Design Criteria Matrix

SUMMARY

·ALEXANDER AVE, North end of Golden Gate Bridge to Sausalito city limit

·begins immediately at the US 101 and Alexander Avenue interchange and ends in Sausalito, for 1.6 kilometers of roadway

·Alexander Ave is classified as major urban arterial route with posted speeds of 45, 35, 25 and 15 mph approaching Sausalito. Roadway winds in a north-south direction through GGNRA

·shared use facility for bicyclist and pedestrians traveling on the shoulder

·two-lane road with median left turn lane at intersection of Alexander Ave/Danes Dr.

·Roadway owners: GGBHTD & Caltrans through easement agreement with NPS

DESIGN STANDARDS FOR ALEXANDER AVENUE

·NPS		
·CFLHD	http://flh.fhwa.dot.gov/resources/manuals/pddm/	Federal Lands Highway Project Development and Design Manual, March 2008
·AASHTO	http://design.transportation.org/Pages/AASHTODesignPublications.aspx	Model Drainage Manual, 2006
·Caltrans	http://www.dot.ca.gov/hq/oppd/hdm/hdmtoc.htm	Highway Design Manual

SUMMARY OF APPLICABLE DESIGN STANDARDS

DESIGN CRITERIA	AGENCY		
	CFLHD	CALTRANS	APPLIED CRITERIA
ROADWAY CLASSIFICATION			
· High-Standard Road	· Design speed > 70 km/hr (45 mph)	***· Conventional Highways***	
	· Design Average Daily Traffic (ADT) > 1500	· Urban Arterial streets, speed 40-60 mph (Ch 100, Table 101.2)	
	· Designated as a critical access road (ex: emergency evacuation routes, sole access to a community, or sole access to critical facilities such as hospitals power plants, water supply and wastewater treatment facilities)		
· Low-Standard Road	· All others		
HYDROLOGY			
	· Rational Method	***· Rational Method***	
	· basin less than 200 acres (80 hectares), 7-22	· basin less than 320 acres	· basin less than 200 acres (80 hectares), 7-22
	· use methods presented in HDS 2 *Highway Hydrology, 7-22*	· concentration time less than 1 hour	
	· use additional quidance presented in HEC 22 *Urban Drainage Design Manual, 7-22*	· storm duration ≥ concentration time	
	· use state deparment or transportation or local flood control agency developed IDF curves	· rainfall uniformly distributed in time and space	
	· for states that are included in the NOAA Atlas 14, an IDF curve can be obtrained directly from the NWS PFDS. For states not covered by Atlas 14, use procedures give in Appendix A of HEC 12. 7-22	· runoff is primarily overland flow · negligible channel storage	
DESIGN CRITERIA			
	· USGS Regional Regression Equations	***· Regional Regression Equations***	
	· peak flows may be be estimated for recurrence intervals ranging from 2 to 500 years for natural streams	· catchment area limit varies by region, use north coast for this project	
		· basin not located on floor of Sacramento or San Joaquin Valleys	
	· Primarily for natural, undeveloped watersheds, with exception for some urbanized areas where regression equations have been developed (otherwise use NFF program or HDS 2 for urban areas)	· Peak discharge value for flow under natural conditions unaffected by urban development and little or no regulation by lakes or reservoirs	
	·ungaged channel or insufficient gage data	·ungaged channel	
	· NRCS (TR55)	*· NRCS (TR55)*	
	· small drainage areas	· small or midsize catchment (< 3 sq mi)	
	· concentration time between 0.1-10 hour	· concentration time range from 0.1-10 hour (tabular hydrograph metod limit < 2 hour)	
	· WinTR-55 computer software package for areas smaller than 6,500 hectares=25 sq mi=16,000 acres	· runoff is overland and channel flow	
		· simplified channel routing	
		· negligible channel storage	
	· Unit Hydrograph (Gaged data)	*· Unit Hydrograph (Gaged data)*	
	· HDS 2, Chapter 6	· midsize or large catchment (0.20 sq mi to 1,000 sq mi)	
	· most common method, NRCS procedure documented in NEH Part 630 of the NRCS *National Engineering Handbood*	· uniformity of rainfall intensity and duration	
	· WinTR-55 computer program generally applicable for areas < 6,500 ha=25 sq mi	· rainfall-runoff relationship is linear	
		· duration of direct runoff constant for all uniform-intensitey storms of same duration, regardless of differences in the total volume of the direct runoff.	
		· time distribution of direct runoff from a given storm duration is indepenent of concurrent runoff from preceding storms	
		· channel-routing techniques used to connect streamflows	

