Basin Study and Prioritization Report

Cold Creek Culvert Replacements and
Channel Stabilization Project
Federal Way, Washington

for
City of Federal Way

April 18, 2022

GeoEngineers
Earth Science + Technology

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April 18, 2022

Prepared for:

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1.0 INTRODUCTION

GeoEngineers, Inc. (GeoEngineers) has prepared this Basin Study and Prioritization Report for the City of Federal Way (City) to document the results of the first phase of a longer-term effort to address water resource related issues in the Cold Creek basin. The project's original focus was on possibly replacing existing undersized culverts under State Route (SR) 509 and the Marine Hills Pool facility, stabilizing unspecified sections of the Cold Creek channel to reduce incision and erosion, and reduce sediment generation and downstream deposition However, during project scoping it was recognized that an initial high-level review of the Cold Creek basin was needed to identify existing conditions, assess conditions of concern, and prioritize potential actions. This Basin Study and Prioritization project focused on Cold Creek, beginning at the location near 10th Avenue South/South 306th Street where the creek first flows in a natural open channel, extending downstream to Puget Sound. Cold Creek originates from Easter Lake; however, outflows from the lake are currently conveyed through shallow ditches and piped storm drains, which discharge into the natural channel near 10th Avenue South/South 306th Street. Cold Creek does not currently have an upstream channel that flows into Easter Lake. Most of the Cold Creek channel is within City limits. The downstream portion of the creek, near Puget Sound, is in City of Des Moines limits; however, services for this study were completed under contract to City of Federal Way without substantive involvement of the City of Des Moines.

1.1. Project Purpose, Objectives and Scope

The goals of the project are to provide fish passage; enhance fish habitat; stabilize the stream channel; reduce flood risks related to aging or undersized culverts; repair or replace damaged culverts; and reduce City maintenance requirements (such as sediment removal). As a first step in this process, GeoEngineers has developed this study with the objective of identifying distinct projects within the basin that can be prioritized and completed in sequence to meet these goals.

The scope of this study includes the following activities:

- complete an initial general characterization of baseline conditions, geomorphic processes, drainage features, etc. considering the overall basin for context, but focusing on the Cold Creek channel where it occurs as a natural, periodically culverted channel (between 10th Avenue South/South 306th Street and Puget Sound);
- identify problem conditions that may need to be addressed to achieve the project goals of providing fish habitat, fish passage, channel stability, reduced flood risk, and reduced channel maintenance;
- identify key stakeholders and initiate public outreach;
- define specific projects and identify a sequence of priorities that can be addressed in future phases; and
- estimate schedule, sequence, and/or funding opportunities available to complete high priority projects.

The Basin Study portion of this report includes a summary of the results from initial evaluations of stream channel conditions, geomorphology, fish habitat, road crossing/culvert infrastructure, and other environmental constraints within the Cold Creek basin. The Prioritization portion of this report identifies and ranks culverts and non-culverted stream channel reaches that warrant corrective actions to address deficiencies that can be addressed through modification of existing infrastructure or stream channel conditions. These potential actions are discussed qualitatively to identify the potential scope and rationale for completing each project, constraints and challenges associated with each project, and potential

sequencing and funding recommendations. Results presented herein will form the basis for further evaluation of feasibility and design alternatives to complete each project.

1.2. Project Location and Context

Cold Creek originates in the northern portion of Federal Way at Easter Lake, which is located near South 308th Street and west of 14th Avenue South and flows northwest approximately 1.6 miles to Puget Sound. Cold Creek drops approximately 440 feet over its length from Easter Lake to Puget Sound, with an average slope of 5 percent, although the upper reaches are slightly steeper (approximately 6 percent) and the lowest reach near Puget Sound is flatter (approximately 2 percent). The Cold Creek basin and focal study area/reaches are illustrated on Figure 1.

Easter Lake has two outlets that discharge to piped storm drains that connect near the intersection of 10th Avenue South/South 308th Street. The combined drainage flows in a piped storm drainage to a discharge point just west of 10th Avenue South/South 306th Street, where the storm drainage discharges to a ravine and flows in a natural open channel, with occasional culverts, discharging to the intertidal zone in Poverty Bay of Puget Sound after flowing under Redondo Beach Drive South. The storm drain at 10th Avenue South/South 306th Street is identified by the Washington State Department of Fish & Wildlife (WDFW) as Site ID 921216 (WDFW 2021a).

This study focuses on the 1.38-mile section of creek between the storm drain discharge west of 10th Avenue South/South 306th Street and Puget Sound. Within the study area, Cold Creek flows in an open channel for 0.97 miles and is culverted for 0.41 miles. For discussion and analysis purposes, the study area is divided into the following open channel reaches and culvert systems, as identified on Figure 1:

- Reach 1 – 10th Avenue South to SR 509/Dash Point Road
- Culvert – SR 509/Dash Point Road (WDFW Site ID 991192)
- Reach 2 – SR 509/Dash Point Road to South 302nd Street
- Culvert – South 302nd Street and Marine Hills Swim and Tennis Club (WDFW Site ID 991878)
- Reach 3 – Marine Hills Swim and Tennis Club to unmapped culvert
- Culvert – unmapped (no WDFW Site ID)
- Reach 4 – unmapped culvert to Redondo Treatment Facility
- Culvert – Redondo Treatment Facility (no WDFW Site ID)
- Reach 5 – Redondo Treatment Facility to Redondo Shores Drive South
- Culvert – Redondo Shores Drive South (WDFW Site ID 921213)
- Reach 6 – Redondo Shores Drive South to Redondo Beach Drive South
- Culvert – Redondo Beach Drive South (WDFW Site ID 921214)

Cold Creek also has a substantial tributary, consisting of a short channel originating at a groundwater-fed spring (Cold Spring) located within Reach 4. Other minor tributaries were not assessed. The study area is mostly within the City of Federal Way. The downstream approximately 0.25 miles is located in City of

Des Moines (see Figure 1). The border between the two cities is just upstream of the Redondo Treatment Facility.

Discharges from the storm drainage system were considered in the project hydrologic analysis and storm drain discharge points into Cold Creek were observed where found; however, assessment of the storm drain system was not part of the scope of this study. The pipes carrying Cold Creek from Easter Lake to the point of discharge into the ravine at 10th Avenue South/South 306th Street were not evaluated.

1.3. Public Outreach

Initial public outreach was completed as part of this study; however, further public engagement and discussions with specific landowners are anticipated to be required during subsequent phases as part of the development of specific actions that address the goals of this project. During development of this study, a notification mailer was developed and sent to all property owners with parcels intersecting the creek, within the extents of the study area. The mailer is included as Appendix A. This mailer provided a general overview and map of the project and study area, notified landowners of fieldwork activity that would be completed during the initial phase, and provided a contact at the City for residents to obtain more information, which was translated into several languages (Russian, Spanish, Korean, and Vietnamese).

2.0 BASIN CHARACTERIZATION

Basin characterization included the following data acquisition and analyses, provided as appendices:

- An Existing Conditions survey base map for the study area is provided as Appendix B (see also Section 2.2.1).
- A detailed field report describing geomorphic assessment and habitat characterization is presented in Appendix C Basin Characterization Field Report. The observations, conclusions, and results described in this field report are summarized in Section 2.0.
- Hydrology and hydraulic modeling outputs are provided in Appendix D (see also Sections 2.5 and 2.6).
- The results of a structural assessment of existing culverts and culvert systems are presented in Appendix E, Structural Assessment of Existing Culverts (Coffman Engineers). This information is also summarized in the following sections, along with other information pertinent to the study gathered during desktop review of the study area.
- As-built records for various infrastructure present within the study area are provided in Appendix F.
- Water quality data provided by the City is included in Appendix G.

2.1. Watershed Overview

Drainage in the upper portion of the watershed above the study area is collected into and controlled by Easter Lake, which is located in a highly urbanized setting. Easter Lake has two outlets, one at the northernmost extent of the lake and another further to the southwest. Both outlets were reconstructed in 2009 and convey flow northward through closed conveyance systems to an outfall near 10th Avenue South, which is the effective point of origin for the open channel flowing section of Cold Creek and is the upstream limit of this study.

Downstream of 10th Avenue South, Cold Creek flows through a ravine with varying levels of adjacent development. Much of this area is forested with development adjacent to the stream limited by the steep slopes associated with the ravine. Other areas contain development right up to the edge of the creek. Several culverts are present and other infrastructure is present in, adjacent to, and below the stream bed as summarized in the following sections and detailed in Appendices C and E.

The major stream sections and culverts within the study area are described below in summary manner, from upstream to downstream.

2.1.1. Reach 1

From the storm drain outlet west of 10th Avenue South/South 306th Street, Cold Creek flows in an open channel through a natural, forested ravine for approximately 1,200 feet. This creek section is designated Reach 1.

2.1.2. SR 509/Dash Point Road Culvert (WDFW Site ID 991192)

At the downstream end of Reach 1, the creek enters an 80 foot-long, 36-inch-diameter corrugated metal pipe (CMP) culvert crossing under SR 509/Dash Point Road. The culvert ends at a manhole with a short, 42-inch-diameter CMP culvert with a concrete discharge apron. The SR 509/Dash Point Road culvert is considered a fish passage barrier (WDFW 2019a).

2.1.3. Reach 2

Reach 2 is a 600-foot-long open channel flowing from the outlet of crossing 991192 to a culvert at South 302nd Street. Most of this section of creek flows in a natural, forested ravine, but in the lower portion the channel setting on the north side of the creek transitions to a residential backyard environment, and there are several small rock and dimensional lumber-grade control structures that appear to have been built by homeowners. At the downstream end of the open channel section is a larger, grade control structure constructed of large riprap with a drop of about 4 feet.

2.1.4. South 302nd Street and Marine Hills Swim and Tennis Club Culverts (WDFW Site ID 991878)

Shortly downstream from the large grade control structure at the downstream end of Reach 2, the creek enters a lengthy conveyance system comprised of several different culverts (typically 36-inch, both square and round) that total approximately 1,000 feet in length. This culverted system conveys the creek under South 302nd Street and the Marine Hills Swim and Tennis Club property. This culvert is considered a fish passage barrier (WDFW 2019d).

2.1.5. Reach 3

Reach 3 flows from the outlet of crossing 991878 downstream of the Swim and Tennis Club, in an open channel for approximately 750 feet. In this section, the creek has numerous cross-log type grade control structures that reportedly were constructed approximately 20 years ago, many of which appear to be failing. Some grade control structures were also observed as rock filled gabion baskets, that are also failing. While cross-log type grade control structures such as those observed were once considered fish habitat enhancements, they are now recognized as being barriers to fish migration because they typically exceed hydraulic drop design standards for fish passage (Barnard et al. 2013) and are prone to failure.

2.1.6. Unmapped Culvert (no WDFW Site ID)

The creek, still in the forested ravine, then enters an approximately 750 foot- long, 48-inch-diameter part CMP/part concrete culvert. The culvert apparently was not identified by WDFW (2021a) and therefore its status as a fish barrier has not been determined; however, if assessed by WDFW, we anticipate it would likely be classified as a fish passage barrier. The purpose of the culvert was not apparent as no infrastructure was identified that crosses the creek along the length of the culvert. Possible explanations are that the culvert was installed in this section of creek to stabilize adjacent steep ravine bluffs in order to protect homes on the adjacent bluff tops or alternatively the culvert may have been installed to stabilize two locations where major sanitary sewer lines cross the creek near the upstream and downstream ends of the culvert. These sanitary sewer lines drain to the Lakehaven Water and Sewer District (LWSD) treatment plant located further downstream, adjacent to Cold Creek.

2.1.7. Reach 4

In Reach 4, the creek flows as an open channel for approximately 1,550 feet through a natural forested ravine with high and steep ravine bluffs. The channel has several cross-log grade control structures that appear to be failing. Towards the upper end of Reach 4, a major tributary joins the creek along the right bank. This tributary originates from a feature known locally as Cold Spring, located partway up the side of the ravine (Figure 1). Cold Spring provides a substantial flow of cold, clear water to the creek. A 1979 construction record drawing (see Appendix F) shows an 8-inch-diameter sanitary sewer line crossing the creek from south to north.

Water intakes for the treatment plant were noted on a 1961 as-built drawing (see Appendix F), which appear to coincide with the infrastructure observed in the field at Cold Spring (see Appendix C). We were not able to confirm whether or not these water lines are actively used or have been abandoned.

2.1.8. Redondo Treatment Facility Culvert (no WDFW Site ID)

As the upstream ravine widens near the Puget Sound, the creek enters the City of Des Moines and flows through an approximately 250-foot-long, 72-inch-diameter CMP culvert under the LWSD Redondo Treatment Plant. The culvert apparently was not identified by WDFW (2021a) and therefore its status as a fish passage barrier has not been determined. However, if assessed by WDFW, we anticipate it would likely be classified as a partial fish barrier.

2.1.9. Reach 5

In Reach 5 the creek flows for approximately 475 feet in an open channel through a forested area in close proximity to residential backyards. Some bank armoring and grade control structures are present.

2.1.10. Redondo Shores Drive South Culvert (WDFW Site ID 921213)

At the downstream end of Reach 5, the creek crosses under Redondo Shores Drive South in an approximately 30-foot-long, 48-inch-diameter CMP culvert, which is identified by WDFW as a total fish barrier (WDFW 2019b).

2.1.11. Reach 6

In Reach 6, the creek flows out of crossing 921213 through an open channel for approximately 540 feet in a residential area with minimal tree cover. The channel is heavily modified with bank armoring and has a degraded riparian zone.

2.1.12. Redondo Beach Drive South Culvert (WDFW Site ID 921214)

Lastly, at the downstream end of Reach 6, the creek flows into an approximately 40-foot-long, 60-inch-span concrete box culvert under Redondo Beach Drive South. Although the culvert is not identified as a fish barrier (WDFW 2019c), the vertical opening is only 38 inches. This culvert will not be further considered in this study, aside from our evaluating its impact on hydrology or the geomorphology of upstream portions of the basin.

2.2. Land and Infrastructure

Land and infrastructure elements within or directly adjacent to the Cold Creek channel are described below.

2.2.1. Survey and Base Map

As part of this study, a survey and base map were developed for the basin utilizing available Light Detection and Ranging (LiDAR) data as well as ground survey by a Professional Land Surveyor (PLS). The resulting survey includes basin topography, existing roadway, culverts, and other infrastructure within and directly adjacent to the creek, and stream cross sections at selected locations. The base map is presented in Appendix D and served as the basis for hydraulic modelling, discussed in Section 2.6 of this report.

2.2.2. Property

Within the study area, Cold Creek is located primarily on private property, except where it crosses public rights-of-way at SR 509/Dash Point Road (Washington State Department of Transportation [WSDOT], City of Federal Way), South 302nd Street (City of Federal Way), and Redondo Beach Drive South (City of Des Moines). Most properties within the City of Federal Way portion of the study area are either undeveloped or are the undeveloped portions of backyards associated with residential lots. However, some backyards, particularly between SR 509/Dash Point Road and South 302nd Street are altered and/or landscaped right up to and including the bank of the creek. A significant section of the stream is also culverted under the Marine Hills Swim and Tennis Club property. The lowest reach of the stream is in the City of Des Moines, where most properties are developed, including a section of stream that is culverted under the Redondo Treatment Plant.

Notable property owners include:

- Marine Hills Swim and Tennis Club, which owns and operates a private road, parking lot, and pool facility, under which Cold Creek is conveyed via a system of culverts;
- Powell, the owner of much of the undeveloped portion of the basin from the pool downstream to the City limits of Federal Way; and
- LWSD, which owns and operates the Redondo Treatment Plant.

2.2.3. Roads

There are four public road crossings within the study area, including from upstream to downstream SR 509/Dash Point Road, South 302nd Street (this road runs along the ravine bottom, and adjacent to the culverted creek for a distance of approximately 600 feet), Redondo Shores Drive South, and Redondo Beach Drive South. The first two are within the limits of the City of Federal Way and the latter two are within the City of Des Moines. We understand that the City of Federal Way, not WSDOT, is responsible for the SR 509/Dash Point Road culvert on Cold Creek.

2.2.4. Storm Drains

Numerous storm drains convey runoff from upstream urban/residential areas to Cold Creek. Some were observed as part of this study; however, the scope of this study did not include a comprehensive evaluation of the storm drainage system within the Cold Creek basin. Of the storm drains observed during assessment of the Cold Creek channel, many were noted to have:

- defects, including damage to conveyance piping and outlet structures;
- erosion around discharge points, potentially resulting in excess sediment delivery to the creek during high flow events; and/or
- locations that are either relatively hidden or in ravine areas inaccessible for maintenance.

2.2.5. Marine Hills Swim and Tennis Club

The Marine Hills Swim and Tennis Club operates a pool facility that was constructed in the base of the valley formed by Cold Creek. Cold Creek is conveyed via a closed culvert system under the private access road to the facility and under the associated parking lot. Within the pool facility, the culvert is believed to be located beneath the concrete slab (pool deck) between the pool and the pool house building.

2.2.6. Redondo Treatment Plant

The Redondo Treatment Plant is located within the City of Des Moines and is owned and operated by LSWD. The LSWD provides water and sewer services to portions of the following communities: Federal Way, Des Moines, Auburn, Milton, Kent, and Tacoma. The Redondo Treatment Plant is located partially over the apparent historic Cold Creek stream channel. The existing creek is culverted beneath a portion of the treatment plant. Specifically, at the plant, bio-filters No. 1 and No. 2 are located over the top of the culverted creek. Primary Clarifier No.1 is located directly adjacent to the culvert. Major sanitary sewer lines are present in the Cold Creek ravine and crossing the creek at several locations including two locations within the extent of the unmapped culvert and at least one additional crossing in Reach 4.

Based on review of the Redondo Treatment Plant's discharge permit (National Pollution Discharge Permit No. WA0023451), the plant discharges treated wastewater to Poverty Bay in Puget Sound via a submerged outfall. Stormwater runoff from the treatment plant (such as from rainfall on site parking and landscaped areas) discharges to Cold Creek.

2.2.7. Culvert Structural Evaluations

GeoEngineers subcontracted the structural evaluation of culverts to Coffman Engineers. Coffman Engineers' full report is provided in Appendix E. Coffman Engineers staff observed shorter culverts from the ends. For the long culvert under the Marine Hills Swim and Tennis Club pool facility and entrance road, the

City provided video footage of the culvert interiors. The dates of the videos ranged from 2011 to 2021. Coffman Engineers did not evaluate the culverts between Reaches 3 and 5, and only provided a safety review rather than a detailed assessment of the culverts between Reach 5 and Poverty Bay, which are in the City of Des Moines. Coffman Engineers' primary conclusions are summarized below:

- Culvert at SR 509/Dash Point Road: Good condition with minor surface corrosion.
- Culvert under South 302nd Street and the Marine Hills Swim and Tennis Club pool facility: This long continuous series of multiple culverts is in poor condition with some areas of severe damage or failure, including breakthrough of some areas of the bottoms of CMP culverts from gravel scour, overhead bulging, and drooping crown with concurrent areas of settlement visible in overhead roadway pavement, and at least one substantial blockage of the culvert by concrete pieces scoured from floor of a section of concrete box culvert. These deficiencies indicate a high concern for future flood damage to infrastructure including the South 302nd Street roadway and buried utilities, as well as the Marine Hills Swim and Tennis Club pool facility and parking area, by inundation, erosion/scour, and sediment deposition.
- Unmapped culvert in ravine (between Reaches 3 and 4): Not assessed by Coffman Engineers; however, GeoEngineers observed that several sections of concrete pipe at the downstream end of the culvert had failed and separated from the upstream portion of the culvert.
- Culvert under Redondo Treatment Plant: Not assessed.
- Culvert at Redondo Shores Drive South: No significant structural deficiencies noted (safety review only).
- Culvert at Redondo Beach Drive South: No significant structural deficiencies noted (safety review only).

2.2.8. Utilities

Water, sanitary and storm sewer, gas, electric, and possible communication lines are believed to be present in South 302nd Street, serving residences along the roadway and extending to the Marine Hills Swim and Tennis Club. Storm drains are also present.

Based on as-builts provided by the LWSD, sanitary sewer lines cross the creek at two locations within the extent of the unmapped culvert and again in the lower part of Reach 4, just upstream of the Redondo Treatment Plant. As-built records are provided in Appendix F.

Water intakes for the treatment plant were noted on a 1961 as-built drawing (see Appendix F), which appear to coincide with the infrastructure observed in the field at Cold Spring (see Appendix C); we were not able to confirm that these water lines have been abandoned.

Utilities in the portion of the basin within City of Des Moines were not identified.

2.3. Habitat and Environmentally Sensitive Areas

2.3.1. Fish Habitat

Cold Creek is identified on the City of Federal Way Critical Areas Map, extending from Poverty Bay up to a point just downstream of Easter Lake (City of Federal Way 2016). The creek is identified as a Class 2 salmonid stream by King County below the Marine Hills Swim and Tennis Club and is not identified as continuing above the pool (King County 2018). The Washington Department of Natural Resources (WDNR)

identifies it as a Type F (fish-bearing) perennial stream up to a point slightly below 10th Avenue South (WDNR 2021). WDFW identifies Cold Creek as containing Coho Salmon and resident Cutthroat Trout up to a point about midway between the Redondo Treatment Plant and the Marine Hills Swim and Tennis Club (WDFW 2021b).

WDNR (2021) also identifies a left bank tributary entering Cold Creek near the upstream end of the Redondo Treatment Plant that is identified as Type U (unknown) and a right bank tributary at Cold Spring that is identified as Type N (non-fish-bearing). WDFW (2021b) also identifies the left bank tributary, which is identified as containing Coho Salmon and resident Cutthroat Trout but does not identify Cold Spring. None of the other sources we reviewed identify these tributaries. Cold Spring was observed in the field and documented by GeoEngineers (Appendix C) but the left bank tributary was not (Figure 1).

WDFW Fish Passage and Diversion Screening Inventory Database reports four culverts in the basin that have been assessed by WDFW (WDFW 2019 a, b, c, d) identifying Chinook Salmon, Coho Salmon, Chum Salmon, Steelhead, sea-run Cutthroat Trout, and resident trout as species potentially present within the basin. Though all four reports were prepared by the same survey crew in 2019, identification of various salmonids were not consistent between reports. Fish distribution described in these reports was based on the professional judgment at the time of field visits and does not reflect sampling results.

Field assessment completed by GeoEngineers indicated that streamflow is seasonal through much of the watershed, which may limit fish distribution. Several trout (unidentified species) were visually observed in the Cold Spring tributary, but no fish were observed within Cold Creek during our site visits. Additional detail, including descriptions of fish habitat conditions for each stream reach, are included in Appendix C.

2.3.2. Wildlife Habitat

Much of the Cold Creek basin, including the forested ravine and riparian area between the Redondo Treatment Facility and Marine Hills Swim and Tennis Club is identified as a *Biodiversity Area and Corridor* by WDFW (2021b). *Biodiversity Areas* are identified by WDFW as areas of habitat that are relatively important to various species of native fish and wildlife, either because they are biologically diverse based on landscape scale and context, and/or represent remaining native vegetation with relatively diverse habitat structure in urban growth areas where native habitat is limited. *Biodiversity Corridors* are areas of relatively undisturbed and unbroken tracts of vegetation that connect fish and wildlife habitat (WDFW 2021c).

2.3.3. Wetlands and Waters of the United States

Cold Creek is identified by multiple sources and maps (see above) and was field verified by GeoEngineers. Cold Creek is considered a Water of the United States and Water of the State, subject to federal Clean Water Act and state Hydraulic Code jurisdiction throughout the study area regardless of streamflow duration or seasonality. Cold Spring, the right bank tributary to Cold Creek, though not occurring on any of the map databases, was observed and documented in the field by GeoEngineers and would also be subject to the same jurisdictions up to its point of origin at a vault (see Appendix C). The left bank tributary shown on two mapped sources was not observed in the field by GeoEngineers. It is possible that the channel was dry and overgrown at the time of our fieldwork and therefore not visually observed, or that the channel has been converted to piped conveyance and was being conveyed by one of numerous stormwater pipes observed discharging to Cold Creek. Further evaluation would be required to ascertain its status as a jurisdictional waterbody.

There were no palustrine wetlands confirmed within the study area. Riverine channels associated with Cold Creek and its tributary would be subject to regulation as described in the preceding paragraph. Other than these riverine channels, neither the City of Federal Way, WDFW, nor United States Fish and Wildlife Service (USFWS) identify wetlands within the basin (City of Federal Way 2016; WDFW 2021b; USFWS 2021). Several seeps and springs on the valley slopes were also observed that may be classified as wetland systems, subject to further assessment and delineation if a project action is proposed that could affect these areas.

2.3.4. Frequently Flooded Areas

A portion of the lowest reach of Cold Creek, extending approximately 165 feet upstream from Redondo Beach Drive South, is identified as a Zone AE Special Flood Hazard Area (SFHA) up to elevation +13 (NAVD88) according to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) (FEMA 2020). The marine area associated with Poverty Bay waterward of Redondo Beach Drive South is identified as Zone VE, also at elevation +13 (NAVD88), which is outside of the study area. No other areas within the study area are identified as SFHAs according to FEMA.

2.3.5. Steep Slopes and Erosion

A large portion of the study area, including the forested ravine surrounding Cold Creek and Cold Spring, is identified as Erosion Hazard Area, Landslide Hazard Area, or both overlapping (City of Federal Way 2016). Additional discussion regarding steep slopes, erosion, and slope instability is provided in the following section.

2.4. Geology and Fluvial Geomorphology

2.4.1. Geology

The geology of the Cold Creek ravine is similar to other nearby Puget Sound shoreline ravines. Over time, the ravine has incised through a series of layers of geologic deposits. Interfaces between strata are often not uniformly horizontal, but rather follow historic topography. The upper geologic layer is glacial till, a mix of clay, silt, sand, gravel, and cobbles. Successive lower strata are advance outwash, (consisting of well-bedded sand with occasional zones of gravel), followed in sequence by coarse- and fine-grained pre-Olympia glacial deposits (older glacial deposits consisting of primarily sand/gravel and silt/clay, respectively). All of these strata have been compressed to a very compact condition by overlying glaciers and are all therefore relatively resistant to erosion. Typically, the layers with lower silt/clay content are more erodible because they have lower cohesive strengths.

The layers with higher silt/clay content also act as barriers to downward migration of groundwater, which can cause groundwater to move laterally within the coarse-grained units or zones. This lateral movement frequently creates groundwater seepage where these geologic transitions are exposed on slopes. Prolonged groundwater seepage on slopes can lead to slope instability, sometimes on a large, deep-seated scale. The mapped “mass wastage” zone on the eastern slope of the ravine near Reaches 3 and 4 may be one example of this type of deep-seated slope failure. These large, deep-seated landslides differ from smaller shallow slides of topsoil that can occur on ravine bluff slopes due to stream channel incision or lateral undercutting of banks. There are several instances of localized sloughing, erosion, and undercutting along the channel banks. However, these localized zones pose lower relative risk than the larger-scale landslides, and typically either do not require mitigation, or can be addressed on a location-by-location basis.

The lowest approximately 500 feet of Cold Creek flows on an alluvial fan formed from deposition of sediment eroded from higher in the watershed as the creek makes its way into Puget Sound.

2.4.2. Geomorphology

2.4.2.1. Profile

Cold Creek drops approximately 440 feet in elevation over its length from Easter Lake to Puget Sound, with an average slope of 5.2 percent. Within the span of Reaches 1, 2, 3, and 4, the Cold Creek channel has an average slope of 6.1 percent. The average channel slopes in Reaches 5 and 6 are 4.2 percent and 2.7 percent, respectively. Within Reaches 1, 2, 3, and 4, the steepest section is the approximately 700-feet-long unmapped culvert between Reaches 3 and 4, with a slope of 8.8 percent. Slopes upstream of this culvert range from 2 to 6 percent due to substantial sediment deposition and historic channel stabilization efforts.

2.4.2.2. Channel Conditions

Cold Creek channel conditions are briefly summarized by reach:

- **Reach 1**: Cold Creek is confined in a forested steep-sided valley. The valley ranges from approximately 60 to 110 feet deep, with a top width of 70 to 160 feet. The creek channel is highly incised with steep to near vertical banks up to about 8 feet high. Channel bottom widths range from 2 to 8 feet and channel top widths range from 4 to 9 feet. The upstream portion of Reach 1 has a meandering planform. The downstream portion is generally straighter. Reach 1 is predominantly an erosional reach, with deposition occurring upstream of the SR 509/Dash Point Road culvert; however, erosion is limited by the underlying glacial till deposits. Streambed material in the creek is primarily gravel and cobbles that exists mainly in thin scattered pockets over the till where it is trapped behind wood debris. Reach 1 was dry during site visits completed in May and June 2021.
- **Reach 2:** Cold Creek is confined in a forested very steep-sided valley that gradually opens up toward the downstream end of the reach. Upstream, the valley is typically approximately 60 feet deep, with a typical top width of less than 100 feet, and the creek channel is highly incised with steep to near vertical banks. No floodplain exists. Downstream, valley side slopes are flatter, and the creek is less incised with some floodplains where residences are present on the east side of the creek. Homeowners appear to have constructed various grade control structures and bank armoring in the lower portion of Reach 2, to attempt to prevent lateral creek migration. The upper portion of Reach 2 is predominantly erosional, while the lower section is acting mainly as a transport reach. Streambed material is predominantly gravel and cobbles in the upper part of the reach and gravels in the lower part of the reach. The inlet to the Reach 2 culvert has a drop of approximately 4 feet over a large riprap grade control structure, which likely aids in minimizing sediment deposition upstream of the long culvert under South 302nd Street and the Marine Hills Swim and Tennis Club. Reach 2 was dry during site visits completed in May and June 2021.
- **Reach 3:** The creek flows through a relatively broad corridor of native forest. The valley side slopes are less steep than Reaches 1 and 2 giving the appearance of a wider valley bottom. However, the creek is still confined with no established floodplains. The creek section is approximately 8 feet wide at the bottom, with side banks approximately 2:1 slopes about 2 to 4 feet high. In 2000, creek incision was mitigated by filling the channel with imported material and constructing grade control structures using logs and rock filled gabion baskets. Many of these grade control structures have failed. The upper section of Reach 3 is an erosional and transport reach, while the lower section is mostly depositional

due to the flatter creek slope upstream of the unmapped culvert. Streambed material is gravel with some sand and cobbles. With the exception of a small puddle near the outlet of the Reach 2 culvert, Reach 3 was dry during site visits completed in May and June 2021.

- **Reach 4:** Reach 4 is mostly unimpacted by development, with a wide, steep-slope riparian zone abutting nearly vertical banks. In this reach, the creek is slightly sinuous, incised in some areas but with localized discontinuous narrow floodplains in others. The channel was generally 8 to 12 feet wide with either steep banks coincident with the valley walls or with very gentle sloping banks leading to narrow floodplain areas). Seeps were commonly observed entering the channel, creating visible flow in the creek. Geology transitions from coarse- to fine-grained glacial deposits in the upper part of the reach, and it is likely that groundwater, as it moves downward in the soil column and hits the fine-grained material, which prevents downward migration, then travels laterally until it intersects the hillslope and flows downslope into the creek. In localized areas, the fine-grained glacial deposits are dense and resistant to erosion, creating discontinuous hard points vertically and laterally. Where the fined-grained materials are softer, valley widening is occurring. In the lower part of the reach upstream from the Redondo Treatment plant, there are a series of artificial steps created by placement of logs and other materials. Reach 4 is predominantly a transport reach for sediment. Streambed material is mainly gravel with sand and cobbles. The tributary from Cold Spring enters Cold Creek in the upper portion of Reach 4. As noted above, Reach 4 had flowing water during site visits completed in May and June 2021. Most the flow appears to originate as seeps in and adjacent to the channel in the upper portion of Reach 4. Inflow from Cold Spring was approximately equal to the flow in Cold Creek above Cold Spring.
- **Reach 5:** The creek slope begins to flatten from 6 to 4 percent as it transitions to the Puget Sound nearshore zone. In this reach, the valley is wider and shallower, but the creek is confined and slightly incised. The channel is approximately 6 to 12 feet wide through most of this reach. Reach 5 is mainly a transport reach for sediment and appears fairly stable except for several areas of local lateral scour due to larger storm drain discharges. Streambed material is mainly gravel with sand and cobbles. Creek banks are altered in numerous areas with riprap armoring. Large boulders were added as a grade control structure where the creek is in close proximity to the Redondo Treatment Plant. Many 6- to 18-inch-diameter corrugated plastic pipes were observed on the left bank, presumably draining stormwater from upslope residential and roadway areas. Reach 5 was observed to have substantial flow of clear and cold water during both site visits.
- **Reach 6:** Downstream of the Redondo Treatment Plant, the creek flows through areas with increasing density of residences. Correspondingly, the creek banks become more modified with riprap and concrete, and the tree canopy thins. Downstream of Redondo Shores Drive South, the creek is basically a narrow ditch through residential back yards with hardened banks and lawns that extend to the creek banks with no adjacent shrub vegetation or tree cover. Reach 6 is predominantly a depositional area due to the flatter creek slope approaching Puget Sound. Streambed material is mainly sand. Reach 6 was observed to have substantial flow during both site visits.

2.5. Hydrology

2.5.1. Base Flow

Summer low/base flows were not assessed as part of our hydrology model. However, we are able to draw some generalized conclusions as a result of our field observations, the overall size of the stream and watershed, and the level of urbanization within the watershed.

For smaller watersheds in highly urbanized settings, such as the Cold Creek basin, runoff from impervious surfaces during rain events is typically concentrated in stormwater systems and is unattenuated discharge into streams. This is a direct result of the level of development creating a landscape dominated by impervious surfaces that do not infiltrate surface water naturally into the groundwater table, where it would otherwise travel slowly through the ground and then discharge into streams from groundwater. The natural process of stormwater infiltration and groundwater discharge in unaltered watersheds maintains base flows in small streams during the dryer parts of the year (summer), supporting aquatic life that depends on flowing water. When this process is interrupted as a result of urbanization, flows in small streams become "flashy," that is, stream flow surges during times of high precipitation and then dries out in between storm cycles and/or during the summer dry season.

During fieldwork completed in Cold Creek in May and June, staff observed very little base flow in the upper portion of the watershed, with most stream reaches being dry at the time of our site visits. We believe that perennial flow occurs in Cold Spring, from the vault at the head of the channel to the confluence with Cold Creek. We also believe that there is perennial flow in Cold Creek upstream from this confluence, originating from numerous springs and seeps on the valley walls in Reach 4. Consequently, base flows from the confluence with Cold Spring to the mouth at Poverty Bay are much more consistent than those in the upper reaches, which significantly improves the habitat potential for fish.

2.5.2. Hydrologic Modeling

An MGSFlood hydrologic model was developed to estimate peak flows at several points along the Cold Creek system to use as input into our hydraulic model of Cold Creek (described in Section 2.5). MGSFlood model development is described in Section 2.5.2.3. In addition, a review of studies conducted on the Cold Creek watershed by MGS Consultants was completed to identify information that could be used in the hydraulic model (MGS Engineering Consultants 2003; MGS Engineering Consultants 2007). MGS Consultants developed a detailed Hydrological Simulation Program – FORTRAN (HSPF) hydrologic model that estimated Easter Lake outlet discharges at different return intervals (MGS Engineering Consultants 2003; MGS Engineering Consultants 2007). GeoEngineers used these values as flow inputs in the hydraulic model (Section 2.6). Peak discharges downstream of Easter Lake were calculated by GeoEngineers using the MGSFlood model and were also used as hydraulic model flow inputs. These discharges are reported in Section 2.5.2.4.

2.5.2.1. Easter Lake Outlet Discharges

Hydrology of the upstream portion of the Cold Creek watershed is controlled by Easter Lake (Appendix D, Figure 1). Easter Lake has two outlets, one at the northernmost extent of the lake and another further to the southwest. Both outlets convey flow northward through closed conveyance systems to an outfall near 10th Avenue South, which is the effective point of origin for the Cold Creek channel. Outflows from Easter Lake significantly affect discharges in the upper Cold Creek watershed.

The northernmost Easter Lake outlet includes an adjustable weir that controls lake water levels. The City of Federal Way Easter Lake Flood Control Improvements As-Builts from 2009 show the weir as having a typical elevation of 428 feet with an adjustable range between 426 and 428.5 feet in elevation (Section A-A' from callout 5/12 on Sheet 12 of 16). The as-built elevations for the weir outlet match those proposed in a Technical Memorandum prepared by MGS Consultants in 2007 (MGS Engineering Consultants 2007). The 2007 Technical Memorandum expands upon a larger scale hydrologic study conducted on the watershed in 2003 (MGS Engineering Consultants 2003). The 2003 study developed a

HSPF model to predict discharges throughout the Cold Creek watershed including Easter Lake outlet discharges. Results from the 2003 model were updated in 2007 to help inform design of the northernmost Easter Lake outlet. The proposed outlet weir design in the 2007 Technical Memorandum appears consistent with the 2009 as-builts, so we assume discharges over the weir reported in the document are reasonable predictions of Easter Lake outlet discharges for this study.

Proposed weir outflows at specific recurrence intervals from Easter Lake reported in the 2007 Technical Memorandum were used in this study as the total discharge exiting Easter Lake. Easter Lake discharges presented in the MGSFlood report at the outlet of Easter Lake (and used in this study) are shown in Table 1. The study conducted by MGS Consultants assumed the southwest outlet was blocked and all flow exited the lake at the northern outlet. The discharges leaving Easter Lake for the specified recurrence intervals were added as flow inputs into the hydraulic model (Section 2.6) in addition to discharges calculated using MGSFlood (Section 2.5.2.3).

TABLE 1. EASTER LAKE OUTLET FLOW FROM MGS CONSULTANTS 2007 TECHNICAL MEMORANDUM

Flood Event	Flow from Easter Lake Outlet (cfs)
2-year	3.5
100-year	8.4

2.5.2.2. Watershed Delineation

Four project-specific watersheds were delineated to aid in determining 2- and 100-year recurrence interval peak flows at key locations along Cold Creek, for incorporation into our hydraulic model. The four defined watersheds are as follows (Appendix D, Figure D-3): (1) the watershed contributing to crossing 991192; (2) the watershed contributing to crossing 991878; (3) the watershed contributing to the unmapped culvert; and (4) the entire Cold Creek watershed. Watershed boundaries were delineated using ArcGIS Pro version 2.8.1 utilizing the 2016 King County LiDAR terrain dataset (WDNR 2016). The delineated watershed boundaries were adjusted to account for stormwater systems based on GIS data provided by the City of Federal Way. We also considered the watershed draining into Easter Lake in our hydraulic model. The Easter Lake watershed was taken to be identical to the basin area presented in the 2007 MGS Consultants Technical Memorandum. This was done because discharges from Easter Lake presented in the MGS Consultants 2007 Technical Memorandum were used in this study (Table 1, Section 2.5.2.3).

Areas for the four delineated Cold Creek watersheds and the Easter Lake watershed are summarized in Table 2. Watershed boundaries are shown on Appendix D Figure D-3.

TABLE 2. WATERSHED AREAS

Watershed	Area (acres)	Source
Easter Lake	97.7	MGS Consultants
Culvert at SR 509 Dash Point Road (Crossing ID 991192)	246.2	GIS Delineation
Culverts at South 302nd Street and Marine Hills Swim and Tennis Club (Crossing ID 991878)	385.5	GIS Delineation
Unmapped Culvert	434.9	GIS Delineation
Entire Cold Creek	533.7	GIS Delineation

The Cold Creek watershed has a total area of 533.7 acres. The delineated Cold Creek watershed closely resembles the watershed delineated by MGS Consultants in the 2007 Technical Memorandum with less than a 1 percent difference in calculated watershed areas.

2.5.2.3. MGSFlood Model

MGSFlood was used to calculate peak flow estimates in the Cold Creek channel at four locations: (1) the outlet to crossing 991192, (2) the outlet to crossing 991878, (3) the outlet of the unmapped culvert and (4) the outlet of the entire Cold Creek watershed. Cold Creek is not gauged, there are no nearby similar watersheds with usable flow records, and the Cold Creek watershed does not meet the criteria for use of United States Geological Survey (USGS) regional regression equations, which are limited by a 5 percent maximum impervious surface area. The Cold Creek watershed is over 50 percent developed.

MGSFlood is a calibrated, continuous simulation hydrologic model that is based on the HSPF system (MGS 2021). MGSFlood inputs include drainage areas, landcover classifications, soil characteristics, percent imperviousness, and precipitation data. The pervious landcover classes (forest and grass) are further categorized by their underlying soil units, classified as "till," "outwash," or "saturated." Soil characteristics for the Cold Creek watershed were determined through the United States Department of Agriculture (USDA) – NRCS Web Soil Survey (Natural Resource Conservation Service 2021). Sub-watershed areas classified as hydrologic soil group B were assumed to be "till" or "outwash" based on underlying geology. Landcover classification was delineated using impervious surface coverage data from the City of Federal Way in addition to King County 2019 aerial imagery.

Table 3 shows the landcover and soils data inputs for each of the four watersheds used in the MGSFlood models. Watershed areas used as inputs into the MGSFlood model to calculate peak flows excluded the area draining into Easter Lake because Easter Lake outflows were estimated from the MGS Consultants reports. MGSFlood models were run with a 15-minute time step based on an approximate time of concentration of 1 hour for the watershed (MGS 2021).

TABLE 3. MGSFLOOD INPUTS

Soil and/or Landcover Type	Culvert at SR 509 Dash Point Road (Crossing ID 991192) (acres)	Culvert System at South 302nd Street and Marine Hills Swim and Tennis Club (Crossing ID 991878) (acres)	Unmapped Culvert (acres)	Entire Cold Creek (acres)
Till Forest	11.8	16.4	17.1	19.9
Till Grass	75.4	129.3	130.2	152.0
Outwash Forest	2.2	7.5	27.8	76.1
Outwash Grass	5.2	36.0	55.3	63.9
Impervious	53.7	98.2	106.4	123.4
TOTAL	**148.3**	**287.4**	**336.8**	**435.3**

2.5.2.4. Peak Discharges (2- and 100-year)

Peak discharges estimated from MGSFlood and used as inputs in the hydraulic model for the 2- and 100-year events for each of the four watersheds are shown in Table 4. Results in Table 4 are the sum of discharges from the Easter Lake outlet and MGSFlood model results.

TABLE 4. PEAK DISCHARGES USED IN HYDRAULIC MODELING

Recurrence interval	Culvert at SR 509 Dash Point Road (Crossing ID 991192) (cfs)	Culvert System at South 302nd Street and Marine Hills Swim and Tennis Club (Crossing ID 991878) (cfs)	Unmapped Culvert (cfs)	Entire Cold Creek (cfs)
2-Year	30.5	52.2	55.3	63.7
100-Year	102.4	176.1	185.3	214.0

2.6. Hydraulic Modeling

A coarse, one-dimensional hydraulic model of the cold Creek system was developed using United States Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) computer program (version 5.0.7). The model was developed to inform hydraulics throughout the Cold Creek system (USACE 2019). The hydraulic model extends from the outlet of the pipe network near 10th Avenue South to just upstream of Redondo Shores Drive South covering approximately 6,300 feet of stream channel. The hydraulic model does not include Reach 6, the Redondo Shores Drive South crossing, or the Redondo Beach Drive South crossing due to limited survey data. The HEC-RAS model is a coarse representation of Cold Creek to inform watershed prioritization efforts and should not be used for design.

