Quarry Park Watershed Assessment and Erosion Prevention Planning Project San Mateo County, California

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View of Quarry Park Property looking west from the top of the quarry.

1. INTRODUCTION

1.1 Background

In 2014, the San Mateo County Parks Department (County Parks) acquired additional land to form the current 567-acre Quarry Park Property (Property). The County's roles and responsibilities as a result of this acquisition include inherited (legacy) existing and/or potential conditions. In 2016, County Parks released a Request for Proposals (RFP) and Gates & Associates (Gates) submitted and was ultimately awarded a contract to develop a Master Plan for the Property. Pacific Watershed Associates (PWA) was part of the winning proposal team and retained by Gates to conduct a Watershed Assessment of the Property and provide an existing conditions report and erosion prevention prioritized plan of action. PWA is providing this summary report of findings resulting from our watershed assessment of the Property. The primary goals of this report are to: (1) provide a preliminary analysis of the existing conditions on the Property; (2) identify, describe and prioritize the most vulnerable areas of the Property; and (3) provide an erosion prevention prioritized plan of action. We understand that this document will be an attachment to the Master Plan which Gates is preparing for the Property.

1.2 Scope of Work

To assist Parks in the process of transforming this Property into a park, PWA's Watershed Assessment includes the following tasks:

- Conduct a comprehensive road and trail erosion assessment of the Property.
- Identify erosional features and categorize them as sediment delivery or non-sediment delivery sites.
- Identify potential areas of concern and potential stream reaches for prioritized rehabilitation.
- Map all observed utilities and infrastructure on the Property.
- Prepare an erosion prevention prioritized plan of action.
- Prepare a report of findings.

1.3 Acknowledgments

PWA staff appreciate the efforts made by many different individuals to make our assessment possible. First and foremost to the Parks staff for their funding in support of this project. And, in particular the following Parks staff that provided continued guidance, onsite field assistance, background literature and data: Sam Herzberg (Senior Planner), Ramona Arechiga (Natural Resource Manager), and Matt DelCarlo and Mark Rodgers (Park Rangers). Thanks to Gates for including us as part of the Master Plan's Project Team.

We would like to thank the original landowners for their initial purchase, their years of land stewardship, and release of land to complete the Quarry Park Property. We appreciate the support of the adjacent private landowners for permitting access to the Property via their properties. Finally, we wish to express our gratitude to a number of professionals whose previous work and detailed reports provided both baseline data and context for this Assessment. Please refer to the References Section for a list of publications and research cited in this report of findings.

2. CERTIFICATION AND LIMITATIONS

This report, entitled *Quarry Park Watershed Assessment and Erosion Prevention Planning Project*, was prepared under the direction of a licensed professional geologist at Pacific Watershed Associates, Inc. (PWA), and all information herein is based on data and information collected by PWA staff. Sediment-source inventory and analysis for the project, as well as erosion control treatment prescriptions, were similarly conducted by or under the responsible charge of a California licensed professional geologist at PWA.

The interpretations and conclusions presented in this report are based on a study of inherently limited scope. Observations are qualitative, or semi-quantitative, and confined to surface expressions of limited extent and artificial exposures of subsurface materials. Interpretations of problematic geologic and geomorphic features (such as unstable hillslopes) and erosion processes are based on the information available at the time of the study and on the nature and distribution of existing features.

The recommendations included in this report are professional opinions derived in accordance with current standards of professional practice, and are valid as of the submittal date. No other warranty, expressed or implied, is made. PWA is not responsible for changes in the conditions of the property with the passage of time, whether due to natural processes or to the works of man, or changing conditions on adjacent areas. Furthermore, to ensure proper applicability to existing conditions, the information and recommendations contained in this report shall be reevaluated after a period of no more than 3 years, and it is the responsibility of the landowner to ensure that no recommendations are inappropriately applied to conditions on the property that have changed since the recommendations were developed.

Finally, PWA is not responsible for changes in applicable or appropriate standards beyond our control, such as those arising from changes in legislation or the broadening of knowledge, which may invalidate any of our findings.

Certified by:

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3. EXISTING CONDITIONS

3.1 Location and Access Description

Located approximately 25 miles south of San Francisco and adjacent to the city of El Granada, the Quarry Park Property covers 567 acres of coastal foothills and a low-gradient coastal marine terrace that lies completely within San Mateo County (Map 1). Details on 2018 current access and conditions are found below. As of the date of this report, the main points of access for County Park staff include the following locations as depicted on Map 2 and summarized below.

3.1.1 Coastal Foothills Area Access locations

1. Main Parking Lot and Property Entrance: Gated access roads and open pedestrian access (Parking Lot, Map 2). Authorized vehicles and visitors can access the coastal foothill section of the Property at this entrance through three access points. There are two separate locked gates within close proximity to this location, Gate 1 and Gate 2 (Map 2), which provide vehicle access to main arterial roads that traverse the Property. Additionally, the restroom and playground area can be accessed from the southern edge of the parking area through an open pedestrian pathway. Gate 1 provides access to the Property via the Quarry Trail. Vehicle access through Gate 1 is primarily utilized by County Park staff, while the public utilizes the foot path adjacent to Gate 1 to access the Property. Gate 2 provides authorized vehicle and pedestrian access to the Property via the Meadow Trail. From Highway 1, head east on Coronado Street. Take a right on Cabrillo Ave. Travel east for one block and turn left onto Alameda. Take a right on Santa Maria Avenue and travel three blocks to the end of the road at the main parking lot for the Property.

2. Playground Entrance Pedestrian Access: This entrance provides open pedestrian access to the Property (Playground, Map 2). Vehicles cannot access the Property at this location; however there is a small ungated foot path leading from Columbus Street to the playground area. Visitors can access the woodland section of the Property at this entrance as well. From the road intersection of Santa Maria Avenue and Columbus Street travel approximately 300 ft to the south and take a left onto the pedestrian trail.

3. Coronado Street Pedestrian Access: This entrance provides open pedestrian trail access to South Ridge Trail (Map 2). Vehicles cannot access the Property at this location; however, there is trail access for hikers and bicyclists. From Highway 1, travel north east on Medio Avenue. Take the second left onto 5th Street. Travel one block on 5th Street and continue onto The Crossways for one block. Turn right onto Coronado Street and travel to the end of the street. There is no parking at this entrance to the Property.

4. Highway 1 Gate 3 Vehicle Access: This entrance provides gated access to Miranda East Fire Road (Gate 3, Map 2). Authorized vehicles can access the Property at this location with a key. In addition, there is trail access for hikers and bicyclists. This road is primarily accessed by vehicles for property maintenance and fire management purposes. From the intersection of Coronado Street and Highway 1 travel 0.34 miles southward on Highway 1. The gate is located just up the native surfaced road off Highway 1.

5. Dolphine Avenue Vehicle Access: This entrance provides gated access to Dolphine Fire Road and the connected trail system (Gate 4, Map 2). Authorized vehicles can access the Property at this location with a key. In addition, there is trail access for hikers and bicyclists. This road is primarily accessed by vehicles for property maintenance and fire management purposes. From

the intersection of Columbus Street and Santa Maria Avenue, travel north west on Columbus Street and turn right on Isabella Road. Turn right immediately onto El Granada Boulevard. Travel approximately 0.49 miles up El Granada Boulevard to the intersection with Dolphine Road. Take a right at the road intersection and travel down Dolphine Road to Gate 4. There is no parking at this entrance to the Property.

6. Private Drive Vehicle Access: This entrance provides gated access to the paved private drive leading to the private residence at the end of the paved road, and to the top of the South Ridge Trail and connected trail system (Gate 7, Map 2). Authorized vehicles can access the Property at this location with a key. Unauthorized access is not permitted through this gate. This road is primarily accessed by vehicles for property maintenance and fire management purposes. From the intersection of Columbus Street and Santa Maria Avenue, travel north west on Columbus Street and turn right on Isabella Road. Turn right immediately onto El Granada Boulevard. Travel approximately 0.74 miles up El Granada Boulevard to the road intersection at a locked double gate. There is no parking at this entrance to the Property and the public is not permitted to enter the park through this entrance.

3.1.2 Coastal Bluff Trail area Access Locations

1. Magellan Avenue Vehicle Access: This entrance provides open access to the Coastal Bluff Trail (Map 2). Authorized vehicles can access the Property through a locked bollard at this location with a key. In addition, there is trail access for pedestrians and bicyclists around the locked bollard. There is parking space for a small number of vehicles to park and a restroom at this location. From Highway 1, turn west onto Magellan Avenue. Travel approximately 275 feet down Magellan Avenue and turn right into the parking lot.

2. Highway 1 Coastal Bluff Trail Access: This entrance provides open access to the Coastal Bluff Trail (Map 2). Vehicles and pedestrians can access the Coastal Bluff Trail area at this entrance to the Property. A paved road runs through the length of this portion of the Property, and a cross walk allows for pedestrian traffic to cross Highway 1 and enter the Coastal Bluff Trial area. Vehicular access to this point can be gained via the Magellan Avenue locked bollard entrance, or through the Pillar Point Harbor Boulevard entrance approximately 0.61 miles up the paved Coastal Trail.

3.2 Hydrology and Subwatershed Description

Rainfall in the area averages 22" per year as recorded at the Pacifica USCG rain gage, DWR #E70 6586 20[1], falling primarily between November-March. The Property is comprised of several midcoast watersheds that drain to Half Moon Bay along the San Mateo County coastline (Map 1). Ground surface elevations on the Property range from sea level to 935 feet. There are 2 primary subwatersheds within the Property; from north to south they are: an unnamed creek (locally known as Santa Maria Creek) and Arroyo de en Medio. The Property is hydrologically isolated from anadromy; therefore, fish passage is not a concern on the Property. In addition, hydrology at the urban interface along the southern property boundary has significantly altered the unnamed drainage that comprises the majority of the Property.

1 ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall Depth-Duration-Frequency/

Currently, excessive sediment delivery from networks of eroding and/or unmaintained roads/trails on the Property is recognized as a significant, but controllable, threat to water quality. Sediment acts as a pollutant in creeks that support non-anadromous aquatic species. Reduction of sediment inputs from anthropogenic sources and improvements in resource management on the Property will improve water quality and reduce impacts throughout.

3.3 Geology

3.3.1 Structural Geologic Setting

The project area is located in the Coast Range geomorphic province of northern California, characterized by northwest trending mountains and valleys which generally mirror the dominant San Andreas Fault system and smaller, en eschelon fault systems including the nearby San Gregorio fault zone, which includes the Denniston Creek fault and Sea Cove fault (Pampeyan, 1994).

The Alquist-Priolo (AP) zoned San Andreas fault zone lies approximately 4.5 miles east of the Property. The Pilarcitos Fault is located approximately 3 mi to the east and the San Gregorio fault zone is located approximately 1 mi offshore to the west (Jennings, 1994; Brabb, 1998). Pilarcitos fault is Quaternary with an unspecified sense of movement and slip rate where as the San Gregorio fault zone is Holocene active and exhibits dextral strike slip displacement as identified by geomorphic expression and offset of geologic and anthropic deposits (Bryant, 1999).

3.3.2 Surface lithology

The distribution of mapped lithological units within the Property was compiled from GIS provided by the NPS Geologic Resources Inventory Program (NPS, 2009). Over half of the Property is underlain by Quaternary lithologies with colluvial slope and ravine debris (Qsr) being the dominant surficial cover material. Slope and ravine debris of Qsr are primarily found in the steeper, upper half portions of amphitheater shaped sub-basins. The Qsr colluvial deposits are a result of shallow landslides, bioturbation and soil creep geomorphic processes, and are comprised of unconsolidated deposits of weathered rock and soil. Poorly consolidated sands, silts, clays, and gravels comprise the remaining Quaternary age alluvium and terraces (Qalo) as you approach the urban interface. Cretaceous age Granitic rocks of Montara Mountain (Kgr) underlie a small portion of the ridgetops along the outer edges of the Property, consisting of highly fractured, deeply weathered, crystalline granitic rock (quartz diorite and granite). These rocks are foliated and found to primarily dominate the higher elevations. In general, the underlying geologic units develop friable sandy soils, with moderate to high erosion potential, particularly when disturbed by natural episodic events or anthropogenic activities.

3.4 Soils

Soil types and characteristics underlying the Property are greater than 90% Miramar soil units, primarily sandy loams along hillsides with moderate to very steep slope gradients and classified as “eroded” by the USDA Natural Resource Conservation Service (NRCS). The remaining <10% include Denison, Farallone, and Tierra soil types (Figure 1, Table 1).

K factors for the Universal Soil Loss Equation (USLE) determined by the National Cooperative Soil Survey (USDA NRCS, 2013) range from 0.15 for the Miramar complex soils to 0.32 for the Tierra complex soils. The higher K factors indicate more potential for erosion.

Figure 1. Soils within Quarry Park Property according to NRCS Websoil Survey.

Soils underlying the Property can also be categorized by Hydrologic Soil Group (HSG). HSG classification indicates (1) the minimum rate of infiltration controlled by surface conditions and (2) minimum rate of transmission controlled by the soil profile. Group "A" soils have low runoff potential due to high infiltration and transmission rates; "B" soils have moderately low runoff potential due to adequate infiltration rates and unimpeded transmission (USDA NRCS, 2007). Group "C" soils have moderately high runoff potential and group "D" has high runoff potential. Both C and D HSG classified soils have restricted infiltration and transmission of water through surface and subsurface soils.

Table 1. Soils within Quarry Park Property according to NRCS Websoil Survey and SSURGO Database, San Mateo County, California[a].

Map unit[a]	Map unit name	Area (acres)	% within property	HSG	Universal soil loss - K factor[b]				Hazard of road/trail erosion[c]		Suitability[d] for road/trail
					Kw (whole soil)		Kf (rock free)				
					Surface	Subsurface	Surface	Subsurface	off	on	
DcA	Denison clay loam, nearly level	13.6	2.4%	C	0.24	0.24-0.37	0.24	0.24-0.37	Slight	Slight	Moderately suited
DdA	Denison clay loam, nearly level, imperfectly drained	3.3	<1%	C/D	0.24	0.24-0.37	0.24	0.24-0.37	Slight	Slight	Moderately suited
DeA	Denison coarse sandy loam, nearly level	7.7	1.4%	C	0.15	0.24-0.32	0.15	0.24-0.32	Slight	Slight	Well suited
DmA	Denison loam, nearly level	7.8	1.4%	C	0.28	0.24-0.37	0.28	0.24-0.37	Slight	Slight	Moderately suited
DmB	Denison loam, gently sloping	6.7	1.2%	C	0.28	0.24-0.37	0.28	0.24-0.37	Slight	Moderate	Moderately suited
FcB	Farallone coarse sandy loam, gently sloping	0.0	<1%	A	0.15	0.20-0.24	0.15	0.20-0.24	Slight	Slight	Well suited
FcC2	Farallone coarse sandy loam, sloping, eroded	10.0	1.8%	A	0.15	0.20-0.24	0.15	0.20-0.24	Slight	Moderate	Moderately suited
FcD2	Farallone coarse sandy loam, moderately steep, eroded	2.3	<1%	A	0.15	0.20-0.24	0.15	0.20-0.24	Moderate	Moderate	Poorly suited
FyC2	Farallone loamy coarse sand, sloping, eroded	0.4	<1%	A	0.10	0.20-0.24	0.10	0.20-0.24	Slight	Moderate	Moderately suited
Gp	Gravel pits	3.0	<1%	-	0.05	0.05	0.10	0.17	-	-	-
Gu	Gullied land (alluvial soil material)	0.3	<1%	-	-	-	-	-	-	-	-
MmD2	Miramar coarse sandy loam, moderately steep, eroded	14.7	2.6%	B	0.15	0.28	0.15	0.28	Moderate	Severe	Poorly suited

Map unit[a]	Map unit name	Area (acres)	% within property	HSG	Universal soil loss - K factor[b]				Hazard of road/trail erosion[c]		Suitability[d] for road/trail
					Kw (whole soil)		Kf (rock free)				
					Surface	Subsurface	Surface	Subsurface	off	on	
MmE2	Miramar coarse sandy loam, steep, eroded	327.4	57.9%	B	0.15	0.28	0.15	0.28	Moderate	Severe	Poorly suited
MmF2	Miramar coarse sandy loam, very steep, eroded	157.3	27.8%	B	0.15	0.28	0.15	0.28	Very severe	Severe	Poorly suited
TcD2	Tierra clay loam, moderately steep, eroded	1.3	<1%	D	0.32	0.24-0.28	0.32	0.24-0.28	Moderate	Severe	Poorly suited
TeE2	Tierra loam, steep, eroded	4.4	<1%	D	0.32	0.24-0.28	0.32	0.24-0.28	Moderate	Severe	Poorly suited
TeE3	Tierra loam, steep, severely eroded	2.3	<1%	D	0.32	0.24-0.28	0.32	0.24-0.28	Moderate	Severe	Poorly suited
WmB	Watsonville loam, gently sloping	1.7	<1%	D	0.32	0.24-0.28	0.32	0.24-0.28	Slight	Moderate	Moderately suited
N/A	No Data Available	0.7	<1%	-	-	-	-	-	-	-	-
	Total	**564.9**	**100%**	-	-	-	-	-	-	-	-

[a] Shaded cells reflect map units that cover the majority (>85%) of the Property. USDA NRCS Soil Survey Geographic (SSURGO) database for San Mateo Area, California, 2013, http://websoilsurvey.nrcs.usda.gov. Note that acreage is approximate based on the area of interest represented in the table.
[b] The higher K factors indicate more potential for erosion.
[c] Hazard of road trail erosion on/off are based on soil erodibility factor K, slope, and content of rock fragments.
[d] Suitability for road/trail building is based on slope, rock fragments, plasticity index, % sand, USC, depth to water table, ponding, flooding, and the hazard of soil slippage.

Regarding runoff potential, greater than 90% of the soils are classified as HSG "B" (moderately-low runoff potential) or HSG "A" (low runoff potential), indicating a majority of the Property has reasonable infiltration rates. Given that soils have higher surface erosion ratings, increased infiltration rating is a benefit to reduce the likelihood of erosion.

Conventional K factors and USLE analyses tell only the surface erosion potential portion of the erosional story within the Property. The sediment generation during chronic or "normal" weather cycles may come predominantly from roads/trails located within poorly suited soil groups and hillslopes above the channels, and from any hydrologically connected expanses of bare soil areas. However, the risk of sediment production generated during catastrophic episodic events, such as post-wildfire runoff, major floods, large landslides, and seismic events are likely to constitute a significantly larger proportion of long term sediment inputs throughout the Property.

Although the USLE analyses describes the inherent natural erodibility of the landscape, it should be noted that other land management activities can alter sediment production estimates regardless of the underlying geologic and soil characteristics. For example, changes in current land use practices can have significant impact on erosion potential due to an increase/decrease in denuded surfaces, especially where locations in close proximity to watercourses and within the riparian corridor (<50 ft from top of streambank).

3.5 Road/Trail Networks in Quarry Park

PWA inventoried approximately 13.87 mi of native surfaced, rocked and paved roads and trails within Quarry Park. All roads and trails were mapped and identified as to their accessibility either "by foot" or "by truck/quad". A brief description of each category is listed below. Refer to Map 2 for the location and visual representation of all mapped roads and trails.

3.5.1 Roads, accessible via truck/quad

PWA assessed 8.29 miles of truck/quad accessible roads. Roads that are characterized as accessible via truck and or quad are currently open and provide adequate road width and clearance to permit vehicular access as well as pedestrian and cyclist use. These roads generally provide trail access to the public, as well as vehicle access to the property for general maintenance and fuels management. For reference regarding the location and designation of roads identified within the Property, refer to Map 2.

3.5.2 Roads, accessible via foot

PWA assessed 4.49 miles of road accessible by foot within the Property. Roads identified as accessible by foot are all native surfaced legacy road alignments that have adequate geometry and potential to be upgraded in order to reestablish vehicle access if desired. Roads that are characterized as accessible by foot do not permit vehicular access due to overgrown vegetation, cutbank failures, downed trees and/or other physical obstacles. These roads are generally not in use by the public or County Park staff. However, they all have the potential for future development and/or rehabilitation. Many of these roads not currently accessible by vehicles provide unique opportunities to either establish additional access routes to areas of the Property and/or potentially implement road to trail conversions that would minimize anthropogenic impacts on the surface hydrology and promote natural hillslope hydrologic processes. Road to trail conversion of these overgrown or otherwise unused road lineaments would effectively remediate existing site specific, and chronic road drainage, erosion issues

3.5.3 Trails, accessible via foot

PWA inventoried 1.09 miles of trails accessible by foot within the Property. Trails identified as accessible by foot are generally native surfaced legacy skid trails or small single track foot and bike paths. These trails generally serve as scenic alternatives and connections between the larger arterial roads. Trails range in width from 2 feet to 6 feet and lack adequate geometry to be upgraded to drivable roads without heavy equipment construction.

4. FIELD TECHNIQUES AND DATA COLLECTION

The Quarry Park Assessment consists of two distinct elements: (1) a complete field inventory of all current and potential road/trail related erosion sources along all identified roads and trails (approximately 10 mi); and (2) the development of a prioritized plan of action for cost-effective erosion control and erosion prevention treatments in the project area. All project elements were completed under the direction of a PWA licensed professional geologist.

To facilitate the field inventory, GIS data layers provided by County Parks were combined with NAIP imagery (CaSIL, 2016) and 3 m DEM contour interval layers to produce field maps at a 1:2,400 scale. These maps were used to document the locations of inventoried sites, and to ground truth the location and configuration of mapped road/trail segments in the field. The GIS roads layer was then modified based on ground truthing, and used in the development of the final project maps.

PWA conducted a field inventory of all identified road/trail segments, and assessed all road/trail related erosion sites and determined if they show evidence of past or potential sediment delivery to the stream system. Because the purpose of the inventory was to quantify the potential magnitude of impacts of road/trail related erosion, we included any site or road reach showing evidence for erosion (past, current, or potential) even if it did not also show evidence for current or potential sediment delivery to a stream.

Inventoried sites for this assessment primarily consist of stream crossings, landslides, gullies below ditch relief culverts, road related erosion affecting springs and swales, and various types of drainage discharge for uncontrolled road/trail surface and/or inboard ditch runoff.[2] For each site identified as an erosion feature, PWA staff plotted its location on a GIS-generated map; collected a GPS waypoint using a handheld GPS unit; and recorded a series of field observations including: (1) detailed site description; (2) nature and magnitude of existing and potential erosion problems; (3) likelihood of erosion or slope failure; (4) length of hydrologically connected (or adjacent) road surface associated with the site; and (5) treatments needed for prevention or elimination of future erosion and/or sediment delivery. The data collected for each site also includes an evaluation of *treatment immediacy* based on the potential or likelihood of future erosion, sediment delivery from the site to a stream channel, and the level of urgency for addressing erosion problems at that location.

2 Detailed definitions of sediment delivery sites are provided in Appendix A.

For each existing or possible problem site in the project area, PWA field staff evaluated the potential for erosion and sediment delivery, and collected field measurements (width, depth, and length of the potential erosion area) to derive erosion and sediment delivery volumes (if applicable). For most stream crossings, PWA field crews used tape and clinometer surveys to develop longitudinal profiles and cross sections of the site. These data were used to calculate road fill and potential sediment delivery volumes with the STREAM computer program. This proprietary software, developed by PWA, provides accurate and reproducible estimates of: (1) the potential volume of erosion at a stream crossing, whether over time or during any possible catastrophic, storm-generated washout; (2) excavation volumes associated with culvert installation, culvert replacement, or complete decommissioning of a stream crossing; and (3) backfill volumes associated with culvert installation or replacement. In addition, field crews measured the lengths of hydrologically connected road to derive estimates for chronic sediment delivery. The roadbed, ditch, and cutbank of hydrologically connected road reaches were inspected and each road reach assigned a 1 to 6 rating (High, High-Moderate, Moderate, Moderate-Low, Low, and N/A) of chronic road surface lowering/cutbank retreat rates ranging from 0-0.33. based on the level of road usage, types of surfacing materials, soil competency, vegetative cover, and observed evidence of surface erosion in progress (Weaver, et al, 2006). Chronic sediment production from hydrologically connected road reaches was calculated on a decadal basis, using the following empirical formula: (measured length) x (xft average measured width, including cutbanks and ditches) x (0-0.3 ft average lowering of the road/trail and ditch/cutbank retreat per decade).

Where new or replacement stream crossing culverts are recommended for installation, culverts are sized to convey the 100-year peak storm flow.[4] PWA staff calculated the necessary culvert sizes using either (1) the Rational Method (Dunne and Leopold, 1978), for drainage areas less than 80 acres; or (2) the empirical equations of the USGS Magnitude and Frequency Method (Wannanan and Crippen, 1977) for drainage areas equal to or larger than 80 acres. These culvert sizing calculations were used for stream crossings where the field-estimated bankfull channel dimensions were greater than approximately 3 ft by 1 ft in cross sectional area.[5]

In the final phase of the project, PWA personnel analyzed preliminary inventory results and discussed recommendations with County Park staff to determine realistic needs for future use from the public in order to assign a treatment designation of either “upgrade” or “decommission” for each treatment site.[6] These designations are intended to provide County Parks with prescriptions for storm-proofing treatment sites and hydrologically connected road segments, and are PWA’s best recommendations for the most efficient and cost-effective methods to accomplish this goal. The specific recommendations for upgrading verse decommissioning a

3 Chronic road surface lowering/cutbank retreat rates are as follows: H=0.3, HM=0.25, M=0.2, ML=0.15, L=0.1, and N/A= 0
4 The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.
5 For stream channels with cross sectional areas of 3 ft^2 or smaller, PWA follows the recommendations outlined in the California Department Fish and Wildlife *Salmonid Stream Habitat Restoration Manual* and defaults to a minimum culvert size of 24”.
6 See Appendix A for additional information on road upgrading and decommissioning.

stream crossing and or particular road reach can be easily changed if the long term planning process so dictates.

5. ASSESSMENT RESULTS

The purpose of the field assessment was to identify and quantify locations of erosional features – those sites that are currently eroding and may have the potential to deliver sediment to streams in the Property, and/or show a potential to do so in the future. We also inventoried on-going or potential erosion sites in the field that did not show evidence for sediment delivery to a stream. These non-delivering sites may impact road or trail maintenance; however, they do not represent as big of a threat to water quality or habitat.

5.1 Erosional Features

PWA inventoried 74 erosional features as part of the existing conditions evaluation. All erosional features were identified as sediment source or non-sediment source sites. Of the 74 erosional features, 52 sites show evidence of past or potential sediment delivery to the stream system and 22 sites do not have the potential to deliver sediment. Table 2 below summarizes the erosional features identified and Map 2 depicts each site spatially.

Table 2. Inventory results for erosional features and adjacent road/trail segments recommended for treatment, *Quarry Park Watershed Assessment and Erosion Prevention Project*, San Mateo County, California.

Site Types	Sediment delivery sites		Non-sediment delivery sites		Total length of roads/trails surveyed for project (mi)
	Sites (#)	Hydrologically connected[a] roads/trails (mi)	Sites (#)	Adjacent[a] roads/trails (mi)	
Stream crossings	32	2.22	-	-	-
Springs	2	0.17	2	0.21	-
Road/trail surface	5	0.45	-	-	-
Landslides	2	0.41	-	-	-
Ditch relief culverts	10	0.99	19	1.00	-
Other	1	0.07	1	-	-
Total	**52**	**4.31**	**22**	**1.21**	**13.87**

[a] *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).
[b] *Adjacent* describes road or trail segments from which eroding sediment is connected to non-delivering sites.

5.1.1 Sediment Delivery Features

PWA's field assessment resulted in the identification of 52 sites which show evidence of past or potential sediment delivery to the Property's stream system. Table 3 below summarizes the sources and the estimated future sediment delivery if sites are left untreated.

Table 3. Estimated future sediment delivery for features and hydrologically connected road/trail segments, *Quarry Park Watershed Assessment and Erosion Prevention Project*, San Mateo County, California.

Sources of sediment delivery	Estimated future sediment delivery (yd^3)	Percent of total
1. Episodic sediment delivery from road/trail related erosion sites (indeterminate time period)		
Stream crossings	13,110	91
Springs	220	2
Road/trail surface	415	3
Landslides	40	<1
Ditch relief culverts	520	4
Other	5	<1
Total episodic sediment delivery	**14,310**	**100**
2. Chronic sediment delivery from road/trail surface erosion (estimated for a 10 yr period)[a]		
Total chronic sediment delivery		**3,305**
Total estimated future sediment delivery for the project area		**17,615**

5.1.2 Non Sediment Delivery Features

PWA's field assessment resulted in the identification of 22 sites which show evidence of erosion but do not result in potential sediment delivery to the Property's stream system. Even though these sites were identified as non-delivering sites, the adjacent road reaches contribute to the accelerated erosion at each site if left untreated. This chronic erosion can result in approximately 500 yd^3 of sediment mobilized downroad and/or downslope from the identified site locations.

5.2 Utilities and Infrastructure

During PWA's field investigations, field crews identified and mapped observed utilities and infrastructure within Quarry Park. All mapping was done from existing roads and trails (Map 2). Therefore, there may be other utilities and/or infrastructure within the Property that was not observed by PWA field staff. We recommend that Park staff use this as a baseline and add locations as they are identified.

