SOUTH ORANGE COUNTY HYDROMODIFICATION MANAGEMENT PLAN (HMP)

April 1, 2015

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ACRONYMS

ACCCMP	Alameda Countywide Clean Water Program	OCHM	Orange County Hydrology Manual
BAHM	Bay Area Hydrology Model	PDP	Priority Development Project
BEHI	Bank Erosion Hazard Index	PLS	Pervious Land Surface
BMI	Benthic Macroinvertebrates Index	PWA	Philip Williams & Associates
BMP	Best Management Practice	S	Slope in Lane's equation
CASQA	California Stormwater Quality Association	Q or Qw	Flow
CCCWP	Contra Costa Clean Water Program	Qcrit - Qc	Critical flow
CEM	Channel Evolution Model	Qcp	Geomorphically critical flow – 10 percent of the 2-year flow
CEQA	California Environmental Quality Act	Qs	Sediment discharge in Lane's equation
D_{50}	Median grain size diameter	RWQCB	Regional Water Quality Control Board
Ep	Erosion potential index	SCCWRP	Southern California Coastal Water Research Project
ET	Evapotranspiration	SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
FSURMP	Fairfield-Suisun Urban Runoff Management Program	SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
GIS	Geographical Information System	STOPPP	San Mateo County Stormwater Pollution Prevention Program
HEC-HMS	Hydrologic Modeling System; distributed by the US Army Corps of Engineers Hydrologic Engineering Center	SSMP	Standard Stormwater Mitigation Plan
HMP	Hydromodification Management Plan	SUSMP	Standard Urban Stormwater Mitigation Plan
HR	Hydraulic Radius	SWM SWMM	Stanford Watershed Model Storm Water Management Model; distributed by USEPA
HSPF	Hydrologic Simulation Program FORTRAN, distributed by USEPA	SWMP	Storm Water Management Plan
IMP	Integrated Management Practices	SWWM	Storm Water Management Model
LEED	Leadership in Energy and Environmental Design	TMDL	Total Maximum Daily Load
LID	Low Impact Development	USACE	United States Army Corps of Engineers
LSPC	Loading Simulation Program in C++	USEPA	United States Environmental Protection Agency
MHHW	Mean Higher High Water	USGS	United States Geological Survey
NOAA	National Oceanic and Atmospheric Administration		
NPDES	National Pollutant Discharge Elimination System		
NRCS	Natural Resource Conservation Service		

1 Introduction

Hydromodification refers to changes in the magnitude and frequency of stream flows and its associated sediment load due to urbanization or other changes in the watershed land use and hydrology and the resulting impacts on receiving channels, such as erosion, sedimentation, and potentially degradation of in-stream habitat. The degree to which a channel will erode or aggrade is a function of the increase or decrease in work (shear stress), the resistance of the channel bed and bank materials – including vegetation (critical shear stress), the change in sediment delivery, and the geomorphic condition (soil lithology) of the channel. Critical shear stress is the shear stress threshold above which motion of bed material load is initiated. Not all flows cause significant movement of bed material—only those that generate shear stress in excess of the critical shear stress of the bank and bed materials. Urbanization increases the discharge rate, amount and timing of runoff, and associated shear stress exerted on the channel by stream flows and can trigger erosion in the form of incision (channel downcutting), widening (bank erosion), or both. Depths that generate shear below critical shear stress levels have no effect on the channel stability.

Program Provision F.1.h of the San Diego California Regional Water Quality Control Board (SDRWQCB) Permit Order R9-2009-0002 (Permit) required "…the Permittees to develop and implement a Hydromodification Management Plan (HMP) to manage increases in runoff discharge rates and durations from all Priority Development Projects." Where receiving stream channels are already unstable, hydromodification management can be thought of as a method to avoid accelerating or exacerbating existing problems. Where receiving stream channels are in a state of dynamic equilibrium, hydromodification management may prevent the onset of erosion, sedimentation, lateral bank migration, or impacts to in-stream vegetation.
The Permit contained certain requirements that strongly influence the methodology chosen in development of the HMP. The Permit required the Permittees to develop an HMP for all Priority Development Projects (with certain exemptions) and develop a performance standard including a geomorphically-significant flow range that ensures the geomorphic stability within the channel. Supporting analyses was required to be based on continuous hydrologic simulation modeling. Similarly, the loss of sediment supply due to the development must be considered. Order R9-2009-0002 has been replaced by the San Diego Regional Permit, Order R9-2013-0001 as amended by Order No. R9-2015-0001. Commencement of coverage under the San Diego Regional Permit for the South Orange County Permittees, became effective April 1, 2015 with adoption of Order R9-2013-0001 as amended by Order No. R9-2015-0001 which was adopted on February 11, 2015.. This HMP has been amended to be consistent with the hydromodification requirements identified in Provision E.3.c.(2) of Order R9-2013-0001 as amended by Order No. R9-2015-0001.

The SDRWQCB jurisdiction area covers the southern portion of Orange County. The northern portion of Orange County is under the jurisdiction of the Santa Ana Regional Water Quality Control Board (SARWQCB) and is not subject to this HMP. MS4 Permittees or dischargers directly or indirectly discharging runoff into waters of the United States within the San Diego Region include the Cities of Aliso Viejo, Dana Point, Laguna Beach, Laguna Hills, Laguna Niguel, Laguna Woods, Mission Viejo, Rancho Santa Margarita, San Clemente, and San Juan Capistrano, as well as the County of Orange and the Orange County Flood Control District. Per note 2 under provision B.1.of Order R9-2013-0001 as amended by Order No. R9-2015-0001, MS4 discharges within the City of Lake Forest located within the San Diego Water Board Region will be regulated by the Santa Ana Water Board when Tentative Order No. R8-2015-0001 is adopted and so the City of Lake Forest will not be subject to this HMP upon adoption of Tentative Order No. R8-2015-0001.

For reference a Practitioner Quick Start Sheet is provided in **Appendix A** that includes the chronological steps that a practitioner should follow for their development project or re-development project to meet the requirements of this South Orange County Hydromodification Management Plan.

2 Permittee HMP Development Process

Although the County of Orange serves as the lead agency for development of the HMP, all 13 Permittees have participated in its development, both financially and through participation in HMP workshops scheduled over the course of the project at times corresponding with key decision points in developing the HMP. Participants in the HMP Workshops created a Permittee HMP Workgroup to provide input on the development of the HMP.

The Permittees will continue to meet to discuss and resolve any issues that may arise during the HMP implementation phase. The Permittee HMP Workgroup will also assist in refining and reinforcing methodologies, criteria, and standards established in the HMP.

The Permittee HMP Workgroup has met four times since August 2011. **Table 2-1** shows meeting dates, locations, and agenda items. In addition to the formal meetings, the Permittee HMP Workgroup coordinated via email to review and discuss technical documents, deliberate on specific HMP-related topics and concur on issues.

Table 2-1: HMP Workgroup Meetings

Date	Location	Agenda
August 8, 2011	Laguna Hills City Hall	Kickoff Workshop Discussion of the proposed South Orange County HMP (SOCHMP) Approach and Methodology
October 12, 2011	RBF Consulting Irvine/Webcast	Presentation of the San Diego Hydrology Model Tool by Clear Creek Solution (Doug Beyerlein) Presentation of the HMP Framework by RBF Consulting (Scott Taylor & Daniel Apt)
November 17, 2011	RBF Consulting Irvine	Draft HMP Document Review
February 21, 2012	RBF Consulting Irvine	South Orange County Hydrology Model Workshop – Presentation of the model tool by Clear Creek Solution (Doug Beyerlein)

A Draft South Orange County HMP was submitted to the San Diego Regional Water Quality Board on December 16, 2012. In response to the draft HMP, the San Diego Water Board sent a comment letter dated April 25, 2012 to the South Orange County Permittees to support the general approach taken by the document. The letter includes several comments to be addressed in the Final South Orange County HMP, which was submitted on October 25, 2012.

As required by Permit item F.1.h(4), the draft document was posted on the Orange County Watersheds website (http://www.ocwatersheds.com/) for public review. Public comments were provided by Tory Walker Engineering and are considered in Revised South Orange County HMP.

In response to the revised Draft HMP submitted to the San Diego Water Board on December 16, 2012, the San Diego Water Board sent a comment letter dated July 31, 2013 to the County of Orange. Comments focused on the ability of the South Orange County Permittees to propose additional exemptions to the hydromodification requirements beyond those identified in Order R9-2009-0002. Subsequent discussions between the South Orange County Permittees and San Diego Water Board resulted in the approach to remove exemptions proposed for instream flood control and restoration projects that were not allowed by the San Diego Regional Board and propose interim exemptions to the hydromodification requirements for discharges to engineered channels and large rivers for inclusion in the San Diego Regional Permit Order R9-2013-0001 at the commencement of coverage under Order R9-2015-0001 for the South Orange County Permittees. The interim exemptions included in Order R9-2015-0001, which amends Order R9-2013-0001, are included in this updated South Orange County HMP. This HMP is consistent with the hydromodification requirements identified in Provision E.3.c.(2) of Order R9-2013-0001 as amended by Order No. R9-2015-0001.

It should be noted that this HMP has in large part been based on the San Diego HMP, which was developed by the County of San Diego and the Permittees for San Diego County. The San Diego HMP was approved by the San Diego Regional Board and served as the starting point for development of the South OC HMP. Although not included in the main body of the HMP a literature review was performed as part of development of the South Orange County HMP, and a summary of the literature review is provided in **Appendix B**.

3 Hydrologic Management Requirements and Standards for Projects

Priority Development Projects are required to implement hydrologic control measures and on-site management controls so that post-project runoff flow rates and durations do not exceed pre-development, i.e. naturally occurring conditions, flow rates and durations where they would result in an increased potential for erosion or degraded instream habitat downstream of Priority Development Projects (Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001 Section E.3.c.(2)(a)). The purpose of this chapter is to identify the HMP criteria, detail the HMP applicability requirements, and provide a framework for alternative compliance.

3.1 HMP Criteria and Performance Standard

The HMP criteria are designed to manage increases in runoff discharge rates and durations from all Priority Development Projects (PDPs) and they apply to all PDPs. The HMP criteria include the following:

- All PDPs must ensure that post-project runoff flow rates and durations for the PDP shall not exceed pre-development, naturally occurring, runoff flow rates and durations by more than 10% of the time, from 10% of the 2-year runoff event up to the 10-year runoff event.

This HMP includes a tool to provide continuous simulation of peak flow rates, from 10% of the 2-year runoff event up to the 10-year runoff event for PDPs. The tool is the South Orange County Hydrology Model, which is an HSPF model based on the San Diego Hydrology Model and is an acceptable method that allows PDPs to meet the HMP criteria through interactive graphic user interface. Description of the model is provided in Section 4.6 below and details about how to use the model are provided in **Appendix C**.

Demonstration of flow-duration matching for the range of geomorphically-significant flows constitutes conformance with the hydrologic element of the performance standard of this HMP. The second element of the HMP performance standard, sediment bed material sources, is the maintenance of pre-project sediment bed material supply. The general approach that a project proponent shall follow to demonstrate compliance with the sediment source performance standard is described in Section 5.

All priority project proponents shall demonstrate compliance with the hydrologic performance standard and the sediment supply performance standard. Compliance with these standards constitutes compliance with the overall performance standard for the HMP.

The lower flow threshold ($0.1Q_2$) satisfies Section F.1.h.(1)(b) of Order No. R9-2009-0002 and Section E.3.c.(2)(a)(i) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001in that it corresponds with the critical channel flow that produces the critical shear stress that initiates channel bed movement or that erodes the toe of channel banks of a soft-bottomed channel. For those PDPs that chose to perform a site-specific analysis, the selected lower flow threshold must also ensure that it meets the requirements of Section E.3.c.(2)(a)(i) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001.

The HMP performance standard is also applicable to those priority projects that are unable to implement flow-duration controls onsite but seek compliance through offsite mitigation projects. The mitigation project must be capable of matching or reducing the equivalent flow-duration curves from the project development.

This HMP offers an alternate hydrologic performance standard to those priority projects that are unable to implement flow-duration matching onsite and offsite, only if the unfeasibility is demonstrated and documented to the governing Copermittee. The alternative performance standard consists of implementing restoration projects that will ensure the channel stability and restore the beneficial uses. The performance equivalency of a restoration project shall be demonstrated to the governing Copermittee.

Priority Development Projects that fail to meet the dual performance standard or do not qualify for the alternate performance standard are required to redesign the project.

3.2 HMP Applicability Requirements

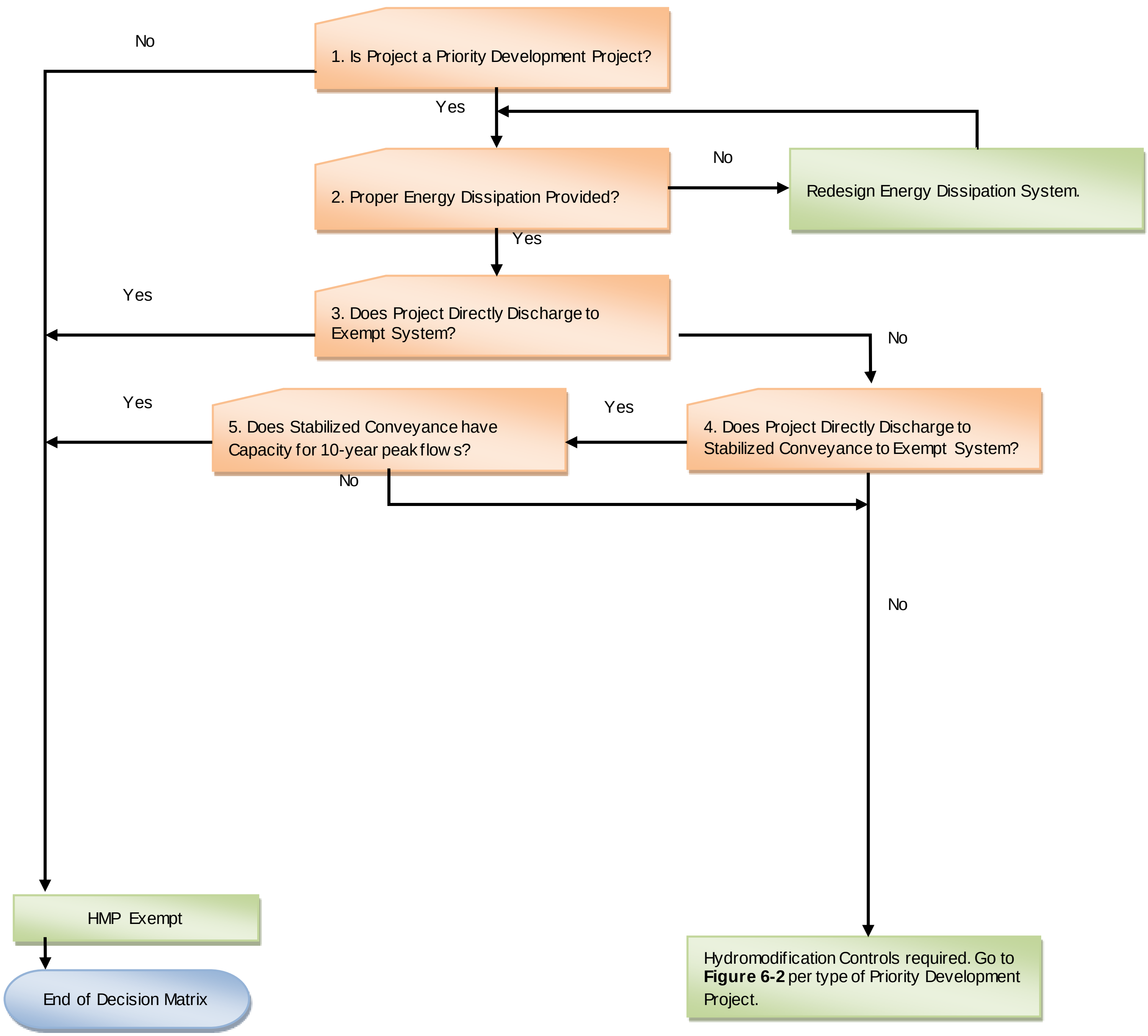
To determine if a proposed project must implement hydromodification controls, refer to the HMP Decision Matrix in **Figure 3-1**. The HMP Decision Matrix can be used for all projects.

It should be noted that all PDPs are subject to the LID and water quality treatment requirements identified in the most recent version of the Local WQMP, for the PDPs jurisdiction, which is based on Orange County Model WQMP and complemented by the Orange County Technical Guidance Document even if hydromodification flow controls are not required.

As noted in **Figure 3-1**, projects may be exempt from HMP criteria under the following conditions.

- If the project is not a PDP; or
- If the proposed project discharges storm water runoff directly into underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean; or
- If the proposed project discharges runoff directly to an exempt receiving water as defined in **Section 4.3.1**; or
- If the project discharges to a large river per the definition provided in **Section 4.3.2**

Figure 3-1: HMP Decision Matrix



- **Figure 3-1**, Node 1 – Hydromodification mitigation measures are only required if the proposed project is a PDP, as defined per Permit Item F.1.d.
- **Figure 3-1**, Node 2 – Properly designed energy dissipation systems are required for all project outfalls to unlined channels. Such systems should be designed in accordance with the Orange County Local Drainage Manual to ensure downstream channel protection from concentrated outfalls.
- **Figure 3-1**, Node 3 – Potential exemptions may be granted for projects discharging runoff directly to an exempt receiving water, such as the Pacific Ocean, an exempt river system (identified in **Table 3-1**), an exempt reservoir system (identified in **Table 3-2**), and a large river stream (identified in **Section 4.3.2**)..
- **Figure 3-1**, Nodes 4 and 5 – For projects discharging runoff directly to an engineered conveyance system that extends to exempt receiving waters detailed in Node 3, potential exemptions from hydromodification criteria may be granted. Such engineered systems could include existing storm drain systems, existing hardened conveyance channels, or stable engineered unlined conveyance channels that are part of the MS4 but that are not receiving waters. To qualify for this exemption, the existing hardened or rehabilitated conveyance system must continue uninterrupted to the exempt system. The engineered conveyance system cannot discharge to a non-engineered channel segment prior to discharge to the exempt system. Additionally, the project proponent must demonstrate that the engineered conveyance system has the capacity to convey the 10-year peak flows through the conveyance system. The 10-year peak flow should be calculated based upon single-event hydrologic criteria as detailed in the Orange County Hydrology Manual.

3.3 HMP Exemptions

PDPs may be exempt from HMP criteria based on specific channel conditions. Section E.3.c.(2)(d) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001identifies exemptions for the hydromodification management BMP requirements. Section E.3.c.(2)(e) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001 identifies interim timeframe exemptions for the hydromodification management BMP requirements. These exemptions and interim timeframe exemptions are detailed in this section.

3.3.1 Exempt Engineered Conveyance & Channel Areas

Section E.3.c.(2)(d) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001identifies exemptions for the following types of conveyances:

- Existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean;
- Conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean.

PDPs that discharge runoff directly into these two types of conveyances or via an engineered conveyance system, as identified in the description of Figure 4-1, Nodes 4 and 5 above, and then into the conveyances identified above are exempt from the South Orange County HMP requirements.

Section E.3.c.(2)(e)(i) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001identifies an interim exemption for engineered channel conveyance systems with a capacity to convey the peak flows generated by the 10-year storm event all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean. Only engineered sections of channel conveyance systems are exempt from the hydromodification requirements. To confirm the exemption, the succession of existing engineered conveyance sections must be continuous from the point of discharge of the PDP to the exempt receiving waters of water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean. PDPs that discharge runoff directly into these engineered channels or via an engineered conveyance system, as identified in the description of Figure 4-1, Nodes 4 and 5 above, and then into the engineered channel are exempt from the South Orange County HMP requirements.

The South Orange County Permit area was screened for identification of channels that meet the exempt conveyances and the interim exempt engineered channel conveyances identified above. The screening analysis was conducted using the 2010 Orange County Countywide Storm Drain Inventory. The storm drain inventory defines the type of material and size composing each section of a channel or storm drain. Major storm drains, concrete lined conveyance channels, and engineered channels that are exempt from hydromodification requirements are presented in **Table 3-1** for reference only. The PDP may use the exemption map for planning purposes and must determine if the development or redevelopment project discharges runoff into a continuous succession of existing engineered conveyance sections all the way to the exempt receiving waters of water storage reservoirs, lakes, enclosed embayments, and the Pacific Ocean. The table contains the name of the exempt systems, as well as the associated downstream and upstream limits. The upstream limit being reported corresponds to the nearest cross street. The resulting map from this effort is presented in **Figure 3-2**. The map shows drainage areas that are exempt from hydromodification criteria.

Table 3-1: Channels Exempt from Hydromodification Requirements in Orange County

Channel	Downstream Limit	Upstream Limit
Laguna Canyon Channel	Pacific Ocean	Philips Street
Sleepy Hollow Storm Drain	Pacific Ocean	Park Avenue
Bluebird Storm Drain	Pacific Ocean	Glenneyre Street
Aliso Creek Channel	Pacific Ocean	Pacific Coast Highway
Salt Creek Channel	Pacific Ocean	300 ft north of Pacific Coast Highway
San Juan Creek Channel	Pacific Ocean	Paseo Michelle
Prima Deshecha Canada Channel	Pacific Ocean	Avenida Vaquero
North Creek	Pacific Ocean	Doheny Park Road
Cacadita Canyon Storm Channel	Prima Deshecha Canada Channel	Via Cascadita
Segunda Deshecha Canada Channel	Pacific Ocean	Calle Frontera
Marquita Storm Channel	Pacific Ocean	Encino Lane
Trafalgar Storm Drain	Pacific Ocean	South Ola Vista

Table 3-2 provides a summary of exempt water storage reservoirs and lakes in South Orange County. Large water storage reservoirs or lakes can be exempt systems from a hydromodification standpoint since water storage reservoir and lake storm water inflow velocities are naturally mitigated by the significant tailwater condition in the water storage reservoir or lake. HMP exemptions would only be granted for projects discharging runoff directly to the exempt reservoirs or into engineered conveyance systems designed convey the peak flows generated by the 10-year storm event discharging into a lake or reservoir. To qualify for the potential exemption, the outlet elevation of the conveyance system must be within (or below) the normal operating water surface elevations of the reservoir and properly designed energy dissipation must be provided.

