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MEMORANDUM

TO:	Scott Smithwick, DEVCON Construction Virginia Calkins, SRGNC	DATE:	August 15, 2019
FROM:	Caitlin Gilmore, PE Charles Anderson, PE	JOB#:	GOOG.03.18
SUBJECT:	West Channel Enhancement for Google Hydraulic Basis of Design		

Introduction

Project Background

The Santa Clara Valley Water District (District, SCVWD) is the in the process of permitting the construction of a channel improvement project for flood control and erosion protection on Sunnyvale West Channel within the City of Sunnyvale. The Project involves the construction of floodwalls atop earthen levees along the entire channel alignment as well as bridge improvements. Google is currently developing two parcels between Caspian Drive and Caribbean Drive and the West Channel bisects these properties (District Reach W2). Google's project goals are to provide flood protection through this reach while providing enhanced environment. In lieu of conventional flood protection improvements planned by the District, which includes levees and floodwalls within limited channel rights-of-way, an enhanced channel corridor will become part of the development landscape; providing flood protection while enhancing campus aesthetics, recreational opportunities and environmental resources for wildlife habitat. The channel will need to work effectively with regional flood control and drainage planning, and be adaptable to future climate conditions.

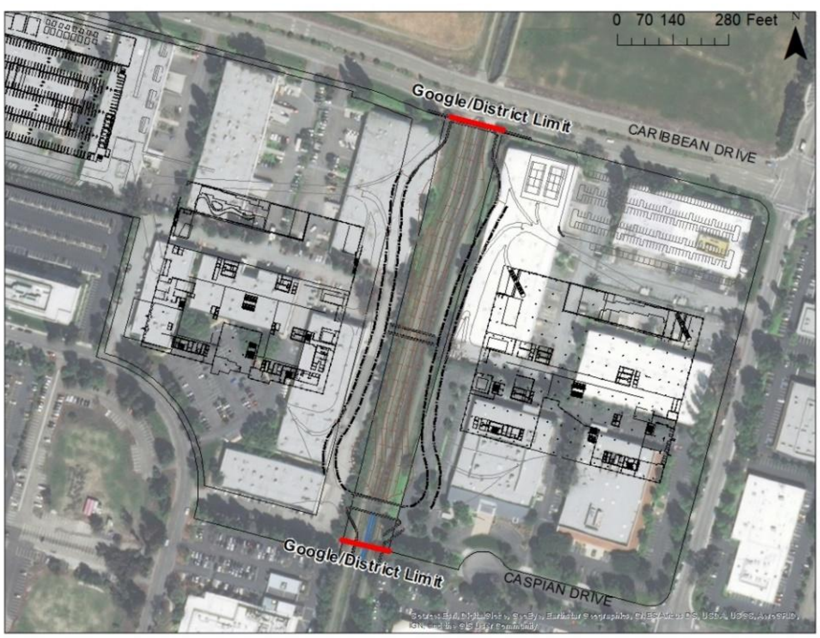

Figure 1: Project Reach

Purpose

The purpose of this Basis of Design Report is to provide the documentation of the engineering analyses, calculations and interpretations that are required to support the design of the enhancement project along Sunnyvale West Channel from Caspian Drive to Caribbean Drive. The project would provide capacity to convey the 1-percent design flow while meeting District performance standards and includes levees, floodwall transitions and bridge improvements.

Previous Reports

Reports previous issued by the District are as follows:

1. Sunnyvale East Channel and Sunnyvale West Channel Flood Protection Project Planning Study Report, June 2010.

Guidance Documents from FEMA and the U.S. Army Corps of Engineers (USACE) are as follows:

1. FEMA "Analysis and Mapping Procedures for Non-Accredited Levee Systems", 2013.
2. FEMA "Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix H: Guidance for Mapping of Areas Protected by Levee Systems", 2003.
3. ETL 1110-2-583, "Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams and Appurtenant Structures", USACE April 2014.
4. ETL 1110-2-1913, "Design and Construction of Levees", USACE April 2000.

Scope of Studies

The Basis of Design Report provides documentation of the engineering analysis, calculations, and interpretations that are required to support the design of the recommended plan for the West Channel Enhancement Project. Several additional studies support this report as described below.

Survey

A topographic survey and base map was created by Kier & Wright Civil Engineers & Surveyors, Inc. The horizontal control is based on the North American Datum (NAD) of 1983, California State Plane Zone 3. Vertical control is based on the North American Vertical Datum (NAVD) of 1988.

Agency Coordination

A number of agencies have jurisdiction over elements of the project design, and several regulatory permits are required to complete the proposed work. The following agencies will be consulted for guidance during design development:

- Santa Clara Valley Water District
- US Army Corps of Engineers (USACE)
- US Fish and Wildlife Service (USFWS)
- California Department of Fish and Wildlife (CDFW)
- San Francisco Bay Regional Water Quality Control Board (RWQCB)
- National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS)
- City of Sunnyvale

Utility Relocations

The project will require the relocation of a 48-inch diameter City of Sunnyvale storm drain line which runs within an easement parallel to the SCVWD right of way on the west side of the channel. Due to the lines lateral location and relative depth, it has to be relocated to be placed outside of the proposed channel and levee.

Maintenance Access

Per coordination with the District, the preferable width for access roads is 18 feet wide, with 12 feet as a minimum. The road should be constructed of an appropriate aggregate base material, or of asphalt pavement which is to be maintained by others after construction. Maintenance access into the channel itself is not currently proposed in the District’s design, but providing for emergency access to the channel bottom is subsequently discussed in this Basis of Design.

