MUKILTEO STORMWATER RETROFIT PROJECT IDENTIFICATION AND PRIORITIZATION REPORT

Prepared for

City of Mukilteo

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1.0 INTRODUCTION

This study builds on the Watershed-Based Stormwater Strategies Plan (Mukilteo 2013) and identifies, prioritizes, and selects stormwater retrofit projects. The Watershed Based Stormwater Strategies Plan identified three target project analysis units (PAUs) - Big Gulch North, Big Gulch South, and Picnic Point Ravine - as the highest priority within the City for stormwater retrofits. In this effort, a finer spatial scale analysis identifies and prioritizes specific stormwater retrofit projects, including:

- Updated Stormwater Geodatabase
- Catchment Delineation and Analysis
- Stormwater Retrofit Project Identification
- Stormwater Retrofit Project Analysis

Numerous studies link development with impaired stream processes, degraded instream habitat, and degraded water quality (Booth 1991; Booth et al. 2002; Alberti et al. 2006). Since the early 1990s, state and local agencies have developed stormwater management manuals to mitigate impacts associated with development on stream hydrology and water quality. However, these manuals focused largely on reducing peak flow events and did not address increases in the duration of erosive flows. Additionally, much of the City was developed prior to the first stormwater management requirements or has stormwater management facilities designed to outdated stormwater regulations and design manuals. As a result of these two situations, much of the study area has little to no flow control or water quality treatment.

This report documents the analysis methods and results of each study element as well as the final stormwater retrofit project recommendations.

1.1 Project Goals

Primary goals of this investigation are to: continue improving regional collaboration and develop work products for advancing stormwater management and public education/outreach. This study has two overarching goals:

- Develop methods for identifying and prioritizing stormwater retrofit projects; and
- Use these methods to identify and pre-design three stormwater retrofit projects.

Although this study focuses on three PAUs, methods developed in this effort can be applied throughout the City to prioritize stormwater retrofit projects. An additional goal is to provide a foundation for the 2013/14 Mukilteo Stormwater Comprehensive Plan Update, which will develop and prioritize stormwater retrofit projects that target watershed process recovery throughout the City.

1.2 Background and History

In 2011, the City and several partners developed a Watershed-Based Stormwater Strategy Plan using grant funding provided by the Department of Ecology (Ecology) through the National Estuary Program

(NEP) Watershed Protection and Restoration Grant Program. The Stormwater Strategy Plan was based on data and methods from the Puget Sound Characterization Study (Stanley et al 2011). The Watershed-Based Stormwater Strategies Plan identified Big Gulch North, and Big Gulch South Picnic Point Ravine PAUs as high priorities for stormwater retrofits as compared to other PAUs evaluated that study (Figure 1).

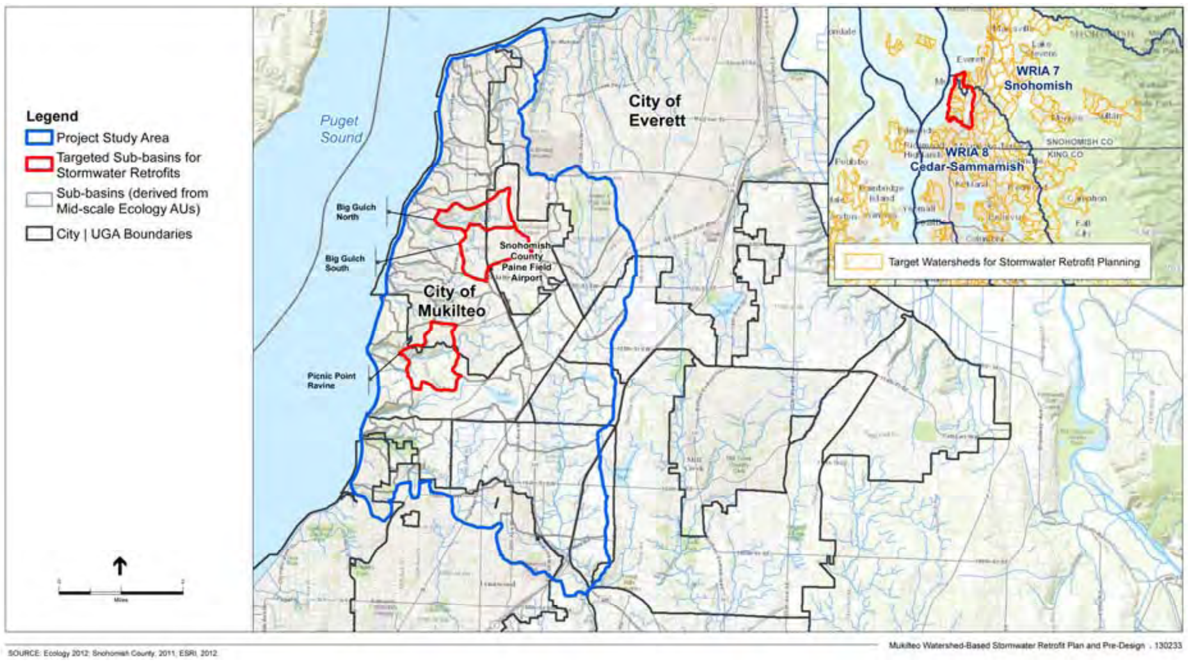

Figure 1. Study Area Location Map.

Several conceptual engineering strategies identified for these PAUs target delivery processes, such as reduced impervious surface area. Retrofitting existing development with stormwater management BMPs to reduce effective impervious surfaces, improve storage, or increase infiltration improves water quality, reduces the frequency and magnitude of peak flow events, and protects summer stream flows. In 2014, the City won another NEP grant to develop methods for the identified strategies, which funds this study.

1.3 Problem Statement

Many studies performed throughout Puget Sound link impervious cover with stream impairment. In general, higher levels of impervious cover relate to higher levels of physical, chemical, and biological impairments (Luchetti et al. 2014). Although detention facilities can attenuate peak flows from impervious surface; literature also indicates that stormwater facilities constructed during the 1990s and early 2000’s are not as effective at minimizing stream impairment (Booth et al. 2002).

Streams within the study area have been degraded as a result of direct manipulations to stream channels and an altered hydrology. Altered hydrology is largely results from changes in land cover dating back to the early 1900s when logging first occurred. Degradation to stream form and function include physical changes that follow the onset of greater runoff volumes, higher peak flows, and longer durations of erosive flows that reduce habitat functioning dependant on the physical and chemical characteristics of the stream channel.

Streams within the study area have been influenced to varying degrees and in some cases have had several decades to reach a new equilibrium. In addition, the City has constructed instream projects to improve the stability and habitat of Big Gulch and Picnic Point Ravines. However, the resulting habitat conditions within the stream will likely not approach desired levels without stormwater retrofits that better mimic natural runoff conditions.

2.0 UPDATED GEODATABASE

As part of this effort, ESA updated the City's Stormwater Inventory geodatabase, including adding in new data and correcting existing datasets. Updates were generally limited to the geographic extents of the study area, which included Big Gulch North and South, and Picnic Point Ravine PAUs, although a limited number of edits were made outside of this spatial extent. Most updates were associated with stormwater management facilities such as vaults, drainage ponds, and dual function ponds. Updates to drainage points, catch basins, and network feature classes were based on georeferenced as-built drawings obtained from the City.

Updates to existing datasets included changing drain features that were incorrectly coded as detention ponds to catch basins, removing an erroneously mapped detention pond record, reversing flow directions of network lines, and adjusting the geographic location of network features based on reviewing georeferenced as-built drawings. A significant portion of the Big Gulch water course line feature was also re-digitized based on a georeferenced CAD drawing of the Big Gulch sewer installation. This study created an additional 57 drainage point and 31 catch basin features; it also removed one drainage pond and two dual function pond features from the original geodatabase. This study also added the year stormwater features were constructed; the construction year was based on the date of as-built drawings or inferred from aerial photograph interpretation.

A new catchment polygon geodatabase feature class was created. Catchment polygons are a subset of the PAU polygons and were extracted from the existing PAU polygon dataset. ESA hydrologists delineated catchment boundaries using topographic data, stormwater drainage infrastructure data; catchments are defined as small areas that drain to a single discharge point. ESA hydrologists adjusted some of the catchment boundaries based on field observations of private or unmapped drainage systems resulted in drainage patterns that differed slightly from those inferred from the geodatabase maps.

3.0 METHODS OVERVIEW

Identification and prioritization of stormwater retrofit projects was conducted using a scoring system that represents three spatial scales. A score was developed at the PAU scale using the results of the

Watershed Based Stormwater Strategies Plan (Mukilteo 2013). Additionally, scores represent the catchment scale and stormwater retrofit project scale (Figure 2).

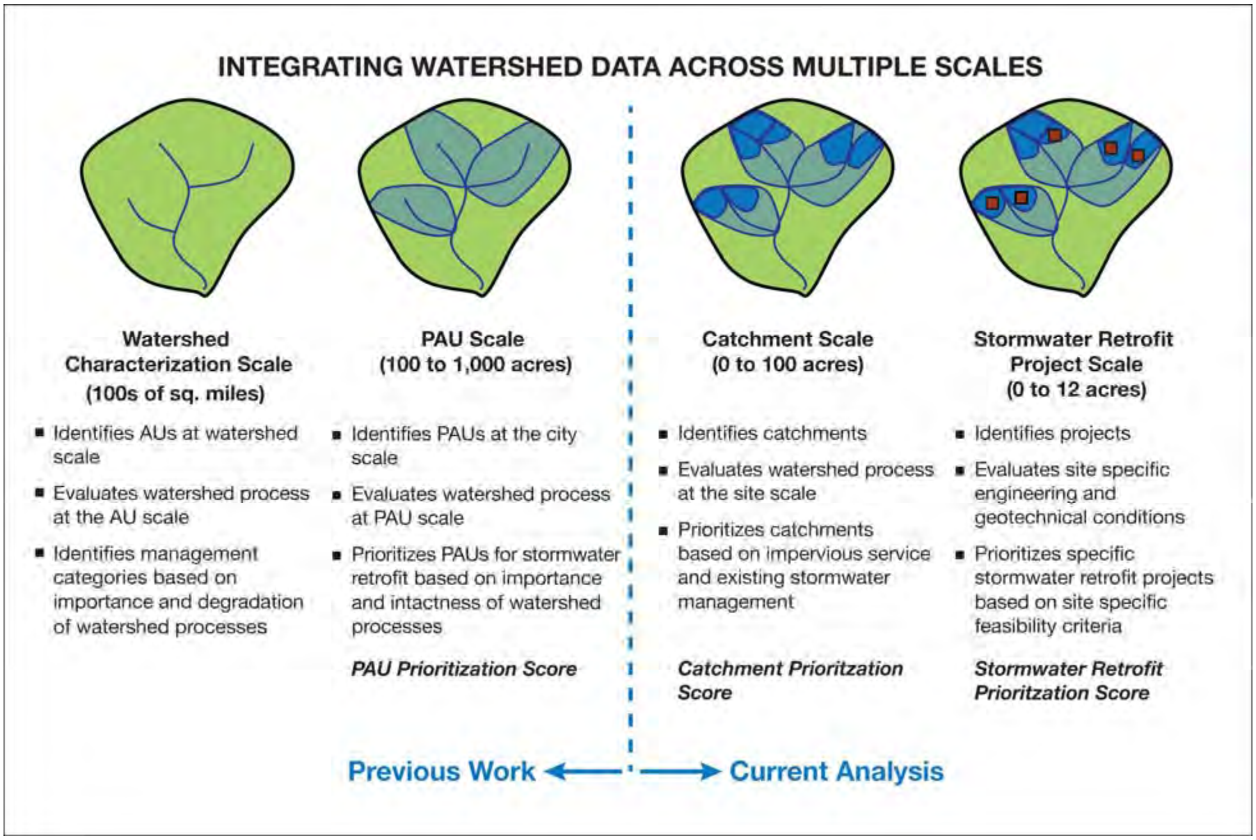

Figure 2. Integrating Watershed Data Across Multiple Scales

The final prioritization score for stormwater retrofit projects is a combination of scores from each spatial scale (Attachment C).

Retrofit Project Recommendation = PAU Score + Catchment Prioritization Score + Stormwater Retrofit Project Score

3.1 PAU Score

The PAU prioritization score developed in the Stormwater Strategies Plan (Mukilteo 2013), is based on the relative importance and level of intactness of watershed processes at the PAU scale. This score also represents secondary processes such as maintenance of fish and wildlife habitat and sediment transport and delivery. The intention of this score is to prioritize stormwater retrofit most important for watershed processes.

3.2 Catchment Prioritization Score

A catchment prioritization score was developed based on relative amount of impervious surface area of each catchment and the level of existing stormwater management. This score prioritizes stormwater retrofit projects with high levels of impervious area and low levels of existing stormwater management. Detailed methods and results of this scoring system are documented in Section 4 of this report.

3.3 Stormwater Retrofit Project Identification and Prioritization Score

The stormwater retrofit project score is intended to prioritize stormwater retrofit projects based on site specific considerations (Figure 3). This score was developed using a field screening analysis to identify catchments where stormwater retrofit would be feasible (Section 5.0). Catchments that did not meet the criteria for field screening were dropped for further consideration.

Following the field screening a more detailed analysis was conducted to identify stormwater retrofit project locations. Section 6.0 presents the methods used to evaluate and rank the stormwater retrofit projects.

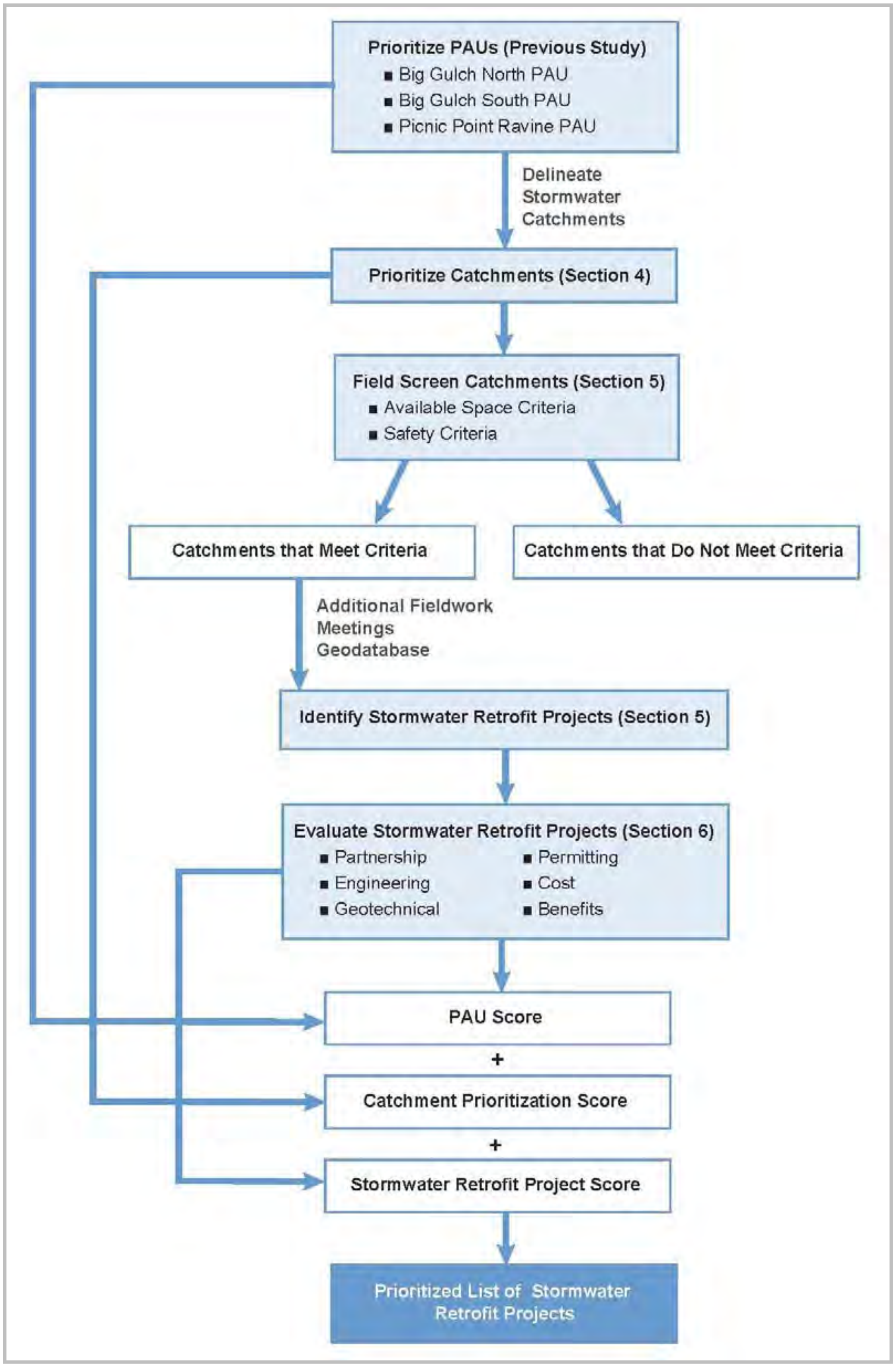

Figure 3. Stormwater Retrofit Identification and Prioritization Flow Chart

4.0 CATCHMENT PRIORITIZATION SCORE

The overall catchment prioritization score, discussed in the following sections, is the sum of the impervious surface and facilities scores and is intended to prioritize the catchment with the largest amount of impervious surface cover and the least amount of existing stormwater detention.

