Tule Wind Project Hydrologic Studies

Note:

The Tule Wind Project Hydrological Studies (October 2009) were written to comply with County of San Diego requirements. The extent of the Proposed Tule Wind Project discussed in these reports is limited to areas on private property within the County of San Diego. In addressing potential hydrologic impacts in this EIR/EIS, Dudek considered the entire Proposed Tule Wind Project and supplemented information from the Tule Wind Project Hydrologic Studies. Information was supplemented from various sources as referenced in the EIR/EIS, and includes information from the EIR/EIS geotechnical and biological sections.

Geo-Logic
ASSOCIATES
Geologists, Hydrogeologists and Engineers

January 25, 2010
JN: 2009-254

HDR, Inc.
2751 Prosperity Avenue, Suite 200
Fairfax, Virginia 22031

Attention: Ms. Shannon D'Agostino, Senior Environmental Project Manager

GROUNDWATER RESOURCES
TULE WIND PROJECT
EAST SAN DIEGO COUNTY, CALIFORNIA

At your request, Geo-Logic Associates (GLA) is pleased to present our estimation of the potable water needs and the "performance standard" required for the Tule Wind Project. The construction related water source will be provided by a separate water supply, and is not included in the discussion herein. GLA understands that Pacific Wind Development LLC, a wholly owned subsidiary of Iberdrola Renewables (IBR), is proposing to construct and operate the Tule Wind Project located near Boulevard, California, in eastern San Diego County. The project will include the operation of 124 wind turbines and associated roads, transmission lines and support facilities. Once operational, the project will require routine system operations and maintenance (O&M) services. The O&M services and critical spare parts will be housed in an approximately 5000 square foot O&M building and staffed with up to 10 technicians. Currently this building is proposed to be built adjacent to the collector station on a 5-acre parcel of land owned by the federal Bureau of Land Management (BLM) and located in portions of Sections 18 and 19 of T16S, R7E. GLA understands that the land proposed for this project is currently undeveloped.

Once operational, the O&M building will require a continuous source of potable water. This area is not supplied by a potable water supply service and review of available San Diego County well data indicates that there are no water wells in a reasonable distance of the proposed O&M building. Therefore, it is proposed that a water well be drilled on the O&M building parcel to supply potable water to this building. Based on an estimated need of 2500 gallons of water per day, the well must be capable of supplying water at a rate of approximately 2 gallons per minute (gpm).

The project site is located on a crystalline granitic bedrock highland on the eastern slope of McCain Valley. Groundwater in this area may occur in the shallow alluvium within the McCain Valley and at depth within the fractures in the crystalline bedrock. Based on the location of the proposed O&M building, it is anticipated that the source of water will be obtained from within the fractured crystalline bedrock. Typically wells drilled within fractured bedrock yield relatively low production capacities, often from only one or a few water-bearing fractures. Since the proposed well's production is anticipated to be fracture-dependent, it is difficult to estimate its potential production rate. In fact, of 750 fractured rock well records in the County of San Diego, the median well yield reported was approximately 15 gpm, though a range from less than 3 gpm to over 100 gpm have been reported[1].

Assuming that the proposed well will yield groundwater in sufficient quantities to support the O&M Building needs, review of available County records indicates that there are no nearby receptors to this area. In addition, there are no surface water bodies or agricultural operations in the vicinity of the proposed O&M building that would be impacted by the withdrawal of this volume of water from the proposed fractured crystalline bedrock well. In a phone conversation, the San Diego County hydrogeologist indicated that no special County oversight (other than standard County well permitting procedures) would be required for drilling the proposed well since the relatively low (2 gpm) pumping rate would not pose an impact to groundwater resources in the area and the volumes to be withdrawn are too small to exceed the anticipated recharge volume to the area and result in an overdraft condition. Therefore, it is concluded that the drilling and withdrawal of 2 gpm poses no impact to human or biological receptors.

I hope that this short project description and discussion of the groundwater resources anticipated for the O&M building operations are helpful to you for the Tule Wind Project. If you have any questions, please give me a call.

Geo-Logic Associates

Sarah J. Battelle, CHG
Principal Geologist

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[1] County of San Diego, Guidelines for Determining Significance and Report Format and Content Requirements, Groundwater Resources, Land Use and Environment Group, Department of Planning and Land Use, Department of Public Works, March 19, 2007.

TULE WIND PROJECT

Preliminary Drainage Summary **_Date: October 2009_**

Reviewed by: Mark Seits, P.E.

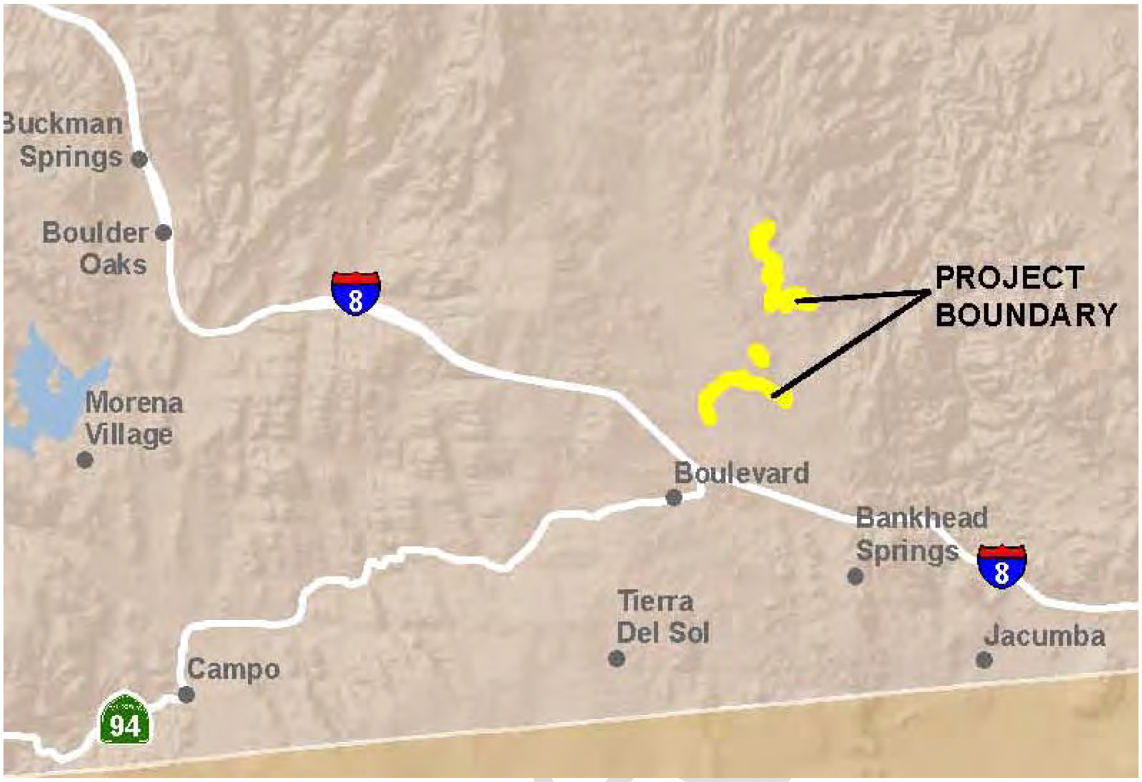
Prepared by: Brinton Swift, P.E.

Introduction and Purpose

A Preliminary Drainage Summary was completed for the Tule Wind Project (Project) to define existing and proposed drainage patterns and support the Storm Water Management Plan (SWMP) and the Plot Plans.

The Tule Wind Project is a large wind farm development that will construct wind turbines with a generating capacity of 200 megawatts. A majority of the development for the Project will take place on Federal Bureau of Land Management (BLM) land or on local Indian reservation land. Only portions of development located on private County of San Diego property are investigated for this Preliminary Drainage Summary. The approximately 145 acre Project site is located approximately 2.5 miles north of the community of Boulevard in the County of San Diego in the State of California. Project development proposed on County of San Diego regulated lands will disturb approximately 68 acres and is located just north of Interstate 8 off Ribbonwood Road. Given the rural nature of the Project area, only the western side of the site is bounded by a physical feature, Ribbonwood Road. Figure 1 presents a Vicinity Map for the Project.

Figure 1: Vicinity Map



Existing and Proposed Conditions

Under existing conditions the Project site is mainly undeveloped naturally vegetated rocky hills. A number of existing access roads traverse the area, providing service routes to existing utility facilities, rural houses, agricultural facilities, and a landing strip. Existing topography is fairly steep with some flatter drainage courses at the base of some of the hills. Naturally occurring native vegetation is predominant throughout the site, with periodic scattered unvegetated rock outcroppings.

Proposed development to be completed on private County of San Diego property will consist of 12 wind turbines, turbine pads, access roads, collector power lines, and the associated revegetation and transformer pads. Turbines are approximately 320-feet to 500-feet tall with a 48-foot diameter concrete foundation. Concrete foundations slope away from the centrally located turbines and will be buried greater than half a foot; such that there is only an exposed foundation 6-inches to 8-inches thick 18-feet to 20-feet in diameter. Turbines also include five-foot by nine-foot concrete pads for individual transformer foundations. Graded dirt pads around the turbines will be approximately 400-feet in diameter. Access roads between turbines will be 36-feet wide to accommodate self propelled cranes and supply trucks, while access roads to the turbine strings will only need to be 24-feet wide, as cranes and other assembly equipment can be brought on site in pieces. Thirty-six foot access roads between turbines are intended to be temporary for construction activities and will be allowed to revegetate to a 16-

foot to 20-foot width, pending construction completion. Proposed access road alignments will follow existing access roads to the maximum extent practicable to limit the amount of additional disturbed areas. Refer to Exhibits A – C for typical Project details.

Electrical collector lines for the Project will be a combination of overhead and buried, with a majority being buried. Overhead collector lines will be supported by single steel or wood poles; typically 60-feet to 80-feet in height. Foundation footprints for collector line poles will be similar to the diameter of the pole itself. Collector line disturbed widths are assumed to be 24-feet to allow construction vehicle access and trenching or pole erection. Natural vegetation surrounding the turbine pads, access roads, and any power poles will be established after construction. Buried collector lines will be completely revegetated after construction.

Project development will increase impervious areas, but by a minimal amount. Each turbine pad represents approximately 375 square feet of impermeable area. Overall Project development proposes to increase impervious area by approximately 5,000 square feet or 0.17% for the overall 68 acre site.

Drainage Patterns

Existing

Project areas are drained by three major drainage channels. Tule Creek drains the majority of the Project site to the southeast into Tule Lake. Tule Lake empties into Carrizo Wash, which ultimately discharges into the Salton Sea. Two small northwestern portions of the Project site are drained by two unnamed tributaries to Carrizo Wash. The southern of the two unnamed washes discharges into Carrizo Wash 2.4 miles upstream of the northern unnamed wash and approximately 10 miles downstream of Tule Lake. Site visits identified existing stream locations and access road crossings. See Exhibit D for existing and proposed drainage patterns.

Tule Creek Basin

Tule Creek Basin containing the Project site includes an expansive upstream area drains approximately 18,250 acres and has an approximately 11.5 mile long flow path. The highest upstream point in the basin is at approximately 5,820-feet and the downstream most point is at approximately 3,475-feet. Upper reaches of Tule Creek and its tributaries are generally fairly steep and confined to mountainous gullies. Tule Creek in the vicinity of the Project flattens out and takes on the form of a meandering stream in a wider valley with floodplains and flatter fields.

Runoff sheet flows across the ground surface until it encounters rivulets which then discharge into larger streams which ultimately discharge into Tule Creek. Precipitation that falls on typical access roads sheet flows off the side of the road where it is collected either in swales running parallel to the road or sheet flows across the surrounding terrain. Swales carry runoff to streams crossing the access road, where it is then conveyed to Tule Creek. There are no major improvements to the drainage features within the basin. However, a number of culverts have been installed on the northeast portion of the drainage basin to facilitate the construction of access roads across the smaller drainage features. An unnamed tributary to Tule Creek along the northeastern edge of the basin crosses a number of public and private roads via culverts just east of the landing strip. Crossings relevant to this Project include two 36-inch culverts for a private road and one 36-inch culvert for McCain Valley Road. Several access roads utilize a depressed on grade type crossing, where flows are conveyed across the top of the road, rather than constructing culverts to carry flows under the road. An existing access road crossing Tule Creek within the Project limits near the downstream half of the basin has this type of crossing.

Southern Unnamed Wash Basin

A portion of the Project site is located in an approximately 490 acre basin that drains to the southern unnamed wash. The drainage basin has a maximum flow path of 1.5 miles with a maximum elevation of 4,065-feet and a minimum elevation of 3,215-feet. A ridge divides the basin into a northern and southern portion, each draining into two respective streams. Both streams then join at a confluence at the bottom of the drainage basin, as shown on Exhibit A. Topography for the southern unnamed wash basin is mountainous with streams confined in steep gullies.

Generally, drainage is similar to the Tule Creek Basin; rainfall sheet flows into rivulets then into larger streams. Terrain is predominantly rocky and steep and will not provide substantial opportunity for infiltration. There are a limited number of developed access roads in this basin, with a majority of the existing roads being more double track trails. There are no existing improvements to the drainage features in the basin, given the limited amount of development in the basin. However, there are several double track roads that cross smaller drainages in the basin.

Northern Unnamed Wash Basin

Northeastern portions of the Project site lie within an approximately 690 acre basin that drains to the northern unnamed wash. Basin drainage has a maximum flow path of approximately 1.4 miles, with a maximum elevation of 4,080-feet and a minimum elevation of 3,640-feet. The northern unnamed was basin drains to confined mountainous gullies that are steep and rocky.

Drainage patterns are similar to the previously discussed basins; precipitation will sheet flow into small rivulets that will join with surrounding streams and eventually discharge into Carrizo Wash. Roads in the northern unnamed wash basin are primarily double track trails and do not have any associated drainage improvements.

Proposed

Proposed Project improvements will aim to mimic existing drainage patterns and will minimize redirection of any flows. Improvements include graded pads, access roads, and utility lines, and engineered crossings at each drainage feature. Preliminary discussion of the proposed

Project drainage features does not include hydrologic or hydraulic analysis, and as such no specific types or sizes of proposed drainage facilities are completed in this report. Project improvements propose minimal additional impervious areas. Any increase in runoff resulting from these impacts is assumed to be negligible, from a flood impact standpoint, with water quality impacts addressed in the Storm Water Management Plan published under a separate cover by HDR.

Tule Creek Basin

Tule Creek Basin drainage patterns will not be altered significantly in proposed conditions. Almost all flow generated by the basin is from existing areas with proposed improvements taking up less than 0.2% of the area. All existing drainage patterns will be maintained to the maximum extent practicable. Future analysis and design of proposed drainage facilities will maintain the existing drainage patterns to the maximum extent practicable.

An access road running east-west between Ribbonwood Road and McCain Valley Road will cross approximately six drainages, two of which are larger streams. The access road will cross Tule Creek and the major eastern unnamed tributary. Improvements to McCain Valley Road will also require improvements to an existing 36-inch culvert crossing with the unnamed tributary. Additional access roads are planned between the turbines in the northeastern corner of the basin and will cross approximately nine drainages that could require culverts. See Exhibit A for preliminary proposed Project crossings. Drainage of access roads will be facilitated by brow ditches/swales parallel to proposed roads, which will convey flows to existing surface drainage features.

Precipitation falling on the exposed portions of the turbine pads will sheet flow off the proposed features and finished surfaces (a total of roughly 5,000 square feet impervious areas) to surrounding brow ditches/swales. Runoff will be directed into the surrounding existing natural drainage features, with overall flow patterns intended to mimic existing drainage features.

Proposed collector lines will be located mainly in the northeastern corner of the basin. Any Project impacts on drainage patterns will only be prevalent during construction. Once the collector lines are either hung or buried the surrounding vegetation and grades will be restored to existing conditions to the maximum extent practicable.

Southern Unnamed Wash Basin

Project improvements completed within the southern unnamed wash basin are located along the ridgelines of the basin, and will not redirect existing flow patterns. Proposed improvements will take up less than approximately 1.6% of the drainage basin area, and will mainly be pervious areas. Project development will maintain existing drainage patterns to the maximum extent practicable.

Because access roads are constructed along ridgelines in the southern unnamed wash basin, no drainage crossings are planned. Access roads will sheet flow to surrounding brow ditches or swales running parallel to the roads. Turbine pads will drain similar to Tule Creek Basin's pads, which will direct flows to surrounding existing drainage features. Connector lines will also be constructed similar to Tule Creek Basin's lines, with minimal impacts to existing drainage patterns.

Northern Unnamed Wash Basin

Proposed Project development within the northern unnamed wash basin will not significantly alter existing drainage patterns. Project improvements occupy approximately 3.4% of the drainage basin area; however the majority of these features will be pervious. Proposed improvements intend to keep existing drainage patterns unchanged.

Access roads located within the northern unnamed wash basin will cross approximately nine drainages, one of which is the main drainage channel for the basin. Roads will be constructed with parallel brow ditches/swales to collect sheet flow and convey runoff to the existing natural surrounding drainage features.

Turbine pads will be graded to mimic existing drainage patterns and will sheet flow to proposed brow ditch/swales around the pads that will convey runoff into existing drainage features. Collector lines will be constructed similarly to the other basins, with minimal impacts to existing drainage patterns once construction is completed.

Floodplain

Currently there are no mapped regulatory floodplains for the Project site. A number of drainage features cross the Project area, but all are located in Federal Emergency Management Agency (FEMA) non-printed Flood Insurance Rate Map panels. There could still be the potential for flooding during storm events; FEMA has just not evaluated the potential hazard for these areas. All drainage crossings should be analyzed and designed during final engineering to ensure adequate capacity and limited impacts to existing water surface elevations. Major drainages, such as Tule Creek, could pose substantial risk to the integrity of proposed access roads without consideration of water surface elevations.

Summary

Based on a preliminary investigation of the proposed Project plan and the existing drainage patterns, impacts from proposed development should be minimal, but will need to be analyzed further as planning progresses. Project development is intended to match existing drainage patterns and will minimize the amount of redirected flows. Increases in runoff resulting from low frequency storm events associated with flooding will be minimal, due to the limited amount of proposed impervious area. Additional hydrologic and hydraulic analysis needs to be completed for the Project to determine flow rates in the existing drainage features, size proposed drainage facilities to convey design storms, impacts additional crossings will have on upstream water surfaces, and potential for increased flow rates from minor increases in impervious areas.

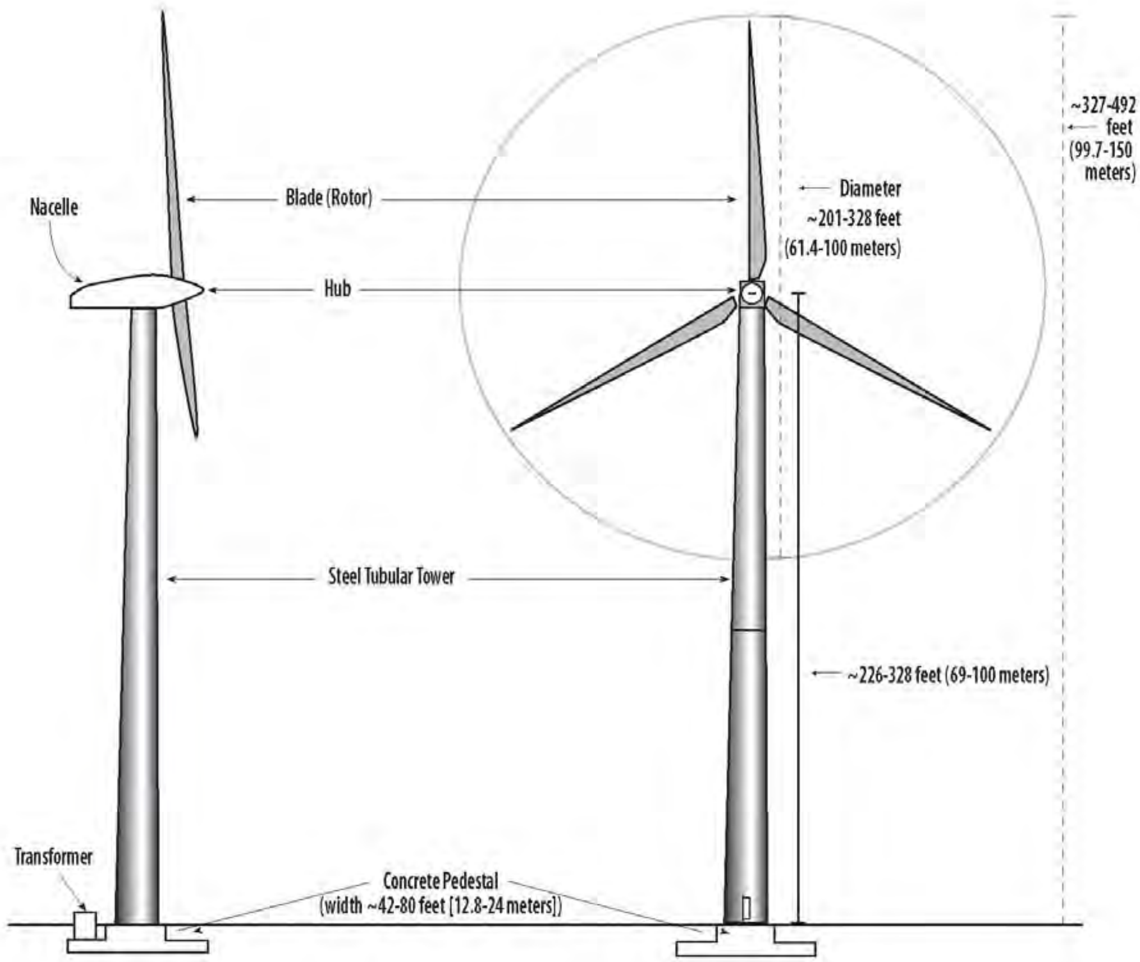


Exhibit A: Turbine Schematic

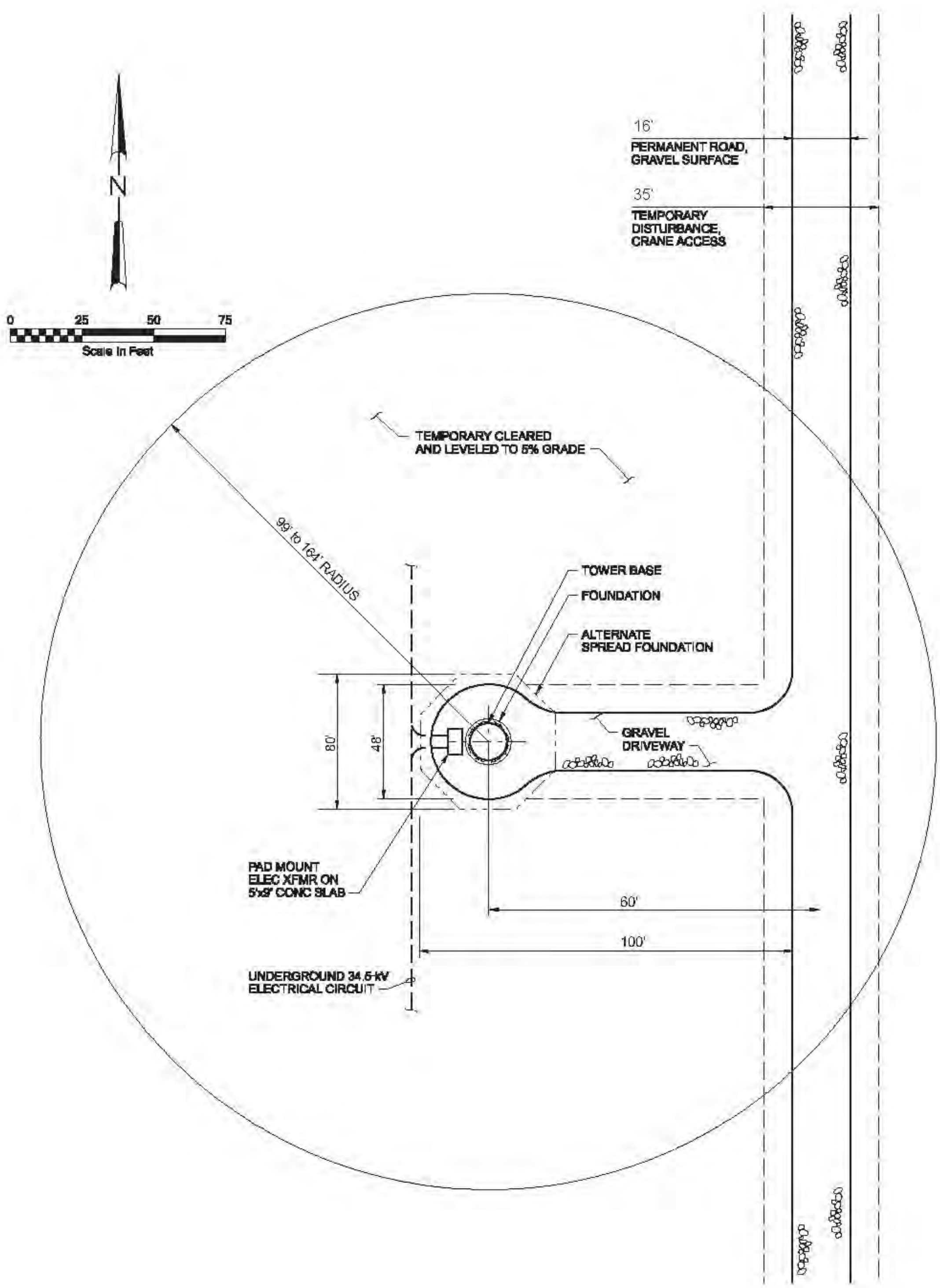
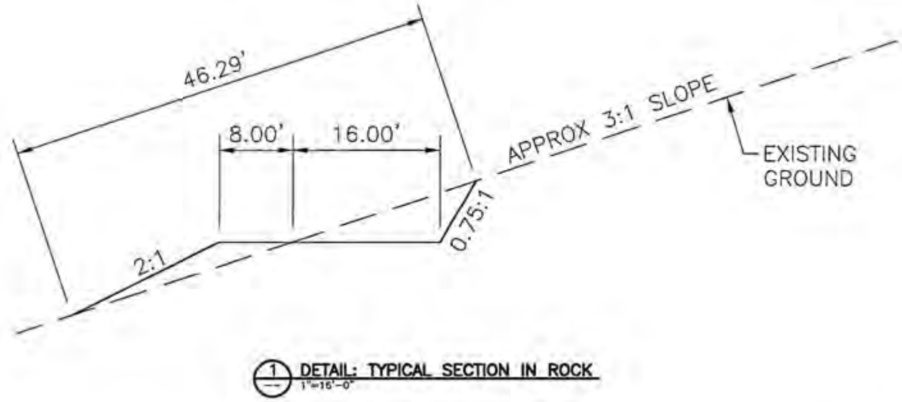