Table 3-2: Reservoirs in Orange County

Reservoir	Watershed
Sulphur Creek Reservoir	Sulphur Creek
El Toro Reservoir	Oso
Rancho Santa Margarita Lake	Middle Trabuco
Dove Canyon Lake	Upper San Juan

3.3.2 Exemption for Large River Reaches

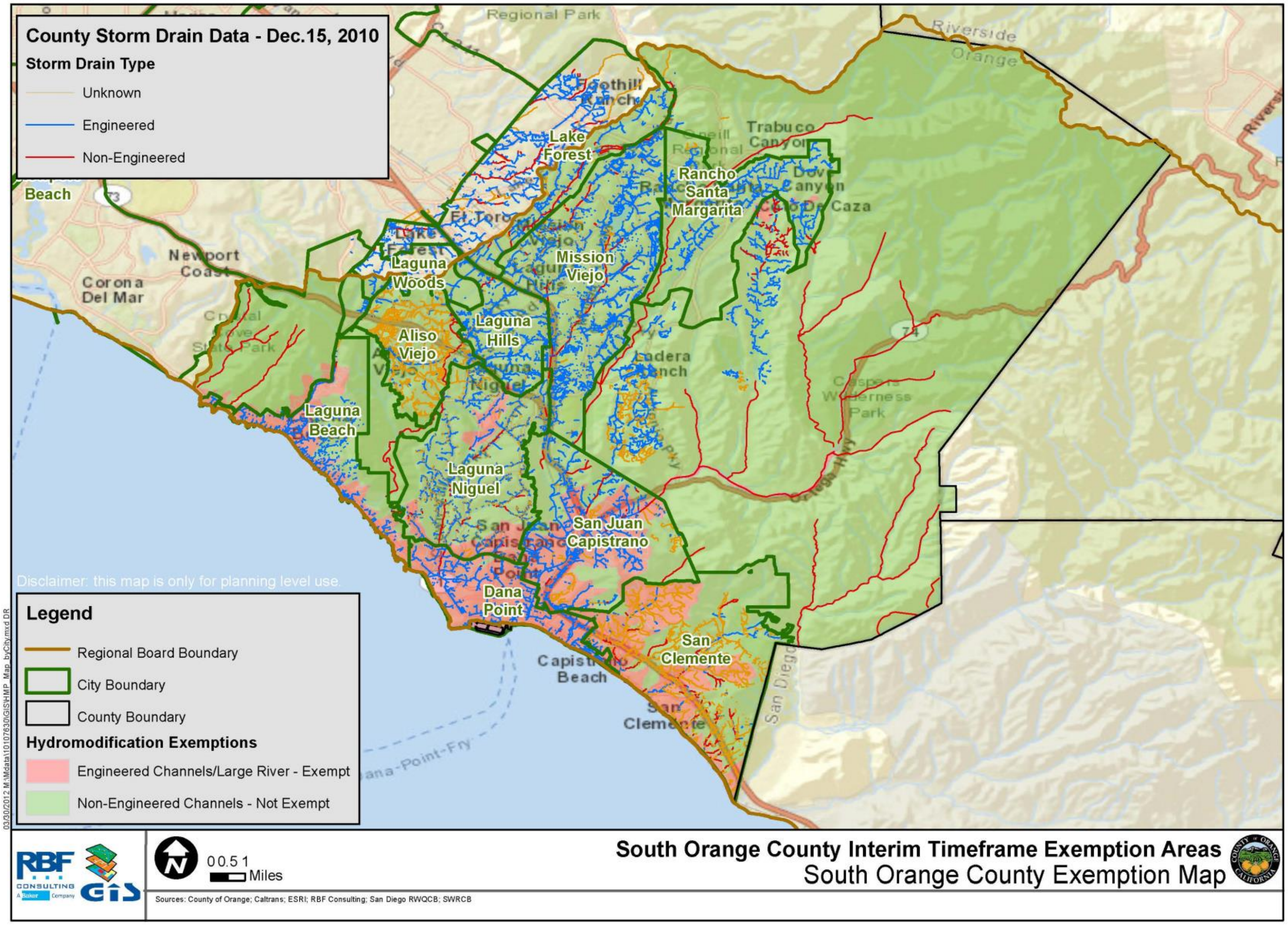
Section E.3.c.(2)(e)(ii) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001identifies an interim exemption for large river reaches with a drainage are larger than 100 square miles and a 100-year flow capacity in excess of 20,000 cubic feet per second, provided that properly sized energy dissipation is included at all Priority Development Project Discharge points. PDPs that discharge either directly or via an engineered conveyance system, as identified in the description of Figure 4-1, Nodes 4 and 5 above, and then into large river reaches are exempt from the South Orange County HMP requirements, provided that properly sized energy dissipation is implemented at the outfall location. All exempt river reaches, which are presented in **Table 3-3** have a drainage area larger than 100 square miles and a 100-year design flow higher than 20,000 cfs (SDRWQCB, 2002). **Table 3-3** also provides the corresponding upstream and downstream limits to define the exempted reach.

Table 3-3: Exempt River Reaches in South Orange County

River	Downstream Limit	Upstream Limit
San Juan Creek	Outfall to Pacific Ocean	Caper Park Road
San Mateo Creek	Outfall to Pacific Ocean	Nickel & Tenaja Canyons

Figure 3-2 below displays the areas of exemption for the entire South Orange County permit area based on the exemptions outlined in Sections 4.3i and 4.3ii above, where the areas in pink are potentially exempt as they discharge to engineered conveyances all the way to exempt receiving waters (water storage reservoirs, lakes, enclosed embayments, and the Pacific Ocean or to large river reaches. Additional jurisdictional specific exemption area maps are provided in Appendix F. Figure 4-2 and the exemption maps provided in Appendix F are for planning purposes and more detailed maps can be found at the County's Georesearch website.

Figure 3-2: Exemption Map



3.4 HMP Alternative Compliance

For some PDPs, implementation of onsite hydromodification controls consistent with the HMP may not be feasible due to site constraints. These projects require alternatives to onsite hydromodification controls. The LID requirements of the Permit require the implementation of LID techniques that effectively result in hydrologic processes that mimic the desired natural watershed conditions. There are two alternative compliance options for PDPs that cannot implement onsite hydromodification controls. One option is for a PDP proponent to identify and construct off-site mitigation to offset the inability to meet the HMP criteria onsite. The other option is for the PDP proponent to pay into an HMP mitigation bank, if an HMP mitigation bank is available to the PDP. Each of these options must also meet the requirements of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001Section E.3.c.(3) in addition to the requirements identified below. The details of these options are provided below.

3.4.1 HMP Alternative Compliance Option 1: Off-site Mitigation

A progression through a defined process is required to document eligibility then implementation of alternative compliance for the HMP. Off-site mitigation is based on a progression of steps to meet compliance that is consistent with Section F.1.h.2 of the MS4 Permit. These steps include the following:

1. Technical feasibility study of onsite hydromodification controls; and
2. Off-site mitigation project within the same hydrologic unit as the PDP or in-stream restoration of the receiving water of the PDP.

3.4.1.1 Step A: Conduct a technical feasibility study for onsite hydromodification controls

A technical feasibility study is required to identify why onsite hydromodification controls cannot be incorporated into the project. The technical feasibility study must include the project constraints and provide detailed technical justification as to why the project constraints prevent implementation of onsite controls. The technical feasibility study will be submitted to the jurisdiction of the location of the PDP for review as part of the Preliminary WQMP. The jurisdiction must approve the technical feasibility before the PDP moves on to Step B.

3.4.1.2 Model WQMP Integration

3.4.1.3 Guidance on the hydromodification technical feasibility study has been incorporated into the Model WQMP and Technical Guidance. The hydromodification technical feasibility study has been integrated with the LID feasibility analysis as part of the Model WQMP; however, it should be noted that the criteria for hydromodification and LID requirements are different.

3.4.1.4 Step B: Implement off-site mitigation within the same hydrologic unit as the PDP or in-stream restoration of the PDP receiving water

For those PDPs where the technical feasibility study for onsite controls has been approved by the jurisdiction, step B for the PDP is to either (1) implement an off-site mitigation project within the same hydrologic unit as the PDP, or (2) implement an in-stream restoration project for the receiving water of the PDP. The process for these options under Step B is detailed below:

3.4.1.4.1 B(1) Implement off-site mitigation within the same hydrologic unit as the PDP

In choosing this option, the PDP must investigate potential locations for implementation of an off-site mitigation project within the same hydrologic unit as the PDP. The off-site mitigation project must be sized to mitigate the equivalent runoff volume as implementing onsite hydromodification controls for the PDP. The PDP will evaluate and identify potential sites in the same hydrologic unit for implementation of an off-site hydromodification project that has the capacity to mitigate the PDP's hydromodification requirements. If an adequate site is identified by the PDP in the same hydrologic unit, the PDP will submit a report detailing:

- that the off-site mitigation project will be sized to mitigate the equivalent volume as implementing onsite hydromodification controls for the PDP; and
- conceptual plans for the off-site mitigation project as part of an amended WQMP for review and approval.

If no potential off-site mitigation project sites are identified in the same hydrologic unit as the PDP, the PDP must implement Option 2(b), an in-stream restoration project of the PDP receiving water.

3.4.1.4.2 B(2) Implement in-stream restoration of the PDP receiving water

In choosing this option, the PDP investigates the potential for implementation of an in-stream restoration project for the receiving water of the project. It must be determined that the receiving water for the project has hydromodification impacts. The in-stream restoration project must be located in the receiving water of the PDP. The PDP must submit a report detailing the condition of the receiving water due to hydromodification, as well as conceptual plans for the in-stream restoration project to the PDP's jurisdiction for review. The Permittee is responsible for ensuring that the level of restoration is adequate given the impacts of the PDP. Permittees will establish individual processes consistent with their ministerial approval procedures to ensure that the applicant's obligations under the HMP alternative compliance process are completed prior to project approval.

Once the project conceptual plans have been approved by the PDP's jurisdiction, the PDP must submit the appropriate permit applications to the appropriate regulatory agencies (e.g., Regional Board, California Department of Fish and Game, U.S. Army Corps of Engineers) for review and approval. If the PDP identifies no opportunities for in-stream restoration in the receiving water that the PDP discharges to, then the PDP must implement Option 2(a), an off-site mitigation project within the same hydrologic unit as the PDP.

3.4.2 HMP Alternative Compliance Option 2: HMP Mitigation Bank

(Note: Option 2 is available only if an HMP mitigation bank has been developed and is available to the PDP.)

The County and the Permittees have the option to develop an HMP mitigation bank or multiple HMP mitigation banks. A mitigation bank will develop regional HMP mitigation projects where PDPs can buy HMP mitigation credits if it is determined that implementing onsite hydromodification controls is infeasible. The development and operation of an HMP mitigation bank will include the identification of potential regional HMP mitigation projects; the planning, design, permitting, construction, and maintenance of regional HMP mitigation projects; the development of a fee structure for PDPs participating in the mitigation bank; and managing the HMP mitigation bank fund. Regional HMP mitigation projects can also serve as projects for an LID waiver program if site conditions allow for implementation of LID-type projects.

If PDPs are unable to meet the HMP criteria by incorporating onsite hydromodification controls, and a HMP mitigation bank is available, the PDP can apply to participate in the bank. The application must include a technical feasibility study to identify why onsite hydromodification controls cannot be incorporated into the project. The technical feasibility study must include the project constraints and detailed technical justification as to why the project constraints prevent implementation of onsite controls. The technical feasibility study will be submitted to the jurisdiction where the PDP is located for review as part of the Preliminary WQMP. The jurisdiction must approve the technical feasibility study for the PDP to participate in a HMP mitigation bank.

3.4.3 Review Mechanism of Alternative Compliance Projects

A review mechanism for alternative compliance projects will be developed and implemented by the County and the Permittees. The governing Permittee(s) will ultimately be responsible for ensuring that the offsite mitigation project or the restoration project will meet the performance standard of the HMP, or adequate restoration for beneficial uses and stream stabilization. In addition, the Permittee having jurisdiction over the project shall ensure that the timing and financing of the project are secured to guarantee that construction will be completed and maintenance performed over the long term.

It is expected that the implementation of offsite mitigation or restoration projects will be sought by project proponents with limited onsite available space. In a first case, the project proponent or a joint group of project proponents may pursue and manage an offsite mitigation or restoration project on its or their own, with or without the support of the local public agency. The second case considers those offsite mitigation or restoration projects being jointly pursued through the HMP Mitigation Bank.

Project proponents are required to submit a project-specific Water Quality Management Plan to the Permittee having jurisdiction over the project. As part of the submittal, the elements demonstrating that the offsite mitigation project or the restoration project is technically viable, financially secured, and guaranteeing long-term maintenance, should be provided. An in-stream restoration project will trigger Section 401/404 permitting requirements of the Clean Water Act, which will involve the San Diego Water Board in the review process.

The project proponent, or person, financially responsible for the construction and the long-term operation and maintenance of the offsite mitigation or restoration project must demonstrate the viability of the established funding mechanism. A security bond program may be required by the local jurisdiction to guarantee completion of the construction. A funding schema for long-term operation and maintenance must be established and presented along with the BMP Operation and Maintenance Plan.

Similar to project-specific WQMPs, a mitigation or restoration project Operation and Maintenance (O&M) Plan must be prepared and submitted as part of the project submittal. Long-term maintenance and operation of the regional facility must be covered by an O&M mechanism under the direction of a local jurisdiction or a project proponent. Such an agreement must be reached and approved prior to the issuance of any construction permits. The agreement shall include legal agreements, maintenance agreements, conditional use permits and funding arrangements. The O&M Plan shall describe the designated responsible party to manage the offsite mitigation or restoration project, employee's training program and duties, operating schedule, maintenance frequency, routine service schedule, specific maintenance activities, copies of resource agency permits, and any other necessary activities.

Construction of the priority project shall not commence prior to approval of the final WQMP and the security of the overall funding mechanism.

3.5 Hydrologic Management Measures

PDPs are encouraged to use the full suite of hydrologic management measures available to meet the HMP criteria identified in **Section 4.1**. The intent of the HMP is not to specify the types of hydrologic control measures that can be used but rather identify the criteria that must be met allowing flexibility for PDPs to use the full suite of management measures to meet the HMP criteria. Section 5 of the Technical Guidance Document (TGD) provides information on hydromodification control design. Section 5.5 of the TGD includes Hydromodification Control BMPs, which specifies the type of BMPs that can be used to meet hydromodification standards. The South Orange County Hydrology Model includes BMPs that can be used to meet the HMP criteria and has been developed as the primary tool to select and size the appropriate hydrologic site design and BMP controls to meet the HMP criteria. The model also incorporates buffer zones as a management measure for those PDPs adjacent to stream channels.

3.5.1 Selection and Design of Hydrologic Management Measures

Selection and design of hydrologic management measures is an iterative process that can be facilitated using the South Orange County Hydrology Model (SOCHM). The SOCHM has a comprehensive menu of hydrologic site design measures and hydrologic management measures that can be selected for implementation for PDPs. The design parameters for these hydrologic measures have been incorporated into the model and can be modified to an extent based on site constraints.

3.5.2 Inspection and Maintenance of Hydrologic Management Measures

Maintenance for hydrologic control measures is critical to ensure there optimal operation. PDPs are conditioned to provide verification of inspections and maintenance operations as defined in Section 7.II-4.0 of the Local WQMPs. The list of such inspections and maintenance operations shall be included in the WQMP submitted by the applicant. Maintenance activities shall ensure that the systems are properly controlling flow rates and durations to ensure the HMP criteria is being met and inspections shall document the maintenance activities performed and that the hydrologic control measure is functioning properly.

3.6 South Orange County Hydrology Model – Continuous Simulation Modeling

As part of the HMP development, an integrated flow control sizing tool has been prepared to help applicants comply with hydromodification requirements. The South Orange County Hydrology Model (SOCHM) offers the same interface as that of the San Diego Hydrology Model, which has been approved by the SDRWQCB. This modeling approach is different from Orange County's calibrated rainfall-runoff procedures and criteria for flood control design and mitigation purposes. HMP requirements from the Regional Board are separate from Orange County's requirement for mitigation within the drainage system of development effects on runoff per the Orange County Hydrology Manual (OCHM). SOCHM uses continuous simulation hydrologic modeling, which is an acceptable method to size storm water facilities to mitigate hydromodification effects. Continuous simulation modeling uses an extended time series of recorded precipitation data as input and generates hydrologic output, such as surface runoff, infiltration, and evapotranspiration, for each model time step.

Continuous hydrologic models are typically run using either 1-hour or 15-minute time steps. Based on a review of available rainfall records in Orange County, SOCHM uses a 1-hour time step (15-minute time series rainfall data are very limited). Continuous models generate model output for each time step. In this case, hydrologic output is generated for each hour of the continuous model. A continuous simulation model with 35 years of hourly precipitation data will generate 35 years of hourly runoff estimates, which corresponds to runoff estimates for 306,600 time steps over the 35-year simulation period.

Use of the continuous modeling approach allows for the estimation of the frequency and duration by which flows exceed the lower flow threshold (adopted as 10 percent of the 2-year flow for this Plan). The limitations to increases of the frequency and duration of flows within that geomorphically significant flow range represent the key component to the South Orange County approach to hydromodification management. Guidance for use of SOCHM is provided in Appendix C. Download of SOCHM is available at:
http://ocwatersheds.com/documents/wqmp.

Additionally the following public domain software models may be used to assess hydromodification controls for storm water facilities to meet the hydromodification criteria:

- Hydrologic Simulation Program – FORTRAN (HSPF), distributed by U.S. EPA
- Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS), distributed by the U.S. Army Corps of Engineers Hydrologic Engineering Center
- Storm Water Management Model (SWMM); distributed by U.S. EPA

Additionally a PDP may perform a site specific hydromodification analysis consistent with Appendix D Conducting a Site-Specific Hydromodification Analysis.

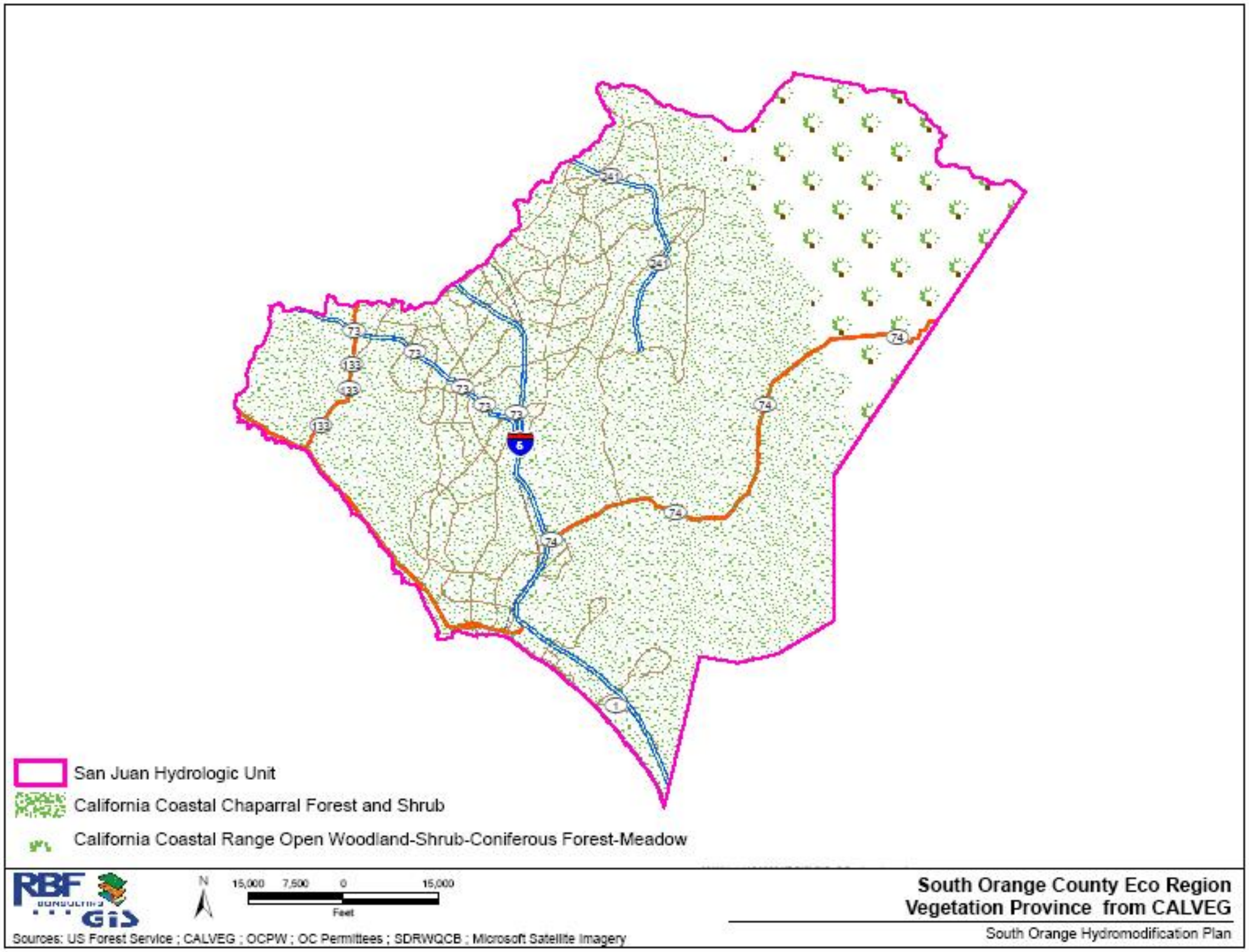
3.7 Identification of Naturally-Occurring Conditions

Language of Section F.1.h of Permit Order R9-2009-0002 required that estimated post-project runoff discharge rates and durations shall not exceed pre-development (naturally occurring) discharge rates and durations. Language of Section E.3.c.(2) of Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001 does not include the term "naturally occurring", however in the Fact Sheet for Order R9-2013-0001 as amended by Order No. R9-2015-0001 on Page F-102, it identifies that determination of "pre-development" is done by "using the hydrology of a natural condition". It is recommended that compliance be based on the results of continuous simulation and the use of the South Orange County Hydrology Model or equivalent model. As part of developing the supporting hydrology model for a development or re-development project, a project proponent shall identify and document, using professional knowledge, pre-development (naturally occurring) conditions in terms of geology, topography, soils, and vegetation,

Several publicly-available information sources may help the developer characterize pre-development conditions, including:

- Soil database #678 from the Natural Resources Conservation Service (NRCS). Among the parameters of interest, the database identifies the type, the original range of observed topographic slopes, the soil erosion factor K, and, if available, plant community information for the native or pre-development soil. The database is accessible through the Web Soil Survey page (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm).
- Vegetation and eco-regional GIS information listed by the US Forest Services. Eco-Region information locates South Orange County in the Southern California Coast and Mountain Ecoregion and references the climate of humid and temperate Mediterranean type. Overall, two vegetation regions are observed, including the California Coastal Chaparral Forest and Scrub (California Sagebrush) on the coastal and inner lands of the County, as well as California Coastal range Open Woodland-Scrub-Coniferous Forest-Meadow (Scrub and Oak Trees) in the upper mountainous parts of South Orange County. In addition, a historical CALVEG GIS vegetation layer is available for the year 1977 (USFS, 2000). Figure 3-4 delineates the distribution of vegetation types in the South Orange County portion of the San Juan Hydrologic Unit. GIS-based layers are available on the USFS website (http://www.fs.usda.gov/detail/r5/landmanagement/gis/).
- Other historical USGS topographic maps and aerials of South Orange County are publicly available from the USGS website.

Figure 3-4: South Orange County Vegetation and Eco-Regions



4 Sediment Supply Management Requirements

Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001Section E.3.c.(2)(b) requires PDPs to avoid critical sediment yield areas known by the Copermittee or identified in the Watershed Management Area Analysis, or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no impact to the receiving water. As the locations of sediment yield areas are not known by the Copermittees and the Watershed Management Area Analysis has yet to be completed this section identifies the steps PDPs must take to or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no impact to the receiving water.

Sediment supply plays a role in the stability of alluvial stream channels. A change in coarse (bed material) sediment supply will cause instability in the channel manifested through general scour or aggradation. Lateral bank migration may also result from changes in sediment supply as the channel slope increases or decreases.

The delivery of bed material during construction may increase as land surface is cleared and the potential for erosion is increased. Once the land surface is urbanized, runoff may be discharged through closed conduits and lined channels. The potential for bed material transport may be reduced as compared to the pre-development condition. The purpose of this portion of the HMP is to maintain the pre-development delivery of bed material to receiving streams following urbanization. Bed material is defined as the sediment that comprises the bed and banks of the receiving stream. Bed material load is the material transported by the stream during runoff events. It is comprised partly of the bed load (material that moves along the bed by sliding or saltating) and partly of the suspended load, including particle size fractions in the channel bed sediments. Bed material load is a primary variable controlling stream channel morphology. Wash load is the portion of the total sediment load carried continuously in suspension by the flow, and generally consists of the finest particles. Changes in wash load are not likely to significantly affect the channel stability, and reductions in wash load are generally assumed to improve habitat function.