Catchment Prioritization Score = Impervious Surface Score + Existing Stormwater Facility Score

Each PAU within the study area was delineated into catchments (Maps 1 and 2). For each catchment, total impervious surface area (TIA) was calculated and level of stormwater management determined. Next, catchments were prioritized based on TIA and the level of existing stormwater management. The maximum score is 2.0 and high scores indicate a higher priority for stormwater retrofit.

4.1 Catchment Delineation

Catchments are areas that drain to an outfall, stormwater facility, or connection with main storm drain. Catchments were delineated using topography, the updated stormwater geodatabase, and field observations. Portions of each PAU were not included in the catchment analysis because they did not contain significant amounts of development or a point source of stormwater runoff. Catchment maps are provided in Attachment A.

4.2 Impervious Surface Score

Within the City limits effective impervious surface area (EIA) was estimated using the equations from Sutherland (2000) and field observations. EIA is a measure of the amount of impervious surface connected directly to the receiving stream, is estimated based on total impervious area (TIA), and is a more specific indictor of hydrologic impairment than TIA.

- $EIA = 0.1*TIA^{1.5}$
  - SFR roofs are NOT connected to the storm drain system
  - Curb and gutter/no infiltration
- $EIA = 0.4*TIA^{1.2}$
  - SFR roofs ARE connected to the storm drain system
  - Curb and gutter/no infiltration
- EIA = TIA
  - All TIA is connected to the storm drain system
- $EIA = 0.04*TIA^{1.7}$
  - SFR roofs are NOT connected to the storm drain system
  - Swales and ditches/some infiltration

TIA for the catchments located within the City was calculated using GIS and converted to EIA using field observations and the equations above. The area of EIA was normalized for the catchments within the City; catchment with the greatest amount of impervious surface received the highest score of 1.0; which corresponds to the highest priority for stormwater retrofit.

4.3 Existing Stormwater Facility Score

To identify catchments that are a high priority for stormwater retrofit, catchments with either no stormwater facilities or stormwater facilities that are undersized were compared to catchments under current regulations. An existing facility score was developed to give catchments with no or undersized stormwater facilities the high prioritization for retrofit.

A high priority designation is given to catchments more likely to contribute to impaired watershed processes (e.g., catchments with older or no stormwater facilities). Table 1 summarizes regulatory updates to surface water design standards that significantly affected detention facility size, thus influenced watershed processes; it is assumed that stormwater facilities designed to more recent manuals provide better protection of watershed processes. Any area served by a stormwater facility designed to the current manual would provide the best protection for watershed processes and would not be considered for stormwater retrofit project.

Table 1. Summary of Stormwater Design Standards

Stormwater Manual	Flow Control Standard			Water Quality Standard
	50%Q2, Q10, Q100 Peak Matching	50%Q2 to Q50 Duration Matching	LID Standard 8% – 50%Q2	6-month storm (91% Annual Vol.)
Ecology 1992	X			
Ecology 2001		X		X
Ecology 2005		X		X
Ecology 2012		X	X	X

Stormwater facilities located within the study area were grouped into three categories based on the year they were constructed. Categories act as surrogates for watershed impairment.

Pre-1992: Facilities constructed prior to 1992 were grouped together. These facilities were designed according to the rational method, which is a hydrologic analysis method that generally results in significantly smaller detention facilities and higher allowable peak discharge rates as compared to Santa Barbara Urban Hydrograph (SBUH) or continuous modeling (Attachment D).

1992-2001: Facilities constructed between 1992 and 2001 were grouped together. These facilities were sized with SBUH and designed to match peak flow rates for 50 percent of the 2-year storm and the 10-year storm. This standard generally results in larger facilities as compared to facilities sized with the rational method, but facilities that are approximately 35 percent smaller than those designed with continuous hydrologic modeling and a duration matching flow control standard (Attachment D).

2001-2012: Facilities constructed between 2001 and 2012 were grouped together. These facilities are generally in compliance with current flow control standards for larger storm events. Facilities constructed after 2012 are in compliance with the current Ecology Manual; including the LID standard for low intensity storm events. However, there are no facilities located within the City in this category.

Scores were given to each facility group based on a range of zero to one, with one being the most impaired (Table 2).

Table 2. Facility Score Summary

Stormwater Facility Group	Facility Score
No Facility	1.0
Facility constructed prior to 1992	0.9
Facility constructed between 1992 to 2001	0.5
Facility constructed between 2001 to 2012	0.2

Note: A score of 0.5 was also given to Paine Field, Washington State DOT facilities, and catchments located within the high flow by-pass system of Big Gulch South

4.4 Catchment Prioritization Score Results

Using the catchment analysis method, a total of 49 catchments were delineated within the study area; 29 of these catchments are located within the city limits (see Maps 1 and 2). Table 3 summarizes the results of the catchment analysis for the catchments located within the city. Results for all of the catchments can be found in Attachment C.

Table 3. Summary of Catchment Analysis Results for City Catchments

Catchment Name	Total Area (acres)	Impervious Surface Score	Facility Score	Catchment Prioritization Score (Impervious Surface Score + Facility Score)
BG21	25.76	1.00	1.00	2.00
BG12	11.96	0.44	1.00	1.44
BG08	17.51	0.80	0.50	1.30
BG22	5.62	0.25	1.00	1.25
PPR09	13.98	0.23	1.00	1.23
BG17	11.01	0.20	1.00	1.20
BG10	11.05	0.14	1.00	1.14
BG25	2.57	0.13	1.00	1.13
BG13	7.57	0.13	1.00	1.13
BG04	6.91	0.11	1.00	1.11
BG02	8.32	0.11	1.00	1.11
BG16	2.28	0.08	1.00	1.08

Catchment Name	Total Area (acres)	Impervious Surface Score	Facility Score	Catchment Prioritization Score (Impervious Surface Score + Facility Score)
PPR08	11.84	0.07	1.00	1.07
BG15	3.16	0.05	1.00	1.05
BG09	26.52	0.05	1.00	1.05
BG03	8.12	0.05	1.00	1.05
PPR20	5.46	0.05	1.00	1.05
BG20	6.94	0.03	1.00	1.03
BG07	8.34	0.03	1.00	1.03
PPR11	23.16	0.25	0.75	1.00
PPR12	13.86	0.16	0.75	0.91
PPR18	15.92	0.10	0.75	0.85
BG06	4.56	0.16	0.75	0.91
PPR10	8.95	0.07	0.75	0.82
PPR19	5.63	0.04	0.75	0.79
BG05	24.49	0.04	0.75	0.79
BG11	1.38	0.04	0.50	0.54
BG18	25.76	0.21	0.50	0.71
BG14	2.00	0.06	0.50	0.56

5.0 STORMWATER RETROFIT PROJECT IDENTIFICATION

An initial field-based screening of each catchment identified potential stormwater retrofit project opportunities. Efforts were focused on the study area within City limits. This effort resulted in the identification of eight projects to be considered for further evaluation (Section 6.0).

5.1 Catchment Field Evaluation Methods

Within the City limits, the team assessed physical characteristics of each catchment in the field to evaluate any limitations to stormwater management based on available space and/or safety concerns of each catchment. Available space was qualitatively evaluated using best professional judgment by considering the physical characteristics of each catchment needed to accommodate either new stormwater ponds, retrofit of existing stormwater ponds, green stormwater infrastructure, or deep infiltration. The purpose of this effort was to identify catchments and locations within each catchment that could be feasible for a stormwater retrofit project. More dispersed retrofits like amended soils or downspout disconnection were not considered.

5.1.1 Available Space

Catchments with open space, either undeveloped or owned by the City, or an existing stormwater facility that had adequate space for expansion were considered to have adequate space for a stormwater retrofit project.

Roads within each catchment were qualitatively evaluated to determine if the right-of-way (ROW) was adequate for a stormwater retrofit project, such as green streets. Roads within the study area included local access and arterials. Local access roads provided the most feasible retrofit opportunities. Arterials were not considered for green streets because of additional risks associated with higher traffic volumes and/or truck traffic.

Criteria were developed for determining road retrofit feasibility. For the purposes of this analysis, a site was considered to have adequate space if the road had at least 30 feet of existing pavement and prohibited street parking. The 30-ft road width is based on the City road standards (Mukilteo 2012) and guidance from the Low Impact Development Technical Guidance Manual for Puget Sound (PSP and WSU, 2012). In the future, as the City evaluates retrofits city-wide, they may consider roads less than 30-ft in width if other site characteristics suggest the location would be a good candidate for stormwater retrofit. Adequate road ROW was also defined as a road with less than 2 percent slope. This threshold was determined using guidance in the Ecology Stormwater Management Manual, which requires additional structural elements for raingardens if installed with a slope greater than 2 percent. Many of the roads within the study area were either narrow or steep making them less feasible for a green street retrofit.

Evaluation of available space included an assessment of site access. If there was an existing road or a maintained ROW, the site had adequate access.

Catchments with steep and/or narrow roads; little or no city owned land, vacant land, or open space; or sites with no access were dropped from further consideration.

5.1.2 Safety Concerns

Stormwater facilities should not be located close to areas with high risk of landslides. An analysis of landslide hazards by Aspect Consulting (2014) divided the study area into three landslide hazard categories:

- High Hazard
- Moderate Hazard
- Low Hazard

Aspect Consulting utilized coarse scale maps to conduct their analysis, with the intention of supporting stormwater retrofit project screening and prioritization. Stormwater facilities dropped from consideration were located in, catchments with steep slopes making it potentially hazardous to construct/retrofit and operate a stormwater facility. Detailed geotechnical evaluation will occur during the pre-design phase for high priority facilities that are located adjacent to or within areas mapped as high or moderate hazards. The detailed analysis will evaluate the amount of infiltration, site-specific geology, and groundwater conditions and refine feasibility and risk assessments.

5.2 Catchment Field Evaluation Results

Based on the catchment field evaluation; initial evaluation identified 10 catchments where additional feasibility and evaluation work is appropriate for prioritizing site specific stormwater retrofit projects (Maps 3 and 4; Table 4).

Table 4. Summary of Field Evaluation Results

Catchment ID	PAU Score[1]	Catchment Prioritization Score[2]
BG08	1.5	1.3
BG12	1.3	1.4
BG14	1.3	0.6
BG17	1.3	1.2
BG21	1.3	2.0
PPR08	1.4	1.1
PPR11	1.4	1.0
PPR18	1.4	1.0
PPR19	1.4	0.8
PPR20	1.4	1.1

1. The maximum score is 1.7 (Mukilteo 2013).
2. The maximum score is 2.0

Detailed information about the entire field screening process is provided in Attachment C.

5.3 Identification of Stormwater Retrofit Projects

A stormwater retrofit project was identified for each catchment identified by the catchment field screening evaluation as being a good candidate for stormwater retrofit projects (see Table 4). Potential stormwater retrofit projects were developed for each catchment based on stormwater infrastructure mapping, topography, field observations of development, flow patterns, and best professional judgment. ESA identified eight potential stormwater retrofit project locations, which were carried forward to a more detailed feasibility and prioritization evaluation (Table 5, see Maps 3 and 4).

Table 5. Potential Stormwater Retrofit Projects

Stormwater Retrofit Project ID	Catchment ID	Description
1	BG08	**Existing pond retrofit:** retrofit pond with additional storage and a modified orifice structure to reduce peak surface discharges. Pond located behind the Staybridge Suites Hotel (Stormwater Retrofit Project Fact Sheet 1, Attachment B). It currently detains runoff from the hotel, a portion of Harbor Point Pl, an office building, and an undeveloped parcel. This pond was constructed in 2000 and is undersized according to current regulations. This catchment also has areas of vacant land, that were recently annexed the City. Future development on this land may be grandfathered into regulations in place at the time of annexation.
2	BG12	**Construct new pond**: construct a new detention pond/infiltration facility in the vacant lot located north and west of Harbor Point Pl. (Stormwater Retrofit Project Fact Sheet 2, Attachment B). Runoff from this catchment is currently undetained.
3	BG14	**Retrofit existing swale**: Retrofit the existing library detention swale. The swale detains stormwater runoff from the library and parking lot. It was constructed in 1997; therefore, it is undersized according to current regulations (Stormwater Retrofit Project Fact Sheet 3, Attachment B).
4	BG17	**Construct bioretention**: construct bioretention to treat and detain parking lot runoff along the Harbor Pointe Middle School parking areas. This project could include bioretention along the entrance drive (Stormwater Retrofit Project Fact Sheet 4, Attachment B). Runoff from this catchment is currently undetained.
5	BG21	**Construct a raingarden**: reconstruct a portion of 47th Place W and the YMCA landscaping to include raingarden and possible deep infiltration (Stormwater Retrofit Project Fact Sheet 5, Attachment B). Runoff from this catchment is currently undetained.
6	PPR08	**Construct stormwater wetland**: daylight a stormwater pipe that currently crosses the Harbor Pointe golf course and create a constructed wetland to provide detention and treatment of the adjacent residential development (Stormwater Retrofit Project Fact Sheet 6, Attachment B). Runoff from this catchment is currently undetained.
7	PPR18/19/20	**Construct a green street**: retrofit 55th Pl. W and 127th St. SW with a green street concept, such as bioretention swales in series, to provide water quality treatment and possible shallow infiltration to reduce peak flows (Stormwater Retrofit Project Fact Sheet 7, Attachment B). The detention ponds in this catchment were constructed in 1988 and are undersized according to current regulations. In addition, field observations indicate that this catchment may have high nutrient loading.
8	PPR11	**Retrofit existing vault**: retrofit an existing stormwater vault, constructed prior to 1992, with deep infiltration (Stormwater Retrofit Project Fact Sheet 8, Attachment B). The City current owns the ROW for access. The vault in this catchment was constructed prior to 1990 and is undersized according to current regulations.

6.0 STORMWATER RETROFIT PROJECT SCORE

Each potential stormwater retrofit project identified during the field evaluation (see Table 5) was further evaluated and prioritized based scores developed for each of the following categories:

- Ease of Partnership
- Engineering Suitability
- Geotechnical Suitability
- Permitting Feasibility
- Cost
- Benefits
- Other Considerations

Scores were developed for each category using a 0 to 3 scale. A score of 3 corresponds to the highest priority and/or projects that are most feasible for a particular category. Scores for each category were summed with equal weight and used to calculate an overall stormwater retrofit project score.