2.6.1. Existing Conditions Model Inputs

HEC-RAS one dimensional (1-D) hydraulic models require channel and overbank topography at each cross section in the model, Manning's n roughness estimates, discharge estimates and information for each culvert. The following sections outline model inputs for the Cold Creek HEC-RAS model and model assumptions.

2.6.1.1. Channel and Overbank Topography

The HEC-RAS model contains 26 cross sections (Appendix D Figure D-4). Cross sections were spaced no more than 500 feet apart with shorter distances in the vicinity of road crossings or other areas of interest. In-channel topography was collected at four surveyed cross sections: one cross section was located in Reach 1, one in Reach 2, one in Reach 3 and one in Reach 5. Cross section surveys were not completed in Reach 4 or Reach 6. The remaining 22 cross section in-channel geometries were inferred using the available survey data. Overbank topography for all 26 cross sections consist of data obtained from 2016 King County LiDAR (WDNR 2016). LiDAR was used to inform overall channel slope throughout the model domain.

2.6.1.2. Manning's n Roughness Estimates

Manning's n is a parameter used to represent roughness of materials. HEC-RAS uses this parameter to calculate frictional energy losses experienced by flowing water. In-channel Manning's n values were estimated based on field observations, slope, and sediment gradation using the United States Forest Service (USFS) Stream Channel Flow Resistance Coefficient Computation Tool (Yochum 2018). In-channel Manning's n values were calculated for each of the five modeled reaches and at specific locations where field observations indicated a change in roughness was warranted. Overbank Manning's n values were kept constant for all modeled reaches, estimated using Chow 1959. Manning's n values are reported in Table 5.

TABLE 5. MANNING'S N HYDRAULIC ROUGHNESS COEFFICIENT VALUES USED IN THE HEC-RAS 1-D MODEL

Location (approximate average slope)	n Value	Notes	Source
Reach 1 Upper 700 feet (6 percent slope)	0.1	Incised, step pool, wood present in channel	Yochum 2018
Reach 1 Reference Reach (6 percent slope)	0.09	Steps with glides and plane bed in between, less incised than upstream	Yochum 2018
Reach 2 (5 percent slope)	0.09	Similar to Reach 1, some larger sediment	Yochum 2018
Reach 3 (4 percent slope)	0.07	Similar sediment to Reach 1, shallower slope than Reach 1, modified with large wood making steps	Yochum 2018
Reach 4 Upstream approximately 600 feet (6 percent slope)	0.08	More fines compared to Reach 1, similar slope to Reach 1, LWM in channel, more vegetation than Reach 3	Yochum 2018
Reach 4 Downstream approximately 950 feet (5 percent slope)	0.07	More fines compared to Reach 1, shallower slope than upstream Reach 4, less wood in channel, more vegetation than Reach 3	Yochum 2018
Reach 5 (4.2 percent slope)	0.06	Pool riffle, less steep than upstream reaches, more armoring	Yochum 2018
Overbanks	0.13	Floodplain - medium to dense brush in the summer	Chow 1959

2.6.1.3. Discharges

Peak discharges used in hydraulic modeling for the 2- and 100-year events for each of the four watersheds are shown in Table 4 above. Flow changes associated with each of the delineated watersheds were entered into the model domain upstream of each of the modeled culverts, producing conservative results.

2.6.1.4. Culvert Information

Culvert invert elevations, culvert size, and top of road elevations for the SR 509 Dash Point Road culvert and the culvert system at South 302nd Street and Marine Hills Swim and Tennis Club were available from survey. The survey was not able to collect any information for the unmapped culvert and Wastewater Treatment Plant culvert. Invert elevations and road surface elevations for the culverts not included in survey were estimated from LiDAR and field observations. Culvert dimensions for culverts without survey were estimated using field measurements and observations. Modeled culvert characteristics can be found in Table 6 below.

TABLE 6. MODELED CULVERT CHARACTERISTICS

Culvert	Opening Shape/ Size	Material	Manning's n	Culvert Bottom Blockage	Other Notes
Culvert at SR 509 Dash Point Road (Crossing ID 991192)	Circular/ 36-inch-diameter	CMP	Top= 0.024 Bottom=0.024	None	None
Culvert System at South 302nd Street and Marine Hills Swim and Tennis Club (Crossing ID 991878)	Box/ 36-inch-wide by 34-inch-high	Concrete opening CMP pipe	Top= 0.024 Bottom=0.05	6 inches sediment	Filled with concrete slabs- increased roughness to help account for this
Unmapped Culvert	Circular/ 48-inch-diameter	Concrete	Top= 0.011 Bottom=0.011	None	large drop at outlet
Wastewater Treatment Plant	Circular/ 72-inch-diameter	Concrete	Top= 0.011 Bottom=0.035	12 inches sediment and baffles	Contains baffles- increased roughness to account for this

2.6.1.5. Model Limitations and Assumptions

The 1-D HEC-RAS model is a low-resolution representation of Cold Creek. Due to the limited available survey information and inherent limitations of 1-D models the Cold Creek model has several limitations:

1. The model represents the generalized creek based on the limited information available and the results are similarly of a generalized nature suitable for use in drawing generalized conclusions at the basin scale. The model results at any specific location may not be accurate and should not be relied upon for other applications such as maximum flood elevations or design, due to limited available surveyed cross sections and other limitations.
2. Because the model is low-resolution, results should be evaluated within each reach instead of at individual cross sections.
3. Backwater extents can only be determined in a relative sense. Cross section spacing is too coarse to provide site-specific backwater extents.
4. HEC-RAS cannot model pipe networks such as that present at South 302nd Street and Marine Hills Swim and Tennis Club. This culvert was modeled as a box with dimensions equal to the most upstream opening, which is the hydraulic control for conditions upstream of this culvert.
5. HEC-RAS cannot model baffles. Baffles at the Wastewater Treatment Plant culvert were modeled as increased roughness (Table 6).
6. HEC-RAS cannot model inconsistent blockages in culverts such as those present in the culvert system at South 302nd Street and Marine Hills Swim and Tennis Club. These blockages were incorporated into the model as an increase in Manning's n.
7. Invert and road surface elevations were estimated from LiDAR for culverts not included in the survey.
8. The model does not consider tidal influence.

9. The model does not contain Easter Lake or the north outlet weir. Easter Lake outflows were estimated from the MGS Consultants reports (Section 2.5.2.3).
10. Change of flow locations are approximate.

2.6.2. Results

Consistent with the modeling limitations noted above, reach average values for velocity, shear stress, and maximum channel depth along with maximum depth at surveyed cross sections were extracted from the model to inform the watershed prioritization matrix. Maximum depth values at the surveyed cross sections are predicted by the model using limited available information. A summary of results broken down by reach for the 2- and 100-year discharge is shown below in Tables 7 and 8, respectively. Additional tabular data surveyed cross section plots, and long profiles with water surface elevations can be found in Appendix D, Figures D-5 through D-13. Average reach velocities and depths presented in the following tables were evaluated at cross sections outside the immediate influence of the culvert. These results were used to inform the Watershed Prioritization presented in Section 3.0.

TABLE 7. 2-YEAR HYDRAULIC MODEL RESULTS BY REACH

Reach	Flow (cfs)	Average Velocity (ft/s)	Average of Maximum Channel Depths[1] (ft)	Max Depth in Surveyed Cross Section (ft)	Overbank Flow in Surveyed XS?
Reach 1	30.5	3.5	1	0.8	No
Reach 2	52.2	5	2.4	2.3	No
Reach 3	52.2	4.5	2.2	2.3	No
Reach 4	55.3	5	2.1	N/A	N/A
Reach 5	63.7	6	1.9	1.8	Yes

Notes:
[1] Average of maximum channel depths for the entire reach.

TABLE 8. 100-YEAR HYDRAULIC MODEL RESULTS BY REACH

Reach	Flow (cfs)	Average Velocity (ft/s)	Average of Maximum Channel Depths[1] (ft)	Max Depth in Surveyed Cross Section (ft)	Overbank Flow in Surveyed XS?
Reach 1	102.4	5	3.2	7.3	Yes
Reach 2	176.1	7	2.4	7.7	Yes
Reach 3	176.1	8	3.2	4.9	Yes
Reach 4	185.3	7.5	4	N/A	N/A
Reach 5	214	8.5	3.5	2.6	Yes

Notes:
[1] Average of maximum channel depths for the entire reach.

Additional information was extracted near the four modeled culverts including average velocity at the upstream and downstream end of each culvert, approximate depth of flow through the culvert and relative

backwater extent. Culvert hydraulic model results for the 2- and 100-year discharges are shown in Tables 9 and 10 below.

Backwater extents upstream of each modeled culvert were characterized as insignificant, minor or significant. The insignificant characterization indicates no backwater was observed while a significant characterization indicates a relatively long length of backwater. Backwater indicates the potential for aggradation attributed to slower velocities and deeper flow depths.

The Wastewater Treatment Plant culvert was the only culvert without significant backwater during the 100-year event. All modeled culverts conveyed the entirety of the 2-year event. Under the 100-year flow event the culvert System at South 302nd Street and Marine Hills Swim and Tennis Club was overtopped indicating the potential for road flooding and flooding of nearby properties. The model does not include the observed concrete chunks blocking a portion of the culvert, which would likely cause additional backwater and flooding. The model indicates all other culverts are able to convey the 100-year flow event.

TABLE 9. 2-YEAR DISCHARGE HYDRAULIC MODEL CULVERT RESULTS

Culvert	Flow (cfs)	Average Velocity Inside Culvert at upstream end (fps)	Average Velocity Inside of Culvert at Downstream End (fps)	Approximate Depth of Flow Through Culvert (ft)	Backwater
Culvert at SR 509 Dash Point Road (Crossing ID 991192)	30.5	6.5	11	1.2	insignificant
Culvert System at South 302nd Street and Marine Hills Swim and Tennis Club (Crossing ID 991878)	52.2	7.5	8	2.2	significant
Unmapped Culvert	55.3	7	>10	1	insignificant
Wastewater Treatment Plant	63.7	6.5	10	1.2	minor

TABLE 10. 100-YEAR DISCHARGE HYDRAULIC MODEL CULVERT RESULTS

Culvert	Flow (cfs)	Average Velocity Inside Culvert at upstream end (fps)	Average Velocity Inside of Culvert at Downstream End (fps)	Approximate Depth of Flow Through Culvert (ft)	Backwater
Culvert at SR 509 Dash Point Road (Crossing ID 991192)	102.4	12	14	3	significant
Culvert System at South 302nd Street and Marine Hills Swim and Tennis Club (Crossing ID 991878)	176.1[1]	8.5	8.5	Flowing Full; Creek Overtops Culvert and Flows Down Road	significant
Unmapped Culvert	185.3	12.5	> 10	1.7	significant
Wastewater Treatment Plant	214	10	>12	2.3	minor

Notes:

[1] Total flow upstream of culvert. Portions of flow through the culvert and over the road were not calculated.

2.7. Water Quality

Easter Lake is the source of Cold Creek. The Easter Lake watershed is relatively small and nearly entirely urbanized. Easter Lake receives stormwater runoff from the upper watershed and is likely recharged by inflows of regional groundwater. Other nearby lakes have a reported history of periodic summer blooms of toxic blue-green algae, with blooms likely related to excess nitrogen and phosphorus inputs from urban stormwater runoff (Federal Way Mirror 2016). Easter Lake is anecdotally mentioned in the referenced Federal Way Mirror article as also being affected by toxic algae, but additional research did not find any confirmation.

Limited water quality information was available for Easter Lake and Cold Creek. GeoEngineers reviewed the water quality data provided by the City, which consisted of 10 water quality sampling events from December 2002 to January 2004 (Appendix G). Most samples were tested for organo-phosphorus, total phosphorus, free and total chlorine, nitrate, and ammonia. Samples were collected between December and May at the outlet of Easter Lake. Most test results were listed as "0", which we interpret to mean "not detected"; however, detection limits were not noted. Assuming appropriate analytical test methods with appropriate detection limits were used, then overall Cold Creek water quality generally appears to be below regulatory levels for the substances tested.

Most samples were also tested using field instruments for turbidity, pH, dissolved oxygen, and temperature. One sample had a dissolved oxygen value of 6 milligrams per Liter (mg/L) compared to the standard for salmonids of 8.0 mg/L. Three samples had pH values as low as 6.2 standard units, below the standard of 6.5 standard units. One sample had a temperature value of 18 degrees C, above the standard of 17.5 degrees C for general salmonid use. Limitations to the data set include short duration of the study period (14 months), age of data (18 years), and limited range of analytes. Although the above data indicates generally favorable water quality, we anticipate that the substantial urban growth and development within the Cold Creek watershed since 2003 most likely has contributed to a reduction in water quality, particularly for non-point source pollutants.

GeoEngineers also reviewed test data for two samples collected by the City of Des Moines in June and July 2019 from lower Cold Creek. Samples were tested for fecal coliform. Reported fecal coliform values for these two samples were 240 and 5 Most Probably Number (MPN), which were below the water quality standard at the time tested. As of 2020, the water quality standard changed from fecal coliform to *E. coli*.

A search of the Washington State Department of Ecology (Ecology) databases did not yield relevant data. Cold Creek is not on Ecology's 303d list of non-compliant water bodies. Typically, water bodies are only listed when sampling data document non-compliance.

In addition to the limited overall information about basin water quality and lack of recent water quality data, a notable data gap is the absence of recent chlorine test results below the pool facility, as chlorinated pools can sometimes leak substantial amounts of chlorinated water.

3.0 WATERSHED PRIORITIZATION

One of the primary goals of the project is to identify problem conditions that occur within the study area and prioritize solutions to these problems. Our approach to accomplishing this goal is to:

- first, identify and prioritize the watershed by stream section (open channel reach or closed conveyance/culvert system) based on the results of our study;
- second, identify potential actions that may be implemented to address in whole or in part the highest priority sections; and
- lastly, consider sequencing, funding, permitting and other considerations that can be used to develop a recommended sequence of projects to initiate.

3.1. Methods

3.1.1. Stream Sections

To prioritize actions within the study area, the creek was dividing into a total of 6 open channel "reaches" which are separated by closed conveyance culvert systems. These reaches and culverts are outlined in Section 1.2 and are consistent with the prior work presented in the Basin Characterization Field Report, Appendix C, as illustrated on Figure 1. Appendix H, Table H-1 provides a brief description of each of these locations, stream stationing, property ownership, and notable infrastructure present.

3.1.2. Evaluation Criteria

The following criteria were used to evaluate each stream section (open channel reach or closed conveyance/culvert) of the Cold Creek basin. These criteria were based on the goals of the project.

- **Geomorphic Conditions**. This includes factors such as channel incision; sediment transport; and delivery, erosion, and associated environmental risks. Locations that are out of equilibrium or with evidence of geomorphic instability and subsequent maintenance requirements, or other problems, received higher scores than stable sections.
- **Flood Risk.** This criterion addresses the potential for high stream discharge during flooding events to overtop the stream bank or overwhelm culverts and cause flood damage to infrastructure or natural resources. Higher risk of flood damage warrants a higher priority score.
- **Habitat Restoration Potential.** This criterion focuses on fish habitat and associated habitat-related parameters (habitat access/passage barriers, hydrography, substrate conditions, riparian cover, etc.). Open channel reaches with potential habitat that is degraded receives a higher score, while those sections with limited potential to provide fish habitat receive a lower score. Culverts that preclude access to quality habitat receive a higher score, while those that are already fish passable or habitat above is of low quality receive a lower score.
- **Structural Condition and Risk.** This criterion evaluates the structural integrity of each closed conveyance system as well as any structural features in open channel reaches, such as bank armoring and grade control structures. Additionally, the degree of risk and consequence of structural failure was considered, with those at high risk or greater consequence receiving a higher score than those at low risk and consequence.
- **Maintenance Requirements.** This criterion is based on requirements for the City Public Works Department to conduct regular maintenance that might otherwise be avoided with correction of the problem. Locations contributing to a regular maintenance requirement were scored higher than those where the City does not have to conduct regular maintenance.

3.1.3. Scoring and Weighting

We assigned each stream section with a score for each evaluation criteria as follows:

- 0 – No action warranted
- 1 – Low priority for action
- 2 – Moderate priority for action
- 3 – High priority for action

Scoring was based on the information gathered during field investigations and desktop research, as documented in this report, and applied the professional judgement of the authors. The scores were also reviewed with City of Federal Way engineers for additional input and concurrence.

Weighting of specific criteria relative to other criteria was considered and the City decided that higher weighting should be applied to those criteria related to risk to life, infrastructure, and/or property. Therefore, we added a weighting factor of 2.0 for the following two criteria: *Flood Risk* and *Structural Condition and Risk*. Sensitivity analysis indicated that the section most sensitive to this weighting was Reach 1, which had very low scores for the two more heavily weighted criteria, yet higher scores in most other criteria. Most other reaches ranked similarly with or without weighting.

3.2. Prioritization Matrix

Detailed results of the watershed prioritization are presented primarily in tabular format in Appendix H, Table H-2, which includes rationale for the score applied to each stream section for each criterion. This matrix includes the location and a brief description of each stream section, identifies property ownership and infrastructure present, and then presents a summary and conclusion for each evaluation criterion with associated score.

Table 11 below presents a summary of weighted scores. For each stream section, weighted scores were summed across the five evaluation criteria to produce an overall reach score.

TABLE 11. WEIGHTED SCORES BY STREAM LOCATION

Stream Section (Reach/Structure)	Geomorphic Condition	Flood Risk	Habitat Restoration	Structural Condition/Risk	Maintenance	Weighted Reach Score
City of Federal Way						
Reach 1 (storm drain outlet at 10th Ave S to SR 509/ Dash Point Road)	3	0	1	0	3	**7**
Culvert at SR 509 Dash Point Road (Crossing ID 99192)	3	2	1	1	3	**13**
Reach 2 (SR 509/Dash Point Road to South 302nd Street)	3	1	1	1	3	**11**
Culvert System at South 302nd Street and Marine Hills Pool (Crossing ID 991878)	3	3	1	3	3	**19**
Reach 3 (below Marine Hills Pool to unmapped culvert)	2	0	1	1	0	**5**
Culvert (unmapped)	2	1	1	2	0	**9**
Reach 4 (Unmapped culvert to Redondo Treatment Plant)	1	0	3	1	0	**6**
City of Des Moines						
Culvert at Redondo Treatment Plant (unidentified crossing)	1	1	2	0	0	**5**
Reach 5 (Redondo Treatment Plant to Redondo Shores Drive South)	1	2	2	1	0	**9**
Culvert at Redondo Shores Drive (Crossing ID 921213)	1	2	3	2	2	**14**
Reach 6 (Redondo Shores Drive to Redondo Beach Drive)	1	3	3	0	0	**10**
Culvert at Redondo Beach Drive (Crossing ID 921214)	0	3	1	0	0	**7**

Note:
Flood Risk and Structural Condition/Risk scores were weighted double relative to other criteria.

Table 12 presents these same results re-ordered by rank within each municipality. It is important to distinguish between municipalities for this analysis because the City of Federal Way is unlikely to take action to correct problems identified in stream sections outside the City limits which are not in its jurisdiction.

TABLE 12. PRIORITY SECTIONS BY RANK

Location (Reach/Structure)	Geomorphic Condition	Flood Risk	Habitat Restoration	Structural Condition/Risk	Maintenance	Weighted Reach Score
City of Federal Way						
Culvert System at South 302nd Street and Marine Hills Pool (Crossing ID 991878)	3	3	1	3	3	**19**
Culvert at SR 509 Dash Point Road (Crossing ID 99192)	3	2	1	1	3	**13**
Reach 2 (SR 509/Dash Point Road to South 302nd Street)	3	1	1	1	3	**11**
Culvert (unmapped)	2	1	1	2	0	**9**
Reach 1 (storm drain outlet at 10th Avenue South to SR 509/ Dash Point Road)	3	0	1	0	3	**7**
Reach 4 (Unmapped culvert to Redondo Treatment Plant)	1	0	3	1	0	**6**
Reach 3 (below Marine Hills Pool to unmapped culvert)	2	0	1	1	0	**5**
City of Des Moines						
Culvert at Redondo Shores Drive (Crossing ID 921213)	1	2	3	2	2	**14**
Reach 6 (Redondo Shores Drive to Redondo Beach Drive)	1	3	3	0	0	**10**
Reach 5 (Redondo Treatment Plant to Redondo Shores Drive South)	1	2	2	1	0	**9**
Culvert at Redondo Beach Drive (Crossing ID 921214)	0	3	1	0	0	**7**
Culvert at Redondo Treatment Plant (unidentified crossing)	1	1	2	0	0	**5**

Note:
Flood Risk and Structural Condition/Risk scores were weighted double relative to other criteria.

Based on the rank order in the table above, the following stream sections within the City of Federal Way had the highest prioritization scores and will be the focus of the potential actions presented in the subsequent sections of this report:

- **Culvert System at South 302nd Street and Marine Hills Pool (Crossing ID 991878).** This culvert received high scores for all criteria except habitat restoration value and was the top-ranking location regardless of the weighting factor we applied.
- **Culvert at SR 509 Dash Point Road (Crossing ID 99192).** This culvert received high scores based on geomorphic condition and maintenance requirements, a moderate score for flood risk, and low scores for habitat restoration value and structural condition/risk.
- **Reach 2 (SR 509/Dash Point Road to South 302nd Street).** This was the highest ranking open-channel reach and occurs between the two culverts that scored higher, above. It received high scores for geomorphic condition and maintenance and low scores for flood risk, habitat restoration potential and structural condition/risk.

Several locations within the City of Des Moines also scored fairly highly, including the Culvert at Redondo Shores Drive (Crossing ID 921213) and Reach 6 between Redondo Shores Drive and Redondo Beach Drive. These reaches and culverts score high due to degraded habitat conditions and the high potential for salmon habitat restoration due to good base flow of cold, clear water from Cold Spring.

We also recommend the City of Federal Way coordinate with LWSD to determine if LWSD has any responsibilities for maintenance and repair of the unmapped culvert.

3.3. Description of Potential Actions

The project actions identified in the following sections focus on the three highest scoring locations within the City of Federal Way limits. Sections in the City of Des Moines are not discussed further in this report.

3.3.1. Replace Culvert System at South 302nd Street and Marine Hills Pool

This project was envisioned by the City during the Request for Statement of Qualifications released in June 2020. The watershed prioritization presented in this report confirms that this project should be a high priority for the City. Potential goals that can be incorporated into a conceptual design include:

- Replacing failing culvert system with a fish passable structure or multiple structures that provide adequate flood flow and sediment/debris conveyance.
- Daylighting as much of the stream as possible to reduce culvert length and improve habitat benefit.
- Shifting South 302nd Street and/or the private access road to accommodate an open channel within the spatial constraints of the ravine.
- Minimizing impacts to private pool facility, access, and parking.
- Regrading stream gradient upstream and/or downstream of the culvert(s) to restore geomorphic processes that will reduce maintenance requirements and improve system performance.
- Evaluating storm drain discharge locations to this reach and repair as needed.

Replacement of this culvert system will address geomorphic processes, aging (and in some locations failing) infrastructure, flood risk, and maintenance issues. Replacement would improve public safety and reduce risks to life, property, and infrastructure. Although this location is not currently accessible to anadromous fish and seasonal flow limits its utility to resident fish, it would also replace a structure identified by WDFW as a fish passage barrier.

Due to its length and location beneath significant infrastructure, most notably the pool facility at the Marine Hills Swim and Tennis Club, replacement of this system is anticipated to be complex. It is possible that sections of this system could be replaced in phases to manage cost, landowner collaboration elements, and construction schedule.

3.3.2. Replace Culvert at SR 509/Dash Point Road

The second priority project was also envisioned by the City during the Request for Statement of Qualifications released in June 2020. The watershed prioritization presented in this report confirms that this project should be a high priority for the City. Potential goals that can be incorporated into a conceptual design include:

- Replacing culvert with a fish passable structure that provides adequate flood flow and sediment/debris conveyance.
- Reducing culvert length through use of retaining walls and/or wingwalls.
- Repairing eroded stormwater outfalls near the culvert.
- Regrading stream gradient upstream and/or downstream of the culvert to restore geomorphic processes that will reduce maintenance requirements and improve system performance.

Replacement of this culvert will address geomorphic processes, flood risk, and maintenance issues. Although this location is not currently accessible to anadromous fish and low seasonal flow limits its utility to resident fish, it would also replace a structure identified by WDFW as a fish passage barrier.

Replacement of this system is anticipated to be relatively straightforward as a simple cut and cover replacement of the existing culvert with a new structure in the same or close to the same alignment, with some adjustment to vertical profile of the culvert and stream sections immediately upstream and downstream. Because this culvert is located under a state route, impacts to traffic and the travelling public will need to be considered. If a temporary closure of SR 509/Dash Point Road is not an option, the replacement of this culvert becomes much more complicated because of the relatively deep fill overlying the culvert and the temporary measures that would be required to maintain traffic during construction.

Additionally, some of the problems and risks associated with Reaches 1 and 2 would likely be addressed as part of this project, including potential stream vertical realignment upstream and downstream of the culvert and modification of the stormwater discharges upstream of the culvert.

3.3.3. Reach 2 Stream Channel Restoration

Restoration of channel conditions in Reach 2 also received a relatively high priority score. This reach is located between the two culvert systems prioritized for replacement above. Due to its location, replacement of the culverts would likely address some, but potentially not all, of the limiting factors and risks within this reach. Specifically, channel vertical realignment upstream or downstream of each culvert would likely be required as part of culvert replacement, helping to address geomorphic conditions in the reach and associated maintenance problems, which were identified as the highest priority categories for this stream section. Other factors, including flood risk, habitat restoration, and structural condition, received low scores.

Some of the possible actions within this section include:

- Extending channel regrade further from each culvert and taking a systematic approach to stream gradient throughout this reach.
- Replacing bank stabilization present in the reach with bioengineered solutions, or removal altogether.
- Removal of grade control structures in favor of geomorphic stabilization using a natural channel process approach.
- Increasing channel complexity and sinuosity through installed habitat features and planform realignment.
- Creating floodplain benches to provide off-channel habitat and attenuate flood flows.
- Working with landowners to restore riparian vegetation conditions.

Some of these possible actions require geomorphic and hydrologic/hydraulic analysis and design and should be considered holistically throughout the reach and/or in conjunction with adjacent culvert replacements. Therefore, we recommend that a conceptual design for the reach as a whole be developed, and then specific elements can be constructed as appropriate and potentially in sequence.

3.3.4. Other Sections and Projects Not Prioritized

Other culverts and reaches within the City of Federal Way received lower scores. Problems in Reach 1 might be addressed, at least in part, in conjunction with corrective action for the Culvert at SR 509. The unmapped culvert and Reaches 3 and 4 are in locations where corrective actions would be challenging due to limited site access. Therefore, these locations are not considered high priority and limiting factors present could be addressed at a later date after other higher-priority problems within the basin are addressed.

As noted above, the City of Federal Way does not propose addressing any of the reaches or culverts outside the City's jurisdictional limits. These locations could be addressed by other entities.

3.4. Funding, Sequencing and Other Considerations

3.4.1. Funding

The culverts at SR 509/Dash Point Road and 302nd Street/Marine Hills Pool are currently barriers to fish passage; however, downstream barriers are currently present and hydrology in these reaches is seasonal, limiting habitat value for resident fish. These culverts are therefore not likely to be highly prioritized for funding using fish barrier removal grants. Additionally, replacement of these culverts would not likely have significant improvements to water quality and the Cold Creek Basin has not been identified as a priority basin for water quality improvements; therefore, it is not realistic to rely on water quality grants for these projects either. Another funding source option would be related to flood hazard mitigation, depending on whether there are any records of flood issues or damage to adjacent infrastructure. However, the project area is not within a mapped flood hazard area, and we are not aware of a specific flood hazard study or flooding records for this area. Based on our hydraulic modeling for the basin (Section 2.6), the culvert at South 302nd Street is believed to be inadequate to convey the 100-year flood flow without overtopping the roadway.

There may be several possibilities for funding of improvements to the SR 509 culvert. One option is to pair the project with a public safety or roadway improvement project. Currently, the road has a very sharp bend at the crossing with Cold Creek, limiting driver site distance, and there is no pedestrian or bicycle infrastructure along this roadway that connects residential areas to the west with Sacajawea Middle School and other commercial areas (including a hospital/emergency room facility) located along Pacific Highway South (SR 99). Federal transportation improvement funding could include culvert replacement costs. A second option would be to collaborate with WSDOT for replacement of this culvert. The culvert conveys Cold Creek under a state highway (SR 509) and this location has been identified as an uncorrected barrier subject to the injunction requiring the State of Washington to restore fish passage to comply with Treaty Rights.

3.4.2. Environmental Permitting

Construction within and/or alteration of regulated streams, including *Waters of the United States* and *Waters of the State*, is subject to a number of environmental permitting requirements from local, state and federal regulatory agencies. Permits and approvals are generally obtainable, but the level of effort involved

with obtaining them can range from low to high depending on specific site conditions, project objectives, and stakeholder requests.

Channel restoration projects are typically subject to similar permit requirements as for culverts and, typically, culvert replacement necessitates some channel modification both upstream and downstream of the subject culvert. Agencies and Tribes are not expected to authorize a deviation from applicable fish passage guidance for culvert replacement even though the seasonal flows in Reaches 1 and 2 limit use by salmonids. Fortunately, there are a number of streamlined mechanisms that can be used to obtain permits for projects that will benefit the natural environment by incorporating appropriate hydraulic design, which can ensure improvement to flow conveyance, sediment and debris transport, and fish habitat/passage.

Vegetation removal necessary for project construction would be mitigated through site restoration to ensure no long-term adverse effects on riparian habitat conditions and/or slope stability. It is possible that engineered solutions would be required to ensure slope stability in some locations. We did not observe other sensitive habitats, such as wetlands, that would likely be adversely impacted by the potential actions identified above.

The following studies and permit applications are anticipated to be needed for all three of the project actions described in the preceding section and we did not identify particular differences between the projects with regard to permitting implications:

- **Aquatic Areas Assessment/Delineation.** This would include delineation of the ordinary high water mark (OHWM) of the stream channel as the jurisdictional line for aquatic permits. We did not identify any wetlands within the project areas associated with the recommended projects that would require delineation, but this would be confirmed during this task. There are likely some wetlands associated with the stream channel in the lower undeveloped portion of the ravine, and we did observe wetland conditions in the vicinity of the unmapped culvert.
- **Application Materials.** The following materials would need to be prepared:
    - Joint Aquatic Resources Permit Application (JARPA) Form and Drawings, used as the primary application form for multiple agencies.
    - Biological Evaluation (BE) for Endangered Species Act (ESA) compliance.
    - Cultural Resources Survey (CRS) for National Historic Preservation Act (NHPA) compliance.
- **Application Submittal.** The following agencies and associated environmental approvals will require application submittals using the materials identified above:
    - USACE for Section 404 Clean Water Act, ESA, and NHPA approvals.
    - Washington State Department of Ecology for Section 401 Clean Water Act approval, if not approved automatically by the USACE.
    - WDFW for Hydraulic Project Approval (HPA).
    - City of Federal Way for State Environmental Policy Act (SEPA) and Critical Areas Ordinance review and approval.

3.4.3. Sequencing and Schedule Considerations

Due to the high priority within the watershed and anticipated complexity associated with replacement of the culvert system at South 302nd Street and the Marine Hills Swim and Tennis Club, we recommend

initiating design concepts to move forward with this project as a first priority. To help manage the complexity and length of this system, it may be possible to break the project into separate sections that would be constructed as funding allows. This approach would enable the City to move forward with conceptual designs and landowner coordination, and then construct the project as funding and easement agreements allow over an extended timeline, possibly over the next decade or longer.

Because of the lengthy time horizon anticipated to be required to replace the culvert at South 302nd Street and the Marine Hills Swim and Tennis Club, it may be desirable to advance a conceptual design for replacement of the culvert at SR 509 concurrently or at least initiate this design prior to completion of the South 302nd Street culvert replacement. This conceptual design would be used for planning and cost estimating purposes as well as potentially to identify, evaluate and apply for grant funding. Once the detailed design phase of this project is underway, and assuming funding is allocated, it may be possible to permit and construct this project within 1 to 2 years.

Finally, due to the need to integrate at least some elements of Reach 2 restoration into the replacement of both culverts identified above, we recommend advancing a conceptual design and stream profile for the entire reach that could be integrated in part into each culvert replacement with follow up actions separate from the culvert replacements at future phases when appropriate, and as funding allows.

3.5. Data Gaps

The following data gaps are identified. These data gaps highlight some of the unknowns related to our assessment of the basin, including development of the hydraulic model. Some of these data gaps may not apply to the potential projects noted above but apply elsewhere in the basin.

- Incomplete identification and detailed characterization of storm drainage systems that discharges to Cold Creek.
- Limited information regarding the size of sediment mobilized at specific discharges.
- Uncertainty regarding stream geomorphic processes, including whether or not it will continue to degrade/incise or if it has stabilized since the observed degradation/incision and will transition to lateral scour (widening). There is also uncertainty regarding how further creek incision or widening could impact adjacent ravine bluffs and residential properties and homes.
- Limited surveyed cross sections available for use in the hydraulic model and limited survey data for several of the culverts included in the model.
- Uncertain timing and duration of flow regime (hydrology) used for hydraulic model including refining how the recently installed additional lake outlet affects downstream hydrology.
- Limited ability of the hydraulic model to capture complexity of some of the culvert systems, particularly the culvert at 302nd Street, and the observed material deposited inside culverts.
- Unknown purpose, design intent, detailed as-built data, or survey data for the unmapped culvert, as well as unknown stream gradient and stream condition prior to placement of this culvert.
- Presumed (by WDFW) rather than confirmed fish use through much of the watershed, but we are not aware of any confirmed species utilization data.
- Undetermined responsibility of party for maintaining and repairing the unmapped culvert.

- Structural assessment has not been completed for unmapped culvert and culvert under the Redondo Treatment Plant, the latter of which appears to be the responsibility of either the City of Des Moines or LSWD.
- Condition of bank armoring and grade control structures was not formally assessed as part of this study.
- Flood damage records were not available and there has not likely been a 100-year flood discharge event in Cold Creek during the period of record.

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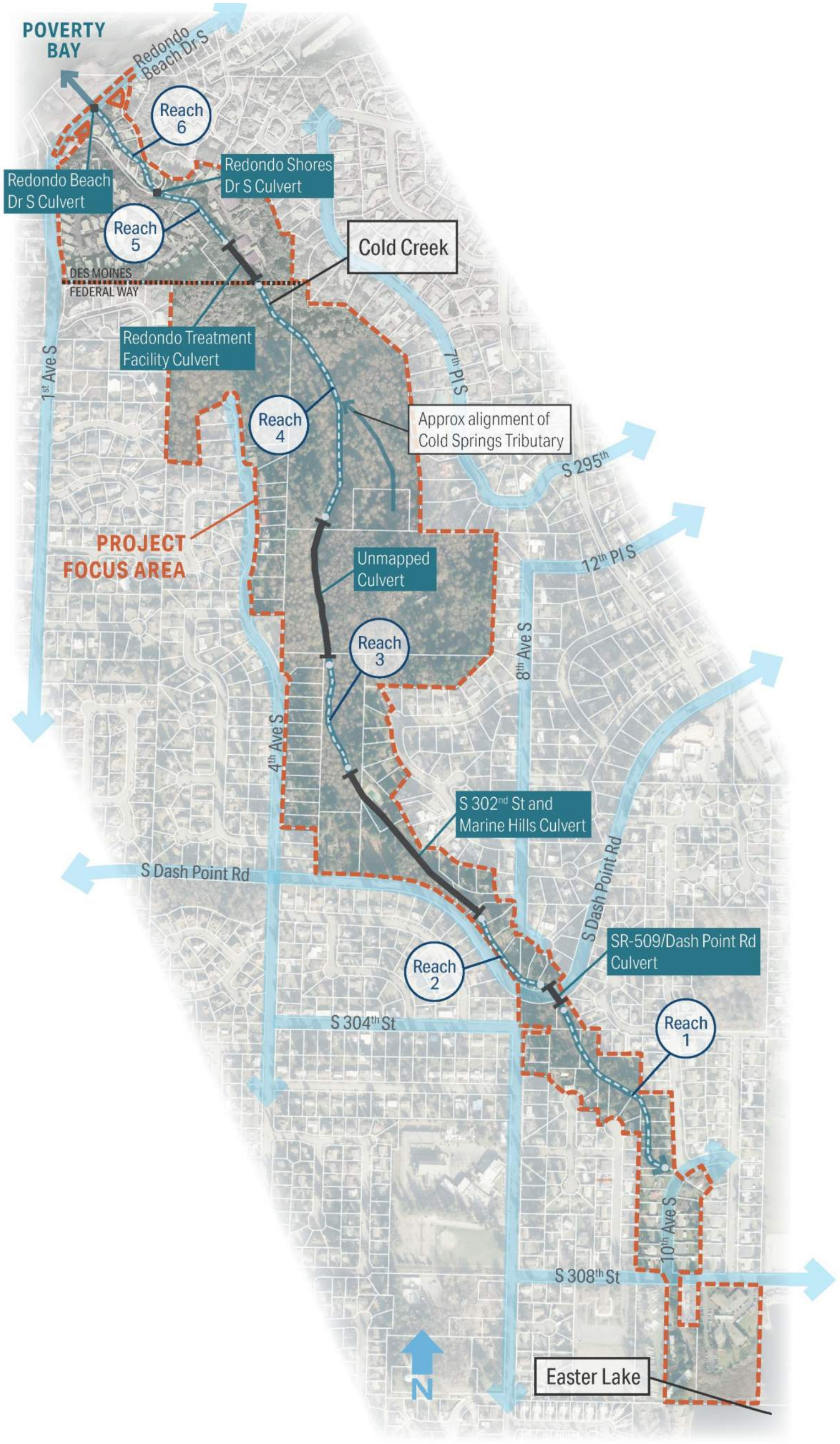
FIGURES

GeoEngineers



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

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Not to Scale

Cold Creek Basin and Study Area

Cold Creek Culvert Replacements and
Channel Stabilization Project
Federal Way, Washington

GeoEngineers KPG

Figure 1

APPENDICES

GeoEngineers

APPENDIX A
Project Outreach Mailer

Cold Creek culvert replacement and creek stabilization project

CITY OF Federal Way

The City of Federal Way (city) is beginning a two phase project to improve conditions in the Cold Creek watershed between Easter Lake and the Puget Sound. The first phase of the project is to gather data and complete initial assessments to plan and prioritize the work. The second phase is to conduct a feasibility study and alternative analysis of the planned improvements. Depending on the results of the second phase, additional project phases may be identified for future work. The city will share progress status updates and technical reports on its website, and hold public meetings to receive your feedback as work progresses.

Project benefits

- ***Reduce flooding***
- ***Improve fish passage***
- ***Replace aging infrastructure***
- ***Restore natural conditions***
- ***Improve fish passage and health of the stream***
- ***Restore stewardship of your neighborhood greenspace***

We'd like your help

A field investigation will be conducted by the project team that will include survey mapping, geotechnical investigation and hydrologic, hydraulic, and biological research along the waterway. You may notice the project team in your neighborhood for this work. Team members may need to access your private property to assess the project site. ***You will be notified before the project team accesses your private property.*** Your cooperation will be a huge support to the success of the project!

Project timeline

- ***Phase 1 (Assessment) - Spring through Summer 2021***
- ***Phase 2 - TBD***
- ***Additional information will be provided to the public after the Phase 1 Assessment is complete***

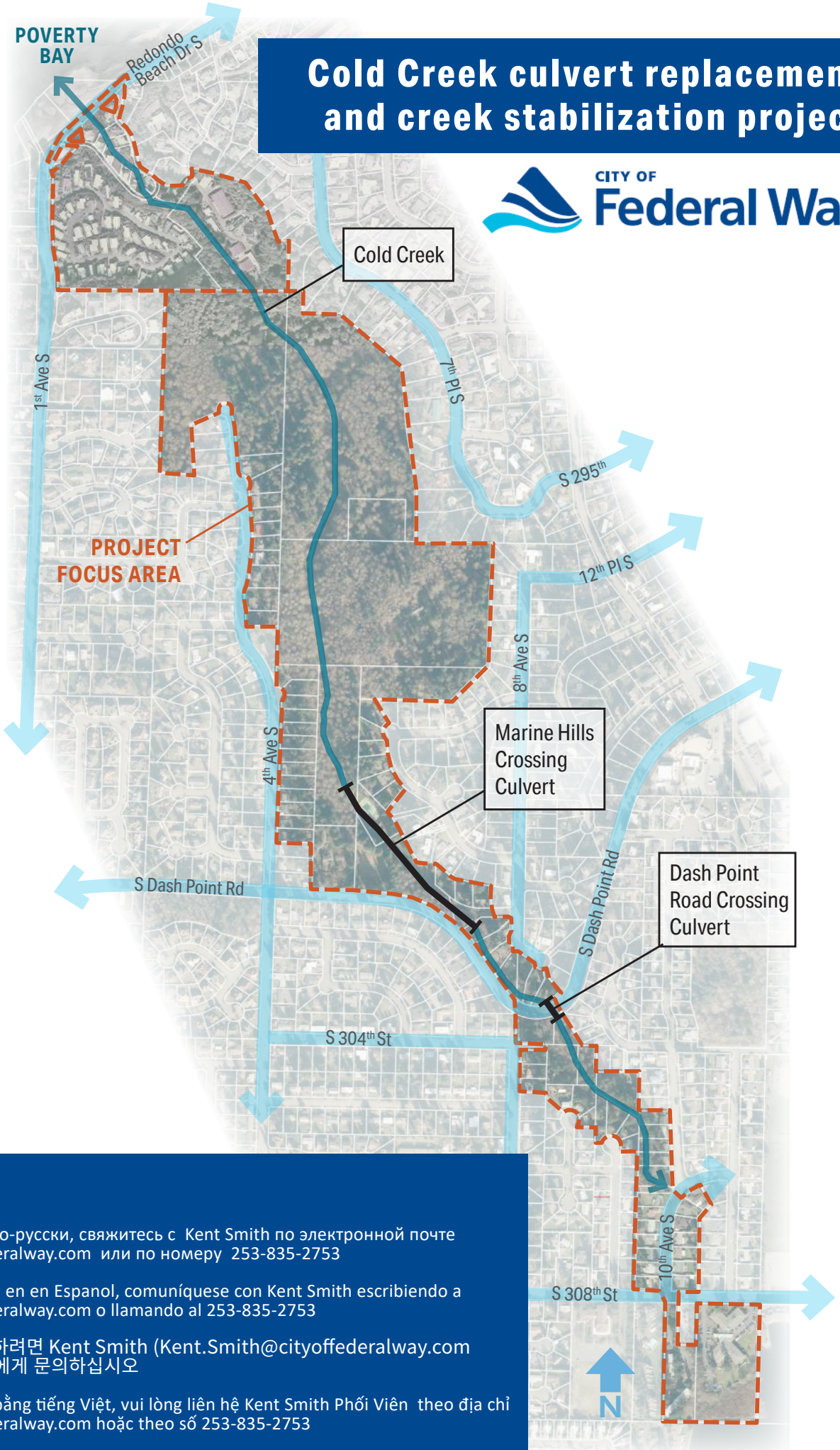
Your Surface Water Management (SWM) dollars at work!