Project Description

District Design

The existing flood control channel through the Google campus is an earthen levee system with a top of levee elevation of approximately 11 feet NAVD88 and adjacent grade of approximately 6 feet NAVD88. The channel is trapezoidal and straight through the reach. The District plans to increase the carrying capacity of the channel by increasing the top of levee elevation to 12 feet NAVD88 with floodwalls on both banks to elevation 18 feet NAVD88. The east side of the channel will have an 11- to 12-foot wide aggregate maintenance road on the inside of the new floodwall while a 12-foot wide asphalt maintenance road and public trail will be constructed on the outboard side of the west bank floodwall. The District designed channel has a varying bank width of 52 to 65 feet through the Google property reach. The District project is contained within the existing SCVWD right-of-way. Figure 2 shows the typical District design channel cross section through the Google reach.

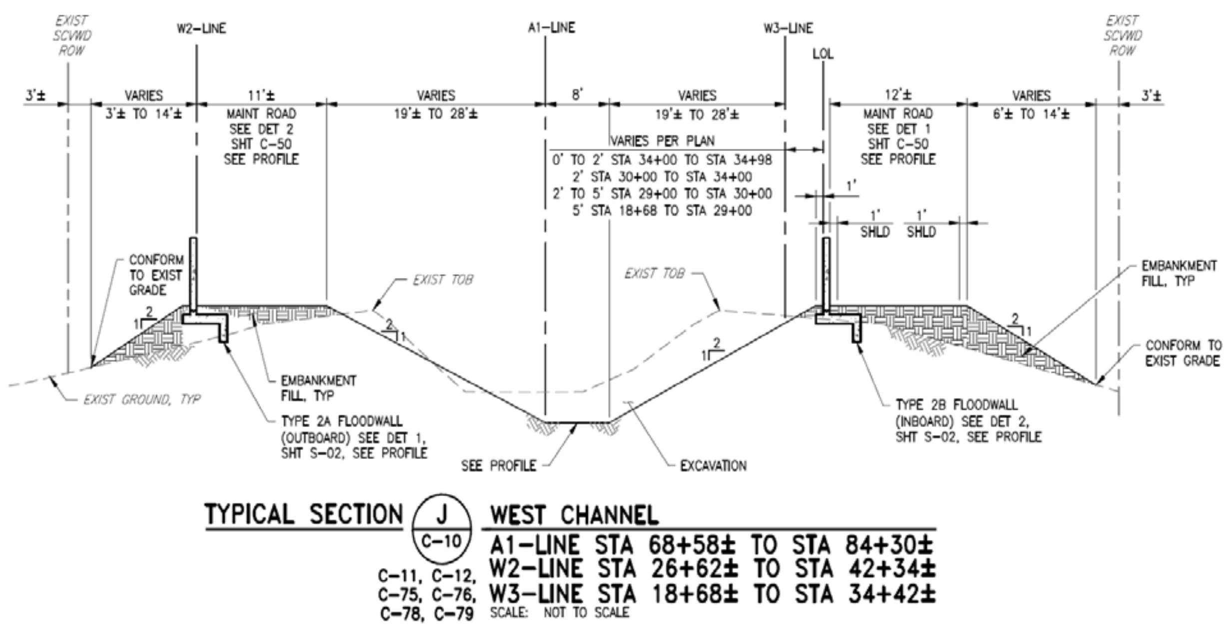

Figure 2: Typical District Channel Design Cross Section

Google's Conceptual Design

The revision proposed to the District project is to widen the channel between Caspian Drive and Caribbean Drive to a bank width varying between 127 and 187 feet. The levees will be widened and raised to an elevation of 18 feet NAVD88. The new widened channel and larger levees will extend past SCVWD right of way onto privately owned Google property. There will be a pedestrian and emergency vehicle bridge just to the north of Caspian Court to allow connectivity within the Google Campus on both sides of the channel. A pedestrian bridge will also be constructed approximately mid-property and the culvert under Caribbean Drive will be extended south to accommodate a new public sidewalk. Figure 3 shows the conceptual channel cross section that Google proposes to construct in lieu of the typical section shown in Figure 2. Figure 4 provides a perspective of the proposed channel geometry.