Notable infrastructure includes: an existing pond and groundwater well with associated subsurface plumbing and surficial infrastructure; parking area, restroom, and playground; a USGS gaging station; an observation deck; several utility boxes and/or markers; and several gates on the Property. Refer to Map 2 for the location of mapped utilities and other infrastructure within the Property.

6. PRIOIRITIZED EROSION PREVENTION AND SEDIMENT CONTROL PLAN

6.1 Identification and Prioritization of Treatment Features

Each of the 74 features recommended for treatment has been prioritized for urgency in implementing the recommended erosion control and erosion prevention measures (Tables 4a and 4b). PWA recommends treatment for all identified sites on inventoried roads and trails within the Property (Map 2; Tables 4a and 4b). In addition, refer to Appendix A for guidance and additional information on terminology and techniques used in road/trail related erosion assessments. Appendix B provides a summary of field observations and treatment recommendations for road related features and Appendix C provides typical construction drawings. Finally, refer to Appendix D for representative site photographs taken during PWA's assessment of the Property.

Table 4a. Evaluation of treatment immediacy for sediment delivery features recommended for treatment in the *Quarry Park Watershed Assessment and Erosion Prevention Project*, San Mateo County, California.

Treatment immediacy	Number of treatment features by type	Road/ trail Length (mi)[a]	Estimated future sediment delivery			
			Site-specific[b]		Chronic[c]	
			(yd^3)	%	(yd^3)	%
High	4 Stream crossings (#4, 8, 19, 39)	0.45	9,735	68	400	12
High-moderate	9 Stream crossings (#1, 7, 9, 13, 32, 35, 36, 41, 43) 2 Road Surface (#34, 71) 1 Landslide (#11) 1 Ditch relief culvert (#40)	0.80	2,445	17	608	18
Subtotal	***18 features***	***1.25***	***12,180***	***85***	***1,008***	***30***
Moderate	12 Stream crossings (#2, 3, 5, 12, 16, 17, 23, 30, 31, 37, 38, 45) 1 Spring (#29) 1 Road Surface (#10) 3 Ditch relief culverts (#25, 28, 55) 1 Other (#14)	1.37	1,540	11	1,178	36
Moderate-low	3 Stream crossings (#20, 26, 44) 1 Spring (#21) 1 Landslide (#74) 1 Ditch relief culvert (#27)	0.73	465	3	509	15
Subtotal	***24 features***	***2.10***	***2,005***	***14***	***1,687***	***51***
Low	4 Stream crossings (#22, 24, 33, 42) 1 Road surface (#15) 5 Ditch relief culverts (#61, 62, 64, 65, 66)	0.95	130	1	610	19
Subtotal	***10 features***	***0.95***	***130***	***1***	***610***	***19***
Total	**52 features**	**4.30**	**14,315**	**100**	**3,305**	**100**

[a]*Road/trail length* refers to hydrologically connected road/trail reaches adjacent to recommended treatment features.
[b]Episodic sediment delivery for road/trail related features (indeterminate time period).
[c]Chronic sediment delivery from adjacent hydrologically connected road/trails and cutbanks (estimated for a 10 yr period).

Table 4b. Evaluation of treatment immediacy for non-sediment delivery features recommended for treatment in the *Quarry Park Watershed Assessment and Erosion Prevention Project*, San Mateo County, California.

Treatment immediacy	Number of treatment features by type	Road/trail Length (ft)[a]
High	1 Other (#73)	-
Subtotal	***1 feature***	***-***
Moderate	1 Spring (#18) 2 Ditch relief culverts (#56, 69)	0.26
Moderate-low	1 Spring (#72)	-
Subtotal	***4 features***	***0.26***
Low	17 Ditch relief culverts (#46-54, 57-60, 63, 67, 68, 70)	0.95
Subtotal	***17 features***	***0.95***
Total	**22 features**	**1.21**

6.2 Recommended Treatments

6.2.1 Sediment delivery site treatments

Sediment delivery site-specific treatments are primarily implemented to reduce the risk of catastrophic failure and sediment delivery resulting from road fill erosion, stream crossing failure or stream diversion along forest roads/trails. Recommended treatments for stream crossings include: (1) replacing undersized, damaged, or poorly installed stream crossing culverts with new properly sized culverts installed at channel grade; (2) installing single trash racks above culverted inlets to reduce plugging potential; (3) oversizing culverts to establish adequate excess capacity to pass anticipated debris and sediment (4) constructing critical dips to prevent diversions at streams with diversion potential; (5) installing new adequately sized culverts at currently unculverted fill crossings; (6) constructing armored fill crossings; (7) decommissioning stream crossings on abandoned roads by excavating and removing all the crossing fill and restoring the historic channel alignment, width, and sideslope configuration; (8) excavating and permanently removing extraneous fill material, primarily at stream crossings and unstable fillslopes for both upgrade and decommission sites; (9) installing rock armor to stabilize stream crossing with steep fillslopes, erodible ditches, and active headcuts; (10) conducting routine maintenance such as clearing out culvert debris; and (11) implementing miscellaneous site-specific treatments (Table 5a).

Table 5a. Recommended erosion control and erosion prevention treatments for sediment delivery sites, *Quarry Park Watershed Assessment and Erosion Prevention Project*, San Mateo County, California.

Treatment type			Total number of locations	Comments
Site specific treatments	Stream crossing treatments	Culvert (replace)	9	Replace an undersized, poorly installed, or worn out culvert (Site #2, 8, 9, 12, 13, 23, 32, 36, and 39)
		Culvert (install)	7	Install new culvert at unculverted fill crossing (Site #3, 4, 20, 21, 29, 31, and 35)
		Culvert (clean/clear)	6	Remove sediment or debris from the culvert (routine maintenance)
		Trash rack	11	Install at culvert inlets to help prevent plugging
		Critical dip	14	Install to prevent stream diversions
		Armored fill or rocked ford (wet) crossing	11	Install rocked armored fill crossing using 262 yd^3 of 0.5-2.0' mixed diameter rock armor (Site #5, 7, 14, 16, 17, 22, 24, 30, 33, 37, and 38)
		Decommission crossing	10	Remove all fill from the stream crossings (or relic ponds) and restore the natural channel dimensions and alignment (Site #1, 3, 19, 26, 37, and 41-45)
	Other	Rock (armor)	21	At 21_sites, add a total of 537 of 0.5-3.0' mixed diameter rock armor on inboard and outboard stream crossing fillslopes, ditches, culvert outlets, and/or headcuts
		Soil excavation	10	At 10 sites, excavate and remove a total of 2,377 yd^3 of sediment, primarily at fillslopes and stream crossings
		Miscellaneous treatments	7	Miscellaneous treatments at 7 site-specific locations
Road/trail surface treatments	Road/trail drainage structures	Ditch relief culvert (install or replace)	6	Install or replace ditch relief culverts to improve road/trail surface drainage
		Rolling dip	103	Install to improve road/trail drainage.
		Cross road drain	28	At 6 locations, install cross road drain to improve road/trail surface drainage on proposed decommission road/trail segment.
	Road/trail shaping treatments	Outslope road/trail and remove ditch	32	At 32 locations, outslope road/trail and remove ditch for a total of 15,380 ft of road/trail to improve road/trail surface drainage
		Outslope road/trail and retain ditch	1	At 1 location, outslope road/trail and retain ditch for a total of 230 ft of road/trail to improve road/trail surface drainage
		Inslope road/trail	3	At 3 locations, inslope road/trail for a total of 290 ft of road/trail to improve road/trail surface drainage
		IPOS road/trail	7	At 7 locations, in-place outslope (IPOS) road/trail for a total of 2,561 ft of road to improve road/trail surface drainage along proposed decommission road/trail segment.
	Other	Remove berm	2	At 2 locations, remove the berm for a total of 290 ft
		Road rock (for road/trail surfaces)	9	At 9 locations, use a total of 170 yd^3 of road rock to rock the road/trail surface at wet, rutted and/or muddy segments.

6.2.2 Non-Sediment delivery site treatments

Recommendations prescribed at non-sediment delivery sites are primarily implemented to reduce the risk of continued erosion and risk of prohibiting access resulting from road/trail surface and/or road fill erosion. Recommended treatments for non-delivering sites include: (1) routine maintenance by removing sediment or debris from the culvert; (2) installing road surface drainage treatments; and (3) relocating the existing observation deck (Table 5b).

Table 5b. Recommended erosion control and erosion prevention treatments for non-sediment delivery sites, *Quarry Park Watershed Assessment and Erosion Prevention Project*, San Mateo County, California.

Treatment type	Total number of locations	Comments
Culvert (clean/clear)	18	Remove sediment or debris from the culvert (routine maintenance)
Install/replace ditch relief culvert	4	Install or replace 4 ditch relief culverts (18” diameter, 120 linear ft) to improve road/trail surface drainage
Rock armor	3	Install rock armor at 3 culvert outlet locations using 20 yd^3 of 0.5-1.5’ mixed diameter rock armor
Armored fill or rocked ford (wet) crossing	1	Install rocked armored fill crossing using 15 yd^3 of 0.5-1.0’ mixed diameter rock armor
Relocate Observation Deck	1	Relocate existing observation deck and maintain a minimum 35 ft setback from existing slope
Rolling dip	24	Install to improve road/trail drainage.
Outslope road/trail and remove ditch	15	At 15 locations, outslope road/trail and remove ditch for a total of 4,920 ft of road/trail to improve road/trail surface drainage
Outslope road/trail and retain ditch	14	At 14 locations, outslope road/trail and retain ditch for a total of 140 ft of road/trail to improve road/trail surface drainage

6.2.3 Road treatments

Road/trail surface treatments are designed to control road/trail drainage by reshaping the road/trail bed, dispersing road/trail surface runoff onto stable slopes and preventing delivery of concentrated runoff. Upgrading treatments to redirect flow include outsloping and insloping road/trail segments; installing rolling dips and ditch relief culverts; cleaning and/or cutting ditches; and removing berms. Road surface erosion is mitigated by reducing hydrologically connected road lengths as feasible to minimize the volume of water that is conveyed via the road surface, subsequently lessening the erosive forces of the overland flow. Road surface erosion if further curtailed by installing road rock, which fortifies the surface and reduces production of fine sediment. Treatments for road/trail decommissioning include installation of frequent cross-road drains and in-place outsloping (IPOS) intended to rapidly disperse and direct water off road and trail surfaces (Tables 5a and 5b).

Complete treatment prescriptions for each erosional feature recommended for treatment are included in the database and in Appendix B. Appendix C includes schematic diagrams of construction and installation techniques to be implemented at most typical features.

6.3 Heavy Equipment Requirements and Estimated Construction Costs

Equipment needs and estimated construction costs for recommended erosion control treatments are not detailed in this report; however, PWA can provide summaries as needed based on feedback from County Parks' on their needs and available staff, equipment, and budget.

Most treatments require the use of heavy equipment, e.g., hydraulic excavator, bulldozer, and water truck. Some smaller trail equipment and/or hand labor will be required to treat trail sites and/or at features needing new culverts or culvert repairs, or for applying erosion control, such as seed and mulch, to ground disturbed during construction. Equipment needs can be estimated using in-house staff and/or subcontracted construction crew(s).

Most of the treatments listed in this plan are not complex or difficult for equipment operators with experience in road upgrading and decommissioning operations on steep forestlands. All work is assumed reasonable if it is performed by experienced operators using modern heavy equipment. The use of inexperienced operators, improper or old equipment, or the wrong combination of heavy equipment would require additional technical oversight and supervision in the field, as well as an escalation of the costs to implement the work.

Estimated costs are dependent on: (1) final treatment package(s); (2) qualifications of construction crew(s); (3) charge out rates of equipment and labor; (4) current material and delivery costs; and (5) permitting, contract management, oversight, conducting effectiveness monitoring, and post-project analysis and reporting. To help insure success of the project, it is imperative that only the most experienced and reliable heavy equipment operators be employed, and that the project coordinator is on-site full time at the beginning of the project and at a minimum intermittently after equipment operations have begun.

6.4 Environmental Compliance and Permitting

Many of the recommended treatments will require natural resource investigations prior to construction in order to comply with California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA). In addition, permitting and agency agreements must be obtained before construction work on any stream crossings is undertaken. These may include, but not be limited to: California Department of Fish and Wildlife (CDFW) Lake and Streambed Alteration Agreement (LSAA) 1602, State Water Resources Control Board (SWRCB) 401 Certification, and Army Corps of Engineers (ACOE) 404 Permit. County permitting may also be required for grading and/or work within streams.

7. SPECIFIC AREAS OF POTENTIAL CONCERN

The following section discusses specific areas on the property where PWA identified locations of episodic active and/or potential future erosion. We've included a brief description of the identified issues. Refer to the Map 2 for locations of each *Area of Concern.* In addition, representative photos are included in Appendix D. Areas of Concern (AOC) are not listed in terms of priority. Each AOC has different issues that may affect priority and can be affected by what management tasks are being addressed.

7.1 Area of Concern 1

The area of concern consisting of coastal bluff retreat and gully erosion has compromised portions of the unpaved coastal trail (AOC 1, Map 2). The bluffs are composed of weakly lithified sandstone; active erosion is a result from groundwater seepage leading to a reduction of tensile strength and subsequent fracture; overland flow or sheetwash eroding the surface of the bluffs forming gullies along flow paths; poor drainage practices along the trail/road and general erosion due to oversteepening and direct erosion from wave action (Photos 30-32 Appendix D). The instability of the bluffs and active erosion along the coastal trail will continue to be a maintenance issue as well as a potential safety concern for visitors as sea level continues to rise.

7.2 Area of Concern 2

There are two locations along the south western boundary of the Property (excluding Mirada Surf) where well defined streams discharge runoff directly to the paved residential surface streets of the city of El Granada (AOC 2 and AOC 3, Map 2). Of the two locations where streams exit the Property and flow into the downstream residential area, AOC 2 has a larger drainage area and poses an increased potential for contributing to damages to downstream residential and city properties. However, both locations convey varying amounts of stream flow and associated suspended and bedload sediments to paved surface streets.

Area of Concern 2 is located at the intersection of Santa Maria Ave. and Columbus St. (Photo 35, Appendix D). This location receives a 0.43 mi^2 drainage area consisting of the entire Santa Maria drainage along with the majority of the Property's watershed. There is no obvious effort to manage this runoff in any form of designed drainage structure ever. During field investigations, stream flow was observed traveling across and down the paved road, choosing its' own flowpath. Anecdotal accounts from residents report flow exiting the Property has resulted in flooding a large portion of the neighborhood during peak storm events. It should be noted that addressing the problem in this AOC would require collaboration with other entities, which may include City, County, and/or private landowner(s) since area is located outside Park's property boundaries.

7.3 Area of Concern 3

The second location along the south western boundary of the Property where flow is conveyed to paved surface streets Area of Concern 3 (AOC 3, Map 2) is located on Moro Ave., midway between the road intersections of Santiago Ave. and Salvador St. Flow and sediment from this Class II stream discharges to an uncontrolled street location approximately 640 ft downstream of Site #39. Stream flow is diverted down the left inboard ditch along Moro Ave. toward the intersection with Santiago Ave., at which point flow disperses and infiltrates into the wooded alluvial area to the south (Photo 36-37, Appendix D). At the time of field investigations, bedload was visible in the ditch along Moro Ave., indicative of sediment transport during winter.

Area of Concern 4Based on aerial imagery analysis, the identified failures are likely new hillslope failures or have at least experienced recent episodic activity, occurring during the 2016-2017 wet weather season. Additionally, the residence located at 540 El Granada Boulevard was constructed in 2006-2007. Initial evidence of disturbance to the hillslope immediately upslope of the existing slide feature below this residence was observed on aerial imagery from 2006 and 2007. Uninvestigated drainage outfalls are visible beneath the residence and are conveying flow to the unstable area.

A washed out fill crossing (Site #41) located on a steep Class III stream has eroded through the road as a result of a debris torrent originating in the upslope headwaters region of this stream (AOC 4, Map 2). The debris torrent passed through this stream crossing delivering sediment and debris to a Class II stream approximately 45’ downstream of Site #41, and then continued farther downstream beyond the confluence of the two channels. The recent active erosion in the headwaters of this channel has resulted in a severely scoured channel both upstream and downstream of the crossing at Site #41. The stream banks through the failed stream crossing are oversteepened and unstable. The remaining perched road fills on both banks of the stream crossing are very susceptible to future failure. However, the bottom of the stream channel has incised down to a more competent resistive bedrock material, and appears to have reached a stable gradient through the crossing.

7.4 Area of Concern 5

A combination of Class III stream flow, upslope residential drainage and emergent cutbank spring flow are actively saturating and eroding the fill at this crossing (Site #19). The road associated with this crossing has been constructed through the steep headwall area of this Class III stream channel (AOC 5, Map 2). There is no formal drainage structure at the crossing; therefore, the combined flows are actively eroding the road fill though the crossing. There are several active cutbank slides on the right road approach and a large section of the road fill has failed on the right hingeline of the stream crossing fillslope (Photos 11 and 12, Appendix D). The remaining outboard fillslope is long and oversteepened. Additionally, there are large, arcuate scarps upslope of the crossing that are indicative of a potential future hillslope failure with debris torrent potential if the entire headwall swale area were to fail. In the event of a catastrophic hillslope debris slide failure, the sediment and vegetal materials being transported downstream would likely result in the complete failure of both Site #19, as well as the downslope stream crossing at Site #7.

There is a private residence upslope of the headwater area that is actively conveying surface drainage and runoff from the graded area surrounding the home toward the unstable hillslope. There is a section of exposed 24” diameter plastic culvert on the hillslope above Site #19 that is likely a drainage outfall from the upslope private property. Site #19 appears to be very near, if not directly on, the Property boundary. Due to the stream crossings proximity to the property boundary, and the unspecified volume and source of increased concentrated runoff being directed to the site, further investigation of the upslope drainage area will be required in order to develop a comprehensive treatment design. The upslope drainage area investigation should be implemented in cooperation with the neighboring property, as it will require access, to determine the exact nature of the influence on the natural drainage. Additionally, treatment development may require property boundary delineation through this area to determine potential responsibility.

7.5 Area of Concern 6

Approximately 685 ft of inboard ditch and springy cutbank adjacent to the paved private road near the top of the Property drains to a 24" diameter ditch relief culvert (Site #40) located in the headwaters of the Santa Maria drainage (AOC 6, Map 2). The ditch relief culvert (DRC) is set shallow in the fillslope, and the inlet area is hardened with concrete. During field inspections, flow was infiltrating into the ground approximately 45 ft up the inboard ditch from the culvert inlet, and was emerges at the base of the actively migrating headcut at the disconnected outlet to the DRC. A large active gully (on average 10 ft deep x 16 ft wide x 175 ft long) has eroded the steep colluvial hollow as a result of the DRC downspout separating and filing in the 2016-2017 winter (Photos 16-18, Appendix D). The disconnected ditch relief culvert downspout was previously ~120 ft longer and conveyed the road and spring runoff to the base of the very erodible colluvial hollow (i.e. protect the hillslope from the observed serious erosion), and deliver the flow to the head of a downslope Class III stream

The lack of slope inspection and maintenance of the drainage structure is a factor in the observed erosion and sediment delivery. In addition, the flow is likely piping through pores and/or infiltrating through the sandy decomposed granitic soils and emerge due to an underlying contact with a less permeable material. The remaining segments of culvert and the underlying hillslope will likely fail as the active headcut continues to enlarge and migrate upslope toward the road. Flow and eroded sediment from Site #40 is routed to an unculverted fill crossing at Site #16, approximately 390 ft downstream.

7.6 Area of Concern 7

An instream pond on a Class II watercourse being retained by an earthen dam associated with stream crossing Site #4 (Map 2). Preliminary evaluations revealed that the majority of the fill face of the dam appears stable, other than the uncontrolled spillway at the right hingeline of reservoir/stream crossing (AOC 7, Map 2). The dam's overflow does not have any formal drainage structure, and therefore is at a high risk of catastrophic failure. The pond outlets at the southwest corner of the dam where pond outflow is bifurcated by a temporary dysfunctional sandbag check dam. The temporary dam sandbag structure is actively diverting approximately 50% of the flow across the road forming an active gully near the right hingeline of the dam face, while the rest of the flow is diverted 90 ft down road causing a relatively new road failure resulting in a completely washed out road prism.

Additionally, there are 4 past diversion gullies further down the western road approach that were likely caused by past uncontrolled pond outflow. Eroded sediment from these two active outflow locations is currently being deposited in broad alluvial meadow area downslope from the dam. The outflow across the meadow flows through small diffuse channels for ~275 ft, at which point flow enters a Class II stream channel. Some seepage is also occurring through a valve at the base of the dam. The active gullying and headcutting at the earthen dam pose a flooding and erosion threat to the downstream watershed areas associated with catastrophic failure potential. Refer to photos 4-8 in Appendix D.

PWA conducted a follow up evaluation of the pond and earthen dam. Our evaluation consisted of the following tasks: (1) conducting a field assessment, total station survey, and subsurface soil investigations to evaluate the structural integrity and seismic susceptibility of the existing dam and identify deficiencies; (2) analyzing the data and develop a treatment plan (short and long term) to improve the structural integrity to keep the existing feature and/or a plan to decommission the pond and restore the stream channel; and (3) preparing a post-project memo report of findings. Please refer to the supplemental memo report of findings in Appendix E for: (a) summary of scope of work; (b) description of existing site conditions and a summary of observations; (c) results of field and/or laboratory surveys, testing, and analysis; (d) site map depicting locations of any testing and/or surveys; and (e) general recommendations for treatment.

7.7 Area of Concern 8

A flashy Class III stream is conveyed via 2 plugged undersized culverts, one 24" diameter and one 12" diameter (Site #39). The culverts are installed high in the fill and both culvert inlets are completely plugged with aggraded sediment. Oversaturated fills and a steep outboard fillslope have resulted in a failure of the outboard fillslope exposing the two culverts in the outboard fillslope (AOC 8, Map 2). The fillslope failure has resulted in an oversteepened outboard fillslope, and the remaining perched fill is now prone to future failure. Additionally, combined concentrated road runoff and diverted stream flow from Site #39 have resulted in a second outboard edge of road fill failure approximately 125 ft down the left road approach to the crossing. This second fill failure delivers sediment directly to the Class III stream at the base of slope and will likely continue to deliver sediment if left uncorrected (Photos 13-15, Appendix D).

7.8 Area of Concern 9

The “observation deck” at the top of the quarry (Site #73) is experiencing erosion beneath one of the footings (AOC 9, Map 2). The active slope failure beneath the footing is undermining the deck and causing instability. (Photos 33 and 34, Appendix D). The active erosion and subsequent destabilization of the deck is a potential safety hazard for visitors. County Parks has closed the site due to potential hazard until it can be relocated. PWA recommends that the infrastructure be relocated a minimum of 35 feet back from the edge of the existing unstable slope.

8. POTENTIAL REACHES FOR PRIORITIZED HABITAT REHABILITATION

There are three distinct reaches which PWA staff has identified as potential locations for prioritized habitat rehabilitation (Map 2). These reaches have been significantly altered due to anthropogenic land use practices resulting in: (1) sediment delivery from episodic failure of road/trail fill; (2) changes in channel morphology from aggradation and/or incision; (3) degradation of native riparian vegetation; (4) reduced hydrologic function; and/or (5) negative effects to suitable habitat. Temporary impacts and disturbance from heavy equipment construction activities would be temporally limited in scope. However, the long term effects of rehabilitation would prevail and promote native riparian revegetation, restore hydrologic function, and improve available habitat.

8.1 Riparian Reach #1

This alluvial stream reach is heavily impacted by the highly erodible nature of the local geology and historic anthropogenic impacts on the landscape. The stream reach (Reach #1, Map 2) has sediment aggradation upstream of stream crossing Site #2 with deeply incised, near vertical banks downstream. The area appears to have been intentionally ponded in the past by the construction of two berms/levees. The ponds have since become inundated with aggraded sediment. Stream flow is currently conveyed through the area via subsurface percolation and a series of two undersized 15" diameter culverts. One culvert is oriented upstream of the Meadow Trail alignment, and the second culvert is approximately 50 ft downstream of the trail. The hydrologic impact of the undersized culverts and subsequent backwatering of the Class II stream has caused aggradation within the two small reservoirs.

Stream flow is actively eroding through the aggraded sediment downstream of Site #2. The flow that is percolating underneath the aggraded material and levee fill emerges downstream of the lower levee at the base of a 6 ft tall headcut. The headcut is actively migrating upstream and the potential for an episodic crossing failure is relatively high. In the event of an episodic failure induced by the headward migration of the headcut, the increased sediment delivery to the downstream channel reach would likely result in uncontrolled riparian bank erosion within the stored alluvial sediments downstream, loss of riparian vegetation, and would likely negatively impact downstream crossing infrastructure.

8.2 Riparian Reach #2

This alluvial stream reach is also heavily inundated with aggraded sediment due to the highly erodible nature of the local geology and historic anthropogenic impacts on the landscape (Reach #2, Map 2). This restorable stream reach extends from stream crossing Site #17 downstream through Site #26 all the way to stream crossing Site #23 at the initiation the Meadow Trail. The upstream reach from Site #26 to Site #17 is incised with near vertical banks for approximately 500 ft. There is a historic levee or small dam that extends across the width of the alluvial valley at Site #26 that is impeding the natural watercourse. The channel downstream of Site #26 is minimally defined and heavily vegetated with invasive species.

8.3 Riparian Reach #3

This restorable stream reach is located within the main historic quarry area at a small failed pond shown as Site #37 (Reach #3, Map 2). The pond likely served as a water storage and or washing facility from industrial quarry activities. Several emergent springs actively deliver sediment to the headwall swale above the pond. Flows have resulted in a gully through the levee fill on the downstream edge of the pond feature and deliver to Site #37 downstream. The pond is not functioning as it retains approximately 25% of its original impoundment capacity.

9. OPPORTUNITIES AND CONSTRAINTS

PWA previously provided County Parks with an *Opportunities and Constraints Analysis* to translate technical information gathered during field investigations. This document and corresponding maps describe; existing and potential future risks to property resources to begin the process of developing conceptual alternatives for controlling accelerated erosion, and altered hydrology, and options to restore and protect natural processes and natural resources. This section summarizes PWA's memo dated May 2017, which provided conceptual findings and recommendations, reliant on input from County Parks, the consultant team, the public, and other stakeholders.

9.1 Opportunities

The recent acquisition of additional land has provided the County with a great opportunity to protect, stabilize, enhance, and restore the existing natural features and processes, infrastructure, access, recreation, and safety for staff and visitors. While PWA considers there is also an opportunity for expansion of the trail networks and/or infrastructure within the Park in the future; based on our site investigations and analysis, we suggest that initial remedial actions and primary focus be placed on the former rather than the latter opportunities with respect to the property.

Final opportunities leading to the development of a final *Master Plan* for the Park should consider the following bulleted outline based on PWA's initial work to date:

(1) Initiate, develop, and foster communications, collaboration, and partnership with neighboring landowners and other stakeholders;

(2) Develop and implement prioritized, cost effective projects to improve, stabilize, restore natural processes or habitats, whereas one project can meet multiple objectives for the Property including, but not limited to:

- (a) Existing and proposed road/trail network
- (b) Park access
- (c) Park infrastructure
- (d) Natural features, resources, and processes
- (e) Water – quality, availability, diversion(s), impoundment(s), and/or storage
- (f) Public safety within the Park
- (g) Recreational uses and overall experience for visitors

(3) Develop and implement Park protocols and methodology (maintenance, monitoring, etc.)

9.2 Constraints

The County's roles and responsibilities as a result of this acquisition include inherited (legacy) existing and/or potential conditions. These include a number of land use activities and land management activities being conducted by upslope adjacent landowners that are have significant impacts on Park resources, as well as a number of deferred maintenance and poorly designed roads, ponds and infrastructure features that pose a risk of significant downstream impacts to both Park resources and/or downslope adjacent land and property owners. Many of these may require careful discussions and negotiations with adjacent landowners and regulatory agencies. Others may require more detailed studies and analysis to evaluate long-term risk to natural resources and Park infrastructure, determine and permit appropriate solutions and evaluate public access and safety constraints.

Identifying opportunities to prepare and execute a final *Master Plan* (goals, objectives, prioritized planning efforts, timeline, etc.) is one step. The other step is identifying the constraints that can play an equal role (if not greater) in actualizing execution of such a Plan. Based on PWA's preliminary work to date, we have included a similar outline of constraints that may restrict, delay, and/or prevent realization of opportunities to include, but not limited to the following:

(1) Prioritizing actions - identifying immediate needs vs. goals (short and long-term),

(2) Overall cost – availability and timing of appropriate funds

(3) Coordinating, collaborating, and securing final approval from the community (visitors), adjacent landowners, stakeholders, and the County

(4) Identifying, addressing, and clarifying roles and responsibilities related to legal responsibilities, permitting, and regulatory compliance

(5) Timeline (planning, approval, funding, implementation, etc.)

