.	110	$	19	$	2,090		
Haul	C.Y.	480	$	5	$	2,400		
Channel Excavation	C.Y.	370	$	15	$	5,550		
Division 8- Miscellaneous Construction								
High Visibility Fencing	L.F.	2,600	$	10	$	26,000		
Stabilized Construction Entrance	S.Y.	3,100	$	19	$	58,900		
Silt Fence	L.F.	1,300	$	2.50	$	3,250		
Wheel Wash	EA	1	$	2,600	$	2,600		
Inlet Protection	EA	3	$	59	$	177		
Interceptor swale geosynthetic liner	S.Y.	1,800	$	3	$	5,400		
Erosion and Sediment Control (ESC) Lead	DAY	180	$	70	$	12,600		
Extra materials on hand - 5% of TESC materials	L.S.			5%	$	5,318.35		
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.			10%	$	10,636.70		
TEMPORARY EROSION AND SEDIMENT CONTROL SUBTOTAL								**$145,716**
Operations and Maintenance Costs								
Catch Basin-Commercial	EA	5	$	1,332	$	6,659		
Pavement	S.F.	283,000	$	1.16	$	328,280		
Detention/Infiltration Tank	EA	2	$	2,664	$	5,327		
Filterra	EA	35	$	27,900	$	976,500		
Operations and Maintenance Subtotal								**$1,316,767**
Design Costs								
Engineering Design Plans and Specifications	LS				$	30,000		
Geotechnical and Hydrogeological	LS				$	22,000		
Design Subtotal								**$52,000**
Grand Total								**$3,619,992**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: 12 - Large Commercial Site, Till Soils, 2005 Requirements

Prepared by: AS
Date: 5/5/2013
Checked by: MF
Date checked: 5/7/2013

Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Engineering Estimate of Probable Construction Cost

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
HMA Pavement						**$1,116,504**
Division 1 - General Requirements						
	Mobilization			8%	$82,704.00	
Division 4- Bases						
	Crushed Surfacing Base Course	TON	9,700	$ 30	$291,000.00	
Division 5- Surface Treatments and Pavements						
	Pavement	TON	7,400	$ 92	$680,800.00	
Division 8- Miscellaneous Construction						
	Filter Fabric/Geotextile	S.Y.	31,000	$ 2	$62,000.00	
Filterra						**$568,588**
Division 1 - General Requirements						
	Mobilization			8%	$42,117.60	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	700	$ 15	$10,500.00	
	Haul	C.Y.	360	$ 5	$1,800.00	
Division 4- Bases						
	Trench Backfill	C.Y.	340	$ 12	$4,080.00	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping	L.F.				
	Storm Sewer Pipe 6"	L.F.	245	$ 25	$6,125.00	
	Filterra Unit	EA				
	4'x6' Filterra Unit	EA	49	$ 10,285	$503,965.00	
Detention Tank/ Infiltration Trench (StormChamber)						**$1,034,645**
Division 1 - General Requirements						
	Mobilization			8%	$76,640.40	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	15,000	$ 5	$75,000.00	
	Haul	C.Y.	15,000	$ 5	$75,000.00	
Division 4- Bases						
	Gravel Reservoir Course	C.Y.	3,900	$ 25	$97,500.00	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	StormChamber Units	EA	2,400	$ 275	$660,000.00	
	Catch Basin Type 2	EA	2	$ 3,400	$6,800.00	
	Catch Basin Type 2 with Outlet Flow Control Structure	EA	1	$ 4,300	$4,300.00	
	Storm Sewer Pipe 12"	L.F.	40	$ 49	$1,960.00	
Division 8- Miscellaneous Construction						
	Heavy duty netting	EA	1	$ 160	$160.00	
	Light duty stabilization netting	EA	109	$ 265	$28,885.00	
	Filter fabric	EA	20	$ 365	$7,300.00	
	Sediment traps	EA	2	$ 550	$1,100.00	
Landscape Soil Quality and Depth						**$131,400**
	Landscape Soil Quality and Depth	S.F.	18,000	$ 7.30	$131,400.00	
Conveyance System						**$86,244**
Division 1 - General Requirements						
	Mobilization			8%	$6,388.48	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	640	$ 15	$9,600.00	
	Haul	C.Y.	340	$ 5	$1,700.00	
Division 4- Bases						
	Trench Backfill	C.Y.	300	$ 5	$1,500.00	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping					
	Storm Sewer Pipe 8"	L.F.	1,696	$ 36	$61,056.00	
	Catch Basin Type 1	EA	5	$ 1,200	$6,000.00	

Onsite Stormwater Management Subtotal					**$1,247,904**
Runoff Treatment and Flow Control Subtotal					**$1,689,477**
Permanent Stormwater Management Subtotal					**$2,937,381**

Temporary Erosion and Sediment Control					
Division 1 - General Requirements					
Mobilization			8%	$11,589.92	
Division 2- Earthwork					
Pond Excavation	C.Y.	441	$ 19	$8,386.74	
Haul	C.Y.	813	$ 5	$4,066.45	
Channel Excavation	C.Y.	372	$ 15	$5,578.23	
Division 8- Miscellaneous Construction					
High Visibility Fencing	L.F.	2,600	$ 10	$26,000.00	
Stabilized Construction Entrance	S.Y.	3,136	$ 19	$59,578.88	
Silt Fence	L.F.	1,278	$ 2.50	$3,194.74	
Wheel Wash	EA	1	$ 2,600	$2,600.00	
Inlet Protection	EA	3	$ 59	$177.00	
Interceptor swale geosynthetic liner	S.Y.	1,813	$ 3	$5,438.78	
Erosion and Sediment Control (ESC) Lead	DAY	180	$ 70	$ 12,600	
Extra materials on hand - 5% of TESC materials	L.S.		5%	$ 5,751.04	
Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.		10%	$11,502.08	
Construction Stormwater Pollution Prevention Subtotal					**$156,464**

Operations and Maintenance Costs					
Catch Basin-Commercial	EA	7	$ 1,332	$9,323.06	
Pavement	S.F.	283,000	$ 1	$328,280.00	
Detention/Infiltration Tank	EA	1	$ 2,664	$2,663.73	
Filterra	EA	49	$ 27,900	$1,367,100.00	
Operations and Maintenance Subtotal					**$1,707,367**

Design Costs					
Engineering Design Plans and Specifications	LS			$ 30,000	
Geotechnical and Hydrogeological	LS			$ 22,000	
Design Subtotal					**$52,000**
Grand Total					**$4,853,212**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: 13 - Large Commercial, Outwash Soils, 2012 Requirements

Prepared by: AS
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Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Engineering Estimate of Probable Construction Cost