6.1 Ease of Partnership

Potential stormwater retrofit projects that would be located on City owned land, easement, or ROW were given the highest score (3) for ease of partnership. Projects that would be located on private property, but held by an entity such as the Mukilteo School District, Sno-Isle Library, or YMCA, were given the next highest score (2) for the ease of partnership. All other projects that would be located on private property were given the lowest score (1).

6.2 Engineering Suitability

Engineering suitability was used to prioritize locations most suitable for stormwater facilities. Engineering suitability elements used for this analysis are based on stormwater management BMPs developed by Ecology (Ecology 2012):

- High Vehicle Traffic Areas
- Suitability to intercept flows in existing stormwater conveyance pipes

Locations with relatively high volumes of traffic or high volumes of truck traffic were given a lower priority due to safety concerns. Scoring was based on the following metrics:

3 points: Project is located on an easement

2 points: Project is located in a street ROW, but street has lower traffic volumes

1 point: Project is located in a street ROW; but has higher traffic volumes/truck traffic

Potential stormwater retrofit projects were also prioritized based on the relative feasibility to connect to the existing conveyance system. Scoring was based on the following site characteristics:

3 points: Project would retrofit an existing facility, or treat roof runoff or sheet flow

2 points: Project would connect to stormwater system less than 6-ft below the surface

1 point: Project would connect to stormwater system greater than 6-ft below the surface.

The overall engineering suitability score was calculated by combing the scores for traffic volume and feasibility to connect to the existing stormwater system;

Engineering Suitability Score = (Traffic Score + Connection Score)/2

6.3 Geotechnical Suitability

Geotechnical suitability prioritizes projects with good potential for shallow or deep infiltration because of the added benefit of reduced runoff volume and improved groundwater recharge. . If a site is not feasible for infiltration (shallow or deep), stormwater detention is likely still an option, but would not receive a high score for this category.

6.3.1 Shallow Infiltration System

Aspect Consulting performed an analysis of mapped surficial geology to estimate the permeability of the surface soils. They identified three broad permeability categories:

- Good Permeability - greater than 10 inches/hour;
- Moderate Permeability -2 – 10 inches/hour; and
- Poor Permeability – 0 - 2-inches/hour.

Aspect Consulting also estimated surface slope from LiDAR to determining the potential for shallow infiltration to migrate along a perched layer and daylight at the ground surface or in a crawl space/basement down slope. They identified three broad slope categories:

- Good - less than 5 percent;
- Moderate - between 5 percent and 15 percent; and
- Poor - greater than 15 percent.

Based on the coarse scale evaluation of landslide hazard, permeability of surface soils, and slope, Aspect Consulting identified three categories of shallow infiltration feasible (Maps 5 and 6). These categories are general and are intended to prioritize projects that would be most cost effective and unlikely to pose any significant hazards.

- Good Potential
    - Low landslide hazard;
    - Good surface slopes (less than 5 percent); and
    - Good or moderate surface soil permeability.
- Moderate Potential
    - Low or moderate landslide hazard;
    - Good or moderate surface slopes (less than 15 percent); and
    - Good or moderate surface soil permeability.
- Poor Potential
    - Poor surface slope (greater than 15 percent); and
    - Poor surface soil permeability.

6.3.2 Deep Infiltration Systems

Aspect Consulting evaluated study area geology to evaluate the suitability of deep infiltration as a technique for managing stormwater runoff. They considered a site suitable when a permeable, unsaturated soil horizon exists beneath low permeability surface soils. Based on their analysis, Aspect identified nine unique hydrogeomorphic units and assigned each unit to a deep infiltration category. These categories are general and are intended to prioritize projects that would be most cost effective and unlikely to pose any significant hazards (Maps 7 and 8).

- Good Potential
    - Low landslide hazard; and
    - Higher potential for a deep infiltration receptor horizon.
- Moderate Potential
    - Low or moderate landslide hazard; and
    - Higher or moderate potential for a deep infiltration receptor horizon.
- Poor Potential
    - High landslide hazard; and
    - Lower potential for a deep infiltration receptor horizon.

6.3.3 Overall Scoring For Geotechnical Suitability

Stormwater retrofit projects were scored for geotechnical suitability based on the suitability of either shallow or deep infiltration according to the site characteristics summarized in Table 6.

Table 6. Geotechnical Suitability Score

Points	Description	Shallow Infiltration		Deep Infiltration
3	Good	Low landslide hazard	or	Low landslide hazard
		Moderate to Good Permeability		Higher potential for a deep infiltration receptor horizon.
		Good surface slopes		
2	Moderate	Low or moderate landslide hazard;	or	Low or moderate landslide hazard; and
		Moderate to Good Permeability		Higher or moderate potential for a deep infiltration receptor horizon.
		Moderate surface slopes		
1	Poor	Poor permeability	or	High landslide hazard
		Poor surface slopes		Lower potential for a deep infiltration receptor horizon.

6.4 Environmental Permitting

Construction of a stormwater retrofit project requires several environmental permits. The purpose of this category is to identify potential stormwater retrofit projects that would have relatively high permitting costs/risks based on the following criteria, which were combined in to a single environmental permitting score:

- Streams/wetlands and their buffers known to be on or near the site;
- Cultural resources known to be on or near the site.

If a site has the potential to affect critical areas such as streams and wetlands or their buffers it was assumed that environmental permitting would be more costly relative to other similar projects and therefore was given a lower priority.

The proximity of a stormwater retrofit project to a critical area was determined using City critical areas maps. Project scoring:

3 points: Project would have no impacts to critical areas or buffers

2 points: Project would impact a critical area buffer

1 point: Projects that would directly impact a stream or wetland.

The proximity of a stormwater retrofit project to a potential cultural resources site was determined using mapping provided by the Washington Information System for Architectural and Archeological Records and Data (WISAARD, 2014) database and the mapped results of the statewide predictive model.

Project scoring was developed to prioritize projects located in an area with a lower risk of encountering a cultural resource.

3 points: Project located in an area as moderate to low risk

2 points: Project located in an area mapped as high risk

1 point: Project located in an area mapped as very high risk

The scores for critical areas and cultural resources were combined into a single score representing the ease of environmental permitting:

Environmental Permitting Score = (Critical Area Score + Cultural Resources Score)/2

6.5 Costs

Numerous studies have been performed throughout the country to evaluate the cost and benefit of stormwater management. Evaluation of costs and benefits are based on construction costs (e.g., Ecology 2013) and operation and maintenance costs (e.g., Minton 2003; Ecology 2013).

Estimates of construction costs vary more due to intrinsic site conditions such as soils, existing development, utility conflicts, design, and site layout. As a result, Minton (2003) concluded that there is too much variability to develop accurate unit costs for specific BMPs or even estimate relative cost differences between retrofit projects and new construction. However, many studies agree that land acquisition is a significant portion of any project cost (Minton 2003; King County 2012; Ecology 2013). Therefore, this evaluation used land acquisition as a screening method for cost. Projects that would be required to acquire land specifically for stormwater management facilities would cost relatively more than those located in an existing easements or within the ROW.

3 points: Project located in an existing easement or ROW

1 point: Project that require land acquisition

Ecology recently completed an evaluation of 14 different development scenarios to evaluate long term costs associated with a variety of stormwater management techniques (Ecology 2013). The Ecology study developed long term operation and maintenance costs per acre for different types of BMPs. Table 7 summarizes the estimated cost per acre for various types of BMPs from 2013 Ecology and the corresponding score developed for this evaluation.

Table 7. Summary of Operation and Maintenance Costs

Points	Cost per acre O&M (Ecology 2013)	BMP
3	Low ($3.36/sf)	Infiltration Basin
2	Moderate ($9.01/sf)	Wet Pond
		Combined Detention/Wetpool
1	Poor ($21.84/sf)	Bioretention
		Raingarden

6.6 Benefits

Many studies throughout Puget Sound have linked development with altered stream hydrology, sediment regime, morphology, and instream habitat (Booth et al. 2002).Altered hydrology due to land use practices is highly correlated to stream condition; however, methods to estimate watershed development do not capture spatial or temporal variation in development patterns that may influence site specific conditions (Luchetti et al. 2014). In addition, there is not a direct correlation between stormwater retrofit at the site scale and stream condition and it is impossible to quantify the benefit of a single stormwater retrofit project. As a result, this study used the total area served by the proposed retrofit project to conceptually represent a beneficial stream response. In some cases, the total contributing area to a stormwater retrofit facility is not the same as the catchment area. The contributing area to each stormwater facility was normalized relative to the contributing area of other stormwater retrofit projects to estimate relative benefit. Projects that would retrofit an existing facility instead of constructing a new facility would have a reduced benefit.

Benefit Score = (contributing area/max contributing area) x 3

6.7 Other Considerations

Each project was then evaluated to determine if there were specific and unique elements of the proposed site that would either elevate its prioritization or decrease its prioritization. Factors considered include:

- Unique opportunities for public outreach and education
- Site specific flooding, erosion or water quality problems,
- Known/anticipated development projects that would include stormwater retrofit

Although erosion and ravine instability are linked to non-point source runoff; these problems exist throughout both ravines located within the study area. Therefore, it was difficult to link specific stormwater retrofit projects with a site specific improvement in stream health.

Additional points were given to sites that address a specific problem such as water quality in small lakes and wetlands, flooding, and outfall erosion.

Points were taken away from a project if the City has already received permit applications or pre-applications for projects that would address stormwater management as part of a planned site improvement.

6.8 Overall Stormwater Retrofit Project Score

The stormwater retrofit project score was calculated by summing normalized scores for each category into one overall score:

> ***Stormwater Retrofit Project score =***
> ***(Ease of Partnership Score + Engineering Suitability Score + Geotechnical Suitability Score + Permitting Feasibility Score + Cost Score + Benefits Score +/-Other Considerations Score)/7***

Based on this methodology the overall stormwater retrofit project score has maximum value of 3.0. This score was then added to the normalized PAU score (maximum value of 1.0) and the normalized catchment score (maximum value of 1.0) to get an overall retrofit project score (Table 8).

Retrofit Project Recommendation = PAU Score + Catchment Prioritization Score + Stormwater Retrofit Project Score

Scores for each individual category are summarized in Attachment C.

Table 8. Summary of Stormwater retrofit Project Scores

Stormwater Retrofit Project Name	Summary				
	Normalized PAU Score	Normalized Catchment Score	Project Specific Score	Total Score	Rank
Project 1: Staybridge Suites Pond	0.9	0.5	2.0	3.4	3
Project 2. Harbor Pointe Pl.	0.8	0.7	1.5	2.9	7
Project 3. Library	0.8	0.3	1.4	2.4	8
Project 4. Harbor Pointe Middle School	0.8	0.6	2.2	3.6	2
Project 5. YMCA/47th Pl. W	0.8	1.0	1.6	3.3	4
Project 6. Harbor Pointe Golf Course	0.8	0.5	1.8	3.1	5
Project 7. 55thPl. W/127th St. SW	0.8	0.5	2.3	3.6	1
Project 8. Private vault	0.8	0.6	1.6	3.0	6

Because this process of scoring is based on a normalization process, the results of this evaluation of stormwater catchments and potential stormwater retrofit projects only applies to the three study area PAUs; Big Gulch North, Big Gulch South, and Picnic Point Ravine.

7.0 FINAL RECOMMENDATIONS

City staff and members of the consulting team discussed opportunities and risks of each potential retrofit project during a meeting held on June 17, 2014. Based on that discussion, City staff determined that all of the projects have merit and should continue to be considered in the context of the Stormwater Comprehensive Plan Update. The final relative ranking of the retrofit projects results in the following projects being identified as the top projects:

(1) Retrofit Project 7. 55thPl. W/127th St. SW
(2) Retrofit Project 4. Harbor Pointe Middle School
(3) Retrofit Project 1. Staybridge Suites Pond

Additional site specific data will be collected and these projects will be carried forward to pre-design.

Furthermore, methods used to delineate catchments, score and prioritize catchments, and identify, score, and prioritize stormwater retrofit projects could be used City wide for additional analysis.

8.0 REFERENCES

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Attachment A: Study Area Maps

Map 1. Big Gulch North and South Catchment Map

Map 2. Picnic Point Ravine Catchment Map

Map 3. Big Gulch North and South Priority Catchments and Stormwater Retrofit Project Locations

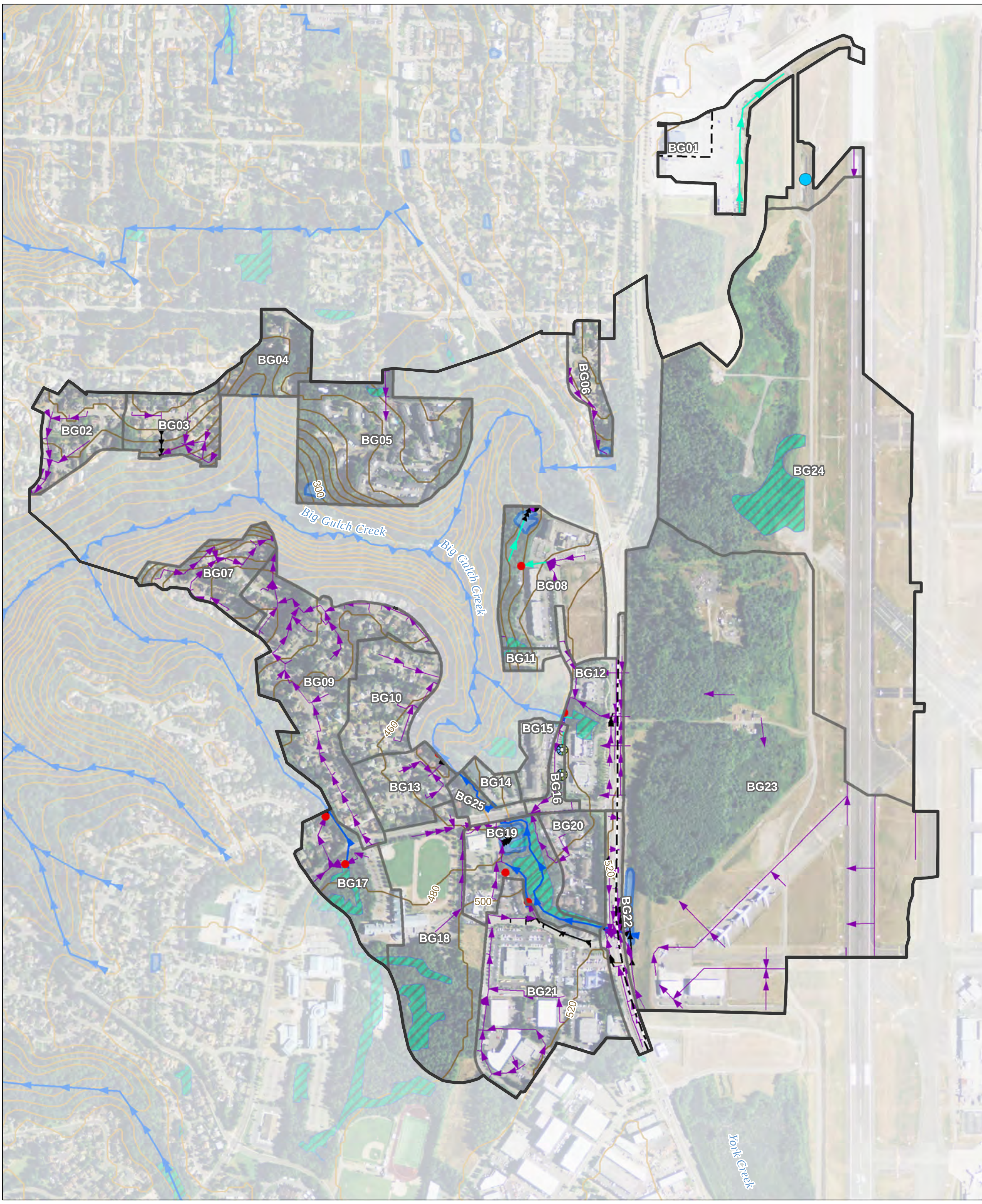
Map 4. Picnic Point Ravine Catchments and Stormwater Retrofit Project Locations

