GEI Consultants

Geotechnical

Water Resources

Environmental and

# COYOTE CREEK LEVEE EVALUATION PROJECT

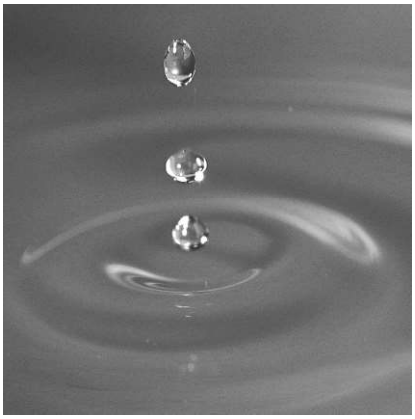
## Geotechnical Data Report

Submitted to:
**Marin County Flood Control and Water Conservation District**
3501 Civic Center Drive, Room 304
P.O. Box 4186
San Rafael, CA 94913

Submitted by:
**GEI Consultants, Inc.**

180 Grand Ave., Suite 1410
Oakland, CA 94612

May 21, 2015, Revision 1
Project 140457-0



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May 21, 2015
Revision 1
Project 140457-0

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## Abbreviations and Acronyms

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| bgs | Below ground surface |
| CPT | Cone Penetration Test |
| DWR | California of Department of Water Resources |
| FEMA | Federal Emergency Management Agency |
| GDR | Geotechnical Data Report |
| gINT | Geotechnical Integrator (Geotechnical data base software) |
| GEI | GEI Consultants, Inc. |
| GER | Geotechnical Evaluation Report |
| ITR | Independent Technical Review |
| HASP | Health and Safety Plan |
| HDR | Henningson Durham and Richardson, Inc. |
| MC | Modified California |
| NAD 83 | North American Datum of 1983 |
| NAVD 88 | North American Vertical Datum of 1988 |
| NGVD 29 | National Geodetic Vertical Datum of 1929 |
| OBM | Older Bay Mud |
| psf | Pounds Per Square Foot |
| QA/QC | Quality Assurance/Quality Control |
| RCP | Reinforced Concrete Pipe |
| RIP | Rehabilitation and Inspection Program |
| SFHA | Special Flood Hazard Area |
| SPT | Standard Penetration Test |
| USA | Underground Service Alert |
| USACE | United States Army Corps of Engineers |
| USCS | Unified Soil Classification System |
| USGS | United States Geological Survey |
| YBM | Younger Bay Mud |

# 1 Introduction

## 1.1 Program Overview

GEI Consultants Inc. (GEI) along with project sub-consultant HDR, Inc. (HDR) is assisting the Marin County Flood Control and Water Conservation District (District) in an evaluation of the Coyote Creek Local Flood Protection Project (Project) located in the unincorporated community of Tamalpais Valley. The overall goal of the Coyote Creek Levee Evaluation is to provide a comprehensive assessment of the current condition of the levee system and develop recommendations for both short- and long-term improvements. The development and assessment of improvement alternatives is necessary in order to identify options for maintaining and, if feasible and cost-effective, increasing the level of protection provided by the project. This project is partially funded by a State of California grant under the Department of Water Resources Local Levee Assistance program.

The project includes an engineering evaluation of Coyote Creek's concrete channel, floodwalls, and earthen levees from Maple St to the Mill Valley-Sausalito Pathway, and an assessment of preliminary improvement alternatives which, if implemented, would satisfy Federal Emergency Management Agency (FEMA) criteria specified in the Code of Federal Regulations, Title 44, Section 65.10 (44CFR 65.10) for levee accreditation. These criteria include stability (including through-seepage and underseepage), liquefaction-induced settlement, lateral spreading, and settlement analyses. Accreditation of the levee is necessary before FEMA can remove the area protected by the levee from the Special Flood Hazard Area (SFHA). However, levee accreditation alone does not remove the area from the SFHA.

Additional evaluation goals are to: 1) assess alternatives to improve the levee protection against future sea-level rise and 2) meet operation and maintenance requirements in agreement with the U.S. Army Corps of Engineers' (USACE) Rehabilitation and Inspection Program (RIP). Coyote Creek's concrete channel, floodwalls and levees have been subject to the RIP since the project was constructed by the Corps in the 1960s and transferred to the District for operation and maintenance.

## 1.2 Purpose and Scope

GEI has undertaken geotechnical explorations along and adjacent to the project levee as part of a comprehensive assessment of the current conditions of the levee system. The purpose of the explorations was to obtain additional information on geotechnical subsurface conditions and refine soil properties for engineering analyses.

The project team reviewed existing information to plan the field and laboratory investigations. Review and discussion of previous relevant reports within the Project area and current site conditions is provided in a Technical Memorandum submitted by GEI to the District on July 24, 2014 Re: *Coyote Creek Levee Evaluation; Summary of Existing Documentation Review and Field Reconnaissance* (GEI, 2014a), which is included in Appendix A of this report. A brief summary of the relevant historical information is provided in the following sections.

The team performed field investigations along the Coyote Creek levee crown, landside areas, concrete and earthen channels, and a potential high ground alignment to supplement the existing subsurface and laboratory data. The project team performed field investigations in consideration of existing subsurface data, geologic and geomorphic setting, current configuration of the existing levees, the underlying technical requirements of the USACE guidelines and FEMA criteria for evaluating and designing levees, and environmental constraints.

This Geotechnical Data Report (GDR) summarizes data collection, subsurface investigations, and laboratory testing performed as part of this project. This report includes boring logs, laboratory test results, and a site plan showing current and historic exploration locations along the Coyote Creek levee system.

The scope of this geotechnical exploration program included:

- Review of existing data;
- Completion of the geotechnical explorations utilizing CPT, geoprobe, and rotary-wash and auger boring methods;
- Documentation of exploration locations and elevations;
- Preparation of boring logs and a gINT database; and
- Geotechnical laboratory testing.

Following the completion of this GDR, the project team will perform geotechnical analyses to evaluate existing conditions as well as improvement alternatives for identified deficient segments. Evaluations will utilize the data compiled in this GDR, including

recently completed explorations and historic explorations performed by others. Results of these analyses will be presented in a Levee Evaluation Technical Memorandum, which will include the results of all stability (including through-seepage and underseepage), liquefaction-induced settlement, lateral spreading, and settlement analyses performed for this project.

It should be noted that future additional design level explorations and analyses will likely be required in areas where deficiencies are identified to assist in the final design phase and the development of construction plans and specifications for needed improvements.

# 2 Site Conditions

## 2.1 Introduction

As mentioned above, several previous geotechnical reports were reviewed by GEI prior to development of the Work Plan. These documents provide discussion of surface and subsurface conditions encountered during subsurface exploration, construction history, levee penetrations, and boring log and geotechnical laboratory testing data. A review and discussion of previous geotechnical explorations within the project area is provided in the Technical Memorandum included in Appendix A. A brief summary of this information, along with newly collected information, is provided below. Refer to Appendix A for a more detailed discussion of these historic reports.

The locations of the new explorations and identified historic explorations by others are shown for reference in plan-view on Figures 1 through 6 and in profile-view on Figures 7 through 14. It should be noted that the stationing alignments included on these figures refer to GEI stationing developed for this evaluation project and not the original USACE channel centerline station alignment; however, USACE stationing is included in the plan-view Figures 1 through 6 for reference. GEI stationing was developed to provide unique station alignments along both sides of channel to aid in developing this report and future analyses of potential levee remediations. The GEI stationing convention begins with 0+00 feet at the downstream limit of a channel and increases in the upstream direction. Separate stationing alignments were created for the left and right banks of Coyote Creek (CC-L, CC-R), the left and right banks of Nyhan Creek (NC-L, NC-R), the high-ground area adjacent to Bothin Marsh (BM-L), and the centerline of the concrete-lined channel portion of Coyote Creek (CC-C, and CC-C2).

## 2.2 Topographic Data

The topographic data utilized for Project evaluations, including the elevation contours presented on Figures 1-6 and the elevation profiles presented on Figures 7-14, was provided by the District. Two separate data sets were provided, which include 1) County of Marin digital topographic-bathymetric surface model, Revision 2013.12.18 (County of Marin, 2013), and 2) topographic and bathymetric data derived from field survey of the Coyote Creek channel and levees, performed by Meridian Surveying Engineering (Meridian, 2013). Brief descriptions of these datasets are provided in the following sections.

### 2.2.1 County of Marin Digital Topographic-Bathymetric Surface Model

The County of Marin digital topographic-bathymetric surface model, Revision 2013.12.18 is a 50cm gridded surface exported from an ESRI Terrain Dataset which includes bare earth topographic and bathymetric elevation surfaces for Marin County and surrounding areas. The Terrain Dataset was developed from multiple source datasets including airborne LiDAR ground-classified points, and multi-beam sonar bathymetric grids. This surface is the fourth edition of an integrated countywide terrain model of Marin County, California. Airborne LiDAR surveys were flown between 2007 and 2010 and multiple bathymetric datasets were fused into a single ESRI Terrain Dataset to develop a best-available surface. The coordinate system datum for this surface model is WGS 1984 (Geoid 2003) and the vertical datum is North American Vertical Datum 1988 (NAVD 88). Elevation values are provided in meters and were converted to feet (by GEI) during project use.

### 2.2.2 Meridian Survey

The Meridian survey was performed in 2013 and includes both ground and bathymetric data of the Coyote Creek channel system within the project area, including the levees, and concrete channel structures, and creek bottom. The survey data generally extends from the creek to the landside levee crest, and in limited areas, extends landward of the levee crest. Bathymetric data of the creek bottom conditions were collected on March 7, 2013, using a Trimble R8 Real-time kinematic GNSS receiver and Sonarmite Echosounder with a single frequency transducer at 200 kHz. Details of the land survey methods were not provided. The basis of coordinates for the survey is California Coordinate System 83 Zone 3 (CCS83) and the basis of elevation is NAVD 88. Survey control at the site was provided by Marin County Public Works Department.

### 2.2.3 Topographic Data Used for Project Evaluations

Topographic data from both datasets provided by the District were used in Project evaluations. It should be noted that inconsistencies in elevation data between the two datasets provided are observed, likely due in part to limitations inherent to data collection methods and survey extents. In areas where data from both survey sources overlap, the data sets were compared, with the data from the source which appeared more accurate used for evaluation. The elevation contours shown on Figures 1-6 were developed using County of Marin, 2013 data, because of the larger spatial extent of the dataset. The elevation profiles shown on Figures 7-14 for each GEI reach alignment were developed using data from both sources (County of Marin, 2013 and Meridian, 2013), as well as original USACE channel as-built elevations (USACE, 1964), as appropriate. A summary of the topographic data used within each GEI reach alignment is provided below.

CC-L: Meridian, 2013, supplemented with County of Marin, 2013 outside Meridian extents (generally areas landward of channel and levees).

CC-R: Meridian, 2013, supplemented with County of Marin, 2013 outside Meridian extents (generally areas landward of channel and levees).

NC-L: Meridian, 2013, supplemented with County of Marin, 2013 outside Meridian extents (generally areas landward of channel and levees and upstream of approximate station 9+50).

NC-R: Meridian, 2013, supplemented with County of Marin, 2013 outside Meridian extents (generally areas landward of channel and levees and upstream of approximate station 8+50).

BM-L: County of Marin, 2013 (Meridian survey extents do not include this area).

CC-C: Meridian, 2013 (survey included channel top-of-wall and invert elevations), supplemented with USACE, 1964. Note that the Meridian survey extents do not include the upstream end of the channel (upstream of approximate station 27+00). Original USACE as-built elevation data was used in these upstream areas of the channel. County of Marin, 2013 data was generally unreliable in this reach, likely due to narrow channel features and dense vegetation, and thus was not used.

## 2.3 Description of Levees

The Coyote Creek levee system protects a portion of the Tamalpais Valley community from high flows in Coyote Creek and Nyhan Creek as well as from high tides from Richardson Bay. The Project consists of an approximate 7,800 ft section of Coyote Creek extending from just upstream of Maple St downstream to the Mill Valley – Sausalito Pathway at Richardson Bay. A second 450 ft segment of earthen levees along Nyhan Creek, from its confluence with Coyote Creek upstream to near Marin Ave, is also included as part of the Project.

The Coyote Creek levee system consists of a concrete channel and system of earthen levees along Coyote Creek and Nyhan Creek. The Project is divided into the following Reaches:

Upper Reach - This reach consists of a concrete channel beginning near Maple St and extending downstream to the end of the concrete channel upstream of Flamingo Rd. Two separate 7 to 9 ft wide reinforced concrete pipe (RCP) box culverts extend from west of Maple St and combine as a single 13 to 16 ft wide rectangular concrete channel just west of Ash St Concrete bridge decks span the concrete channel at Ash St, Spruce St, Pine St, Poplar St, Laurel Way, and Ross Dr The concrete channel extends east of Ross Dr,

transitioning to a stilling basin and terminating where the concrete channel wing walls transition into the earthen levee segment (Middle Reach).

Middle Reach - This reach consists of earthen levee beginning at the downstream end of the concrete channel and extending downstream to the Highway 1 / Shoreline Hwy. Bridge. This section also includes a portion of Nyhan Creek beginning near the Marin Ave. Bridge and extending downstream to the confluence of Nyhan Creek with Coyote Creek. Portions of the left bank downstream of Flamingo Rd include a concrete block floodwall constructed on top of the original earthen levee. It should be noted that several feet of fill material have been added to the areas surrounding the Middle Reach as part of development in this area, and fill has been placed on the levee crest in an effort to maintain design crest elevations lost due to settlement.

Lower Reach - This reach consists of earthen levee beginning at the Highway 1 / Shoreline Highway Bridge and extending downstream along Bothin Marsh to the Mill Valley – Sausalito Pathway. This section also includes a portion of high ground along Bothin Marsh beginning approximately 350 feet downstream of Highway 1 / Shoreline Highway Bridge on the left of Coyote Creek and extending along Bothin Marsh high ground to Almonte Boulevard. Like much of the project area, this reach has experienced substantial settlement due to soft soils. However, unlike other levee segments, the Lower Reach has not been maintained to its original design elevation and is regularly overtopped by high tides in the vicinity of the Coyote Creek channel. Other than the original levee fill, no other fill material has been placed in the vicinity of the channel, with the exception of fill placed in a few developed areas adjacent to the channel, including the high ground. A portion of the left bank along a developed commercial property (currently Dipsea Café) includes a concrete floodwall approximately 2 ft in height.

## 2.4 Construction History

The Project was originally designed in the late 1950s by USACE and construction of the levees, concrete channel, and interior drainage structures was completed between 1965 and 1967. After construction, the Project was transferred to the District for operation and maintenance. Previous modifications along specific sections include adding earth fill or floodwall construction to maintain design crest elevations, construction of pump stations to improve internal drainage, maintenance dredging of the channel to maintain flow capacities, and installation of a seepage barrier to mitigate local levee through-seepage conditions. Public access improvements along a portion of the right bank have also been recently constructed.

To compensate for settlement within areas of the site, sections of the levees were raised in 1977 by adding new fill or constructing floodwalls. Previous levee raises may have

also been completed, but were not noted during our review of available documents. One of the floodwalls constructed extends on the left bank from approximately Station CC-L 13+00 to CC-L 16+50 (25+00 to 28+50 USACE channel centerline station alignment) at the U.S. Highway 1 Bridge. A second floodwall, constructed between approximately Station CC-L 21+50 and CC-L 31+40 (33+00 and 44+00 USACE channel centerline station alignment), consists of two parallel concrete walls connected with tie-rods and filled in between with compacted earth to provide an access road on the crown of the levee. The District continues to periodically add fill material to earthen sections of the levee crown in order to maintain levee elevations. In 2006 and 2007, the levees were raised by placing earth on the right bank upstream of the Flamingo Rd Bridge between Station CC-R 32+80 to CC-R 35+10 CC-R (44+60 to 46+90 USACE channel centerline station alignment), and also on the right bank downstream of the Flamingo Rd Bridge between approximately CC-R 29+20 (41+00 USACE channel centerline station alignment) wrapping along the left bank of Nyhan Creek to Station NC-R 2+80 (44+00 USACE channel centerline station alignment). Additionally in 2013, according to the District, minor amounts of fill were added to raise local low spots along the left and right levees near the Flamingo Rd Bridge.

The combination of added fill material and limited levee widening due to the close proximity of residences has resulted in steepened slopes along portions of levee. Notable steepened slopes include the left bank between Station CC-R 35+00 to CC-R 36+00 (46+80 to 47+80 USACE channel centerline station alignment), the right bank between Station CC-R 32+80 to CC-R 35+10 (44+60 to 46+90 USACE channel centerline station alignment), and the right bank between Station CC-R 29+20 and NC-R 2+80 (41+00 to 44+00 USACE channel centerline station alignment).

A series of pump stations were constructed between 1978 and 1985. These include the Crest Marin (1978), Cardinal, (1983), and Shoreline (1985) storm water pump stations and are shown on Figures 3 and 4. Both the Cardinal and Shoreline pump stations discharge directly into Coyote Creek while the Crest Marin pump station discharges into Nyhan Creek.

Plans for Maintenance dredging within the Middle Reach of Coyote Creek, dated August 12, 2003 (MCFCWCD, 2003), show limits of installation of an impermeable clay barrier to address seepage concerns within the left bank levee between approximate Stations CC-L 25+20 to 29+70 (37+60 to 42+60 USACE channel centerline station alignment) (Figure 3). According to the District, the actual length of barrier along the levee is approximately 450 ft.

In 2006, Kleinfelder recommended that a cut-off trench be installed within the levee prism and an abandoned storm drain culvert pipe crossing the levee be properly

abandoned along a portion of the right bank of the Middle Reach, upstream of the Flamingo Rd Bridge, behind the houses along Starling Rd and Flamingo Rd. These recommendations were meant to address high groundwater conditions observed in this area. Based on our document review, however, it is uncertain if any improvements were constructed to address these recommendations.

In recent years local erosion along the waterside levee slope was repaired with rip rap as an emergency levee repair along Nyhan Creek levee near the PG&E tower between Station NC-L 3+60 and NC-L 3+80 (no USACE channel centerline station alignment along Nyhan Creek). The repair was reported in good condition during the 2012 USACE Periodic Inspection.

In 2013, construction of the Tennessee Valley Pathway was completed, providing improved public pedestrian and bicycle access along the right (i.e. south) bank of Coyote Creek between the Marin Ave. and the Sausalito – Mill Valley Bike Path. The pathway includes raised or at-grade aggregate base surface, sections of wooden boardwalk, and a new pedestrian bridge across the creek on the southwest side of Highway 1.

## 2.5 Levee Penetrations

Levee penetrations are generally defined as utilities, conduits, pipelines, or other facilities that pass through or under the levee. During review of existing information and site reconnaissance, the project team identified 4 major levee penetrations including piping associated with the Crest Marin, Cardinal, and Shoreline storm water pump stations as well an abandoned storm drain culvert pipe crossing the on the right bank of the Middle Reach, upstream of the Flamingo Rd Bridge. A few other minor penetrations providing landside drainage were also identified. A more detailed discussion of these penetrations is provided in the Technical Memorandum included in Appendix A.

## 2.6 Past Performance

Based on review of levee inspection records, historic documents, and existing reports, the project area has primarily experienced issues with settlement, internal drainage, and levee seepage, with no documented deep-seated slope stability problems. Reports of past performance issues are notably more frequent within the Middle and Lower Reach of the Project area.

Settlement: Settlement resulting from compression of the Bay Mud layer in the levee foundation began to occur throughout the project site following completion of initial construction. The levee section between Station 11+05 and 28+40 (Lower Reach, downstream of the U.S. Highway 1 Bridge) has settled significantly and as a result, areas downstream of the U.S. Highway 1 Bridge experience flooding during high tide events.

As mentioned previously, no maintenance or placement of additional fill has been performed by the District in this reach.

Internal Drainage: Settlement has also affected internal drainage within the project area. Because of ongoing settlement both along the levee alignment and surrounding areas, gravity drainage no longer provides sufficient drainage to prevent ponding of storm water landward of the levee. This led to the series of pump stations constructed between 1978 and 1985, which now facilitate drainage of the landside areas.

High groundwater conditions have historically been observed along a portion of the right bank of the Middle Reach, upstream of the Flamingo Rd Bridge, behind the houses along Starling Rd and Flamingo Rd Geotechnical investigation in 2006 revealed that the conditions were likely due in part to an abandoned storm drain culvert which crossed beneath the levee and discharged into Coyote Creek (Kleinfelder, 2006). Local ground settlement over time may also have been a contributing factor.

Levee Seepage: Saturated conditions on the landside of the levee, which may be attributed to high groundwater, through-seepage, or shallow underseepage, were historically observed during very high tides along a portion of the left bank of the Middle Reach behind the houses along Cardinal Rd from the Flamingo Rd Bridge to just west of Highway 1. A geotechnical investigation in 2003 revealed the presence of granular material within the levee prism and it was recommended that a shallow seepage barrier be installed through the levee prism to help prevent levee seepage (Kleinfelder, 2003). As discussed in Section 2.3 of this report, a shallow clay barrier was installed through the left bank levee based on Kleinfelder's recommendations.

## 2.7 General Subsurface Conditions

General subsurface conditions within the Project extents are discussed below based on results of recent GEI explorations, historic mapping, and previous exploration logs. A compilation of historic information is provided in electronic format on the CD included in Appendix A. Data collection details and methods are further discussed in Section 3 of this GDR. Further evaluation of subsurface conditions will be performed during geotechnical analysis and will be described in the Levee Evaluation Technical Memorandum.

Subsurface conditions within the majority of the site consist of varying amounts of fill underlain by Younger Bay Mud (YBM) deposits, consisting of soft clay and silt material. YBM deposits generally thicken towards Richardson Bay (east) and with distance from the surrounding hill slopes. Stiff material or bedrock is found below the Bay Mud layer at depth. The stiff material below YBM deposits likely consists of either Older Bay Mud

(OBM) or alluvial and colluvial deposits. Bedrock encountered is typically of the Franciscan Formation.

Historic topographic mapping from the late 1800's indicates that the majority of the present day Project site is located on what was once tidal wetland. This area appears to include the entire extents of the Lower and Middle Reaches and a portion of the Upper Reach extending upstream to the vicinity of Pine Street. Later topographic mapping shows that residential development had occurred throughout the Upper and Middle Reaches by the mid-1950's, however, the Lower Reach was still mapped as tidal wetland. Mapping from the late 1960's shows the presence of a channelized Coyote Creek and development within the upstream extents of the present day Lower Reach, just downstream (east) from U.S. Highway 1.

Historic logs and current GEI exploration logs indicate the general subsurface conditions, grouped by Reach, are as follows:

Upper Reach: Subsurface conditions within this reach generally consist of up to 5 feet of fill (associated with residential development and construction of U.S. Highway 1), overlying an approximately 5-10-foot thick YBM layer. Below the YBM deposits, a thin layer of alluvial and colluvial deposits is found overlying Franciscan bedrock.

Middle Reach: From U.S. Highway 1 to the confluence with Nyhan Creek, the right bank of the Middle Reach abuts high ground features of the surrounding hillsides. Adjacent to the channel in this high ground segment, fill thicknesses range from approximately 4-5 feet, with localized deposits of colluvium extending from the hill slopes. YBM thicknesses below the fill range from approximately 7-20 feet, overlying sandstone and siltstone bedrock. Within the right bank levee segment in the vicinity of Flamingo Rd, fill thickness ranges from approximately 7-10 feet. The total thickness of the YBM layer in this levee segment is approximately 55 feet. Along the left bank of the Middle Reach, the thickness of fill ranges from 5-9 feet, overlying YBM deposits approximately 30-50 feet thick. Stiffer clays (OBM) and Franciscan bedrock were encountered below the YBM layer.

Lower Reach: Along both banks of the Lower Reach, there is generally a thin layer of artificial fill between 3 and 5 feet thick overlying Younger Bay Mud (YBM) deposits. The bottom of the YBM layer extends up to 90 feet below the ground surface with stiff material (OBM) or Franciscan bedrock below.

Nyhan Creek: The right bank of Nyhan Creek abuts high ground features of the surrounding hillsides. Previous explorations along this bank indicate a fill thickness of approximately 5 feet. The left bank of Nyhan Creek consists of an earthen levee from Marin Ave downstream to the confluence with Coyote Creek. The thickness of levee fill

along the left bank is approximately 5-8 feet, overlying approximately 20 feet of YBM deposits. OBM, alluvial, and Franciscan bedrock deposits were encountered below the YBM layer.

## 2.8 Groundwater Conditions

Current explorations encountered the groundwater table at depths between approximately 2.5 and 9.0 ft (elevation between -0.1 and 6.5 ft NAVD88). Historic explorations encountered a larger fluctuation in the groundwater table between approximately 0.5 and 11.0-ft depth (elevation between -1.7 and 9.3 ft NAVD88). Historic explorations that noted water depths were performed during March of 1990, May of 2007, and January of 2008. In addition to current and historic explorations, a 2008 report by Kleinfelder titled "Review of Water Level Survey Data" provided a review of groundwater level data and tidal data for the period between July 3rd and July 30th, 2007 along the south (right) bank of Coyote Creek. The report shows that the tide ranged between approximately 0.5 feet and 4.0 feet (NGVD29) and did not appear to have a significant correlation with groundwater level except when tidal level exceeded approximately 3.2 feet.

# 3 Field Exploration

## 3.1 General

The field exploration program summarized in this report was generally performed as described in the *Subsurface Exploration Work Plan, Coyote Creek Levee Evaluation Project* (Work Plan), dated August 2014 (GEI, 2014). The work plan was reviewed and approved by the District.

The selection of subsurface exploration locations, sampling intervals, sample types, and exploration depths was based on a number of factors, including available geotechnical data from past investigations, and USACE guidance as described in the *Geotechnical Levee Practice*, REFP10L0 (USACE, 2008). Table 1 summarizes the subsurface explorations performed as part of this investigation. Figures 1 through 6 show an aerial image of the Coyote Creek levee system, the levee alignment and stationing (GEI levee stationing and USACE channel centerline stationing), recent and historic exploration locations, and other site features. Figures 7 through 14 show longitudinal profiles along the centerline of the levee crest, and include logs of recent and historic investigations. Project boring and geoprobe logs are included in Appendix B of this report and the CPT logs are included in Appendix C.

Review of the historic subsurface investigations provided information on the nature of subsurface materials at the site. This knowledge allowed the project team to evaluate conditions and to select the appropriate exploration strategy and equipment. Specific considerations at the Coyote Creek site relative to the investigation approach included:

- The presence of soft bay mud deposits generally increasing in stiffness with depth below the levee fill material;
- Areas of artificial fill including levee alignments and landside areas;
- The depth to bedrock below the soft bay mud deposits;
- The presence of organics within the soft bay mud deposits.

Based on these considerations, an investigation program was developed utilizing mud rotary and auger borings, direct push geoprobes, and cone penetration tests through the levee and area landward of the levee.

Prior to the inception of field investigations, the goals and challenges of the exploration program were identified through discussion and site reconnaissance with District staff

and exploration subcontractors. Because this project involved exploration activities in a number of privately owned parcels, site access agreements in these areas were coordinated by District staff during investigation program planning. Other significant considerations of the exploration program included:

- Project goals and objectives;
- Project Health and Safety Plan
- The scope of field investigations;
- Sampling procedures and sample requirements;
- Specific sampling targets and strategies to optimize sampling methods;
- Exploration depth targets;
- Site access and contact information;
- Utility clearance and permits;
- Site security and noise;
- Backfill requirements;
- Disposal of cuttings;
- Site restoration requirements;
- Applicable standards (DWR Division of Flood Management *Soil and Rock Logging, Classification, Description and Presentation Manual,* September 2009) ASTM standards, and USACE guidance).