Contact:

Kent Smith, P.E. | Senior Capital Engineer
Kent.Smith@cityoffederalway.com
253-835-2753
project website:
www.cityoffederalway.com/coldcreekculvert

Cold Creek culvert replacement and creek stabilization project

CITY OF Federal Way



Contact:

Чтобы запросить на по-русски, свяжитесь с Kent Smith по электронной почте Kent.Smith@cityoffederalway.com или по номеру 253-835-2753

Para pedir información en en Espanol, comuníquese con Kent Smith escribiendo a Kent.Smith@cityoffederalway.com o llamando al 253-835-2753

한국어로 정보를 요청하려면 Kent Smith (Kent.Smith@cityoffederalway.com 또는 253-835-2753) 에게 문의하십시오

Để yêu cầu thông tin bằng tiếng Việt, vui lòng liên hệ Kent Smith Phối Viên theo địa chỉ Kent.Smith@cityoffederalway.com hoặc theo số 253-835-2753

APPENDIX B
Existing Conditions Survey Base Map

EXISTING LEGEND

MIC	MONUMENT IN CASE	T	TELEPHONE RISER
MON	SURFACE MONUMENT	TV	TV RISER
△	MAG NAIL/SPIKE	GV	GAS VALVE
□	CATCH BASIN	WV	WATER VALVE
SD	STORM DRAIN MANHOLE	WM	WATER METER
YD	YARD DRAIN	W	WATER VAULT LID
⌒	CULVERT OPENING	PIV	POST INDICATOR VALVE
○	SEWER MANHOLE	ICV	IRRIGATION CONTROL VALVE
	POWER POLE	U	UTILITY VAULT LID (GENERIC/UNKNOWN)
	POWER POLE W/UNDERGROUND CONNECT	GP	GUARD POST
	POWER POLE WITH LUMINAIRE		BOULDER
	GUY ANCHOR		SIGN
	JUNCTION BOX		MAILBOX
	STREET LIGHT (LUMINAIRE)		SHRUB
	LOT LIGHT		BARD & SHRUB
	YARD LIGHT	XX"	DECIDUOUS TREE, DIAMETER (# OF TRUNKS)
		XX"	CONIFEROUS TREE, DIAMETER (# OF TRUNKS)

SD	STORM
W	WATERLINE
S	SANITARY SEWER
x x x	FENCE
	HEDGE (HEIGHT NOTED)
	BUILDING
	PAINTED STRIPE
	PAINTED SKIP STRIPE
	EDGE OF PAVEMENT
	FLOWLINE
	CREEK FLOW LINE w/DIRECTION (LOCATION APPROXIMATE)
245	CONTOUR (BASED ON FIELD SURVEY & LIDAR INFORMATION)
	RIGHT OF WAY (BASED ON GIS INFORMATION)
	PROPERTY/PARCEL LINE (BASED ON GIS INFORMATION)
	CONCRETE
	GRAVEL
	GRASS
	ROCKERY
	BRICK
	METAL GRATE
AC	ASPHALT/CONCRETE
CHLK	CHAINLINK
DWY	DRIVEWAY
0521049177	PARCEL ID NUMBER

ABBREVIATIONS

AC	ASPHALT CONCRETE	MH	MANHOLE
ACP	ASPHALT CONCRETE PAVEMENT	MIC	MONUMENT IN CASE
ADA	AMERICANS WITH DISABILITIES ACT	MJ	MECHANICAL JOINT
AP	ANGLE POINT	MON	MONUMENT
APPROX	APPROXIMATE	N	NORTH OR NORTHING
BLDG	BUILDING	NAVD	NORTH AMERICAN VERTICAL DATUM
CB	CATCH BASIN	NO	NUMBER
CCP	CEMENT CONCRETE PAVEMENT	NTS	NOT TO SCALE
CDF	CONTROLLED DENSITY FILL	OC	ON CENTER
CHLK	CHAINLINK	OD	OUTSIDE DIAMETER
℄	CENTERLINE	PC	POINT OF CURVE
CL	CLASS	PCC	POINT OF COMPOUND CURVATURE
CO	CLEANOUT	PCCP	PERVIOUS CEMENT CONCRETE PAVEMENT
COFW	CITY OF FEDERAL WAY	PI	POINT OF INTERSECTION
COL	COLUMN	POB	POINT OF BEGINNING
CONC	CONCRETE	POE	POINT OF ENDING
CSBC	CRUSHED SURFACING BASE COURSE	PRC	POINT OF REVERSE CURVATURE
CSTC	CRUSHED SURFACING TOP COURSE	PT	POINT OF TANGENT
DI	DUCTILE IRON	PVC	POLYVINYL CHLORIDE OR POINT OF VERTICAL CURVATURE
DIA	DIAMETER		
DW	DRIVEWAY	PVT	POINT OF VERTICAL TANGENT
E	EAST OR EASTING	PVI	POINT OF VERTICAL INTERSECTION
EA	EACH	R	RADIUS
ELEV	ELEVATION	ROW	RIGHT OF WAY
EOP	EDGE OF PAVEMENT	RT	RIGHT
EW	EACH WAY	S	SLOPE OR SOUTH
EXIST	EXISTING	SD	STORM DRAIN
FF	FINISHED FLOOR	SDMH	STORM DRAIN MANHOLE
FL	FLOW LINE	SE	SOUTHEAST
FO	FIBER OPTIC	SHT	SHEET
FOC	FACE OF CURB	SQ	SQUARE
HMA	HOT MIX ASPHALT	SS	SANITARY SEWER
HORIZ	HORIZONTAL	SSMH	SANITARY SEWER MANHOLE
HP	HIGH POINT	ST	STREET
ID	INSIDE DIAMETER	STA	STATION
IE	INVERT ELEVATION	STD	STANDARD
IN	INCH/INCHES	STCR	STRUCTURE
JB	JUNCTION BOX	SW	SOUTHWEST
L	LENGTH LT LEFT	TYP	TYPICAL
LF	LINEAR FEET	VERT	VERTICAL
LP	LOW POINT	W	WEST
MAX	MAXIMUM	YD	YARD DRAIN
MIN	MINIMUM		

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Approved By

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PROJECT MANAGER DATE

PROJECT ENGINEER DATE

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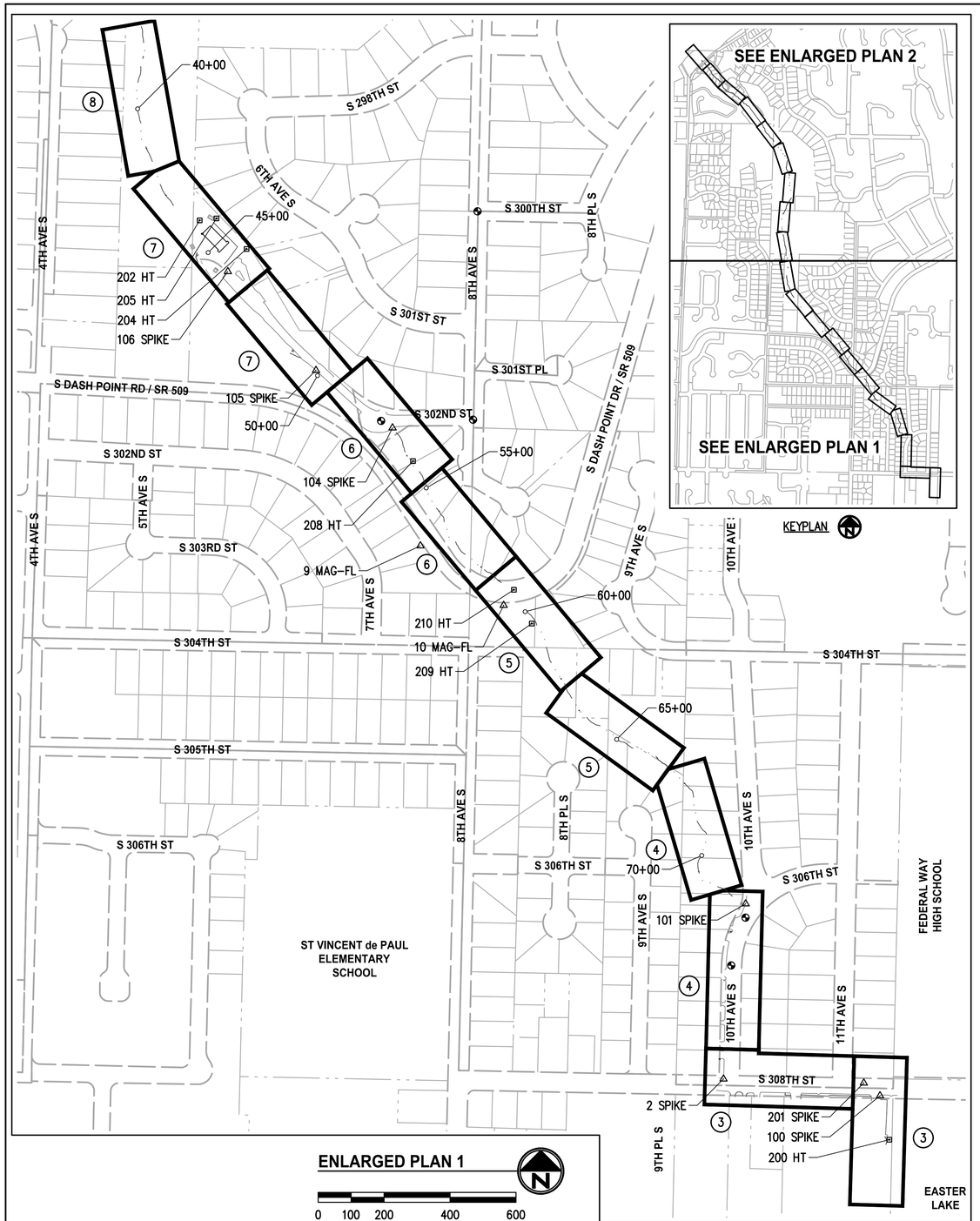
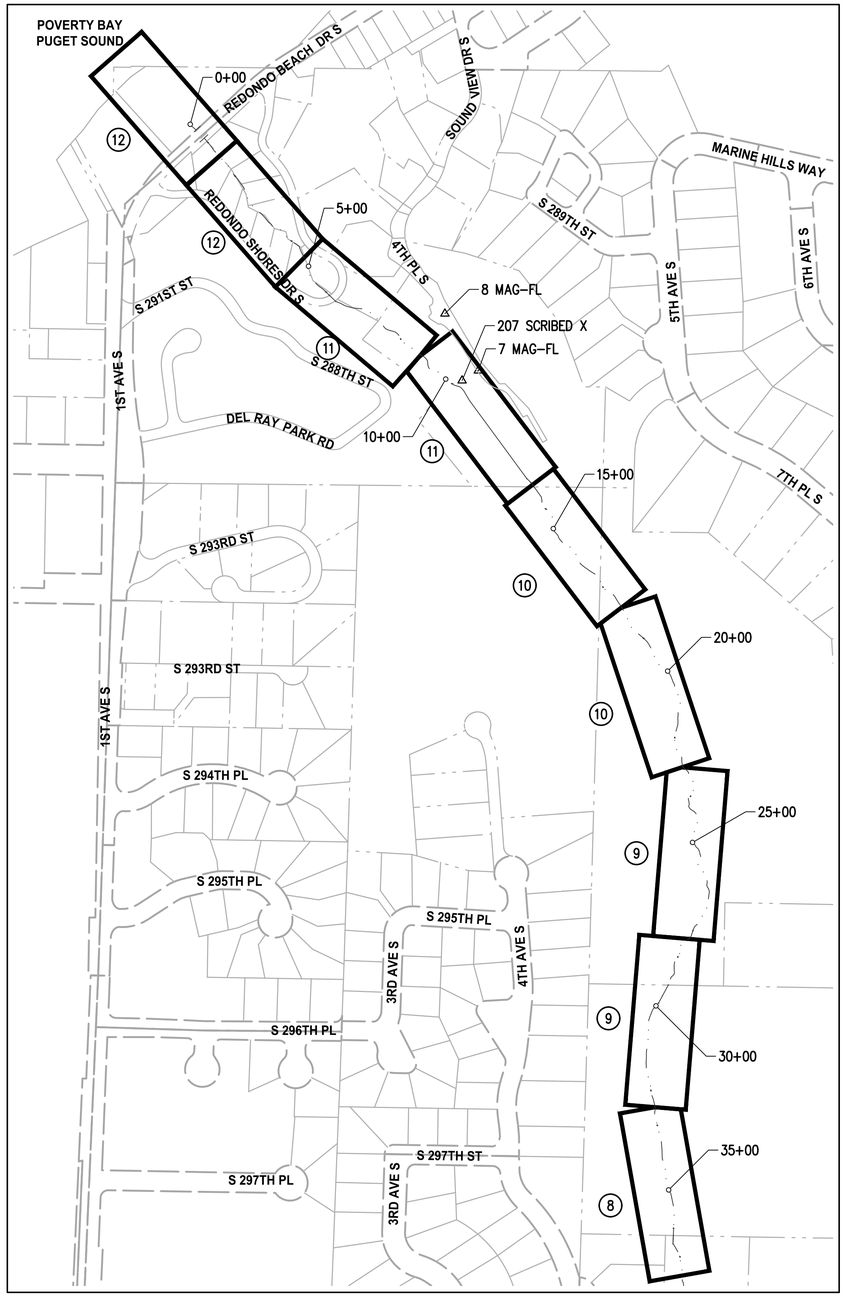
COLD CREEK CULVERT REPLACEMENT
AND CHANNEL STABILIZATION

LEGEND AND ABBREVIATIONS

KPG PROJECT No. 20060

SHT 1 OF 12





SHEET NUMBER LEGEND

(X) EXISTING CONDITIONS

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HORIZONTAL DATUM: NAD 83/11

VERTICAL DATUM NAVD 88

HORIZONTAL AND VERTICAL DATUMS ESTABLISHED BY RTK GPS OBSERVATION UTILIZING WSRN (WASHINGTON STATE REFERENCE NETWORK) WITH CHECKS TO WSDOT CONTROL POINTS GP17005-133 AND GP17005-238

CONTROL POINT LIST

PT #	DESCRIPTION	NORTHING	EASTING	ELEVATION
2	SPIKE	122505.18	1271540.38	437.16'
7	MAG-FL	128096.27	1269236.68	76.97'
8	MAG-FL	128246.69	1269148.61	67.95'
9	MAG-FL	124122.20	1270621.11	349.56'
10	MAG-FL	123941.63	1270873.63	363.08'
100	SPIKE	122454.28	1272014.91	436.88'
101	SPIKE	123036.43	1271607.47	432.38'
104	SPIKE	124479.90	1270536.52	318.89'
105	SPIKE	124654.22	1270304.38	300.75'
106	SPIKE	124953.91	1270037.05	277.41'
200	HT	122320.96	1272043.17	435.12'
201	SPIKE	122493.02	1271965.85	437.97'
202	HT	125109.22	1269951.64	271.39'
204	HT	125022.33	1270093.89	277.22'
205	HT	125115.01	1270002.56	275.55'
207	SCRIBED X	128070.17	1269193.99	54.88'
208	HT	124379.00	1270598.68	315.17'
209	HT	123886.33	1270958.75	352.86'
210	HT	123988.80	1270904.63	360.01'

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Approved By

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PROJECT MANAGER DATE

PROJECT ENGINEER DATE

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INDEX SHEET AND SURVEY CONTROL

KPG PROJECT No. 20060 SHT 2 OF 12

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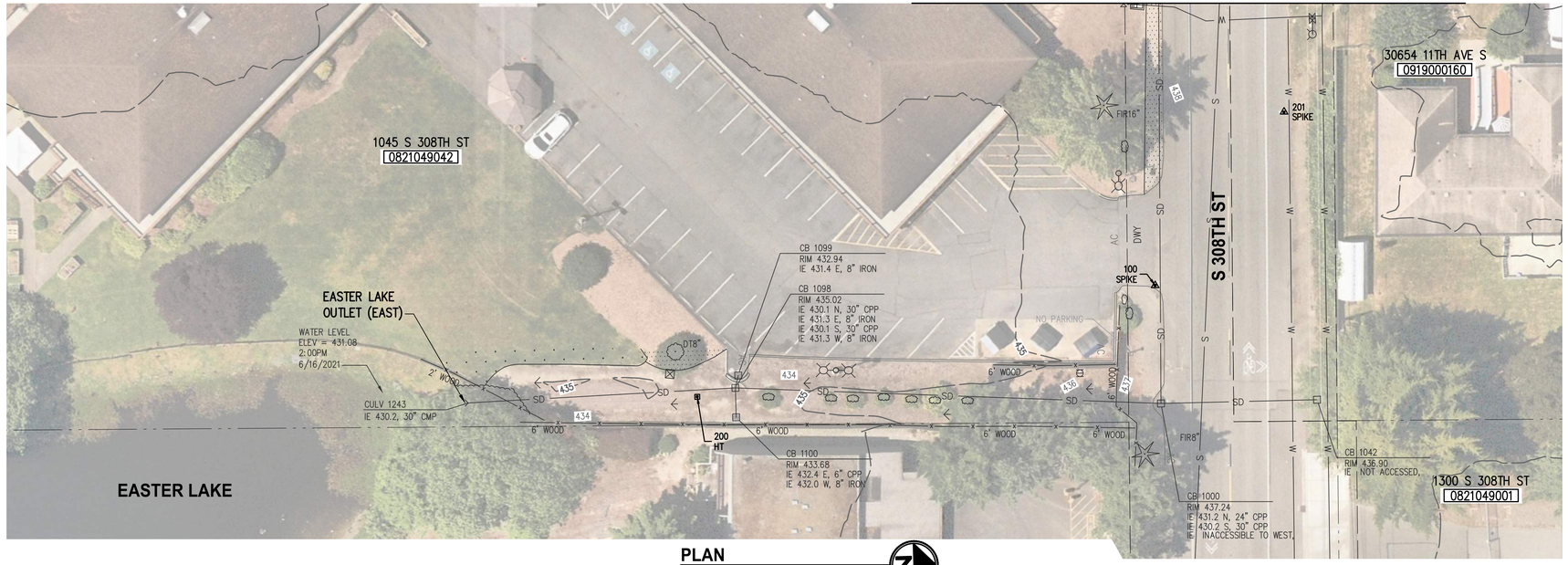

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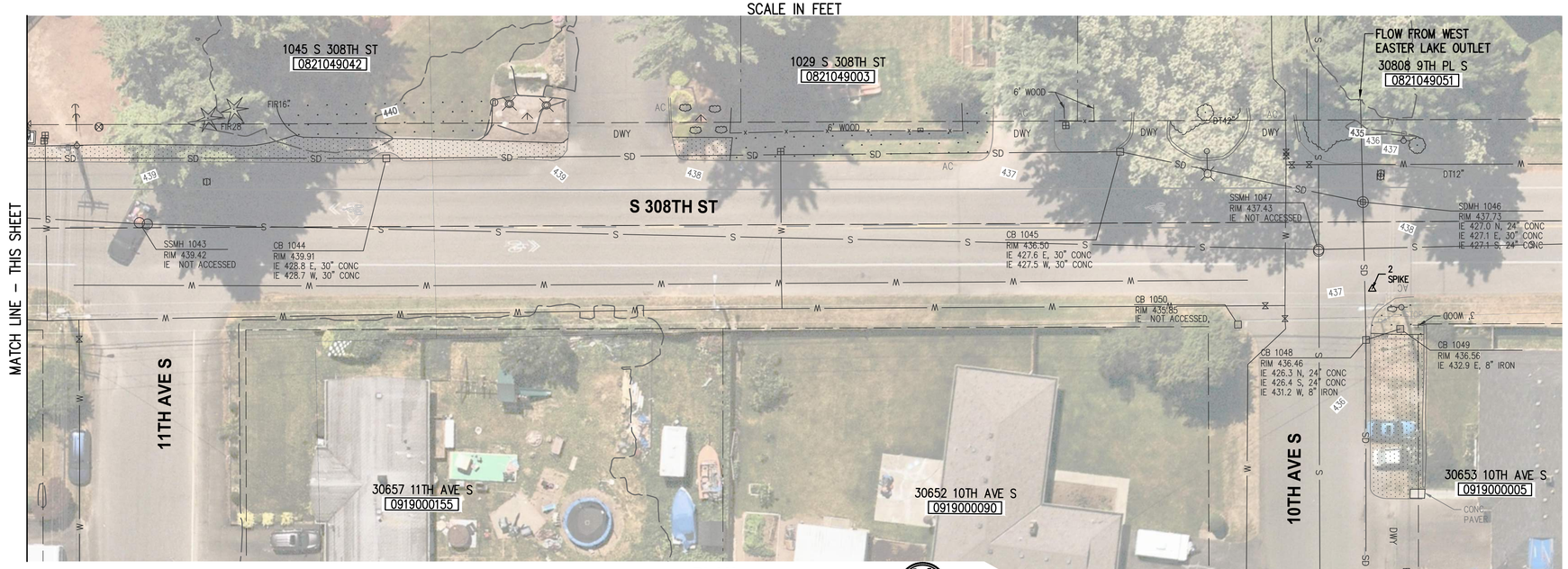

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SCALE IN FEET

MATCH LINE – SHEET 4

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VERTICAL DATUM	NAVD 88

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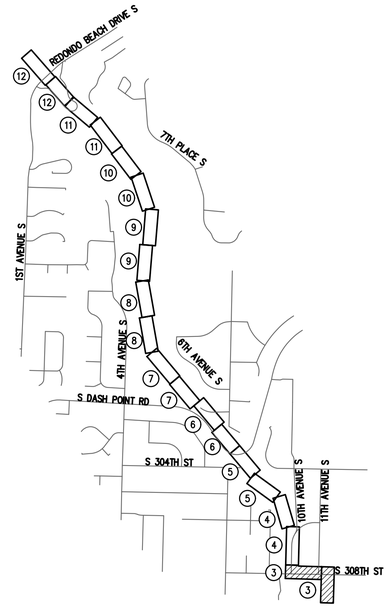

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EXISTING CONDITIONS - 1

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SHT 3 OF 12

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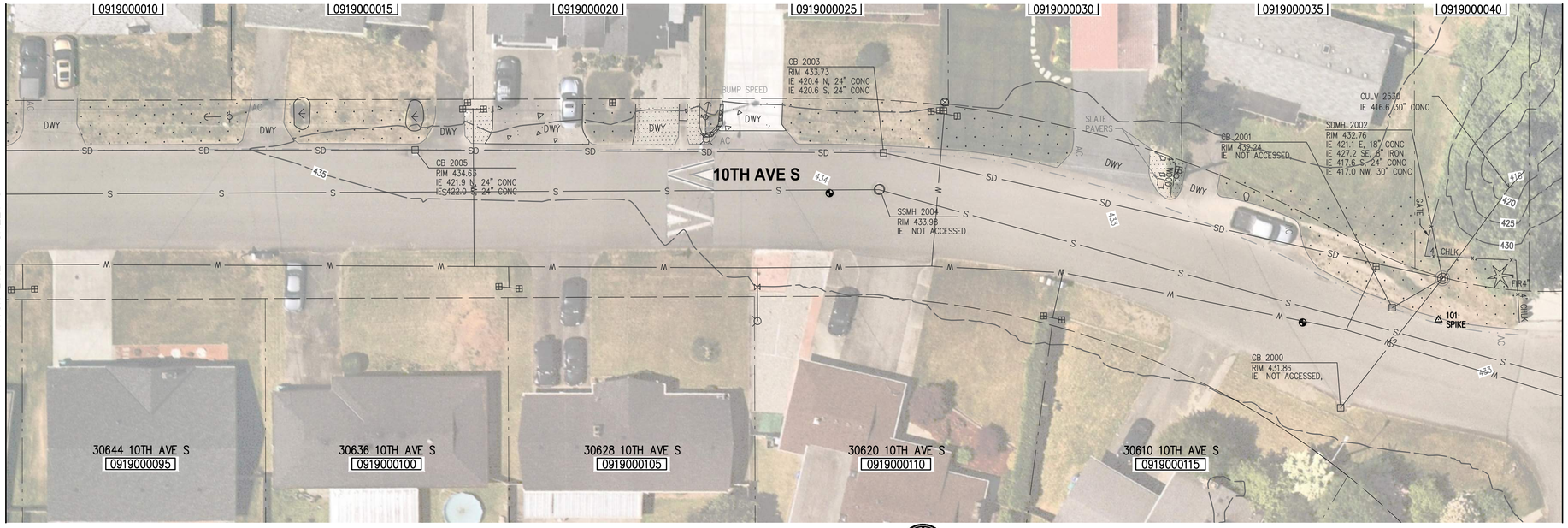

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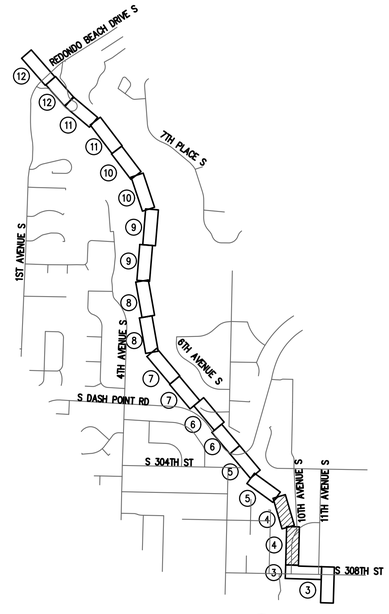

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EXISTING CONDITIONS - 2

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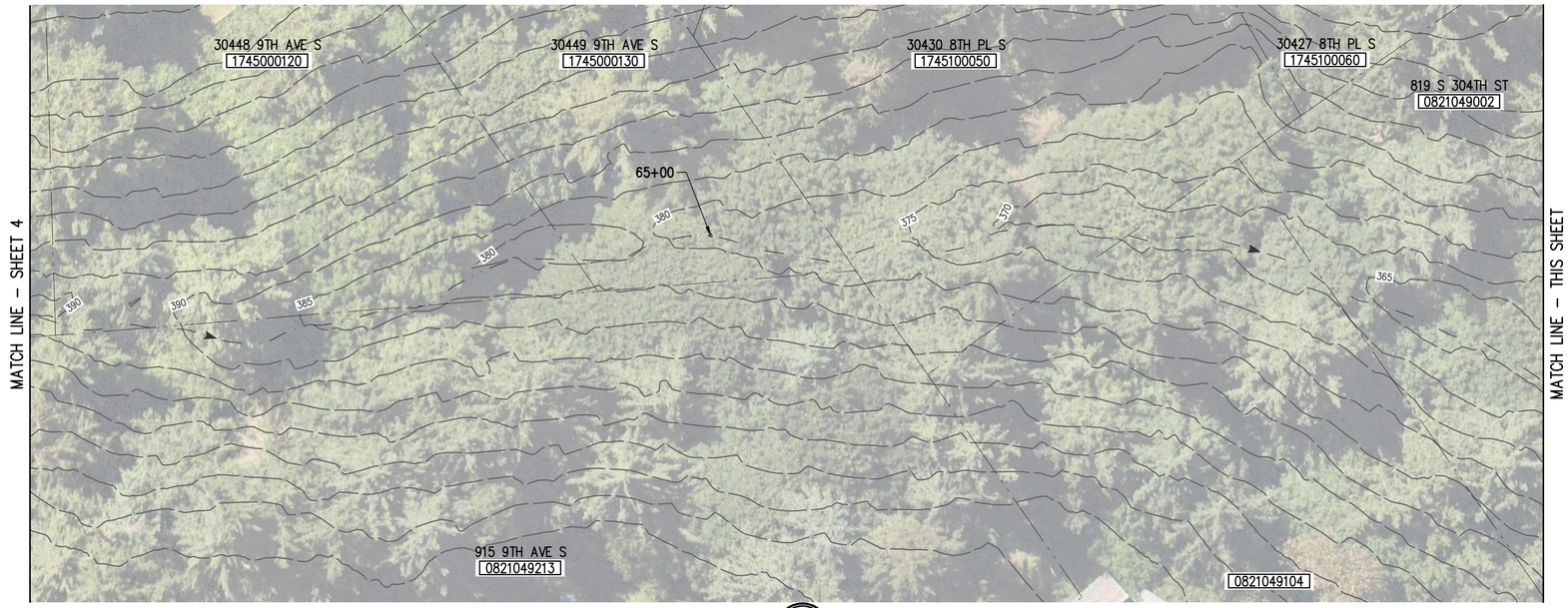

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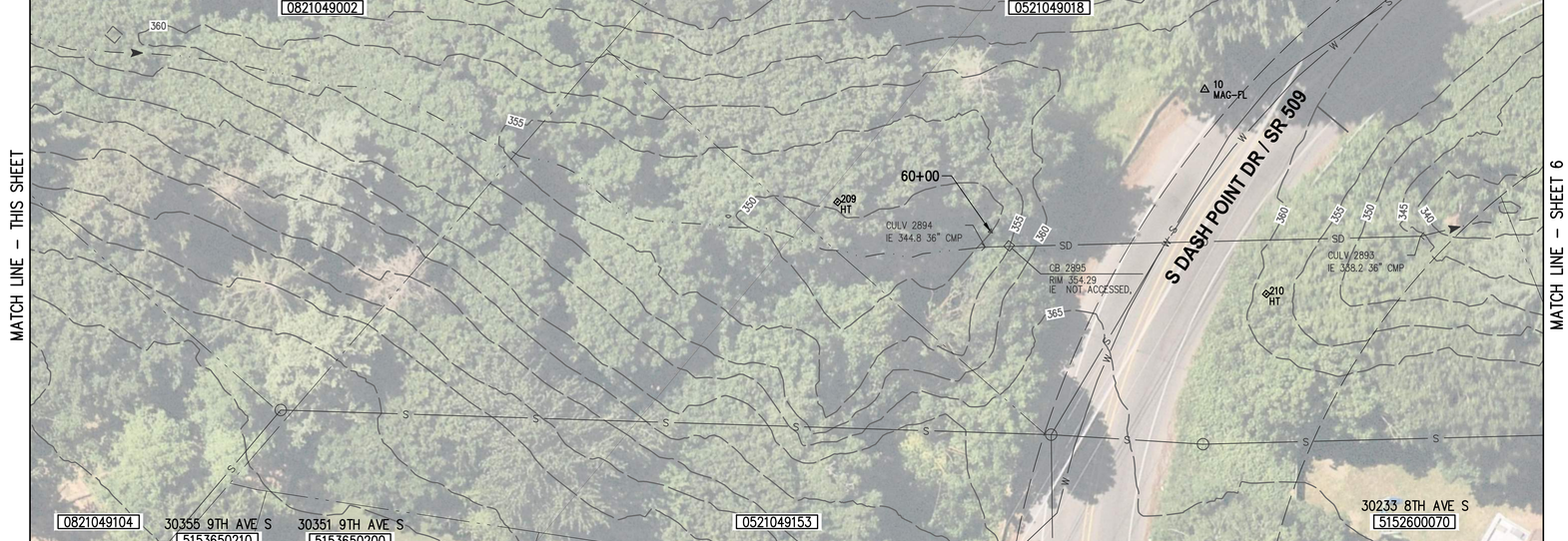

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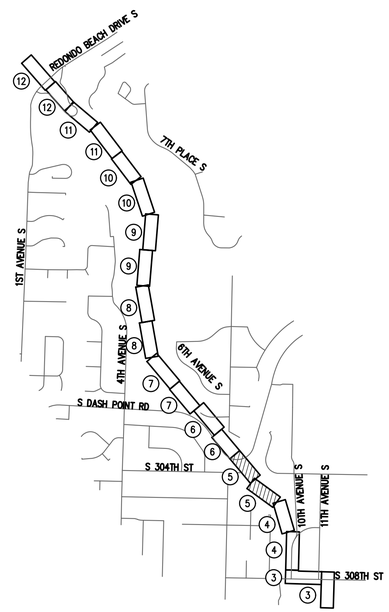

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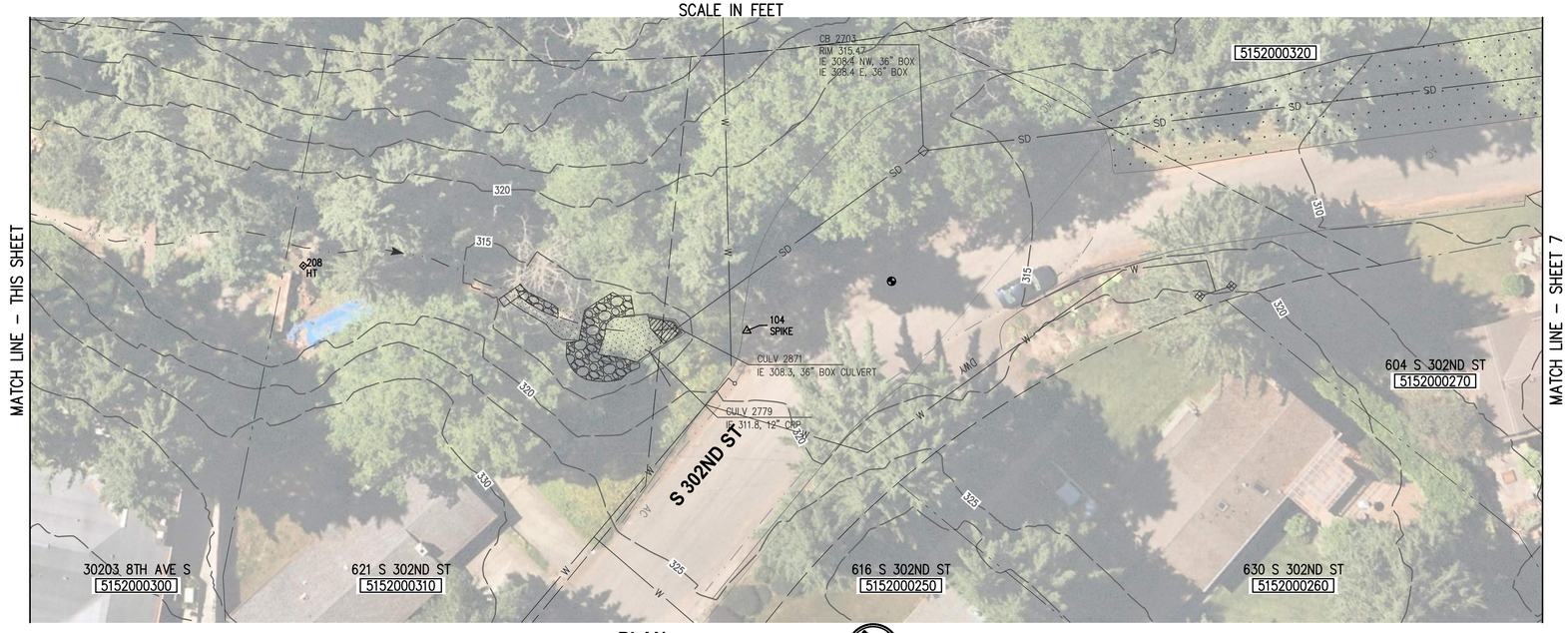

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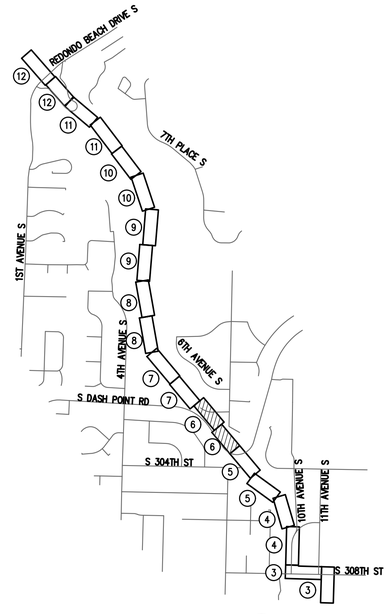

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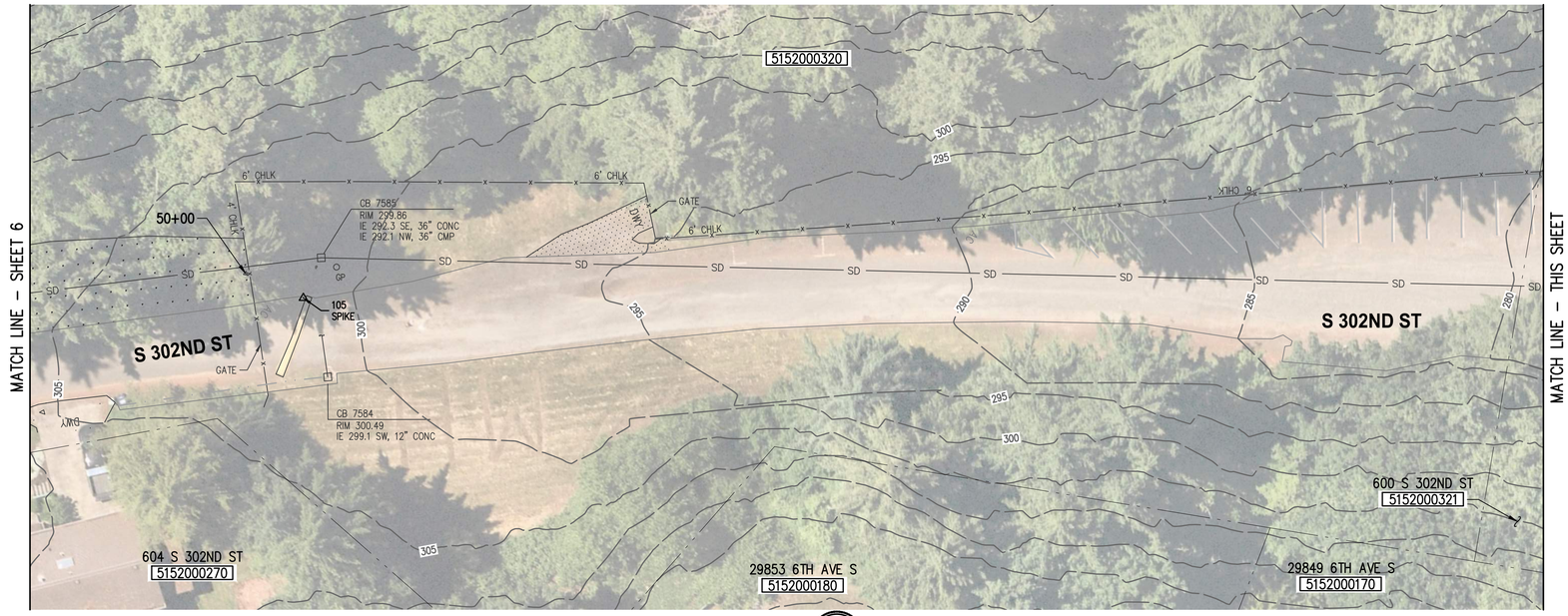

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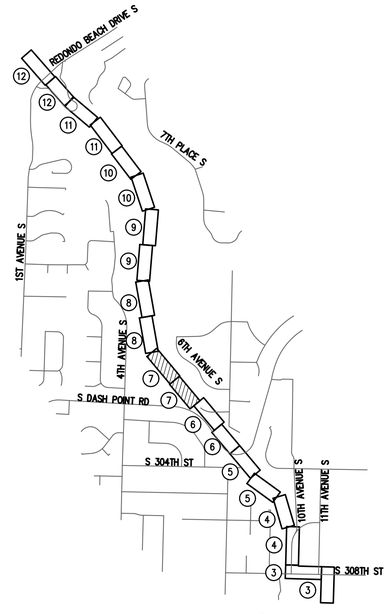

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COLD CREEK CULVERT REPLACEMENT
AND CHANNEL STABILIZATION

EXISTING CONDITIONS - 5

KPG PROJECT No. 20060

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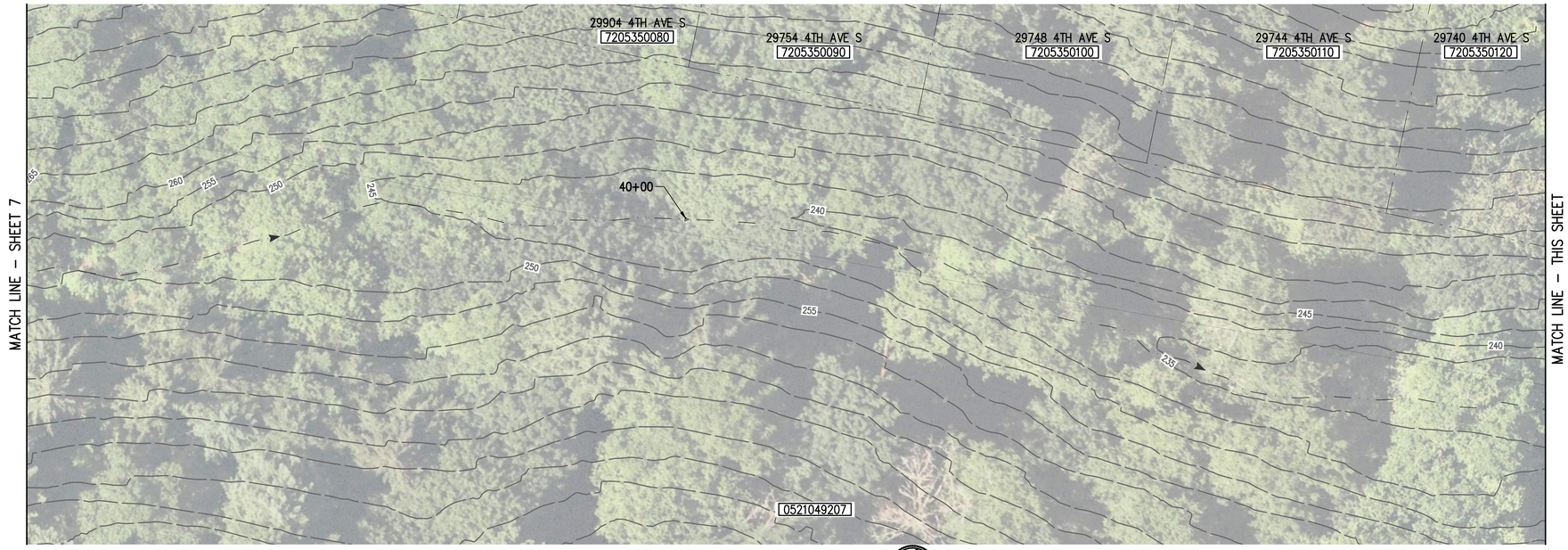