SUMMARY OF APPLICABLE DESIGN STANDARDS			
DESIGN CRITERIA	AGENCY		
	CFLHD	CALTRANS	APPLIED CRITERIA
		· *Statistical (Gage Data)*	
		· midsize or large catchments with stream gage data	
		· appropriate station and/or generalized skew coefficient relationship applied	
		· channel storage	
		· *Basin Transfer of Gage Data*	
		· similar hydrologic characteristics	
		· channel storage	
CROSS DRAINAGE			
· METHODOLOGY	· FHWA HDS 5 "Hydraulic Design of Highway Culverts"	· FHWA HDS 5 "Hydraulic Design of Highway Culverts"	· FHWA HDS 5 "Hydraulic Design of Highway Culverts"
	· HY8	· AASHTO highway Drainage Guidelines	· HY8
· SELECTION OF DESIGN FLOOD			
BRIDGES		· Pass 2% probability flood (50-year)	
		· Clearance between low chord and 1% probability flood (100-year)	
		· 2-feet of freeboard is often assumed for preliminary bridge designs	
· CULVERTS	***· High Standard***	***· For all roadway classes, both storms should be considered***	
	· Culverts will convey runoff from the 50-year flood, 7-27	· 1% probability flood (100-year) without headwaters rising above an elevation that would cause objectionable backwater depths or outlet velocities, 820-2	· 1% probability flood (100-year) without headwaters rising above an elevation that would cause objectionable backwater depths or outlet velocities, 820-2
	· Culverts for temporary detours will convey runoff from the 10-year flood, unless seasonal construction justifies a lower standard, 7-27	· 10% probability flood (10-year) without causing the headwater elevation to rise above the inlet top of the culvert, 820-2	
	· *Low Standard*		
	· Culverts will convey runoff from the 25-year flood, 7-27	· 10% probability flood (10-year) without causing the headwater elevation to rise above the inlet top of the culvert	
	· Culverts for temporary detours will convey runoff from the 2-year flood, unless seasonal construction justifies a lower standard, 7-27		
· MATERIAL	· Prefer to use CMP to maintain existing conditions, but will consider these materials: reinforced concrete, steel, aluminum, and plastic but are not all applicable, 7-30 & 7-49, 7.3.6	· Reinforced concrete prefered (852.1)	CMP or RCP - will be based on who will maintain
· COVER		· Minimum of 1-foot	
		See Table 856.5, See Index 626.2 for criteria for when and how to use flexible or rigid shoulders (Note 4 Fig 602.1, 600-4)	
METAL	· Diameter 12" to 96", minimum cover 12" FLH 602-1	***· Flexible Pavements***	
	· Diameter 102" to 144", minimum cover 18" FLH 602-1	· 1/5 (diameter or span) or 2-feet minimum	· 1/5 (diameter or span) or 2-feet minimum
		· Rigid Pavements	
		· 1/5 (diameter or span) or 1.2-feet minimum	· 1/5 (diameter or span) or 1.2-feet minimum
CONCRETE	· Diameter 12" to 96", minimum cover 12" FLH 602-7	***· Flexible Pavements***	
	· Diameter 108", minimum cover 14" FLH 602-7	· 2-feet minimum	· 2-feet minimum
		· Rigid Pavements	
		· 1-feet minimum	· 1-feet minimum
· ANCHORS	· Pipe anchors are required for any exposed pipe, (i.e., laid on embankment fill or natural ground). Use pipe anchors for concrete pipe on a slope of ≥ 10% and fro CMP pipes on a slope ≥ 25%, 7-30	· Where the pipe diameter is ≤ 60" and the pipe slope is ≥ 33% and fill over top of pipe < 1.5 times outside diameter of pipe measured perpendicular to slope	· Where the pipe diameter is ≤ 60" and the pipe slope is ≥ 33% and fill over top of pipe < 1.5 times outside diameter of pipe measured perpendicular to slope
		· Where the pipe diameter is > 60" and the pipe slope is ≥ 33% regardless of fill over top of pipe	
· SKEW	· Maximum culvert skew, relative to the roadway centerline is 45 degrees	· Eliminate small skews, retain moderate, reduce either	· Maximum culvert skew, relative to the roadway centerline is 45 degrees
· ENTRANCE TREATMENTS	· New structures	· Should be considered to improve culvert function	· New structures
	· Pipe diameter ≤ 48" (1200 mm) : flared end sections	· FES recommended at both ends	· Pipe diameter ≤ 48" (1200 mm) : flared end sections
	· Pipe diameter ≥ 48" (1200 mm) : headwalls (with beveled edges)		· Pipe diameter ≥ 48" (1200 mm) : headwalls (with beveled edges)
	· Multiple pipes : headwalls (with beveled edges)		· Multiple pipes : headwalls (with beveled edges)
	· Long culverts under inlet control : tapered inlets (improved inlets)		· Long culverts under inlet control : tapered inlets (improved inlets)
· OUTLET TREATMENTS	· Riprap, CFL C255-50 or HEC 14, design up to 50-year flood, 7-92	· flared end section or headwall is required for circular culverts 60" or greater in diameter and for pipe arches of equivalent size	· Riprap, CFL C255-50 or HEC 14, design up to 50-year flood, 7-92
	· Energy Dissipator, HEC 14, HY8	· Energy Dissipator, HEC 14, velocities > 18 fps, 820-9	· Energy Dissipator, HEC 14, HY8
· HEADWATER ELEVATION	***· Existing Culverts***	· Not stated	