The resiliency of receiving channels to forestall changes in the watershed due to urbanization varies with the magnitude of the change and characteristics of the channel (bed and bank material, vegetation, channel cross section and slope). It is difficult to quantitatively predict the response in a receiving channel to changes in the fundamental variables described by Lane (1955) of discharge, bed material grain size, channel slope and sediment supply. Accordingly, the most effective approach to ensuring channel stability may be to avoid changes in the fundamental variables (Lane's relationship) during urbanization through the implementation of stream channel management guidelines. In the case of bed material sediment supply, this will be accomplished by avoiding development in areas that are a significant contributor of bed material load to the receiving channel.

The general approach to ensure maintenance of the pre-project sediment supply is a three-step process:

1. Determine whether the site is a significant source of bed material to the receiving stream.
2. Avoid significant bed material supply areas in the site design.
3. Replace significant bed material supply areas that are eliminated through urbanization.

In the event of a projected reduction in sediment supply, the project proponent shall investigate the feasibility of sediment management measures, including rerouting drainage pathways through coarse bed sediments onsite, otherwise maintaining pre-project bed material discharge from the site, or providing additional mitigation in site runoff. Specific guidance on sediment management measures will be provided in the Model WQMP for South Orange County.
An alternative compliance option allows the project applicant to model the site conditions and the receiving stream and provide additional mitigation in site runoff to compensate for the reduction (or addition) of bed material. An erosion potential management objective must comply with the HMP performance standard as defined in Section 4.1. This option may only be used if the general approach outlined above is deemed infeasible by the permitting authority, or if the project site design requires significant alteration of on-site streams.

4.1 Methodology

The project applicant must determine the location of the downstream alluvial receiving water that may be impacted by the project. Only the first downstream conveyance that is unlined (invert, side slopes or both) will be considered and will serve as the “assessment” or “receiving” stream for the project. The following methodology will be used to ensure that the project does not adversely impact bed material load to the assessment stream.

4.1.1.1 Step 1

A triad approach will be completed to determine whether the site is a significant source of bed material to the receiving stream and includes the following components:

1. Site soil assessment, including an analysis and comparison of the bed material in the receiving stream and the onsite streams;
2. Determination of the capability of the onsite streams to deliver the site bed material (if present) to the receiving stream; and
3. Present and potential future condition of the receiving stream.

A geotechnical and sieve analysis is the first piece of information to be used in a triad approach to determine if the site is a significant source of bed material load to the assessment stream. An investigation shall be completed of the assessment stream to complete a sieve analysis of the bed material. Two samples shall be taken of the assessment stream using the “reach” approach (TS13A, 2007). Samples in each of the two locations should be taken using the surface and subsurface bulk sample technique (TS13A, 2007) for a total of four samples.

A similar sampling assessment should be conducted on the project site. First-order and greater streams that will be impacted by the project (drainage area changed, stabilized, lined or replaced with underground conduits) will be analyzed in each subwatershed. One stream per subwatershed that will be impacted on the site must be assessed. A subwatershed is defined as tributary to a single discharge point at the project property boundary.

The sieve analysis should report the coarsest 90 percent (by weight) of the material for comparison between the site and the assessment stream. The Professional Engineer shall render an opinion if the material found on the site is of similar gradation to the material found in the receiving stream. The opinion will be based on the following information:

- Sieve analysis results
- Soil erodibility (K) factor
- Topographic relief of the project area
- Lithology of the soils on the project site

The Professional Engineer shall rate the site as having either a high, medium or low probability of supplying bed material load to the receiving stream. This site soil assessment serves as the first piece of information for the triad approach.

The second piece of information is to qualitatively assess the sediment delivery potential of the site streams to deliver the bed material load to the receiving stream, or the bed material sediment delivery potential or ratio. There is no documented procedure to estimate the sediment delivery ratio; it is affected by a number of factors, including the sediment source, proximity to the receiving stream, on-site channel density, project watershed area, slope, length, land use and land cover, and rainfall intensity. The Engineer will qualitatively assess the bed material sediment delivery potential and rate the potential as high, medium or low potential. The final piece of information is the present and potential future condition of the receiving stream. The Engineer shall assess the receiving stream for the following:

- Bank stability. Receiving streams with unstable banks may be more sensitive to changes in bed material load.
- Degree of incision. Receiving streams with moderate to high incision may be more sensitive to changes in bed material load.
- Bed material gradation. Receiving streams with more coarse bed material (such as gravel) are better able to buffer change in bed material load as compared to beds with finer gradation of bed material (sand).
- Transport vs. supply limited streams. Receiving streams that are transport limited may be better able to buffer changes in bed material load as compared to streams that are supply limited.

The Engineer will qualitatively assess the receiving stream using the gathered observations and rate the potential for adverse response based on a change in bed material load as high, medium or low.

The Engineer shall use a triad assessment approach, weighting each of the components based on professional judgment to determine if the project site provides a significant source of bed material load to the receiving stream, and the impact the project would have on the receiving stream. The final assessment and recommendation shall be documented in the HMP portion of the WQTR.

The recommendation may be any of the following:

- Site a significant source of sediment bed material – all on-site streams must be preserved.
- Site a source of sediment bed material – some of the on-site streams must be preserved (with identified streams noted).
- Site is not a significant source of sediment bed material.

The final recommendation will be guided by the triad assessment. Projects with predominantly "high" values for each of the three assessment areas would indicate preservation of on-site streams. Sites with predominantly "medium" values may warrant preservation of some of the on-site streams, and sites with generally "low" values would not require site design considerations for bed material.

The Engineer shall also assess if the receiving stream has been altered either for alignment, cross section, or longitudinal grade, or has degraded to the extent that an in-stream restoration project would be required to restore the functions and values of the stream bed. In such cases, the Engineer should discuss options for participating in an in-stream project in lieu of on-site design features to preserve bed material load.

Provision for waiver of sediment assessment. If any of the following are present, the site shall not be required to consider sediment component as a part of the HMP mitigation.

1. The site was previously developed and is being redeveloped.
2. There was no stormwater discharge from the site to a receiving water for the range of flows associated with the HMP.
3. The site discharges directly to a bay, estuary, reservoir, lake or the ocean, or through engineered channels to any of these receiving waters.

4.1.1.2 Step 2

If the analysis in Step 1 indicates that some or all of the site stream courses must be preserved as a contributor of bed material load to the receiving stream, the site plan shall be developed to avoid impacting the identified streams. The Engineer will designate streams onsite that should be avoided to preserve the discharge of bed material load from the site. The Engineer may consider the factors discussed above when determining whether a specific on-site stream course is a significant contributor of bed material load and should be preserved.

4.1.1.3 Step 3

If it is infeasible to avoid on-site streams that contribute significant bed material load in the design of the site plan, the drainage(s) may be moved and replicated elsewhere on the site, provided the Engineer will certify that the relocated drainage course has a similar potential to generate bed material load. The Professional Engineer will also certify that the revised drainage location is in substantially similar material as the natural stream location.

4.2 Alternative Compliance Methodology

The alternative compliance program may only be pursued if the significant replacement of bed material supply is deemed infeasible by the permitting authority, or if the project site design requires significant alteration of on-site streams. The infeasibility of the different sediment management measures stated in the general approach may only be demonstrated and documented by a Professional Engineer. The Professional Engineer may also demonstrate the expected feasibility of the alternative compliance methodology.

In such an eventuality, applicants may propose an alternative compliance methodology for bed material load mitigation from a project based on numerical modeling. The Engineer may propose adjusting the flow duration curve to maintain pre-project conditions in the receiving channel with the expected change in bed material load discharge from the site. This option may not be practical when the changes in bed material supply from the project are relatively small, due to limitations in the accuracy of modeling. The Engineer shall determine, using best professional judgment, if the alternative modeling approach is applicable.

The alternative modeling approach shall include the following:

1. Continuous hydrologic simulation for the project baseline condition and proposed condition over the range of flow values up to the pre-project 10-year event.
2. Sediment transport model of the receiving stream for the project baseline condition and proposed condition.
3. Analysis of the change in sediment bed material from the project baseline condition to the proposed condition
4. Explanation of method used to control the discharge from the project to account for changes in the delivered sediment bed material.
5. Summary report

An erosion potential (Ep) management objective will serve as the alternative performance standard for this option. As described in the modeling approach, hydromodification management measures will be selected and designed to maintain the Ep ratio within 10 percent of the target value in the receiving waters. The target Ep will be adjusted to account for changes in bed sediment supply. Studies have demonstrated that achieving an optimum capacity-supply ratio within 10 percent of the unity should ensure the dynamic stability of a stream while allowing the river to recover of some of the morphological detail that cannot be designed a-priori (USACE, 2001).

Site specific modeling is discussed further in **Appendix D**.

5 HMP and Local WQMP Integration

The HMP requirements including the HMP criteria, alternative compliance options and steps, and the sediment supply management methodology and steps will be incorporated into the Section 7II-2.4.2.2 Determine Hydromodification Performance Criteria of the Local WQMPs. The HMP alternative compliance and the alternative compliance for sediment supply management will also be integrated into the Section 7.II-3.0 Alternative Compliance Approaches of the Local WQMPs.

Guidance regarding the hydromodification technical feasibility study is integrated as part of the TGD. Section 5.4, "System Design to Address HCOCs" in South Orange County of the TGD has been updated to include the requirements of the HMP. The Permittees will use the revised Local WQMPs and TGD with the HMP requirements to incorporate requirements into the local approval processes and municipal ordinances.

6 HMP Revisions

Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001has provisions that will require the update of the South Orange County HMP as additional analysis is performed. Per Section E.3.c.(2)(e) of this permit the interim timeframe exemptions of the engineered channels and the large river reaches expire upon approval of the update of the BMP Design Manual, which is to be submitted with the complete Water Quality Improvement Plan per Section F.2.b.(1). Per section F.1.b.(1) the submittal of the complete WQIP is due within 24 months after commencement of coverage under the Order, which for the Orange County Permittees is April 1, 2015, therefore the update of the BMP Design Manual is to be submitted on April 1, 2017.

Per Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001Section B.3.b.(4)(a) the Copermittees have the option to perform a Watershed Management Area Analysis for each Watershed Management Area. Per Section B.3.b.(4)(c) the Copermittees must use the results of the Watershed Management Area Analysis to identify areas within the Watershed Management Area where it is appropriate to allow Priority Development Projects to be exempt from the hydromodification management BMP performance requirements described in Provision E.3.c.(2), including supporting rationale. Per Section F.1.a.(3)(c) the Copermittees must submit the Water Quality Improvement Plan requirements of Provision B.3, which include the Watershed Management Area Analysis and the areas appropriate to allow Priority Development Projects to be exempt from the hydromodification management BMP performance requirements including supporting rationale, to the San Diego Water Board as early as 9 months (January 1, 2016) and no later than 18 months (October 1, 2016) after the commencement of coverage under the Permit.

At this time critical sediment yield areas have not been identified by the Copermittees, however Permit Order R9-2013-0001 as amended by Order No. R9-2015-0001Section E.3.c.(2)(b) allows for the Watershed Management Area Analysis to identify the critical sediment yield areas. Understanding critical sediment yield areas is critical as Section E.3.c.(2)(b) requires Priority Development Projects to avoid critical sediment yield areas or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no net impact to the receiving water.

It is the intent of the County of Orange and the South Orange County Permittees to perform the Watershed Management Area Analysis and use it to 1) identify areas within the Watershed Management Area where it is appropriate to allow Priority Development Projects to be exempt from the hydromodification management BMP performance requirements described in Provision E.3.c.(2) with the supporting rationale; and 2) identify the critical sediment yield areas; which will both be submitted with the Water Quality Improvement Plan requirements of Section B.3 no later than October 1, 2016. Based on the results of the review and potential approval of the San Diego Regional Board of the areas to be exempt from the hydromodification management BMP performance requirements and the identification of the critical sediment yield areas, based on the results of the Watershed Management Area Analysis, the South Orange County HMP will be updated.

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APPENDIX A

Practitioner Quick Start Sheet

The quick start summary lists the chronological steps that a practitioner should follow for their development project or re-development project to meet the requirements of this South Orange County Hydromodification Management Plan. The chronological steps are, as follows:

1. The first step consists of verifying if the project is exempt from hydromodification requirements. Exemption occurs:
   - If the project is not classified as Priority Development Project per permit item F.1.d., or,
   - If the proposed project discharges runoff directly to an exempt receiving water such as the Pacific Ocean, water storage reservoirs, lakes, enclosed embayments, engineered channel, or an exempt river reach. Or, if the proposed project discharges to an engineered conveyance system with the capacity to convey the 10-year ultimate condition that extends to the Pacific Ocean, water storage reservoirs, lakes, enclosed embayments, engineered channel, or an exempt river reach (See **Section 3.3.1**), or,
   - If the project discharges to a large river per the definition provided in **Section 3.3.2**

2. If the project is non-exempt, the practitioner shall implement the hydrologic management requirements identified in Section 4.0 and the sediment supply management requirements identified in Section 5.0 for the proposed project. These include hydrologic management controls and sediment supply management:
   a. Hydrologic management controls

All PDPs must ensure that post-project runoff flow rates and durations for the PDP shall not exceed pre-development, naturally occurring, runoff flow rates and durations by more than 10% of the time, from 10% of the 2-year runoff event up to the 10-year runoff event. Onsite hydrologic controls are to be designed based on the South Orange County Hydrology Model. Alternatively, the practitioner may develop its own numerical criteria but should support his findings with continuous simulation models. Technical infeasibility of a type of hydrologic control should be documented. If infeasible to implement onsite hydrologic controls alternative compliance options are available. Specifics are provided in **Section 3.4**.

   b. Sediment supply management

The practitioner may follow a three-step process to ensure maintenance of the pre-project sediment supply to the stream:

1. Determine whether the site is a significant source of bed material to the receiving stream.
2. Avoid significant bed material supply areas in the site design.
3. Replace significant bed material supply areas that are eliminated through urbanization.

If the three-step process is deemed infeasible, an alternative compliance option allows the project applicant to model the site conditions and the receiving stream and provide additional mitigation in site runoff to compensate for the reduction (or addition) of bed material. Specifics are detailed in **Section 4.1**.

3. The practitioner shall integrate hydrologic management controls and sediment supply management into the project site design, and define the design specifics in the preliminary WQMP that should be submitted to the jurisdiction. The jurisdiction may approve the proposed design upon identification of compliance with the requirements of this HMP.

APPENDIX B

Literature Review

Pursuant to Permit Section F.1.h(1)(e), this section provides the results of a literature review conducted as a basis for the development of the HMP.

Hydromodification in the context of this Plan refers to changes in the magnitude and frequency of stream flows due to urbanization and the resulting impacts on the receiving channels in terms of erosion, sedimentation, and degradation of in-stream habitat. The processes involved in aggradation and degradation are complex, but are caused by an alteration of the hydrologic regime of a watershed due to increases in impervious surfaces, more efficient storm drain networks, and a change in historic sediment supply sources, among other factors. The study of hydromodification is an evolving field, and regulations to manage the impacts of hydromodification must be grounded in the latest science available.

HMPs seek ways to mitigate erosion impacts by establishing requirements for controlling runoff from new development. In order to establish appropriate regulations, it is important to understand 1) how land use changes alter storm water runoff; and 2) how these changes can impact stream channels. These and other issues central to HMPs adopted in California have been addressed in numerous journal articles, books, and reports. This report builds upon previous literature reviews developed for the San Diego County HMP, including recent studies or information relevant to Southern California.

B.1 Managing Hydromodification

There are many different approaches to managing hydromodification impacts from urbanization and most HMPs provide multiple options for achieving and documenting compliance with National Pollutant Discharge Elimination System (NPDES) permit requirements. In general, hydrograph management approaches focus on managing runoff from a developed area to not increase instability in a channel, and in-stream solutions focus on managing the receiving channel to accept an altered flow regime without becoming unstable. This section briefly summarizes various approaches for HMP compliance.

B.1.1.1 Hydrograph Management Solutions

Facilities that detain or infiltrate runoff to mitigate development impacts are the focus of most HMP implementation guidance. They work by either reducing the volume of runoff (infiltration facilities) or holding water and releasing it below Q_c (detention facilities). These facilities, also referred to as BMPs, can range from regional detention basins designed solely for flow control, to bioretention facilities that serve a number of functions. A number of BMPs, including swales, bioretention, flow-through planters, and extended detention basins have been developed to manage storm water quality, and several resources describe the design of storm water quality BMPs (CASQA 2003; Richman et al. 2004). In many cases, these facilities can be designed to also meet hydromodification management requirements.

Many HMPs also provide guidance for applying LID approaches to site design and land use planning to preserve the hydrologic cycle of a watershed and mitigate hydromodification impacts. These plans typically include decentralized storm water management systems and protection of natural drainage features, such as wetlands and stream corridors. Runoff is typically directed toward infiltration-based storm water BMPs that slow and treat runoff. The following sections summarize how hydromodification management BMPs developed for existing HMPs have been designed and implemented.

B.1.1.1.1 Sizing Hydromodification BMPs

Hydromodification BMPs differ from those used to meet water quality objectives in that they focus more on generating a flow-duration curve that matches or reduces the undeveloped flow duration curve than on removing potential pollutants, although these two functions can be combined into one facility. Various methods exist for sizing hydromodification BMPs.

- **Hydrograph Matching** uses an outflow hydrograph for a particular site that matches closely with the pre-project hydrograph for a design storm. This method is most traditionally used to design flood-detention facilities to mitigate for a particular storm recurrence interval (e.g., the 100-year storm). Although hydrograph matching can be employed for multiple storm recurrence intervals, this method generally does not take into account the smaller, more frequent storms that are identified by the actual state of the science as performing a majority of the erosive work in stream channel and is therefore not widely accepted for HMP compliance nor recommended for use as a part of this plan.
- **Volume Control** matches the pre-project and post-construction runoff volume for a project site. Any increase in runoff volume is either infiltrated on site, or discharged to another location where streams will not be impacted. The magnitude of peak flows and time of concentration is not controlled, so while this method ensures there is no increase in total volume of runoff, it can result in higher erosive forces during storms.
- **Flow Duration Control** matches or reduces both the duration and magnitude of a specified range of storms. The entire hydrologic record is taken into account, and pre-project and post-construction runoff magnitudes and volumes are matched as closely as possible. Excess runoff is either infiltrated onsite or discharged below Q_{cp} (Geomorphically critical flow – 10 percent of the 2-year flow).

The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVUPPP) HMP reviewed each of these methods and concluded that a Flow Duration Control approach was the most effective in controlling erosive flows. Two examples were evaluated using this approach, one on the Thompson Creek subwatershed in Santa Clara Valley and one on the Gobernadora Creek watershed in Orange County. The evaluation approach used continuous simulation modeling to generate flow-duration curves, and then designed a test hydromodification management facility to match pre-project durations and flows.

In addition to the SCVURPP HMP, the flow duration control approach has been applied by the Alameda Countywide Clean Water Program (ACCWP), SMCWPPP, the Fairfield-Suisun Urban Runoff Management Program (FSURMP), Contra Costa Clean Water Program (CCCWP), and

San Diego County. Among these agencies, different approaches have emerged on how to demonstrate that proposed BMPs meet flow-duration control guidelines. Both methods employ continuous simulation to match or reduce flow-durations, but differences exist in how continuous simulation is used (site-specific simulation vs. unit area simulation). Differences also exist in the focus of the two approaches (regional detention facilities vs. on-site LID facilities). Both approaches were evaluated by the different RWQCBs and deemed valid (Butcher 2007).

B.1.1.1.2 BAHM Approach

The Bay Area Hydrology Model (BAHM) is a continuous simulation rainfall-runoff hydrology model developed for ACCWP, SMCWPPP, and SCVURPP. It was developed from the Western Washington Hydrology Model, which focuses primarily on meeting hydromodification management requirements using storm water detention ponds alone or combined with LID facilities (Butcher 2007). The Western Washington Hydrology model is based on the Hydrologic Simulation Program – FORTRAN (HSPF) modeling platform, developed by the United States Environmental Protection Agency (U.S. EPA), and uses HSPF parameters in modeling watersheds.

Project proponents who want to size a hydromodification BMP select the location of their project site from a map of the county and BAHM correlates the project location to the nearest rainfall gauge and applies an adjustment factor to the hourly rainfall for the nearest gauge, to produce a weighted hourly rainfall at the project site. The user then enters parameters for the proposed project site describing soil types, slope, and land uses. BAHM then runs the continuous rainfall-runoff simulation for both the pre-project and the post-construction conditions of the project site. Output is provided in the form of flow-duration curves that compare the magnitude and timing of storms between the pre-project and the post-construction modeling runs.

If an increase in flow durations is predicted, the user can select and size mitigation BMPs from a list of modeling elements. An automatic sizing subroutine is available for sizing detention basins and outlet orifices that matches the flow duration curves between the pre-project scenario and a post-construction mitigation scenario. Manual sizing is necessary for other BMPs included in the program, such as storage vaults, bioretention areas, and infiltration trenches. The program is designed so that, once a BMP is selected and sized, the modeling run can be transferred to the local agency for approval. The model reviewer at the local agency can launch the program and verify modeling parameters and sizing techniques.

A HMP tool was also developed to support developers and applicants with the San Diego County HMP. The San Diego Hydrology Model (SDHM) derives from the BAHM, and integrates parameters that are specific to the San Diego region.

A similar approach will be used for the South Orange County HMP. The Western Washington Continuous Simulation Hydrology Model (WWHM) has been modified to include local rainfall and loss rate information, in addition to preferred local BMP selection to provide project proponents a user-friendly tool to develop a hydromodification mitigation strategy. The South

Orange County Hydrology Model (SOCHM) allows the user to match or reduce the flow duration curve for the selected range of flows using locally preferred BMPs.

B.1.1.1.3 Contra Costa Clean Water Program (CCCWP) Approach

The CCCWP developed a protocol for selecting and sizing hydromodification BMPs, which are referred to as Integrated Management Practices (IMPs) in their guidebook. Instead of a project proponent running a site-specific continuous simulation to size hydromodification control facilities, the CCCWP provides sizing factors for designing site level IMPs. Sizing factors are based on the soil type of the project site and are adjusted for Mean Annual Precipitation. Sizing factors are provided for bioretention facilities, flow-through planters, dry wells and a combination cistern and bioretention facility.

Sizing factors were developed through continuous-simulation HSPF modeling runs for a variety of development scenarios. Flow-durations were developed for a range of soil types, vegetation and land use types, and rainfall patterns for development areas in Contra Costa County. Then, based on a unit area (one acre) of impervious surface, flow-durations were modeled using several IMP designs. These IMPs were then sized to achieve flow control for the range of storms required, (from 10 percent of the 2-year storm up to the 10-year storm). These sizing factors were then transferred to a spreadsheet form for use by project proponents.

The primary difference between the CCCWP approach and the BAHM approach is the level of modeling required. The CCCWP approach is simplified for the project proponent in that both hydromodification and water quality mitigation are incorporated into the IMP sizing factors. The BAHM allows for more flexibility in that regional BMPs may be used for hydromodification, and if desired, water quality, in addition to site level approaches. The South Orange County NPDES Permit allows for regional mitigation of hydromodification impacts. Therefore, an approach that uses continuous simulation to assess regional or neighborhood level BMP implementation is preferred for this Plan.