Map 5. Big Gulch North and South Shallow Infiltration Feasibility

Map 6. Picnic Point Ravine Shallow Infiltration Feasibility

Map 7. Big Gulch North and South Deep Infiltration Feasibility

Map 8. Picnic Point Ravine Deep Infiltration Feasibility



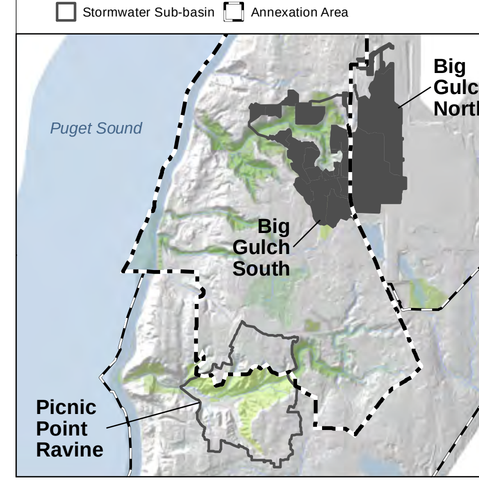
Legend

Stormwater Drainage Network
- Bioswale
- Control Structure
- Detention Pond
- Stormwater Outfall
- Open Channel System
- Stormwater Drainage Network
- Connection Network
- Stream
- Detention Pond
- Dual Function

- Stormwater Catchment Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- PAU Boundary
- Mukilteo City Limits
- Annexation Area

Stormwater Sub-basin Index Map

- Mapped Catchments
- Stormwater Sub-basin
- Mukilteo City Limits
- Annexation Area



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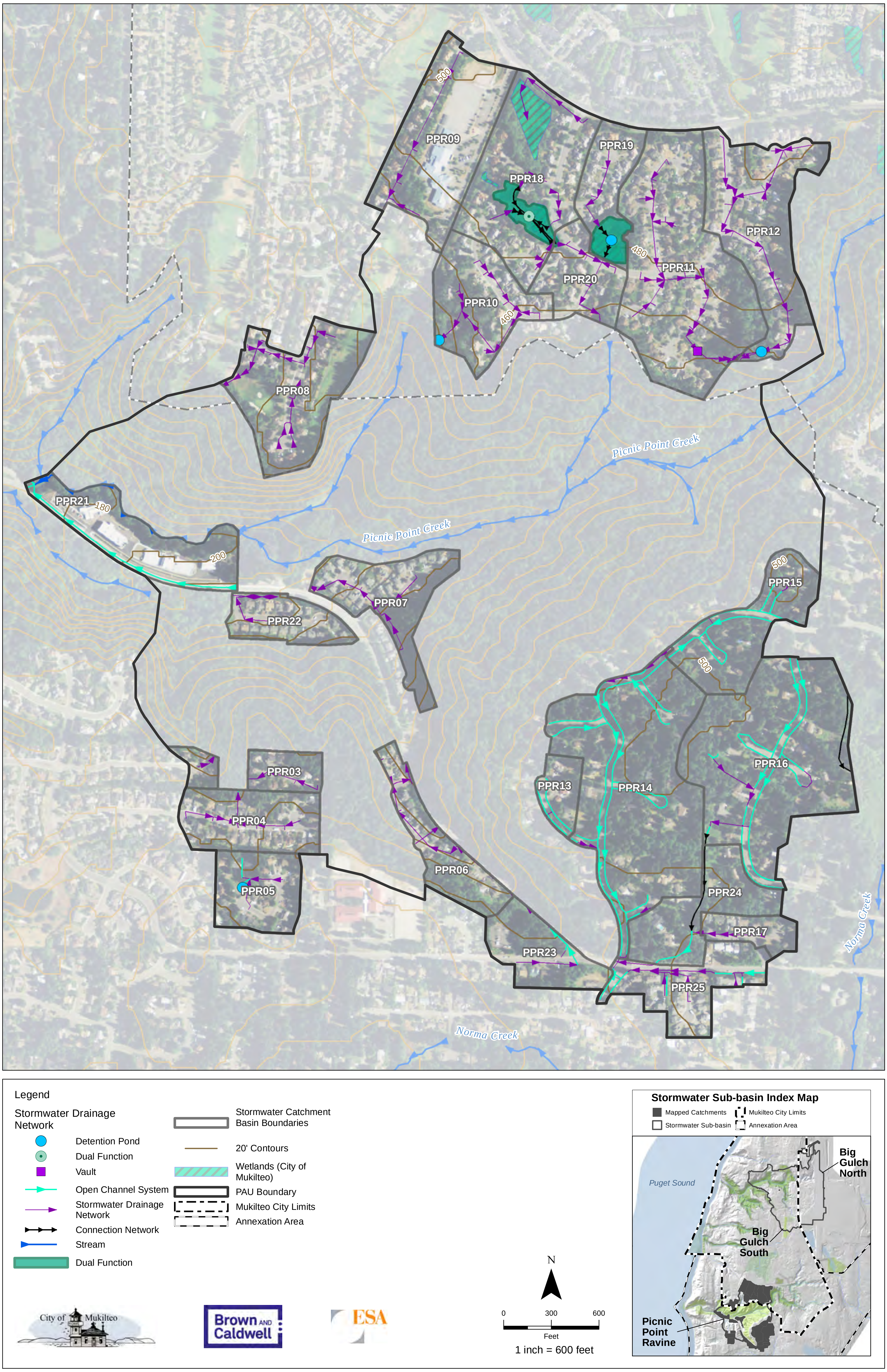
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

City of Mukilteo Stormwater Management Plan . 130589

Map1: Big Gulch North and South Catchment Map

Big Gulch North and South
City of Mukilteo, Washington



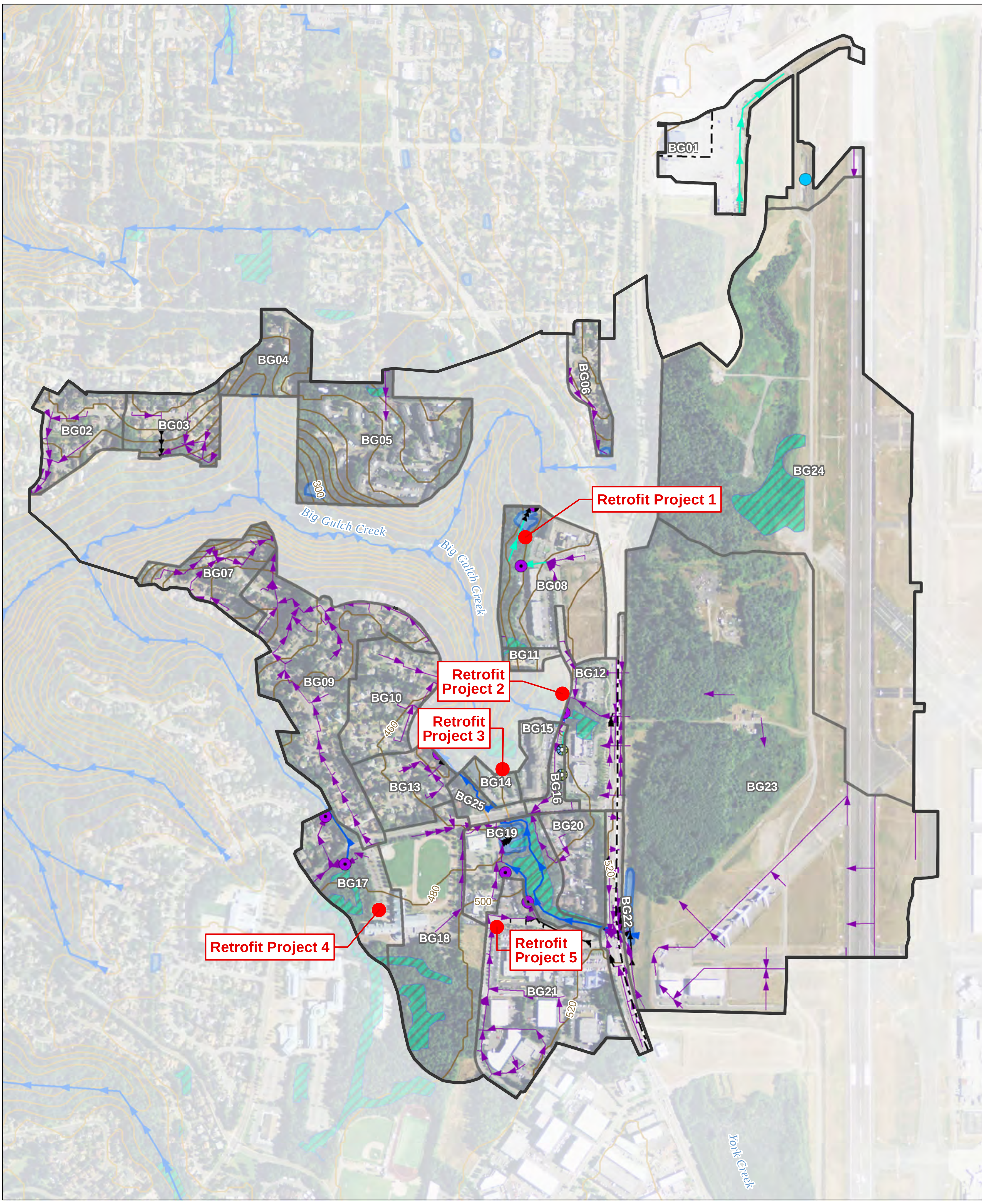
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

City of Mukilteo Stormwater Management Plan . 130589

Map 2: Picnic Point Ravine Catchment Map

Picnic Point Ravine

City of Mukilteo, Washington



Legend

- Retrofit Project Location

Stormwater Drainage Network

- Bioswale
- Control Structure
- Detention Pond
- Stormwater Outfall
- Open Channel System
- Stormwater Drainage Network
- Connection Network
- Stream
- Detention Pond
- Dual Function
- Stormwater Catchment Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- PAU Boundary
- Mukilteo City Limits
- Annexation Area

City of Mukilteo

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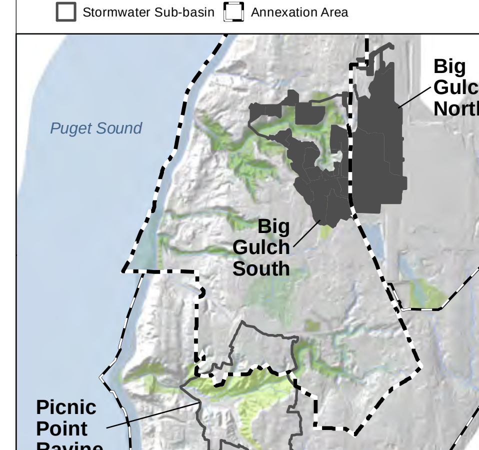
Feet

1 inch = 800 feet

Stormwater Sub-basin Index Map

- Mapped Catchments
- Mukilteo City Limits
- Stormwater Sub-basin
- Annexation Area



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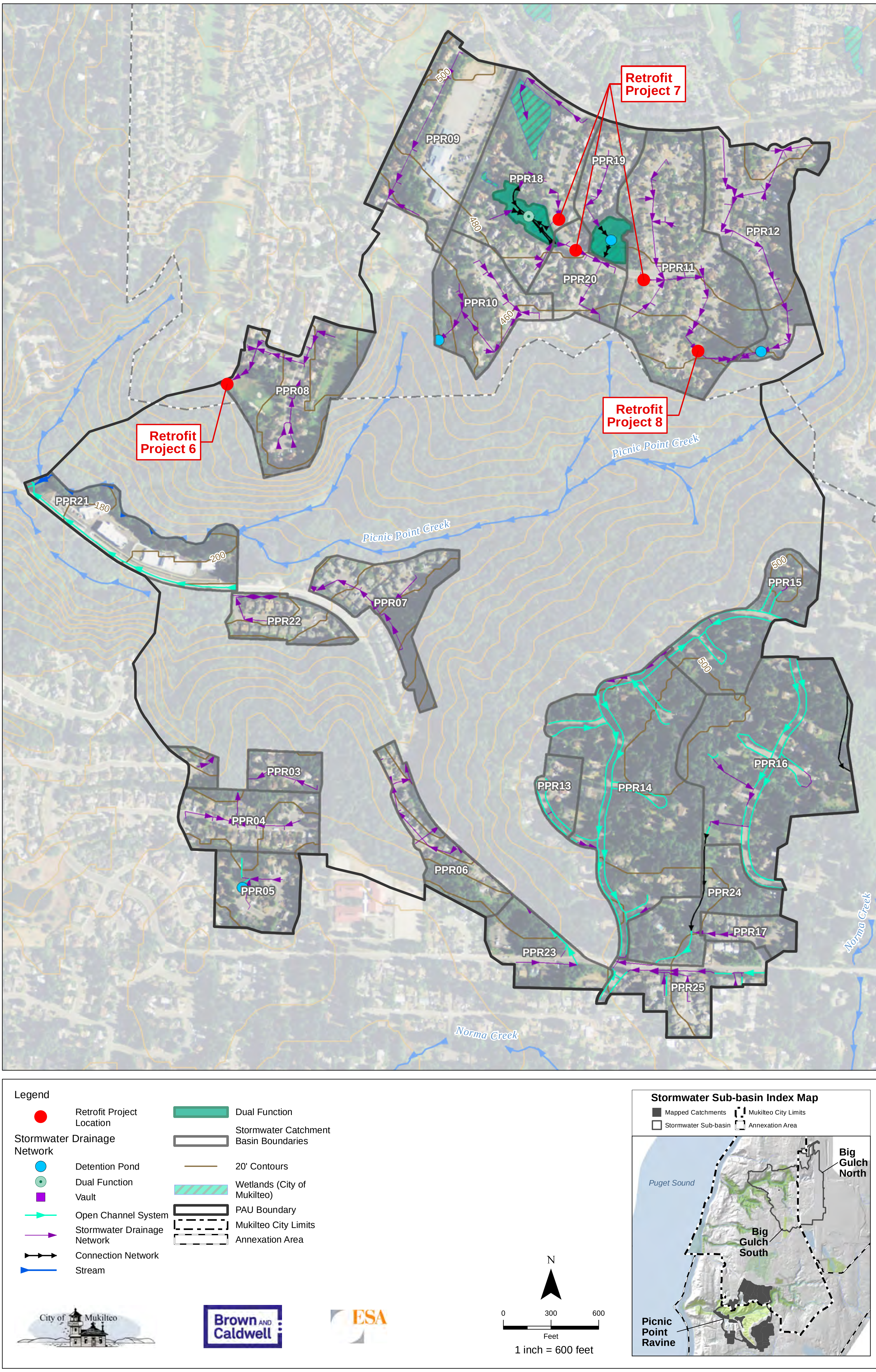
City of Mukilteo Stormwater Management Plan . 130589

SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

Map 3: Big Gulch North and South Priority Catchments and Stormwater Retrofit Project Locations