SUMMARY OF APPLICABLE DESIGN STANDARDS

DESIGN CRITERIA	AGENCY		
	CFLHD	CALTRANS	APPLIED CRITERIA
	· Headwater elevation will not be greater than the shoulder hinge point at the local roadway low point (i.e. ponding will not be allowed to spread onto the shoulder of the roadway)		· Headwater elevation will not be greater than the shoulder hinge point at the local roadway low point (i.e. ponding will not be allowed to spread onto the shoulder of the roadway)
	· New Culverts		
	· Headwater elevation will not be greater than the bottom of the aggregate base layer for the roadway pavement structure at the local roadway low point		· Headwater elevation will not be greater than the bottom of the aggregate base layer for the roadway pavement structure at the local roadway low point
	· Temporary Culverts		
	· Headwater elevation will not be greater than the shoulder hinge point at the local roadway low point (i.e. ponding will not be allowed to spread onto the shoulder of the roadway)		· Headwater elevation will not be greater than the shoulder hinge point at the local roadway low point (i.e. ponding will not be allowed to spread onto the shoulder of the roadway)
· HW/D RATIO	· culverts ≤ 48" (1200 mm) : 1.5	· Not stated	· culverts ≤ 48" (1200 mm) : 1.5
	· culverts > 48" (1200 mm) : 1.2		· culverts > 48" (1200 mm) : 1.2
	· Debris or Sediment: ration between 0.8 - 1.0, if sedimetation is a concern		
· MINIMUM SIZE	· 24" (600 mm) or equivalent	· 18" or equivalent, if pipe exceeds 100-feet minimum pipe should be 24"	· 24" (600 mm) or equivalent
· MINIMUM SLOPE	· ≥ 2% whenever possible, minimum of 0.5%, maximum of 10% for concrete pipes or 25% for metal pipes, without using pipe anchors	· Not stated	· ≥ 2% whenever possible, minimum of 0.5%, maximum of 10% for concrete pipes or 25% for metal pipes, without using pipe anchors
	· minimum of 0.5%		
	· maximum of (without using pipe anchors)		
	· 10% for concrete pipes		
	· 25% for metal pipes		
	· where practical, the pipe slope should equal or exceed the roadside ditch grade		
ROADSIDE DITCHES			
· SELECTION OF DESIGN FLOOD			
· METHODOLOGY	· HEC 15		
· DITCH CAPACITY	· Convey the runoff from the 10-year flood for both High- and Low-Standard roadways, but capacity should not exceed 50 cfs, 7-33 & 7-34	· Not stated	· Convey the runoff from the 10-year flood for both High- and Low-Standard roadways, but capacity should not exceed 50 cfs, 7-33 & 7-34
· DEPTH	***· Existing Ditches***		
	· Depth shall not exceed the shoulder hinge point on the roadway (i.e. flow should not spread onto the shoulder of the roadway)	· Not stated	· Depth shall not exceed the shoulder hinge point on the roadway (i.e. flow should not spread onto the shoulder of the roadway)
	· New Ditches		
	· Depth shall not exceed the elevation of the bottom of the aggregate base layer for the roadway pavement sturcture		· Depth shall not exceed the elevation of the bottom of the aggregate base layer for the roadway pavement sturcture
CULVERTS	· Convey the runoff from the 10-year flood for both High- and Low-Standard roadways	· Not stated	· Convey the runoff from the 10-year flood for both High- and Low-Standard roadways
· MINIMUM CULVERT SIZE	· 18" (450 mm) or equivalent	· 12" or equivalent or 18" if self-cleansing velocities are not produced	· 18" (450 mm) or equivalent
· DEPTH	***· Existing Ditches***		
	· Depth shall not exceed the shoulder hinge point on the roadway (i.e. flow should not spread onto the shoulder of the roadway)	· Not stated	· Depth shall not exceed the shoulder hinge point on the roadway (i.e. flow should not spread onto the shoulder of the roadway)
	· New Ditches		
	· Depth shall not exceed the elevation of the bottom of the aggregate base layer for the roadway pavement sturcture		· Depth shall not exceed the elevation of the bottom of the aggregate base layer for the roadway pavement sturcture
· SLOPE	· Minimum of 0.5%, desired minimum of 1.0%	· Minimum of 0.25% for earth ditches, 0.12% for paved ditches	· Minimum of 0.5%, desired minimum of 1.0%
· STABILITY	· For the 10-year flood for both High- and Low-Standard roadways , HEC 15 (7.3.2.2.2)	· When grade is steep enough to cause erosion, the ditch should be paved. Permissible velocities range from 2.5 ft/s to 10 ft/s depending on the soil type, See Table 862.2 & 873.3E)	Both
		· Fine loam (NRCS, dominant soil is 79% Tamalpais-Barnabe variant very gravelly loams) 3.5 fps for intermittent flow, 3.5 for sustained flow (Table 862.2)	
		· When ditch grade exceeds 4:1 slope, a downdrain is advisable	
· TEMPORARY LINING	· Temporary channel linings should be stable for the 2-year flood, 7-34	· Not stated	· Temporary channel linings should be stable for the 2-year flood, 7-34
· OVERSIDE DRAINS		· Metal or plastic	· Metal or plastic
		· Used where side slopes are ≥ 4:1	· Used where side slopes are ≥ 4:1
		· Minimum pipe diameter is 8"	· Minimum pipe diameter is 8"
		· Energy dissipator should be used to prevent erosion	· Energy dissipator should be used to prevent erosion
		· For slopes ≥ 3:1 drains should be anchored with 6-foot pipe stakes	· For slopes ≥ 3:1 drains should be anchored with 6-foot pipe stakes
MEDIAN DRAINAGE			
· DRAINAGE ACROSS MEDIAN	· Inlets are required immediately upstream of median breaks	· If sheet flow is allowed to cross median, slot drains or an equivalent facility should be used (See Standard Plan D98-B for slotted drain details)	· Inlets are required immediately upstream of median breaks
· GRADE AND CROSS SLOPE		· In Existing conditions control median grades and attainable cross slope on rehabilitation projects	
		· Earth medians, minimum desirable grade is 0.25%	
		· Paved medians, minimum desirable grade is 0.12%	

