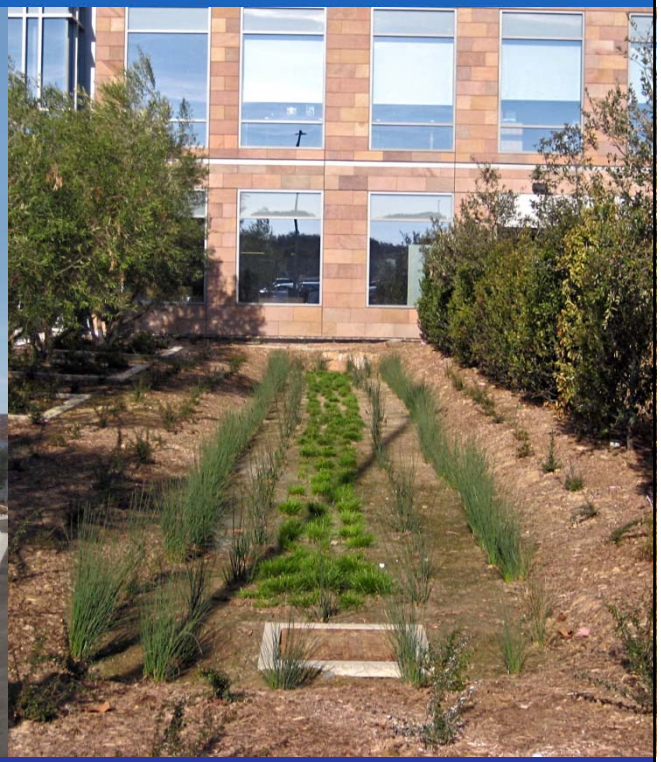
2-DAY SWMM TRAINING WORKSHOP

EXAMPLE PROJECT USING STORM WATER MANAGEMENT MODEL (SWMM) FOR HYDROMODIFICATION MANAGEMENT IN SAN DIEGO COUNTY



Presented by: Rick Engineering Company -- Water Resources Division | June 25, 2015

Day 2 Training Outline

- An example project will be detailed from start to finish during today's training. Several sections of the training will involve hands-on components.

TOPIC(S)	SPEAKER(S)
Design Approach and Layout Prepare Model Inputs	Brendan Hastie
Review of Local Performance Standard for Flow Control Requirements for Flow Control Facility Design	Laura Henry
Pre-project Model **Post-project (Unmitigated) Model**	Nobu Murakami
Post-processing: Pre- and Post-Unmitigated	Sharon Liu
Post-project (Mitigated Scenario 1) Model	Nobu Murakami
Post-processing: Post-project (Mitigated Scenario 1) **Post-project (Mitigated Scenario 2) Model** Post-processing: Post-project (Mitigated Scenario 2)	Sharon Liu
Example Project Summary	Brendan Hastie
Plan Check Module	Laura Henry
Q & A	All

DESIGN APPROACH AND LAYOUT

Definitions & Intent

STORMWATER REGULATION/PERMITS

Municipal Permit (MS4 - San Diego Region)

- Initially implemented in 2001
- Enforced through Storm Water Standards manuals for New Development and Redevelopment projects

Permit updated in 2007 added requirements:

- More effective Water Quality Treatment BMPs
- Low Impact Development (LID) design strategies
- Hydromodification Management Plan (HMP) criteria

Permit updated in 2013 added requirements:

- Even more effective Water Quality Treatment BMPs
- HMP to Natural Ground Cover

Definitions & Intent

WATER QUANTITY

Hydromodification

Any activity that increases the velocity and volume (flow rate), and often the timing, of runoff.

Detention Basin

The practice of holding stormwater runoff in ponds, vaults, within berms, or in depressed areas and letting it discharge slowly to the storm drain system.

Retention Basin

The practice of holding stormwater in ponds or basins, or within berms or depressed areas, and allowing it to slowly infiltrate into underlying soils. Some portion will evaporate.

Definitions & Intent

WATER QUALITY

Infiltration

The process by which water ponded or flowing over the land surface moves into the soil

Bioretention/Biofiltration

The use of plants and soils for removal of pollutants from stormwater runoff. Stormwater runoff entering the bioretention system is filtered through the soil planting bed before being either conveyed downstream by an underdrain system (i.e. biofiltration) or infiltrated into the existing subsoil below the soil bed (i.e. bioretention/infiltration). Vegetation in the soil planting bed provides uptake of pollutants and runoff and helps maintain the pores and associated infiltration rates of the soil in the bed.

Definitions & Intent:

Changes to Pollutant Control Requirements

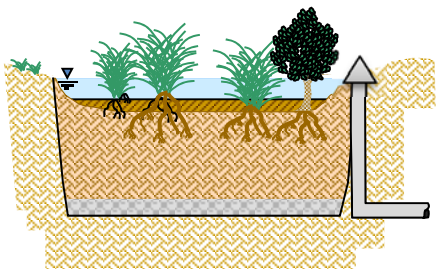
2013 Permit Pollutant Control Hierarchy:

- **Retain** onsite 85th percentile runoff (infiltrate, evaporate, evapotranspire, harvest and use)
  - Volume-based sizing – "Design Capture Volume" (DCV)
- **Biofiltration** if infeasible to retain runoff onsite
- Flow-thru treatment BMPs AND mitigate (off-site) for the DCV that was not retained onsite, if infeasible to retain or use biofiltration

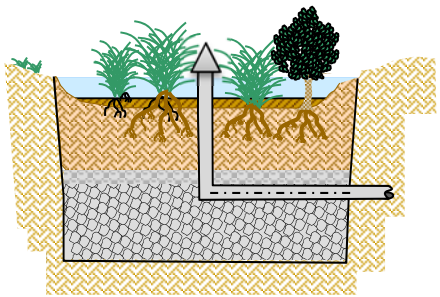
Definitions & Intent:

"Bioretention vs. Biofiltration"

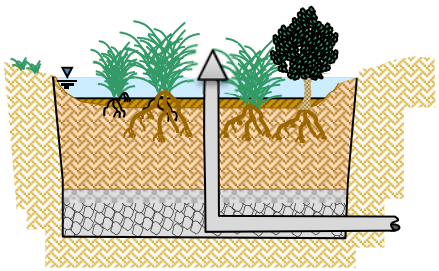
- Bioretention (full retention/infiltration)
- Biofiltration (partial retention/infiltration)
- Biofiltration (no retention/infiltration)



Bioretention:
No Underdrain



Biofiltration:
Raised Underdrain /
No Liner

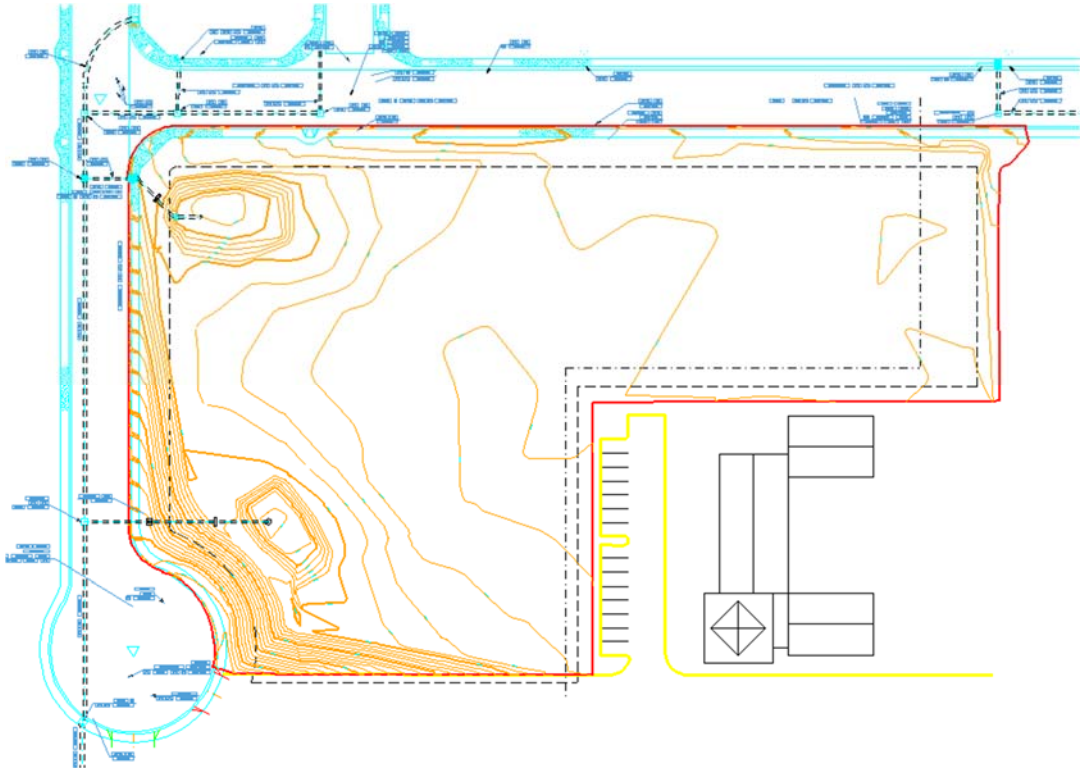


Biofiltration:
Underdrain at Bottom

Typical Design Concepts w/ Biofiltration

Project Evaluation for HMP

Existing Site:



Project Evaluation for HMP

Step 1 – Project HMP Requirements

- Is the project a “Priority Development Project”?
- If so, is it subject to HMP Requirements (i.e. – No Exemption)
- If so, are the downstream channels potentially more stable than “High Susceptibility”?