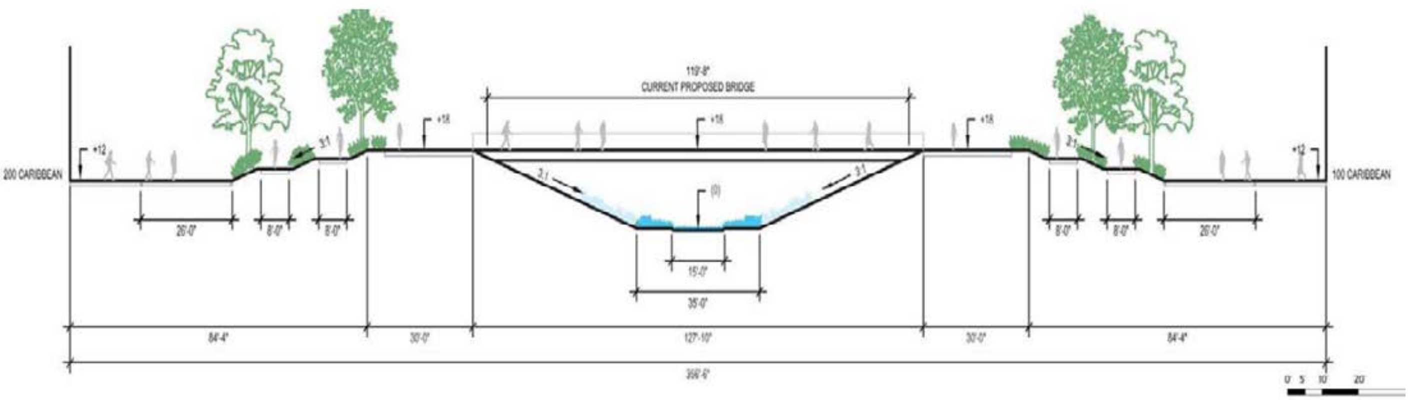

Figure 3: Conceptual Google Reach Design

Figure 4: Three-dimensional Perspective Looking North

Design Criteria

Hydraulic Criteria

In order to verify the channel reach capacity and the target water surface elevations established by the District are reached, the HEC-RAS model originally prepared by the District is used as refined herein. Relevant hydraulics modeling parameters include: flow, boundary conditions, channel geometry, channel roughness, bridge modeling and transition losses.

Design Flow

According to the Planning Study Report (PSR) for Sunnyvale East Channel and Sunnyvale West Channel the design one-percent (100-year) discharge rate for Sunnyvale West Channel is 380 cfs downstream from California Highway 237, which encompasses the entire subject project reach.[1]

Boundary Condition Criteria

The Google channel enhancement encompasses the reach between Caspian Drive and Caribbean Drive. In order to provide the same level of service the project must utilize the downstream boundary condition based on the PSR 1-percent flow and the 10-percent tide with 2.0 feet of future sea level rise equal to 13.49 feet NAVD88 just upstream of Caribbean Drive (HEC-RAS cross section 6704.145). The 2 feet of sea level rise is associated with a project design life of 50 years and represents the high range of estimated sea level rise; an estimate associated with a 99.5 percent confidence of non-exceedance.[2]

National Flood Insurance Program (NFIP) and FEMA regulations, however, require that only existing conditions are reflected on the Flood Insurance Rate Map (FIRM), and future sea level rise is not an existing condition. When processing changes to the FIRM reflecting project completion, FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* require that when the downstream boundary of a modeled stream (in this case Guadalupe Slough) is within a coastal tidal reach, the tidal boundary of the model should be taken as equal to the Mean Higher High Water (MHHW) level of the nearby tide station.

However, evidence shows that mean tide elevations are not necessarily an appropriate boundary condition during storm events and tide elevations in San Francisco Bay are elevated (relative to predicted tides) during periods of heavy rainfall. Furthermore, the relationship between coincident tides and maximum annual runoff can be quantified and used in the model, providing for a more statistically correct solution than an arbitrarily selected tide condition.

A coincident one-percent tide analysis has been performed to establish the downstream boundary for Guadalupe Slough at San Francisco Bay, to provide a hydraulic backwater condition appropriate for an ultimate submittal to FEMA by the SCVWD. (The procedures described herein have been approved by FEMA for similar streams and rivers discharging directly to San Francisco Bay.)

The 19-year mean tide cycle for San Francisco Bay represents average tide heights over a specific period known as the tidal epoch, which spans the 19 years it takes for every possible combination of relative

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[1] *Santa Clara Valley Water District, Sunnyvale East Channel and Sunnyvale West Channel Flood Protection Project Planning Study Report, June 2010.*

[2] *Griggs, G, Arvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group). Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust, April 2017.*

positions for the sun, moon and earth to occur. This cycle consists of two high tides (one higher than the other) and two low tides (one lower than the other) each lunar day. Based on calculations for relative celestial positions, it is possible to predict tides for any day of the year at any time of the day. Astronomic tides, created by the gravitational forces of the moon and sun acting on earth's oceans, are provided in tide prediction calendars. The mean tide cycle is simply the long-term average of astronomic tides. Observed tides, on the other hand, are actual tidal elevations recorded by National Oceanic and Atmospheric Administration (NOAA) gaging stations located throughout coastal areas.

The El Niño storm of February 2-3, 1998 provided an ideal event for examining potential correlations between runoff events and tide action. While stream runoff as measured by local gages often approached historic recorded levels, observed tides in San Francisco Bay were substantially higher than predicted. Figure 5 shows predicted and recorded tides in early February 1998 at Redwood City, which has the closest NOAA tide gage to Permanente Creek. Recorded tides during the week of this runoff event were consistently higher (on the order of up to 4 feet) than the astronomic (predicted) tide heights due to storm surge.

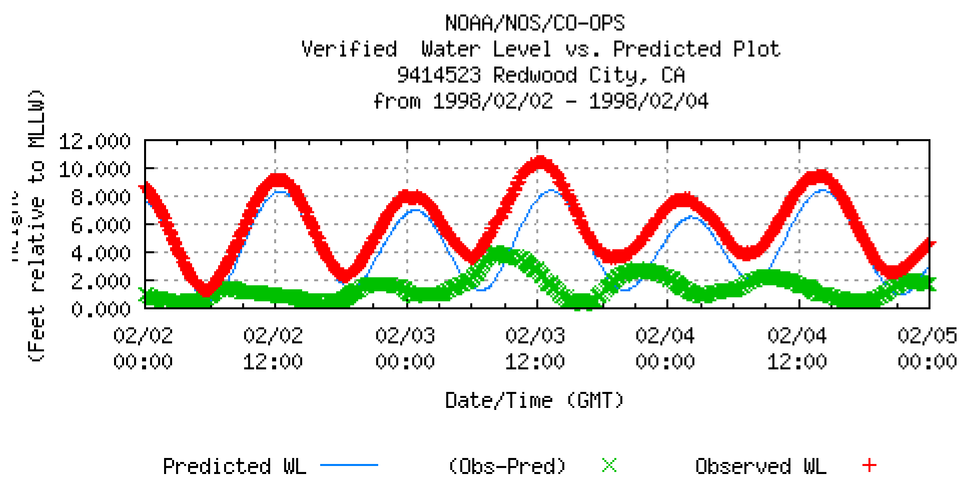

Figure 5: San Francisco Bay Tide During Feb. 2-3, 1998 Storm Event

As a control, observed tide heights are compared to predicted tides six months later at the same station, using the same sets of data. Figure 6 shows tide elevations during early August 1998, when there is very close agreement between the predicted and the actual tides and no rainfall. Both figures present tides on the local Mean Lower Low Water (MLLW) datum.