B.1.1.2 Sediment Management Solutions

Sediment discharge is one of the fundamental independent variables impacting stream stability. Lane (1955) described alluvial channel stability in the relation:

$$Q_s \times D_{50} \propto Q_w \times S$$

Where:

Q_s = Sediment discharge
D_{50} = Median sediment size
Q_w = Flow
S = Channel Slope

As seen by Lane's relationship, if any of the four variables are altered, one or more of the remaining variables must change. In the case of urbanization, runoff usually is increased, causing a reduction in channel slope (S) through downcutting or increased channel meander. Urbanization may also result in a change in sediment discharge (Q_s). Streambed material is

derived from the channel bed and banks. If channels are altered by development in such a way as to reduce or increase sediment discharge, instability may occur.
Only a portion of the total sediment load in a channel is important for stream stability. Total channel sediment load may be classified by size or transport mechanism. The wash load commonly refers to the portion of the total sediment load that remains continuously in suspension (based on particle size). The wash load has a nominal impact on channel stability. Bed material load refers to the material that moves along the channel bed via saltation, and is continuously in contact or exchange with the channel bed. Bed material load is the critical portion of total sediment discharge for channel stability.

Urbanization can reduce the mass of bed material transported through the elimination of alluvial channel sections. This occurs in site development when first order and particularly larger streams are lined or placed into underground conduits. There are two general approaches for managing the bed material load relative to urbanization and channel stability. The first approach attempts to correct for the change in bed material load by increasing or decreasing the discharge rate as appropriate to generally maintain the balance between hydrologic and geomorphic processes as conceptualized in Lane's interrelationship. While theoretically a sound approach, this option requires a significant amount of detailed information that is difficult to obtain and requires good calibration of sediment models. Sediment transport models are non-linear and relatively sensitive to the rate of sediment supply and particle size distribution. This HMP does not recommend any specific sediment transport equation or model as the selection of such a model should be based on stream and watershed specific information, and the amount and quality of available data. Examples of sediment transport equations the designer may consider include: Duboys Formula, Meyer-Peter Formula, Einstein Bed Load Function, Modified Einstein Procedure, Colby's Method, Engelund and Hansen Method, Ackers and White Method. There are several models that use these transport formulas to predict long-term sediment transport. General guidance for site specific analysis is provided in **Appendix D**.

The second approach to maintaining sediment supply is physically based, relying on a field assessment of site locations that may supply bed material load to the receiving channel, and protecting those sources during the site planning and development process. With this approach, the project proponent need only provide engineered solutions for flow mitigation. Protection of site bed material sources is the preferred approach since it is physically based and potentially less prone to error. Guidelines for field assessment of bed material sources are provided with the Sediment Supply Management approach, which is described in **Section 5.1**.

B.1.1.3 In-Stream Stabilization Solutions

In-stream solutions focus on managing the stream corridor to provide stability, modifying the stream channel to accept an altered flow regime. In cases where development is proposed in a watershed with an impacted stream it may be beneficial to focus on rehabilitating the stream channel to match the new independent variables of channel cross section, sediment discharge, flow discharge and channel slope rather than retrofitting the watershed or only controlling a percentage of the runoff with on-site controls. This type of approach can restore stream functions, beneficial uses, and values at a much more rapid pace, especially in locations that cannot physically be returned to their natural state due to changes in stream channel alignment and restrictions on the channel cross section due to adjacent development. In addition, in some cases where a master-planned watershed development plan is being implemented it may be more feasible to design a new channel to be stable under the proposed watershed land use rather than to construct distributed on-site facilities.

In-stream stabilization and restoration solutions are available as alternative compliance as a part of the South OC HMP. In-stream restoration projects are available if on-site controls are not feasible and it has been determined that the receiving water that the project discharges to has impacts due to hydromodification. Tiered benefits (benthic communities, morphology) of such in-stream restoration projects must offset the hydrologic and sediment changes induced by the associated PDP(s).

B.1.1.3.1 Other Methods

A number of methods exist for managing channels to accept altered flow regimes and higher shear forces. These have been covered in detail in a number of sources available to watershed groups and public agencies. (A few helpful sources include Riley 1998, Watson and Annable 2003, and FISRWG 1998.)

B.1.1.4 Stream Susceptibility - Domain of Analysis

Southern California Coastal Water Research Project (SCCWRP) has developed a series of screening tools that evaluate the susceptibility of a stream to hydromodification impacts (SCCWRP, 2010). These screening tools allow a project proponent to rate the susceptibility of the evaluated stream to erosion for a variety of geomorphic scenarios including alluvial fans, broad valley bottoms, incised headwaters, etc.

The development of HMPs in most Southern California counties is correlated to the ultimate findings of SCCWRP studies on hydromodification (SCCWRP, 2008 through 2011). It is generally acknowledged that SCCWRP's formulation of regional standards for hydromodification management may serve as a baseline for development of HMPs for specific regions in Southern California.

When evaluating the stream susceptibility though the SCCWRP screening tools, a domain of analysis is defined. This domain of analysis corresponds to the reach lengths upstream and downstream from a project from which hydromodification assessment is required. The domain of analysis determination includes an assessment of the incremental flow accumulations downstream of the site, identification of grade control points in the downstream conveyance system, and quantification of downstream tributary influences. The south Orange County program elected not to perform the extensive susceptibility mapping required to correlate channel reaches with variable low-flow discharge thresholds, since the return on investment for this type of analysis appears to be very low.

The effects of hydromodification may propagate for significant distances downstream (and sometimes upstream) from a point of impact such as a stormwater outfall. Accordingly, the domain of analysis serves as a representative buffer domain across which the susceptibility of a stream should be evaluated. This representative domain spans multiple channel types/settings, and is defined as follows in this HMP (SCCWRP, 2010):

- Proceed downstream until reaching the closest of the following:
  - at least one reach downstream of the first grade-control point (but preferably the second downstream grade-control location)
  - tidal backwater/lentic waterbody
  - equal order tributary (Strahler 1952)
  - a 2-fold increase in drainage area

OR demonstrate sufficient flow attenuation through existing hydrologic modeling.

- Proceed upstream to extend the domain:
  - upstream for a distance equal to 20 channel widths OR to grade control in good condition – whichever comes first. Within that reach, identify hard points that could check headward migration, evidence that head cutting is active or could propagate unchecked upstream

Within the analysis domain there may be several reaches that should be assessed independently based on either length or change in physical characteristics. In more urban settings, segments may be logically divided by road crossings (Chin and Gregory 2005), which may offer grade control, cause discontinuities in the conveyance of water or sediment, etc.

The domain of analysis is discussed here since it may be relevant for use in site-specific analysis as discussed in **Appendix D**. It is not used in this HMP as a discriminator for HMP applicability to a specific project except in the case of urban infill projects.

B.2 Flow Control Approach

HMPs that have been developed in the San Francisco Bay Area, Northern California (Contra Costa, Santa Clara, and Alameda Counties and the Sacramento area), and San Diego County vary with regard to the emphasis placed on lower flow control thresholds as compared to other approaches, such as distributed low impact development (LID) methods. The South Orange County HMP was developed using the lower flow control threshold approach. There is consensus in that both the frequency and duration of flows must be controlled using continuous simulation hydrologic modeling (rather than the standard design storm approach used for flood control design) to mitigate for potential development impacts. At this point, it is generally accepted that events more frequent than the 10-year flow are the most critical for hydromodification management, since flows within this range of return period (up to the 10-year event) have been documented to perform the most work on the channel bed and banks. However, the range of analysis could potentially change in the future if new studies provide sufficient evidence warranting a modification.

The Santa Clara HMP focused on using detention basins for hydromodification management and emphasized the lower flow control limit for site runoff. Extended detention flow control basins can be constructed with multi-stage outlets to mitigate both the duration and magnitude of flows within a prescribed range. To avoid the erosive effects of extended low flows, the maximum rate (depth) at which runoff is discharged is set below the erosive threshold. Per the Santa Clara HMP, the lower flow control limit was defined as the flow rate that generates critical shear stress on the channel bed and banks. Both Santa Clara and Alameda Counties correlated the lower flow control limit to a value equal to 10 percent of the 2-year runoff event.

The Contra Costa HMP emphasized the importance of using LID methods to meet hydromodification management criteria. LID approaches to hydromodification management rely on site design and distributed LID Best Management Practices (BMPs) to control the frequency and duration of flows and to mitigate hydrograph modification impacts. By minimizing directly connected impervious areas and promoting infiltration, LID approaches mimic natural hydrologic conditions to counteract the hydrologic impacts of development. LID systems are sized to achieve flow control for the range of storms required (from 10 percent of the 2-year storm up to the 10-year storm).

The County of San Diego HMP defined an adaptive lower flow threshold based on the channel susceptibility rating (High, Medium, or Low). Receiving streams in San Diego County were individually classified by their susceptibility to channel erosion impacts using a critical flow calculator and a channel screening tool developed by Southern California Coastal Water Research Project (SCCWRP). This classification produced three lower flow thresholds which are 0.1Q2, 0.3Q2, and 0.5Q2. The upper range of the mitigation flow was considered the pre-project 10-year storm event.

Rates of sediment production from southern California rivers depend upon bedrock geology, rates of tectonic uplift, land use, and precipitation (Warrick et al., 2003). The California Geological Survey agency identifies 13 unique geomorphic zones based on geology, faults, topographic relief, and climate (California Department of Conservation, 2002). South Orange County is located within the Peninsular Ranges geomorphic zone, whose geology is characterized by the granitic rocks intruding the older metamorphic rocks. San Diego County is also located within the same geomorphic zone, thus exhibits similar macro-scale geomorphic trends to those in South Orange County.

The approach developed for the San Diego County HMP was approved by the SDRWQCB and selected as the base approach for the South Orange County HMP. However, the South Orange County program elected not to perform the extensive susceptibility mapping required to correlate channel reaches with variable low-flow discharge thresholds. The implementation of HMPs in Northern California and in San Diego has shown that numerically larger low flow thresholds generally have very limited applicability in practice. Accordingly, a base low flow threshold ($0.1Q_2$) was selected for this HMP. The selection of the low flow threshold ($0.1Q_2$) was based on other approved HMPs in California with similar hydrologic and geologic conditions. The low flow threshold ($0.1Q_2$) is the most conservative of the potential range identified in the San Diego HMP. Nonetheless, the applicant may compute a site-specific low flow threshold at their option, following a methodology developed by the applicant. An example of such a procedure is described in the San Diego County HMP document.

If the applicant opts for developing a site-specific criterion, the selected lower flow threshold shall correspond to the critical channel flow that produces the critical shear stress that initiates channel bed movement or that erodes the toe of channel banks. For a channel segment that is lined but not exempt by this HMP, the low flow threshold must be computed assuming the lining has been removed.

B.2.1 Previous Studies

Previous hydromodification literature reviews were conducted by Geosyntec Consultants (Mangarella and Palhegyi, 2002) for the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) and by the Contra Costa Clean Water Program (CCCWP 2004). Mangarella and Palhegyi provide a detailed overview of the geomorphic and hydrologic processes involved in hydromodification (see **Section Error! Reference source not found.**) for additional details on the mechanics of stream erosion). Channel assessment methods described in Section 6 of this HMP rely heavily on those reviewed by Bledsoe et al. (2008) for SCCWRP.

To date, six approved HMPs have been published. These include HMPs for SCVURPPP (2005), the CCCWP (2005), the Fairfield-Suisun Urban Runoff Management Program FSURMP (2005), the Alameda Countywide Clean Water Program (ACCCMP 2005), the San Mateo Countywide Stormwater Pollution Prevention Program (SMCWPPP [formerly STOPPP] 2005), and the San Diego County Hydromodification Plan (2009). In addition, a number of HMPs were implemented while agencies developed their final plans. Interim HMPs are not detailed in this report because these plans have adopted findings from the above listed HMPs.

B.2.2 Hydrograph Modification Processes

The effects of urbanization on channel response have been the focus of many studies (see Paul and Meyer, 2001 for a review), and the widely accepted consensus is that increases in impervious surfaces associated with urbanizing land uses can cause channel degradation. Urbanization generally leads to a change in the amount and timing of runoff in a watershed, which increases erosive forces on channel bank and bed material and can cause large-scale channel enlargement, general scour, stream bank failure, loss of aquatic habitat and degradation of water quality.

Channel erosion, like most physical processes, is a complex system based on a variety of influences. Channel erosion is non-linear (Philips 2003), meaning the response of streams is not directly proportional to changes in land use and flow regimes. Small changes or temporary disturbances in a watershed may lead to unrecoverable channel instability (Kirkby 1995). These disturbances may give rise to feedback systems whereby small instabilities can be propagated into larger and larger instabilities (Thomas 2001).

A number of studies have sought to correlate the amount of urbanization in a watershed and stream instability (Bledsoe 2001; Booth 1990, 1991; Both and Jackson 1997; MacRae 1992; 1993; 1996; Coleman et al. 2005). Evidence from these studies suggests that below a certain threshold of watershed imperviousness, streams maintain stability. This threshold or imperviousness transition zone appears to be around seven to ten percent watershed urbanization for perennial streams (Schueler 1998 and Booth 1997), but may begin at a lower level for intermittent streams such as those found in Southern California. Studies done in Santa Fe, New Mexico (Leopold and Dunne 1978) suggest that changes occur at four percent impervious area of the watershed. Initial studies by Coleman et al. (2005) suggest that a response in the stream channel may begin to occur at two to three percent watershed imperviousness for intermittent streams in Southern California. It is important to understand that use of impermeable cover alone is a poor predictor of channel erosion due to differences in storm water detention and infiltration within regions. In highly urbanized watersheds returning a stream to a natural condition is infeasible due to existing development in the watershed. In these scenarios the focus should be on in-stream restoration to restore the beneficial uses of the receiving water.

Though it is well established that watershed urbanization causes channel degradation, a detailed understanding of how development alters runoff and how this altered runoff in turn causes erosion is still being developed. This section briefly describes these processes and summarizes methods used to quantify hydromodification impacts.

B.2.2.1 Effective Work

The ability of a stream to transport sediment is proportional to the amount of flow in the stream: as flow increases, the amount of sediment moved within a channel also increases. The ability of a stream channel to transport sediment is termed stream power, which integrated over time is work. Leopold (1964) introduced the concept of effective work, whereby the flow-frequency relationship of a channel is multiplied by sediment transport rate. This gives a mass-frequency relationship for erosion rates in a channel. Flows on the lower end of the relationship (e.g., two-year flows) may transport less material, but occur more frequently than higher flows, thereby having a greater overall effect on the work within the channel. Conversely, higher magnitude events, while transporting more material, occur infrequently so cause less effective work. Leopold found that the maximum point on the effective work curve occurred around the 1-to 2-year frequency range. This maximum point is commonly referred to as the dominant discharge. It corresponds roughly to a bankfull event (a flow that fills the active portion of the channel up to a well-defined break in the bank slope).

Urbanization tends to have the greatest relative impact on flows that are frequent and small, and which tend to generate less-than-bankfull flows. Change is greatest in these events because prior to urbanization, infiltration would have absorbed much or all of the potential runoff, but following urbanization, a high percent of the rainfall runs off. Thus, events that might have generated little or no flow in a non-urbanized watershed can contribute flow in urban settings. These smaller less-than-bankfull events have been found to cause a significant proportion of the work in urban streams (MacRae 1993) due to their high frequency, and can lead to channel instability. Less frequent, larger magnitude flows (e.g., flows greater than Q_{10}) are less strongly affected by urbanization because during such infrequent storm events, the ground rapidly becomes saturated, and acts (for purposes of runoff generation) in a similar manner as impervious surfaces.

B.2.2.2 Estimating Critical Q_c

Due to the increase in impervious surfaces and fewer opportunities for infiltration of storm water, urbanization creates a higher runoff rate and more runoff volume than an un-urbanized watershed. Opportunities for infiltration of excess storm water exist in urbanized areas, but many times are infeasible due to cost, technical barriers or land use constraints. Therefore, some of the excess storm water must be discharged to a receiving stream. In order to achieve a comparable E_p to a pre-developed condition, this excess runoff volume must be discharged at a rate at which insignificant effective stream work is done.

Bed load sediment moves through transmission of shear stress from the flow of water on the channel bed. An increase in the hydraulic radius (measure of channel flow efficiency through a ratio of the channel's cross sectional area of the flow to its wetted perimeter) corresponds to an increase in shear stress. In order to initiate movement of bed material, however, a shear stress threshold must be exceeded. This is commonly referred to as critical shear stress, and is dependent on sediment and channel characteristics. For a given point on a channel where the bed composition and cross-section is known, the critical shear can be related to a stream flow. The flow that corresponds to the critical shear is known as the critical flow, or Q_c. For a given cross-section, flows that are below the value for Q_c do not initiate bed movement, while flows above this value do initiate bed movement.

SCVURPPP expressed Q_c as a percentage of the two-year flow in order to develop a common metric across watersheds of different size, and allow for easy application of HMP requirements. For the two watersheds studied in detail in the SCVURPPP study, a similar relationship was found where Q_c corresponded to 10 percent of the two-year flow. Several methodologies were used to determine both the two-year flows and the ten-year flows across the evaluated watersheds. The two-year flow was computed based on either the rational method, as described in the Santa Clara Valley Hydrology Procedures, or the Cunnane ranking schema applied to "all event frequency" curves. The ten-year flow was computed based on the Log Pearson type III distribution applied to annual flow frequency curves. This became the basis for the lower range of geomorphically significant flows under the SCVURPPP HMP and is referred to as Q_{cp} to indicate that it is a percentage of flow. That program also adopted the 10-year flow as the upper end of the range of flows to control with the justification that increases in stream work above the 10-year flow were small for urbanized areas.

A similar study was conducted for the FSURMP on two watersheds in Fairfield, California following a geomorphic assessment. That study found Q_{cp} to be 20 percent of the pre-development two-year flow. The differences in the two values may be attributable to differences in watershed characteristics in Santa Clara County and Fairfield, the number of streams studied, the methodology used to compute the two-year flow, and the precision of the modeling tools. Channels in Fairfield were found to have a more densely vegetated riparian corridor and may have a higher resistance to increases in shear stresses (FSURMP). Values for Q_{cp} appear to be similar among neighboring watersheds, but there appears to be a range of appropriate Q_{cp} values. The characteristics of individual biomes (climatically and geographically defined areas of ecologically similar climatic conditions, such as communities of plants, animals, and soil organisms, often referred to as ecosystems) should be taken into account when developing a Q_{cp}. For example, Western Washington State, which has more densely vegetated riparian zones than either Fairfield or Santa Clara County, has adopted a Q_{cp} of 50 percent of the 2-year flow.

A summary of flow control standards adopted in each of the approved HMPs in California and western Washington is given in **Error! Reference source not found.**.

Table B-1: Summary of Flow Control Standards – Approved HMPs

Permitting Agency	Q_{cp}	Largest Managed Flow
Alameda County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
Contra Costa County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
Fairfield-Suisun Urban Runoff Management Program	20 percent of the 2-year flow (0.2Q2)	10-year flow (Q10)
San Diego County	10, 30, or 50 percent of the 2-year flow (0.1Q2, 0.3Q2, or 0.5Q2)	10-year flow (Q10)
San Mateo County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
Santa Clara County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
Western Washington State	50 percent of the 2-year flow (0.5Q2)	50-year flow (Q50)

As noted previously the South Orange County HMP has selected a low flow threshold ($0.1Q_2$) as a default value. The determination of the two-year flow should be based on the guidance provided in Section 3.3. The project proponent may put forth other low flow thresholds for individual projects, but other low flow thresholds will require site-specific justification using modeling or field tests to support the unique threshold value.

B.2.3 Stream Channel Stability

Numerous stream channel stability assessment methods have been proposed to help distinguish which channels are most at risk from hydrograph modification impacts and/or define where HMP requirements should apply. Assessment strategies range from purely empirical approaches to channel evolution models to energy-based models (see Simon et al., 2007 for a critical evaluation). Stream channel stability assessment methods are useful in assessing the impact of urbanization, or control programs over time. Their value lies in showing trends as changes in a watershed occur, rather than classifying the reach of a discrete channel section at a given point in time.

B.2.3.1 Stream Classification Systems

A recent study by Bledsoe et al. (2008) for SCCWRP describes nine types of classification and mapping systems with an emphasis on assessing stream channel susceptibility in Southern California. The summary below is taken from that study. Bledsoe also provides a summary of the implications of these classification and mapping systems to the development of hydromodification tools for Southern California. The article provides a detailed breakdown of guidelines for developing hydromodification tools given the advantages and disadvantages of each system previously assessed.

B.2.3.1.1 Planform Classifications and Predictors

Alluvial channels form a continuum of channel types whose lateral variability is primarily governed by three factors: flow magnitude, bank erodibility, and relative sediment supply. Though many natural channels conform to a gradual continuum between straight and intermediate, meandering, and braided patterns, abrupt transitions in lateral variability imply the existence of geomorphic thresholds where sudden change can occur. The conceptual framework for geomorphic thresholds has proven integral to the study of the effects of disturbance on river and stream patterns. Many empirical and theoretical thresholds have been proposed relating stream power, sediment supply and channel gradient to the transition between braiding and meandering channels. Accounting for the effects of bed material size has been shown to provide a vital modification to the traditional approach of defining a discharge-slope combination as the threshold between meandering and braided channel patterns. The many braided planforms in Southern California indicate the need to refine and calibrate established thresholds to river networks of interest. However, at this time there is not a well-accepted model to predict how hydromodification affects channel planform.

B.2.3.1.2 Energy-Based Classifications

The link between channel degradation and urbanization has been studied; however, impervious area is not the solitary factor influencing channel response. Studies have shown that the ratio between specific stream power and median bed material size D50b, where b is approximately 0.4 to 0.5 for both sand-and gravel-bed channels, can be used as a valuable predictor of channel form. Stream power, which is linearly related to the total discharge, is the most comprehensive descriptor of hydraulic conditions and sedimentation processes in stream channels. Several studies have been performed relating channel stability to a combination of parameters such as discharge, median bed-material size, and bed slope, as an analog for stream power.

B.2.3.1.2 General Stability Assessment Procedures

By assessing an array of qualitative and quantitative parameters of stream channels and floodplains, several investigators have developed qualitative assessment systems for stream and river networks. These assessment methods have been incorporated into models used to analyze channel evolution and stability. Many parameters used to establish methodologies such as the Rosgen approach are extendable to a qualitative assessment of channel response in Californian river networks. Field investigations in Southern California have shown that grade control can be the most important factor in assessing the severity of channel response to hydromodification. Qualitative methodologies have proven extendable to many regions, and they use many parameters that may provide valuable information for similar assessments in California.