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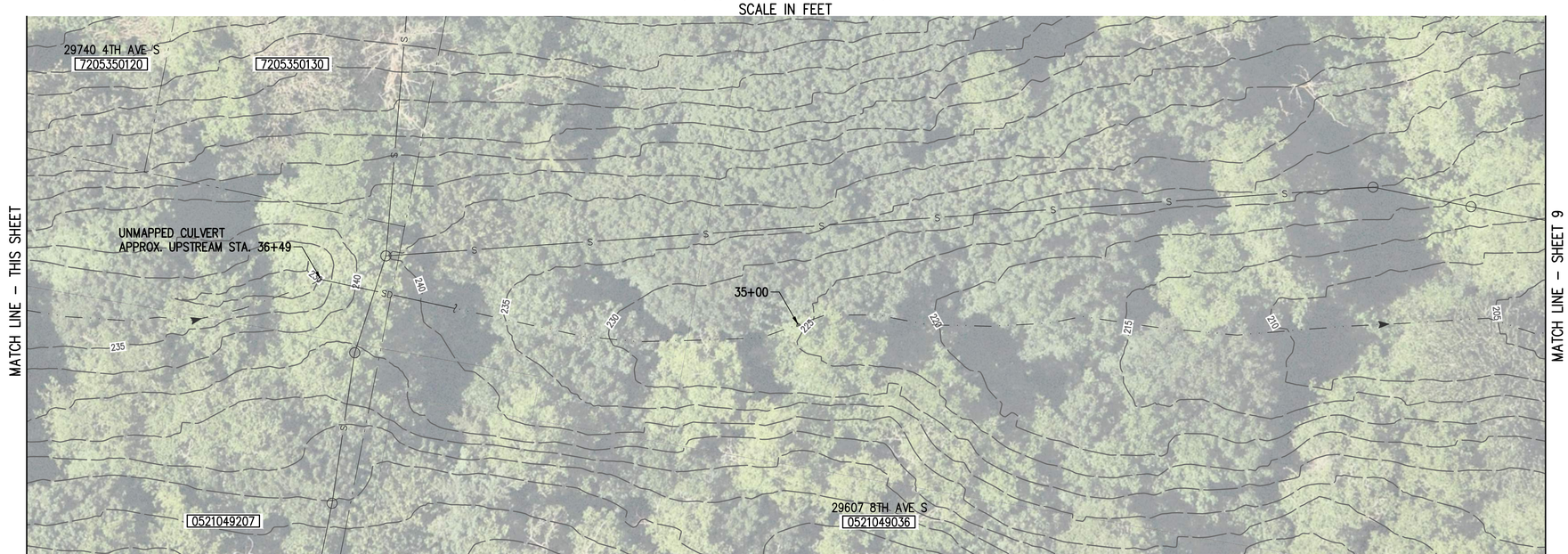

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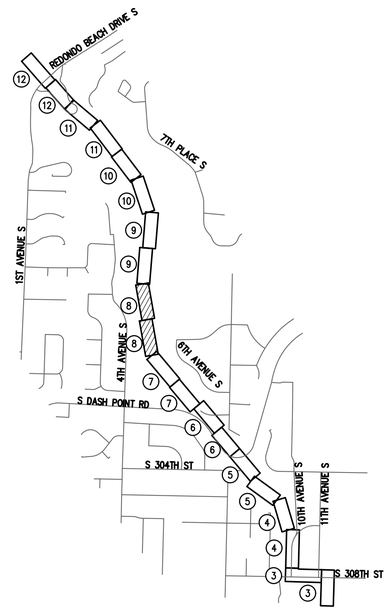
VERTICAL DATUM	NAVD 88

HORIZONTAL AND VERTICAL DATUMS ESTABLISHED BY RTK GPS OBSERVATION UTILIZING WSRN (WASHINGTON STATE REFERENCE NETWORK) WITH CHECKS TO WSDOT CONTROL POINTS GP17005-133 AND GP17005-238



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EXISTING CONDITIONS - 6

KPG PROJECT No. 20060 | SHT 8 OF 12

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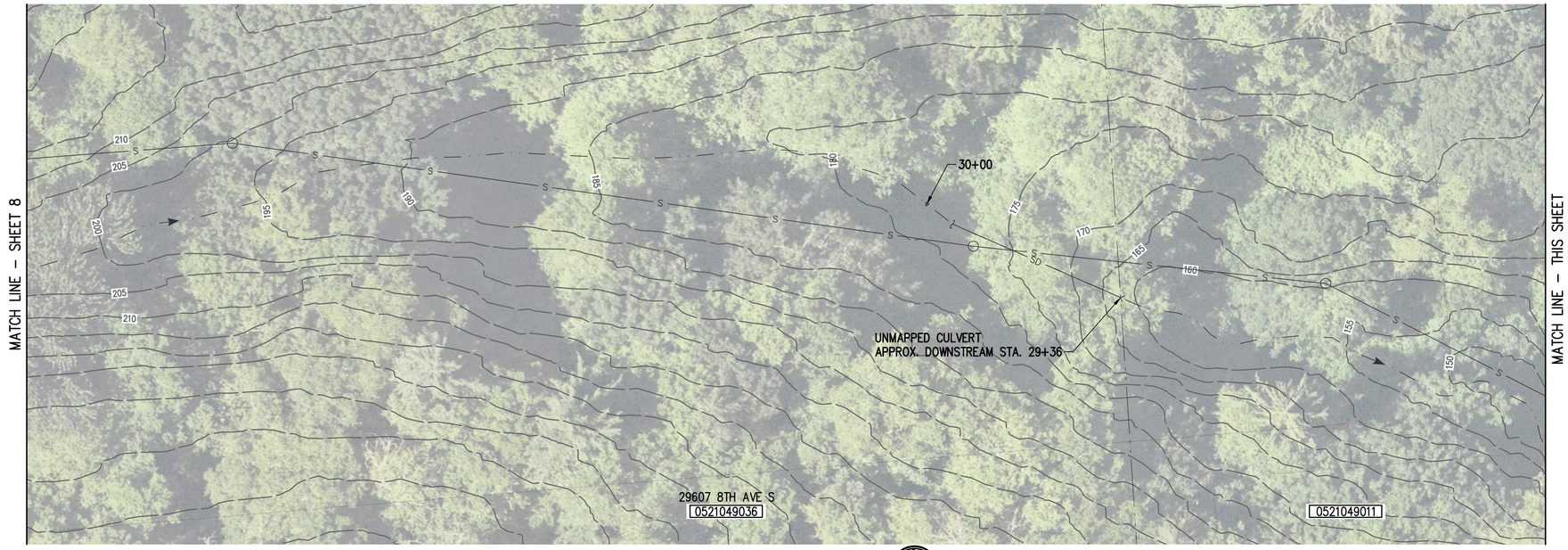

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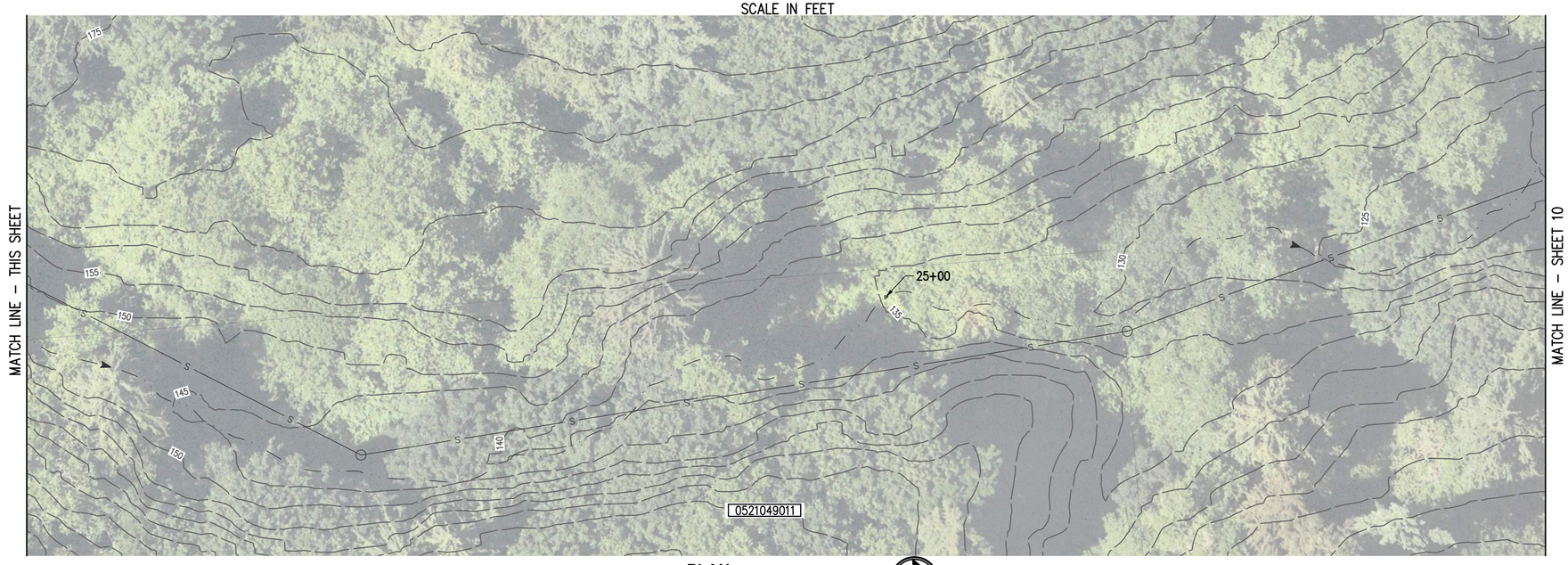

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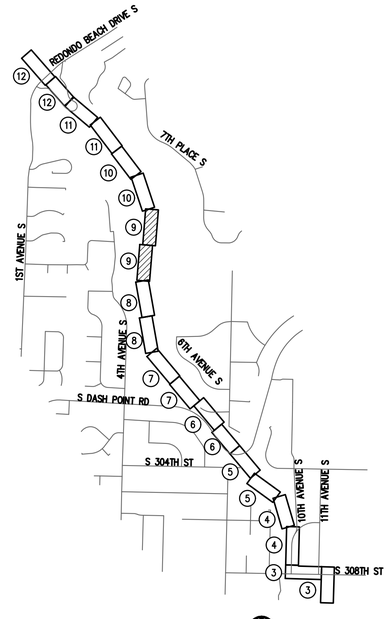

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EXISTING CONDITIONS - 7

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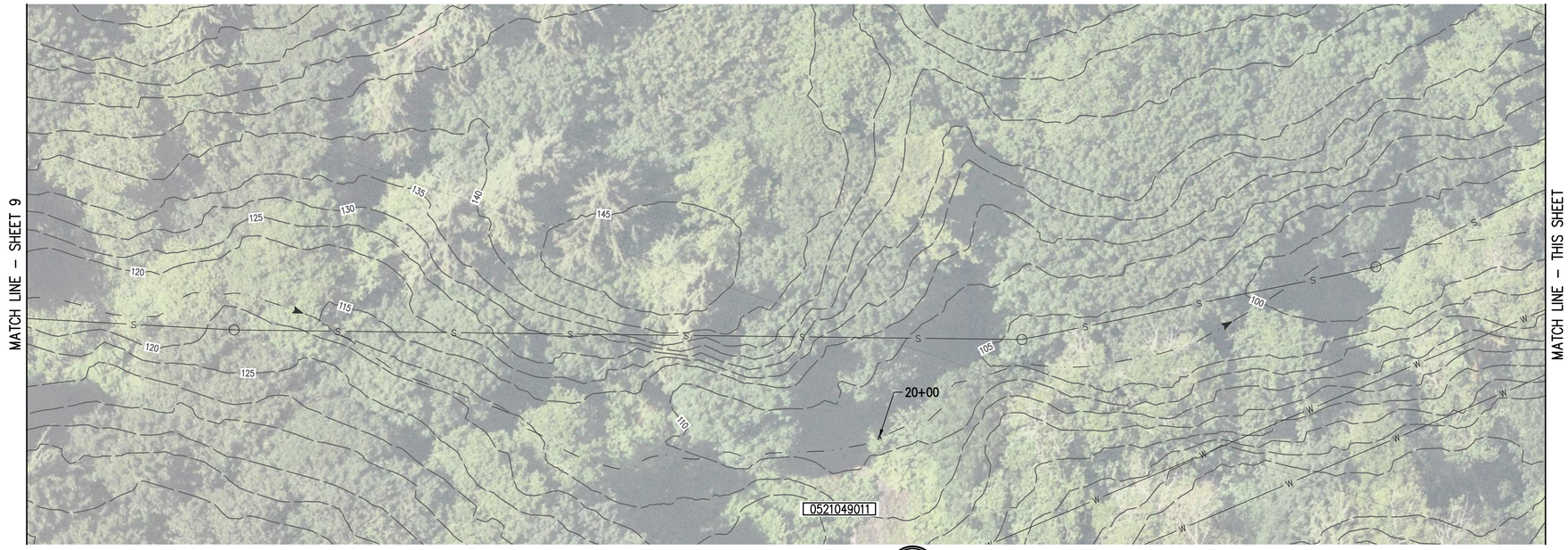

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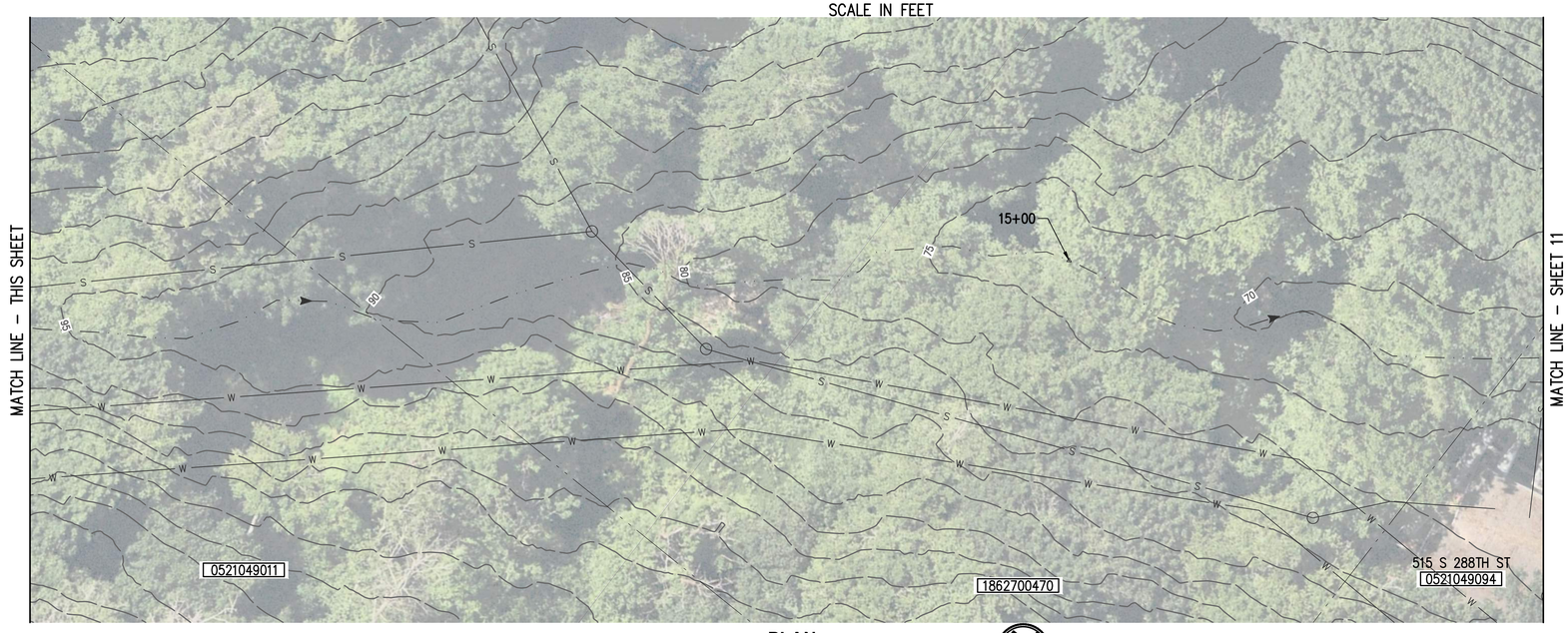

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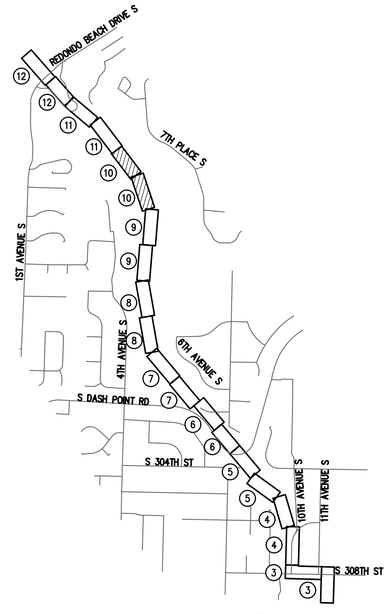

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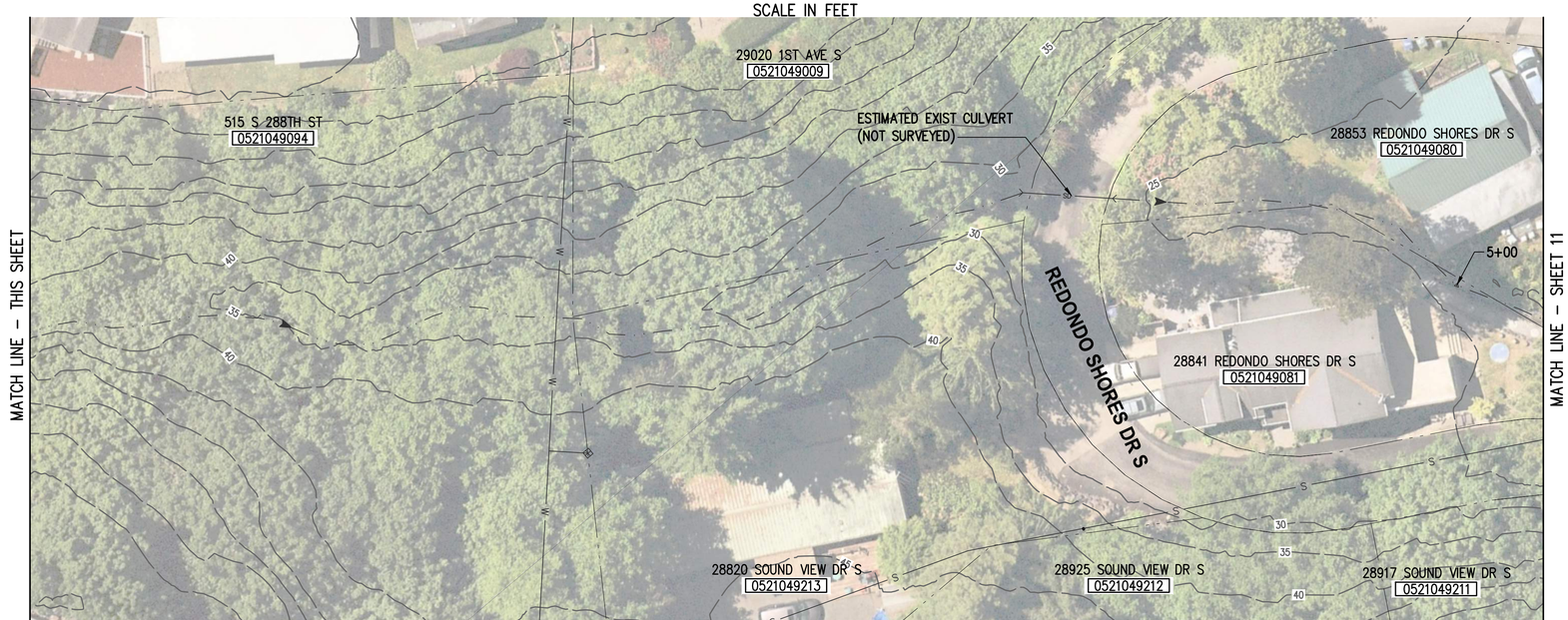

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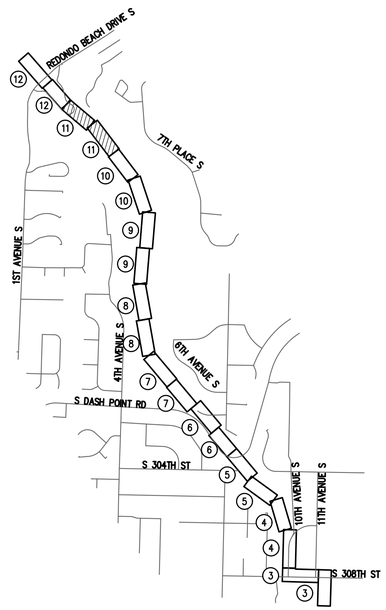

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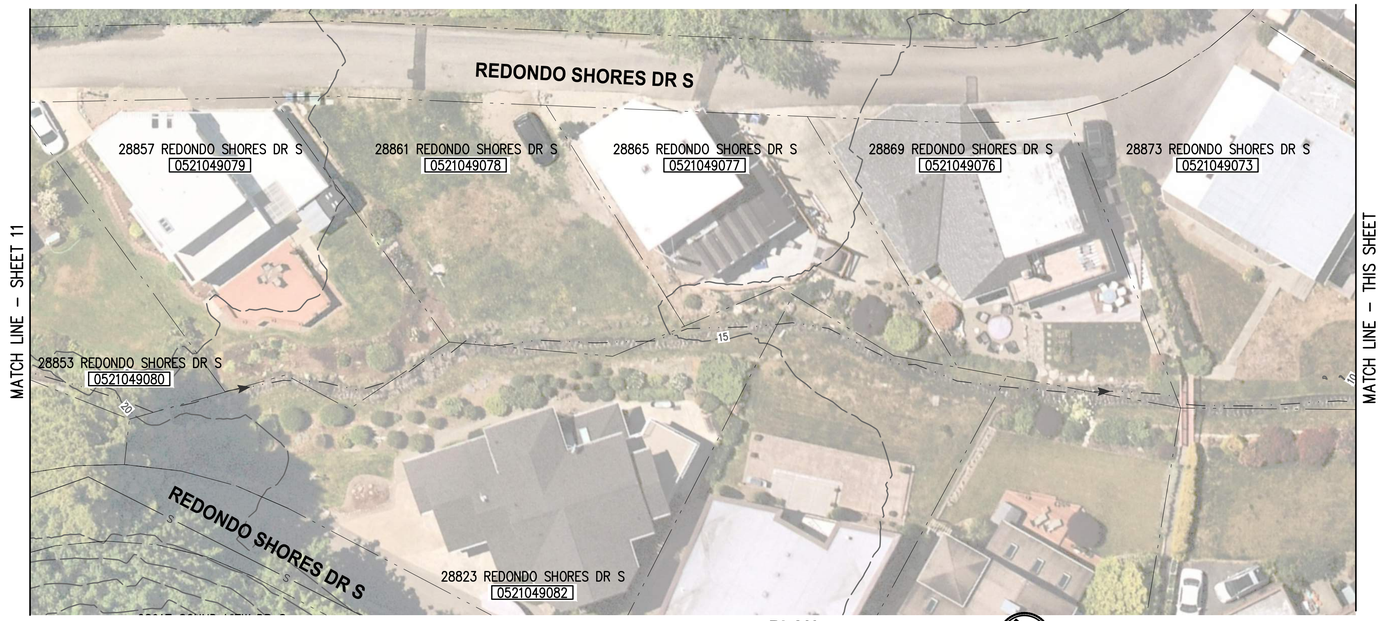

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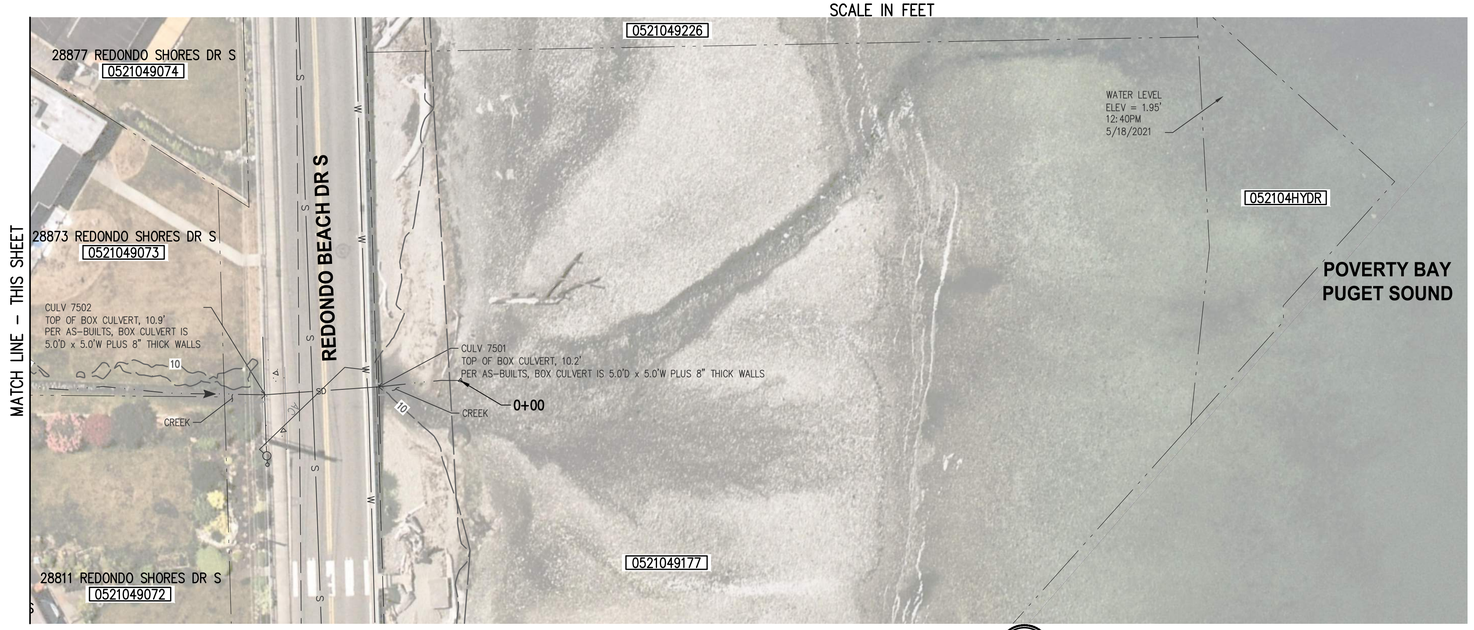

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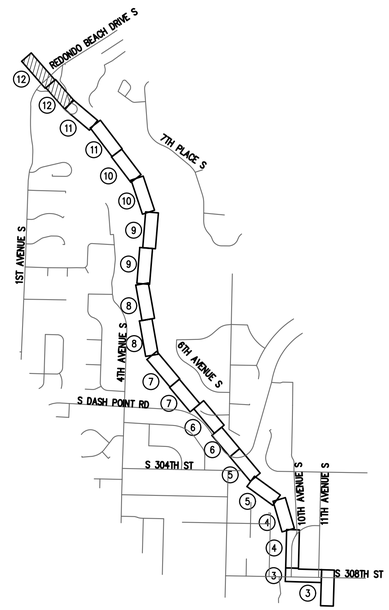

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APPENDIX C
Basin Characterization Field Report

GeoEngineers	**FIELD REPORT**	File Number: 2207-017-00
1101 Fawcett Ave Suite 200 Tacoma, WA 98402 253.393.4940	Project: Cold Creek Culvert Replacement and Channel Stabilization	Date of Site Visits: 5/10/2021 6/4/2021
	Owner: City of Federal Way	
Prepared by: Minda Troost and Adam Wright	Location: Cold Creek Basin, Federal Way, Washington	
Purpose of visit: Basin Characterization: Geomorphic and Habitat Investigation		

Introduction

GeoEngineers completed a field reconnaissance of Cold Creek on May 10 and June 4, 2021. Field personnel included a fluvial geomorphologist and a biologist from GeoEngineers, Inc. (GeoEngineers). Data collection focused on documenting existing conditions of the stream channel, with particular emphasis on potential restoration activities that could improve channel stability, fish passage and fish habitat.

The assessment began at the upstream origin of open-channel conditions, near the intersection of South 306th Street and 10th Avenue South in Federal Way. Upstream of this location, flows are conveyed in a closed system from Easter Lake. The outlet conveyance at the lake was not formally assessed. Locations described in the field report are referenced to stations (Sta) associated with the long profile, presented in Figures 1 through 5.

Field observations described in this report are described from upstream to downstream. For the purposes of this report, the stream has been divided into six distinct reaches based on key feature locations, culvert crossings and conditions of the channel and riparian zone, as follows (Figure 1):

1. 10th Avenue South to SR 509/Dash Point Road (Sta 7200 - 6000)
    - Washington Department of Fish and Wildlife (WDFW) Crossing ID 991192 (Sta – 6000-5900)
2. SR 509/Dash Point Road downstream to South 302nd Street culvert inlet (Sta 5900 – 5300)
    - WDFW Crossing ID 991878 (Sta 5300 - 4300)
3. Marine Hills Swim and Tennis Club downstream to unmapped culvert inlet (Sta 4300 – 3650)
    - Unmapped crossing (Sta 3650-2900)
4. Unmapped culvert outlet to wastewater treatment plant (Sta 2900 – 1350)
    - Unmapped wastewater treatment plant crossing (Sta 1350-1100)
5. Wastewater treatment plant to Redondo Shores Drive South (Sta 1100 – 625)
    - WDFW Crossing ID 921213 (Sta 625 – 595)
6. Redondo Shores Drive to Redondo Beach Drive (Sta 595 – 0)
    - WDFW Crossing ID 921214 (Sta 55 – 15)

The total length of creek and crossings is approximately 7,200 feet. The total length of crossings is approximately 2,170 feet. Approximately 30 percent of the creek has been routed through crossing structures.

		FIELD REPRESENTATIVE	DATE
	THIS FIELD REPORT IS PRELIMINARY A preliminary report is provided solely as evidence that field observation was performed. Observations and/or conclusions and/or recommendations conveyed in the final report may vary from and shall take precedence over those indicated in a preliminary report.	Adam Wright	8/18/2021
		Minda Troost	8/18/2021
X	**THIS FIELD REPORT IS FINAL** A final report is an instrument of professional service. Any conclusions drawn from this report should be discussed with and evaluated by the professional involved.	**REVIEWED BY**	**DATE**
		David B. Conlin, PWS, Snr Biologist	7/7/2021
		John T. Monahan, Principal	7/20/2021
		Morgan McArthur, Associate	8/16/2021

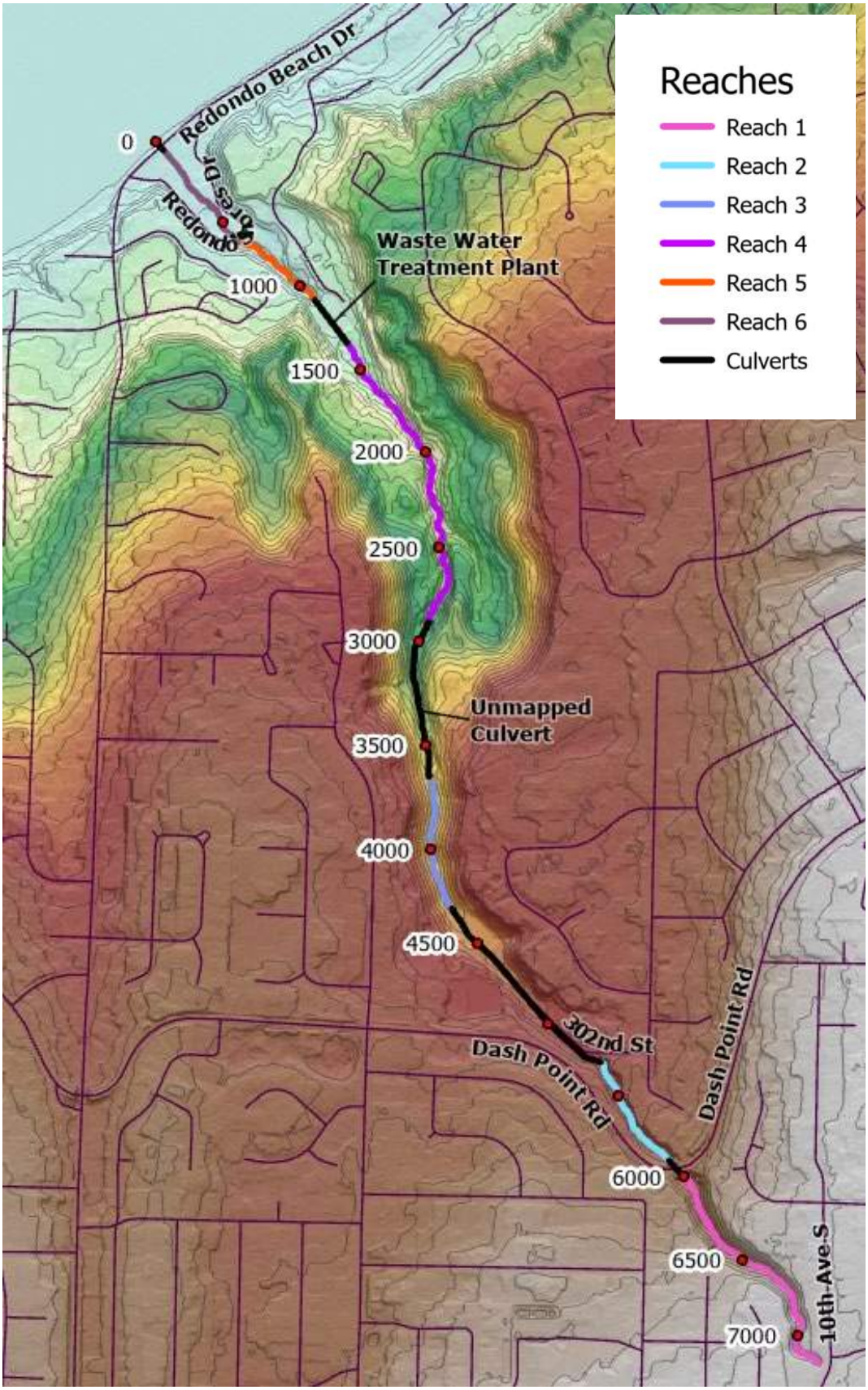

Figure 1: Plan view with profile stationing and reaches

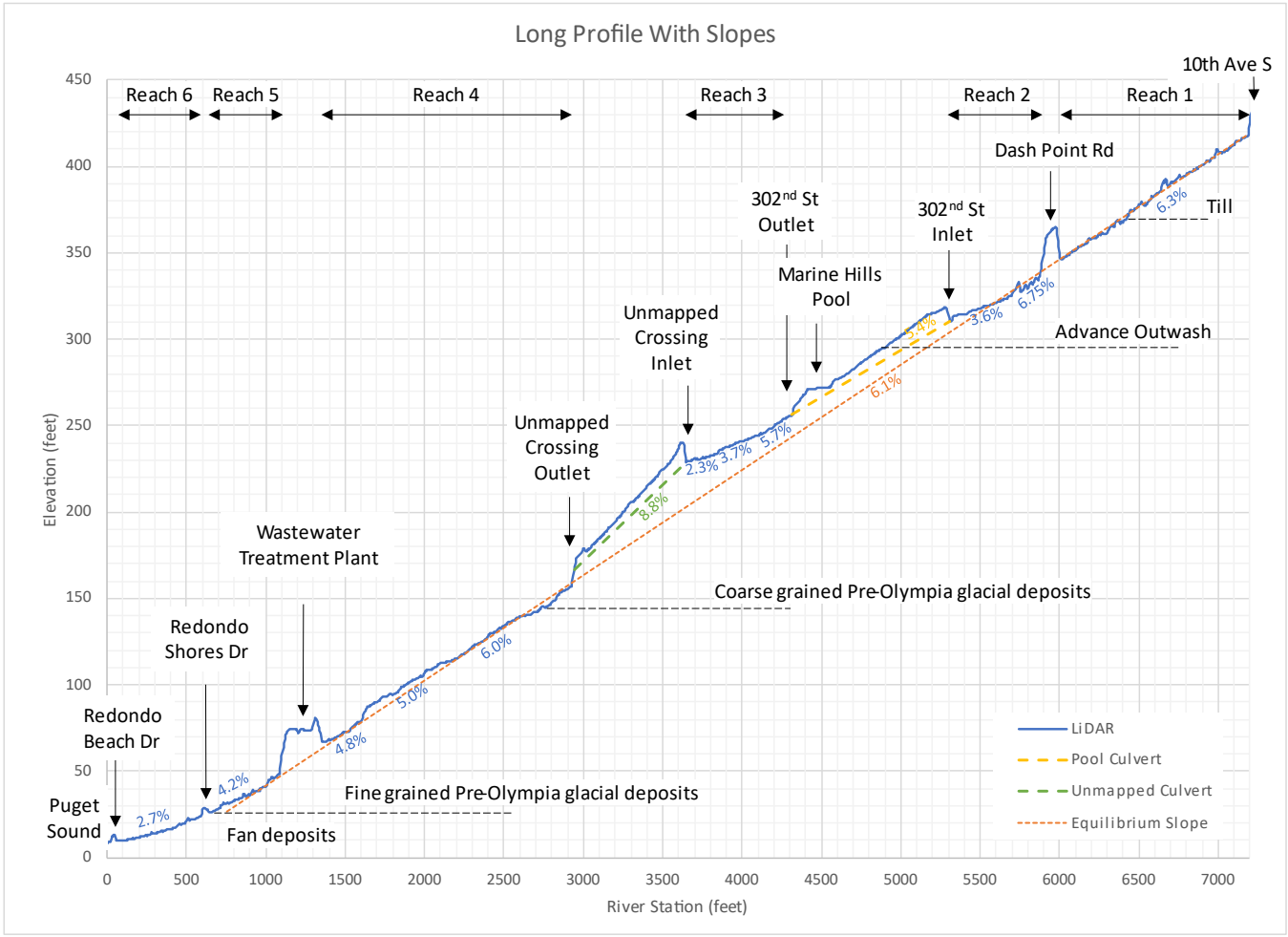

Figure 2: Long profile of the watershed from 10th Avenue South down to the Puget Sound.

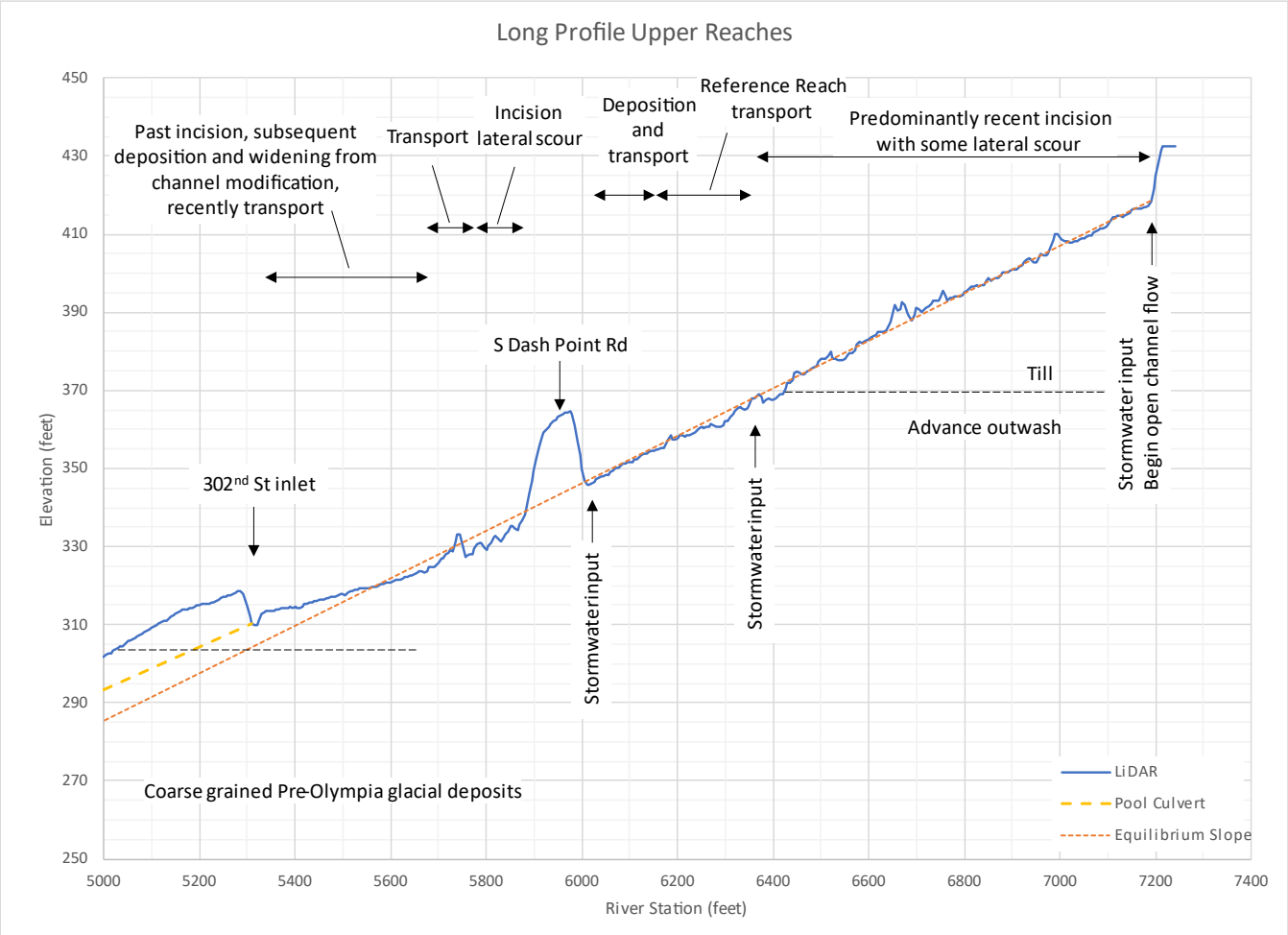

Figure 3: Reaches 1 and 2 (Sta 7200 – 5000) - upper section of the watershed with geomorphic processes.

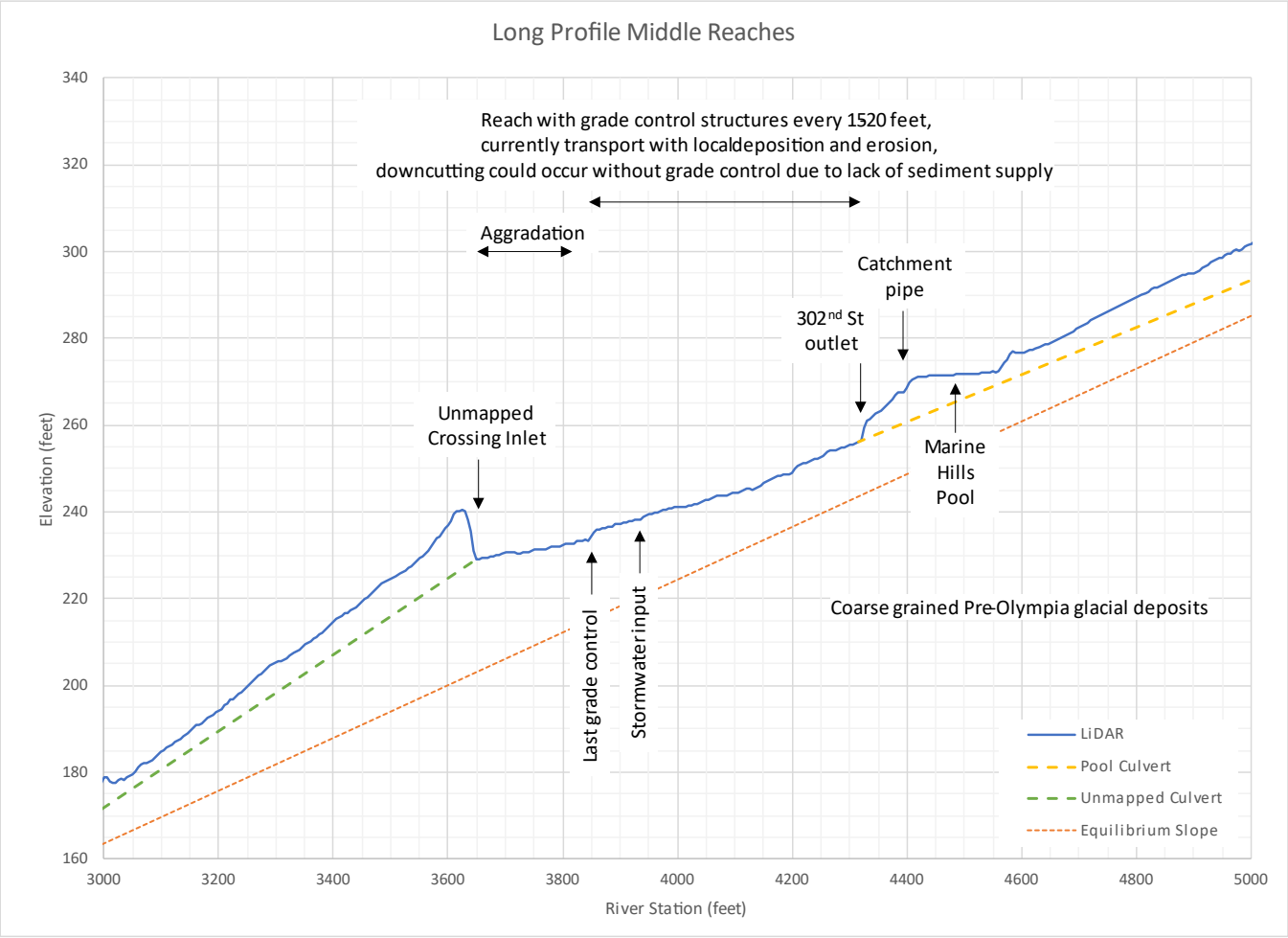

Figure 4: Reach 3 (Sta 5000 – 3000): middle watershed and geomorphic processes.