Big Gulch North and South

City of Mukilteo, Washington



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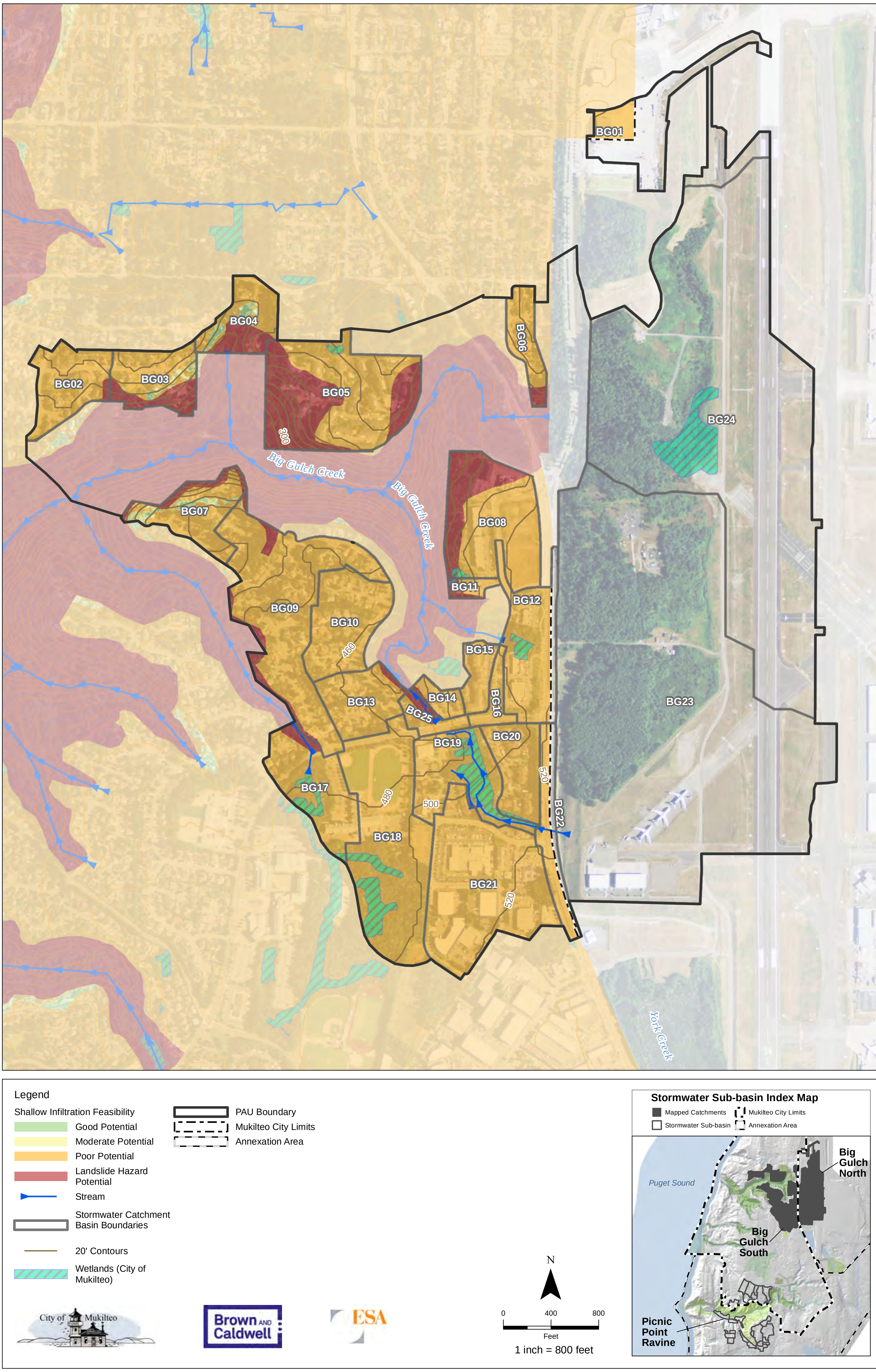
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

Map 4: Picnic Point Ravine Catchments and Stormwater Retrofit Project Locations

Picnic Point Ravine

City of Mukilteo, Washington



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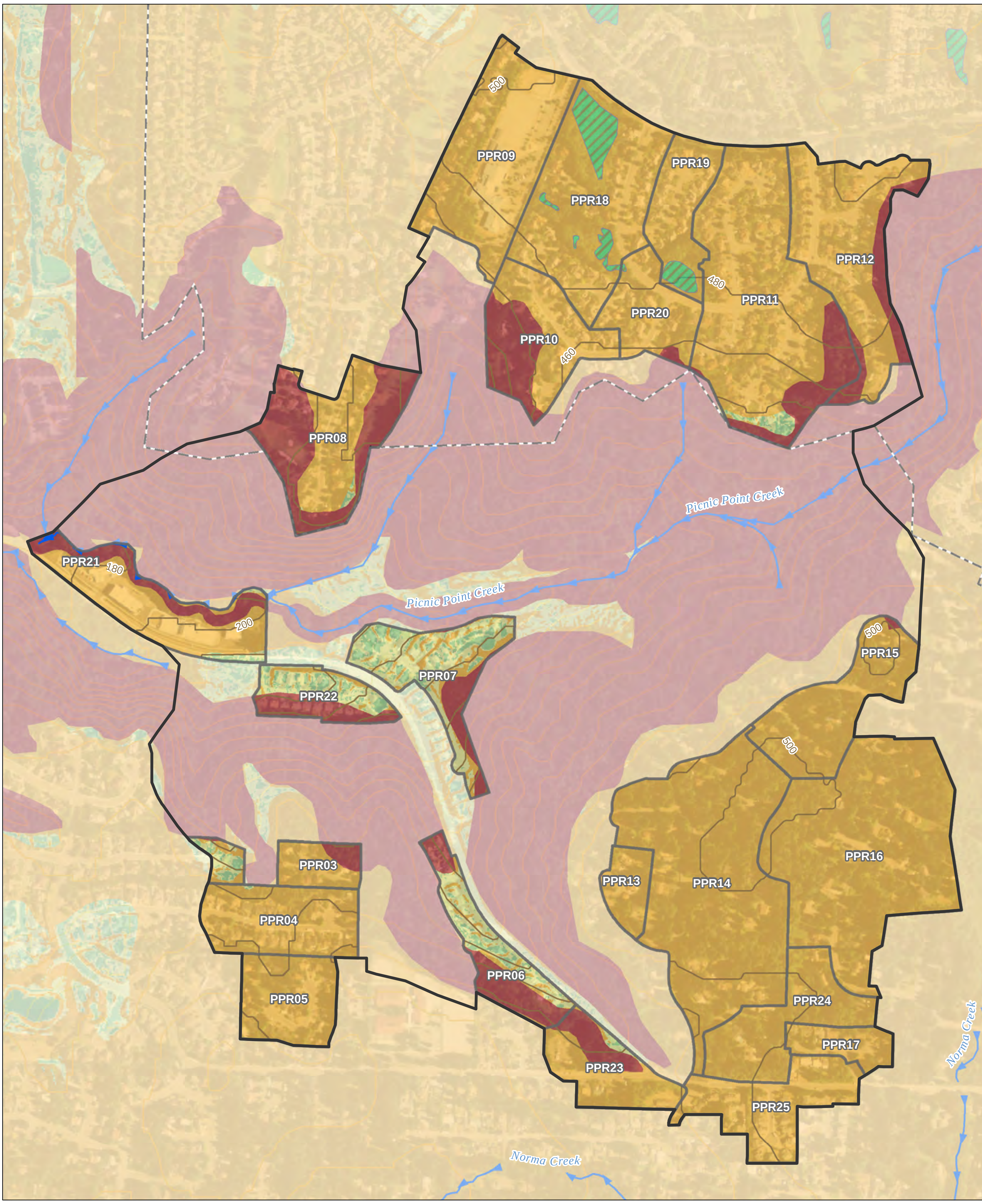
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

City of Mukilteo Stormwater Management Plan . 130589

Map 5: Big Gulch North and South Shallow Infiltration Feasibility

Big Gulch North and South

City of Mukilteo, Washington



Legend

Shallow Infiltration Feasibility
- Good Potential
- Moderate Potential
- Poor Potential
- Landslide Hazard Potential
- Stream
- Stormwater Catchment Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- PAU Boundary
- Mukilteo City Limits
- Annexation Area

N

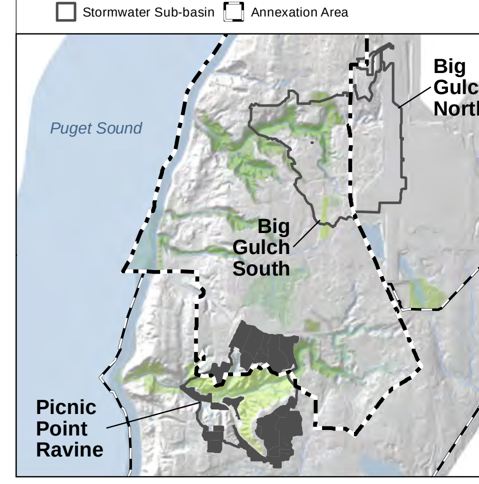
0 300 600

Feet

1 inch = 600 feet

Stormwater Sub-basin Index Map

- Mapped Catchments
- Stormwater Sub-basin
- Mukilteo City Limits
- Annexation Area



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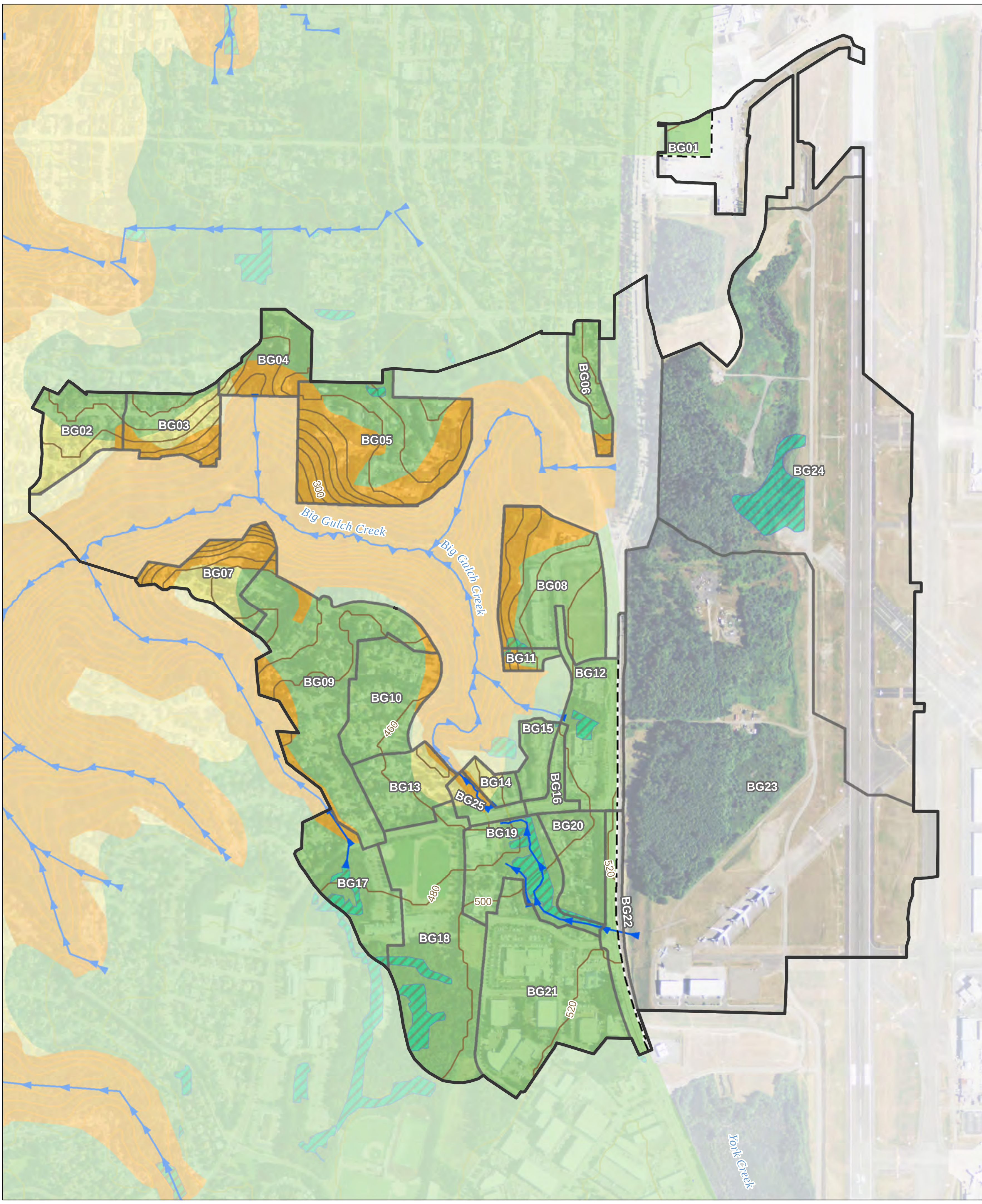
City of Mukilteo Stormwater Management Plan . 130589

SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

Map 6: Picnic Point Ravine Shallow Infiltration Feasibility

Picnic Point Ravine

City of Mukilteo, Washington



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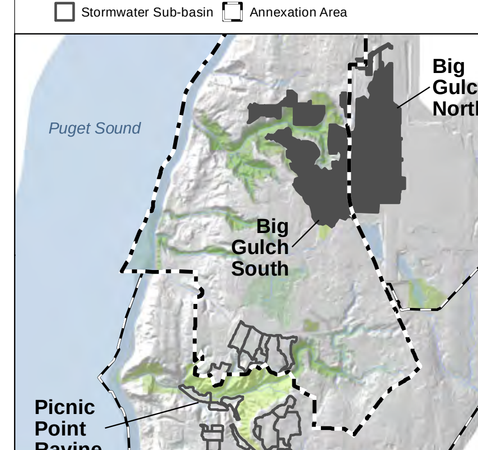
Legend

Deep Infiltration Feasibility
- Good Potential
- Moderate Potential
- Poor Potential
- Stream
- Stormwater Catchment Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- PAU Boundary
- Mukilteo City Limits
- Annexation Area

Stormwater Sub-basin Index Map

- Mapped Catchments
- Mukilteo City Limits
- Stormwater Sub-basin
- Annexation Area



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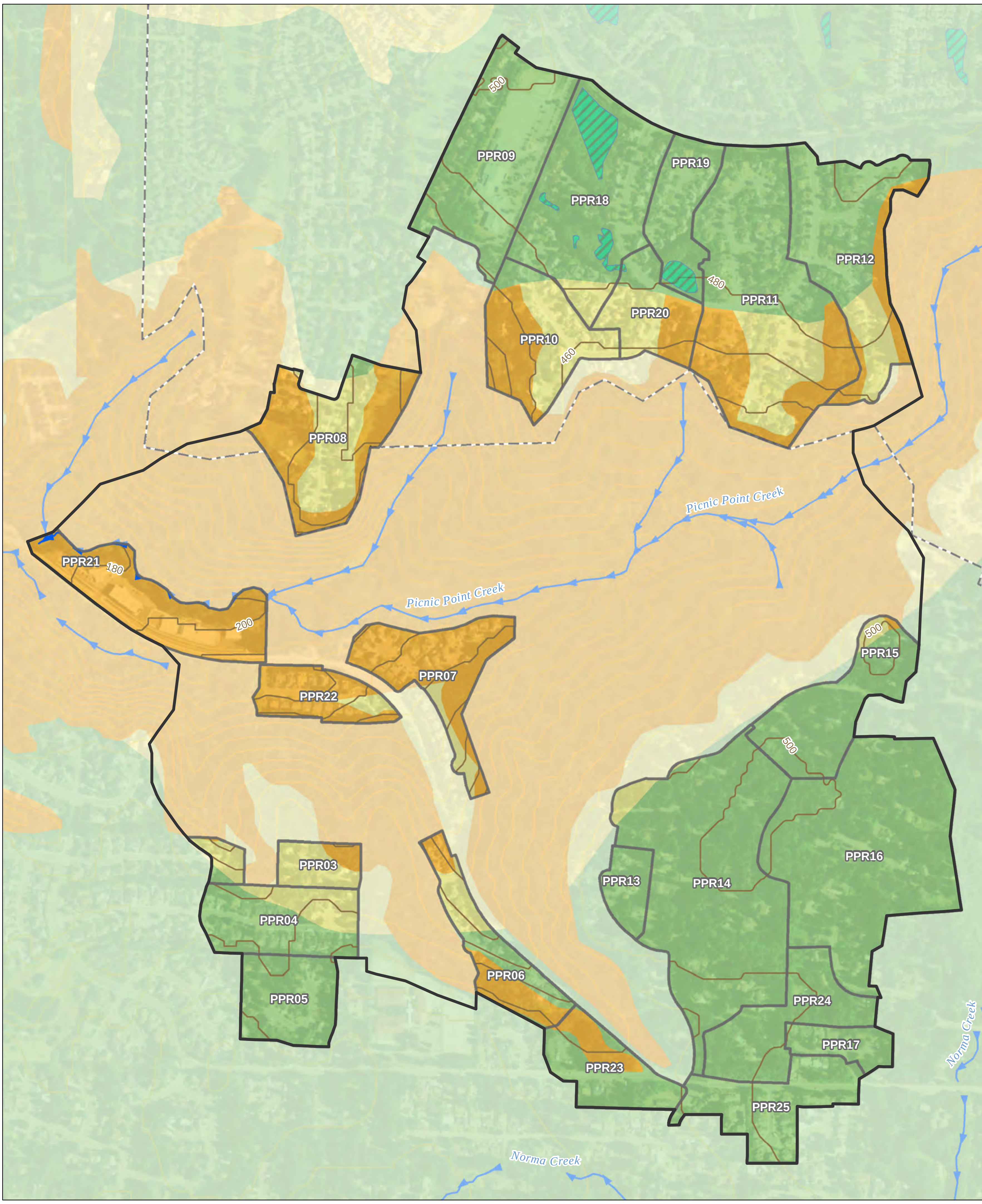
Feet
1 inch = 800 feet