10. CONCLUSIONS

This assessment is a comprehensive inventory of ongoing and future road and trail related erosion and sediment delivery to streams along a total of 13.87 mi of road and trail within Quarry Park, San Mateo County, California. It provides field data to identify and quantify currently observable and possible future sources of erosion and sediment delivery originating from roads and trails on the Property owned and managed by San Mateo County Parks Department.

A fundamental result of this erosion assessment is a prioritized plan of action for erosion and sediment control and erosion prevention for identified erosional features within the Property. When implemented and employed in combination with protective land use practices, the treatment prescriptions outlined in this report may be expected to significantly contribute to the long-term protection and improvement of water quality and habitat in the Property.

We understand that treatments are likely to be implemented. However, we also understand that a variety of factors, such as available funds, public input, and results of the Master Plan may dictate the number and order of implemented treatments. Therefore, PWA offers our assistance to County Parks with developing specific treatment packages based on a variety of factors upon request.

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Appendix A

Terminology and techniques used in road related erosion assessments

Quarry Park Watershed Assessment and Erosion Prevention Planning Project San Mateo County, California

1 TERMINOLOGY AND TECHNIQUES USED IN ROAD RELATED EROSION ASSESSMENTS

1.1 Sources of Road Related Erosion

Sources for erosion and sediment delivery in the assessment area are divided into two categories: (1) sediment from specific treatment features, and (2) sediment from the surfaces of road segments of varying lengths—and their associated cutbanks and inboard ditches—that are hydrologically connected1 to streams.

Feature-specific erosion is termed *episodic*, as it is projected to occur over an indeterminate time frame, usually from months to decades as typically triggered by some event (usually intense or significant rainfall or peak flows in a stream). Some features may show evidence for imminent failure, erosion, and sediment delivery, such as unstable road cuts or fills on steep hillslopes. Other features may show the potential for erosion and sediment delivery, but will not activate until a threshold is reached based on a combination of factors at the feature (for example, type of geologic substrate, type and density of vegetative cover; size of channel, steepness of terrain, intensity and duration of rainfall, peak flows, etc.).

In contrast to feature-specific episodic erosion, erosion from road surfaces is termed *chronic* because it occurs on an on-going basis, every time there is surface runoff, and is primarily dependent on the level of road usage, the erodibility of the ditch or road surface, and the steepness of the road. PWA estimates chronic erosion for a 10-year period, based on empirical calculations for fine sediment generation from hydrologically connected road surfaces and associated cutbanks and ditches. The amount of fine sediment delivered to stream channels from eroding road surfaces can be substantial when evaluated on timescales similar to those applied to episodic erosion features (mulit-decades), and in some watersheds may represent the greater detriment to water quality and fish habitat.

1.1.1 Feature-specific erosion sources

Stream crossings

A *stream crossing* is a ford or drainage structure on a road (such as a culvert or bridge) installed across a stream or watercourse (USDA Forest Service, 2000). When they erode, sediment delivery from stream crossings is always assumed to be 100%, because any sediment eroded is delivered directly to the stream. Once eroded sediment is delivered to a stream, the grain size of the sediment and the size of the stream affects the rate of sediment movement down the channel. Regardless, any eroded sediment delivered to small ephemeral streams in upland areas will eventually be transported to downstream larger fish-bearing stream channels.

Common features of stream crossings that lead to erosion problems include (1) fill crossings without culverts, (2) crossings with undersized culverts, (3) crossings with culverts susceptible to being plugged, (4) crossings with logs or debris buried in the fill intended to convey streamflow

1 *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

(i.e., *Humboldt log crossings*), (5) crossings with a potential for stream diversion, and (6) crossings that have currently diverted streams.

An unculverted *fill crossing* is a stream crossing without a culvert to carry the flow through the road prism. At such features, stream flow either crosses the road surface and flows over and back down the outside fillslope, or is diverted down the road via the road surface or inboard ditch. Most fill crossings are located at small Class II or III streams that only have flow during larger runoff events. *Armored fill crossings* and *ford crossings* are similarly designed to be functional, unculverted stream crossings. A properly constructed armored fill crossing contains fill in the stream crossing that is protected from erosion by the use of rock armor. It is based on a feature-specific design, using a mix of riprap-sized rock to minimize or prevent erosion during flood events while allowing the stream to flow across the surface of the road prism (Weaver et al., 2015). A ford crossing may use rock armor to stabilize the roadway where it crosses the stream, but the road is built essentially on the naturally armored stream bed, and fill is not used.

Humboldt log crossings were typically constructed during historic logging activities from logs or woody debris, usually dumped into or laid parallel to flow, which are then covered with fill. Humboldt crossings are susceptible to plugging, collapse, gullying, and washout when the woody debris rots or peak flows erode the poorly built crossing during storm events (Weaver et al., 2006). Older Humboldt log crossing structures beneath more recently installed culverts are often found in rural northern California road networks. Their existence often shows up only when sink holes develop in the road surface.

Significant erosion may occur at stream crossings when culverts are too small for the peak flow and storm flows exceed culvert capacity, or when culverts become plugged by sediment and debris. In these instances, flood runoff will pond behind the road prism and eventually spill across the roadbed causing erosion of the stream crossing fill and development of a partial or complete *washout crossing*. The larger the stream crossing fill, and the larger the stream discharge, the greater the volume of erosion and sediment delivery that will occur when flood flows overtop the crossing. Washout crossings will remain highly problematic as the stream erodes down through the erodible road fill and the banks of the developing gully continue to erode back to a natural grade.

Even more significant erosion can occur at a stream crossing that exhibits a *diversion potential*, which means that flow is diverted down the road, either on the roadbed or in the ditch, instead of spilling over the fill and back into the same stream channel. In this case, the adjacent roadbed, hillslope, and/or stream channel that receives the diverted stream flow may become deeply gullied or destabilized. As road and hillslope gullies enlarge over time, they will deliver increasingly greater quantities of sediment to downslope stream channels (Hagans et al., 1986), and streamflow diverted onto steep, unstable hillslopes may trigger large landslides or debris flows.

To be considered adequately sized, culverts at stream crossings must have the capacity to convey a 100-year peak storm flow,[2] including sediment and organic debris in transport (Weaver et al., 2006). In areas where large, floating debris may also be a problem, trash racks and trash barriers should be installed slightly upstream from culvert inlets to screen out the larger woody debris as an additional precaution against plugging. Substandard stream crossing culverts include those that are not large enough to convey a 100-year flow, or are installed at too low of a gradient through the stream crossing fill to prevent plugging. Improper, low-gradient culvert installations were once common because they required shorter lengths of pipe to convey flow through the road, and were therefore used to minimize construction costs. However, in the long run these cost-cutting measures often prove detrimental to erosion control and road maintenance costs because the low gradient culvert is more likely to plug with sediment and debris, and at its outlet it discharges stream flow onto steep, unconsolidated road fill rather than into the pre-existing stream channel below the road fill, resulting in pronounced erosion of the outboard, downstream fill face.

Ditch relief culverts

A *ditch relief culvert* (DRC) is a plastic, metal, or concrete pipe installed beneath the road surface to convey flow from an inside road ditch to an area beyond the outer edge of the road fill. When properly spaced, DRCs collect road and cutbank runoff and disperse it to the downslope hillside at frequent intervals along the road. They limit the quantity of water available in the ditch so that it cannot cause erosion in the ditch or at the outlet of the culvert. It is sometimes necessary to install downspouts or rock armor at DRC outlets to further disperse energy and prevent erosion.

Landslides

Unstable road cutbanks and fillslopes with the potential to fail during periods of high and prolonged rainfall events are identified in the field by tension cracks, scarps showing vertical displacement, corrective regrowth on trees (i.e., pistol butt trees) and perched, hummocky fill indicating surface instability. As a standard practice, PWA maps all active and potential road-related landslides observed in the field, but only inventories those that exhibit a potential to fail and deliver sediment to a watercourse. Types of landslides in a road-related erosion assessment typically include (1) road fill failures, (2) landing fill failures, (3) cutslope debris slides, (4) hillslope debris slides, and (5) deep-seated, slow landslides. The majority of treatable landslides in an assessment area are often the result of failure of unstable fill and sidecast material from earlier road construction on steep hillslopes. Typically, the most cost-effective preventive treatment for unstable or potentially unstable fillslopes is the excavation and removal of unstable fill material and redepositing it in a stable, designated spoil disposal site (preferably nearby) where it cannot fail or erode and enter a watercourse. Conversely, large, deep-seated landslides are often technically infeasible or not cost-effective to treat.

2 The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.

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Additional feature-specific sediment sources

Other, less frequent sources of sediment delivery include: (1) discharge points for road surface, cutbank, and ditch erosion (e.g., the outlets of rolling dips, waterbars or lead-out ditches); (2) point source springs or multiple, closely spaced springs feeding a ditch; (3) features of bank erosion at or near a stream crossing or where the road has been built within or immediately next to a small watercourse; (4) active or beheaded headwall swales; (5) channel scour at or near stream crossings; and (6) non-road related upslope gullying caused by past logging, including eroding skid trail stream crossings, skid trail stream diversions or concentrated surface runoff from skid trail systems.

Unpaved road surfaces, and their associated cutbanks and inboard ditches, are often major sources for erosion and delivery of fine sediment to stream channels. Road surface, cutbank, and ditch erosion is termed "chronic" because it occurs throughout the year, any time there is significant surface runoff, and may include one or more of the following processes: (1) mechanical pulverizing and wearing down of road surfaces by vehicular traffic, and the use of unpaved roads during wet weather and wet soil conditions; (2) erosion of unpaved road surfaces by rainsplash and runoff during periods of wet weather; (3) erosion of poorly drained road surfaces characterized by steep grades, deep vehicle treads, outside berms or throughcut road sections that prevent surface drainage; (4) erosion of inboard ditches by road surface and cutbank runoff and emergent spring flow during wet weather periods; (5) active erosion within recently graded or maintained (bare) ditches, and (6) erosion of cutbanks by dry ravel, rainfall, slope failures, and brushing/grading practices.

Discharge points for road surface, cutbank, and ditch erosion are locations where sediment-laden flow from poorly drained road/cutbank/ditch segments exits the roadway to be delivered into the stream system. The most common discharge points include: (1) stream crossings, where road surfaces and ditch runoff exits the road alignment and directly enters the stream; (2) ditch relief culverts where runoff leaves the road close enough to a stream to allow storm flow to enter the watercourse or where the culvert discharges runoff into a gully that connects to a downslope stream channel; (3) road surface drainage structures, including rolling dips, waterbars, berm breaks, lead-out ditches and natural low spots in the road alignment that drain runoff and eroded sediment from the road surface, down the fillslope and into a nearby watercourse.

Point source springs refer to features where spring flow is entering the roadbed and causing erosion. Flow from multiple springs may become concentrated along a road or ditch with inadequate drainage structures, creating roadside gullies or fillslope failures. *Swales* are channel-like depressions that only carry minor flow during periods of extreme rainfall. *Bank erosion* features refer to locations of streambank erosion caused or exacerbated by emplacement of a nearby road or stream crossing. *Non-road related upslope gullies* form upslope of the road (often on logged areas) and discharge runoff and eroded sediment onto the road during storm events.

1.1.2 Evaluation of hydrologically connected road segments

During our road erosion assessments, PWA measures the lengths of hydrologically connected road segments adjacent to sediment delivery features, such as on one or both approaches to stream crossings, ditch relief culverts, or other discharge points, to derive an estimate for total potential sediment delivery from all connected road surfaces and ditches in the project area. In addition, because the adjacent hydrologically connected road segments contribute to the overall erosion and sediment delivery problem at a feature, PWA considers the treatment feature and adjacent road segments as a unit when estimating future sediment delivery and developing treatment prescriptions for that location. Thus, for example, prescriptions for a culverted stream crossing would include the necessary treatments to upgrade the culvert for the 100-year peak flow, as well as those drainage treatments on one or both road approaches that are needed to reduce and minimize road surface and ditch runoff that drains to the watercourse.

1.2 Overview of Storm-proofing Roads (Road Upgrading and Decommissioning)

Forest and rural roads may be storm-proofed by one of two methods: upgrading or decommissioning (Pacific Watershed Associates, 1994; Weaver and Hagans, 1999; Weaver et al., 2006). Upgraded roads are kept open, and are inspected and maintained. Their drainage facilities and fills are designed or treated to accommodate the 100-year peak storm flow[3]. Conversely, properly decommissioned roads are closed and no longer require maintenance. Whether through upgrading or decommissioning, the goal of storm-proofing is to make the road as "hydrologically invisible" as possible; that is, to reduce or prevent future sediment delivery to the local stream system. A well-designed storm-proofed road includes specific characteristics (see table, next page), all proven to contribute to long-term improvement and preservation of watershed hydrology and aquatic habitat.

1.2.1 Road upgrading

Road upgrading involves a variety of treatments used to make a road more resilient to large storms and flood flows. The most important of these include upgrading stream crossings (especially culvert upsizing to accommodate the 100-year peak storm flow and debris in transport, and correct or prevent stream diversion); removing unstable sidecast and fill materials from steep slopes; and applying road drainage techniques (e.g., installing ditch relief culverts, removing berms, constructing rolling dips, insloping or outsloping the road) to improve dispersion of surface runoff. Road upgrading may also include adding road rock or riprap as needed to fortify roads and stream crossings.

Installing rolling dips

Rolling dips are installed on low- to moderate-gradient hydrologically connected[4] road segments to disperse surface runoff and discharge it onto the native hillslope below the road. Rolling dips extend from the inboard edge to the outboard edge of a road, and are constructed at intervals as needed to disperse surface runoff and control erosion (typically 100, 150, or 200 ft). They are effective in reducing year-round ("chronic") erosion and sediment delivery from road surfaces, and are designed to be easily drivable and not impede vehicular traffic.

3 The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.
4 *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

Characteristics of storm-proofed roads (Weaver et al., 2006).

Storm-proofed stream crossings

- All stream crossings have a drainage structure designed for the 100-year peak storm flow (with sediment and debris in transport).
- Stream crossings have no diversion potential (functional critical dips are in place).
- Stream crossing inlets have low plug potential (trash barriers installed).
- Stream crossing outlets are protected from erosion (extended beyond the base of fill; dissipated with rock armor).
- Culvert inlet, outlet, and bottom are open and in sound condition.
- Undersized culverts in deep fills (greater than backhoe reach) have emergency overflow culvert.
- Bridges have stable, non-eroding abutments and do not significantly restrict 100-year flood flow.
- Fills are stable (unstable fills are removed or stabilized).
- Road surfaces and ditches are "hydrologically disconnected" from streams and stream crossing culverts.
- Class I stream crossings meet CDFG and NMFS fish passage criteria (Taylor and Love, 2003).

Storm-proofed fills

- Unstable and potentially unstable road and landing fills are excavated or structurally stabilized.
- Excavated spoil is placed in locations where it will not enter a stream.
- Excavated spoil is placed where it will not cause a slope failure or landslide.

Road surface drainage

- Road surfaces and ditches are "hydrologically disconnected" from streams and stream crossing culverts.
- Ditches are drained frequently by functional rolling dips or ditch relief culverts.
- Outflow from ditch relief culverts does not discharge to streams.
- Gullies (including those below ditch relief culverts) are dewatered to the extent possible.
- Ditches do not discharge (through culverts or rolling dips) onto active or potential landslides.
- Decommissioned roads have permanent drainage and do not rely on ditches.
- Fine sediment contributions from roads, cutbanks, and ditches are minimized by utilizing seasonal closures and implementing a variety of surface drainage techniques including berm removal, road surface shaping (outsloping, insloping, or crowning), road surface decompaction, and installing rolling dips, ditch relief culverts, waterbars, and/or cross-road drains to disperse road surface runoff and reduce or eliminate sediment delivery to the stream.

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Road shaping

Road shaping changes the existing geometry or orientation of the road surface, and is accomplished through insloping (sloping the road toward the cutbank), outsloping (sloping the road toward the outside road edge), or crowning (creating a high point somewhere near the center axis of the road so that it slopes equally inward and outward). Like rolling dips, road shaping is used to quickly drain surface runoff off the road surface and direct it to the inside ditch or to the outside road shoulder. Road shaping keep water from standing on, or flowing down, the road bed, thereby reducing roadbed saturation, surface deterioration and surface erosion.

Installing ditch relief culverts

A ditch relief culvert is a drainage structure (usually an 18 inch diameter pipe) installed across a road prism to move water and sediment from the inboard ditch to the base of the outside road fill so that it can be dispersed on the native hillslope beneath the road. Ditch relief culverts are used to drain ditch flow on roads that are insloped or crowned, that have springs and seeps draining to the ditch, or that are too steep for rolling dips or outsloping.

Excavating unstable fills and fillslopes

The fillslope, the sloping part of the road fill located between the outboard edge of the road prism and the natural hillslope below, may fail or show signs of instability and potential failure. As a preventative measure, before failure occurs, fillslope materials that shows signs of instability (cracks, scarps, or hummocky topography) or that are perched on steep slopes above a stream can be excavated and hauled or pushed to a stable spoil deposal site where they no longer threaten water quality. This is often the most cost-effective treatment for unstable road fills on forest roads.

Upgrading stream crossings

Techniques used to prevent or remediate road related erosion at a stream crossing are dependent on the size of the stream channel, and specific physical characteristics at the crossing feature. Crossings of Class I and large Class II watercourses may require a bridge, or, if their banks are small or low gradient, a ford crossing may be suitable if seasonal use is anticipated. A common approach to upgrading moderate sized crossings of Class II and III watercourses is to construct a culverted fill crossing capable of withstanding the 100-year flood flow.

Techniques for upgrading small stream crossings include:

- *Installing or replacing culverts.* A culvert capable of passing the 100-year storm flow, including expected sediment and debris in transport, is installed or replaced in the fill crossing. Culverts on non fish-bearing streams are placed at the base of fill, in line and on grade with the natural stream channel upstream and downstream of the crossing feature. Backfill material, free of woody debris, is compacted in 0.5-1.0 ft thick lifts until at least 1/3 of the diameter of the culvert has been covered, and then backfilled over the top of the pipe to the final road tread elevation. At features where fillslopes are steeper than 2:1, or where eddying currents might erode fill on either side of the inlet, rock armor is applied to the fillslope as needed.

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- *Installing an armored fill.* Armored fills are installed on smaller stream crossings with relatively small fill volume, but where debris torrents are common, channel gradients are steep, or inspection and maintenance of a culverted crossing is not feasible. The roadbed is heavily rocked, and a keyway in the outboard fillslope is excavated and backfilled with interlocking rock armor of sufficient size to resist transport by stream flow (Weaver at al., 2015). Armored fill crossings are constructed with a dip in the axis of the crossing to prevent diversion of the stream flow during the design flood event, and focus the flow over the axial part of the fill that is most densely armored.
- *Installing secondary drainage structures.* A variety of secondary structures may be used to increase the function of small stream crossings by preventing culvert plugging, decreasing backwater flooding, and controlling erosion. Where a culvert has been improperly installed too high in the fill, a *downspout* may be added to its outlet to carry stream flow to the base of the fill and into the natural stream channel, rather than letting it cascade from the height of the culvert. *Rock armor* may be used to buttress steep fillslopes, as well as to prevent erosion of inboard or outboard fillslopes by eddying currents. A *trash rack* placed in the channel slightly upstream of the culvert inlet will trap large debris and reduce the potential for culvert plugging. To prevent stream diversion should the culvert become plugged or its capacity exceeded, a *critical dip* (essentially a rolling dip constructed in line with the stream channel) may be installed to ensure that stream flow will be directed across the road and back into the natural channel rather than diverted down the road or ditch. Finally, an *overflow culvert* may be a necessary addition higher in the fill at a culverted crossing where, because of site conditions, plugging or capacity exceedence of the primary culvert is anticipated.

1.2.2 Road decommissioning

In essence, decommissioning is “reverse road construction,” although complete topographic obliteration of the roadbed is not usually required to achieve cost-effective erosion prevention. In most cases, serious erosion problems are confined to a few, isolated locations along a road (perhaps 10% to 20% of the full road network to be decommissioned) where stream crossings need to be excavated, unstable sidecast on the downslope side of a road or landing needs to be removed before it fails, or the road crosses unstable terrain and the entire road prism must be removed. But typically, most of the road to be decommissioned (outside of stream crossings and unstable road fills) usually requires simpler, permanent improvements to surface drainage, such as surface decompaction (road ripping), additional road drains, and/or partial outsloping. As with road upgrading, the heavy equipment techniques used in road decommissioning have been extensively field tested, and are widely accepted (Weaver and Sonnevil, 1984; Weaver and others, 1987, 2006; Harr and Nichols, 1993; Weaver et al., 2015).

Road ripping or decompaction

Road ripping is a technique in which the surface of a road or landing is disaggregated or "decompacted" to a depth of at least 18 in. using mechanical rippers. This action reduces or eliminates surface runoff and enhances revegetation of formerly compacted roadbeds.

Installing cross-road drain

Cross-road drains (also called "deep waterbars") are large ditches or trenches excavated across a road or landing surface to provide drainage and prevent runoff from traveling along, or pooling on, the former road bed. They are typically installed at 50, 75, 100 or 200 ft intervals, or as necessary at springs and seeps. In some locations (e.g., streamside zones), partial outsloping may be used instead of cross-road drain construction to accomplish the same objectives.

In-place stream crossing excavation (IPRX)

IPRX is a decommissioning treatment used for roads or landings that are built across stream channels. The fill (including the culvert or Humboldt log crossing) is completely excavated and the original streambed and side slopes are exhumed. Excavated spoil is stored at nearby, stable locations where it will not erode and enter the stream. In some cases, this may necessarily be as far as several hundred feet from the crossing. An IPRX typically involves more than simply removing a culvert, as the underlying and adjacent fill material must also be removed and stabilized. As a final measure, the sides of the channel may be excavated back to slopes a typically stable 2:1 slope gradient, and mulched and seeded for erosion control.

Exported stream crossing excavation (ERX)

ERX is a decommissioning treatment in which stream crossing fill material is excavated and the spoil is hauled off-site for storage (the act of moving spoil material off-site is called "endhauling"). This procedure is necessary when large, stable storage areas are not available at or near the excavation site. It is most efficient to use dump trucks to endhaul the spoil material.

In-place outsloping (IPOS)

IPOS (also called "pulling the sidecast") calls for excavation of unstable or potentially unstable sidecast material along the outside edge of a road prism or landing, and placement of the spoil on the roadbed and/or against the corresponding, adjacent cutbank within several hundred feet of the site. As a further decommissioning measure, the spoil material placed against the cutbank helps block unwanted access to the decommissioned road.

Export outsloping (EOS)

EOS is a technique comparable to IPOS, except that spoil material is moved off-site to a permanent, stable storage location. EOS is required when it is not possible to place spoil material against the adjacent cutbank (e.g., where the road prism is narrow or where there are springs along the cutbank). EOS usually requires dump trucks to endhaul the spoil material. This technique is used for both decommissioning and upgrading roads, but as the roadbed is partially or completely removed, EOS is more commonly used for decommissioning.

1.3 Determining Treatment Immediacy and Cost-Effectiveness

Identifying *treatment immediacy* is an integral part of an assessment used to prioritize features prior to implementation. Treatment immediacy is a professional evaluation of how important it is to quickly perform erosion control or erosion prevention work. It is defined as "high," "moderate," or "low," and represents the urgency of treating the feature before it erodes or fails. An evaluation of treatment immediacy is based on the following criteria: (1) *erosion potential*, or whether there is a low, moderate, or high likelihood for future erosion at a feature; (2) *sediment delivery*, which is an estimate of the sediment volume projected to be eroded from a feature and delivered to a nearby stream; and (3) the value or sensitivity of downstream resources being protected. Generally, features that are likely to erode or fail in a normal winter, and are expected to deliver significant quantities of sediment to a stream channel, are rated as having high treatment immediacy.

The *erosion potential* of a feature is a professional evaluation of the likelihood that erosion will occur during a future storm, based on local site conditions and field observations. It is a subjective probability estimate, expressed as "low," "moderate," or "high," and not an estimate of how much erosion is likely to occur. The volume of sediment projected to erode and reach stream channels is described by *sediment delivery*, which plays a significant role in determining the treatment immediacy for a feature. The larger the volume of potential future sediment delivery to a stream, the more important it becomes to closely evaluate the need for treatment.

From this assessment, treatment immediacy and *cost-effectiveness* may be analyzed, along with the client's transportation needs, to prioritize treatment features or locations for implementation. *Cost-effectiveness* is not only a necessary consideration for environmental protection and restoration projects for which funding may be limited, but is also an accepted and well-documented tool for prioritizing potential treatment features in an area (Weaver and Sonnevil, 1984; Weaver and Hagans, 1999; Weaver et al., 2006). A quantitative estimate for cost-effectiveness is determined by dividing the cost of accessing and treating a feature by the volume of sediment prevented from being delivered to local stream channels. The resulting value, or *sediment savings*, provides a comparison of cost-effectiveness among features, and an average for the entire project area. For example, if the cost to develop access and treat an eroding stream crossing is projected to be $5000, and the treatment will potentially prevent 500 yd^3 of sediment from reaching the stream channel, the predicted cost-effectiveness for that feature would be $5000/500yd^3$, or $10/yd^3$.

PWA further evaluates cost-effectiveness for an entire assessment area by organizing features into logistical groups based on similar requirements for heavy equipment and materials, and addressing these as a unit to minimize expenses. Furthermore, although features and road segments with the lowest immediacy ratings are placed last on the list for treatment, it is sometimes possible to treat these features once the project is underway, as opportunities to cost-effectively treat low-immediacy features often arise when heavy equipment is already located nearby to perform maintenance or restoration at higher-immediacy features.

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Appendix B

Field observations and treatment recommendations for road related features

Quarry Park Watershed Assessment And Erosion Prevention Planning Project San Mateo County, California

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
1	Meadow Trail Spur 3	HM	116	0	0	A Class II stream crossing at a terminal landing. Stream flow is actively eroding a large gully. There is a network of legacy skids in the immediate area. The road surface leading to the site is densely vegetated. There is a bedrock cascade at the TOP. Future erosion has been calculated with gully dimension enlargement.	1) Decommission crossing, excavate TOP to BOT, establish a 5' wide channel bottom with 2:1 side slopes. 2) Store spoils locally, utilize materials for local IPOS on right road approach.
2	Meadow Trail	M	601	75	687	A large Class II stream appears to have been ponded in the past by the construction of two berms/levees. The ponds have since been filled with aggraded sediments, the upstream channel has been heavily tractored. Stream flow is conveyed through two 15" undersized culverts, one is upstream and the other downstream of the active trail. The culverts have been installed at a shallow grade and high in the fill. A 6' headcut has formed downstream of the lower culvert outlet. The existing trail traverses along the inboard edge of the lower past pond feature.	1) Excavate TOP to BOT, remove both culverts. Define new 8' wide channel bottom with 2:1 slopes from TOP to the new culvert inlet, and define an 8' wide channel bottom from the culvert outlet to the BOT. 2) Install a new 48"x 70' corrugated metal pipe at base of fill. 3) Define an 8' wide channel with 2:1 slopes below new corrugated metal pipe outlet for 200'. 4) Store spoils locally for IPOS on Quarry Park trail 9B, use remaining soils to raise and shape the left road to parking lot. 5) Install 5yds^3 of 0.5' to 1.5' diameter armored rock at outlet to act as an energy dissipater. 6) Install a galvanized trash rack. 7) Install 3 rolling dips on right road approach. 8) Outslope and fill ditch for 687' of right road approach.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
3	Pond Trail	M	97	0	165	A near origin Class III stream crossing with no formal drainage structure. The stream is forming from an extensive network of skid road drainages and is conveyed down a through cut skid. The upstream channel is tractored to headwaters. The stream drains to a pond downstream. There is active headcutting through a lower skid prism.	1) Excavate from TOP to BOT and Install a 24"x50' long culvert. 2) Upon fill rebuild establish a 30-degree angle and armor lower 1/4 OBF with 7 yd^3 of 1-2.5' diameter riprap 3) Install 3 yd^3 of 0.5-1.5' diameter rip rap at CMP outfall for energy dissipation. 4) Install a critical dip along the left hingeline. 5) Decommission stream crossing through the lower road crossing from TOP#2 at the outlet of the new culvert to BOT#2 at the base of the headcut. Establish a 4' wide channel bottom with 2:1 sideslopes throughout the excavation. 6) Spoil locally for and utilize the spoil materials to decommission the lower road alignment via IPOS road decommissioning treatment. 7) Install 5 cross road drains up road on right bank of upstream channel reach. 8) Rock road through crossing with 10 yd^3 road rock.