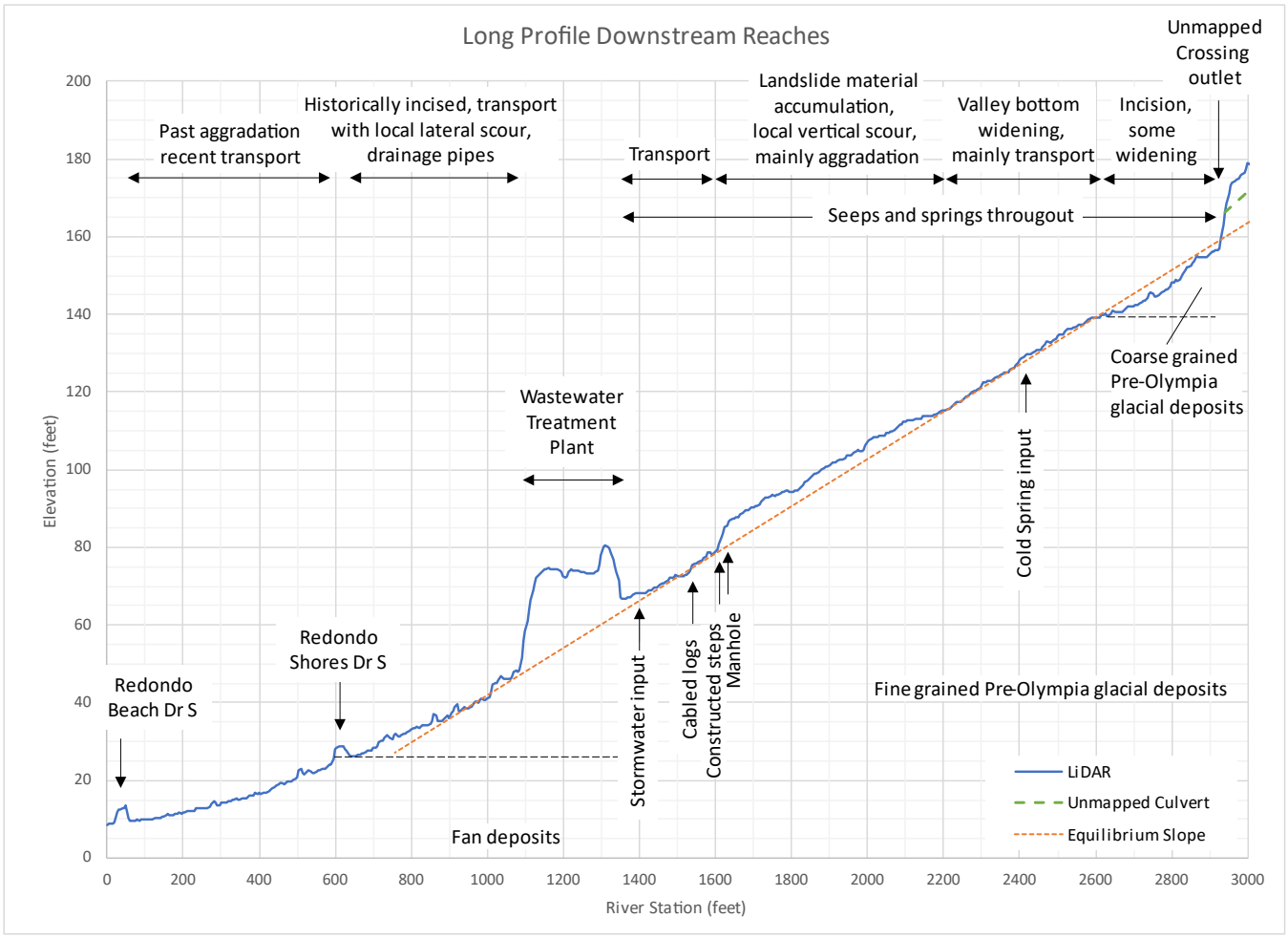

Figure 5: Reaches 4, 5, and 6 (Sta 3000 – 0): lower watershed and geomorphic processes.

Reach 1: 10th Avenue South to SR 509/Dash Point Road (Sta 7200 – 6000)

Reach Summary and Riparian Conditions

The culvert at 10th Avenue South constitutes the upstream limit of this basin assessment and Reach 1. The culvert is a 30-inch concrete pipe aligned at-grade with the channel bottom. Flowing water was not observed; only two shallow, isolated pools were observed in the entire reach, located at roughly Sta 6500. At the downstream end of the reach the creek flows under Dash Point Road through a 3.5-foot concrete pipe equipped with a steel grate debris rack.

Reach 1 is confined in a steep forested valley approximately 100 to 150 feet wide at the top. Residential development surrounds the creek valley throughout the reach. Impacts from adjacent land use were apparent throughout, including landscaping debris (tree/shrub cuttings and lawn clippings), tires, metal debris, plastic refuse, and occasional paths and platforms down the valley slopes and adjacent to the channel. Invasive species were frequently present adjacent to the channel and up the valley slopes, including cherry laurel (*Prunus laurocerasus*), Himalayan blackberry (*Rubus armeniacus*) and English ivy (*Hedera helix*). Overhead canopy is near full closure, comprised of primarily Douglas-fir (*Pseudotsuga menziesii*), bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*).

Three stormwater inputs were observed, one near Sta 6350 and two at Sta 6050, just upstream of the Dash Point Road crossing (Figure 3). The stormwater pipe at Sta 6350 was a 12-inch corrugated metal pipe (CMP) that appeared to lie on top of the hillslope but protruded approximately 3 feet from the top edge of the hillslope (Photo 1). It has created a 12-foot-high vertical bank below it as the hillslope has eroded due to the excess water input.

Photo 1: Stormwater input at Sta 6350 forming 12-foot-high headcut bank

Two stormwater inputs near Sta 6050 were observed directly upstream of Dash Point Road on the right bank looking downstream. The first is a 24-inch CMP that is at least partially buried in the hillslope. It forms a 14-foot-high vertical bank and has scoured a path 10 feet in top width approximately 20 feet into the hillslope (Photo 2). The second is a 12-inch CMP protruding from the road base spilling onto riprap (Photo 3). A flume was observed bent and twisted in the jumble of riprap that may have once conveyed water from this pipe. Currently, there is a 2-foot-wide and equally deep incised channel beneath downed tree limbs and roots that appeared to convey water, although none was flowing at the time of the field visit.

Photo 2: Stormwater pipe at Sta 6050 with 14-foot-high headcut bank

Photo 3: Stormwater input at Sta 6050; incised conveyance channel leads from outlet toward lower center of photo and then down to the left of the standing tree in the center of photo.

Geomorphology

The upper 700 feet of Reach 1 in Cold Creek can be characterized as highly incised (Photo 4); banks are commonly steep to near vertical and up to 8 feet tall. The creek downcut over time into native material with a meandering valley planform in the upper 400 feet (Figure 1) before generally straightening out in the downstream portion of the reach.

Bedform throughout the entire reach is forced step-pool with some cascades, riffles and shallow plane bed segments. Steps typically consist of accumulations of wood, either haphazardly dropped into the channel by humans or naturally formed from stream flow but with human modified wood commonly incorporated (Photo 5). Steps are typically 1.5 to 3 feet high and spaced from 50 to 150 feet apart.

Photo 4: Incised condition.

Photo 5: Wood step with modified wood.

The sediment in the channel near the stormwater outlet appeared more angular than typical for streambed material, suggesting it was added to the system at some point in time (Photo 6). Elsewhere, bed material appears to have been derived naturally and ranges from coarse sand to boulders with large gravel as the dominant material (Photo 7). There was a clear deficiency of fine-grained material in the bed material even though it is abundant in the banks, suggesting fine material is easily carried out of this upper portion of the system.

Photo 6:Sediment near outlet and lack of material finer than coarse sand.

Photo 7: Boulders and smaller rounded material.

Till, a highly indurated, compact material deposited across the landscape by glacial ice (Tabor et. al. 2014) is mapped in the upper 700 feet of channel, but observations suggest it extends another 50 feet downstream, with the boundary between till and advance outwash near Sta 6450. The till is exposed in the bed with scour pools in several locations downstream of woody debris jams that trap sediment, indicating recent incision (Photo 8). This suggests only a thin veneer of streambed material lies on top of the till and little material is stored in the channel unless trapped behind debris. Other locations have experienced significant and recent incision such as at Sta 6750 (Photo 9) and Sta 6450 (Photo 10). Photo 9 illustrates approximately 6 feet of degradation over time; note the two large trees at the top of the banks which were once at or near the same elevation as the creek. One- to 2-foot vertical banks at the stream edge indicate a recent cycle of incision. Photo 10 illustrates a 3-foot step where the wood that generated the step is being flanked, forming a headcut that is likely to work its way upstream. The creek from this location down to the reference reach (described below) has similar characteristics as upstream, although within a different geologic unit.

Photo 8: Looking upstream: scour and headcutting, exposing underlying geologic material.

Photo 9: 6 feet of incision over time; approximately 2 feet of recent incision illustrated by vertical banks at edge of creek. Arrows indicate large trees that were once at the edge of and near the same elevation as the creek.

Photo 10: 3-foot step, incision above and below step; blue arrow points to streambed upstream of the step.

A reference reach was identified upstream of Dash Point Road between Sta 6350 and Sta 6150. A reference reach is used for channel restoration and culvert design to exemplify typical channel conditions such as gradient, substrate characteristics and cross-sectional geometry. To provide useful information it must be outside the influence of human modification such as culvert crossings, stormwater inputs, or bank armoring.

Stream gradient varied locally within the reach, but the overall gradient generally matches the equilibrium slope of 6.1 percent (Figure 1 and Figure 3). The valley bottom is slightly wider than upstream where the creek occupies the entire bottom width. Discontinuous, narrow fluvial surfaces were commonly observed in in the reference reach (Photo 11). The creek is single thread with no sinuosity. Bedform was step-pool with either glide or plane bed characteristics between steps. Steps are formed by large boulders or a combination of coarse substrate and wood and occur from 25 to 75 feet apart. Sediment ranges from coarse sand to boulder.

Photo 11: Reference reach with slightly wider valley bottom than further upstream and narrow fluvial surface.

The remaining stream segment down to Dash Point Road is influenced by the culvert, with a combination of sediment deposition and transport occurring in this area. A 3-foot-diameter, corrugated pipe, with a trash rack, has approximately 1 foot depth of material backed up behind the culvert. The inside of the pipe was mostly free of material.

Fish Habitat

In the existing condition, Reach 1 has limited capacity to support fish at various life stages. The Dash Point Road crossing (WDFW Crossing ID 991192 in the WDFW barrier assessment database [WDFW 2021]) lists Coho Salmon (*Oncorhynchus kisutch*), sea-run cutthroat trout (*Oncorhynchus clarkii*) and resident trout as potential species as potentially present. The reach also appears of appropriate size and gradient for steelhead trout (*Oncorhynchus mykiss*), which are listed as potentially present at downstream WDFW Crossing ID 991878 (South 302nd Street).

Fish passage issues downstream of this reach currently preclude access to the site. While eventual correction of these issues should always be presumed when assessing potential habitat gain, the length and complicated nature of several downstream crossings, the upstream stormwater infrastructure conveying flow from Easter Lake, and the surrounding dense residential development increases the potential timeline and level of effort required to improve fish passage at this site.

In addition to existing fish access constraints, the site currently appears to experience a flashy, intermittent flow regime, most likely exacerbated by development of the surrounding watershed. Increased impervious surface coverage within a basin is known to increase the magnitude of peak storm flows, while lowering baseflows due to reduced hyporheic connection. Intermittent flow regimes do not preclude salmonid presence, but in such a modified state the frequency and timing of flowing water presence should be investigated prior to initiating any habitat restoration activities.

Patches of spawning-sized gravels were observed during the assessment; however, the depth and stability of surface streambed layers is not likely to support spawning activity. Flashy, high-flow events followed by rapid drying of the creek are also not conducive to successful spawning and survival during early life history.

Fish presence in the existing condition is likely limited to the wetter months of late fall, winter and early spring. Assuming road crossing barriers are corrected, the reach could provide juvenile salmonids rearing habitat in well-shaded pools below forced steps, interspersed between shallower stretches of flowing water. Off-channel habitat is limited by the steep valley walls and vertical channel banks, limiting refuge potential that would be required by juvenile salmonids during high flow events.

It is unknown whether Cold Creek supported perennial flows in its pre-development state. Restorative actions that do not address the current flow regime would not likely provide realized benefit to fish populations.

Reach 2: SR 509/Dash Point Road to South 302nd Street Culvert Inlet (Sta 5900-5300)

Reach Summary and Riparian Conditions

Cold Creek enters Reach 2 through a 3.5-foot-diameter, corrugated steel pipe extending under Dash Point Road for a length of approximately 100 feet, between Sta 6000 and Sta 5900. The inlet of this crossing is protected by a steel debris cage where approximately 1 foot of small wood and soil was observed accumulated on the upstream end. There is also a vertical catch basin with a debris guard inlet, presumably allowing flow to enter the culvert when the main inlet becomes blocked. The culvert outlet directly downstream of Dash Point Road has a concrete rectangle built into the concrete apron, which acts as a flow dispersion structure. This structure forces flow toward the margins of the stream as it exits the culvert, resulting in flanking of the concrete apron (Photo 12). The stream has scoured around the structure and downstream where there is over 3 feet of elevation drop down to a cascade of cobbles and boulders that drops another 2 feet down to the creek, outside the influence of the culvert.

Photo 12: Concrete apron and flow dispersion structure (arrow). Apron has been flanked on both sides.

The riparian corridor within Reach 2 is even more constricted than upstream, averaging less than 100 feet wide at the top. The Dash Point Road fill prism extends nearly to the left channel bank to the south, while fill slopes below houses similarly extend to the creek on the north. Ivy dominates most of these slopes and has grown over many trunks of the fir, alder and maple canopy. The upstream half of the channel is covered by a dense shrub layer of salmonberry (*Rubus spectabilis*), red elderberry (*Sambucus racemosa*) and laurel (Photo 13). The lower half of the reach features flat benches adjacent to the channel utilized by landowners for recreation, including firepits, firewood prep and storage, and small tables and benches (Photo 14). Grass, ferns and ivy are the dominant vegetation in this lower section, with limited overhead cover provided by trees 30 to 50 feet from the channel to the south.

Photo 13. Upstream portion of Reach 2 constricted by steep slopes with dense shrub layer.

Photo 14. Downstream portion of the Reach 2, modified with residential land use adjacent to the creek.

Geomorphology

The entire length of stream from the Dash Point Road crossing down to the culvert at South 302nd Street has experienced some incision. The upper 100 feet of this reach may still be experiencing incision while the next 100 feet downstream may be experiencing deposition and lateral scour. A pebble count was obtained mid-reach near Sta 5735. Sediment is similar to upstream with large gravel as the predominant substrate.

The lower 400 feet of this reach, which encompasses the remaining stretch of creek upstream of the South 302nd Street culvert (WDFW Crossing ID 991878), has been modified by landowners who have placed artificial grade controls to hold sediment. One grade control consists of a boulder and cobble step approximately 1-foot-high. Another consists of wooden slats held together and in place by metal fence posts protruding from the stream and is also about 1-foot-high. The last is a large band of rock that forms a cascade style step approximately 4 feet high at the lower end approximately 20 feet upstream of the culvert inlet (Photo 15). Landowners have also sought to hold the creek in place laterally by lining the banks with large rock or gabion baskets. This lower modified section is most likely acting as a transport reach at this time.

The culvert is a 4-foot by 4-foot square concrete opening with wing walls and a trash rack. The culvert appeared to have about 6 inches of sediment in the bottom.

Photo 15: Lower artificial grade control downstream of residential area.

Fish Habitat

Reach 2 habitat conditions are similar to upstream. The intermittent flow regime appears to still be the dominant limiting factor in the creek, along with passage barriers upstream, and downstream. The upper half of the reach features dense overhead cover and some large wood spanning the creek; however, little interaction with low-flow conditions appeared likely. The downstream half of the reach is almost entirely exposed, with short, mostly armored vertical banks and low complexity (Photo 16). Several of the channel-spanning features likely limit passage to certain life stages, particularly during low-flow conditions. These conditions all limit migration and rearing habitat potential throughout the reach. Pockets of spawning-sized gravels were observed in the upstream half of the reach, while longer, gravel-dominant riffles were observed within the lower half.

Photo 16. Additional channel modifications in downstream portion of Reach 2.

Reach 3: Marine Hills Swim and Tennis Club downstream to unmapped culvert inlet (Sta 4300 – 3650)

Reach Summary and Riparian Conditions

Flow is routed into Reach 3 through a culvert spanning approximately 1,000 feet (Sta 5300 - 4300) under South 302nd Street and the pool at the Marine Hills Swim and Tennis Club. The upstream inlet was a concrete box culvert with debris guard, while the outlet pipe was a round, 4-foot-diameter CMP. The outlet pipe flows from a concrete catch basin that has two inputs, both CMP, one estimated 3-foot-diameter and the other 18 inches wide. It is unknown where along this length the crossing type changes, but given the length, slope and configuration it constitutes a total fish passage barrier.

Through Reach 3, the creek flows through a relatively broad corridor of native forest with high overhead canopy cover and relatively dense tree and shrub growth along each bank (Photo 17). There is a dirt/gravel walking path immediately adjacent to the right bank for most of the reach, often separated from the creek with a thin but dense buffer of vine maple, salmonberry and sword fern. The left bank is a relatively steep slope densely vegetated with trees and shrubs directly to the channel bank.

A single stormwater input is observed in this reach other than that entering the creek at the junction in the catch basin just downstream of the pool. The stormwater pipe is an 18-inch CMP that follows the hillslope until it gets near the stream where it goes vertical adjacent to the trail before flattening to go underneath the trail, after which it is angled slightly downstream as it enters the stream (Photo 18).

Photo 17. General channel and vegetation conditions looking downstream along Reach 3.

Photo 18: Stormwater input on right bank.

Geomorphology

This section of Cold Creek is straight and has been highly modified. According to the PowellsWood website (PowellsWood Garden Foundation 2021), this area was significantly incised before the stream underwent restoration in the year 2000 to restore and hold grade. Large logs were squared, notched to concentrate low flow and placed perpendicular to the flow at approximately 15-foot intervals. Streambed material was brought in to refill the channel. It appears that most, if not all, logs are still in place. Some were buried while others have experienced lateral or vertical scour threatening to undermine them. Rock gabions downstream of the logs are commonly exposed (Photo 19). The last grade control forms a significant drop (Photo 20 and Figure 4).

Photo 19: Notched log with wire gabion basket downstream.

Photo 20: Last grade control series of gabions forming two 2-foot drops.

Deposition downstream of the last grade control structure is evident as this area is influenced by the unmapped culvert. The culvert at the downstream end of this reach is a 4-foot-diameter CMP encased in concrete. The opening is blocked by debris which stacks up sediment behind it, although the pipe is free of material (Photo 21). Medium to coarse sediment has accumulated downstream of the last grade control, filling the channel evenly such that the stream has no defined thalweg (Photo 22). Deposited material transitions to mainly sand within approximately 25 feet of the inlet.

This reach was dry during the site visit except for a puddle near the outlet of the South 302nd Street culvert. The puddle may represent the last vestige of seasonal flows, or the water could be going subsurface here. No inputs flowing to this location were observed, suggesting the former.

Photo 21: Unmapped culvert inlet, half blocked by debris, sand deposited upstream of inlet.

Photo 22: Sediment filled channel downstream of grade control but upstream of unmapped culvert.

Fish Habitat

The stream through Reach 3 provides less degraded habitat conditions as compared to upstream; however, the 20 plus-year old restoration work likely limit passage for smaller fish at low flows. Most of the log weirs have become exposed and feature vertical drops between 6 inches and 2 feet high, typically with noticeable moderate-sized scour pools. While these pools would provide holding habitat for rearing juveniles and migrating adults, they are likely associated with passage barriers at some flows and could become isolated as water levels drop, potentially trapping fish as the reach goes dry.

Spawning habitat capacity of the reach is limited by the frequency of larger cobbles, exposed geotextile fabric and relatively rapid succession of steps associated with the log weirs (Photo 23). The only large accumulation of gravel was observed at the very downstream end of the reach (Photo 22), near the inlet of a long barrier culvert that does not appear to span any infrastructure, nor is it listed on barrier inventory maps.

While native vegetation and the overall riparian corridor condition improved within Reach 3, the creek at this location appears to continue to suffer from a flashy hydrograph, reducing flow duration across the year and increasing magnitude of flows following storm events.

Photo 23. Series of log steps with moderate-sized scour pools and occasional exposed geotextile fabric.

Reach 4: Unmapped Culvert Outlet to Wastewater Treatment Plant (Sta 2900 – 1350)

Reach Summary and Riparian Conditions

Flow enters Reach 4 through a culvert not identified on WDFW's inventory (WDFW 2021). We estimated a culvert length of 750 feet, spanning from Sta 3650 to Sta 2900. The crossing inlet is a 4-foot-diameter CMP while the outlet is pre-cast concrete, also 4-foot-diameter, with wingwalls and an apron that extends to a roughly 5-foot drop onto boulder armoring (Photo 24). Approximately 10 feet of the concrete pipe is exposed, with the lowest section separated, exacerbating the erosion around this outfall (Photo 25).

Photo 24: Outlet of unmapped culvert with boulder cascade. Apron is 2 feet thick. Refer to Photo 21 for view of inlet to this culvert.

Photo 25:Separation of concrete pipe sections (marked with stadia rod) and erosion upstream of unmapped culvert outlet.

Reach 4 is mostly unimpacted by development, with a wide, steep-slope riparian zone abutting often vertical banks of consolidated fine material. Seeps were commonly observed entering the channel, and hydrophytic vegetation such as skunk cabbage (*Lysichiton americanus*) and slough sedge (*Carex obnupta*) were observed above the channel on valley slopes (Photo 26). A right bank tributary ("Cold Spring") input was identified at approximately Sta 2450, contributing

roughly equal flow as the mainstem (Photo 27). Forest composition remained relatively dense mixed deciduous and evergreen species with occasional openings, particularly around a recent landslide observed near Sta 2200.

What appeared to be an overgrown utility corridor was observed near Sta 1800 (Photo 28). A concrete manhole is located just above the left bank (Photo 29), and an 18-inch CMP discharges approximately 15 feet further upslope, with large rock armoring placed between the pipe and the creek (Photo 30). Two smaller flexible black plastic pipes were also observed on the slope in this area. It did not appear that the CMP is associated with the manhole. Instead, it is suspected that this feature is associated with the wastewater treatment plant just downstream. The channel at and below this feature appeared modified, with artificial large-rock steps and placed large woody material (LWM) extending for approximately 200 feet (Photo 31). Each drop was 2 to 3 feet high with relatively deep plunge pools leading up to each step.

Photo 26. Frequent hillside seeps along channel banks.

Photo 27. Tributary input (left) contributing roughly equal flow to mainstem (right).

Photo 28. Cut vegetation along evenly-graded slope adjacent to CMP uphill of manhole.

Photo 29. Manhole adjacent to creek.

Photo 30. Large rock placed along left bank below CMP outlet.

Photo 31. Series of artificial steps and placed logs in creek near manhole/CMP outlet.

Geomorphology

The outlet of the unmapped culvert has been severely damaged. Erosion of material downstream of the outlet has undermined the outlet causing it and the concrete apron to dip downward, resulting in a break at a joint in the concrete pipe 20 feet upstream of the outlet (see thin band of light shining just inside the culvert in Photo 24). The pipe at the outlet is different than at the inlet; the pipe at the outlet is concrete where the inlet is a CMP encased within concrete. Much of the fill material behind the wingwalls has also eroded as a result of stream flows flanking around the wingwalls. A cascade of large boulders has been placed at the base of the concrete apron. The apron is 2 feet thick with an approximate 2-foot gap under the apron and down to bed material for a 4-foot drop. The cascade drops approximately another 4 vertical feet over about 20 to 25 linear feet of stream channel length.

This reach is slightly sinuous and characterized by seeps and/or springs flowing from the valley walls into the creek. At the time of the site visit water was observed to flow in the channel, starting from a pool near the base of the cascade downstream of the outlet. Geology transitions from coarse- to fine-grained glacial deposits between 120 and 320 feet downstream of the culvert. Fine-grained material which appeared to be varved clays and thicker layers of silts was observed starting around 120 feet downstream of the culvert outlet although fine-grained material is mapped by Tabor et al. (2014) at as beginning about 320 feet downstream of the outlet. It is likely that groundwater, as it moves downward in the soil column, hits the fine-grained material which it cannot infiltrate and then travels laterally until it intersects and flows down the hillslope into the creek.

According to Tabor et al. (2014), most of Reach 4 consists of landslide deposits. If this is correct, the fine-grained material described and mapped in Tabor et al. (2014) may be a large slump block since it appears mainly intact. There are locations where the plane of the bedding seems to dip back into the slope, potentially supporting a slumped block theory. In other locations, the layers are vertical, suggesting separate massive blocks, some of which were upended while others may have just slid down the scarp.

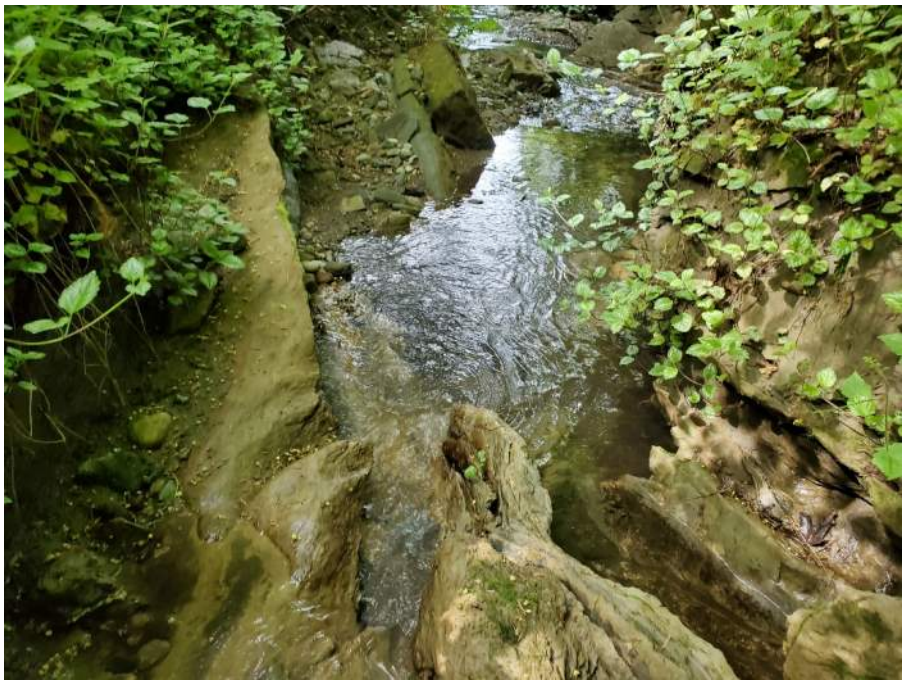

Photo 32: Tilted varved clays and silts.

Throughout much of this reach, the channel incised in the past into the fine-grained material whether it is in-situ or slump blocks. However, more recent processes, from upstream to downstream, include incision, lateral scour and local deposition, mainly aggradation but some short stretches of vertical scour, and finally transport (Figure 5). Based on the long profile relative to the equilibrium slope, the first 300 feet downstream of the culvert may still be incising, due to a lack of sediment input as the upstream culverts have blocked much of the sediment being transported from upstream (Photo 33). Some valley widening may be occurring where less resistant beds of fine-grained material along the banks show signs of recent erosion (Photo 34).

Photo 33: Looking downstream, stream appears to be downcutting into varved clays.

Photo 34: Erosion along valley wall, creek is to right of photo looking downstream.

From Sta 2600 to Sta 2200, the creek may currently be widening as significant lateral scour was observed, resulting in deposition of fine-grained material in the channel. Deposition of landslide material from approximately Sta 2200 to Sta 1600 is the likely cause for the rise in elevation of the profile relative to the equilibrium slope in Figure 5. Widening has occurred but the more dominant process may be aggradation as sediment is trapped behind numerous log jams in this reach (Photo 35).

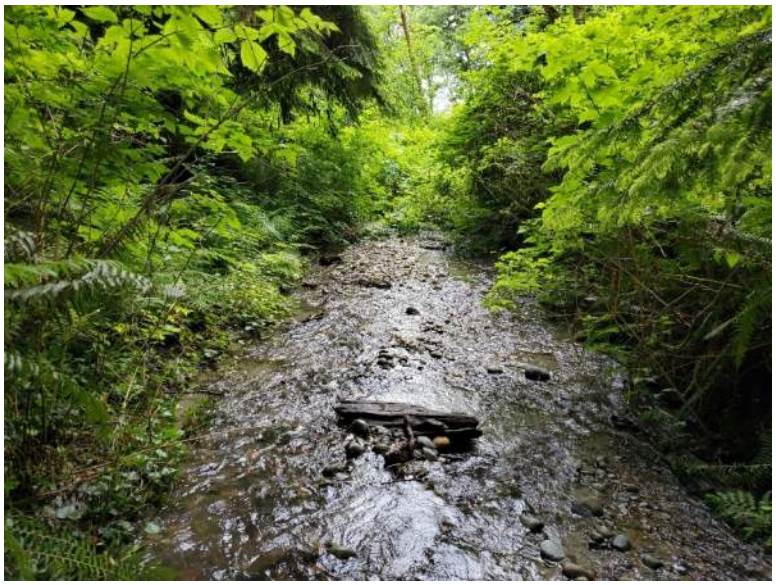

Photo 35: Deposition in channel, accumulation of sediment in middle of channel.

The section between Sta 1600 and the water treatment plant culvert at approximately Sta 1350 is downstream of the artificial steps and grade control associated with the manhole along the left bank. This reach is mainly a transport reach with minor local deposition upstream of logs in the creek.

Photo 36: Transport reach to the culvert inlet at the water treatment plant.

Fish Habitat

This reach provides high quality salmonid rearing habitat, with diverse pools, riffles, substrate sizes and high instream cover in the form of undercut banks, wood and occasional boulders (Photo 37). LWM was frequently observed spanning across and interacting with the channel, occasionally forming small jams. Areas with suitable substrate size of flow conditions for spawning are present but infrequent. The tributary input was observed at the mainstem confluence and its headwaters (Cold Spring), additional quality channelized habitat likely exists on this drainage as well.

Habitat conditions within this reach appear high functioning. Restoration activity aimed at improving habitat conditions would not likely provide significant uplift. The primary limiting factor within Reach 4 is downstream passage barriers. The Redondo Shores Drive South crossing (WDFW Crossing ID 921213) is mapped by WDFW as a total passage barrier due

to slope. Barrier status for the outlet culvert to Puget Sound under Redondo Beach Drive South (WDFW Crossing ID 921214) and the wastewater treatment plant culvert (unmapped by WDFW) are unknown.

Photo 37. Quality habitat within reach featuring pools, riffles, large wood and dense overhanging vegetation.

Cold Spring

A tributary enters Cold Creek along the right bank near Sta 2450 (Figure 5). The tributary originates at a spring emanating from a collection vault with no defined stream channel upstream of it (Photo 38). A small amount of water coalesces upstream of the vault and flows around the outside wall of the vault. A weir was observed approximately 50 feet downstream of the vault (Photo 39). Multiple roughly 4-inch salmonids were observed within the weir. A concrete dam was observed approximately 40 feet downstream of the weir (Photo 40). No other anthropogenic features were observed.

Photo 38: Cold Spring vault.

Photo 39: Weir downstream of Cold Spring vault

Photo 40: Concrete dam downstream of weir.

Reach 5: Wastewater Treatment Plant to Redondo Shores Drive South (Sta 1100 – 625)

Reach Summary and Riparian Conditions

Flow is conveyed into Reach 5 under roughly half of the wastewater treatment plant facility through a baffled, round concrete pipe, estimated 250 feet long (Sta 1100 – 1350). Formal assessment was not conducted but the culvert appears potentially passable to at least some fish at some flows.

The culvert spanning the uphill portion of the wastewater treatment plant features a series of concrete baffles that likely improve passage conditions; however, a formal assessment was not conducted (Photo 41). Downstream of the culvert the creek flows directly adjacent to development along the right bank (Photo 42), with approximately 50 to 75 feet of forested slope separating homes from the left bank. Numerous polyvinyl chloride (PVC) drain pipes between 6 and 18 inches diameter were observed along this left bank, presumably draining homes and roadways atop the slope. Vegetation gradually shifts through the reach to include more invasive species, including ivy, blackberry and a patch of Japanese knotweed (*Fallopia japonica*) upstream of the Redondo Shores Drive South culvert that marks the downstream end of the reach (Photo 43).

Photo 41. Baffled wastewater treatment plant culvert outlet.

Photo 42. Treatment plant directly adjacent to right bank.

Photo 43. Culvert at downstream end of reach with rock armoring and invasive species.

Geomorphology

The reach downstream of the water treatment plant is confined but there are small discontinuous inset fluvial surfaces in some locations (Photo 44). It is less steep than the upstream reaches, at approximately 4.2 percent, and bedform is pool-riffle with some steps. A cascade that incorporates large boulders was observed near Sta 1020, presumably added as grade control as this segment of the creek is in close proximity to several treatment plant buildings (Photo 45). It is mainly a transport reach with local lateral scour observed where several larger stormwater inputs were located (Photo 46). This reach appears otherwise fairly stable.

Photo 44: Arrows identify inset fluvial surfaces.

Photo 45: Cascade downstream of outlet to culvert under treatment plant.

Photo 46: Local lateral scour.

Fish Habitat

This reach provides moderate rearing and regular stretches of potential spawning habitat (Photo 47). Pools are generally small and not particularly deep; however, often are well shaded and associated with LWM (Photo 48). LWM was present but less frequent within this reach compared to more natural, less developed areas upstream. A large rock cascade (Photo 45) likely limits passage in the upper $^{1}/_{3}$ of the reach.

Photo 47. Potential spawning riffle upstream of stormwater pipe input.

Photo 48. Pool with overhanging LWM.

Reach 6: Redondo Shores Drive South to Marine Outlet under Redondo Beach Drive South (Sta 625 – 0)

Reach Summary and Riparian Conditions

Flow is conveyed to this reach through WDFW Crossing ID 921213 which is a 30-foot-long culvert under the private road of Redondo Shores Drive South. The approach to the culvert is lined on both banks by large riprap that form near vertical banks up to 6 feet high. It is bound by large riprap and partially cemented rock wall and platform on the downstream side (Photo 49). The lowest reach provides no natural riparian corridor or channel features. Landscaping, patios and lawns directly abut the creek which has been manipulated with various types of rock, concrete and earthen banks (Photo 50).

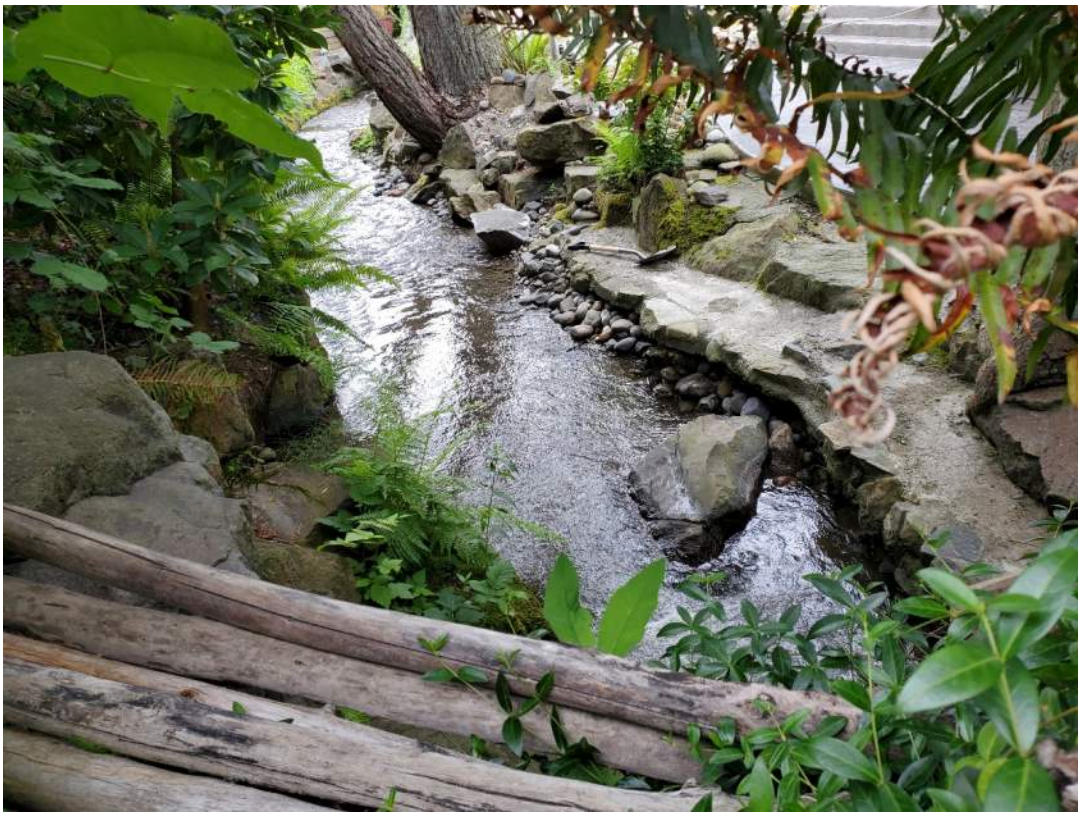

Photo 49: Hardened channel edges

Photo 50: Highly modified channel conditions within reach.

Geomorphology

The furthest downstream reach is heavily impacted by landowners. It is lined with rock or rock/concrete vertical walls throughout much of its length. The average slope is 2.7 percent (Figure 5). The channel appears smaller than upstream and there is little evidence for flow outside of the banks. This could suggest a losing reach with flow infiltrating into the less consolidated alluvial fan material.

The creek flows through a culvert under Redondo Beach Drive South (WDFW Crossing ID 921214) after which it begins forming a small delta as it reaches Puget Sound (Photo 51).

Photo 51: Delta at Puget Sound/Poverty Bay

Fish Habitat

Despite the obvious alterations the area does appear to hold some spawning-sized gravels that appear accessible during most flow and tidal conditions. No resting or holding habitat was observed. However, some of the short vertical drops likely have created scour pools. This limited complexity also reduces juvenile rearing habitat potential. The culvert under Redondo Beach Drive South (WDFW Crossing ID 921214) has less than 1 foot of freeboard and appears to backwater for most of its length during high tide. However, signs of saltwater presence in the upstream channel were not observed.