City of Mukilteo Stormwater Management Plan . 130589

SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

Map 7: Big Gulch North and South Deep Infiltration Feasibility

Big Gulch North and South
City of Mukilteo, Washington



Legend

Deep Infiltration Feasibility

- Good Potential
- Moderate Potential
- Poor Potential
- Stream
- Stormwater Catchment Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- PAU Boundary
- Mukilteo City Limits
- Annexation Area

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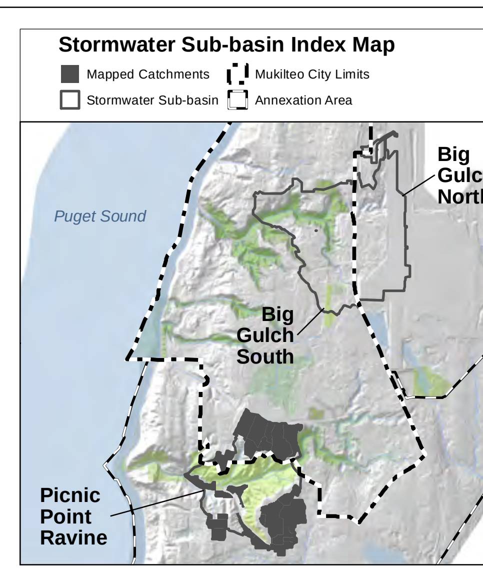
Feet
1 inch = 600 feet

Stormwater Sub-basin Index Map



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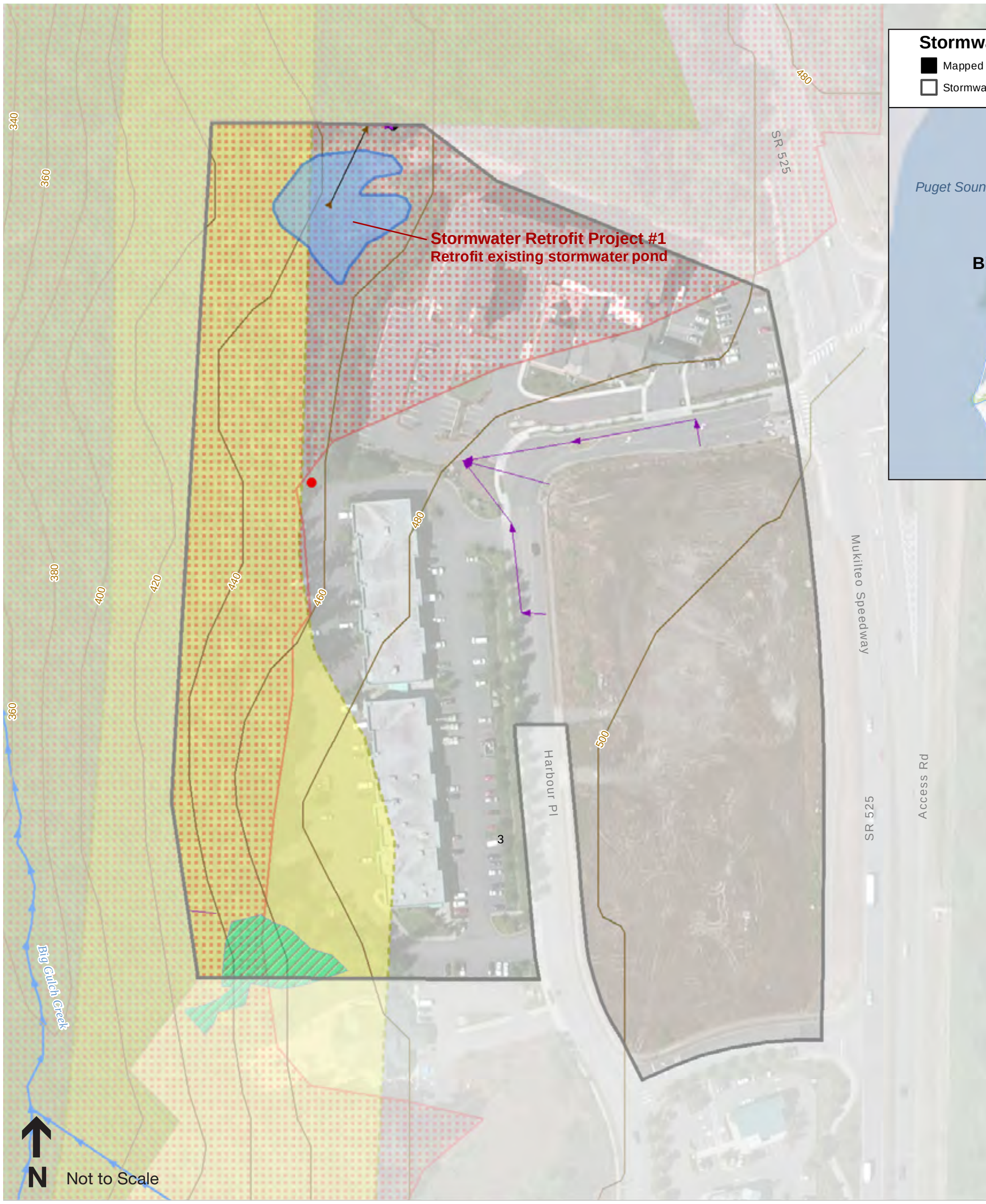
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-13

Map 8: Picnic Point Ravine Deep Infiltration Feasibility

Picnic Point Ravine

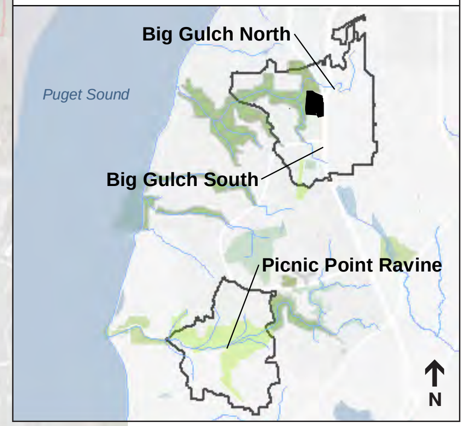
City of Mukilteo, Washington

Attachment B: Stormwater Retrofit Project Fact Sheets



Stormwater Sub-basin Index Map

Mapped Catchment
Stormwater Sub-basin



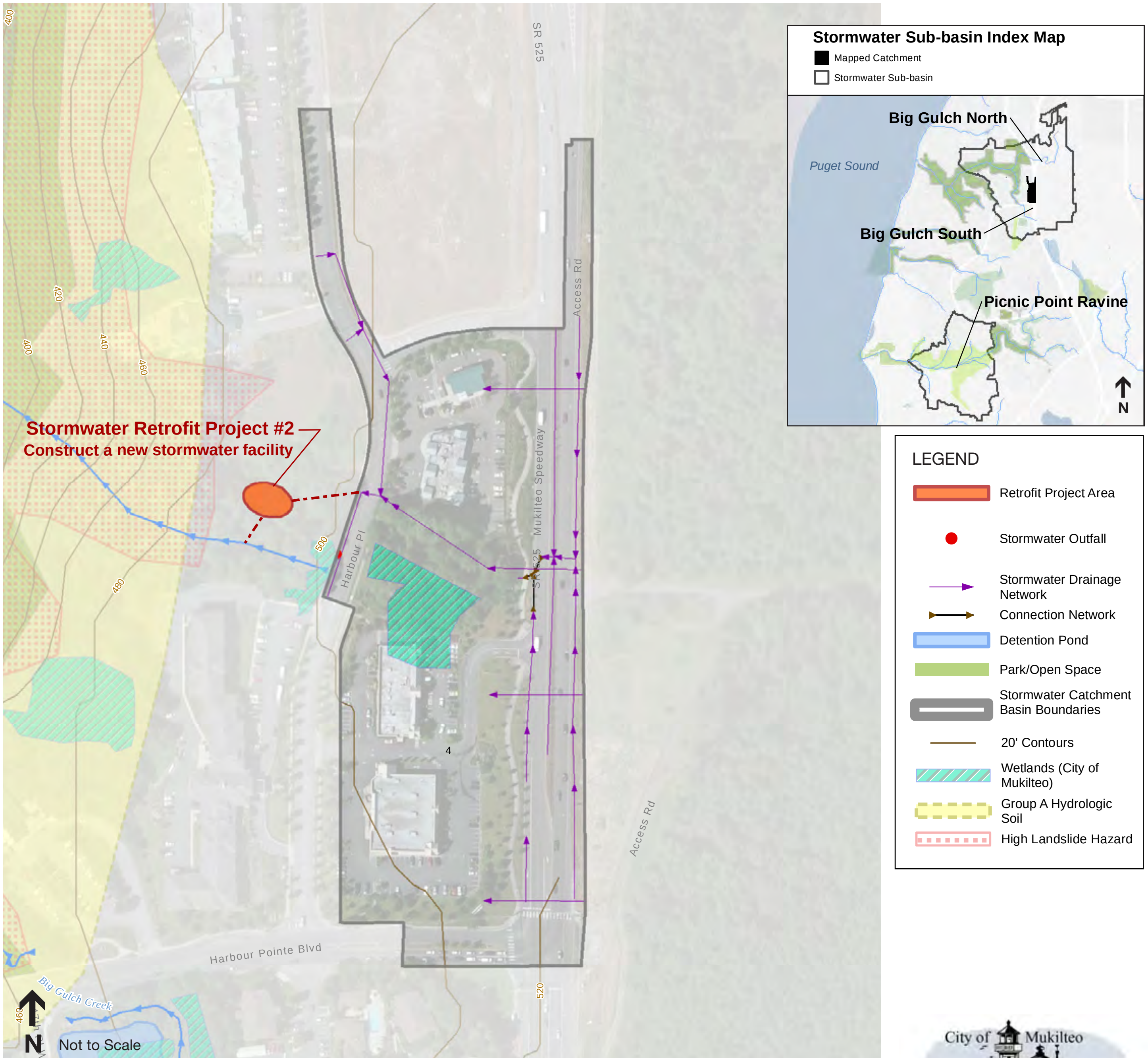
LEGEND

- Control Structure
- Stormwater Outfall
- Stormwater Drainage Network
- Connection Network
- Detention Pond
- Park/Open Space
- City Owned Property
- Stormwater Catchment Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- Group A Hydrologic Soil
- High Landslide Hazard

Stormwater Retrofit Project #1 Summary	
Staybridge Suites Pond	
PAU Name	Big Gulch North
Catchment Name	BG08
Existing Stormwater Facility	yes
Estimated Contributing Area (acres)	12.0
Priotization Score	3.4
Project Rank (1-8)	3

Stormwater Retrofit Project Fact Sheet : Project #1

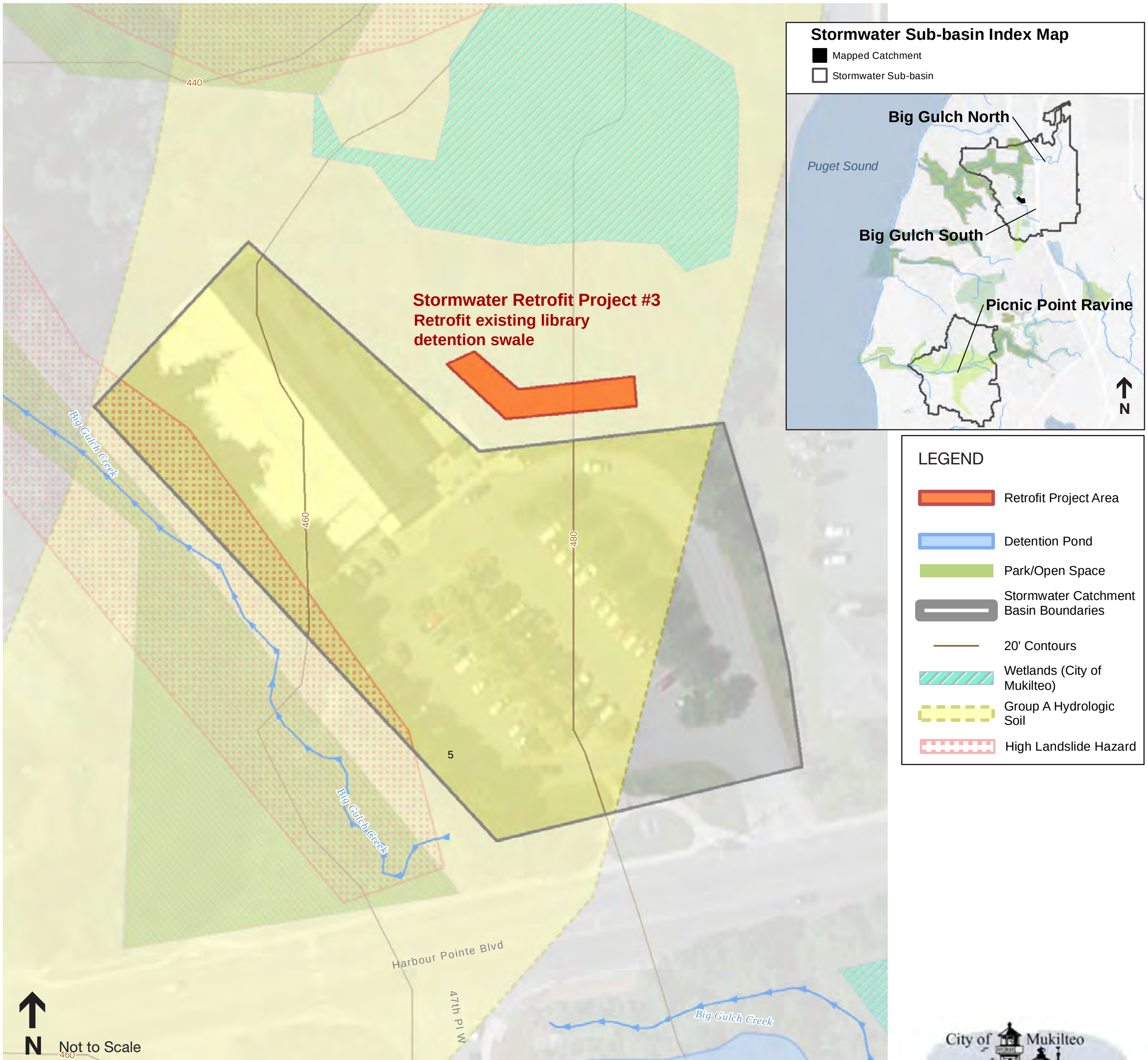
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013