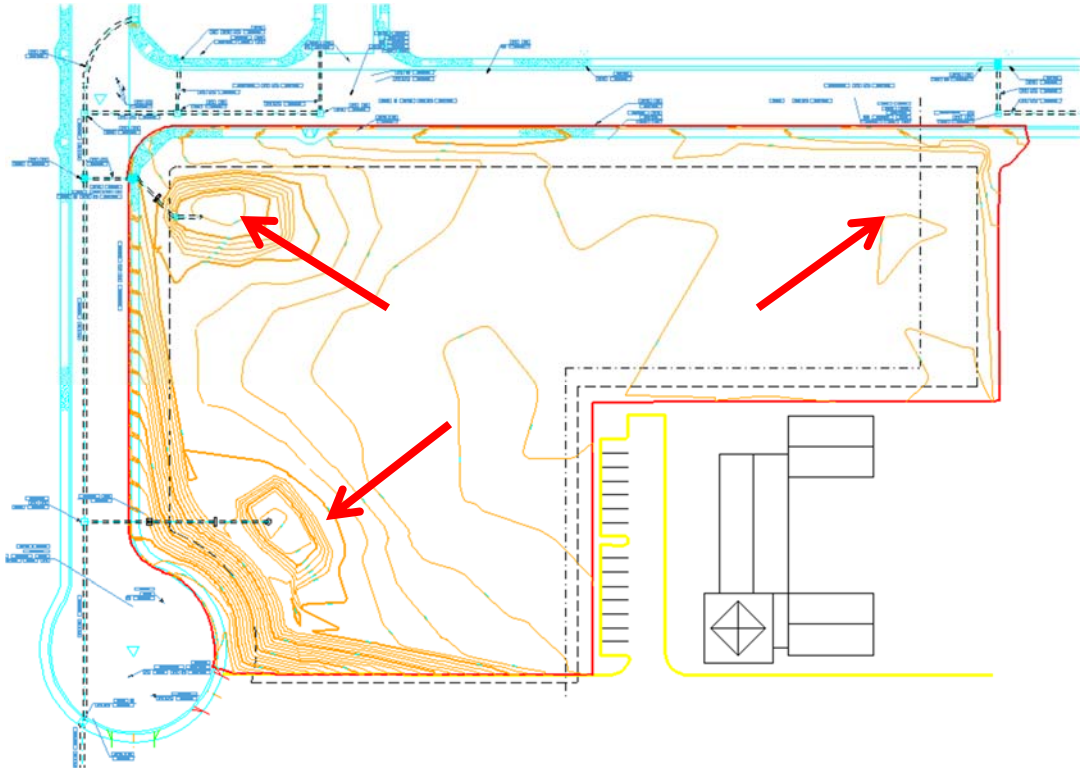
Project Evaluation for HMP

Step 2 – Design Approach to Structural BMPs

- Existing Drainage Patterns
- Downstream Storm Drain System(s) or Channels
- Conceptual Site Plan
- Evaluate BMP Types (Infiltration, Harvest & Use, Biofiltration)
- Develop Conceptual Layout for LID, WQ, HMP, and Drainage

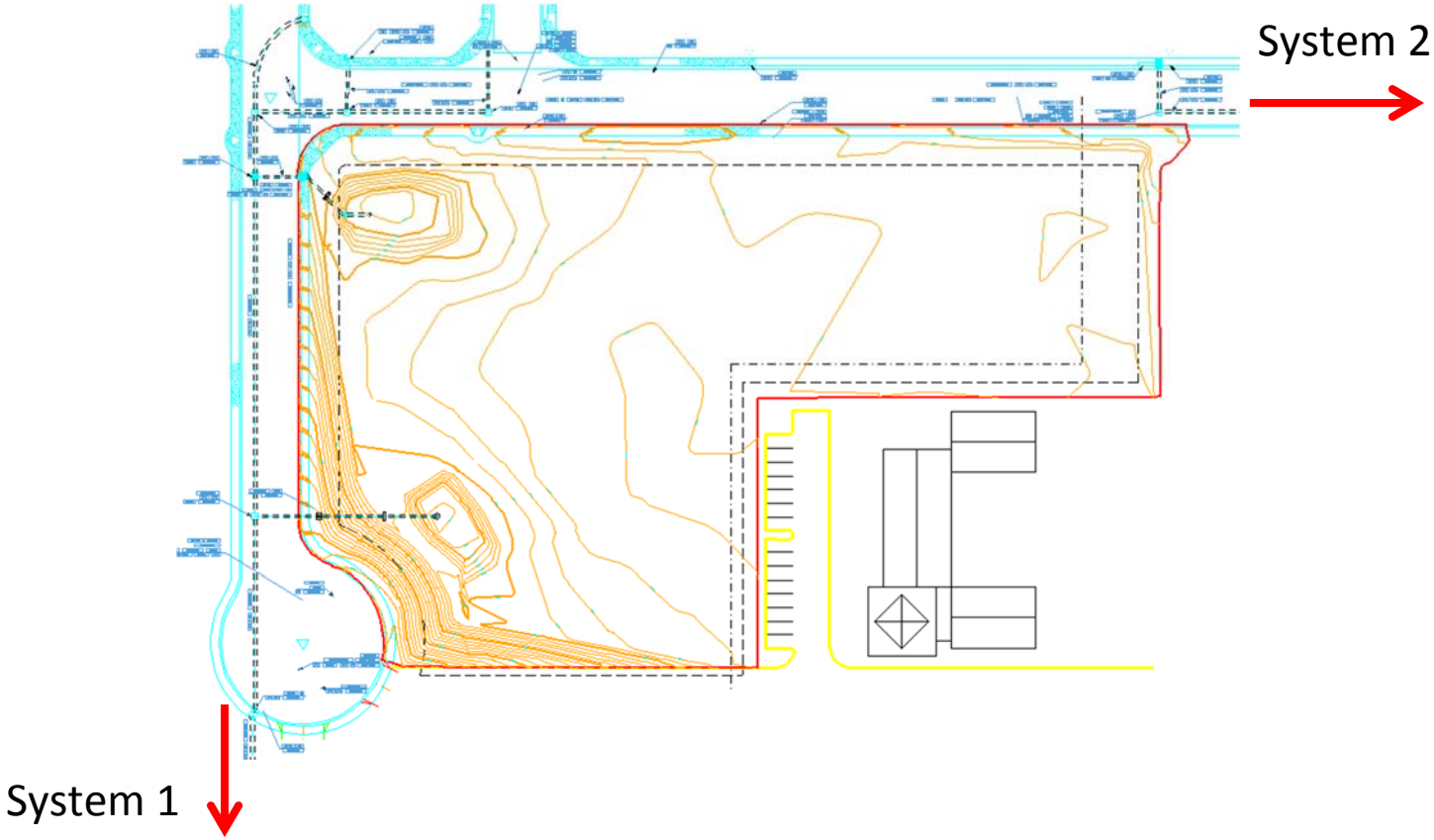
Project Evaluation for HMP

Existing Drainage Patterns:



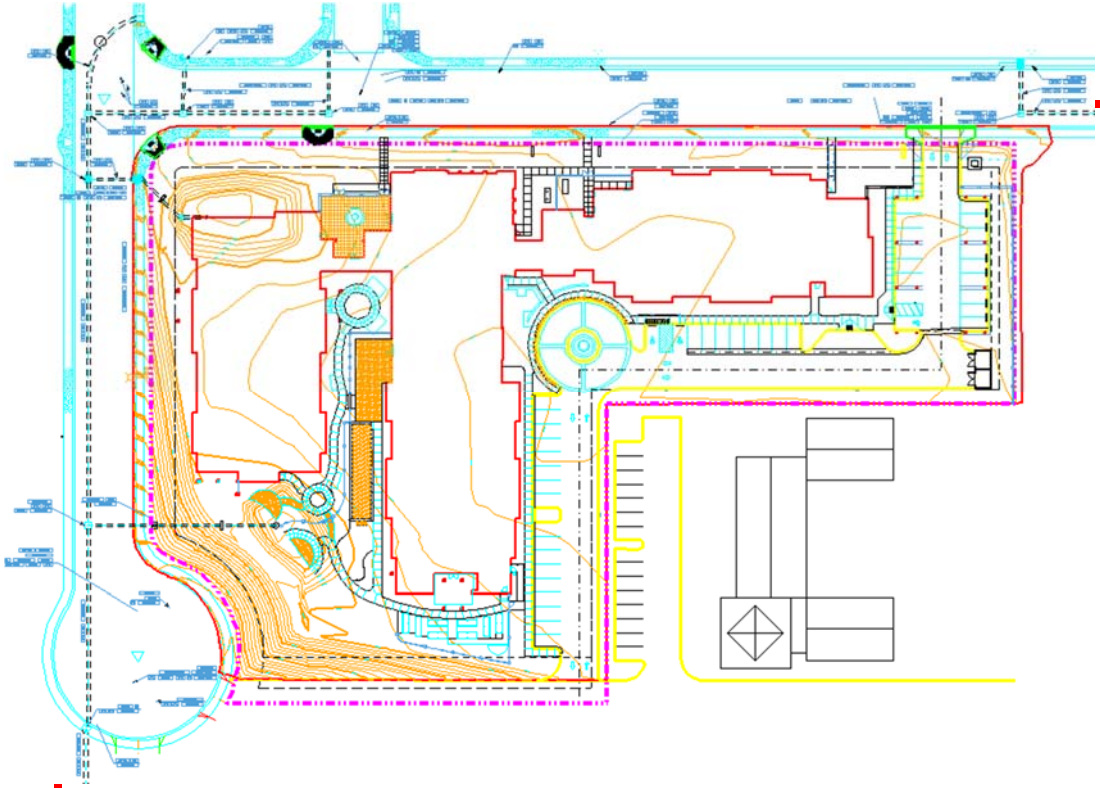
Project Evaluation for HMP

Downstream SD System:



Project Evaluation for HMP

Conceptual Site Plan:

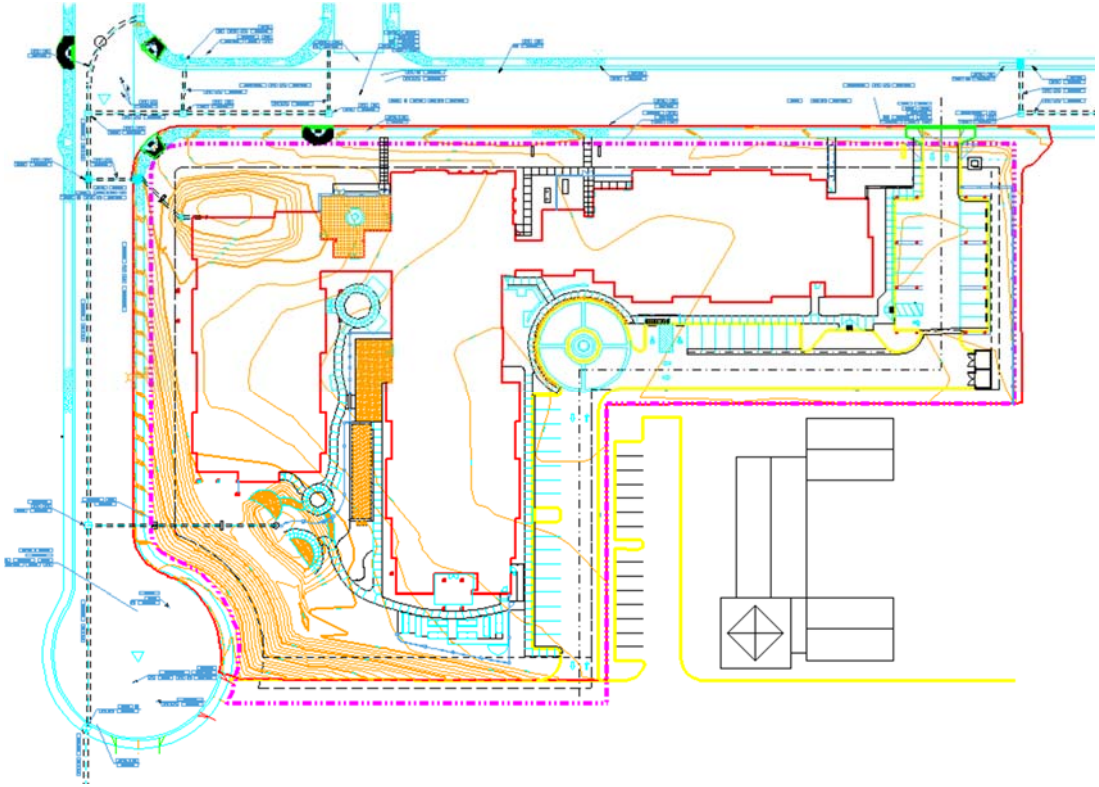


System 2

System 1

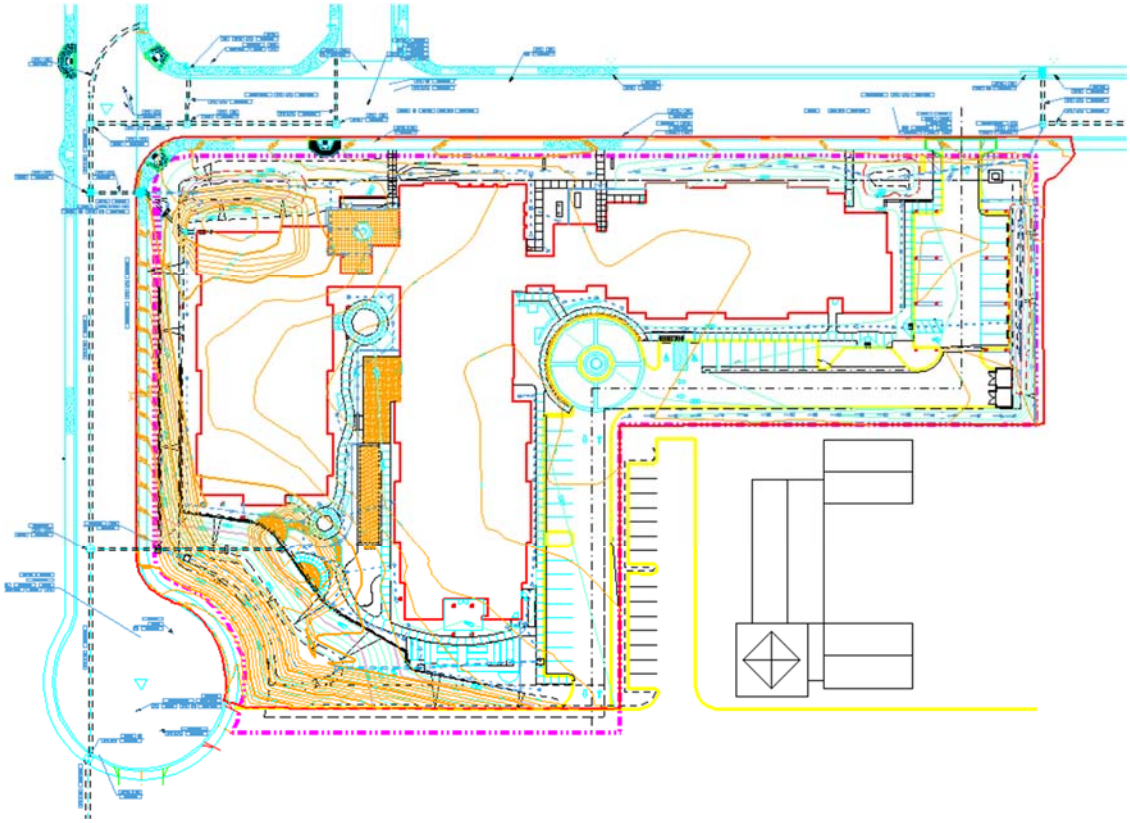
Project Evaluation for HMP

Evaluate BMP Types: Infiltration, Harvest and Use, Biofiltration

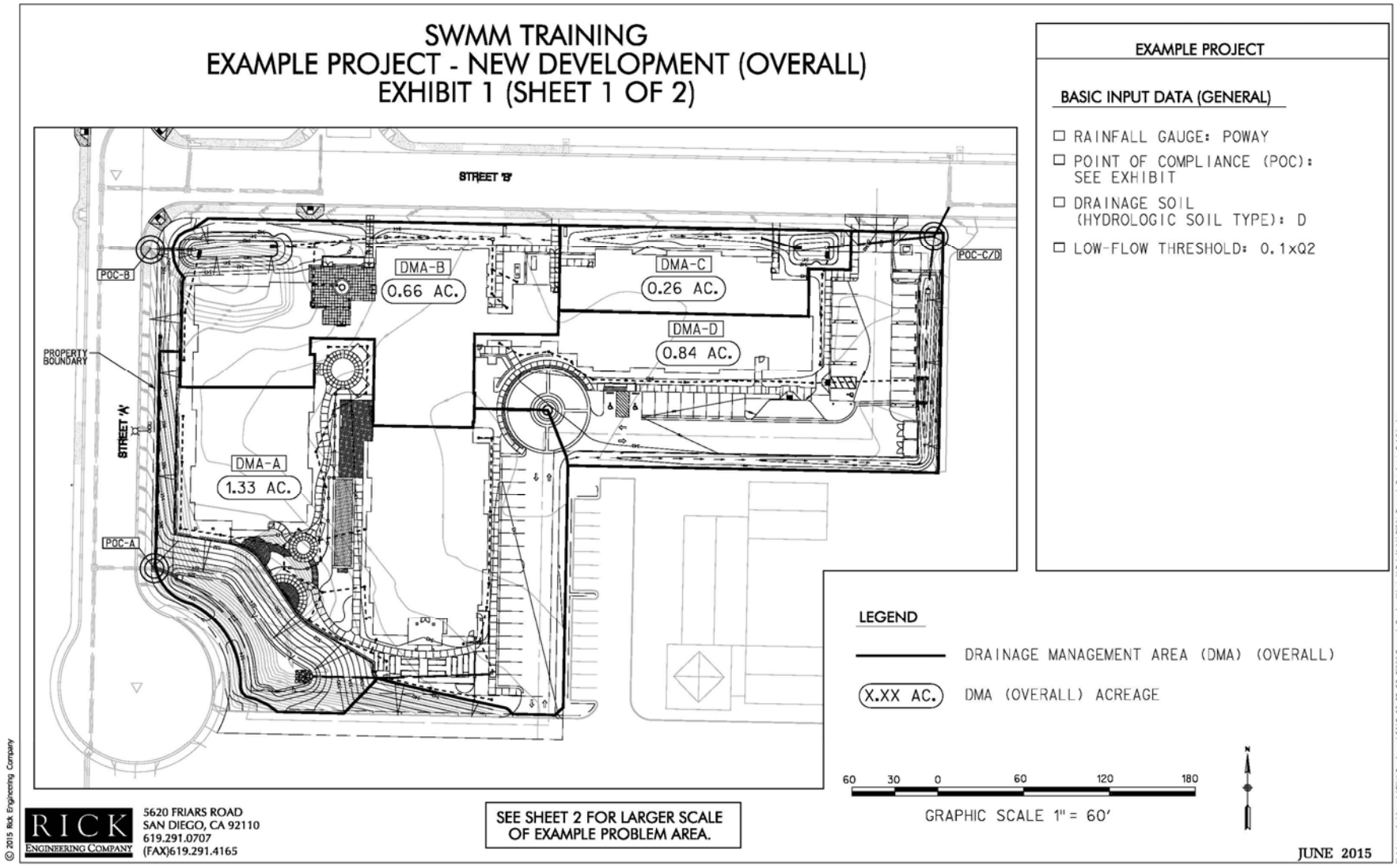


Project Evaluation for HMP

Conceptual Layout for LID, WQ, HMP, and Drainage:



Results for Preliminary BMP Layout



Example Project – Institutional Living

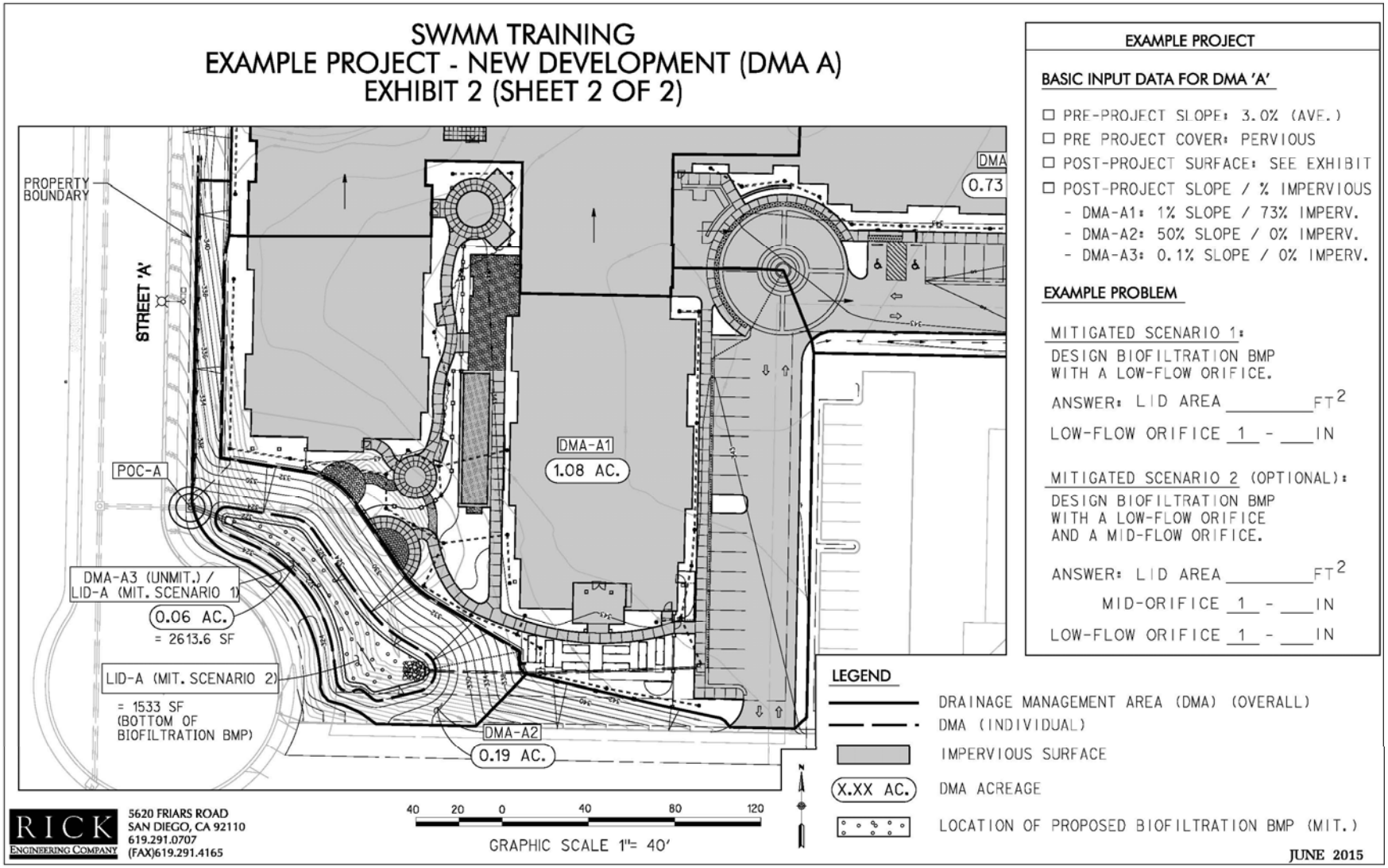
PREPARE MODEL INPUTS

Model Setup for HMP Analysis (DMA "A")