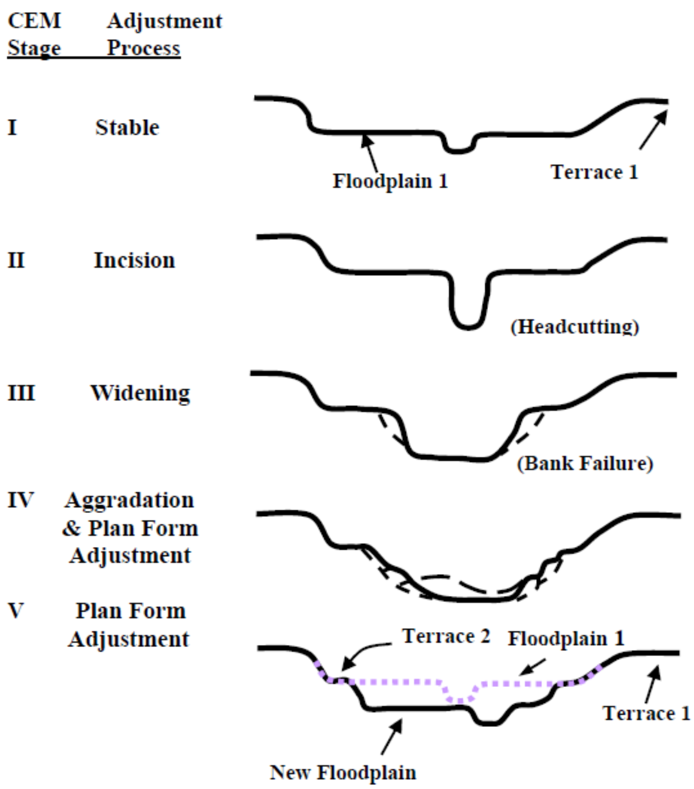
B.2.3.1.4 Sand vs. Gravel Behavior / Threshold vs. Live-Bed Contrasts

It is well recognized that the fluvial-geomorphic behavior varies greatly between sand and gravel/cobble systems. Live bed channels (of which sand channels are good examples) are systems where sediment moves at low flows, and where sediment is frequently in motion. Threshold channels, such as gravel streams, by contrast, require considerable flow to initiate bedload movement. Live bed channels are more sensitive to increases in flow and decreases in sediment supply than threshold channels. Scientific consensus shows that sand bed streams lacking vertical control show greater sensitivity to changes in flow and sediment transport regimes than do their gravel/cobble counterparts. Factors such as slope, and sedimentation regimes are known to have greater impact on sand-bed streams. This can be an important issue for storm water systems receiving runoff from watersheds composed primarily of streams with sandy substrate. The transition between sand and gravel bed behavior can be rapid, enabling the use of geographic mapping methods to prioritize channel segments according to their susceptibility to the effects of hydromodification.

B.2.3.1.5 Channel Evolution Models of Incising Channels

The Channel Evolution Model (CEM) developed by Schumm et al. (1984) posits five stages of incised channel instability organized by increasing degrees of instability severity, followed by a final stage of quasi-equilibrium. Work has been done to quantify channel parameters, such as sediment load and specific stream power, through each phase of the CEM. A dimensionless stability diagram was developed by Watson et al. (2002) to represent thresholds in hydraulic and bank stability. This conceptual diagram can be useful for engineering planning and design purposes in stream restoration projects requiring an understanding of the potential for shifts in bank stability.

Figure B-1: Five Stages of the Channel Evolution Model (CEM)



(Schumm et al. 1984)

B.2.3.1.6 Channel Evolution models Combining Vertical and Lateral Adjustment Trajectories

Originally, CEMs focused primarily on incised channels with geotechnically, rather than fluvially, driven bank failure. Several CEMs have been proposed that incorporate channel responses to erosion and sediment transport into the original framework for channel instability.

In these new systems, an emphasis is placed on geomorphic adjustments and stability phases that consider both fluvial and geomorphic factors. The state of Vermont has developed a system of stability classification that suggests channel susceptibility is primarily a function of the existing Rosgen stream type and the current stream condition referenced to a range of variability. This system places more weight on entrenchment (vertical erosion of a channel that occurs faster than the channel can widen, resulting in a more confined channel) and slope than differentiation between bed types.

B.2.3.1.7 Equilibrium Models of Supply vs. Transport-capacity / Qualitative Response

The qualitative response model builds on an understanding of the dynamic relationship between the erosive forces of flow and slope relative to the resistive forces of grain size and sediment supply to describe channel responses to adjustments in these parameters. In this system, qualitative schematics provide predictions for channel response to positive or negative fluctuations in physical channel characteristics and bed material. Refinements to such frameworks have been made to account for channel susceptibility relative to existing capacity and riparian vegetation among other influential characteristics.

B.2.3.1.8 Bank Instability Classifications

Early investigations provided the groundwork for bank instability classifications by analyzing shear, beam, and tensile failure mechanisms. The dimensionless stability approach developed by Watson characterized bank stability as a function of hydraulic and geotechnical stability. Rosgen (1996) proposed the widely applied Bank Erosion Hazard Index (BEHI) as a qualitative approach based on the general stability assessment procedures outlined above. Other classification systems, like the CEM, determine bank instability according to channel characteristics that control hydrogeomorphic behavior.

B.2.3.1.9 Hierarchical Approaches to Mapping Using Aerial Photographs / GIS

It has become increasingly common practice to characterize stream networks as hierarchical systems. This practice has presented the value in collecting channel and floodplain attributes on a regional scale. Multiple studies have exploited geographical information systems (GIS) to assess hydrogeomorphic behavior at a basin scale. Important valley scale indices such as valley slope, confinement, entrenchment, riparian vegetation influences, and overbank deposits can provide information for river networks in California. Many agencies are developing protocols for geomorphic assessment using GIS and other database associated mapping methodologies. These tools may be useful as they are further developed in a monitoring program, but are not viable at a scale useful for reach-by-reach channel analysis.

The approach taken by this HMP to monitor its effectiveness is embedded in a derivative of the channel classification approach defined by Rosgen (1996). The author distinguishes three different levels of stream classification including (1) level I that generally describes stream relief, landform, and valley morphology; (2) level II that describes the morphology of stream and associates the later to a stream type based on channel form and bed composition. Field measurements of entrenchment, width-to-depth ratio, sinuosity, slope, and representative sampling of channel material may be suitable ; (3) level III that assesses stream condition and departure. A stream that is geomorphically stable per Rosgen's definition is characterized by two elements: dimension, pattern, and profile of a stream are maintained over time; the transport capacity of a watershed's flows and detritus is maintained. As such, physical and biological functions of a geomorphologically stable stream remain at an optimum.

B.3 Continuous Simulation Modeling

As part of the HMP development, an integrated flow control sizing tool has been prepared. The tool offers the same interface as that of the San Diego Hydrology Model, which has been approved by the SDRWQCB. The SOCHM has been developed to help applicants comply with hydromodification requirements. This modeling approach is different from Orange County's calibrated rainfall-runoff procedures and criteria for flood control design and mitigation purposes. HMP requirements from the Regional Board are separate from Orange County's requirement for mitigation within the drainage system of development effects on runoff per the Orange County Hydrology Manual (OCHM). Specific evaluation criteria were developed for the design and analysis of hydromodification controls using continuous simulation hydrologic modeling. Evaluation criteria discussed herein focuses on the following items:

- Continuous Simulation Hydrologic Modeling
- Continuous Simulation Modeling Software
- Long-Term Hourly Precipitation Gauge Data
- Parameter Validation for Rainfall Losses
- Hydromodification Control Processes
- Peak Flow and Flow Duration Statistics

The use of continuous simulation hydrologic modeling is an acceptable method to size storm water facilities to mitigate hydromodification effects. Continuous simulation modeling uses an extended time series of recorded precipitation data as input and generates hydrologic output, such as surface runoff, infiltration, and evapotranspiration, for each model time step.

Continuous hydrologic models are typically run using either 1-hour or 15-minute time steps. Based on a review of available rainfall records in Orange County, SOCHM uses a 1-hour time step (15-minute time series rainfall data are very limited). Continuous models generate model output for each time step. In this case, hydrologic output is generated for each hour of the continuous model. A continuous simulation model with 35 years of hourly precipitation data will generate 35 years of hourly runoff estimates, which corresponds to runoff estimates for 306,600 time steps over the 35-year simulation period.

Use of the continuous modeling approach allows for the estimation of the frequency and duration by which flows exceed the lower flow threshold (adopted as 10 percent of the 2-year flow for this Plan). The limitations to increases of the frequency and duration of flows within that geomorphically significant flow range represent the key component to the South Orange County approach to hydromodification management.

B.3.1 Continuous Simulation Modeling Software

The following public domain software models may be used to assess hydromodification controls for storm water facilities to meet the hydromodification criteria:

- Hydrologic Simulation Program – FORTRAN (HSPF), distributed by U.S. EPA
- Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS), distributed by the U.S. Army Corps of Engineers Hydrologic Engineering Center
- Storm Water Management Model (SWMM); distributed by U.S. EPA

B.3.2 Parameter Validation for Rainfall Losses

In preparing computer models to assess storm water controls and meet the hydromodification criteria, rainfall loss parameters describing soil characteristics, land cover descriptions, and evapotranspiration data have been validated to prove consistency with the local environment and climatic conditions. The validation process should include documentation of the source of evapotranspiration data and commentary of the effects of varying evapotranspiration patterns between the subject site and parameter data source. To meet the hydromodification criteria, soil and land cover parameter validation are based on the following:

- Calibration to local stream flow data, where applicable. Examples of local calibration studies include, but are not limited to, modeling efforts prepared for the Orange County Retrofit Study. Two watersheds were modeled, including the Anaheim Bay-Huntington Harbor watershed and the Aliso Creek watershed.
- Published parameter values consistent with previous studies for Orange County and Southern California, such as HSPF-related regional calibration studies, research projects, regional soil surveys, etc.
- Recommended parameter value ranges from BASINS (Better Assessment Science Integrating point and Nonpoint Sources) Technical Notice 6, Estimating Hydrology, and Hydraulic Parameters for HSPF, U.S. EPA, July 2000.

Where parameters have been transposed or modified from calibration efforts outside of Southern California, the source was determined and justification provided stating why such data are applicable for Orange County. Details have been provided justifying how parameters from such studies were adjusted to be applicable to Orange County conditions. Storm water flow control devices designed to meet the hydromodification criteria have been analyzed pursuant to the following criteria:

- Infiltration processes have been modeled with sufficient complexity to properly quantify the flow control benefit to the receiving streams.
- Infiltration quantification includes provisions for water head and pore suction effects for multiple layers of varying materials (i.e., ponding areas, amended soil layer, gravel layer, etc.)
- Storage processes associated with each layer of the storm water device are quantified.
- Device outflow curves are considered controls associated with device underdrains.

B.3.3 Peak Flow and Flow Duration Statistics

To assess the effectiveness of storm water flow control devices in mitigating hydromodification effects to meet the hydromodification criteria, peak flow frequency statistics are required. Peak flow frequency statistics estimate how often flow rates exceed a given threshold. In this case, the key peak flow frequency values are the lower and upper bounds of the geomorphically significant flow range. Peak flow frequency statistics can be developed using either a partial-duration or peak annual series. Partial-duration series frequency calculations consider multiple storm events in a given year while the peak annual series considers just the peak annual storm event.

Flow duration statistics are also summarized to determine how often a particular flow rate is exceeded. To determine if a storm water facility meets the hydromodification criteria, peak flow frequency and flow duration curves are generated for the pre-development condition, or naturally occurring condition, and the post-project condition. Both pre-development and post-project simulation runs are extended for the entire length of the rainfall record.

The need for partial-duration statistics is more pronounced for control standards based on more frequent return intervals (such as the 2-year runoff event), since the peak annual series does not perform as well in the estimation of such events. This phenomenon is especially pronounced in the South Orange County region's semi-arid climate. After a review of supporting literature, the use of a partial-duration series is recommended for semi-arid climates similar to Orange County, where prolonged dry periods can skew peak flow frequency results determined by a peak annual series for more frequent runoff events.

For the statistical analysis of the rainfall record, partial duration series events have been separated into discrete unrelated rainfall events assuming the following criteria.

1. A minimum interval of 24 hours between peaks is applied to capture those peaks generated from back-to-back storms.
2. The Weibull plotting method is used to rank the selected peaks as the method was specifically developed for California-based streams, where wet-weather and dry-weather years produce two populations of flood events.

B.4 Rainfall Data

The SOCHM integrates local rainfall data to design storm water flow control devices. To provide for clear climatic designation between coastal, foothill and mountain areas of the southern part of Orange County, historical records for a series of two rainfall data stations located throughout South Orange County were compiled, formatted and quality controlled for analysis.

Long-term rainfall records of 15-minute intervals have been prepared for these two rainfall stations. Sources of the rainfall data include Orange County Automated Local Evaluation in Real Time (ALERT) telemetry system rain gauges (extending back to 1991), the California Climatic Data Archive, National Oceanic and Atmospheric Administration (NOAA), the

National Climatic Data Center, and the Western Regional Climate Center. In all cases, the length of the overall rainfall station record is a minimum of 49 years.

Gauge selection was further governed by minimum continuous simulation modeling requirements, including the following:

- The selected precipitation gauge data set should be located near the project site to ensure that long-term rainfall records are similar to the anticipated rainfall patterns for the site. Thus, gauges were selected near areas planned for future development and redevelopment.
- Recording frequency for the gauge data set should be at least hourly
- The recorded rainfall data should be disaggregated to at least a 15-minute interval. It is expected that the time of concentration for most projects will be below 15 minutes.
- The gauge rainfall data set should extend for the entire length of the record. Where the gauge record length is less than 49 years, then adjacent gauge data sets were used to extend the rainfall record to at least 49 years.
- Use of the most applicable long-term rainfall gauge data, as opposed to the scaling of rainfall patterns from Laguna Beach, is required to account for the diverse rainfall patterns across South Orange County.

As part of developing SOCHM, hourly time series were disaggregated into time series of 15-minute intervals and incorporated into the model to optimize the estimation of peak flows and ultimately the sizing of LID BMPs. The disaggregation was based on the rainfall disaggregation model for continuous hydrologic modeling as developed by Ormsbee (1989). The stochastic algorithm determines, for each independent storm event, a synthetic peak depth based on an initial observed peak depth and a total rainfall for the event.

The County operates the Orange County Automated Local Evaluation in Real Time (ALERT) telemetry system rain gauges, which includes the Sulphur Creek raingage station located in the Aliso Creek watershed. Complete real-time information from this station, including the timing of the peak, the peak rainfall depth, and the total rainfall depth, is available for 167 recorded storm events between October 1991 and December 2006. In addition, the difference in rainfall depths between the Sulphur Creek ALERT station and the Laguna Beach NOAA station (ID# CA044647) are not statistically different (-3% cumulative difference in mean rainfall depth). Thus, the records from the Sulphur Creek station were used to calibrate statistically the disaggregation scheme: a spiking factor of 0.33 coupled with a stochastic pulse depth of 0.01 inch returned the highest statistical results.

Data gathered from precipitation gauges are summarized in **Error! Reference source not found.** below. Disaggregated time series all have computed frequencies of 15-minute intervals and recording data ranges of at least 49 years.

Table B-2: Summary of Precipitation Gauges

Station	Elevation (feet)	Watershed	Hourly data span
Laguna Beach (CA044647)	35	Laguna Coastal Streams	December 1948 – December 2006
Trabuco Canyon (CA048992)	970	San Juan	August 1957 – March 2006

For a given project location, the following factors have been considered in the selection of the appropriate rainfall data set.

In most cases, the rainfall data set nearest the project site is the appropriate choice. A rainfall station map associated with this HMP is presented in **Error! Reference source not found.** for public use.

In some cases, the rainfall data set nearest the project site was a less applicable data set. Such a scenario involved a data set, for instance, with an elevation significantly different from the project site. In addition to a simple elevation comparison, the project proponent may also consult with the Orange County's average annual precipitation isopluvial map, which is provided in the Orange County Technical Guidance Manual, Appendix XVI (2013) located at: http://ocwatersheds.com/documents/wqmp. Review of this map could provide an initial estimate as to whether the project site is in a similar rainfall zone as compared to the rainfall stations. Generally, precipitation totals in South Orange County increase with increasing elevation.

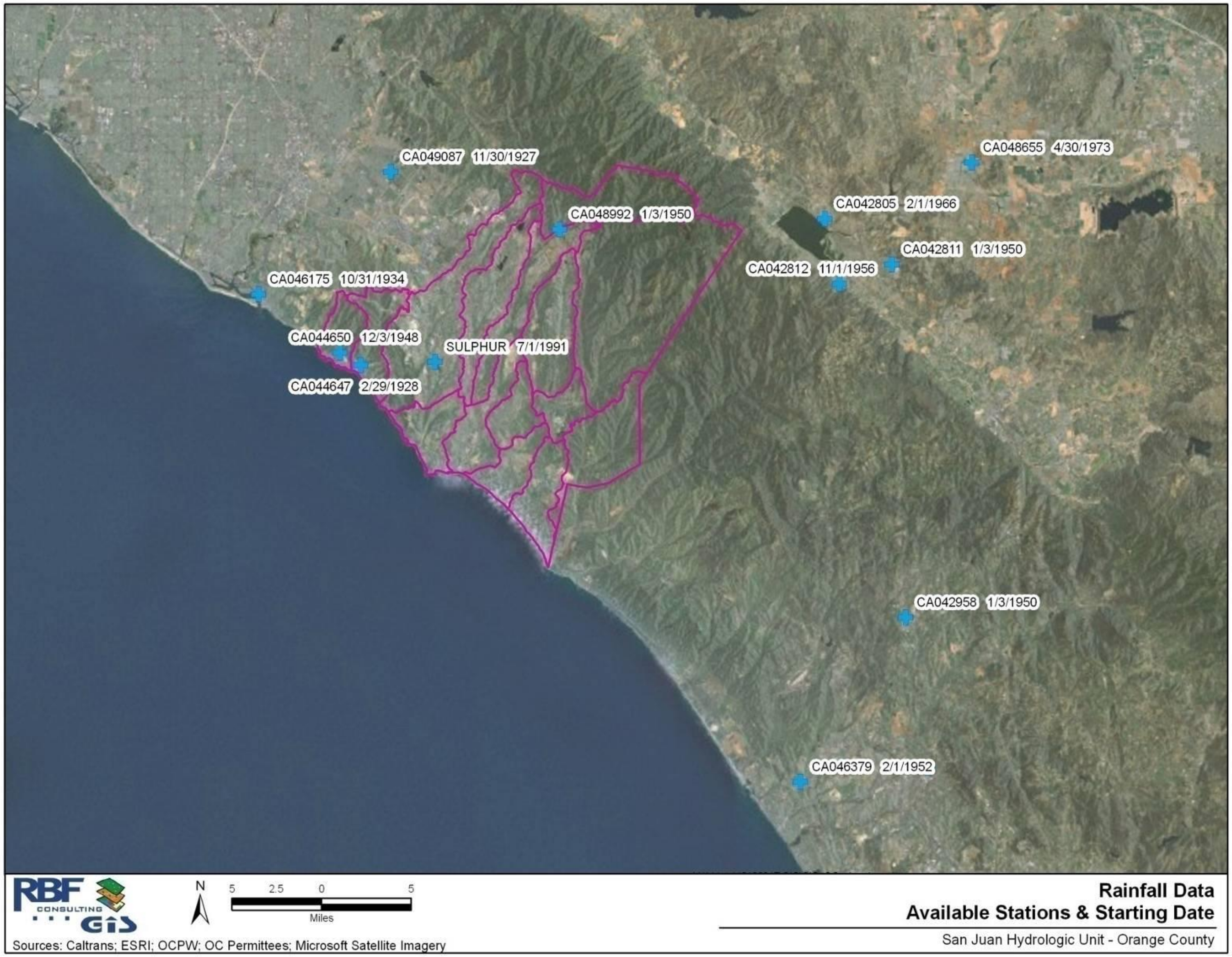
Where possible, rainfall data sets located in the same topographic zone (coastal and foothill, or mountain) as the project should be selected.

B.5 Rainfall Losses – Infiltration Parameters

Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of runoff using locally derived parameters for initial infiltration. A review was conducted of available continuous hydrologic simulation modeling reports in Southern California. These included water quality HSPF models developed for the County of Orange, regional continuous models developed by SCCWRP, and watershed-level continuous models developed for river and large creek systems in San Diego and Los Angeles Counties. Of particular interest and focus in this review was how local and regional continuous hydrologic models simulated the pervious land surface for various combinations of soils and land use types, because this component of hydrologic modeling is typically the most variable and difficult to describe.

The HSPF software package is an industry standard for continuous simulation hydrologic modeling. However, HEC-HMS and SWMM also provide adequate public domain continuous modeling alternatives. The HMP allows the option to use HEC-HMS for a project submittal but only provides infiltration data review for HSPF modeling approaches. Therefore, applicants choosing HEC-HMS should seek prior authorization by the governing municipality.
In preparing computer models to assess storm water controls and meet hydromodification criteria, rainfall loss parameters describing soil characteristics, land cover descriptions, and slope should be validated to prove consistency with the local environment and climatic conditions. The goal, with regard to the South Orange County HMP, is to develop a set of appropriate parameter ranges to account for variations.

Figure B-2: Rainfall Data – Available Stations and Starting Date



In addition to the reports listed in Table B-3, other TMDL reports in Southern California were reviewed. However, only those reports with a substantial description of modeling activities were summarized in the table.

Table B-3: TMDL Technical Reports

No.	Title	Authors	Date	Summary/Comments
1	Orange County Stormwater Program – Identification of Retrofitting Opportunities – Watershed HSPF Model Development	County of Orange / RBF Consulting	September 12, 2009	Combination of hydrologic and water quality modeling to estimate both pollutant loadings and pollutant removal from retrofitting opportunities. Two watersheds were modeled: Anaheim Bay-Huntington Harbor and Aliso Creek HSPF calibration parameters are specific to each local watershed.
2	TMDL to Reduce Bacterial Indicator Densities at Santa Monica Bay Beaches During Wet Weather (Preliminary Draft)	Los Angeles RWQCB / Tetra Tech	June 21, 2002	Combination of hydrologic and water quality modeling to estimate bacterial loadings to Santa Monica Bay. The HSPF/LSPC model was calibrated and validated using stream flow data collected on Malibu Creek and Ballona Creek. (LSPC stands for Loading Simulation Program in C++, a recoded C++ version of HSPF.) No HSPF model parameters are included.
3	Technical Report – TMDLs for Indicator Bacteria in Baby Beach and Shelter Island Shoreline Park	San Diego RWQCB / Tetra Tech	June 11, 2008	HSPF/LSPC model was calibrated to flow data collected in Aliso Creek and Rose Creek. Calibrated infiltration rates were reported for Natural Resources Conservation Survey (NRCS) Group A, B, C, and D soils. However, it is unclear if these rates correspond to specific HSPF model parameters. The issue of how to apply the calibrated infiltration rates should be addressed through correspondence with study authors.
4	Evaluating HSPF in an Arid, Urbanized Watershed (in Journal of the American Water Resources Association, 2005, p477-486)	Drew Ackerman, Kenneth Schiff, Stephen Weisburg (SCCWRP)	February 2005	HSPF was used to simulate hydrologic processes in arid region, e.g., precipitation on dry soils, effect of irrigation. The model was calibrated to gauge data collected in the lower reaches of Malibu Creek. The calibration set aggregated the soil and land cover variations in the watershed (i.e., spatially "lumped" parameters). Pervious land surface (PWATER) parameters were included.
5	TMDL for Indicator Bacteria Project I – Twenty Beaches and Creeks in the San Diego Region	San Diego RWQCB / Tetra Tech	December 12, 2007	HSPF/LSPC model parameters were selected from regional calibration. Calibration efforts used daily average stream flows as the baseline calibration condition. The Appendices describe the regional calibration process. The modeling files are provided by the San Diego RWQCB.
6	Lake Elsinore and Canyon Lake Nutrient Source Assessment (Final Report) for Santa Ana Watershed Project Authority	Tetra Tech, Inc.	January 2003	The HSPF/LSPC model was calibrated and validated using United States Geological Survey (USGS) gauging site data in the San Jacinto watershed. Model simulated pollutant loading to Lake Elsinore and Canyon Lake. Pervious land surface (PWATER) parameters were not published in the report.