## 3.2 Health and Safety

A project-specific Health and Safety Plan (HASP) was developed for the Coyote Creek field investigation. Field personnel were given a health and safety briefing by the Field Investigations Manager, and attended regular health and safety tailgate meetings. Field personnel were also provided with specific guidelines and information about emergency action protocols, including the location of the closest emergency medical facility. Field personnel had no reportable incidents during field investigations.

## 3.3 County Drilling Permits

A Marin County "test hole/soil boring" permit was issued by the Environmental Health Services Department. The permit is applicable for one year, beginning on August 25, 2014. The permit requires that field operations follow all Marin County rules, regulations, Codes, laws and statutes as per County well drilling procedures. Exploration permit documentation is contained in Appendix D.

## 3.4 Utility Clearance

Each exploration location was initially chosen after a review of available maps and plans containing utility information. The locations were visually observed for the presence of overhead and underground utilities and then outlined in white paint as required by Underground Service Alert (USA). USA was then contacted a minimum of 48 hours before subsurface investigation of the site. A USA ticket number as well as the clearance date, expiration date and extension date were obtained for the work area and documented in the project file.

Prior to performing exploration activities at each location, the presence of underground utilities was also evaluated by Subtronic Corporation of Concord, CA, a private utility locator. In general, no major utility conflicts were encountered and each exploration could be performed at, or very close to, the planned location.

## 3.5 Biological and Cultural Survey and Clearance

The possible presence of potentially sensitive wildlife species was evaluated and confirmed by the District within sections of the Lower Reach of the Project site. Species of concern identified by the District included the California Clapper Rail and the Salt Marsh Harvest Mouse. Exploration locations were selected, to the best of our ability, to avoid sensitive areas and to cause minimal disturbance to these species and the surrounding habitats. The District provided biological monitoring onsite during the exploration program at locations deemed possibly sensitive to clear each exploration location prior to beginning work activities.

The District has also noted that historic cultural resources may also be present within the Project. Cultural monitoring was not necessary during exploration activities in the field, however, recovered soil samples were reviewed by Michael Newland (Sonoma State University) prior to laboratory testing.

## 3.6 Exploratory Program Description

Auger and mud rotary borings were drilled by Gregg Drilling and Testing, Inc./Pitcher Drilling Co. CPT explorations were conducted by California Push Technologies, Inc. GEI personnel coordinated and observed the drilling program, logged the borings, and collected and transported the soil samples.

The exploration program consisted of 19 explorations at potentially critical locations and provided investigations at a minimum possible overall spacing. Eleven of the explorations were located on the levee crest and eight were located along the landside toe and landward area. The 19 explorations consisted of 10 geotechnical borings, six CPTs,

and three direct push geoprobes. The exploration strategy was to advance the CPTs and direct push geoprobes first, in order to define the nature of subsurface materials. Auger/mud rotary drilling followed, with the intent of focused sampling based on information from the CPT and geoprobe explorations. Exploration types, locations, and exploration depths are summarized in Table 1, and are shown in Figures 1 through 6.

CPT and direct push geoprobe investigations began on September 15, 2014 and were completed September 17, 2014. Three of the six total CPT's were advanced on the levee crest and the remaining three were advanced on the landside of the levee or adjacent to earthen channel areas. Three direct push geoprobes were advanced on the landside of the levee, adjacent to the landside CPT locations. Originally, nine total CPT's were planned, however, three of the proposed CPT locations were not completed due to refusal in near surface gravelly, concrete, and asphalt rubble/fill. These three proposed CPT locations were replaced with geotechnical borings more capable of penetrating the near-surface materials. The replaced CPT locations proposed in the Work Plan were GEI CPT-2 (now GEI B-8), GEI CPT-4 (now GEI B-10), and GEI CPT-5 (now GEI B-9).

Typically the upper five feet of the CPT explorations were piloted with a "dummy" probe to prevent damage to the CPT probe tip in the dense near surface materials encountered. Once piloted, the CPT was advanced from the bottom of the "dummy" probe pilot hole. Therefore, no CPT data was collected where the "dummy" probe was advanced.

Subsurface borings began on September 29, 2014 and were completed October 7, 2014. Eight borings were drilled along the levee crest, high ground, or adjacent to earthen channel areas and two borings were drilled along the landside of the levee. Soil sampling and logging was completed as the borings were advanced. Sampling of the subsurface material was performed using Pitcher barrel/Shelby tube thin wall samplers, SPT (Standard Penetration Test) samplers, and modified California barrel samplers. The type of sampler used at each sampling depth interval was determined by the sampling protocol and/or the material encountered or expected. Drive samples were driven using an automatic trip 140 pound hammer with a free fall of 30 inches.

The relatively undisturbed samples in the thin-walled tubes were labeled in the field and transported from the site upright and with care not to disturb the sample integrity. The samples were taken to Cooper Testing Laboratory in Palo Alto, California for testing and analysis.

### *3.6.1 Subsurface Investigation Methods*

Nineteen exploratory borings and probes were completed for the exploration program, using auger/mud rotary, direct push geoprobe, and CPT. The following sections describe the drilling and sampling techniques employed for this project.

#### 3.6.1.1 Cone Penetration Soundings (CPTs)

CPT explorations were completed using a limited-access, self-anchoring, 6625CPT track-mounted rig with a 20-ton push capacity. This rig incorporates the Swedish-made Geotech AB Cone Penetration Testing tools which meet the ASTM D5778 Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils. The CPT apparatus utilized a 1.4 inch diameter cone which measures bearing, sleeve friction, and dynamic pore pressure. The data was plotted in real time and recorded on a laptop computer adjacent to the push platform. The CPT contractor provided the generated reports within 48 hours of completing the CPTs for the day.

#### 3.6.1.2 Direct Push Geoprobes

Direct push geoprobe explorations were completed using the 6625CPT track-mounted rig described above (CPTs). The direct push apparatus used a 2-inch diameter steel casing and an inner 1.25 inch diameter clear poly liner tube that was continuously advanced with the use of percussion hammer attached to the drilling rig. Direct push geoprobe sampling was performed in order to obtain disturbed samples of shallow subsurface material adjacent to select CPT explorations for visual-manual classification and laboratory testing. Each geoprobe exploration extended through fill material and 1-2 feet into the underlying Bay Mud; generally 6-10 feet below existing ground surface.

#### 3.6.1.3 Exploratory Borings

Exploratory borings were vertical and excavated using a truck and track-mounted drill rig with rotary wash and/or augers. Per USACE and DWR guidelines for levee geotechnical explorations, borings intended to explore the levee embankment and foundation were generally drilled to a minimum depth equal to three times the levee height into the foundation but not less than 40 feet. In general, most borings extended through the Bay Mud layer and approximately 5-10 feet into underlying bedrock or stiff material, as conditions and schedule permitted. Depending on the depth to bedrock, these borings ranged between approximately 21 and 102 feet deep. Two shallow borings were advanced 13 and 15 feet to evaluate the shallow embankment/fill material.

In accordance with USACE geotechnical investigation guidelines, no fluid was discharged into the levee during drilling. Only auger drilling was used while drilling through the levee embankment, which transitioned to rotary-wash for investigating the levee foundation. Prior to transitioning to rotary-wash drilling, a conductor casing was installed through the levee to prevent fluid discharge. Observed groundwater levels were measured for all borings prior to grouting the holes or switching to rotary wash.

### *3.6.2 Types of Samplers*

Four types of soil samplers were used during the geotechnical field investigation program: standard penetration test (SPT) split spoon samplers, Modified California (MC) sampler, thin-walled tubes, and clear poly liner tube samplers from the direct push geoprobe. Boring diameters ranged from approximately 4 to 6 inches, producing soil samples with diameters ranging from approximately 1.25 to 3 inches. The sampler type used at each sampling interval is indicated on each boring log.

#### 3.6.2.1 Drive Sampling

The SPT sampler has a 2-inch outside diameter and 1.375-inch inside diameter with a 1.375-inch inside diameter shoe. The MC sampler has a 2.5-inch outside diameter and 2-inch inside diameter with a 1.875-inch inside diameter shoe; this sampler was advanced with 6” inch long brass liners. Both samplers were driven using either FEDP for the truck mounted rig or NWJ rod, otherwise known as “N rod”, for the track mounted rig.

Sampling was performed in accordance with the procedures described in ASTM D 1586-11. Samplers were advanced in 18-inch increments into the soil by using a 140-pound automatic trip hammer falling from a vertical height of 30 inches. The number of blows required for each 6-inch penetration was recorded on the boring logs. Sampler refusal (defined by 50 or more blows in one 6-inch interval) was typically encountered in the bedrock materials. The most recent automatic trip hammer calibration reports are included in Appendix E.

The densities of coarse-grained soils were described in the field using the number of measured blow counts to drive an SPT sampler. Consistencies of fine-grained soils were based on pocket penetrometer measures and laboratory test results, and evaluated qualitatively from measured blow counts.

#### 3.6.2.2 Thin-Walled Tube Sampling

Where soft fine-grained soils were encountered, thin-walled tube samplers were utilized. The tubes were generally 3-foot long thin-walled tube samplers (“shelby tubes”) with a nominal 3–inch diameter. The tubes were advanced hydraulically, generally by slowly lowering a portion of the drilling head onto the end of the rod. Thin-walled tube samples were collected in general accordance with ASTM D 1587.

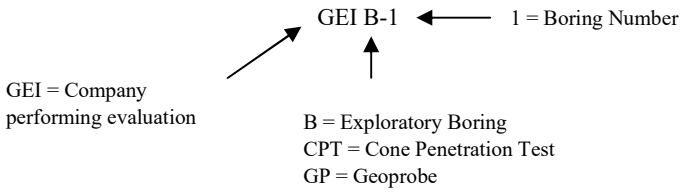
Generally, samples were recovered without incident in the soft bay mud following the procedures described in the Work Plan. Collected samples were maintained in an upright position, stabilized with compression plugs (Acker plugs), capped and sealed with duct tape, and secured with foam padding for storage and transportation.

#### 3.6.2.3 Geoprobe Sampling

Geoprobe samplers were obtained adjacent to three CPTs. The samples were recovered and contained in 4-foot long 1.25-inch diameter clear poly liners which were opened to allow logging of the collected soil material. Sampling intervals were 4 feet in length, with each 4-foot core sample removed from the subsurface prior to driving or pushing the subsequent sample interval and core. The sampling was continuous.

### *3.6.3 Exploration and Sample Identification*

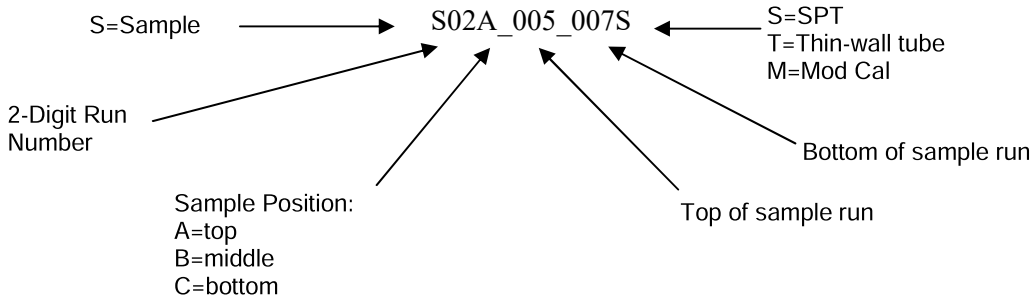
Boring locations were identified by listing the company performing the evaluation, the type of exploration, and a boring identification number. A description of the soil boring numbering scheme is provided below.




SPT, MC, and thin-walled tube ("shelby") samples were numbered according to the following protocol (note: All sample depths used in the sample numbering protocols described below are rounded up to the nearest one foot interval):

### *3.6.4 Boring Logs*

A boring log was completed for each rotary-wash, auger, or geoprobe boring performed during exploration program. The procedures for logging are described in detail in ASTM 2486 and the *DWR Division of Flood Management Logging Manual* (September 2009). At the beginning of a boring, field personnel recorded the following information on the log:



- Project name;
- Consultant company;
- Field logger;
- The boring number;
- The date when boring began;
- Types of samplers used;
- Weight of hammer used for drive samples, as reported by drilling subcontractor;
- Type of hammer;
- Drilling contractor, driller's name, helper's name;
- Type of drill rig;
- Drilling method;

As the boring progressed and was completed, the field logger completed the following information on the log:

- Date of boring completion;
- Total depth of boring;
- Depth to groundwater, if observed;
- Method of backfilling borehole.

Subsurface conditions observed in soil samples and drill cuttings or perceived through the performance of the drill rig (for example, ease/difficulty of drilling or rig chatter in gravel or debris) were described in the "Remarks" column on the log. Beside descriptions of individual soil samples and subsurface conditions observed at the time of drilling, the boring logs indicate the approximate extents of the soil layers encountered. Descriptions are included for each soil layer, with horizontal lines drawn to separate subjacent layers.

All field logging was overseen or carried out on site by GEI field staff overseen by a California-Licensed Geologist. Logs were then entered into gINT (Version 8) and updated, as needed, based on laboratory test results which were incorporated as they were received by the project team. Field SPT blow counts (i.e., N values) were converted to $N_{60}$ values by applying the relevant hammer energy correction in accordance with ASTM D6066-96, *Standard Practice for Determining Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential* (ASTM, 2004) and the computed $N_{60}$ values were entered into the gINT log.

### 3.6.5 Sampling Intervals

Soil sampling was conducted at targeted intervals in the auger/mud rotary borings. Target depths and materials were originally identified during exploration planning during review of the existing nearby boring logs and refined in the field based on soil conditions encountered within the current boring. At each sampling interval within the fill material and bedrock, the MC sampler would typically be driven first, to obtain a larger quantity of soil sample for laboratory testing. The SPT barrel would then be advanced immediately following the MC sampler. The SPT sampler was typically not driven within the soft bay mud deposits. Generally, MC samples followed by SPT samples were attempted at intervals of depth not exceeding 5 feet within the levee embankment and shallow foundation, below this depth either MC or SPT samples were attempted at intervals of depth not exceeding 5 feet for the top 40 to 50 feet. Below 40 to 50 feet cuttings were observed, or if time permitted samples were attempted at intervals of approximately 10 feet or until drilling reached bedrock. The sampling interval was logged on the boring log forms attached in Appendix B. For SPT and MC samples, the blows to drive the sampler were recorded in the "Blows per 6 in." column.

For the thin-walled tube samplers, the distance the sampler was pushed was indicated graphically on the log in the "Sample Location" column of a boring log form and recorded in the "Recovery" column. The sampler push pressure was also generally recorded in the "Remarks" column of the boring log form.

### 3.6.6 Handling of Soil Cuttings

The drilling contractor contained the cuttings from the drilling spoils in 55-gallon drums which were sealed and labeled. At the end of each workday, the drums were typically moved to a designated site for temporary storage until the end of the exploration program. At the completion of the exploration program, GEI coordinated with the drum disposal sub-contractor, Woodward Drilling, for testing and off-site disposal of the drums according to state, federal, and local laws.

## 3.7 Backfill of Explorations

Explorations were sealed with a cement-bentonite grout in accordance with Marin County Environmental Health and USACE standards including but not limited to County Well Standards and State Department of Water Resources Bulletin 74-81 and 74-90. All grout was mixed in batches using 55-gallon drums. The grout was placed in the boreholes by the tremie method, with the tremie pipe extending to the bottom of the boreholes. Grout levels were monitored during equipment tear-down at the work sites and any loss of grout was noted and grout was replaced.

## 3.8 Site Restoration

Where borings penetrated a paved surface, they were patched to existing grade with dry-mix concrete and/or asphaltic concrete cold patch. Drill sites were cleaned and restored as closely as practical to pre-drilling conditions.

# 4 Laboratory Testing

## 4.1 Soil Testing

Laboratory tests were performed on selected soil samples from boreholes to obtain information about the geotechnical characteristics of subsurface soil, and to supplement existing information from past geotechnical work. The laboratory testing program was developed based on the project team's review of past geotechnical work and review of information generated during subsurface investigations performed as part of this program.

Laboratory testing samples were selected from materials and locations where estimates of engineering properties are required for geotechnical evaluation. Laboratory testing results will be used, along with existing data and other relevant information, to evaluate typical soil parameters for geotechnical analyses (e.g., slope stability, seepage, etc.). Laboratory testing was performed by Cooper Testing Laboratory in Palo Alto, California.

Soil sample laboratory testing included index tests (in-situ moisture content and density, Atterberg limits, and grain-size distribution), strength tests, and consolidation. The list below summarizes the laboratory testing program.

- Sieve analysis, ASTM D 422
- Moisture content and dry density of soils, ASTM D 2216 and ASTM D 2937
- Unconsolidated Undrained Triaxial Compression, ASTM D 2850
- Atterberg Limits, ASTM D 4318
- One-Dimensional Consolidation Testing of Soils, ASTM D 2435 (Incremental)
- Isotropically Consolidated Undrained Triaxial Compression, Modified ASTM D 4767

Laboratory test results are presented in Appendix F and summarized in Table 2. Index test results are also included on the boring logs included in Appendix B. Historical laboratory test results are included in Appendix G.

# 5 Quality Assurance and Quality Control

Quality Assurance/Quality Control (QA/QC) was performed on all work products (deliverables) at the project and task level. QA/QC procedures were performed under the direction of the Project Manager. QA/QC was also performed on all subcontractor deliverables.

## 5.1 Hammer Energy Measurement

To ensure the consistency of data collected from SPTs, which are critical to liquefaction evaluation, the drilling subcontractor performed SPT energy measurements on SPT hammers to evaluate the energy that each hammer delivered. Hammer calibrations for the two drilling rigs equipped with automatic trip hammers utilized for this project were conducted in accordance with ASTM D 4633. Reports describing hammer calibration test results are included in Appendix E.

## 5.2 Boring Logs

Borings were logged in the field by engineers in general accordance with ASTM and California State guidelines. Field QC measures were carried out by the Field Investigations Manager, who supervised field activities over the duration of geotechnical investigations. Boring logs for this project were created by carrying out the following QC steps:

- Entering field sampling details and soil descriptions on boring logs.
- The Field Manager and other geotechnical staff performing QC checks on field logs.
- Preparing draft gINT (Version 8) logs based on checked field logs.
- Engineering staff reviewing laboratory test results to gauge conformance with field boring logs.
- Refining boring log soil classifications and descriptions where appropriate based on laboratory test results.
- Geotechnical staff reviewing updated gINT boring logs

All gINT work was carried out by the project team's staff engineers and geologists. The gINT logs were taken through various levels of checks by the respective field loggers, the project team's engineers/geologists responsible for the gINT input, and the project geotechnical engineer.

## 5.3 Laboratory Testing and Test Results

While the tests were in progress, project team engineers reviewed test results as they became available, maintained regular coordination with the laboratory representatives, addressed questions posed by laboratory representatives and provided additional instructions as necessary.

Laboratory index test results were reviewed by project team engineers to gauge conformance with field boring logs. If laboratory results were in conflict with the field boring log information, the matter was typically resolved through a visual check and classification of a sample of the soil in question by the Project Engineer or Project Geologist.

## 5.4 Report

QA is performed on all deliverables and consists of independent technical review (ITR), audits, documentation, and reporting. QC is also performed on all deliverables and includes tasks like detail checking, computer program documentation, and nonconformance and corrective action documentation. QC is performed under the direction of the Project Manager.

# 6 Key Participants and Limitations

## 6.1 Key Participants

The work presented in this GDR is based on the work of the GEI/HDR project team. For the Coyote Creek Levee Evaluation Project, this team includes:

- Marin County Flood Control and Water Conservation District – client
- GEI – project prime consultant, coordination, field logging, geology, and geotechnical engineering
- HDR – project sub-consultant, hydraulics and hydrology, and geotechnical engineering
- Gregg/Pitcher Drilling Company – drilling
- California Push Technologies – CPT explorations and Direct Push Geoprobes

The project team included personnel involved with field activities, report preparation, and report review and QA/QC. Personnel associated with the project are listed below along with their project roles:

Field Personnel

- Field Logger – Hugo Velasquez, EIT
- Project Engineer/Field Logger – Ian Maki, PE
- Field Explorations Manager – Matt Powers, PE
- Project Manager – Graham Bradner, PG, CEG, CHG

Report Preparation Personnel

- Project Engineer/Field Logger – Ian Maki, PE
- Field Explorations Manager – Matt Powers, PE
- Project Manager – Graham Bradner, PG, CEG, CHG

Senior Review

- Mark Freitas, PE, GE
- Mark Stanley, PE, GE

## 6.2 Limitations

This geotechnical data report, associated data collection and preparation have been performed in accordance with the standard of care commonly used as the state-of-practice in the engineering profession for levee evaluation projects. Standard of care is defined as the

ordinary diligence exercised by fellow practitioners in this area performing the same services under similar circumstances during the same period.

Discussions of subsurface conditions summarized in this report are based on subsurface soil and groundwater conditions at limited exploration locations. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able identify all adverse conditions in the levee and/or its foundation.

No warranty, either expressed or implied, is made in the furnishing of this report. The project team makes no warranty that actual encountered site and subsurface conditions will exactly conform to the conditions described herein, nor that this report's interpretations and recommendations will be sufficient for all construction planning aspects of the work. The design engineer and/or contractor should perform a sufficient number of independent explorations and tests as they believe necessary to verify subsurface conditions rather than relying solely on the information presented in this report.

The project team does not attest to the accuracy, completeness, or reliability of geotechnical borings and other subsurface data by others that are included in this report. The project team has not performed independent validation or verification of data by others.

Data presented in this report are time-sensitive in that they apply only to locations and conditions existing at the time of the exploration and preparation of this report. Data should not be applied to any other projects in or near the area of this study nor should they be applied at a future time without appropriate verification.

This report is for the use and benefit of Marin County Flood Control and Water Conservation District. Use by any other party is at their own discretion and risk.

This report is one of multiple documents describing work completed. It will be supplemented with other reports presenting evaluations of this information.

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# Tables

***Table 1. Summary of Subsurface Explorations for the Coyote Creek Levee***

| Exploration ID | Station[1] | Project Reach | Levee/ Channel Bank | Exploration Type | Location | Exploration Depth (feet) | Longitude[1] | Latitude[1] | Elevation |
|---|---|---|---|---|---|---|---|---|---|
| GEI B-1[3] | CC-C 3+75 | Upper Reach | Channel | Mud Rotary | Landside | 21.3 | -122.529456 | 37.878706 | 7.5 |
| GEI B-2[2] | CC-R 35+00 | Middle Reach | Right | Mud Rotary | Levee Crest | 45.3 | -122.527325 | 37.878843 | 10.7 |
| GEI B-3[2] | CC-L 30+75 | Middle Reach | Left | Solid Flight Auger | Levee Crest | 13.0 | -122.526209 | 37.878636 | 8.9 |
| GEI B-4[2] | CC-L 19+25 | Middle Reach | Left | Mud Rotary | Levee Crest | 46.5 | -122.523866 | 37.879035 | 11.1 |
| GEI B-5[2] | CC-R 4+20 | Lower Reach | Right | Mud Rotary | Landside | 101.5 | -122.519948 | 37.881735 | 9.0 |
| GEI B-6[3] | BM-L 4+85 | Bothin Marsh | Left | Mud Rotary | High Ground | 80.5 | -122.52221 | 37.881662 | 12.4 |
| GEI B-7[2] | NC-L 6+50 | Nyhan Creek | Left | Mud Rotary | Top of Channel Bank | 31.5 | -122.526629 | 37.876511 | 10.0 |
| GEI B-8[2] | CC-L 32+00 | Middle Reach | Left | Solid Flight Auger | Levee Crest | 15.0 | -122.526564 | 37.878873 | 9.3 |
| GEI B-9[2] | CC-L 24+50 | Middle Reach | Left | Mud Rotary | Levee Crest | 28.4 | -122.52469 | 37.877959 | 9.1 |
| GEI B-10[2] | NC-L 0+85 | Nyhan Creek | Left | Mud Rotary | Levee Crest | 73.1 | -122.52624 | 37.87807 | 9.9 |
| GEI CPT-1[3] | CC-L 35+75 | Middle Reach | Left | Cone Penetration Test | Landside | 16.1 | -122.527766 | 37.879288 | 9.5 |
| GEI CPT-3[2] | CC-L 30+75 | Middle Reach | Left | Cone Penetration Test | Landside | 66.3 | -122.526069 | 37.878761 | 6.2 |
| GEI CPT-6[3] | CC-L 19+25 | Middle Reach | Left | Cone Penetration Test | Landside | 66.8 | -122.52407 | 37.879173 | 10.7 |
| GEI CPT-7[2] | CC-L 11+00 | Lower Reach | Left | Cone Penetration Test | Levee Crest | 91.2 | -122.522234 | 37.881075 | 6.1 |
| GEI CPT-8[3] | BM-L 9+50 | Bothin Marsh | Left | Cone Penetration Test | High Ground | 60.6 | -122.52339 | 37.882047 | 9.5 |
| GEI CPT-9[2] | NC-L 9+00 | Nyhan Creek | Left | Cone Penetration Test | Top of Channel Bank | 30.2 | -122.526231 | 37.875867 | 9.0 |
| GEI GP-1[3] | CC-L 35+75 | Middle Reach | Left | Direct Push Geoprobe | Landside | 6.0 | -122.527688 | 37.879406 | 10.2 |
| GEI GP-2[2] | CC-L 30+75 | Middle Reach | Left | Direct Push Geoprobe | Landside | 6.0 | -122.526069 | 37.878761 | 6.4 |
| GEI GP-3[3] | CC-L 19+25 | Middle Reach | Left | Direct Push Geoprobe | Landside | 10.0 | -122.52407 | 37.879173 | 9.9 |

[1] Locations are approximate - based on field GPS and GIS tools (NAD83); refers to GEI Station alignment

[2] Elevations estimated from 2013 Meridian Channel Survey (NAVD88)

[3] Elevations estimated from County of Marin digital topographic-bathymetric surface model; Revision 2013.12.18 (NAVD88)