Required Input Parameters from Site Plan:

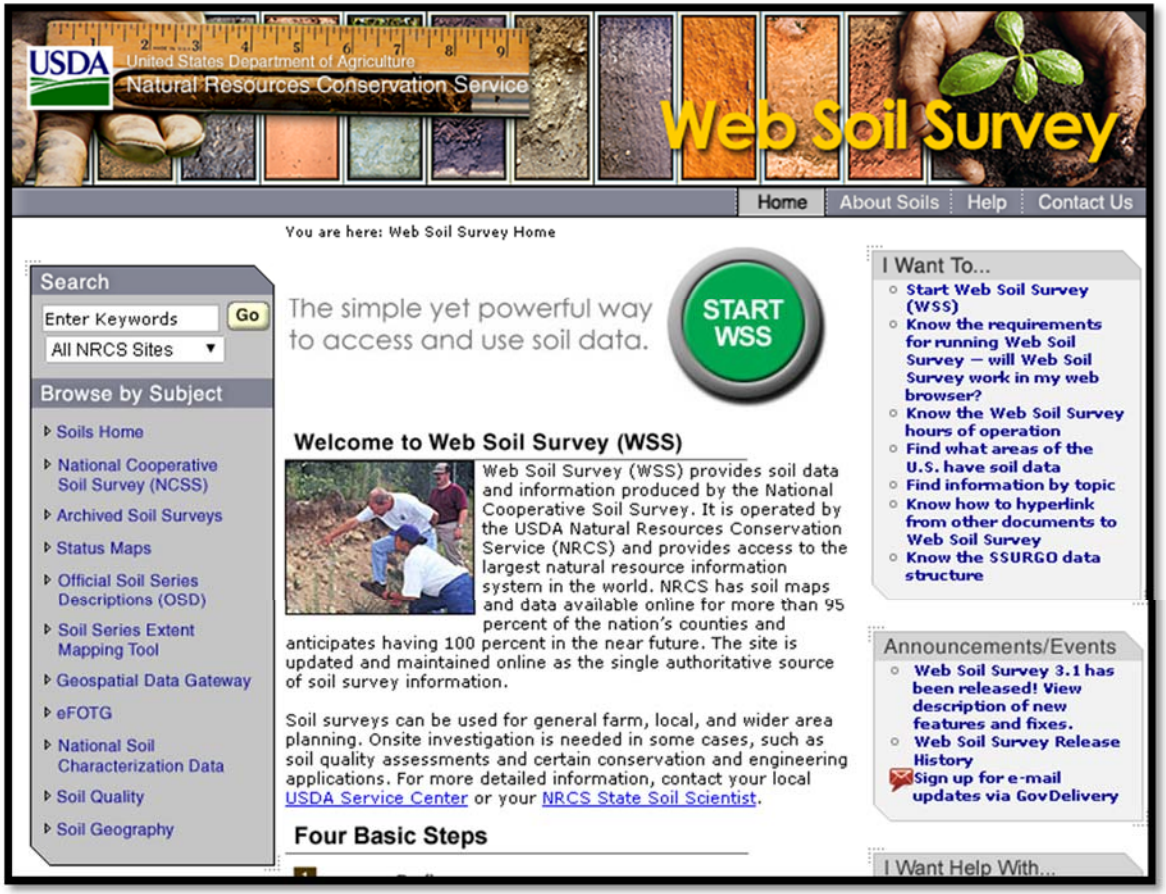
- Drainage Area to BMP
  - Soil Types
  - Slope
  - Impervious Cover

Model Setup for HMP Analysis (DMA "A")



Hydrologic Soil Group

- USDA Natural Resource Conservation Service (NRCS) websoilsurvey.sc.egov.usda.gov
- Use the Web Soil Survey (WSS) to obtain a summary report on Hydrologic Soil Group(s)

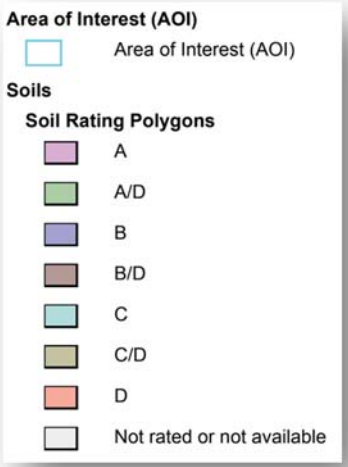


Web Soil Survey Report

- In WSS, generate a Hydrologic Soil Group Report for your project site ("Area of Interest (AOI)").
- If there are multiple "soil ratings," pro-rate the soil parameters as necessary based on the "Percent AOI."

Map

Legend



Soil Summary Table

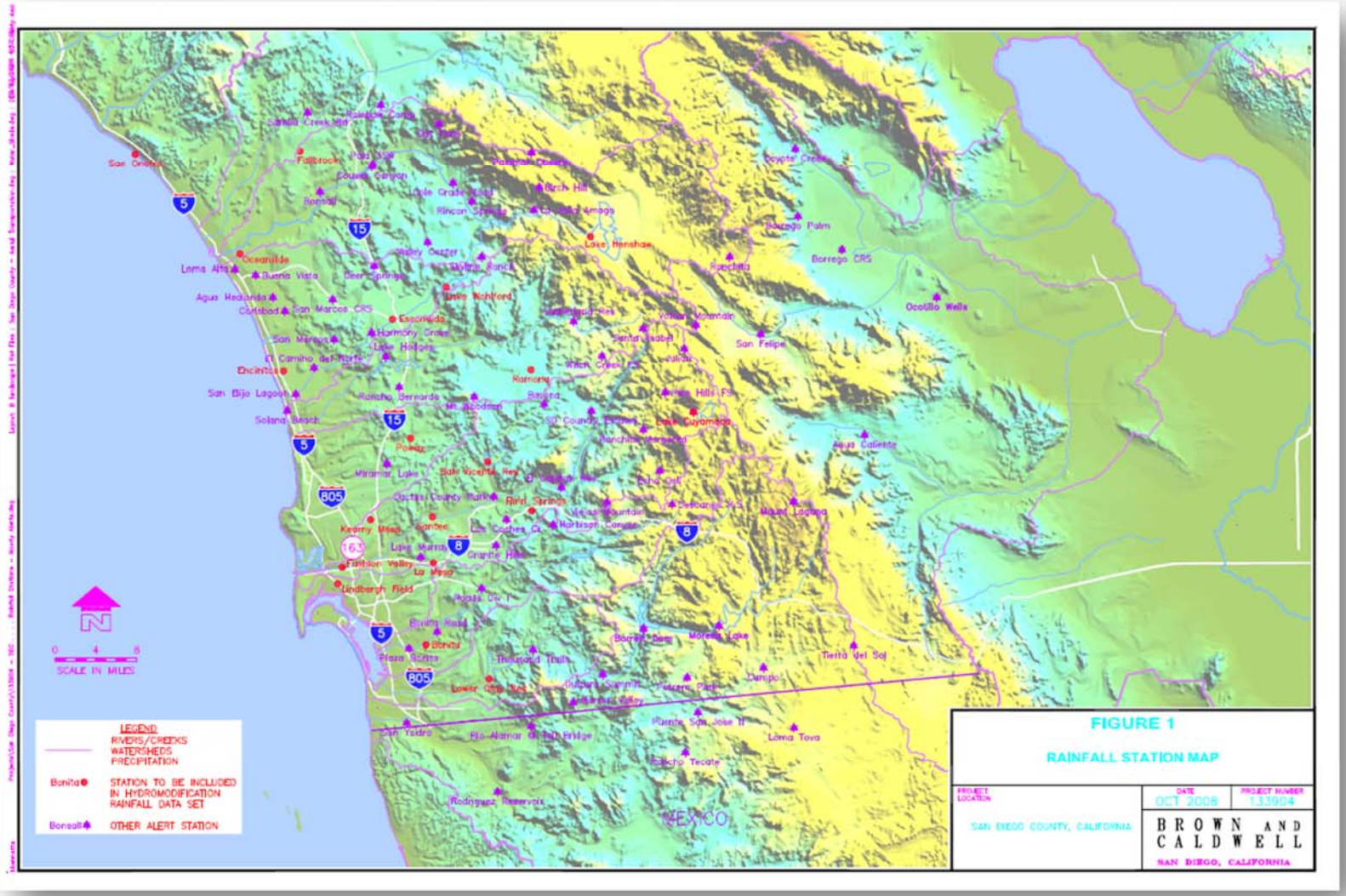
Hydrologic Soil Group— Summary by Map Unit — San Diego County Area, California (CA638)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
HrC	Huerhuero loam, 2 to 9 percent slopes	D	3.3	100.0%
Totals for Area of Interest			**3.3**	**100.0%**

Model Setup for HMP Analysis (DMA "A")