Stormwater Retrofit Project #2 Summary	
Harbor Pointe	
PAU Name	Big Gulch South
Catchment Name	BG12
Existing Stormwater Facility	no
Estimated Contributing Area (acres)	3.5
Priotization Score	2.9
Project Rank (1-8)	7

Stormwater Retrofit Project Fact Sheet : Project #2

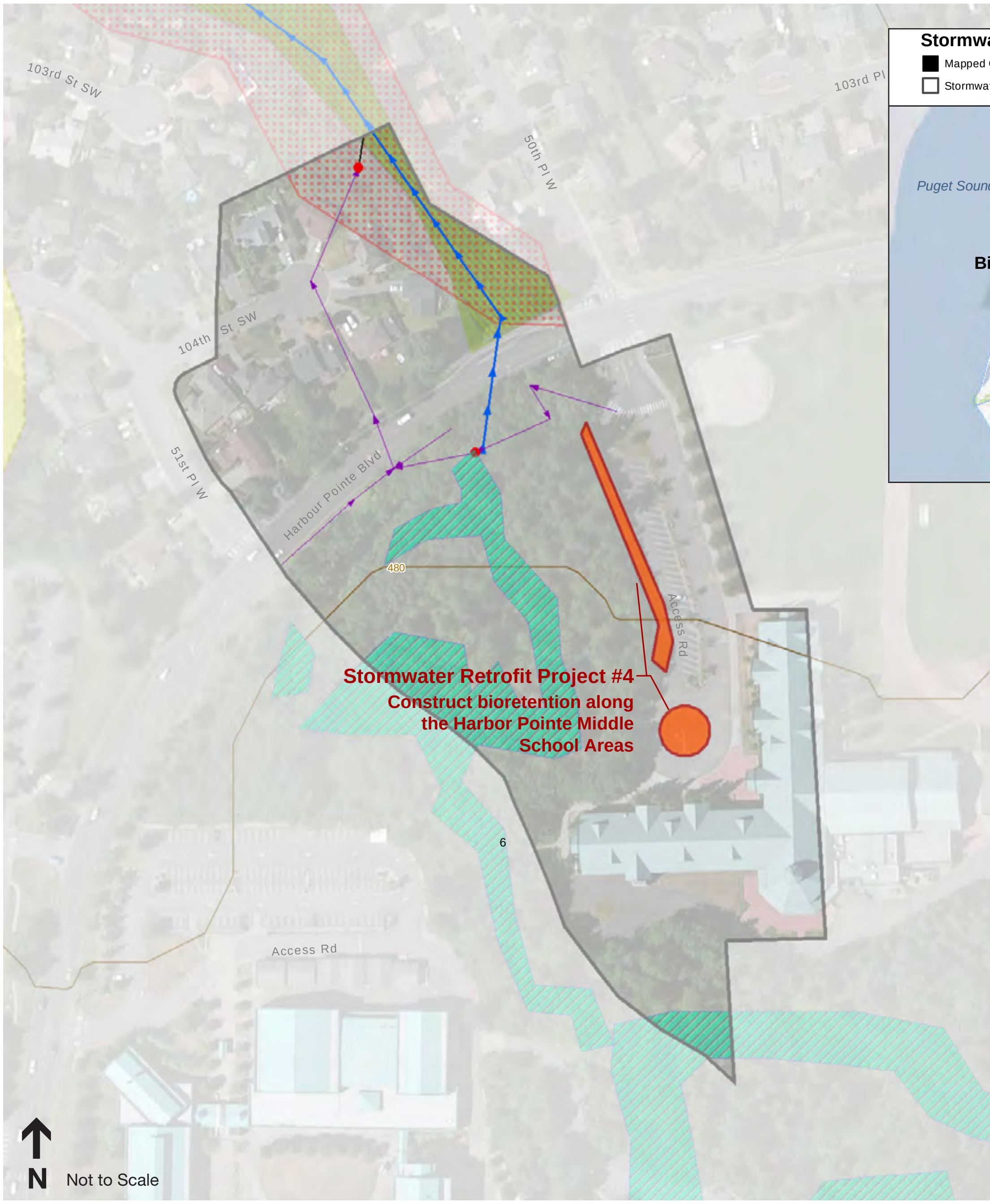
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013



Stormwater Retrofit Project #3 Summary	
Sno-Isle Library	
PAU Name	Big Gulch South
Catchment Name	BG14
Existing Stormwater Facility	yes
Estimated Contributing Area (acres)	2.0
Priotization Score	2.4
Project Rank (1-8)	8

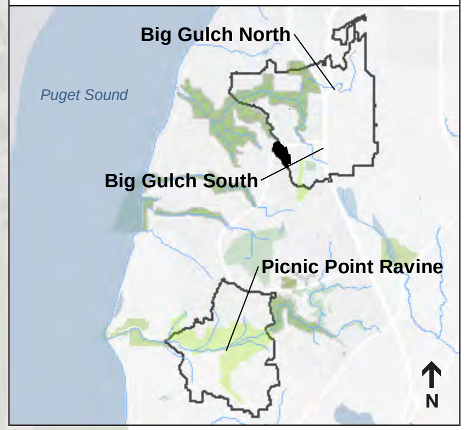
Stormwater Retrofit Project Fact Sheet : Project #3

SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013



Stormwater Sub-basin Index Map

■ Mapped Catchment
□ Stormwater Sub-basin



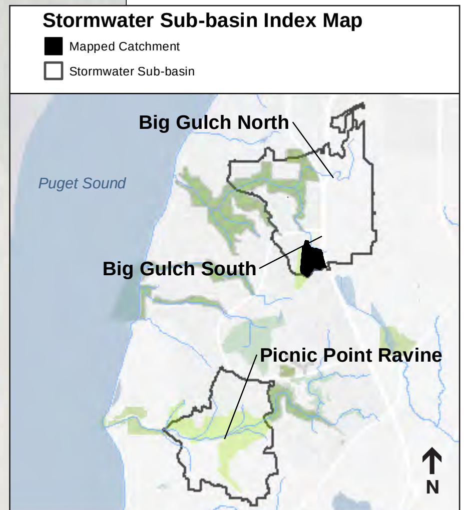
LEGEND

- Retrofit Project Area
- Stormwater Outfall
- Stormwater Drainage Network
- Connection Network
- Stream
- Park/Open Space
- City Owned Property
- Stormwater Catchment Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- Group A Hydrologic Soil
- High Landslide Hazard

Stormwater Retrofit Project #4 Summary	
Harbor Pointe Middle School	
PAU Name	Big Gulch South
Catchment Name	BG17
Existing Stormwater Facility	no
Estimated Contributing Area (acres)	1.7
Priotization Score	3.6
Project Rank (1-8)	2

Stormwater Retrofit Project Fact Sheet : Project #4

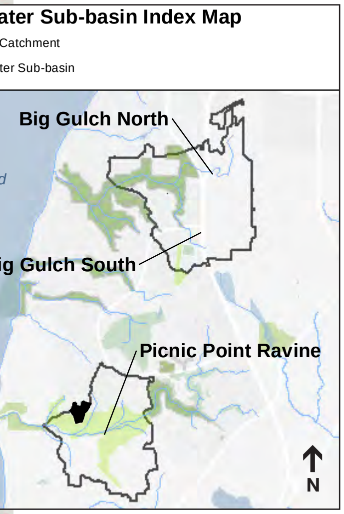
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013



Stormwater Retrofit Project #5 Summary	
YMCA/47th Place West	
PAU Name	Big Gulch South
Catchment Name	BG21
Existing Stormwater Facility	no
Estimated Contributing Area (acres)	15.1
Priotization Score	3.3
Project Rank (1-8)	4

Stormwater Retrofit Project Fact Sheet : Project #5

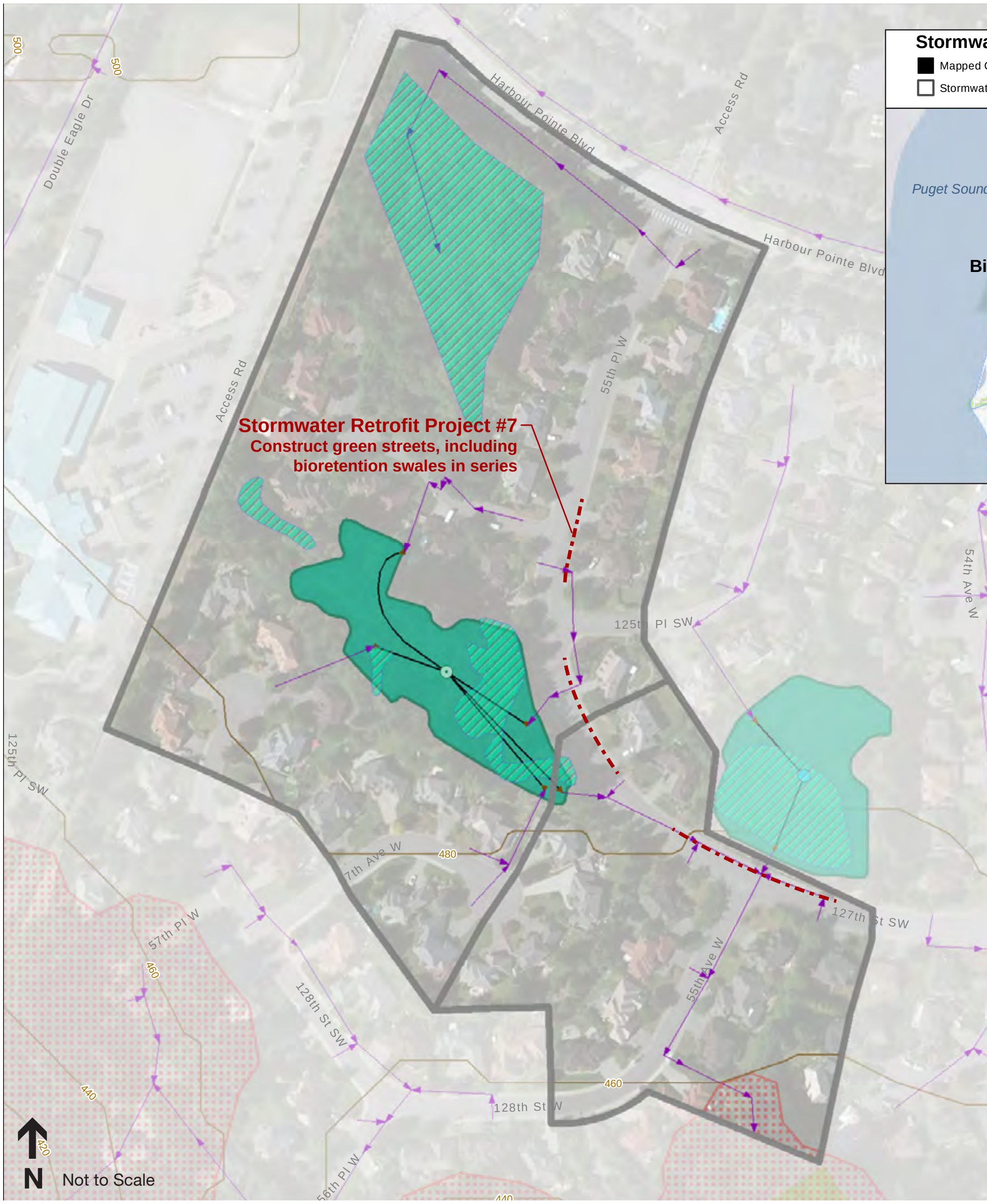
SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013



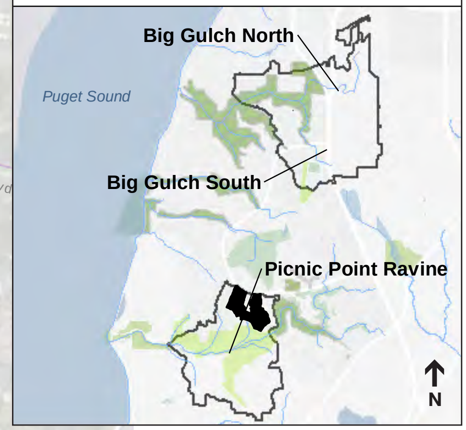
Stormwater Retrofit Project #6 Summary	
Harbor Pointe Golf Course	
PAU Name	Picnic Point Ravine
Catchment Name	PPR08
Existing Stormwater Facility	no
Estimated Contributing Area (acres)	11.8
Priotization Score	3.1
Project Rank (1-8)	5

Stormwater Retrofit Project Fact Sheet : Project #6

SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013



Stormwater Sub-basin Index Map
Mapped Catchment
Stormwater Sub-basin



LEGEND

- Retrofit Project Area
- Detention Pond
- Dual Function

Stormwater Drainage Network

- Stormwater Drainage Network
- Connection Network
- Dual Function
- Park/Open Space
- Stormwater Catchmen Basin Boundaries
- 20' Contours
- Wetlands (City of Mukilteo)
- High Landslide Hazard

Stormwater Retrofit Project #7 Summary	
55th Place West/127th Street Southwest	
PAU Name	Picnic Point Ravine
Catchment Name	PPR18/20
Existing Stormwater Facility	yes
Estimated Contributing Area (acres)	5.6
Priotization Score	3.6
Project Rank (1-8)	1

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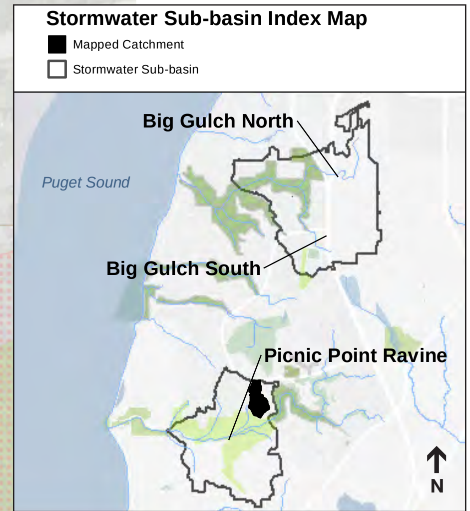
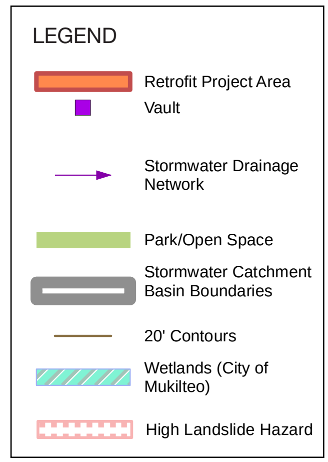
ESA

Stormwater Retrofit Project Fact Sheet : Project #7

SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013





Stormwater Retrofit Project #8 Summary	
Private Stormwater Vault	
PAU Name	Picnic Point Ravine
Catchment Name	PPR11
Existing Stormwater Facility	yes
Estimated Contributing Area (acres)	3.5
Priotization Score	3.0
Project Rank (1-8)	6