*Table 2. Summary of Laboratory Test Data for the Coyote Creek Levee*

| Sample Information | | | USCS Group Symbol | Passing # 200 (%) | Atterberg Limits | | Organic Content (%) | Specific Gravity (%) | Moisture Content (%) | Dry Density (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Boring Number | Sample Number | Sampler Interval | | | LL | PI | | | | | |
| GEI GP-1 | S01A_000_002G | 0 - 2 | CH | 54 | | | | | | | |
| | S02A_002_004G | 2 - 4 | SC | 32 | | | | | | | |
| GEI GP-2 | S01A_000_002G | 0 - 2 | SC | 37 | | | | | | | |
| | S02A_002_004G | 2 - 4 | SC | 39 | | | | | | | |
| GEI GP-3 | S01A_000_002G | 0 - 2 | SC | 34 | | | | | | | |
| | S02A_002_006G | 2 - 6 | GC | 32 | | | | | | | |
| GEI B-1 | S02A_003_003B | 2.5 - 3 | CL | 86 | 32 | 12 | | | | | |
| | S03A_005_007M | 5 - 6.5 | CH | | | | | | 99.6 | | |
| | S04A_010_012T | 10 - 12 | CH | | | | 4 | | 44.3 | 77.3 | 1) TX-UU |
| | S05A_015_016M | 15 - 16.5 | CL | 61 | | | | | 20.4 | 110.9 | |
| GEI B-2 | S03B_005_005S | 4.5 - 5.5 | SC | 50 | 39 | 18 | | | | | |
| | S04A_008_009M | 8 - 9.5 | CH | | | | | | 76.7 | 53.4 | |
| | S05A_013_016T | 13 - 16 | CH | | | | | | 88.5 | 49.3 | 1) Consolidation |
| | S06A_018_020M | 18 - 19.5 | CH | | | | | | 100.3 | 45.9 | |
| | S08A_028_029M | 28 - 29.5 | CH | 75 | | | | | | | |
| | S08B_029_030M | 28 - 29.5 | CH | | | | | | 81.9 | 52.0 | |
| | S09A_033_036T | 33 - 36 | CH | | | | | | 46.7 | 73.4 | 1) TX-UU |
| | S10A_038_039M | 38 - 39.5 | CH | 96 | | | | | 91.5 | 47.8 | |
| | S12A_043_044M | 43 - 44.5 | CH | 79 | | | | | 25.9 | 101.2 | |
| GEI B-3 | S02A_005_007M | 5 - 6.5 | GC | 28 | | | | | | | |
| | S03A_007_008S | 6.5 - 8 | SC | 40 | | | | | | | |
| | S04A_010_013T | 10 - 13 | CH | | | | | | 89.0 | 49.0 | 1) TX-ICU<br>2) Consolidation |
| GEI B-4 | S02A_003_004M | 3 - 4.5 | GC | 21 | | | | | | | |
| | S03A_005_006M | 5 - 6.5 | CL | 65 | | | | | | | |
| | S05A_012_015T | 12 - 15 | CH | | | | 4 | | 84.1 | 51.2 | 1) TX-ICU |
| | S07A_020_022M | 20 - 21.5 | CH | | | | | | 88.6 | 49.5 | |
| | S08A_025_027M | 25 - 26.5 | CH | | | | | | 102.6 | 44.1 | |
| | S09A_030_033T | 30 - 33 | CH | | | | | | 92.1 | 47 | 1) TX-UU<br>2) Consolidation |
| | S11A_040_042M | 40 - 41.5 | CH | 56 | | | | | 15.1 | 119.7 | |

*Table 2. Summary of Laboratory Test Data for the Coyote Creek Levee*

| Sample Information | | | USCS Group Symbol | Passing # 200 (%) | Atterberg Limits | | Organic Content (%) | Specific Gravity (%) | Moisture Content (%) | Dry Density (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Boring Number | Sample Number | Sampler Interval | | | LL | PI | | | | | |
| GEI B-5 | S01A_001_001B | 0.5 - 1.5 | SC | 45 | | | | | | | |
| | S03A_005_006T | 5 - 8 | CH | | | | | | 15.8 | 118.2 | |
| | S06A_018_021T | 18 - 21 | CH | | | | | | 74.3 | 55.9 | 1) Consolidation |
| | S07A_025_026M | 25 - 26.5 | CH | | | | | | 38.5 | | |
| | S08A_030_031M | 30 - 31.5 | CH | | | | | | 97.0 | 44.7 | |
| | S09A_035_036M | 35 - 36.5 | CH | | | | | | 88.6 | 47.4 | |
| | S10A_040_042T | 40 - 42 | CH | | | | 4 | | 81.2 | 51.9 | 1) TX-UU |
| | S11A_045_046M | 45 - 46.5 | CH | | | | | | 86.4 | 50.4 | |
| | S12A_050_051M | 50 - 51.5 | CH | | | | | | 77.7 | 53.0 | |
| GEI B-6 | S02A_003_004M | 3 - 4.5 | GC | 30 | | | | | | | |
| | S03A_005_006M | 5 - 6.5 | SC | 48 | | | | | 26.9 | 97.2 | |
| | S05A_013_014M | 13 - 14.5 | GC | 18 | | | | | 12.4 | 129.7 | |
| | S06A_020_023T | 20 - 23 | CH | | | | 4 | | 75.1 | 54.7 | 1) TX-UU<br>2) Consolidation |
| | S07A_025_027M | 25 - 26.5 | CH | | | | | | 73.0 | 56.2 | |
| | S08A_030_031M | 30 - 31.5 | CH | | | | | | 87.2 | | |
| | S09A_035_037M | 35 - 36.5 | CH | | | | | | 82.0 | | |
| | S10A_050_051M | 50 - 51.5 | CH | | | | | | 94.1 | | |
| GEI B-7 | S02A_003_004M | 3 - 4.5 | GC | 36 | | | | | | | |
| | S03A_005_007M | 5 - 6.5 | CL-ML | 92 | 26 | 5 | | | 35.5 | 83.6 | |
| | S04A_010_012T | 10 - 13 | CH | | | | | | 92.6 | 47.3 | 1) TX-UU |
| | S05A_015_017M | 15 - 16.5 | CH | | | | | | 95.2 | 47.7 | |
| | S06A_018_021T | 18 - 21 | CH | | | | | | 40.2 | 80.2 | 1) TX-UU |
| | S07A_025_027M | 25 - 26.5 | CH | | | | | | 83.6 | 51.4 | |
| | S08A_030_031M | 30 - 31.5 | SC | | | | | | 16.6 | 116.3 | |
| GEI B-8 | S02A_002_003M | 2 - 3.5 | GP-GC | 9 | | | | | | | |
| | S03A_005_007M | 5 - 6.5 | SC | 34 | | | | | 9.4 | 128.2 | |
| | S06A_012_015T | 12 - 15 | CH | | | | | | 89.9 | 48.4 | |

*Table 2. Summary of Laboratory Test Data for the Coyote Creek Levee*

| Sample Information | | | USCS Group Symbol | Passing # 200 (%) | Atterberg Limits | | Organic Content (%) | Specific Gravity (%) | Moisture Content (%) | Dry Density (%) | Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Boring Number | Sample Number | Sampler Interval | | | LL | PI | | | | | |
| GEI B-9 | S03A_005_007M | 5 - 6.5 | SC | 26 | | | | | | | |
| | S06A_013_016T | 13 - 16 | CH | | | | 5 | | 93.4 | 47.4 | 1) TX-UU<br>2) Consolidation |
| | S07A_018_019M | 18 - 19.5 | CH | | | | | | 109.9 | 41.3 | |
| | S08A_023_024M | 23 - 24.5 | GC | 45 | | | | | 24.3 | 104.0 | |
| GEI B-10 | S03A_005_006S | 4.5 - 6 | SC | 25 | 24 | 6 | | | | | |
| | S04A_008_009M | 8 - 9.5 | CH | | | | | | 27.3 | | |
| | S05A_013_016T | 13 - 16 | CH | | | | | | 85.6 | 50.9 | 1) TX-UU<br>2) Consolidation |
| | S06B_019_020M | 18 - 19.5 | CH | | | | | | 82.5 | 50.7 | |
| | S07A_024_024M | 23 - 24.5 | CH | 99 | | | | | | | |
| | S07B_024_025M | 23 - 24.5 | CH | | | | | | 74.3 | 56.6 | |
| | S10A_039_040M | 38 - 39.5 | CH | | | | | | 37.5 | 80.8 | |
| | S11A_043_045M | 43 - 44.5 | CH | 72 | | | | | 47.6 | 73.3 | |
| | S12A_053_055T | 53 - 54.75 | CH | | | | | | 21.4 | 105.7 | |
| | S14A_063_064M | 63 - 64.5 | SC | 21 | | | | | 17.3 | 105.4 | |

# Figures


20-Jan-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

200 100 0 200

Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

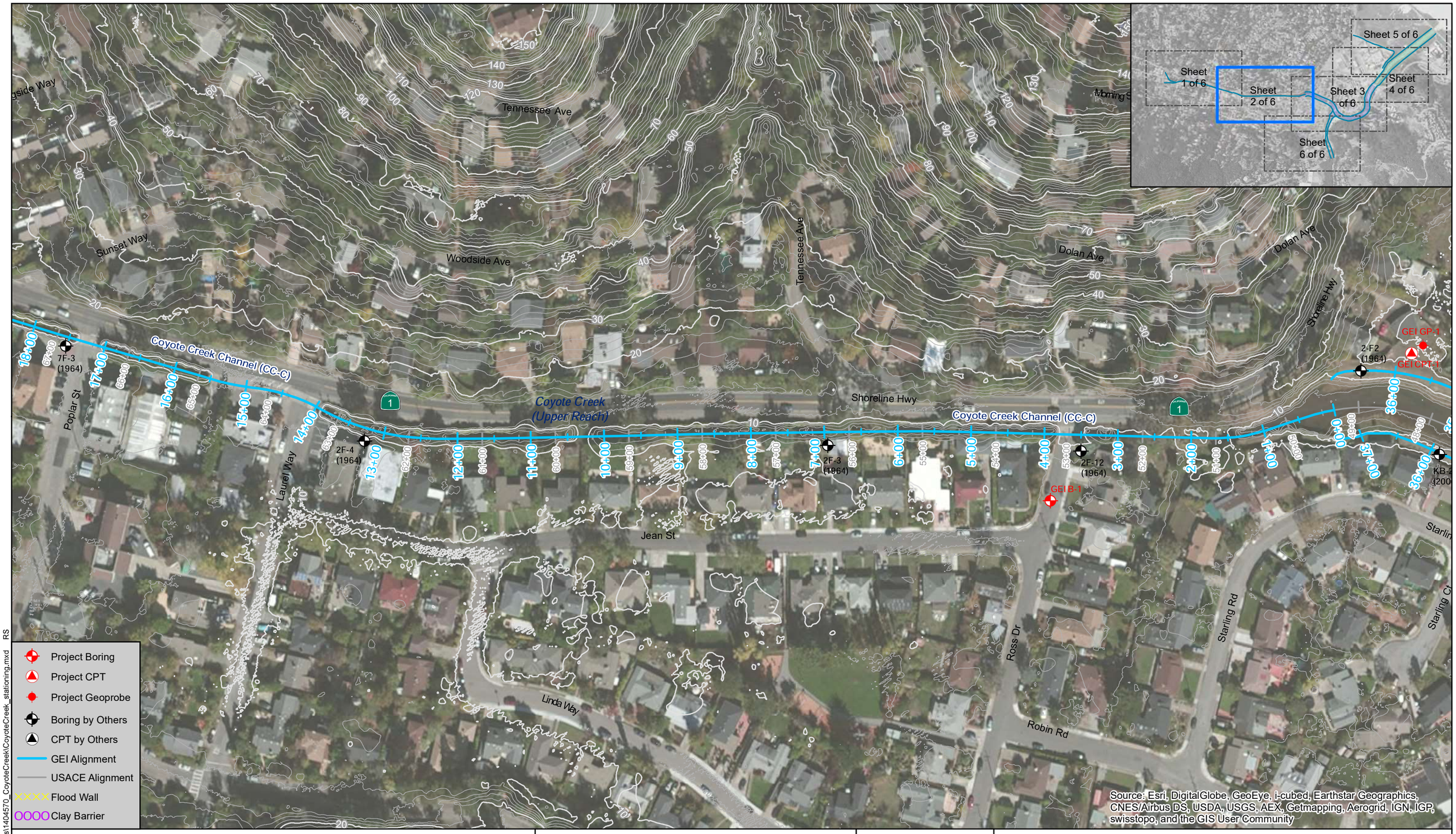
Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE PLAN

JANUARY 2015

FIGURE 1

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Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

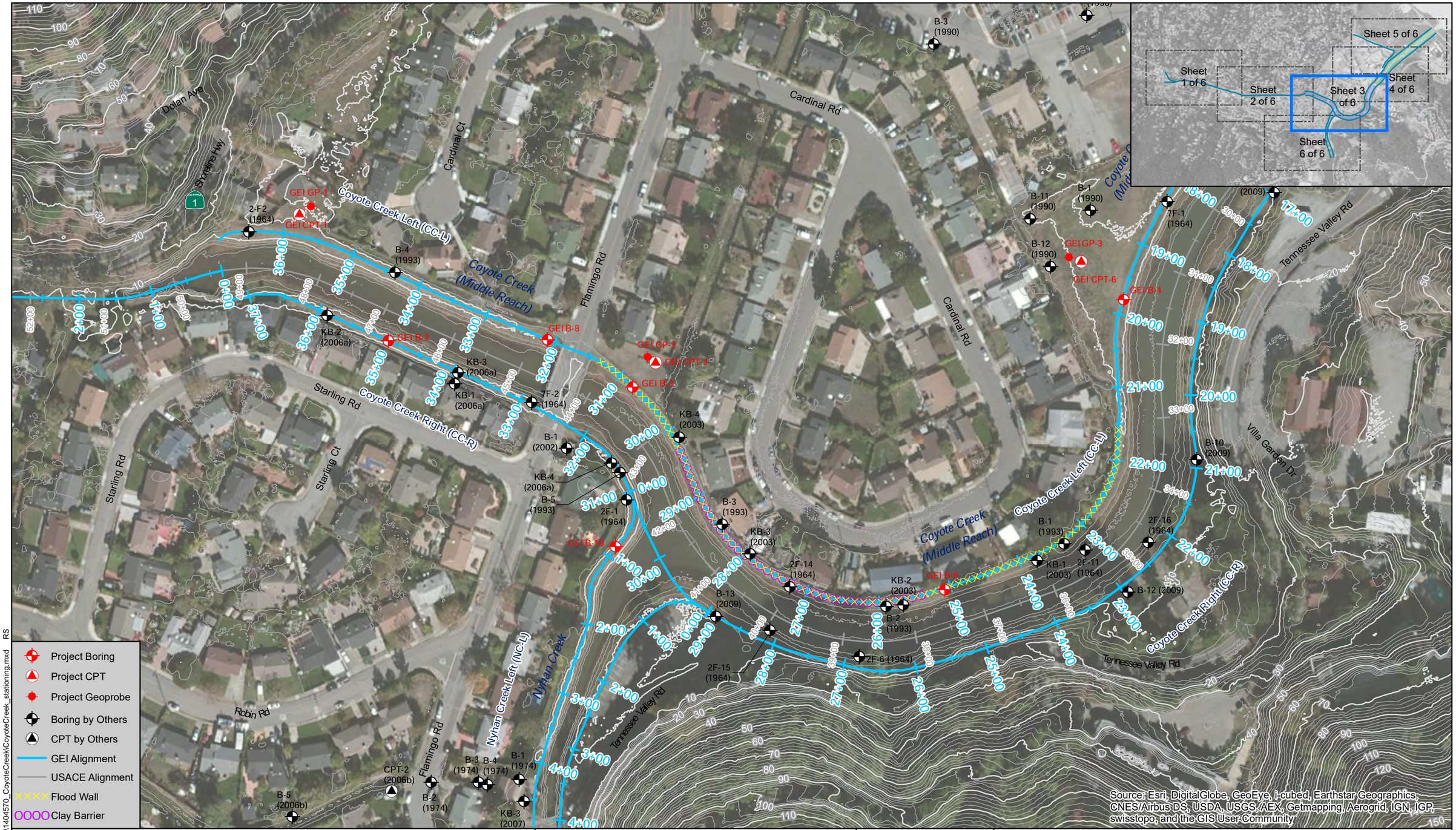
GEI Consultants

# SITE PLAN

JANUARY 2015

FIGURE 2

20-Jan-2015 Z:\Projects\14004570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

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Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE PLAN

JANUARY 2015

FIGURE 3

20-Jan-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

Sheet 1 of 6
Sheet 2 of 6
Sheet 3 of 6
Sheet 4 of 6
Sheet 5 of 6
Sheet 6 of 6

Coyote Creek (Lower Reach)
Coyote Creek (Middle Reach)
Coyote Creek Left (CC-L)
Coyote Creek Right (CC-R)
Bothin Marsh High Ground (BM-L)
Shoreline Hwy
Cardinal Rd
Tennessee Valley Rd

GEI B-5
GEI CPT-7
GEI GP-3
GEI CPT-6
GEI B-4

2F-18 (1964)
2F-19 (1964)
2F-17 (1964)
2F-21 (1964)
B-4 (2009)
B-6 (2009)
B-7 (2009)
B-9 (2009)
B-8 (2009)
7F-1 (1964)
B-1 (1990)
B-3 (1990)
B-4 (1990)
B-5 (1990)
B-6 (1990)
B-7 (1990)
B-9 (1990)
B-11 (1990)
B-12 (1990)
B-13 (1990)

- Project Boring
- Project CPT
- Project Geoprobe
- Boring by Others
- CPT by Others
- GEI Alignment
- USACE Alignment
- Flood Wall
- Clay Barrier

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Feet

N W E S

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE PLAN

JANUARY 2015

FIGURE 4

20-Jan-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS


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Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE PLAN

JANUARY 2015

FIGURE 5

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N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

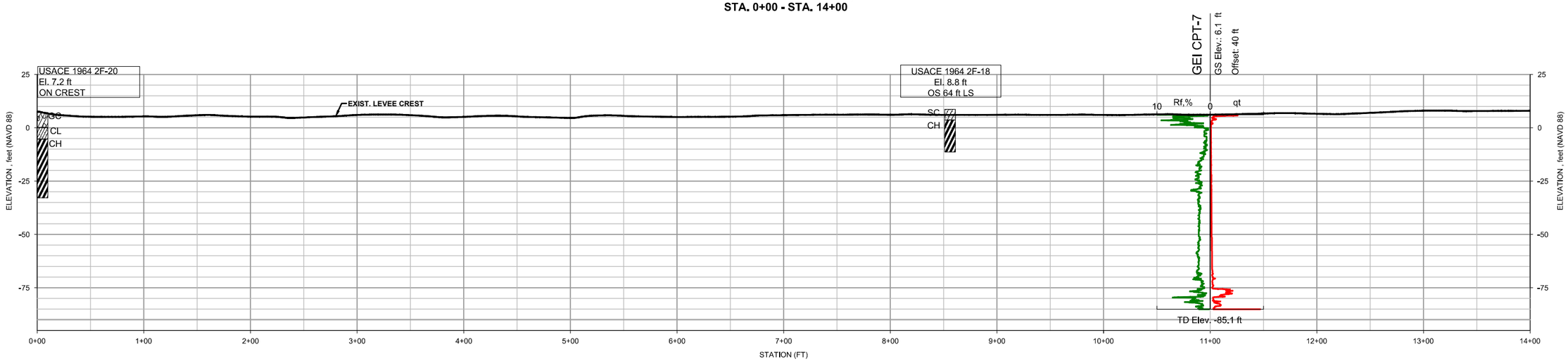
GEI Consultants

# SITE PLAN

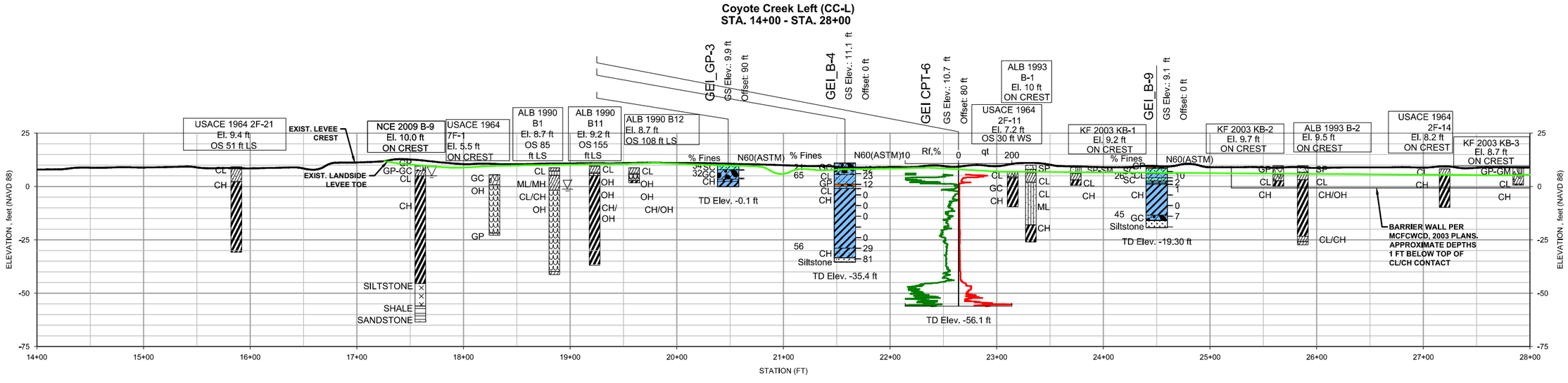
JANUARY 2015

FIGURE 6

## Coyote Creek Left (CC-L)
## STA. 0+00 - STA. 14+00




## Coyote Creek Left (CC-L)
## STA. 14+00 - STA. 28+00




**NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)**

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VERT. SCALE (FEET)

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HORIZ. SCALE (FEET)

Vertical Exaggeration = 2x

| | | |
|---|---|---|
| Coyote Creek Evaluation Project<br>Marin County, California | GEI Consultants | **COYOTE CREEK LEFT PROFILES**<br>**(SHEET 1 OF 2)** |
| Marin County Flood Control and Water Conservation District | Project 140457-0 | April 2015 **Figure 7** |

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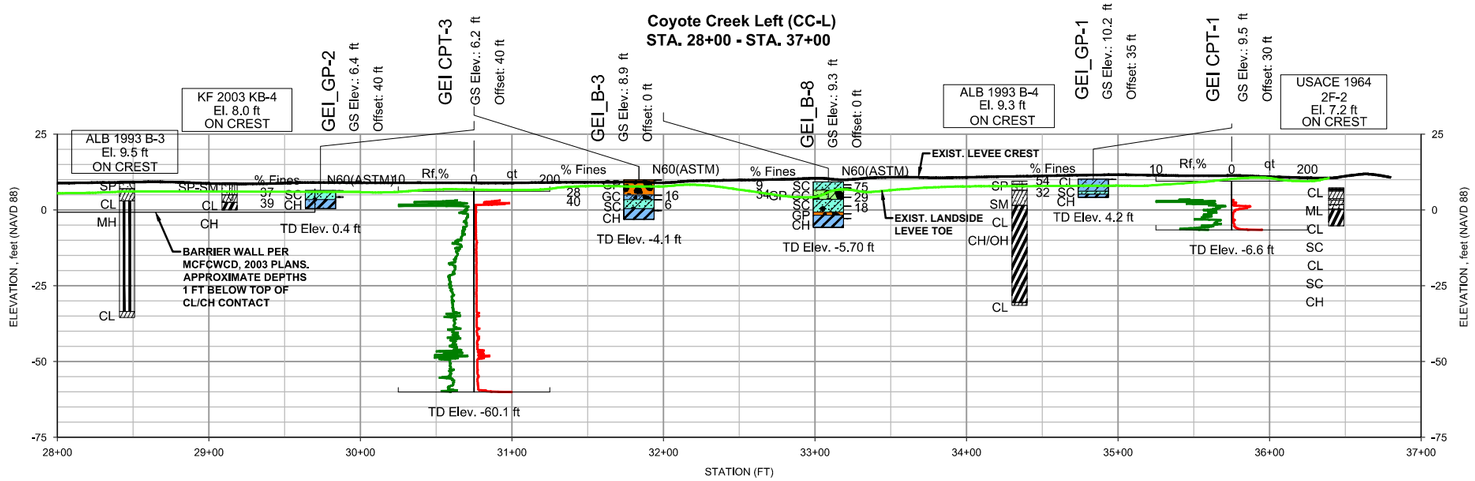


**NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)**

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HORIZ. SCALE (FEET)

Vertical Exaggeration = 2x

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|---|---|---|
| Coyote Creek Evaluation Project<br>Marin County, California | GEI Consultants | **COYOTE CREEK LEFT PROFILES (SHEET 2 OF 2)** |
| Marin County Flood Control and Water Conservation District | Project 140457-0 | April 2015 **Figure 8** |

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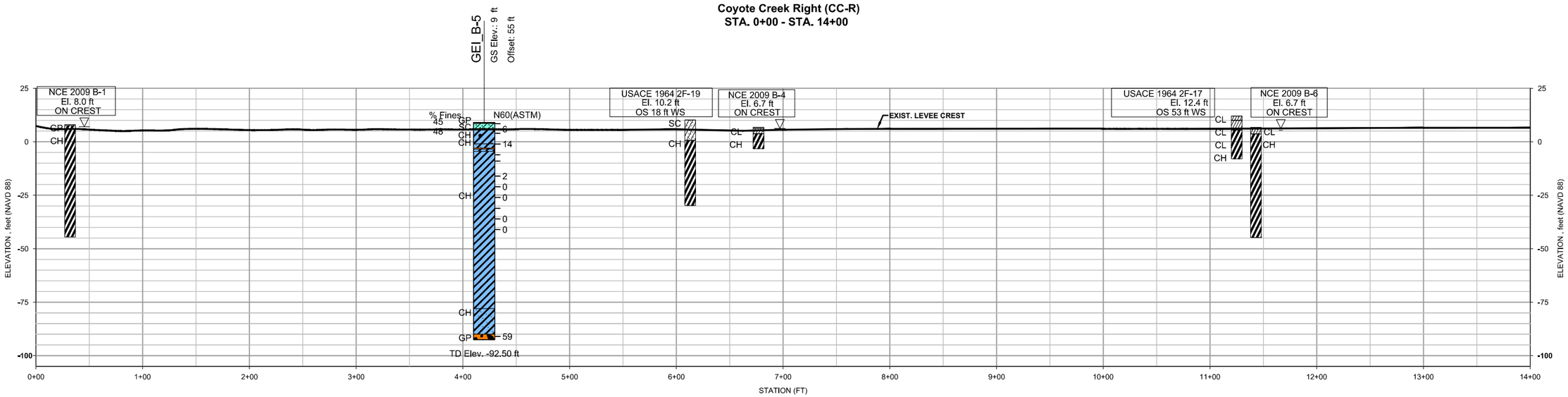
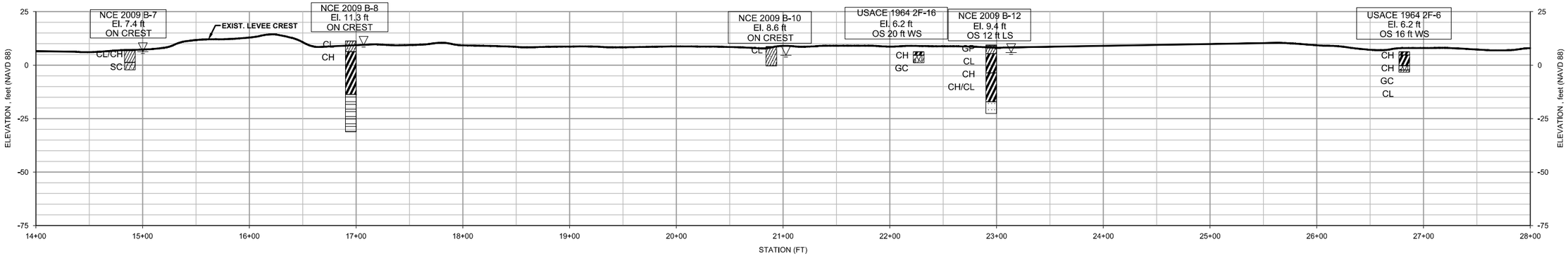
## Coyote Creek Right (CC-R)
## STA. 0+00 - STA. 14+00




## Coyote Creek Right (CC-R)
## STA. 14+00 - STA. 28+00




**NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)**

VERT. SCALE (FEET): 0, 25, 50

HORIZ. SCALE (FEET): 0, 50, 100, 200

**Vertical Exaggeration = 2x**

| | | |
|---|---|---|
| Coyote Creek Evaluation Project<br>Marin County, California | GEI Consultants | **COYOTE CREEK RIGHT PROFILES (SHEET 1 OF 2)** |
| Marin County Flood Control and Water Conservation District | Project 140457-0 | April 2015 **Figure 9** |