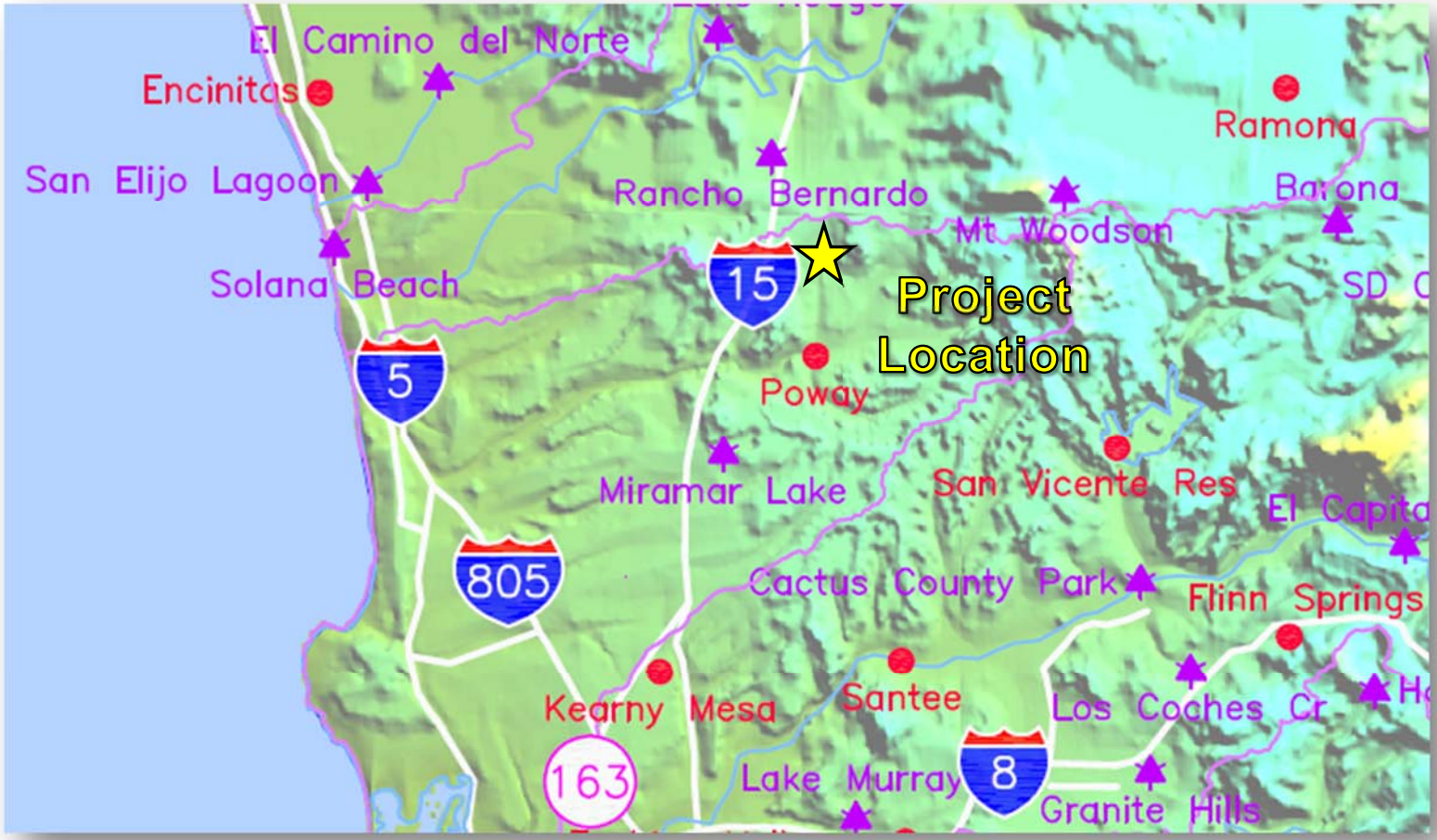
Required Input Parameters from Project Location:

- Historic Rainfall Data
- Evaporation Data
  - Regional Long-Term Averages

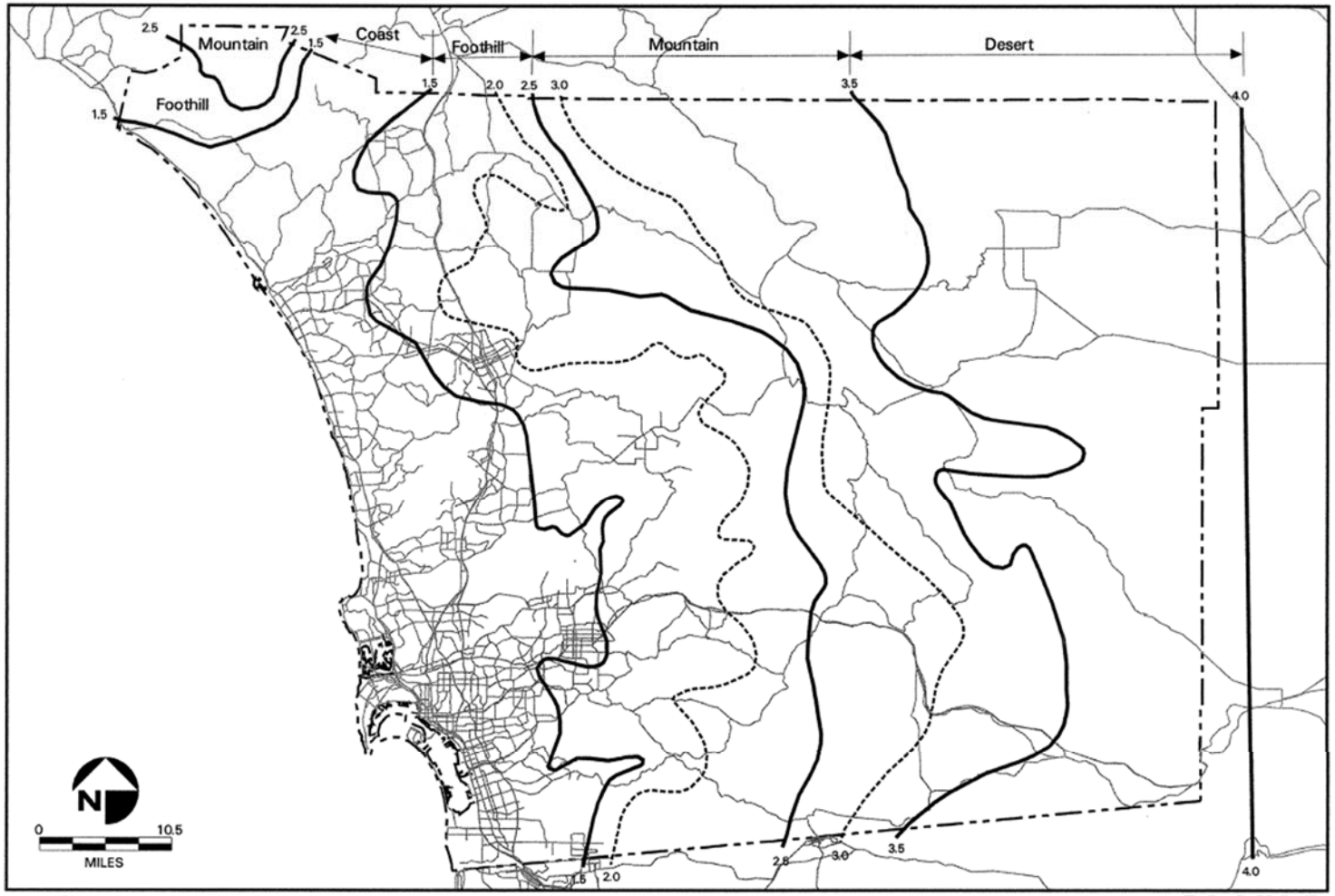
PROJECT CLEAN WATER
RAIN GAUGE MAP



PROJECT CLEAN WATER RAIN GAUGE MAP



2003 County of San Diego Hydrology Manual PZN Map



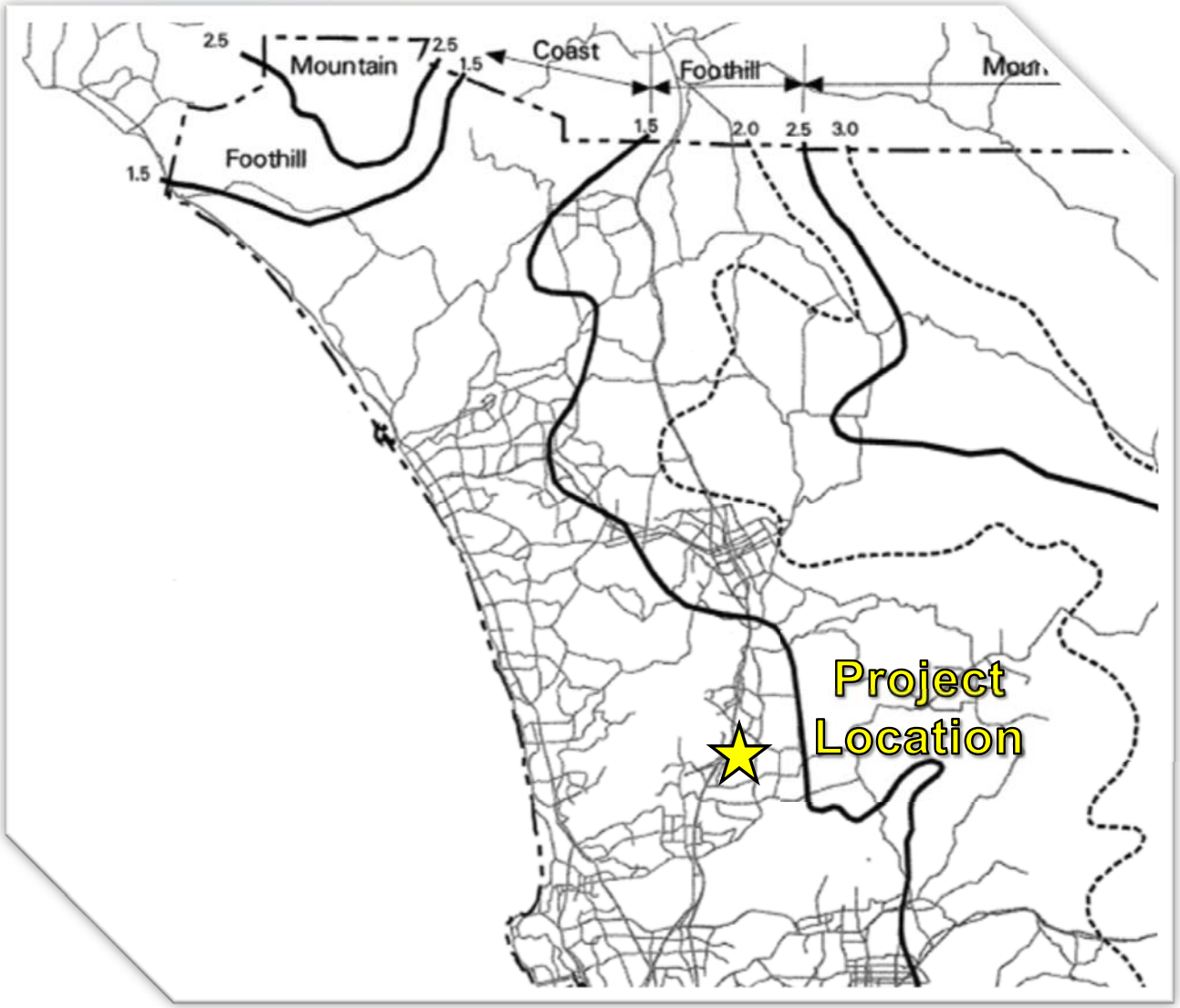
County of San Diego Hydrology Manual

Precipitation Zone Numbers (PZN)