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
Permeable Pavement (BMP T5.15) (Asphalt)						**$1,446,139**
Division 1 - General Requirements						
	Mobilization			8%	$ 107,121	
Division 4- Bases						
	Gravel Leveling Course	TON	3,300	$ 38	$ 125,400	
	Sand Treatment Layer	TON	9,700	$ 27	$ 261,900	
Division 5- Surface Treatments and Pavements						
	Pavement	TON	7,400	$ 109	$ 806,600	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Underdrain Pipe	L.F.			$ -	
	Underdrain Pipe 4"	L.F.	330	$ 11	$ 3,630	
Division 8- Miscellaneous Construction						
	Internal check dams	L.F.	8,832	$ 9	$ 79,488	
	Filter Fabric/Geotextile	S.Y.	31,000	$ 2	$ 62,000	
Landscape Soil Quality and Depth						**$131,400**
	Landscape Soil Quality and Depth	S.F.	18,000	$ 7.30	$ 131,400	
Onsite Stormwater Management Subtotal						**$1,577,539**
Runoff Treatment and Flow Control Subtotal						**$0**
Permanent Stormwater Management Subtotal						**$1,577,539**
Temporary Erosion and Sediment Control						
Division 1 - General Requirements						
	Mobilization			8%	$ 15,028	
Division 2- Earthwork						
	Pond Excavation	C.Y.	110	$ 19	$ 2,090	
	Haul	C.Y.	480	$ 5.00	$ 2,400	
	Channel Excavation	C.Y.	370	$ 15.00	$ 5,550	
Division 8- Miscellaneous Construction						
	High Visibility Fencing	L.F.	2,600	$ 10.00	$ 26,000	
	Stabilized Construction Entrance	S.Y.	3,100	$ 19	$ 58,900	
	Silt Fence	L.F.	1,300	$ 2.50	$ 3,250	
	Wheel Wash	EA	1	$ 2,600	$ 2,600	
	Inlet Protection	EA	3	$ 59	$ 177	
	Interceptor swale geosynthetic liner	S.Y.	1,800	$ 3	$ 5,400	
	Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	5,167	$ 10	$ 51,667	
	Erosion and Sediment Control (ESC) Lead	DAY	180	$ 77	$ 13,860	
	Extra materials on hand - 10% of TESC materials	L.S.		5%	$ 5,318.35	
	Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.		10%	$ 10,637	
Construction Stormwater Pollution Prevention Subtotal						**$202,877**
Operations and Maintenance Costs						
	Permeable Pavement-Street and Parking	S.F.	283,000	$ 1.20	$ 339,600	
Operations and Maintenance Subtotal						**$339,600**
Design Costs						
	Engineering Design Plans and Specifications	LS			$ 15,000	
	Geotechnical and Hydrogeological	LS			$ 32,000	
Design Subtotal						**$47,000**
Grand Total						**$2,167,016**

Project: Cost Analysis for Western Washington LID Requirements and Best Management Practices
Scenario: 14 - Large Commercial, Till Soils, 2012 Requirements

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Note: This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the engineers.

Planning Level Engineering Estimate of Probable Construction Cost

No.	Item Description	Unit	Quantity	Unit Cost	Price	Total Price
Permanent Stormwater Management						
Permeable Pavement (BMP T5.15) (Asphalt)						**$1,828,509**
Division 1 - General Requirements						
	Mobilization			8%	$ 135,445	
Division 4- Bases						
	Gravel Leveling Course	TON	3,200	$ 38	$ 121,600	
	Gravel Reservoir Course	TON	25,900	$ 25	$ 647,500	
Division 5- Surface Treatments and Pavements						
	Pavement	TON	7,400	$ 109	$ 806,600	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Underdrain Pipe	L.F.			$ -	
	Underdrain Pipe 8"	L.F.	710	$ 22	$ 15,620	
Division 8- Miscellaneous Construction						
	Internal check dams	L.F.	4,416	$ 9	$ 39,744	
	Filter Fabric/Geotextile	S.Y.	31,000	$ 2	$ 62,000	
Landscape Soil Quality and Depth						**$131,400**
	Landscape Soil Quality and Depth	S.F.	18,000	$ 7.30	$ 131,400	
Conveyance System						**$3,208**
Division 1 - General Requirements						
	Mobilization			8%	$ 238	
Division 2- Earthwork						
	Structure Excavation Class B	C.Y.	15	$ 15	$ 225	
	Haul	C.Y.	9	$ 5	$ 45	
Division 4- Bases						
	Trench Backfill	C.Y.	6	$ 5	$ 30	
Division 7- Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits						
	Piping				$ -	
	Storm Sewer Pipe 12"	L.F.	30	$ 49	$ 1,470	
	Catch Basin Type 1	EA	1	$ 1,200	$ 1,200	
Onsite Stormwater Management Subtotal						**$1,963,117**
Runoff Treatment and Flow Control Subtotal						**$0**
Permanent Stormwater Management Subtotal						**$1,963,117**
Temporary Erosion and Sediment Control						
Division 1 - General Requirements						
	Mobilization			8%	$ 16,710	
Division 2- Earthwork						
	Pond Excavation	C.Y.	440	$ 19	$ 8,360	
	Haul	C.Y.	810	$ 5	$ 4,050	
	Channel Excavation	C.Y.	370	$ 15	$ 5,550	
Division 8- Miscellaneous Construction						
	Seeding and Mulching	AC	9	$ 800	$ 6,942	
	Riprap	C.Y.	2	$ 140	$ 280	
	High Visibility Fencing	L.F.	2,600	$ 10	$ 26,000	
	Stabilized Construction Entrance	S.Y.	3,136	$ 19	$ 59,578	
	Silt Fence	L.F.	1,278	$ 2.50	$ 3,195	
	Wheel Wash	EA	1	$ 2,600	$ 2,600	
	Inlet Protection	EA	3	$ 59	$ 177	
	Interceptor swale geosynthetic liner	S.Y.	1,813	$ 3	$ 5,439	
	Phased Excavation to Protect Permeable Pavement Subgrade	C.Y.	5,167	$ 10	$ 51,667	
	Erosion and Sediment Control (ESC) Lead	DAY	217	$ 77	$ 16,709	
	Extra materials on hand - 5% of TESC materials	L.S.		5%	$ 6,108.52	
	Maintenance, Inspection, Monitoring - 10% of all TESC materials	L.S.		10%	$ 12,217	
Construction Stormwater Pollution Prevention Subtotal						**$225,581**

Operations and Maintenance Costs					
Catch Basin-Commercial	EA	1	$ 1,332	$1,332	
Permeable Pavement-Street and Parking	S.F.	283,000	$ 1.20	$339,600	
Operations and Maintenance Subtotal					**$340,932**
Design Costs					
Engineering Design Plans and Specifications	LS			$ 15,000	
Geotechnical and Hydrogeological	LS			$ 32,000	
Design Subtotal					**$47,000**
Grand Total					**$2,576,630**