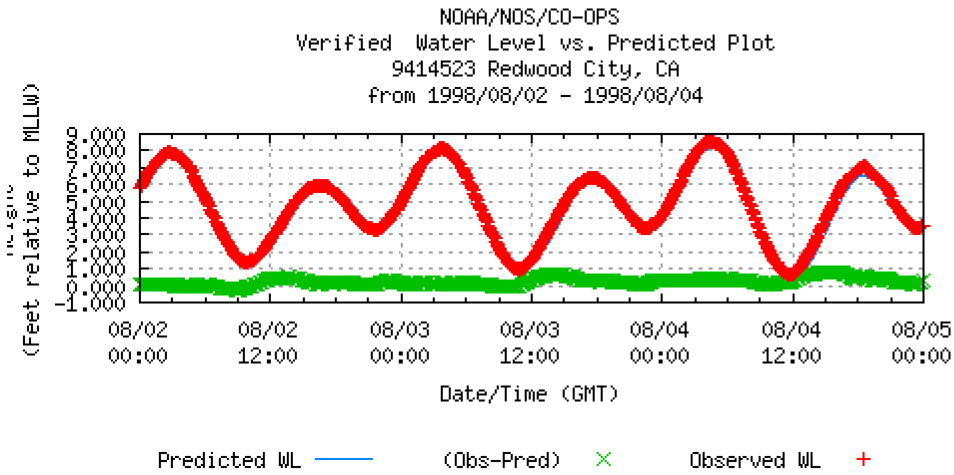

Figure 6: San Francisco Bay Tide During Early August 1998

The observed phenomenon presented in Figure 5 is not strongly dependent upon tide gage location, particularly within San Francisco Bay, and is exhibited during many historic storm events. Data indicate that higher tides as observed during the February 1998 event are not an isolated incident; rather, higher than predicted tides can be expected during storm events that generate significant runoff. Increases in the data set between observed tides over predicted tides range from 0.3 foot to 2 feet for the highest tide, and from 0.9 foot to 3 feet for the lowest tide. From observed historical data, it appears that storm-related forces induce higher tides during rainfall events, and by extension, runoff events. This phenomenon may be due to a number of meteorological or hydrologic factors. NOAA refers to the term “inverse barometer effect”, and defines it as higher tides that are caused by lower barometric pressures associated with winter storm systems. References to “storm surges”, the meteorological effects of low barometric pressures and/or strong southerly winds, are also found in the literature.

The exact nature and cause of this phenomenon, however, are not as important as potential impacts to backwater conditions for Guadalupe Slough. To model an appropriate San Francisco Bay high tide condition for the one percent storm event, the high tide elevation is set based on the one-percent conditional probability of coincident occurrence with the annual maximum discharge of San Francisquito Creek at Stanford, which represents the closest USGS stream flow gauging location with sufficient length of record for analysis.

This procedure is as described by Dixon (1986), whose hypothesis was that high tide events tend to occur the same day as flood flow events using conditional probability:

$$P(x,y) = P(x|y)\,P(y)$$

where $P(x,y)$ is the probability of occurrence of x and y; $P(x|y)$ is the probability of occurrence of x given y; $P(y)$ is the probability of occurrence of y; x is tide elevation; and y is maximum annual peak discharge. Since we are interested only in annual maximum discharges, $P(y)$ is one and the probability of joint occurrence, $P(x,y)$, is equal to the probability of x given y.

Coincident higher high tides are fitted to a probability curve using the median plotting position for every recorded tide extreme at San Francisco (Presidio/Golden Gate) that occurred within 24 hours of the recorded maximum annual discharge. Figure 7 shows the probability distribution on the MLLW datum.