FIGURE

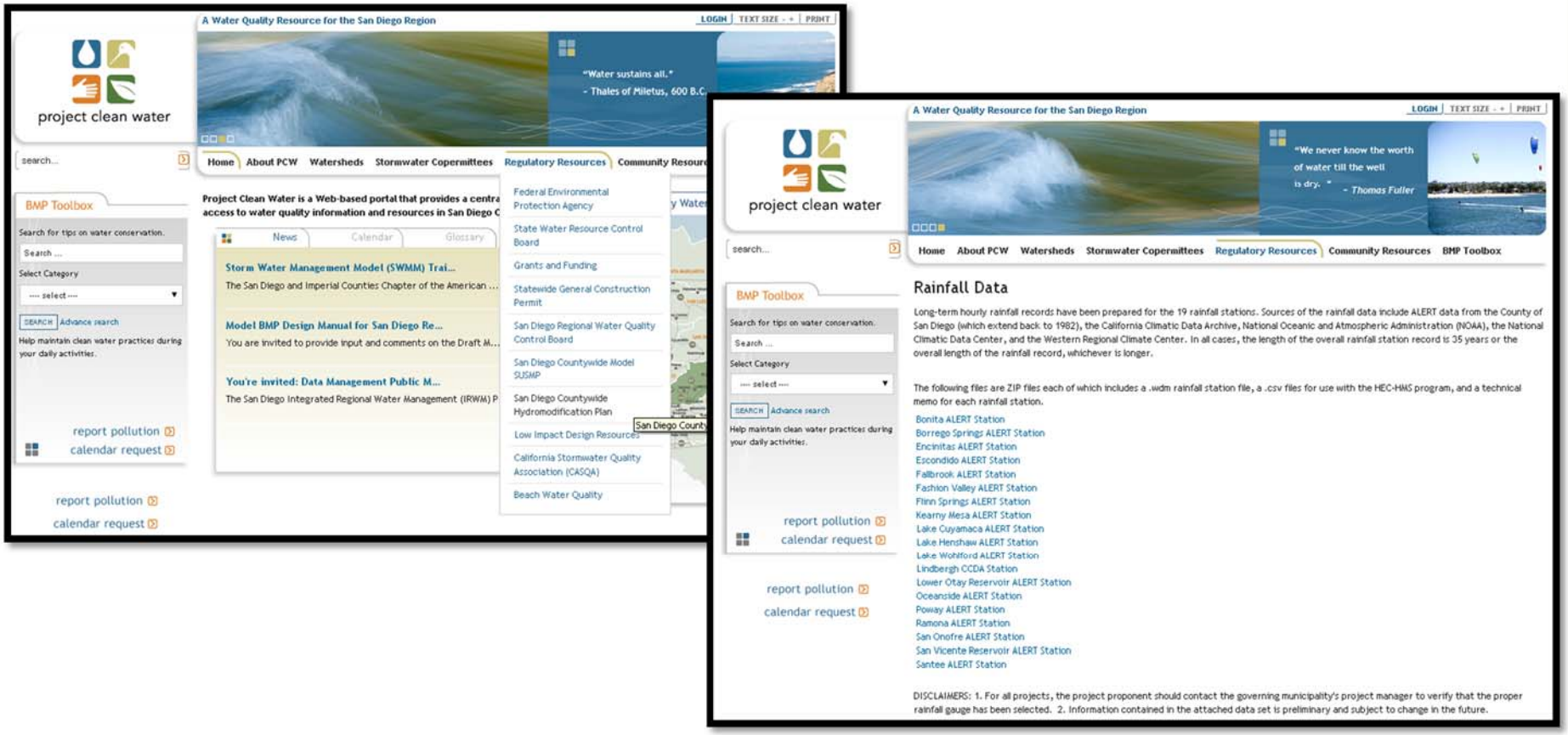
C-1

2003 County of San Diego Hydrology Manual PZN Map



Project Clean Water Rainfall Data

- Obtain the appropriate rainfall gage data from Project Clean Water
- Under “HMP Resources”, click on the “Rainfall Data” link
- Click the appropriate gage to download the data.



Format Rainfall Data

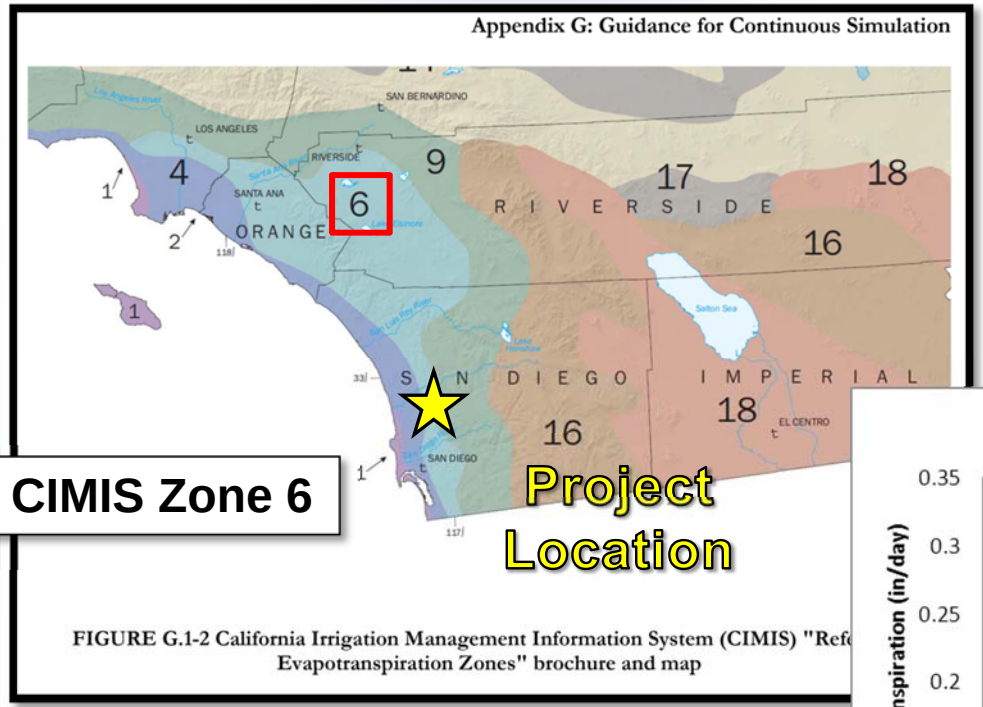
Download Rainfall Data (.zip) from Project Clean Water Website
Extract Data and open CSV file
Format the Data into Three Columns
"MM/DD/YYYY" | "HH:MM" | "PRECIP (IN.)"

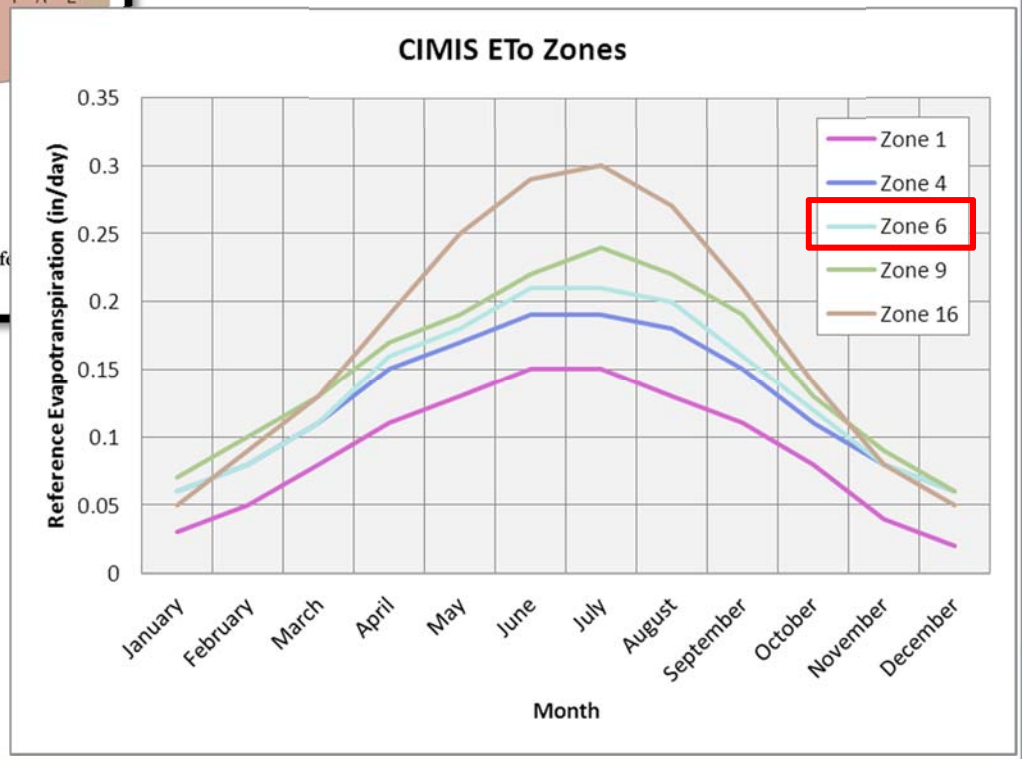
PCW RAW DATA **FORMATTED DATA**

A	B	C	D	E	F	G	H	I	J
10	4	1962	15	0.01	in	NNDC Lake Wolford	10/4/1962	15:00	0.01
10	4	1962	16	0.01	in	NNDC Lake Wolford	10/4/1962	16:00	0.01
12	17	1962	9	0.04	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/17/1962	9:00	0.04
12	18	1962	4	0.02	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/18/1962	4:00	0.02
12	18	1962	5	0.02	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/18/1962	5:00	0.02
12	18	1962	6	0.04	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/18/1962	6:00	0.04
12	18	1962	7	0.03	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/18/1962	7:00	0.03
12	18	1962	8	0.03	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/18/1962	8:00	0.03
12	18	1962	9	0.02	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/18/1962	9:00	0.02
12	19	1962	10	0.01	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/19/1962	10:00	0.01
12	20	1962	11	0.01	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	12/20/1962	11:00	0.01
1	9	1963	2	0.02	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	1/9/1963	2:00	0.02
1	9	1963	3	0.02	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	1/9/1963	3:00	0.02
1	9	1963	4	0.04	in	Poway CRS hrly 1962-73 (units corrected) (aggregated)	1/9/1963	4:00	0.04

Copy and Paste Formatted Data into Text File with .DAT extension (e.g. "poway.dat")

CIMIS Reference Evapotranspiration (ETo) Data





- Select California Irrigation Management Information System (CIMIS) "Reference Evapotranspiration Zone" based on project location