Unit Costs for Cost Estimate Preparation

Herrera Environmental Consultants, Inc. 11-05240-000

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Checked by: M. Ewbank

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Division 2 - Earthwork					
Structure Excavation Class B - 5 CY to 750 CY	Excavation of pipe trenches and vaults	2-09.3(4)	**CY**		**$15**
Mallard Pond Wetland Enhancement	Structure Excavation Class B Incl Haul		CY	510	27.00
WSDOT UBA (Job # 12X303)	Structure Excavation Class B		CY	50	20.52
WSDOT UBA (Job # 12A023)	Structure Excavation Class B Incl Haul		CY	580	5.00
WSDOT UBA (Job # 11A003)	Structure Excavation Class B Incl Haul		CY	540	8.36
Structure Excavation Class B - 750 CY to 5,000 CY	Excavation of pipe trenches and vaults	2-09.3(4)	**CY**		**$5**
SR 18 – 180th to Maple Valley	Structure Excavation Class B Incl Haul		CY	8024	6.64
WSDOT UBA (Job # 09A032)	Structure Excavation Class B Incl Haul		CY	851	4.35
WSDOT UBA (Job # 12A018)	Structure Excavation Class B Incl Haul		CY	2910	7.10
WSDOT UBA (Job # 11A004)	Structure Excavation Class B Incl Haul		CY	4716	10.18
Private	Excavation		CY	2400	3.54
Pond Excavation	Excavation of ponds and bioretention	2 SP	**CY**		**$19**
Bear Creek Park WQ Facility	Pond Excavation		CY	900	20.75
San Juan County Eastsound constructed wetland	Pond Excavation		CY	2860	5.82
Lacey 2011 Street Overlay	Pond Excavation incl. haul		CY	31	31.38
Haul	Hauling material offsite	2-03.3(7)B	**CY**		**$5**
RSMeans Building Construction Cost Data. 2010. 31 23 23.20 - 1018.	Haul. 12 CY truck , Cycle 2 miles, 15 MPH average, 15 min. wait/Ld./Uld.		CY	NA	4.66
Compacted Earth Berm	Pond embankments	2-03.3(14)B	**CY**		**$6**
San Juan County Eastsound constructed wetland	Embankment compaction, method C		CY	250	11.07
Mallard Pond Wetland Enhancement	Embankment compaction		CY	1500	19.63
Redmond 185th Ave NE Extension	Embankment compaction		CY	510	3.16
WSDOT UBA (Job # 12A001)	Embankment compaction		CY	7580	0.75
WSDOT UBA (Job # 11A003)	Embankment compaction		CY	7970	3.66
WSDOT UBA (Job # 10A048)	Embankment compaction		CY	8940	3.21
WSDOT UBA (Job # 10A021)	Embankment compaction		CY	14170	2.34
WSDOT UBA (Job # 09A032)	Embankment compaction		CY	10700	1.09
Division 3 - Aggregate Production and Acceptance					
No items					

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Item	General Description	Spec Division	Units	Quantity Range	Low Jan 2013 Unit Price
Division 4 - Bases					
Gravel Filter Course	Permeable pavement filter/leveling course	4-04()	**TON**		**$38**
139th St E Cul-de-sac	Gravel Leveling Course		TON	190	35.31
8th Ave NW LID Retrofit	Permeable Crushed Surfacing (SP 4-04)		TON	250	41.42
Gravel Reservoir Course	Permeable pavement reservoir course	4-02()	**TON**		**$25**
Bear Creek Park WQ Facility	Porous pavement base course		TON	346	39.98
139th St E Cul-de-sac	Gravel Base Course		TON	1630	20.77
8th Ave NW LID Retrofit	Permeable Ballast (SP 4-04)		TON	2250	18.19
Sprinker Parking Lot LID Phase II	Gravel Base		TON	3607.5	14.21
WSDOT UBA (Job # 12A018)	Permeable Ballast		TON	404	19.50
SeaTac 138th St. Neighborhood Ped Improvements	Drain Rock Base Course		TON	1088	36.13
Crushed Surfacing	Base for traditional pavement	4-04	**TON**		**$30**
SR 18 – 180th to Maple Valley	Crushed surfacing base course		TON	108865	10.28
WSDOT UBA (Job # 08A808)	Crushed surfacing base course		TON	185	47.83
WSDOT UBA (Job # 99A037)	Crushed surfacing base course		TON	12670	18.53
WSDOT UBA (Job # 07A023)	Crushed surfacing base course		TON	1200	30.99
WSDOT UBA (Job # 10A008)	Crushed surfacing base course		TON	8526	21.75
Mallard Pond Wetland Enhancement	Crushed surfacing top course		TON	440	30.68
Bear Creek Park WQ Facility	Crushed surfacing top course		TON	440	47.64
Sand	Sand treatment layer	4 SP	**TON**		**$27**
Sprinker Parking Lot LID Phase II	Drainage sand		TON	840	25.49
136TH Ave NE/Redmond Way Stabilization	Filter sand/gravel		TON	975	32.01
Red-E Vendor Quote	Washed sand (truck and trailer- to Kirkland ~10mi)		TON	2000	16.50
Cadman Vendor Quote	Coarse, washed sand		TON	2000	32.39
Cadman Vendor Quote	Coarse, washed sand		TON	2000	27.10
Division 5 - Surface Treatments and Pavements					
Asphalt Pavement	Hot mix asphalt, asphalt for parking or roadway	5-04.3	**TON**		**$92**
SPU JOC Unit Cost Report 2010	Pavement, HMA (CL 3/8 IN)		TON	Machine	124.61
West Valley Highway Improvements	HMA CL. 1" PG 64-22		TON	800	81.00
West Valley Highway Improvements	HMA CL. 1/2" PG 64-22		TON	3000	77.88
SeaTac 138th St. Neighborhood Ped Improvements	HMA CL. 1/2" PG 64-22		TON	1153	86.29
Porous Asphalt	Porous asphalt	5 SP	**TON**		**$109**
Central Park Lot-Issaquah	Pervious asphalt		TON	1650	92.33
8th Ave NW LID Retrofit	Porous HMA Class 1/2" PG70-22 (SP 5-04)		TON	480	103.05
Bear Creek Park WQ Facility	Porous HMA pavement		TON	282	130.31
Division 6 - Structures					
No items					

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Division 7 - Drainage Structures, Storm Sewers, Sanitary Sewers, Water Mains, and Conduits					
Underdrain pipe 4"	Perforated pipe for residential	7-01.3(2)	**LF**		**$11**
Sprinker Parking Lot LID Phase II	4" perforated underdrain		LF	690	6.73
Mercer Island City Hall LID Retrofit Engineer's Estimate	Rain Garden Underdrain pipe 4 in Diameter		LF	57	15.18
Underdrain pipe 8" or 12"	Perforated pipe for commercial	7-01.3(2)	**LF**		**$22**
West Valley Highway Improvements	Perforated PVC Underdrain Pipe 8in Diameter		LF	100	41.54
West Valley Highway Improvements	Perforated Corrugated Polyethylene Underdrain Pipe 12in Diameter		LF	1063	39.46
Redmond 185th Ave NE Extension	Underdrain pipe 8in diam.		LF	548	10.28
SR 18 – 180th to Maple Valley	Underdrain pipe 8in diam.		LF	3544	7.96
WSDOT UBA (Job # 10A020)	Underdrain pipe 12in diam		LF	594	17.15
WSDOT UBA (Job # 10A046)	Underdrain pipe 12in diam		LF	1095	16.68
Drain Pipe 4"	Storm drain for residential - assume same as underdrain	7-04.3	**LF**		**$11**
Drain Pipe 6"	Storm drain	7-04.3	**LF**		**$25**
Redmond 185th Ave NE Extension	Solid wall PVC storm sewer pipe 6in diameter		LF	10	42.75
WSDOT UBA (Job # 11C509)	Plain conc. Storm sewer pipe 6in diameter		LF	350	10.63
WSDOT UBA (Job # 12X301)	Plain conc. Storm sewer pipe 6in diameter		LF	165	21.77
Storm Sewer Pipe 8"	Storm drain	7-04.3	**LF**		**$36**
2011 Street Overlay Project	8" Diameter Storm Sewer Pipe		LF	70	35.34
West Valley Highway Improvements	Storm Sewer Pipe (PVC- SDR-35)		LF	128	40.50
Redmond 185th Ave NE Extension	Solid wall PVC storm sewer pipe 8in diameter		LF	72	31.62
Storm Sewer Pipe 12"	Storm drain	7-04.3	**LF**		**$49**
2011 Street Overlay Project	12" Diameter Storm Sewer Pipe		LF	450	25.98
West Valley Highway Improvements	Storm Sewer Pipe (PVC, SDR-35)		LF	180	72.69
Redmond 185th Ave NE Extension	Solid wall PVC storm sewer pipe 12in diameter		LF	262	37.42
WSDOT UBA (Job # 04A040)	Solid wall PVC storm sewer pipe 12in diameter		LF	274	46.79
WSDOT UBA (Job # 07A013)	Solid wall PVC storm sewer pipe 12in diameter		LF	695	36.04
Private	12" Storm Mainline		LF	585	47.94
Private	12" ADS Pipe		LF	92	32.57
Private	12" DI Pipe		LF	145	61.06
Private	12" DIP - Storm		LF	555	75.91
NDS 12" x 12" Catch Basin	CB for ROW and commercial	7(SP)	**EA**		**$54**
Home Depot Cost + 30% markup	NDS 12" x 12" Catch Basin		EA	1	54

