Report for **Trinidad ASBS Stormwater Project**

Design Basis Memorandum

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1. Introduction

1.1 Purpose

This Basis of Design Memorandum (DBM) establishes criteria for the design of stormwater improvements for the Trinidad Area of Special Biological Significance (ASBS) Stormwater Improvement Project. This document summarizes basic project data, specified design criteria, relevant design guidelines, and other key project information. The basic project features outlined in this DBM are intended to provide the background understanding for the development of the preliminary design. The DBM builds on the work, *Geotechnical Analysis* (GHD 2012) and *Groundwater Technical Report* (GHD 2013), completed as part of the City's ASBS Stormwater Improvement Project.

1.2 Background

The City of Trinidad ("City") is undertaking the Trinidad ASBS Stormwater Improvement Project ("Project") to make improvements to the municipal stormwater drainage system with the intent to eventually eliminate the existing stormwater outfall to Trinidad Bay. The City's existing stormwater system was constructed in the early 1970's and discharges to a single 32-inch stormwater outfall (State Board identification: TRI032), which discharges just south of the boat launch at Trinidad Head to Trinidad Bay, as shown on Figure A-1, in Appendix A. The current system is designed to capture and convey runoff to the outfall and does not incorporate modern retention, treatment, or infiltration features.

Trinidad Bay is designated as an Area of Special Biological Significance (ASBS) and is one of 34 ASBS ocean areas monitored and maintained for water quality by the State Water Resources Control Board (SWRCB). ASBS designated areas cover much of the length of California's coastal waters and support an unusual variety of aquatic life and often host unique individual species. Trinidad Bay was designated as an ASBS in part because of the fluctuating presence of bull kelp (Nereocystis luetkeana), which are considered biologically significant in providing an ecological base for fish and invertebrate habitats by supplying food and shelter. All ASBS designated areas may be adversely affected by polluted stormwater discharges, which could damage their unique ecosystems. The intent of the ASBS designation is to give these areas a special status so that the valuable and sensitive biological resources can be protected from pollution through more restrictive regulations. The law prohibits an undesirable alteration in natural water quality from waste and discharges, and requires non-point source pollution to be controlled to the extent practicable.

Two stormwater sampling efforts have been conducted by the City of Trinidad in order to determine the quality of water flowing through the City's stormwater system. Stormwater samples were collected at the City's stormwater discharge, two streams, one sample of parking lot runoff, one seep, and from ocean water. The analyses indicated that for the Trinidad Bay ASBS, water quality objectives for some metals and some polycyclic aromatic hydrocarbons (PAHs) could be exceeded. The second sampling effort

consisted of quarterly sampling of biological contamination and other water quality indicators for four consecutive quarters from streams and seeps as part of an Onsite Waste Water Treatment Management Program (OWWTMP) supported by the SWRCB and the National Environmental Service Center at USEPA. Initial sampling of surface waters indicated that some waters may be contaminated by discharge from leach fields; however this was not confirmed in subsequent sampling efforts.

The long term goal of the City in implementing the Project is to help protect the ASBS by making improvements to the stormwater drainage system including implementation of Low Impact Development/Best Management Practices (LID/BMPs) to capture, treat, and infiltrate stormwater runoff from rainfall events.

1.3 Project Area

The Project is generally located within the City limits of Trinidad, Humboldt County, California and is shown on Figure A-1 in Appendix A. The City is located in rural northern California, approximately 25 miles from the county seat of Eureka and 300 miles from San Francisco. The community has a population of approximately 1,000 people with approximately 350 living within the City limits.

Much of the urban area overlies a fairly uniform fine sand aquifer, which in turn overlies low permeability Franciscan melange (bedrock). The Project area is bounded by Mill Creek in the North, Parker Creek to the East, and Highway 101 to the Northeast. The Project area is also bounded by coastal bluffs and the Pacific Ocean and Trinidad Bay along the west and south. The Project study area covers approximately 228 acres.

The City has a rudimentary and aging stormwater network which discharges stormwater runoff through an outfall pipe to Trinidad Bay and the Pacific Ocean. Water quality within the ASBS could be impacted by pollution from a number of sources, including, urban runoff from City roads, private parcels, and pets, among other sources. As such, the City is moving towards eliminating its direct stormwater discharge into the ASBS through a series of alternative stormwater management practices.

The proposed project encompasses two areas of the City, defined as the upper area (Phase 1) and lower area (Phase 2) as shown in Figure A-1 in Appendix A. Although the final design and construction will only be completed for the upper area, the lower area was included in the concept development as the upper and lower areas are hydrologically connected and it is important to have the concept for the entire project worked out before commencing with design and construction on the upper area. The upper area was chosen as the priority for the final design and implementation, because improvements to the lower area cannot be effective without the upper area improvements due to limitations in the capacity to manage the entire volume of stormwater collected.

1.4 Design Considerations

To gain an understanding of the existing stormwater system, the hydrology, geology, and existing infrastructure in the project area were studied. These technical assessments were necessary to determine the quantity of stormwater that needs to be managed, locations where stormwater could be

infiltrated, and to ensure that the proposed stormwater system upgrades did not cause negative impacts to existing infrastructure or the environment.

1.5 Special Considerations

Coastal bluff stability is a major concern in the City of Trinidad. The City is surrounded by coastal bluffs on the south and west sides. Roads, residences, and other infrastructure exist in close proximity to the bluffs; therefore new stormwater improvements should not adversely affect existing bluff stability. GHD contracted with Crawford & Associates, Inc. a geotechnical engineering firm to conduct stability modeling of the bluff slopes above Trinidad Bay and the Pacific Ocean under existing conditions and with increased stormwater infiltration into the marine terrace sediments as a result of the proposed preliminary design.

The City does not have a centralized wastewater system, and all residences and businesses use on-site septic systems. The septic tanks are buried at a depth of approximately 1 to 3 feet BGS depending on installation date, with newer septic system installed 2 to 3 feet BGS. Leach lines are typically set between 3 to 5 feet BGS in a gravel filled trench. The effluent infiltrates into the subsurface under a gravity system allowing for biological treatment and breakdown of the organic matter prior to reaching groundwater. The volume of water introduced to the subsurface is referred to as the septic loading rate.

Potential impacts to Parker Creek and Mill Creek due to infiltration of stormwater was another consideration. Both creeks were included in the groundwater model, to assess potential impacts.

2. Site and Environmental Conditions

This section presents the site and environmental conditions in the Project area and there relevance to the design of the proposed stormwater improvements.

2.1 Geology

A geotechnical analysis was conducted to better understand the geology and groundwater system underlying the City of Trinidad. Full details on the analysis can be found in the City of Trinidad ASBS Improvement Project Geotechnical Analysis, GHD (2012). A summary of key findings as they relate to the preliminary design are presented below.

Results of the geotechnical investigations revealed that the hydrogeology of the study area consists of an unconfined sandy marine terrace aquifer generally composed of medium to well graded silty sands, underlain by impermeable Franciscan Complex bedrock. Hydraulic conductivities throughout the project area were found to be very high due to the sandy marine terrace layers within the aquifer. The Franciscan Complex bedrock surface was mapped using a combination of soil boring data which identified the depth of bedrock and geophysical analyses, including seismic refraction and electrical resistivity, which revealed the bedrock topography, including several ancient underground sea stacks protruding close to the ground surface.

Groundwater levels were monitored for a period of six months at 15-minute intervals to provide an indication of the current groundwater levels and the response to rainfall events. Review of the groundwater level readings indicated rapid groundwater movement and infiltration.

Springs and seeps in the study area were also mapped to determine locations where groundwater emerges from the surface. Springs and Seeps are generally located at sharp breaks in slope (coastal bluffs), often where the bedrock outcrops along the coastal bluffs within the project area, and are more widespread on the low point of bedrock cliff slopes, corresponding with paleochannels, pervasive jointing and sheared bedrock.