Exhibit B: Turbine Site



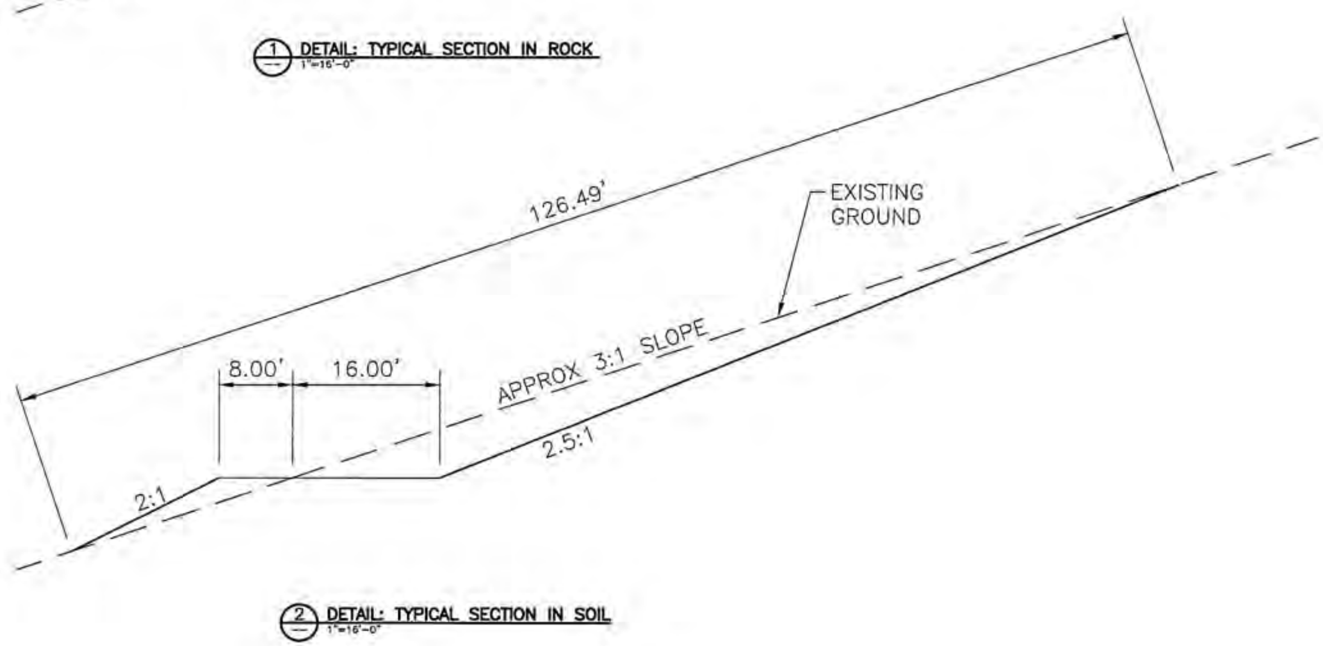
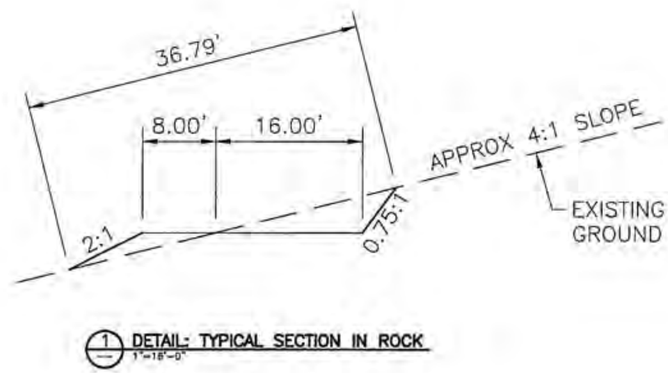


Exhibit C1: Typical Access Road Cross Sections



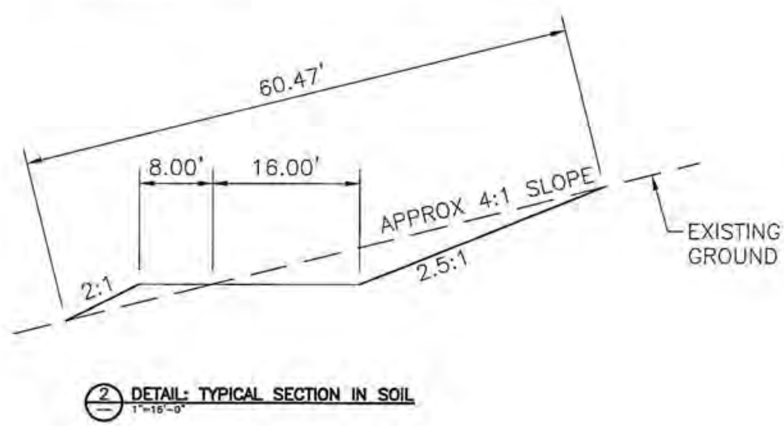
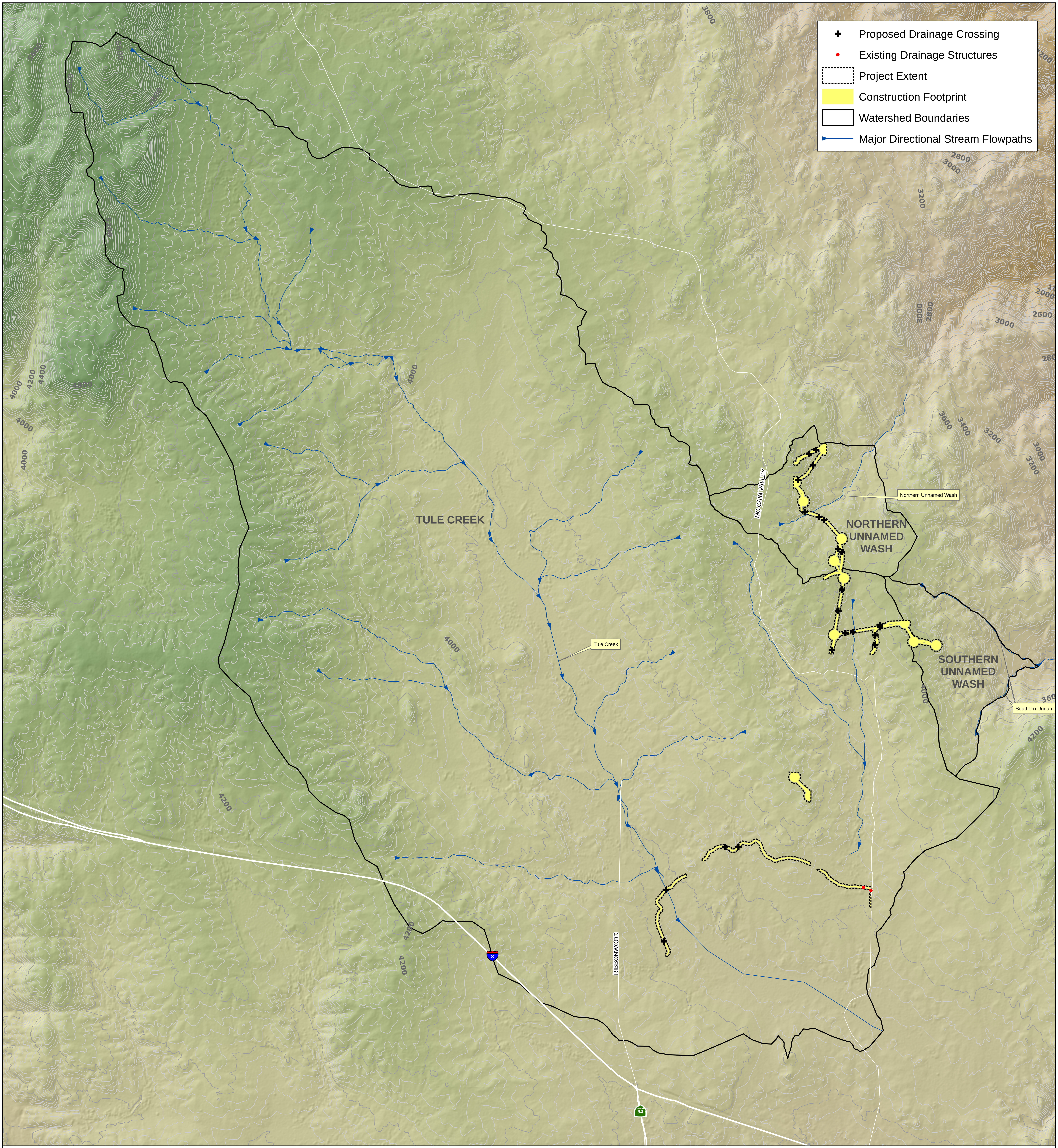


Exhibit C2: Typical Access Road Cross Sections



0 0.35 0.7 1.4 Miles

Existing and Proposed Conditions Drainage Map

Exhibit D

Iberdrola | Tule Wind Project | Preliminary Drainage Summary

HDR ONE COMPANY | *Many Solutions*

TULE WIND PROJECT

MAJOR USE PERMIT

STORM WATER MANAGEMENT PLAN

County of San Diego

DRAFT

Prepared for:

Iberdrola Renewables, Inc.
1125 NW Couch Street, Suite 700
Portland, Oregon

Prepared by:

HDR Engineering, Inc.
8690 Balboa Avenue, Suite 200 San Diego, California 92123 858-712-8400

October 2009

Tables

Figures

Appendices

Executive Summary

The purpose of this Storm Water Management Plan (SWMP) is to investigate Best Management Practices (BMPs) and Hydromodification Impacts for the Tule Wind Project (Project). This report is intended to accompany and support the Major SWMP form from Appendix C of the San Diego County Standard Urban Storm Water Mitigation Plan (SUSMP). The following documents apply to the water quality for the Project:

- San Diego County Standard Urban Storm Water Mitigation Plan (SUSMP), March 2008,
- County of San Diego Watershed Protection, Storm Water Management and Discharge Control Ordinance (County Ordinance 9589),
- County of San Diego Stormwater Standards Manual,
- Standard Specifications for Public Works Construction,
- San Diego Regional National Pollutant Discharge Elimination System (NPDES) Storm Water Permit (Order Number 2001-01, NPDES Number CAS0108758

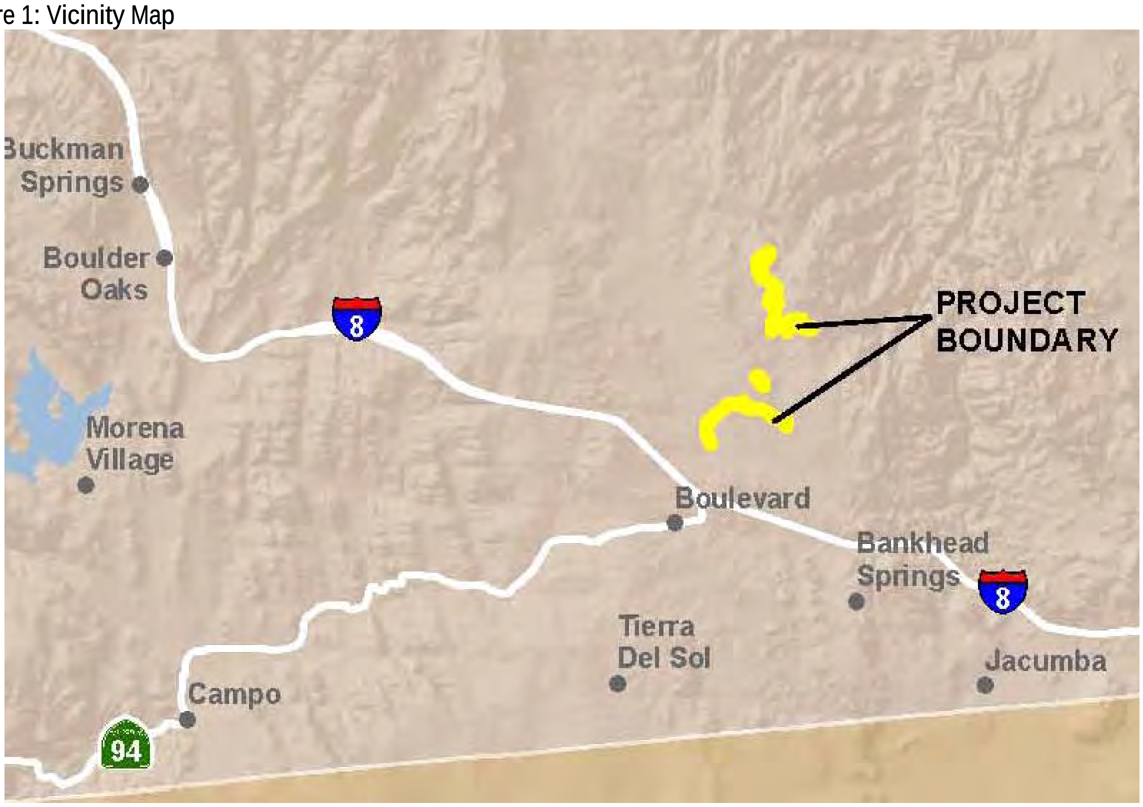
Based on these governing documents the following items are included in the SWMP:

- Project description and vicinity map,
- Site map defining drainage patterns, existing storm drain systems, proposed drainage crossings, soil types, existing land types, and existing and proposed slopes,
- Identification of Pollutants of Concern,
- Identification of Conditions of Concern,
- Identification of Site Design BMP recommendations,
- Preliminary Hydromodification analysis and discussion,
- Identification of Source Control BMPs,
- BMPs for Individual Priority Project Categories,
- Identification of Treatment Control BMP recommendations, and
- Storm Water BMP maintenance discussion.

1.0 PROJECT DESCRIPTION

The Tule Wind Project proposes to develop a wind turbine "farm" for power generation, in the County of San Diego in the State of California. Portions of the Project discussed in this report are limited to areas on private property within the County of San Diego. A majority of the overall Project will be developed on Bureau of Land Management (BLM) Federal land, outside the County of San Diego Planning Department jurisdiction. Total Project site area proposed on County of San Diego regulated lands is approximately 145 acres, which will disturb approximately 68 acres. The Project is located just north of Interstate 8 east of Ribbonwood Road, approximately two and half miles northeast of the community of Boulevard, California. Given the rural nature of the Project area, only the western side of the site is bounded by a physical feature, Ribbonwood Road.

Figure 1: Vicinity Map



Under existing conditions the Project site is mainly undeveloped naturally vegetated rocky hills. A number of existing access roads traverse the area, providing service routes to existing utility facilities, commercial facilities, rural houses, agricultural facilities, and a landing strip. Existing topography is fairly steep with some flatter drainage courses at the base of the some of the hills and gullies. Naturally occurring native vegetation is predominant throughout the site, with periodic scattered unvegetated rock outcroppings.

Development to be completed on private County of San Diego property will consist of 12 wind turbines, turbine pads, access roads, collector power lines, and the associated revegetation and transformer pads. Turbines are approximately 320-feet to 500-feet tall with a 48-foot diameter concrete foundation. Concrete foundations slope away from the centrally located turbine and will be buried greater than half a foot, so that exposed concrete foundations are approximately 6-inches to 8-inches thick and 18-feet to 20-feet in diameter. Turbines also include five-foot by nine-foot concrete pads for transformer foundations. Graded dirt pads around the turbines will be approximately 400-feet in diameter. Access roads between turbines will be 36-feet wide to accommodate self propelled cranes and supply trucks, while access roads to the turbine strings will only need to be 24-feet wide, as the crane and other assembly equipment can be brought onsite in pieces. Thirty-six foot access roads between turbines are intended to be temporary for construction activities and will be allowed to revegetate to a 16-foot to 20-foot width, pending construction completion. Proposed access road alignments will follow existing access roads to the maximum extent practicable to limit the amount of additional disturbed areas. New access roads will follow existing contours to maximum extent practicable to limit the amount of disturbed areas resulting from grading cuts. Appendix A contains preliminary details for Project features.

Electrical collector lines for the Project will be a combination of overhead and buried, with a majority being buried. Overhead collector lines will supported by single steel or wood poles; typically 60-feet to 80-feet in height. Foundation footprints for collector line poles will be similar to the diameter of the pole itself. Collector line disturbed widths are assumed to be 24-feet to allow construction vehicle access and trenching or pole erection. Natural vegetation surrounding the turbine pads, access roads, and any power poles will be established after construction. Buried collector lines will be completely revegetated after construction.

Project development will increase impervious areas by a very small amount. Each turbine pad represents approximately 1,900 square feet of impermeable area. Overall Project development proposes to increase impervious area by approximately 22,900 square feet or 0.77% for the overall 68 acre site. Impervious areas reported in the SWMP vary from those in the Preliminary Drainage Summary published under a separate cover by HDR. This is intentional as shallow spread footings will impede slower water quality infiltration used in hydromodification calculations, but will not have as great an impact on drainage study hydrologic runoff coefficients used for flooding storm events.

1.1 PROJECT REQUIREMENTS

A Stormwater Intake Form for Development Projects was completed for the Project and is included in Appendix B. Based on the checklist Tule Wind Project is considered a priority project and is required to adhere to Major SWMP requirements. A completed Major SWMP form is included in Appendix C. Priority project criteria are outlined in the SUSMP Standard Storm Water BMP Selection Matrix as shown in Table 1. Project development will require site design, source control, priority project BMPs, and treatment control BMPs, to be discussed in Sections 4, 5, 6, and 7, respectively.

Table 1: Standard Storm Water BMP Selection Matrix

Priority Project Category	Site Design BMPs(1)	Source Control BMPs(2)	Requirements Applicable to Individual Priority Project Categories(3)										
			a. Private Roads	b. Residential Driveways & Guest Parking	c. Dock Areas	d. Maintenance Bays	e. Vehicle Wash Areas	f. Outdoor Processing Areas	g. Equipment Wash Areas	h. Outdoor Processing Areas	i. Surface Parking Areas	j. Fueling Areas	k. Hillside Landscaping
Detached Residential Development	R	R	R	R									R
Attached Residential Development	R	R	R	R									R
Commercial Development >1 Acre	R	R			R	R	R	R					
Heavy industry/industrial development	R	R	R		R	R	R	R	R			R	
Automotive Repair Shop	R	R			R	R	R		R	R		R	
Restaurants	R	R			R				R				
Hillside Development >5,000 ft^2	R	R	R										R
Parking Lots	R	R								R(4)			
Retail Gasoline Outlets	R	R				R	R					R	
Streets, Highways & Freeways	R	R									R		

R=Required; select one or more applicable and appropriate BMPs from the applicable steps in section 4.1 &4.2, or equivalent as identified in section 4.6.1-4.6.3.
(1) Refer to Section 4.1.
(2) Refer to Section 4.2.
(3) Priority project categories must apply specific stormwater BMP requirements, where applicable. Projects are subject to the requirements of all priority project categories that apply.
(4) Applies to the paved area totals >5,000 square feet or with >15 parking spaces and is potentially exposed to urban runoff.

2.0 POLLUTANTS OF CONCERN

Under existing conditions pollutants generated by the Project site include sediments, oil and grease. Based on the County of San Diego SUSMP anticipated pollutants for hillside developments are sediment, nutrients, oil & grease, trash and debris, oxygen demanding substances, and pesticides. Table 2 outlines the pollutants of concern as shown in the County of San Diego SUSMP. However, based on the minimal amount of development that is proposed anticipated pollutants are more likely sediment from dirt roads and pads, and oil and grease from the roads and turbines.

Table 2: Anticipated and Potential Pollutants Generated by Land Use Type.

	General Pollutant Categories								
Priority Project Categories	Sediments	Nutrients	Heavy Metals	Organic Compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticides
Detached Residential Development	X	X			X	X	X	X	X
Attached Residential Development	X	X			X	P(1)	P(2)	P(1)	X
Commercial Development >1 Acre	P(1)	P(1)		P(2)	X	P(5)	X	P(3)	P(5)
Heavy industry/industrial development	X		X	X	X	X	X		
Automotive Repair Shop			X	X(4)(5)	X		X		
Restaurants					X	X	X	X	
Hillside Development >5,000 ft^2	**X**	**X**			**X**	**X**	**X**		**X**
Parking Lots	P(1)	P(1)	X		X	P(1)	X		P(1)
Retail Gasoline Outlets			X	X	X	X	X		
Streets, Highways & Freeways	X	P(1)	X	X(4)	X	P(5)	X		

X = anticipated
P = potential
(1) A potential pollutant if landscaping exists on-site.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves food or animal waste products.
(4) Including petroleum hydrocarbons.
(5) Including solvents.

2.1 RECEIVING WATERS

A number of existing streams will convey flows generated by the Project. A majority of the Project drains to Tule Creek via McCain Valley and Lark Canyon. These flows are conveyed into Tule Lake which discharges into Tule Canyon, then Carrizo Wash in Carrizo Gorge. A northern eastern portion of the Project drains into Carrizo Wash through Rodando and Palm Grove. Carrizo Wash continues in a northerly direction to a junction with an unnamed wash that drains the northern most part of the Project. Finally, all flows are conveyed north into Carrizo Creek, into San Felipe Creek, and finally into the Salton Sea. The Salton Sea is a minimum of approximately 45 miles downstream of the Project.

Based on the Project location and the existing conditions, there are no dry weather flows for drainages associated with this Project. There are minimal existing rural developments within the Project drainage basins that would generate flows during dry weather. Frequent site visits during the dry season confirmed that no flows were present in drainages associated with the Project.

All Project areas, Tule Creek, McCain Valley, Lark Canyon, Tule Lake, and Carrizo Creek are located in the McCain hydrologic sub-area in the Jacumba hydrologic area in the Anza Borrego watershed, defined by hydrologic unit number 722.71. Carrizo Creek drains through the Carrizo hydrologic sub-area in the Agua Caliente hydrologic area (722.61) where it confluences with San Felipe Creek in the Ocotillo Lower Felipe hydrologic area (722.20).

Based on the 303(d) list approved by the United States Environmental Protection Agency (USEPA) in 2006, only the Salton Sea is listed for nutrients, salinity, and selenium. Pollutant sources are identified as agricultural, major industrial, point source, or out of state.

Currently there are no Region 9 State Water Resources Control Board special requirements for any water bodies that will be impacted by this Project. Based on the available information there are no High Risk Areas within the Project limits.

A hazardous waster search conducted by HDR with the County of San Diego did not identify any existing hazardous or contaminated soils.

Comparison of the anticipated pollutants and the receiving water bodies' impairments indicates there are no primary pollutants of concern. Secondary pollutants of concern are sediment and oil and grease.

3.0 CONDITIONS OF CONCERN

A Preliminary Drainage Summary dated October 2009 was completed by HDR under a separate cover and discusses the existing and proposed drainage patterns for the Project. A review of this drainage summary is presented below.

3.1 EXISTING DRAINAGE PATTERNS

Project areas are drained by three major drainage basins:

- Tule Creek Basin – 18,250 acres
- Southern Unnamed Wash Basin – 490 acres
- Northern Unnamed Wash Basin – 690 acres

Tule Creek drains the majority of the Project site to the southeast into Tule Lake. Tule Lake empties into Carrizo Wash, which ultimately discharges into the Salton Sea. Two small northwestern portions of the Project site are drained by two unnamed tributaries to Carrizo Wash. The southern of the two unnamed washes discharges into Carrizo Wash 2.4 miles upstream of the northern unnamed wash and approximately 10 miles downstream of Tule Lake. Site visits identified existing stream locations and access road crossings. Refer to Exhibit A for an existing and proposed conditions drainage map.

All basins have similar drainage patterns. Runoff sheet flows across the ground surface until it encounters rivulets which then discharge into larger streams which ultimately discharge into Tule Creek or Carrizo Wash. Precipitation that falls on typical access roads sheet flows off the side of the roads where it is either collected in swales running parallel to the road or continues to sheet flow across the natural terrain. Swales carry runoff to streams crossing the access road, where they are then conveyed to major drainage features.

There are no major improvements to the drainage features within the basin. However, a number of culverts have been installed on portions of the Tule Creek Basin to facilitate the construction of access roads across the smaller drainage features. An unnamed tributary to Tule Creek along the northeastern edge of the Tule Creek Basin crosses a number of public and private roads via culverts just east of the landing strip. Several access roads utilize a depressed on grade type crossing, where flows are conveyed across the top of the road, rather than constructing culverts to carry flows under the road.

3.2 PROPOSED DRAINAGE PATTERNS

Proposed Project improvements will mimic existing drainage patterns and will minimize redirection of any flows. Improvements include graded pads, access roads, and utility lines, and constructed crossings at each drainage feature.