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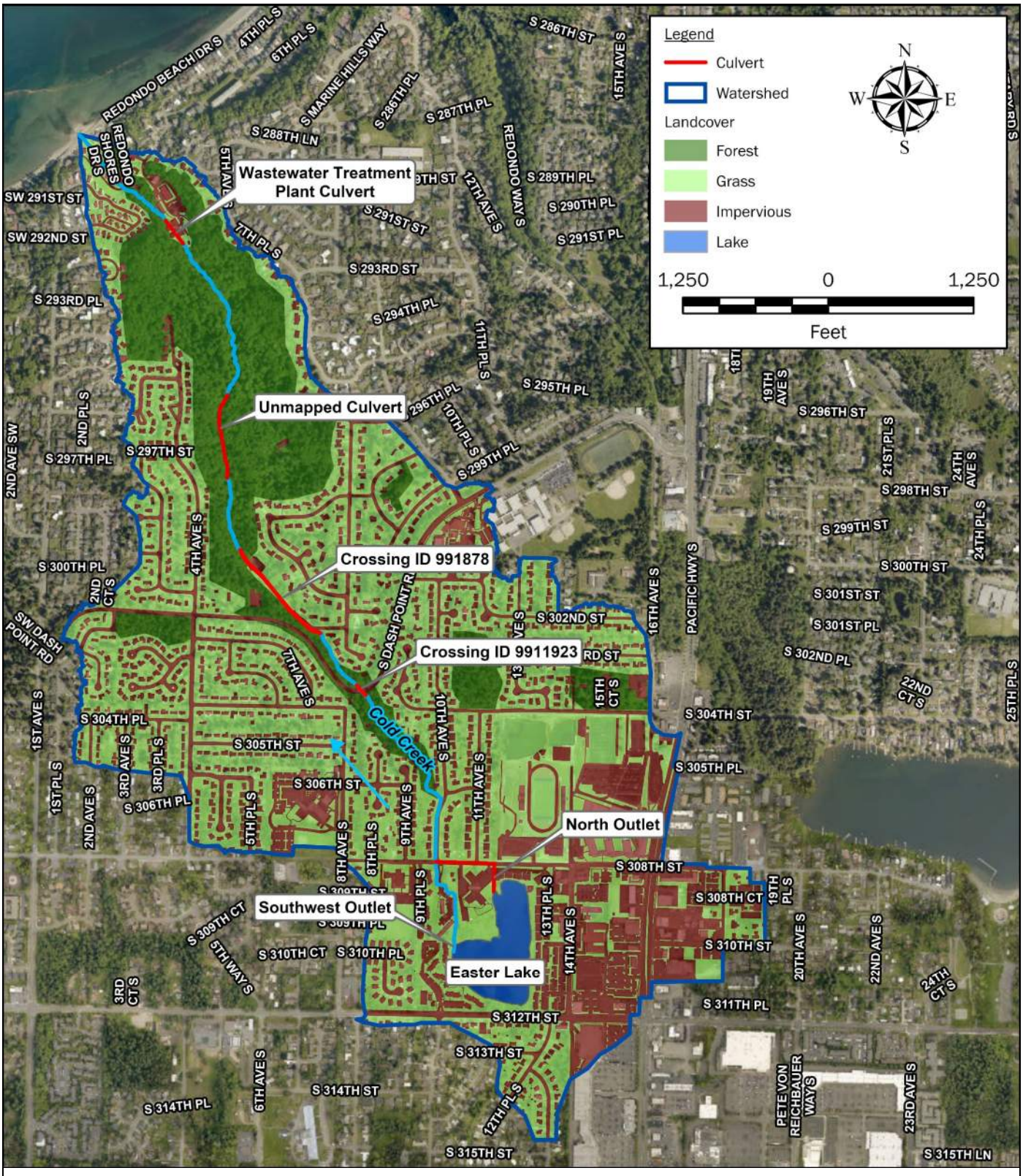
APPENDIX D
Hydraulic Modeling Data Output



Cold Creek Watershed with Land Use

Cold Creek
City of Federal Way, Washington

GeoEngineers

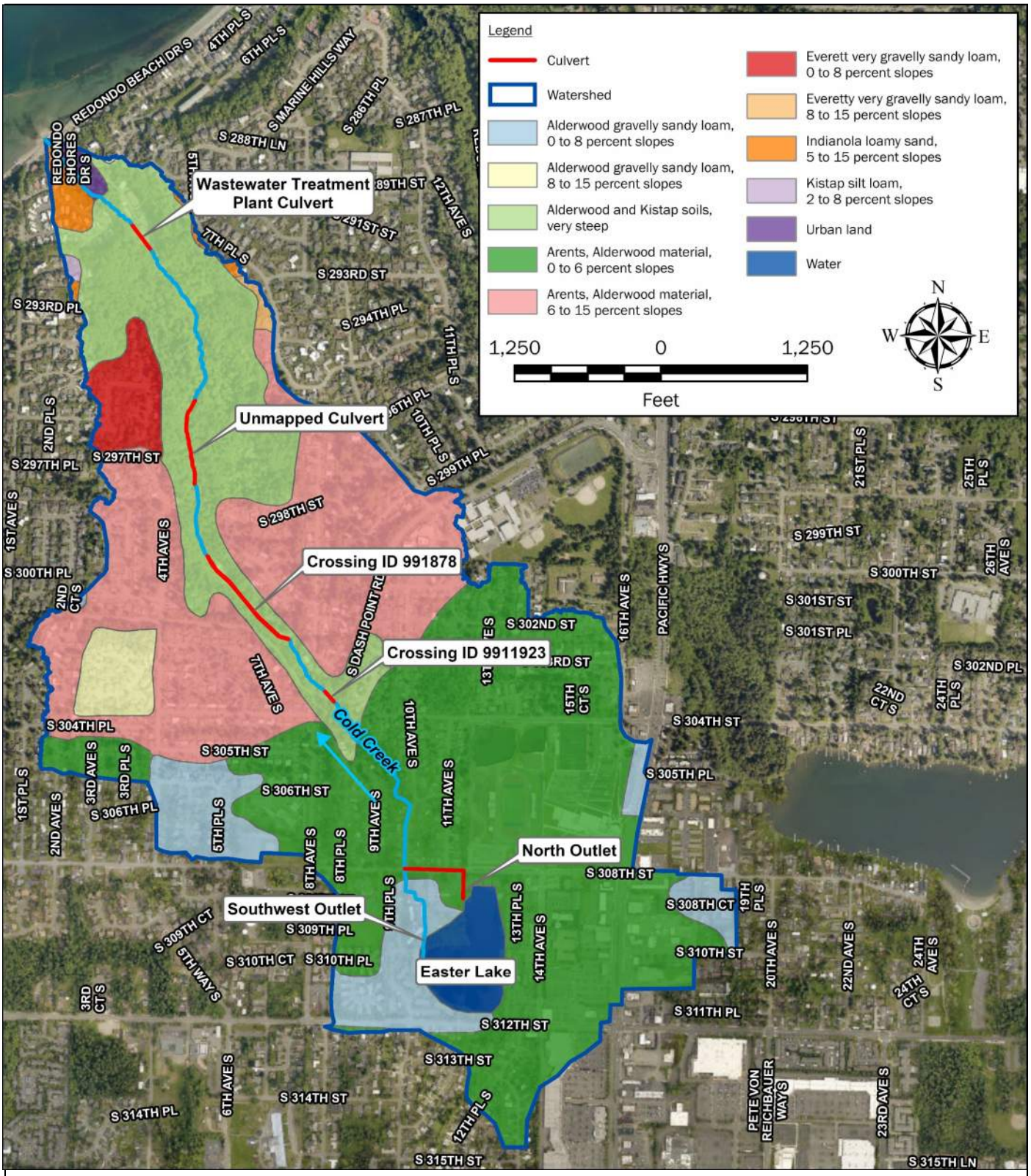
Figure D-1

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

XXXX-XXX-XX Date Exported: 04/09/15



Cold Creek Watershed with Soils

Cold Creek
City of Federal Way, Washington

GeoEngineers

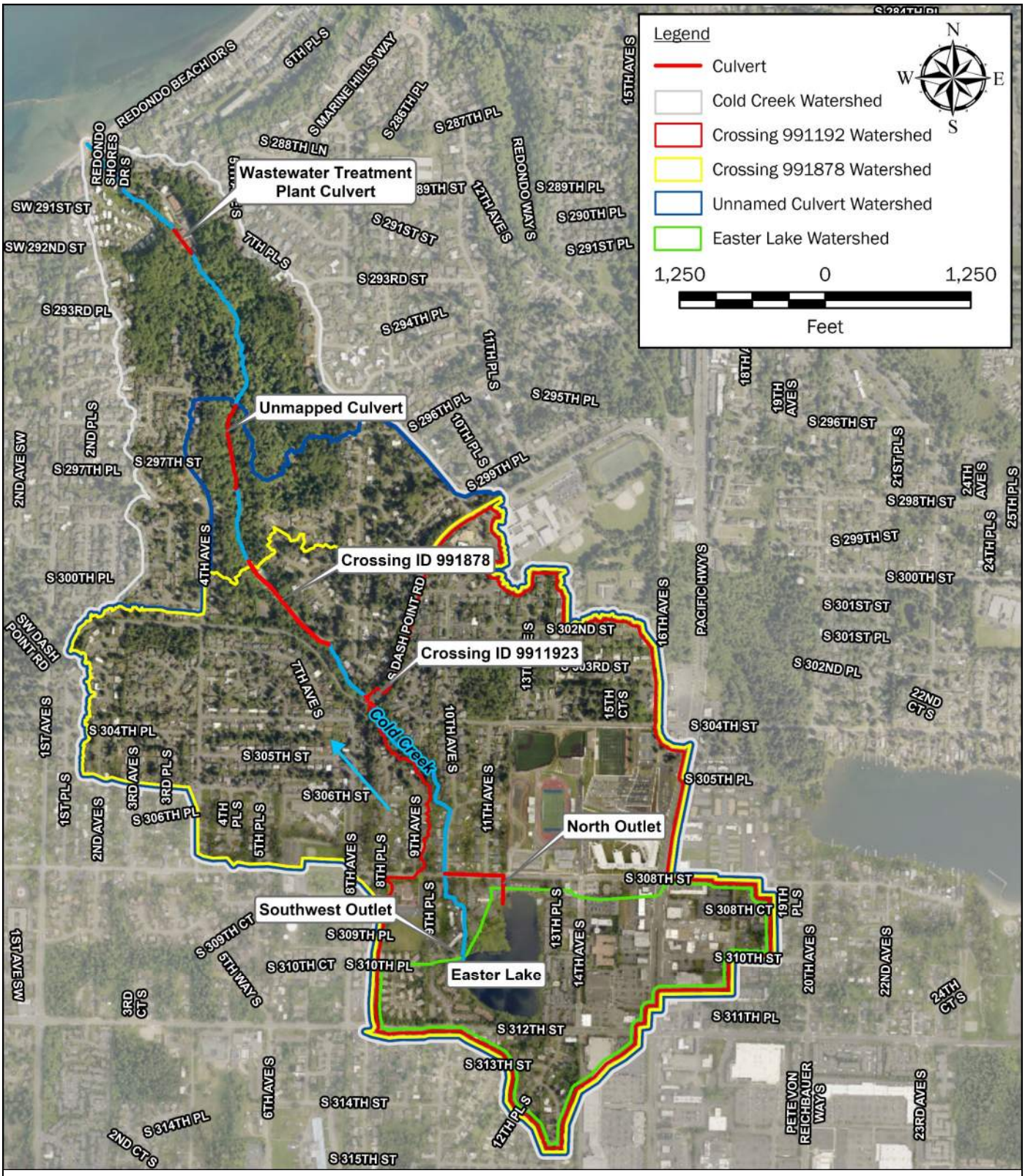
Figure D-2

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

XXXX-XXX-XX Date Exported: 04/09/15



Cold Creek Hydraulic Model Watersheds

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-3

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

XXXX-XXX-XX Date Exported: 04/09/15

***Station labels refer to location along the long profile and correspond to the surveyed cross sections.**
***Both surveyed cross sections and interpolated cross sections are included in model (26 total)**
***Lengths of lines do not correspond with cross section length.**

N
W E
S

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS Model

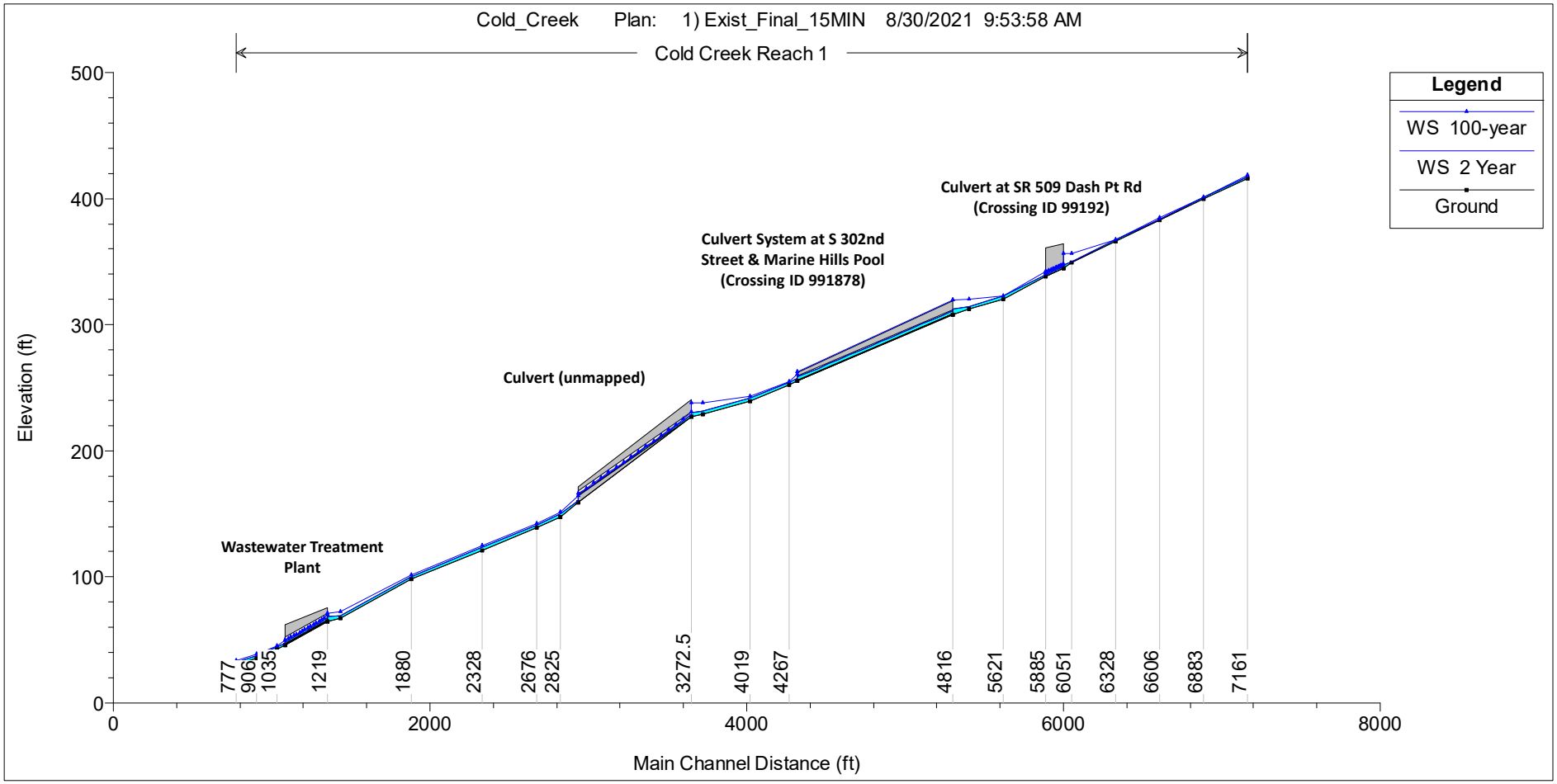
Cold Creek Hydraulic Model and Surveyed Cross Sections

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-4

XXXX-XXX-XX Date Exported 9/29/2021



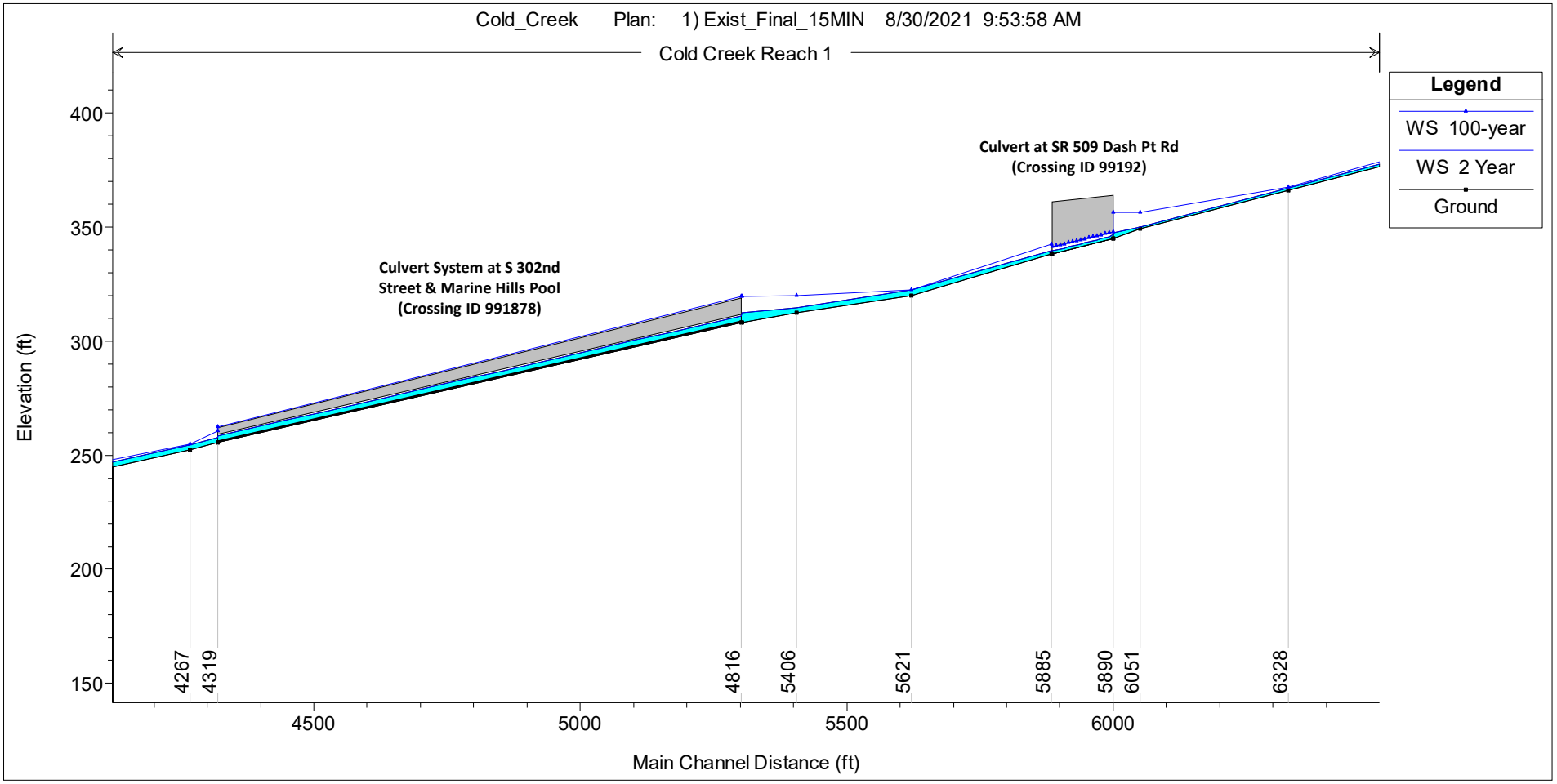
Full Long Profile

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS 5.0.7

Cold Creek Hydraulic Model Long Profile	
Cold Creek City of Federal Way, Washington	
GeoEngineers	Figure D-5

02207-017-00 Date Exported: October 2021



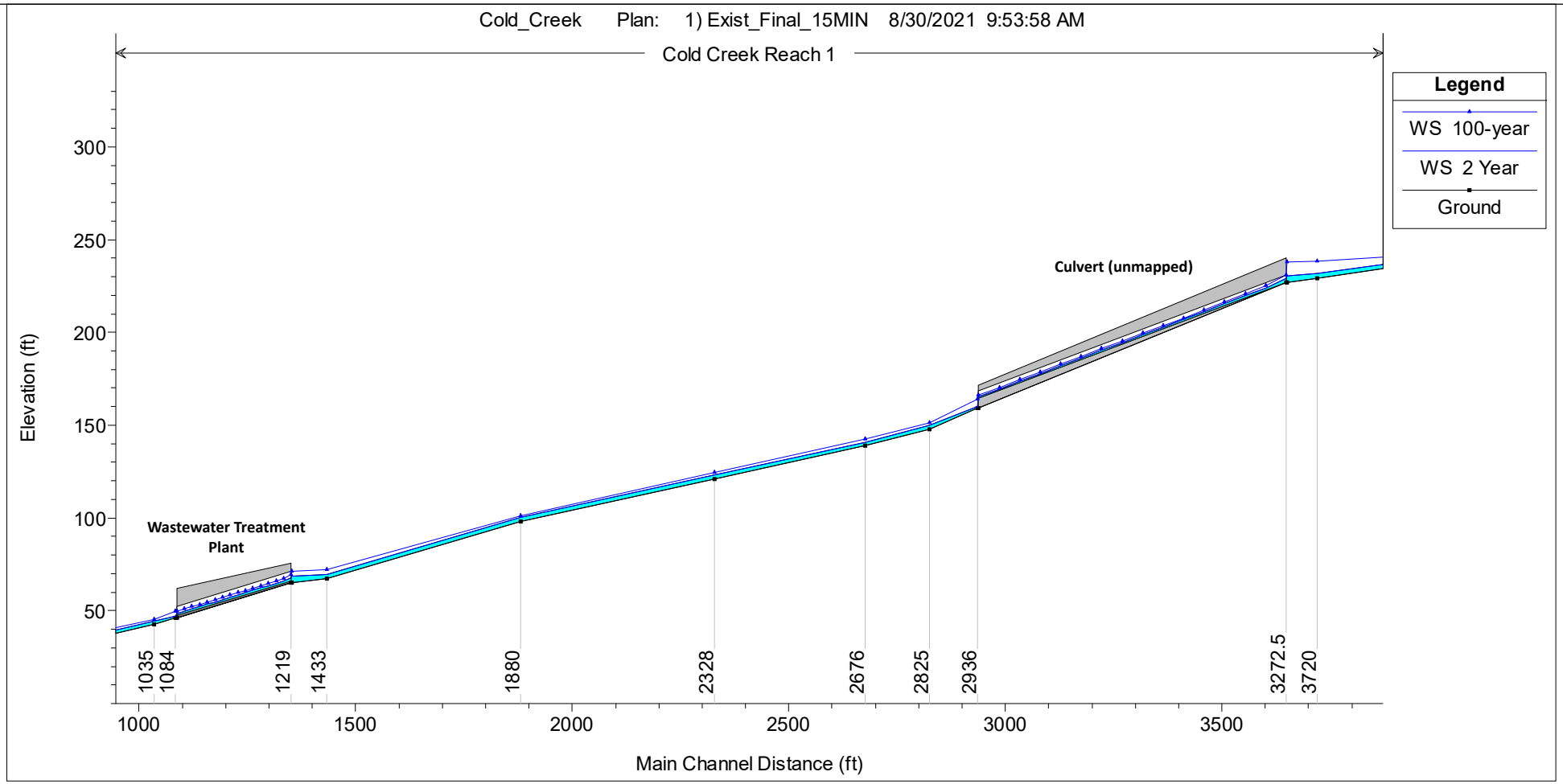
Upper Model Long Profile

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS 5.0.7

Cold Creek Hydraulic Model Long Profile	
Cold Creek City of Federal Way, Washington	
GeoEngineers	Figure D-6

02207-017-00 Date Exported: October 2021



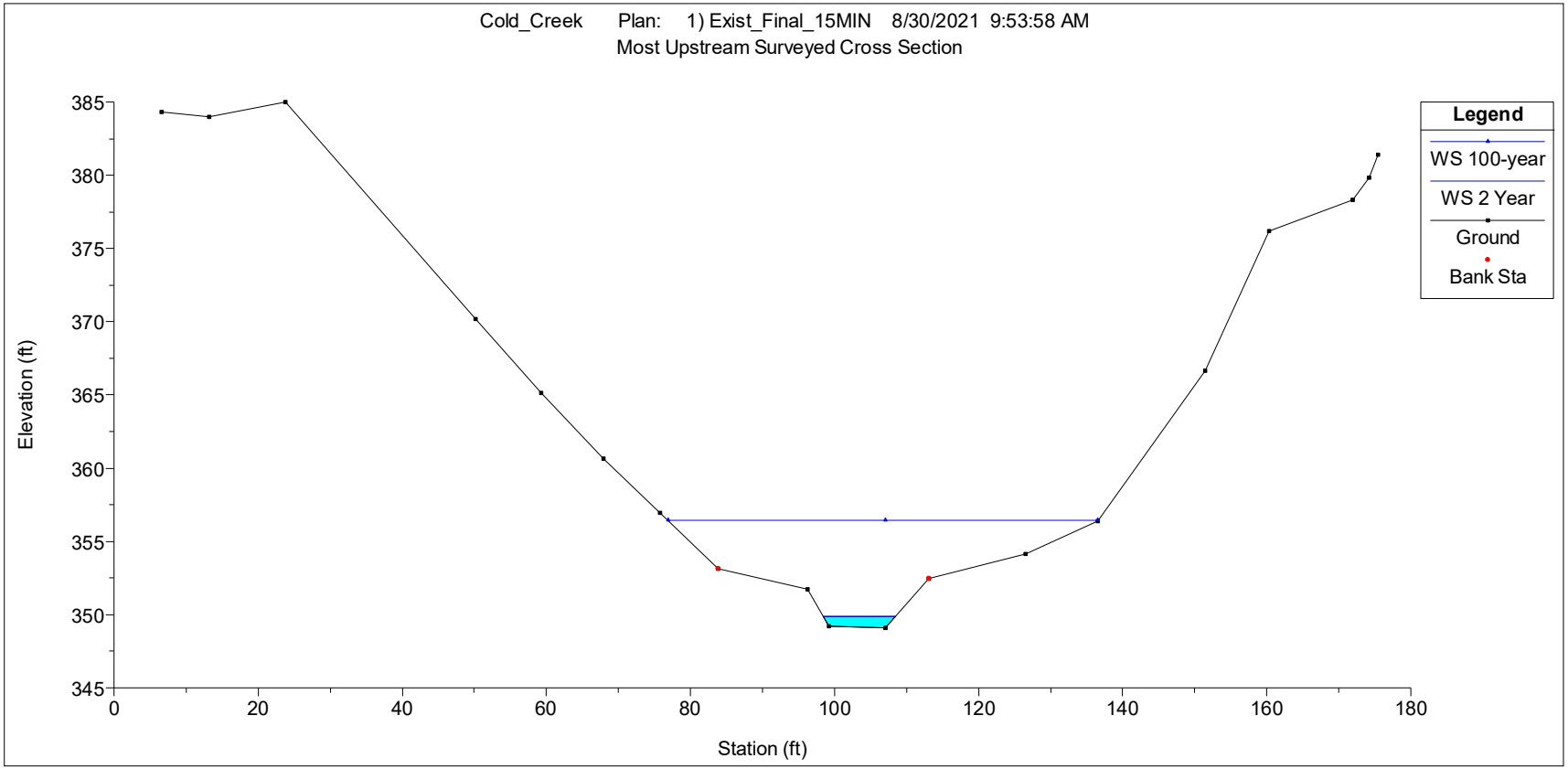
Lower Model Long Profile

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS 5.0.7

Cold Creek Hydraulic Model Long Profile	
Cold Creek City of Federal Way, Washington	
GeoEngineers	Figure D-7

02207-017-00 Date Exported: October 2021



Station 6051

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS 5.0.7

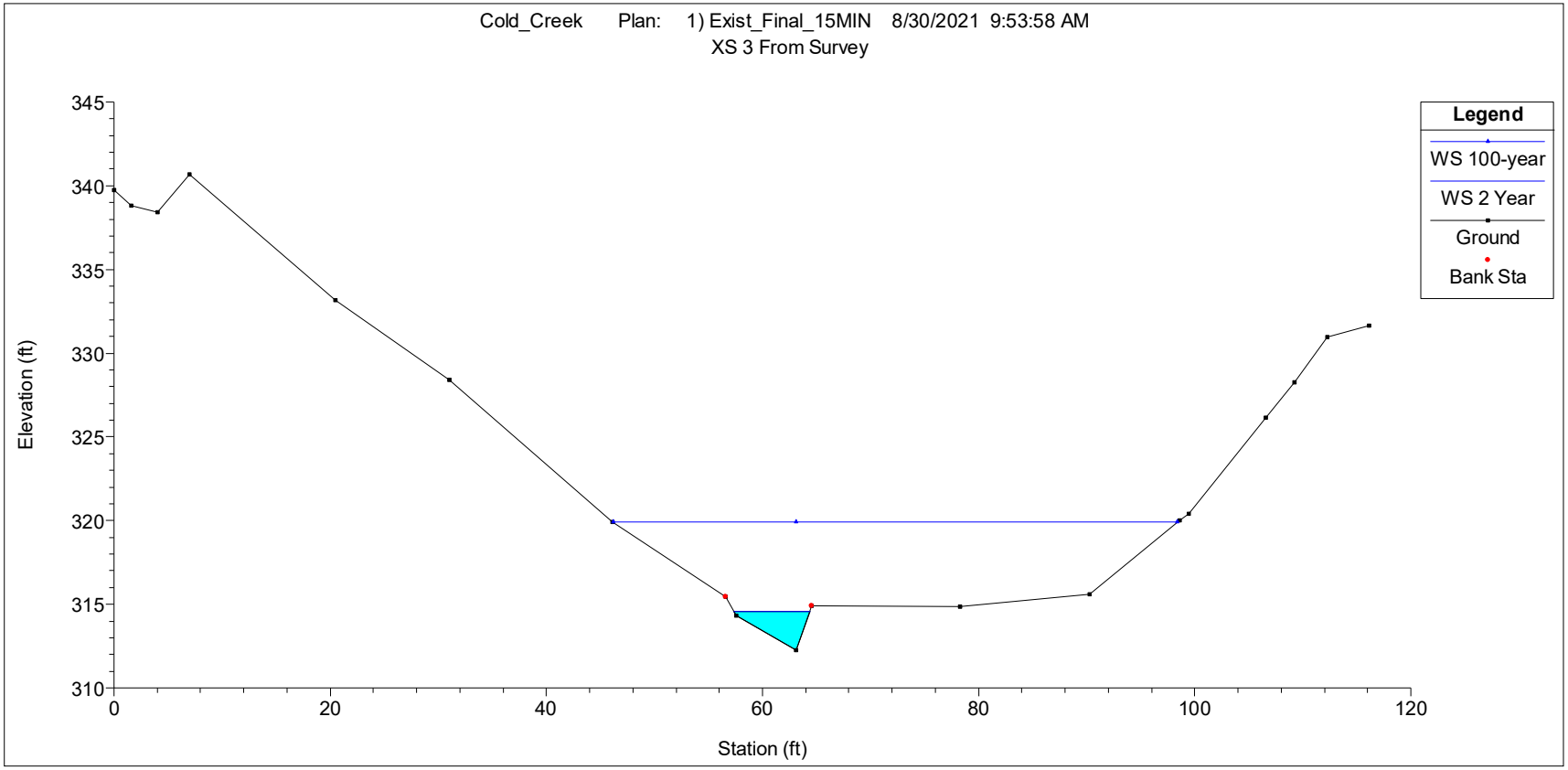
02207-017-00 Date Exported: October 2021

Cold Creek Hydraulic Model Results at Surveyed Cross Section

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-8



Station 5406

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS 5.0.7

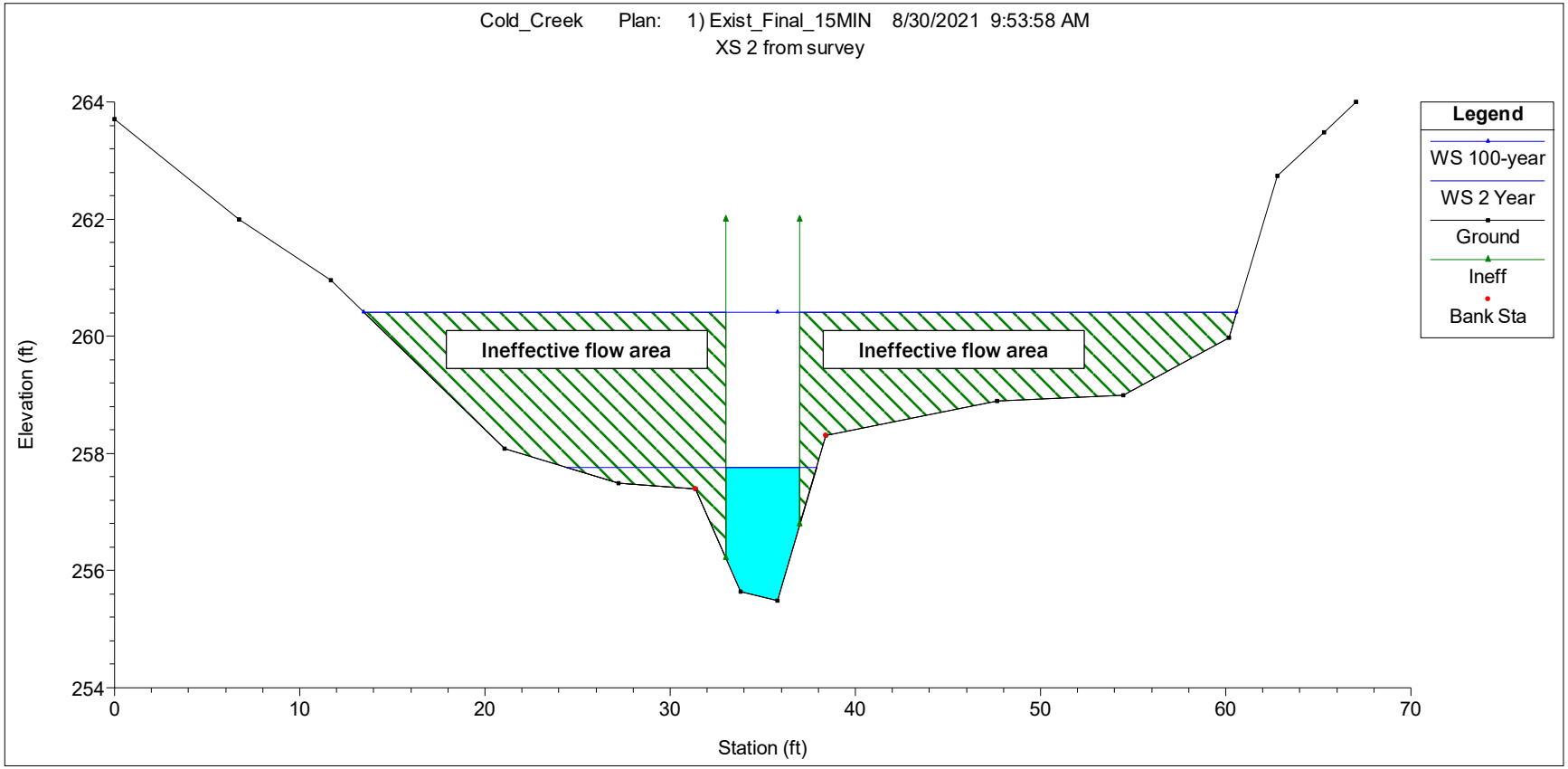
02207-017-00 Date Exported: October 2021

Cold Creek Hydraulic Model Results at Surveyed Cross Section

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-9



Station 4319

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS 5.0.7

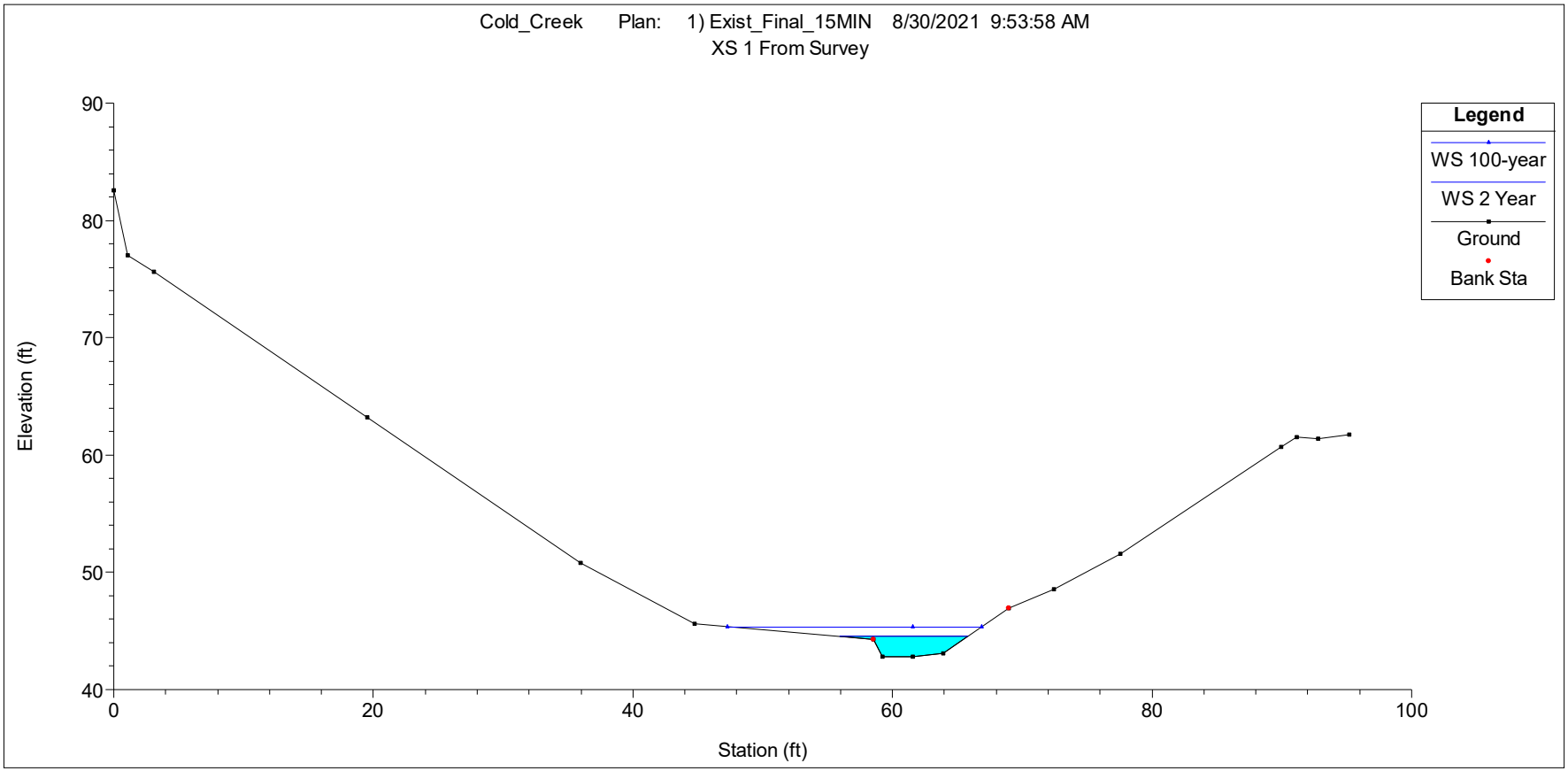
02207-017-00 Date Exported: October 2021

Cold Creek Hydraulic Model Results at Surveyed Cross Section

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-10



Station 1035

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: HEC-RAS 5.0.7

02207-017-00 Date Exported: October 2021

Cold Creek Hydraulic Model Results at Surveyed Cross Section

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-11

2-Year Reach Results

	Flow (cfs)	Average Channel Slope in Model (%)	Average Velocity (ft/s)	Average Max Channel Depth in Reach (ft)	Max Depth in Surveyed Cross Section (ft)	Overbank Flow in Surveyed XS?	Approximate velocity in overbank (ft/s)	Top of Bank to Top of Bank Channel Width in Surveyed XS (ft)	Number of Surveyed XS in Reach
Reach 1	30.5	6.3	3.5	1	0.8	No	NA	15	1
Reach 2	52.2	4.8	5	2.4	2.3	No	NA	7	1
Reach 3	52.2	4.3	4.5	2.2	2.3	No	NA	6	1
Reach 4	55.3	6	5	2.1	NA	NA	NA	NA	0
Reach 5	63.7	4.5	6	1.9	1.8	Yes	0.7	7	1

2-Year Culvert Results

	Flow (cfs)	Average Slope in Model (%)	Average Velocity Inside Culvert at upstream end	Average Velocity Inside of Culvert at Downstream End	Approximate Depth of Flow Through Culvert	Backwater (insignificant, minor, or significant)
Dash Point	30.5	5.7	6.5	11	1.2	insignificant
Pool Culvert	52.2	5.3	7.5	8	2.2	significant
Unampped Culvert	55.3	8.8	7	> 10	1	insignificant
Treatment Plant	63.7	7.1	6.5	10	1.2	minor

Notes:
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Data Source: HEC-RAS 5.0.7

2-Year Hydraulic Model Results

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-12

02207-017-00 Date Exported: October 2021

100-Year Reach Results

	Flow (cfs)	Average Channel Slope in Model (%)	Average Velocity (ft/s)	Average Max Channel Depth in Reach (ft)	Max Depth in Surveyed Cross Section (ft)	Overbank Flow in Surveyed XS?	Approximate velocity in overbank (ft/s)	Top of Bank to Top of Bank Channel Width in Surveyed XS (ft)	Number of Surveyed XS in Reach
Reach 1	102.4	6.3	5	3.2	7.3	Yes	0.2	15	1
Reach 2	176.1	4.8	7	2.4	7.7	Yes	0.6	7	1
Reach 3	176.1	4.3	8	3.2	4.9	Ineffective flow area	NA	6	1
Reach 4	185.3	6	7.5	4	NA	NA	NA	NA	0
Reach 5	214	4.5	8.5	3.5	2.6	Yes	2.7	7	1

100-Year Culvert Results

	Flow (cfs)	Average Slope in Model (%)	Average Velocity Inside Culvert at upstream end	Average Velocity Inside of Culvert at Downstream End	Approximate Depth of Flow Through Culvert	Backwater (insignificant, minor, or significant)
Dash Point	102.4	5.7	12	14	3	significant
Pool Culvert	176.1	5.3	8.5	8.5	Overtops	significant
Unampped Culvert	185.3	8.8	12.5	> 10	1.7	significant
Treatment Plant	214	7.1	10	>12	2.3	minor

Notes:
1. The locations of all features shown are approximate.
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Data Source: HEC-RAS 5.0.7

100-Year Hydraulic Model Results

Cold Creek
City of Federal Way, Washington

GeoEngineers

Figure D-13

02207-017-00 Date Exported: October 2021

APPENDIX E
Structural Assessment of Existing Culverts (Coffman Engineers)

COFFMAN ENGINEERS

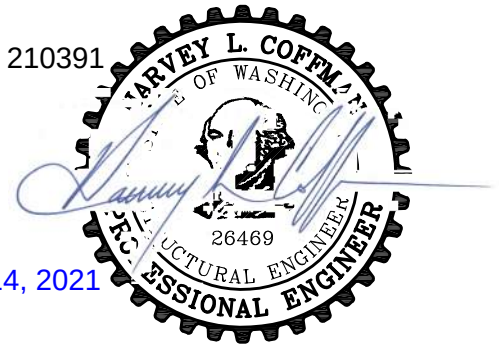
Date: July 14, 2021

Project: Subtask 2.7 – Structural Considerations - Structural Assessment of Existing Culverts Cold Cr. Culvert Replacement and Channel Stabilization Project

To: Morgan McArthur
Associate Geotechnical Engineer
GeoEngineers, Inc.
1101 Fawcett Ave, Suite 200
Tacoma, WA 98402

Project No.: 210391

From: Harvey Coffman, PE, SE



Memorandum

Summary:

Coffman Engineers, Inc. (Coffman) conducted a review of the existing culverts as described in the referenced subtask 2.7. A copy of this scope is provided in the reference documents at the end of this memo (reference document 6).

Project Understanding:

The goal of subtask 2.7 is to assess the structural condition of the existing culverts located within the Cold Creek Project at SR 509/Dash Point Road and under the Marine Hills Pool and Tennis Club property. See Site Map (reference document 1). Additionally, a structural safety assessment was provided on the Redondo Shores Drive South and Redondo Beach Drive South culverts, both owned by the City of Des Moines.

Observations:

On May 4, 2021 Harvey Coffman of Coffman Engineers conducted a site visit to observe the existing conditions of the culverts. The review of each culvert was conducted by visual inspections at inlets and outlets of each structure. Additionally, videos provided by the City of Federal Way were reviewed to assess culvert bores. See list of videos provided in the reference documents, at the end of this memo (reference document 3). Photos taken during the site assessment are provided in reference document 4. Culvert condition code definitions are provided in the Item 62 Culvert Condition Codes (referenced document 5).

SR 509/Dash Point Rd Crossing

The structural assessment of this culvert consisted of visual inspection from the inlet and outlet. The culvert is about 80 lineal feet. The length of the pipe was visible from the inlet. The inlet consisted of a steel grate over the opening of a 36" Ø Corrugated Metal Pipe, CMP. The pipe immediately connects to a manhole with a steel grate overflow weir inlet to accommodate high flows or relieve stream flow when the 36" Ø CMP inlet becomes overwhelmed during high flow events. See photos 1 and 2. The inlet pipe had about 18" of debris and gravel built up above

the pipe invert against the steel grate. The pipe is coated with a black asphalt coating. The sides of the pipe at mid height are missing this coating with a light buildup of surface corrosion. The invert in the 36" Ø CMP has a layer of sand and small gravel wash that remains from a previous flow. See photos 4 and 5.

The upstream channel has eroded embankments with little vegetation growth. The soil is a sandy gravel easily eroded.

The overflow weir structure is a 48" Ø concrete manhole. The weir appears to be in good condition with a moss layer covering the exterior. The interior bottom is covered with a thin layer of sands and gravel. See photo 3.

The manhole outflow pipe is a 42" Ø CMP. This pipe is also covered with the same black tar coating. The pipe is in generally good condition with minor damage to the coating on the front edge of the pipe. The bore of the 42" Ø CMP was straight and appears clean and free of debris or other damage. See photos 3, 4 and 5.