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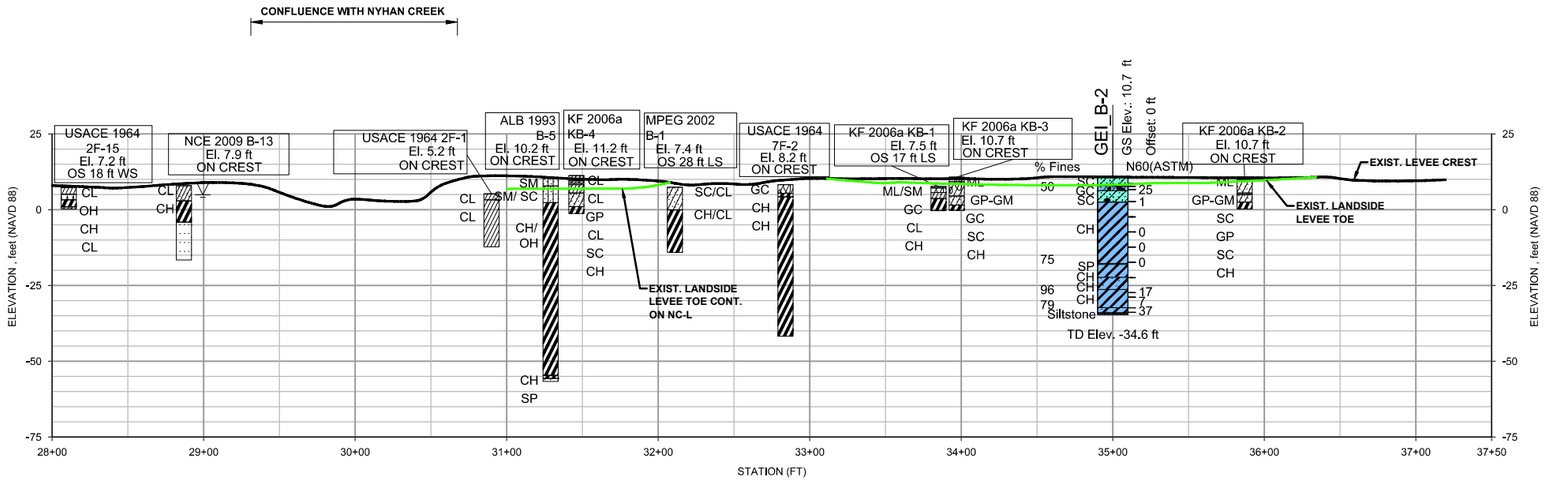
# Coyote Creek Right (CC-R)
## STA. 28+00 - STA. 37+50

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VERT. SCALE (FEET)

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HORIZ. SCALE (FEET)

Vertical Exaggeration = 2x

NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)

| | | |
|---|---|---|
| Coyote Creek Evaluation Project<br>Marin County, California | GEI Consultants | COYOTE CREEK RIGHT PROFILES<br>(SHEET 2 OF 2) |
| Marin County Flood Control and Water Conservation District | Project 140457-0 | April 2015 **Figure 10** |

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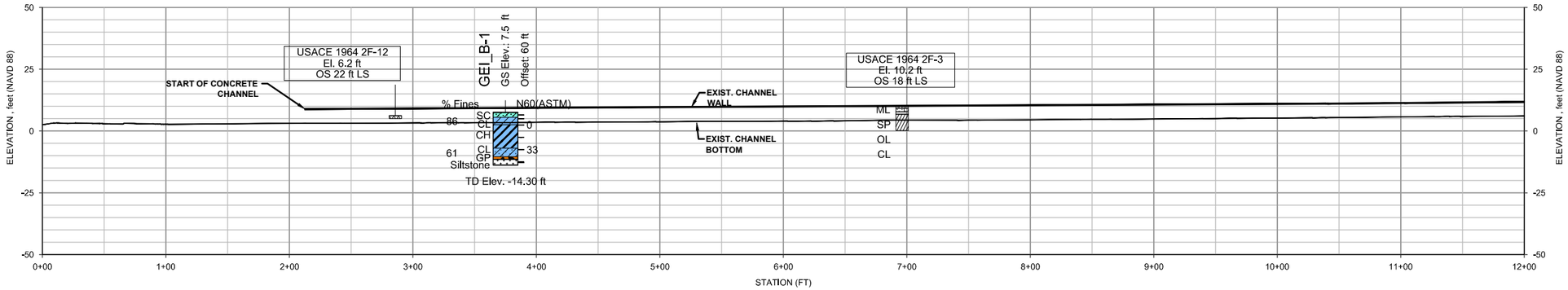
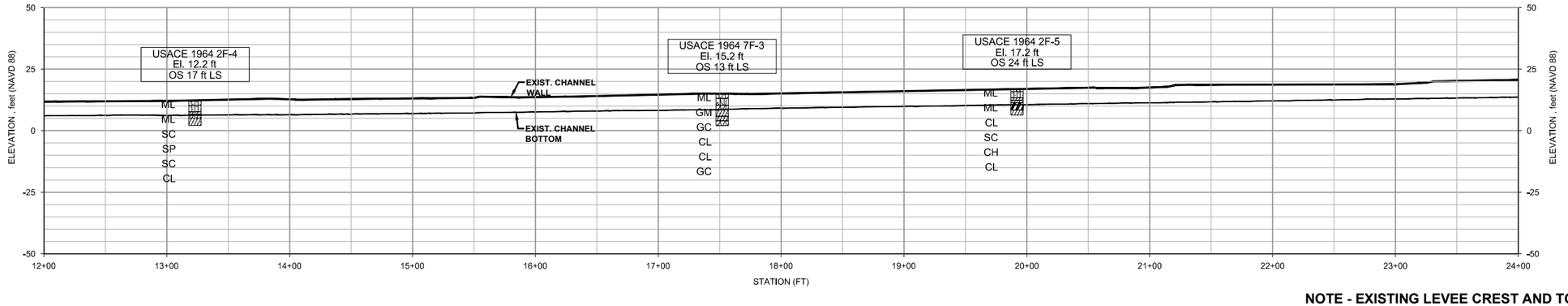
## Coyote Creek Channel (CC-C)
## STA. 0+00 - STA. 12+00




## Coyote Creek Channel (CC-C)
## STA. 12+00 - STA. 24+00




**NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)**

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HORIZ. SCALE (FEET)

Vertical Exaggeration = 2x

Coyote Creek Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

Project 140457-0

**COYOTE CREEK CHANNEL PROFILES**
**(SHEET 1 OF 2)**

April 2015 **Figure 11**

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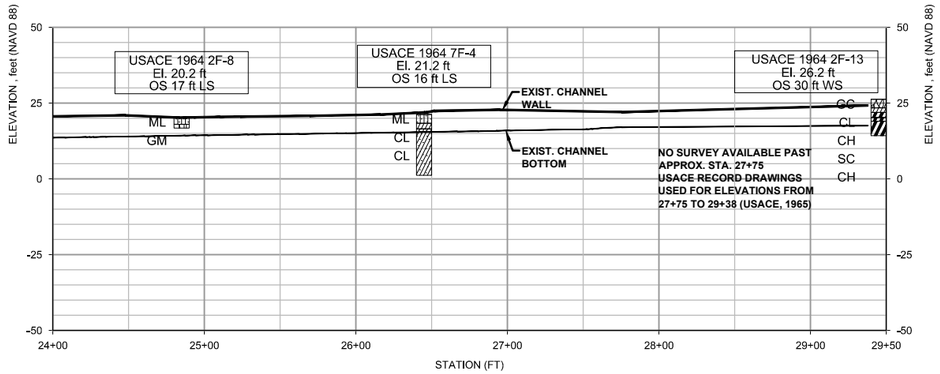
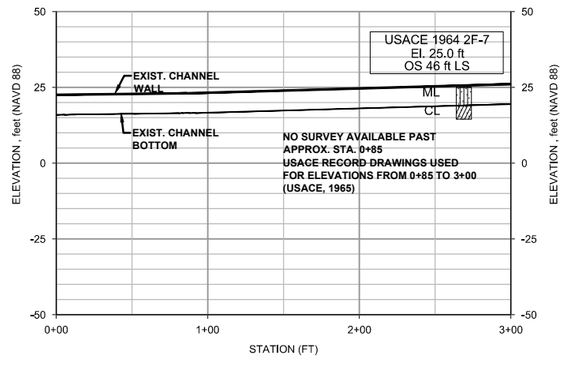
## Coyote Creek Channel (CC-C)
## STA. 24+00 - STA. 29+50




## Coyote Creek Channel (CC-C2)
## STA. 0+00 - STA. 3+00




**NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)**

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HORIZ. SCALE (FEET)

**Vertical Exaggeration = 2x**

Coyote Creek Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

Project 140457-0

**COYOTE CREEK CHANNEL PROFILES**
**(SHEET 2 OF 2)**

April 2015 **Figure 12**

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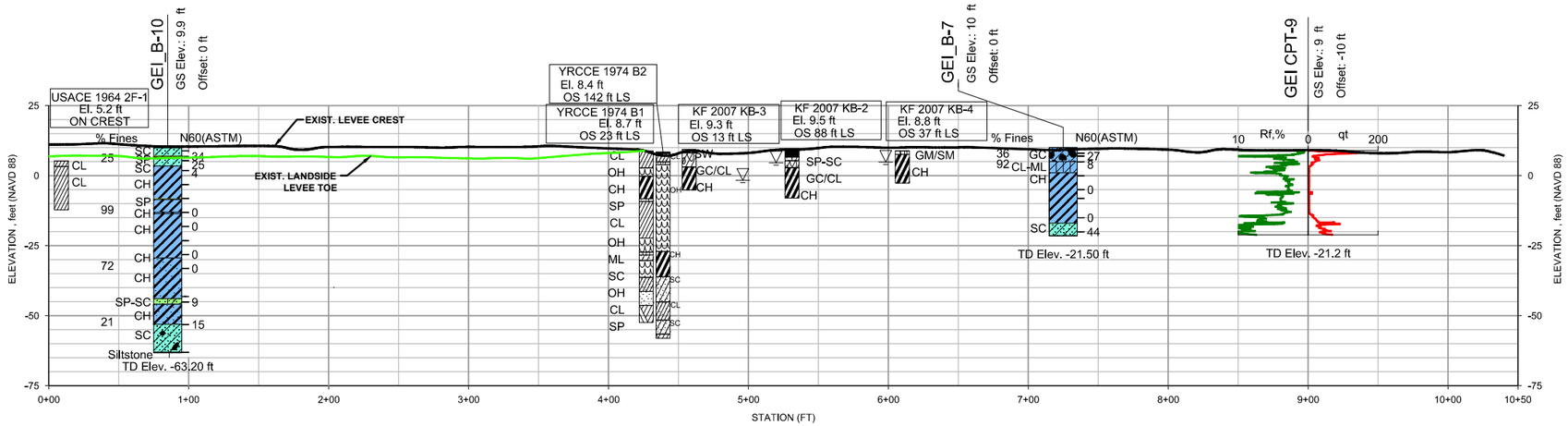
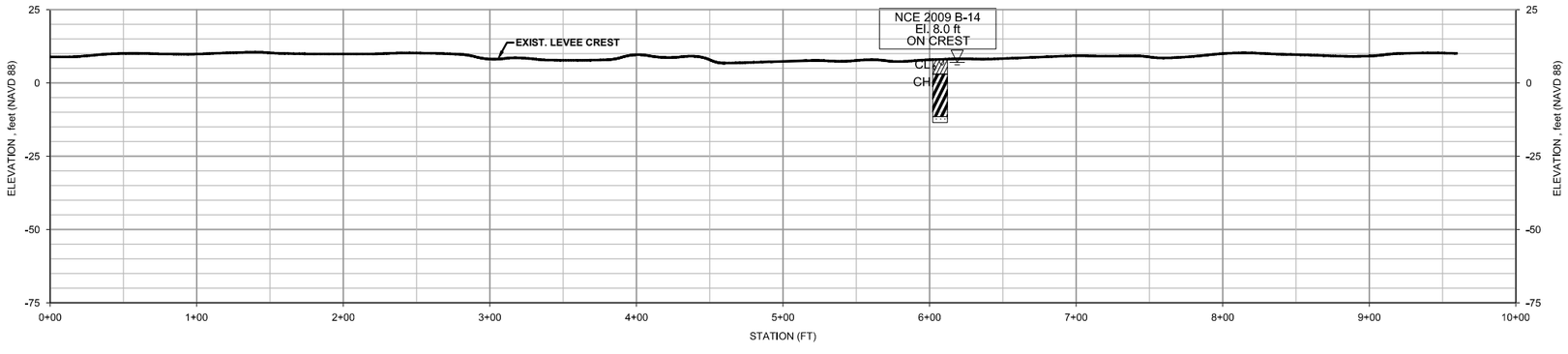
## Nyhan Creek Left (NC-L)
## STA. 0+00 - STA. 10+50




## Nyhan Creek Right (NC-R)
## STA. 0+00 - STA. 10+00




**NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)**

50 / 25 / 0 **VERT. SCALE (FEET)**

0 50 100 200 **HORIZ. SCALE (FEET)**

**Vertical Exaggeration = 2x**

Coyote Creek Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

**NYHAN CREEK LEFT AND NYHAN CREEK RIGHT PROFILES**
**(SHEET 1 OF 1)**

Project 140457-0 | April 2015 | **Figure 13**

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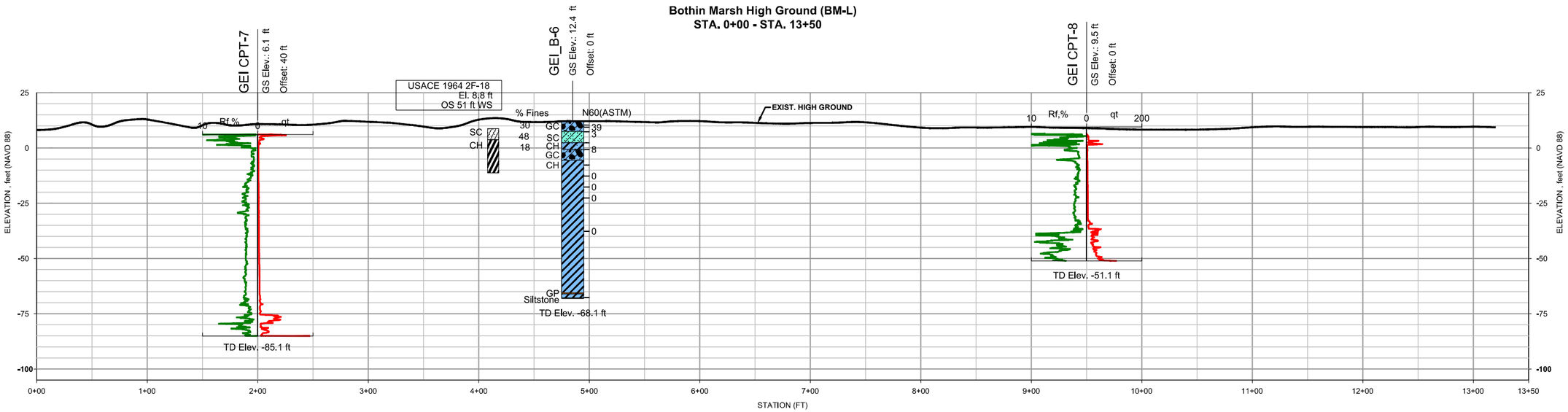
## Bothin Marsh High Ground (BM-L)
## STA. 0+00 - STA. 13+50

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VERT. SCALE (FEET)

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HORIZ. SCALE (FEET)

Vertical Exaggeration = 2x

NOTE - EXISTING LEVEE CREST AND TOE PROFILES BASED ON 2013 MERIDIAN CHANNEL SURVEY, USGS 2011 GEOTIFF, AND USACE RECORD DRAWING (1965)

| | | |
|---|---|---|
| Coyote Creek Evaluation Project<br>Marin County, California | GEI Consultants | **BOTHIN MARSH HIGH GROUND PROFILES**<br>**(SHEET 1 OF 1)** |
| Marin County Flood Control and Water Conservation District | Project 140457-0 | April 2015 **Figure 14** |

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# Appendix A

## Historical Document Review

# TECHNICAL MEMORANDUM

**To:** Neal Conatser, Hugh Davis, PE, GE; Marin County Flood Control and Water Conservation District

**From:** Matt Powers, PE, and Graham Bradner, PG, CEG, CHG; GEI Consultants

**Date:** July 24, 2014

**Re:** Coyote Creek Levee Evaluation; Summary of Existing Documentation Review and Field Reconnaissance

---

## 1.0 Background and Purpose

GEI Consultants Inc. (GEI) along with project sub-consultant HDR, Inc. (HDR) is assisting the Marin County Flood Control and Water Conservation District (District) in an evaluation of the Coyote Creek Local Flood Protection Project (Project) located in the unincorporated community of Tamalpias Valley. The overall goal of the Coyote Creek Levee Evaluation is to provide a comprehensive assessment of the current condition of the levee system and develop recommendations for both short- and long-term improvements. The development and assessment of improvement alternatives is necessary in order to determine options for maintaining and, if feasible and cost-effective, increasing the level of protection provided by the Project.

As part of our scope of services under Task 3 – Geotechnical Investigation, GEI has completed a review of existing documentation (subtask 3.1) and performed a site reconnaissance of the Coyote Creek levee system (subtask 3.2). This Technical Memorandum (TM) provides a summary of our review of existing documentation and presents findings from our recent geotechnical reconnaissance of the levee system. Relevant documents and site reconnaissance findings will be utilized for evaluation purposes including planning of the subsurface exploration program, site characterization, hydraulic and geotechnical evaluations, and alternatives assessment.

## 2.0 Review of Existing Documentation and Subsurface Data

Available existing documentation and subsurface data was reviewed by GEI in order to develop an understanding of the Coyote Creek levee system including the original Project design basis, performance history, and historic modifications. The available documentation and data was also used to locate previous geotechnical explorations and will be utilized to help characterize subsurface conditions, identify missing information and data gaps, and plan the subsurface exploration program.

### 2.1 Documents and Data Reviewed

Several documents were provided by the District for GEI review. These include:

- Documents provided by the District as part of the Coyote Creek Levee Evaluation RFP,
- Documents provided by the District in response to GEI's May 6, 2014 information request, and
- Documents made available to GEI during previous work with the District for the Coyote Creek LLAP Support Project

In general, documents included original Project design drawings, recent and historic construction plans and as-built drawings, original and draft revised operations and maintenance manuals, survey and right-of-way data, hydraulic and geotechnical evaluations, assessments of potential habitat restoration opportunities,

USACE inspection reports, and channel dredging studies and drawings. A summary of the documents and data reviewed by GEI is provided on **Table 1**. Documents with relevant geotechnical information and data are discussed further in Section 2.4.

## 2.2 Description of Coyote Creek Levee System

The Coyote Creek Local Flood Protection Project was originally designed in the late 1950s by the U.S. Army Corps of Engineers (USACE) and construction of the levees, concrete channel, and interior drainage structures was completed between 1965 and 1967. The Project protects a portion of the Tamalpias Valley community from high flows in Coyote Creek and Nyhan Creek as well as from high tides from Richardson Bay. After construction, the Project was transferred to the District for operation and maintenance and is presently subjected to the USACE Rehabilitation and Inspection Program (RIP) per P.L. 84-99. The Project consists of a concrete channel and system of earthen levees situated along an approximate 7,800 ft. section of Coyote Creek extending from just upstream of Maple St. downstream to the Mill Valley – Sausalito Pathway at Richardson Bay. A second 450 ft. segment of earthen levees along Nyhan Creek, from its confluence with Coyote Creek upstream to Marin Ave., is also included as part of the Project.

The Project is divided into the following reaches:

Upper Reach - approximate Station 78+75 to 49+50: This reach consists of a concrete channel beginning near Maple St. and extending downstream to the end of the concrete channel upstream of Flamingo Rd. Two separate 7 to 9 ft. wide reinforced concrete pipe (RCP) box culverts extend from west of Maple St. and combine as a single 13 to 16 ft. wide rectangular concrete channel just west of Ash St. Concrete bridge decks span the concrete channel at Ash St., Spruce St., Pine St., Poplar St., Laurel Wy., and Ross Dr. The concrete channel extends east of Ross Dr., transitioning to a stilling basin and terminating where the concrete channel wing walls transition into the earthen levee segment (Middle Reach).

Middle Reach - approximate Station 49+50 to 28+50: This reach consists of earthen levee beginning at the downstream end of the concrete channel and extending downstream to the Highway 1 / Shoreline Hwy. Bridge. This section also includes a portion of Nyhan Creek beginning at the Marin Ave. Bridge and extending downstream to the confluence of Nyhan Creek with Coyote Creek. Portions of the left bank downstream of Flamingo Rd. include a concrete block floodwall constructed on top of the original earthen levee.

Lower Reach - approximate Station 28+50 to 12+00: This reach consists of earthen levee beginning at the Highway 1 / Shoreline Highway Bridge and extending downstream along Bothin Marsh to the Mill Valley – Sausalito Pathway. Like much of the project area, this reach has experienced substantial settlement due to soft soils. However, unlike other levee segments, the Lower Reach has not been maintained to its original design elevation and is regularly overtopped by high tides. A portion of the left bank along a developed commercial property includes a concrete floodwall.

USACE requires the District to maintain the Project to its original design specification, which was intended to convey the 20 year design flow of 1,750 cfs (USACE, 1959). The District maintains the Project by removing accumulated sediment from the creek and channel, with sediment removal occurring in 1974, 1983, 1988, 1990, 1991, 1998, and 2003. The next sediment removal episode is tentatively scheduled for 2016, as of the time of this writing. Additional maintenance includes annual pump station maintenance and repairs, vegetation maintenance, and rodent abatement.

## 2.3 Performance History and Previous Modifications

Based on review of levee inspection records, historic documents, and existing reports, the project area has primarily experienced issues with settlement, internal drainage, and levee seepage, with no documented deep-seated slope stability problems. Reports of past performance issues are notably more frequent within the Middle and Lower Reach of the Project area. Previous modifications along specific sections include

adding earth fill or floodwall construction to maintain design crest elevations, construction of pump stations to improve internal drainage, and installation of seepage barriers to mitigate local levee through-seepage conditions. Public access improvements along a portion of the right bank have also been recently constructed.

Settlement: Settlement resulting from compression of the Bay Mud layer in the levee foundation began to occur throughout the project site following completion of initial construction. The levee section between Station 11+05 and 28+40 (U.S. Highway 1 Bridge) has settled significantly and as a result, areas downstream of the U.S. Highway 1 Bridge experience flooding during high tide events. To compensate for settlement in other areas of the site, sections of the levees were raised in 1977 by adding new fill or constructing floodwalls. Previous levee raises may have also been completed, but were not noted during our review of available documents. One of the floodwalls constructed extends on the left bank from Station 25+00 to 28+50 (U.S. Highway 1 Bridge). A second floodwall, constructed between Station 33+00 and 44+00, consists of two parallel concrete walls connected with tie-rods and filled in between with compacted earth to provide an access road on the crown of the levee.

The District continues to periodically add fill material to earthen sections of the levee crown in order to maintain levee elevations. In 2006 and 2007, the levees were raised by placing earth on the right bank upstream of the Flamingo Rd. Bridge between Station 44+60 to 46+90, and also on the right bank downstream of the Flamingo Rd. Bridge between approximately Station 41+00 wrapping along the left bank of Nyhan Creek to Station 44+00. Additionally in 2013, according to the District, minor amounts of fill were added to raise local low spots along the left and right levees near the Flamingo Rd. Bridge.

Internal Drainage: Settlement has also affected internal drainage within the project area. Gravity drainage proved to be insufficient to prevent ponding of storm water landward of the levee. As such, a series of pump stations were constructed between 1978 and 1985. These include the Crest Marin (1978), Cardinal, (1983), and Shoreline (1985) storm water pump stations. Both the Cardinal and Shoreline pump stations discharge directly into Coyote Creek while the Crest Marin pump station discharges into Nyhan Creek.

High groundwater conditions have historically been observed along a portion of the right bank of the Middle Reach, upstream of the Flamingo Rd Bridge, behind the houses along Starling Rd. and Flamingo Rd. Geotechnical investigation revealed that the conditions were likely due in part to an abandoned storm drain culvert which crossed beneath the levee and discharged into Coyote Creek (Kleinfelder, 2006). Local ground settlement over time may also have been a contributing factor. It was recommended that a trench cut-off be installed within the levee prism and the pipe properly abandoned. Based on our document review, it is uncertain if any improvements were constructed to address these recommendations.

Levee Seepage: Saturated conditions on the landside of the levee, which may be attributed to high groundwater, through-seepage, or shallow underseepage, were historically observed during very high tides along a portion of the left bank of the Middle Reach behind the houses along Cardinal Rd. from the Flamingo Rd. Bridge to just west of Highway 1. Geotechnical investigation revealed the presence of granular material within the levee prism and it was recommended that a shallow seepage barrier be installed through the levee prism to help prevent levee seepage (Kleinfelder, 2003). Plans for Maintenance dredging within the Middle Reach of Coyote Creek, dated August 12, 2003 (MCFCWCD, 2003), show limits of installation of an impermeable clay barrier within the left bank levee between approximate USACE Stations 37+60 to 42+60. The actual length of barrier along the levee is approximately 450 ft. .

Public Access: Construction of the Tennessee Valley Pathway, which provides improved public pedestrian and bicycle access along the right (i.e. south) bank between the Marin Ave. and the Sausalito – Mill Valley Bike Path, was recently completed in 2013. The pathway includes raised or at-grade aggregate base surface as well as sections of wooden boardwalk.

## 2.4 Relevant Geotechnical Documents and Subsurface Explorations

Several previous geotechnical reports were included in the documents provided by the District during document review. These documents provide discussion of surface and subsurface conditions encountered during subsurface exploration as well as boring log and geotechnical laboratory testing data. Information and data provided in these documents will be utilized as appropriate to help in planning upcoming Project explorations and characterization of surface and subsurface conditions. A summary of previous geotechnical explorations within the Project area is provided on **Table 2,** including reference source, boring depth, and type of laboratory testing performed. Boring logs from these previous explorations are compiled for reference in **Appendix A**. The approximate location of these previous geotechnical explorations is shown on **Figures 1-6**. A brief discussion of the relevant geotechnical reports reviewed is provided below:

USACE, 1964: Geotechnical investigation by USACE for the planning and design of Coyote Creek Channel Improvements. Explorations were performed between 1957 and 1963. Exploration locations and stick logs of 23 geotechnical borings were included on the drawing set for channel improvements.

Yarnell and Ron, 1974: Geotechnical investigation for construction of the Crest Marin Pump Station and storm drain pipeline adjacent to Nyhan Creek. The scope of work included completing four test borings along the pipeline alignment and at the proposed pump station location, laboratory testing of recovered soil samples, and providing conclusions and geotechnical recommendations for pump station foundation and wall design.

ALB Associates, 1990: Geotechnical investigation for a planned shopping center between Shoreline Highway, Flamingo Road, and Coyote Creek. The scope of work included completing thirteen test borings within the proposed development, laboratory testing of recovered soil samples, and providing conclusions and geotechnical recommendations for foundation and wall design and construction. The report also includes a map depicting estimated Bay Mud thickness contours within the project area.