Tule Creek Basin has an access road running east-west between Ribbonwood Road and McCain Valley Road which will cross approximately six drainages, two of which are larger streams. Drainage of access roads will be completed by brow ditches/swales parallel to proposed roads, which will convey flows to existing surface drainage features. Project development within the southern unnamed wash basin does not propose any crossing of existing surface drainage features. Access roads located within the northern unnamed wash basin will cross approximately nine drainages, one of which is the main drainage channel for the basin.

Precipitation falling on the turbine pads will sheet flow off the proposed features and finished surfaces to brow ditches/swales that will collect runoff. Runoff will then be directed to the existing natural surface drainage features, with flow patterns intended to mimic existing conditions.

Proposed electrical collector lines will be located mainly in the northeastern corner of the Project. Any impacts on drainage patterns from collector lines will only be prevalent during construction. Once the collector lines are either hung or buried the surrounding vegetation and grades will be restored to existing conditions to the greatest extent practicable.

A complete discussion of the Project drainage is completed in the report Preliminary Drainage Summary, dated October 2009, published under a separate cover by HDR.

3.3 HYDROMODIFICATION

Based on the County of San Diego Major Storm Water Management Plan form this Project is required to complete a Hydromodification Plan (HMP). Interim HMP criteria were defined by Region 9 of the State Water Resources Control Board and were used in establishing hydromodification requirements for this Project. In order to meet these requirements a continuous hydrologic simulation was completed for the proposed development.

3.3.1 Hydromodification Analysis

San Diego Hydrology Manual (SDHM) created by Clear Creek Solutions was used to create a continuous hydrologic simulation for the Project. SDHM uses Hydrological Simulation Program FORTRAN (HSPF) as a platform for the hydrologic modeling. A number of HSPF variables are predefined in SDHM based on Clear Creek Solutions experience in modeling arid regions similar to San Diego County. User controlled variables in SDHM include local historic rainfall, local historic evapotranspiration rates, local soil properties, site slope characteristics, local vegetation properties, and predicted irrigation rates. A statistical analysis is completed within the program to determine occurrence intervals for Project runoff rates based on the user inputs. A comparison of existing and proposed conditions runoff rates is then completed to determine impacts from Project development on site discharges.

Given the preliminary nature of the Project, only on-site areas within the construction footprint were analyzed in SDHM. Drainage patterns were separated into the three major drainage basins, with each basins onsite areas being analyzed as one drainage area. This approach will provide a representative detention volume required for each major basin to meet the hydromodification requirements. Once planning progresses to a point where grading and drainage design information is available a more detailed study can be completed that will more precisely define the Project's detention needs.

Precipitation used in the SDHM model was based on one-hour rain gage information at the Morena Dam gauging station for events from October 2, 1959 to December 31, 2001. Historical evapotranspiration data was obtained from data collection at Lindbergh field. United States Geological Survey (USGS) soil maps for the area were used to determine soil properties. A Geographical Information System database was created for the drainage basins to characterize and quantify all physical features. Exhibits B1 through B6 present existing and proposed condition SDHM maps.

Based on the preliminary stage of planning and in an attempt to be conservative, proposed improvements were classified as either urban or impervious, with a majority defined as urban, since they are pervious but highly compacted; representative of graded pads and dirt roads. Collector lines were assumed to be urban as well to account for the compaction of soil resulting from construction equipment. All proposed development is defined as having similar slope to existing conditions based on the Project intent to closely match surrounding terrain, with the least amount of grading possible. Impervious areas are composed of the concrete pad foundations for the wind turbines. Pad foundations are beneath the ground surface, but in an attempt to be conservative; these pads were assumed impervious as they will limit the amount of deeper infiltration. Table 3 presents a summary of the existing and proposed land use areas used in SDHM for each of the three major drainage basins. Land use areas were also broken into soil type and slope categories, with a complete breakdown of areas presented in Appendix E within the preliminary hydromodification calculations.

Table 3: Existing and Proposed SDHM Land Use Type Summary.

Tule Creek Basin

Existing		Proposed	
Vegetation/Surface	Area (acres)	Vegetation/Surface	Area (acres)
Forest	0.25	Urban	37.13
Shrub	31.48	Impervious	0.24
Grass	4.80	**Total**	**37.37**
Urban	0.84		
Total	**37.37**		

Northern Unnamed Wash Basin

Existing		Proposed	
Vegetation/Surface	Area (acres)	Vegetation/Surface	Area (acres)
Forest	0.58	Urban	22.77
Shrub	9.59	Impervious	0.21
Grass	0.45	**Total**	**22.98**
Dirt	12.35		
Total	**22.98**		

Southern Unnamed Wash Basin

Existing		Proposed	
Vegetation/Surface	Area (acres)	Vegetation/Surface	Area (acres)
Shrub	6.98	Urban	6.93
Total	**6.98**	Impervious	0.05
		Total	**6.98**

All user inputs were entered into the SDHM program and a statistical comparison of the hydrologic performance of existing and proposed conditions was completed. SDHM has an automatic detention basin sizing function that determines an optimal basin size and outlet which will limit proposed flows to existing levels in accordance with the current requirements. Basins sized using this feature provides a good preliminary estimate of the detention volumes needed to meet the HMP requirements. A square basin with a trapezoidal cross section was assumed for this application.

3.3.2 Hydromodification Results

Initial SDHM modeling results indicated a measurable increase in runoff resulting from the increased compaction and decreased vegetation planned under proposed conditions. SDHM analysis of the three major drainage basins was completed to determine HMP volumes based on proposed development. Table 4 presents a summary of the basin detention analysis for the major drainage basins. Square basin lengths represent a square basin bottom with three horizontal to one vertical side slopes. See Appendix E for complete SDHM baseline HMP detention calculations.

Table 4: HMP Baseline Detention Basin Summary

Drainage Basin	Square Basin Length (ft)	Basin Depth (ft)	Max Flow Depth (ft)	Basin Volume (ft^3)
Tule Creek	129	9	7.9	183,000
Northern Unnamed Wash	81	9	7.9	88,000
Southern Unnamed Wash	45	8	6.8	29,000
			Total	**300,000**

Preliminary sizing calculations indicate that approximately 300,000 cubic feet of detention will be required to mitigate the impacts of the approximately 68-acre disturbed area.

3.3.3 Discussion of Results

Preliminary SDHM analysis was completed assuming only disturbed footprint areas and assumed three major drainage basins. Model results indicated that Project development will alter existing drainage patterns; requiring mitigation measures to meet the Region 9 interim hydromodification requirements. Preliminary SDHM results did not break down Project areas into the smaller local drainage basins since grading and ultimate site planning have not been completed. Once specifics from the site are established a more accurate model can be created which will account for the impacts from flow divisions of smaller local drainage basins. Required detention volumes could be reduced as pad grades, drainage patterns, and land uses are better defined. Given the topography of the site, it will be necessary to distribute hydromodification detention basins around the Project to properly capture and reduce the runoff rates and durations, rather than construct one large regional facility. For example, it is likely that each of the 12 turbine pads will each have a detention basin of some sort, and smaller detention basin/bioretention facilities will be scattered at low points along access roads.

Low Impact Development (LID) features are an alternative to hydromodification detention basins, when sized appropriately. LID features are easily applied in rural site plans due to the availability of surrounding open land to implement these features. It is likely that given the standard construction techniques for rural roads a number of these LID features will be implemented into the final project design. Once the final design of the Project is established a more refined hydrologic analysis of the proposed development can be completed to quantify the benefits of the LID features. A more in depth discussion of these LID features is completed in the next section of this report.

4.0 SITE DESIGN BMPS

Site design requirements outlined in the County of San Diego Storm Water Management Plan Form and discussed in Section 4.1 of the County of San Diego Standard SUSMP are presented below. Site design BMPs listed below are all those listed on the County of San Diego Storm Water Management Plan Form, however some may not apply given the limited amount of development proposed. Since the Project is in the preliminary stages of planning, site design BMPs could change as planning progresses.

Principle 1: Maintain Pre-Development Rainfall Runoff Characteristics

1. Locate the Project and road improvement alignments to avoid or minimize impacts to receiving waters or to increase the preservation of critical (or problematic) areas such as floodplains, steep slopes, wetlands, and areas with erosive or unstable soil conditions.
2. Minimize the Project impervious footprint.
3. Conserve natural areas.
4. Where landscape is proposed drain rooftops, impervious sidewalks, walkways, trails and patios into adjacent landscaping.
5. Design and locate roadway structures and bridges to reduce the amount of work in live streams and minimize the construction impacts.
6. Implement the following methods to minimize erosion from slopes:
    - Disturb existing slopes only when necessary;
    - Minimize cut and fill areas to reduce slope lengths;
    - Incorporate retaining walls to reduce steepness of slopes or to shorten slopes;
    - Provide benches or terraces on high cut and fill slopes to reduce concentration of flows;
    - Round and shape slopes to reduce concentrated flow;
    - Collect concentrated flows in stabilized drains and channels.

Project development will incorporate nearly all of the Principle 1 criteria. Access road development and improvements are sited to follow existing roads to the maximum extent practicable and typically follow ridgelines to limit the amount of grading and the amount of disturbed vegetated areas. Overall areas disturbed by the Project are kept to the minimum required for construction and operation of the facilities, and limit the amount of grading, crossings of drainages, and removal of vegetation. All improvements will drain to vegetated brow ditches/swales rather than a hardened storm drain system. There are no proposed large graded slopes that would require retaining walls or special shaping to prevent erosion, so criteria for these situations are not applicable.

Principle 2: Protect Slopes and Channels

1. Minimize disturbances to natural drainages.
2. Convey runoff safely from the tops of slopes
3. Vegetate slopes with native or drought tolerant vegetation.
4. Stabilize permanent channel crossings.
5. Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
6. Other design principles which are comparable and equally effective.

Preliminary planning for the Project has not identified specific slope and channel protection measures, but Principle 2 criteria will be implemented. Project planning will limit the number of unnecessary drainage crossings, but will include engineered crossings at locations where crossings are required. All drainage crossing will be completed such that San Diego County Drainage Design Manual criteria are met, including outfall energy dissipation design guidelines. Any slope grading will be completed such that direction and impacts of runoff are carefully controlled with brow ditches, grading methods, or other similar alternatives.

4.1 LOW IMPACT DEVELOPMENT FEATURES

LID features requirements are identified in the Major SWMP form and are discussed in further detail in the County LID Handbook. LID feature requirements reviewed for the Project are as follows:

1. Conserve natural areas, soils, and vegetation
    - Preserve well draining soils (Type A or B)
    - Preserve Significant Trees
2. Minimize disturbance to natural drainages
    - Set-back development envelope from drainages
    - Restrict heavy construction equipment access to planned green/open space areas
3. Minimize and disconnect impervious surfaces
    - Preserve well draining soils (Type A or B)
    - Preserver Significant Trees
4. Minimize soil compaction
    - Restrict heavy construction equipment access to planned green/open space areas
    - Re-till soils compacted by construction vehicles/equipment
    - Collect and reuse upper soil layers of development site containing organic materials
5. Drain runoff from impervious surfaces to pervious areas
    - Curb-cuts to landscaping
    - Rural swales
    - Concave median
    - Cul-de-sac landscaping design
6. LID parking lot design
    - Permeable pavements
    - Curb-cuts to landscaping
7. LID driveway, sidewalk, bike-path design
    - Permeable pavements
    - Pitch pavements toward landscaping
8. LID Building Design
    - Cisterns and rain barrels
    - Downspout to swale
    - Vegetated roofs
9. LID landscaping design
    - Soil amendments
    - Reuse of native soils
    - Smart irrigation systems

- Street trees

Project development proposes to utilize applicable LID features. Nearly all runoff generated by the Project site will discharge to surrounding naturally landscaped areas. This includes surrounding brow ditches or vegetated swales. Potential additional LID features considered are bioretention facilities and buffer strips. Disturbances to existing natural features will be limited during Project development by concentrating development on areas that have already been disturbed, typically existing roads. Soil compaction will be minimized by having well planned out access paths between the turbine sites, which will limit the disturbed areas impacted by the larger cranes required for turbine construction. Impervious areas will all drain to surrounding naturally vegetated areas. No impermeable parking lots, sidewalks, roads, or other impermeable access features are planned for the Project, as nearly all surface improvements will be gravel or compacted dirt. All landscaping will be completed to match the existing surrounding conditions and will be composed of similar slopes and drought tolerant native species of plants.

5.0 SOURCE CONTROL BMPS

Source control requirements outlined in the County of San Diego SUSMP, Section 4.2 are discussed below. Given the preliminary stage of Project development the following source control BMPs are recommended and will be updated during planning to better reflect utilized source control BMPs. Future site planning will be subject to standards in effect at the time of development.

Principle 3: Provide Storm Drain System Stenciling and Signage

1. All storm drain inlets and catch basins within the Project area shall have a stencil or tile placed with prohibitive language (such as: "NO DUMPING – I LIVE IN <<name receiving water>>") and/or graphical icons to discourage illegal dumping.
2. Signs and prohibitive language and/or graphical icons, which prohibit illegal dumping, must be posted at public access points along channels and creeks within the Project area.

Project development will not likely contain any storm drain inlets, however any inlets constructed will contain the standard stenciling and signage packages. All access roads to the turbines are intended to be private and as such will not provide public access points to the natural drainage systems.

Principle 4: Design Outdoors Material Storage Areas to Reduce Pollution Introduction

1. Hazardous materials with the potential to contaminate urban runoff shall either be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the stormwater conveyance system; or (2) protected by secondary containment structures such as berms, dikes, or curbs.
2. The storage area shall be paved and sufficiently impervious to contain leaks and spills
3. The storage area shall have a roof or awning to minimize direct precipitation within the secondary containment area.

Maintenance and operation buildings are to be constructed as part of the larger Tule Wind Project and will be located off County of San Diego privately owned lands. However, these facilities are intended to safely house any materials that could potentially pollute storm water in a dedicated indoor facility. All operation and maintenance materials will be located in these structures.

Principle 5: Design Trash Storage Areas to Reduce Pollution Introduction

1. Paved with an impervious surface, designed not to allow run-on from adjoining areas, screened or walled to prevent off-site transport of trash; and,
2. Provide attached lids on all trash containers that exclude rain, or roof or awning to minimize direct precipitation.

Similar to material storage, trash storage areas are intended to be regional and will be located at the proposed maintenance facilities. These buildings will be off County of San Diego privately owned lands but will utilize indoor trash storage or trash containers with covers to limit direct precipitation and runoff.

Principle 6: Use Efficient Irrigation Systems and Landscape Design

1. Employ rain shutoff devices to prevent irrigation after precipitation.
2. Design irrigation systems to each landscape area's specific water requirements.

3. Use flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
4. Employ other comparable, equally effective, methods to reduce irrigation water runoff.

Landscaping to be incorporated in Project design is likely to be similar to exiting vegetation and as such will not require any irrigation. However, any irrigation that would be required, either short term (for vegetation establishment) or permanent, would be constructed with rain shutoff devices, flow reducers, and specific design for water requirements.

6.0 INDIVIDUAL PRIORITY PROJECT BMPS

The County of San Diego SUSMP requires specific BMPs for private roads, residential driveways & guest parking, dock areas, maintenance areas, vehicle wash areas, equipment wash areas, outdoor processing areas, surface parking areas, fueling areas, or steep hillside landscaping. Preliminary site planning includes private roads, surface parking areas, and steep hillside landscaping. Applicable individual priority project BMP requirements are presented below with discussion of the utilized BMPs.

6.1 PRIVATE ROADS

The design of private roadway drainage requires at least one of the following;

- Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings;
- Urban curb/swale system: street slopes to curb, periodic swale inlets drain to vegetated swale/biofilter
- Dual drainage system: first flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to stormwater conveyance system.
- Other methods which are comparable and equally effective within the Project.

Current Project planning uses gravel or compacted dirt permeable roads with parallel swale/brow ditch drainage facilities. Precipitation will sheet flow off the private roads where it will be collected in the swale/brow ditch system. There are no hardened storm drains facilities planned for the proposed private roads at this time.

6.2 SURFACE PARKING AREAS

To minimize the offsite transport of pollutants from parking areas, the following design concepts shall be considered, and incorporated and implemented where determined applicable and feasible by the County;

- Where landscaping is proposed in surface parking areas, incorporate landscape areas into the drainage design; or
- Overflow parking (parking stalls provided in excess of the County's minimum parking requirements) may be constructed with permeable paving.
- Other design concepts which are comparable and equally effective.

Surface parking areas proposed for Project development are all small areas intended for accommodating only several vehicles at a time. Parking areas will be constructed of gravel or compacted dirt and will sheet flow to surrounding landscaping. There is no hardened storm drain features proposed for the Project at this time.

6.3 STEEP HILLSIDE LANDSCAPING

Hillside areas, as defined in the County of San Diego SUSMP, that are disturbed by Project development shall be landscaped with deep-rooted, drought tolerant plant species selected for erosion control, satisfactory to the County.

Hillside areas disturbed during Project development will be revegetated with drought tolerant native species to stabilize the new slopes. Vegetation will be selected based on its ability to provide erosion resistance to the slopes as well as survive the arid local climate.

7.0 TREATMENT CONTROL BMPS

7.1 STRUCTURAL TREATMENT CONTROL BMP SELECTION

Selection of treatment control BMPs is influenced by primary pollutants of concern, removal efficiencies, expected flows, and applicability to site design constraints. Treatment control BMP selection criteria from the County of San Diego SUSMP were used for BMP recommendations. Table 5 contains Table 4.2, Treatment Control Selection Matrix, from the County of San Diego SUSMP.

Table 5: Groups of Pollutants and Relative Effectiveness of Treatment Facilities

Pollutant of Concern	Bioretention Facilities (LID)	Settling Basins (Dry Ponds)	Wet Ponds and Wetlands	Infiltration Facilities or Practices (LID)	Media Filters	High-rate biofilters	High-rate media filters	Trash Rack & Hydro-dynamic Devices
Course Sediment and Trash	**High**	**High**	**High**	**High**	**High**	**High**	**High**	**High**
Pollutants that tend to associate with fine particles during treatment	**High**	**High**	**High**	**High**	**High**	**Medium**	**Medium**	**Low**
Pollutants that tend to be dissolved following treatment	Medium	Low	Medium	High	Low	Low	Low	Low

There are no primary pollutants of concern for the Project but in this case the County of San Diego SUSMP requires the Project to focus on the secondary pollutants of concern. Secondary pollutants of concern are trash and oil and grease; which represent course sediment and trash as well as pollutants that tend to associate with fine particles during treatment. Table 8 identifies bioretention facilities, settling basins, wet ponds, infiltration facilities, and media filters as having the highest removal rates for the pollutants of concern. High-rate biofilters and high-rate media filters are also considered, since they have medium removal effectiveness for oil and grease, which is a secondary pollutant of concern. Given the preliminary stage of planning all appropriate BMPs will be considered.

7.1.1 Discussion of Applicable Treatment Control BMPs

Treatment BMP design requirements reviewed for recommendation in the Project were the County of San Diego SUSMP and the California Stormwater Quality Association (CASQA) California Stormwater BMP Handbooks.

Based on the arid climate of the Project wet ponds or wetlands are not feasible. Wet ponds or wetlands depend on consistent standing water in the feature to create an environment that will remove pollutants of concern. Precipitation and or groundwater are not prevalent enough to sustain these features.

Project development does not propose to construct any storm drain collection systems other than surface features, and as such would be difficult to install media filter systems. Typically, media filters are used in applications with underground storm drain collection systems and allow for underground installations that maintain a somewhat developable surface. Any installation would require a large number of non standard inlet and outlet structures. Given the large amount of open space associated with the Project available it is likely that the selected treatment BMPs will be surface LID features.

Similar to media filters, high-flow media filters are typically located underground and require a substantial storm drain infrastructure to collect and convey the flows to regional facilities. Given the rural setting of the Project and the lack of infrastructure to support these devices, they are likely not applicable.

USGS maps indicate the presence of type A, B, C, and D soils throughout the Project. Based on this there is a potential for implementation of infiltration facilities throughout the Project depending on local soil properties. Infiltration has been shown to have high pollutant removal efficiencies, but requires site specific engineering based on soils reports and more detailed analysis of the sensitivity of groundwater to pollution. Infiltration would require bioretention or detention basins upstream to ensure pollutants removal to prevent infiltration into the groundwater. Due to only secondary pollutants of concern existing for the Project, and the requirement for upstream BMPs, infiltration is not likely to be used for Project stormwater treatment.

Bioretention would function similar to infiltration basins as no under drain system would be constructed to collect infiltrated storm water; however, an outfall would be created to release discharges downstream per standard bioretention design requirements. Bioretention typically works better in areas with well drained soils, but, applications have been completed with engineered media beneath the features. These features would be located and sized during final engineering, and could be easily implemented along the side of pads and roads as needed. Additional analysis during final engineering of bioretention would quantify the benefits for hydromodification detention requirements.

Settling basins are also a feasible option for Project development. These BMPs are detention basins that provide pollutants an opportunity to settle out of storm water before discharging downstream. Given the large amount of open space basins could easily be installed. However, settling basins are usually located at the downstream most end of a project and typically treat large portions of the project site with one feature. The multiple smaller drainage basins that make up this Project would create the need for a large number of settling basins. Settling basin volumes could also be incorporated into hydromodification detention basins, to be quantified during final design.

High-rate biofilters such as bioswales and buffer strips provide good opportunities for treatment of larger particles and the pollutants that are attached to them. These features could be incorporated well into swales/brow ditches around the graded areas and access roads. Bioswales and buffer strips would mimic existing conditions and would not require any substantial drainage structures or improvements.

Based on the location of the Project site, drainage patterns, site constraints, treatment efficiencies, maintenance concerns, the recommended treatment control devices for the Project are bioretention facilities, high-flow biofilters, and settling basins. Appendix F provides additional information on design, maintenance, and performance characteristics and requirements for the treatment control BMPs.

7.2 BMP SIZING CRITERIA

In accordance with the County of San Diego SUSMP Design of Treatment Control BMPs Standards bioretention facilities and setting basins were sized according to a volume based approach, using the 85th percentile storm for the area. High-flow biofilters are sized using a flow based approach, assuming a 0.2-inch event. Table 6 identifies the sizing criteria and the sizing requirements to treat the entire Project by each method. Preliminary sizing of treatment control BMPs assumes the following:

- Only onsite areas will be treated and are considered in sizing criteria
- A runoff coefficient of 0.46 is used assuming some loss of infiltration due to compaction of dirt roads and pads.
- All treatment areas and flows represent the values needed for treatment of the total Project site.

Table 6: Treatment Control BMP Sizing Criteria

Treatment Control BMP	BMP Sizing Criteria	BMP Required Size[1]	BMP Area/Flow Required for Total Site Treatment
Bioretention	Store the 85th percentile storm and release over max. 72-hours	Volume=CIA Volume=0.46*0.0625*68=1.96 acre-feet	1.96 acres[2]
Settling Basin	Store the 85th percentile storm and release over max. 72-hours	Volume=CIA Volume=0.46*0.0625*68=1.96 acre-feet	0.49 acres[3]
High-flow Biofilter	Treat flows generated by a 0.2-inch rainfall event	Q=CiA Q=0.46*0.2*68=6.3 cfs	6.3 cfs[4]

(1) Sizing criteria taken from County of San Diego Standard Urban Storm Water Mitigation Plan dated March 2008 and the CASQA California BMP Handbook.
(2) BMP area assumes a basin with 1-foot depth and vertical walls
(3) BMP area assumes a basin with 4-foot depth and vertical walls
(4) Represents flow rate to treat entire 78-acre Project site. In reality flow will be divided into smaller drainage basins.
I = Rainfall Intensity in feet per hour
i = Rainfall Intensity in inches per hour
A = Area in acres
Q = BMP treatment flow rate

BMP treatment areas and flows are intended to represent what would be required to treat the total disturbed areas of the Project site. Once final engineering is completed and more detailed drainage patterns have been defined, determination of the BMP locations and sizes can be completed. Access road construction and pad grading will likely include bioswales running parallel to the disturbed areas throughout the Project; which will function as treatment BMPs for runoff prior to discharging to existing natural drainages. Treatment BMPs will be scattered throughout the site and will likely be associated with the hydromodification detention requirements. Depending on the final drainage design for the Project, HMP detention volumes could be adequate to treat storm water runoff from the Project without application of additional BMPs. Exhibit C includes a BMP Map which defines potential locations for treatment BMPs as well as typical site design and source control BMPs. The BMP Map is only intended to be representative of potential BMP locations and is not intended to exclude additional locations of features.

Responsible parties for the capital costs associated with construction of the treatment control BMPs are presented in Table 7.

Table 7: Treatment Control BMP Capital Cost Responsible Party

Treatment Control BMP	Responsible Party
Bioretention	Iberdrola
Settling Basins	Iberdrola
High-flow Biofilters	Iberdrola

8.0 STORM WATER BMP MAINTENANCE

In accordance with Section 5.2 of the County of San Diego SUSMP the Project BMPs will be classified as First Category. BMPs will largely "maintain themselves" via the natural process of vegetation growth cycles. Biofiltration, high-flow biofilters, and settling basins will be vegetated with local naturally occurring plant types, which will be allowed to grow naturally in these facilities. Table 8 defines the anticipated BMP responsible parties.