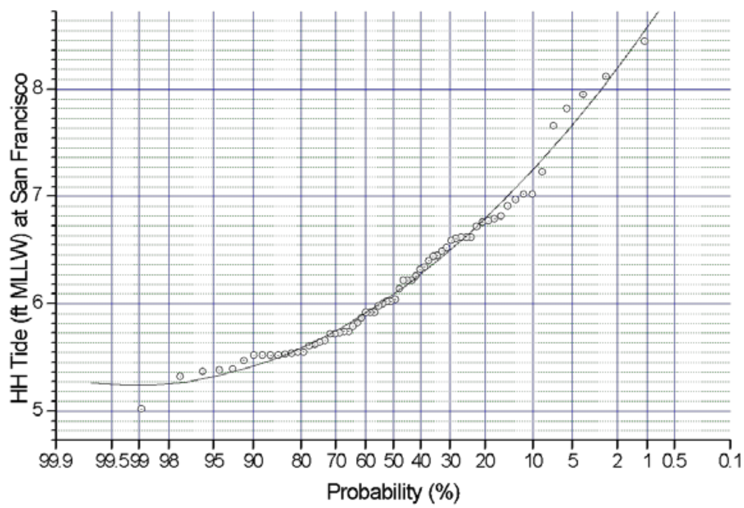

Figure 7: Coincident 1% Tide at San Francisco

The coincident one-percent high tide elevation at San Francisco is 8.63 feet MLLW. A tide elevation at the Golden Gate can be corrected for a different location within San Francisco Bay. The correction at the mouth of Guadalupe Slough is to add 2.7 feet to high tides. On the MLLW datum, the coincident one-percent tide for Guadalupe Slough is 11.33 feet. The MLLW datum can be converted the NAVD88 datum at this location by subtracting 1.33 feet (AECOM, 2016). This sets the coincident one-percent high tide at 10.0 feet NAVD88. This compares favorably to the District's starting water surface elevation of 10.05 feet NAVD88, without future sea level rise.

The entire project reach is within tidal influence ranging from elevation -1.3 feet NAVD88 at mean lower low water (MLLW) and 7.4 feet NAVD88 at mean higher high water (MHHW); the latter equating to a maximum depth of approximately 8.6 feet above the design invert and 5.1 feet above the invert of the Caribbean Drive culvert, which is assumed to be the estimated long-term sedimentation level. Figure 8 shows the mean tide cycle at the mouth of Guadalupe Slough.

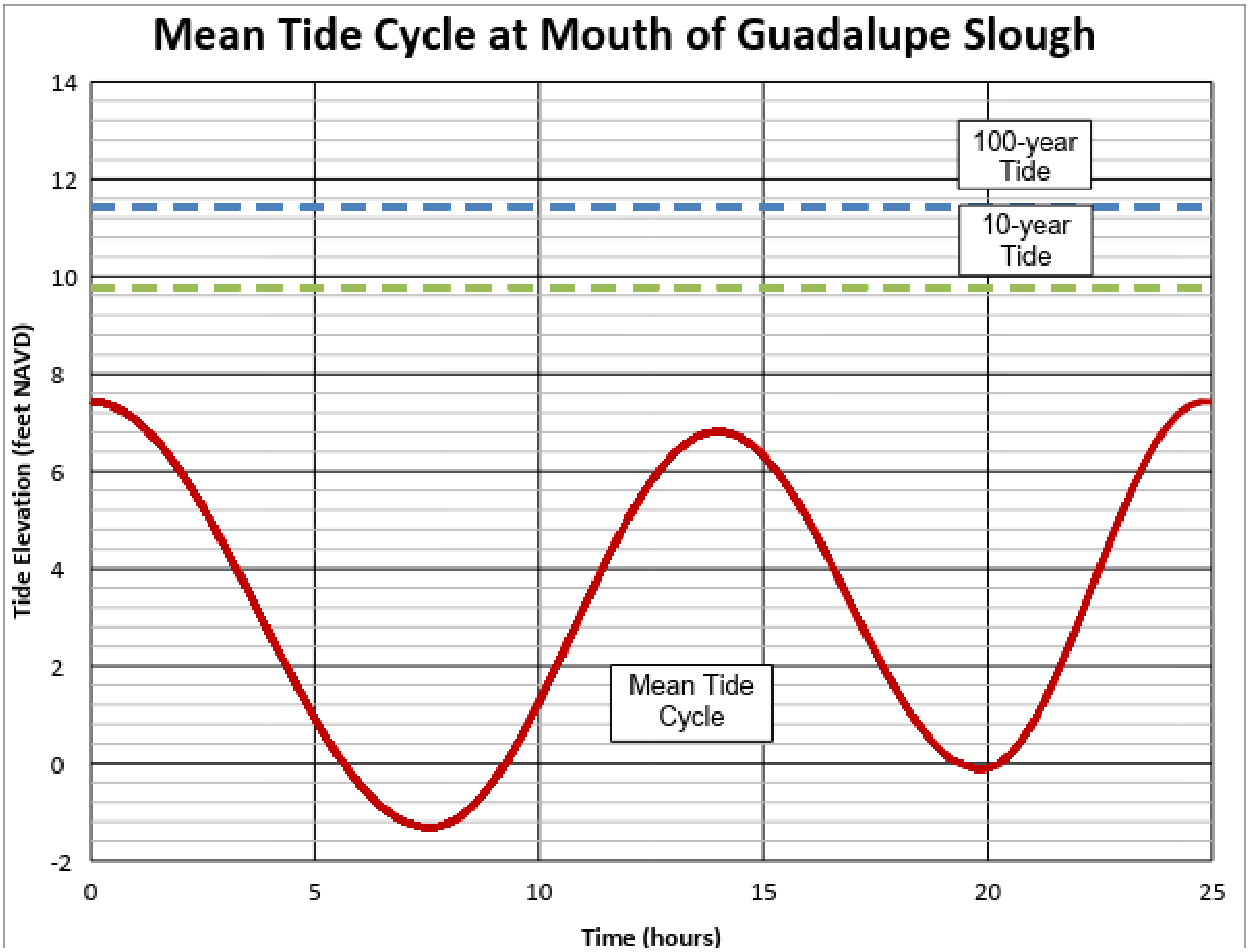

Figure 8: Mean Tide Cycle

The upstream 1-percent water surface elevation based on the District design is 13.69 feet NAVD88 at the Google property limits (HEC-RAS cross section 7800).