ALB Associates, 1993: Geotechnical investigation for levee improvements including raising of the existing levees and floodwalls and maintenance dredging within the Coyote Creek channel. The scope of work included completing five test borings along the existing levees, laboratory testing of recovered soil samples, performing settlement and stability analyses, and submitting a geotechnical report including conclusions and recommendations.

Miller Pacific Engineering Group, 2002: Geotechnical investigation to evaluate foundation conditions for the Flamingo Rd. Sanitary Pump Station. One test boring was performed along the south bank of Coyote Creek at the Flamingo Rd. Bridge. The document provided includes only the boring location plan and boring log.

Kleinfelder, 2003: Geotechnical investigation of possible levee leakage along the north (left) bank of Coyote Creek. Levee leakage conditions were historically observed during very high tides behind the houses along Cardinal Rd. from the Flamingo Rd. Bridge to just west of Highway 1. The scope of work included completing four test borings along the existing levees and laboratory testing of recovered soil samples. The investigation revealed that the upper 3-4 feet of levee fill consisted of predominantly pervious coarse grained material which allowed water to pass through the levee prism during very high tides. Kleinfelder recommended installing a seepage barrier along this reach of levee.

Kleinfelder, 2006a: Geotechnical investigation of high groundwater conditions and potential for levee seepage along a portion of the south (right) bank of Coyote Creek. These conditions were observed behind the houses along Starling Rd. and Flamingo Rd. The scope of work included completing 4 test borings along the existing levees, converting two of the borings to observation wells, laboratory testing of recovered soil samples, periodic measurement of groundwater levels within the observation wells, and preparation of a geotechnical report including conclusions and recommendations. The investigation revealed that ongoing local ground settlement and an abandoned 12 inch drainage culvert were possibly contributing to the

observed conditions. Kleinfelder recommended installing a trench cut-off and pipe abandonment within the levee prism and, if necessary, seepage cut-off and interior drainage improvements.

Kleinfelder, 2006b: Geotechnical investigation for drainage improvements along Crest Marin Creek. Although the investigation project site is not directly along Coyote Creek, Crest Marin Creek drains into the Crest Marin Pump Station located along Nyhan Creek. Eight explorations, including CPTs, hand augers, and dynamic cone tests, were performed in the vicinity of Nyhan Creek near Marin Ave.

Kleinfelder, 2007: Geotechnical investigation for Marin Ave. Drainage Improvement Project. Four borings were performed along Marin Ave. adjacent to Nyhan Creek and Crest Marin Pump Station.

Kleinfelder, 2008: Evaluation of groundwater and tidal level data from July, 2007 in conjunction with Kleinfelder's previous investigation of high groundwater conditions along a portion of the south bank of Coyote Creek (Kleinfelder, 2006a). This evaluation supported the previous investigation's findings.

Nichols Consulting Engineers, 2009: Geotechnical investigation for the Tennessee Valley / Manzanita Connector Pathway along the south bank of Coyote Creek beginning at Marin Ave. and ending at the Sausalito – Mill Valley Bike Path. The scope of work included completing 11 test borings along the south bank of Coyote Creek and the east bank of Nyhan Creek, laboratory testing of recovered soil samples, geotechnical evaluation and analysis, and providing conclusions and geotechnical recommendations relevant to pathway construction.

Marin County Flood Control District, 2012: Settlement data for ten survey monitoring points along the Project alignment over the period from 1978 through 2012.

### 2.5 General Subsurface Conditions

General subsurface conditions within the Project extents are discussed below based on preliminary review of historic mapping and previous exploration logs. It appears that subsurface conditions within the majority of the site consist of varying amounts of fill underlain by Bay Mud deposits, which generally thicken towards Richardson Bay (east) and with distance from the surrounding hill slopes. Stiff material or bedrock is found below the Bay Mud layer at depth.

Historic topographic mapping from the late 1800's indicates that the majority of the present day Project site is located on what was once tidal wetland. This area appears to include the entire extents of the Lower and Middle Reaches and a portion of the Upper Reach extending upstream to the vicinity of Pine St. Later topographic mapping shows that residential development had occurred throughout the Upper and Middle Reaches by the mid-1950's; however; the Lower Reach was still mapped as tidal wetland. Mapping from the late 1960's shows the presence of a channelized Coyote Creek and development within the upstream extents of the present day Lower Reach, just downstream (east) from U.S. Highway 1.

Lower Reach: Along both banks of the Lower Reach, there appears to be a thin layer of artificial fill up to 3 feet thick. The bottom of the Bay Mud layer was not encountered in previous explorations performed in the Lower Reach, but based on the available logs it appears to extend to over 50 feet below the ground surface. No subsurface information on the material underlying the Bay Mud deposits in this reach was noted during document review.

Middle Reach: From U.S. Highway 1 to the confluence with Nyhan Creek, the right bank of the Middle Reach abuts high ground features of the surrounding hillsides. Adjacent to the channel in this high ground segment, fill thicknesses range from approximately 4-5 feet, with localized deposits of colluvium extending from the hill slopes. Bay Mud thicknesses below the fill range from approximately 7-20 feet, overlying sandstone and siltstone bedrock. Within the right bank levee segment in the vicinity of Flamingo Rd., fill thickness ranges from approximately 8-10 feet. The total thickness of the Bay Mud layer in this levee segment has not been previously explored. Along the left bank of the Middle Reach, the thickness of fill ranges from 5-8 feet, overlying Bay Mud deposits approximately 30-50 feet thick. Stiff clay and bedrock

were encountered below the Bay Mud layer. Based on the limited information presented on the available logs (material description including coloring and composition), it is possible that the stiff clay layer represents Old Bay Mud deposits while the bedrock (shale, sandstone, and greywacke) is likely Franciscan Formation.

Upper Reach: Original USACE design drawings (USACE, 1964) include exploration locations along the concrete channel alignment along with the accompanying stick boring logs showing limited soil descriptions. Based on the available stick logs it appears that subsurface conditions within this reach consist of up to two feet of fill (likely associated with residential development and construction of U.S. Highway 1), overlying alluvial, and colluvial deposits. Historic topographic mapping shows the extents of historic wetlands mapped upstream to the vicinity of Pine St., however; Bay Mud deposits are not shown on the USACE logs within the Upper Reach. Several of the logs in the Upper Reach show the presence of organic clay materials inter-bedded with alluvial and colluvial deposits. This appears consistent with an alluvial and colluvial deposits at the distal edges of an estuarine environment.

Nyhan Creek: The right bank of Nyhan Creek abuts high ground features of the surrounding hillsides. Previous explorations along this bank indicate a fill thickness of approximately 5 feet. The left bank of Nyhan Creek consists of an earthen levee from Marin Ave. downstream to the confluence with Coyote Creek. The thickness of levee fill along the left bank is uncertain as no previous explorations were noted along the left bank levee of Nyhan Creek during document review. We anticipate that the levee fill along the left bank is approximately 8-10 feet thick, based on observations during recent site reconnaissance. Based on historic topographic mapping, Bay Mud deposits likely extend upstream to the vicinity of Marin Ave. with a maximum thickness of approximately 50 feet near the confluence with Coyote Creek. Upstream of Marin Ave, Nyhan Creek is an earthen channel with no levees. It is anticipated that subsurface material is composed of predominantly inter-bedded alluvial and colluvial deposits.

### 2.6 Significant Findings and Missing Information

In general, subsurface information from previous explorations will be useful in planning Project explorations and constructing subsurface profiles. Previous explorations were performed both along the channel alignment and in a few landside areas, including the vicinity of Marin Ave. and north of Cardinal Rd. Several of the previous geotechnical documents, including recent work performed for the design of the Tennessee Valley / Manzanita Connector Pathway appear to provide high quality laboratory data as well.

Past performance can be considered a useful indicator of future performance if levee conditions do not significantly deteriorate (through mechanisms such as rodent activity, human action, or waterside erosion). Thus, performance records provide valuable data helpful in identifying levee reaches where future problems may occur and assessing the need for remediation. As discussed previously, settlement has occurred along the Project alignment and improvements have been constructed in order to maintain design crest elevations. Unmaintained levee segments within the Lower Reach experience periodic over-topping during high tide events. Through seepage and high ground water conditions have also been historically observed within the Middle Reach.

Information found missing from our review of available documents include reports and records of past performance during riverine high water events, historic aerial imagery, and as-built construction documentation and details from previous Project modifications.

Records of levee performance during riverine high water events were not provided in the available documents. A report prepared by USACE in 1983 provides documentation of damages throughout the Bay Area region from a specific flood event in 1982; however, no reports or observations relevant to Coyote Creek were noted.

Historic aerial imagery is useful in overall Project site characterization and in understanding the how the site has been altered due to development. No aerial imagery was initially provided for review; however, at the suggestion of the District, GEI has requested available historic aerial imagery from District GIS personnel.

As-built construction documentation and details from previous Project modifications are important in anticipating localized site conditions. During document review, several previous modifications or performance history issues were noted as discussed in Section 2.3. In some instances, as-built construction documentation and details were not available. Specifically, plans for Maintenance dredging within the Middle Reach of Coyote Creek, dated August 12, 2003 (MCFCWCD, 2003), show limits of installation of an impermeable clay seepage barrier within the left bank levee between approximate USACE Stations 37+60 to 42+60. Aside from documented observations of construction activities by Kleinfelder on April 29, 2005 (Kleinfelder, 2005), no other information on the construction of seepage barriers was available during our review and the as-built details and overall extents of seepage barriers along Coyote Creek are uncertain.

Additionally, installation of a cut-off trench and proper abandonment of a drainage culvert along the right bank of the Middle Reach was recommended by Kleinfelder, 2006, in response to observations of high groundwater conditions along Starling Rd. and Flamingo Rd. No construction records or details of construction work was noted during our review, however, the drainage invert appears to have been abandoned or removed as it does not appear on utility maps provided by the District and was not observed during recent site reconnaissance. Further information relevant to these specific modifications, if available, would be useful in understanding localized site conditions, delineating representative reach extents, and identifying representative cross section locations.

## 3.0 Site Geotechnical Reconnaissance

Site reconnaissance of the Coyote Creek levee system was performed by GEI to gain an understanding of the existing site conditions to assess access opportunities and constraints for the subsurface exploration program and identify cross section locations and extents. Additionally, follow-up observations of current site conditions relative to 2012 USACE PI inspection categories were also documented while on-site.

### 3.1 Reconnaissance Methods, Approach, and Goals

The site geotechnical reconnaissance was performed on May 28, 2014 and covered the Coyote Creek Project extents including the Upper, Middle, and Lower (downstream to Mill Valley – Sausalito Pathway) Reaches, Nyhan Creek, and the Bothin Marsh high ground area. Members of the reconnaissance team included Matt Powers, and Tim Haynes of GEI. Neal Conatser and Hugh Davis of the District were on-site as well during the first hour of the reconnaissance. The majority of the reconnaissance was performed on foot. A vehicle was used to travel between levee reaches and access points. Reconnaissance of the Upper Reach was performed from outside of the concrete channel with observations restricted to locations where the existing roadway bridges spanned the concrete channel.

Observations were documented in the field using a combination of field notes and descriptions associated with photographs, site location, and any necessary measurements specific to each observation. Topographic and aerial base maps were used to log the location, extent, and orientation of observations in the field. Representative photographs were taken during the reconnaissance to illustrate relevant site features specific to each observation.

The main goals of the site geotechnical reconnaissance were as follows:

- Walk the site to gain general familiarity and perform photo documentation of general site conditions and Project features.
- Perform field measurement of typical levee and floodwall sections.

- Document any observations relevant to identified historic seepage/leakage areas and related modifications.
- Document any evidence of erosion (including observed toe scour), seepage, or stability features, or any obvious areas requiring specific analysis.
- Assess 2012 USACE PI inspection findings compared to existing conditions, with particular attention to geotechnical inspection categories.
- Locate potential exploration access points/paths and staging areas, and potential utility conflicts, including areas along the Bothin Marsh high ground and along Nyhan Creek upstream of Marin Ave.

### 3.2 Summary of GEI Reconnaissance Observations

The May 28, 2014 site geotechnical reconnaissance was performed between 8:30 AM and 3:30 PM. Weather conditions were sunny with temperatures in the low 70s. Based on available tide observations (NOAA, 2013), the morning low tide at the site occurred at approximately 6:25 AM (-1.0 ft. MLLW), rising through the morning with an afternoon high tide occurring at approximately 1:21 PM (+4.6 ft. MLLW). Due to rising tide conditions in the late morning and afternoon, observations of some site features within the Coyote Creek channel, particularly near the waterside levee toe, were not possible. A summary of site conditions and significant observations for each reach are provided below. GEI observation points are shown on **Figures 1-6** for reference. Details of each GEI observation are provided in **Table 3**, along with the location and associated representative photographs. Photographs are included as **Attachment A**. In general, GEI observation points were not recorded at 2012 USACE inspection ID points. Observations related to 2012 USACE ID points are discussed in Section 3.3.

Upper Reach: Reconnaissance of the Upper Reach consisted of observations taken from each of the roadway overcrossings which span the concrete channel, including Maple St., Ash St., Spruce St., Pine St., Poplar St., Laurel Way, and Ross Dr. In general, the channel bottom was clear of sediment and debris, with exception of 1) the section upstream of Ash St. which appeared to have approximately 3-6 inches of sediment or vegetated shoaling along the channel and 2) downstream from Laurel Way which appeared to have approximately 3 inches of coarse grained sediment along the channel. Water levels in the channel were approximately 3 inches above the channel bottom from Maple St. to downstream of Laurel Way. Water levels downstream of Laurel Way were higher due to tidal influence at the time of observation. Minor amounts of vegetation were observed overhanging the channel. No obvious wall deflections or deformations were observed within the channel except for one panel with approximately 4 inches of offset within the wingwall section of the left bank channel. This offset has been observed and recorded by USACE during the 2012 PI.

GEI observations within the Upper Reach are described on **Table 3**, and include observations **GEI 22-25**. The photographs associated with each observation are included in **Appendix A.**

Middle Reach: Reconnaissance of the Middle Reach was performed on foot along the levee crest and Tennessee Valley / Manzanita Connector Pathway boardwalk, accessing the landside and waterside toe areas where possible. Access to the waterside slope and toe areas was not possible from the boardwalk structure along the right bank. Between the end of the concrete channel (Upper Reach) and Flamingo Rd., both the left and right banks consist of earthen levees. Downstream of Flamingo Rd., the left bank consists of a concrete block floodwall constructed on top of the original earthen levee. The right bank downstream of the confluence with Nyhan Creek consists of the adjacent hillside slope along Tennessee Valley Rd and no levee or floodwall features exist. Tall grasses up to 3 feet high on the levee sections of the Middle reach obstructed observation of some levee slope and crest features. Tall grasses were observed along the Middle Reach left bank between the end of the concrete channel (Upper Reach) and Flamingo St. Bridge and along the right bank between the end of the concrete channel and the confluence with Nyhan Creek.

Field measurement of observed typical and critical cross sections along the Middle Reach were recorded and included as GEI observation points. Typical waterside levee slopes in this reach upstream of Flamingo

Rd. were observed between 1.7H:1V and 2.1H:1V. Areas with steeper waterside slopes generally coincided with observed erosion features near the waterside toe of the levee. Erosion near the toe was observed to be occurring within the existing channel sediment, but appears close to encroaching on the levee prism. Within the floodwall segment of this reach, the alignment dimensions were fairly consistent, including a crest width of approximately 10.75 feet and flat levee slopes below the floodwall structure. The concrete floodwall appeared to be in good condition, with only minor spawling of the surficial concrete and exposed rebar observed in one localized area. Evidence of historic levee seepage issues documented within this reach was not observed during site reconnaissance, but it is noted that evidence of seepage issues may only be discernable during high water events. Remedial modifications completed in these areas, as discussed in Section 2.2, are assumed to be effective as there were no reports of additional seepage conditions following remediation.

GEI observations within the Middle Reach are described on **Table 3**, and include observations **GEI 6-20.** The photographs associated with each observation are included in **Appendix A.**

Nyhan Creek: Reconnaissance along Nyhan Creek was performed on foot along the levee crest and Tennessee Valley / Manzanita Connector Pathway. Access to the waterside slope and toe areas was mostly prohibited due to steep slope conditions, water levels in the channel, and lack of access from the boardwalk structure. Tall grasses up to 3 feet high along the left bank levee sections of Nyhan Creek between Crest Marin Pump Station and the confluence with Coyote Creek obstructed observation of some levee slope and crest features.

Field measurement of observed typical and critical cross sections along the Middle Reach were recorded and included as GEI observation points. Critical cross sections included areas with overly steepened slopes and narrow crest widths relative to the remainder of the reach. Waterside levee slopes in this reach were observed between 1H:1V (over-steepened case) and 1.7H:1V to 2H:1V (typical case). Levee crest widths were observed between 5 feet and 9 feet.

GEI observations along Nyhan Creek are described on **Table 3**, and include observations **GEI 1-5 and 21.** Photographs associated with each observation are included in **Appendix A.**

Lower Reach: Reconnaissance of the Lower Reach was performed on foot along the left bank floodwall and levee segments and the right bank Tennessee Valley / Manzanita Connector Pathway boardwalk. Access to the landside and waterside areas was restricted due to soft and wet ground conditions within tidal wetland areas adjacent to the channel and within Bothin Marsh.

In general, the presence of levee prism features was not discernable along the left and right banks of the Lower Reach. Ground elevations along the levee alignments appeared to be less than 6 inches higher than the surrounding grade. The floodwall section along the left bank, just downstream from U.S. Highway 1 appeared to be in good condition, with no observed wall deflections or deformations.

No GEI observation points were recorded within the Lower Reach. Photographs illustrating observed site conditions are included in **Appendix A** (Photos 87-89 and 92-96)**.**

Bothin Marsh High Ground: Reconnaissance of the Bothin Marsh high ground area consisted of observations from the adjacent areas of the Lower Reach and along the vehicular access route near the intersection of U.S. Highway 1 and Almonte Blvd. The high ground alignment is located to the south of Bothin Marsh and consists of a relatively flat grade containing a mix of industrial and undeveloped parcels. The high ground is approximately 5-6 feet above the adjacent marsh area, with an approximate 3H:1V slope extending down into the marsh. It was noted that the parcels along the Bothin Marsh high ground alignment are privately owned. Reconnaissance of this area was performed primarily to evaluate geotechnical exploration access opportunities and constraints. GEI observations along the Bothin Marsh high ground alignment are described on **Table 3**, and include observation **GEI 26.** Photographs associated with this observation are included in **Appendix A.**

### 3.3 USACE 2012 Inspection ID Points

Recent USACE RIP inspections conducted in 2012 have found portions of the project to be out of compliance with the original project agreement and current USACE operation and maintenance standards. Summary tables of the 2012 USACE Inspection IDs were provided by the District. During the site reconnaissance, observations of current conditions were recorded at the 2012 USACE Inspection ID points, with particular attention to geotechnical related points. The locations of the 2012 USACE Inspection ID points are shown for reference on **Figures 1-6.** Details of each 2012 USACE Inspection ID point are provided in **Table 4**, along with observations of current conditions recorded by GEI during the recent site reconnaissance. Photographs associated with each USACE Inspection ID, taken by GEI during the site reconnaissance, are included in **Attachment A**.

Of the 50 total 2012 USACE Inspection ID points, 11 were considered by GEI to be related to geotechnical categories. Geotechnical related ID points are highlighted on **Figures 1-6** and **Table 3** for reference. A brief discussion of these ID points, including GEI observations of current conditions (in italics) is provided below:

USACE_CESPN_COYL_2012_a_0001: Lower Reach left bank: Unmaintained levee – *Settlement of the levee is apparent as no visible levee features were observed during GEI reconnaissance*.

USACE_CESPN_COYL_2012_a_0002: Middle Reach left bank: Floodwall segment - *Floodwall appears to be in good condition except for some minor spawling*.

USACE_CESPN_COYL_2012_a_0017: Middle Reach left bank: Rodent burrows and abatement measures – *Burrows and evidence of active abatement program observed*.

USACE_CESPN_COYL_2012_a_0021: Lower Reach left bank: Breach along levee alignment - *Levee breach observed but does not appear to have widened or deepened since 2012 inspection*.

USACE_CESPN_COYL_2012_a_0022: Lower Reach left bank: floodwall segment along Dipsea Café – *Floodwall observed in good condition*.

USACE_CESPN_COYL_2012_a_0028: Upper Reach left bank: Displaced wall panel on the channel wing wall – *Observed wall displacement was equal to 2012 USACE recorded displacement (4 inches)*.

USACE_CESPN_COYR_2012_a_0002: Lower Reach right bank: Unmaintained levee – *Settlement of the levee is apparent as no visible levee features were observed during GEI reconnaissance*.

USACE_CESPN_COYR_2012_a_0020: Nyhan Creek left bank: Rip rap slope protection along the foundation of power line tower - *Rip rap observed to be in good condition*.

USACE_CESPN_COYR_2012_a_0022: Nyhan Creek left bank: Rodent burrows and abatement measures – *Burrows and evidence of active abatement program observed*.

USACE_CESPN_COYR_2012_a_0028: Upper Reach left bank: Displaced wall panel on the channel wing wall – *Observed wall displacement was equal to 2012 USACE recorded displacement (4 inches)*. (Duplicate of left bank ID point USACE_CESPN_COYL_2012_a_0028).

USACE_CESPN_COYR_2012_a_0039: Middle Reach right bank: Settlement at the Flamingo Road Bridge - *Observed settlement was equal to 2012 USACE recorded settlement (3 inches)*.

Based on site reconnaissance observations, it appears that in general, site conditions are consistent with those observed during the 2012 USACE PI. Floodwall structures and areas of rip rap slope protection appear to be in good condition and it appears that the District continues to implement an effective rodent abatement program. The District has also added minor amounts of fill to raise local low spots along the left

and right levees near the Flamingo Rd. Bridge. Observed settlement conditions at Flamingo Rd. Bridge (Middle Reach), displacement of the left channel wing wall panel (Lower Reach), and the dimensions of the identified levee breach (Lower Reach) do not appear to have worsened since the 2012 USACE inspection. Local settlement within the unmaintained Lower Reach has resulted in almost complete loss of levee features in this area.

### 3.4 Geotechnical Exploration Access Opportunities, Constraints, and Utility Conflicts

The ability to perform subsurface geotechnical investigations at locations on the levee crest and toe within the study area is controlled by the overall access of exploration equipment including drilling and CPT rigs. In general, access along existing levee and floodwall alignments will be limited to track mounted or hand-portable equipment due to narrow levee crest widths and limited access routes from the levee crest to landside areas. Truck rig access may be possible along the sides of the channel within the Upper Reach. The presence of overhead and underground utilities in certain areas of the Project site may prevent exploration in these areas.

Preliminary observations of site access opportunities, constraints, and potential utility conflicts were recorded during site reconnaissance and summarized below. It should be noted that exploration access within the Project site will ultimately be dictated by input from exploration subcontractors, site conditions at the time of exploration, and confirmed utility locations.

Upper Reach: Access within the upper reach will likely be limited to areas along the left bank above the channel (U.S. Highway 1 roadway shoulder) and along the right bank along public roadways adjacent to the channel (Maple St., Ash St., Spruce St., Pine St., Poplar St., Laurel Way, and Ross Dr). Access may be possible by truck-mounted equipment; however, access by smaller, track-mounted equipment may be more practical from an encroachment standpoint given the narrow street widths.

Middle Reach: Access to the left bank levee crest is provided adjacent to the Flamingo Rd. Bridge and from an access driveway adjacent to the Shoreline Pump Station. Accessible landside areas along the left bank include the area upstream of Flamingo Rd. near Station 49+50, downstream of Flamingo Rd at Station 43+50, and upstream of U.S. Highway 1 between Station 30+00 and 33+00. Access is likely limited to track mounted exploration equipment due to narrow levee crest widths, however, truck access may be possible along the levee crest and landside areas between Station 30+00 and 33+00. An underground utility exists within the left bank levee prism between approximate Station 48+00 and 44+50, and along the landside levee toe between approximate Station 43+25 and 44+50. Any explorations in these areas will need to safely avoid the utility.

Access to the right bank is provided at three locations including adjacent to the Flamingo Rd. Bridge, the intersection of U.S. Highway 1 and Tennessee Valley Rd. along the pedestrian pathway, and at the pedestrian path parking lot at Station 35+00. It is observed that the right bank is likely considered high ground and explorations may not be required in this area of the Project site.

Nyhan Creek: Access to the left bank levee crest is provided at the Flamingo Rd. Bridge along the Coyote Creek right bank. Access to the levee from Marin Ave. is blocked by the power line tower structure and foundation within the levee alignment. Overhead power lines parallel the left bank levee alignment and boring explorations are likely not possible because a drilling mast cannot be safely extended beneath the power lines. CPT or hand-portable explorations may be possible depending on rig mast height, but may be limited to the area with a wider levee crest near the confluence with Coyote Creek. Upstream of the confluence, the levee crest narrows to approximately 5 feet. Access to the left bank levee segment upstream of the power line tower structure is provided along Marin Ave at the Crest Marin Pump Station. Upstream of Marin Ave., access along the left channel bank is limited to the area within the Tamalpias Valley Community Center parking lot.

Access to the right bank is provided along Tennessee Valley Rd. and within the existing staging parcel adjacent to the channel at the confluence with Coyote Creek. It is observed that the right bank is likely considered high ground and explorations may not be required in this area of the Project site.

Lower Reach: Access along the left bank is provided from U.S. Highway 1 through the driveways and parking lots of the parcels adjacent to the Coyote Creek Channel. Access by truck-mounted equipment is possible within the parking lot area adjacent to the floodwall segment (Dipsea Café) however; access by smaller, track-mounted equipment may be more practical from an encroachment standpoint given the space limitations within the parking lot. Because of the anticipated soft ground conditions and narrow access routes downstream of the floodwall segment, access is limited to track mounted equipment. Access downstream of the levee breach at Station 18+00 would require temporary bridging over the breach feature.

Access to the right bank is not possible between Station 18+00 and 27+50 due to the boardwalk structure. Access downstream of Station 18+00 is provided from the driveway and parking lot of the Holiday Inn, along the portion of the public access pathway adjacent to this property. The area directly downstream of U.S. Highway 1 at Station 28+00 is also accessible. Access is likely limited to track-mounted equipment due to the narrow access routes along the right bank.

Bothin Marsh High Ground: Access along the Bothin Marsh high ground alignment is limited to the unpaved roadway at the intersection of U.S. Highway 1 and Almonte Blvd. It is uncertain whether this road is held privately. An undeveloped gated lot at the end of this roadway may also provide additional access opportunities if access can be provided.

## 4.0 Summary and Conclusions

This TM summarizes our review of available documentation and presents findings from our recent geotechnical reconnaissance of the Coyote Creek levee system. Several of the documents provided for review included information and data from previous geotechnical evaluations within the Project area. Exploration logs and geotechnical lab testing data provided in these documents will be utilized in planning of the subsurface exploration program, development of subsurface profiles and material properties, and identification of characteristic levee reach extents. Site reconnaissance of the Coyote Creek levee system provided an opportunity to observe existing site conditions for general familiarity and to compare to conditions observed during the 2012 USACE PI. Observation and field measurement of typical and critical cross section locations and extents was also performed along with preliminary identification of site access opportunities and constraints. Observations from site reconnaissance will be utilized in planning of the subsurface exploration program, geotechnical evaluations, and assessment of remedial alternatives.