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Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
4	Meadow Trail	H	9259	25	0	Overflow of an instream pond on a Class II system which has no formal drainage structure. Fill face of dam appears stable other than the uncontrolled spillway at right hinge of stream crossing. Overflow is bifurcated 45' down road by a dysfunctional sandbag check dam, which is shunting some of the flow across the road and forming a gully near the dam face, the rest of the flow is diverted 90' down road where is has caused a failure and washed out most of the road. Sediment is being deposited in broad meadow beneath dam through diffuse channels. Some seepage is occurring through a valve at the base of the dam. Active headcuts pose a threat to the pond with catastrophic potential. A formal drainage structure should be installed at spillway to prevent failure. In depth evaluation of pond is needed for sediment delivery potential and stability analysis.	**Upgrade option *(upon request, an engineered design package will provide complete treatment details based on County Parks short/long term preference)*** 1) Install a 48"x30' culvert in the axis of the spillway to convey flows through the levee. 2) Attach a 10-degree 48" diameter elbow to the culvert outlet to convey flow into the downspout. 3) Install a 48"x70' downspout culvert to covey the flow to the base of the fill. 4) Define a rocked outboard fillslope to act as an emergency spillway in the event of culvert plugging. Define a keyway 75' long x 25' wide at the top x 20' wide at the base x 3' deep on average. Rock armor the spillway with 190yd^3 of 0.5'-2.5' rock armor. 5) The CMP should be installed with 6 culvert stakes driven into the slope no more than 40 feet apart in accordance with the manufacturer's recommendations. A 3/8 galvanized wire rope should extend from the top set of culvert stakes to the bottom set and bonded to the CMP at every joint to distribute the load. 6) Install a culvert 48" diameter "T" at the outlet of the culvert to dissipate outflow energy onto rock armor.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

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5	Meadow Trail Spur 2	M	2	0	85	A low volume Class II stream crossing on a small mountain bike trail in an alluvial setting. Downstream of crossing the majority of stream flow is diverting to Meadow Trail access road. Efforts have been made to mitigate this diversion. A ditch has been recently constructed 130' downstream to divert the flow back to its original orientation but has failed. The flow has traveled down the park road forming multiple large gullies in road surface. The majority of the diverted stream flow travels to Site #6 and has formed a large sediment fan.	1) Install an armored fill stream crossing, lower road by at least 1' in axis of dip, construct broad dip such that it disconnects road approaches. Excavate a keyway 18' wide at the top x 12' wide at the base x 10' long x 2' deep, armor the keyway with 12yd^3 of 0.5-2' diameter rock armor. 2) Rock road through stream crossing with 5yds of road rock. 3) Define channel from base of keyway to BOT#2 downstream from the crossing, establish an 8' wide x 150' long x 1.5' deep channel with 2:1 sideslopes to convey flow back to natural channel and prevent future diversions.. 4) Outslope and remove ditch for 85' on right road approach. 5) Store the spoil materials locally on the trail approaches and utilize the material for trail shaping.
6	Meadow Trail	HM	177	0	904	Concentrated road runoff and diverted stream flow has eroded multiple gullies down the road. Gullies have been intersected via several recently installed non-functioning crossroad drains. The majority of the sediment has laid out in the alluvial meadow up road from the parking lot near cement pad. The fans will continue to build and may gully through and deliver to the Class II stream. Stream channel definition prescribed at Site #5 should abate active diversion.	1) Install 6 rolling dips up the right road approach. 2) Rock road at each rolling dip, install 10yd^3 of coarse road rock at through the trough of each dip feature, 60yd^3 total road rock. 3) Install sediment basin at edge of meadow 20' wide x30' long by 3' deep with 3:1 sideslopes.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

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				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
7	Dolphine Fire Road	HM	62	156	278	A fill crossing on a Class III stream. There is a small springy swale to the left which should be conveyed into crossing. There is aggraded sediment at the inboard edge of fill which has developed a fan. The crossing is dipped adequately, flow is actively gullying the outboard edge of fill.	1) Install an armored fill, clear the fan at the inboard edge of the road, establish a broad dip that conveys stream flow though the crossing and lower the road by 1' through the axis of the dip, excavate a keyway 21' wide at the top x 8' wide at the base x 21' long x 2' deep, armor the keyway with 25yd^3 of 0.5'-2' diameter rock armor. 2) Rock road with through the crossing with 15yd^3 of road rock. 3) Outslope and fill ditch for 278' of right road. 4) Install 1 rolling dip on the right road approach.
8	Dolphine Fire Road	H	210	92	417	Class III stream flow is conveyed through this crossing via an undersized 15" diameter corrugated metal pipe that is installed high and short in the fill. The inlet of the culvert is 50% plugged. A section of the outboard fill has failed, exposing the bent culvert in the outboard fill vacancy. There is a stump on the edge of the outboard fill exhibiting basal flair. The upstream channel reach has been heavily tractored.	1) Excavate TOP to BOT, replace corrugated metal pipe with new 30"x60' culvert at the base of fill. 2) Excavate 35' upstream and define a 4' wide channel bottom with 2:1 sideslopes. 3) Install critical dip on left hinge of the stream crossing. 4) Place 5yd^3 of 0.5'-2' diameter rock armor as energy dissipater. 5) Upon fill rebuild armor lower 1/4 of outboard fill with 10yd^3 of 2-3' diameter rock armor to buttress the steep fillslope. 6) Spoil locally on road to left and right, utilize spoil material for outslope road fill ditch road upgrade treatment. 7) Install a single post trash rack.

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Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
9	Dolphine Fire Road	HM	92	0	110	A flashy Class III stream is conveyed through this crossing via an undersized 15" diameter corrugated metal pipe. The culvert is installed high and short in the fill. The outboard edge of fill has failed, resulting in a shotgunned outlet with an 11' plunge. Upstream channel has been heavily tractored. This crossing is actively failing. The outlet of the culvert is crushed.	1) Excavate TOP to BOT, replace existing culvert with a new 30"x 50' corrugated metal pipe at the base of fill. 2) Install a single post trash rack. 3) Install rock armor to the lower 3/4 of the outboard edge of fill with $21yd^3$ of 1'-3' diameter rock. 4) Place $4yd^3$ of 0.5'-1.5' diameter rock armor at outlet as an energy dissipater. 5) Enhance the critical dip on left hinge of stream crossing. 6) Outslope road and fill ditch for 110' on right road approach. 7) Store spoil materials locally on road to left and right.
10	Dolphine Fire Road	H	6	120	120	Concentrated road runoff from the hydrologically connected road is evacuating the road at this location. The uncontrolled flow has eroded a gully down the outboard fillslope which has laterally destabilized the slope and caused a failure in the outboard fill. Flow is being directed to the failure along a 60' long berm on the right road approach. The berm was likely created by storing material from a failed cutbank on the outside edge of fill.	1) Excavate perched material on either side of failure from left to right 20' wide x 15' long x 1' deep, spoil locally and use material for rolling dip and outsloping. 2) Install armored fill at existing drainage outflow location, establish a broad dip that conveys flow into the axis of the keyway, excavate a keyway 15' wide at the top x 7' wide at the base x 15' long x 2' deep, armor the keyway with $12yd^3$ of 0.5'-1.5' diameter rock armor. 3) Install 1 rolling dip on left road approach and outslope the left road for 120'. 4) Inslope right road approach for 160' through site #11, and retain a berm to avoid outletting flow onto the unstable slopes below the road.

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11	Dolphine Fire Road	HM	38	0	163	A section of perched outboard edge of fill has failed with delivery to a Class II stream downslope. There are cracks in remaining material along the outboard edge of fill. The right road is connected for 163'. The decomposed granite cutbanks are raveling.	1) Excavate the perched outboard fill material from left to right, 60' wide x 15' long x 1.5' deep. 2) Install 1 rolling dip up right road approach at swale, and outslope right road approach for 163'. 3) Spoil locally to left and right. 4) Install a 5yd^3 keyway at the outboard edge of fill break in slope at the outlet of the rolling dip.
12	Dolphine Fire Road	M	119	15	90	Class III stream flow is conveyed through this crossing via an undersized 15" diameter culvert. The channel upstream of the culvert is a box channel with a bedrock nick point upstream. The culvert has been installed short and high in the fil and is undersized. There is aggraded sediment aggraded at the inlet of the culvert. The channel has incised through the old tractored fill upstream of the crossing. Shallow bedrock may inhibit excavation. Cutbanks are composed of decomposed granite. There is a 2' diameter tree under the existing culvert in the outboard edge of fill, and a large tree is laying in the channel downstream of crossing.	1) Excavate TOP to BOT, remove the existing culvert and install a new 36"x 50' culvert at the base of fill. 2) Upon rebuild of the outboard fillslope armor the lower 3/4 of slope with 27yd^3 of 2'-3' diameter armored rock to buttress the steep fillslope. 3) Install an energy dissipater at culvert outfall with 3yd^3 of 0.5-1.5 diameter rock. 4) Install a critical dip at left hinge of crossing. 5) Define a 4' wide channel bottom with 2:1 sideslopes from the TOP to the culvert inlet for 60' 6) Outslope and remove berm on right road approach for 90' 7) Establish 15' wide road through the crossing upon fill rebuild. 8) Install a single post trash rack at the inlet of the culvert.

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13	Dolphine Fire Road	HM	112	0	85	Class III stream flow is conveyed through this crossing via an undersized 15" culvert which is set high and short in the fill. A large part of the outboard edge of fill has failed due to being oversteep and likely saturated by road runoff from the right approach. Logs have been placed on the right outboard edge of fill. Remaining outboard edge of fill is near vertical and prone to future failure.	1) Excavate TOP to BOT, replace existing culvert with a new 36"x 50' corrugated metal pipe at the base of fill, clear debris and define channel below BOT for 15' 2) Lay back streamside banks upstream of TOP for 35' to the bedrock headcut. 3) Install a single post trash rack at the culvert inlet. 4) Outslope road and remove ditch on right road for 85'. 5) install 1 rolling dip 6) Install energy dissipater at culvert outlet with 5yd^3 of 1'-2.5' diameter rock armor. 7) Install a critical dip on the left hinge of the crossing. 8) Armor the lower 3/4 of the outboard edge of fill slope with 8' wide at the top x 20' wide at the base x 12' long x 3' deep with 20yd^3 of 1'-3' diameter armored rock.
14	Dolphine Fire Road	M	6	0	375	Headwall swale flow and combined concentrated road runoff are directed off the road via a crossroad drain up the right road from Site #13. An armored fill crossing should be installed to disconnect diverted flow. There is active rilling and gullying development occurring which is ultimately delivering to the Class II stream downstream of crossing Site #13.	1) Construct an armored fill crossing; establish a broad dip that conveys flow, excavate a keyway 20' wide at the top x 8' wide at the base x 18' long x 3' deep, armor the keyway with 30yd^3 of 0.5-1.5' diameter rock armor. 2) Outslope road and remove ditch on right road approach for 350' 3) Install 1 type 1 rolling dip up right road.

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15	Dolphine Fire Road	M	56	30	156	Combined diverted stream flow from Site #16 and concentrated road runoff have formed two active gullies in middle of the road. The gullies exit the road surface and are actively eroding down the outboard fillslope and delivering to a Class III stream downslope from the road. Treatment of Site #16 should abate the majority of the flow from the right road approach.	1) Treat Site #16 to mitigate the stream crossing diversion. 2) Install 2 rolling dips up the right road approach. 3) Outslope road and fill ditch for 160' of right road approach. 4) Outslope road and fill ditch for 30' of left road approach.
16	Dolphine Fire Road	M	8	0	130	A Class III stream is actively diverting down the left road to the road surface discharge Site #15. The right road is connected for 130'. The stream crossing is on the edge of the forest, flow emerges from underneath thick brush and duff. There is an active spring to the left which should be incorporated into the new crossing. The crossing is at the head waters of the Denniston Creek drainage and drains into a large pond downstream. There is a large volume of sediment suspended upstream of this crossing due to past debris torrent at Site #40. This site should be maintained as sediment pulses through the system to prevent failure.	1) Construct an armored fill crossing; establish a broad dip that conveys stream flow though the crossing, excavate a keyway 18' wide at the top x 8' wide at the base x 15' long x 2.5' deep, armor the keyway with 20yd^3 of 0.5-1.5' diameter rock armor. 2) Outslope and remove ditch for 130' on the right road approach. 3) Install 1 rolling dip on the right road approach. 4) Rock the road through the crossing with 20yd^3 of road rock.

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Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
17	Quarry Trail	M	32	27	564	A low volume fill crossing on a Class III stream. There are 2 connected roads on the right and a short portion on the left. The long right approach coming down from Site #35 is actively rilling and delivering to the crossing. The treatment immediacy at this site will increase as will active erosion as upstream diversions are corrected.	1) Construct an armored fill crossing; establish a broad dip that conveys stream flow though the crossing, excavate a keyway 18' wide at the top x 8' wide at the base x 14' long x 2' deep, armor the keyway with 15yd^3 of 0.5-1.5' diameter rock armor. 2) Install a sediment basin downstream and to the right of the crossing, 6' wide x 10' Long with 3:1 sideslopes. 3) Outslope road and fill ditch on the longer right road approach that comes down from Site #35 for 371'. 4) Install 2 rolling dips on the right road approach. 5) Outslope road for 27' on left road approach. 6) Define a 5' channel bottom with 2:1 sideslopes upstream of crossing for 150'. 7) Spoil locally.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
19	Middle Ridge Trail Legacy road	H	186	165	20	Class III stream flow and emergent cutbank spring flow are actively saturating and eroding the fill at this crossing. There is no formal drainage structure, and the road fill is actively failing. The outboard fillslope is long and oversteep. The road has been installed through the headwall area of this Class III stream. There are numerous active cutbank slides on the right road approach, and a large section of the road fill has failed on the right hinge of the crossing. There is a residence atop the slope that is actively conveying drainage to this swale from the graded flat. There is a section of exposed culvert on the hillslope above the crossing. There is a large tree in the axis of the channel that is undercut by recent failures and prone to failure. This site appears to be on the property boundary. Additionally, there are large scarps upslope of the crossing that are indicative of a potential torrent activity if the entire swale were to fail. This large-scale failure would likely blow out stream crossing site #7 downstream. Treatment at this site may be contentious due to the fact that one of the factors of instability may be the excessive drainage being conveyed to the crossing from the property at the top of the hill. The Client should be advised of the potential property boundary issue.	1) Decommission the stream crossing, excavate from TOP to Bot and establish a 4' wide channel bottom with 2:1 slopes. 2) Construct a rock grade control structure (GCS) at the TOP of the excavation. Excavate a 20' wide x 10 ' long x 3' deep keyway at the top of the excavation and armor the keyway with $25yd^3$ of 0.5-2.5' diameter armor to stabilize any potential headcutting. 3) Construct a rock GCS at the BOT of the excavation. Excavate a 20' wide x 10 ' long x 3' deep keyway at the top of the excavation and armor the keyway with $25yd^3$ of 0.5-3' diameter armor to stabilize any potential headcutting. 4) Store spoil materials locally on the road to the left and utilize spoil materials for local IPOS. NOTE: Due to the driving factor of instability potentially being the excessive drainage being conveyed to the crossing from the property at the top of the hill, treatment design will require investigation of the neighboring drainage infrastructure to determine impact to the site.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
20	Pond Trail	ML	154	0	332	A crossing on a small near origin Class III stream with no formal drainage structure. The channel upstream of the crossing is heavily tractored. The stream morphology is diffuse due to the dense debris layer. The right road approach is heavily vegetated. This site drains to the pond associated with Site #4. There is a second road prism downslope of this crossing that should be decommissioned in concert with this crossing. The site is not actively disaggregating, but if the road were re-opened the site would be an erosion issue.	1) The crossing through the main road alignment will be upgraded and the lower crossing will be decommissioned. Excavate from TOP#1 to BOT#1 and install a 24"x60' CMP at the base of fill. 2) Install a critical dip on the left hinge of the crossing. 3) Rebuild the road 12' wide through the axis of the crossing, establish a 45 degree inboard fillslope rebuild and rock the entire inboard fillslope with 5yd^3 of 0.5'-2' diameter rock armor to buttress the steep fill and prevent scour. 4) Rebuild the outboard fillslope at 42 degrees and armor the lower 3/4 of the fillslope with 40yd^3 1'-3' rock armor to buttress the steep fillslope. 5) Install 3yd^3 of 0.5'-2' diameter rock armor at the culvert outfall to serve as energy dissipation. 6) Install 3 rolling dips up the right road approach. 7) Outslope and fill ditch for 332' up the right road approach. 8) Decommission the lower stream crossing, excavate from TOP to BOT and establish a 4' wide channel bottom with 2:1 slopes. 9) Store spoil materials locally on the left road and utilize spoil materials for local IPOS.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
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21	Pond Trail	ML	105	0	421	A headwall swale with emergent spring flow. The spring flow delivers to a Class III stream downslope. The road bench and the cutbank are very springy and vegetated with hydrophilic vegetation. The road is effectively dipped through the crossing to prevent diversion. Class II Denniston Creek is at the base of the stream valley downslope of the crossing.	1) Excavate from TOP to BOT and install a new 24"x60' CMP at the base of fill. 2) Upon fill rebuild establish a 12' wide road through the axis of the crossing and an outboard fill rebuild angle of 40 degrees. Armor the lower 3/4 of the outboard fillslope with 50yd^3 of 1'-3' diameter rock armor to buttress the steep fillslope. 3) Install 3yd^3 of 0.5-2' diameter rock armor the outlet of the newly installed culvert to serve as energy dissipation. 4) Install 2 rolling dips on the right road approach. 5) Outslope and fill ditch for 427' of right road.
22	Meadow Trail	L	14	502	0	A near origin low power Class III stream crosses the road with no formal drainage structure. Sediment is actively being deposited on the right road for ~200'. The left road is contributing flow for 502'. Active erosion at the site is minimal, and flow is actively diverting down the right road. There is a swale 220' up the left road approach that should be drained across the road.	1) Construct an armored fill crossing; establish a broad dip that conveys stream flow though the crossing, excavate a keyway 18' wide at the top x 8' wide at the base x 15' long x 2' deep, armor the keyway with 15yd^3 of 0.5'-1.5' diameter rock armor. 2) Outslope road and fill ditch on left approach for 502'.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
23	Meadow Trail	M	22	1089	0	A Class II stream crossing at the intersection of Quarry Trail and Meadow Trail. Flow is conveyed through this crossing via an 18" diameter cement culvert. The crossing receives diverted stream flow from Meadow trail and stream flow from stream crossing Site #26. The stream flow appears to overtop the crossing at high flows and is actively eroding he ditch 35' upstream and 185' downstream of the crossing. The stream evacuates the park and flows onto the Columbus Ave. The channel should be defined to prevent erosion and contain the seasonal high flow volumes. Flow is also contributed to the crossing from a marshy alluvial area to the right of the culvert inlet.	1) Excavate from TOP to BOT removing the existing undersized CMP and install a new 13ft^2 cement box culvert installed at the base of fill. (4' wide x 3.25' tall x 15' long) 2) Define the channel upstream of the crossing for 250', establishing a 5' wide channel bottom with 2:1 banks. 3) Install 3 rolling dips up the left road approach on Meadow Trail. 4) Install 3 rolling dips up the left road approach on Quarry Trail. 5) Define the ditch downstream of the crossing 5' wide with 2:1 banks to Columbus Ave. 6) Drain 70% of the new surface of the parking lot to the south toward the playground into the grassy alluvial setting. 7) Remove and replace the fencing as necessary.
24	Meadow Trail Spur 1	L	33	20	200	A small makeshift bridge crosses a Class II stream on a small single-track trail Meadow Trail Spur 1. The channel upstream and downstream of the crossing avulses during high flow events. The stream banks are near vertical. The bridge is not a permanent crossing but appears to be moderately stable.	1) Upgrade the existing crossing by installing a rocked ford crossing, remove the bridge and define a 6' wide channel bottom and lay the road approaches back to 3:1. Install 5yd^3 of 0.5-2' diameter rock armor through the channel 10' wide x 6' long x 2' deep 2) Define a 5'-6' wide channel bottom with 2:1 banks upstream and downstream of the crossing for 100' in total length. 3) Rock the road approaches with 5yd^3 of road rock per approach, for 10yd^3 total. 4) Install 2 rolling dips on the right road approach.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
25	Quarry Trail	M	25	657	0	A confined section of road and springy ditch has a 12" diameter DRC that conveys flow to stream crossing site #26. The swale upslope does not display any channel morphology. There is significant portion of right IBD that flows to this site as well.	1) Install 1 rolling dip on the left hinge of the crossing to function as a critical dip. 2) Install 4 rolling dips on the right road approach. 3) Outslope road and fill ditch for 650' of right road approach. 4) Replace the existing 12" DRC and install an 18"x40' DRC at the base of fill.
26	Quarry Trail Spur 1	ML	97	0	0	A Class II stream in an alluvial setting is conveyed through this site via a 15" diameter culvert with a dropped inlet. The stream valley has been dammed via a levee that conveys all stream flow in the valley to this pond. The ponded area also receives flow from Site #25. The area should be decommissioned, and the stream valley should be redefined up and downstream of the crossing. The channel could be defined from Site #17 to Site #23 which would include the removal of many large diameter trees.	1) Decommission the stream crossing, excavate from TOP to BOT and establish a 6' wide channel bottom with 2:1 sideslopes. 2) Remove the levee and pond area and convey the DRC outflow from Site #25 to this crossing. 3) Revegetate the disturbed riparian area with willows. 4) Define the channel upstream of the crossing for 200', establish a 6' wide channel bottom with 2:1 banks. 5) Define the downstream channel 6' wide with 2:1 banks to the TOP of Site #23.
27	Miranda East Fire Road	ML		633	165	A DRC in a headwall swale setting. There is a 24" diameter DRC that with a T-outlet that delivers IBD flow from and upslope road prism to this site. The crossing is effectively dipped, but the left road approach is long and insloped. Combined DRC and road run off deliver to the downstream swale with no active erosion.	1) Clean the outlet area and install $3yd^3$ of 0.5-1.5' diameter rock armor to serve as energy dissipation. 2) Inslope the road through the slide up the left road approach for 80'. 3) Install 4 rolling dips on the left road approach. 4) Outslope and fill ditch for 700' of left road approach, do not outslope the road through the slide feature. 5) Maintain the DRC up the left road approach, open outlet and clean IBD.

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Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
28	Vista Point Trail	M	27	235	0	A 24" diameter DRC with active IBD flow. The inlet is 50% plugged. There is a 3' drop at the outlet of the DRC with a gully working headward into the OBF slope. The DRC is currently conveying a long section of IBD and spring flow from Site #29. There is also a 75% plugged DRC up the left road approach.	1) Outslope the left road approach for 235'. Retain the active IBD approach to the DRC up the left road and clean the inlet. 2) Armor the DRC outfall to prevent splash zone erosion, install $3yd^3$ of 0.5-1' diameter rock armor and define spillway.
29	Vista Point Trail	M	115	463	0	A headwall setting with emergent spring flow. Spring flow along with inboard ditch flow from the left approach deliver to Site #28 down the right road. The springy headwall swale should be delivering flow to the downslope swale across the road, but the majority of flow is currently gullying down the right road approach. The inboard fill area is very wet and there is a large downed tree.	1) Install a 30"x50' CMP at the base of fill on the right hinge of the turn. 2) Clean and define the upslope area to convey spring flow into the culvert inlet. 3) Install a critical dip on the right hinge of the crossing. 4) Outslope and fill ditch for 463' of left road approach. 5) Install 3 rolling dips on the left road approach, connected to cutbank. 6) Rebuild the inboard fillslope at 40 degrees and install 5yd of 1'-2' diameter rock armor on the inboard fillslope to buttress the steep fill. 7) Armor the lower half of the outboard fillslope with $10yd^3$ of 1'-2' diameter rock armor. 8) Install a single post trash rack. 9) Install $2yd^3$ of 1' diameter rock at the culvert outfall to serve as energy dissipation.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds³)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
30	Vista Point Trail	M	116	579	0	An at origin Class III stream crossing in a headwall swale. Road diverts stream flow to right. Combined road runoff and stream flow have diverted over the outboard edge of fill 50' to the right, resulting in a laterally destabilized outboard fillslope. 90% of the outboard fill at this location has failed. There is a cutbank failure above the washed out outboard fillslope where spoils have been stored/unintentionally perched. Road surface drainage should not be discharged at this location.	1) Install an armored fill crossing, establish a broad dip that conveys stream flow across the road, excavate a keyway 25' wide x 10' wide x 25' long x 2.5' deep, and armor the keyway with $40yd^3$ of 0.5-2.0' diameter rock armor. 2) Outslope road and fill ditch for 579' of left road. 3) Install 3 rolling dips up the left road approach. 4) Pull the outboard berm at the OBF failure to the right and inslope the road through the feature (~50'), direct drainage to the next rolling dip outlet.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

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Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
31	Vista Point Trail	M	124	265	0	A stream crossing on a near origin Class III stream with emergent springs in a headwall setting with no formal drainage structure. Diverted stream flow from Site #30 up the left road approach and Class III stream flow have saturated the fill and induced a failure on the outboard edge of the fill prism. Sediment from the fill failure has delivered to a Class II stream approximately 125' below the road. Remaining perched outboard fill will likely continue to fail and deliver sediment. Additionally, the stream flow is also partially diverted down the right road.	1) Excavate remaining perched fill on the outboard edge of the road to the left and right of the crossing for 50'. 2) Excavate TOP to BOT and Install a new 24"x60' culvert at the base of fill. 3) Upon fill rebuild rock the lower 3/4th of the outboard fillslope with $30yd^3$ of 1'-3' diameter rock armor to buttress the steep fill face. 4) Construct an rock apron at the culvert outfall with $2yd^3$ of 0.5'-1' diameter rock armor to serve as energy dissipation. 5) Install critical dip on the right hinge of the crossing 6) Outslope road and fill ditch on left road approach for 120'. 7) Install 1 rolling dip up the left road approach. 6) Install single post trash rack at the inlet of the culvert. 7) Install $3yd^3$ of 0.5'-1' diameter rock armor on the lower half of the inboard fillslope.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

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Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
32	Vista Point Trail	HM	242	324	0	An intermittent Class II stream is conveyed through crossing via a 12" diameter corrugated metal pipe with a vented drop inlet. Sediment has aggraded above crossing to the TOP. This site has a high diversion potential. The left inboard ditch is actively conveying springy flow into the crossing. The road surface is actively rilling/gullying. Another road runs above the right bank of the crossing.	1) Replace existing CMP, excavate TOP to BOT and install new 36"x60' CMP at base of fill. 2) Bowl out the immediate upstream channel reach to convey active ditch flow into new culvert inlet. Convey 65' of left inboard ditch into the new CMP inlet. 3) Install 3 rolling dips up the left road approach. 4) Construct critical dip at right hinge of crossing. 5) Install $3yd^3$ of 0.5'-2.0' diameter rock armor at new culvert outlet to act as energy dissipater. 6) Store spoil materials locally, and utilize spoils to outslope road to the left and right. 7) Outslope left road approach and fill ditch for 325' 8) Install a single post trash rack.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
33	Dolphine Fire Road	L	15	564	1277	A near origin Class III stream is actively diverting down right road. This site has no formal drainage structure at the crossing. A skid road running along the right hillslope above crossing also intersects at this point and shows evidence of conveying flow.	1) Construct an armored fill crossing; establish a broad dip that conveys stream flow though the crossing, excavate a keyway 18' wide at the top x 8' wide at the base x 15' long x 2' deep, armor the keyway with 15yd^3 of 0.5'-1.5' diameter rock armor. 2) Outslope road and fill ditch on right approach for 827'. 3) Outslope road and fill ditch on left approach for 564'. 4) Install 4 broad Type I rolling dips connected to the cutbank on the left road approach. 5) Install 6 broad Type I rolling dips connected to the cutbank on the right road approach. 6) Install 6 cross road drains on hiking trail above right bank.
34	Vista Point Trail	HM	178	811	0	Convergent concentrated road runoff has combined with spring flow to cause a 30' wide failure to form in the outboard fill. A cross road drain 20' down from the fork of Vista Point Trail and a spur off Dolphine Fire Road is actively diverting flow to the outboard edge of fill. Active 2' wide by 1' deep gullies are incising the road. Sediment from the gullies and outboard fill are being delivered to a Class II stream below.	1) Outslope road and remove ditch for both right road approaches on Dolphine Fire Road and South Ridge Road Spur. 2) Install 1 rolling dip where the roads converge. 3) Install 1 rolling dip on the right road approach for Dolphine Fire Road. 4) Install 4 rolling dips on the right road approach for South Ridge Road Spur. 5) Excavate perched outboard fill 50' wide x 10' Long x 1' Deep, maintain drivable road width.

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Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

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35	Vista Point Trail	HM	611	742	0	A marshy intermittent Class II stream is actively diverting down right ditch and delivering flow to fill crossing at road intersection where Site #17 is located. The stream channel has been heavily tractored. The upper stream channel reach has split flow for 175', the channels combine at the aggraded sediments upstream of road and divert right. The left ditch is actively conveying sediment from the inboard ditch and insloped road surface to this crossing. Channel should be decommissioned upstream of crossing for 200'; however, a steel culvert may be installed without optional upstream decommission if aggraded sediment is excavated.	1) Excavate TOP to BOT, install a new 36"x 60' corrugated metal pipe at base of fill. 2) Bowl out inlet area to convey spring flow into inlet and clear aggraded sediment. 3) Construct a critical dip on right hinge of crossing. 4) Decommission upstream bifurcated channel for 250' up to TOP #1, define a 5' wide channel bottom with 2:1 banks. 5) Install 4 type 1 rolling dips connected to cutbank up left road. 6) Install a single post trash rack 7) Spoil on road Quarry Park trail 9 to raise road and establish an outsloped road surface. 8) Establish 20' wide road at stream crossing. 9) Outslope and fill ditch for 742' of left road approach.