SUMMARY OF APPLICABLE DESIGN STANDARDS			
DESIGN CRITERIA	AGENCY		
	CFLHD	CALTRANS	APPLIED CRITERIA
STREAM CROSSINGS			
· SELECTION OF DESIGN FLOOD	· Designed to carry the design discharge from a basin without exceeding the allowable headwater criteria		
	· Pipe slope will generally conform to the average streambed flow line and should match channel elevations on both the upstream and downstream sides		
ROADWAY DRAINAGE			
· STORM DRAIN METHODOLOGY	· HEC-22	· HEC-22	· HEC-22
· SELECTION OF DESIGN FLOOD	· On-grade, Sags, and Parking Areas: Design roadway conveyance and collection systems for the 10-year flood (7.3.4)	· Urban speeds 45 mph and under, 10-year, and Local Standards fro Design water spreard, Table 831.3	· Urban speeds 45 mph and under, 10-year, and Local Standards fro Design water spreard, Table 831.3
	· Sumps: Design drainage inlet system to accommodate the 50-year flood	· For depressed Sections the 2% or 50-year design storm shall be used	· For depressed Sections the 2% or 50-year design storm shall be used
· INLET CLOGGING FACTOR	***· On-grade***		
	· Assume that on-grade inlets are not subject to debris clogging, unless clogging is a known problem	· Not stated, but typically 50%, 830-14	· Assume that on-grade inlets are not subject to debris clogging, unless clogging is a known problem
	· Sumps and Sags		
	· Grate Inlets: 50%		· Grate Inlets: 50%
	· Curb Inlets: Assume that on-grade inlets are not subject to debris clogging, unless clogging is a known problem		· Curb Inlets: Assume that on-grade inlets are not subject to debris clogging, unless clogging is a known problem
	· Rehabilitation Projects: Assume ALL inlets are not subject to clogging, unless clogging is a known problem		· Rehabilitation Projects: Assume ALL inlets are not subject to clogging, unless clogging is a known problem
· INLET TYPE	· Type 1 Catch Basin - grate inlet with a tilt-bar grate (Type A or B), intended for use on-grade in a curb and gutter section or in a ditch flowline, 7-40	· Standard Plan D72 through D75, D98-A and D98-B (See Figure 837.1, Storm Drain Inlet T ypes)	· Standard Plan D72 through D75, D98-A and D98-B (See Figure 837.1, Storm Drain Inlet T ypes)
	· Type 2 Catch Basin with Down Drain - Grate Inlet with a tilt-bar grate (Type A or B), intended for use on-grade and gutter section, roadway in fill, 7-40	Type OS and OL for Type A or B curbs	Type OS and OL for Type A or B curbs
	· Type 5A Inlet - Grate Inlet with a P 64 x 108 (P 2.5 x 4.24) grate, for use on-grade or in sags, 7-40	Standard Plan D77B for bicycle proof grates	Standard Plan D77B for bicycle proof grates
	· Type 6B Inlet - Grate inlet with a cast iron grate, for use in valley gutters or parabolic ditches, 7-40	Type GO and GDO for Combination inlets	Type GO and GDO for Combination inlets
	· Type 7A/B Inlet - Grate inlet with wide bar-spacing, for use in a ditch flowline, 7-40		
· CAPTURE EFFICIENCY	· The minimum recommended capture efficiency for on-grade inlets is 70%, 7-39	· Not stated	· The minimum recommended capture efficiency for on-grade inlets is 70%, 7-39
· SPREAD	***· High Standard***		
	· Spread shall not exceed 3-feet (90 mm) of one travel lane for gutter flow, both on-grade and in roadway sags	· Local Standards (Ch 830, Table 831.3)	· Spread shall not exceed 3-feet (90 mm) of one travel lane for gutter flow, both on-grade and in roadway sags
	· Low Standard		
	· Spread shall not exceed half of one travel lane for gutter flow, both on-grade and in roadway sags		
· DEPTH	· On-grade and Sags: the flow depth at the curb should not exceed the curb height or the allowable spread for the design discharge	· Depth of 0.5 the curb height for grades up to 10%, and 0.4 the curb height for grades over 10% in locations where parking is allowed or where driveways are constructed, 830-9	· On-grade and Sags: the flow depth at the curb should not exceed the curb height or the allowable spread for the design discharge
	· Sumps: the depth of flow at the gutter flowline shal not exceed 6" (150 mm)		· Sumps: the depth of flow at the gutter flowline shal not exceed 6" (150 mm)
	· Parking Areas: inlets adjacent to curbs, the flow depth should not exceed the curb height; for sags the depth of flow at the gutter flowline shall not exceed 6" (150 mm)		· Parking Areas: inlets adjacent to curbs, the flow depth should not exceed the curb height; for sags the depth of flow at the gutter flowline shall not exceed 6" (150 mm)
· MIN DIAMETER	· 15" or equivalent	· Trunk Drain 18"	· Trunk Drain 18"
		· Trunk laterals 15" (18" if wholly or partly under roadbed)	· Trunk laterals 15" (18" if wholly or partly under roadbed)
		· Inlet laterals 15" (18" if wholly or partly under the roadbed)	· Inlet laterals 15" (18" if wholly or partly under the roadbed)
· MIN SLOPE	· Sufficient to develop a self-cleansing velocity of 0.9 m/s (3 fps) when flowing full, slope less than 0.5% should be avoided for constructability reasons	· Minimum longitudinal slope should be such that when flowing half full, a self cleaning velocity of 3 fps is attained	· Sufficient to develop a self-cleansing velocity of 0.9 m/s (3 fps) when flowing full, slope less than 0.5% should be avoided for constructability reasons
· HGL	· Compute the HGL over the full length of storm drains with 4 or more inlets connected in series	·should be designed for full flow conditions	· Compute the HGL over the full length of storm drains with 4 or more inlets connected in series
	· in sections where the HGL for design flood must exceed the pipe soffit (pipe flows under pressure) the HGL for the design flood will remain below the ground elevation at all inlets and access structures, and watertight gaskets should be specifid for the pipe joints	· closed conduits allowed to operate under pressure, provided the hydraulic gradient is 0.75 feet or more below the intake lip of any inlet that may be affected	· in sections where the HGL for design flood must exceed the pipe soffit (pipe flows under pressure) the HGL for the design flood will remain below the ground elevation at all inlets and access structures, and watertight gaskets should be specifid for the pipe joints
		· energy gradient s hould not rise above the lip of the intake	· energy gradient s hould not rise above the lip of the intake
· SPACING B/W STRUCTURES	· 15"-24" (375mm-600mm) 300' (90m)	< 48" 300-700'	· 15"-24" (375mm-600mm) 300' (90m)
	· 27"-36" (675mm-900mm) 400' (120m)		· 27"-36" (675mm-900mm) 400' (120m)
	· 42"-54" (1050mm-1350mm) 600' (180m)	· ≥ 48" 700-1200'	· 42"-54" (1050mm-1350mm) 600' (180m)
	· 60"+ (1500mm +)1000' (300m)	· if self-cleansing velocity of 3 fps are unobtainable 300' spacing should be used	· 60"+ (1500mm +)1000' (300m)
· INLET LOCATION	· At all low points in the gutter grade, 7-39	· Sag points, 830-14	Guidelines are the same
	· Immediately upstream of median breaks, entrance/exit ramp gores, cross walks, and street intersections, i.e., at any location where a concentrated flow path could flow onto the travel lanes, 7-39	· Points of superelevation reversal, 830-14	