2.2 Hydrology

Hydrological data was gathered and analyzed to understand and quantify precipitation, stormwater runoff, groundwater movement, and surface-groundwater interactions. A hydrologic model was developed using USACE Hydrologic Engineering Center's Hydrologic Modeling System software (HEC-HMS) to simulate precipitation and runoff in the project area and estimate existing infiltration. The model included watersheds and sub-watersheds over the study area that were developed based on topographical data from the California Coastal Conservancy LiDAR Project digital elevation model and field reconnaissance. Precipitation depth data from NOAA Atlas II was used in the HEC-HMS model to develop simulated 24-hour storm events for the 2, 25, 50, and 100-year recurrence intervals. Precipitation data from specific storm events was obtained from the NOAA Precipitation Frequency Data Server, which was collected at the Woodley Island gage, located in Eureka California. Eleven (11) months of stormdrain flow data was collected at the stormdrain inlet at the corner of Galindo and Van Wycke Avenues. The precipitation data and corresponding stormdrain flow data were used to calibrate the HEC-HMS model by comparing the modelled response to storm events with the flows measured in the stormdrain, and adjusting the model parameters to match the actual data. More information on the HEC-HMS model can be found in the Trinidad ASBS Stormwater Groundwater Model Technical Report, GHD (2013).

After the HEC-HMS model was calibrated, it was used to develop hydrographs for each sub-watershed in the City area for the 2, 25, 50, and 100-year/24-hour recurrence intervals, which could then be used to aid in the design of stormwater catchment, treatment and infiltration systems. The 50-year/24-hour storm event was chosen as the design storm event for sizing of the proposed stormwater upgrades.

A groundwater model was developed using the Groundwater Vistas (v6) interface, and the MODFLOW-SURFACT (v4) application to simulate groundwater movement in the aquifer beneath the project area. The model was used to guide the design process by providing a tool to determine what quantities and locations stormwater runoff could be infiltrated and assess impacts of stormwater infiltration on existing septic systems, coastal bluff stability, and nearby creeks.

Data collected during the geotechnical investigations and hydrologic analyses were used to develop the groundwater model. The Coastal LiDAR data was used to establish model boundaries consisting of the existing ground surface, coastal bluffs, and locations of Mill and Parker Creeks. The basement geology, which acts as an aquitard was modeled based on the bedrock data collected during the geotechnical

investigations. The hydraulic properties and spatial data of the various soils within the aquifer were modeled based on data collected from the soil borings. The completed model accounted for infiltration through four zones (e.g., upper marine terrace soils, lower marine terrace sands, coastal bluffs and paleochannels interpreted from the bedrock topographical data), and simulates flows between the nearby creeks and the aquifer, stormwater infiltration, septic infiltration, drainage through hillside seeps/springs (field verified during the geotechnical investigations), and groundwater recharge based upon land use.

The groundwater model was calibrated by comparing model predictions with observed groundwater levels measured at nine groundwater monitoring wells. Hydraulic conductivities, zonation of hydraulic conductivities, unsaturated soil parameters, and recharge and bedrock topography were all adjusted iteratively until modeled groundwater levels matched measured levels by +/- 10%. The calibrated model was subjected to a third party review by HydroGeoLogic, Inc, a pioneer in the groundwater modeling field since 1987. Several improvements to the model were identified and those changes were incorporated into the model (e.g., hydraulic conductivity and storage sensitivity analysis). Full details of the groundwater model are presented in the Trinidad ASBS Stormwater Groundwater Model Technical Report (GHD 2013).

2.3 Water Quality Treatment Criteria

Urbanization increases the variety and amount of pollutants carried into streams, rivers, and lakes (EPA 2003). The most common stormwater pollutants for urban areas include:

- Sediment
- Oil, grease, and toxic chemicals from motor vehicles
- Pesticides and nutrients from lawns and gardens
- Viruses, bacterial, and nutrients from pet waste and failing septic systems
- Salts
- Heavy metals from roof shingles, motor vehicles, and other sources

LID/BMPs that were selected for this Project are targeted to remove sediment from the stormwater.

3. Preliminary Design Approach

The preliminary design strategy was to develop citywide stormwater infrastructure improvements to collect, treat, and dispose of stormwater using LID/BMP technologies within the Phase 1 and Phase 2 areas (Figure A-1, Appendix A), such that the existing outfall to Trinidad Bay could be eliminated.

The design process began with a review of commonly implemented LID/BMP technologies to ascertain which technologies were appropriate for the Project. LID/BMP technology selection criteria consisted of:

1) Ability to treat, store, or infiltrate stormwater

2) Fit within the existing City right of way

3) The ability to upgrade stormwater treatment efficiencies, if needed

4) Minimize reduction of city parking

5) Minimize operation and maintenance requirements

6) Maintain Project capital costs to be within budget

Once appropriate LID/BMPs technologies were identified, a preliminary design concept was developed. The overall design concept is to:

1) Intercept stormwater upstream of the Trinidad Bay outfall via LID/BMPs technologies and the existing stormwater system.

2) Use LID/BMPs technologies to treat and infiltrate stormwater throughout the City at locations selected to minimize impacts to bluff stability and the performance of existing septic systems.

Specifically, the system is designed to capture stormwater via a series of bio-swales, the existing stormwater collection system, and new stormdrains. Stormwater is then channeled to various rain gardens and infiltration galleries located throughout the City where it can percolate into the soil. Stormwater treatment would occur through physical and biological activities associated with the rain gardens and bio-swales, designed in accordance with California Stormwater Quality Association (CASQA) guidelines.

Historic water quality testing conducted in the Project area has shown that stormwater quality is impacted predominately by high sediment loading. Excessive sediment entering underground infiltration chambers will cause them to clog over time, reducing their life span and ability to infiltrate. Therefore, each infiltration chamber will be equipped with a sedimentation/solids separator at the inlet which will allow sediment to settle out prior to the water entering the infiltration chamber. A cleanout located above these sedimentation/solids separator will allow City crews to periodically remove collected silts and grit. The number of sedimentation/solids separators was minimized during the preliminary design phase to reduce required maintenance.

Locations for the proposed improvements were strategically selected based on the existing topography, available open spaces within the City right of way, and proximity to coastal bluffs to avoid potential detrimental impacts to bluff stabilization. The proposed stormwater system, as shown in Appendix D, would allow stormwater to be infiltrated at various locations dispersed throughout the City. In the event that a large storm event overloads the system, excess runoff would flow to the Pacific Ocean via overland flow and through Mill Creek and Parker Creeks on the outskirts of Trinidad, as would naturally occur if the area were undeveloped. To ensure that pretreatment mechanisms are effective the following were incorporated into the preliminary stormwater design: grassed swales; detention; and/or plunge pools in series.

The following Sections describe LID/BMPs technologies that have been selected for this Project.

3.1 Bio-Swales

Bio-swales should be considered wherever site conditions and climate allow vegetation to be established and where flow velocities will not cause scour. A minimum vegetative cover of approximately 70% is required for treatment to occur. Biofiltration Strips and swales are one of several BMPs for treatment of stormwater runoff from project areas that are anticipated to produce pollutants of concern (e.g., roadways and parking lots. These devices are well suited to be part of a treatment train system of BMPs and should be considered whenever siting other BMPs that could benefit from pretreatment, especially infiltration basins, infiltration trenches, and wet basins.

Bio-swales are engineered, vegetated channels which collect, convey, treat, store, and infiltrate stormwater. They are very effective at removing sediment by trapping suspended particles as stormwater flows through the vegetation, which acts like a filter. Bio-swales also help remove other contaminants and can store and infiltrate stormwater similar to rain gardens.

3.1.1 Design and Sizing Criteria

The following siting and design factors were considered when placing and sizing bio-swales:

- Locations for swales where flow velocities will not cause scour
- Use the Rational Method to determine the Water Quality Flow (WQF) and peak flows for the peak drainage facility design event
- Swales shall be designed to have a hydraulic residence time of 5 minutes or more; maximum velocity of 1.0 feet per second and maximum depth of flow of 0.5 feet
- Swales shall be sloped in the direction of flow with a minimum 0.25%, a maximum of 6%, and a preferred 1 to 2% preferred
- Swales shall have a minimum width at the invert of a trapezoidal Biofiltration swale typically 2.0 feet, maximum bottom typically up to 10 feet, side slope ratio should be 4:1 (H:V) or flatter
- Swales shall not have velocities greater than 4 feet per second without armoring

Street side bio-swales were designed to capture stormwater and route it to underground infiltration basins while providing treatment, infiltration and some storage. The swales were designed to gently slope towards a stormdrain inlet at the low end of the swale, which is slightly elevated to allow the swale to store a small amount of stormwater. Once enough water accumulates and the water level rises, stormwater flows into the stormdrain system that collects water from other nearby bio-swales and routes it to an underground sediment/solids chamber and then to an infiltration chamber constructed beneath the swales. The surfaces of the bio-swales were designed to be paved with vegetated, permeable pavers to stabilize the channel and allow vehicles to park on them.