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Catch Basin Type 1	CB for ROW and commercial	7-05.3/9-05.50(3)	**EA**		**$1,200**
Snohomish County 116th St SE/ 56th Ave SE Intersection Improvements	Catch Basin Type 1		EA	3	847.43
Thurston County Hawaiian Court Stormwater Improvement Project	Catch Basin Type 1		EA	2	1160.97
West Valley Highway Improvements	Catch Basin Type 1		EA	9	986.48
2011 Street Overlay Project	Catch Basin Type 1		EA	14	1039.33
Hawaiian Court Stormwater Improvement Project	Catch Basin Type 1		EA	2	1160.97
Private	Catch Basins, Inlets, Area Drains		EA	10	1105.10
Private	Catch Basin		EA	3	1221.26
Private	Storm Catch Basin		EA	3	1923.17
Catch Basin Type 2	For large pipe connections and control structures.	7-05.3/9-05.50(3)	**EA**		**$3,400**
Thurston County Hawaiian Court Stormwater Improvement Project	Catch Basin Type 2		EA	1	3433.32
West Valley Highway Improvements	Catch Basin Type 2		EA	3	4153.62
2011 Street Overlay Project	Catch Basin Type 2		EA	1	2561.95
Hawaiian Court Stormwater Improvement Project	Catch Basin Type 2		EA	1	3433.32
Outlet Control Device	Flow restrictor within the manhole or CB		**EA**		**$4,300**
Average of WSDOT UBA and SPU JOC Unit Cost Report 2010	Flow control structure 48in		EA	1	4343.04

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Bird cage/ debris barrier	For ponds	7 SP	**EA**		**$500**
Snohomish County 2012 Drainage Improvements	Debris barrier		EA	1	507.95
Gravel Backfill for Drain	Infiltration trench backfill	7-01	**CY**		**$35**
West Valley Highway Improvements	Gravel Backfill for drain		CY	1033	38.94
SR 18 Maple Valley to Issaquah Hobart Road	Gravel Backfill for drain		CY	3461	26.63
Snohomish County 35th Ave SE and 180th st SE	Gravel Backfill for drain		CY	330	40.63
Trench Backfill	Gravel backfill above pipe zone bedding.	7-09.1(1)E	**CY**		**$12**
Lacey 2011 Street Overlay Project	Bank Run Gravel for Trench Backfill		CY	233	1.56
WSDOT UBA (Job # 07A017)	Gravel for trench backfill		CY	31	18.00
WSDOT UBA (Job # 10A042)	Bank Run Gravel for Trench Backfill for AGMT .01495		CY	8110	17.54
Division 8 - Miscellaneous Construction					
Mulch	Mulch for bioretention and possibly TESC	8-01.3(2)D	**CY**		**$41**
SR 18 Maple Valley to Issaquah Hobart Road	Bark or wood chip mulch		CY	4259	35.04
SR 18 – 180th to Maple Valley	Bark or wood chip mulch		CY	398	38.48
Ballard Roadside Rain Gardens	Mulch (Shredded)		CY	59	49.14
Compost	Compost for soil amendment	8	**CY**		**$38**
SR 18 Maple Valley to Issaquah Hobart Road	CompostType 1		CY	8255	28.03
SR 18 Maple Valley to Issaquah Hobart Road	CompostType 2		CY	222	42.05
Ballard Roadside Rain Gardens	Composted Material		CY	288	45.05
Bioretention Soil	For bioretention	8 SP	**CY**		**$44**
Ballard Roadside Rain Gardens	Bioretention soil, Landscape mix		CY	1100	40.19
Ballard Roadside Rain Gardens	Bioretention soil, turf mix		CY	122	43.68
Redmond 185th Ave NE Extension	Bioretention soil		CY	350	47.44
Planting - Bioretention (Includes irrigation)	Bioretention	8-02.3(8)	**SF**		**$5**
Snohomish County LID Engineers Estimate	Plants		SF	996	4.59
Mercer Island City Hall LID Retrofit Engineers Estimate	Plantings		SF	NA	3.04
NDS swale cost from Pinehurst in Seattle	Landscape		SF	13200	2.81
Ballard Roadside Rain Gardens	Estimate based on total plant cost/total rain garden area		SF	29473	4.52

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Planting - Wetland	Planting for wetpond	8-02.3(8)	**SF**		**$0.5**
San Juan County Eastsound constructed wetland	Pond Excavation		SF	43560	0.54
Planting - Landscaping (Includes irrigation)	Landscape strips along road or in commercial property	8-02.3(8)	**SF**		**$5**
Cost Estimate (Kate Forrester)	Landscape - plants		SF	1000	3.50
Turf Soil Quality and Depth (Includes irrigation)	Soil quantity and Depth	8 SP	**SF**		**$1.90**
Turf	Based on bottom up estimate		SF	10000	0.44
Landscaping Soil Quality and Depth (Includes irrigation)	Soil quantity and Depth	8 SP	**SF**		**$7.30**
Plantings	Based on bottom up estimate		SF	10000	5.83
Seeding and Mulching	Seeding ponds or similar facilities, hydroseeding	8-01.3(2)B	**AC**		**$3,300.00**
SR 18 – 180th to Maple Valley	Seeding, fertilizing, and mulching		AC	122	1035.11
SR 18 Maple Valley to Issaquah Hobart Road	Seeding, fertilizing, and mulching		AC	65	1191.43
2011 Street Overlay Project	Seeding, fertilizing, and mulching		AC	1	4573.05
Private	Hydroseed		AC	0.054292929	4396.19
Streambed Gravel	For bioretention	9-03.11	**CY**		**$61**
SR 18 Maple Valley to Issaquah Hobart Road	Streambed gravel		CY	703	63.08
SR 18 – 180th to Maple Valley	Streambed gravel		CY	307	79.62
Snohomish County 2012 Drainage Improvements	Streambed gravel		CY	47	45.72
WSDOT UBA (Job # 04A024)	Streambed gravel		CY	15	69.69
WSDOT UBA (Job # 07A010)	Streambed gravel		CY	110	45.01
Streambed Cobbles	For bioretention	9-03.11(2)	**CY**		**$67**
230th Street SW Reconstruction Project	Streambed Cobbles		CY	11	61.11
Ballard Roadside Rain Gardens	Streambed cobbles (1in-4in)		CY	180	65.53
WSDOT UBA (Job # 11A020)	Streambed Cobbles		CY	10	101.33
WSDOT UBA (Job # 09A021)	Streambed Cobbles		CY	67	39.32
Riprap	For energy dissipation at inlet and outlet of ponds	9-13.1(2)			**$140**
SR 18 – 180th to Maple Valley	Light loose riprap		CY	20	92.89
Mallard Pond Wetland Enhancement	Light loose riprap		CY	20	184.06
Weir	For bioretention	8 SP	**LF**		**$56**
Ballard Roadside Rain Gardens	Weir (Type 1)		LF	395	76.45
Ballard Roadside Rain Gardens	Weir (Type 2)		LF	34	23.48
Shope Concrete	Rain Garden Weir (108"x30"x6")		LF	9	52.29
Shope Concrete	Rain Garden Weir (60"x30"x6")		LF	5	72.02