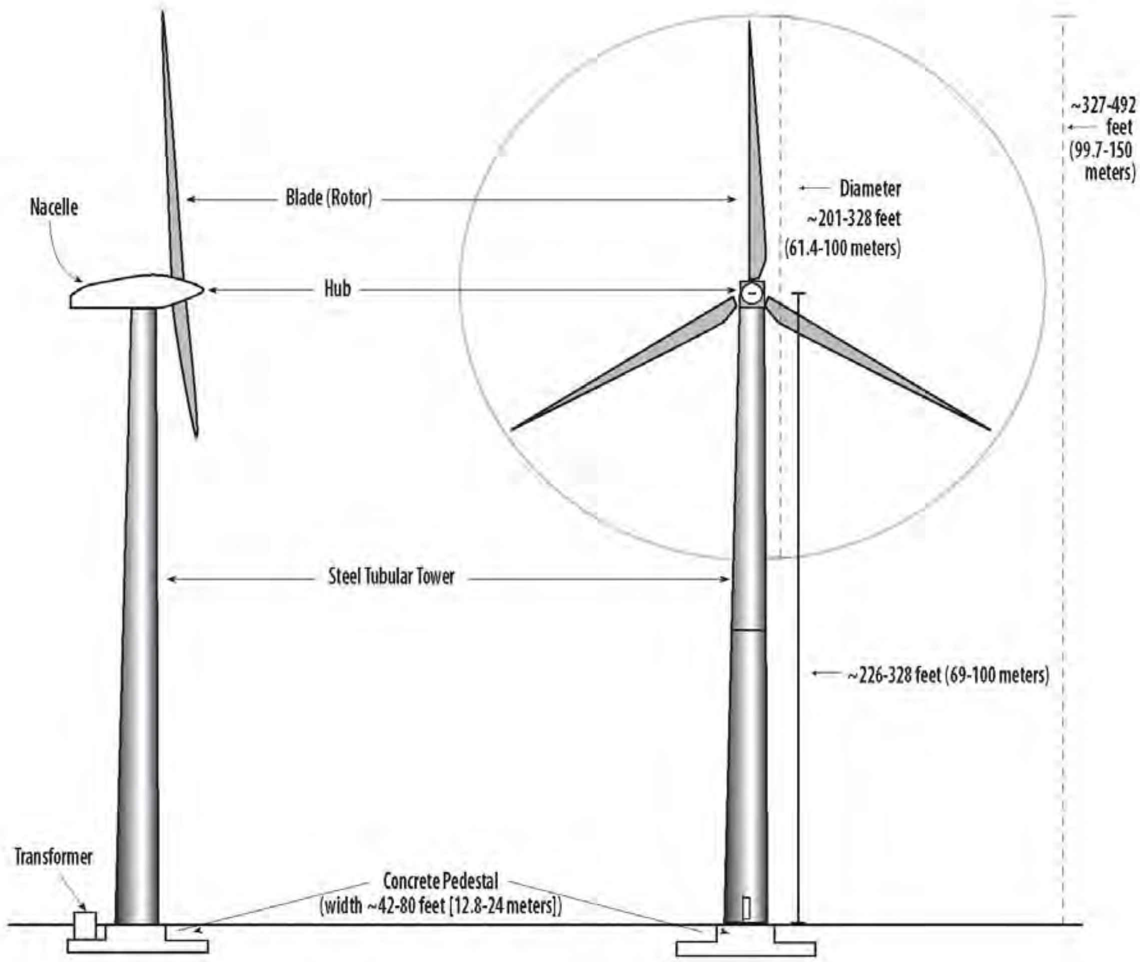
Table 8: BMP Maintenance Responsibility

Treatment Control BMP	Responsible Party
Bioretention	Iberdrola
Settling Basins	Iberdrola
High-flow Biofilters	Iberdrola

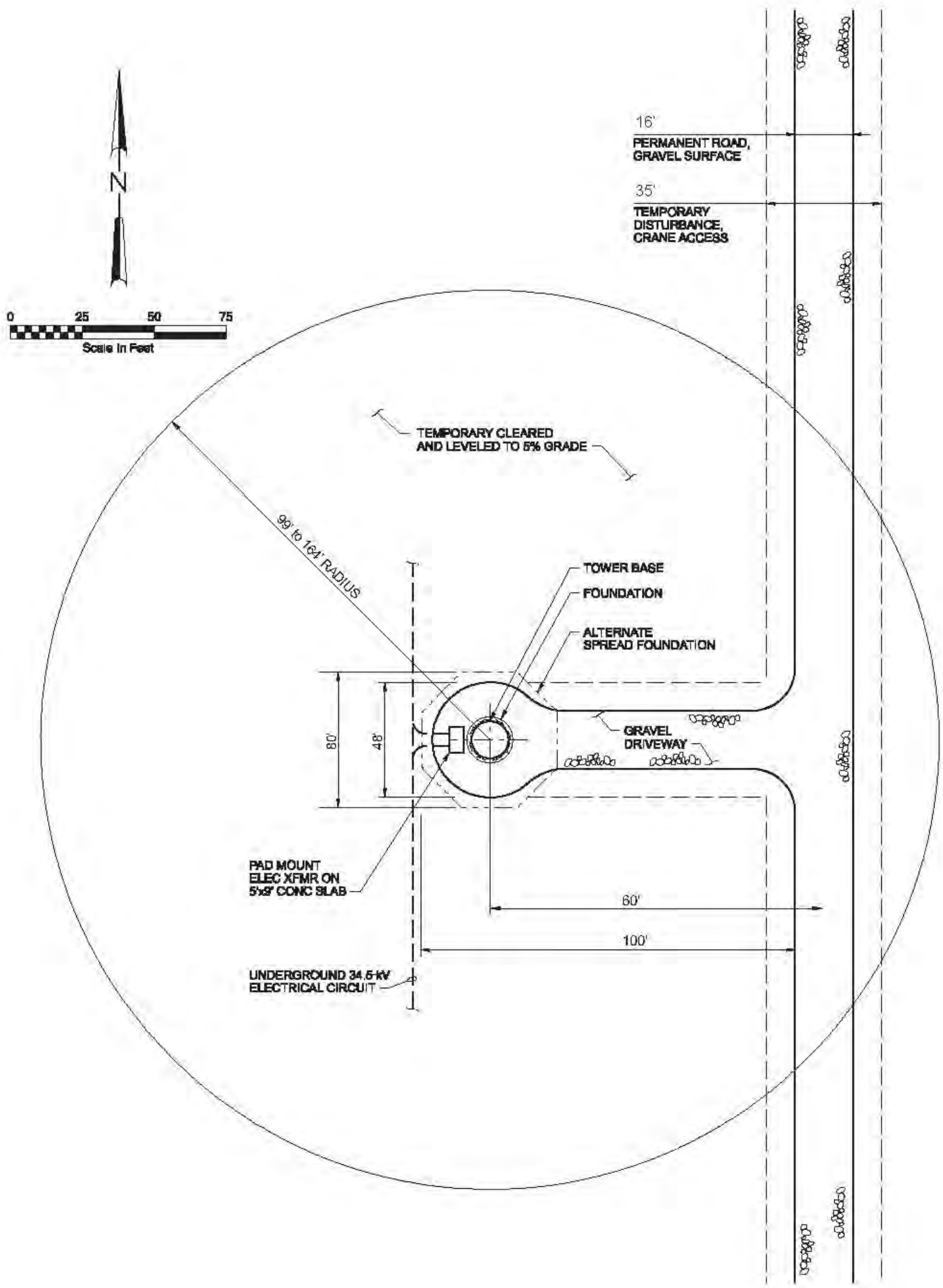
All operation and maintenance required by these BMPs will be the responsibility of Iberdrola. More specific operation and maintenance of the BMPs will be established during final Project design.

APPENDIX A – PRELIMINARY PROJECT DETAILS

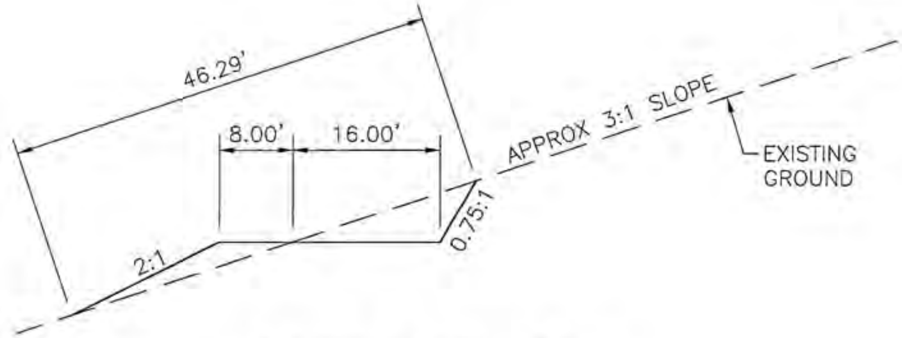
- Typical Turbine Schematic
- Typical Turbine Site
- Typical Access Road Sections



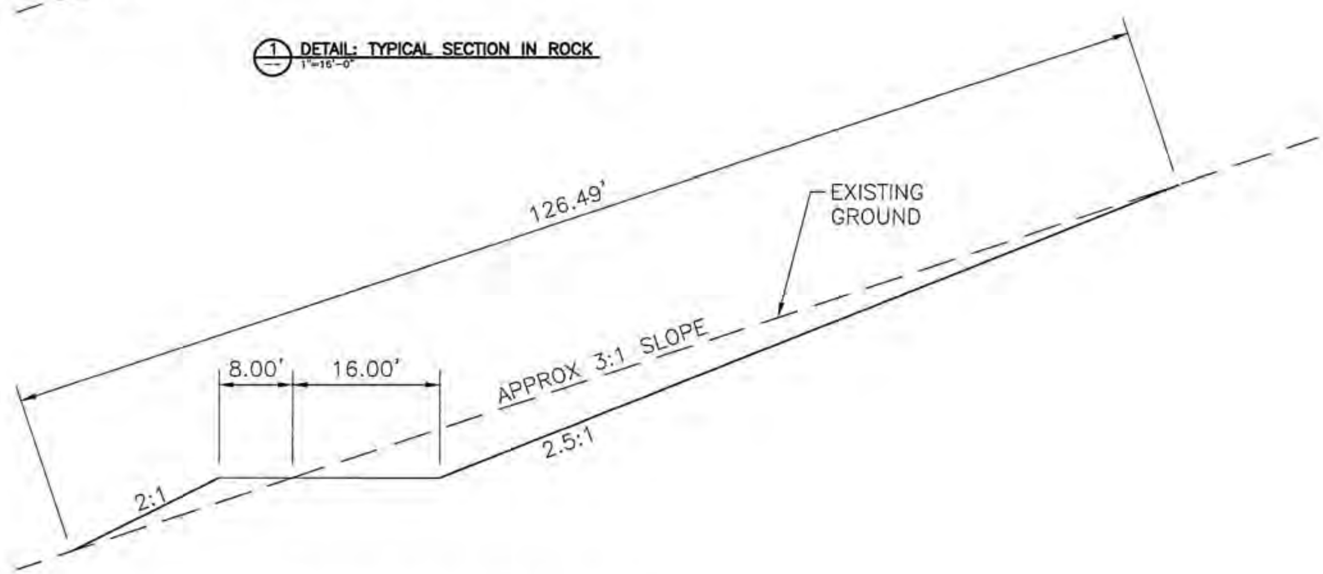
Turbine Schematic



Turbine Site

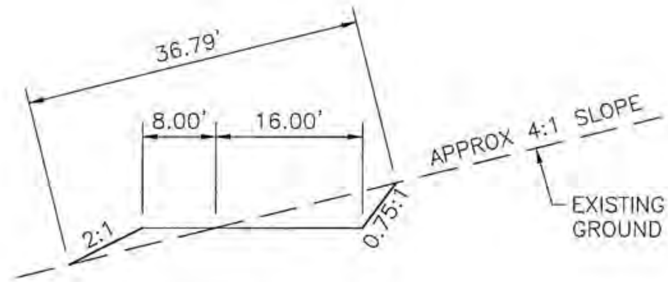


1 DETAIL: TYPICAL SECTION IN ROCK
1"=16'-0"

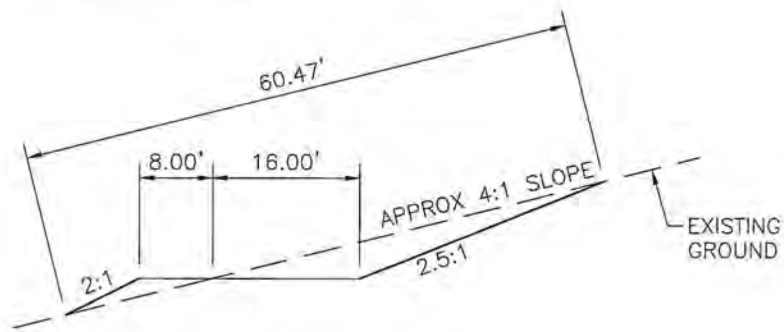


2 DETAIL: TYPICAL SECTION IN SOIL
1"=16'-0"

Typical Access Road Cross Sections



1 DETAIL: TYPICAL SECTION IN ROCK
1"=16'-0"



2 DETAIL: TYPICAL SECTION IN SOIL
1"=16'-0"

Typical Access Road Cross Sections

APPENDIX B – COUNTY OF SAN DIEGO STORMWATER INTAKE FORM FOR DEVELOPMENT PROJECTS

- County of San Diego Stormwater Intake Form for Development Projects

County of San Diego

STORMWATER INTAKE FORM FOR DEVELOPMENT PROJECTS

This form must be completed in its entirety and accompany applications for any of the discretionary or ministerial permits and approvals referenced in Sections 67.803(c)(1) and 67.803(c)(2) of the County of San Diego Watershed Protection, Stormwater Management and Discharge Control Ordinance (WPO).

STEP 1: IDENTIFY RELEVANT PROJECT INFORMATION

Applicant Name: Andrew Linehan		Contact Information: Jeffrey Durocher
Project Address: Multiple Properties	APN(s): See APN list	Permit Application #:

STEP 2: DETERMINE PRIORITY DEVELOPMENT PROJECT STATUS

WPO Section 67.802(w) defines the criteria for determining whether your project is considered a Priority Development Project (PDP). If you answer "Yes" to any of the questions below, your project is a PDP subject to review and approval of a Major Stormwater Management Plan (SWMP). If you answer "No" to all of the questions below, your project is subject to review and approval of a Minor SWMP.

1. Residential subdivision of 10 or more dwelling units (Single-family, Multi-family, Condo, or Apartment Complex) ...... Yes No

2. Commercial development that includes development of land area greater than one (1) acre .... Yes No

3. Industrial development greater than one (1) acre .... Yes No

4. Automotive repair shop .... Yes No

5. Restaurant or restaurant facilities with an area of development of 5,000 square feet or greater .... Yes No

6. On a steep hillside (>25% natural slope) <u>AND</u> proposes 5,000 square feet of impervious surface or more, or includes grading of any natural slope >25% [(1)] *.. Yes No*

7. Located within 200 feet of an Environmentally Sensitive Area <u>AND</u> creates 2,500 square feet or more of impervious surface or increases the area of imperviousness of a site to more than 10% of its naturally occurring condition [(1)] [(2)] *...... Yes No*

8. A parking lot that is 5,000 square feet or greater <u>OR</u> proposes at least 15 new parking stalls .... Yes No

9. Streets or roads that create a new paved surface that is 5,000 square feet or greater.. Yes No

10. Retail gasoline outlet.. Yes No

[(1)] In lieu of a Major SWMP, Ministerial Permit Applications for residential dwellings/additions on an existing legal lot answering "Yes" may be able to utilize the Minor Stormwater Management Plan upon approval of a county official. Please note that upon further analysis, staff may determine that a Major SWMP will be required.
[(2)] A County technician will assist you in determining whether your project is located within 200 feet of an Environmentally Sensitive Area.

STOP **If you answered "Yes" to any of the questions, please complete a Major SWMP for your project.**
Instructions and an example of the form can be downloaded from http://www.co.san-diego.ca.us/dpw/watersheds/land_dev/susmp.html

If you answered "NO" to all of the questions above, please complete a Minor SWMP for your project.
Instructions and an example of the form can be downloaded from http://www.sdcounty.ca.gov/dplu/docs/LUEG-SW.pdf

STEP 3: SIGN AND DATE THE CERTIFICATION

<u>APPLICANT CERTIFICATION</u>: I have read and understand that the County of San Diego has adopted minimum requirements for managing urban runoff, including stormwater, from construction and land development activities. I certify that this intake form has been completed to the best of my ability and accurately reflects the project being proposed. I also understand that non-compliance with the County's WPO and Grading Ordinance may result in enforcement by the County, including fines, cease and desist orders, or other actions.

Applicant : *Date:*

APPENDIX C – COUNTY OF SAN DIEGO STORM WATER MANAGEMENT PLAN FOR PRIORITY PROJECTS (MAJOR SWMP) FORM

- County of San Diego Major SWMP Form

Storm Water Management Plan
For Priority Projects
(Major SWMP)

The Major Stormwater Management Plan (Major SWMP) must be completed in its entirety and accompany applications to the County for a permit or approval associated with certain types of development projects. To determine whether your project is required to submit a Major or Minor SWMP, please reference the County's Stormwater Intake Form for Development Projects.

Project Name:	Tule Wind Project
Permit Number (Land Development Projects):	
Work Authorization Number (**CIP only**):	
Applicant:	Iberdrola Renewables, Inc.
Applicant's Address:	San Marcos, CA
Plan Prepare By (*Leave blank if same as applicant*):	HDR Engineering San Diego, CA
Date:	September, 2009
Revision Date (If applicable):	

The County of San Diego Watershed Protection, Storm Water Management, and Discharge Control Ordinance (WPO) (Ordinance No. 9926) requires all applications for a permit or approval associated with a Land Disturbance Activity to be accompanied by a Storm Water Management Plan (SWMP) (section 67.806.b). The purpose of the SWMP is to describe how the project will minimize the short and long-term impacts on receiving water quality. Projects that meet the criteria for a priority development project are required to prepare a Major SWMP.

Since the SWMP is a living document, revisions may be necessary during various stages of approval by the County. Please provide the approval information requested below.

Project Stages	Does the SWMP need revisions?		If YES, Provide Revision Date
	YES	NO	

Instructions for a Major SWMP can be downloaded at
http://www.sdcounty.ca.gov/dpw/watersheds/susmp/susmp.html

Completion of the following checklists and attachments will fulfill the requirements of a Major SWMP for the project listed above.

PROJECT DESCRIPTION

Please provide a brief description of the project in the following box. Please include:

- Project Location
- Project Description
- Physical Features (Topography)
- Surrounding Land Use
- Proposed Project Land Use
- Location of dry weather flows (year-round flows in streams, or creeks) within project limits, if applicable.

The Tule Wind Project is a large project that proposed to develop a wind turbine "farm," for power generation, in the County of San Diego in the State of California. Portions of the project discussed in this report are limited to areas within private properties within the County of San Diego. A majority of the overall project will be developed on Bureau of Land Management (BLM) Federal land, outside the County of San Diego Planning Department jurisdiction. Project development proposed on County of San Diego regulated lands will disturb approximately 68 acres and is located just north of Interstate 8 off Ribbonwood Road, approximately two and half miles northeast of the community of Boulevard, California. Given the rural nature of the Project area, only the western side of the site is bounded by a physical feature, Ribbonwood Road.

PRIORITY DEVELOPMENT PROJECT DETERMINATION

Please check the box that best describes the project. Does the project meet one of the following criteria?

Table 1

PRIORITY DEVELOPMENT PROJECT	YES	NO
Redevelopment that creates, adds or replaces at least 5,000 square feet of impervious surface area <u>and</u> falls under one of the criteria listed below.	X	
Residential development of more than 10 units.		X
Commercial developments with a land area for development of greater than 1 acre.		X
Heavy industrial development with a land area for development of greater than 1 acre.		X
Automotive repair shop(s).		X
Restaurants, where the land area for development is greater than 5,000 square feet.		X
Hillside development, in an area with known erosive soil conditions, where there will be grading on any natural slope that is twenty-five percent or greater, if the development creates 5,000 square feet or more of impervious surface.	X	
Environmentally Sensitive Areas (ESA): All development located within or directly adjacent to or discharging directly to an ESA (where discharges from the development or redevelopment will enter receiving waters within the ESA), which either creates 2,500 square feet of impervious surface on a proposed project site or increases the area of imperviousness of a proposed project site to 10% or more of its naturally occurring condition. "Directly adjacent" means situated within 200 feet of the ESA. "Discharging directly to" means outflow from a drainage conveyance system that is composed entirely of flows from the subject development or redevelopment site, and not commingled with flows from adjacent lands.		X
Parking Lots 5,000 square feet or more or with 15 parking spaces or more and potentially exposed to urban runoff.		X
Streets, roads, highways, and freeways which would create a new paved surface that is 5,000 square feet or greater.		X
Retail Gasoline Outlets (RGO) that meet the following criteria: (a) 5,000 square feet or more or (b) a projected Average Daily Traffic (ADT) of 100 or more vehicles per day.		X

Limited Exclusion: Trenching and resurfacing work associated with utility projects are not considered Priority Development Projects. Parking lots, buildings and other structures associated with utility projects are subject to the WPO requirements if one or more of the criteria above are met.

If you answered **NO** to all the questions, then **STOP**. Please complete a Minor SWMP for your project.
If you answered **YES** to any of the questions, please continue.

HYDROMODIFICATION DETERMINATION

The following questions provide a guide to collecting information relevant to hydromodification management issues.

Table 2

	QUESTIONS	YES	NO	Information
1.	Will the proposed project disturb 50 or more acres of land? (Including all phases of development)	X		If YES, continue to 2. If NO, go to 6.
2.	Would the project site discharge directly into channels that are concrete-lined or significantly hardened such as with rip-rap, sackcrete, etc, downstream to their outfall into bays or the ocean?		X	If NO, continue to 3. If YES, go to 6.
3.	Would the project site discharge directly into underground storm drains discharging directly to bays or the ocean?		X	If NO, continue to 4. If YES, go to 6.
4.	Would the project site discharge directly to a channel (lined or un-lined) and the combined impervious surfaces downstream from the project site to discharge at the ocean or bay are 70% or greater?		X	If NO, continue to 5. If YES, go to 6.
5.	Project is required to manage hydromodification impacts.	X		Hydromodification Management Required as described in Section 67.812 b(4) of the WPO.
6.	Project is not required to manage hydromodification impacts.			Hydromodification Exempt. Keep on file.

An exemption is potentially available for projects that are required (No. 5. in Table 2 above) to manage hydromodification impacts: The project proponent may conduct an independent geomorphic study to determine the project's full hydromodification impact. The study must incorporate sediment transport modeling across the range of geomorphically-significant flows and demonstrate to the County's satisfaction that the project flows and sediment reductions will not detrimentally affect the receiving water to qualify for the exemption.

STORMWATER QUALITY DETERMINATION

The following questions provide a guide to collecting information relevant to project stormwater quality issues. Please provide the following information in a printed report accompanying this form.

Table 3

	QUESTIONS	COMPLETED	NA
1.	Describe the topography of the project area.	X	
2.	Describe the local land use within the project area and adjacent areas.	X	
3.	Evaluate the presence of dry weather flow.	X	
4.	Determine the receiving waters that may be affected by the project throughout all phases of development through completion (i.e., construction, long-term maintenance and operation).	X	
5.	For the project limits, list the 303(d) impaired receiving water bodies and their constituents of concern.	X	
6.	Determine if there are any High Risk Areas (which is defined by the presence of municipal or domestic water supply reservoirs or groundwater percolation facilities) within the project limits.	X	
7.	Determine the Regional Board special requirements, including TMDLs, effluent limits, etc.	X	
8.	Determine the general climate of the project area. Identify annual rainfall and rainfall intensity curves.	X	
9.	Determine the soil classification, permeability, erodibility, and depth to groundwater for Treatment BMP consideration.		X
10.	Determine contaminated or hazardous soils within the project area.	X	
11.	Determine if this project is within the environmentally sensitive areas as defined on the maps in Appendix A of the *County of San Diego Standard Urban Storm Water Mitigation Plan for Land Development and Public Improvement Projects.*	X	
12.	Determine if this is an emergency project.	X	

WATERSHED

Please check the watershed(s) for the project.

☐ San Juan 901	☐ Santa Margarita 902	☐ San Luis Rey 903	☐ Carlsbad 904
☐ San Dieguito 905	☐ Penasquitos 906	☐ San Diego 907	☐ Sweetwater 909
☐ Otay 910	☐ Tijuana 911	☐ Whitewater 719	☐ Clark 720
☐ West Salton 721	X Anza Borrego 722	☐ Imperial 723	

Please provide the hydrologic sub-area and number(s)

Number	Name
722.71	Jacumba hydrologic sub area

Please provide the beneficial uses for Inland Surface Waters and Ground Waters. Beneficial Uses can be obtained from the Water Quality Control Plan for the San Diego Basin, which is available at the Regional Board office or at
http://www.waterboards.ca.gov/sandiego/water_issues/programs/basin_plan/index.shtml

SURFACE WATERS	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRESH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Inland Surface Waters																
Tule Creek	722.71	O	X			X			X	X		X		X		
Carrizo Creek	722.71		X			X			X	X		X		X	X	
Ground Waters																
Anza-Borrego	722.00	X	X	X												

*** Excepted from Municipal**

X Existing Beneficial Use
0 Potential Beneficial Use

POLLUTANTS OF CONCERN

Using Table 4, identify pollutants that are anticipated to be generated from the proposed priority project categories. Pollutants associated with any hazardous material sites that have been remediated or are not threatened by the proposed project are not considered a pollutant of concern.

Table 4. Anticipated and Potential Pollutants Generated by Land Use Type

	General Pollutant Categories								
PDP Categories	Sediments	Nutrients	Heavy Metals	Organic Compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticides
Detached Residential Development	X	X			X	X	X	X	X
Attached Residential Development	X	X			X	P(1)	P(2)	P	X
Commercial Development 1 acre or greater	P(1)	P(1)		P(2)	X	P(5)	X	P(3)	P(5)
Heavy industry /industrial development	X		X	X	X	X	X		
Automotive Repair Shops			X	X(4)(5)	X		X		
Restaurants					X	X	X	X	
Hillside Development >5,000 ft^2	X	X			X	X	X		X
Parking Lots	P(1)	P(1)	X		X	P(1)	X		P(1)
Retail Gasoline Outlets			X	X	X	X	X		
Streets, Highways & Freeways	X	P(1)	X	X(4)	X	P(5)	X		

X = anticipated
P = potential
(1) A potential pollutant if landscaping exists on-site.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves food or animal waste products.
(4) Including petroleum hydrocarbons.
(5) Including solvents.