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36	Quarry Trail	HM	54	0	360	Flow from a Class II stream along with concentrated road run off is conveyed through an undersized 12" corrugated metal pipe. A 2' headcut has formed in the stream 3' in front of the culvert inlet in what appears to be an old pond levee. The outlet delivers to an alluvial watercourse downstream of road. Gullies are forming on the right road approach.	1) Excavate TOP to BOT and replace existing culvert with a 24"x 50' corrugated metal pipe at the base of fill. 2) Install critical dip at left hinge of crossing. 3) Outslope right road for approach for 360'. 4) Install a type 2 rolling dip on right road approach at edge of landing and 1 rolling dip midway up right road approach. 5) Install a single post trash rack. 6) Armor lower 1/4 of outboard fill slope with 8 yd^3 of 1'-2' diameter rock armor. 7) Armor lower 1/2 of inboard fill slope with 2 yd^3 of 1'-2' diameter rock armor. 8) Remove berm along right road for 200'.

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				Left	Right		
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37	Quarry Floor Trail	M	149	0	0	A pond in a large landing within a large quarried area. Several springs are contributing flow to the pond. The pond fill face has a gully through the right hinge that appears to be occupied during high flow events and will continue to enlarge over time until the pond is undercut. Considerable seepage from the pond is saturating through the base of the small levee that is forming a marshy ponded area situated upstream from site #36. This site can be decommissioned, and the trail retained. Additionally, the inboard landing ditch conveys flow to the head of the pond. If levee were to episodically fail site #36 would likely be deleteriously impacted.	1) Decommission pond, drain pond and excavate from TOP to BOT, to the TOP of Site #36. Define a 4' channel bottom with 2:1 sideslopes. 2) Spoil locally and use spoil material to construct dips on trail. 3) Define 2 broad dips at the two flagged springy locations and install 2 armor fills, establish a broad dip that conveys spring flow though the crossing, excavate a keyway 20' wide at the top x 10' wide at the base x 15' long x 2.5' deep, armor the keyway with $20yd^3$ of 0.5-2' diameter rock armor. (Or install 2 24"x 20' long corrugated metal pipes with energy dissipaters.) 4) Bowl out and define left springy area to convey flow into the corresponding armored fill, convey inboard landing ditch into the right armored fill. 5) Rock road/trail with $20yd^3$ for 10' wide x180' long x 0.3 deep. 6) Install rolling dip on right road approach.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
38	South Ridge Vista Trail	M	25	0	600	An at origin Class III stream with emergent spring flow. A hiking trail traverses the axis of the swale. The concentrated road runoff, spring flow and swale sheet flow is diverting down the left road. Flow had previously been delivered to the Class III stream valley just downslope from the road. Social trail should be rocked and shaped to convey flow into the axis of the swale, alternatively the trail could be removed or relocated.	1) Construct an armored fill crossing; establish a broad dip that conveys stream flow though the crossing, excavate a keyway 25' wide at the top x 10' wide at the base x 25' long x 2.5' deep, armor the keyway with 40yd^3 of 0.5-2' diameter rock armor. 2) Decommission/ discontinue the use of the small trail running down the swale upslope from this crossing and install 6 cross road drains. 3) Define a 4' wide channel for 60' upstream of the inboard edge of the road. 4) Rock road through dip with 20yd^3 of rip rap. 5) Outslope road and fill ditch for 320' on right road approach, (Quarry Park trail 8). 6) Define a 4' wide channel with 2:1 sideslopes from BOT to base of keyway.

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Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
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39	Miranda East Fire Road	H	770	0	742	A flashy Class III stream is conveyed through this crossing via 2 plugged culverts, 24" and 12". The inlet is completely filled with aggraded sediment. The outboard edge of fill has failed exposing the two culverts. The outboard fill slope is prone to future failure. There is also another failure in the outboard edge of fill at a low in the road 125' to the left of the crossing, this failure delivers directly to the Class III stream at the base of slope and will likely deliver sediment due to future erosion.	1) Excavate TOP to BOT and replace old culverts with a new 54"x 80' corrugated metal pipe at base of fill. Upon Fill rebuild establish a 20' wide road through the axis of the crossing and lower the road surface by 2'. 2) Install a critical dip at the left hinge of crossing. 3) Install 5yd^3 of 0.5-2' diameter rock armor at the outfall. 4) Outslope road and fill ditch for 742' on right road approach. 5) Construct 4 rolling dips on right road. 6) Outslope road and fill ditch for 250' on left road approach. 7) Excavate remaining perched fill at failure on the outboard edge of fill for 120' 8) Rebuild inboard fill at 40 degrees and rock the lower 3/4 of slope 22' wide at the top x 10' wide at the base x 6' long x 2' deep with 10 yd^3 of 0.5-2' diameter rock armor. 9) Install a galvanized single post trash rack. 10) Rock the road through the crossing with 20yd^3 of road rock.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
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40	Private Paved Road	HM	468	687	0	A long section of the inboard ditch off the private paved road delivers to the inlet of this ditch relief culvert. The ditch relief culvert is set shallow in the hillslope, and the inlet area is hardened with concrete. Flow from this site delivers to site #16 approximately 450' downstream. The ditch relief culvert has separated below road and has subsequently eroded a very long 10' deep and 16' wide gully, the gully develops into a juvenile Class III stream channel downslope of the site. The active flow in the inboard ditch infiltrates into the ground upstream of the inlet of the ditch relief culvert and emerges at the base of the headcut at the top of the gully. The main issues associated with this large failure are likely due to an excessive length of springy inboard ditch that delivers to this site, and the shallow depth at which the culvert is installed.	1) Install 2, 18"x60' ditch relief culverts up left road approach. 2) Layback oversteepened banks for 250' define 4' channel bottom with 2:1 slopes. 3) Decommission ditch relief culvert, excavate TOP to BOT at base of existing headcut.
41	Upper Pond legacy road	HM	274	83	2	A Class III stream at a washed out fill crossing. The channel has washed out and left steep tall perched walls on either side of the channel that will likely fail. The bottom of the channel has incised down to component bedrock and will likely not cut down any further. A debris torrent appears to have flowed down the channel in the past, large logs are laying in and across the channel. Several houses are perched directly above the channel at the top of the swale and are in imminent danger of failing.	1) Decommission crossing, install temporary crossing and lay back left and right bank side slopes 2:1 or to stable slopes where applicable. Remove temporary crossing to finish decommissioning site. 2) store spoils locally and use for IPOS on left and right road approaches.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
42	Dolphine Mt Bike Trail	L	66	0	0	A Class III stream at a washed out crossing downstream of Site #14. The channel has eroded down to stable bedrock throughout the channel. Future erosion is minimal and will likely result from small oversteep banks failing along length of channel through road. There is shallow bedrock throughout area. There is a high flow diversion on the left edge of crossing. Shallow bedrock may inhibit excavation.	1) Define channel through remainder of crossing. 2) Spoil on right edge of crossing, reshape banks to keep flow in channel to left. 3) IPOS for 309' on right road approach.
43	Ridge Top Vista Trail Spur 3	HM	22	86	100	A fill crossing on a Class III stream, the stream Is actively eroding the road with an active head cut in the outboard fill. A secondary road prism exists downstream. A springy swale to the right of the crossing should be conveyed through the crossing.	1) Decommission crossing, Excavate TOP to BOT, create a 3' channel bottom with 2:1 streamside banks. 2) Spoil locally. 3) IPOS Left and right road for 186'
44	Ridge Top Vista Trail Spur 5	ML	108	0	324	A Class III stream has washed out a fill crossing. Most of the fill has washed away, creating a large gully and leaving oversteepened gully walls and material perched over the channel. The left bank has cut back to nearly the edge of the valley. The oversteepened right bank will continue to fail and deliver sediment to the downstream watercourse. This large failed fill crossing has likely destabilized the upstream stream reach. There are several undercut residential properties.	1) Decommission crossing, install temporary crossing and remove perched material on left bank, remove material on right bank to a 2:1 slope and remove temporary crossing. 2) Store spoils locally and use for road shaping. 3) Outslope and fill ditch for 324' of the right road. 4) Install 3 rolling dips on the right road approach.

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Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
45	Ridge Top Vista Trail Spur 5	M	15	0	332	A washed out fill crossing on a Class III stream. The majority of fill has eroded with a small block of fill remaining on the inboard half of road. The channel upstream and downstream have eroded down to the granite Bedrock. The right road approach is intact while the left has failed 50%.	1) Decommission crossing. Establish 4' wide channel with 2:1 side slope banks. 2) Spoil locally on road to left and right, utilize materials for IPOS. 3) IPOS right road approach for 332'. 4) Establish broad cross road drains at springy areas.
55	Vista Point Trail	M		0	557	A 24" partially crushed and plugged corrugated metal pipe that conveys road and ditch runoff to Site #27. The hydrologically connected road length can be disconnected via outsloping and rolling dip installation. There is a through cut up right road approach that will likely be retained in perpetuity due to the depth of the cut.	1) Regular maintenance, clean out ditch and culvert. 2) Install 2 rolling dips up right road, one on either side of through cut. 3) Install type 1 rolling dip at the ditch relief culvert and drain to ditch relief culvert. 4) Rock outlet of ditch relief culvert on downstream side of through cut with 5yd^3 of 0.5-1.5' diameter rock armor at outboard fill transition. 5) Outslope 200' of right road approach on either side of through cut.
61	Private Paved Road	L		650	0	A 15" corrugated metal pipe with a drop inlet box and an elbow. Flow delivers to headwaters of Class III downstream. The ditch relief culvert is located on a long relatively flat paved section of road high on the watershed.	1) Regular maintenance, clean out ditch and culvert. 2) Install two 18"x40' ditch relief culverts on right road approach, Install 5yd^3 of 0.5' - 1.5' diameter rock armor at each outlet as an energy dissipater.
62	Private Paved Road	L		621	0	A 15" ditch relief culvert that conveys the springy inboard ditch through a dirt driveway. There is some active erosion occurring in the inboard ditch approach.	1) Regular maintenance, clean out ditch and culvert.

Table B1. Field observations and treatment recommendations for road/trail related sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Future sediment delivered (yds^3)	Hydrologically connected road/trail length (ft)		Comment on Problem	Comment on treatment
				Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards; DRC = Ditch relief culvert; IBD = Inboard ditch. Left and Right directions are referenced as looking downstream or downslope.							
64	Private Paved Road	L		502	182	A springy inboard ditch and cutbank are drained by this drop inlet ditch relief culvert. The outboard edge of fill is buttressed by a retaining wall and appears stable.	1) Regular maintenance, clean out ditch and culvert. 2) Install one 18" x 40' ditch relief culvert on left road approach, Install 5yd^3 of 0.5'-1.5' diameter rock armor at outlet as an energy dissipater.
65	Private Paved Road	L		270	0	A 15" ditch relief culvert that conveys paved inboard ditch flow through intersection with dirt road leading up to the USGS station. The inboard ditch has some active erosion.	1) Regular maintenance, clean out ditch and culvert.
66	Private Paved Road	L		54	0	A 12" ditch relief culvert that conveys paved inboard ditch flow through second intersection with dirt road leading up to the USGS station.	1) Regular maintenance, clean out ditch and culvert.
71	Dolphine Fire Road	L		246	0	Outboard edge of fill erosion at a rolling dip outlet with delivery to a springy swale.	1) Increase road drainage, outslope left road for 246'. 2) Maintain and enhance the existing rolling dip feature. 3) Install armored fill 17' wide x 6' wide x 16' long x 2' deep, 15 yd^3 of 0.5-1' diameter rock armor. 4) Apply 10yd^3 of rock to road surface through the dip.
74	Quarry Trail	ML		2000	0	A landslide 210' long and 45' wide slide deposit has covered the road. A cross road drain above the slide on Middle Ridge Trail is actively diverting flow to above slide and likely induced the failure, but the uncontrolled road drainage exacerbated the existing hillslope instability.	1) Clear slide debris and redefine the road through the slide. 2) Install 11 rolling dips on the Middle Ridge Trail upslope from the slide feature to minimize the hydrologically connected road drainage. 3) Outslope and fill ditch for 2,000' of left road approach. Extend the road shaping up Middle Ridge Trail.

Table B2. Field observations and treatment recommendations for road/trail related non-sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Adjacent road/trail length (ft) Left	Adjacent road/trail length (ft) Right	Comment on Problem	Comment on treatment
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards.						
18	Middle Ridge Trail	M	108	1000	Spring flow emerges out of the cutbank at the base of small swale. Spring flow is actively diverting down the right road. Spring flow combines with concentrated road runoff to form several severe gullies. There is a recently installed breach in the berm that is capturing a portion of the concentrated road runoff. There are also numerous emergent cutbank springs on the left road approach. Flow should be conveyed directly across the road and directed in to the natural swale downslope. There is no direct sediment delivery at this site.	1) Construct an armored fill crossing; establish a broad dip that conveys stream flow though the crossing, excavate a keyway 15' wide at the top x 6' wide at the base x 17' long x 2' deep, armor the keyway with 15yd3 of 0.5'-1.5' diameter rock armor. 2) Outslope road and fill ditch for 108' of left road approach 3) Outslope road and fill ditch for 1000' of the right road approach. 3) Install 1 rolling dip up the left road approach. 4) Install 5 rolling dips up the right road approach.
46	South Ridge Trail	L	200	0	An 18" ditch relief culvert with a wooden box drop inlet. No Delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install 1 rolling dip on left approach.
47	South Ridge Trail	L	162	0	An 18", 50% plugged ditch relief culvert with a T outlet in poor condition that has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach, maintain inboard ditch at inlet of culvert for 10'.
48	South Ridge Trail	L	240	0	An 18" ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left road approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install rolling dip on left approach.
49	South Ridge Trail	L	186	0	An 18" partially plugged ditch relief culvert which has a T outlet and has no direct sediment delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install rolling dip on left approach.

Table B2. Field observations and treatment recommendations for road/trail related non-sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Adjacent road/trail length (ft)		Comment on Problem	Comment on treatment
			Left	Right		
Abbreviations and Acronyms: BOT = Bottom of excavation; TOP = Top of excavation; IPOS = In-place outslope; CMP = Corrugated metal pipe; OBF = Outboard edge of fill; IBF = Inboard edge of fill; TI = treatment immediacy; and yd^3 = cubic yards.						
50	South Ridge Trail	L	494	0	An 18" partially plugged ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install 2 rolling dips on left approach.
51	South Ridge Trail	L	0	216	An 18" partially plugged ditch relief culvert which has a T outlet and has no direct sediment delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on right approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install 1 rolling dip on right approach.
52	South Ridge Trail	L	0	239	An 18" partially plugged ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on right approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install 1 rolling dip on right approach.
53	South Ridge Trail	L	0	208	An 18" 50% plugged ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on right approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install 1 rolling dip on right approach.
54	South Ridge Vista Trail	L	247	0	An 18" 90% plugged ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install 1 rolling dip on left approach.
56	Vista Point Trail	M	216	0	A 24" 60% plugged ditch relief culvert which has a T outlet and has no delivery. No active erosion at outlet ditch is vegetated and stable.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach, maintain inboard ditch at inlet of culvert for 10'. 3) Install 1 rolling dip at ditch relief culvert and one up left road approach.
57	South Ridge Vista Trail	L	146	0	An 18" partially plugged ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach, maintain inboard ditch at inlet of culvert for 10'.

Table B2. Field observations and treatment recommendations for road/trail related non-sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Adjacent road/trail length (ft)		Comment on Problem	Comment on treatment
			Left	Right		
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58	South Ridge Vista Trail	L	255	0	An 18" partially plugged ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on left approach for 245', maintain inboard ditch at inlet of culvert for 10'. 3) Install 1 rolling dip on left road approach.
59	Miranda East Fire Road	L	0	409	An 18" partially plugged ditch relief culvert which has a T outlet and has no delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on right approach for 399', maintain inboard ditch at inlet of culvert for 10'. 3) Install 2 rolling dips on right approach.
60	Miranda East Fire Road	L	0	734	An 18" partially plugged ditch relief culvert which has no delivery. The culvert is located at the bottom of the park in a semi wet land environment, puddling is occurring in front of the inlet.	1) Regular maintenance, clean out ditch and culvert. 2) Outslope road on right approach for 724', maintain inboard ditch at inlet of culvert for 10'. 3) Install 3 rolling dips on right approach.
63	Private Paved Road	L	216	332	A ditch relief culvert with a drop box inlet and a T outlet. The inlet is located at a low, there is minimal active erosion at the outlet but no sediment delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Install one 18" x 40' ditch relief culvert on right road approach, Install 5 yd3 of 0.5 to 1.5 diameter rock armor at outlet as an energy dissipater.
67	Deer Creek Trail	L	0	224	A 12" ditch relief culvert that conveys flow from the inboard ditch on the lower paved road that does not have delivery. Inlet and outlet are entirely clogged.	1) Regular maintenance, clean out ditch and culvert.
68	Deer Creek Trail	L	0	487	A 15" ditch relief culvert that is 50% plugged. Flow is conveyed in the inboard ditch along the lower paved road for 487'; however, there is no sediment delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Install 1 18" x 40' ditch relief culverts on right road approach, Install 5 yd3 of 0.5'-1.5' diameter rock armor at each outlet as an energy dissipater.
69	Deer Creek Trail	M	0	40	A 15" ditch relief culvert that is 50% plugged and partially crushed. A gully is occurring at the outlet along the steep outboard edge of fill; however, there is no sediment delivery.	1) Regular maintenance, clean out ditch and culvert. 2) Replace culvert with 18"x40' culvert, install 5yd3 of 0.5-'1.5' diameter rock armor at outlet to act as an energy dissipater.
70	Deer Creek Trail	L	0	30	A ditch relief culvert with a drop inlet located in the middle of the paved road at a low point near front of gate with no delivery.	1) Regular maintenance, clean out ditch and culvert.

Table B2. Field observations and treatment recommendations for road/trail related non-sediment source sites. Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

Site #	Road/trail Name	TI	Adjacent road/trail length (ft)		Comment on Problem	Comment on treatment
			Left	Right		
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72	Middle Ridge Trail	ML	0	0	Spring flow emerges from the base of the cutbank. The majority of the spring flow diverts down right road. There is no direct sediment delivery.	1) Install 1 rolling dip at spring.
73	Vista Point Trail	H	0	0	The lookout deck at the top of the quarry is experiencing erosion beneath one of the footings. The active debris slide slope failure beneath the footing is undermining the deck and causing instability. The active erosion and subsequent destabilization of the deck is a potential safety hazard for visitors. There is no direct sediment delivery from this site.	1) Relocate the observation deck away from the failing slope. Maintain a 35' set back has been established to prevent future destabilization.

Appendix C

Typical drawings (schematic diagrams) showing construction and installation techniques for recommended erosion control and erosion prevention treatments.

Quarry Park Watershed Assessment And Erosion Prevention Planning Project San Mateo County, California

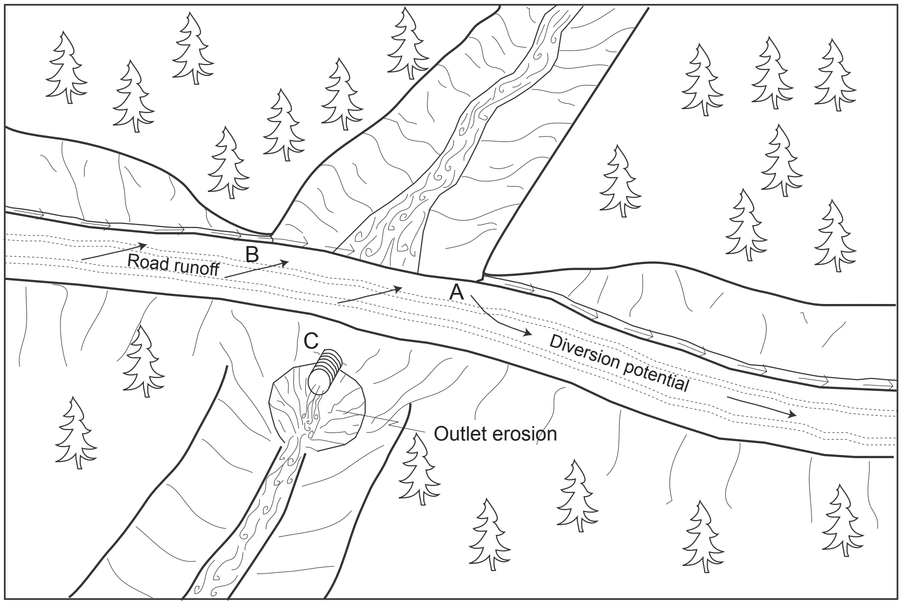
Typical Problems and Applied Treatments for a Non-fish Bearing Upgraded Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

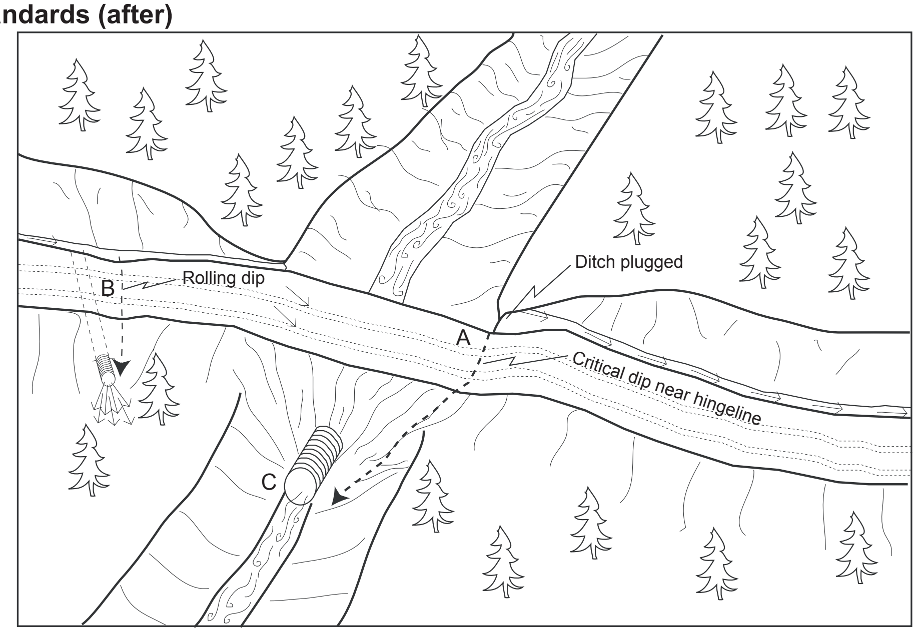


Treatment standards (after)

A - No diversion potential with critical dip installed near hingeline

B - Road surface and ditch disconnected from stream by rolling dip and ditch relief culvert

C - 100-year culvert set at base of fill



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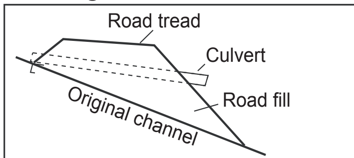
Typical Drawing #1

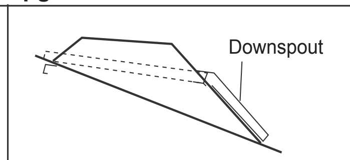
Typical Design of a Non-fish Bearing Culverted Stream Crossing

Existing



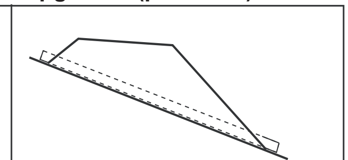
1. Culvert not placed at channel grade.
2. culvert does not extend past base of fill.

Upgraded



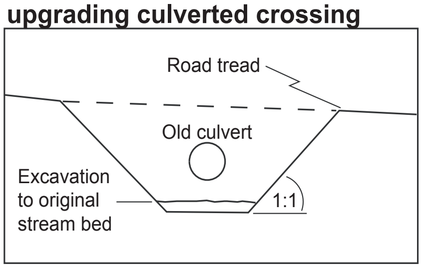
1. Culvert not placed at channel grade.
2. Downspout added to extend outlet past road fill.

Upgraded (preferred)

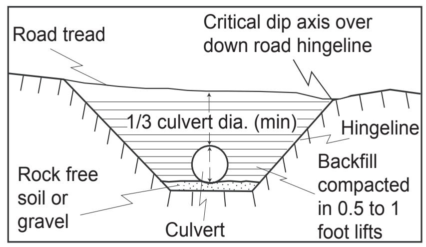


1. Culvert placed at channel grade.
2. Culvert inlet and outlet rest on, or partially in, the originial streambed.

Excavation in preparation for upgrading culverted crossing



Upgraded stream crossing culvert installation



Note:
Road upgrading tasks typically include upgrading stream crossings by installing larger culverts and inlet protection (trash barriers) to prevent plugging. Culvert sizing for the 100-year peak storm flow should be determined by both field observation and calulations using a procedure such as the Rational Formula.

Stream crossing culvert Installation

1. Culverts shall be aligned with natural stream channels to ensure proper function, and prevent bank erosion and plugging by debris.
2. Culverts shall be placed at the base of the fill and the grade of the original streambed, or downspouted past the base of the fill.
3. Culverts shall be set slightly below the original stream grade so that the water drops several inches as it enters the pipe.
5. To allow for sagging after burial, a camber shall be between 1.5 to 3 incher per 10 feet culvert pipe length.
6. Backfill material shall be free of rocks, limbs or other debris that could dent or puncture the pipe or allow water to seep around pipe.
7. First one end then the other end of the culvert shall be covered and secured.;The center is covered last.
8. Backfill material shall be tamped and compacted throughout the entire process:
   - Base and side wall material will be compacted before the pipe is placed in its bed.
   - Backfill compacting will be done in 0.5 - 1 foot lifts until 1/3 of the diameter of the culvert has been covered. A gas powered tamper can be used for this work.
9. Inlets and outlets shall be armored with rock or mulched and seeded with grass as needed.
10. Trash protectors shall be installed just upstream from the culvert where there is a hazard of floating debris plugging the culvert.
11. Layers of fill will be pushed over the crossing until the final designed road grade is achieved, at a minimum of 1/3 to 1/2 the culvert diameter.

Erosion control measures for culvert replacement

Both mechanical and vegetative measures will be employed to minimize accelerated erosion from stream crossing and ditch relief culvert upgrading. Erosion control measures implemented will be evaluated on a site by site basis. Erosion control measures include but are not limited to:

1. Minimizing soil exposure by limiting excavation areas and heavy equipment distrubance.
2. Installing filter windrows of slash at the base of the road fill to minimize the movement of eroded soil to downslope areas and stream channels.
3. Retaining rooted trees and shrubs at the base of the fill as “anchor” for the fill and filter windrows.
4. Bare slopes created by construction operations will be protected until vegetation can stabilize the surface. Surface erosion on exposed cuts and fills will be minimized by mulching, seeding, planting, compacting, armoring, and/or benching prior to the first rains.
5. Excess or unusable soil will be stored in long term spoil disposal locations that are not limited by factors such as excessive moisture, steep slopes greater than 10%, archeology potential, or proximity to a watercourse.
6. On running streams, water will be pumped or diverted past the crossing and into the downstream channel during the construction process.
7. Straw bales and/or silt fencing will be employed where necessary to control runoff within the construction zone.

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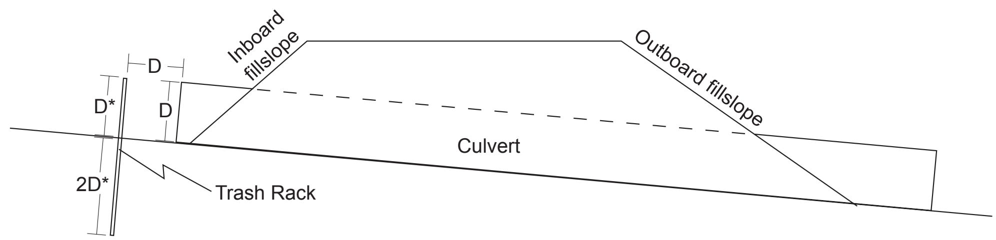
Typical Drawing #2

Typical Design of a Single-post Culvert Inlet Trash Rack

Cross section view



D - Culvert diameter

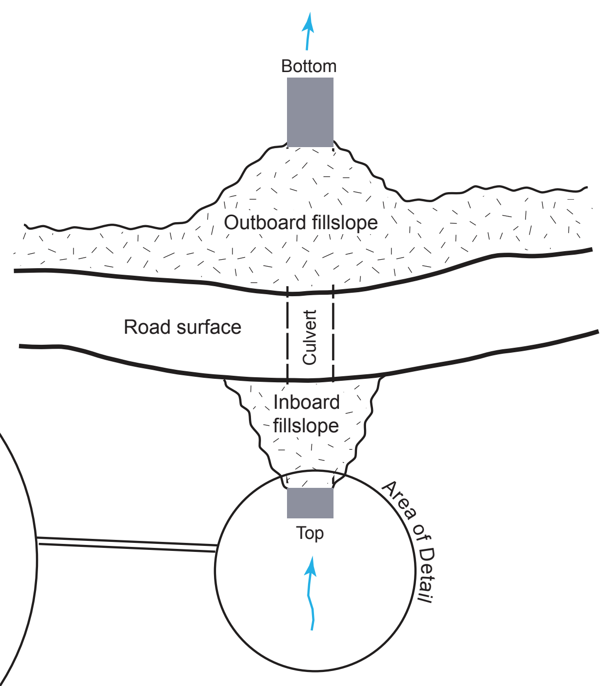
D* - If the culvert is designed for the 100-year peak storm flow, the trash rack height above the streambed should equal D.
If the culvert is undersized, then the trash rack needs to be extended vertically above the streambed to match or exceed the expected headwall height.