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Impermeable liner	For ponds	8 SP	**SF**		**$0.70**
NW Linings Estimate	30 MIL PVC liner		SF	1000	0.60
NW Linings Estimate	36 MIL PVC liner		SF	1000	0.80
Chain Link Fencing	For ponds	8-12.3(1)	**LF**		**$21**
Mallard Pond Wetland Enhancement	Chain Link Fence Type 1		LF	1500	21.47
230th Street SW Reconstruction Project	Chain Link Fence		LF	35	52.23
SR 18 – 180th to Maple Valley	Chain Link Fence Type 3		LF	42220	7.30
SR 18 – 180th to Maple Valley	Chain Link Fence Type 4		LF	127	13.27
SR 18 – 180th to Maple Valley	Chain Link Fence Type 6		LF	923	10.62
Geotextile / Filter Fabric	For soil separation in bioretention, pavement, or trenches	2-12.3(1)	**SY**		**$2**
Redmond 185th Ave NE Extension	Construction Geotextile for Underground Drainage		SY	780	2.11
Snohomish County 2012 SWM Drainage Improvement Projects (Zone 1)	Construction Geotextile for Underground Drainage		SY	220	1.01
Hawaiian Court Stormwater Improvement Project	Construction Geotextile for Underground Drainage		SY	200	4.16
SR 18 – 180th to Maple Valley	Construction Geotextile for Underground Drainage		SY	490	2.65
SeaTac 138th St. Neighborhood Ped Improvements	Construction Geotextile for Separation		SY	510	1.08
SR 18 Maple Valley to Issaquah Hobart Road	Construction Geotextile for Underground Drainage		SY	6320	$2.66
8th Ave NW LID Retrofit	Construction Geotextile for Separation (SP 2-12)		SY	2345	$1.01
Cement Concrete Sidewalk	Concrete for driveway aprons or sidewalks	8-14	**SY**		**$49**
8th Ave NW LID Retrofit	Cement concrete sidewalk		SY	385	59.36
SPU JOC Unit Cost Report 2010	Sidewalk, CEM CONC		SY	250-500	41.54
Lacey Carpenter Road Reconstruction	Cement Conc. Sidewalk		SY	9232	22.15
SR 18 – 180th to Maple Valley	Cement Concrete Sidewalk		SY	3145	26.54
West Valley Highway Improvements	Cement Concrete Sidewalk		SY	75	55.04
230th Street SW Reconstruction Project	Cement Concrete Sidewalk		SY	160	65.81
SPU JOC Unit Cost Report 2010	Sidewalk, Cem conc		SY	<10	58.15
SPU JOC Unit Cost Report 2010	Sidewalk, Cem conc		SY	10to50	46.52
WSDOT UBA (Job # 10A063)	Cement conc. sidewalk		SY	15	83.91
WSDOT UBA (Job # 10A034)	Cement conc. sidewalk		SY	1639	37.32
WSDOT UBA (Job # 10A007)	Cement conc. sidewalk		SY	690	43.53
Ballard Roadside Rain Gardens	Sidewalk, CEM CONC		CY	223	49.14

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Pervious Concrete Sidewalk	Pervious concrete sidewalk	8-14 SP	**SY**		**$54**
8th Ave NW LID Retrofit	Pervioius concrete sidewalk		SY	385	59.36
The Guide, Winter 2013 edition	Pervious concrete paving		SY	NA	58.50
West Valley Highway Improvements	Pervious concrete sidewalk		SY	750	57.11
Seatac 138th St. Neighborhood Ped Improvements	Porous Concrete Sidewalk		SY	1334	39.86
High Visibility Fencing	TESC	9-14.5(8)	**LF**		**$10**
West Valley Highway Improvements	Sensitive area fence		LF	270	12.46
Bear Creek Park WQ Facility	High visibility fencing		LF	2500	2.08
Redmond 185th Ave NE Extension	Security fence		LF	1002	30.41
Snohomish County 35th Ave SE and 180th st SE	High visibility fencing		LF	1910	3.56
Snohomish County 116th Ave SE Intersection	High visibility fencing		LF	990	3.91
Wattle	TESC	8-01.3(10)	LF		**$3**
SR 18 Maple Valley to Issaquah Hobart Road	Wattle		LF	39620	2.80
Bear Creek Park WQ Facility	Wattle		LF	380	2.61
Auburn WVH	Wattle		LF	115	4.17
Stabilized Construction Entrance	TESC	8-01.3(7)	**SY**		**$19**
139th St E Cul-de-sac	Stabilized construction entrance		SY	86	28.04
SR 18 Maple Valley to Issaquah Hobart Road	Stabilized construction entrance		SY	2130	16.82
SR 18 – 180th to Maple Valley	Stabilized construction entrance		SY	1139	19.91
Bear Creek Park WQ Facility	Stabilized construction entrance		SY	100	9.59
Silt Fence	TESC	8-01.3(9)A	**LF**		**$2.50**
Auburn WVH	Silt Fence		LF	1320	3.65
SR 18 Maple Valley to Issaquah Hobart Road	Silt Fence		LF	38910	3.08
Redmond 185th Ave NE Extension	Silt Fence		LF	1310	3.16
Snohomish County 35th Ave SE and 180th st SE	Silt Fence		LF	2570	3.71
Private	Silt Fence		LF	2735	1.61
Private	Silt Fence		LF	2545	1.47

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Level Spreader Board	For downspout dispersion	8 SP	**LF**		**$14**
Bottom up estimate	Based on bottom up estimate		LF	100	9.14
Private	Flow Spreader		LF	24	25.23
Private	Flow Spreader		LF	17	12.30
Tire wash	TESC		**EA**		**$2,600**
Redmond 185th Ave NE Extension	Tire wash		EA	1	2635.40
Temporary seeding	TESC	8-01.3(2)	**AC**		**$800**
WSDOT UBA (Job # 11A014)	Temporary seeding		AC	10.1	232.54
WSDOT UBA (Job # 10A017)	Temporary seeding		AC	2.9	1265.24
WSDOT UBA (Job # 07A028)	Temporary seeding		AC	5.7	991.62
Storm drain inlet protection	TESC	8-01.3(9)D	**EA**		**$59**
Snohomish County 35th Ave SE and 180th st SE	Inlet protection		EA	38	66.03
Snohomish County 2012 Drainage Improvements	Inlet protection		EA	14	60.95
Snohomish County 116th Ave SE Intersection	Inlet protection		EA	13	44.70
Private	Inlet Protection		EA	10	65.60
Private	Inlet Protection		EA	10	55.67
Interceptor swale geosynthetic liner	TESC	8 SP	**SY**		**$3**
NW Linings Estimate	Jute (4'x225' roll=100SY)+Labor (2.00/SY)		SY	100	2.56
NW Linings Estimate	Coir matting (13.1'x82' roll=120SY)- Coir 400		SY	100	3.05
NW Linings Estimate	Coir matting (13.1'x82' roll=120SY)- Coir 700		SY	100	3.88
NW Linings Estimate	Coir matting (13.1'x82' roll=120SY)- Coir 900		SY	100	4.05