3.2 Permeable Pavers

Permeable paving systems allow surfaces to be walked or driven on and stormwater to infiltrate through them, decreasing runoff. Permeable paver systems are typically constructed of concrete blocks or interlocking plastic geo-tiles which allow grass or other vegetation to grow between or through them. Such systems are typically constructed in parking lots or walkways where vehicle speeds are expected to be low and are used as an alternative to asphalt or concrete paving. The City of Trinidad recently installed a fire access road to the Trinidad Museum using a vegetated permeable paving system, similar to what is proposed for this Project.

The preliminary design also features modifications to allow the existing tennis court parking lot on Trinity Street to treat, store and infiltrate stormwater. The parking lot is currently paved with conventional asphalt paving which drains to the gutter along Trinity Street. Proposed modifications involve constructing a rain garden at the back of the lot (adjacent to the tennis court), reversing the parking lot slope to drain from Trinity Street to the proposed rain garden, and paving the parking lot with vegetated, permeable pavers to allow stormwater to infiltrate as it flows toward the rain garden. Parking lot safety would also be improved by routing the sidewalk around the parking lot such that pedestrians would walk adjacent to the rain garden, in front of parked cars, rather than behind them, as is currently the case. The rain garden would be constructed at a lower level than the adjacent sidewalk and would be surrounded by concrete retaining walls with inlets to allow stormwater to enter from the parking lot. A stormdrain inlet located in the rain garden would allow water to flow into the stormdrain and be routed to the infiltration basins underneath Trinity Street during large storm events.

3.2.1 Design and Sizing Criteria

Permeable pavers were designed and sized with the following criteria:

- Only pavers that can withstand regular traffic loading will be selected.
- Pavers must be flexible to match swale contours.

3.3 Rain Gardens

Stormwater can be stored, treated, and infiltrated through rain gardens. Rain gardens are constructed as depressions in the ground, which fill with rainwater during a storm event and allow the water to percolate into the ground through plant roots and soil. Nutrients, metals, sediment, and other common stormwater contaminants become trapped in the rain garden soil and are eventually taken up by the plants as they grow. Rain gardens are typically constructed on roadsides, in parking lots, traffic islands, private yards, and other areas.

Two sites were identified within the Project area as suitable locations for rain gardens. Stormwater runoff flowing down adjacent streets would be channeled by curbs and gutters and low asphalt humps into the rain gardens. Stormwater entering the gardens will flow into a small area that will allow sediment to settle out prior to flowing into the main rain garden area. During large storm events, the rain gardens are designed to fill then overflow to a nearby stormdrain which conveys the water to underground infiltration

chambers. Specific native plant species and soil mixtures which optimize stormwater nutrient and contaminant removal will be selected during the final stage of design.

3.3.1 Design and Sizing Criteria

Rain gardens were designed and sized with the following criteria:

- Rain garden inlets shall incorporate plunge pools and sedimentation chambers to allow sediment to settle and collect prior to infiltration
- Rain gardens shall be designed to allow 10 feet minimum depth from the infiltration surface to the maximum water table level
- Design infiltration rates shall be 2 inch/hour
- Maximum infiltration rates shall be 2.5 inch/hour
- Water quality volume infiltrated within 40 to 48 hours minimum
- Minimum outlet length 3 feet as overflow weir or riser
- Minimum 12 inches of freeboard (the difference between the surface water elevation during the overflow event and the lowest elevation of the confinement)

3.4 Drainage Inlets and Conveyance Piping

Drainage inlets are typically curb drains or grate drains or a combination thereof. Each type of stormdrain has advantages and disadvantages, and should be selected appropriately depending on the site conditions.

Stormwater piping comes in many different sizes and materials. For this application, corrugated smooth walled HDPE pipe was selected for its hydraulic characteristics, strength, and resistance to corrosion. Pipes were sized by developing a model for each collection system using EPA Stormwater Management Model (SWMM) to simulate open channel flow.

3.4.1 Design and Sizing Criteria

Drainage inlets and conveyance piping was designed and sized with the following criteria:

- Flows of no more than 0.083 cubic feet per second shall be allowed to concentrate and flow across roadway
- Maximize interception of gutter flow above superelevation transitions
- Limit ponding duration and depth
- Gutter capacity will be determined on a depth equal to 0.5 times the curb height for grades up to 10 percent and 0.4 times the curb height for grades over 10 percent in locations where parking is allowed or where driveways are considered

- Standard, pre-fabricated inlets will be used wherever possible
- Inlets shall be designed to allow for pipe entrance losses plus 9 inches of freeboard between the design water surface and the intake opening
- Inlets in series shall be spaced a minimum of 18 feet apart unless it is determined that hydrologic conditions warrant closer spacing
- Pipes will be sized such that the water surface elevation is 0.5 times the pipe diameter during the peak design storm flow

3.5 Oil/Water Solids Separator

In order to improve the efficiency and lengthen the life span of a proposed infiltration system, an oil-water solids separator that removes dirt, oil, and floatables by gravity separation is proposed on the front end of the infiltration galleries. With the built-in internal high flow bypass, pollutants are trapped in the settling chambers of this below-ground structure even during excessive runoff events. Solids separators are commonly used as a pretreatment device in a treatment train configuration. When installed as pretreatment, solid separators will prolong the maintenance interval and improve the function of the downstream stormwater system (i.e., infiltration gallery). For this Project, solids separators that have the ability to be upgraded (e.g., coalescing plates and filtration components) to enhance their treatment efficiencies have been selected.

3.6 Underground Infiltration Galleries

Underground infiltration galleries allow collected stormwater to be stored underground and percolate into the soil. They are typically constructed of pre-fabricated concrete, aluminum, galvanized metal, or plastic units that are connected together and backfilled with gravel, most of which can be installed below streets or parking lots and are capable of supporting traffic loads. Once installed, underground infiltration galleries take up no space on the surface, and can handle runoff from large rain events by storing water underground and allowing it to percolate into the soil over time, allowing for groundwater recharge. Infiltration galleries can be expected to remove up to 90 percent sediments, metals, coliform bacteria and organic matter, and up to 60 percent of phosphorous and nitrogen in the infiltrated runoff (Galli 1992).

3.6.1 Design and Sizing Criteria

A key design element for infiltration galleries sited in highly permeable soils is to provide pretreatment before the stormwater enters the infiltration galleries. Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural stormwater management practices, but it is particularly important for infiltration practices. The following methodology was used for the development of the preliminary design and sizing of the infiltration galleries:

- The maximum contributing area to an individual infiltration practice should generally be less than 5 acres
- Infiltration galleries require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D
- For infiltration rates greater than 2.4 inches/hour, runoff should be fully treated prior to infiltration to protect groundwater quality
- Infiltrate the Water Quality Volume (WQV) within 96 hours
- The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR 146.5(e)(4)
- Use representative infiltration or permeability rate to size the device
- Provide maintenance access and observation wells, if appropriate
- Infiltration devices should not be placed in service within a construction contract until all upstream runoff is stabilized, or shall be protected from sediment-laden runoff
- Infiltration trenches shall have the ability to treat a WQV greater than or equal to 0.1 acre-feet
- Runoff quality must meet or exceed standards for infiltration to local groundwater
- Infiltration devices shall not be sited in locations over previously identified contaminated groundwater plumes
- Separation from seasonally high water table greater 10 feet
- Soil should have a clay content greater than 30% and a combined silt/clay content less than 40 percent
- Locate where sloping ground greater than 15%, and where infiltrated water is unlikely to affect the stability down gradient of structures, slopes, or embankments

Infiltration chambers were sized using an infiltration basin model developed to simulate inflow, storage, and infiltration over a 24-hour storm event. The model uses runoff data generated by the hydrologic (HEC-RAS) model to calculate the anticipated quantity of water collected by the new stormdrain system which would flow to each infiltration basin. The Green-Ampt equation was used to determine the rate of infiltration based on hydraulic head and advancement of the saturated soil front at each time step. Soil permeability and depth to bedrock were based on values determined during the geotechnical investigations. The model uses mass balance calculations to determine the volume of stormwater stored in each chamber, which reached maximum values as the hydrographs peaked. The calculated storage volumes were input into an infiltration basin sizing calculator (Contech Engineering Solutions), which calculates the required infiltration basin area. The area calculation is then input back into the basin sizing calculation to generate a new required storage volume. Sizing of the infiltration basins was iteratively optimized in this manner to balance available infiltration area with storage volume. The preliminary

design calls for infiltration galleries to be constructed of 24-inch perforated HDPE pipe. Infiltration gallery model and sizing results are included in Appendix C.