SUMMARY OF APPLICABLE DESIGN STANDARDS

DESIGN CRITERIA	AGENCY		
	CFLHD	CALTRANS	APPLIED CRITERIA
	· Immediately upgrade of bridges (to prevent water from flowing onto bridge decks), 7-39	· Upstream of ramp gores, 830-14	
	· Immediately dowstream of bridges (to intercept bridge deck drainage), 7-39	· Upstream and downstream of bridges - bridge drainage design prodedure assumes no flow onto bridge from approach roadway, and flow off bridge to be handled by the district, 830-14	
	· Immediately up grade of cross-slope reversals, 7-39	· Street intersections, 830-14	
	· Immediately up grade from pedestrian cross walks, 7-39	· Upstream of pedestrian crosswalks, 830-14	
	· On side streets immediately upgrade from intersections, 7-39	· Upstream of curbed median openings, 830-14	
	· At the end of channels in cut sections, 7-39		
	· Behind curbs, shoulders, or sidewalks to drain low areas, 7-39		
	· Additional on-grade inlets spaced to meet the allowable spread criteria, 7-39		
· OVERSIDE DRAINS		834.4	
Pipe Downdrains		· Metal & plastic adaptable to any slope	· Metal & plastic adaptable to any slope
		· slopes 4:1 or steeper	· slopes 4:1 or steeper
		· long pipe downdrains should be anchored	· long pipe downdrains should be anchored
		· Min 8", but large flows, debris or long pipe installations may dictate a larger diameter	· Min 8", but large flows, debris or long pipe installations may dictate a larger diameter
		· watertight joints to prevent leakage, causing slope erosion	· watertight joints to prevent leakage, causing slope erosion
		· Standard Plan D87-A for pipe tapers	· Standard Plan D87-A for pipe tapers
Flume Downdrains		· corrugated metal flumes with tapered entrance	· corrugated metal flumes with tapered entrance
		· Standard Plan D87-D	· Standard Plan D87-D
		· best for slopes 2:1 or flatter, if 1.5:1 lengths over 60' are not recommended	· best for slopes 2:1 or flatter, if 1.5:1 lengths over 60' are not recommended
Paved Spillways		· only use on 4:1 or flatter	· only use on 4:1 or flatter

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MEMORANDUM

TO: Matt Wessell, P.E., PBS&J Project Manager

Tammy Kirkbride, P.E., PBS&J Water Resource Engineer

FROM: Amy Finseth, PBS&J Water Resources Engineer

DATE: January 13, 2009

SUBJECT: Hydrologic and Hydraulic Criteria and Computational Methods Technical Memorandum
Alexander Avenue
Task Order Number: CA PRA GOGA 99(2)
PBS&J Project No. 100011041

Acronyms

AASHTO: American Association of State Highway and Transportation Officials
Caltrans: California Department of Transportation
CEQA: California Environmental Quality Act
CFLHD: Central Federal Lands Highway Division
FEMA: Federal Emergency Management Agency
FLH: Federal Lands Highway
FHWA: Federal Highway Administration
GGBHTD: Golden Gate Bridge, Highway and Transportation District
GGNRA: Golden Gate National Recreational Area
HEC: Hydraulic Engineering Circular
HDS: Hydraulic Design Series
HDM: Highway Design Manual
NEPA: National Environmental Policy Act
NOAA: National Oceanic and Atmospheric Administration
NRCS: Natural Resource Conservation Service
NPS: National Park Service
PDDM: Project Development and Design Manual
PWR: Pacific West Region
USDOT: United States Department of Transportation
USGS: United States Geological Survey

1.0 Purpose

The purpose of this Hydrologic and Hydraulic Criteria and Computation Methods Technical Memorandum is to provide a brief summary of the applicable criteria that will be applied to the planning study and for proposed improvements for Alexander Avenue.