Herrera Environmental Consultants, Inc. 11-05240-000

CLIENT: Department of Ecology
PROJECT: Cost Analysis for Western Washington LID Requirements and Best Management Practices
DESCRIPTION: Unit Costs for Cost Estimate Preparation

Prepared by: C. Echterling
Checked by: M. Ewbank

Item	General Description	Spec Division	Units	Quantity Range	Low Jan 2013 Unit Price
Erosion and Sediment Control (ESC) Lead	TESC		**DAY**		**$70**
SeaTac S. 154th St Improvements (ST-130)	ESC Lead	8-01.3(1)B	DAY	150	70.00
Permeable Pavement Check Dam	Soil quantity and Depth	8 SP	**LF**		**$9**
Permeable Pavement Check Dam	Based on bottom up estimate		LF	1000	9
Pervious Concrete Roadway	Pervious concrete	5 SP	**SY**		**$48**
Sprinker Parking Lot LID Phase II	Porous concrete pavement		SY	5380	35.21
139th St E Cul-de-sac	Porous concrete pavement		SY	77	48.81
8th Ave NW LID Retrofit	Pervious concrete		SY	385	59.36

APPENDIX C

Modeling

General Assumptions

MGSFlood Version 4.31 was used to perform conceptual sizing of stormwater management facilities for this analysis. MGSFlood is a continuous simulation hydrologic model that simulates rainfall runoff based on land use, soils, and vegetation. Modeling was conducted to appropriately size BMPs for each site, soil type (till and outwash), and performance standard (forest flow duration and water quality treatment standards) included in this analysis. MGSFlood was also used to evaluate the performance of prescriptively sized LID BMPs implemented to satisfy Minimum Requirement #5 (on-site stormwater management), where applicable.

Infiltration (e.g., bioretention, permeable pavement) and detention (e.g., vault) facilities were sized to meet Ecology's minimum requirement for flow control assuming a pre-developed forest land cover (referred to in this document as the forest duration standard). This standard requires matching peak flow rates and flow durations from half of the 2-year to the 50-year recurrence interval flows to a pre-developed forest condition (on till or outwash soil). Depending on which Minimum Requirements were triggered for a particular example development site (single family residential, small commercial, and large commercial) or surfacing type (non-PGHS roofs or sidewalks, PGHS driveways or roads, and PGPS lawn and landscaping), some facilities were also sized to achieve the Ecology water quality treatment standard (i.e., infiltrate or detain the 91st percentile, 24-hour runoff volume).

Precipitation and Evaporation Timeseries

Mean annual precipitation in western Washington ranges from 18 inches west of central Puget Sound to more than 270 inches in the Olympic Mountain range (see Figure C-1). However, the majority of development is likely to occur in the lowlands of western Washington (i.e., up to approximately 1,500 feet in elevation) where the precipitation range (while still highly variable) is narrower (ranging from approximately 18 inches to approximately 120 inches). For the purposes of this costing effort, a single mean annual precipitation depth of 44 inches was selected to represent precipitation in areas most likely to experience development in the next decade. A rainfall pattern consistent with precipitation observed in the western Puget Sound region will be used for this effort because the nature of these storm events results in larger facility sizes than that of the eastern Puget Sound, producing slightly conservative facility sizes for the costing efforts. Rainfall depths and patterns in western Washington lowlands will be represented by an extended precipitation and evaporation time series developed by MGS Engineering Consultants, Inc. (MGS 2002, 2010) (i.e., "Puget West 44" precipitation).

Simulation Time Step

To adequately represent storage and routing for smaller sites, a 15-minute model simulation time step was used for modeling of all infiltration and water quality BMP sizing performed in MGSFlood.

Soil Types and Infiltration Rates

Uncorrected infiltration rates of 0.3 inches per hour for till soils and 6 inches per hour for outwash soils will be used for all infiltrating facilities. These infiltration rates were corrected to produce design infiltration rates in accordance with the 2012 manual as follows:

- Bioretention facilities (underlying subgrade soils)
  - Design infiltration rate, till = **0.20 inch per hour**
  - Design infiltration rate, outwash = **4.02 inches per hour**
- Permeable pavement facilities
  - Design infiltration rate, till = **0.19 inch per hour**
  - Design infiltration rate, outwash = **3.84 inches per hour**
- All other infiltrating facilities
  - Design infiltration rate, till = **0.18 inch per hour**
  - Design infiltration rate, outwash = **3.6 inches per hour**

Land Cover

Land cover for each of the sample development sites (i.e., single-family residential, small commercial, large commercial) was calculated based on a "birds-eye view" of the site to ensure that each square foot of the site was allocated to only one surface type. For example, roof that overhangs the lawn and driveway around the perimeter of the dwelling was classified as an impervious surface rather than lawn or in some cases, permeable pavement. For this reason, the land cover quantities for lawn and permeable pavement in this appendix may differ slightly from the quantities used in the cost estimate. The cost estimate quantities were tabulated based on the actual quantity on the ground, rather than based on a "bird's eye view" of the site. The birds-eye view was used for modeling because it is representative of which surface will receive precipitation. Table C-1 provides a summary of model land cover inputs by development site.

BMP Representation

LID BMPs were represented in MGSFlood according to the modeling methods prescribed in the 2005 and 2012 manuals.

Bioretention

Bioretention facilities were modeled using the Ecology-approved bioretention module with infiltration applied to the facility bottom area and 3H:1V side slopes.