3.7 Bluff Stability and Impacts to Septic Systems

The groundwater model was used to simulate stormwater infiltration below ground at the proposed underground infiltration basin locations to verify that the area could accommodate increased infiltration without detrimental impacts to streams, septic systems and bluff stability. Groundwater modeling results were reviewed by third party engineers at Crawford & Associates, Inc. to verify that the locations and quantities of stormwater infiltration will not impact the performance of septic systems, compromise bluff stability, or cause significant changes to flows in nearby streams. The technical memorandum from Crawford & Associates, Inc. describing their findings is included in Appendix C.

4. Conclusions

The proposed stormwater project was split into two phases based primarily upon watershed geometry, with available grant funding in mind. Watershed geometry determined the locations where runoff could feasibly be collected and treated, while available funding controlled the number of improvements which could be constructed in Phase 1. Phase 1 (upper area) includes the improvements designed to handle runoff from sub-watersheds, located in the higher elevation portion of Trinidad where drainage naturally flows to, or could be routed to flow toward the proposed infiltration basins at the intersection of Trinity and Main streets. Phase 2 (lower area) includes sub-watersheds which drain toward the parking areas near Trinidad Beach and Trinidad Bay. The preliminary design stage included data collection, modeling, analysis and conceptual design of both Phase 1 and 2 improvements because the two areas are hydrologically connected and must be analyzed together. Options for infiltration of stormwater in the Phase 2 area have been continually developed, and are consistent with the same technical approaches utilized in Phase 1.

The preliminary design was based on a 50-year/24-hour design storm. Various alternatives for stormwater catchment systems and infiltration galleries were sized to handle the 2, 25, 50, and 100 year/24 hour storm events. These alternatives were assessed to select an appropriate design storm, taking regulatory requirements and guidelines into consideration. The 50-year/24-hour storm was selected for the design storm, and was used to determine the volume of stormwater that needs to be managed. The 2-year/24-hour storm was selected for the water quality storm event. The project area was divided into sub-watersheds for each stormwater interception and treatment system. Peak flow rates for each system were determined based on hydrologic analysis, and are shown in Table 1 in Appendix C.

Crawford & Associates, Inc. completed slope stability analyses along selected bluff sections. Their analyses were based on the cross section geometry developed in the Geotechnical Report (GHD 2012) with soil parameters obtained from laboratory and field observations. A comparison between water surface elevations under existing conditions and under maximum (peak) infiltration based on a 50-year/24-hour storm event was conducted. Each cross section was analyzed to determine the critical

failure surface, recognizing that the south bluffs along Trinidad Bay have experienced past failures within the terrace soils. The North Slope was also field-reviewed for stormwater discharging to a tributary of Mill Creek. Crawford & Associates, Inc. analyses showed a relatively small reduction in the Factor of Safety (FS) at the 50-year/24-hour storm event. Since the peak groundwater level will only exist for a few hours duration, the analysis concluded the reduced FS to be acceptable for these short (transient) periods of time. Crawford & Associates, Inc. also reviewed the Mill Creek tributary, which is relatively steep, heavily vegetated, with the slope comprised of terrace soils similar to the bluffs. Their observations did not show instability along these slopes and therefore it is not anticipated that the short-term increase in hydraulic head will have an adverse impact to these slopes.

Septic loadings were incorporated into the groundwater model which was used to evaluate the potential for impacts to septic systems from the proposed new stormwater infiltration. The results of the groundwater model showed adequate separation from groundwater can be maintained. This is explained in greater detail in the *Groundwater Technical Report* (GHD 2013).

The existing outfall to Trinidad Bay must remain in use until all of the stormwater improvements are constructed. During construction of the Phase 2 improvements, the existing 30-inch diameter corrugated metal pipe outfall to Trinidad Bay may be partially removed, with the pipe down the bluff filled with slurry, capped with concrete, and abandoned in place.

The proposed stormwater improvements, presented in this Design Basis Memorandum, allow the City of Trinidad to effectively manage stormwater in a phased holistic manner. The improvements will reduce the pollutant loading to the ASBS, thus increasing protection of this valuable resource.

5. References

Alth, M. (1992). *Wells and Septic Systems.* TAB Books, a division of McGraw-Hill, Inc.

Galli, J. 1997. Analysis of Urban BMP Performance and Longevity in Prince George's County Maryland. Metropolitan Washington Council of Governments, Washington DC.

GHD, 2012. *ASBS Stormwater Improvement Project – Geotechnical Analysis*. Prepared for City of Trinidad. Report No. 01063/11005/11005.

GHD, 2013. *ASBS Stormwater Improvement Project – Groundwater Modeling Technical Report*. Prepared for City of Trinidad. Report No. 01063/11005/11007.

NOAA Coastal Service Center if SAR digital surface model (5 meter grid) for inland elevations east of Highway 101

USDA. (1986) Urban Hydrology for Small Watersheds. Natural Resources Conservation Service, Conservation Engineering Division, Technical Release 55. June 1986

Winzler and Kelly (2008) *Stormwater Assessment Affecting Kelp Beds at Trinidad Head Trinidad California*

Document Status

Rev #	Author/Editor	Approved for Issue	
		Name	Signature/Stamp
A	Rebecca Crow, PE	Design Basis Memorandum	REGISTERED PROFESSIONAL ENGINEER REBECCA STANSEL CROW No. C 69664 Exp. 6/2014 CIVIL STATE OF CALIFORNIA 9/30/2013

Appendices

Appendix A

Figures

A-1 Vicinity Map City of Trinidad

A-2 Site Map, Geophysical Transect, Boring, and Monitoring Well Locations

A-3 Mill Creek Watershed Sub-Basins

A-4 City Watershed Sub-Basins

A-5 Parker Creek Watershed Sub-Basin

Phase 1
Phase 2
Area of Special Biological Significance (ASBS)
Project Area
Trinidad City Limits
Humboldt County
Counties

Paper Size ANSI A
0 200 400 600 800
Feet
Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

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City of Trinidad
Trinidad ASBS Stormwater Project
Initial Study and Mitigated Negative Declaration

Job Number	0106311005
Revision	1
Date	15 Oct 2013

Vicinity Map

Figure A-1

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Data source: StreetMapUSA, Roads, Boundaries, 2010. Bing Aerials, Aerial Imagery, 2012. City of Trinidad, Area of Special Biological Significance, 2011. Humboldt County, Watersheds, 2011. Created by:amshows

Paper Size 11" x 17" (ANSI B)

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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Soil Boring

Monitoring Well

Preexisting Monitoring Well

Project Area Boundary

Geophysical Transect
(Seismic Reflection & Electrical Resistivity)