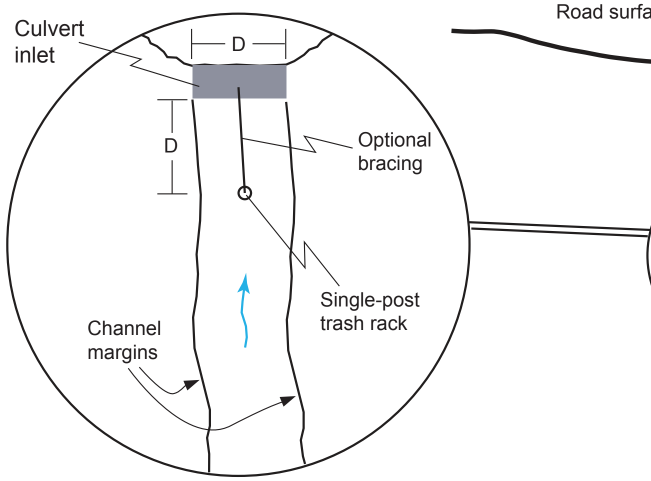
Plan view

Notes:

1. Many materials can be used for a single-post trash rack including old railroad track, galvanized pipe, and fence posts.

2. The diameter of single-post trash racks should be sized based on the size of expected woody debris. As a basic rule of thumb, the diameter of the trash rack should be equal to the diameter of the expected woody debris up to 4 inches.





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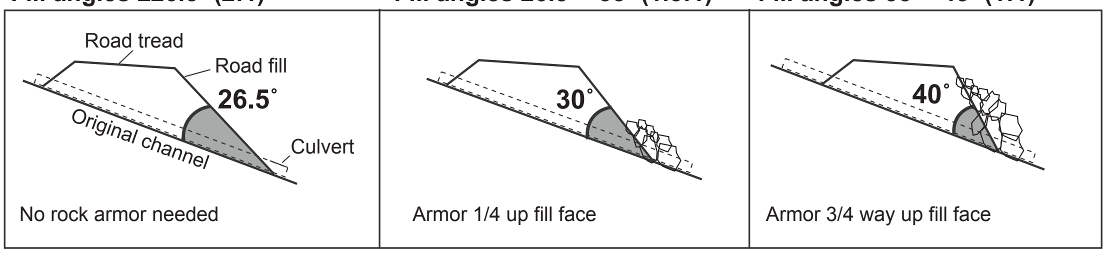
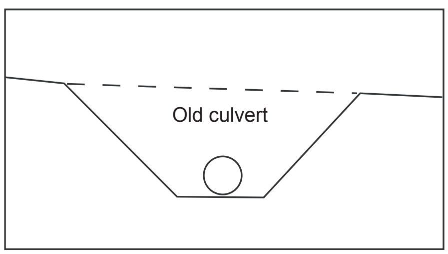
Typical Drawing #3

Typical Design of Stream Crossing Fill Armor

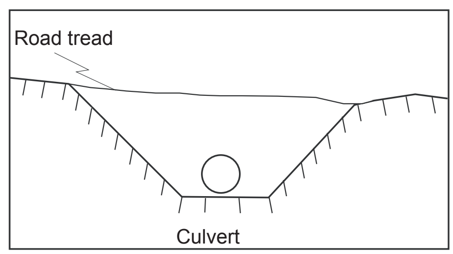
Fill angles ≤26.5˚ (2:1) **Fill angles 26.5˚ - 35˚ (1.5:1)** **Fill angles 35˚ - 45˚ (1:1)**



Fill angles 26.5˚ - 35˚ (1.5:1)



Fill angles 35˚ - 45˚ (1:1)



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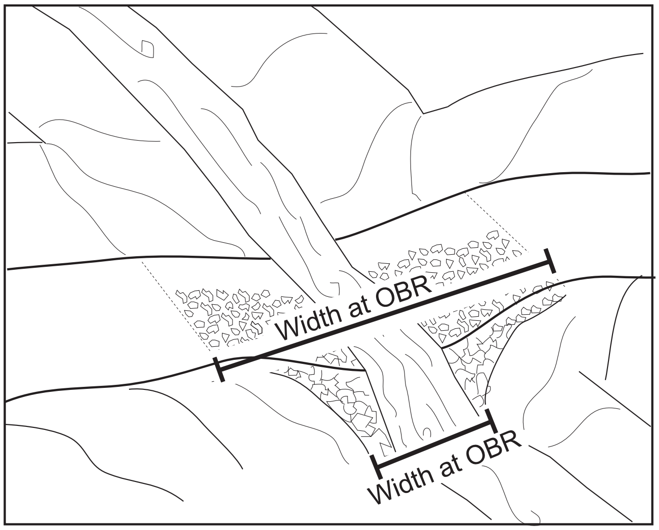
Typical Drawing #4

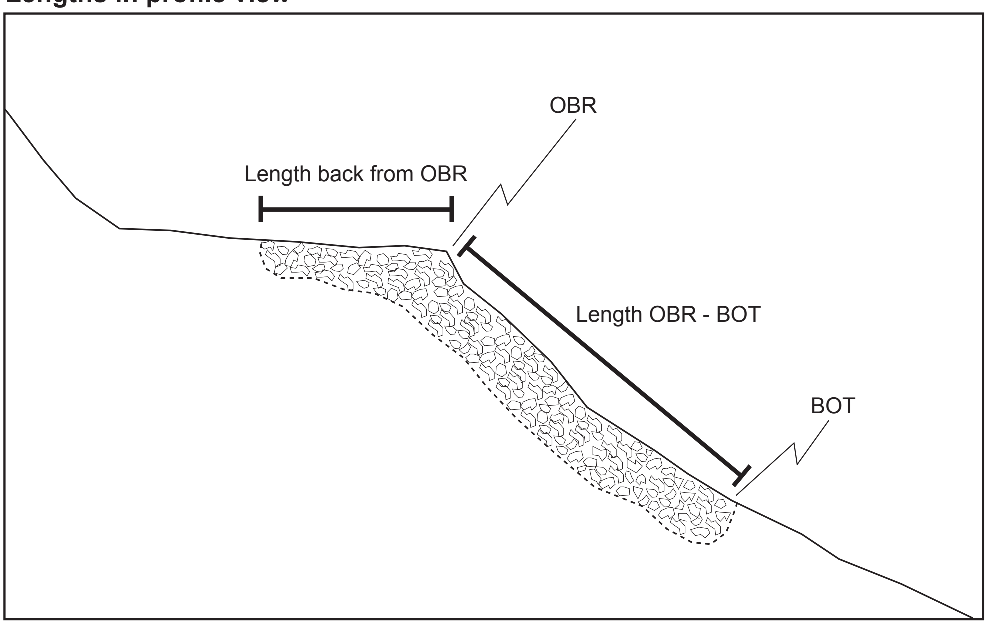
Typical Dimensions Refered to for Armored Fill Crossings

Widths in oblique view



OBR - Outboard edge of road

Lengths in profile view



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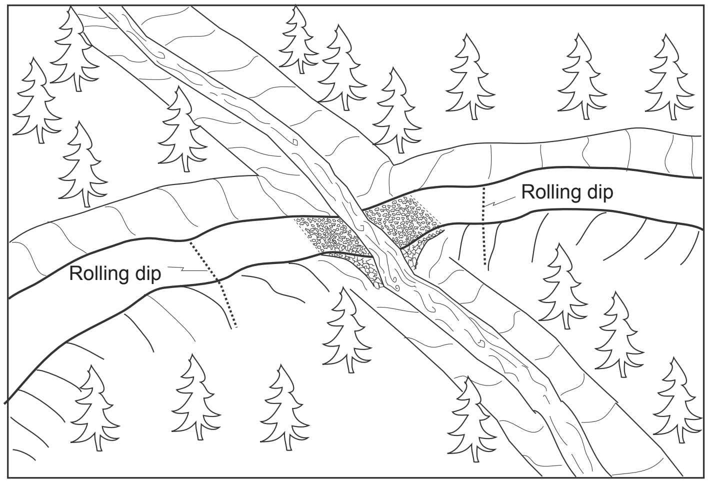
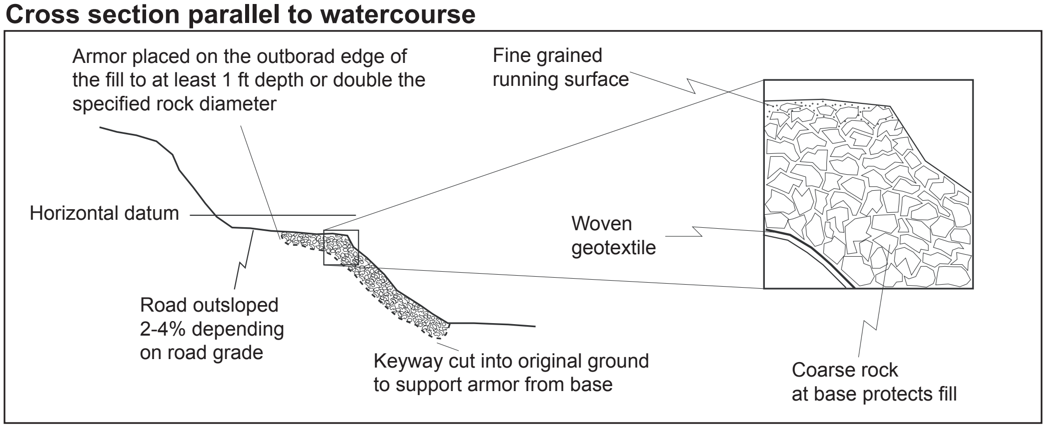
Typical Drawing #5

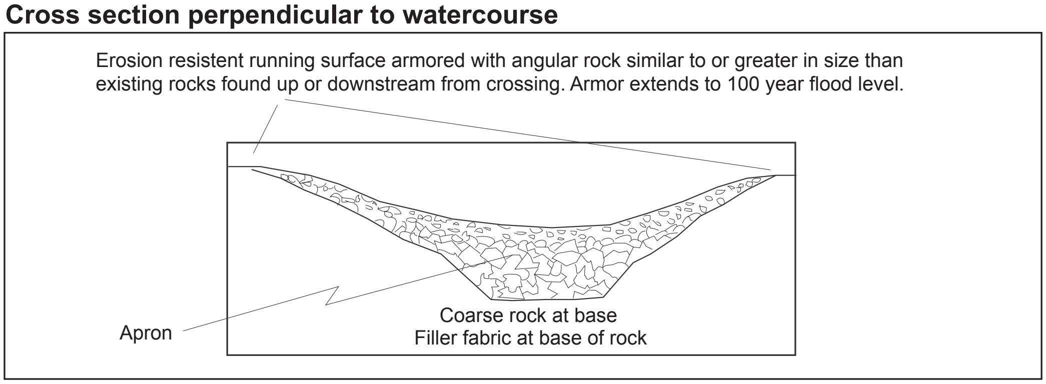
Typical Armored Fill Crossing Installation



Cross section parallel to watercourse



Cross section perpendicular to watercourse



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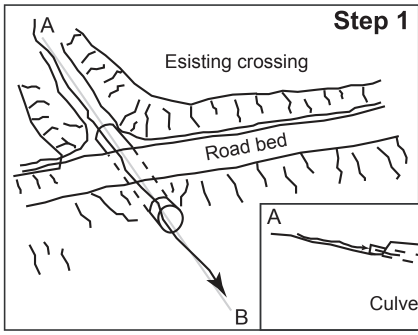
Typical Drawing #6

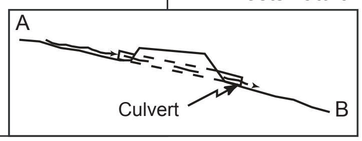
Ten Steps for Constructing a Typical Armored Fill Stream Crossing

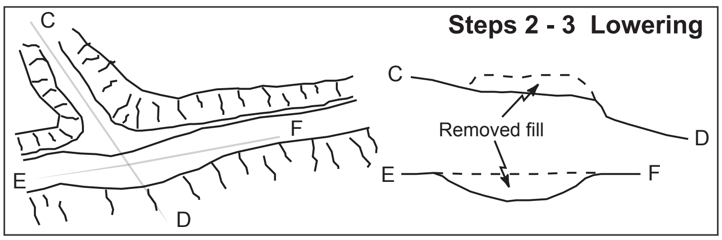


1. The two most important points are:

A) **The rock must be placed in a "U" shape across the channel to confine flow within the armored area.** (Flow around the rock armor will gully the remaining fill. Proper shape of surrounding road fill and good rock placement will reduce the likelihood of crossing failure).

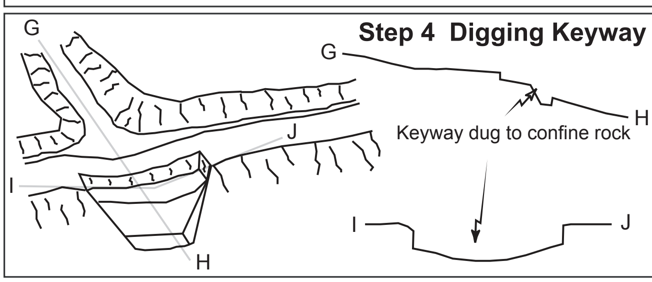
B) **The largest rocks must be used to buttress the rest of the armor in two locations:** (i) The base of the armored fill where the fill meets natural channel. (This will butress the armor placed on the outboard fill face and reduce the likelihood of it washing downslope). (ii) The break in slope from the road tread to the outer fill face. (This will butress the fill placed on the outer road tread and will determine the "base level" of the creek as it crosses the road surface).





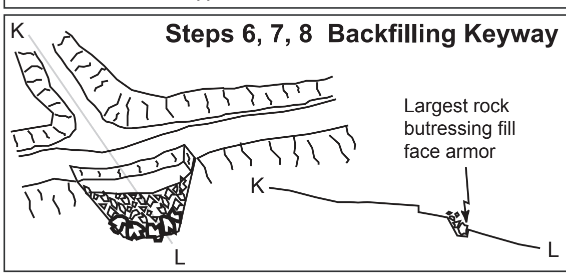
2. Remove any existing drainage structures including culverts and Humboldt logs.

3. Construct a dip centered at the crossing that is large enough to accomodate the 100-year peak storm flow and prevent diversion (C-D, E-F).



4. Dig a keyway (to place rock in) that extends from the outer 1/3 of the road tread down the outboard road fill to the point where outbaord fill meets natural channel (up to 3 feet into the channel bed depending on site specifics) (G-H, I-J).

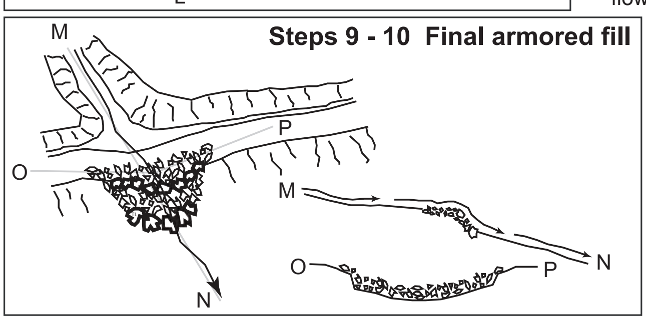
5. Install geofabric (optional) within keyway to support rock in wet areas and to prevent winnowing of the crossing at low flows.



6. Put aside the largest rock armoring to create 2 buttresses in the next step.

7. Create a buttress using the largest rock (as described in the site treatments specifications) at the base of fill. (This should have a "U" shape to it and will define the outlet of the armored fill.)

8. Backfill the fill face with remaining rock armor making sure the final armored area has "U" shape that will accomodate the largest expected flow (K-L).



9. Install a second buttress at the break in slope between the outboard road and the outboard fill face. (This should define the base level of the stream and determine how deep the stream will backfill after construction). (M-N)

10. Back fill the rest of the keyway with the unsorted rock armor making sure the final armored area has a "U" shape that will accommodate the largest expected flow (O-P).

Typical Drawing #7

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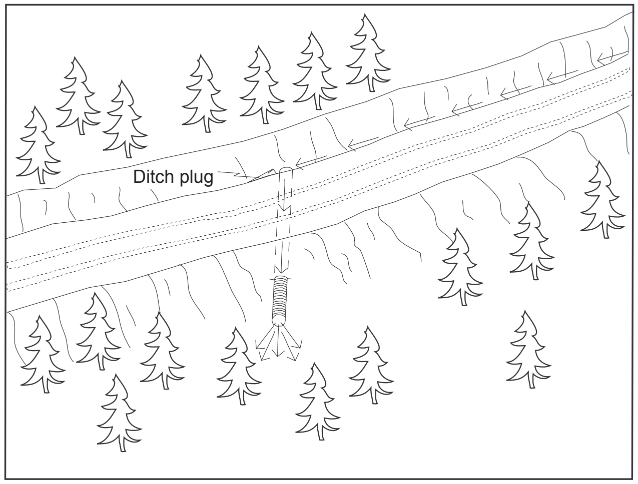
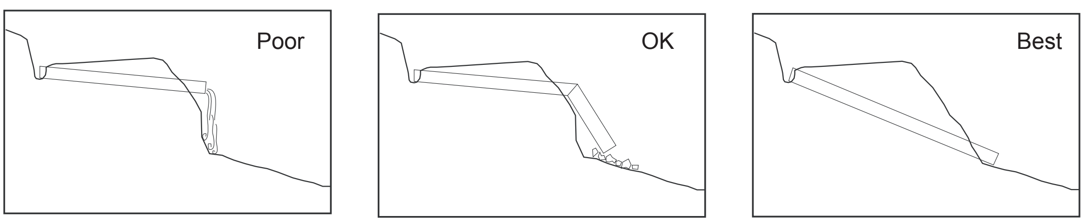
Typical Ditch Relief Culvert Installation





Ditch relief culvert installation

1) The same basic steps followed for stream crossing installation shall be employed.
2) Culverts shall be installed at a 30 degree angle to the ditch to lessen the chance of inlet erosion and plugging.
3) Culverts shall be seated on the natural slope or at a minimum depth of 5 feet at the outside edge of the road, whichever is less.
4) At a minimum, culverts shall be installed at a slope of 2 to 4 percent steeper than the approaching ditch grade, or at least 5 inches every 10 feet.
5) Backfill shall be compacted from the bed to a depth of 1 foot or 1/3 of the culvert diameter, which ever is greater, over the top of the culvert.
6) Culvert outlets shall extend beyond the base of the road fill (or a flume downspout will be used). Culverts will be seated on the natural slope or at a depth of 5 feet at the outside edge of the road, whichever is less.

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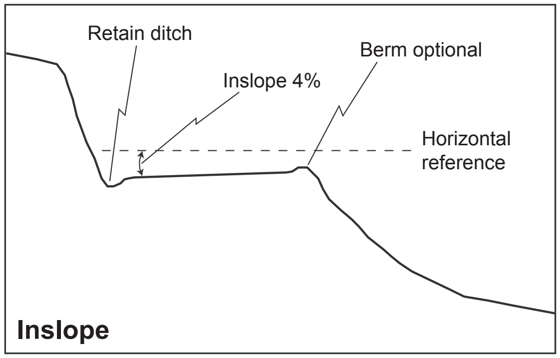
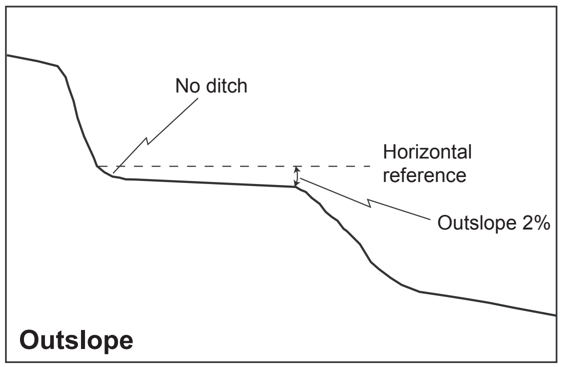
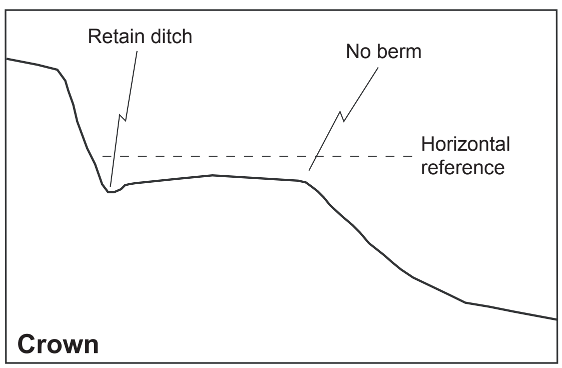
Typical Drawing #8

Typical Designs for Using Road Shape to Control Road Runoff







Outsloping Pitch for Roads Up to 8% Grade		
Road grade	**Unsurfaced roads**	**Surfaced roads**
4% or less	3/8" per foot	1/2" per foot
5%	1/2" per foot	5/8" per foot
6%	5/8" per foot	3/4" per foot
7%	3/4" per foot	7/8" per foot
8% or more	1" per foot	1 1/4" per foot

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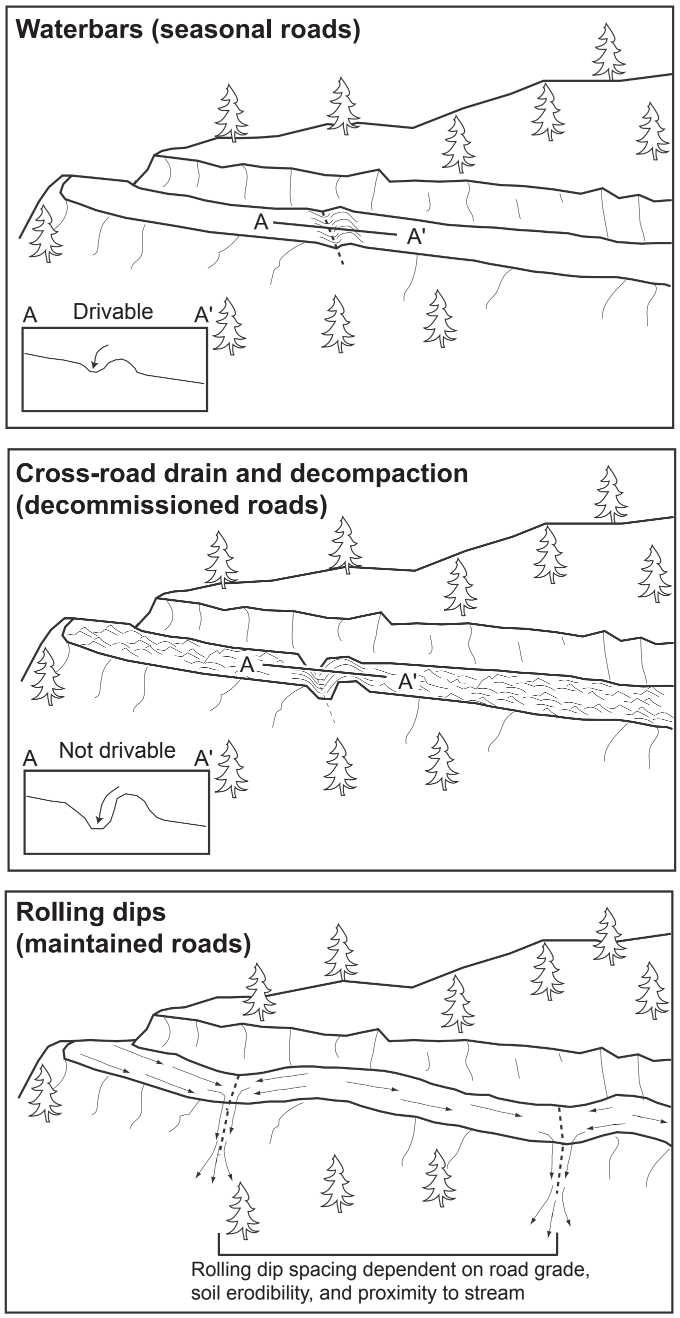
Typical Drawing #9

Typical Methods for Dispersing Road Surface Runoff with Waterbars, Cross-road Drains, and Rolling Dips



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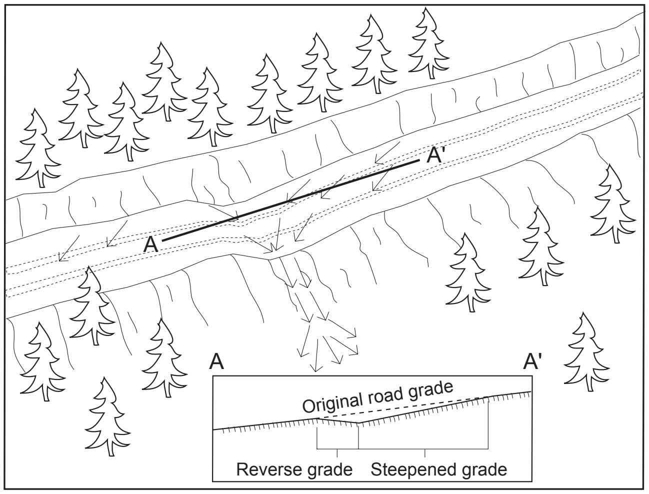
Typical Drawing #10

Typical Road Surface Drainage by Rolling Dips



Rolling dip installation:

1. Rolling dips will be installed in the roadbed as needed to drain the road surface.
2. Rolling dips will be sloped either into the ditch or to the outside of the road edge as required to properly drain the road.
3. Rolling dips are usually built at 30 to 45 degree angles to the road alignment with cross road grade of at least 1% greater than the grade of the road.
4. Excavation for the dips will be done with a medium-size bulldozer or similar equipment.
5. Excavation of the dips will begin 50 to 100 feet up road from where the axis of the dip is planned as per guidelines established in the rolling dip dimensions table.
6. Material will be progressively excavated from the roadbed, steepening the grade unitl the axis is reached.
7. The depth of the dip will be determined by the grade of the road (see table below).
8. On the down road side of the rolling dip axis, a grade change will be installed to prevent the runoff from continuing down the road (see figure above).
9. The rise in the reverse grade will be carried for about 10 to 20 feet and then return to the original slope.
10. The transition from axis to bottom, through rising grade to falling grade, will be in a road distance of at least 15 to 30 feet.