Note: If other monitoring data that is relevant to the project is available. Please include as Attachment C.

CONSTRUCTION BMPs

Please check the construction BMPs that may be implemented during construction of the project. The applicant will be responsible for the placement and maintenance of the BMPs incorporated into the final project design.

- ☒ Silt Fence
- ☒ Fiber Rolls
- ☐ Street Sweeping and Vacuuming
- ☐ Storm Drain Inlet Protection
- ☒ Stockpile Management
- ☒ Solid Waste Management
- ☒ Stabilized Construction Entrance/Exit
- ☐ Dewatering Operations
- ☒ Desilting Basin
- ☒ Gravel Bag Berm
- ☒ Sandbag Barrier
- ☒ Material Delivery and Storage
- ☒ Spill Prevention and Control
- ☒ Concrete Waste Management
- ☒ Water Conservation Practices
- ☐ Paving and Grinding Operations
- ☒ Vehicle and Equipment Maintenance
- ☒ Any minor slopes created incidental to construction and not subject to a major or minor grading permit shall be protected by covering with plastic or tarp prior to a rain event, and shall have vegetative cover reestablished within 180 days of completion of the slope and prior to final building approval.

EXCEPTIONAL THREAT TO WATER QUALITY DETERMINATION

Complete the checklist below to determine if a proposed project will pose an "exceptional threat to water quality," and therefore require Advanced Treatment Best Management Practices.

Table 5

No.	CRITERIA	YES	NO	INFORMATION
1.	Is all or part of the proposed project site within 200 feet of waters named on the Clean Water Act (CWA) Section 303(d) list of Water Quality Limited Segments as impaired for sedimentation and/or turbidity? Current 303d list may be obtained from the following site: http://www.swrcb.ca.gov/tmdl/docs/303dlists2006/approved/r9_06_303d_reqtmdls.pdf		X	If YES, continue to 2. If NO, go to 5.
2.	Will the project disturb more than 5 acres, including all phases of the development?			If YES, continue to 3. If NO, go to 5.
3.	Will the project disturb slopes that are steeper than 4:1 (horizontal: vertical) with at least 10 feet of relief, and that drain toward the 303(d) listed receiving water for sedimentation and/or turbidity?			If YES, continue to 4. If NO, go to 5.
4.	Will the project disturb soils with a predominance of USDA-NRCS Erosion factors k_f greater than or equal to 0.4?			If YES, continue to 6. If NO, go to 5.
5.	Project is not required to use Advanced Treatment BMPs.			Document for Project Files by referencing this checklist.
6.	Project poses an "exceptional threat to water quality" and is required to use Advanced Treatment BMPs.			Advanced Treatment BMPs must be consistent with WPO section 67.811(b)(20)(D) performance criteria

Exemption potentially available for projects that require advanced treatment:
Project proponent may perform a Revised Universal Soil Loss Equation, Version 2 (RUSLE 2), Modified Universal Soil Loss Equation (MUSLE), or similar analysis that shows to the County official's satisfaction that advanced treatment is not required

Now that the need for treatment BMPs has been determined, other information is needed to complete the SWMP.

SITE DESIGN

To minimize stormwater impacts, site design measures must be addressed. The following checklist provides options for avoiding or reducing potential impacts during project planning. If YES is checked, it is assumed that the measure was used for this project.

Table 6

	OPTIONS		YES	NO	N/A
1.	Has the project been located and road improvements aligned to avoid or minimize impacts to receiving waters or to increase the preservation of critical (or problematic) areas such as floodplains, steep slopes, wetlands, and areas with erosive or unstable soil conditions?		X		
2.	Is the project designed to minimize impervious footprint?		X		
3.	Is the project conserving natural areas where feasible?		X		
4.	Where landscape is proposed, are rooftops, impervious sidewalks, walkways, trails and patios be drained into adjacent landscaping?				X
5.	For roadway projects, are structures and bridges be designed or located to reduce work in live streams and minimize construction impacts?		X		
6.	Can any of the following methods be utilized to minimize erosion from slopes:				
	6.a.	Disturbing existing slopes only when necessary?	X		
	6.b.	Minimize cut and fill areas to reduce slope lengths?	X		
	6.c.	Incorporating retaining walls to reduce steepness of slopes or to shorten slopes?			X
	6.d.	Providing benches or terraces on high cut and fill slopes to reduce concentration of flows?			X
	6.e.	Rounding and shaping slopes to reduce concentrated flow?	X		
	6.f.	Collecting concentrated flows in stabilized drains and channels?	X		

LOW IMPACT DEVELOPMENT (LID)

Each numbered item below is a LID requirement of the WPO. Please check the box(s) under each number that best describes the Low Impact Development BMP(s) selected for this project.

Table 7

1. Conserve natural Areas, Soils, and Vegetation-County LID Handbook 2.2.1
☒ Preserve well draining soils (Type A or B)
☐ Preserve Significant Trees
☐ Other. Description:
☐ 1. Not feasible. State Reason:
2. Minimize Disturbance to Natural Drainages-County LID Handbook 2.2.2
☐ Set-back development envelope from drainages
X Restrict heavy construction equipment access to planned green/open space areas
☐ Other. Description:
☐ 2. Not feasible. State Reason:
3. Minimize and Disconnect Impervious Surfaces (see 5) -County LID Handbook 2.2.3
☒ Clustered Lot Design
☐ Items checked in 5?
☐ Other. Description:
☐ 3. Not feasible. State Reason:
4. Minimize Soil Compaction-County LID Handbook 2.2.4
X Restrict heavy construction equipment access to planned green/open space areas
☐ Re-till soils compacted by construction vehicles/equipment
Collect & re-use upper soil layers of development site containing organic materials
☐ Other. Description:
4. Not feasible. State Reason:
5. Drain Runoff from Impervious Surfaces to Pervious Areas-County LID Handbook 2.2.5

LID Street & Road Design
☐ Curb-cuts to landscaping
☒ Rural Swales
☐ Concave Median
☐ Cul-de-sac Landscaping Design
☐ Other. Description:
LID Parking Lot Design
☐ Permeable Pavements
☐ Curb-cuts to landscaping
☐ Other. Description:
LID Driveway, Sidewalk, Bike-path Design
☐ Permeable Pavements
☐ Pitch pavements toward landscaping
☐ Other. Description:
LID Building Design
☐ Cisterns & Rain Barrels
☐ Downspout to swale
☐ Vegetated Roofs
☐ Other. Description:
LID Landscaping Design
☐ Soil Amendments
☐ Reuse of Native Soils
☐ Smart Irrigation Systems
☐ Street Trees
☐ Other. Description:
☐ 5. Not feasible. State Reason:

CHANNELS & DRAINAGES

Complete the following checklist to determine if the project includes work in channels.

Table 8

No.	CRITERIA	YES	NO	N/A	COMMENTS
1.	Will the project include work in channels?	X			If YES go to 2 If NO go to 13.
2.	Will the project increase velocity or volume of downstream flow?		X		If YES go to 6.
3.	Will the project discharge to unlined channels?	X			If YES go to. 6.
4.	Will the project increase potential sediment load of downstream flow?	X			If YES go to 6.
5.	Will the project encroach, cross, realign, or cause other hydraulic changes to a stream that may affect downstream channel stability?	X			If YES go to 8.
6.	Review channel lining materials and design for stream bank erosion.			X	Continue to 7.
7.	Consider channel erosion control measures within the project limits as well as downstream. Consider scour velocity.	X			Continue to 8.
8.	Include, where appropriate, energy dissipation devices at culverts.	X			Continue to 9.
9.	Ensure all transitions between culvert outlets/headwalls/wingwalls and channels are smooth to reduce turbulence and scour.	X			Continue to 10.
10.	Include, if appropriate, detention facilities to reduce peak discharges.	X			Continue to 11.
11.	“Hardening“ natural downstream areas to prevent erosion is not an acceptable technique for protecting channel slopes, unless pre-development conditions are determined to be so erosive that hardening would be required even in the absence of the proposed development.			X	Continue to 12.
12.	Provide other design principles that are comparable and equally effective.			X	Continue to 13.
13.	End				

SOURCE CONTROL

Please complete the following checklist for Source Control BMPs. If the BMP is not applicable for this project, then check N/A only at the main category.

Table 9

	BMP		YES	NO	N/A
1.	**Provide Storm Drain System Stenciling and Signage**				
	1.a.	All storm drain inlets and catch basins within the project area shall have a stencil or tile placed with prohibitive language (such as: “NO DUMPING – DRAINS TO ________”) and/or graphical icons to discourage illegal dumping.			X
	1.b.	Signs and prohibitive language and/or graphical icons, which prohibit illegal dumping, must be posted at public access points along channels and creeks within the project area.			X
2.	**Design Outdoors Material Storage Areas to Reduce Pollution Introduction**				
	2.a.	This is a detached single-family residential project. Therefore, personal storage areas are exempt from this requirement.			X
	2.b.	Hazardous materials with the potential to contaminate urban runoff shall either be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the storm water conveyance system; or (2) protected by secondary containment structures such as berms, dikes, or curbs.			X
	2.c.	The storage area shall be paved and sufficiently impervious to contain leaks and spills.			X
	2.d.	The storage area shall have a roof or awning to minimize direct precipitation within the secondary containment area.			X
3.	**Design Trash Storage Areas to Reduce Pollution Introduction**				
	3.a.	Paved with an impervious surface, designed not to allow run-on from adjoining areas, screened or walled to prevent off-site transport of trash; or,			X
	3.b.	Provide attached lids on all trash containers that exclude rain, or roof or awning to minimize direct precipitation.			X
4.	**Use Efficient Irrigation Systems & Landscape Design**				
	The following methods to reduce excessive irrigation runoff shall be considered, and incorporated and implemented where determined applicable and feasible.				X
	4.a.	Employing rain shutoff devices to prevent irrigation after precipitation.			X
	4.b.	Designing irrigation systems to each landscape area’s specific water requirements.			X
	4.c.	Using flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.			X
	4.d.	Employing other comparable, equally effective, methods to reduce irrigation water runoff.			X
5.	**Private Roads**				

BMP			YES	NO	N/A
	The design of private roadway drainage shall use at least one of the following				
	5.a.	Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings.	X		
	5.b.	Urban curb/swale system: street slopes to curb, periodic swale inlets drain to vegetated swale/biofilter.		X	
	5.c.	Dual drainage system: First flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to storm water conveyance system.		X	
	5.d.	Other methods that are comparable and equally effective within the project.		X	
6.	**Residential Driveways & Guest Parking**				
	The design of driveways and private residential parking areas shall use one at least of the following features.				
	6.a.	Design driveways with shared access, flared (single lane at street) or wheelstrips (paving only under tires); or, drain into landscaping prior to discharging to the storm water conveyance system.			X
	6.b.	Uncovered temporary or guest parking on private residential lots may be: paved with a permeable surface; or, designed to drain into landscaping prior to discharging to the storm water conveyance system.			X
	6.c.	Other features which are comparable and equally effective.			X
7.	**Dock Areas**				
	Loading/unloading dock areas shall include the following.				
	7.a.	Cover loading dock areas, or design drainage to preclude urban run-on and runoff.			X
	7.b.	Direct connections to storm drains from depressed loading docks (truck wells) are prohibited.			X
	7.c.	Other features which are comparable and equally effective.			X
8.	**Maintenance Bays**				
	Maintenance bays shall include the following.				
	8.a.	Repair/maintenance bays shall be indoors; or, designed to preclude urban run-on and runoff.			X
	8.b.	Design a repair/maintenance bay drainage system to capture all wash water, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.			X
	8.c.	Other features which are comparable and equally effective.			X
9.	**Vehicle Wash Areas**				
	Priority projects that include areas for washing/steam cleaning of vehicles shall use the following.				
	9.a.	Self-contained; or covered with a roof or overhang.			X
	9.b.	Equipped with a clarifier or other pretreatment facility.			X
	9.c.	Properly connected to a sanitary sewer.			X
	9.d.	Other features which are comparable and equally effective.			X

BMP			YES	NO	N/A
10.	**Outdoor Processing Areas**				
	Outdoor process equipment operations, such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, waste piles, and wastewater and solid waste treatment and disposal, and other operations determined to be a potential threat to water quality by the County shall adhere to the following requirements.				
	10.a.	Cover or enclose areas that would be the most significant source of pollutants; or, slope the area toward a dead-end sump; or, discharge to the sanitary sewer system following appropriate treatment in accordance with conditions established by the applicable sewer agency.			X
	10.b.	Grade or berm area to prevent run-on from surrounding areas.			X
	10.c.	Installation of storm drains in areas of equipment repair is prohibited.			X
	10.d.	Other features which are comparable or equally effective.			X
11.	**Equipment Wash Areas**				
	Outdoor equipment/accessory washing and steam cleaning activities shall be.				
	11.a.	Be self-contained; or covered with a roof or overhang.			X
	11.b.	Be equipped with a clarifier, grease trap or other pretreatment facility, as appropriate			X
	11.c.	Be properly connected to a sanitary sewer.			X
	11.d.	Other features which are comparable or equally effective.			X
12.	**Parking Areas**				
	The following design concepts shall be considered, and incorporated and implemented where determined applicable and feasible by the County.				
	12.a.	Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design.	X		
	12.b.	Overflow parking (parking stalls provided in excess of the County's minimum parking requirements) may be constructed with permeable paving.			X
	12.c.	Other design concepts that are comparable and equally effective.			X
13.	**Fueling Area**				
	Non-retail fuel dispensing areas shall contain the following.				
	13.a.	Overhanging roof structure or canopy. The cover's minimum dimensions must be equal to or greater than the area within the grade break. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. The fueling area shall drain to the project's treatment control BMP(s) prior to discharging to the storm water conveyance system.			X
	13.b.	Paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete shall be prohibited.			X
	13.c.	Have an appropriate slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of urban runoff.			X

BMP			YES	NO	N/A
	13.d.	At a minimum, the concrete fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.			X

Please list other project specific Source Control BMPs in the following box. Write **N/A** if there are none.

There will be regional maintenance facilities constructed to store any material needed for operation and maintenance of the wind farm facilities. All operation and maintenance activities associated with the Project will be staged at these locations. All of these facilities are located outside of County of San Diego jurisdiction.

TREATMENT CONTROL

To select a structural treatment BMP using Treatment Control BMP Selection Matrix (Table 10), each priority project shall compare the list of pollutants for which the downstream receiving waters are impaired (if any), with the pollutants anticipated to be generated by the project (as identified in Table 4). Any pollutants identified by Table 4, which are also causing a Clean Water Act section 303(d) impairment of the receiving waters of the project, shall be considered primary pollutants of concern. Priority projects that are anticipated to generate a primary pollutant of concern shall select a single or combination of stormwater BMPs from Table 10, which **maximizes pollutant removal** for the particular primary pollutant(s) of concern.

Priority development projects that are **not** anticipated to generate a pollutant for which the receiving water is CWA 303(d) impaired shall select a single or combination of stormwater BMPs from Table 10, which are effective for pollutant removal of the identified secondary pollutants of concern, consistent with the "maximum extent practicable" standard.

Table 10. Treatment Control BMP Selection Matrix

Pollutants of Concern	Bioretention Facilities (LID)*	Settling Basins (Dry Ponds)	Wet Ponds and Wetlands	Infiltration Facilities or Practices (LID)*	Media Filters	High-rate biofilters	High-rate media filters	Trash Racks & Hydro -dynamic Devices
Coarse Sediment and Trash	High	High	High	High	High	High	High	High
Pollutants that tend to associate with fine particles during treatment	High	High	High	High	High	Medium	Medium	Low
Pollutants that tend to be dissolved following treatment	Medium	Low	Medium	High	Low	Low	Low	Low

*Additional information is available in the County of San Diego LID Handbook.

NOTES ON POLLUTANTS OF CONCERN:
In Table 11, Pollutants of Concern are grouped as gross pollutants, pollutants that tend to associate with fine particles, and pollutants that remain dissolved.

Table 11

Pollutant	Coarse Sediment and Trash	Pollutants that tend to associate with fine particles during treatment	Pollutants that tend to be dissolved following treatment
Sediment	X	X	
Nutrients		X	X
Heavy Metals		X	
Organic Compounds		X	
Trash & Debris	X		
Oxygen Demanding		X	
Bacteria		X	
Oil & Grease		X	
Pesticides		X	

A Treatment BMP must address runoff from developed areas. Please provide the post-construction water quality treatment volume or flow values for the selected project Treatment BMP(s). Guidelines for design calculations are located in Chapter 5, Section 4.3, Principle 8 of the County SUSMP. Label outfalls on the BMP map. The Water Quality peak rate of discharge flow (Q_{WQ}) and the Water Quality storage volume (V_{WQ}) is dependent on the type of treatment BMP selected for the project.

Outfall	Tributary Area (acres)	Q_{WQ} (cfs)	V_{WQ} (ft^3)
Bioretention	68		85,400
Settling Basin	68		85,400
High-Flow biofilter	68	6.3	

Please check the box(s) that best describes the Treatment BMP(s) selected for this project.

Biofilters
☒ Bioretention swale
☒ Vegetated filter strip
☐ Stormwater Planter Box (open-bottomed)
☐ Stormwater Flow-Through Planter (sealed bottom)
☒ Bioretention Area
☐ Vegetated Roofs/Modules/Walls
Detention Basins
☒ Extended/dry detention basin with grass/vegetated lining
☐ Extended/dry detention basin with impervious lining
Infiltration Basins
☐ Infiltration basin
☐ Infiltration trench
☐ Dry well
☐ Permeable Paving
☐ Gravel
☐ Permeable asphalt
☐ Pervious concrete
☐ Unit pavers, ungrouted, set on sand or gravel
☐ Subsurface reservoir bed
Wet Ponds or Wetlands
☐ Wet pond/basin (permanent pool)
☐ Constructed wetland
Filtration
☐ Media filtration
☐ Sand filtration
Hydrodynamic Separator Systems
☐ Swirl Concentrator
☐ Cyclone Separator
Trash Racks and Screens

Include Treatment Datasheet as Attachment E. The datasheet should include the following:	**COMPLETED**	**NO**
1. Description of how treatment BMP was designed. Provide a description for each type of treatment BMP.	X	
2. Engineering calculations for the BMP(s)		X

Please describe why the selected treatment BMP(s) was selected for this project. For projects utilizing a low performing BMP, please provide a detailed explanation.

Based on the location of the Project site, drainage patterns, site constraints, treatment efficiencies, maintenance concerns, the recommended treatment control devices for the Project are bioretention facilities, high-flow biofilters, and settling basins. It is likely that HMP detention basins will meet a portion of the treatment BMP criteria.

MAINTENANCE

Please check the box that best describes the maintenance mechanism(s) for this project. Guidelines for each category are located in Chapter 5, Section 5.2 of the County SUSMP.

CATEGORY	SELECTED	
	YES	NO
First	X	
Second[1]		X
Third[1]		X
Fourth		X

Note:
1. Projects in Category 2 or 3 may choose to establish or be included in a Stormwater Maintenance Assessment District for the long-term maintenance of treatment BMPs.

ATTACHMENTS

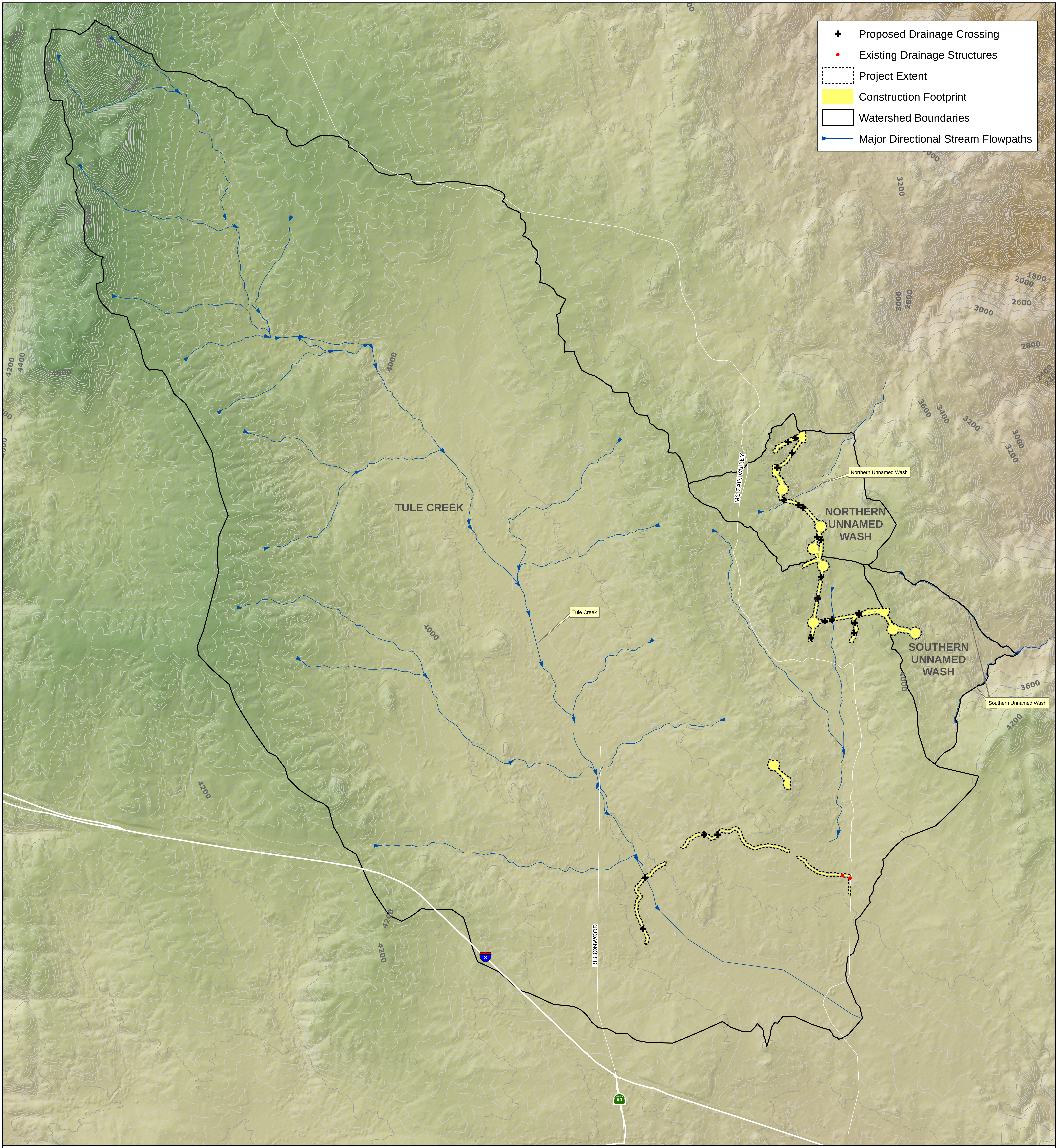
Please include the following attachments.

ATTACHMENT		COMPLETED	N/A	
A	Project Location Map	X		See Figure 1
B	Site Map	X		See Exhibit A
C	Relevant Monitoring Data		X	
D	LID and Treatment BMP Location Map	X		See Exhibit C
E	Treatment BMP Datasheets	X		See Appendix F
F	Operation and Maintenance Program for Treatment BMPs		X	
G	Fiscal Resources		X	
H	Certification Sheet See Appendix 1	X		
I	Addendum			

Note: Attachments A and B may be combined.