City of Trinidad
Trinidad ASBS Stormwater Project

Job Number	0106311005
Revision	A
Date	15 Oct 2013

Site Map, Geophysical Transect, Boring, and Monitoring Well Locations

Figure A-2

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-2_Site_Map.mxd

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. Created by:amshows

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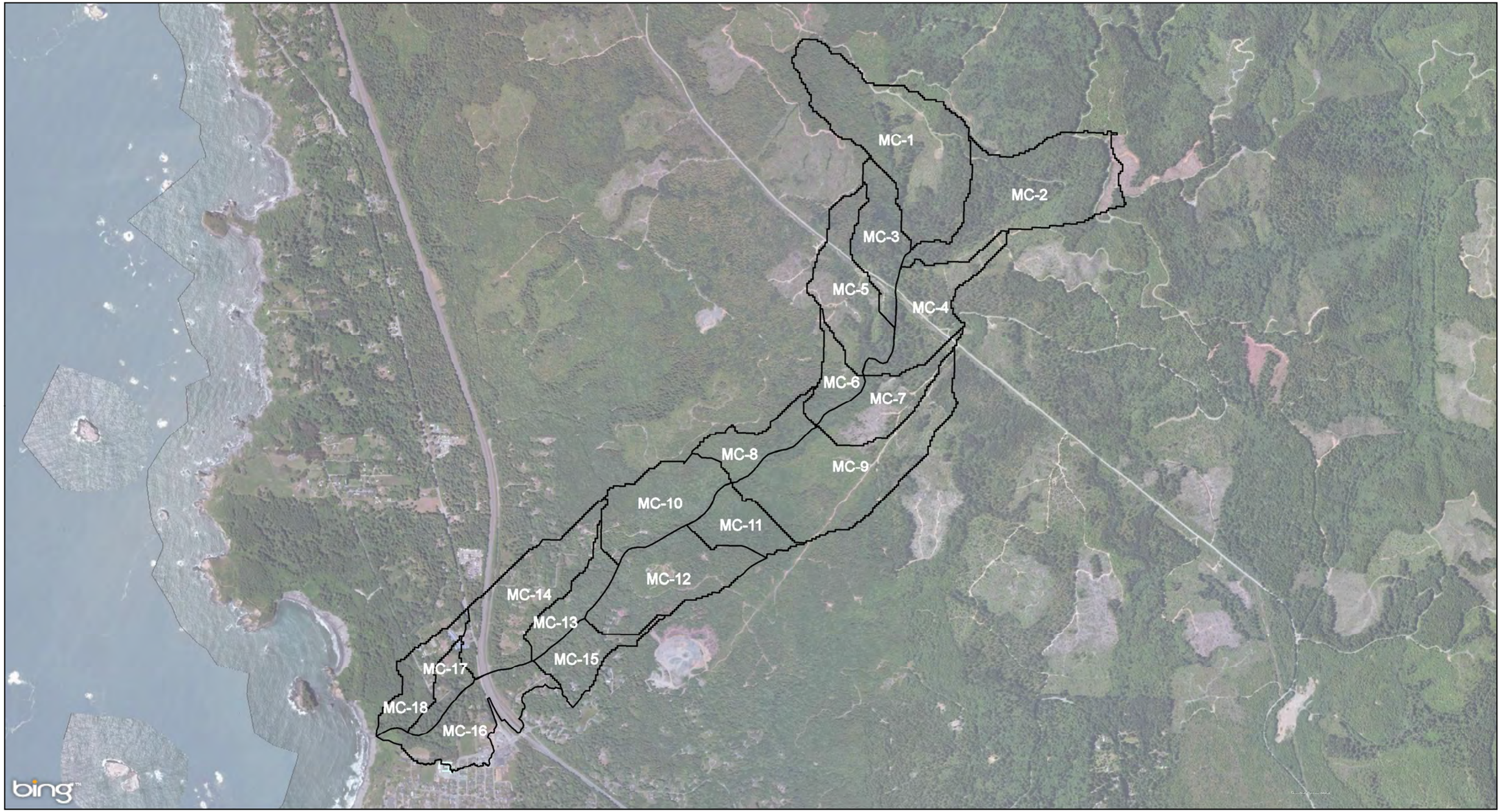

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Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

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Mill Creek Sub-Basins

City of Trinidad
Trinidad ASBS Stormwater Project

Job Number	0106311005
Revision	A
Date	15 Oct 2013

Mill Creek Watershed Sub-Basins

Figure A-3

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-3 Mill Creek WS.mxd

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Data source: NOAA, CA Coastal Conservancy Coastal Lidar Project, 2012. GHD Inc., Field Points, 2012. Created by:amshows

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Paper Size 11" x 17" (ANSI B)

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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

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City Sub-Basins

City of Trinidad
Trinidad ASBS Stormwater Project

Job Number	0106311005
Revision	A
Date	15 Oct 2013

City Watershed Sub-Basins

Figure A-4

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Data source: NOAA, CA Coastal Conservancy Coastal Lidar Project, 2012. GHD Inc., Field Points, 2012. Created by:amshows

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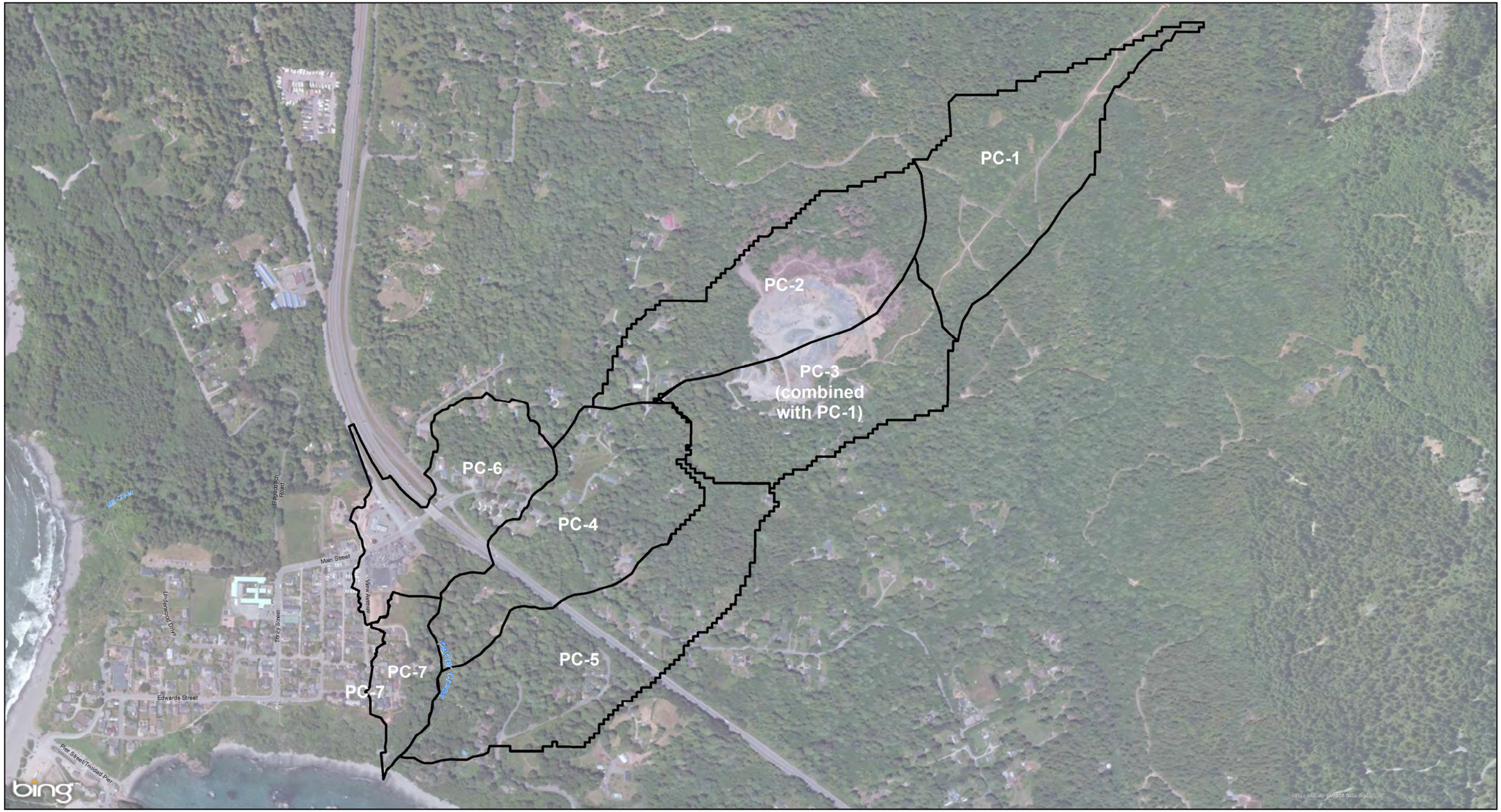

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Parker Creek Sub-Basins

City of Trinidad
Trinidad ASBS Stormwater Project

Job Number	0106311005
Revision	A
Date	15 Oct 2013

Parker Creek Watershed Sub-Basins

Figure A-5

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-5 Parker Creek Watersheds.mxd

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Appendix B

Crawford & Associates, Inc. Model Review Memo

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Sacramento • Modesto • Roseville • Pleasanton

October 3, 2013

Mr. Patrick Sullivan
GHD
718 Third Street
Eureka, CA 95501-0417

Subject: **Slope Stability Analyses**
Trinidad Stormwater Improvement Project
Trinidad, California

Dear Mr. Sullivan,

Crawford & Associates, Inc. (CAInc) completed slope stability analyses along selected bluff sections using SLIDE software by RocScience. Our analyses were based on the cross-section geometry for Sections H-H', AB-AB', and G-G' as provided by GHD. Comparisons were made between water surface elevations under existing conditions and under maximum (peak) infiltration based on a 50-year storm, per GHD hydrologic data.