The 42" Ø CMP outlet is covered in vegetation (Ivy) and a large tree has fallen over top of the outlet but has not damaged the apron or restrict the water flow at this time. See photos 6 and 7. The outlet has a 9-foot-wide concrete apron with an 18" tall flow energy dissipation wall. The flow is hitting the wall with enough velocity to cause erosion of the embankments on both sides of the stream. The apron slab is also perched about 18" above the stream bed at the downstream face. The apron is exposed on all three sides with heavy riprap present. See photos 8 and 9.

Overall, the CMP pipes in this segment are in good condition with a culvert condition code rating of 7. No immediate structural repairs or concern were noted with the structural condition.

City of Federal Way Culverts under Marine Hills Pool/Tennis Club Facility and Access Road

The structural assessment of this culvert consisted of visual inspection from the inlets and outlets along with a review of culvert bore videos provide by the City of Federal Way. This culvert is about 1000 lineal feet with intermediate connecting manhole/catch basins throughout. The structure is referenced by five segments each with its own asset number listed in order of alignment beginning at the upstream end. They are Asset ID #'s; 19017, 21520, 19021, 21522 and 21523. See Exhibit 1 Map of Marine Hill Asset Numbers (referenced document 2).

1. <u>Asset # 19017</u>
   The first segment of the culvert is constructed of a 36" rectangular four-sided cast-in-place concrete box culvert. The inlet is covered with a steel grating and has a head wall on the righthand side. The head wall top is cut to fit a 12" Ø drainpipe. The wall has a substantial ¼" vertical crack adjacent to the pipe cutout. The upstream half of the wall is broken with ½" outward tilt into the stream. See photos 10 and 11. There was one video provided, dated March 30, 2021 (length of 4.82 minutes), which was reviewed for the internal culvert condition. This video demonstrated longitudinal cracks in the walls that appear to be related to concrete cold joints created at the time of construction. There are numerous spalls with exposed and lightly corroded reinforcement bars in the box ceiling. The culvert bottom slab is unreinforced concrete with exposed aggregate. This culvert may have originally been constructed as three sided and a bottom slab added after the walls were constructed. At about 8 feet in the from the inlet the concrete floor is broken up as there are pieces of concrete slabs/chunks present in the bore. See photo 12.

The outlet runs into an existing manhole/catch basin located adjacent to S. 302nd St. and was not accessed during the field review. There was contract equipment and materials staged in this area related to a neighborhood paving project that was active at the time of the site visit.

As a result of the bottom slab damage this portion of the culvert has a culvert condition code of 3 “severe” deterioration because of the broken bottom slab. The headwall damage is also in this category but is not deemed as significant to the culvert function.

2. Asset # 21520

This segment of the culvert is also constructed of a 36” rectangular four-sided cast-in-place concrete box culvert (approximately 60 to 70 lineal feet) with similar properties to the previous segment. This segment is enclosed by manholes at both ends therefore, the assessment was made by reviewing the two videos provided by the City of Federal Way. The bore was not accessed during the site visit. The first video is dated November 9, 2011 (5.92 minutes) and a second video dated March 30, 2021 (2.55 minutes).

Both videos show significant debris blocking the bore. See photos 13 and 14. The first video from an upstream approach locates the debris at about 13.4 feet into the bore. The second video approaches from the downstream side. The ROV is stopped at about 27.2 feet into the bore as the bottom slab is broken up and is missing for up to 15 feet. A sizable pool of water remains in the eroded bottom slab and was unpassable by the ROV. Video shows the debris is located another 20 to 30 feet up the bore from this side. The bottom slab is unreinforced and has broken up with at least two large pieces jammed into the bore ceiling with further debris stacked in behind it. There are longitudinal cracks in bore walls that appear to be from cold joints created during culvert construction.

As a result of the bottom slab damage, this portion of the culvert has a culvert condition rating of 2 “failed” because of the broken bottom slab and the partially plugged bore reducing the flow capacity.

3. Asset # 19021

This segment of the culvert is constructed of 36” Ø Galvanized CMP with a length of about 408 lineal feet. This segment is enclosed by manholes at both ends. Therefore, the assessment was made by reviewing two videos. The bore was not accessed during the site visit. This segment has two videos provided by the City of Federal Way dated Nov. 9, 2011 (length 6.73 minutes) and August 8, 2014 (length 14.8 minutes).

The bottom 1/3 of the CMP is severely corroded over the entire length with more than 50% of the section nonexistent. The remaining portions of the corrugation ribs are twisted and torn. Gravel is visible thru the corrosion holes and is washing with water flows. See photo 15.

The last 23 lineal feet of the pipe have concrete repair to the invert which covers the center ¼ of the pipe. See photo 16. Surface corrosion extends up the side to nearly halfway.

A 2-foot drop exits into the downstream manhole. See photo 19.

As a result of the corrosion severity of the invert this portion of the culvert has a culvert condition rating of 3 “severe”. However, the condition assessment could easily be set at 2 “failed”. The distinction between these two condition code levels is a lack of evidence of settlement because of the open and unprotected soils at the bottom of the culvert or that the bore of the pipe has not begun to crush. There is likely very little bottom and lateral support of the CMP. In this condition, the next event could cause unwanted further damage.

4. Asset # 21522
This segment of the culvert is constructed of 36” Ø Galvanized CMP with two legs one of approximately 193 lineal feet and a second of approximately 45 lineal feet for a total length of 238 lineal feet. These segments are enclosed by manholes at all ends. Therefore, the assessment was made by reviewing three videos. The bore was not accessed during the site visit. This segment has three videos provided by the City of Federal Way. The videos of the first two segment are dated Nov. 9, 2011 (length 9.12 and 4.99 minutes). The third video is dated August 11, 2014 (length 19.07) covering the entire length of both segments.

   There are areas of damage to the crown that is displayed in each of the videos. The first damage occurs between 20 to 45 feet into first the segment. See photo 20. The crown is crushed in about 12 inches. At 40 feet into the first segment of the culvert, there is heavy damage and a hole torn into the crown. See photos 21 and 22. It looks like an excavator dug into and tore the CMP. The damage is unrepaired and looks to have been covered with additional sheet metal. Dirt and boulders are visible thru the opening around the perimeter of the torn hole.

   The bottom 1/3 of the pipe of the CMP is severely corroded over the entire length. The bottom invert has been covered with a cast-in-place concrete layer over the entire length. The bottom of the CMP is not visible. Surface corrosion is visible above the concrete on both wall sides of the CMP invert. In spots the corrosion outside of the concrete repair show holes thru with 100% section loss. It is suspected the bottom of this CMP is corroded as severely as the previous segments.

   The video identifies a manhole not shown in the Exhibit 1 map at approximately 193 feet downstream of the inlet (parking lot manhole) located under the pool deck area.

   As a result of the severity of the damage to the CMP crown this portion of the culvert has a culvert condition rating of 2 “failed”. However, the bottom of the culvert is covered by concrete so the severity of the corrosion cannot be ascertained. The corrosion is visible at the edges of the concrete and suspected to be as severe as the previous segment.

5. Asset # 21523
This segment of the culvert is constructed of 42” Ø Galvanized CMP with an unknown length but relatively short (~50 lineal feet). This segment is enclosed by a manhole at the inlet and is open to the creek channel at the outlet. The entire length of the culvert can be seen thru the outlet. See photos 26 and 27.
The CMP is in good condition with light surface corrosion on the invert. The assessment this segment is rated at a culvert condition code of 7.

City of Des Moines Redondo Shore Dr. So. Crossing

This culvert is within the city of Des Moines and was reviewed for a structural safety inspection only. The inspection consisted of a visual assessment looking through each end of the CMP. The culvert is a 48" Ø Galvanized CMP pipe. It is about 30 lineal feet long. The bore and alignment are straight. There is light corrosion in the bottom 1/3 of the bore. The stream makes a hard turn at the entrance to the inlet of about 20 degrees. The left-hand side of the embankment is the bottom of a built-up stacked boulder wall. The driveway over the culvert was new asphalt indicting there may have been some over topping or washing of the roadway recently. The outlet pipe is squished vertically to about 30" wide at mid-height. See photos 28 to 30. No significant structural deficiencies were noted.

City of Des Moines Redondo Beach Dr. So. Crossing

This culvert is owned by the city of Des Moines and was reviewed for a structural safety inspection only. The inspection consisted of a visual assessment looking through each end of the box culvert. The culvert is made up of cast-in-place concrete three-sided box (a bottom slab was not visible at the time of the inspection) with a span of 5'-0" and overall length of 30 lineal feet. See photos 31 and 32. The roadway consists of two travel lanes, 5'-6" sidewalk on the eastside and a 19" curb on the westside (bay side). The outlet is covered by a bulkhead that extends below the slab soffit by 18". This leaves about 12" to the stream bed. This material is beach sand and is highly transportable. The inlet water surface elevation at the time of the inspection was located 50" below the top of curb/sidewalk providing a vertical opening of 38". No significant structural deficiencies were noted.

Conclusion:

The overall assessment of the SR 509 and the City of Des Moines culverts is they are in good condition with no structural deficiencies noted.

The City of Federal Way culvert under the Marine Hill Pool and Tennis Club facility and access road is in "Poor" condition with many portions in severe or failed condition as defined in this review. For this reason, the culvert should be considered for replacement. A summary of the critical findings is listed the following table.

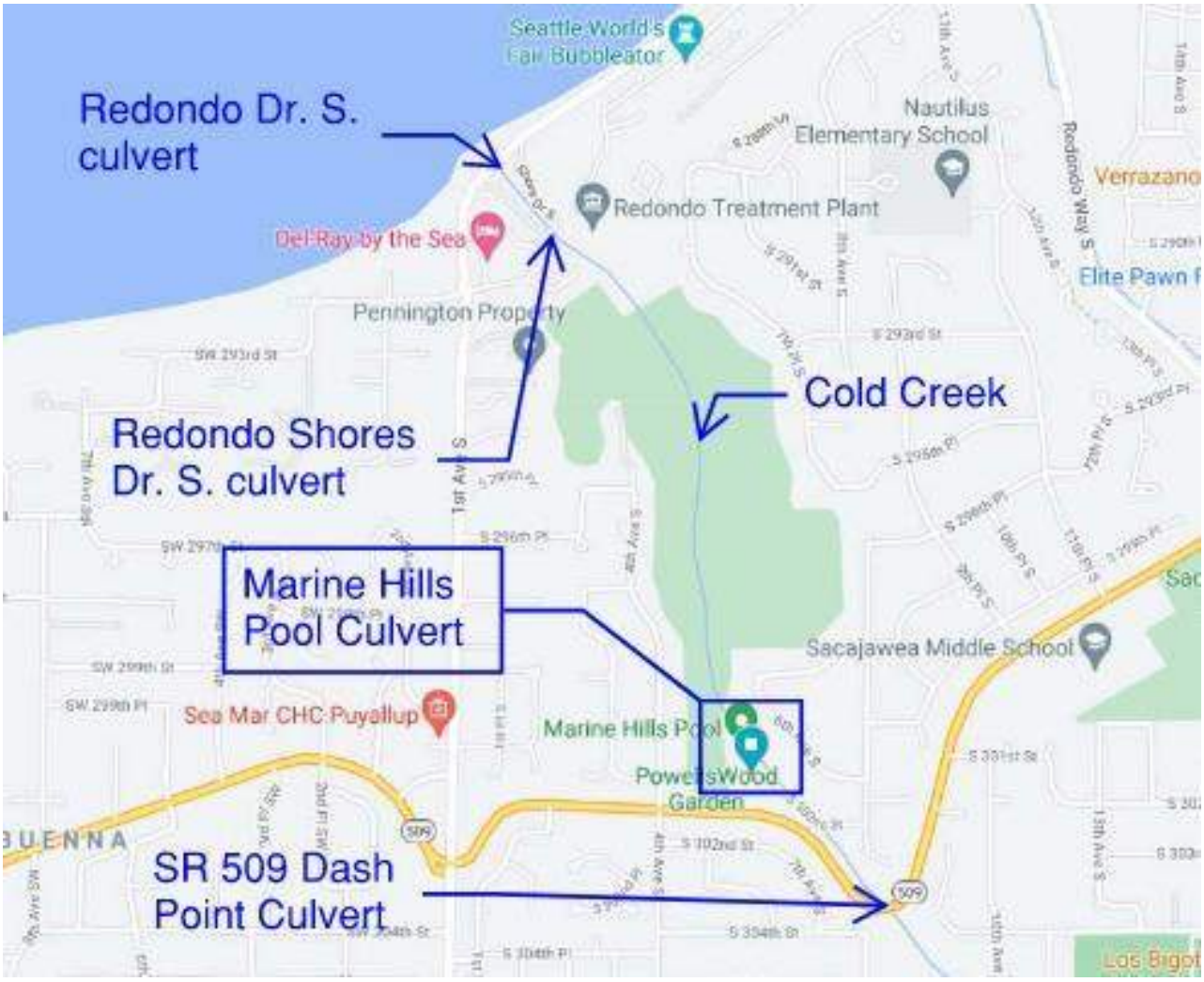
Asset	Observation	Condition Code
SR 509/Dash Point Rd	Good Condition with minor surface corrosion.	7
#19017	Bottom slab broken up and other minor defects.	3
#21520	Broken bottom slab and the partially plugged bore reducing the flow capacity. The bottom slab is unreinforced and has broken up with at least two large pieces jammed into the bore ceiling with further debris stacked in behind it.	2
#19021	Severe corrosion and substantial section loss of the CMP invert.	3

#21522	Severe damage to the CMP crown and severe corrosion of the bottom of the culvert with substantial section loss.	2
#21523	CMP is in good condition with light surface corrosion on the invert.	7
Redondo Shore Dr. So. Crossing	No significant structural deficiencies noted.	Structural Safety Inspection
Redondo Beach Dr. So. Crossing	No significant structural deficiencies noted.	Structural Safety Inspection

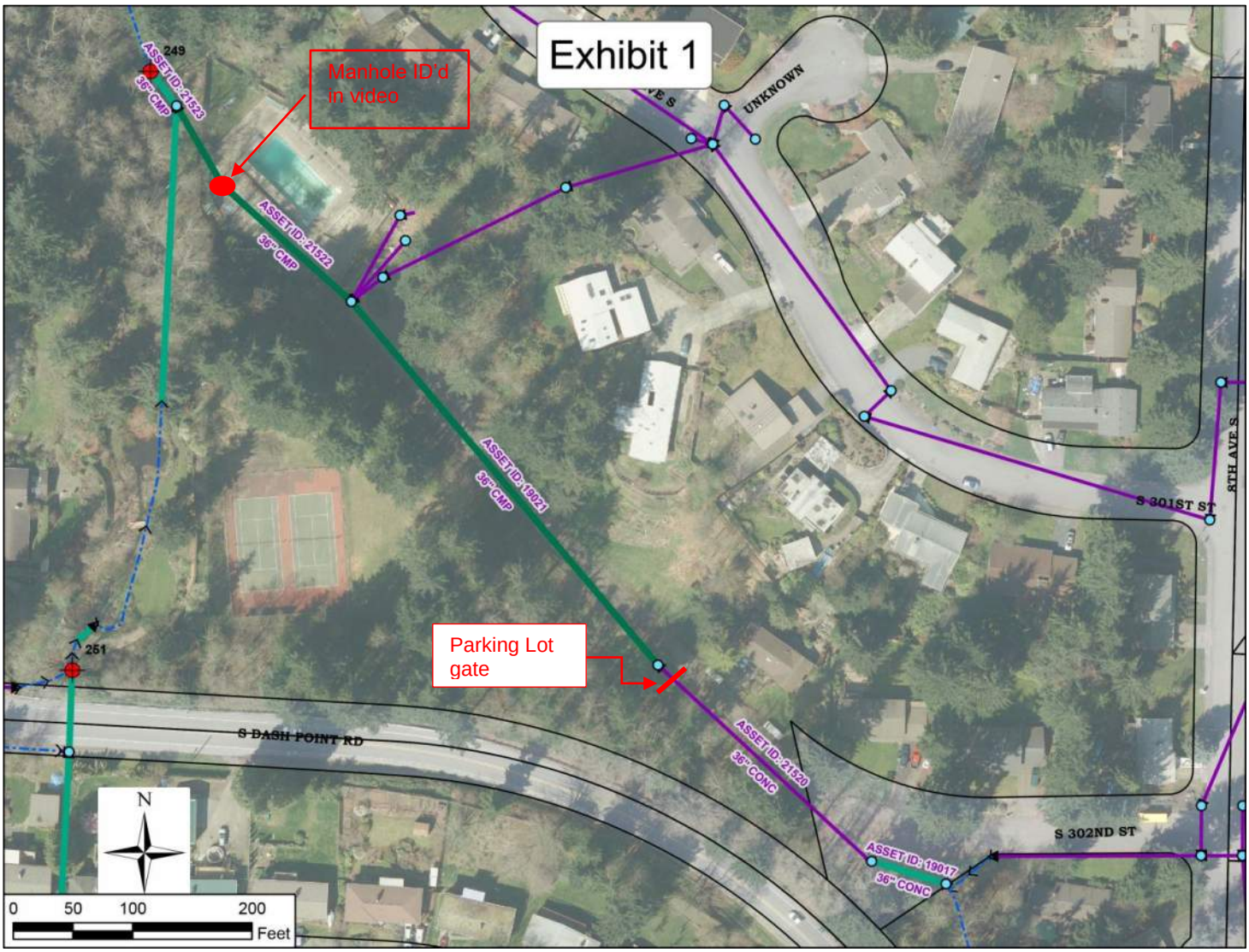
Reference Documents:

1. Site Map
2. Exhibit 1 Map Marine Hill Asset ID Numbers
3. Videos
    - Cold Creek Marine Hills Closed Conveyance-Pipe#19017 Against Flow MAR 30 2021
    - Cold Creek Marine Hills Closed Conveyance-Pipe#21520 With Flow MAR 30 2021
    - 2011_11_09_Asset_21520
    - 2011_11_09_Asset_19021
    - 2014-08-11_Asset_19021
    - 2011_11_09_Asset_21522
    - 2011_11_09_Asset_21522-2
    - 2014-08-11_Asset_21522
4. Photos
5. Item 62 Culvert Condition Code Definition
6. Project Scope Subtask 2.7

1. Site Map


Redondo Dr. S. culvert
Redondo Shores Dr. S. culvert
Marine Hills Pool Culvert
SR 509 Dash Point Culvert
Cold Creek
Seattle World's Fair Bubbleator
Nautilus Elementary School
Redondo Treatment Plant
Del Ray by the Sea
Pennington Property
Sacajawea Middle School
Sea Mar CHC Puyallup
Marine Hills Pool
Powell's Wood Garden
Redondo Way S
Verrazano
Elite Pawn
SW 293rd St
S 293rd St
SW 299th St
SW 299th Pl
S 331st St
S 302nd St
S 304th St
S 304th Pl
1st Ave S
4th Ave S
7th Ave S
509

2. Exhibit 1 Map Marine Hill Asset ID Numbers



3. Videos File Names

- 2011_11_09_Asset_19021.mpg
- 2011_11_09_Asset_21520.mpg
- 2011_11_09_Asset_21522.mpg
- 2011_11_09_Asset_21522-2.mpg
- 2014-08-11_Asset_19021.mpg
- 2014-08-11_Asset_21522.mpg
- Cold Creek Marine Hills Closed Conveyance-Pipe#19017 Against Flow MAR 30 2021.mpg
- Cold Creek Marine Hills Closed Conveyance-Pipe#21520 With Flow MAR 30 2021.mpg

4. Photos

Photo 1 SR 509 36" CMP inlet and steel grate. Stream bed is filled in ~18 inches above CMP invert.

Photo 2 SR 509 overflow inlet weir.

Photo 3 SR 509 View inside overflow weir and 42" CMP out flow.

Photo 4 SR 509 View looking thru 36” CMP at inlet of 42" CMP.

Photo 5 SR 509 View inside 36" CMP inlet looking at/thru 42" CMP.

Photo 6 SR 509 Tree fallen over outlet.

Photo 7 SR 509 42" CMP outlet.

Photo 8 SR 509 Outlet slab perched end.

Photo 9 SR 509 perched outlet slab and flow dissipater wall.

Photo 10 Marine Hills ID 19017 Inlet and steel grate cover.

Photo 11 Marine Hills ID 19017 Headwall at inlet.

Photo 12 Marine Hills ID # 19017 Inlet Bore bottom slab broken pieces.

Photo 13 Asset ID # 21520 Broken bottom slab concrete stuck in bore looking upstream at 7.9 feet.

Photo 14 Asset ID # 21520 Broken bottom slab concrete stuck in bore.

Photo 15 Typical heavy corrosion in CMP invert. Note the holes in the invert.

Photo 16 Typical concrete bottom liner for corrosion repair in CMP.

Photo 17 Asset ID 19021 looking west from inlet (adjacent to pool gate) along alignment towards pool and segment outlet.

Photo 18 Asset ID 19021 to 21522 catch basin structure in pool west end of parking lot.

Photo 19 Asset # 19021 spring line drop into outlet manhole, approx. 2-foot drop.

Photo 20 Asset ID # 21522 crushed CMP crown at ~22 feet.

Photo 21 Asset # 21522 Crown damage at 35 feet. Hole torn in crown.

Photo 22 Asset # 21522 closeup of torn hole and debris.

Photo 23 Catch basin/inlet between Asset ID # 21522 and ID # 21523 west of pool.

Photo 24 Asset ID # 21522 outlet CMP at manhole between Asset ID # 21522 and ID # 21523.

Photo 25 Outlet of Asset ID # 21522 between Asset ID # 21522 and ID # 21523. CMP Concrete Repair of Invert.

Photo 26 Outlet Asset ID 21523.

Photo 27 Outlet Asset ID 21523 corrosion at invert.

Photo 28 Redondo Shores Dr. S. inlet covered by vegetation.

Photo 29 Redondo Shores Dr. S. inlet and CMP bore.

Photo 30 Redondo Shores Dr. S. outlet.

Photo 31 Redondo Beach Dr. looking NE. culvert location before crosswalk.

Photo 32 Redondo Beach Dr. S. inlet and bore.

5. Item 62 Culvert Condition Code Definition
(FHWA Recording and Codding Guide for the Structural Inventory of the Nation's Bridges)

Item 62 - Culverts 1 digit

This item evaluates the alignment, settlement, joints, structural condition, scour, and other items associated with culverts. The rating code is intended to be an overall condition evaluation of the culvert. Integral wingwalls to the first construction or expansion joint shall be included in the evaluation. For a detailed discussion regarding the inspection and rating of culverts, consult Report No. FHWA-IP-86-2, Culvert Inspection Manual, July 1986.

Item 58 - Deck, Item 59 - Superstructure, and Item 60 - Substructure shall be coded N for all culverts.

Rate and code the condition in accordance with the previously described general condition ratings and the following descriptive codes:

Code	Description
N	Not applicable. Use if structure is not a culvert.
9	No deficiencies.
8	No noticeable or noteworthy deficiencies which affect the condition of the culvert. Insignificant scrape marks caused by drift.
7	Shrinkage cracks, light scaling, and insignificant spalling which does not expose reinforcing steel. Insignificant damage caused by drift with no misalignment and not requiring corrective action. Some minor scouring has occurred near curtain walls, wingwalls, or pipes. Metal culverts have a smooth symmetrical curvature with superficial corrosion and no pitting.
6	Deterioration or initial disintegration, minor chloride contamination, cracking with some leaching, or spalls on concrete or masonry walls and slabs. Local minor scouring at curtain walls, wingwalls, or pipes. Metal culverts have a smooth curvature, non-symmetrical shape, significant corrosion or moderate pitting.
5	Moderate to major deterioration or disintegration, extensive cracking and leaching, or spalls on concrete or masonry walls and slabs. Minor settlement or misalignment. Noticeable scouring or erosion at curtain walls, wingwalls, or pipes. Metal culverts have significant distortion and deflection in one section, significant corrosion or deep pitting.
4	Large spalls, heavy scaling, wide cracks, considerable efflorescence, or opened construction joint permitting loss of backfill. Considerable settlement or misalignment. Considerable scouring or erosion at curtain walls, wingwalls or pipes. Metal culverts have significant distortion and deflection throughout, extensive corrosion or deep pitting.

(codes continued on the next page)

Item 62 - Culverts (cont'd)

3 Any condition described in Code 4 but which is excessive in scope. Severe movement or differential settlement of the segments, or loss of fill. Holes may exist in walls or slabs. Integral wingwalls nearly severed from culvert. Severe scour or erosion at curtain walls, wingwalls or pipes. Metal culverts have extreme distortion and deflection in one section, extensive corrosion, or deep pitting with scattered perforations.

2 Integral wingwalls collapsed, severe settlement of roadway due to loss of fill. Section of culvert may have failed and can no longer support embankment. Complete undermining at curtain walls and pipes. Corrective action required to maintain traffic. Metal culverts have extreme distortion and deflection throughout with extensive perforations due to corrosion.

1 Bridge closed. Corrective action may put back in light service.

0 Bridge closed. Replacement necessary.

Item 63 - Method Used to Determine Operating Rating 1 digit

Use one of the codes below to indicate which load rating method was used to determine the Operating Rating coded in Item 64 for this structure.

Code	Description
1	Load Factor (LF)
2	Allowable Stress (AS)
3	Load and Resistance Factor (LRFR)
4	Load Testing
5	No rating analysis performed

6. Project Scope Subtask 2.7 (excerpted from Prime agreement)

Scope of Work

Task 2.7 – Structural Assessment

This subtask will be performed by Coffman Engineers. GeoEngineers will support Coffman Engineers to complete the following:

- Coffman will review video scope provided by City for SR 509 and Marine Hills Pool to develop basis of structure condition.
- A site visit to inspect the conditions of the structures (SR 509, Marine Hills Pool, Shore Dr. S., and Redondo Beach Dr. S.) and develop understanding of structure type and general assessment. The inspection team will collect structural assessment information thru visual review as feasible without the use of exploratory devices.
- Structural assessment of three culverts/culvert systems identified in the reach. These culvert systems include:
    - (1) SR 509/Dash Point Rd,
    - (2) S 302nd St/Marine View Swim & Tennis Club, and
    - (3) Redondo Shores Dr S.

The structure at Redondo Beach Dr. S. will receive a safety review.

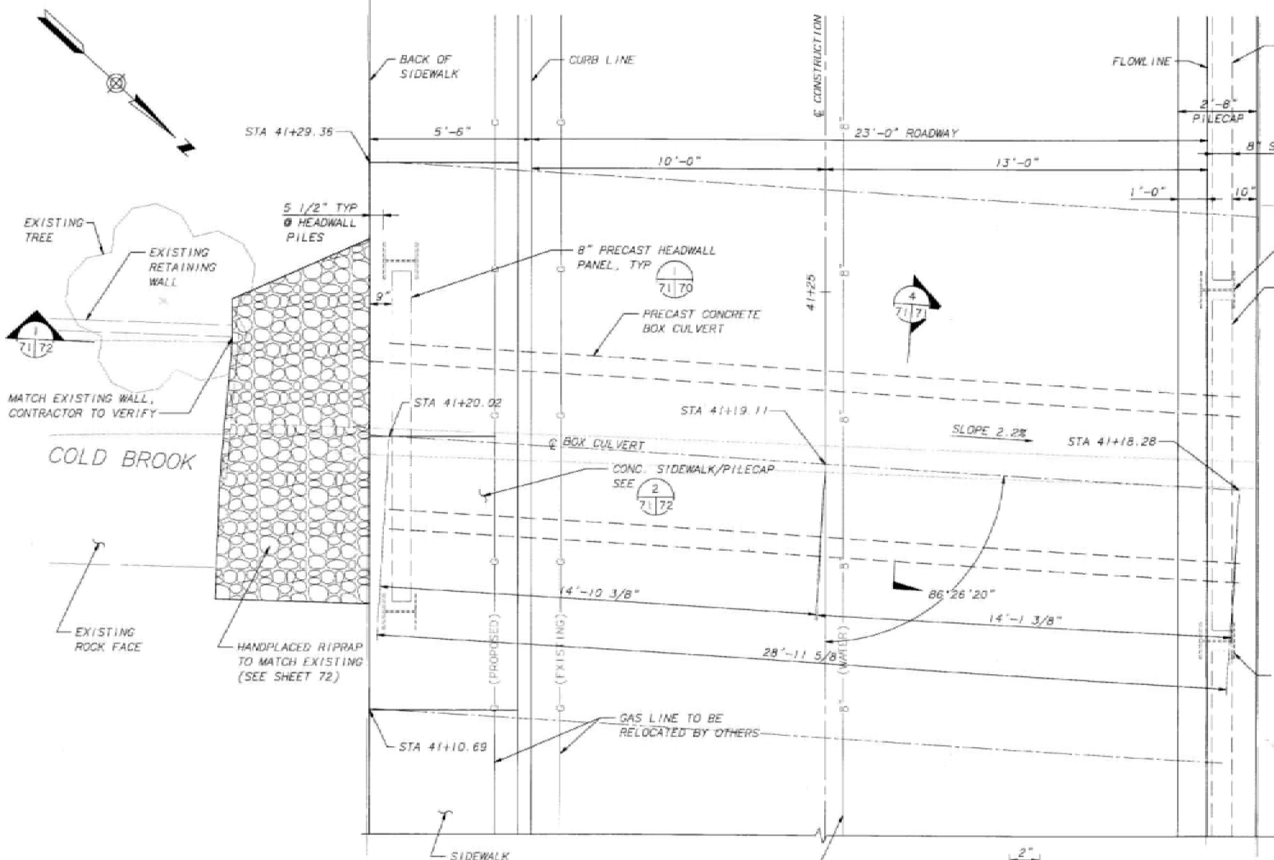
Assumptions

- Based off previous conversations with the City of Federal Way, no existing information regarding the structures are available for review. We anticipate (1) site visit to observe the structures and perform a condition assessment.
- The condition assessment will not include any determination of culvert alignment.

Deliverables

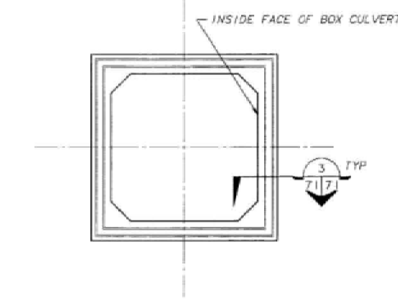
- Draft and Final Structural Assessment Memorandum outlining the observed condition of each culvert system.

APPENDIX F
As-Built Reports



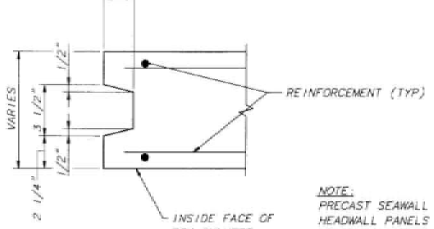
CONTRACTOR SHALL FIELD VERIFY WATERLINE HORIZONTAL & VERTICAL LOCATION WITHIN THE WORK AREA NECESSARY FOR BOX CULVERT CONSTRUCTION PRIOR TO PERFORMING ANY WORK IN THIS AREA. WATER LINE DOES BEND DOWN TO GO UNDER EXISTING 36" CULVERT EXACT LOCATION OF BENDS IS NOT KNOWN COORDINATE WITH LAKE HAVEN UTILITY DISTRICT.

1 / 71 71 PLAN – BOX CULVERT @ COLD BROOK
SCALE: N.T.S.



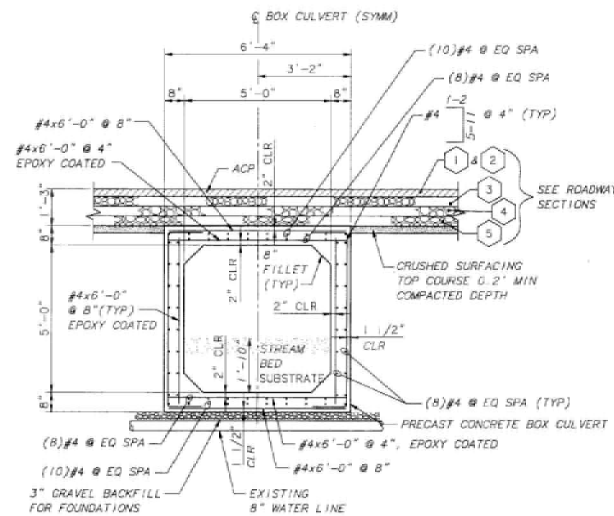
NOTE:
SHEAR KEYS REQ'D AT JOINTS BETWEEN BOX CULVERT AND SEAWALL PANEL, BETWEEN BOX CULVERT AND HEADWALL PANEL, AND BETWEEN ADJACENT PRECAST BOX CULVERT SECTIONS. PRECAST BOX CULVERT AND PRECAST PANELS SHALL BE MATCH CAST IN THE PLANT TO ASSURE TIGHT JOINTS DURING PLACEMENT IN THE FIELD.

2 / 71 ? SECTION – SHEAR KEY LOCATION
SCALE: N.T.S.



NOTE:
PRECAST SEAWALL & HEADWALL PANELS SHALL NOT BE INDENTED AT SHEAR KEYS

3 / 71 71 SECTION – SHEAR KEY
SCALE: N.T.S.



4 / 71 71 SECTION – TYPICAL BOX CULVERT (PRECAST)
SCALE: N.T.S.

NOTE:
LENGTH OF PRECAST CONCRETE BOX CULVERT SECTIONS ARE AT THE DISCRETION OF THE CONTRACTOR. MINIMUM LENGTH = 6'-0".

CALL 2 DAYS BEFORE YOU DIG
1-800-424-5555
(UNDERGROUND UTILITY LOCATIONS ARE APPROX)

FIELD BOOK:		
SURVEYED:		
SURVEY BASE MAP:		
DESIGN ENTERED:	RGP	4/19
DESIGNED	TM	4/19
CHECKED:	BEG	4/19
		DATE

REVISION	BY	DATE

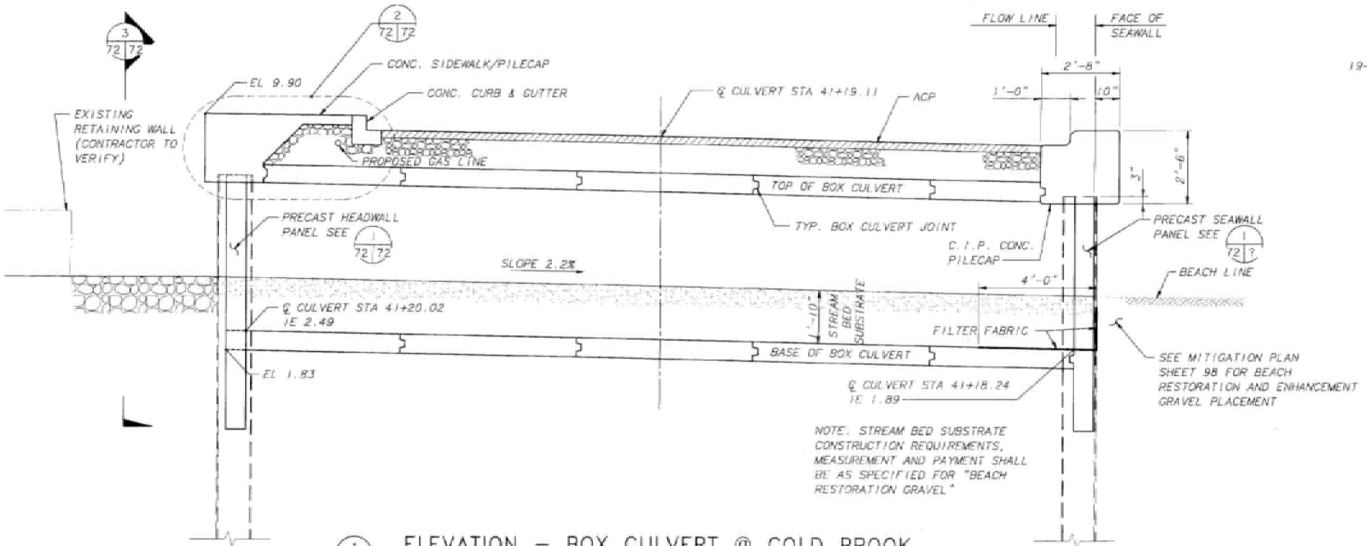
BERGER/ABAM ENGINEERS INC.

FED. AID No.
PROJECT No. 501288
SURVEY No. 5-21-4-51
MAINTENANCE DIVISION No. 5

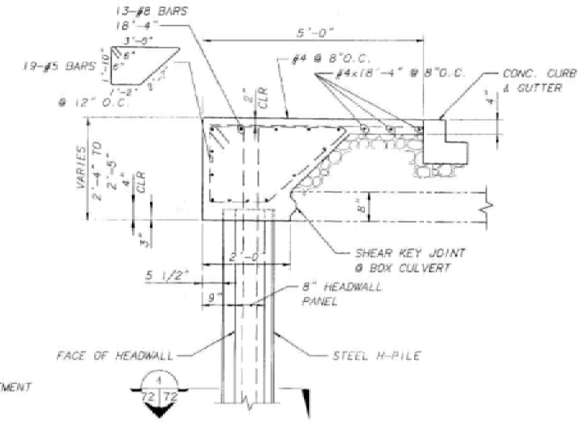
KING COUNTY DEPT OF TRANSPORTATION
PAUL TOLIVER, DIRECTOR
REDONDO SEAWALL
BOX CULVERT PLAN

SHEET 71 OF 98 SHEETS

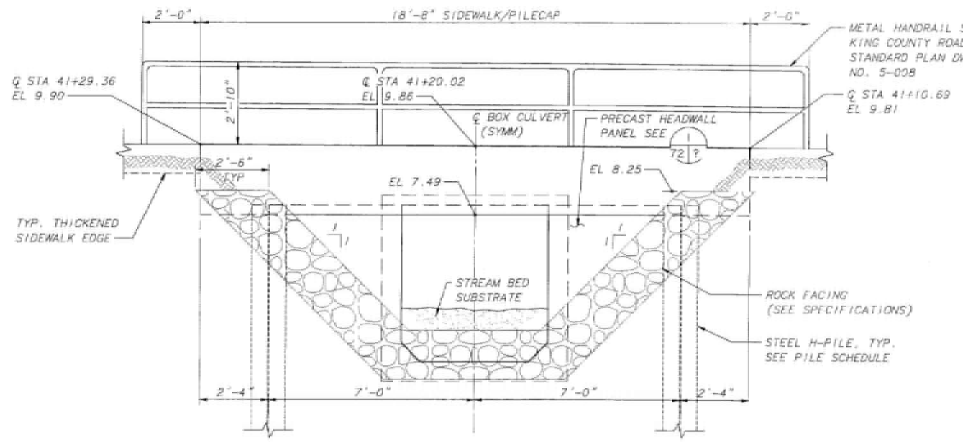
306-86 (71)



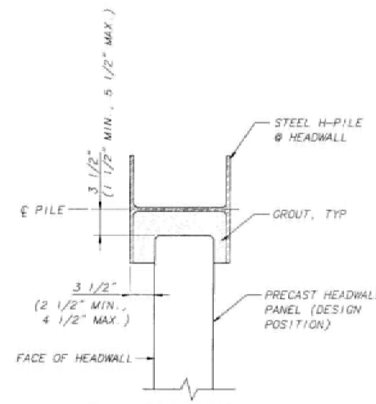
ELEVATION – BOX CULVERT @ COLD BROOK
SCALE: 1/2"=1'-0"



SECTION – SIDEWALK/PILECAP
SCALE: 3/4"=1'-0"



ELEVATION – NEAR BOX CULVERT HEADWALL
SCALE: N.T.S.



SECTION
SCALE: 1 1/2"=1'-0"

CALL 2 DAYS BEFORE YOU DIG 1-800-424-5555
(UNDERGROUND UTILITY LOCATIONS ARE APPROX)

			REVISION	BY	DATE
FIELD BOOK:					
SURVEYED:					
SURVEY BASE MAP:					
DESIGN ENTERED:	RGP	4/19			
DESIGNED:	CLP	4/19			
CHECKED:		4/19			
	DATE				

BERGER/ABAM ENGINEERS INC.

FED. AID No.
PROJECT No. 501288
SURVEY No. 5-21-4-51
MAINTENANCE DIVISION No. 5

KING COUNTY DEPT OF TRANSPORTATION
PAUL TOLIVER, DIRECTOR

REDONDO SEAWALL
BOX CULVERT DETAILS

SHEET 72 OF 98 SHEETS

306-86 (72)


24" Gravity
24 Cast Iron Mech Jt.
CONST BK 2 PG 15
CONST BK 1, PG 7
24 Gravity Sewer Pipe
CONST BK 2 PG 9, 10
Approximate Restored Grade
CREEK
Filled
SPECIAL BEDDING GRAVEL
CREEK CROSSING
66 LF 24" C.I. Pipe
Class 100 M.J. &
16 LF of Pipe Encasement
10 Ton Rip Rap
10 LF of Pipe Encasement
POINT - LIMIT OF CONTRACT
MH A-1
MH A-2
MH A-3
MH A-4
MH A-5
MH A-6
MH A-7
MH A-8
PLAN
MH A-1
Scale: None
Limit
Future 12"
Future 24"
Temporary backing
S.E. COR. GOV. LOT 4
SEC. 5-22-4
N 0° 38' 06" E
265.01'
TREATMENT PLANT SITE
CONTRACT Nº V
Limit of Contract I
ABANDONED 5-62
MARY HELMICK
MARINE HILLS CO. INCORP.
5440576
VOL 4287 P. 483
5399193
VOL 4252 P 56
EXISTING 12 A.C.
EXISTING 6 A.C.
NOTE: CONTOURS SHOWN ABOVE REPRESENT TOPOGRAPHY PRIOR TO CONSTRUCTION.
AS BUILT
BY: J.C.
DATE 11-9-62
UNITED CONCRETE SEWER PIPE INSTALLED EXCEPT FOR C.I.
7-10-15 JPS 1. ADDED SHEET REFERENCE PER RSL 4-1-15
DATE INITIAL REVISION
HILL & INGMAN
CONSULTING ENGINEERS
SEATTLE, WASHINGTON
SEWER PLAN & PROFILE
U.L.I.D. NO. 2
LAKEHAVEN SEWER DISTRICT
APPROVED DATE
12/7/61
SCALES: HORIZONTAL 1" = 50' VERTICAL 1" = 10'
PROJ. No. 4189-6-2
FILE No.
DWG. No.
A-1
LAKEHAVEN DOES NOT VERIFY, NOR IS RESPONSIBLE FOR, THE ACCURACY OF THESE DRAWINGS.
SCALE IN FEET
PROFILE
SURVEYED
PLOTTED
GRADES CHECKED
STRUCTURE NOTAT'NS CH'KD
PLAN
SURVEYED
PLOTTED
ALIGNMENT CHECKED
RT. OF WAY CHECKED
122

24" Gravity Sewer Pipe
CONST. BK. 1, PG. 23

24" Cast Iron CL 100
24" Pressure Pipe (Cylinder) CL 100
CONST. BK. 2, PP. 11, 13, 14

24" Pressure Pipe (Cylinder) CL 100
18" Cast Iron CL 100
CONST. BK. 2, PG. 5
18" Pressure Pipe (Cylinder) CL 100
CONST. BK. 2, PG. 1, 310.9

Approximate Restored Grade

MH A-8 ▲POINT 164.0
MH A-9 158.25
210.24' S=0.08918
MH A-10 RIM=191.45 I.E.=177.15
46.18' S=0.17900
MH A-10A RIM=195.54 I.E.=185.42
228.10' S=0.08308
MH A-11 RIM=211.27 I.E.=204.37
170.30' S=0.11309
MH A-12 RIM=228.01 I.E.=218.71
116.58' S=0.21351
RIM=229.37 I.E.=222.25
294.82' S=0.02625
MH A-13 ▲POINT 237.0
RIM=237.09 I.E.=229.99
MH A-15 314.0
173.7' S=0.01007
18" 301.75'
308.50
1/16 BEND 277.00
145'
MH A-14 254.8
SEE DETAIL SH. A-2A
239.9
47'
1/16 BEND 251.60
248.00
1/16 BEND 240.00
1/32 BEND 238.30
35'
1/8 BEND 231.87
VERT DEFL. 1° PER 18'
RIM=237.09 I.E.=229.99

8x6 REDUCER
80.6' 8" PVC S=3.0%

NOTE:
MH INSTALLED UNDER SIDE SEWER
PERMIT # 21679
4-14-95 / TKS

Existing 12"AC.
Existing 6"AC.