## Figures:

Figures 1-6 – Site Reconnaissance and Historic Exploration Summary

## Tables:

Table 1 – Document Review summary

Table 2 – Summary of Previous Geotechnical Explorations

Table 3 – Summary of GEI Site Reconnaissance Observations

Table 4 – Summary of 2012 USACE Inspection IDs

## Appendices:

Appendix A – Previous Geotechnical Exploration Logs

Appendix B – Site Reconnaissance Photographs

# Figures


200 100 0 200

Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE RECONNAISSANCE AND HISTORIC EXPLORATION SUMMARY UPPER REACH

JULY 2014

FIGURE 1

10-Jun-2014 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_ddp_v4.mxd SET


200 100 0 200

Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE RECONNAISSANCE AND HISTORIC EXPLORATION SUMMARY UPPER REACH

JULY 2014

FIGURE 2

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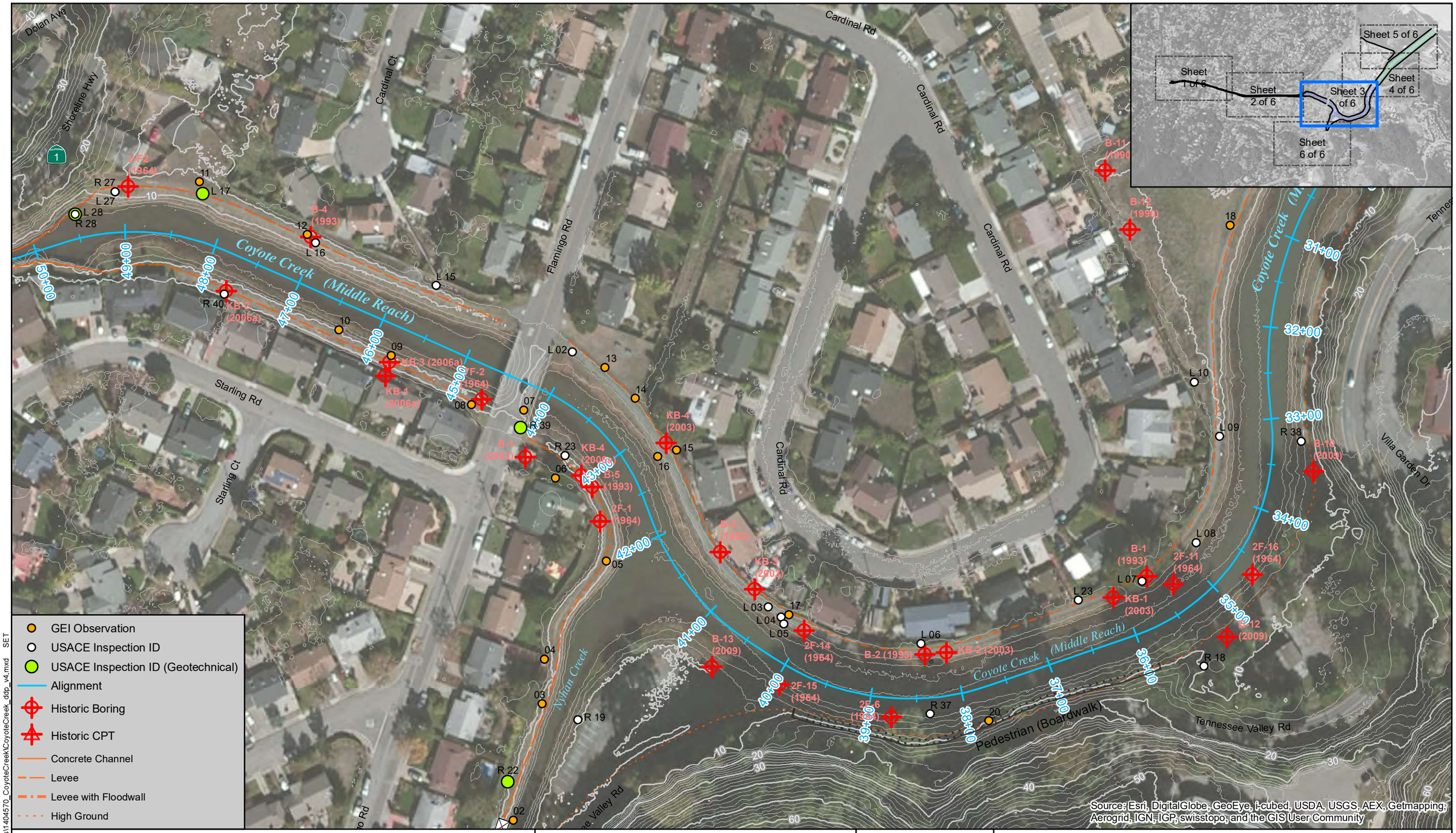


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Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE RECONNAISSANCE AND HISTORIC EXPLORATION SUMMARY MIDDLE REACH AND NYHAN CREEK

JULY 2014

FIGURE 3


GEI Observation
USACE Inspection ID
USACE Inspection ID (Geotechnical)
Alignment
Historic Boring
Historic CPT
Concrete Channel
Levee
Levee with Floodwall
High Ground

200 100 0 200
Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE RECONNAISSANCE AND HISTORIC EXPLORATION SUMMARY LOWER REACH

JULY 2014

FIGURE 4

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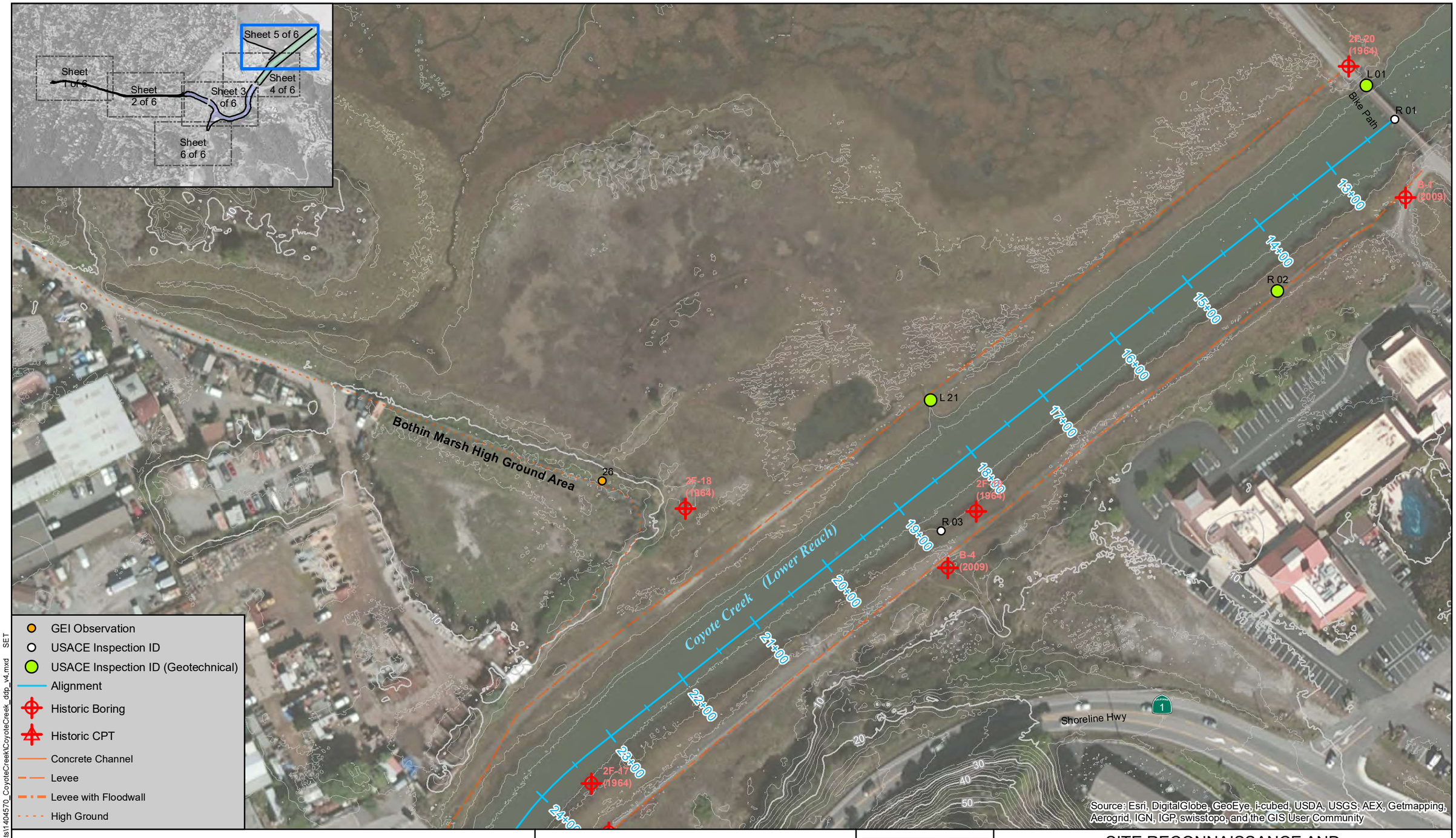



200 100 0 200

Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

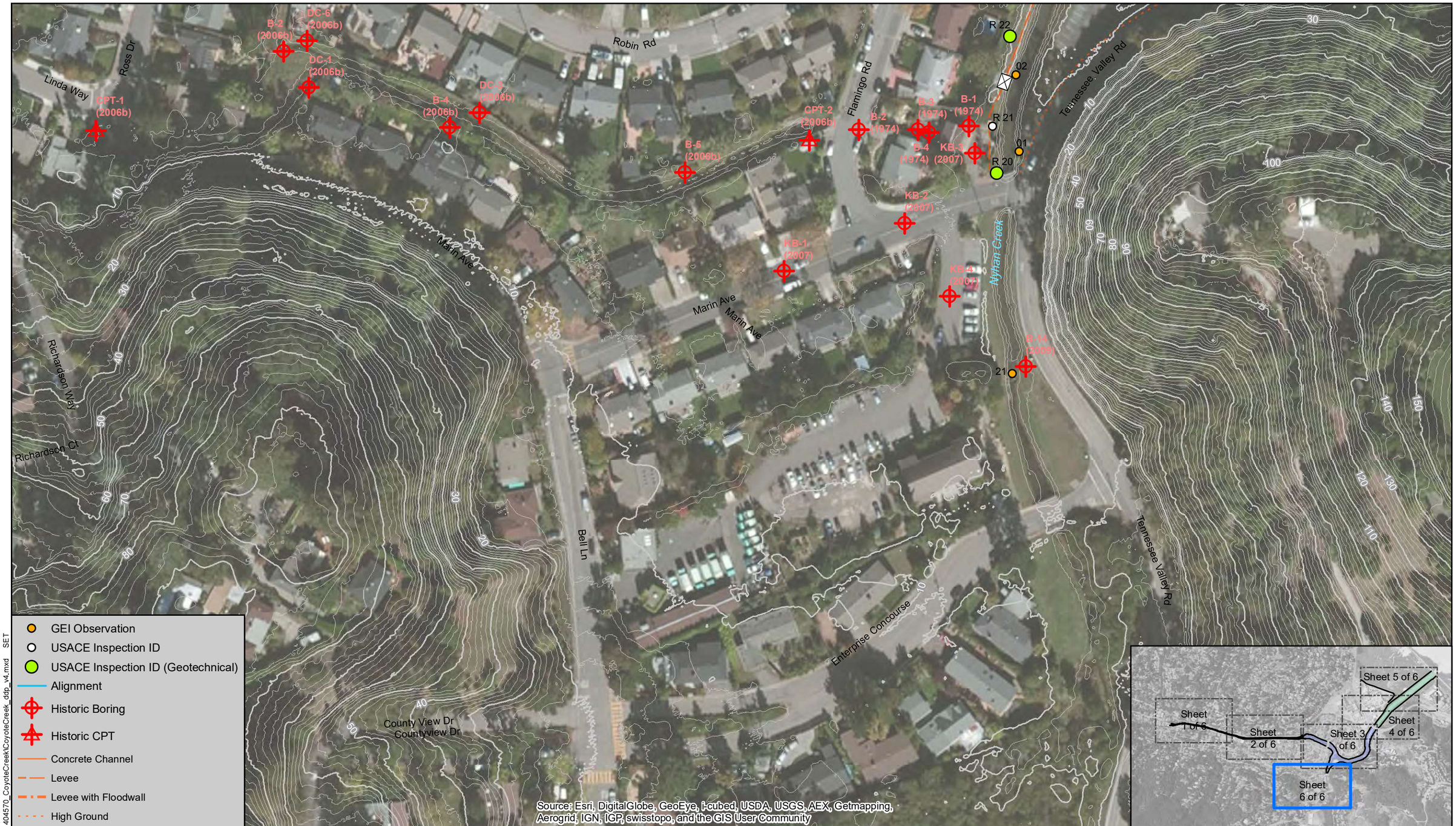
GEI Consultants

# SITE RECONNAISSANCE AND HISTORIC EXPLORATION SUMMARY LOWER REACH

JULY 2014

FIGURE 5

10-Jun-2014 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_ddp_v4.mxd SET




10-Jun-2014 Z:\Projects\11404570_CoyoteCreek\CoyoteCreek_ddp_v4.mxd SET

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Feet

N W E S

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

# SITE RECONNAISSANCE AND HISTORIC EXPLORATION SUMMARY NYHAN CREEK

JULY 2014

FIGURE 6

# Tables

**Table 1 - Document Review Summary**

| No. | File Name | File Type | Document Name | Author | Year | Type | Subject | Description | Other Comments | Pages/ Sheets | Geotechnical Data | GEI Folder |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | cardinal-ps-and-intertie(1982) | TIFF Image | Tamalpias Valley Storm Drainage Improvements Cardinal Road Storm Drain Intertie and Pump Station | County of Marin DPW | 1982 | Drawings | Structural | Drawings of Cardinal Road Pump Station | Includes levee and pipe section details at pump station outlet to Coyote Creek | 12 | | Requested Docs |
| 2 | cardinal-ps-electrical(1981) | TIFF Image | Cardinal Road Storm Water Pump Station Bid Package for Pumps, Electrical Drivers, Controls, and Generator | County of Marin DPW | 1981 | Drawings | Electrical | Drawings of Cardinal Road Pump Station | | 3 | | Requested Docs |
| 3 | coyote-creek-levee(1977) | TIFF Image | Spruce Street Diversion and Coyote Creek Levee Construction Tamalpias Valley Storm Drainage Improvements | County of Marin DPW | 1977 | Drawings | Structural, Geotechnical | As-built drawings of Coyote Creek Levee, floodwalls, and diversion | Includes original typical levee and floodwall sections | 5 | | Requested Docs |
| 4 | crest-marin-ps(1984) | TIFF Image | Crest Marin Pump Station | County of Marin DPW | 1978 | Drawings | Structural | As-built drawings of Crest Marin Pump Station | Includes pumpstation and outlet sections at creek | 16 | | Requested Docs |
| 5 | flamingo-rd-bridge(1964) | TIFF Image | Flamingo Road Bridge Across Coyote Creek | County of Marin DPW | 1964 | Drawings | Structural | Drawings of Flamingo Road bridge across Coyote Creek | Includes bridge pile tip elevations and channel section at bridge | 7 | | Requested Docs |
| 6 | shoreline-ps-1(1984) | TIFF Image | Shoreline Pump Station and Drainage Improvements | County of Marin DPW | 1984 | Drawings | Structural | As-built drawings of Shoreline Pump Station | Includes levee and pipe section details at pump station outlet to Coyote Creek | 18 | | Requested Docs |
| 7 | shoreline-ps-2(1984) | TIFF Image | Shoreline Pump Station Property Acquisition | County of Marin DPW | 1984 | Drawings | Survey/ROW | Parcel map of Shoreline Pump Station site and surroundings | | 1 | | Requested Docs |
| 8 | USACE PowerPoint | PowerPoint | Lower Coyote Creek Flood Management & Marsh Enhancement Project | PWA | 2006 | Presentation | H&H, Restoration | Ecology, hydraulics, and restoration opportunities along Coyote Creek and Bothin Marsh | Includes site photographs and potential restoration alternatives | 42 | | Requested Docs |
| 9 | CCrk_USACE_Inspection-Rpt_LB_2012 | PDF | Continuing Eligibility (Routine) Inspection Report for Coyote Creek, Left Bank - 2012 | USACE | 2012 | Inspection Report | USACE Periodic Inspection | USACE Periodic Inspection Report - Coyote Creek Left Bank | Includes overall system rating and identified deficiencies | 56 | | Requested Docs |
| 10 | CCrk_USACE_Inspection-Rpt_RB_2012 | PDF | Continuing Eligibility (Routine) Inspection Report for Coyote Creek, Right Bank - 2012 | USACE | 2012 | Inspection Report | USACE Periodic Inspection | Periodic Inspection Report - Coyote Creek Right Bank | Includes overall system rating and identified deficiencies | 50 | | Requested Docs |
| 11 | CCrk_USACE_Inspection-Rpt-LB_2010 | PDF | Continuing Eligibility (Routine) Inspection Report for Coyote Creek, Left Bank - 2010 | USACE | 2010 | Inspection Report | USACE Periodic Inspection | USACE Periodic Inspection Report - Coyote Creek Left Bank | Includes overall system rating and identified deficiencies | 294 | | Requested Docs |
| 12 | CCrk_USACE_Inspection-Rpt-RB_2010 | PDF | Continuing Eligibility (Routine) Inspection Report for Coyote Creek, Right Bank - 2010 | USACE | 2010 | Inspection Report | USACE Periodic Inspection | Periodic Inspection Report - Coyote Creek Right Bank | Includes overall system rating and identified deficiencies | 256 | | Requested Docs |
| 13 | Coyote Creek O & M Manual_DRAFT_071712 | PDF | Draft Coyote Creek Operations & Maintenance Manual | MCFCWCD | 2012 | Manual | O&M | Draft O&M Manual for Coyote Creek System | Includes description of facilities associated with Coyote Creek Flood Protection System (channels, levees, pump stations, interior drainage) | 35 | | Requested Docs |
| 14 | Coyote Creek_Meridian_ Survey Dwgs_3-15-13 | PDF | Topographic Survey of Portion of Coyote Creek | Meridian Surveying Engineering, Inc. | 2013 | Drawings | Topography | Topographic surface of Coyote Creek Levee Evaluation study area | Associated AutoCAD files provided in zip file | 6 | | Requested Docs |
| 15 | 4_Project Description_4-3-13 | PDF | Memorandum 4 Re: Project Description - Coyote Creek Sediment Stabilization Project | Noble Consultants, Inc. | 2013 | Memorandum | Dredging | Project description for proposed dredging of Coyote Creek | Includes plan drawings of proposed dredging extents | 10 | | Additional Docs |
| 16 | 6_Hydraulic Study with FEMA flow | PDF | Memorandum 6 Re: Hydraulic Analysis for the 20-Year FEMA flow event | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of hydraulic analysis | Includes input parameters | 6 | | Additional Docs |
| 17 | 7_Coyote Creek_Sedimentation Analysis_6-4-13 | PDF | Memorandum 7 Re: Sedimentation Analysis | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of evaluation of sedimentation in Coyote Creek | Includes estimates of available freeboard | 10 | | Additional Docs |

**Table 1 - Document Review Summary**

| No. | File Name | File Type | Document Name | Author | Year | Type | Subject | Description | Other Comments | Pages/ Sheets | Geotechnical Data | GEI Folder |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 8_Coyote Creek_Hydraulic Impact of Boardwalk Memo_7-18-13 | PDF | Memorandum 8 Re: HEC-RAS Analysis without Boardwalk or Pedestrian Bridge | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of evaluation of hydraulic impact of new boardwalk and pedestrian bridge along Coyote Creek | | 5 | | Additional Docs |
| 19 | 9_Coyote Creek_Supplemental Topography | PDF | Memorandum 9 Re: Supplemental Topography & Levee Height | Noble Consultants, Inc. | 2013 | Memorandum | Topography | Survey data in 5 areas to supplement 2013 base survey | | 14 | | Additional Docs |
| 20 | 11_Coyote Creek_Extra Task 10-2 culvert input data | PDF | Memorandum 11 Re: Extra Task 10-2: HEC-RAS Bridge Input Data | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of data compilation for bridges along concrete channel | Includes input parameters | 5 | | Additional Docs |
| 21 | 12_Coyote Creek_Extra Task 10-4 gage rating curve Rev 09-17-2013 | PDF | Memorandum 12 Re: Extra Task 10-4: HEC-RAS Analysis to Develop Rating Curve at Stream Gage | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of development of rating curve | Includes comparison between UASCE (1959) and FEMA (2009) rating curves | 5 | | Additional Docs |
| 22 | 13_Coyote Creek_Extra Task 10-5 Flow Impact of Boardwalk Memo_9-23-13 | PDF | Memorandum 13 Re: Impact of the Newly Built boardwalk and Hwy-1 Pedestrian Bridge on Flow Capacity of Coyote Creek Earthen Channel | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of hydraulic analysis of flow condition changes within earthen channel segment | | 5 | | Additional Docs |
| 23 | 1952_Cotton_ReportFloodControlCityMillValleyandAdjoiningAreas | PDF | Report on Flood Control for City of Mill Valley and Adjoining Areas Marin County, California | John S. Cotton | 1952 | Report | H&H | Historic evaluation of flood control opportunities for Mill Valley area | Includes preliminary recommendations | 63 | | Additional Docs |
| 24 | 1976_CooperClark_GeotechInvestigationProposedLaurelWaySiltBasin | PDF | Geotechnical Investigation Proposed Laurel Way Silt Basin Tamalpias Valley Marin County, California | Cooper Clark & Associates | 1976 | Report | Geotechnical | Summary of geotechnical investigation for proposed silt basin | Project area is at south end of Laurel Way in hillslope area (outside project limits) | 14 | 5 boring logs (6-20'); 2 seismic velocity lines | Additional Docs |
| 25 | 1983_ACOE_ReportSFFloods_Jan4-61982 | PDF | Report on the Floods of 4-6 January 1982 in the San Francisco and Monterey Bay Areas | USACE | 1983 | Report | H&H | Summary of flooding extents and damages from 1982 storm | | 102 | | Additional Docs |
| 26 | 1998_Bennett_LandHistory_TennesseeValley | PDF | The Landscape history of Tennessee Valley: The uses of historical perspectives in ecological planning | Andrea R. Bennett (UC Berkeley) | 1998 | Masters Thesis | Ecology | Environmental, cultural, and ecological history of Tennessee Valley area | Map in Figures shows Bay mud extents, though it is uncertain the location in relation to project | 115 | | Additional Docs |
| 27 | 2003_RHAA_TamValley_Trail_Alternatives | PDF | Tennessee Valley Multi-Use Pathway Alternative Analysis | Royston Hanamoto Alley & Abey | 2003 | Report | Recreation | Summary of alternatives analysis for pathway | Includes photographs of pre-boardwalk conditions | 35 | | Additional Docs |
| 28 | 2005_PWA_ReassessmentCoyoteCk_ChannelManagementRequirements | PDF | Reassessment of Coyote Creek Channel Management Requirements | PWA | 2005 | Report | H&H | Summary of management alternatives for Coyote Creek | Includes summary of project design history, and details of hydraulic modeling | 85 | | Additional Docs |
| 29 | 2006_CrestMarin-FS_DRAFT | PDF | Technical Memorandum No. 1 Draft Crest Marin Creek Flood Study / Marin County | Winzler & Kelly | 2006 | Memorandum | H&H | Analysis of Crest Marin Creek drainage system including identified deficiencies and development of improvement alternatives | Outside Coyote Creek Project area | 90 | | Additional Docs |
| 30 | 2006_GDA_TAM_Valley_Pilot_Project | PDF | TAM Valley Pilot Project | GeoData Analytics LLC | 2006 | Report | GIS | Summary of development GIS database | | 14 | | Additional Docs |
| 31 | 2007_PWA_Bothin Marsh_Summary | PDF | Coyote Creek Flood Management and Marsh Enhancement Project | PWA | 2007 | Report | Restoration | Summary of proposed Coyote Creek flood management and marsh restoration project | Includes proposed alternatives for Bothin Marsh restoration | 15 | | Additional Docs |
| 32 | 2008_EDS_ACMDP_CoyoteCk_Novatock_DischargeSampling | PDF | Arroyo Corte Madera, Corte Madera Creek, Coyote Creek and Novato Creek - Discharge Sampling, Water Years 2006, 2007, and 2008 Field Methods and Procedures | Environmental Data Solutions | 2008 | Report | H&H | Overview of methodologies for creek discharge monitoring program | | 44 | | Additional Docs |

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| No. | File Name | File Type | Document Name | Author | Year | Type | Subject | Description | Other Comments | Pages/ Sheets | Geotechnical Data | GEI Folder |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 2008_WRA_CoyoteCreek_Wet_Delin_Draft | PDF | DRAFT Delineation of Potential Jurisdictional Wetlands and "Other Waters" Under Section 404 of the Clean Water Act, Coyote Creek Flood Control Project, Marin County, California | PWA | 2008 | Report | Ecology | Preliminary delineation of Section 404 Wetlands and Waters | Includes tidal datum elevations at Sausalito COE dock | 47 | | Additional Docs |
| 34 | CC-Lower-Improvements_1967 | PDF | Coyote Creek Channel Improvements | USACE | 1967 | Drawings | Geotechnical | Channel plan and sections downstream of Hwy 1 Bridge | | 3 | | Additional Docs |
| 35 | CC-Topo-Control-Net_1957 | PDF | Coyote Creek Topography NWPRR Bridge to Maple Street | USACE | 1957 | Drawings | Topography | Topography from NWPRR Bridge to Maple Street | | 8 | | Additional Docs |
| 36 | FCZ3_CC-Levee-Seepage_Rpt_2005May | PDF | Geotechnical Consultation Coyote Creek Levee Mill Valley, CA | Kleinfelder | 2005 | Letter | Geotechnical | Summary of construction observation of seepage barrier along Coyote Creek Levee | No details of as-built extents. | 2 | | Additional Docs |
| 37 | FCZ3_Plans_CC-Levee | PDF | N/A | N/A | N/A | Drawings | Geotechnical | Channel plan and sections downstream of Hwy 1 Bridge | | 3 | | Additional Docs |
| 38 | FCZ3_Plans_CC-Levee_a1 | PDF | N/A | N/A | N/A | Drawings | Geotechnical | Channel plan and sections downstream of Hwy 1 Bridge | | 1 | | Additional Docs |
| 39 | TM_No-3_RBTFS-Report_Revised_010209(DRAFT) | PDF | Technical Memorandum No. 3 (Revised) Richardson Bay Tidal Flood Study - Final Alternatives Analysis | Winzler & Kelly | 2009 | Memorandum | H&H | Summary of improvement alternatives for tidal flooding at several sites | Manzanita West site is nearby Coyote Creek Project location | 70 | | Additional Docs |
| 40 | TM1 Crest Marin Creek Flood Study 102706 | PDF | Technical Memorandum No. 1 Draft Crest Marin Creek Flood Study / Marin County | Winzler & Kelly | 2006 | Memorandum | H&H | Analysis of Crest Marin Creek drainage system including identified deficiencies and development of improvement alternatives | Outside Coyote Creek Project area | 17 | | Additional Docs |
| 41 | TM2_CM-Crk-Alter-FINAL-w-attach-03-26-07 | PDF | Technical Memorandum No. 2 Alternative Analysis - Crest Marin Creek Flood Improvement Project | Winzler & Kelly | 2007 | Memorandum | H&H | Alternatives analysis for Crest Marin Creek improvement alternatives | Outside Coyote Creek Project area | 28 | | Additional Docs |
| 42 | TM3 Crest Marin Creek Final Alternatives070307 with Append | PDF | Technical Memorandum No. 3 Crest Marin Creek Flood Improvement Project - Final Alternative Analysis | Winzler & Kelly | 2007 | Memorandum | H&H | Evaluation of final improvement alternatives for Crest Marin Creek | Outside Coyote Creek Project area | 45 | | Additional Docs |
| 43 | CoyoteCrk-Sed-Rmvl_Plans_2003 (11x17sm) | PDF | Plans for Maintenance Dredging of the Middle Reach of Coyote Creek Mill Valley CA | Marin County FCD | 2003 | Drawings | Geotechnical/Dredging | Plans for maintenance dredging and seepage barrier installation within Coyote Creek Middle Reach | Shows location of Middle Reach right bank seepage barrier | 10 | | Additional Docs |
| 44 | Rating Curve at Gauge | MS Excel | N/A | N/A | N/A | Data | H&H | Data for gage rating curve | | 1 | | Additional Docs |
| 45 | sediment_reuse_memo | MS Word | Agency Guidance for Sediment Disposal/Reuse from Coyote Creek Flood Control Dredge Project | WRA | 2013 | Letter | Dredging | Summary of options for dredged sediment reuse from Coyote Creek | | 3 | | Additional Docs |
| 46 | coyote-creek-cross-sections(1970) | TIFF Image | N/A | County of Marin DPW | 1970 | Drawings | Geotechnical | Station 1+00 to 52+00 | | 8 | | Additional Docs |
| 47 | coyote-creek-dredging(1974) | TIFF Image | N/A | County of Marin DPW | 1974 | Drawings | Geotechnical | Dredging sections for Coyote Creek | | 6 | | Additional Docs |
| 48 | coyote-creek-dredging(1991) | TIFF Image | Coyote Creek Maintenance Dredging Plans Sections & Details | County of Marin DPW | 1991 | Drawings | Geotechnical | Dredging plans for Coyote Creek | | 6 | | Additional Docs |
| 49 | coyote-creek-easements(1974) | TIFF Image | Coyote Creek Easements | County of Marin DPW | 1974 | Drawings | Survey/ROW | Vicinity of Hwy 1 bridge and downstream | | 1 | | Additional Docs |
| 50 | coyote-creek-landscaping-1(1965) | TIFF Image | Coyote Creek Landscaping | County of Marin DPW | 1965 | Drawings | Planting | Planting details | | 1 | | Additional Docs |