CAInc assigned strength parameters of ϕ=30° and a cohesion = 200 psf to the near surface terrace soils (silty sand and poorly graded sand). These parameters are supported by GHD boring and laboratory data and our field observations of the relatively strong, Pleistocene marine terrace soils as exposed along the bluff face (near-vertical in some places, reflecting their partly cemented nature). The underlying bedrock is comprised of highly sheared, greywacke sandstone of the late Mesozoic Franciscan Formation; we assigned strength parameters of ϕ=42° and a cohesion = 1000 psf to the bedrock formation.

We analyzed each section to determine the critical failure surface, recognizing that the south bluffs along Trinidad Bay (Sections G.1-G.1' and H-H') have experienced past failures within the terrace soils. Section AB-AB' evaluated the west slope facing the ocean. We also field-reviewed the north slope discharging to a tributary of Mill Creek.

Our computed minimum factors of safety (FS) for the existing slopes range from 1.22 to 2.09. The added hydraulic head as shown by GHD groundwater modeling for the 50-year storm condition (short-term, transient model) reduces the Factors of Safety to 1.05 (G.1-G.1') to 2.92 (AB-AB').

We summarize our results in Table 1 below, show the stability plots on Figure 1 through 6, and show the cross section locations on Figure 7.

Table 1: Slope Stability Results			
Cross Section[1]	Minimum Factor of Safety		
	Existing Condition	50-year Storm Condition	Reduction
H-H'	1.24	1.15	7%
G.1-G.1' Plus 25 Cells West	1.22	1.05	14%
AB-AB'	2.09	1.92	8%

[1]We show the cross section locations on Figure 7.

Our analyses show a relatively small (about 14% or less) reduction in FS at the 50-year storm event. Based on our discussion with GHD we understand that the 50-year event will cause a peak groundwater level for only a few hours in duration. We consider the reduced factor of safety to be acceptable for these short (transient) periods of time. We also compared the (50-year storm) condition at section G-G' (FS=1.05) with a more typical, 2-year storm profile; these results show a FS of 1.14.

At the Mill Creek tributary, our review indicated this drainage to be relatively steep and heavily vegetated, with the slope comprised of terrace soils similar to the bluffs. We did not observed evidence of significant instability along these slopes. We do not anticipate the short-term increase in hydraulic head to have an adverse impact to these slopes.

LIMITATIONS

CAInc prepared this report in accordance with generally accepted geologic and geotechnical engineering principles and practices currently used in this area. This report is based on data provided by GHD at specific bluff locations. The input parameters represent a simplified model using the limited data and conditions at other locations may be different. This report should be reviewed and modified if conditions change or if further data is made available.

Crawford & Associates, Inc.

REGISTERED PROFESSIONAL ENGINEER
BENJAMIN D. CRAWFORD
No. GE 2861
GEOTECHNICAL
STATE OF CALIFORNIA

Rick Sowers, P.E., C.E.G.
Principal

Benjamin Crawford, P.E., G.E.
Principal

Attachment: Figure 1 through 6, Slope Stability Trials
Figure 7, Cross Section Locations