WATER INTAKE WATER DISTRICT Nº56

WATER DISTRICT Nº 56

MARINE HILLS CO. INCORP.

MH A-15 — 18" — MH A-16 — A-3

MH A-14A

MH A-14 — A-2A — CREEK

5393821 VOL 4247 P 375

5420774 VOL 4270 P 447

5399193 VOL 4252 P 56

5401782 VOL 4254 P 166

MH A-8 — A-1

MH A-9 N 26543.04 E 29535.03

MH A-10 N 26499.31 E 29520.19

MH A-10A N 26271.38 E 29529.06

MH A-11 N 26145.31 E 29536.71

MH A-12 N 26128.82 E 29538.39

MH A-13 N 25851.08 E 29637.29

NOTE: CONTOURS SHOWN ABOVE REPRESENT TOPOGRAPHY PRIOR TO CONSTRUCTION.

AS BUILT
BY J.C.
CK'D [illegible]
DATE 11-14-62

NOTE: ⚠ AS-BUILT REVISED MAY 17, 1982 PER LAKEHAVEN SEWER DISTRICT'S REQUEST. -BLH-

UNITED CONCRETE SEWER PIPE INSTALLED EXCEPT FOR C.I.

4th AVE. S.

DATE	INITIAL	REVISION
4-95	RGL	ADDED FIELD MEASURED FOOTAGE

SEWER PLAN & PROFILE
U.L.I.D. NO. 2

HILL & INGMAN
CONSULTING ENGINEERS
SEATTLE, WASHINGTON

APPROVED — DATE
HILL & INGMAN
12/7/61
CITY PROJ. ENGR.
P.D.U. ENGR.

LAKEHAVEN SEWER DISTRICT

SCALES: HORIZONTAL 1"=50' VERTICAL 1"=10'

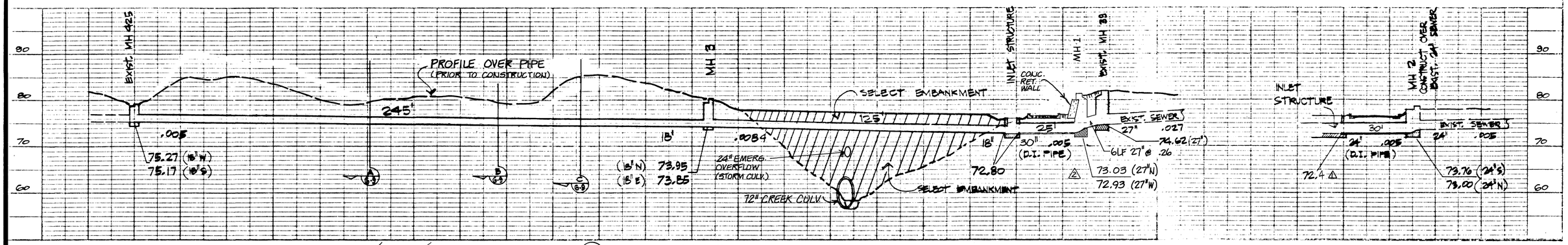
PROJ. No. 4189-6-2
FILE No.
DWG. No. A-2

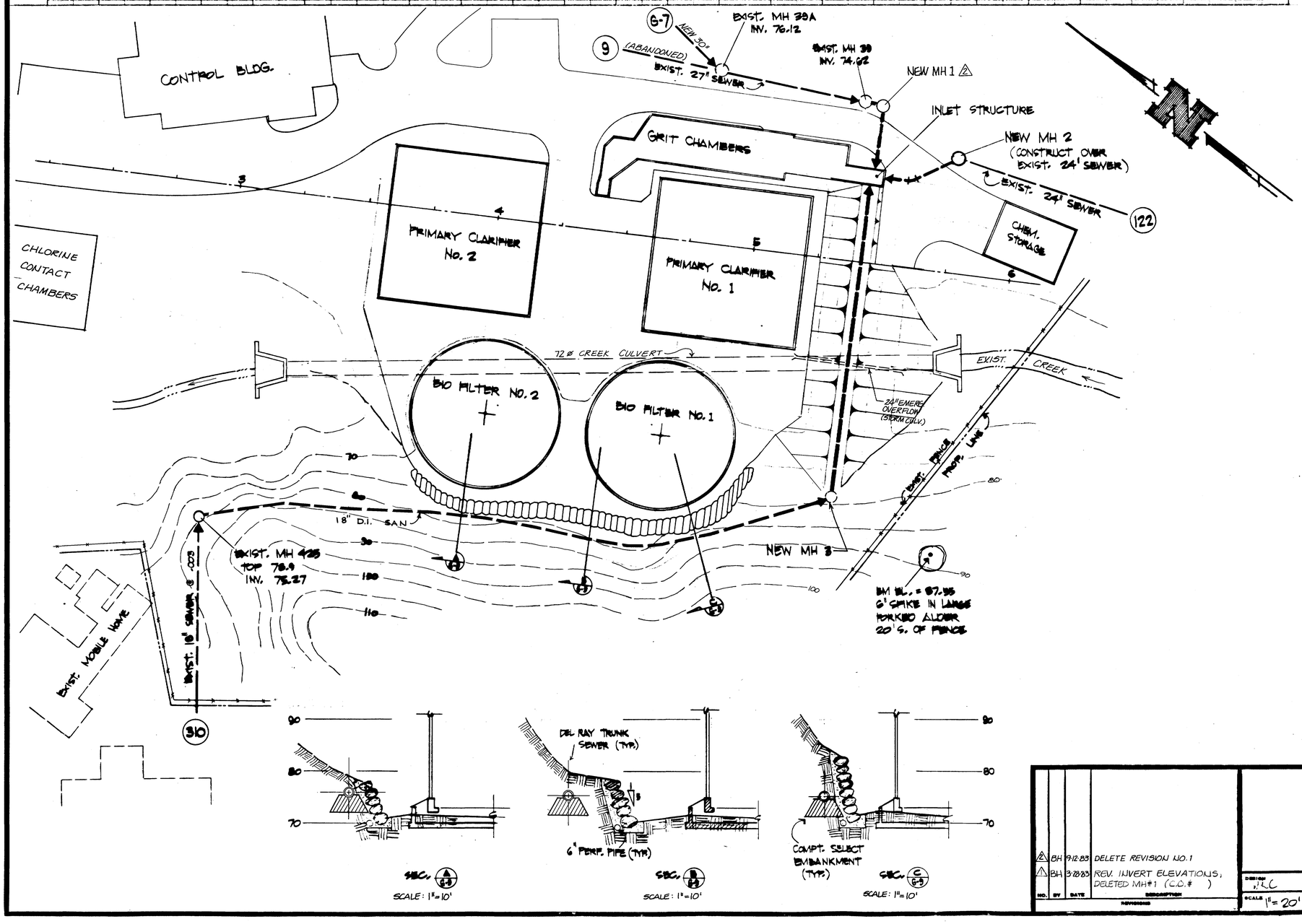
PROFILE
NOTE BOOK NO.
SURVEYED
PLOTTED
GRADES CHECKED
STRUCTURE NOTATNS CH'K'D
BY
DATE

PENCIL DESIGN
SHEET CROSS
FIELD CHECK
REVISIONS
BY
DATE

RE-CHECK B.C.
TRACING CH'KD
BY
DATE

PLAN
NOTE BOOK NO.
SURVEYED
PLOTTED
ALIGNMENT CHECKED
RT. OF WAY CHECKED
BY
DATE





REVISED TO INDICATE CONSTRUCTION RECORDS. DIMENSIONS AND ELEVATIONS NOT VERIFIED IN ALL INSTANCES
INSP. BY: N. NELSON
REV. BY: B.L. HULSE
DATE: 4.11.84

S-815

NO.	BY	DATE	DESCRIPTION
2	BH	9-12-83	DELETE REVISION NO. 1
1	BH	3-7-83	REV. INVERT ELEVATIONS, DELETED MH#1 (C.O.#)

REVISIONS

DONALD M. WILLIAMS — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

DESIGN	DRAWN	APPVD
RLC	JBLOCK	DMW
SCALE 1"= 20'	DATE JUL 28 1977	JOB 03-133

ADDITIONS TO REDONDO TREATMENT PLANT

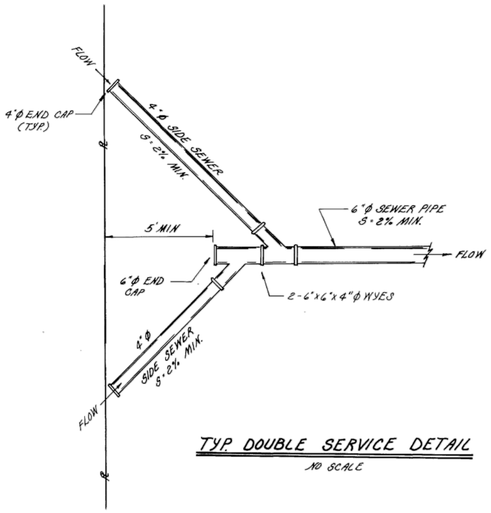
SEWER PLAN & PROFILE

(18") DEL RAY TRUNK & RELOCATION OF EXIST. PLANT INFLUENT PIPES (24" & 30")

LAKEHAVEN SEWER DISTRICT

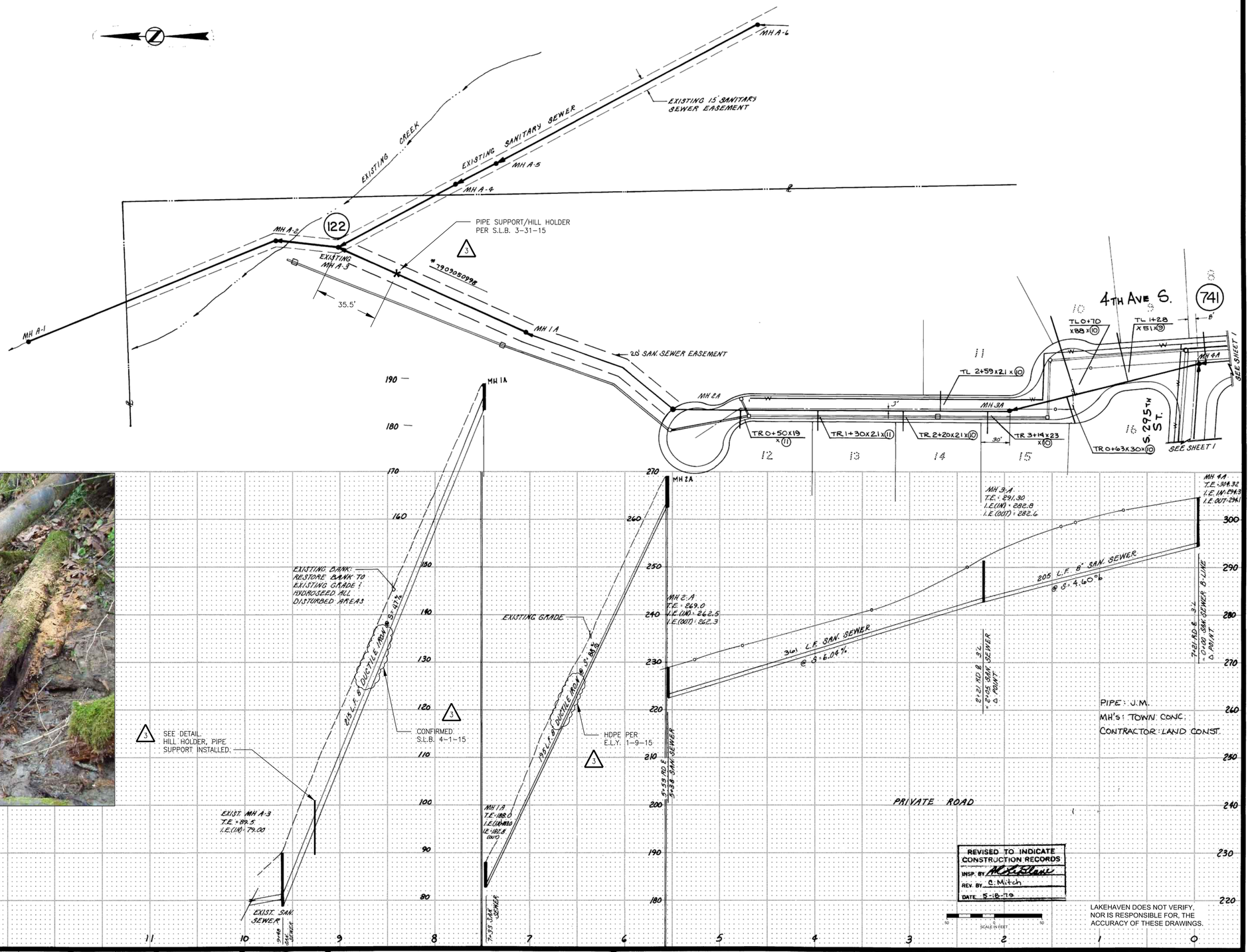
HART, WILLIAMS & ROTH, INC.
ENGINEERS • SURVEYORS • PLANNERS
KIRKLAND, WASHINGTON 822-6171

SHEET G-9



TYP DOUBLE SERVICE DETAIL

NO SCALE



3 DETAIL

PIPE: J.M.
MH'S: TOWN. CONC.
CONTRACTOR: LAND CONST.

REVISED TO INDICATE CONSTRUCTION RECORDS
INSP. BY M. Sullivan
REV. BY C. Mitch
DATE 5-18-79

SCALE IN FEET 50 0 50

LAKEHAVEN DOES NOT VERIFY, NOR IS RESPONSIBLE FOR, THE ACCURACY OF THESE DRAWINGS.

REV. NO.	DATE	DESCRIPTION	MADE BY	CHECKED
3	7-13-15	ADDED NOTES PER FIELD OPS	JPS	RSL
2	8/19/78	PER L.H.S.D.		
1	8/2/78	PER L.H.S.D.		

SCALE: HORZ. 1"=50' VERT. 1"=10'
DATE: 7/6/78
DRAWN: BML
DESIGNED: MNA
CHECKED: RAB
APPROVED: CRB

ROBERT A. BENNETT STATE OF WASHINGTON 12879 REGISTERED PROFESSIONAL LAND SURVEYOR

CHARLES R. BENNETT STATE OF WASHINGTON REGISTERED PROFESSIONAL ENGINEER

Bennett and Fox, Inc.
SURVEYORS and ENGINEERS
P.O. BOX 1031 PUYALLUP WA. 98371
PUYALLUP 845-8833 SEATTLE 838-3474

CROWN POINT
SANITARY SEWER PLAN AND PROFILE

SHEET NO. 2 OF 2

JOB NO. 78-650

APPENDIX G
Water Quality Data

Poverty Bay Fecal Coliform Sample Results and Loading (2019)

Precipitation:
6/27/2019: 0.08 inch
7/11/2019: 0.00 inch
7/10/2019: 0.17 inch
7/9/2019: 0.17 inch

Massey Creek

Site	Date	FC Value	GPM	CFS	Daily Load
Massey	6/27/2019	140	330	0.74	2.52 x10^9
Massey	7/11/2019	540	384	0.85	1.13 x10^10

Woodmont Creek

Site	Date	FC Value	GPM	CFS		Daily Load
Woodmont	6/27/2019	350	103	0.23		1.97 x10^9
Woodmont	7/11/2019	540	99	0.22		2.91 x10^9

Redondo Creek

Site	Date	FC Value	GPM	CFS	Daily Load
Redondo	6/27/2019	49	512	1.14	1.37 x10^9
Redondo	7/11/2019	130	150	0.33	1.06 x10^9

Cold Creek

Site	Date	FC Value	GPM	CFS	Daily Load
Cold	6/27/2019	240	1196	2.66	1.56 x10^10
Cold	7/11/2019	4.6	1158	2.58	2.90 x10^8

Federal Way Stream Team Data
Cold Creek 001 (Downstream from Easter Lake, Winter Only)
Data Set #1

Legend

x = No Reading

Date	Tester 1	Tester2	Tester3	Tester4	Time	Weather Conditions	Air Temp	Water Appearance	Odor	Stream Bed Coating	Substrate	Water Temp	Water Temp	Water Temp
	1	2	3	4								1st	2nd	Ave
1/11/2003	Leesha	Carol	n/a	n/a	12:00	Solid Overcast	10.0	Clear	None	None	Gravel	6.6	6.6	6.6
2/18/2003	Leesha	Carol	n/a	n/a	12:40	Partly Cloudy	x	Clear	None	None	Other	10.0	10.0	10.0
3/25/2003	Carol	Leesha	n/a	n/a	15:30	Solid Overcast	12.8	Clear	musty	Orange to red	Gravel	15.0	15.0	15.0
4/27/2003	Leesha	Carol	n/a	n/a	13:00	Clear	15.5	Clear	None	None	Gravel	12.0	18.0	18.0
5/17/2003	Leesha	Carol	n/a	n/a	13:25	Partly Cloudy	x	Scum	Other/dirty	Other/Algae	Gravel	10.0	x	10.0

Federal Way Stream Team Data
Cold Creek 001 (Downstream from Easter Lake, Winter Only)
Data Set # 2

Legend

O-PO4 = Orthophosphate	Total Cl = Total Chlorine	DO = Dissolved Oxygen
PO4 = Phosphate	Turb = Turbidity	x = no sample
P = Phosphorous	NO3 = Nitrate	* = aberrant result
Free Cl = Free Chlorine	NH3 = Ammonia	

Date	O - PO4	O - PO4	O - PO4	O - PO4	PO4	PO4	PO4	PO4	P	P	P	P	Free Cl	Free Cl	Free Cl	Free Cl	Total Cl	Total Cl	Total Cl	Total Cl	Turb	Turb	Turb	Turb	NO3	NO3	NO3	NO3	NH3	NH3	NH3	NH3	pH	pH	pH	pH	DO	DO	DO	DO
	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave
1/11/2003	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	6.2	6.1	x	6.2	6	6	x	6.0
2/18/2003	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	6.2	6.3	x	6.3	10	8	x	9.0
3/25/2003	0	*5	0	2.5	0	0.1	0	0	0	0.03	0	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	6.7	6.0	6.2	6.3	11	11	x	11.0
4/27/2003	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0.8	0	x	0.4	x	x	x	x	10	8	x	9.0
5/17/2003	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	0	0	x	0	x	x	x	0	0	0	x	0	0	0	x	0	7.0	x	x	7.0	11	12	x	11.5

Federal Way Stream Team Data
Cold Creek 002 (Upstream from Discharge to Puget Sound, Winter
Data Set #1

Legend

x = No Reading

Date	Tester 1	Tester 2	Tester 3	Tester 4	Time	Weather Conditions	Air Temp	Water Appearance	Odor	Stream Bed Coating	Substrate	Water Temp	Water Temp	Water Temp
	1	2	3	4								1st	2nd	Ave
12/20/02	NanCee	Leslie	n/a	n/a	10:30	Partly Cloudy	x	Clear	None	None	Gravel	8.0	8.0	8
2/28/03	Sautbine	NanCee	n/a	n/a	10:00	Solid Overcast	10.0	Clear	None	None	Gravel	7.0	x	7
11/24/03	Warren	n/a	n/a	n/a	4:30	Clear	9	Clear	None	None	Gravel	8	x	8
12/24/03	Warren	n/a	n/a	n/a	2:30	Clear	8	Clear	None	None	Gravel	6	6	6
1/10/04	Warren	n	n/a	n/a	4:00	Partly Cloudy	9	Clear	Fuel	None	Gravel	4.5	x	4.5

Federal Way Stream Team Data
Cold Creek 002 (Upstream from Discharge to Puget Sound, Winter Only)
Data Set # 2

Legend

O-PO4 = Orthophosphate	Total Cl = Total Chlorine	DO = Dissolved Oxygen
PO4 = Phosphate	Turb = Turbidity	x = no sample
P = Phosphorous	NO3 = Nitrate	* = aberrant result
Free Cl = Free Chlorine	NH3 = Ammonia	

Date	O - PO4	O - PO4	O - PO4	O - PO4	PO4	PO4	PO4	PO4	P	P	P	P	Free Cl	Free Cl	Free Cl	Free Cl	Total Cl	Total Cl	Total Cl	Total Cl	Turb	Turb	Turb	Turb	NO3	NO3	NO3	NO3	NH3	NH3	NH3	NH3	pH	pH	pH	pH	DO	DO	DO	DO
	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave	1st	2nd	3rd	Ave
12/20/02	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	7.4	6.9	6.7	**7.0**	13	13	x	**13.0**
2/28/03	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	0	0	x	**0**	200	x	x	**200**	0	0	x	**0**	0	0	x	**0**	7.7	7.6	x	**7.7**	12	11	x	**11.5**
11/24/03	5	x	x	**5**	0.1	x	x	**0.1**	0.03	x	x	**0.03**	0	x	x	**0**	0	x	x	**0**	0	x	x	**0**	2	x	x	**0**	0	x	x	**0**	7	x	x	**7.0**	12	x	x	**12.0**
12/24/03	0	0	x	**0**	0	x	x	**0**	0	x	x	**0**	0	x	x	**0**	0	x	x	**0**	0	x	x	**0**	0	x	x	**0**	0	x	x	**0**	7.1	7.2	x	**7.2**	11	11	x	**11.0**
1/10/04	5	x	x	**5**	0.1	x	x	**0.1**	0.03	x	x	**0.03**	0	x	x	**0**	0	x	x	**0**	0	x	x	**0**	2	x	x	**2**	0	x	x	**0**	6.8	x	x	**6.8**	12	x	x	**12.0**

APPENDIX H
Prioritization Matrices

Table H-1

Reach/Structure Summary

Cold Creek

City of Federal Way, Washington

Location (Reach/Structure)	Stream Stationing	Description	Property Ownership	Infrastructure Present
Reach 1 (storm drain outlet at 10th Avenue South to SR 509/Dash Point Road)	7200 - 6000	Deeply incised channel in ravine with banks up to 8 feet and valley side slopes ranging from 2:1 to about 1.5:1 (hoirzontal to vertical) and extending about 20 to 50 feet above the channel; channel side slopes in one surveyed cross section just upstream of Dash Point Rd indicate slopes steeper than 1.5:1 (H:V).	Numerous private residential parcels	Several storm drains discharge down side slopes
Culvert at SR 509/Dash Point Road (Crossing ID 99192)	6000 - 5900	Approximately 80 linear feet 36-inch-diameter corrugated metal pipe (CMP)culvert with debris cage at inlet. Downstream end has 48-inch-diameter manhole, then approximately 20 linear feet 42-inch-diameter CMP discharging to concrete apron.	City of Federal Way /WSDOT right-of-way	SR 509/Dash Point Road, associated stormwater pipes
Reach 2 (SR 509/Dash Point Road to South 302nd Street)	5900 - 5300	Modified channel through residential property backyards	Numerous private residential parcels	Concrete apron and flow dipsersion baffle at upstream culvert outlet; grade control and bank armoring; adjacent residences
Culvert System at S 302nd Street and Marine Hills Pool (Crossing ID 991878)	5300 - 4300	System of 5 culverts of various types spanning approximately 1,000 feet. Culvert types include 36-inch by x36-inch concrete box and 36-inch by 42-inch-diameter CMP	City of Federal Way ROW, Marine Hills Swim & Tennis Club, and Powell	S 302nd St; Marine Hills Pool private road, parking & pool facility; adjacent residences
Reach 3 (below Marine Hills Pool to unmapped culvert)	4300 - 3650	Modified channel with cross log type grade control structures at approx. 15-foot intervals.	Powell	Grade control in channel, adjacent trail system, one stormwater pipe
Culvert (unmapped)	3650 - 2900	Approximately 750 linear feet, 48-inch-diameter CMP transitions to 48-inch-diameter concrete pipe with apron and wingwalls	Powell	None other than culvert
Reach 4 (Unmapped culvert to Redondo Treatment Plant)	2900 - 1350	Natural channel with a few manmade alterations associated with a utility crossing and landslide deposition	Powell, City of Federal Way	Utility corridor crosses creek in lower part of reach; adjacent manhole and buried pipe under stream with associated channel armoring; several stormwater discharges.
Culvert at Redondo Treatment Plant (unidentified crossing)	1350 - 1100	72-inch pipe with baffles	Lakehaven Utility District	Culvert conveys flow under portion of existing facility
Reach 5 (Redondo Treatment Plant to Redondo Shores Drive South)	1100 - 625	Modified channel with bank armoring, grade control and numerous stormwater pipe discharges	Lakehaven Utility District, Del Rey Park LLC, and Adams	Numerous drain pipes discharge into this reach; adjacent residences
Culvert at Redondo Shores Drive (Crossing ID 921213)	625 - 595	48-inch-diameter CMP	Redondo Shores Homeowners Association	Redondo Shores Drive
Reach 6 (Redondo Shores Drive to Redondo Beach Drive)	595 - 55	Heavily modified and manipulated channel with bank armoring and degraded riparian zone. Mostly in residential backyards.	Numerous private residential parcels	Backyard landscaping features; adjacent residences
Culvert at Redondo Beach Drive (Crossing ID 921214)	55-15	60-inch span concrete box with 38-inch vertical opening	Redondo Shores Homeowners Association, City of Des Moines right-of-way	Redondo Beach Drive South

Table H-2

Prioritizaton Matrix

Cold Creek

City of Federal Way, Washington

Location (Reach/Structure)	Geomorphic Condition		Flood Risk		Habitat Restoration Potential		Structural Condition and Risk		Maintenance Requirements	
	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
Reach 1 (storm drain outlet at 10th Avenue South to SR 509/Dash Point Road)	Reach is mostly at equilibrium slope but confined in valley bottom; recent incision up to 6 feet locally exposing underlying geologic material; localized lateral scour (bank erosion) in upper portion; stormwater inputs causing erosion;channel velocities in hydraulic model appear reasonable for size and gradient of system. Reach is considered high priority due to noted incision, erosion and subsequent deposition of material.	3	Not within FEMA mapped SFHA; flow is confined in the ravine in this reach and flood flows don't extend to adjacent infrastructure; therefore, there is no flood risk at this location and action is not warranted.	0	Incised channel with forced step-pool morphology with limited pool habitat; deficient in fine-grained (gravel and finer) material; seasonal hydrology and assumed flashy flows due to development in watershed and stormwater inputs of unknown origin; no overbank flow/floodplain engagement at 2-year flow, but does at 100-year indicating limited flood refuge; invasive species and waste/debris in riparian forest; numerous downstream barriers and limited capacity to support fish.	1	No significant infrastructure present in this reach, resulting in no risk with action not warranted.	0	Occassional tree removals required; deposition of eroded material above culvert requiring regular maintenance (sediment removal). Reach is considered high priority due to deposition of material requiring regular maintenance.	3
Culvert at SR 509/Dash Point Road (Crossing ID 99192)	Hydraulic modeling indicates insignificant backwater effect upstream of the culvert at the 2-year flow and a significant backwater effect at the 100-year flow, contributing to slower-than-average velocities and deposition immediately upstream at flows exceeding the 2-year. High velocities (exceeding 8 ft/s) are present downstream of the culvert at both the 2-year and 100-year flows causing incision and lateral scour immediately downstream. Culvert is considered high priority because of the backwater effect above the culvert and erosion below.	3	Not within FEMA mapped SFHA; hydraulic modeling indicates an insignificant backwater effect upstream of the culvert at the 2-year flow and a significant backwater effect at the 100-year flow, indicating flow is constricted at 100-year event; there were no visible signs of prior flood damage, but risk of future flood damage is considered medium priority as a result of this constriction.	2	High velocity with scour and vertical cascade at outlet; total fish barrier based on WDFW assessment due to water surface drop at outlet. Culvert velocities range from approximately 6.5 ft/s at the upstream end to approximately 11 ft/s at the downstream end during the 2-year event and range from approximately 12 ft/s at the upstream end to approximately 14 ft/s at the downstream end during the 100-year event; culvert slope is 5.7%. Slope, velocity and water surface drop at outlet all limit fish passage but benefits of correction are limited.	1	The CMP pipes are in good condition with Culvet Condition Rating = 7; issues include corrosion in CMP pipes, sediment build up at inlet, and erosion at outlet apron; modeling indicates higher-than-average velocity at downstream end of crossing at the concrete outlet apron, however, there was no evidence of damage to the roadway prism; overall, structural condition and risk of damage are considered low priority.	1	Culvert backwater effect causing deposition of sediment above culvert, requiring regular maintenance (sediment removal). Reach is therefore considered high priority.	3
Reach 2 (SR 509/Dash Point Road to South 302nd Street)	Incision and lateral scour below Dash Pt Rd, in part due to scour from high velocity as flows exit culvert, then deposition in lower half of reach to downstream culvert; stream gradient starts steeper then flattens to less than equilibrium slope. Average channel velocities range from approximately 5 ft/s at the 2-year event to approximately 7 ft/s at the 100-year event, indicating moderate potential for erosive forces. Reach is considered high priority due to change in gradient, resulting in erosion and subsequent deposition of material.	3	Not within FEMA mapped SFHA; model shows that no homes would be inundated during 100-year flood events, indicating low priority for flood risk; however, backwater during 50- to 100-year events from pool crossing could pose a threat to existing yards and associated bank stabilization.	1	Gravel-dominated substrate with grade control structures in channel and armored banks; limited LWM and low channel complexity; seasonal hydrology and assumed flashy flows due to development in watershed and stormwater inputs of unknown origin; no overbank flow/floodplain engagement at 2-year flow indicating limited flood refuge; riparian degradation with invasive species dominant; passage barriers downstream and upstream; downstream barriers and limited capacity to support fish in reach result in a low priority score for restoration.	1	Several small-scale, possibly home-owner-built grade control structures and areas of bank armoring are present, with condition ranging from good to failed. The risk of localized erosion related to these structures is high, but the overall risk of reach scale degradation due to these structures appears low. Average channel velocities range from approximately 5 ft/s at the 2-year event to approximately 7 ft/s at the 100-year event.	1	Deposition in lower half of reach to downstream culvert resulting in maintenance requirements above culvert. Reach is considered high priority due to deposition of material, requiring maintenance.	3
Culvert System at South 302nd Street and Marine Hills Pool (Crossing ID 991878)	Hydraulic modeling indicates a significant backwater effect upstream of the culvert at the 2-year and 100-year flows. This contributes to slower-than-average velocities here (compared to upstream reach) and associated deposition. Sediment deposition is also present inside culvert. Culvert is considered high priority due to sediment deposition inside and immediatey upstream.	3	Not within FEMA mapped SFHA; model predicts culvert is overwhelmed at the 50-year flow and above (including 100-year flow); culvert may be capable of conveying lower flows, however, concrete slabs observed inside culvert that are not captured in the model increases risk of overtopping at lower flow; there is potential for the roadway to be flooded as well as some homes to be inundated during the 50- to 100-year events, resulting in a high priority for flood risk at this location.	3	Length of culvert system, structural failures, debris in culvert and vertical drops associated with catch basins between culvert sections presents total fish passage barrier; total fish barrier based on WDFW assessment due to slope. Culvert velocities range from approximately 7.5 ft/s at the upstream end to approximately 8 ft/s at the downstream end during the 2-year event and approximately 8.5 ft/s at the upstream and downstream ends during the 100-year event; culvert slope is 5.3%. There is no fish passage through this culvert but benefits of correction are limited.	1	Videos of culvert provided by City ranging from 2011 to 2021 indicate failed bottom and substantial obstruction by eroded concrete pieces; top of culvert bulging indicating overhead settlement, and settlement observed in pavement at approximately the same location. The five sections received condition codes of 2 (2 sections), 3 (2 sections) and 7 (one section), indicating that a significant portion of this system is in poor condition with severe damage or failed, resulting in high concern for future flood damage to infrastructure including culverts, roadways, utilities, and pool facility. Modeling indicates higher-than-average velocity at downstream end of crossing.	3	Backwater effect of culvert contributes to slower-than-average velocities and associated deposition, requiring maintenance. Culvert is considered high priority due to deposition upstream requiring maintenance.	3
Reach 3 (below Marine Hills Pool to unmapped culvert)	Transport reach with existing grade control limiting downcutting; gradient less than equilibrium slope; lack of sediment supply due to upstream infrastructure; aggradation/deposition at downstream end potentially due to backwater from downstream culvert and low stream gradient. Relative stability from installed grade control (check structures). Average channel velocities range from approximately 4.5 feet per second at the 2-year event to approximately 8 ft/s at the 100-year event, indicating that erosive forces may occur at flows exceeding the 2-year event. Medium priority for action due to slope out of equilibrium, presence of grade control structures, and deposition.	2	Not within FEMA mapped SFHA; flood flows remain confined within the ravine in this reach with little opportunity to affect infrastructure or natural resources, resulting in no flood risk action warranted.	0	Relatively broad and intact riparian forest conditions with high canopy closure; some human disturbance including grade control in channel, some forming significant drops potentially limiting fish passage at some flows; cobble-dominated and embedded substrate with limited appropriate spawning habitat; seasonal hydrology and assumed flashy flows due to development in watershed and one stormwater input mid-reach; floodplain engages at both 2-year and 100-year provides some flood refuge; downstream fish passage barrier; limited benefit of restoration due to existing downstream barrier and lack of perennial flow.	1	Some grade control structures present (typically log-type). The risk of localized erosion related to the failed structures is high, but the overall risk of reach scale degradation due to these structures appears low. Future degradation is unlikely, but if it occurs, it could impact the maintenance road/trail crossing accessible from PowellWood.	1	None known	0

Location (Reach/Structure)	Geomorphic Condition		Flood Risk		Habitat Restoration Potential		Structural Condition and Risk		Maintenance Requirements	
	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
Culvert (unmapped)	Sediment deposition is present upstream of culvert. Hydraulic modeling indicates an insignificant backwater effect at the 2-year event and a significant backwater effect at the 100-year event, contributing to slower-than-average velocities and deposition immediately upstream at flows exceeding the 2-year. Culvert has high gradient and significantly deviates from equilibrium slope. There is also a 5-foot vertical drop at the downstream end that contributes to high velocities (exceeding 10 ft/s in both the 2-year and 100-year flows) and scour here, which has been fixed with armor rock. Culvert and fill above it support sanitary sewer crossing and may also provide support to toe of steep slopes that are within mapped landslide geologic unit. Culvert is considered medium priority.	2	Not within FEMA mapped SFHA; hydraulic modeling indicates an insignificant backwater effect upstream of the culvert at the 2-year flow and a significant backwater effect at the 100-year flow; flow is constricted during the 100-year event at inlet, however, culvert is able to convey the 100-year event without overtopping; adjacent infrastructure and/or sensitive habitat is generally absent, therefore, flood risk is low priority.	1	Perched outlet presents total fish barrier; steep gradient (8.8 percent) with high associated velocities. Culvert velocities range from approximately 7 ft/s at the upstream end to greater than 10 ft/s at the downstream end during the 2-year event and from approximately 12.5 ft/s at the upstream end to greater than 10 ft/s at the downstream end during the 100-year event. There is no fish passage through this culvert but benefits of correction are limited.	1	Not formally assessed; separation of lower part of culvert from most of culvert length, potentially at a culvert joint, observed in the field, causing slumping of the pipe and associated apron; modeling indicates higher-than-average velocity at downstream end of crossing. Risk of structural failure leading to geomorphic problems is moderate, but risk to other infrastructure low.	2	None known	0
Reach 4 (Unmapped culvert to Redondo Treatment Plant)	Mostly transport reach with some incision, channel widening (lateral scour) and deposition locally; landslide accumulation in lower reach causing local vertical scour; reach is mostly at equilibrium slope except where landslide material has deposited and therefore believed to be close to equilibrium and, therefore, low priority. Average channel velocities range from approximately 5 ft/s at the 2-year event to approximately 7.5 ft/s at the 100-year event, indicating moderately erosive forces during high flow events.	1	Not within FEMA mapped SFHA; flood flows remain confined within the ravine in this reach with little opportunity to affect infrastructure or natural resources, resulting in no flood risk action warranted.	0	Low level of development and/or channel modification; intact riparian forest; seeps and springs on valley walls throughout reach; Cold Spring flow joins stream in upper portion of reach; flow through much of reach may be perennial; generally high quality salmonid habitat limited by downstream passage barriers and artificially constructed grade control associated with the utility crossing potentially limiting fish passage at some flows. Restoration potential is therefore high.	3	Utility crossing and associated installed channel grade control structures and adjacent standpipe/manhole structure. The risk of localized erosion related to the failed structures is high, but the overall risk of reach scale degradation due to these structures appears low.	1	None known	0
Culvert at Redondo Treatment Plant (unidentified crossing)	Hydraulic modeling indicates a minor backwater effect upstream of the culvert at both the 2-year and 100-year flows. This contributes to slightly slower-than-average velocities here (compared to upstream reach), resulting in potential for deposition above the culvert and indicating the culvert causes a minor constriction of flow. High velocities (exceeding 10 ft/s) are present downstream of the culvert at both the 2-year and 100-year flows, indicating quite erosive flows. Rock armoring/cascade on banks downstream of culvert and in channel bed approximately 75 feet downstream of culvert indicates that there may have been unwanted histroic erosion but appears stable now. Therefore, culvert is of low concern.	1	Not within FEMA mapped SFHA; hydraulic modeling indicates a minor backwater effect upstream of the culvert at both the 2-year and 100-year flows; however, culvert is able to convey the 100-year event without overtopping the crossing, resulting in low priority for risk to adjacent infrastructure.	1	Culvert is very long with a high overall slope (7.1 percent), indicating partial barrier; wier-pool design appears intact and likely passable to some fish at some flows in spite of velocities, likely assisted by baffles. Culvert velocities range from approximately 6.5 ft/s at the upstream end to approximately 10 ft/s at the downstream end during the 2-year event and from approximately 10 ft/s at the upstream end to greater than 12 ft/s at the downstream end during the 100-year event. Moderate priority for habitat restoration because it is partially passable and improvement would provide access to high quality reach upstream.	2	Not formally assessed; grade control in channel immediately downstream could be protecting culvert from upstream channel degradation. Modeling indicates higher-than-average velocity at downstream end of crossing, but there were no specific concerns observed during reconnaissance at this location.	0	None known	0
Reach 5 (Redondo Treatment Plant to Redondo Shores Drive South)	Confined transport reach that was historically incised with local lateral scour associated with stormwater pipes on channel bank; gradient less than equilibrium slope; grade control structure (rock cascade) installed and channel appears stable. Average channel velocities range from approximately 6 ft/s at the 2-year event to approximately 8.5 ft/s at the 100-year event, indicating moderately erosive forces that have been stabilized with armoring, resulting in low priority.	1	Not within FEMA mapped SFHA; the hydraulic model extends approximately 300 feet downstream of the treatment plant; based on this limited model, 100-year flows in this reach are anticipated to overtop the stream bank, creating a moderate flood risk for 1 adjacent structure in this reach that may be inundated during a the 100-year flood event and, therefore, medium priority.	2	Partially intact riparian forest but most areas dominated by invasive species and other areas developed; pool-riffle morphology with some articial steps from installation of grade control; moderate quality rearing and spawning habitat present, rock cascade likely partially limits passage in upper part of reach; numerous drain pipes of unknown origin discharge into this reach. Moderate priority for habitat restoration to improve riparian and bank conditions and improve fish passage.	2	Bank armoring and grade control protecting Treatment Plant and adjacent residences; risk of failure is low and overall risk of reach scale degradation if any structures fail is also considered low.	1	None known	0
Culvert at Redondo Shores Drive (Crossing ID 921213)	Channel entering and exiting culvert has been stabilized by heavy bank armoring; low priority for action	1	Not within FEMA mapped SFHA; hydraulic model did not extend this far downstream; based on amount of armoring present, it is assumed that there has been some historic damage during lesser flood events and that the culvert is therefore at a moderate risk for flood damage during future floods and therefore, medium priority.	2	Total fish barrier based on WDFW assessment due to slope; culvert is low in the watershed and precludes access to high quality fish habitat immediately upstream, resulting in high priority for barrier correction.	3	No significant structural deficiencies of immediate safety concern were noted based on structural review but pavement settling and minor deformation of pipe culvert indicate potential long-term failure potentially requiring correction at some time.	2	Evidence of recent pavement repairs over culvert, resulting in medium priority for corrective action.	2
Reach 6 (Redondo Shores Drive to Redondo Beach Drive)	Transport reach with historic aggradation and low gradient; channel straightened and armored throughout, therefore, bank erosion absent; low sinuousity, lack of opportunity for channel migration, artificial grade control structures and artificially armored banks. Overall, low priority for action.	1	Area located partially within a FEMA SFHA (Zone AE, 100-year base flood elevation at 13 feet), potentially affecting a number of residential properties; hydraulic model did not extend this far downstream; estimated that at least 10 structures/homes within the SFHA may be inundated during flood events, resulting in a high priority for addressing flood risk.	3	Limited spawning habitat in what may be the only reach accessible to anadromous fish at most flows; highly degraded channel bank and riparian conditions; limited habitat complexity reduces value for rearing; restoration has the potential to be valuable to anadromous fish.	3	Channel lining/armor and small pedestrian crossing. Appears to mostly home-owner built. These structures were not observed or assessed in detail but there were no specific concerns observed during geomorphic and habitat reconnaissance of this reach.	0	None known	0

Location (Reach/Structure)	Geomorphic Condition		Flood Risk		Habitat Restoration Potential		Structural Condition and Risk		Maintenance Requirements	
	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
Culvert at Redondo Beach Drive (Crossing ID 921214)	Culvert may constrict flow during high stream discharge due to limited freeboard. Not apparently affecting highly modified channel upstream or tidal waters downstream. Sediment was not observed building up, no scour was observed upstream of culvert, and therefore this culvert action is not warranted.	0	Redondo Beach Dr. is within the FEMA SFHA (Zones AE and VE, 100-year base flood elevation at 13 feet) and the roadway is lower than the base flood elevation, resulting in high priority for addressing flood risk to the culvert crossing and associated roadway.	3	Fish passage may be limited during lower flows and low tides, but fish passage may be facilited during high tides and/or times of higher stream discharge; unknown barrier status based on WDFW assessment due to insufficient data; restoration (replacement) could improve fish passage and facilitate access to upstream habitat.	1	Inlet okay, outlet constrained by low road and unnecessarily low railing support structure. No significant structural deficiencies noted based on visual observation during May 2021 site visit.	0	None known	0

Note:

ft/s = feet per second

Scores were as follows: 0 (action not warranted), 1 (low priority for action), 2 (medium priority for action), 3 (high priority for action)

GeoEngineers