City of Mukilteo

Brown AND Caldwell

ESA

Stormwater Retrofit Project Fact Sheet : Project #8

SOURCE: ESA, 2010-2012; City of Mukilteo, 2012-2013

Attachment C: Scoring Results

Table. C-1. Catchment Analysis Results

Catchment ID	Total Area (acres)	TIA (acres)	Normalized TIA Retrofit	Facility Type	Facility Year	Facility Score	Prioritization Score (TIA Retrofit + Facility Score)	City	#1 EIA = $0.1*TIA^{1.5}$	#2 EIA = $0.4*TIA^{1.2}$	#3 EIA = TIA	EIA (ac)
BG01	15.3	4.9	0.13	Detention Pond	Airport	0.5	0.63	no				
BG02	8.3	3.9	0.10	none		1	1.10	yes		X		2.7
BG03	8.1	2.8	0.07	none		1	1.07	yes		X		2.1
BG04	6.9	1.2	0.03	none		1	1.03	yes		X		1.3
BG05	24.5	10.1	0.26	Detention Pond	1980	0.9	1.16	yes			X	10.1
BG06	4.6	1.7	0.04	Detention Pond	1986	0.9	0.94	yes		X		0.8
BG07	8.3	3.0	0.08	none		1	1.08	yes	X	X		2.4
BG08	17.5	4.3	0.11	Harbor Point Master Plan	2000	0.5	0.61	yes			X	4.3
BG09	26.5	11.4	0.30	none		1	1.30	yes	X	X		4.0
BG10	11.1	4.5	0.12	none		1	1.12	yes		X		2.5
BG11	1.4	0.6	0.02	Harbor Point Master Plan		0.5	0.52	yes		X		0.2
BG12	12.0	8.2	0.21	none		1	1.21	yes			X	8.2
BG13	7.6	3.5	0.09	none		1	1.09	yes		X		1.8
BG14	2.0	1.1	0.03	detention swale	1997	0.5	0.53	yes		X	X	1.1
BG15	3.2	2.1	0.06	none		1	1.06	yes			X	2.1
BG16	2.3	1.4	0.04	none		1	1.04	yes			X	1.4
BG17	11.0	3.8	0.10	none		1	1.10	yes			X	3.8
BG18	25.8	4.0	0.10	bioretention swale	between 1994 and 2002	0.5	0.60	yes			X	4.0
BG19	10.8	3.4	0.09	Detention Pond	1996	0.5	0.59	yes			X	3.4
BG20	6.9	4.4	0.12	none		1	1.12	yes			X	4.4
BG21	25.8	18.8	0.49	none		1	1.49	yes			X	18.8
BG22	5.6	4.7	0.12	none		1	1.12	yes				
BG23	136.5	30.3	0.79	Detention Pond; High Flow By-Pass Pipe	Airport	0.5	1.29	no				
BG24	112.9	38.5	1.00	Detention Pond	Airport	0.5	1.50	no				
BG25	2.6	0.8	0.02	none		1	1.02	yes				
PPR02	1.2	0.4	0.01	none		1	1.01	no				
PPR03	2.7	0.8	0.02	none		1	1.02	no				
PPR04	7.6	3.1	0.08	none		1	1.08	no				
PPR05	6.0	2.0	0.05	Detention Pond	between 1994 and 2002	0.5	0.55	no				
PPR06	6.0	1.9	0.05	none		1	1.05	no				
PPR07	8.0	3.5	0.09	Detention Pond	1996	0.5	0.59	no				
PPR08	11.8	2.8	0.07	none		1	1.07	50%		X		1.4
PPR09	14.0	7.3	0.19	Detention Pipe		1	1.19	yes		X		4.4
PPR10	9.0	2.6	0.07	Detention Pond	previous to 1990	0.9	0.97	yes		X		1.2
PPR11	23.2	7.7	0.20	Vault	previous to 1990	0.9	1.10	yes		X		4.6
PPR12	13.9	5.2	0.14	Detention Pond	previous to 1990	0.9	1.04	yes		X		2.9
PPR13	2.5	0.6	0.02	none		1	1.02	no				
PPR14	25.7	3.1	0.08	none		1	1.08	no				
PPR15	8.7	1.3	0.04	none		1	1.04	no				
PPR16	24.1	3.6	0.09	none		1	1.09	no				
PPR17	2.6	0.9	0.02	none		1	1.02	no				
PPR18	15.9	3.6	0.09	Dual Function	1988	0.9	0.99	yes		X		1.9
PPR19	5.6	1.6	0.04	Detention Pond	previous to 1990	0.9	0.94	yes		X		0.7
PPR20	5.5	1.9	0.05	none		1	1.05	yes		X		0.9
PPR21	9.5	2.1	0.05	none		0.5	0.55	no				
PPR22	4.5	2.1	0.05	none		1	1.05	no				
PPR23	5.8	1.4	0.04	none		1	1.04	no				
PPR24	7.7	0.6	0.02	none		1	1.02	no				
PPR25	7.4	4.1	0.11	none		1	1.11	no				

Table. C-2. City Wide Catchment Analysis Results

Catchment ID	Total Area (acres)	TIA (acres)	EIA (ac)	Normalized EIA Retrofit	Facility Score	Catchment Prioritization Score[1.]
BG02	8.32	3.94	2.07	0.11	1.00	1.11
BG03	8.12	2.75	1.35	0.03	1.00	1.03
BG04	6.91	1.19	0.49	0.54	1.00	1.54
BG05	24.49	10.12	10.12	0.04	0.90	0.94
BG06	4.56	1.72	0.77	0.04	0.90	0.94
BG07	8.34	3.03	2.36	0.13	1.00	1.13
BG08	17.51	15.00	15.00	1.00	0.50	1.50
BG09	26.52	11.37	3.96	0.21	1.00	1.21
BG10	11.05	4.55	2.46	0.13	1.00	1.13
BG11	1.38	0.60	0.22	0.01	0.50	0.51
BG12	11.96	8.17	8.17	0.54	1.00	1.54
BG13	7.57	3.51	1.81	0.10	1.00	1.10
BG14	2.00	1.14	1.14	0.08	0.50	0.58
BG15	3.16	2.13	2.13	0.08	1.00	1.08
BG16	2.28	1.45	1.45	0.08	1.00	1.08
BG17	11.01	3.84	3.84	0.26	1.00	1.26
BG18	25.76	4.02	4.02	0.21	0.50	0.71
BG20	6.94	4.43	4.43	1.00	1.00	2.00
BG21	25.76	18.77	18.77	1.25	1.00	2.25
BG22	5.62	4.69	4.69	0.25	1.00	1.25
BG25	2.57	0.76	0.29	0.07	1.00	1.07
PPR08	11.84	2.83	1.39	0.09	1.00	1.09
PPR09	13.98	7.33	4.36	0.23	1.00	1.23
PPR10	8.95	2.57	1.24	0.07	0.90	0.97
PPR11	23.16	7.69	4.63	0.31	0.90	1.21
PPR12	13.86	5.24	2.92	0.19	0.90	1.09
PPR18	15.92	3.59	1.86	0.12	0.90	1.02
PPR19	5.63	1.58	0.69	0.05	0.90	0.95
PPR20	5.46	1.91	0.87	0.06	1.00	1.06

1. Normalized EIA Retrofit Score + Facility Score

Table. C-3. Field Screening Results

Catchment ID	space feasibility/access	
BG21	high	1.0
BG14	high	1.0
PPR20	high	1.0
PPR11	high	1.0
BG08	high	1.0
PPR18	high	1.0
BG17	high	1.0
BG12	high	1.0
PPR19	high	1.0
PPR08	high	1.0
Catchments screened out by space/feasiblity qualitative score		
~~BG10~~	~~low~~	~~0.0~~
~~BG22~~	~~low~~	~~0.0~~
~~BG02~~	~~low~~	~~0.0~~
~~BG13~~	~~low~~	~~0.0~~
~~BG16~~	~~low~~	~~0.0~~
~~BG09~~	~~low~~	~~0.0~~
~~BG07~~	~~low~~	~~0.0~~
~~PPR10~~	~~low~~	~~0.0~~
~~BG06~~	~~low~~	~~0.0~~
~~PPR09~~	~~low~~	~~0.0~~
~~BG18~~	~~low~~	~~0.0~~
~~BG11~~	~~low~~	~~0.0~~
~~PPR12~~	~~low~~	~~0.0~~
~~BG20~~	~~low~~	~~0.0~~
~~BG04~~	~~low~~	~~0.0~~
~~BG15~~	~~low~~	~~0.0~~
~~BG03~~	~~low~~	~~0.0~~
~~BG25~~	~~low~~	~~0.0~~
~~BG05~~	~~low* (no access, poor safety)~~	~~0.0~~

Table. C-4. Stormwater Retrofit Project Evauation Results

				Cost					Benefit Score				Engineering Suitability Score					Geotechnical Suitability Score			Permitting Score					Partnership Score		Other Considerations Score	
Project Name		Catchment ID	Retrofit Project Score	Land Acquisitio	Score	O&M	Score	Cost Score	Existing Facility	Total Area Treated	Raw Score	Normalized Benefit Score	Connection to existing storm	Score	High Traffic	Score	Engineering Score	Shallow infiltration	Deep infiltration (aspect)	Geotechnical Score	Proximity to Critical Areas/buffers	Score	Cultural Resouces	Score	Permitting Score	Ease of partnership	Partnership Score	Notes	Score
1	Staybridge Suites Pond	BG08	2.0	No	3	pond/infiltration vault	2	2.5	Yes	12.0	7.2	1.4	high	3	low	3	3	low	low	1	no impacts	3	low/moderate risk	3	3	high: public facility	3		
2	Harbor Pointe Pl.	BG12	1.5	Yes	1	pond/infiltration vault	2	1.5	No	3.5	3.5	0.7	medium	2	low	3	3	low	good	3	buffer impacts	2	high risk	1	2	low: private	1		
3	Sno-Ilse Library	BG14	1.4	No	3	pond/infiltration vault	2	2.5	Yes	2.0	1.2	0.2	high	3	low	3	3	low	good	3	buffer impacts	2	moderate/high risk	2	2	medium: library	2	known project	-3
4	Harbor Point Middle School	BG17	2.2	No	3	bioretention	1	2.0	No	1.7	1.7	0.3	high	3	mid	2	3	low	good	3	buffer impacts	2	low/moderate risk	3	3	medium: school	2	Education opportunities	3
5	YMCA/47th Pl. W	BG21	1.6	No	3	bioretention	1	2.0	No	15.1	15.1	3.0	medium	2	High Traffic	1	2	low	good	3	no impacts	3	moderate/high risk	2	3	medium: YMCA	2	Big Gulch By-pass pipe	-3
6	Harbor Pointe Golf Course	PPR08	1.8	No	3	pond/wetland	2	2.5	No	11.8	11.8	2.4	medium	2	low	3	3	low	low	1	no impacts	3	low/moderate risk	3	3	low: golf course	1		
7	55thPl. W/127th St. SW	PPR18/20	2.3	No	3	bioretention	1	2.0	Yes	5.6	3.4	0.7	high	3	mid	2	3	low	moderate	2	no impacts	3	low/moderate risk	3	3	high: public street	3	public outreach/water quality	3
8	Private vault	PPR11	1.6	No	3	infiltration vault	2	2.5	Yes	3.5	2.1	0.4	high	3	low	1	2	low	good	3	buffer impacts	2	low/moderate risk	3	3	low: private	1		

Table. C-5. Overall Stormwater Retrofit Project Priority Scores

Stormwater Retrofit Project		Catchment ID	Normalized PAU Score	Normalized Catchment Score	Project Specific Score	Total Score	Rank
1	Staybridge Pond	BG08	0.9	0.7	2.0	3.5	3
2	Harbor Pointe Pl.	BG12	0.8	0.7	1.5	2.9	7
3	Library	BG14	0.8	0.3	1.4	2.4	8
4	Middle School	BG17	0.8	0.6	2.2	3.6	2
5	YMCA/47th Pl. W	BG21	0.8	1.0	1.6	3.3	4
6	Golf Course	PPR08	0.8	0.5	1.8	3.1	5
7	55thPl. W/127th St. SW	PPR18/20	0.8	0.5	2.3	3.6	1
8	Private vault	PPR11	0.8	0.6	1.6	3.0	6

Attachment D: Hydrologic Analysis

Appendix D. Hydrologic Analysis: Land Use Scenarios

Unit Analysis Scenario 1			2 ac, 20% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	35%	2.00	0.70
C, Lawn	79	45%		0.90
Impervious	98	20%		0.40
Total			*2.00*	*2.00*
			70	75

Unit Analysis Scenario 2			2 ac, 30% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	25%	2.00	0.50
C, Lawn	79	45%		0.90
Impervious	98	30%		0.60
Total			*2.00*	*2.00*
			70	76

Unit Analysis Scenario 3			2 ac, 40% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	15%	2.00	0.30
C, Lawn	79	45%		0.90
Impervious	98	40%		0.80
Total			*2.00*	*2.00*
			70	77

Unit Analysis Scenario 4			5 ac, 20% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	35%	5.00	1.75
C, Lawn	79	45%		2.25
Impervious	98	20%		1.00
Total			*5.00*	*5.00*
Wtd CN			70	75

Unit Analysis Scenario 5			5 ac, 30% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	25%	5.00	1.25
C, Lawn	79	45%		2.25
Impervious	98	30%		1.50
Total			*5.00*	*5.00*
Wtd CN			70	76

Unit Analysis Scenario 6			5 ac, 40% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	15%	5.00	0.75
C, Lawn	79	45%		2.25
Impervious	98	40%		2.00
Total			*5.00*	*5.00*
Wtd CN			70	77

Unit Analysis Scenario 7			10 ac, 20% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	35%	10.00	3.50
C, Lawn	79	45%		4.50
Impervious	98	20%		2.00
Total			*10.00*	*10.00*
Wtd CN			70	75

Unit Analysis Scenario 8			10 ac, 30% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	25%	10.00	2.50
C, Lawn	79	45%		4.50
Impervious	98	30%		3.00
Total			*10.00*	*10.00*
Wtd CN			70	76

Unit Analysis Scenario 9			10 ac, 40% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	15%	10.00	1.50
C, Lawn	79	45%		4.50
Impervious	98	40%		4.00
Total			*10.00*	*10.00*
Wtd CN			70	77

Unit Analysis Scenario 10			20 ac, 20% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	35%	20.00	7.00
C, Lawn	79	45%		9.00
Impervious	98	20%		4.00
Total			*20.00*	*20.00*
Wtd CN			70	75

Unit Analysis Scenario 11			20 ac, 30% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	25%	20.00	5.00
C, Lawn	79	45%		9.00
Impervious	98	30%		6.00
Total			*20.00*	*20.00*
Wtd CN			70	76

Unit Analysis Scenario 12			20 ac, 40% TIA	
Land Cover	**CN**	**%Cover**	**pre-dev**	**dev**
C, Forest	70	15%	20.00	3.00
C, Lawn	79	45%		9.00
Impervious	98	40%		8.00
Total			*20.00*	*20.00*
Wtd CN			70	77

Appendix D. Hydrologic Analysis: Predicted Pond Sizes
WWHM, Everett Gage 0.8 SF
optimize pond with 1-hr timestep (appx. 100 interations)

WWHM Pond Size (acre-ft)			
Area	WWHM 20% TIA	WWHM 30% TIA	WWHM 40% TIA
2	0.20	0.27	0.28
5	0.38	0.64	0.93
20	2.09	2.63	3.62

SBUH Pond Size (acre-ft)			
Area	SBUH 20% TIA	SBUH 30% TIA	SBUH 40% TIA
2	0.12	0.17	0.20
5	0.32	0.41	0.51
20	1.21	1.51	1.91

WWHM Pond Size (acre-ft)/Area			
Area	20% TIA	30% TIA	40% TIA
2	0.10	0.13	0.14
5	0.08	0.13	0.19
20	0.10	0.13	0.18
Average	0.09	0.13	0.17

SBUH Pond Size (acre-ft)/Area			
Area	20% TIA	30% TIA	40% TIA
2	0.06	0.09	0.10
5	0.06	0.08	0.10
20	0.06	0.08	0.10
Average	0.06	0.08	0.10

Relative Difference (SBUH/ WWHM)			
Area	20% TIA	30% TIA	40% TIA
2	0.60	0.64	0.72
5	0.85	0.64	0.55
20	0.58	0.58	0.53
		Average	0.63