Slope Stability Trials

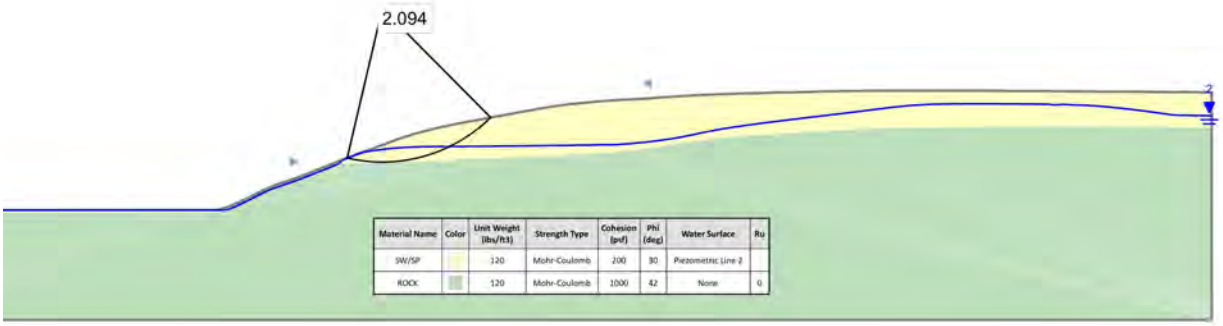


Figure 1: AB-AB' Existing Condition

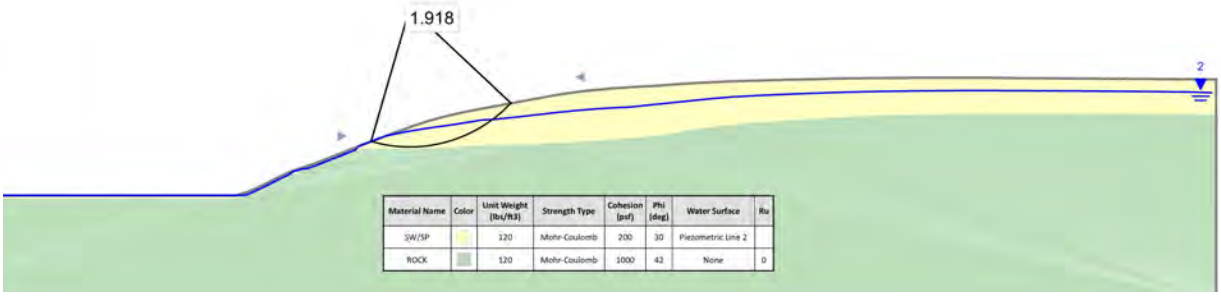


Figure 2: AB-AB' Proposed Condition

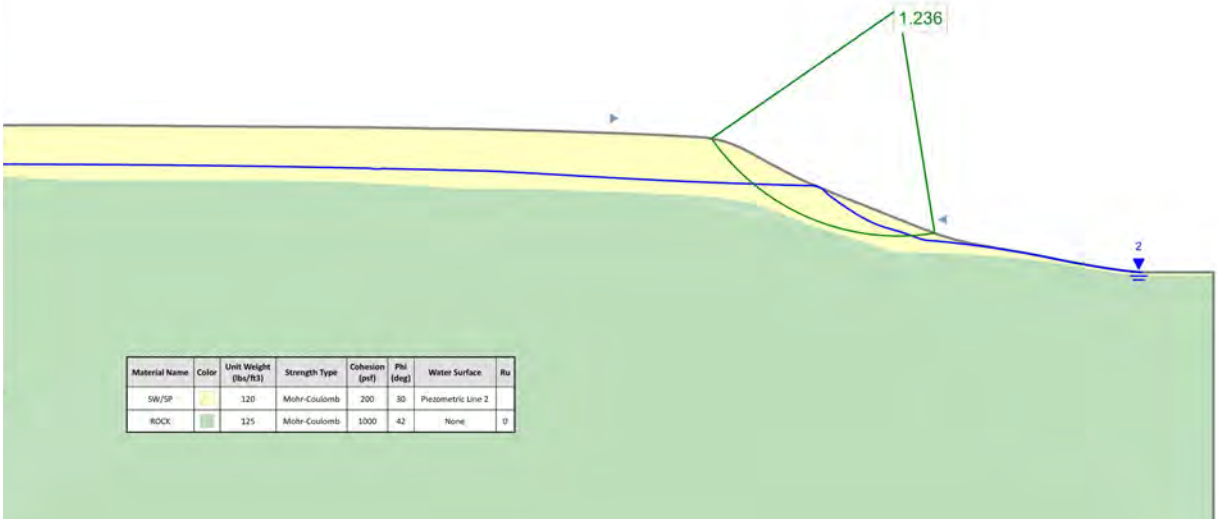


Figure 3: H-H' Existing Condition

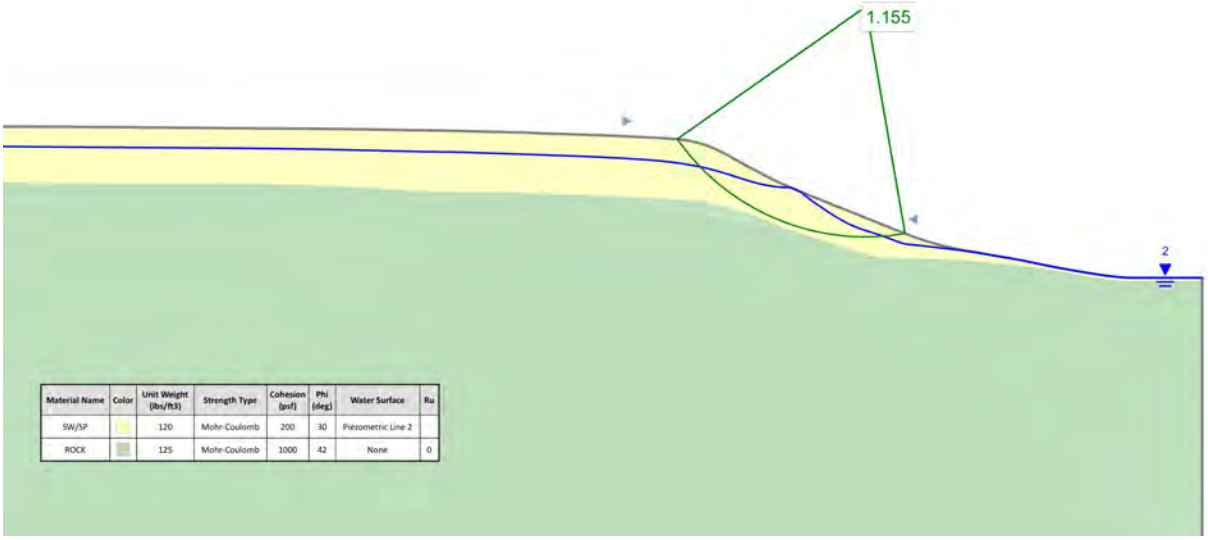


Figure 4: H-H' Proposed Condition

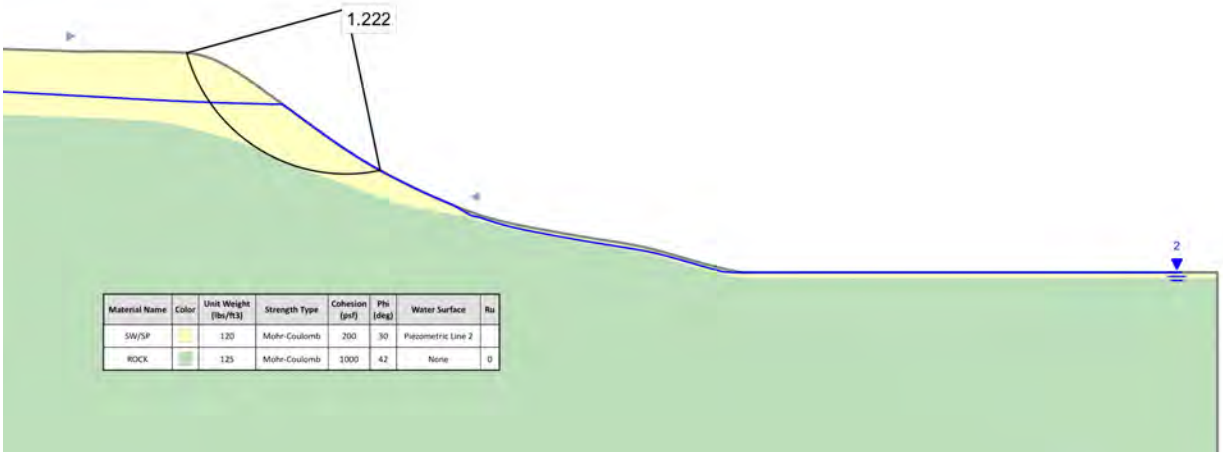


Figure 5: G.1-G.1' Plus 25 Cells West Existing Condition

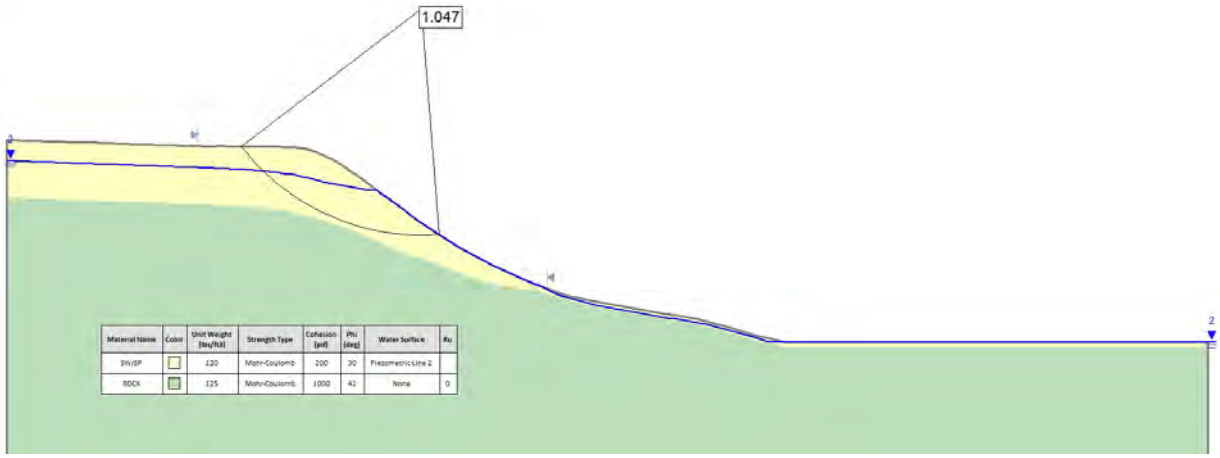


Figure 6: G.1-G.1' Plus 25 Cells West Proposed Condition

Figure 7: Cross Section Locations

Appendix C

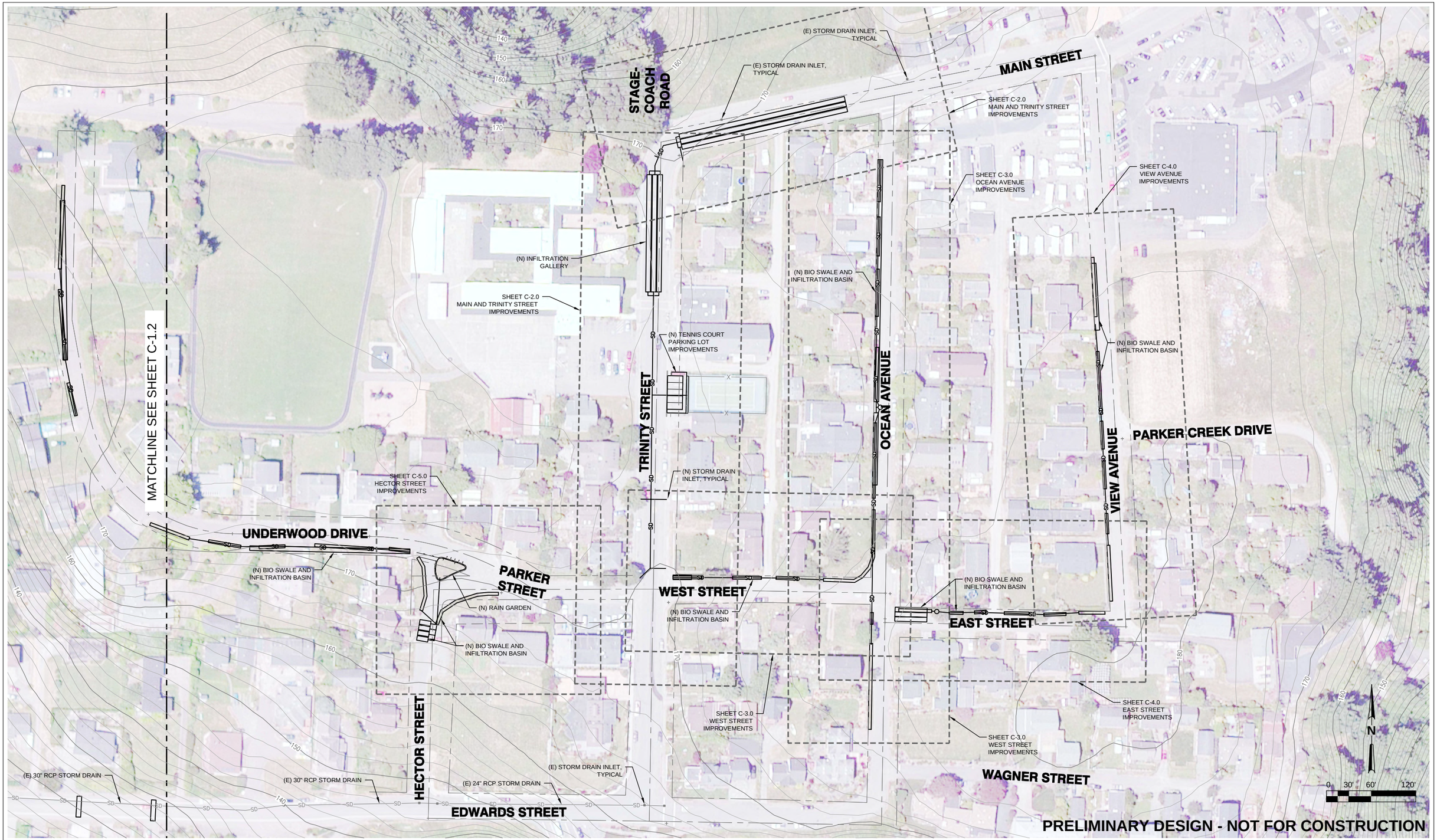
Infiltration Gallery Model and Sizing Results