The technical reports listed in **Error! Reference source not found.** demonstrate that a variety of detailed HSPF modeling studies have been conducted in the past 10 years in Southern California. The modeling efforts conducted in Orange County, particularly the HSPF model for Aliso Creek watershed, have been adapted for use in the South Orange County HMP (see No. 1 above). The parameters developed for this watershed model were specifically calibrated and validated by using stream flow and water quality data from the Aliso Creek watershed. In addition, the Ackerman study (**Error! Reference source not found.**, item No. 4) published a set of generalized parameters that aggregates or "spatially lumps" the contributions of different soil/land use combinations in the lower watershed.

The HSPF model described in the Ackerman paper (**Error! Reference source not found.**, item No. 4) simulates all soil and land use combinations using a single composite parameter set. The purpose of the model was to estimate pollutant loadings to area beaches and water bodies. Therefore, the HSPF model was calibrated only to gauge data in the lower Santa Monica Bay watershed. Additionally, the effect of upstream surface water impoundments would have made the development of an accurate, detailed calibration at the sub-catchment scale very difficult to achieve. Unfortunately, this "spatially lumped" parameter set is of limited usefulness for the purpose of the HMP project, given the need to develop parameter sets that describe a variety of common soil and land use combinations.

The following model parameters were incorporated into the Aliso Creek HSPF model. Specific values were associated to each type of land use such that several values are possible for each pervious parameter.

Table B-4: Model Parameters

Pervious Parameters	Acronym	Value	Unit
Fraction of Remaining Evapotranspiration (E-T) from Active Groundwater Storage	AGEWTP	0.05	-
Basic Groundwater Recession Rate	AGWRC	0.8/0.99	1/day
Fraction of Remaining E-T from baseflow	BASETP	0.2	-
Interception Storage Capacity	CEPSC	0.2	inch
Fraction of Groundwater to Deep Aquifer	DEEPFR	0.05/0.15	-
Forest Fraction	FOREST	0 or 1	-
Infiltration Equation Exponent	INFEXP	2	-
Ratio between the Maximum and Mean Infiltration Capacities	INFILD	2	-
Infiltration Capacity	INFILT	0.1/2	inch/hour
Interflow Inflow Parameter	INTFW	0.2	-
Interflow Recession Parameter	IRC	0.5	1/day
Groundwater Recession Flow Coefficient	KVARY	5/8	1/inch
Overland Flow Length	LSUR	75 to 190	feet
Lower Zone E-T Parameter	LZETP	0.9	-
Lower Zone Nominal Storage	LZSN	0.8/2.4/3.2	in
Manning's n for Overland Flow	NSUR	0.15/0.25/0.35	Complex
Temperature Maximum for E-T	PETMAX	35	deg F

Pervious Parameters	Acronym	Value	Unit
Temperature that E-T is Zero	PETMIN	30	deg F
Overland Flow Slope	SLSUR	0.2	foot/feet
Upper Zone Nominal Storage	UZSN	0.05/0.07	inch

Additional reference material is contained in the BASINS Technical Notice 6, Estimating Hydrology and Hydraulic Parameters for HSPF, prepared by U.S. EPA (July 2000). This document provides details regarding pervious and impervious land hydrology parameters along with flow routing parameters. Parameter and value range summary tables are included in the document.

B.6 Rainfall Losses - Evapotranspiration Parameters

Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of rainfall runoff using locally derived parameters for evaporation and evapotranspiration. Known data sources for potential evapotranspiration data in South Orange County are listed below.
Historical potential evapotranspiration at Laguna Beach station (CA044647) is considered to best represent the coastal evapotranspiration conditions of the San Juan hydrologic unit. Historical potential evapotranspiration at Vista station (CA049378) was found to best correspond to the foothills and mountainous conditions. It is located in San Diego County but remains in the San Juan hydrologic unit.

Other gauging stations that record potential evapotranspiration were not selected because the elevation and land use were not representative of the specific foothill and mountainous conditions present in South Orange County. The potential evapotranspiration will be coupled with historical records of temperature to determine the actual daily evapotranspiration. **Error! Reference source not found.** summarizes available sources for potential evapotranspiration in South Orange County.

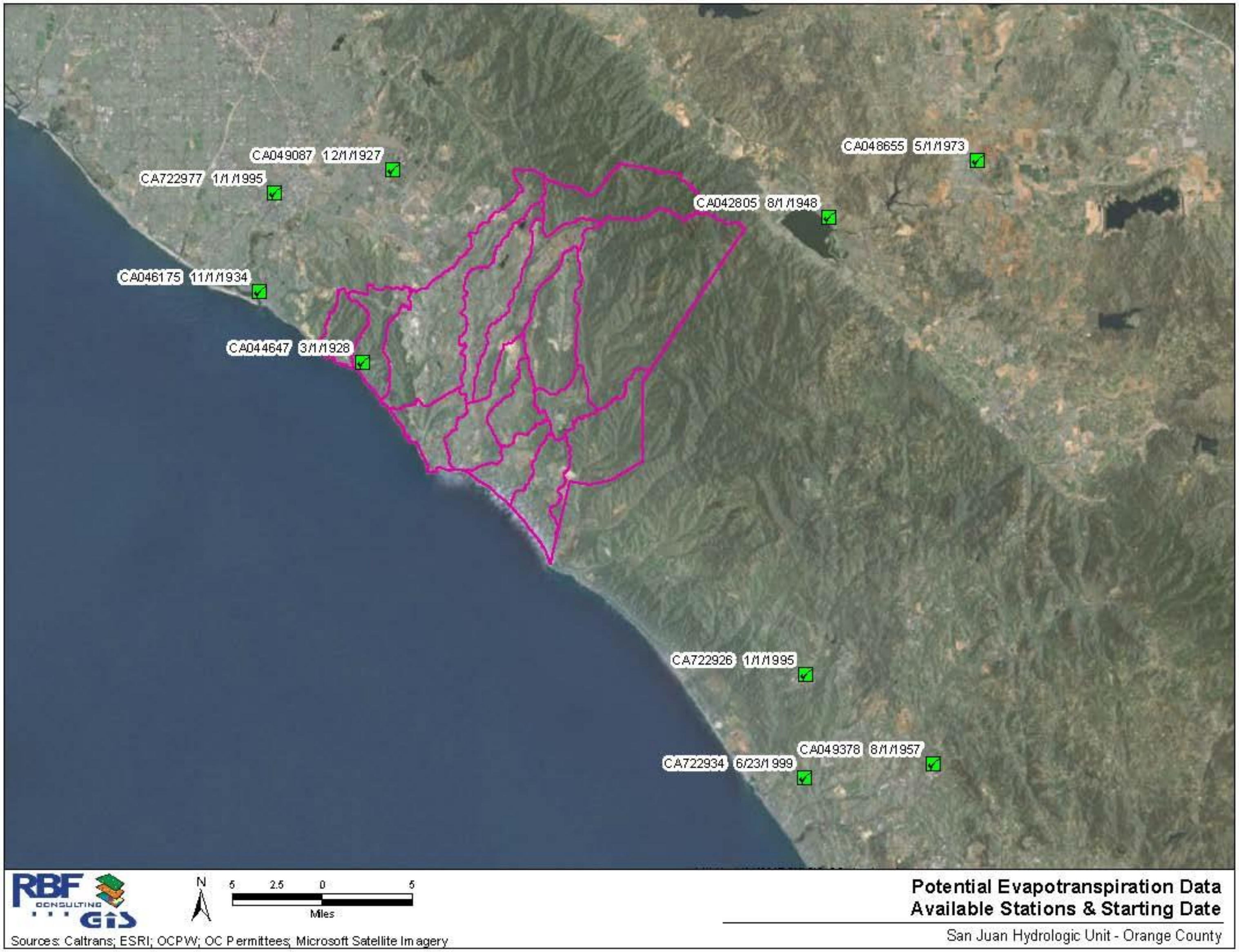
Table B-5: Available Evapotranspiration Sources

Station Name ID	Data Type	Data Source	Recording Frequency	Hourly data span
Laguna Beach (CA044647)	Potential Evapotranspiration	BASIN	Daily	December 1948 – December 2006
Vista (CA049378)	Potential Evapotranspiration	BASIN	Daily	August 1957 – December 2006

Long-term evaporation / evapotranspiration data sets are being generated to correspond with long-term rainfall records. The final selection of rainfall loss parameters and evaporation data is part of the SOCHM development process.

In summary, the published literature reviewed as part of this study support the methods and approach taken in developing the South Orange County HMP.

Figure B-3: Potential Evapotranspiration Data – Available Stations and Starting Date



APPENDIX C

South Orange County Hydrology Model Instructions

South Orange County Hydrology Model

Guidance Document

Clear Creek Solutions, Inc.
www.clearcreeksolutions.com

April 2012

To download the South Orange County Hydrology Model
and the electronic version of this document,
please go to www.clearcreeksolutions.com/downloads

If you have questions about SOCHM or its use, please contact:
Clear Creek Solutions, Inc.
360-943-0304 (8 AM – 5 PM Pacific time)

End User License Agreement

End User Software License Agreement (Agreement). By clicking on the “Accept” Button when installing the South Orange County Hydrology Model (SOCHM) Software or by using the South Orange County Hydrology Model Software following installation, you, your employer, client and associates (collectively, “End User”) are consenting to be bound by the following terms and conditions. If you or User do not desire to be bound by the following conditions, click the “Decline” Button, and do not continue the installation process or use of the South Orange County Hydrology Model Software.

The South Orange County Hydrology Model Software is being provided to End User pursuant to a sublicense of a governmental licensee of Clear Creek Solutions, Inc. Pursuant to the terms and conditions of this Agreement, End User is permitted to use the South Orange County Hydrology Model Software solely for purposes authorized by participating municipal, county or special district member agencies of signatory programs which are organized on a county-wide basis for implementation of stormwater discharge permits issued by the California Regional Water Quality Control Board, under the National Pollutant Discharge Elimination System. The End User is not permitted to use the South Orange County Hydrology Model Software for any other purpose than as described above.

End User shall not copy, distribute, alter, or modify the South Orange County Hydrology Model Software.

The SOCHM incorporates data on soils, climate and geographical features to support its intended uses of identifying site-appropriate modeling parameters, incorporating user-defined inputs into long-term hydrologic simulation models of areas within the County of Orange, and assisting design of facilities for flow duration control as described in the accompanying documentation. These data may not be adequate for other purposes such as those requiring precise location, measurement or description of geographical features, or engineering analyses other than those described in the documentation.

This program and accompanying documentation are provided 'as-is' without warranty of any kind. The entire risk regarding the performance and results of this program is assumed by End User. Clear Creek Solutions Inc. and the governmental licensee or sublicensees disclaim all warranties, either expressed or implied, including but not limited to implied warranties of program and accompanying documentation. In no event shall Clear Creek Solutions Inc, or authorized representatives be liable for any damages whatsoever (including without limitation to damages for loss of business profits, loss of business information, business interruption, and the like) arising out of the use of, or inability to use this program even if Clear Creek Solutions Inc., has been advised of the possibility of such damages.

FOREWORD

The South Orange County Hydrology Model (SOCHM) is a tool for analyzing the hydromodification effects of land development projects and sizing solutions to mitigate the increased runoff from these projects. This section of the guidance documentation provides background information on the definition and effects of hydromodification and relevant findings from technical analyses conducted in response to regulatory requirements. It also summarizes the current Hydromodification Management Standard and general design approach for hydromodification control facilities, which led to the development of the SOCHM.

Effects of Hydromodification

Urbanization of a watershed modifies natural watershed and stream processes by altering the terrain, modifying the vegetation and soil characteristics, introducing pavement and buildings, installing drainage and flood control infrastructure, and altering the condition of stream channels through straightening, deepening, and armoring. These changes affect hydrologic characteristics in the watershed (rainfall interception, infiltration, runoff and stream flows), and affect the supply and transport of sediment in the stream system. The change in runoff characteristics from a watershed caused by changes in land use conditions is called *hydrograph modification*, or simply hydromodification.

As the total area of impervious surfaces increases in previously undeveloped areas, infiltration of rainfall decreases, causing more water to run off the surface as overland flow at a faster rate. Storms that previously didn't produce runoff under rural conditions can produce erosive flows. The increase in the volume of runoff and the length of time that erosive flows occur ultimately intensify sediment transport, causing changes in sediment transport characteristics and the hydraulic geometry (width, depth, slope) of channels. The larger runoff durations and volumes and the intensified erosion of streams can impair the beneficial uses of the stream channels.

Regulatory Context

The California Regional Water Quality Control Board (Water Board) requires stormwater programs to address the increases in runoff rate and volume from new and redevelopment projects where those increases could cause increased erosion of receiving streams. Phase 1 municipal stormwater permits in Orange County contain requirements to develop and implement hydromodification management plans (HMPs) and to implement associated management measures.

Development of the South Orange County Hydrology Model

The concept of designing a flow duration control facility is relatively new and, as described above, requires the use of a continuous simulation hydrologic model. To facilitate this design approach, Clear Creek Solutions (CCS) has created a user-friendly, automated modeling and flow duration control facility sizing software tool adapted from its Western Washington Hydrology Model (WWHM). The WWHM was developed in

2001 for the Washington State Department of Ecology to support Ecology's *Stormwater Management Manual for Western Washington*[1] and assist project proponents in complying with the Western Washington hydromodification control requirements. The South Orange County Hydrology Model (SOCHM) is adapted from WWHM Version 4, but has been modified to represent Orange County hydrology and enhanced to be able to size other types of control measures and low impact development (LID) techniques for flow reduction as well.

SOCHM is a useful tool in the design process, but must be used in conjunction with local design guidance to ensure compliance for specific projects. The reader should refer to Appendix C and local stormwater program guidance for additional information and suggestions for using the SOCHM.

Acknowledgements

The following individuals are acknowledged for their contributions to the development of SOCHM and guidance documentation:

- Doug Beyerlein, Joe Brascher, Gary Maxfield, and Shanon White of Clear Creek Solutions, Inc., for development of WWHM, BAHM, and SOCHM and preparation of the SOCHM guidance documentation.
- Daniel Apt, Scott Taylor, and Remi Candaele of RBF Consulting for providing SOCHM meteorological data, maps, and technical specifications.

[1] Washington State Department of Ecology. 2001. Stormwater Management Manual for Western Washington. Volume III: Hydrologic Analysis and Flow Control Design/BMPs. Publication No. 99-13. Olympia, WA.

TABLE OF CONTENTS

INTRODUCTION TO SOCHM

SOCHM is the South Orange County Hydrology Model. SOCHM is based on the WWHM (Western Washington Hydrology Model) stormwater modeling platform. WWHM was originally developed for the Washington State Department of Ecology. More information about WWHM can be found at www.clearcreeksolutions.com. More information can be found about the Washington State Department of Ecology's stormwater management program and manual at www.ecy.wa.gov/programs/wq/stormwater/manual.html.

Clear Creek Solutions is responsible for SOCHM and the SOCHM guidance documentation.

This guidance documentation is organized so as to provide the user an example of a standard application using SOCHM (described in *Quick Start*) followed by descriptions of the different components and options available in SOCHM. The *Tips and Tricks* section presents some ideas of how to incorporate LID (Low Impact Development) facilities and practices into the SOCHM analysis. Appendices A and B provide a full list of the HSPF parameter values used in SOCHM. Appendix C contains additional guidance and recommendations by the stormwater programs that have sponsored the SOCHM development. Appendix D is a checklist for use by SOCHM project reviewers.

Throughout the guidance documentation notes using this font (sans-serif italic) alert the user to actions or design decisions for which guidance must be consulted that is external to the SOCHM software, either provided in Appendix C of this guidance documentation or by the local municipal permitting agency.

Purpose

The purpose of SOCHM is to size hydromodification management or flow control facilities to mitigate the effects of increased runoff (peak discharge, duration, and volume) from proposed land use changes that impact natural streams, wetlands, and other water courses.

SOCHM provides:

- A uniform methodology for South Orange County
- A more accurate methodology than single-event design storms
- An easy-to-use software package

SOCHM is based on:

- Continuous simulation hydrology (HSPF)
- Actual long-term recorded precipitation data
- Measured pan evaporation data
- Existing vegetation (for predevelopment conditions)
- Regional HSPF parameters

Computer Requirements

- Windows 2000/XP/Vista/7 with 300 MB uncompressed hard drive space
- Internet access (only required for downloading SOCHM, not required for executing SOCHM)
- Pentium 3 or faster processor (desirable)
- Color monitor (desirable)

Before Starting the Program

- Knowledge of the site location and/or street address.
- Knowledge of the actual distribution of existing site soil by category (A, B, C, or D).
- Knowledge of the actual distribution of existing and proposed site land cover by category (scrub, open brush, or gravel).
- Knowledge of the actual distribution of existing and proposed site topography by category (flat, moderate, steep, or very steep).
- Knowledge of the planned distribution of the proposed development (buildings, streets, sidewalks, parking, lawn areas) overlying the soil categories.

SOCHM OVERVIEW

The SOCHM software architecture and methodology is the same as that developed for BAHM (Bay Area Hydrology Model), SDHM (San Diego Hydrology Model), and WWHM and uses HSPF as its computational engine[2]. Like BAHM, SDHM, and WWHM, SOCHM is a tool that generates flow duration curves for the pre- and post-project condition and then sizes a flow duration control pond/basin or vault and outlet structure to match the predevelopment curve. The software package consists of a user-friendly graphical interface with screens for input of predevelopment and post-project conditions; an engine that automatically loads appropriate parameters and meteorological data and runs continuous simulations of site runoff to generate flow duration curves; a module for sizing or checking the control measure to achieve the hydromodification control standard; and a reporting module.

The HSPF hydrology parameter values used in SOCHM are based on best professional judgment using our experience with calibrated watersheds in other parts of California. SOCHM uses the Orange County long-term 15-minute precipitation data records selected to represent South Orange County rainfall patterns.

HSPF is the U.S. Geological Survey and U.S. Environmental Protection Agency continuous simulation hydrology software package maintained by AQUA TERRA Consultants. The HSPF continuous simulation hydrology model is preferred over single-event hydrology models because of its ability to compute and keep track of all of the individual components of the hydrologic cycle including surface runoff, interflow, groundwater, soil moisture, and evapotranspiration. HSPF, since its introduction in 1980, has become the industry standard for hydrologic modeling.

One of the major advantages of continuous simulation hydrologic modeling is the ability to accurately determine soil moisture conditions immediately prior to storm events. Single-event hydrologic models have to make assumptions about the antecedent soil moisture conditions – assumptions which are often not accurate or appropriate. This is an important distinction because antecedent soil moisture conditions play a major role in determining the amount and timing of runoff.

Not all continuous simulation hydrologic models handle the calculation of soil moisture conditions in the same level of detail. HSPF uses a potential evapotranspiration time series to compute actual evapotranspiration each time step. HSPF uses parameter values to determine the proportion of the actual evapotranspiration from interception storage, upper soil layer storage, lower soil zone layer storage, groundwater storage, and base flow. Other continuous simulation hydrologic models, SWMM included, use a much more simplified approach to determining soil moisture. Such simplified approaches do not accurately reflect the seasonal and daily variability of the actual evapotranspiration and its effects on soil moisture.

[2] SOCHM is based on WWHM Version 4.

SOCHM computes stormwater runoff for a site selected by the user. SOCHM runs HSPF in the background to generate a 15-minute runoff time series from the available rain gage data over a number of years. Stormwater runoff is computed for both predevelopment and post-project land use conditions. Then, another part of the SOCHM routes the post-project stormwater runoff through a stormwater control facility of the user's choice.

SOCHM uses the predevelopment peak flood values from a partial duration series of individual peak events to compute the predevelopment 2-year through 25-year flood frequency values[3]. The post-project runoff 2-year through 25-year flood frequency values are computed at the outlet of the proposed stormwater facility. The model routes the post-project runoff through the stormwater facility. As with the predevelopment peak flow values, partial duration post-project flow values are selected by the model to compute the developed 2-year through 25-year flood frequency.

The predevelopment 2-year peak flow is multiplied by a percentage (10 percent) to set the lower limit of the erosive flows, in accordance with the current HMP performance criteria. The predevelopment 10-year peak flow is the upper limit. A comparison of the predevelopment and post-project flow duration curves is conducted for 100 flow levels between the lower limit and the upper limit. The model counts the number of 15-minute intervals that predevelopment flows exceed each of the flow levels during the entire simulation period. The model does the same analysis for the post-project mitigated flows.

Low impact development (LID)/best management practices (BMPs) have been recognized as opportunities to reduce and/or eliminate stormwater runoff at the source before it becomes a problem. They include compost-amended soils, bioretention, permeable pavement, green roofs, rain gardens, and vegetated swales. All of these approaches reduce stormwater runoff. SOCHM can be used to determine the magnitude of the reduction from each of these practices and the amount of stormwater detention storage still required to meet HMP requirements.

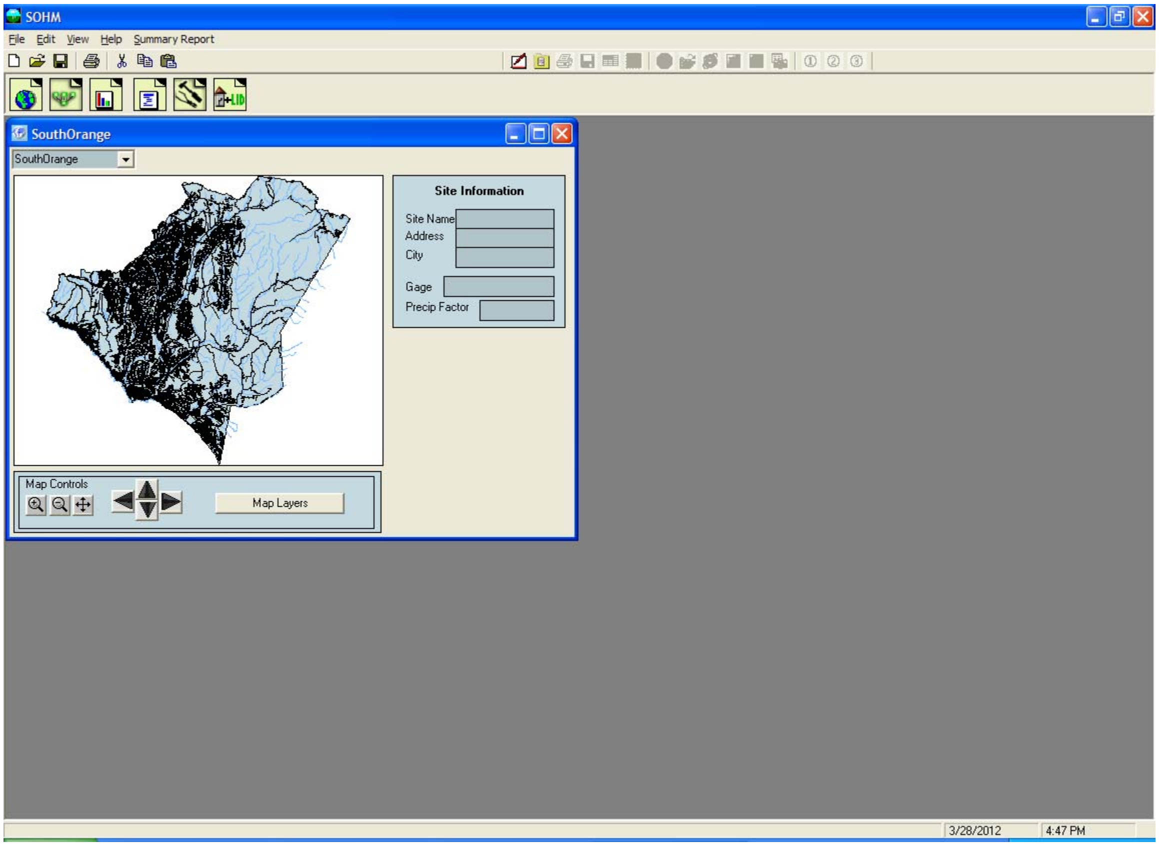
[3] The actual flood frequency calculations are made using the Cunnane flood frequency equation.