Table of rolling dip dimensions by road grade

Road grade %	**Upslope approach distance** (from up road start to trough) ft	**Reverse grade distance** (from trough to crest) ft	**Depth at trough outlet** (below average road grade) ft	**Depth at trough inlet** (below average road grade) ft
<6	55	15 - 20	0.9	0.3
8	65	15 - 20	1.0	0.2
10	75	15 - 20	1.1	0.01
12	85	20 - 25	1.2	0.01
>12	100	20 - 25	1.3	0.01

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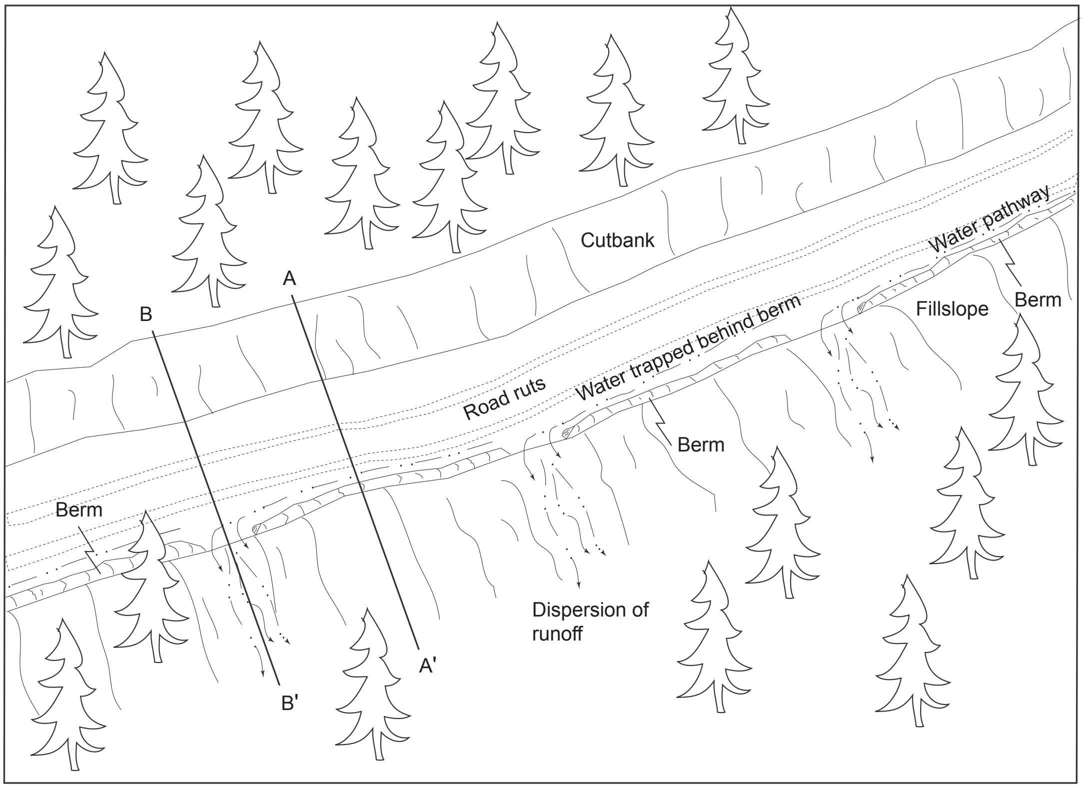
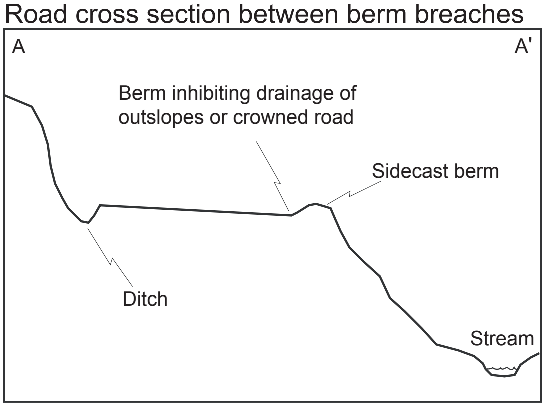
Typical Drawing #11

Typical Sidecast or Excavation Methods for Removing Outboard Berms on a Maintained Road

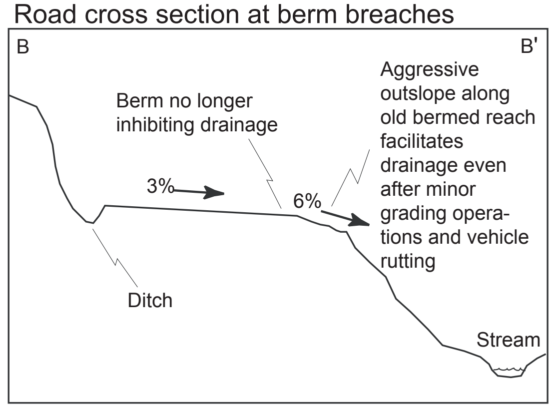
1. On gentle road segments berms can be removed continuously (see B-B').
2. On steep road segments, where safety is a concern, the berm can be frequently breached (see A-A' & B-B') Berm breaches should be spaced every 30 to 100 feet to provide adequate drainage of the road system while maintaining a semi-continuous berm for vehicle safety.



Road cross section between berm breaches



Road cross section at berm breaches



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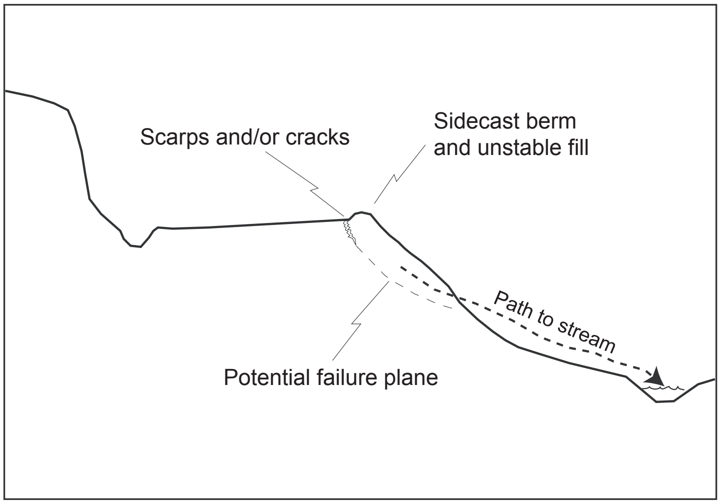
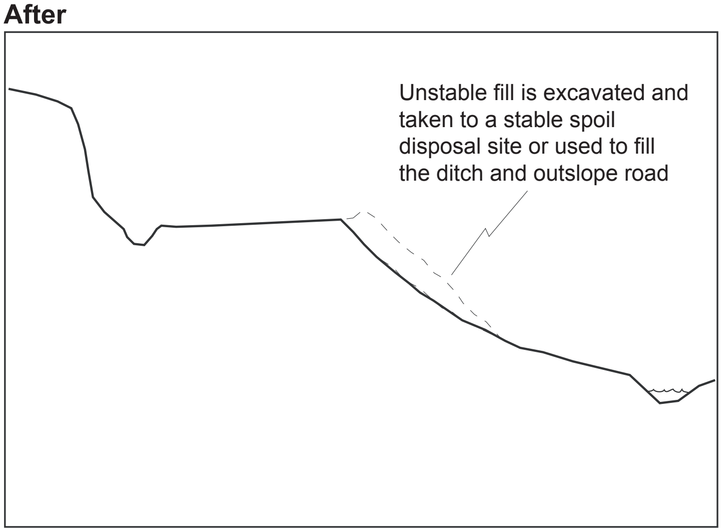
Typical Drawing #12

Typical Excavation of Unstable Fillslope on an Upgraded Road

Before



After



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Typical Drawing #13

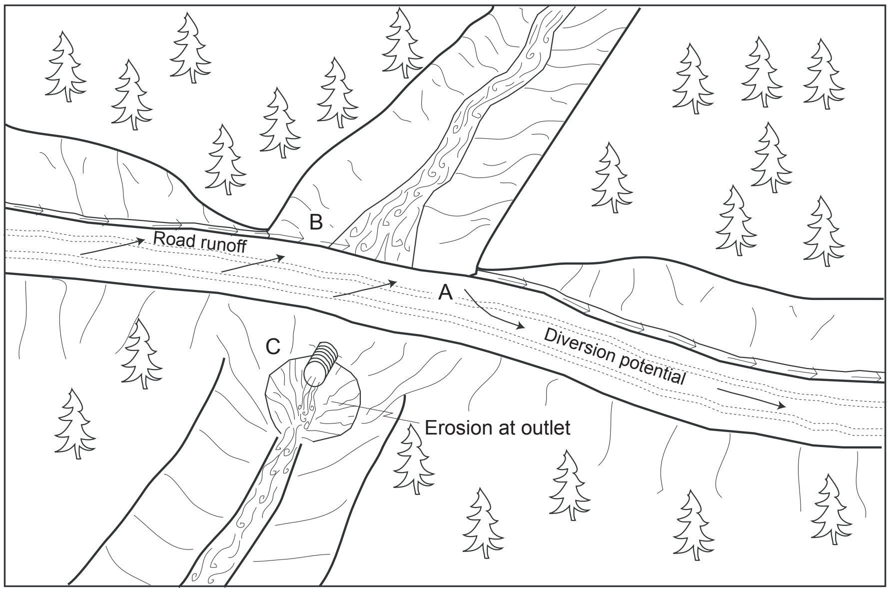
Typical Problems and Applied Treatments for a Decommissioned Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

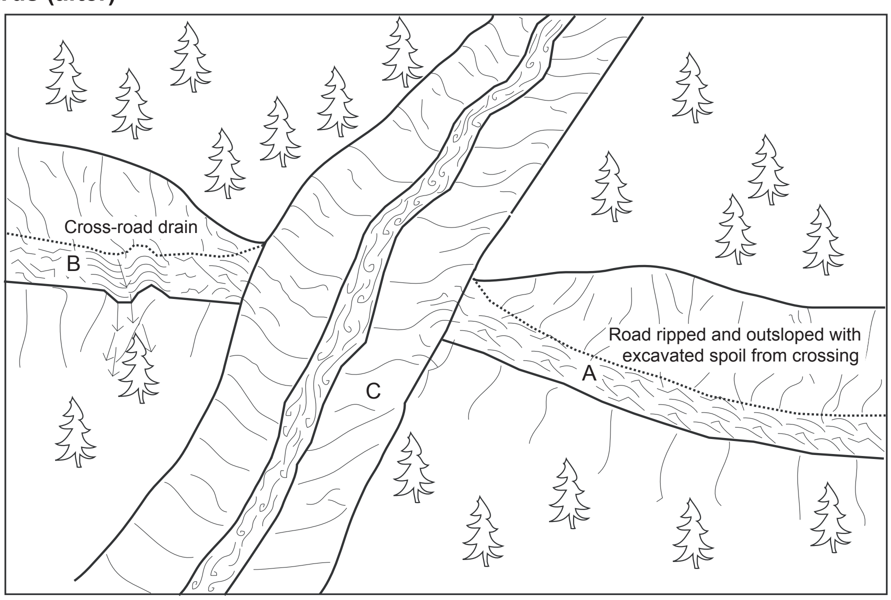


Treatment standards (after)

A - Diversion prevented by road surface ripping and outsloping using excavated spoils

B - Road surface and ditch disconnected from stream by road surface decompaction and cross-road drains

C - Stream crossing fill completely excavated



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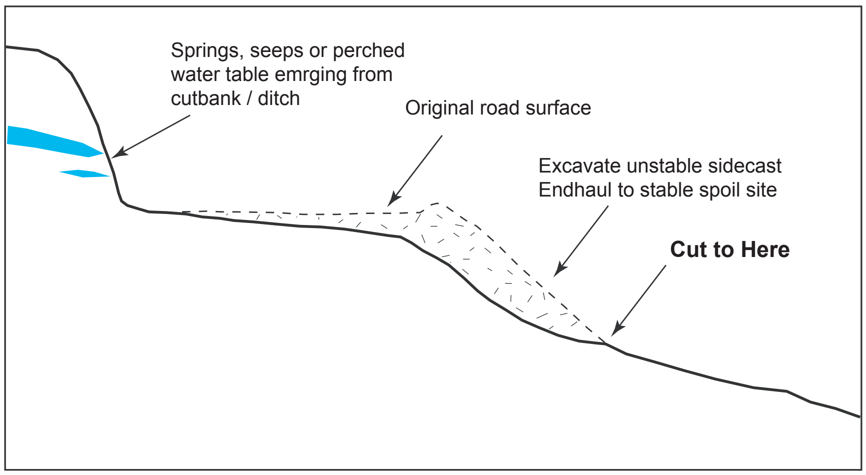
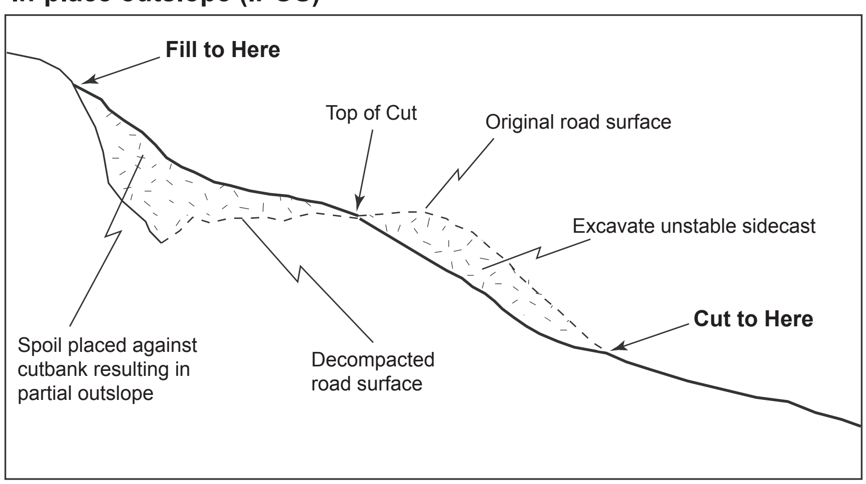
Typical Drawing #14

Typical Design for Road Decommisioning Treatments Employing Export and In-Place Outsloping Techniques

Export outslope (EPOS)



In-place outslope (IPOS)



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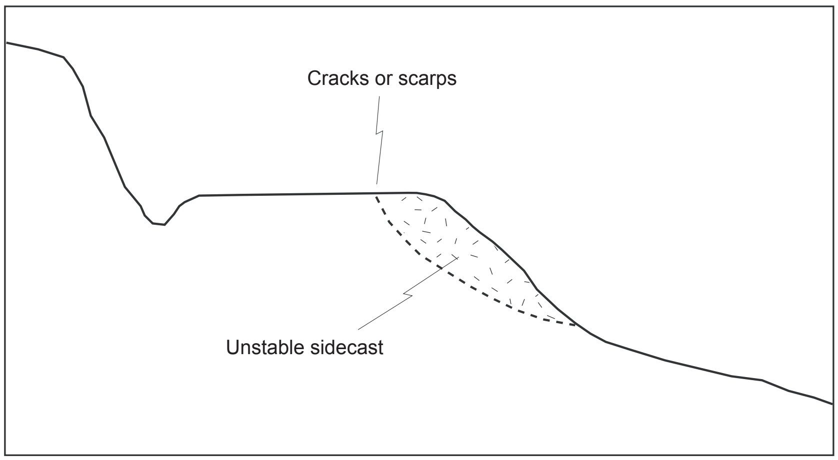
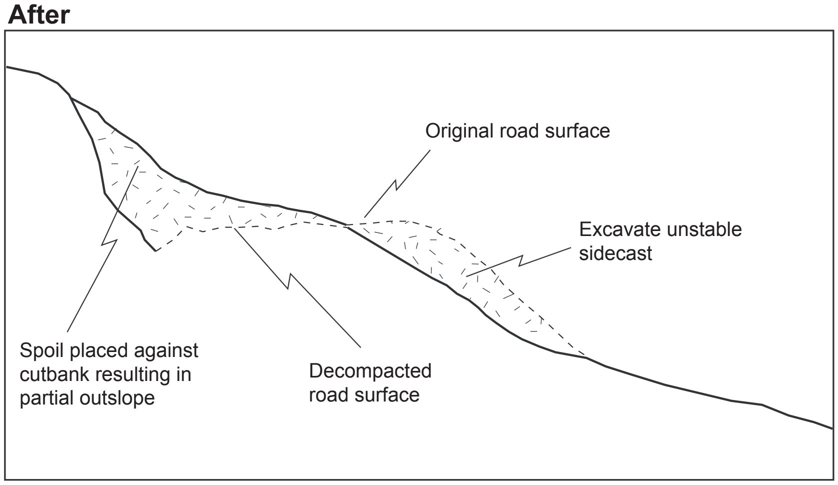
Typical Drawing #15

Typical Excavation of Unstable Fillslope on a Decommissioned Road

Before



After



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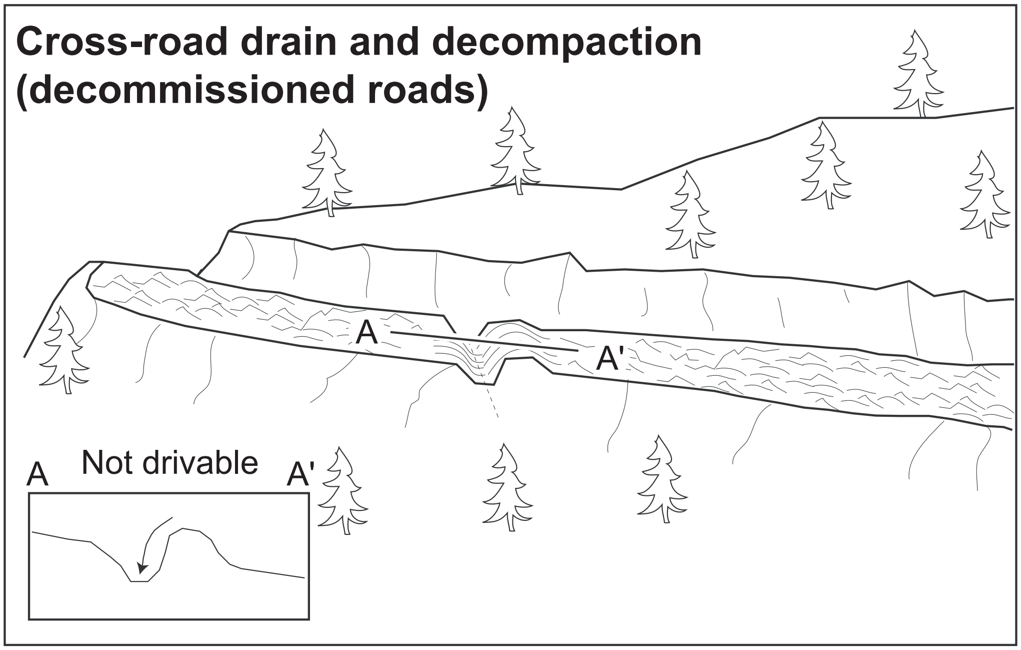
Typical Drawing #16



Cross road drain construction will ensure gullies, springs, road runoff and other concentrated flow will no longer collect over long lengths of road causing gully erosion and sediment delivery to streams. Cross road drains will be constructed at approximately 75 ft spacing intervals and these cross road drains will direct road surface runoff off the road onto stable hillslope locations.

Ripping the road surface 16 to 24 inches deep will increase road surface infiltration rates, decompact the road surface, and prevent concentrated runoff. Road ripping will also pulverize the compacted road surface or hardpan and allow for vegetation to establish and recover naturally.

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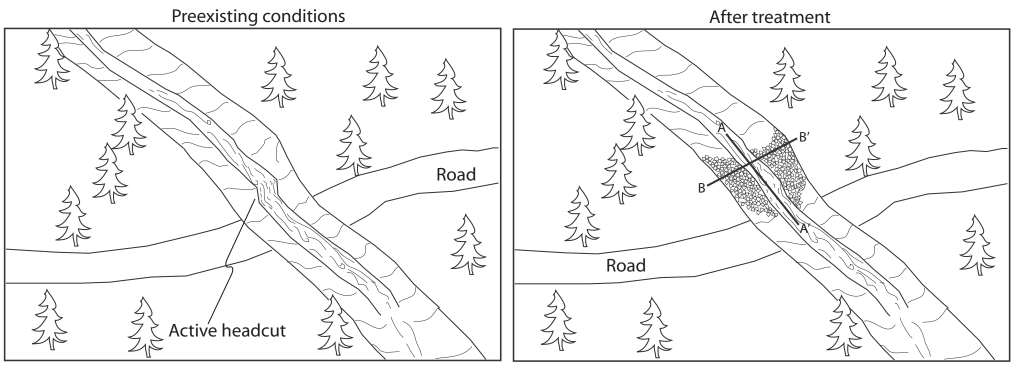
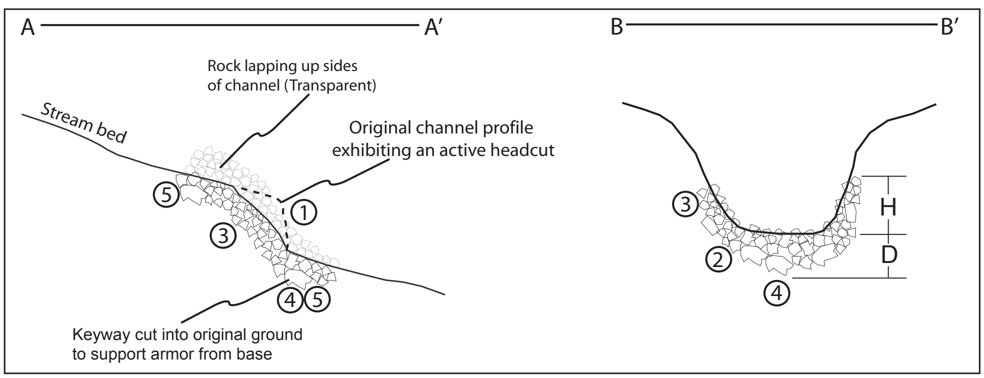
PWA Typical Drawing #17

Typical Rock Grade Control Structure Installation at man-made headcuts/knickpoints in a non-fish bearing stream channel



Cross section parallel and perpendicular to watercourse



Notes

The main objective is to create a structure that will not be flanked, undercut, or eroded by the stream.

The critical elements of a successful grade control structure are:

1) Excavating the headcut to a gentler channel gradient over a distance of stream (See road log for details)
2) rock selection- rock should be selected that is resistant to transport during design flows, and has a bell shaped distribution of sizes with the median diameter equivalent to the D50 particle size of the stream at the site of installation (See road log for range of rock diameters).
3) The rock must be placed in a “U” shape that will contain the 100 yr. return interval stream flow, won’t constrict the channel cross sectional area, and be flush with the streambed and not deflect flow.
4) The rock must be imbedded into the channel at least two rock diameters in thickness.
5) The largest rock should be used at the base and top of the grade control structure to buttress the other rock

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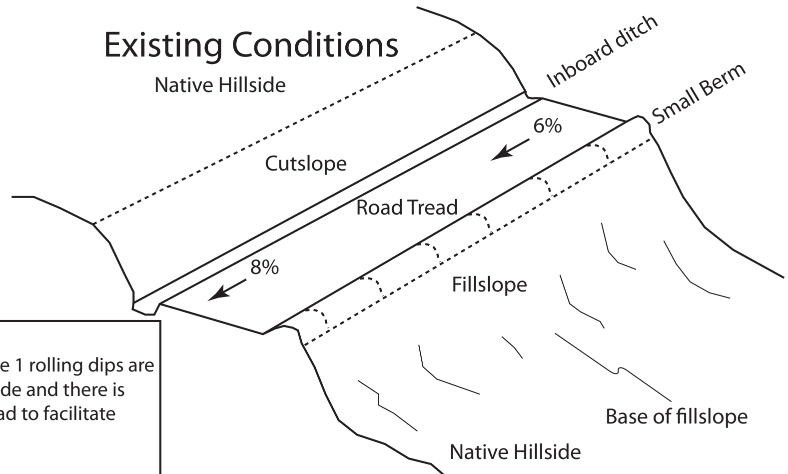
PWA Typical Drawing #18

Standard (Type 1) Rolling Dip Construction

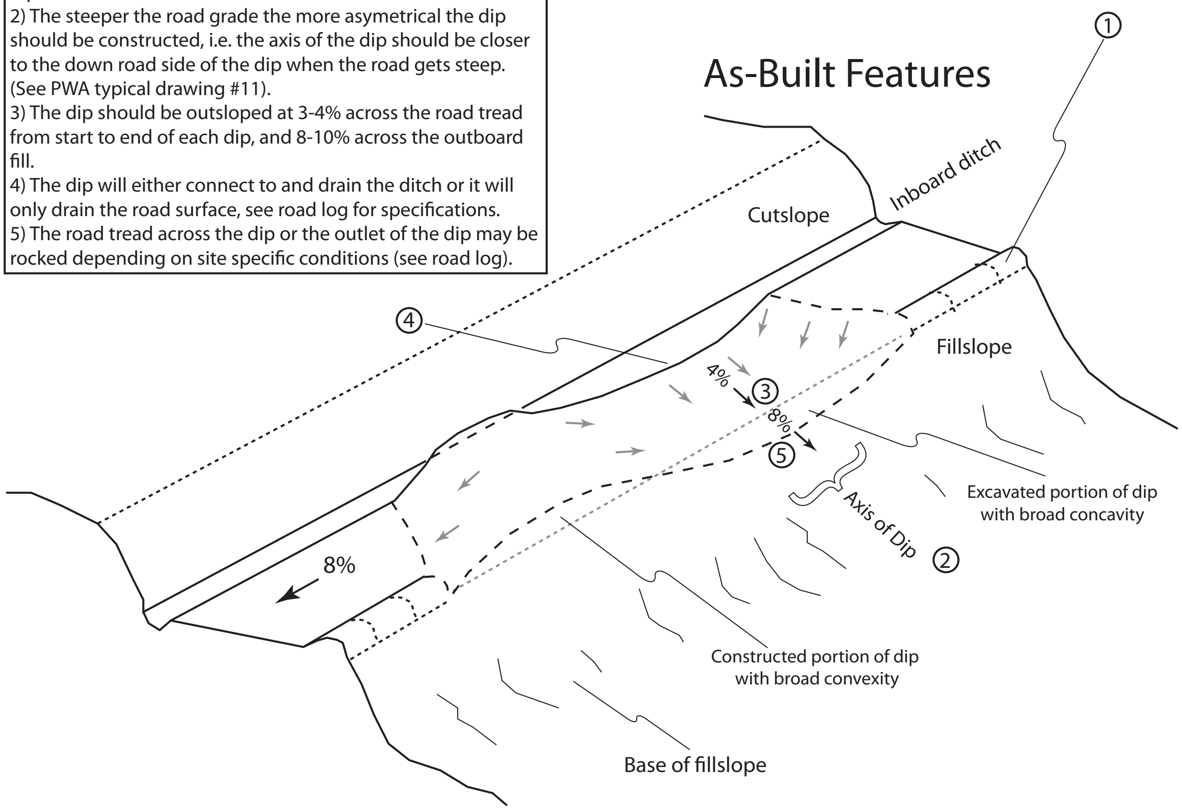


Notes

Rolling dip type 1 existing conditions: Type 1 rolling dips are utilized when roads are less than 12-14% grade and there is proximal outfall adjacent to the outboard road to facilitate road drainage.

Design Notes:

1) The berm should be removed for the entire length of the dip.
2) The steeper the road grade the more asymetrical the dip should be constructed, i.e. the axis of the dip should be closer to the down road side of the dip when the road gets steep. (See PWA typical drawing #11).
3) The dip should be outsloped at 3-4% across the road tread from start to end of each dip, and 8-10% across the outboard fill.
4) The dip will either connect to and drain the ditch or it will only drain the road surface, see road log for specifications.
5) The road tread across the dip or the outlet of the dip may be rocked depending on site specific conditions (see road log).



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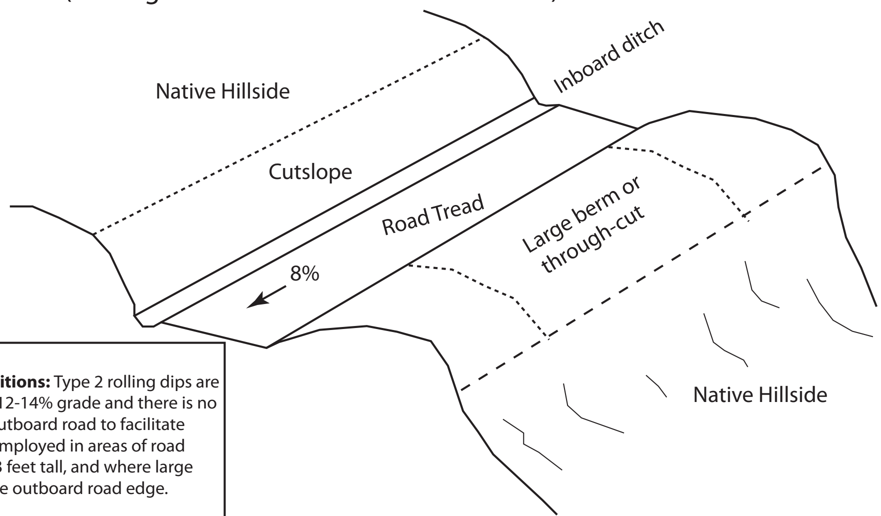
PWA Typical Drawing #19a

Type 2 Rolling Dip Construction

(Through-cut or thick berm road reaches)



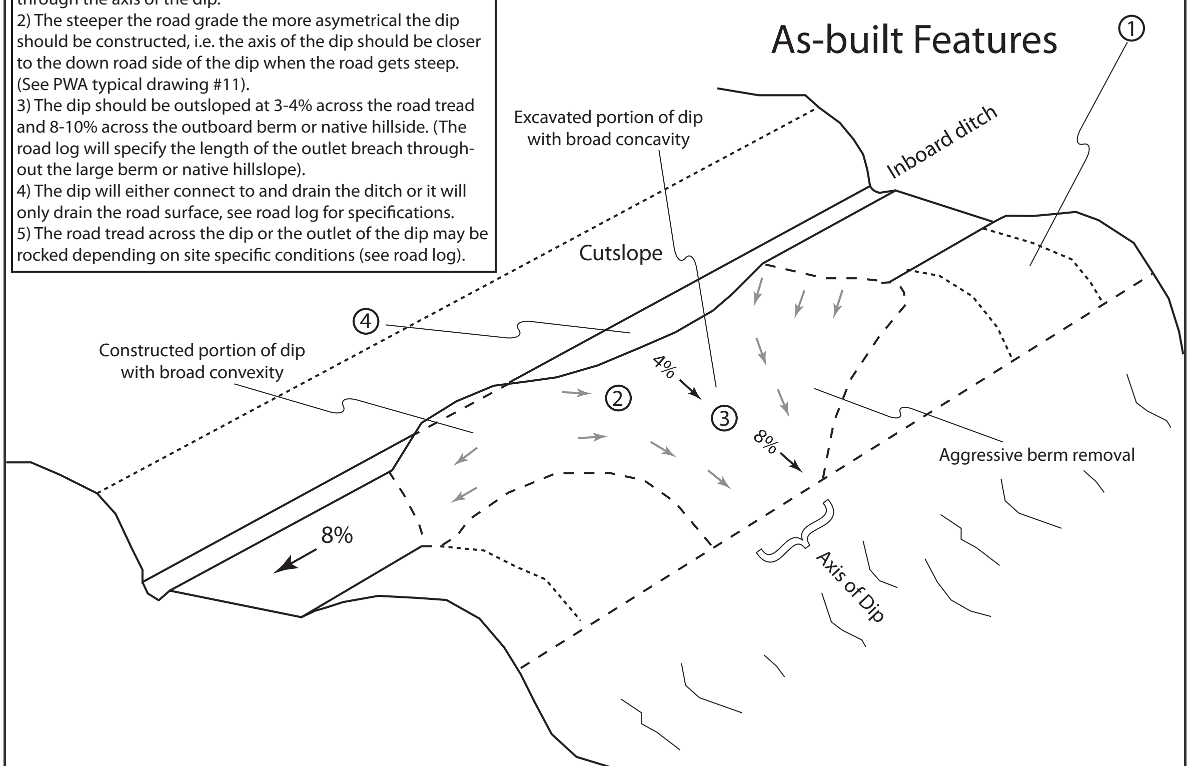
Notes

Rolling dip type 2 existing conditions: Type 2 rolling dips are utilized when roads are less than 12-14% grade and there is no proximal outfall adjacent to the outboard road to facilitate road drainage. These should be employed in areas of road through-cuts generally less than 3 feet tall, and where large wide and/or tall berms exist on the outboard road edge.