APPENDIX D – PROJECT EXIBITS

- Exhibit A – Existing and Proposed Conditions Drainage Map
- Exhibit B1-B5 – Existing and Proposed Conditions SDHM Map
- Exhibit C – BMP Map



HDR
ONE COMPANY | *Many Solutions*℠

0 0.35 0.7 1.4 Miles
1 inch = 1,500 feet

N W E S

Existing and Proposed Conditions Drainage Map

Exhibit A

Iberdrola | Tule Wind Project | Storm Water Management Plan

HDR ONE COMPANY | *Many Solutions*™

0 100 200 400 Feet
1 in = 200 feet
N W E S

Project Extent

Proposed Land Use Conversion
Urban
Impervious

Existing Land Use / Slope Class
Grass, Flat
Grass, Moderate
Grass, Steep
Dirt, Flat
Dirt, Moderate
Dirt, Steep
Dirt, Very Steep
Shrub, Flat
Shrub, Moderate
Shrub, Steep
Shrub, Very Steep
Forest, Flat
Forest, Moderate
Forest, Steep
Urban, Flat
Urban, Moderate
Urban, Steep
Impervious, Flat
Impervious, Moderate

Existing and Proposed Conditions SDHM Map B1 of 5

Iberdrola | Tule Wind Project | Storm Water Management Plan

HDR
ONE COMPANY | *Many Solutions*™

0 100 200 400
Feet
1 in = 200 feet
N W E S

Project Extent

Proposed Land Use Conversion
- Urban
- Impervious

Existing Land Use / Slope Class
- Grass, Flat
- Grass, Moderate
- Grass, Steep
- Dirt, Flat
- Dirt, Moderate
- Dirt, Steep
- Dirt, Very Steep
- Shrub, Flat
- Shrub, Moderate
- Shrub, Steep
- Shrub, Very Steep
- Forest, Flat
- Forest, Moderate
- Forest, Steep
- Urban, Flat
- Urban, Moderate
- Urban, Steep
- Impervious, Flat
- Impervious, Moderate

Existing and Proposed Conditions SDHM Map B2 of 5

Iberdrola | Tule Wind Project | Storm Water Management Plan

HDR
ONE COMPANY | *Many Solutions*™

0 100 200 400 Feet
1 in = 200 feet

Project Extent

Proposed Land Use Conversion
- Urban
- Impervious

Existing Land Use / Slope Class
- Grass, Flat
- Grass, Moderate
- Grass, Steep
- Dirt, Flat
- Dirt, Moderate
- Dirt, Steep
- Dirt, Very Steep
- Shrub, Flat
- Shrub, Moderate
- Shrub, Steep
- Shrub, Very Steep
- Forest, Flat
- Forest, Moderate
- Forest, Steep
- Urban, Flat
- Urban, Moderate
- Urban, Steep
- Impervious, Flat
- Impervious, Moderate

Existing and Proposed Conditions SDHM Map B3 of 5

Iberdrola | Tule Wind Project | Storm Water Management Plan

HDR
ONE COMPANY | *Many Solutions*™

0 100 200 400 Feet
1 in = 200 feet
N S E W

Project Extent

Proposed Land Use Conversion
Urban
Impervious

Existing Land Use / Slope Class
Grass, Flat
Grass, Moderate
Grass, Steep
Dirt, Flat
Dirt, Moderate
Dirt, Steep
Dirt, Very Steep
Shrub, Flat
Shrub, Moderate
Shrub, Steep
Shrub, Very Steep
Forest, Flat
Forest, Moderate
Forest, Steep
Urban, Flat
Urban, Moderate
Urban, Steep
Impervious, Flat
Impervious, Moderate

Existing and Proposed Conditions SDHM Map B4 of 5

Iberdrola | Tule Wind Project | Storm Water Management Plan

HDR
ONE COMPANY | Many Solutions℠

0 100 200 400 Feet

1 in = 200 feet

N W E S

Project Extent

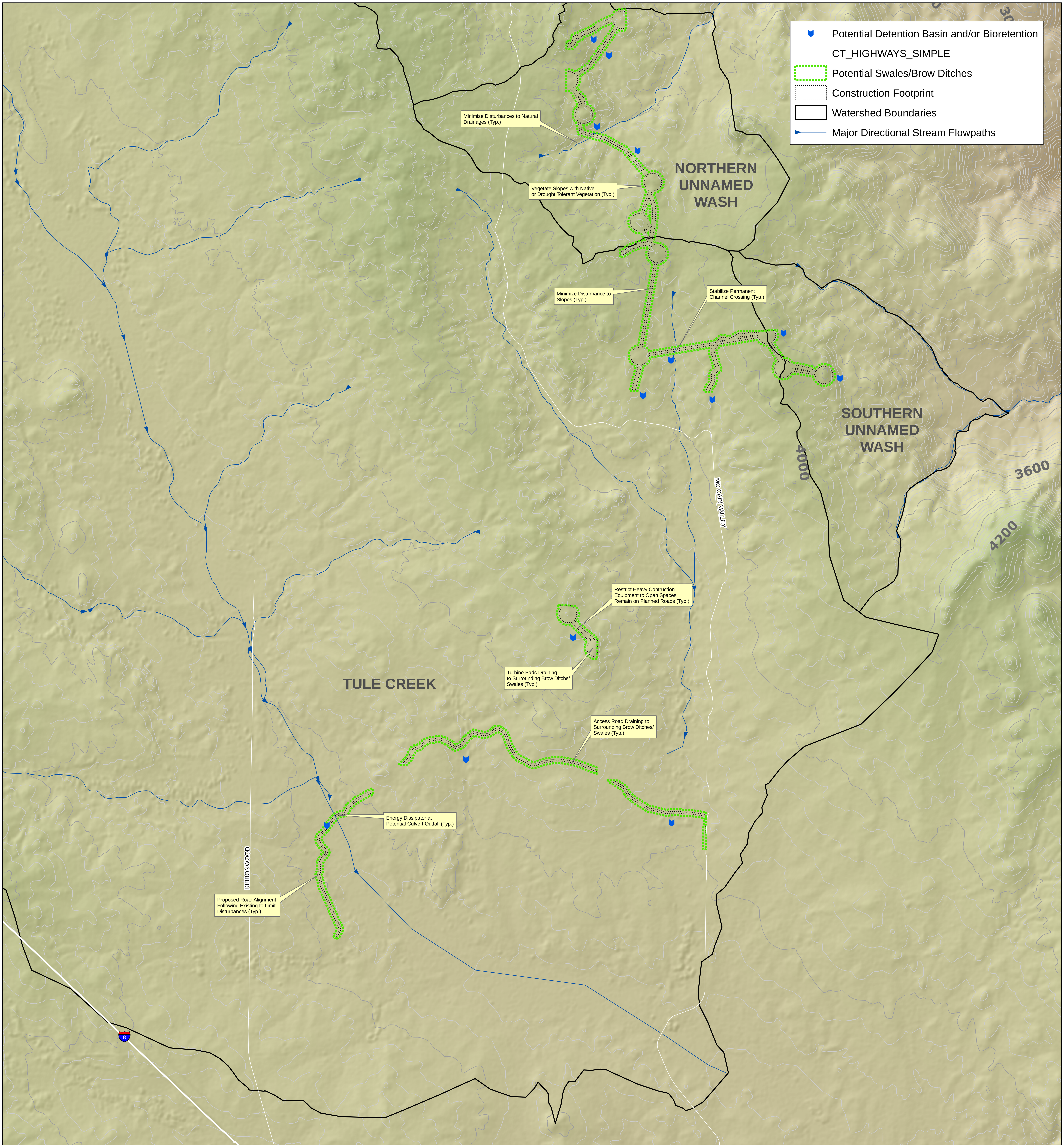
Proposed Land Use Conversion
- Urban
- Impervious

Existing Land Use / Slope Class

- Grass, Flat
- Grass, Moderate
- Grass, Steep
- Dirt, Flat
- Dirt, Moderate
- Dirt, Steep
- Dirt, Very Steep
- Shrub, Flat
- Shrub, Moderate
- Shrub, Steep
- Shrub, Very Steep
- Forest, Flat
- Forest, Moderate
- Forest, Steep
- Urban, Flat
- Urban, Moderate
- Urban, Steep
- Impervious, Flat
- Impervious, Moderate

Existing and Proposed Conditions SDHM Map B5 of 5

Iberdrola | Tule Wind Project | Storm Water Management Plan



HDR ONE COMPANY | *Many Solutions*℠

0 0.2 0.4 0.8 Miles

1 inch = 833.33 feet

N W E S

BMP Map

Exhibit C

Iberdrola | Tule Wind Project | Storm Water Management Plan

APPENDIX E – PRELIMINARY SDHM HYDROMODIFICATION CALCULATIONS

- Tule Creek Basin HMP Analysis
- Northern Unnamed Wash Basin HMP Analysis
- Southern Unnamed Wash Basin HMP Analysis

San Diego Hydrology Model
PROJECT REPORT

Project Name: Tule_Clip
Site Address:
City :
Report Date : 10/8/2009
Gage : San Diego Airport
Data Start : 1959/10/02
Data End : 2000/12/31
Precip Scale: 2.00
SDHM Version:

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	Acres
A,Forest,Flat(0-5%)	.25
A,Shrub,Flat(0-5%)	.85
A,Grass,Flat(0-5%)	1.17
A,Urban,Flat(0-5%)	.75
B,Shrub,Flat(0-5%)	19.02
B,Shrub,Mod(5-10%)	2.88
B,Grass,Flat(0-5%)	2.38
B,Grass,Mod(5-10%)	.37
B,Urban,Flat(0-5%)	.09
C D,Shrub,Flat(0-5%)	7.38
C D,Shrub,Mod(5-10%)	1.35
C D,Grass,Flat(0-5%)	.86
C D,Grass,Mod(5-10%)	.02

Impervious Land Use	Acres

Element Flows To:

Surface	Interflow	Groundwater

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	Acres
A,Urban,Flat(0-5%)	3.02
B,Urban,Mod(5-10%)	3.25
B,Urban,Flat(0-5%)	21.34
C D,Urban,Flat(0-5%)	8.15
C D,Urban,Mod(5-10%)	1.37

Impervious Land Use	Acres		
Roads,Flat(0-5%)	0.16	,Flat(0-5%)	0.08

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1,	Trapezoidal Pond 1,	

Name : Trapezoidal Pond 1
Bottom Length: 128.107934793892ft.
Bottom Width: 128.107934793892ft.
Depth : 9ft.
Volume at riser head : 3.0174ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 24 in.
NotchType : Rectangular
Notch Width : 1.997 ft.
Notch Height: 0.436 ft.
Orifice 1 Diameter: 6.30405248819814 in. **Elevation:** 0 ft.

Element Flows To:
Outlet 1 **Outlet 2**

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.377	0.000	0.000	0.000
0.100	0.380	0.038	0.330	0.000
0.200	0.384	0.076	0.467	0.000
0.300	0.387	0.115	0.572	0.000
0.400	0.391	0.154	0.660	0.000
0.500	0.395	0.193	0.738	0.000
0.600	0.398	0.232	0.808	0.000
0.700	0.402	0.272	0.873	0.000
0.800	0.406	0.313	0.934	0.000
0.900	0.409	0.354	0.990	0.000
1.000	0.413	0.395	1.044	0.000
1.100	0.417	0.436	1.095	0.000
1.200	0.420	0.478	1.143	0.000
1.300	0.424	0.520	1.190	0.000
1.400	0.428	0.563	1.235	0.000
1.500	0.432	0.606	1.278	0.000
1.600	0.435	0.649	1.320	0.000
1.700	0.439	0.693	1.361	0.000
1.800	0.443	0.737	1.400	0.000
1.900	0.447	0.781	1.439	0.000
2.000	0.451	0.826	1.476	0.000
2.100	0.455	0.872	1.513	0.000
2.200	0.458	0.917	1.548	0.000
2.300	0.462	0.963	1.583	0.000
2.400	0.466	1.010	1.617	0.000
2.500	0.470	1.056	1.650	0.000
2.600	0.474	1.104	1.683	0.000
2.700	0.478	1.151	1.715	0.000
2.800	0.482	1.199	1.747	0.000
2.900	0.486	1.248	1.777	0.000
3.000	0.490	1.297	1.808	0.000
3.100	0.494	1.346	1.838	0.000
3.200	0.498	1.395	1.867	0.000
3.300	0.502	1.445	1.896	0.000
3.400	0.506	1.496	1.925	0.000
3.500	0.510	1.547	1.953	0.000
3.600	0.515	1.598	1.980	0.000
3.700	0.519	1.650	2.008	0.000
3.800	0.523	1.702	2.035	0.000
3.900	0.527	1.754	2.061	0.000
4.000	0.531	1.807	2.088	0.000
4.100	0.535	1.860	2.113	0.000
4.200	0.540	1.914	2.139	0.000
4.300	0.544	1.968	2.164	0.000
4.400	0.548	2.023	2.189	0.000

4.500	0.552	2.078	2.214	0.000
4.600	0.557	2.133	2.239	0.000
4.700	0.561	2.189	2.263	0.000
4.800	0.565	2.245	2.287	0.000
4.900	0.570	2.302	2.310	0.000
5.000	0.574	2.359	2.334	0.000
5.100	0.578	2.417	2.357	0.000
5.200	0.583	2.475	2.380	0.000
5.300	0.587	2.534	2.403	0.000
5.400	0.591	2.592	2.425	0.000
5.500	0.596	2.652	2.448	0.000
5.600	0.600	2.712	2.515	0.000
5.700	0.605	2.772	2.825	0.000
5.800	0.609	2.833	3.275	0.000
5.900	0.614	2.894	3.829	0.000
6.000	0.618	2.955	4.470	0.000
6.100	0.623	3.017	5.107	0.000
6.200	0.627	3.080	6.254	0.000
6.300	0.632	3.143	7.733	0.000
6.400	0.636	3.206	9.481	0.000
6.500	0.641	3.270	11.46	0.000
6.600	0.646	3.334	13.65	0.000
6.700	0.650	3.399	16.02	0.000
6.800	0.655	3.465	18.57	0.000
6.900	0.660	3.530	21.29	0.000
7.000	0.664	3.596	24.15	0.000
7.100	0.669	3.663	27.17	0.000
7.200	0.674	3.730	30.32	0.000
7.300	0.678	3.798	33.60	0.000
7.400	0.683	3.866	37.02	0.000
7.500	0.688	3.934	40.55	0.000
7.600	0.693	4.004	44.21	0.000
7.700	0.698	4.073	47.98	0.000
7.800	0.702	4.143	51.87	0.000
7.900	0.707	4.214	55.86	0.000
8.000	0.712	4.284	59.96	0.000
8.100	0.717	4.356	64.16	0.000
8.200	0.722	4.428	68.46	0.000
8.300	0.727	4.500	72.86	0.000
8.400	0.732	4.573	77.36	0.000
8.500	0.736	4.647	81.95	0.000
8.600	0.741	4.720	86.63	0.000
8.700	0.746	4.795	91.41	0.000
8.800	0.751	4.870	96.27	0.000
8.900	0.756	4.945	101.2	0.000
9.000	0.761	5.021	106.3	0.000
9.100	0.766	5.097	111.4	0.000

MITIGATED LAND USE

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	3.02759
5 year	12.303586
10 year	25.60041
25 year	42.363167

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	2.18217
5 year	9.643523
10 year	14.476719
25 year	24.078786

Yearly Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated

1961	1.199	3.757
1962	0.010	0.536
1963	3.685	1.707
1964	0.010	0.462
1965	0.030	0.713
1966	1.258	1.807
1967	61.714	38.941
1968	2.639	2.247
1969	7.935	4.590
1970	6.752	2.157
1971	4.197	9.532
1972	1.278	1.565
1973	0.451	1.442
1974	2.596	2.440
1975	0.561	1.481
1976	2.107	2.109
1977	3.529	10.755
1978	1.668	2.182
1979	10.808	12.544
1980	28.721	20.283
1981	37.810	20.582
1982	8.576	6.116
1983	11.876	5.885
1984	16.311	9.727
1985	0.068	1.166
1986	6.533	2.128
1987	19.840	3.946
1988	0.675	2.031
1989	6.064	2.653
1990	0.119	1.436
1991	0.520	1.573
1992	7.162	9.124
1993	6.922	2.611
1994	12.625	13.658
1995	2.719	2.074
1996	27.401	14.733
1997	0.103	1.550
1998	0.854	1.976
1999	17.587	7.978
2000	3.028	1.992
2001	2.657	2.020

Ranked Yearly Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	61.7137	38.9414
2	37.8101	20.5817
3	28.7211	20.2833
4	27.4006	14.7326
5	19.8398	13.6579
6	17.5869	12.5437
7	16.3108	10.7546
8	12.6245	9.7275
9	11.8757	9.5316
10	10.8080	9.1238
11	8.5765	7.9782
12	7.9348	6.1158
13	7.1623	5.8851
14	6.9219	4.5897
15	6.7519	3.9456
16	6.5332	3.7572
17	6.0638	2.6529
18	4.1972	2.6107
19	3.6854	2.4399
20	3.5288	2.2466
21	3.0276	2.1822
22	2.7187	2.1573
23	2.6575	2.1275
24	2.6389	2.1094
25	2.5957	2.0737
26	2.1065	2.0309
27	1.6684	2.0197
28	1.2776	1.9922

29	1.2576	1.9756
30	1.1993	1.8066
31	0.8542	1.7068
32	0.6752	1.5734
33	0.5608	1.5650
34	0.5197	1.5504
35	0.4512	1.4814
36	0.1192	1.4417
37	0.1025	1.4355
38	0.0675	1.1660
39	0.0298	0.7128
40	0.0103	0.5363
41	0.0099	0.4625

POC #1
The Facility PASSED

The Facility PASSED.

Flow(CFS)	Predev	Dev	Percentage	Pass/Fail
2.4607	181	164	90	Pass
2.6945	161	132	81	Pass
2.9282	137	115	83	Pass
3.1619	120	104	86	Pass
3.3957	113	95	84	Pass
3.6294	101	92	91	Pass
3.8631	95	85	89	Pass
4.0969	89	79	88	Pass
4.3306	81	71	87	Pass
4.5643	76	66	86	Pass
4.7981	71	62	87	Pass
5.0318	63	58	92	Pass
5.2655	59	56	94	Pass
5.4993	55	55	100	Pass
5.7330	52	53	101	Pass
5.9667	51	50	98	Pass
6.2005	49	46	93	Pass
6.4342	47	44	93	Pass
6.6679	45	42	93	Pass
6.9017	43	39	90	Pass
7.1354	38	35	92	Pass
7.3691	37	33	89	Pass
7.6029	36	32	88	Pass
7.8366	35	30	85	Pass
8.0703	34	29	85	Pass
8.3041	33	27	81	Pass
8.5378	33	26	78	Pass
8.7715	31	26	83	Pass
9.0053	31	25	80	Pass
9.2390	30	21	70	Pass
9.4727	30	20	66	Pass
9.7065	30	19	63	Pass
9.9402	29	18	62	Pass
10.1739	28	18	64	Pass
10.4077	25	18	72	Pass
10.6414	25	18	72	Pass
10.8752	23	17	73	Pass
11.1089	23	17	73	Pass
11.3426	23	15	65	Pass
11.5764	23	15	65	Pass
11.8101	21	14	66	Pass
12.0438	18	14	77	Pass
12.2776	18	14	77	Pass
12.5113	17	12	70	Pass
12.7450	16	10	62	Pass
12.9788	16	10	62	Pass
13.2125	16	10	62	Pass
13.4462	16	10	62	Pass
13.6800	15	9	60	Pass
13.9137	14	9	64	Pass
14.1474	14	9	64	Pass
14.3812	14	7	50	Pass

14.6149	14	6	42	Pass
14.8486	14	5	35	Pass
15.0824	14	5	35	Pass
15.3161	14	5	35	Pass
15.5498	14	5	35	Pass
15.7836	14	5	35	Pass
16.0173	14	5	35	Pass
16.2510	14	5	35	Pass
16.4848	13	5	38	Pass
16.7185	13	5	38	Pass
16.9522	12	4	33	Pass
17.1860	12	4	33	Pass
17.4197	10	4	40	Pass
17.6534	9	4	44	Pass
17.8872	9	4	44	Pass
18.1209	9	4	44	Pass
18.3546	9	4	44	Pass
18.5884	9	4	44	Pass
18.8221	9	4	44	Pass
19.0559	9	4	44	Pass
19.2896	9	4	44	Pass
19.5233	7	4	57	Pass
19.7571	7	4	57	Pass
19.9908	6	4	66	Pass
20.2245	6	4	66	Pass
20.4583	6	3	50	Pass
20.6920	5	2	40	Pass
20.9257	5	2	40	Pass
21.1595	5	2	40	Pass
21.3932	5	2	40	Pass
21.6269	5	2	40	Pass
21.8607	5	2	40	Pass
22.0944	5	2	40	Pass
22.3281	5	2	40	Pass
22.5619	5	2	40	Pass
22.7956	5	2	40	Pass
23.0293	4	2	50	Pass
23.2631	4	2	50	Pass
23.4968	4	2	50	Pass
23.7305	4	2	50	Pass
23.9643	4	2	50	Pass
24.1980	4	2	50	Pass
24.4317	4	2	50	Pass
24.6655	4	2	50	Pass
24.8992	4	2	50	Pass
25.1329	4	2	50	Pass
25.3667	4	2	50	Pass
25.6004	4	2	50	Pass

Drawdown Time Results
Pond: Trapezoidal Pond 1

Days	Stage(feet)	Percent of Total Run Time
1	9.000	0.0000
2	9.000	0.0000
3	9.000	0.0000
4	9.000	0.0000
5	9.000	0.0000

Maximum Stage: 7.916
Drawdown Time: 00 21:20:30

Perlnd and Implnd Changes

No changes have been made.

Land Use Report For Tule_Clip   Predeveloped

Pervious Land Areas

	Basin 1
A-Forest-Flat(0-5%)	.25
A-Shrub-Flat(0-5%)	.85
A-Grass-Flat(0-5%)	1.17
A-Urban-Flat(0-5%)	.75
B-Shrub-Flat(0-5%)	19.02
B-Shrub-Mod(5-10%)	2.88
B-Grass-Flat(0-5%)	2.38
B-Grass-Mod(5-10%)	.37
B-Urban-Flat(0-5%)	.09
C D-Shrub-Flat(0-5%)	7.38
C D-Shrub-Mod(5-10%)	1.35
C D-Grass-Flat(0-5%)	.86
C D-Grass-Mod(5-10%)	.02

Land Use Report For Tule_Clip   Developed Mitigated

Pervious Land Areas

	Basin 1
A-Urban-Flat(0-5%)	3.02
B-Urban-Flat(0-5%)	21.34
B-Urban-Mod(5-10%)	3.25
C D-Urban-Flat(0-5%)	8.15
C D-Urban-Mod(5-10%)	1.37

Impervious Land Areas

	Basin 1
Roads-Flat(0-5%)	.16
Driveways-Flat(0-5%)	.08

San Diego Hydrology Model
PROJECT REPORT

Project Name: North_Clip
Site Address:
City :
Report Date : 9/28/2009
Gage : San Diego Airport
Data Start : 1959/10/02
Data End : 2000/12/31
Precip Scale: 2.00
SDHM Version:

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	Acres
B,Forest,Flat(0-5%)	.19
B,Forest,Mod(5-10%)	.13
B,Forest,Stee(10-20)	.05
B,Shrub,Flat(0-5%)	2.97
B,Shrub,Mod(5-10%)	.73
B,Shrub,Stee(10-20%)	.29
B,Dirt, Flat(0-5%)	6.13
B,Dirt, Mod(5-10%)	.79
B,Dirt, Stee(10-20%)	.15
C D,Forest,Flat(0-5)	.04
C D,Forest,Mod(5-10)	.16
C D,Shrub,Flat(0-5%)	2.7
C D,Shrub,Mod(5-10%)	1.8
C D,Shrub,St(10-20%)	1.1
C D,Grass,Flat(0-5%)	.13
C D,Grass,Mod(5-10%)	.32
C D,Dirt, Flat(0-5%)	4.75
C D,Dirt, Mod(5-10%)	.44
C D,Dirt, St(10-20%)	.11

Impervious Land Use	Acres

Element Flows To:

Surface	Interflow	Groundwater

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	Acres
B,Urban,Mod(5-10%)	1.64
B,Urban,Flat(0-5%)	9.17
B,Urban,Stee(10-20%)	.49
C D,Urban,St(10-20%)	1.21
C D,Urban,Mod(5-10%)	2.72
C D,Urban,Flat(0-5%)	7.53

Impervious Land Use	Acres		
Roads,Flat(0-5%)	0.12	,Flat(0-5%)	0.08

Element Flows To:

Surface	**Interflow**	**Groundwater**
Trapezoidal Pond 1,	Trapezoidal Pond 1,	

Name : Trapezoidal Pond 1
Bottom Length: 80.9403219557808ft.
Bottom Width: 80.9403219557808ft.
Depth : 8ft.
Volume at riser head : 1.3772ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 24 in.
NotchType : Rectangular
Notch Width : 1.997 ft.
Notch Height: 0.235 ft.
Orifice 1 Diameter: 5.59785023424557 in. **Elevation:** 0 ft.