Channel Geometry

Modified channel geometry within the design reach is taken from the project preliminary design prepared by The Olin Studio. The channel will expand from a District design width of 52 to 65 feet to a varying bank-to-bank width of 127 to 187 feet. The design incorporates a low flow channel and terraced vegetation benches at varying elevations. The proposed channel is generally straight through the reach, with the variance coming from width, not necessarily meander.

Channel Roughness

Based on a sensitivity analysis performed using the hydraulic model, the composite channel roughness (Manning's "n" value) within the project reach can increase to 0.06 without causing an increase in hydraulic grade line based on roughness alone. Therefore it is conservatively assumed that the channel vegetation is allowed to develop to an n-value equal to 0.05 representing sluggish reaches, weedy, with deep pools; light brush and full summer trees. Actual vegetation will probably be less dense in the final project design, and the composite roughness can iteratively be established during design development of the channel grading and vegetation plans.

While HEC-RAS has a built-in composite roughness routine wherein roughness estimates for each channel section may be input from station to station, according to the HEC-RAS Hydraulic Reference Manual (USACE 2002), a composite Manning's "n" is calculated using Chow's Equation 6-17:

$$n_c = \left[\frac{\sum_{1}^{N} \left(P_N \, n_N^{1.5} \right)}{P} \right]^{2/3}$$

This equation assumes that each part of the cross sectional area has the same mean velocity, which at the same time is equal to the mean velocity of the whole section. This may not be an appropriate working assumption for a multi-stage channel with different types and densities of vegetation across the cross section, as anticipated for the West Channel Enhancement Project.

Methods for computing the composite roughness coefficient based on a weighted distribution of roughness elements are available in the literature. Soong and Hoffman present ten methods for determining a weighted roughness coefficient, which are summarized by Table 1. The composite design roughness estimate will be an average of nine of the ten methods shown in Table 1. Composite roughness estimates achieved using the Lotter Equation (Equation 1) appear to be low outliers and have in the past been discarded from the overall average based on engineering judgment.

Table 1: Equations for Computing Design Composite Channel Roughness

Equation	Literature Reference	Basic Assumption	Reference Equation No.
$n_c = \dfrac{PR^{5/3}}{\sum \dfrac{P_i R_i^{5/3}}{n_i}}$	Lotter (1933)	Total discharge is sum of subarea discharge.	1
$n_c = \dfrac{\sum \left(n_i P_i R_i^{1/3}\right)}{PR^{1/3}}$		Total shear force is sum of subarea shear forces. $V_i/V = (R_i/R)^{1/2}$	2
$n_c = \dfrac{\sum \left(n_i P_i / R_i^{1/6}\right)}{P/R^{1/6}}$		Same as (2) but $V_i/V = 1$	3
$n_c = \left[\dfrac{1}{P}\sum \left(n_i^2 P_i\right)\right]^{1/2}$	Pavlovskii (1931) Einstein and Banks (1950)	Total resistance force is sum of resistance forces.	4
$n_c = \left[\dfrac{1}{P}\sum \left(n_i^{3/2} P_i\right)\right]^{2/3}$	Horton (1933) Einstein (1934)	$V = V_i$; $S = S_i$; $A = \Sigma A_i$	5
$n_c = \dfrac{P}{\sum \left(P_i / n_i\right)}$	Felkel (1960)	Manning's Eq. with $R_i/R = 1$	6
$n_c = \dfrac{\sum \left(n_i P_i\right)}{P}$		Component roughness linearly proportional to wetted perimeter.	7
$n_c = \exp\left[\dfrac{\sum P_i h_i^{3/2} \ln n_i}{\sum P_i h_i^{3/2}}\right]$	Krishnamurthy and Christiansen (1972)	Logarithmic velocity distribution over depth h for wide channel.	8
$n_c = \dfrac{\sum n_i A_i}{A}$	USACE (1968) Cox (1973)		9
$n_c = \left[\dfrac{\sum \left(n_i^{3/2} A_i\right)}{A}\right]^{3/2}$	Colebatch (1941)	Same as Eq. 1	10

Key to Parameters

x_i = parameter in the i^{th} subarea
X = parameter for entire cross section
n = Manning's roughness coefficient
P = wetted perimeter
A = cross sectional area
R = hydraulic radius
V = flow velocity
S = energy gradient

Erosion and Sedimentation

The District's Planning Study Report identified the project reach as containing erosion at the toe of the trapezoidal channel. Additional erosion control will not be necessary. The Google channel enhancement project will increase the carrying capacity of the channel and thereby reduce channel velocities throughout the reach. Average channel velocities will be reduced from 0.92 to 0.78 foot per second. This change in velocity, coupled by a reconstruction of the channel bed eliminates the need to provide erosion protection.

The District's design has channel bed invert that slopes from elevation 0.95 foot NAVD at the upstream Google property limit to elevation -1.2 feet NAVD at Caribbean Drive, while the downstream boundary invert is elevation 2.3 feet NAVD at the hard-surface Caribbean Drive culvert. The proposed conceptual design mimics this invert condition, which leaves a sink for sediment deposition just upstream from Caribbean Drive. It is understood that due to the tidal influence, sediment may generally deposit and settle to elevation 2.3 feet NAVD, which is the hard downstream control at Caribbean Drive. The District does not currently perform regular sediment removal in this reach of channel and anticipates an operating sediment level of approximately elevation 2.3 NAVD.

Transition Loss

Transition between the upstream walled channel section and the downstream project reach will be gradual so as to reduce hydraulic losses associated with a rapid widening of the channel. This channel widening will occur over a 100-foot distance, increasing from 52 feet from bank to bank to 120 feet in the enhanced channel. This transition is modeled with ineffective flow area at an expansion ratio of 2:1 per the figure below. The area of ineffective flow caused by the widening of the channel is defined as expanding 1 foot laterally for every 2 feet in channel length.