QUICK START

Quick Start very briefly describes the steps to quickly size a stormwater detention pond using SOCHM. New users should read the descriptions of the SOCHM screens, elements, and analysis tools before going through the steps described below.

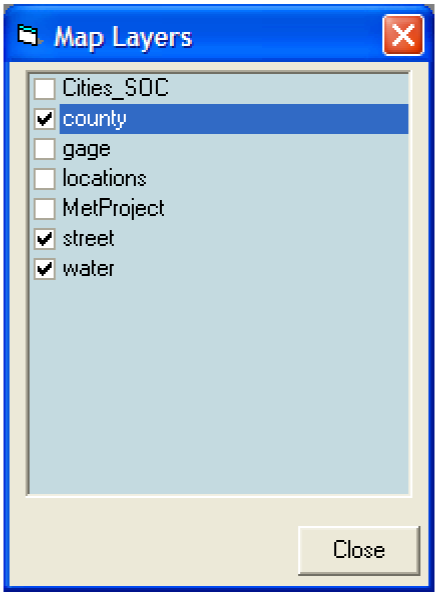
1. Open SOCHM.

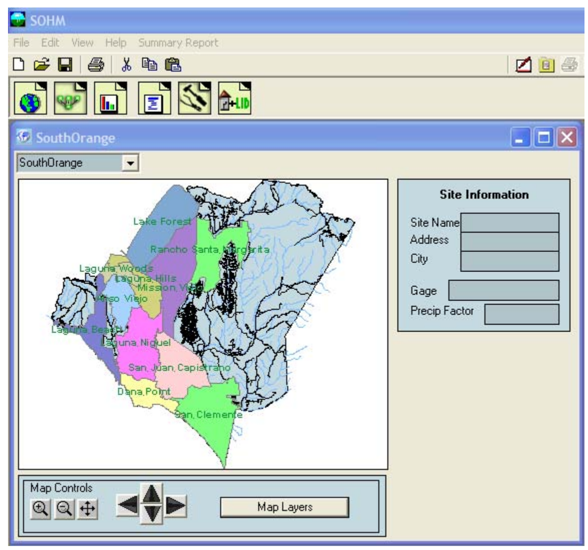
SOCHM will open with a map of South Orange County.



Projects that discharge directly to an exempt system as defined by Section 4.3 of the HMP are exempt from the HMP criteria. Projects however that discharge to an exempt system but not directly to the exempt system must discharge runoff directly to an engineered conveyance system that extends to the exempt system in order to qualify for the HMP criteria exemption.

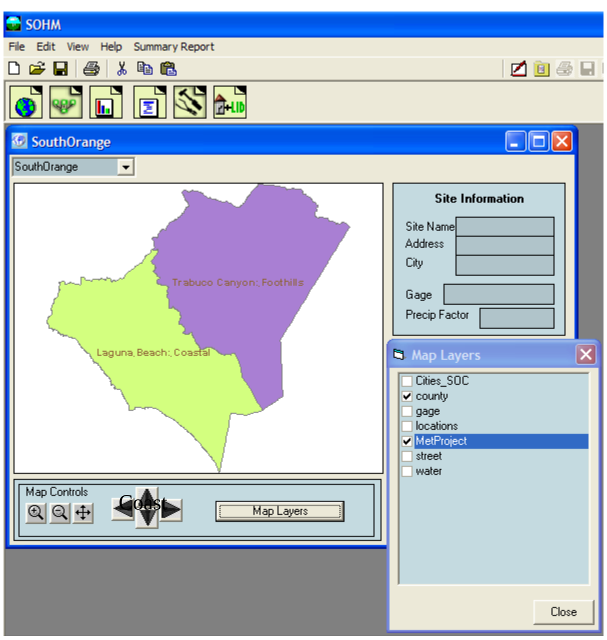
Users can view different SOCHM map layers by clicking on the “Map Layer” button.





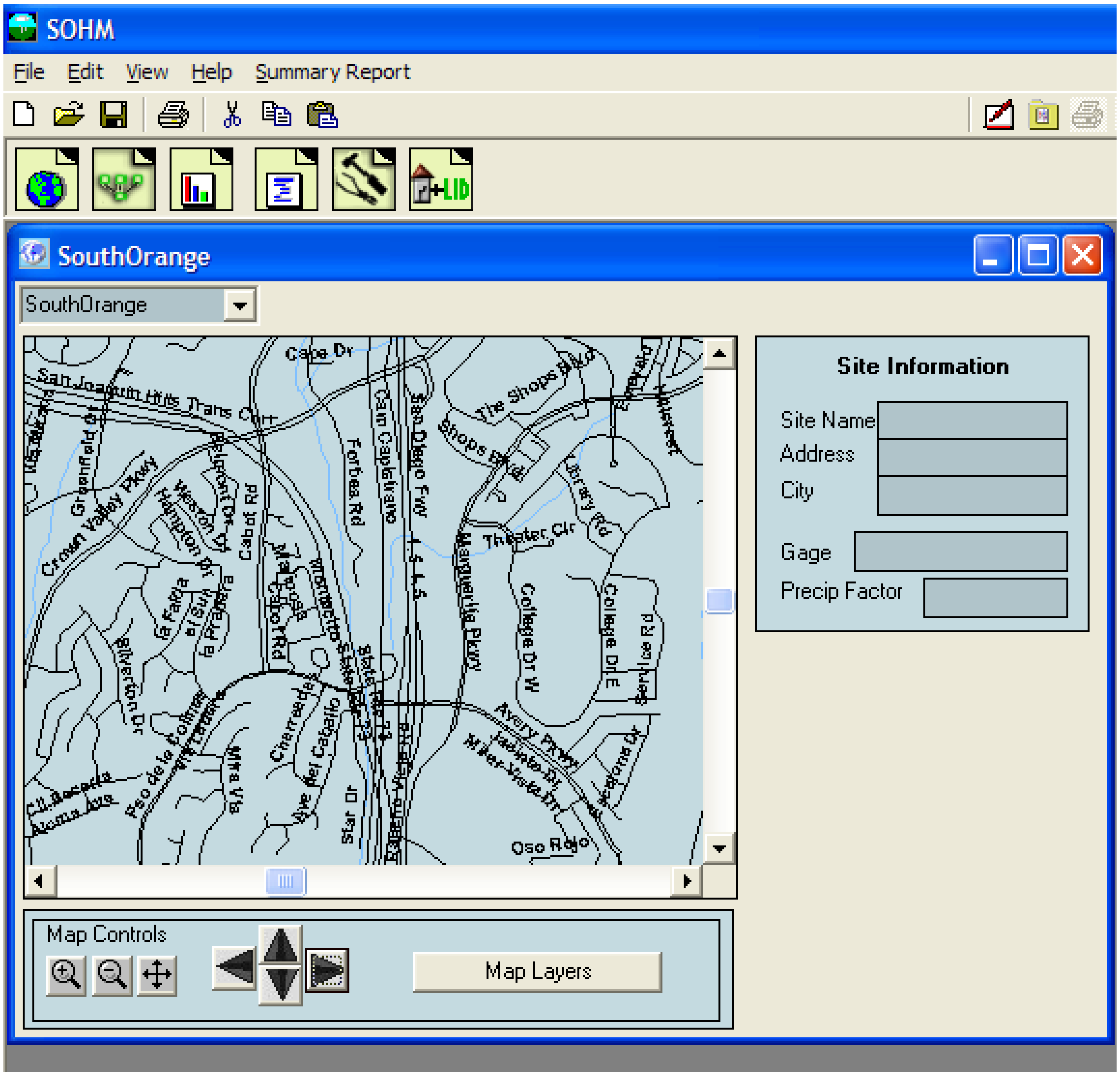
Selection of the cities layer identifies the individual cities in South Orange County.

Other layers identify other features in South Orange County.



The MetProject layer identifies the portion of South Orange County that the coastal region and the portion that is the foothill region.

The Laguna Beach precipitation gage is automatically used for projects located in the coastal portion of the county and Trabuco Canyon for the foothills.

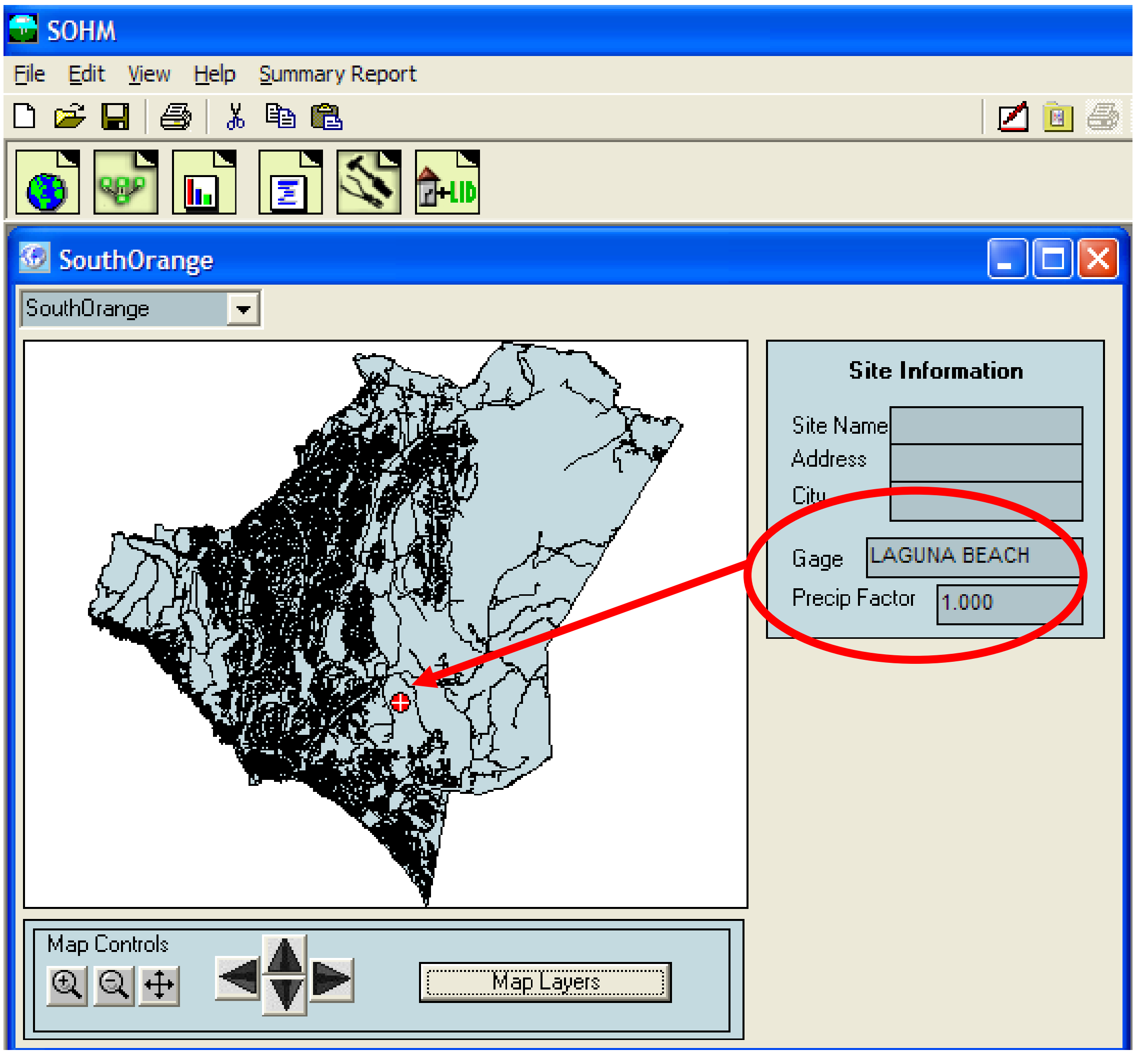


The map controls can be used to enlarge a specific area on the street map layer. This option helps to locate the specific project site.

When the street map layer is enlarged a sufficient amount the individual street names are shown on the map.

2. Select the project site location.

Locate the project site on the map. Use the map controls to magnify a portion of the map, if needed. Select the project site by left clicking on the map location. A red square will be placed on the map identifying the project site.

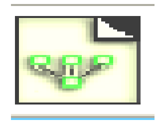


The model will then automatically select the appropriate rain gage record for the project site. South Orange County has two long-term 15-minute precipitation records: Laguna Beach for the coastal portion of the county and Trabuco Canyon for the foothills.

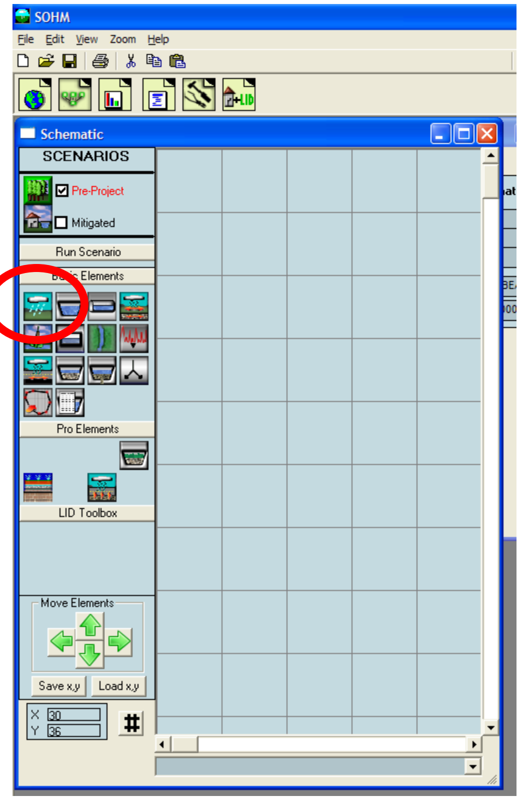
For this example we will use the Laguna Beach rain gage.

The site name, address, and city information is optional. It is not used by SOCHM, but will be included in the project report summary.

3. Use the tool bar (immediately above the map) to move to the Scenario Editor. Click on the General Project Information button.



The General Project Information button will bring up the Schematic Editor.



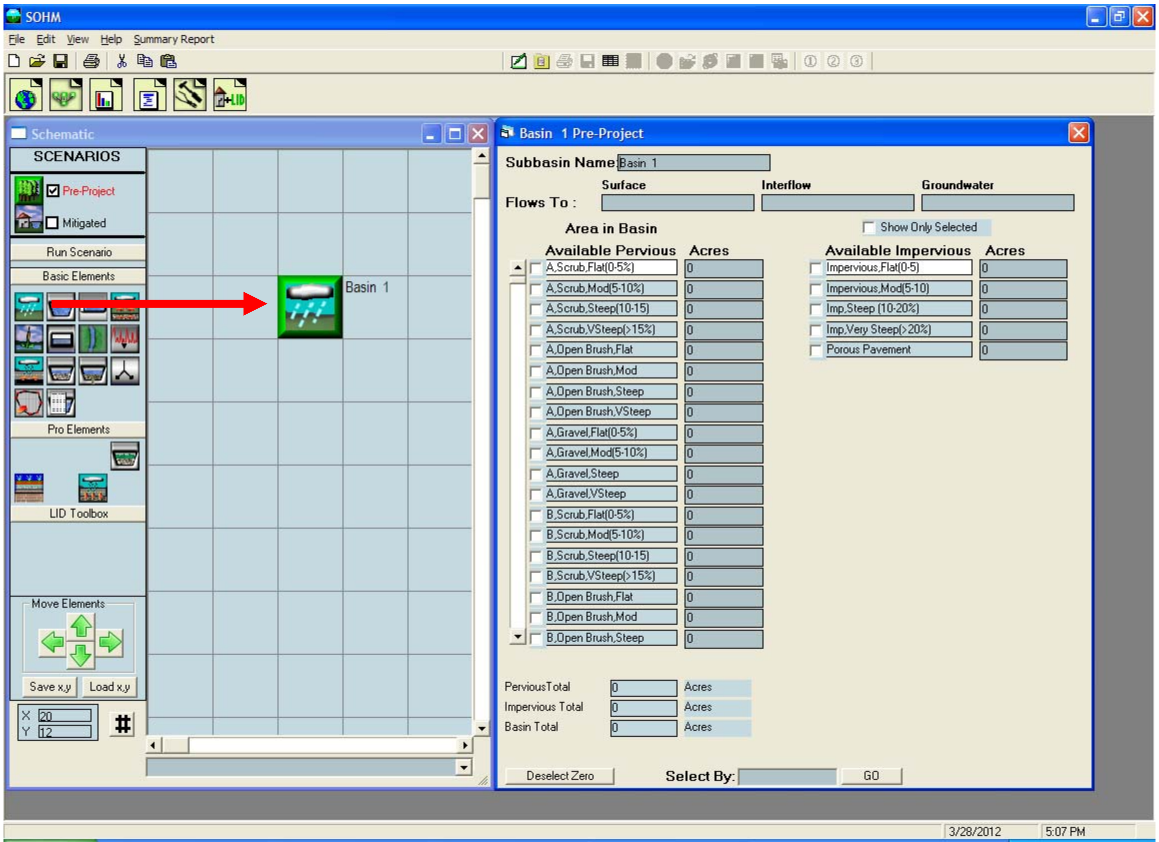
The schematic editor screen contains two scenarios: Pre-Project (Predevelopment) and Mitigated.

Set up first the Predevelopment scenario and then the Mitigated scenario.

Check the Predevelopment scenario box.

Left click on the Basin element under the Elements heading. The Basin element represents the project drainage area. It is the upper left element.

Select any grid cell (preferably near the top of the grid) and left click on that grid. The land use basin will appear in that grid cell.



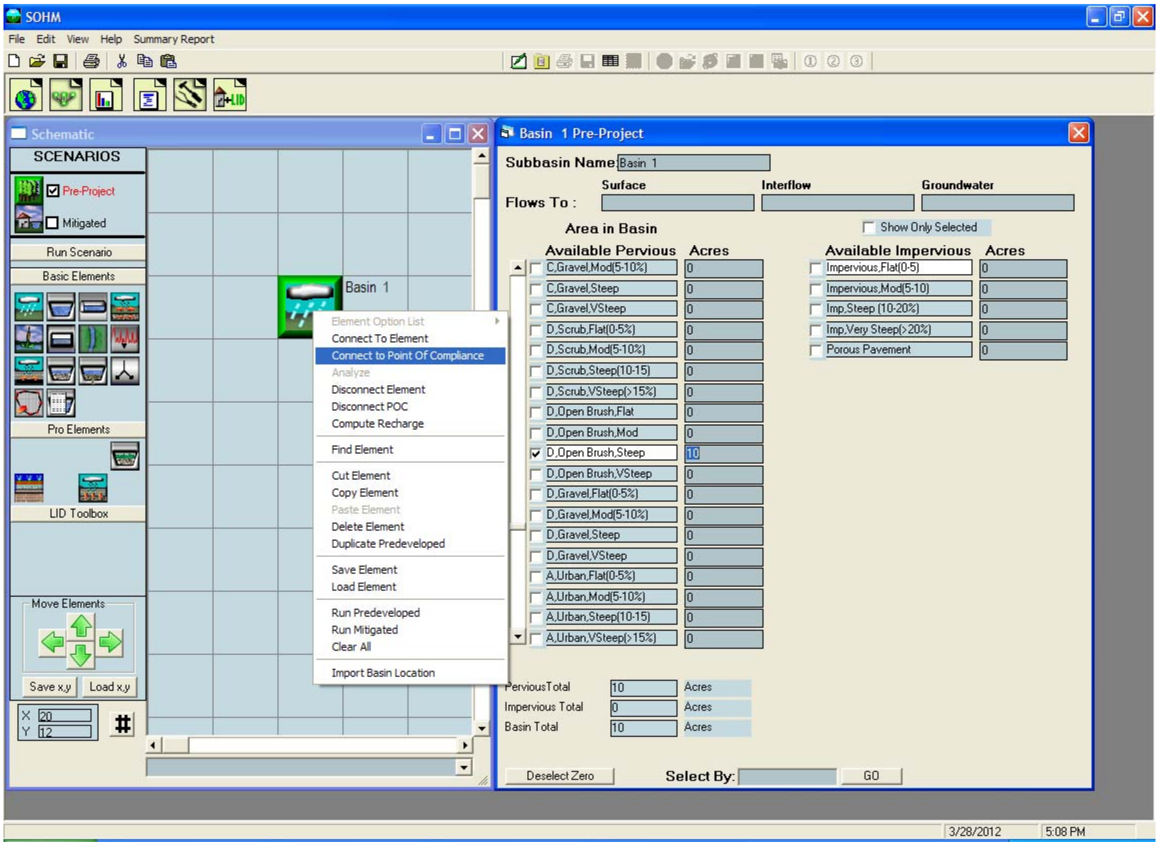
To the right of the grid is the land use information associated with the basin element. Select the appropriate soil, land cover, and land slope for the Predevelopment scenario. Soils are based on SCS general categories A, B, C, and D.

Land cover is based on the native vegetation for the Predevelopment area and the planned vegetation for the planned development (Mitigated scenario). Non-urban land cover has been divided into scrub, open brush, and gravel. In contrast, the developed landscape will consist of urban vegetation (lawns, flowers, planted shrubs and trees) and is regularly irrigated.

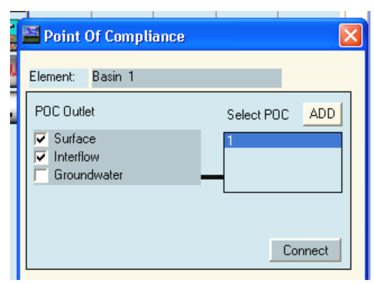
Land slope is divided into flat (0-5%), moderate (5-10%), steep (10-15%), and very steep (> 15%) land slopes.

HSPF parameter values in SOCHM have been adjusted for the different soil, land cover, and land slope categories.

For this example we will assume that the Predevelopment land use is 10 acres of D soil with open brush vegetation on a steep slope (10-15%). Note that the Predevelopment land use never includes man-made impervious areas. Existing impervious areas must be modeled as they were prior to any land use development on the project site.