2.0 Project Background and Description

The Federal Highway Administration, Central Federal Lands Highway Division, in cooperation with the National Park Service, Pacific West Region, Golden Gate National Recreational Area, California Department of Transportation, Golden Gate Bridge, Highway and Transportation District, Marin County and the City of Sausalito are proposing a planning study to identify deficiencies along the corridor and to develop conceptual alternatives for improvements to Alexander Avenue corridor. Alexander Avenue begins immediately at the US 101 and Alexander Avenue interchange, just north of the Golden Gate Bridge. The project extends for 1.6 kilometers (1.0 mile) to the City of Sausalito in Marin County. Alexander Avenue is classified as a major urban arterial route that functions as a shared use roadway for bicyclists and pedestrians traveling on the shoulder. Alexander Avenue also services several bus routes. Within the study limits, Alexander Avenue is primarily a two-lane road with a median left turn lane at the intersection of Alexander Avenue and Danes Drive. The owners of Alexander Avenue are GGBHTD and Caltrans through an easement agreement with NPS. The southern section, from Conzelman Road intersection to north of Highway 101 interchange are owned and operated by Caltrans. The northern section from north of Highway 101 interchange to the City of Sausalito is owned by GGBHTD.

The general scope of this study is to conduct a coordinated, comprehensive evaluation of Alexander Avenue Corridor and to develop a multi-jurisdictional corridor management plan that includes stakeholder input and consensus on a set of prioritized improvements for Alexander Avenue. The study will build upon and update existing studies within the GGNRA and incorporate the most recent transportation forecasts based upon current land use plans for the county, park, and district throughout the corridor.

The proposed study will closely follow the existing road incorporating new design elements, as appropriate, to improve the roadway to current standards, reduce congestion, and better accommodate the mixed traffic uses. These elements will be designed and implemented in accordance with NPS, CFLHD, AASHTO, and Caltrans highway design standards. Input to the project elements will come from the stakeholder team which includes the GGNRA, PWR, GGBHTD, Caltrans, City of Sausalito, and Marin County.

Specific hydrologic and hydraulic components to the scope of this planning study will include the development of applicable criteria memorandum, identification and evaluation of existing drainage facilities, identify and evaluate potential floodplain encroachments and channel stability issues, support the planning process with water quality recommendations, preparation of a technical memorandum to document existing hydraulic conditions, and develop recommendations for proposed conditions as the study progresses.

At the completion of the study and compilation of alternatives NEPA and CEQA studies will be conducted.

3.0 Drainage Criteria References

Drainage analysis and design work associated with the proposed improvements will be in accordance with the methods, guidelines, and criteria set forth by NPS, CFLHD, AASHTO, and Caltrans highway design standards. Of these agencies FLH (CFLHD) and Caltrans have developed drainage criteria manuals establishing guidance or references to aid in the design process and or specific design standards.

- Federal Lands Highway Project Development and Design Manual (FLH PDDM, March 2008)
- California Department of Transportation, Highway Design Manual (Caltran HDM, September 2006)

A design matrix was developed with criteria from both agencies and the more stringent criteria will be applied as the design criteria for this planning study.

4.0 Hydrology

Hydrologic analysis for the Alexander Avenue planning study will be determined using the Rational Method. Design rainfall used for this analysis is based on criteria obtained from the National Oceanic and Atmospheric Administration and rainfall depth-duration-frequency data obtained from California Department of Water Resources from the Marin City Station (station number, E20 5342 35). Design Point Rainfall values for the site are shown in Table 1. These curves will be used with the Rational Method for the hydrologic comparative analysis performed as part of the drainage calculations.

Table 1: Design Point Rainfall

Return Period	1-hour (inches)	6-hour (inches)	24-hour (inches)
2-year	0.64	1.26	1.92
5-year	0.91	1.77	2.69
10-year	1.08	2.11	3.22
50-year	1.46	2.86	4.34
100-year	1.62	3.16	4.81

Watershed basin delineations will be prepared using available U.S. Geological Survey Quad maps and surveyed topography.

Soil survey data and maps were obtained from the NRCS. Based on the NRCS soil survey of the project area, the soils in the vicinity of Alexander Avenue are primarily part of the Tamalpais-Barnabe Variant. These soils have a slow infiltration rate. Additional soil types in the area include Cronkhite-Barnabe Complex and Xerorthents-Urban Land Complex. All of the soils are classified as a Type "C" hydrologic soil group. These soils have a "slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission" (NRCS).

Alexander Avenue lies within Flood Insurance Rate Map Panel numbered 06041C0526D and 06041C0528D. Alexander Avenue does not lie within a FEMA mapped flood zone.

5.0 Hydraulic Analysis

5.1 Culverts

Existing culverts will be evaluated for the 10-, 50- and 100-year events for potential encroachments and to determine water surface elevations and determine whether they meet current criteria. Culverts will be analyzed using HY8 Culvert Analysis software.

Corrugated metal pipe (CMP) is proposed for use with the culverts requiring replacement. Existing culverts will be evaluated, if they do not meet current criteria culverts will be replaced in-kind. Existing conditions will be evaluated during the first design phase. For proposed conditions, culverts will be evaluated and designed based on the lowest headwater elevation based on the criteria given in Table 3. It is recommended that culverts have end treatments to increase efficiency, embankment stability, aesthetics and safety for vehicles.

Table 3 summarizes the culvert requirements per FLH's PDDM and Caltrans Highway Design Manual.