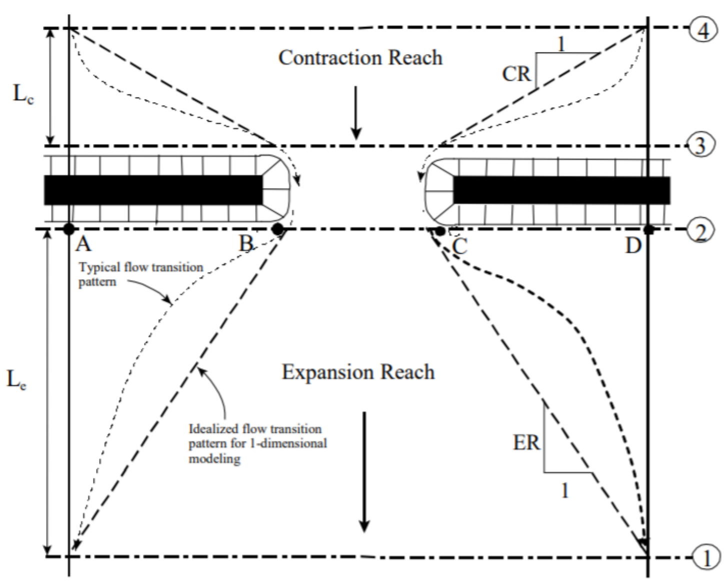

Figure 9: Expansion and Contraction Ratios[3]

[3] USACE HEC-RAS User's Manual, CPD-68, February 2016

Similarly, a downstream channel width taper will be provided upstream of the existing Caribbean Drive to transition from an approximate 180 foot channel to the 10 foot wide culvert over a 165-foot distance. This transition is accomplished within the model as ineffective flow area at a contraction ratio of 1:1.

Note that the District design model did not apply expansion and contraction coefficients at the bridge structures for Java or Caribbean. In keeping with similar methodology, ineffective flow areas are used to represent the transition losses in the enhanced channel, while maintaining the expansion and contraction coefficients for gradually varied flow

Bridges

There are two proposed bridges as part of the project: a pedestrian bridge mid-campus and an emergency vehicle bridge north of Caspian Court. The 1–percent water surface elevation needs to be contained by bridge headwalls with 4 feet of freeboard, but that freeboard does not necessarily need to be provided by the soffit elevation, provided that the bridges are designed for pressurized flow to the headwall and adjacent floodwall elevation. Due to the urbanized source of the flow to Sunnyvale West Channel, it is unlikely that large debris (trees and so forth) would be carried in the channel and cause an obstruction of flow at the bridges. The bridges will be designed to be free span over the 1-percent water surface elevation; or, be designed for pressure flow with the soffit and any conveyed utilities below the 1-percent water elevation. The free span alternative will have no impact to the channel hydraulics or the target design water surface criteria. A pressurized flow alternative will have no impact to the target design water surface elevation provided the bridge soffits are at or above elevation 12. Any intermediate piers necessary for structural support of the bridge should be evaluated hydraulically, in terms of size and placement within the channel.

The existing 95-foot long culvert under Caribbean Drive will be extended approximately 10 feet to the south to accommodate a new public sidewalk. The existing culvert is undersized for the 1-percent event and pressurized. The extension results in an approximate 0.1 foot increase in hydraulic grade due to culvert losses, making the water surface elevation upstream of the Google property elevation 13.74 at cross section 7800 (District design elevation 13.69). The entire project reach for Sunnyvale West Channel has been modelled to include this 0.05 foot increase in hydraulic grade at the upstream edge of the Google project. The required freeboard is met and exceeded for the full length of the District project.

Stability Criterion

Flood flows can be carried within channels either as subcritical flow or supercritical flow, often referred to as “tranquil” and “rapid” flow, respectively. It is not the velocity of flow, however, that distinguishes the flow regime; rather, the flow regime is defined by how fast the water is moving relative to the velocity of the wave that results from a small disturbance in the water surface. Disturbances in subcritical flow move upstream; disturbances in supercritical flow cannot move upstream because such waves must be swept downstream. The Froude number (F_r), which is analogous to the Mach number for gas flow, is defined as the ratio of stream velocity to wave velocity:

$$F_r = \frac{v}{\sqrt{g\,y}}$$

where v = stream velocity (feet per second)
g = gravitational acceleration (feet per second squared)
y = water depth (feet)

A Froude number greater than unity signifies supercritical flow (stream velocity greater than wave velocity), while a Froude number less than one indicates subcritical flow. When the Froude Number is between 0.8 and 1.2, however, the flow can be unstable, characterized by standing waves and other disturbances that may tend to propagate upstream or downstream depending upon the state of flow. Due to the high tailwater and low velocities, the conceptual channel design maintains subcritical flow with Froude numbers less than 0.2 at all modeled cross sections.

Freeboard Criteria

Freeboard, expressed in terms of feet above the design base flood elevation, is necessary whenever a levee system is used to provide flood protection.

Note that for channels without the water surface elevation (WSEL) above natural grade, FEMA has no freeboard requirements. Throughout the project reach the proposed adjacent grade is approximately elevation 12 feet NAVD88 while the 1-percent water surface elevation without adding sea level rise is approximately elevation 11.7 feet NAVD88. Therefore, according to FEMA criterion, there is no regulatory levee system within the Google project reach, and the proposed project levee is not required to meet Title 44 of the Code of Federal Regulations (44 CFR §65.10).