**Table 1 - Document Review Summary**

| No. | File Name | File Type | Document Name | Author | Year | Type | Subject | Description | Other Comments | Pages/ Sheets | Geotechnical Data | GEI Folder |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | coyote-creek-landscaping-2(1965) | TIFF Image | Coyote Creek Landscaping | County of Marin DPW | 1966 | Drawings | Geotechnical/Planting | Planting details and levee/floodwall typical sections | Includes typical floodwall and levee section in lower reach | 2 | | Additional Docs |
| 52 | coyote-creek-survey(XXXX) | TIFF Image | Coyote Creek Flood Control Project | George Nolte | | Drawings | Survey/ROW | Property boundaries in project area | | 5 | | Additional Docs |
| 53 | coyote-creek-topo-1(1963) | TIFF Image | Coyote Creek Topography NWPRR Bridge to Maple Street | USACE | 1963 | Drawings | Topography | Topography from NWPRR Bridge to Maple Street | | 8 | | Additional Docs |
| 54 | coyote-creek-topo-2(1963) | TIFF Image | Coyote Creek Detailed Topography Vicinity of Maple St | USACE | 1963 | Drawings | Topography | Topography at upstream end of upper reach | | 1 | | Additional Docs |
| 55 | 1957_Flood Control Study Appendix | PDF | Appendix to Flood Control Study Marin County Flood Control Zone No. 3 | Clyde C. Kennedy | 1957 | Report | H&H | Summary of hydraulic and geotechnical data for flood control study for Richardson Bay | Geotech data outside Project area | 111 | boring logs and lab data in App G | Reference Docs |
| 56 | 1957_Flood Control Study Zone No3 | PDF | Flood Control Study Marin county Flood Control Zone No. 3 | Clyde C. Kennedy | 1957 | Report | H&H | Summary of flood control study | Study of flood barrier alternative sites across Richardson Bay | 58 | | Reference Docs |
| 57 | 1959_Detailed Project Report Coyote Ck | PDF | Detailed Project Report on Coyote Creek Marin County, CA | USACE | 1959 | Report | H&H | Project description for Coyote Creek Project | Includes description of original channel and levee segments | 33 | | Reference Docs |
| 58 | 1963_Coyote-Crk_ROW | PDF | Coyote Creek real Estates Rights of Way Requirements for Channel Improvement | USACE | 1963 | Drawings | Survey/ROW | Property boundaries in project area | | 7 | | Reference Docs |
| 59 | 1964_Channel Improvements Coyote Ck | PDF | Specifications Channel Improvements Coyote Creek Marin County, CA | USACE | 1964 | Report | Specifications | Construction specifications for project | | 136 | | Reference Docs |
| 60 | 1964_Engineering Study Richardson Bay | PDF | Engineering Study of Richardson Bay Marin County, CA | Lee and Prasker | 1964 | Report | Geotechnical | Summary of study for dredging project at Richardson Bay | Outside Coyote Creek Project area | 41 | | Reference Docs |
| 61 | 1964_USACE_Coyote-Crk_Planset | PDF | Coyote Creek Channel Improvements | USACE | 1964 | Drawings | Geotechnical | Original design drawings | Includes original USACE boring logs | 23 | 23 boring logs (up to 50') no lab data | Reference Docs |
| 62 | 1965_Coyote Ck Local Flood Project | PDF | Coyote Creek Local Flood Protection Project - O&M Manual | USACE | 1965 | Manual | O&M | Original project O&M manual | | 76 | | Reference Docs |
| 63 | 1967_Streams Flowing into Richardson Bay | PDF | Flood Control and Allied Purposes Streams Flowing into Richardson Bay Marin County, CA | USACE | 1967 | Report | H&H | Summary of flood control study for Richardson Bay area | | 162 | | Reference Docs |
| 64 | 1970_Coyote Ck Cross Sections | PDF | N/A | County of Marin DPW | 1970 | Drawings | Geotechnical | Station 1+00 to 52+00 | | 8 | | Reference Docs |
| 65 | 1973_Master Drainage Plan Tam Valley | PDF | Master Drainage Plan for the Tamalpias Valley Watershed | Murray-McCormick Environmental Group | 1973 | Report | H&H | Summary of Master Drainage Plan | Includes map of drainage facilities in Project area | 94 | | Reference Docs |
| 66 | 1973_Proposed Dredging Disposal Dredged Spoils Coyote Creek | PDF | Environmental Impact Report Proposed Dredging and Disposal of Dredged Spoils Coyote Creek, Marin County, CA | Yarnell & Ron | 1973 | Report | Environmental | EIR for Coyote Creek Dredging | | 21 | | Reference Docs |
| 67 | 1973_Proposed Master Drainage Plan for the Tam Valley | PDF | Environmental Impact Report Proposed Master Drainage Plan for the Tamalpias Valley Watershed | Allied Science and Resource Planning, Inc. | 1973 | Report | Environmental | EIR for Master Drainage Plan Tamalpias Valley Watershed | Includes proposed spoils disposal site | 73 | | Reference Docs |
| 68 | 1990_Hyraulic Study Coyote Canal Tam Junction West | PDF | Hydraulic Study of Coyote Canal | Majors Engineering, Inc. | 1990 | Report | H&H | Study of flooding characteristics for Tam Junction site | Study includes Project area | 66 | | Reference Docs |
| 69 | 1991_Coyote Ck Dredge Plans | PDF | Coyote Creek Maintenance Dredging Plans Sections & Details | County of Marin DPW | 1991 | Drawings | Geotechnical | Dredging plans for Coyote Creek | | 6 | | Reference Docs |

**Table 1 - Document Review Summary**

| No. | File Name | File Type | Document Name | Author | Year | Type | Subject | Description | Other Comments | Pages/ Sheets | Geotechnical Data | GEI Folder |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 1993_Geotechnical Investigation Coyote Ck Levee | PDF | Geotechnical Investigation Coyote Creek Levee Improvements Marin County, CA | ALB Associates | 1993 | Report | Geotechnical | Geotechnical investigation for levee improvements | Borings in Middle and Upper Reaches | 20 | 5 borings (36-66'), lab testing, settlement and stability analysis | Reference Docs |
| 71 | 1995_Mill Valley Watershed Project | PDF | Monthly Report - July 1995 | Jessica Fiorillo | 1995 | Report | Recreation, Ecology | Mill Valley Watershed Project Monthly Report | | 95 | | Reference Docs |
| 72 | 1997_Mill Valley Watershed Volunteer Stream Survey Manual | PDF | Mill Valley Watershed Volunteer Stream Survey Manual | Mill Valley Watershed Project | 1997 | Report | Recreation, Ecology | Stream survey manual | | 26 | | Reference Docs |
| 73 | 2003_Coyote Creek-Sediment Sampling Analysis | PDF | Dredge Sediment Characterization Coyote Creek Dredging Project Mill Valley, CA | Kleinfelder | 2003 | Letter | Dredging | Results of sampling and analysis of stockpiled dredge spoils from Coyote and Tennessee Valley Creeks | | 11 | | Reference Docs |
| 74 | 2003_Delineation Waters Coyote Ck | PDF | Delineation of Waters of the United States at Coyote Creek, Marin county, CA | ESA | 2003 | Report | Environmental | Summary of extents of documented waters of the United States including jurisdictional wetlands and water associated habitats | | 34 | | Reference Docs |
| 75 | 2003_Geotechnical Levee Leakage Coyote Ck | PDF | Geotechnical Report, Levee Leakage, Coyote Creek, Marin County, CA | Kleinfelder | 2003 | Report | Geotechnical | Summary of geotechnical investigation of levee leakage at Coyote Creek along Cardinal Road | Upper 3-4 feet of levee material found to be pervious. Seepage barrier recommended | 10 | 4 borings (8-10') and lab data (sieve) | Reference Docs |
| 76 | 2004_Bothin Marsh Enhancement Plan | PDF | Bothin Marsh Enhancement Plan | WRA | 2004 | Report | Ecology | Recommendations for enhancement options at Bothin Marsh | | 81 | | Reference Docs |
| 77 | 2004_Drainage Improvement Crest Marin Ck | PDF | Drainage Improvement Investigation, Crest Marin Creek | LTD Engineering, Inc. | 2004 | Report | H&H | Summary of hydraulic improvement alternatives for drainage at Crest Marin Creek | Outside Coyote Creek Project area | 85 | | Reference Docs |
| 78 | 2005_Laurel Way Bypass Hydrologic and Hydraulic | PDF | Memorandum Re: Laurel Way Bypass Hydrologic and Hydraulic Analyses | PWA | 2005 | Memorandum | H&H | Summary of H&H analyses for improvements along Crest Marin Creek | Outside Coyote Creek Project area | 19 | | Reference Docs |
| 79 | 2006_Crest Marin Ck Flood Improvement | PDF | Technical Memorandum No. 1 Draft Crest Marin Creek Flood Study / Marin County | Winzler & Kelly | 2006 | Memorandum | H&H | Analysis of Crest Marin Creek drainage system including identified deficiencies and development of improvement alternatives | Outside Coyote Creek Project area | 17 | | Reference Docs |
| 80 | 2006_Geotechnical Investigation Crest Marin Ck Box Culvert | PDF | Geotechnical Investigation report, Crest Marin Creek Box Culvert, Mill Valley, CA | Kleinfelder | 2006 | Report | Geotechnical | Summary of geotechnical investigation for improvements at Crest Marin Creek | Outside Coyote Creek Project area | 51 | 2 CPT (30'), 4 hand augers, 3 DPT, lab data | Reference Docs |
| 81 | 2006_Geotechnical Levee Seepage High Groundwater | PDF | Geotechnical Report, Levee Seepage/High ground Water, Coyote Creek, Marin County, CA | Kleinfelder | 2006 | Letter | Geotechnical | Summary of geotechnical investigation of high groundwater conditions and potential for levee seepage at Coyote Creek along Starling Rd and Flamingo Rd | Abandoned storm drain likely contributing to problem | 23 | 4 borings (8-12'), lab data (sieve) | Reference Docs |
| 82 | 2007_Geotechnical Evaluation Marin Ave Drainage | PDF | Geotechnical Evaluation, Marin Avenue Drainage Improvement Project, Mill Valley, CA | Kleinfelder | 2007 | Letter | Geotechnical | Results of geotechnical evaluation of subsurface conditions for Marin Avenue Drainage Improvement Project | Adjacent to Nyhan Creek reach of Coyote Creek | 17 | 4 borings (12-18'), lab data (consol) | Reference Docs |
| 83 | 2008_Coyote Ck Levee Water Level | PDF | Review of Water Level Survey Data, Coyote Creek Levee, Mill Valley, CA | Kleinfelder | 2008 | Letter | Geotechnical | Review of groundwater level data and tidal data 7/3/07 - 7/30/07 | Results compared to 2006 assessment of levee seepage/high groundwater | 6 | Groundwater data from 2 wells | Reference Docs |
| 84 | 2009-01-22_Geotech_Rpt - TV pathway | PDF | Geotechnical Investigation Report, Tennessee Valley/Manzanita Connector Pathway, Marin County, CA | Nichols Consulting Engineers | 2009 | Report | Geotechnical | Results of geotechnical investigation for Tennessee Valley/Manzanita Connector Pathway (boardwalk). | Pathway along southern bank, Middle and Lower Reaches | 110 | 10 borings (10-73'), lab data | Reference Docs |

**Table 1 - Document Review Summary**

| No. | File Name | File Type | Document Name | Author | Year | Type | Subject | Description | Other Comments | Pages/ Sheets | Geotechnical Data | GEI Folder |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 85 | 2012_Lower Coyote Ck Feasibility | PDF | Lower Coyote Creek, Feasibility Study, Flood Management and Marsh Enhancement Project | ESA PWA | 2012 | Report | H&H, Restoration | Summary of proposed Coyote Creek flood management and marsh restoration project | | 164 | | Reference Docs |
| 86 | 2012_Middle Coyote Ck Mgmt Maintenance | PDF | Middle Reach of Coyote Creek: Sediment Management and Maintenance Plan | PWA | 2012 | Report | H&H | Summary of maintenance plan including levee improvements, channel monitoring, and maintenance recs | | 42 | | Reference Docs |
| 87 | 4_Project Description_4-3-13 | PDF | Memorandum 4 Re: Project Description - Coyote Creek Sediment Stabilization Project | Noble Consultants, Inc. | 2013 | Memorandum | Dredging | Project description for proposed dredging of Coyote Creek | Includes plan drawings of proposed dredging extents | 10 | | Reference Docs |
| 88 | 6_Hydraulic Study with FEMA flow | PDF | Memorandum 6 Re: Hydraulic Analysis for the 20-Year FEMA flow event | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of hydraulic analysis | Includes input parameters | 6 | | Reference Docs |
| 89 | 7_Coyote Creek_Sedimentation Analysis_6-4-13 | PDF | Memorandum 7 Re: Sedimentation Analysis | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of evaluation of sedimentation in Coyote Creek | Includes estimates of available freeboard | 10 | | Reference Docs |
| 90 | 8_Coyote Creek_Hydraulic Impact of Boardwalk Memo_7-18-13 | PDF | Memorandum 8 Re: HEC-RAS Analysis without Boardwalk or Pedestrian Bridge | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of evaluation of hydraulic impact of new boardwalk and pedestrian bridge along Coyote Creek | | 5 | | Reference Docs |
| 91 | 9_Coyote Creek_Supplemental Topography | PDF | Memorandum 9 Re: Supplemental Topography & Levee Height | Noble Consultants, Inc. | 2013 | Memorandum | Topography | Survey data in 5 areas to supplement 2013 base survey | | 14 | | Reference Docs |
| 92 | 11_Coyote Creek_Extra Task 10-2 culvert input data | PDF | Memorandum 11 Re: Extra Task 10-2: HEC-RAS Bridge Input Data | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of data compilation for bridges along concrete channel | Includes input parameters | 5 | | Reference Docs |
| 93 | 12_Coyote Creek_Extra Task 10-4 gage rating curve Rev 09-17-2013 | PDF | Memorandum 12 Re: Extra Task 10-4: HEC-RAS Analysis to Develop Rating Curve at Stream Gage | Noble Consultants, Inc. | 2013 | Memorandum | H&H | Summary of development of rating curve | Includes comparison between UASCE (1959) and FEMA (2009) rating curves | 5 | | Reference Docs |
| 94 | Kay_Park-Tam_Valley_2012(1) | MS Excel | Settlement Elevations for Kay Park/Tam Valley | Marin County FCD | 2012 | Data | Geotechnical | Settlement Data for Coyote Creek Levees | 10 SMs along levees - need map of locations | 1 | Settlement Data | Reference Docs |
| 95 | TCSD Flamingo Road Pump StationSoils_Feb2002_Miller_Pacific | PDF | Flamingo Road Pump Station | Miller Pacific | 2002 | Figures | Geotechnical | Site plan and boring log | | 4 | 1 boring | Reference Docs |
| 96 | 1974_YRCCE_SoilInvest_CMC PS | PDF | Soil and Foundation Investigation Crest Marin Pump Station, Marin County, CA | Yarnell and Ron | 1974 | Report | Geotechnical | Results of geotechnical investigation for Crest Marin Pump Station and storm drain pipeline | Crest Marin Pump Station along Nyhan Creek | 27 | 4 borings (5-66'), lab data | Additional Docs 060314 |
| 97 | 1976_CCA_GeoTechInvest_LWSB | PDF | Geotechnical Investigation Proposed Laurel Way Silt Basin Tamalpias Valley Marin County, California | Cooper Clark & Associates | 1976 | Report | Geotechnical | Summary of geotechnical investigation for proposed silt basin | Project area is at south end of Laurel Way in hillslope area (outside project limits) | 14 | 5 borings (6-20'); 2 seismic velocity lines | Additional Docs 060314 |
| 98 | 1990_ALB_Soilinvestigation_PlannedShoppingCtr_ShorelineandFlamingo_MillValley | PDF | Soil Investigation Planned Shopping Center Shoreline Highway and Flamingo Road Mill Valley, CA | ALB Associates | 1990 | Report | Geotechnical | Summary of geotechnical investigation for planned shopping center between Shoreline Highway, Flamingo Road, and Coyote Canal. | Project area is at downstream end of Middle Reach (Highway 1) | 32 | 13 borings (5-55'), lab data | Additional Docs 060314 |
| 99 | 1990_ALB_SoilInvestigation_graphic1 | PDF | Soil Investigation Planned Shopping Center Shoreline Highway and Flamingo Road Mill Valley, CA | ALB Associates | 1991 | Figure | Geotechnical | Project and boring location plan | Project area is at downstream end of Middle Reach (Highway 1) | 1 | | Additional Docs 060314 |
| 100 | 1990_ALB_SoilInvestigation_graphic2 | PDF | Soil Investigation Planned Shopping Center Shoreline Highway and Flamingo Road Mill Valley, CA | ALB Associates | 1992 | Figure | Geotechnical | Bay mud thickness contour map within project vicinity | Project area is at downstream end of Middle Reach (Highway 1) | 1 | | Additional Docs 060314 |

**Table 2 - Summary of Previous Geotechnical Explorations**

| Boring ID | Source | Total Depth (ft) | Drilling Method | Lab Testing | Exploration Location[1] |
|---|---|---|---|---|---|
| 2F-7 | USACE, 1964 | 12 | N/A | | **Alignment (Upper Reach)** |
| 2F-13 | USACE, 1964 | 10.5 | N/A | | **Alignment (Upper Reach)** |
| 7F-4 | USACE, 1964 | 20 | N/A | MD | **Alignment (Upper Reach)** |
| 2F-8 | USACE, 1964 | 3.5 | N/A | | **Alignment (Upper Reach)** |
| 2F-5 | USACE, 1964 | 10.5 | N/A | | **Alignment (Upper Reach)** |
| 7F-3 | USACE, 1964 | 13 | N/A | MD | **Alignment (Upper Reach)** |
| 2F-4 | USACE, 1964 | 10 | N/A | | **Alignment (Upper Reach)** |
| 2F-3 | USACE, 1964 | 10 | N/A | | **Alignment (Upper Reach)** |
| 2F-12 | USACE, 1964 | 1 | N/A | | **Alignment (Upper Reach)** |
| 2F-2 | USACE, 1964 | 12.5 | N/A | | **Alignment (Middle Reach)** |
| 7F-2 | USACE, 1964 | 50 | N/A | | **Alignment (Middle Reach)** |
| 2F-1 | USACE, 1964 | 17.5 | N/A | | **Alignment (Middle Reach)** |
| 2F-14 | USACE, 1964 | 18 | N/A | | **Alignment (Middle Reach)** |
| 2F-15 | USACE, 1964 | 7 | N/A | | **Alignment (Middle Reach)** |
| 2F-6 | USACE, 1964 | 9.5 | N/A | | **Alignment (Middle Reach)** |
| 2F-11 | USACE, 1964 | 16 | N/A | | **Alignment (Middle Reach)** |
| 2F-16 | USACE, 1964 | 5 | N/A | | **Alignment (Middle Reach)** |
| 7F-1 | USACE, 1964 | 28 | N/A | MD | **Alignment (Middle Reach)** |
| 2F-21 | USACE, 1964 | 40 | N/A | | **Alignment (Lower Reach)** |
| 2F-17 | USACE, 1964 | 20 | N/A | | **Alignment (Lower Reach)** |
| 2F-18 | USACE, 1964 | 20 | N/A | | **Alignment (Lower Reach)** |
| 2F-19 | USACE, 1964 | 40 | N/A | | **Alignment (Lower Reach)** |
| 2F-20 | USACE, 1964 | 40 | N/A | | **Alignment (Lower Reach)** |

1: Alignment - Located along or within 150 feet of Project levee/floodwall alignment
Landward - Located further than 150 feet landward of Project alignment

**Table 2 - Summary of Previous Geotechnical Explorations**

| Boring ID | Source | Total Depth (ft) | Drilling Method | Lab Testing | Exploration Location[1] |
|---|---|---|---|---|---|
| Boring 1 | YRCCE, 1974 | 61 | N/A | Consol (3), Atterberg | **Alignment (Nyhan Creek)** |
| Boring 2 | YRCCE, 1974 | 66.5 | N/A | MD, Consol, Atterberg | **Alignment (Nyhan Creek)** |
| Boring 3 | YRCCE, 1974 | 5 | Hand auger | MD, Consol, Atterberg | **Alignment (Nyhan Creek)** |
| Boring 4 | YRCCE, 1974 | 8.5 | Hand auger | MD, Consol | **Alignment (Nyhan Creek)** |
| Boring 1 | ALB, 1990 | 50 | Rotary-wash | MD, Consol (2), TX/UU (2), Atterberg | **Alignment (Middle Reach)** |
| Boring 2 | ALB, 1990 | 44 | Rotary-wash | Moisture | Landward (Middle Reach) |
| Boring 3 | ALB, 1990 | 8 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 4 | ALB, 1990 | 9 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 5 | ALB, 1990 | 10 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 6 | ALB, 1990 | 8 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 7 | ALB, 1990 | 55 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 8 | ALB, 1990 | 10 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 9 | ALB, 1990 | 41 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 10 | ALB, 1990 | 10 | Solid-flight auger | | Landward (Middle Reach) |
| Boring 11 | ALB, 1990 | 46 | Solid-flight auger | | **Alignment (Middle Reach)** |
| Boring 12 | ALB, 1990 | 7 | Solid-flight auger | | **Alignment (Middle Reach)** |
| Boring 13 | ALB, 1990 | 5 | Solid-flight auger | | LA (Middle Reach) |
| B-1 | ALB, 1993 | 36 | Hollow-stem auger | | **Alignment (Middle Reach)** |
| B-2 | ALB, 1993 | 37 | Hollow-stem auger | | **Alignment (Middle Reach)** |
| B-3 | ALB, 1993 | 45 | Hollow-stem auger | | **Alignment (Middle Reach)** |
| B-4 | ALB, 1993 | 41 | Hollow-stem auger | | **Alignment (Middle Reach)** |
| B-5 | ALB, 1993 | 67 | Hollow-stem auger | Consol (2) | **Alignment (Middle Reach)** |

1: Alignment - Located along or within 150 feet of Project levee/floodwall alignment
Landward - Located further than 150 feet landward of Project alignment

**Table 2 - Summary of Previous Geotechnical Explorations**

| Boring ID | Source | Total Depth (ft) | Drilling Method | Lab Testing | Exploration Location[1] |
|---|---|---|---|---|---|
| B-1 | MPEG, 2002 | 21.5 | N/A | MD | **Alignment (Middle Reach)** |
| KB-1 | Kleinfelder, 2003 | 8.5 | Solid-flight auger | #200 wash | **Alignment (Middle Reach)** |
| KB-2 | Kleinfelder, 2003 | 9.5 | Solid-flight auger | #200 wash | **Alignment (Middle Reach)** |
| KB-3 | Kleinfelder, 2003 | 8 | Solid-flight auger | #200 wash | **Alignment (Middle Reach)** |
| KB-4 | Kleinfelder, 2003 | 9 | Solid-flight auger | #200 wash | **Alignment (Middle Reach)** |
| KB-1 | Kleinfelder, 2006a | 8 | Solid-flight auger | Grain-size distribution | **Alignment (Middle Reach)** |
| KB-2 | Kleinfelder, 2006a | 10.5 | Solid-flight auger | Grain-size distribution | **Alignment (Middle Reach)** |
| KB-3 | Kleinfelder, 2006a | 11 | Solid-flight auger | Grain-size distribution | **Alignment (Middle Reach)** |
| KB-4 | Kleinfelder, 2006a | 12.5 | Solid-flight auger | Grain-size distribution | **Alignment (Middle Reach)** |
| DC-1 | Kleinfelder, 2006b | 23 | Dynamic cone | | Landward (Crest Marin Creek) |
| DC-2 | Kleinfelder, 2006b | 15 | Dynamic cone | | Landward (Crest Marin Creek) |
| DC-3 | Kleinfelder, 2006b | 13 | Dynamic cone | | Landward (Crest Marin Creek) |
| B-2 | Kleinfelder, 2006b | 16 | Hand auger | | Landward (Crest Marin Creek) |
| B-4 | Kleinfelder, 2006b | 4 | Hand auger | MD | Landward (Crest Marin Creek) |
| B-5 | Kleinfelder, 2006b | 4.5 | Hand auger | | Landward (Crest Marin Creek) |
| CPT-1 | Kleinfelder, 2006b | 30 | CPT | | Landward (Crest Marin Creek) |
| CPT-2 | Kleinfelder, 2006b | 60 | CPT | | Landward (Crest Marin Creek) |
| KB-1 | KF, 2007 | 12.5 | Solid-flight auger | MD, TX/UU | Landward (Nyhan Creek) |
| KB-2 | KF, 2007 | 17.5 | Solid-flight auger | MD | **Alignment (Nyhan Creek)** |
| KB-3 | KF, 2007 | 14.5 | Solid-flight auger | MD, TX/UU | **Alignment (Nyhan Creek)** |
| KB-4 | KF, 2007 | 11.5 | Solid-flight auger | MD, TX/UU | **Alignment (Nyhan Creek)** |