Table 1 Stormwater Peak Flow Rates by Stormwater System Improvements

Location:	Watershed Tributary Area (ft^2):	2-Year Storm	50-Year Storm
		Max Flow Rate (cfs):	Max Flow Rate (cfs):
Main/Trinity Street Infiltration Gallery	9.42	6.79	18.34
View Avenue Bio Swales & Infiltration Gallery	0.74	0.53	1.43
Ocean Avenue Bio Swales & Infiltration Gallery	3.44	2.48	6.7
East Street Bio Swales & Infiltration Gallery	1.05	0.75	2.04
West Street Bio Swales & Infiltration Gallery	0.20	0.15	0.39
Hector St Rain Garden, Bio Swales and Infiltration Gallery	0.50	0.28	0.78
Upper Underwood Drive Bio Swales & Infiltration Galleries	2.85	0.7	2.07
Lower Underwood Drive Bio Swales & Infiltration Galleries	1.45	0.8	2.28
Edwards Avenue Infiltration Galleries	8.86	4.89	13.87
Galindo Street Bio Swale & Infiltration Gallery	0.45	0.15	0.45
Lighthouse Road Infiltration Galleries	1.38	0.53	1.57
Van Wycke St East Bio Swale & Infiltration Gallery	2.03	0.68	2.00
Van Wycke St West Bio Swales & Infiltration Galleries	0.84	0.28	0.83

Appendix D

Trinidad ASBS Stormwater Improvements Project Preliminary Design Drawings



No	Revision	Drawn	Job Manager	Project Director	Date
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Drafting Check SG | Design Check SA
Approved (Project Director)
Date
Scale AS SHOWN
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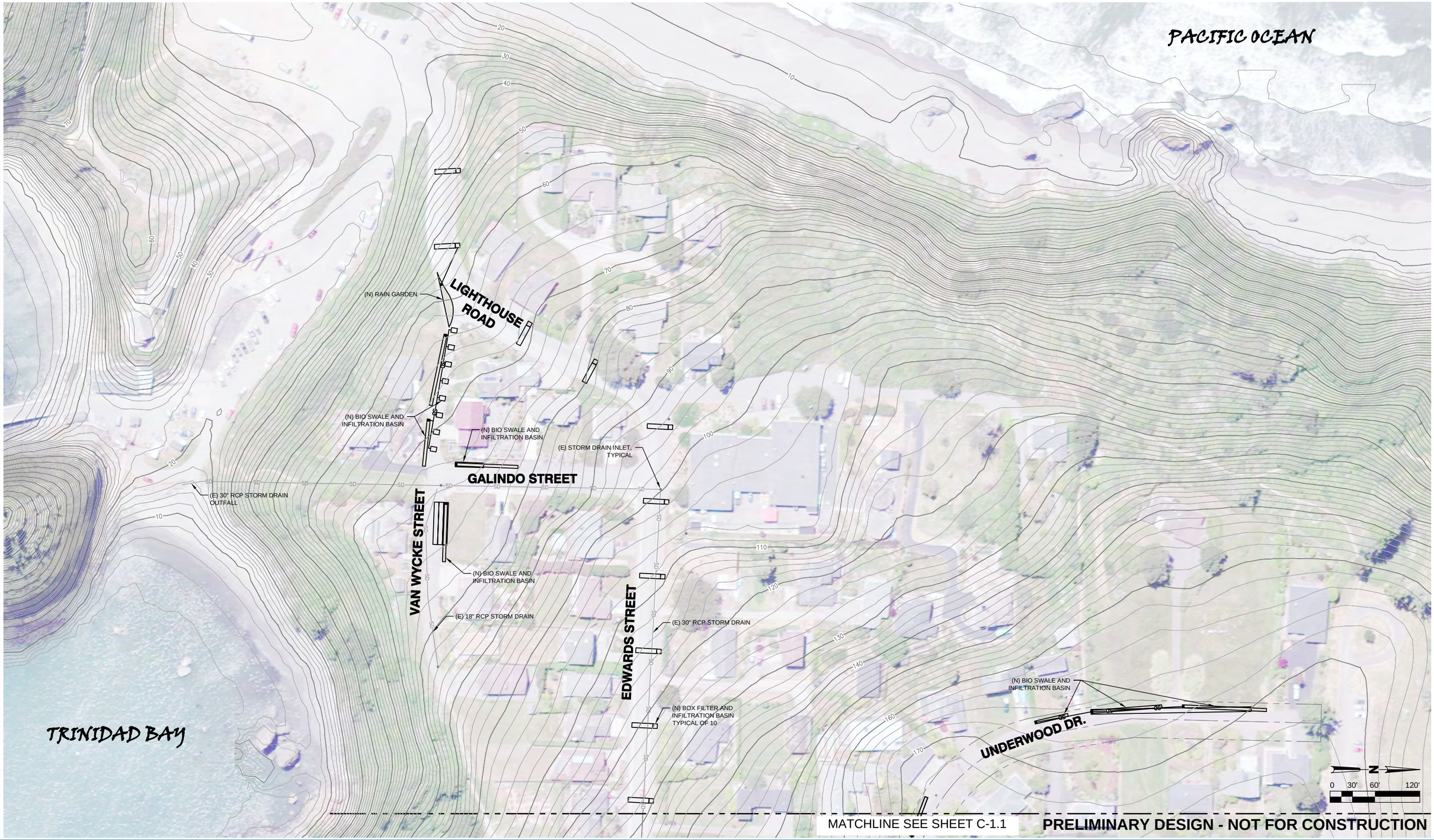
Client **CITY OF TRINIDAD**
Project **ASBS STORMWATER IMPROVEMENTS PROJECT**
Title **SITE PLAN - UPPER AREA**

Contract No. 01063-11-005
Original Size **Ansi D** **Drawing No: C-1.1**
Sht 3 of 15
Rev:

Plot Date: 11 July 2013 - 4:49 PM Plotted by: Tyler Duncan Cad File No: G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\06-CAD\Sheets\0106311005_C1-C6 Site Plan.dwg



No	Revision	Drawn	Job Manager	Project Director	Date
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Client **CITY OF TRINIDAD**
Project **ASBS STORMWATER IMPROVEMENTS PROJECT**
Title **SITE PLAN - LOWER AREA**

Contract No. 01063-11-005

Original Size **Ansi D** **Drawing No: C-1.2**

Sht 4 of 15
Rev:

Plot Date: 11 July 2013 - 4:53 PM Plotted by: Tyler Duncan Cad File No: G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\06-CAD\Sheets\0106311005_C1-C6 Site Plan.dwg

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