Table 3: Culverts	
Storm Event:	100-year for proposed cross culverts (Caltrans) 50-year for proposed cross culverts (CFLHD) 10-year for culverts conveying roadside ditches
Headwater Elevation (HW)	• Existing: HW shall not be greater that the shoulder hinge point at the local roadway low point and not allowed to spread onto roadway shoulder • New: HW shall not be greater than the bottom of the aggregate base layer for the roadway pavement structure at the local roadway low point
HW/D Ratio	1.5 for culverts less than or equal to 48-inches 1.2 for culverts greater than 48-inches
Minimum Pipe Size	Cross Culverts : 24-inches or equivalent Parallel Culverts in ditches : 18-inches or equivalent
Slope	Minimum: 0.5% All Materials Desirable: Greater than or equal to 2% Maximum: 25% Metal, 10% Concrete
Cover	Flexible Pavements: 2-feet Rigid Pavements: 1.2-feet
Anchors	Metal: Slopes 25% or greater
Materials	Corrugated Metal Pipe
Maximum Culvert Skew	45-degrees with roadway centerline
End Treatments	For new structures: • Pipe diameters less than or equal to 48-inches, use flared end sections • Pipe diameters greater than 48-inches or multiple pipes, use headwalls with beveled edges
Outlet Protection	• No scour potential or expected scour can be tolerated: no protection required • Standard outlet treatment: simple riprap outlet protection, Standard Detail CFL C255-50 • Minimal Outlet Protection: bedding, filter material, geotextile • Energy Dissipator for velocities greater than 18 fps (Caltran)

5.2 Storm Drains

Table 4 summarizes design criteria and standards for inlets and Table 5 summarizes criteria for storm drain and culvert sizing.

Table 4: Inlets (Pavement Drainage)	
Storm Event	On-grade: 25-year (Caltrans) On-grade: 10-year (CFLHD) Sumps: 50-year
Spread	Shall not exceed the shoulder or parking lane or in depressed sections shall not exceed that of adjacent roadway sections
Depth	• On-grade: Depth not to exceed the curb height or allowable spread • Sumps: Depth not to exceed 6-inches • Parking areas: Inlets adjacent to curbs, the flow depth shall not exceed the curb height; for sags the depth of flow at the gutter flowline shall not exceed 6-inches
Inlet Clogging Factor	On-grade: no clogging factor, unless it has previously been a problem If clogging is considered minimum is 70% Sumps: • Grate Inlets: 50% • Curb Inlets: no clogging factor, unless it has previously been a problem • Rehabilitation Projects: no clogging factor, unless it has previously been a problem. If clogging is considered minimum is 50%
Inlet Types	• Catch Basin Type 1 (Standard 604-1) • Metal Frame and Grate Type B (Standard 604-3)

Table 5: Storm Drains	
Storm Event Capacity Design	On-grade: 25-year (Caltrans) On-grade: 10-year (CFLHD) Sumps: 50-year No pressure flow
Minimum size	• Trunk Line: 18-inches • Trunk Laterals: 15-inches (18-inches if wholly or partly under the roadbed) • Inlet Laterals: 15-inches (18-inches if wholly or partly under the roadbed)
Minimum Slope	3-feet per second to insure self cleansing 0.5% as a minimum for constructability
Hydraulic Grade Line (HGL)	• Needs to be calculated over the full length of storm drains with four or more inlets connected in a series • If the design flood creates pressure flow, the HGL must remain below ground elevation • Energy gradient should not rise above the lip of the intake
Spacing between structures	15 to 24-inches: 300-feet 27 to 36-inches: 400-feet 42 to 54-inches: 600-feet 60-inches and up: 1000-feet If self cleansing velocity of 3 fps is unobtainable, spacing of 300-feet should be used

5.3 Ditches/Open Channels

Roadside ditches will be analyzed using Bentley's FlowMaster. Table 6 summarizes the ditch requirements.

Table 6: Ditches	
Storm Event	10-year flood
Depth	• Existing Ditches: no greater than the shoulder hinge point • New Ditches: no greater than the bottom of the aggregate sub-base layer of the roadway pavement
Slope	Desired Minimum: 1.0% Allowable Minimum: 0.5%
Cross Section Shape	Vee, trapezoidal
Stability	• 10-year flood • Permissible velocities are 4.0 fps for intermittent flow and 2.5 fps for sustained flows in vegetated ditches • Temporary lining should be stable for the 2-year storm event
Erosion Protection	Lined with rock, stone, concrete

5.4 End Treatment

Where possible, all proposed outlets will be designed to include some degree of scour protection. The proposed treatments include either flared end sections or headwalls for the entrances of culverts and pipe rundowns for the outlets. Table 3 includes criteria for end treatments and outlet protection. Typical outlet protection will use CFL Detail C-255-50. If additional protection is required the design methods in HEC14 will be applied.

Where practical, outlet protection is recommended for the existing culverts that are exhibiting erosion. Outlet protection will be provided when feasible for each new cross culvert and will be sized using the design storm event for the proposed culvert. Culvert outlet protection will consist of paved rundowns or placed riprap aprons per the FHWA standards.

5.5 Construction Site BMPs

Erosion control measures will be used to protect the existing system and outfalls from sediment transport during construction. An erosion control plan will be prepared for the project based on FHWA Best Management Practices for Erosion and Sediment Control as well as Caltrans Storm Water Quality Handbooks, Project Planning and Design Guide. These plans will be prepared in the final Roadway Submittal. The follow erosion control practices will be used, but not limited to:

- Inlet protection
- Silt fence
- Erosion control logs
- Vehicle tracking control

Permanent (post-construction) erosion control measures will include revegetation, riprap aprons and pipe rundowns.