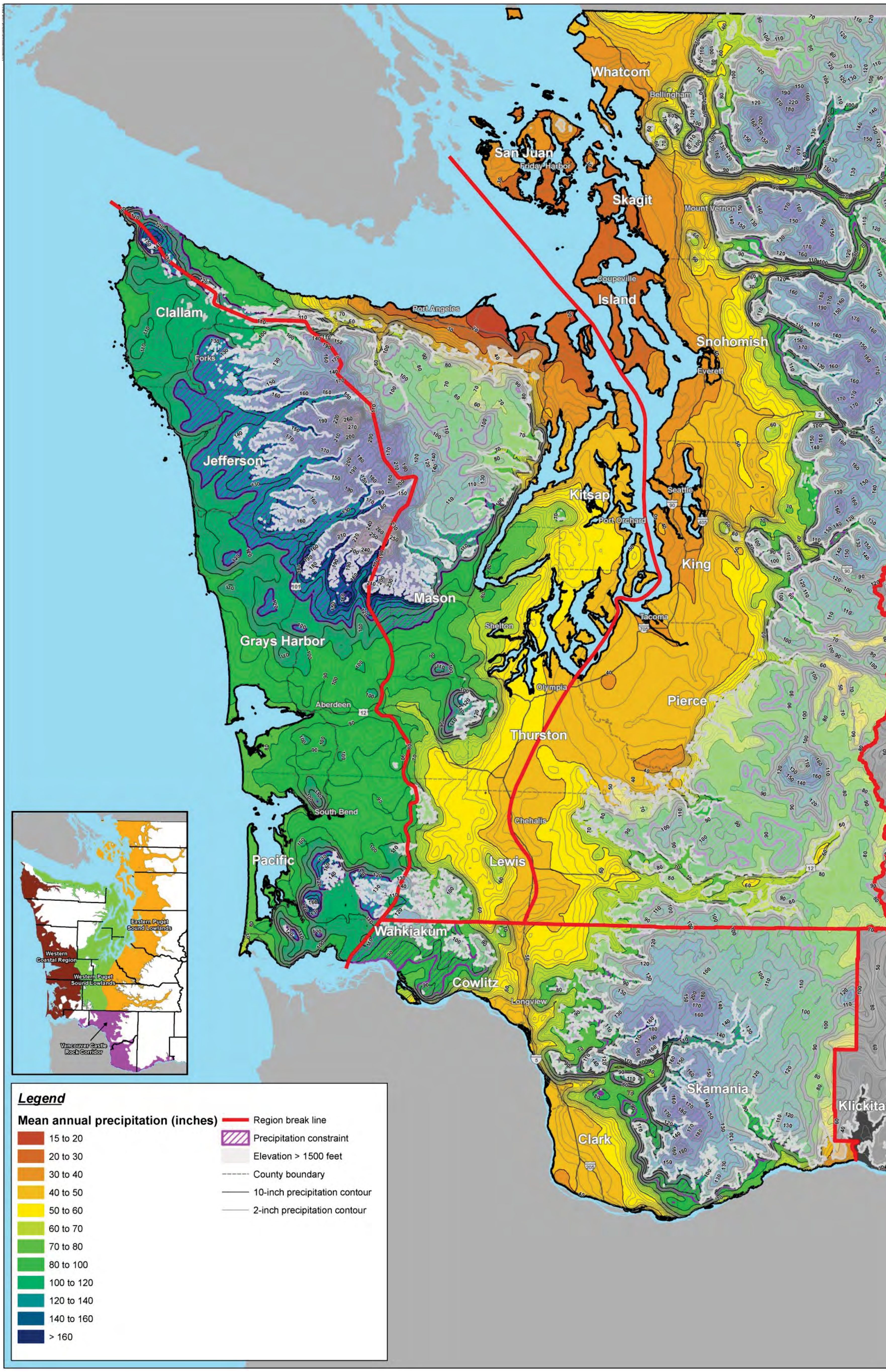


Figure C-1. Western Washington Mean Annual Precipitation.

Table C-1. Sample Development Site Land Cover.				
Single-Family Residential Development				
	Without LID Principles		**With LID Principles**	
Typical SFR Lot [1]				
Landscape Area	4,422 sf	0.102 ac	2,400 sf	0.055 ac
Roof Area	2,400 sf	0.055 ac	2,000 sf	0.046 ac
Pathway Area	125 sf	0.003 ac	120 sf	0.003 ac
Driveway Area	553 sf	0.013 ac	480 sf	0.011 ac
TOTAL	7,500 sf	0.172 ac	5,000 sf	0.115 ac
Total Right-of-Way				
Roadway	51,856 sf	1.190 ac	31,753 sf	0.729 ac
Curb and Gutter	3,704 sf	0.085 ac	2,925 sf	0.067 ac
Sidewalk	18,520 sf	0.425 ac	8,520 sf	0.196 ac
Driveway Apron	5,460 sf	0.125 ac	5,390 sf	0.124 ac
Planting Strip	13,060 sf	0.300 ac	8,808 sf	0.202 ac
TOTAL	92,600 sf	2.126 ac	57,396 sf	1.318 ac
Small Commercial Development				
Landscape Area	8,045 sf	0.185 ac		
Roof Area	5,000 sf	0.115 ac		
Sidewalk Area	775 sf	0.018 ac		
Parking Area	29,740 sf	0.683 ac		
TOTAL	43,560 sf	1.0 ac		
Landscape Area	18,245 sf	0.419 ac		
Roof Area	127,565 sf	2.928 ac		
Sidewalk Area	6,360 sf	0.146 ac		
Parking Area	283,430 sf	6.507 ac		
TOTAL	435,600 sf	10.0 ac		

1 All typical single-family residential lot land cover areas multiplied by the total number of developable lots for the scenario to estimate land cover totals for the 10-acre development.

General Assumptions

- Ponding depth equals 6 inches for all bioretention facilities
- Minimum freeboard equals 6 inches for all bioretention facilities
- Bottom area shall be flat (0 percent slope)

- Side slopes within the ponded area shall be no steeper than 3H (horizontal):1V (vertical).
- Imported bioretention soil mix assumed to meet Ecology infiltration treatment soil requirements, have a design infiltration rate of 3.0 inches per hour, and 40 percent porosity
- Bioretention soil depth shall be a minimum of 12 inches for flow control, and a minimum of 18 inches for water quality treatment
- No underdrain or impermeable layer shall be used
- Overflow structure diameter equals 12 inches for all residential applications and 24 inches for all commercial applications

Additional Considerations

- Bottom geometry varies by site and application, as follows:
    - Residential, parcel-based: modeled as square
    - Residential, right-of-way based: modeled as linear assuming an average bottom width of 2 feet. Average bottom width based on available planter strip top width (10 feet), design ponding and freeboard depths, and assumed longitudinal site slopes of 2 percent.
    - Commercial: modeled as linear assuming an average bottom width of 2 feet and 3 feet for 10-foot and 15-foot wide planter strips respectively. Average bottom width based on available planter strip top width, design ponding and freeboard depths, and assumed longitudinal site slopes of 2 percent.
- Checkdams used as grade controls to maintain bioretention design requirements (e.g., ponding depth, bottom width) but not explicitly modeled.
- Bioretention bottom area removed from lawn/landscaped area to prevent double counting of surfaces in the model.

Bioretention facilities have been sized to meet the specified standards. For residential, parcel-based bioretention, sizing is based on Ecology's prescriptive sizing provided in the 2012 manual (i.e., projected water surface equals 5 percent of the contributing drainage area). These on-site stormwater management facilities have been explicitly modeled in MGSFlood in an effort to credit their ancillary flow control and water quality benefits, including elimination, or reduction in the footprint of, downstream centralized facilities. For bioretention facilities providing water quality treatment or flow control to partially or fully satisfy minimum requirements for the site, the bottom length of the facility was iteratively sized in MGSFlood to the nearest whole foot increment.

Permeable Pavement

Permeable pavement facilities were modeled using the porous pavement module with infiltration applied to the facility footprint area and vertical side slopes.

General Assumptions

- Permeable pavement infiltration rate equals 100 inches per hour (non-limiting)
- Gravel porosity equals 30 percent
- Modeled pavement/trench slope equals zero

Permeable pavement aggregate thickness has been iteratively sized, to the nearest hundredth of a foot, to meet the specified standards. Because the sample development sites are sloped, the aggregate thickness sized in the model corresponds to the average storage depth required to meet the stormwater requirements. To achieve this average storage depth on the sloped site, additional aggregate and grade control structures (subsurface checkdams) are required. This actual aggregate thickness was calculated based on the modeling results and subsequently used in the cost estimating efforts. In some instances, the aggregate thickness required to meet the stormwater requirements was less than what was required to support the design pavement loads. In these cases, the structural depth was included in the model, resulting in permeable facilities that over perform relative to the standards.

Full Infiltration (BMP T5.10A)/Onsite Stormwater Management Infiltration Trench

Required trench length (linear feet) per 1,000 square feet of roof area is prescribed in the Ecology manual based on soil type. For the purposes of this effort, soils were assumed to be "medium sand", requiring 30 linear feet of trench per 1,000 square feet of contributing roof area.

All areas routed to these facilities were assumed to fully infiltrate runoff. As a result, areas managed by full infiltration practices were removed from the model.

Soil Quality and Depth (BMP T5.13)

All areas that meet the soil quality and depth requirement were modeled as pasture (on outwash or till) in the post-developed condition.