CIMIS Data – San Diego

Appendix G: Guidance for Continuous Simulation

Table G.1-1 Monthly Average Reference Evapotranspiration by ETo Zone
(inches/month and inches/day for use in SWMM Models for Hydromodification Management Studies in San Diego County
CIMIS Zones 1, 4, 6, 9, and 16 (See CIMIS ETo Zone Map)

	January	February	March	April	May	June	July	August	September	October	November	December
Zone	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month	in/month
1	0.93	1.4	2.48	3.3	4.03	4.5	4.65	4.03	3.3	2.48	1.2	0.62
4	1.86	2.24	3.41	4.5	5.27	5.7	5.89	5.58	4.5	3.41	2.4	1.86
6	1.86	2.24	3.41	4.8	5.58	6.3	6.51	6.2	4.8	3.72	2.4	1.86
9	2.17	2.8	4.03	5.1	5.89	6.6	7.44	6.82	5.7	4.03	2.7	1.86
16	1.55	2.52	4.03	5.7	7.75	8.7	9.3	8.37	6.3	4.34	2.4	1.55
	January	February	March	April	May	June	July	August	September	October	November	December
Days	31	28	31	30	31	30	31	31	30	31	30	31
Zone	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day	in/day
1	0.030	0.050	0.080	0.110	0.130	0.150	0.150	0.130	0.110	0.080	0.040	0.020
4	0.060	0.080	0.110	0.150	0.170	0.190	0.190	0.180	0.150	0.110	0.080	0.060
6	0.060	0.080	0.110	0.160	0.180	0.210	0.210	0.200	0.160	0.120	0.080	0.060
9	0.070	0.100	0.130	0.170	0.190	0.220	0.240	0.220	0.190	0.130	0.090	0.060
16	0.050	0.090	0.130	0.190	0.250	0.290	0.300	0.270	0.210	0.140	0.080	0.050

Use in/day

Model Setup for HMP Analysis- (DMA "A")

Additional Input Parameters for SWMM Modeling:

- Infiltration Model – Green-Ampt
- Routing Model – Kinematic Wave
- Subcatchment Parameters
  - Measure longest overland flow path
  - Calculating the width

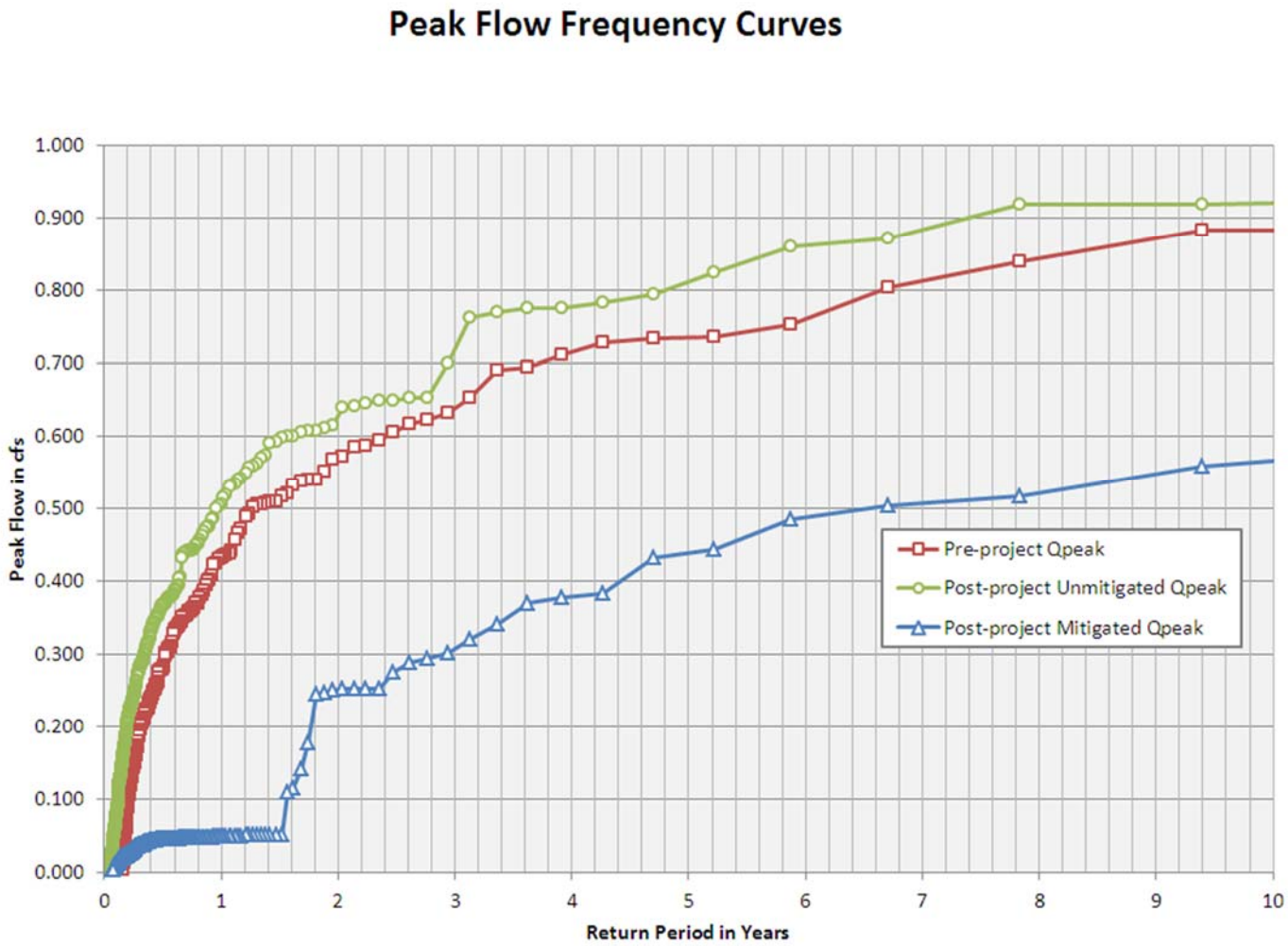
REVIEW OF LOCAL PERFORMANCE STANDARD FOR FLOW CONTROL AND REQUIREMENTS FOR FLOW CONTROL FACILITY DESIGN

Flow Control Performance Standard for Hydromodification Management

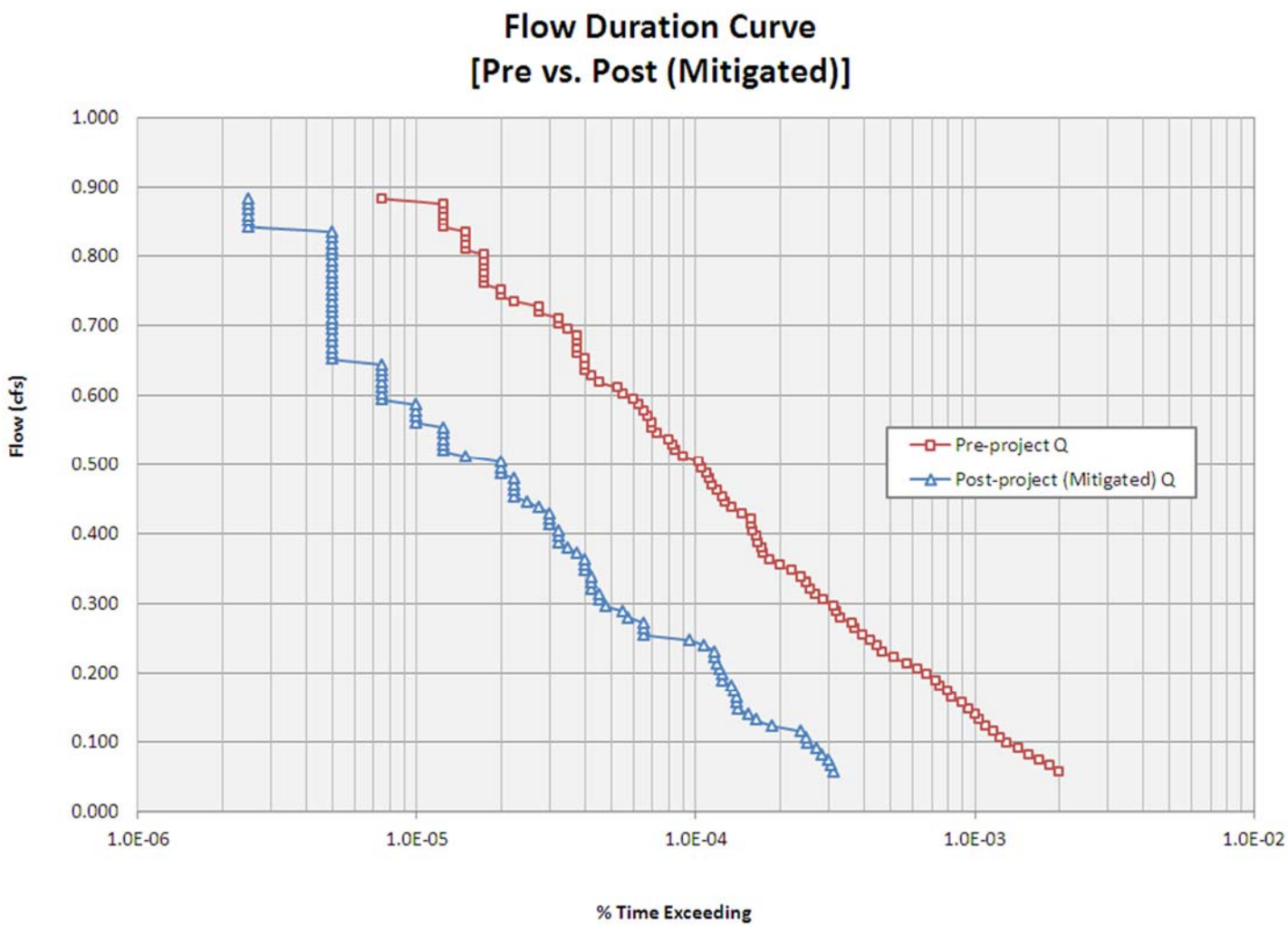
- For flow rates ranging from 10 percent, 30 percent or 50 percent of the pre-development 2-year runoff event ($0.1Q_2$, $0.3Q_2$, or $0.5Q_2$) to the pre-development 10-year runoff event (Q_{10}), the post-project discharge rates and durations shall not deviate above the pre-development rates and durations by more than 10 percent over and more than 10 percent of the length of the flow duration curve. The specific lower flow threshold will depend on the erosion susceptibility of the receiving stream for the project site.

- For flow rates ranging from the lower flow threshold to Q_5, the post-project peak flows shall not exceed pre-development peak flows. For flow rates from Q_5 to Q_{10}, post-project peak flows may exceed pre-development flows by up to 10 percent for a 1-year frequency interval. For example, post-project flows could exceed pre-development flows by up to 10 percent for the interval from Q_9 to Q_{10} or from $Q_{5.5}$ to $Q_{6.5}$, but not from Q_8 to Q_{10}.