The freeboard requirements for the project are based on the District's design criteria. The top of levee elevation throughout the reach is designed to meet the District project height of elevation 18 feet NAVD88. A minimum of 4.3 feet of freeboard is provided throughout the enhanced project reach, which exceeds the District freeboard criteria listed in Table 2 below.

Table 2: Freeboard Criteria

Situation	FEMA*	District
WSEL above natural grade	3.0 feet	3.5 feet
Within 100 feet of a structure	4.0 feet	4.0 feet
Upstream end of a levee	3.5 feet	3.5 feet
Minimum Freeboard	n/a	1.0 foot or 0.2E

**Note that this criteria is relative to the 1-percent water surface elevation without sea level rise*

Project Design Criteria

Levees

Levees will be designed with a maximum slope of 2:1, with most slopes not exceeding 3:1 (H:V) for enhanced vegetation establishment. Top of levee elevations will be 18 feet NAVD88 to match the protection provided by the District project. Despite not being regulatory levees without sea level rise, as described previously, project levees will be designed in full compliance with National Flood Insurance Program (NFIP) and USACE freeboard criteria, to provide an equivalent level of flood protection as the District's design reaches. Top of levee width will vary between 12 feet and 40 feet. Additional width has been included to allow for future sea level rise adaptation.

Levee Vegetation

Vegetation will be located within the channel, the levee top and the outboard side of the levee. Vegetation will consist of native shrubs, grasses and trees. Care will be given to selecting planting palettes and spacing to allow for channel maintenance from the top of levee access roads.

The USACE vegetation policy[4] for levees forbids the planting of levees or within 15 feet on each side with any planting except perennial grasses as shown by Figure 9. However, the Corps policy applies only to projects with USACE partnership which is not a consideration at this site. As previously explained the proposed project levee is not considered to be a levee subject to Federal regulations as the 1-percent water surface elevation without sea level rise is below natural grade. Additionally, The Corps provides a variance to the vegetation guidelines in Section 1-2(b) in order to enhance environmental values and natural resources. The establishment of a riparian corridor would "enhance local environmental and aesthetic values". For these reasons the Corps levee vegetation policy does not apply to this project.

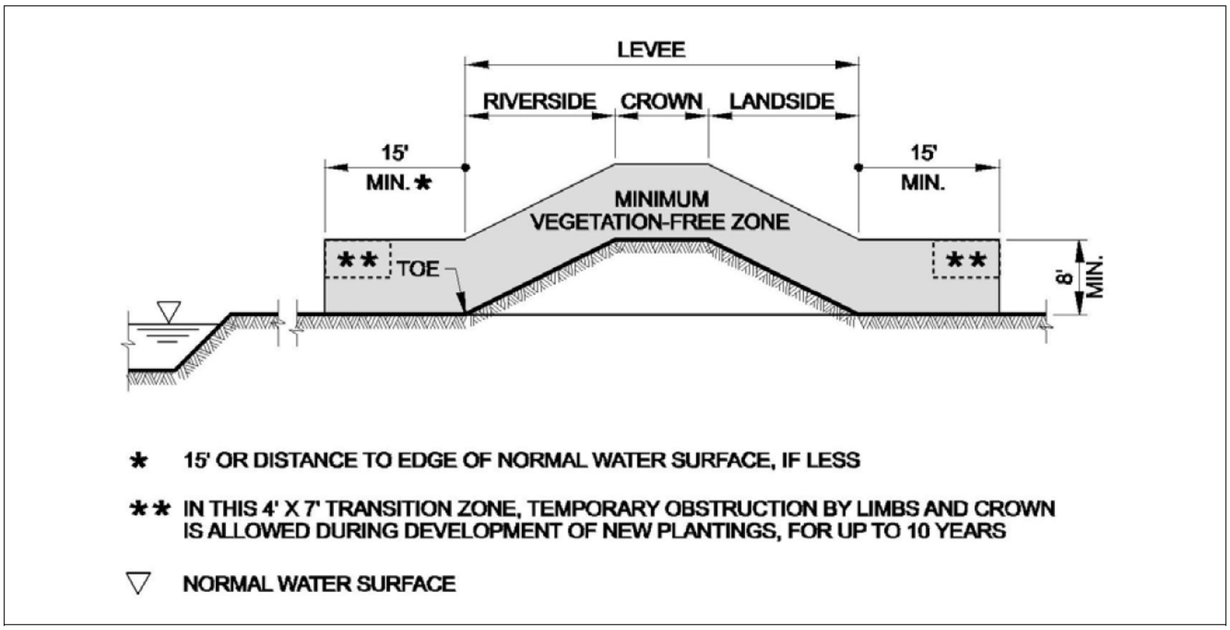

Figure 9: Army Corps Vegetation Free Zone

Vegetated Benches

The project proposes vegetated benches within the expanded channel to allow for habitat development and vegetation establishment.

Floodwalls

Floodwalls within the project reach are limited to the transitions from the District floodwalls to the enhanced project levee tops. Floodwalls will be constructed as part of the headwall replacement upstream of Caribbean Drive. This extended wing wall will taper between the bridge and the levees at elevation 18 feet. The second set of floodwalls south of Caspian will be tapered to meet the abutments of

[4] *USACE, ETL 1110-2-583, 30 April 2014*

the Caspian Bridge extension with a top of wall and bridge elevation of 18 feet. Floodwalls will be designed to meet District design criteria and provide at least 4 feet of freeboard above the design water surface elevation.