Stormwater Treatment Planter Vaults

Stormwater treatment planter vaults were modeled using the structure (pond and sand-filter) module with infiltration applied to the facility surface area and vertical side slopes. Facilities were sized to allow for 91 percent of the influent runoff file to pass through the treatment facility at the design hydraulic conductivity. Because site constraints (namely MS4 depth) limit the application of standard size planter vaults, a shallow facility configuration was used instead. To meet the treatment intent of the standard system (a function of facility contact time), shallow facility applications will be upsized per Table C-2, below.

Table C-2. Standard to Shallow Planter Vault Configuration Conversion.	
Standard Depth	**Equivalent Shallow Depth**
4x4	4x6
4x6	6x6
4x8	6x8
6x6	6x10
6x8	6x12
6x10	7x13

Source: Filterra General Use Level Designation for Basic (TSS), Enhanced, and Oil Treatment. February 2013.

General Assumptions:

- Filter media depth equals 1.8 feet
- Effective ponding depth equals 0.75 feet (6 inches of ponding plus 3 inches of mulch)
- Side slopes within the facility are assumed to be vertical
- Hydraulic conductivity of filter assumed to be 35.46 inches per hour for basic treatment and 24.82 inches per hour for enhanced treatment (these values are based on the Filterra General Use Level Designation for Basic (TSS), Enhanced, and Oil Treatment)

Centralized Infiltration Trench

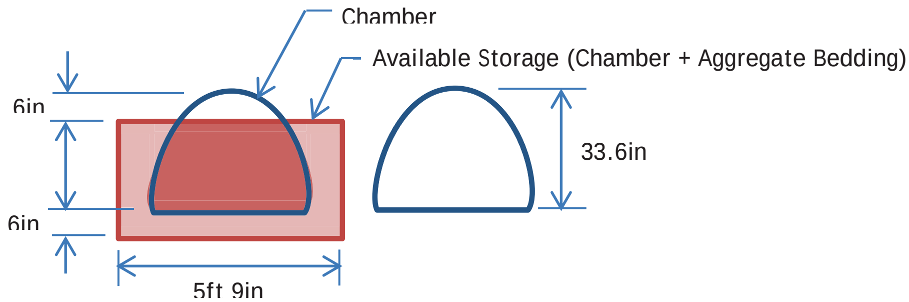
Infiltration trench facilities were modeled using the structure (pond) module with infiltration applied to the facility surface area. Facilities were sized to satisfy flow control requirements (i.e., match pre-developed discharge durations from 50 percent of the 2-year to the full 50-year peak flow from a forested condition). For the purposes of this effort, perforated, pre-fabricated chambers were used to increase the voids fraction in the facility.

General Assumptions (see sketch):

- Pipe cross-sectional area assumed to be equivalent to a 30-inch storm chamber
- Pipe assumed to be perforated to utilize storage capacity of aggregate bedding material and infiltration capacity of underlying native soil
- Typical trench cross section (including chamber and aggregate bedding) equals 5 feet, 9 inches
- Aggregate bedding porosity equals 30 percent
- Volume-weighted porosity equals 70.9 percent (i.e., actual depth times volume-weighted porosity of chamber and aggregate bedding)

- Effective depth equals 1.99 feet (accounts for porosity of storage layer)
- Overflow diameter equals 18 inches
- Freeboard equals 6 inches

Infiltration trench facilities sized to the nearest foot in length.



Detention Tank

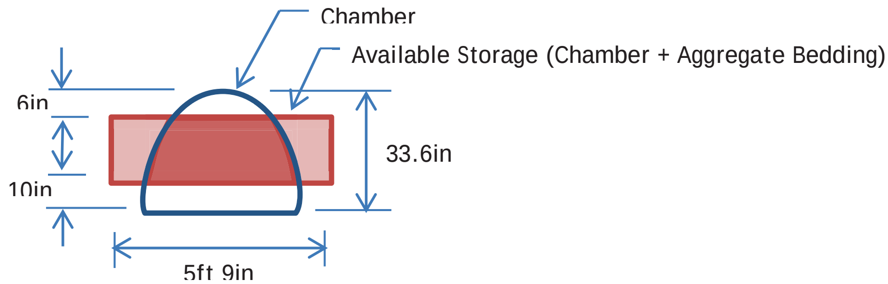
Detention tank facilities were modeled using the structure (pond) module with incidental infiltration applied to the facility surface area and vertical side slopes. Facilities were sized to satisfy flow control requirements (i.e., match pre-developed discharge durations from 50 percent of the 2-year to the full 50-year peak flow from a forested condition). For the purposes of this effort, perforated, pre-fabricated, chambers were used to increase the voids fraction in the facility. Outflow from the facility is controlled by an outlet control structure (i.e., orifice or combination of orifices and overflow riser). These structures were optimized using the MGSFlood optimization routine for an equivalent, prismatic storage chamber. To properly account for head on the outlet structure, storage in the detention tank was represented with a stage storage curve (instead of the optimized prismatic storage chamber) and iteratively sized to meet the performance standards. Note that the stage-storage curve was produced external to the model, then input into MGSFlood using the elevation volume table in the structure module. Due to site constraints (namely MS4 depth), only a fraction of the available chamber volume serves as live storage in the facility.

General Assumptions (see sketch):

- Pipe cross-sectional area assumed to be equivalent to a 30-inch storm chamber
- Pipe assumed to be perforated to utilize storage capacity of aggregate bedding material and infiltration capacity of underlying native soil
- Typical trench cross section (including chamber and aggregate bedding) equals 5 feet, 9 inches
- Aggregate bedding porosity equals 30 percent

- Overflow depth equals 1.74 feet
- Overflow diameter equals 18 inches
- Orifice heights and dimensions vary by scenario
- Freeboard equals 6 inches

Detention tanks sized to the nearest foot in length.



Infiltration Basin

Infiltration basins were modeled using the structure (pond) module with infiltration applied to the facility surface area and 3H:1V side slopes. Facilities were sized to satisfy flow control requirements (i.e., match pre-developed discharge durations from 50 percent of the 2-year to the full 50-year peak flow from a forested condition).

General Assumptions (see sketch):

- Storage depth equals 4 feet
- Freeboard depth equals 1 foot
- Side slopes within the ponded area shall be no steeper than 3H (horizontal):1V (vertical)
- Overflow diameter equals 18 inches
- Facility geometry assumed to be square (length = width)

Infiltration basins sized to the nearest 0.5 feet in length and width.

Wetponds

Wetponds were sized based on the methods prescribed by Ecology in the manual. The water quality treatment volume was determined for each scenario using MGSFlood.

General Assumptions:

- Facility represented as a two-celled system for water quality treatment volumes greater than 4,000 cubic feet (a single cell configuration was used for scenarios with sufficiently small water quality treatment volumes)
- Freeboard depth equals 1 foot

Two-celled facility assumptions:

- First cell sized to contain approximately 35 percent of the water quality treatment volume
- First cell ponding depth equals 7 feet
- Second cell sized to contain remaining volume
- Second cell ponding depth equals 4 feet
- Second cell flow path length at least 3:1, as measured from inlet to outlet, at the mid-depth of the facility

Single-celled facility assumptions:

- Ponding depth varies (when water quality treatment volume is sufficiently small, the depth of the facility has been reduced to provide only the necessary amount of storage)
- Flow path length at least 5:1, as measured from inlet to outlet, at the mid-depth of the facility