Flow Control Performance Standard for Hydromodification Management



Flow Control Performance Standard for Hydromodification Management



General Requirements

- The flow control performance standard must be met for each natural or un-lined channel that will receive runoff from the project
- Runoff from offsite undeveloped areas should be routed around structural BMPs for flow control whenever feasible
- Structural BMPs for flow control must be designed to avoid trapping sediment from natural areas regardless of whether the natural areas are critical coarse sediment yield areas or not
- The 2013 MS4 Permit requires that post-project runoff be controlled to match pre-development conditions, not pre-project conditions

Pre-Project Condition vs. Pre-Development Condition

- **Pre-development condition** means approximate flow rates and durations that exist or existed onsite before land development occurs

- **Redevelopment PDPs:** Use available maps or development plans that depict the topography of the site prior to development, otherwise use existing onsite grades if historic topography is not available. Assume the infiltration characteristics of the underlying soil. Use available information pertaining to existing underlying soil type such as soil maps published by the Natural Resource Conservation Service (NRCS). Do not use runoff parameters for concrete or asphalt to estimate pre-development runoff conditions.

- **New development PDPs:** The pre-development condition typically equates to runoff conditions immediately before project construction. However if there is existing impervious area onsite, as with redevelopment, the new development project must not use runoff parameters for concrete or asphalt to estimate pre-development runoff conditions.

Range of Flows to Control

- The range of flows to control for hydromodification management depends on the erosion susceptibility of the receiving stream
  - $0.1Q_2$ to Q_{10} for projects discharging to streams with high susceptibility to erosion (and this is the default range of flows to control when a stream susceptibility study has not been prepared)
  - $0.3Q_2$ to Q_{10} for projects discharging to streams with medium susceptibility to erosion as determined by a stream susceptibility study
  - $0.5Q_2$ to Q_{10} for projects discharging to streams with low susceptibility to erosion as determined by a stream susceptibility study
- Use of a higher low flow threshold of $0.3Q_2$ or $0.5Q_2$ must be supported by a channel screening report

BMP Design Manual Guidance for Continuous Simulation Modeling

- Flow control facilities for hydromodification management must be designed based on continuous simulation modeling
- Guidance has been prepared in the Model BMP Design Manual Appendix G
  - Identifies acceptable models
  - Guidance for climatology input
  - Standards for rainfall loss parameters
  - Standards for physical characteristics of LID components
  - Guidance for demonstrating compliance with the flow control performance standard

Model BMP Design Manual

- Screen captures of *Appendix G: Guidance for Continuous Simulation* from the **DRAFT Model BMP Design Manual** are provided in the following slides as *reference* for training purposes.
- The **FINAL Model BMP Design Manual** (available soon) will provide final guidance on SWMM parameters.
- Refer to the Project Clean Water website for a copy of the Model BMP Design Manual.

Table G.1-4 Subcatchment Parameters for SWMM Studies for Hydromodification Management in San Diego

SWMM Parameter Name	Unit	Range	Use in San Diego
Name X-Coordinate Y-Coordinate Description Tag Rain Gage Outlet	N/A	N/A – project-specific	Project-specific
Area	acres (ac)	Project-specific	Project-specific
Width	feet (ft)	Project-specific	Project-specific
% Slope	percent (%)	Project-specific	Project-specific
% Imperv	percent (%)	Project-specific	Project-specific
N-imperv	--	0.011 – 0.024 presented in Table A.6 of SWMM Manual	default use 0.012 for smooth concrete, otherwise provide documentation of other surface consistent with Table A.6 of SWMM Manual
N-Perv	--	0.05 – 0.80 presented in Table A.6 of SWMM Manual	default use 0.15 for short prairie grass, otherwise provide documentation of other surface consistent with Table A.6 of SWMM Manual
Dstore-Imperv	inches	0.05 – 0.10 inches presented in Table A.5 of SWMM Manual	0.05
Dstore-Perv	inches	0.10 – 0.30 inches presented in Table A.5 of SWMM Manual	0.10
%ZeroImperv	percent (%)	0% – 100%	25%
Subarea routing	--	OUTLET IMPERVIOUS PERVIOUS	Project-specific, typically OUTLET
Percent Routed	%	0% – 100%	Project-specific, typically 100%
Infiltration	Method	HORTON GREEN_AMPT CURVE_NUMBER	GREEN_AMPT

Subcatchment and Infiltration Parameters

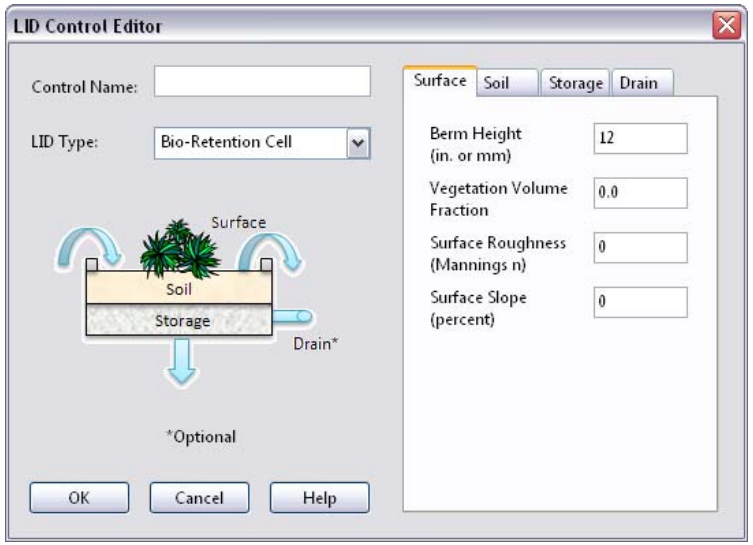
SWMM Parameter Name	Unit	Range	Use in San Diego
Suction Head (Green-Ampt)	Inches	1.93 – 12.60 presented in Table A.2 of SWMM Manual	Hydrologic Soil Group A: 1.5 Hydrologic Soil Group B: 3.0 Hydrologic Soil Group C: 6.0 Hydrologic Soil Group D: 9.0
Conductivity (Green-Ampt)	Inches per hour	0.01 – 4.74 presented in Table A.2 of SWMM Manual by soil texture class 0.00 – ≥0.45 presented in Table A.3 of SWMM Manual by hydrologic soil group	Hydrologic Soil Group A: 0.3 Hydrologic Soil Group B: 0.2 Hydrologic Soil Group C: 0.1 Hydrologic Soil Group D: 0.025
Initial Deficit (Green-Ampt)		The difference between soil porosity and initial moisture content. Based on the values provided in Table A.2 of SWMM Manual, the range for completely dry soil would be 0.097 to 0.375	Hydrologic Soil Group A: 0.30 Hydrologic Soil Group B: 0.31 Hydrologic Soil Group C: 0.32 Hydrologic Soil Group D: 0.33 Note: in long-term continuous simulation, this value is not important as the soil will reach equilibrium after a few storm events regardless of the initial moisture content specified.
Groundwater	yes/no	yes/no	NO
LID Controls			Project Specific
Snow Pack Land Uses Initial Buildup Curb Length			Not applicable to hydromodification management studies

Subcatchment and Infiltration Parameters (Continued)

Parameters for LID Control: Bio-Retention Cell

Table G.1-7 Parameters for SWMM "Bio-Retention Cell" Module for Hydromodification Management Studies in San Diego

SWMM Parameter Name	Unit	Use in San Diego
Surface		
Storage Depth	inches	Project-specific
Vegetative Cover Fraction	---	0
Surface Roughness	---	0 (this parameter is not applicable to bio-retention cell)
Surface Slope	---	0 (this parameter is not applicable to bio-retention cell)
Soil		
Thickness	inches	project-specific
Porosity	---	0.40
Field Capacity	---	0.2
Wilting Point	---	0.1
Conductivity	Inches/hour	5
Conductivity Slope	---	5
Suction Head	inches	1.5
Storage		
Height	inches	Project-specific
Void Ratio	---	0.67
Conductivity	Inches/hour	Conductivity from the storage layer refers to infiltration from the bottom of the structural BMP into the native soil. This variable is project-specific, see Section G.5.1. Use 0 if the bio-retention cell includes an impermeable liner
Clogging Factor	---	0
Underdrain		
Drain Coefficient	---	Project-specific
Drain Exponent	---	Project-specific, typically 0.5
Drain Offset Height	Inches	Project-specific



$$n = \frac{1}{1+e}$$

where: n = porosity
e = void ratio

Parameters for Engineered Soil Media

Table G.1-6 Characteristics of Sandy Loam to Represent Engineered Soil Media in Continuous Simulation for Hydromodification Management Studies in San Diego

Soil Texture	Porosity	Field Capacity	Wilting Point	Conductivity	Suction Head
Sandy Loam	0.4	0.2	0.1	5 inches/hour	1.5 inches

- Porosity is the volume of pore space (voids) relative to the total volume of soil (as a fraction).
- Field Capacity is the volume of pore water relative to total volume after the soil has been allowed to drain fully (as a fraction). Below this level, vertical drainage of water through the soil layer does not occur.
- Wilting point is the volume of pore water relative to total volume for a well dried soil where only bound water remains (as a fraction). The moisture content of the soil cannot fall below this limit.
- Conductivity is the hydraulic conductivity for the fully saturated soil (in/hr or mm/hr).
- Suction head is the average value of soil capillary suction along the wetting front (inches or mm).

Conductivity in the Subcatchment vs. Conductivity in the Structural BMP

- Subcatchment conductivity parameter (in the Green-Ampt infiltration method) is used to determine runoff from the subcatchment. Standard values based on NRCS hydrologic soil group are used.

- Conductivity parameter in the LID bio-retention cell soil represents transmission through the engineered soil. Standard value is 5 inches per hour.

- Conductivity parameter in the LID bio-retention cell storage represents infiltration from the bottom of the structural BMP into the native soil. This parameter is project-specific and must be determined based on methods presented in Appendix D of the manual.

Demonstrating Compliance
Flow Frequency

- Flow rates for hydromodification management must be based on partial duration analysis of the continuous hourly flow output
- Parse the continuous hourly flow data into discrete runoff events
- Rank the peak flows from each discrete flow event, and compute the return interval or plotting position for each event
- HMP and BMP Design Manual are flexible about methods for determining unique runoff events and plotting position

Demonstrating Compliance
Flow Duration

- Flow duration summary must be based on the entire length of the flow record
- Rank the entire hourly runoff time series output
- Extract the portion of the ranked hourly time series output from the lower flow threshold to the upper flow threshold
- Divide the applicable portion of the record into 100 equal flow bins
- Count the number of hours that fall into each flow bin

Next up- Model Setup

Next, let's setup **SWMM models** using these local HMP requirements for **peak flow rates** and **flow durations**.