Element Flows To:

Outlet 1	**Outlet 2**

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.150	0.000	0.000	0.000
0.089	0.152	0.013	0.245	0.000
0.178	0.154	0.027	0.347	0.000
0.267	0.156	0.041	0.425	0.000
0.356	0.158	0.055	0.491	0.000
0.444	0.160	0.069	0.549	0.000
0.533	0.163	0.083	0.601	0.000
0.622	0.165	0.098	0.649	0.000
0.711	0.167	0.113	0.694	0.000
0.800	0.169	0.128	0.736	0.000
0.889	0.171	0.143	0.776	0.000
0.978	0.173	0.158	0.814	0.000
1.067	0.175	0.173	0.850	0.000
1.156	0.177	0.189	0.885	0.000
1.244	0.179	0.205	0.918	0.000
1.333	0.182	0.221	0.950	0.000
1.422	0.184	0.237	0.981	0.000
1.511	0.186	0.254	1.012	0.000
1.600	0.188	0.270	1.041	0.000
1.689	0.190	0.287	1.070	0.000
1.778	0.193	0.304	1.097	0.000
1.867	0.195	0.321	1.124	0.000
1.956	0.197	0.339	1.151	0.000
2.044	0.199	0.356	1.177	0.000
2.133	0.202	0.374	1.202	0.000
2.222	0.204	0.392	1.227	0.000
2.311	0.206	0.411	1.251	0.000
2.400	0.209	0.429	1.275	0.000
2.489	0.211	0.448	1.298	0.000
2.578	0.213	0.466	1.321	0.000
2.667	0.216	0.486	1.344	0.000
2.756	0.218	0.505	1.366	0.000
2.844	0.221	0.524	1.388	0.000
2.933	0.223	0.544	1.410	0.000
3.022	0.225	0.564	1.431	0.000
3.111	0.228	0.584	1.452	0.000
3.200	0.230	0.604	1.472	0.000
3.289	0.233	0.625	1.493	0.000

3.378	0.235	0.646	1.513	0.000
3.467	0.238	0.667	1.532	0.000
3.556	0.240	0.688	1.552	0.000
3.644	0.243	0.710	1.571	0.000
3.733	0.245	0.731	1.590	0.000
3.822	0.248	0.753	1.609	0.000
3.911	0.250	0.775	1.628	0.000
4.000	0.253	0.798	1.646	0.000
4.089	0.255	0.820	1.664	0.000
4.178	0.258	0.843	1.682	0.000
4.267	0.261	0.866	1.700	0.000
4.356	0.263	0.889	1.718	0.000
4.444	0.266	0.913	1.735	0.000
4.533	0.268	0.937	1.752	0.000
4.622	0.271	0.961	1.769	0.000
4.711	0.274	0.985	1.786	0.000
4.800	0.276	1.009	1.803	0.000
4.889	0.279	1.034	1.820	0.000
4.978	0.282	1.059	1.836	0.000
5.067	0.285	1.084	1.853	0.000
5.156	0.287	1.109	1.869	0.000
5.244	0.290	1.135	1.885	0.000
5.333	0.293	1.161	1.901	0.000
5.422	0.296	1.187	1.916	0.000
5.511	0.298	1.214	1.932	0.000
5.600	0.301	1.240	1.948	0.000
5.689	0.304	1.267	1.963	0.000
5.778	0.307	1.294	1.988	0.000
5.867	0.310	1.322	2.209	0.000
5.956	0.313	1.349	2.562	0.000
6.044	0.315	1.377	2.963	0.000
6.133	0.318	1.405	3.744	0.000
6.222	0.321	1.434	4.851	0.000
6.311	0.324	1.462	6.205	0.000
6.400	0.327	1.491	7.767	0.000
6.489	0.330	1.521	9.512	0.000
6.578	0.333	1.550	11.42	0.000
6.667	0.336	1.580	13.48	0.000
6.756	0.339	1.610	15.69	0.000
6.844	0.342	1.640	18.03	0.000
6.933	0.345	1.671	20.49	0.000
7.022	0.348	1.701	23.07	0.000
7.111	0.351	1.732	25.77	0.000
7.200	0.354	1.764	28.57	0.000
7.289	0.357	1.795	31.48	0.000
7.378	0.360	1.827	34.49	0.000
7.467	0.363	1.859	37.60	0.000
7.556	0.366	1.892	40.81	0.000
7.644	0.369	1.924	44.11	0.000
7.733	0.372	1.957	47.50	0.000
7.822	0.375	1.990	50.97	0.000
7.911	0.379	2.024	54.53	0.000
8.000	0.382	2.058	58.18	0.000
8.089	0.385	2.092	61.90	0.000

MITIGATED LAND USE

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	5.1678
5 year	10.059916
10 year	18.512552
25 year	29.748162

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	2.55472

5 year	8.635944
10 year	12.186248
25 year	19.083733

Yearly Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1961	1.860	5.988
1962	0.007	0.688
1963	3.743	1.677
1964	0.020	0.613
1965	0.221	0.842
1966	2.221	1.732
1967	42.303	26.671
1968	4.331	2.934
1969	9.247	7.837
1970	6.082	2.555
1971	8.865	12.228
1972	2.262	1.590
1973	1.692	1.446
1974	6.565	4.549
1975	1.232	1.452
1976	5.168	2.034
1977	5.373	8.200
1978	3.506	2.026
1979	9.908	9.069
1980	21.217	17.298
1981	26.794	16.890
1982	9.733	6.465
1983	10.174	5.687
1984	12.413	6.885
1985	0.308	1.240
1986	5.918	1.880
1987	15.260	4.050
1988	2.019	1.962
1989	8.411	4.028
1990	0.772	1.452
1991	1.537	1.559
1992	6.455	7.213
1993	6.203	4.329
1994	9.555	12.054
1995	2.985	1.934
1996	19.529	9.989
1997	0.288	1.577
1998	1.465	1.899
1999	13.165	8.963
2000	3.109	1.878
2001	4.285	1.914

Ranked Yearly Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	42.3025	26.6714
2	26.7942	17.2984
3	21.2174	16.8900
4	19.5291	12.2277
5	15.2596	12.0536
6	13.1651	9.9886
7	12.4130	9.0694
8	10.1735	8.9632
9	9.9085	8.1996
10	9.7334	7.8369
11	9.5552	7.2132
12	9.2469	6.8848
13	8.8650	6.4655
14	8.4113	5.9879
15	6.5649	5.6867
16	6.4550	4.5492
17	6.2029	4.3291
18	6.0818	4.0501
19	5.9176	4.0284
20	5.3728	2.9342
21	5.1678	2.5547

22	4.3313	2.0338
23	4.2849	2.0258
24	3.7426	1.9625
25	3.5061	1.9341
26	3.1093	1.9145
27	2.9848	1.8994
28	2.2619	1.8800
29	2.2209	1.8785
30	2.0190	1.7324
31	1.8601	1.6774
32	1.6921	1.5897
33	1.5367	1.5772
34	1.4651	1.5589
35	1.2323	1.4524
36	0.7716	1.4524
37	0.3077	1.4462
38	0.2879	1.2398
39	0.2215	0.8419
40	0.0201	0.6879
41	0.0073	0.6130

POC #1
The Facility PASSED

The Facility PASSED.

Flow(CFS)	Predev	Dev	Percentage	Pass/Fail
2.0120	272	201	73	Pass
2.1787	250	175	70	Pass
2.3453	224	158	70	Pass
2.5120	202	149	73	Pass
2.6787	185	136	73	Pass
2.8453	172	130	75	Pass
3.0120	151	121	80	Pass
3.1787	138	113	81	Pass
3.3454	129	103	79	Pass
3.5120	118	99	83	Pass
3.6787	109	94	86	Pass
3.8454	100	87	87	Pass
4.0121	94	80	85	Pass
4.1787	87	76	87	Pass
4.3454	79	69	87	Pass
4.5121	75	69	92	Pass
4.6787	74	63	85	Pass
4.8454	70	63	90	Pass
5.0121	67	62	92	Pass
5.1788	61	60	98	Pass
5.3454	61	59	96	Pass
5.5121	57	57	100	Pass
5.6788	55	55	100	Pass
5.8454	53	50	94	Pass
6.0121	49	47	95	Pass
6.1788	47	46	97	Pass
6.3455	45	41	91	Pass
6.5121	43	40	93	Pass
6.6788	42	38	90	Pass
6.8455	40	38	95	Pass
7.0122	39	35	89	Pass
7.1788	38	34	89	Pass
7.3455	37	32	86	Pass
7.5122	35	31	88	Pass
7.6788	33	31	93	Pass
7.8455	33	28	84	Pass
8.0122	33	27	81	Pass
8.1789	31	27	87	Pass
8.3455	30	25	83	Pass
8.5122	28	24	85	Pass
8.6789	27	23	85	Pass
8.8456	27	21	77	Pass
9.0122	25	18	72	Pass
9.1789	25	14	56	Pass
9.3456	23	14	60	Pass

9.5122	20	14	70	Pass
9.6789	19	14	73	Pass
9.8456	18	13	72	Pass
10.0123	17	11	64	Pass
10.1789	17	10	58	Pass
10.3456	16	10	62	Pass
10.5123	16	10	62	Pass
10.6789	15	10	66	Pass
10.8456	15	9	60	Pass
11.0123	14	9	64	Pass
11.1790	14	9	64	Pass
11.3456	14	9	64	Pass
11.5123	14	9	64	Pass
11.6790	14	8	57	Pass
11.8457	14	8	57	Pass
12.0123	13	8	61	Pass
12.1790	13	6	46	Pass
12.3457	13	4	30	Pass
12.5123	12	4	33	Pass
12.6790	12	4	33	Pass
12.8457	12	4	33	Pass
13.0124	12	4	33	Pass
13.1790	10	4	40	Pass
13.3457	10	4	40	Pass
13.5124	10	4	40	Pass
13.6791	10	4	40	Pass
13.8457	9	4	44	Pass
14.0124	8	4	50	Pass
14.1791	8	4	50	Pass
14.3457	8	4	50	Pass
14.5124	8	4	50	Pass
14.6791	8	4	50	Pass
14.8458	7	4	57	Pass
15.0124	7	4	57	Pass
15.1791	7	4	57	Pass
15.3458	5	4	80	Pass
15.5124	5	4	80	Pass
15.6791	5	4	80	Pass
15.8458	4	4	100	Pass
16.0125	4	4	100	Pass
16.1791	4	4	100	Pass
16.3458	4	4	100	Pass
16.5125	4	4	100	Pass
16.6792	4	4	100	Pass
16.8458	4	4	100	Pass
17.0125	4	3	75	Pass
17.1792	4	3	75	Pass
17.3458	4	2	50	Pass
17.5125	4	2	50	Pass
17.6792	4	2	50	Pass
17.8459	4	2	50	Pass
18.0125	4	2	50	Pass
18.1792	4	2	50	Pass
18.3459	4	2	50	Pass
18.5126	4	2	50	Pass

Drawdown Time Results
Pond: Trapezoidal Pond 1

Days	Stage(feet)	Percent of Total Run Time
1	7.000	0.0005
2	7.000	0.0005
3	7.000	0.0005
4	7.000	0.0005
5	7.000	0.0005

Maximum Stage: 7.896
Drawdown Time: 05 00:00:10

Perlnd and Implnd Changes

No changes have been made.

Land Use Report For North_Clip   Predeveloped

Pervious Land Areas

	Basin 1
B-Forest-Flat(0-5%)	.19
B-Forest-Mod(5-10%)	.13
B-Forest-Stee(10-20)	.05
B-Shrub-Flat(0-5%)	2.97
B-Shrub-Mod(5-10%)	.73
B-Shrub-Stee(10-20%)	.29
B-Dirt- Flat(0-5%)	6.13
B-Dirt- Mod(5-10%)	.79
B-Dirt- Stee(10-20%)	.15
C D-Forest-Flat(0-5)	.04
C D-Forest-Mod(5-10)	.16
C D-Shrub-Flat(0-5%)	2.7
C D-Shrub-Mod(5-10%)	1.8
C D-Shrub-St(10-20%)	1.1
C D-Grass-Flat(0-5%)	.13
C D-Grass-Mod(5-10%)	.32
C D-Dirt- Flat(0-5%)	4.75
C D-Dirt- Mod(5-10%)	.44
C D-Dirt- St(10-20%)	.11

Land Use Report For North_Clip   Developed Mitigated

Pervious Land Areas

	Basin 1
B-Urban-Flat(0-5%)	9.17
B-Urban-Mod(5-10%)	1.64
B-Urban-Stee(10-20%)	.49
C D-Urban-Flat(0-5%)	7.53
C D-Urban-Mod(5-10%)	2.72
C D-Urban-St(10-20%)	1.21

Impervious Land Areas

	Basin 1
Roads-Flat(0-5%)	.12
Driveways-Flat(0-5%)	.08

San Diego Hydrology Model
PROJECT REPORT

Project Name: South_Clip
Site Address:
City :
Report Date : 9/28/2009
Gage : San Diego Airport
Data Start : 1959/10/02
Data End : 2000/12/31
Precip Scale: 2.00
SDHM Version:

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	Acres
B,Shrub,Flat(0-5%)	4.13
B,Shrub,Mod(5-10%)	.72
C D,Shrub,Mod(5-10%)	.7
C D,Shrub,St(10-20%)	1.3
C D,Shrub,Very(>20%)	.13

Impervious Land Use	Acres

Element Flows To:

Surface	Interflow	Groundwater

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	Acres
B,Urban,Mod(5-10%)	.72
B,Urban,Flat(0-5%)	4.13
C D,Urban,Mod(5-10%)	.7
C D,Urban,St(10-20%)	1.26
C D,Urban,Very(>20%)	.13

Impervious Land Use	Acres		
Roads,Flat(0-5%)	0.01	,Flat(0-5%)	0.04

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1,	Trapezoidal Pond 1,	

Name : Trapezoidal Pond 1
Bottom Length: 44.2979278788277ft.
Bottom Width: 44.2979278788277ft.
Depth : 7ft.
Volume at riser head : 0.5594ft.
Side slope 1: 3 To 1

Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 24 in.
NotchType : Rectangular
Notch Width : 1.974 ft.
Notch Height: 0.295 ft.
Orifice 1 Diameter: 3.017 in. **Elevation:** 0 ft.

Element Flows To:
Outlet 1 **Outlet 2**

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.045	0.000	0.000	0.000
0.078	0.046	0.004	0.067	0.000
0.156	0.047	0.007	0.094	0.000
0.233	0.048	0.011	0.115	0.000
0.311	0.049	0.015	0.133	0.000
0.389	0.050	0.018	0.149	0.000
0.467	0.051	0.022	0.163	0.000
0.544	0.052	0.026	0.176	0.000
0.622	0.053	0.030	0.189	0.000
0.700	0.054	0.035	0.200	0.000
0.778	0.055	0.039	0.211	0.000
0.856	0.056	0.043	0.221	0.000
0.933	0.057	0.048	0.231	0.000
1.011	0.058	0.052	0.240	0.000
1.089	0.059	0.057	0.249	0.000
1.167	0.060	0.061	0.258	0.000
1.244	0.062	0.066	0.267	0.000
1.322	0.063	0.071	0.275	0.000
1.400	0.064	0.076	0.283	0.000
1.478	0.065	0.081	0.291	0.000
1.556	0.066	0.086	0.298	0.000
1.633	0.067	0.091	0.306	0.000
1.711	0.068	0.096	0.313	0.000
1.789	0.070	0.102	0.320	0.000
1.867	0.071	0.107	0.327	0.000
1.944	0.072	0.113	0.333	0.000
2.022	0.073	0.118	0.340	0.000
2.100	0.074	0.124	0.346	0.000
2.178	0.076	0.130	0.353	0.000
2.256	0.077	0.136	0.359	0.000
2.333	0.078	0.142	0.365	0.000
2.411	0.079	0.148	0.371	0.000
2.489	0.081	0.154	0.377	0.000
2.567	0.082	0.160	0.383	0.000
2.644	0.083	0.167	0.389	0.000
2.722	0.084	0.173	0.394	0.000
2.800	0.086	0.180	0.400	0.000
2.878	0.087	0.187	0.406	0.000
2.956	0.088	0.194	0.411	0.000
3.033	0.090	0.200	0.416	0.000
3.111	0.091	0.208	0.422	0.000
3.189	0.092	0.215	0.427	0.000
3.267	0.094	0.222	0.432	0.000
3.344	0.095	0.229	0.437	0.000
3.422	0.096	0.237	0.442	0.000
3.500	0.098	0.244	0.447	0.000
3.578	0.099	0.252	0.452	0.000
3.656	0.101	0.260	0.457	0.000
3.733	0.102	0.268	0.462	0.000
3.811	0.104	0.276	0.467	0.000
3.889	0.105	0.284	0.471	0.000
3.967	0.106	0.292	0.476	0.000
4.044	0.108	0.300	0.481	0.000

4.122	0.109	0.309	0.485	0.000
4.200	0.111	0.317	0.490	0.000
4.278	0.112	0.326	0.494	0.000
4.356	0.114	0.335	0.499	0.000
4.433	0.115	0.344	0.503	0.000
4.511	0.117	0.353	0.508	0.000
4.589	0.118	0.362	0.512	0.000
4.667	0.120	0.371	0.516	0.000
4.744	0.122	0.381	0.521	0.000
4.822	0.123	0.390	0.525	0.000
4.900	0.125	0.400	0.529	0.000
4.978	0.126	0.409	0.533	0.000
5.056	0.128	0.419	0.538	0.000
5.133	0.129	0.429	0.542	0.000
5.211	0.131	0.439	0.546	0.000
5.289	0.133	0.450	0.550	0.000
5.367	0.134	0.460	0.554	0.000
5.444	0.136	0.471	0.558	0.000
5.522	0.138	0.481	0.562	0.000
5.600	0.139	0.492	0.566	0.000
5.678	0.141	0.503	0.570	0.000
5.756	0.143	0.514	0.648	0.000
5.833	0.144	0.525	0.879	0.000
5.911	0.146	0.536	1.195	0.000
5.989	0.148	0.548	1.578	0.000
6.067	0.149	0.559	1.976	0.000
6.144	0.151	0.571	2.714	0.000
6.222	0.153	0.583	3.689	0.000
6.300	0.155	0.595	4.852	0.000
6.378	0.156	0.607	6.178	0.000
6.456	0.158	0.619	7.648	0.000
6.533	0.160	0.632	9.249	0.000
6.611	0.162	0.644	10.97	0.000
6.689	0.164	0.657	12.81	0.000
6.767	0.165	0.670	14.75	0.000
6.844	0.167	0.683	16.79	0.000
6.922	0.169	0.696	18.93	0.000
7.000	0.171	0.709	21.16	0.000
7.078	0.173	0.722	23.48	0.000

MITIGATED LAND USE

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	1.12375
5 year	2.7089
10 year	5.393939
25 year	8.639142

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.559778
5 year	2.244449
10 year	3.233513
25 year	5.373247

Yearly Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1961	0.776	1.341
1962	0.001	0.251
1963	1.025	0.460
1964	0.002	0.239
1965	0.050	0.284
1966	0.582	0.456
1967	12.455	7.494
1968	1.084	0.560

1969	2.378	1.804
1970	1.701	0.563
1971	1.656	3.268
1972	0.646	0.442
1973	0.466	0.391
1974	1.190	0.779
1975	0.390	0.394
1976	1.124	0.544
1977	1.257	2.364
1978	0.859	0.529
1979	2.362	2.669
1980	6.007	4.874
1981	7.741	4.585
1982	2.356	1.890
1983	2.708	1.408
1984	3.435	2.012
1985	0.029	0.362
1986	1.592	0.505
1987	4.266	0.973
1988	0.498	0.526
1989	1.812	0.765
1990	0.279	0.391
1991	0.478	0.425
1992	1.710	2.086
1993	1.705	0.637
1994	2.710	3.122
1995	0.780	0.507
1996	5.747	2.989
1997	0.022	0.428
1998	0.447	0.512
1999	3.778	2.055
2000	0.786	0.491
2001	1.054	0.504

Ranked Yearly Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	12.4551	7.4939
2	7.7413	4.8743
3	6.0071	4.5848
4	5.7465	3.2682
5	4.2657	3.1225
6	3.7779	2.9886
7	3.4349	2.6689
8	2.7096	2.3636
9	2.7080	2.0855
10	2.3779	2.0554
11	2.3622	2.0118
12	2.3556	1.8903
13	1.8116	1.8041
14	1.7099	1.4076
15	1.7055	1.3415
16	1.7010	0.9729
17	1.6562	0.7786
18	1.5919	0.7646
19	1.2568	0.6369
20	1.1896	0.5634
21	1.1238	0.5598
22	1.0840	0.5437
23	1.0537	0.5294
24	1.0252	0.5261
25	0.8592	0.5122
26	0.7855	0.5071
27	0.7795	0.5051
28	0.7764	0.5040
29	0.6461	0.4911
30	0.5817	0.4604
31	0.4976	0.4558
32	0.4776	0.4420
33	0.4662	0.4280
34	0.4474	0.4254
35	0.3898	0.3938
36	0.2788	0.3911

37	0.0503	0.3911
38	0.0291	0.3625
39	0.0219	0.2837
40	0.0021	0.2513
41	0.0012	0.2385

POC #1
The Facility PASSED

The Facility PASSED.

Flow(CFS)	Predev	Dev	Percentage	Pass/Fail
0.5418	280	261	93	Pass
0.5908	251	129	51	Pass
0.6398	225	111	49	Pass
0.6888	200	104	52	Pass
0.7378	174	99	56	Pass
0.7868	153	91	59	Pass
0.8359	140	87	62	Pass
0.8849	127	80	62	Pass
0.9339	115	74	64	Pass
0.9829	105	69	65	Pass
1.0319	99	68	68	Pass
1.0809	92	65	70	Pass
1.1299	79	62	78	Pass
1.1789	74	58	78	Pass
1.2279	71	56	78	Pass
1.2770	67	52	77	Pass
1.3260	64	52	81	Pass
1.3750	58	50	86	Pass
1.4240	57	49	85	Pass
1.4730	52	48	92	Pass
1.5220	51	44	86	Pass
1.5710	49	42	85	Pass
1.6200	47	40	85	Pass
1.6690	45	39	86	Pass
1.7181	40	38	95	Pass
1.7671	38	38	100	Pass
1.8161	36	35	97	Pass
1.8651	36	33	91	Pass
1.9141	35	32	91	Pass
1.9631	35	30	85	Pass
2.0121	33	29	87	Pass
2.0611	32	26	81	Pass
2.1102	31	25	80	Pass
2.1592	30	24	80	Pass
2.2082	30	24	80	Pass
2.2572	29	24	82	Pass
2.3062	26	23	88	Pass
2.3552	26	22	84	Pass
2.4042	23	21	91	Pass
2.4532	23	21	91	Pass
2.5022	22	21	95	Pass
2.5513	22	20	90	Pass
2.6003	20	19	95	Pass
2.6493	18	19	105	Pass
2.6983	18	16	88	Pass
2.7473	16	16	100	Pass
2.7963	16	14	87	Pass
2.8453	16	13	81	Pass
2.8943	15	12	80	Pass
2.9434	15	11	73	Pass
2.9924	15	8	53	Pass
3.0414	15	8	53	Pass
3.0904	14	8	57	Pass
3.1394	14	7	50	Pass
3.1884	14	6	42	Pass
3.2374	14	6	42	Pass
3.2864	14	4	28	Pass
3.3354	14	4	28	Pass
3.3845	14	4	28	Pass
3.4335	14	4	28	Pass

3.4825	13	4	30	Pass
3.5315	12	4	33	Pass
3.5805	12	4	33	Pass
3.6295	12	4	33	Pass
3.6785	11	4	36	Pass
3.7275	10	4	40	Pass
3.7766	10	4	40	Pass
3.8256	9	4	44	Pass
3.8746	9	4	44	Pass
3.9236	9	4	44	Pass
3.9726	9	4	44	Pass
4.0216	8	4	50	Pass
4.0706	8	4	50	Pass
4.1196	8	4	50	Pass
4.1686	7	4	57	Pass
4.2177	7	4	57	Pass
4.2667	6	4	66	Pass
4.3157	5	4	80	Pass
4.3647	5	4	80	Pass
4.4137	5	4	80	Pass
4.4627	5	4	80	Pass
4.5117	5	4	80	Pass
4.5607	4	4	100	Pass
4.6098	4	3	75	Pass
4.6588	4	3	75	Pass
4.7078	4	3	75	Pass
4.7568	4	3	75	Pass
4.8058	4	3	75	Pass
4.8548	4	3	75	Pass
4.9038	4	2	50	Pass
4.9528	4	2	50	Pass
5.0018	4	2	50	Pass
5.0509	4	2	50	Pass
5.0999	4	2	50	Pass
5.1489	4	2	50	Pass
5.1979	4	2	50	Pass
5.2469	4	2	50	Pass
5.2959	4	2	50	Pass
5.3449	4	2	50	Pass
5.3939	4	2	50	Pass

Drawdown Time Results
Pond: Trapezoidal Pond 1

Days	Stage(feet)	Percent of Total Run Time
1	7.000	0.0000
2	7.000	0.0000
3	7.000	0.0000
4	7.000	0.0000
5	7.000	0.0000

Maximum Stage: 6.744
Drawdown Time: 00 16:00:20

Perlnd and Implnd Changes

No changes have been made.

Land Use Report For South_Clip   Predeveloped

Pervious Land Areas

	Basin 1
B-Shrub-Flat(0-5%)	4.13
B-Shrub-Mod(5-10%)	.72
C D-Shrub-Mod(5-10%)	.7
C D-Shrub-St(10-20%)	1.3
C D-Shrub-Very(>20%)	.13

Land Use Report For South_Clip   Developed Mitigated

Pervious Land Areas

	Basin 1
B-Urban-Flat(0-5%)	4.13
B-Urban-Mod(5-10%)	.72
C D-Urban-Mod(5-10%)	.7
C D-Urban-St(10-20%)	1.26
C D-Urban-Very(>20%)	.13

Impervious Land Areas

	Basin 1
Roads-Flat(0-5%)	.01
Driveways-Flat(0-5%)	.04

APPENDIX F – ADDITIONAL BMP INFORMATION

- Bioretention Information
- Settling Basin Information
- High-Flow Biofilter Information

Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).

- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 ft^2 of bioretention area should be included.
- Cover area with about 3 inches of mulch.

Construction/Inspection Considerations

Bioretention area should not be established until contributing watershed is stabilized.

Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)

Pollutant	Removal Rate
Total Phosphorus	70-83%
Metals (Cu, Zn, Pb)	93-98%
TKN	68-80%
Total Suspended Solids	90%
Organics	90%
Bacteria	90%

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

Cost

Construction Cost

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock,). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

Maintenance Cost

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

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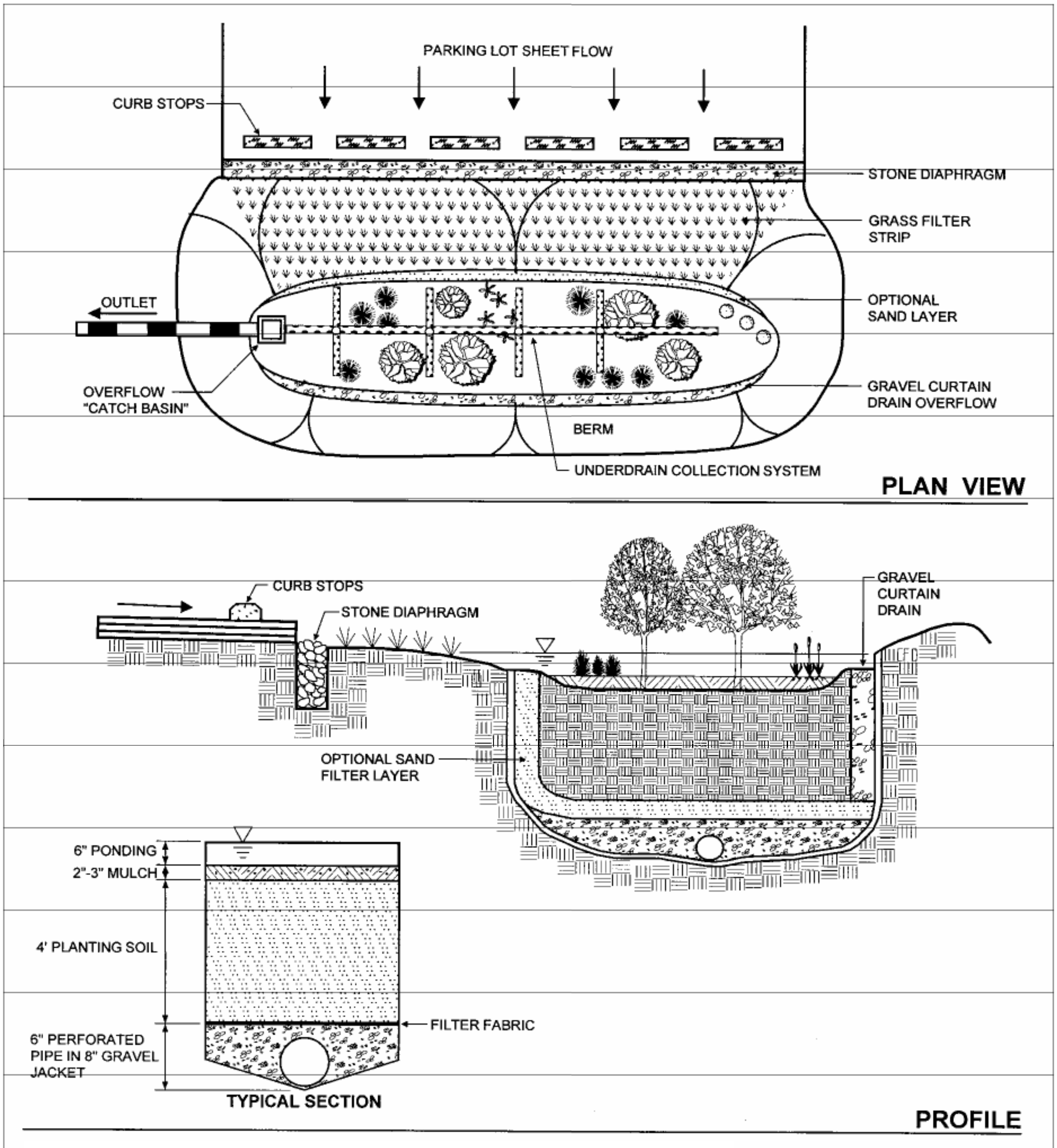

Schematic of a Bioretention Facility (MDE, 2000)

Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	■
☑	Metals	▲
☑	Bacteria	▲
☑	Oil and Grease	▲
☑	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of hours.
- Length to width ratio of at least 1.5:1 where feasible.
- Basin depths optimally range from 2 to 5 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.
- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.
- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

Figure 1
Example of Extended Detention Outlet Structure

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_0))^{0.5}$$

where: Q = discharge (ft^3/s)
C = orifice coefficient
A = area of the orifice (ft^2)
g = gravitational constant (32.2)
H = water surface elevation (ft)
H_0= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_0. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft^3).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1 Estimated Average Annual Maintenance Effort

Activity	Labor Hours	Equipment & Material ($)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	0	0	0
Administration	3	0	132
Materials	-	535	535
Total	56	$668	$3,132

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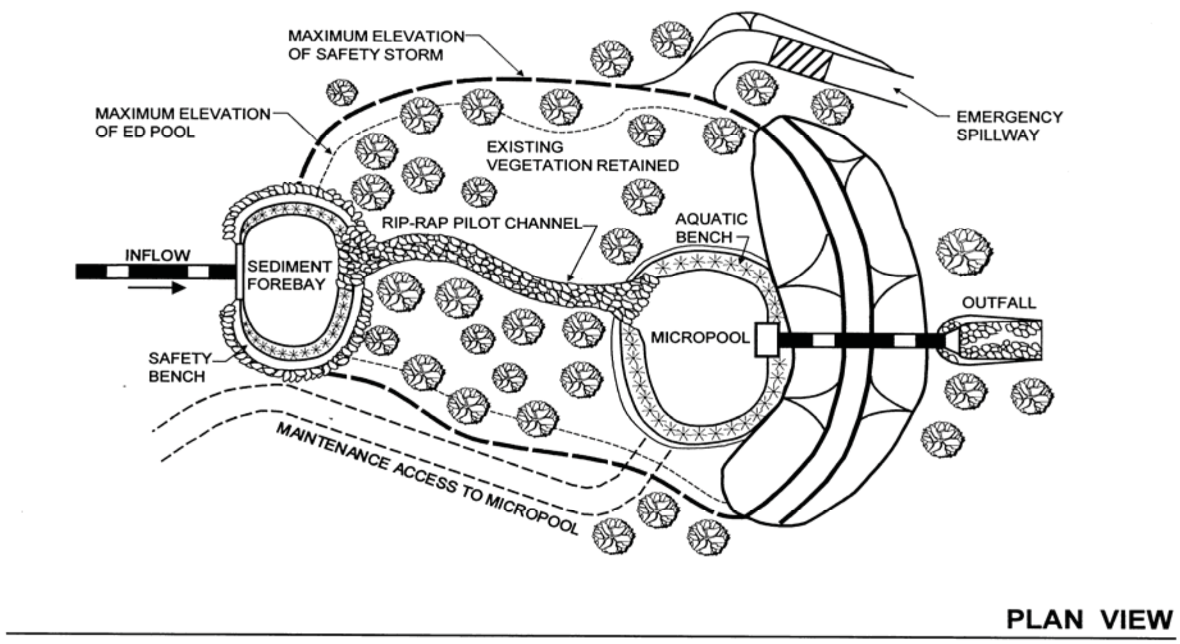

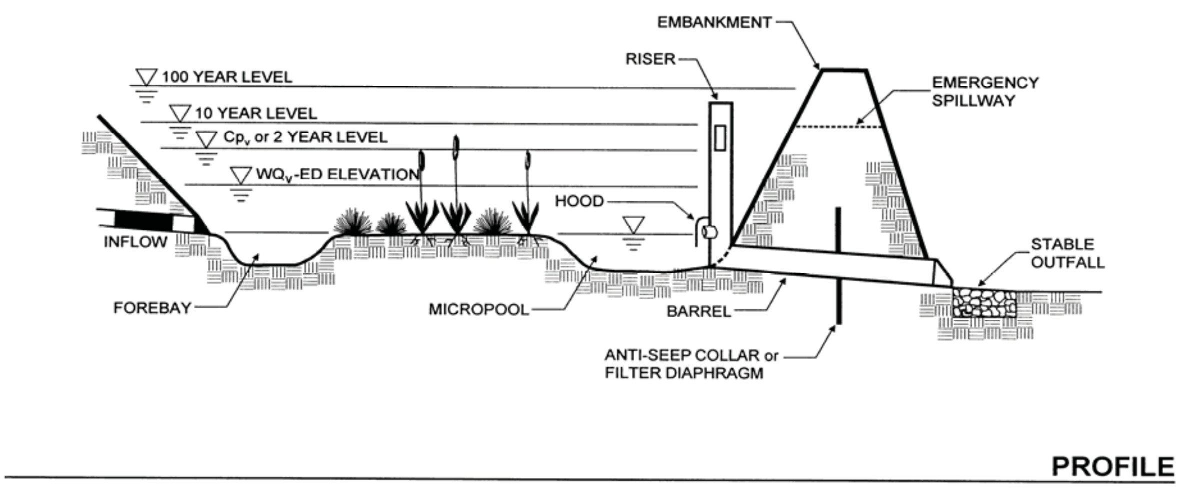

Schematic of an Extended Detention Basin (MDE, 2000)

Vegetated Swale

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

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- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.

- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.

- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.

- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data

Study	Removal Efficiencies (% Removal)						Type
	TSS	TP	TN	NO_3	Metals	Bacteria	
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f] ..	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC. 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	\$0.85 / 1,000 ft^2/ mowing	\$0.14 / linear foot	\$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	\$9.00 / 1,000 ft^2/ year	\$0.18 / linear foot	\$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	\$0.10 / linear foot / year	\$0.10 / linear foot	\$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	\$0.30 / yd^2	\$0.01 / linear foot	\$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	\$0.15 / linear foot / year, plus \$25 / inspection	\$0.15 / linear foot	\$0.15 / linear foot	Inspect four times per year
Total	--	**\$0.58 / linear foot**	**\$ 0.75 / linear foot**	—

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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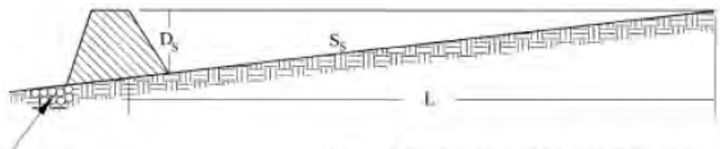
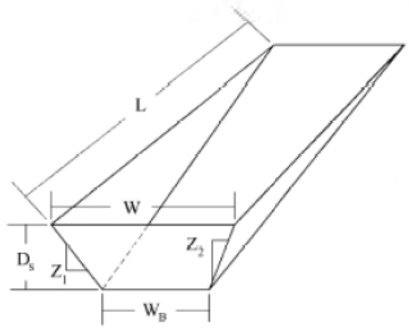


(a) **Cross section of swale with check dam.**



(b) **Dimensional view of swale impoundment area.**

Notation:

L = Length of swale impoundment area per check dam (ft)
D_S = Depth of check dam (ft)
S_S = Bottom slpe of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1\&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Vegetated Buffer Strip

Design Considerations

- Tributary Area
- Slope
- Water Availability
- Aesthetics

Description

Grassed buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure. Consequently, there is little resistance to their use.

California Experience

Caltrans constructed and monitored three vegetated buffer strips in southern California and is currently evaluating their performance at eight additional sites statewide. These strips were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the southern California sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- Buffers require minimal maintenance activity (generally just erosion prevention and mowing).
- If properly designed, vegetated, and operated, buffer strips can provide reliable water quality benefits in conjunction with high aesthetic appeal.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	●
☑	Trash	▲
☑	Metals	■
☑	Bacteria	●
☑	Oil and Grease	■
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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- Flow characteristics and vegetation type and density can be closely controlled to maximize BMP effectiveness.
- Roadside shoulders act as effective buffer strips when slope and length meet criteria described below.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Buffer strips cannot treat a very large drainage area.
- A thick vegetative cover is needed for these practices to function properly.
- Buffer or vegetative filter length must be adequate and flow characteristics acceptable or water quality performance can be severely limited.
- Vegetative buffers may not provide treatment for dissolved constituents except to the extent that flows across the vegetated surface are infiltrated into the soil profile.
- This technology does not provide significant attenuation of the increased volume and flow rate of runoff during intense rain events.

Design and Sizing Guidelines

- Maximum length (in the direction of flow towards the buffer) of the tributary area should be 60 feet.
- Slopes should not exceed 15%.
- Minimum length (in direction of flow) is 15 feet.
- Width should be the same as the tributary area.
- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install strips at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be required.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

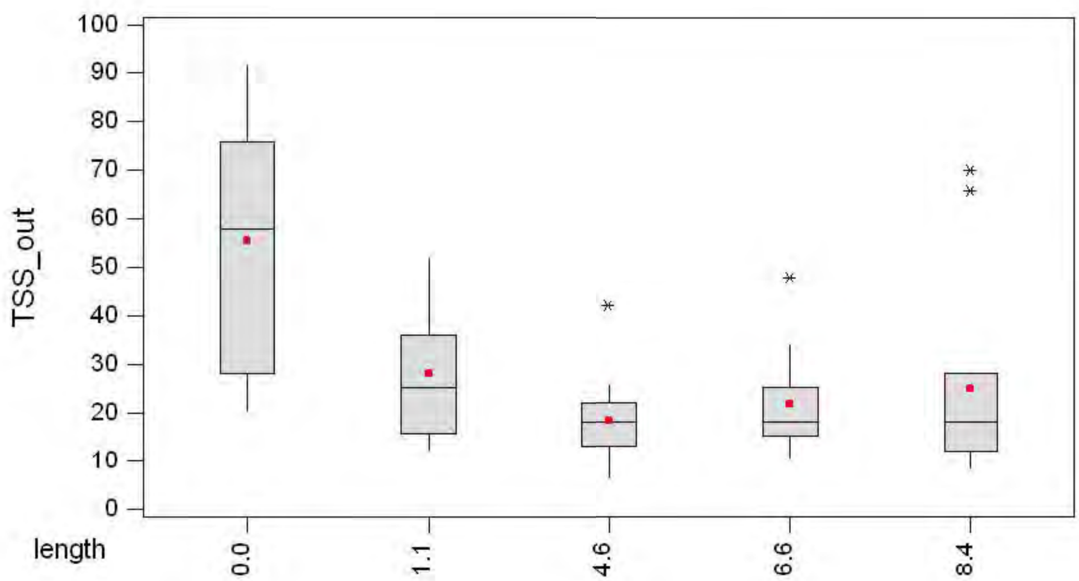
Vegetated buffer strips tend to provide somewhat better treatment of stormwater runoff than swales and have fewer tendencies for channelization or erosion. Table 1 documents the pollutant removal observed in a recent study by Caltrans (2002) based on three sites in southern California. The column labeled "Significance" is the probability that the mean influent and effluent EMCs are not significantly different based on an analysis of variance.

The removal of sediment and dissolved metals was comparable to that observed in much more complex controls. Reduction in nitrogen was not significant and all of the sites exported phosphorus for the entire study period. This may have been the result of using salt grass, a warm weather species that is dormant during the wet season, and which leaches phosphorus when dormant.

Another Caltrans study (unpublished) of vegetated highway shoulders as buffer strips also found substantial reductions often within a very short distance of the edge of pavement. Figure 1 presents a box and whisker plot of the concentrations of TSS in highway runoff after traveling various distances (shown in meters) through a vegetated filter strip with a slope of about 10%. One can see that the TSS median concentration reaches an irreducible minimum concentration of about 20 mg/L within 5 meters of the pavement edge.

Table 1 Pollutant Reduction in a Vegetated Buffer Strip

Constituent	Mean EMC Influent (mg/L)	Mean EMC Effluent (mg/L)	Removal %	Significance P
TSS	119	31	74	<0.000
NO_3-N	0.67	0.58	13	0.367
TKN-N	2.50	2.10	16	0.542
Total N[a]	3.17	2.68	15	-
Dissolved P	0.15	0.46	-206	0.047
Total P	0.42	0.62	-52	0.035
Total Cu	0.058	0.009	84	<0.000
Total Pb	0.046	0.006	88	<0.000
Total Zn	0.245	0.055	78	<0.000
Dissolved Cu	0.029	0.007	77	0.004
Dissolved Pb	0.004	0.002	66	0.006
Dissolved Zn	0.099	0.035	65	<0.000



Filter strips also exhibit good removal of litter and other floatables because the water depth in these systems is well below the vegetation height and consequently these materials are not easily transported through them. Unfortunately little attenuation of peak runoff rates and volumes (particularly for larger events) is normally observed, depending on the soil properties. Therefore it may be prudent to follow the strips with another practice than can reduce flooding and channel erosion downstream.

Siting Criteria

The use of buffer strips is limited to gently sloping areas where the vegetative cover is robust and diffuse, and where shallow flow characteristics are possible. The practical water quality benefits can be effectively eliminated with the occurrence of significant erosion or when flow concentration occurs across the vegetated surface. Slopes should not exceed 15 percent or be less than 1 percent. The vegetative surface should extend across the full width of the area being drained. The upstream boundary of the filter should be located contiguous to the developed area. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc) to facilitate overland sheet flow is not normally recommended because of maintenance considerations and the potential for standing water.

Filter strips are applicable in most regions, but are restricted in some situations because they consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer or as pretreatment to a structural practice. In arid areas, however, the cost of irrigating the grass on the practice will most likely outweigh its water quality benefits, although aesthetic considerations may be sufficient to overcome this constraint. Filter strips are generally impractical in ultra-urban areas where little pervious surface exists.

Some cold water species, such as trout, are sensitive to changes in temperature. While some treatment practices, such as wet ponds, can warm stormwater substantially, filter strips do not are not expected to increase stormwater temperatures. Thus, these practices are good for protection of cold-water streams.

Filter strips should be separated from the ground water by between 2 and 4 ft to prevent contamination and to ensure that the filter strip does not remain wet between storms.

Additional Design Guidelines

Filter strips appear to be a minimal design practice because they are basically no more than a grassed slope. In general the slope of the strip should not exceed 15fc% and the strip should be at least 15 feet long to provide water quality treatment. Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion. The top of the strip should be installed 2-5 inches below the adjacent pavement, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.

A major question that remains unresolved is how large the drainage area to a strip can be. Research has conclusively demonstrated that these are effective on roadside shoulders, where the contributing area is about twice the buffer area. They have also been installed on the perimeter of large parking lots where they performed fairly effectively; however much lower slopes may be needed to provide adequate water quality treatment.

The filter area should be densely vegetated with a mix of erosion-resistant plant species that effectively bind the soil. Native or adapted grasses, shrubs, and trees are preferred because they generally require less fertilizer and are more drought resistant than exotic plants. Runoff flow velocities should not exceed about 1 fps across the vegetated surface.

For engineered vegetative strips, the facility surface should be graded flat prior to placement of vegetation. Initial establishment of vegetation requires attentive care including appropriate watering, fertilization, and prevention of excessive flow across the facility until vegetation completely covers the area and is well established. Use of a permanent irrigation system may help provide maximal water quality performance.

In cold climates, filter strips provide a convenient area for snow storage and treatment. If used for this purpose, vegetation in the filter strip should be salt-tolerant (e.g., creeping bentgrass), and a maintenance schedule should include the removal of sand built up at the bottom of the slope. In arid or semi-arid climates, designers should specify drought-tolerant grasses to minimize irrigation requirements.

Maintenance

Filter strips require mainly vegetation management; therefore little special training is needed for maintenance crews. Typical maintenance activities and frequencies include:

- Inspect strips at least twice annually for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall run-off to be sure the strip is ready for winter. However, additional inspection after periods of heavy run-off is most desirable. The strip should be checked for debris and litter and areas of sediment accumulation.

- Recent research on biofiltration swales, but likely applicable to strips (Colwell et al., 2000), indicates that grass height and mowing frequency have little impact on pollutant removal;

consequently, mowing may only be necessary once or twice a year for safety and aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in strip areas, particularly along highways. The need for litter removal should be determined through periodic inspection but litter should always be removed prior to mowing.

- Regularly inspect vegetated buffer strips for pools of standing water. Vegetated buffer strips can become a nuisance due to mosquito breeding in level spreaders (unless designed to dewater completely in 48-72 hours), in pools of standing water if obstructions develop (e.g. debris accumulation, invasive vegetation), and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available on the actual construction costs of filter strips. One rough estimate can be the cost of seed or sod, which is approximately 30¢ per ft^2 for seed or 70¢ per ft^2 for sod. This amounts to between $13,000 and $30,000 per acre of filter strip. This cost is relatively high compared with other treatment practices. However, the grassed area used as a filter strip may have been seeded or sodded even if it were not used for treatment. In these cases, the only additional cost is the design. Typical maintenance costs are about $350/acre/year (adapted from SWRPC, 1991). This cost is relatively inexpensive and, again, might overlap with regular landscape maintenance costs.

The true cost of filter strips is the land they consume. In some situations this land is available as wasted space beyond back yards or adjacent to roadsides, but this practice is cost-prohibitive when land prices are high and land could be used for other purposes.

Maintenance Cost

Maintenance of vegetated buffer strips consists mainly of vegetation management (mowing, irrigation if needed, weeding) and litter removal. Consequently the costs are quite variable depending on the frequency of these activities and the local labor rate.

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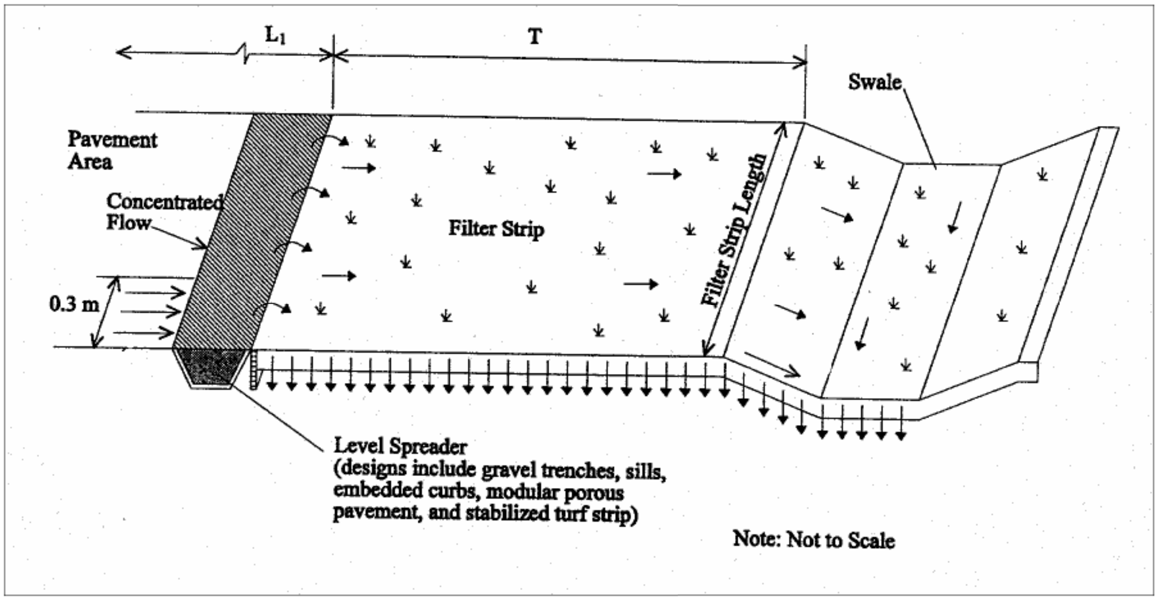
L1
T
Swale
Pavement Area
Concentrated Flow
Filter Strip
Filter Strip Length
0.3 m
Level Spreader
(designs include gravel trenches, sills, embedded curbs, modular porous pavement, and stabilized turf strip)
Note: Not to Scale

APPENDIX G – STORM WATER MANAGEMENT PLAN CERTIFICATION SHEET

- SWMP Certification Sheet

ATTACHMENT H

CERTIFICATION SHEET

This Stormwater Management Plan has been prepared under the direction of the following Registered Civil Engineer. The Registered Civil Engineer attests to the technical information contained herein and the engineering data upon which recommendations, conclusions, and decisions are based.

________________________________ ______________

Date

Geo-Logic
ASSOCIATES
Geologists, Hydrogeologists and Engineers

January 25, 2010
JN: 2009-254

HDR, Inc.
2751 Prosperity Avenue, Suite 200
Fairfax, Virginia 22031

Attention: Ms. Shannon D'Agostino, Senior Environmental Project Manager

GROUNDWATER RESOURCES
TULE WIND PROJECT
EAST SAN DIEGO COUNTY, CALIFORNIA

At your request, Geo-Logic Associates (GLA) is pleased to present our estimation of the potable water needs and the "performance standard" required for the Tule Wind Project. The construction related water source will be provided by a separate water supply, and is not included in the discussion herein. GLA understands that Pacific Wind Development LLC, a wholly owned subsidiary of Iberdrola Renewables (IBR), is proposing to construct and operate the Tule Wind Project located near Boulevard, California, in eastern San Diego County. The project will include the operation of 124 wind turbines and associated roads, transmission lines and support facilities. Once operational, the project will require routine system operations and maintenance (O&M) services. The O&M services and critical spare parts will be housed in an approximately 5000 square foot O&M building and staffed with up to 10 technicians. Currently this building is proposed to be built adjacent to the collector station on a 5-acre parcel of land owned by the federal Bureau of Land Management (BLM) and located in portions of Sections 18 and 19 of T16S, R7E. GLA understands that the land proposed for this project is currently undeveloped.

Once operational, the O&M building will require a continuous source of potable water. This area is not supplied by a potable water supply service and review of available San Diego County well data indicates that there are no water wells in a reasonable distance of the proposed O&M building. Therefore, it is proposed that a water well be drilled on the O&M building parcel to supply potable water to this building. Based on an estimated need of 2500 gallons of water per day, the well must be capable of supplying water at a rate of approximately 2 gallons per minute (gpm).

The project site is located on a crystalline granitic bedrock highland on the eastern slope of McCain Valley. Groundwater in this area may occur in the shallow alluvium within the McCain Valley and at depth within the fractures in the crystalline bedrock. Based on the location of the proposed O&M building, it is anticipated that the source of water will be obtained from within the fractured crystalline bedrock. Typically wells drilled within fractured bedrock yield relatively low production capacities, often from only one or a few water-bearing fractures. Since the proposed well's production is anticipated to be fracture-dependent, it is difficult to estimate its potential production rate. In fact, of 750 fractured rock well records in the County of San Diego, the median well yield reported was approximately 15 gpm, though a range from less than 3 gpm to over 100 gpm have been reported[1].

Assuming that the proposed well will yield groundwater in sufficient quantities to support the O&M Building needs, review of available County records indicates that there are no nearby receptors to this area. In addition, there are no surface water bodies or agricultural operations in the vicinity of the proposed O&M building that would be impacted by the withdrawal of this volume of water from the proposed fractured crystalline bedrock well. In a phone conversation, the San Diego County hydrogeologist indicated that no special County oversight (other than standard County well permitting procedures) would be required for drilling the proposed well since the relatively low (2 gpm) pumping rate would not pose an impact to groundwater resources in the area and the volumes to be withdrawn are too small to exceed the anticipated recharge volume to the area and result in an overdraft condition. Therefore, it is concluded that the drilling and withdrawal of 2 gpm poses no impact to human or biological receptors.

I hope that this short project description and discussion of the groundwater resources anticipated for the O&M building operations are helpful to you for the Tule Wind Project. If you have any questions, please give me a call.

Geo-Logic Associates

Sarah J Battelle

Sarah J. Battelle, CHG
Principal Geologist

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[1] County of San Diego, Guidelines for Determining Significance and Report Format and Content Requirements, Groundwater Resources, Land Use and Environment Group, Department of Planning and Land Use, Department of Public Works, March 19, 2007.