Design Notes:

1) The berm or native hillside should be removed for the entire length of the excavated portion of the dip, or, at a minimuim through the axis of the dip.
2) The steeper the road grade the more asymetrical the dip should be constructed, i.e. the axis of the dip should be closer to the down road side of the dip when the road gets steep. (See PWA typical drawing #11).
3) The dip should be outsloped at 3-4% across the road tread and 8-10% across the outboard berm or native hillside. (The road log will specify the length of the outlet breach throughout the large berm or native hillslope).
4) The dip will either connect to and drain the ditch or it will only drain the road surface, see road log for specifications.
5) The road tread across the dip or the outlet of the dip may be rocked depending on site specific conditions (see road log).

As-built Features



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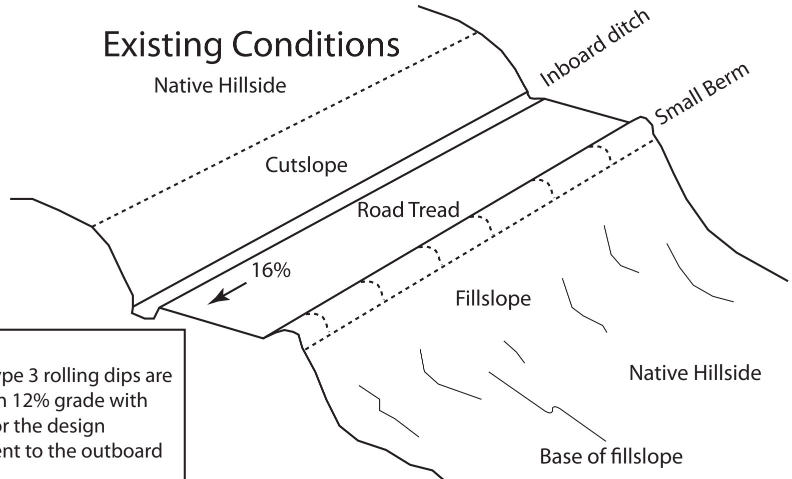
PWA Typical Drawing #19b

Type 3 Rolling Dip Construction (steep slope outslope)

Existing Conditions

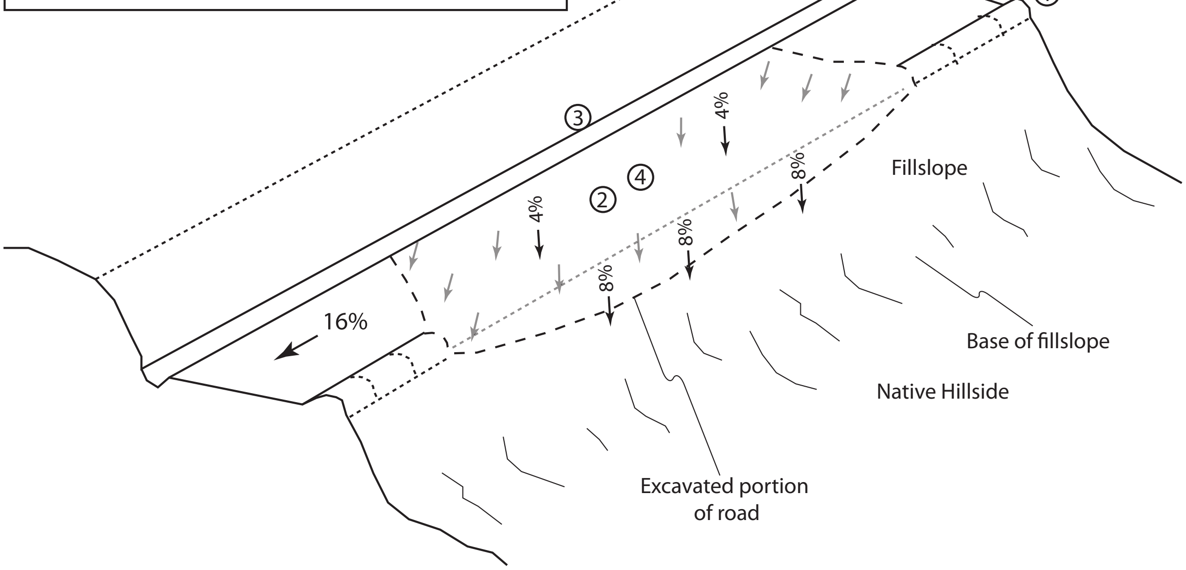


Notes

Rolling dip type 3 existing conditions: Type 3 rolling dips are utilized when roads grades are steeper than 12% grade with little opportunity to create reverse grade for the design vehicle, and there is proximal outfall adjacent to the outboard road to facilitate road drainage.

Design Notes:

1) The berm should be removed for the entire length of the outsloped section.
2) The dip should be outsloped at 2-4% across the road tread and 4-8% across the outboard fill. (The road log will specify the length of road to be type 3 outsloped).
3) The outsloping will rarely connect to and drain the ditch (see road log for specifications).
4) The road tread across the outsloped section or the outboard road will be rocked depending on site specific conditions (see road log).



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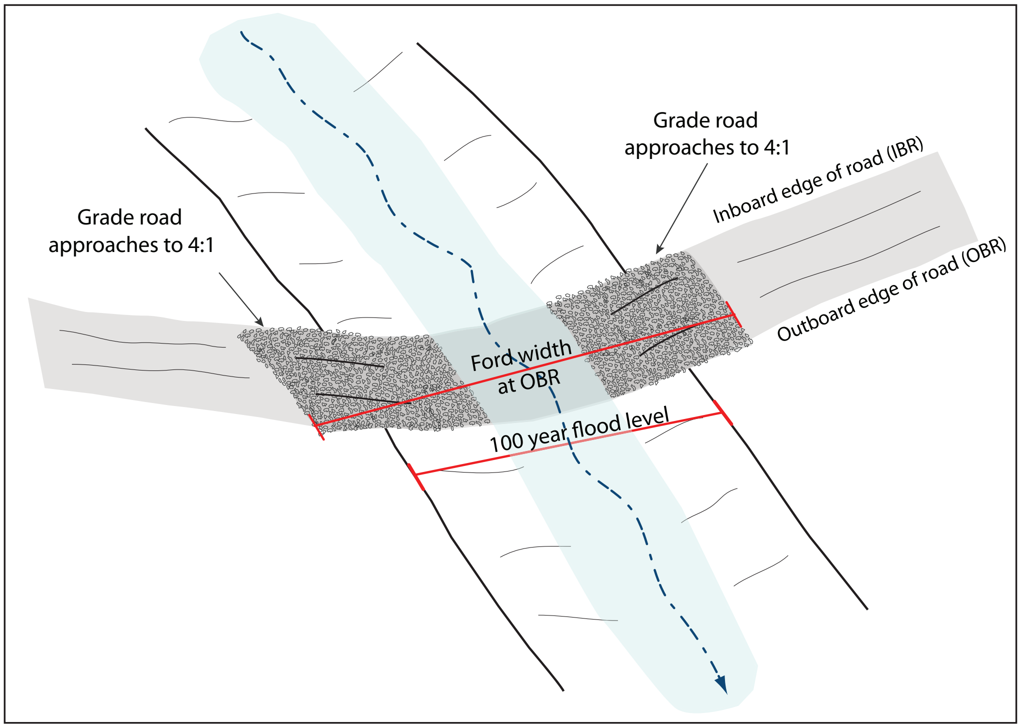
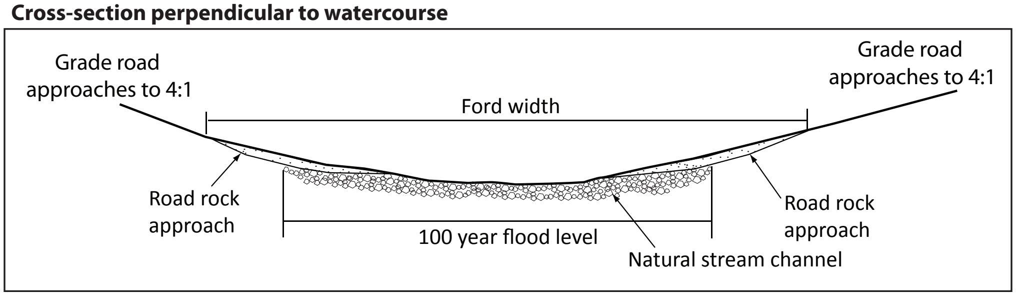
PWA Typical Drawing #19c

Typical Ford Crossing Installation

Oblique view



Cross-section perpendicular to watercourse



<u>Steps for ford crossing construction:</u>

1. Remove any existing structures (culverts, logs, large boulders, etc.)
2. Remove all road fill as you dip through the crossing to reach natural stream channel.
3. Establish a "U" shape across the channel at the width specified in the road logs.
4. Grade road approaches to specified slope angle (e.g., 4:1). Approaches may or may not be rocked; follow specifications in the road logs.

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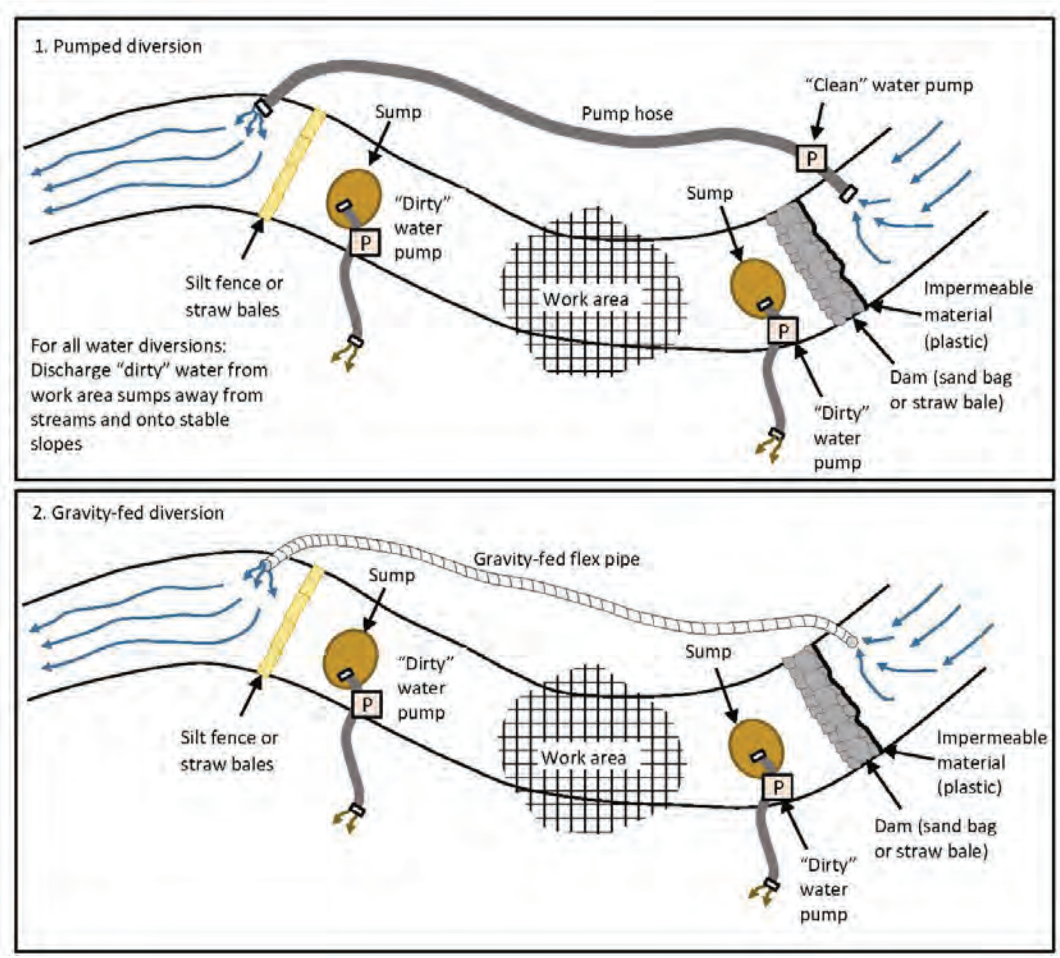
Typical Drawing #20

Typical Design for De-watering Streams



Stream crossing de-watering

Prior to working in and around the active stream channel, proper stream dewatering and avoidance of increasing downstream turbidity should be employed. Stream flows will be isolated upstream of the work area using cofferdams and transported downstream / around the work site through either a pumped diversion (Type 1) or by gravity diversion (Type 2) to keep the stream "live" (flowing) below the work area. An additional dam will be installed downstream of the work areas to capture any subsurface flow that might travel through the construction area. Any "dirty" water will be collected at this location and pumped away from the site where it can infiltrate into the ground without the potential to delivery to the stream and/or be used to wet fill being deposited in the spoil disposal areas.

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PWA Typical Drawing #21

Appendix D
Representative Photos

Quarry Park Watershed Assessment and Erosion Prevention Planning Project San Mateo County, California

Photo 1 (Dolphine Fire Road): View of the existing road conditions of the native surfaced Dolphine Fire Road near the road intersection with the Middle Ridge Fire Road.

Photo 2 (Miranda East Fire Road): View of the existing road conditions on the Miranda East Fire Road at Gate 4 as shown on Map 2.

Photo 3 (Meadow Trail): View of active gully erosion along the Meadow trail. Combined diverted steam flow and concentrated road runoff are eroding the road surface along this native surfaced road.

Photo 4 (Site #4): View of the on-stream pond located at Site #4 looking upstream from the left edge of the levee. Note the aggraded sediment at the upstream edge of the pond.

Photo 5 (**Site #4):** View of the levee associated with the on-stream reservoir Site #4, looking west-southwest across the top of the dam face.

Photo 6 (Site #4): View of temporary dysfunctional sandbag spillway at the southwest corner of the on-stream pond Site #4.

Photo 7 (Site #4): View of a road fill failure caused by diverted pond outflow. This erosion feature is located down the right road from the levee. Note the road prism is completely washed out.

Photo 8 (Site #4): View of the seeping drainage valve at base of the dam fillslope in the axis of the valley downstream of pond.

Photo 9 (Site #2): View of stream crossing through this shallow sediment filled pond. Stream sediment transport has deposited a large volume of fine sediment in this old pond, inundating the pond and trail.

Photo 10 (Site #2): View of an active 5.5ft tall headcut at the downstream extent of the inundated pond at stream crossing Site #2 on the Meadow trail shown in the previous photo.

Photo 11 (Site #19): View of failing cutbank immediately upslope of the right edge of stream crossing Site #19. This cutbank failure delivers directly to the Class III stream in the axis of the crossing fill crossing.

Photo 12 (Site #19): View of failing outboard fillslope, looking downslope at the fill failure deposits below the right hingeline of the fill crossing at Site #19. This photo was taken from the outboard edge of the road.

Photo 13 (Site #39): View looking downstream from the upstream extent of the of the failing stream crossing. Note the recently deposited sediments that have plugged the culvert inlets. The sediment is causing the stream flow to divert down the left road which is inducing a delivering fill failure.

Photo 14 (Site #39): View of an outboard fill failure to the left of the stream crossing. The fill failure was induced by the diverted streamflow from the plugged stream crossing at Site #39 and excessive concentrated road surface runoff.

Photo 15 (Site #39): View looking upstream at the failing outboard fillslope of this plugged stream crossing. The photo was taken standing approximately 8ft downstream of the culvert outlets.

Photo 16 (Site #40): View of a section of disconnected culvert downspout at the top of an actively migrating headcut and gully below the paved Private Drive at Site #40. Oxidation exposed on the stake is indicative of the previous depth of burial prior to the episodic hillslope failure.

Photo 17 (Site #40): View looking upslope at the same disconnected downspout and active erosion as shown in the previous photo. The photo was taken from the base of the gully downslope of the headcut standing on top of one of the failed sections of culvert.

Photo 18 (Site #40): View of active hillslope gully below Site #40 looking upstream. This photo was taken from the edge of the tree-line near the headwaters of a small Class III stream that drains to Site #16 downstream. The gully is conveying sediment from the gully erosion upslope to the Class III stream.

Photo 19 (Site #41): View looking upstream at a washed out fill crossing on a near origin Class III stream downslope from residential area on Santa Maria Avenue. This view of the scoured stream channel was taken from the outboard edge of road at Site #41.

Photo 20 (Site #41): View of a hillslope failure and undermined residences upstream from Site #41. This area upslope extent of AOC 4 as discussed in the text of the report. This photo was taken from the outboard edge of the Fire Break Road upslope from the Upper Pond Legacy Road as shown on Map 2.

Photo 21 (Site #9): View of the perched culvert outlet at stream crossing Site #9. The culvert at this crossing is undersized and installed high and short in the fill with a 6ft drop at the outlet and subsequent outboard fill erosion.

Photo 22 (Site #16): View of the fill crossing at Site #16 on the Dolphine Fire Road. Diverted stream flow is actively eroding gullies down the left road from this stream crossing.

Photo 23 (Site #16): View of the left road approach to fill crossing Site #16. Diverted stream flow is actively eroding gullies down the left road from this stream crossing and delivering to a watercourse at Site #15.

Photo 24 (Site #23): View of the outlet of the culvert at stream crossing Site #23 at the edge of the main parking lot. This culvert is undersized and stream flow avulses out of the drainage alignment and onto the parking lot surface.

Photo 25 (Site #24): View of a makeshift foot bridge at stream crossing Site #24. The active erosion at this site is minimal, and a formal crossing should be established.

Photo 26 (Site #31): View of an outboard fill failure at Site #31 on the Vista Point Trail. Concentrated road run off had saturated the steep outboard fill and subsequently destabilized the fillslope leading to failure.

Photo 27 (Site #36): View of a culvert inlet on a small Class III stream at Site #36. This site is downstream of the pond Site #37 in the base of the quarry.

Photo 28 (Site #38): View of the right road approaches to a fill on crossing on a Class III stream on the South Ridge Trail.

Photo 29 (Site #11): View of the hydrologically connected left road approach to landslide Site #11. Long reaches of concentrated road runoff have eroded a gully down the outboard fillslope and induced a failure.

Photo 30 (Coastal Bluff Trail): View of bluff retreat looking south along unpaved coastal trail. The gullies located along the wave cut bluffs are exacerbated by concentrated runoff from the trail and upslope marine terrace meadows.

Photo 31 (Coastal Bluff Trail): View of bluff retreat looking northward along unpaved coastal trail. This photo is looking up the hydrologically connected right road reach to the gullies displayed in the previous photo.

Photo 32 (Coastal Bluff Trail): View of road surface erosion along the coastal trail due to concentrating runoff. Note the exposed beach protection rock armor at the edge of the park boundary in the distance.

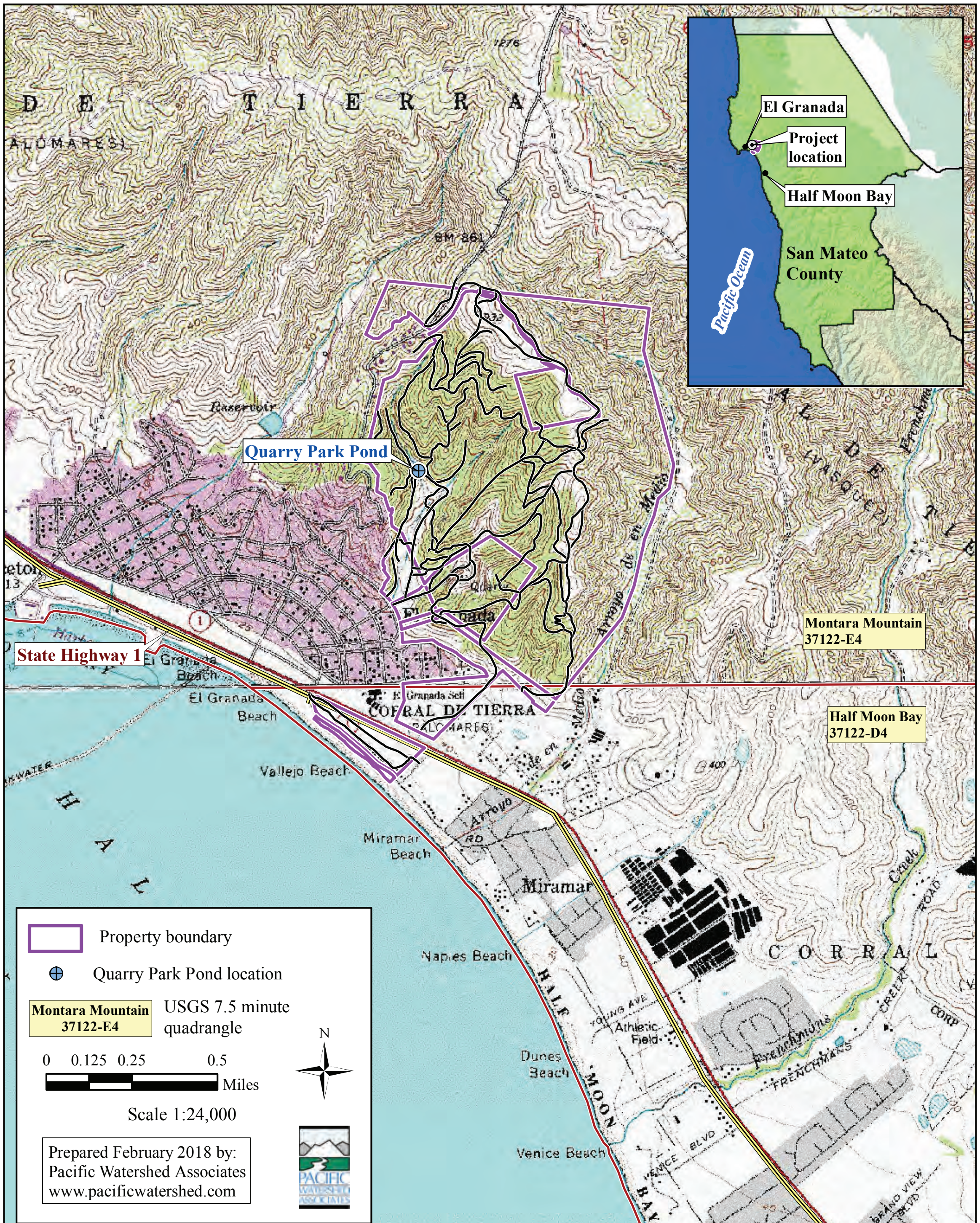
Photo 33 (Lookout Vista): View of the lookout deck and failing hillslope below the outermost footing. This photo was taken looking upslope from the base of the quarry floor.

Photo 34 (Lookout Vista): View of the failing hillslope below the wooden lookout vista platform. The quarry cutslope is oversteep and is actively failing in multiple locations along the upper edge of the quarry area.

Photo 35 (Urban Drainage Interface - AOC 2): View of uncontrolled Class II stream flow exiting the Park at Santa Maria Avenue (AOC2, Map 2). Combined flow from the stream and road surface runoff travel down Santa Maria Ave. The majority of the Park's drainage area evacuates the Property into the residential area downstream at this location.

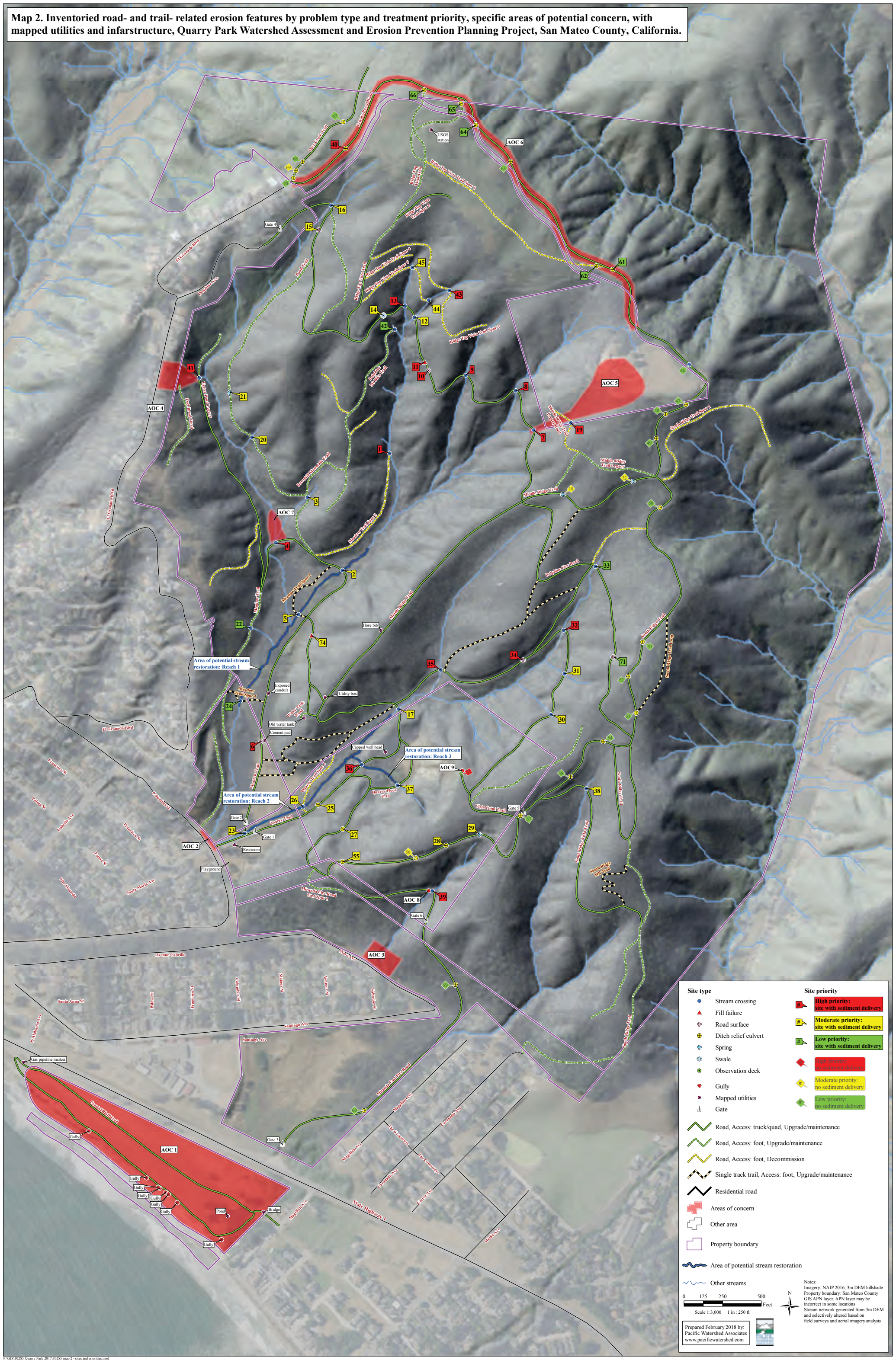
Photo 36 (Urban Drainage Interface - AOC 3): View of a seasonal Class II stream channel downstream from Site #39, ~30 ft upstream from an uncontrolled urban drainage interface (AOC 3) at Moro Drive on the south western boundary of the Park (AOC3, Map 2).

Photo 37 (Urban Drainage Interface – AOC 3): View of the urban drainage interface located on Moro Ave, (AOC 3, Map 2). Flow is conveyed down the inboard ditch for ~325’ to a ditch relief culvert at the intersection of Santiago Ave. and Moro Ave. The crowned road surface keeps the majority of the stream flow on the inboard edge of the road.



Map 1. Location of the Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.

P:\GIS\10285 Quarry Park 2017\10285 map 1 - location.mxd



Map 2. Inventoried road- and trail- related erosion features by problem type and treatment priority, specific areas of potential concern, with mapped utilities and infarstructure, Quarry Park Watershed Assessment and Erosion Prevention Planning Project, San Mateo County, California.