1: Alignment - Located along or within 150 feet of Project levee/floodwall alignment
Landward - Located further than 150 feet landward of Project alignment

**Table 2 - Summary of Previous Geotechnical Explorations**

| Boring ID | Source | Total Depth (ft) | Drilling Method | Lab Testing | Exploration Location[1] |
|---|---|---|---|---|---|
| B-1 | NCE, 2009 | 52.5 | Rotary-wash | MD, Consol, TX/UU | **Alignment (Lower Reach)** |
| B-4 | NCE, 2009 | 10 | Rotary-wash | MD, TX/UU | **Alignment (Lower Reach)** |
| B-6 | NCE, 2009 | 51.5 | Rotary-wash | MD, Consol | **Alignment (Lower Reach)** |
| B-7 | NCE, 2009 | 9.5 | Rotary-wash | | **Alignment (Lower Reach)** |
| B-8 | NCE, 2009 | 42.5 | Rotary-wash | MD, TX/UU | **Alignment (Middle Reach)** |
| B-9 | NCE, 2009 | 73.5 | Rotary-wash | MD, TX/UU | **Alignment (Middle Reach)** |
| B-10 | NCE, 2009 | 9 | Rotary-wash | MD | **Alignment (Middle Reach)** |
| B-12 | NCE, 2009 | 32 | Rotary-wash | MD, TX/UU | **Alignment (Middle Reach)** |
| B-13 | NCE, 2009 | 24.5 | Rotary-wash | MD, TX/UU | **Alignment (Middle Reach)** |
| B-14 | NCE, 2009 | 21.5 | Rotary-wash | MD, Consol | **Alignment (Nyhan Creek)** |

1: Alignment - Located along or within 150 feet of Project levee/floodwall alignment
Landward - Located further than 150 feet landward of Project alignment

**Table 3 - Summary of GEI Site Reconnaissance Observations**

| Location | Bank (Looking DS) | Station | Easting | Northing | Remarks | GEI Observation ID | Associated GEI Photos |
|---|---|---|---|---|---|---|---|
| Nyhan Creek | Both | | -122.526477 | 37.877116 | Vegetation near Crest Marin Pump Station. | GEI 01 | 3, 4 |
| Nyhan Creek | Left | | -122.526496 | 37.877345 | **GEI Cross Section 1**: Views of waterside and landside slopes and crest. Critical cross-section between Marin Avenue Culvert and the confluence with Coyote Creek. Landside Slope - 2H:1V, Landside Height - 3.5 feet above toe, Crest Width - 5 feet, Waterside Slope - 2H:1V from waterside hinge to 1 foot below hinge and 1H:1V from 1 foot below hinge to waterside toe. | GEI 02 | 5, 6, 7, 8 |
| Nyhan Creek | Left | | -122.526396 | 37.877695 | Large tree (~36-inch diameter) tree within 15 feet of the levee toe landside- non-compliant with USACE vegetation guidance. | GEI 03 | 12 |
| Nyhan Creek | Left | | -122.526391 | 37.877829 | Wooden ramp from fence to levee toe - possible encroachment. | GEI 04 | 13 |
| Nyhan Creek | Left | | -122.52616 | 37.878126 | **GEI Cross Section 2**: Views of waterside and landside slopes and crest. Typical cross-section between Marin Avenue Culvert and the confluence with Coyote Creek. Landside Slope - 1.8H:1V, Landside Height - 8 feet above toe, Crest Width - 9 feet, Waterside Slope - 1.7H:1V. | GEI 05 | 14, 15, 16 |
| Coyote Creek (Middle Reach) | Right | 43+25 | -122.526365 | 37.878372 | 4-inch drainage pipe along the landside levee toe. | GEI 06 | 17 |
| Coyote Creek (Middle Reach) | Both | 44+30 | -122.52649 | 37.878573 | Shoaling and vegetation in the channel looking upstream and downstream from Flamingo Road Bridge | GEI 07 | 21, 22 |
| Coyote Creek (Middle Reach) | Right | 44+65 | -122.526687 | 37.878585 | Vegetation on the waterside and landside slopes and crest of the levee looking upstream from Flamingo Road Bridge | GEI 08 | 23, 24 |
| Coyote Creek (Middle Reach) | Right | 45+75 | -122.526995 | 37.878728 | 5-inch diameter Christy Box housing a 1.25-inch PVC pipe installed in the levee crest. | GEI 09 | 25 |
| Coyote Creek (Middle Reach) | Right | 46+40 | -122.527194 | 37.878801 | **GEI Cross Section 3**: Views of waterside and landside slopes and crest. Typical cross-section between the end of the concrete channel and the confluence with Nyhan Creek. Landside Slope - 1.7H:1V, Landside Height - 6 feet, Crest Width - 8 feet, Waterside Slope - 1.8H:1V. | GEI 10 | 26, 27, 28 |

**Table 3 - Summary of GEI Site Reconnaissance Observations**

| Location | Bank (Looking DS) | Station | Easting | Northing | Remarks | GEI Observation ID | Associated GEI Photos |
|---|---|---|---|---|---|---|---|
| Coyote Creek (Middle Reach) | Left | 48+40 | -122.527732 | 37.87923 | **GEI Cross Section 4**: Views of waterside and landside slopes and crest. Erosion at waterside toe. Critical cross-section between the end of the concrete channel and Flamingo Road Bridge. Landside Slope - 5H:1V, Landside Height - 2 feet above toe, Crest Width - 10 feet, Waterside Slope - 2.6H:1V. | GEI 11 | 31, 32, 33, 34, 35 |
| Coyote Creek (Middle Reach) | Left | 47+00 | -122.527322 | 37.879084 | **GEI Cross Section 5:** Views of waterside and landside slopes and crest. Typical cross-section between the end of the concrete channel and Flamingo Road Bridge. Landside Slope - 2.4H:1V, Landside Height - 3.75 feet above toe, Crest Width - 9 feet, Waterside Slope - 2.1H:1V. | GEI 12 | 43, 44, 45 |
| Coyote Creek (Middle Reach) | Left | 43+75 | -122.526186 | 37.878706 | **GEI Cross Section 6**: Views of waterside and landside slopes and crest. Typical cross-section between Flamingo Road Bridge and Station 33+00. Landside Height - 2.5 feet above toe, Landside Floodwall Height - 2 feet, Landside Slope (below floodwall) - 5H:1V, Landside Wall Thickness - 8 inches, Crest Width - 10.75 feet, Waterside Height above channel - 2.5 feet, Waterside Wall Thickness - 6 inches, Waterside Slope - 5H:1V. | GEI 13 | 49, 50, 51 |
| Coyote Creek (Middle Reach) | Left | 43+25 | -122.526070 | 37.878615 | Plugged head wall and grated storm drain at the base of levee wall on landside. | GEI 14 | 52 |
| Coyote Creek (Middle Reach) | Left | 42+50 | -122.52591 | 37.878463 | Wooden ramp from fence to landside levee wall - possible encroachment. | GEI 15 | 53 |
| Coyote Creek (Middle Reach) | Left | 42+50 | -122.525979 | 37.878442 | Concrete spall and exposed rebar on the top of the waterside levee wall. | GEI 16 | 54 |
| Coyote Creek (Middle Reach) | Left | 40+10 | -122.525471 | 37.877978 | Cardinal Pump Station | GEI 17 | 56 |
| Coyote Creek (Middle Reach) | Left | 30+50 | -122.523837 | 37.879172 | **GEI Cross Section 7**: Views of waterside and landside slopes and crest. Typical cross-section between Station 33+00 and Station 29+00. Landside Slope - 5H:1V, Landside Height above toe - 1 foot, Crest Width - 6 feet, Waterside Slope - 2.8H:1V. | GEI 18 | 65, 66, 67 |

**Table 3 - Summary of GEI Site Reconnaissance Observations**

| Location | Bank (Looking DS) | Station | Easting | Northing | Remarks | GEI Observation ID | Associated GEI Photos |
|---|---|---|---|---|---|---|---|
| Coyote Creek (Middle Reach) | Right | 29+00 | -122.523178 | 37.879554 | 18-inch corrugated metal pipe located at the waterside levee toe. Clear of debris | GEI 19 | 68 |
| Coyote Creek (Middle Reach) | Right | 38+00 | -122.524708 | 37.877673 | 12-inch reinforced metal pipe located at the waterside levee toe. The pipe was submerged during our site visit. | GEI 20 | 72 |
| Nyhan Creek | Left | | -122.526484 | 37.876452 | Nyhan Creek looking upstream from Marin Avenue Culvert and looking downstream from Enterprise Concourse Culvert. | GEI 21 | 74, 75 |
| Coyote Creek (Upper Reach) | Both | 76+00 | -122.537197 | 37.879804 | Looking downstream the concrete channel section from Ash Street Culvert. Minor sedimentation and organic debris observed in channel. | GEI 22 | 77 |
| Coyote Creek (Upper Reach) | Both | 72+75 | -122.536073 | 37.879638 | Looking downstream the concrete channel section from Spruce Street Culvert. Minor sedimentation and organic debris observed in channel. | GEI 23 | 78 |
| Coyote Creek (Upper Reach) | Both | 69+65 | -122.535034 | 37.879452 | Looking upstream and downstream the concrete channel section from Pine Street Culvert. Minor sedimentation and organic debris observed in channel. | GEI 24 | 79, 80 |
| Coyote Creek (Upper Reach) | Both | 66+50 | -122.533994 | 37.879211 | Looking downstream the concrete channel section from Poplar Street Culvert. Minor sedimentation and organic debris observed in channel. | GEI 25 | 82 |
| Bothin Marsh | | | -122.522015 | 37.881658 | Bothin Marsh high ground and access road from Shoreline Highway. | GEI 26 | 90, 91, 97, 98 |

**Table 4 - 2012 USACE Inspection IDs and GEI Reconnaisance Comments**

| Location | Bank (Looking DS) | Station | Easting | Northing | Remarks[1] | Inspect_ID | Associated GEI Photos | Observations from GEI Reconnaisance |
|---|---|---|---|---|---|---|---|---|
| Coyote Creek (Lower Reach) | Left | 12+00 | -122.51916 | 37.88289 | Views upstream and downstream at the downstream extent of the project (Sta. 10+00) at low tide. Looking upstream along the crest of the right bank levee. This section (Sta. 10+00 to 27+00) is no longer maintained by the sponsor and floods regularly during high tides | USACE_CESPN_COYL_2012_a_0001 | 89, 93 | Levee features not discernable due to subsidence. |
| Coyote Creek (Middle Reach) | Left | 43+75 | -122.52631 | 37.87875 | Typical view (Sta. 43+00) of floodwall added to the left bank levee. This configuration was a result of the need to raise the crest elevation and the lack of real estate to extend the side slopes. | USACE_CESPN_COYL_2012_a_0002 | 49, 50, 51 | Floodwall appears to be in good condition except for some minor spawling. |
| Coyote Creek (Middle Reach) | Both | 40+00 | -122.52555 | 37.878 | Typical channel conditions near the confluence with the creek (Sta. 41+00). Moderate shoaling and minor amounts of debris should be cleared from the channel. | USACE_CESPN_COYL_2012_a_0003 | 57, 58 | Moderate shoaling and minor debris still in channel. |
| Coyote Creek (Middle Reach) | Left | 40+10 | -122.5255 | 37.87797 | 24-inch outfall from XXX (Cardinal Rd.) Pump Station. Culvert is clear and in good conditon. Riprap is in good condition and shows no signs of displacement. | USACE_CESPN_COYL_2012_a_0004 | 55 | Outfall submerged during site reconnaisance. |
| Coyote Creek (Middle Reach) | Left | 38+25 | -122.52497 | 37.8779 | Upstream extent (Sta. 37+50) of dredge dewatering pipe. Pipe is 12-inch PVC and runs on the levee side slope parallel to the channel alignment and terminates at Sta. 33+50. | USACE_CESPN_COYL_2012_a_0006 | 59 | Observed upstream extent at ~Sta. 38+25 and downstream extent at ~Sta. 35+00. |
| Coyote Creek (Middle Reach) | Left | 35+00 | -122.52394 | 37.87822 | Obstructed concrete pipe culvert should be cleared of riprap and sediment. | USACE_CESPN_COYL_2012_a_0008 | 61 | Observed ~8 inches of sediment in pipe. |
| Coyote Creek (Middle Reach) | Left | 33+10 | -122.52386 | 37.87854 | Downstream extent (Sta. ) of levee floodwall. Vegetation type (i.e. grasses to 0.5-inch stalks) and density increases downstream of this point and should be cleared. | USACE_CESPN_COYL_2012_a_0009 | 62 | Vegetation observed. |
| Coyote Creek (Middle Reach) | Left | 32+50 | -122.52396 | 37.8787 | Headwall to 8-inch culvert. Concrete apron should be cleared of vegetation and sediment. 12-inch flap gate modified to an 8-inch flap gate with HDPE pipe grouted into 12-inch gate. Sponsor should provide documentation that this modification maintains (the design intent) | USACE_CESPN_COYL_2012_a_0010 | 63, 64 | Vegetation observed. |
| Coyote Creek (Middle Reach) | Left | 29+50 | -122.52351 | 37.8796 | Two 36-inch smooth HDPE outlets from the Shoreline put station. Outlets are clear. The area at exit of the downstream culvert where riprap is sparse should be monitored for scour. | USACE_CESPN_COYL_2012_a_0012 | | Not observed during reconnaisance. |
| Coyote Creek (Middle Reach) | Left | 29+10 | -122.52343 | 37.87962 | Abandoned 12-inch CMP culvert. Pipe is filled with concrete. | USACE_CESPN_COYL_2012_a_0013 | | Not observed during reconnaisance. |
| Coyote Creek (Middle Reach) | Left | 29+50 | -122.52367 | 37.87958 | Shoreline pump station. The sponsor maintains a log of maintainence visits, repairs, testing, operation hours, etc. This log is located at the pump station and will be maintained at a centrally located offsite location at a future date. | USACE_CESPN_COYL_2012_a_0014 | 67 | N/A |
| Coyote Creek (Middle Reach) | Left | 45+80 | -122.52683 | 37.87894 | Encroachment at Sta. 45+00 of a ramp over a 12-inch CMP culvert. Ramp should be removed. | USACE_CESPN_COYL_2012_a_0015 | 46 | Possible encroachment observed. |

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**Table 4 - 2012 USACE Inspection IDs and GEI Reconnaisance Comments**

| Location | Bank (Looking DS) | Station | Easting | Northing | Remarks[1] | Inspect_ID | Associated GEI Photos | Observations from GEI Reconnaisance |
|---|---|---|---|---|---|---|---|---|
| Coyote Creek (Middle Reach) | Left | 48+25 | -122.52729 | 37.87906 | Storm sewer manhole at Sta. 46+00. Sewer alignment runs parallel and beneath levee to a junction at Flamingo Road. | USACE_CESPN_COYL_2012_a_0016 | 36, 37 | Storm sewer alignment observed. |
| Coyote Creek (Middle Reach) | Left | 47+00 to 48+50 | -122.52772 | 37.8792 | 1-inch rodent holes spaced 1 to 20 ft apart observed from roughly Sta. 47+00 to 48+00. The sponsor has an active rodent abatement program of backfilling holes with a bentonite soil slurry. | USACE_CESPN_COYL_2012_a_0017 | | Observed during reconnaisance. |
| Coyote Creek (Lower Reach) | Left | 18+00 | -122.52078 | 37.88192 | Left bank levee breach at Sta. 17+00. Breach is roughly 4 to 5 ft wide and 2 ft deep relative to the top of existing levee. Breach should continue to be monitored for widening/deepening. | USACE_CESPN_COYL_2012_a_0021 | 92 | Levee breach does not appear to have widened or deepened. |
| Coyote Creek (Lower Reach) | Left | 25+00 to 28+50 | -122.52301 | 37.88006 | Ad-hoc floodwall constructed by tenant (Dipsea Café) from Sta. 22+00 to 24+00. Floodwall protects the parking lot of the business during spring tides and/or fluvial flood events. | USACE_CESPN_COYL_2012_a_0022 | 87, 88 | Floodwall observed in good condition. |
| Coyote Creek (Middle Reach) | Left | 36+10 | -122.52438 | 37.87804 | Public access foot path constructed by private resident at Sta. 35+50. Access point should be physically blocked and/or signage installed identifying the levee is not a public trail. | USACE_CESPN_COYL_2012_a_0023 | 60 | Observed - pathway between Cardinal Rd. and levee includes small stairway at landside levee wall. |
| Coyote Creek (Upper Reach) | Left | 49+50 | -122.52805 | 37.8792 | Downstream extent (Sta. 49+00) of the concrete channel. Energy dissipators are nearly buried in sediment. Shoaling immediately downstream of the channel is significant and distributed acrosss the channel but largely unvegeated. | USACE_CESPN_COYL_2012_a_0027 | 38, 39, 40 | Energy dissipators submerged during reconnaisance. Shoaling still present. |
| Coyote Creek (Upper Reach) | Left | 49+50 | -122.5282 | 37.87913 | Displaced wall panel on the left side channel wing wall at Sta. 49+00. | USACE_CESPN_COYL_2012_a_0028 | 41, 42 | Wall panel displaced ~4 inches. |
| Coyote Creek (Upper Reach) | Left | 49+50 | -122.52862 | 37.87901 | Flap gates and shoaling at Sta. 50+00. | USACE_CESPN_COYL_2012_a_0029 | 40 | Flap gates not observed during reconnaisance. Shoaling still present. |
| Coyote Creek (Upper Reach) | Both | 53+00 | -122.52943 | 37.87896 | Typical view of concrete channel from Sta. 52+00 (Ross Drive). | USACE_CESPN_COYL_2012_a_0030 | 85, 86 | Minor vegetation overhang. Tide level obstructed observation of shoaling. |
| Coyote Creek (Upper Reach) | Both | 53+00 | -122.52963 | 37.87899 | Typical view on the concrete channel. Vegetation overhangs the channel with minimal within the channel cross-section. Sedimention is roughly 6-inches deep and distributed evenly across the bottom. | USACE_CESPN_COYL_2012_a_0031 | 85, 86 | Minor vegetation overhang. Tide level obstructed observation of shoaling. |
| Coyote Creek (Upper Reach) | Both | 76+25 | -122.53726 | 37.8796 | Confluence of tributary streams near the upstream extent of the project (Sta. 75+50). | USACE_CESPN_COYL_2012_a_0033 | 76 | Minor vegetation overhang. |
| Coyote Creek (Upper Reach) | Both | 64+90 | -122.53341 | 37.87911 | Minor Shoaling upstream of Sta. 64+00 | USACE_CESPN_COYL_2012_a_0034 | 83 | Minor shoaling present. |
| Coyote Creek (Upper Reach) | Both | 66+70 | -122.53402 | 37.87925 | View upstream of Sta. 66+00 (Poplar Street). | USACE_CESPN_COYL_2012_a_0035 | 81 | Minor vegetation overhang. |
| Coyote Creek (Upper Reach) | Both | 63+25 | -122.53294 | 37.87901 | View downstream of Sta. 62+50 (Laurel Way). | USACE_CESPN_COYL_2012_a_0036 | 84 | Minor shoaling present. |

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**Table 4 - 2012 USACE Inspection IDs and GEI Reconnaisance Comments**

| Location | Bank (Looking DS) | Station | Easting | Northing | Remarks[1] | Inspect_ID | Associated GEI Photos | Observations from GEI Reconnaisance |
|---|---|---|---|---|---|---|---|---|
| Coyote Creek (Lower Reach) | Both | 12+00 | -122.51905 | 37.88279 | Views upstream and downstream at the downstream extent of the project at low tide. Improperly abandoned 18-inch culvert (encroachment). Culvert should be removed. | USACE_CESPN_COYR_2012_a_0001 | Not observed | Not observed during reconnaisance. |
| Coyote Creek (Lower Reach) | Right | 12+00 | -122.51948 | 37.88227 | Looking upstream along the crest of the right bank levee. This section (Sta. 10+00 to 27+00) is not longer maintained by the sponsor and due to several feet of settlement since initial construction floods regularly during high tides. | USACE_CESPN_COYR_2012_a_0002 | 94 | Levee features not discernable due to subsidence. |
| Coyote Creek (Lower Reach) | Right | 19+00 | -122.52073 | 37.88153 | 18-inch CMP culvert at Sta. 18+00. The culvert appears to be clear of sediment and debris, however, the springline is concave up (~1-2 ft) due to settlement at the levee centerline. | USACE_CESPN_COYR_2012_a_0003 | 95 | Pipe appears corroded. |
| Coyote Creek (Lower Reach) | Right | 24+00 | -122.52252 | 37.88021 | Typical channel condtions looking upstream and downstream from Sta. 25+00. Channel is clear of debris and significant shoaling downstream of Sta. 27+00. | USACE_CESPN_COYR_2012_a_0004 | 96 | Channel appears clear of debris and shoaling. |
| Coyote Creek (Middle Reach) | Right | 35+50 | -122.5239 | 37.87785 | 24-inch corrugated HDPE culvert (Sta. 34+50) viewed from the left bank. Culvert is clear of sediment/debris, however, is boarded up on the protected side. The sponsor was not aware why this condition exists, but suggested it may have been a temporary. | USACE_CESPN_COYR_2012_a_0018 | 70, 71 | Boards on landside removed. ~8 inches of sediment on the landside end of pipe. |
| Nyhan Creek | Left | | -122.52626 | 37.87765 | Unauthorized 4-inch drainage pipe installed by a local resident. The pipe appears to be roughly 6- to 12-inches beneath the surface of the levee crown and side slopes. | USACE_CESPN_COYR_2012_a_0019 | 10, 11 | Drainage pipe observed. |
| Nyhan Creek | Left | | -122.52656 | 37.87705 | Looking downstream from Crest Marin pump station. Channel has only minor amounts of debris. The foundation of the high tension power line tower has been repaired/hardened since the last inspection. | USACE_CESPN_COYR_2012_a_0020 | 1, 2 | Rip rap around the tower footings appears to be in good condition. |
| Nyhan Creek | Left | | -122.52658 | 37.87719 | Emergency supplies (backfill) at Crest Marin pump station. Station is well maintained and tested on a regular basis. | USACE_CESPN_COYR_2012_a_0021 | Not observed | N/A |
| Nyhan Creek | Left | | -122.52652 | 37.87746 | On the levee crown 1-inch rodent holes spaced a few inches to 5 ft apart were observed +/- 50 ft from the inspection point. The sponsor has an active rodent abatement program of backfilling holes with a bentonite soil slurry. | USACE_CESPN_COYR_2012_a_0022 | 9 | Observed - Rodent holes backfilled with cement bentonite backfill. |
| Coyote Creek (Middle Reach) | Right | 43+50 | -122.52633 | 37.87844 | Large tree (1-foot diameter at base) in the levee toe at Sta. 42+50. | USACE_CESPN_COYR_2012_a_0023 | 18 | Tree observed. |
| Coyote Creek (Upper Reach) | Right | 49+50 | -122.52805 | 37.8792 | Downstream extent (Sta. 49+00) of the concrete channel. Energy dissipators are nearly buried in sediment. Shoaling immediately downstream of the channel is significant and distributed acrosss the channel but largely unvegeated. | USACE_CESPN_COYR_2012_a_0027 | 38, 39, 40 | Energy dissipators submerged during reconnaisance. Shoaling still present. |
| Coyote Creek (Upper Reach) | Right | 49+50 | -122.5282 | 37.87913 | Displaced wall panel on the left side channel wing wall at Sta. 49+00. | USACE_CESPN_COYR_2012_a_0028 | 41, 42 | Wall panel displaced ~4 inches. |
| Coyote Creek (Upper Reach) | Right | 49+50 | -122.52862 | 37.87901 | Flap gates and shoaling at Sta. 50+00 | USACE_CESPN_COYR_2012_a_0029 | 40 | Flap gates not observed during reconnaisance. Shoaling still present. |

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|---|---|---|---|---|---|---|---|---|
| Coyote Creek (Upper Reach) | Right | 53+00 | -122.52943 | 37.87896 | Typical view of concrete channel from Sta. 52+00 (Ross Drive). | USACE_CESPN_COYR_2012_a_0030 | 85, 86 | Minor vegetation overhang. Tide level obstructed observation of shoaling. |
| Coyote Creek (Upper Reach) | Right | 53+00 | -122.52963 | 37.87899 | Typical view on the concrete channel. Vegetation overhangs the channel with minimal within the channel cross-section. Sedimention is roughly 6-inches deep and distributed evenly across the bottom. | USACE_CESPN_COYR_2012_a_0031 | 85, 86 | Minor vegetation overhang. Tide level obstructed observation of shoaling. |
| Coyote Creek (Upper Reach) | Right | 76+25 | -122.53726 | 37.8796 | Confluence of tributary streams near the upstream extent of the project (Sta. 75+50). | USACE_CESPN_COYR_2012_a_0033 | 76 | Minor vegetation overhang. |
| Coyote Creek (Upper Reach) | Right | 64+90 | -122.53341 | 37.87911 | Minor Shoaling upstream of Sta. 64+00 | USACE_CESPN_COYR_2012_a_0034 | 83 | Minor shoaling present. |
| Coyote Creek (Upper Reach) | Right | 66+70 | -122.53402 | 37.87925 | View upstream of Sta. 66+00 (Poplar Street). | USACE_CESPN_COYR_2012_a_0035 | 81 | Minor vegetation overhang. |
| Coyote Creek (Upper Reach) | Right | 63+25 | -122.53294 | 37.87901 | View downstream of Sta. 62+50 (Laurel Way). | USACE_CESPN_COYR_2012_a_0036 | 84 | Minor shoaling present. |
| Coyote Creek (Middle Reach) | Right | 35+75 to 39+75 | -122.52493 | 37.87769 | Tennessee Valley nonmotorized path. New structure extends between high ground at roughly Sta. 33+00 and Sta. 40+00. Sponsor stated that the elevation of the walkway is above the 100-year water surface and the process for approving the wakway as an autho | USACE_CESPN_COYR_2012_a_0037 | 57, 73 | Tennessee Valley nonmotorized path is in good condition. |
| Coyote Creek (Middle Reach) | Right | 33+50 | -122.52355 | 37.87853 | 24-inch corrugated HDPE culvert (Sta. 32+00) viewed from the left bank. Culvert is clear of sediment/debris. Riprap at the outlet of the culvert is in good condition. | USACE_CESPN_COYR_2012_a_0038 | 69 | Rip rap at pipe outlet observed in good condition. |
| Coyote Creek (Middle Reach) | Right | 44+10 to 44+50 | -122.5265 | 37.87852 | Settlement at the Flamingo Road Bridge. The gap between the bridge sidewalk and roadway is roughly 3 inches, the same magnitude observed at the 2010 PI. | USACE_CESPN_COYR_2012_a_0039 | 19, 20, 47, 48 | Measured gap between the bridge sidewalk and roadway is approximately 3 inches |
| Coyote Creek (Middle Reach) | Right | 47+00 to 49+00 | -122.52763 | 37.8789 | View from left bank of homes and respective fences from Sta. 44+00 to 48+00 encroaching on the right bank levee. | USACE_CESPN_COYR_2012_a_0040 | 29, 30 | Vegetation observed. |
| Coyote Creek (Middle Reach) | Both | 28+25 | -122.523277 | 37.87959638 | Significant cracking, spalling, etc. was noted on the piers to the CA 1 bridge. Repairs over these areas were noted during the current inspection. | USACE_CESPN_COYR_2012_a_0041 | Not observed | Not observed during reconnaisance. |

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