6.0 Summary

The information contained in this memorandum is only a summary of the applicable criteria. All criteria will be reviewed and adhered to by the project engineer. The review will check adherence to this criteria during the QA/QC process. Any changes to the design criteria during the design process will be noted in future memorandums.

Drainage analysis and design work associated with the proposed improvements will be in accordance with the methods, guidelines, and criteria set forth in the FLH PDDM (March 2008), USDOT FHWA HEC and HDS Publications and Caltran Highway Design Manual (September 2006).

7.0 Drainage Criteria References

AASHTO, Model Drainage Manual, 2006.

California Department of Water Resources, Rainfall Depth-Duration-Frequency Data for Marin City, 2005.

Caltrans, Storm Water Quality Handbooks, March 2003.

Caltrans, Highway Design Manual, September 2006.

FEMA, Flood Insurance Rate Map, Marin County, California, May 4, 2009.

FLH, Project Development and Design Manual, March 2008.

NRCS Version 4, Web Soil Survey, Marin County, California, December 2009.

NOAA Atlas 2, Volume XI-California, Precipitation-Frequency Atlas of the Western United States, 1973.

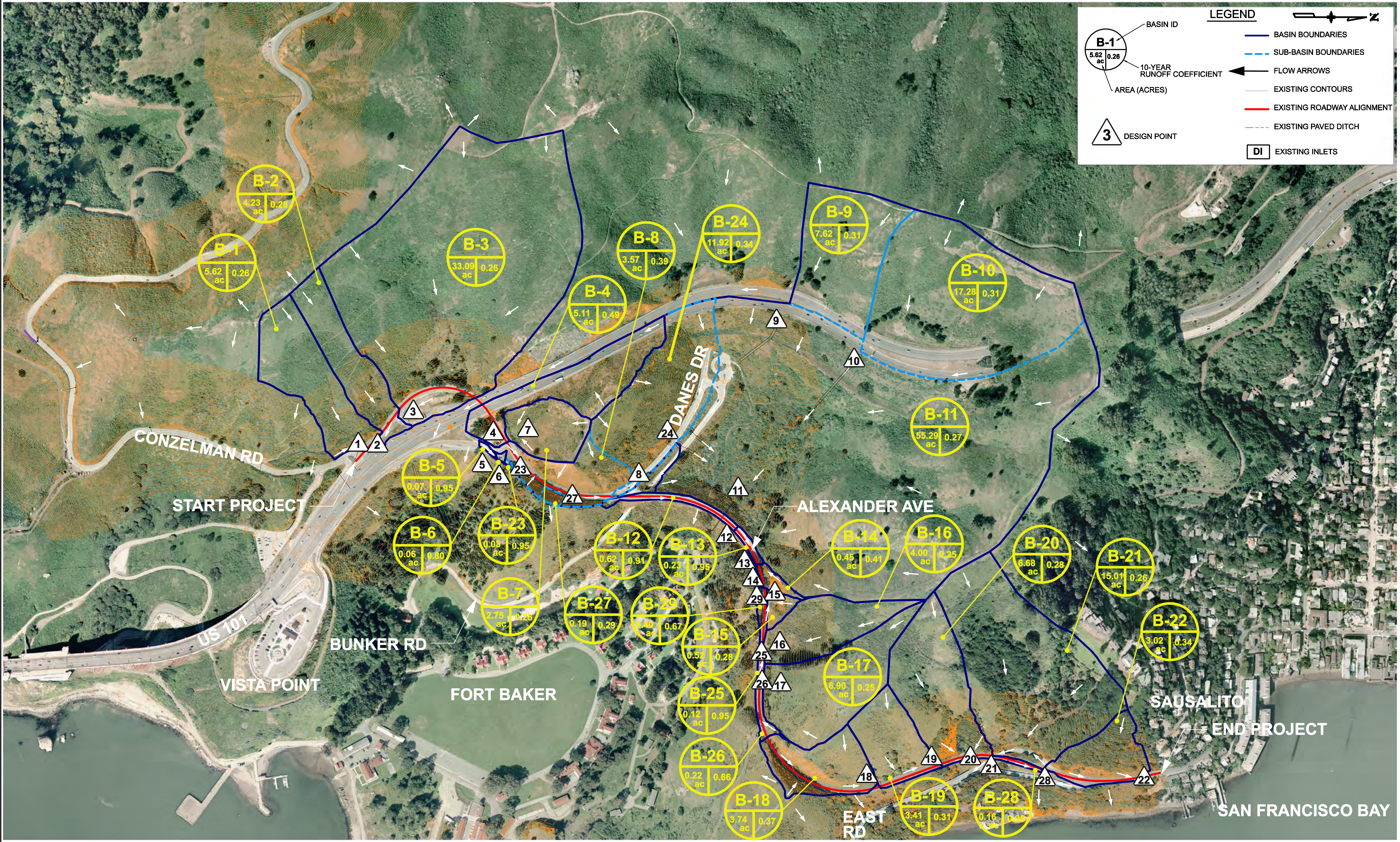
USDOT FHWA, HY-8, 2009.

USDOT FHWA, Hydraulic Design Series No. 2, October 2002.

USDOT FHWA, HEC No. 14, Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006.

USDOT FHWA, HEC No. 15, Design of Roadside Channels with Flexible Linings, April 1988.

USDOT FHWA, HDS No. 5, Hydraulic Design of Highway Culverts, September 1985.



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Index of Revisions

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EXISTING CONDITIONS BASIN MAP
ALEXANDER AVENUE PLANNING STUDY

Designer:
Detailer:
Sheet Subset: 1 of 1

Figure 1. Alexander Avenue Existing Drainage Structures