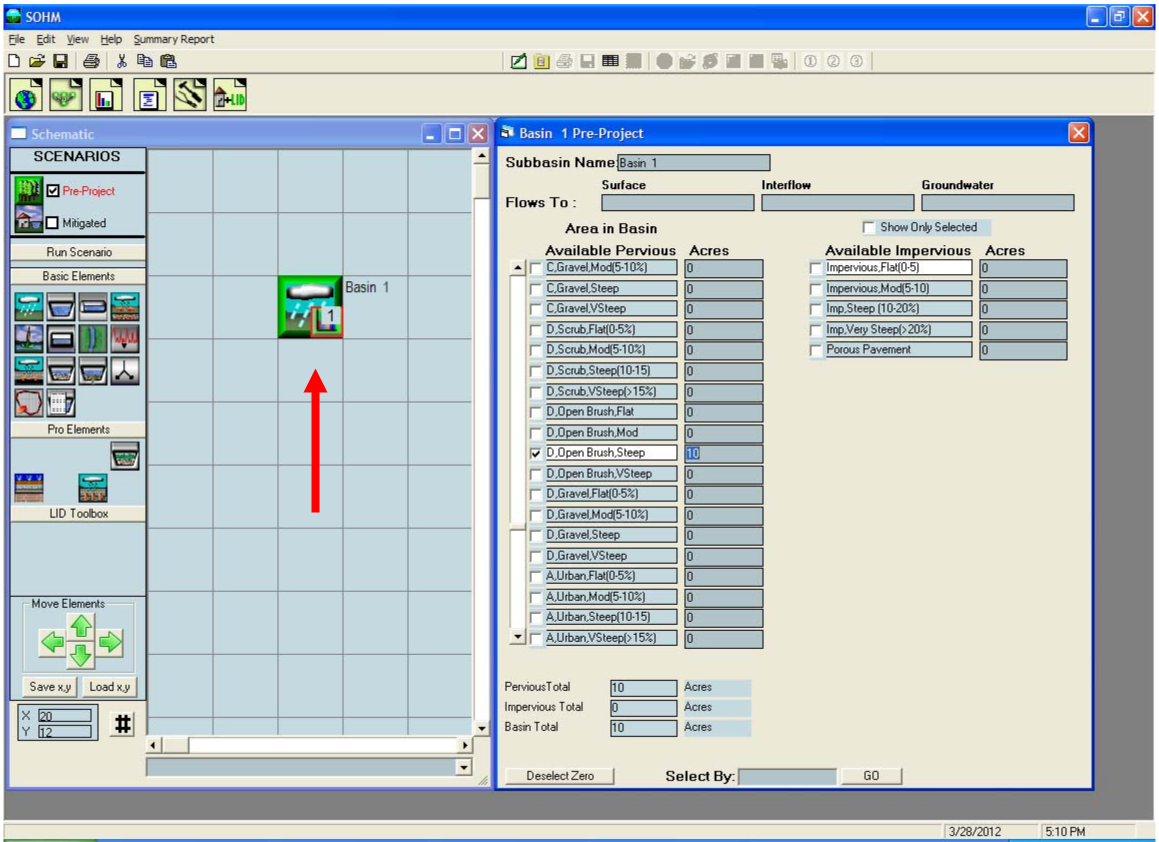


The exit from this land use basin will be selected as our point of compliance for the Predevelopment scenario. Right click on the basin element and highlight Connect to Point of Compliance (the point of compliance is defined as the location at which the runoff from both the Predevelopment scenario and the Mitigated scenario are compared).



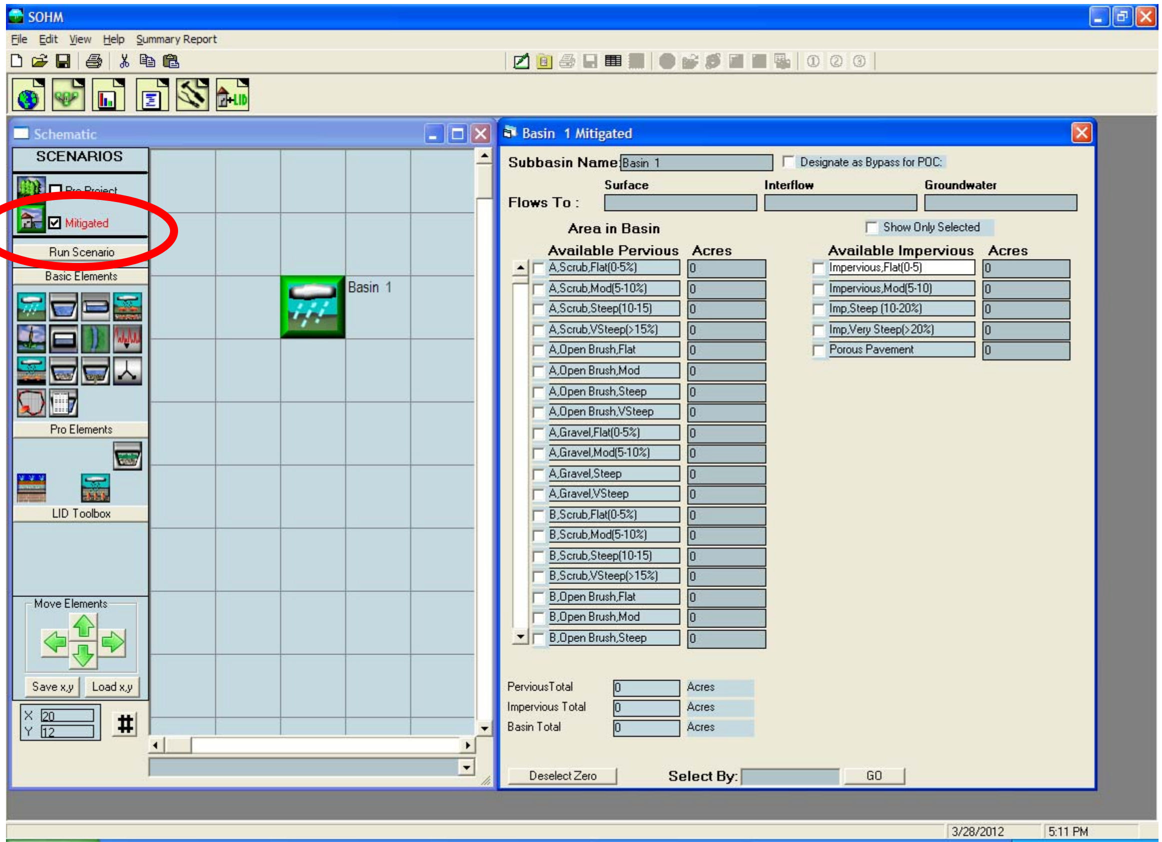
The Point of Compliance screen will be shown for Predevelopment Basin 1. The POC (Point of Compliance) outlet has been checked for both surface runoff and interflow (shallow subsurface flow). These are the two flow components of stormwater runoff. Do not check the groundwater box unless there is observed and documented base flow on the project site.

Click the Connect button in the low right corner to connect this point of compliance to the Predevelopment basin.

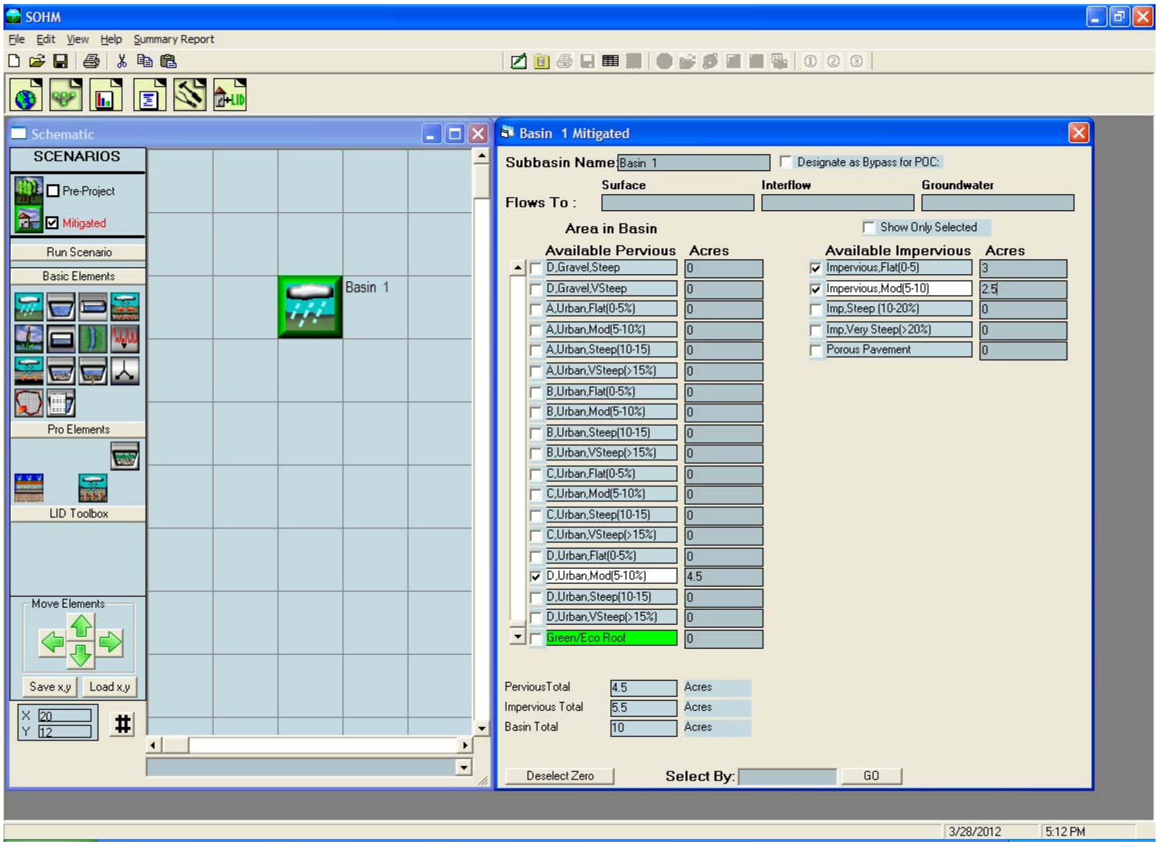


After the point of compliance has been added to the land use basin the basin element will change. A small box with a bar chart graphic and a number will be shown in the lower right corner of the basin element. This small POC box identifies this basin as a point of compliance. The number is the POC number (e.g., POC 1).

4. Set up the Mitigated scenario.



First, check the Mitigated scenario box and place a land use basin element on the grid.

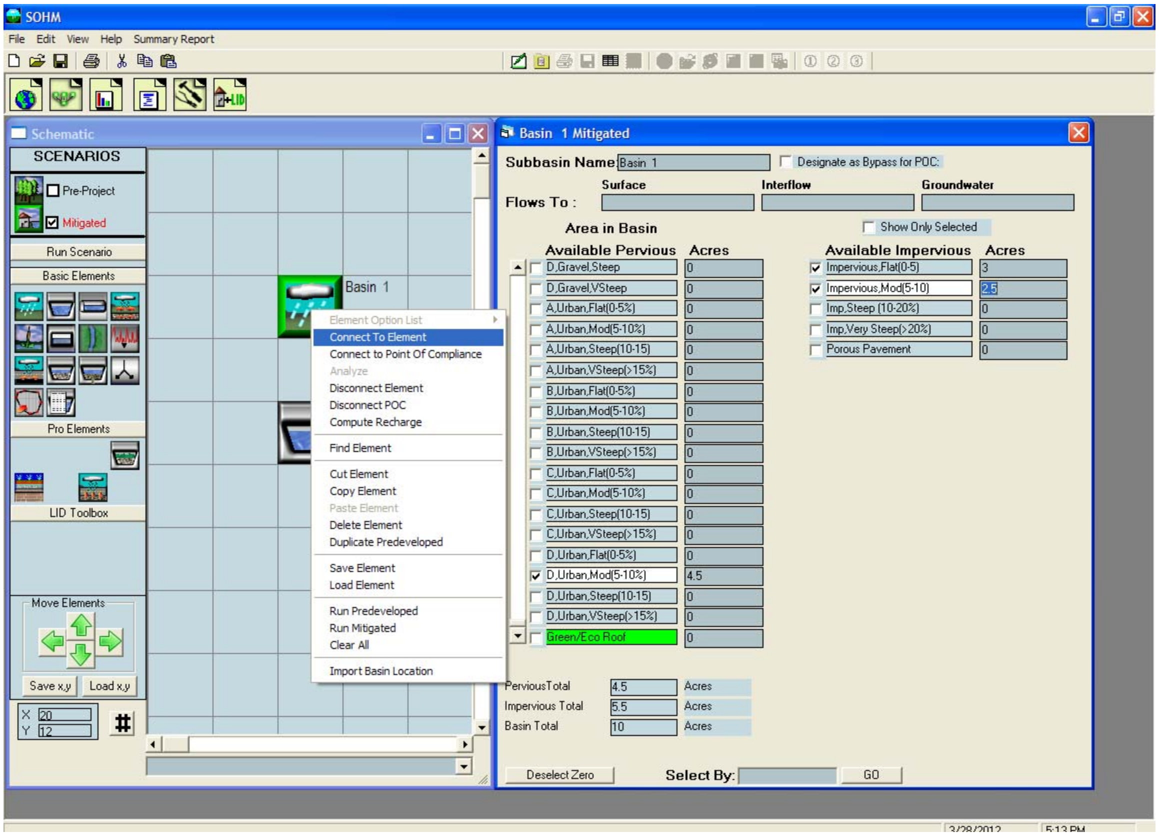


For the Mitigated land use we have:

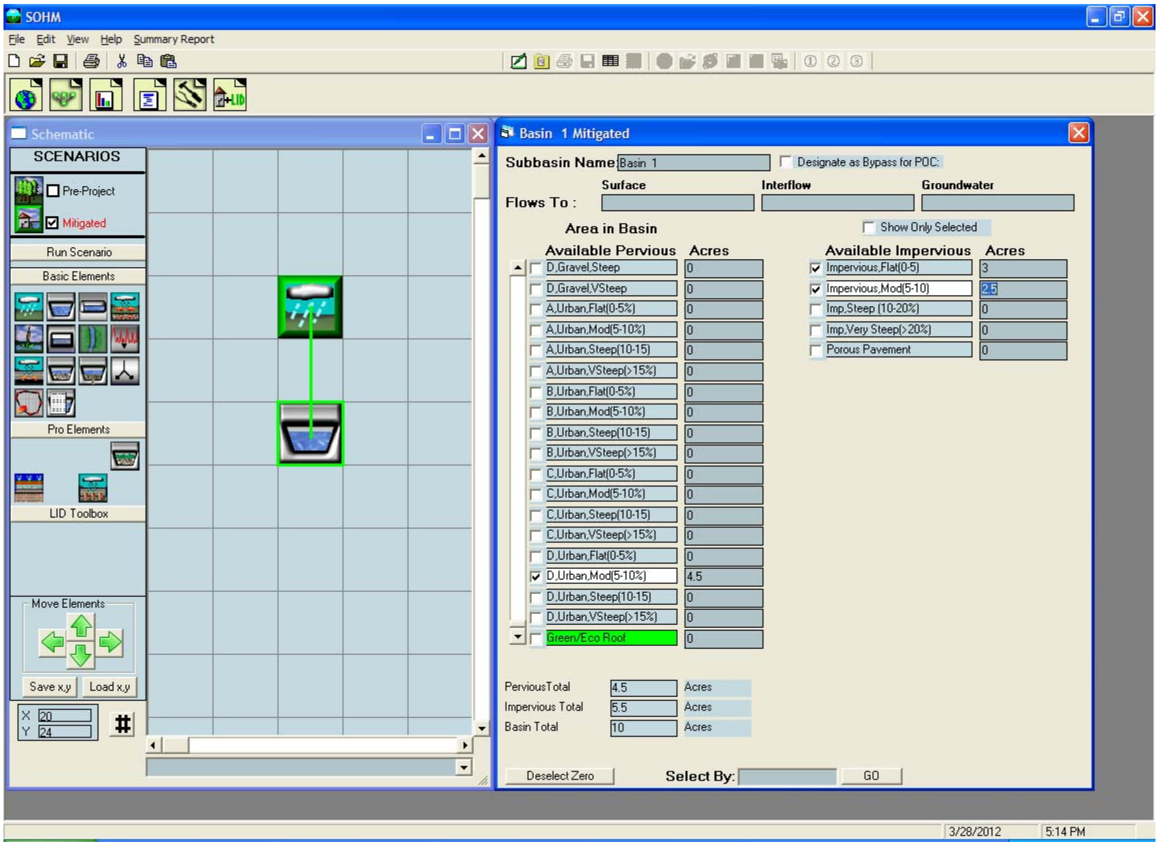
- 4.5 acres of D soil, urban vegetation, moderate slope
- 3 acres of impervious, flat slope
- 2.5 acres of impervious, moderate slope

We will add a trapezoidal pond downstream of the basin.

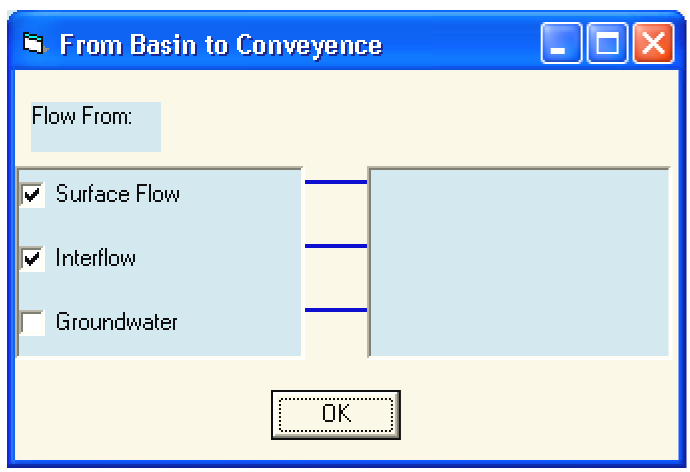
The impervious land categories include roads, roofs, sidewalks, parking, and driveways. All are modeled the same, except that steeper slopes have less surface retention storage prior to the start of surface runoff.

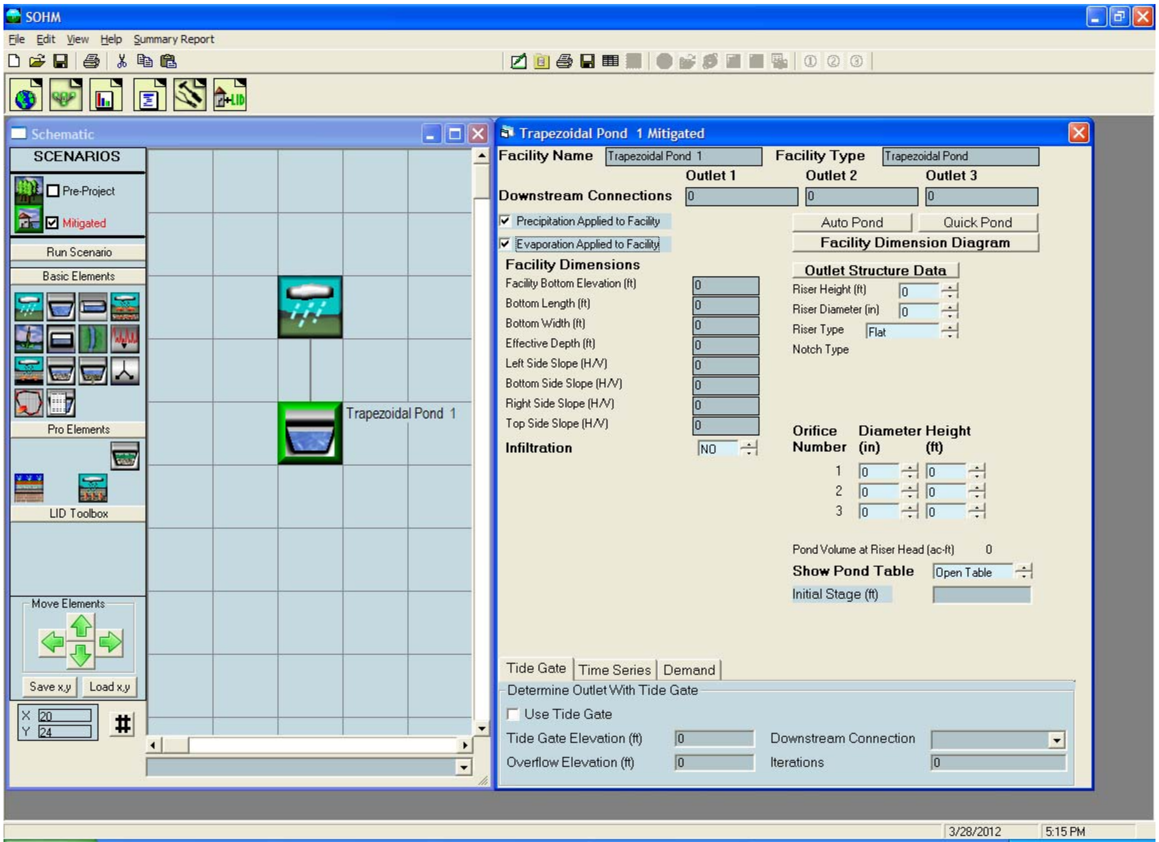


The trapezoidal pond element is placed below the basin element on the grid. Right click on the basin and select Connect To Element. A green line will appear with one end connected to the basin.

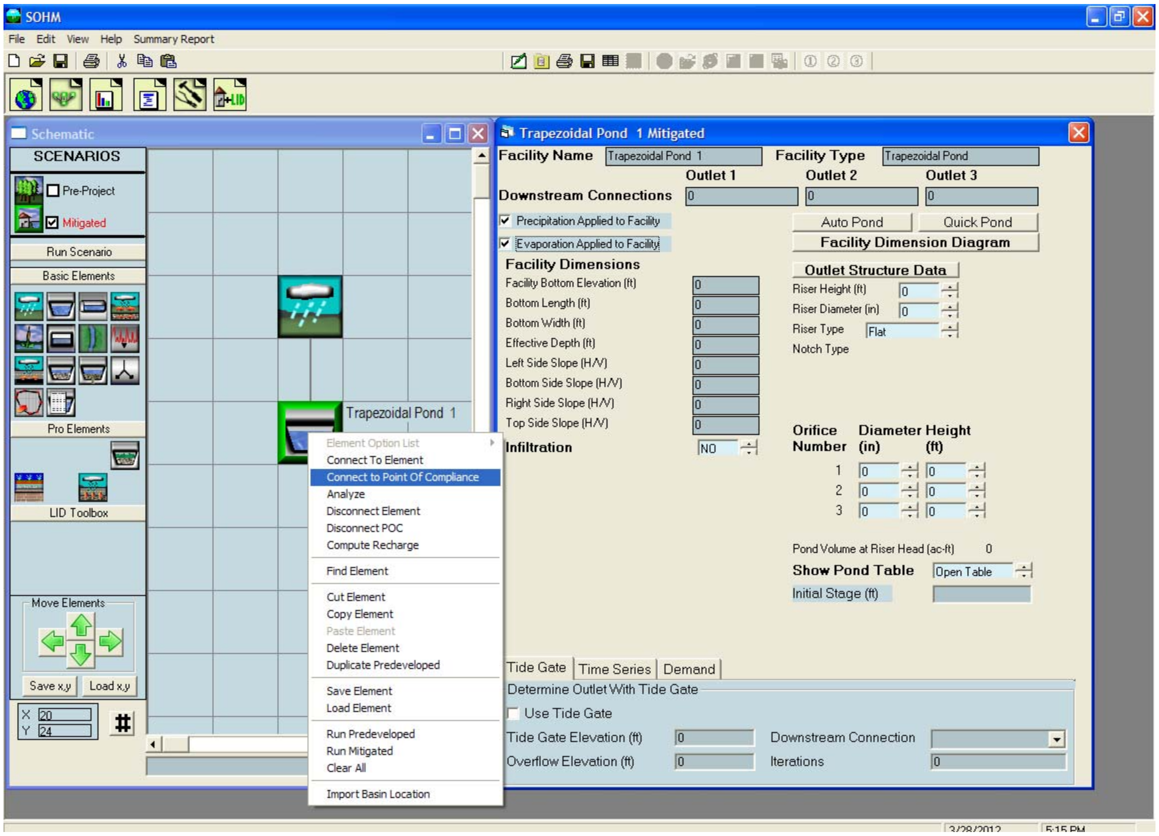


With the mouse pointer pull the other end of the line down to the trapezoidal pond and click on the pond. This will bring up the From Basin to Conveyance screen. As with the Predevelopment scenario we want to only connect the surface flow and the interflow (shallow subsurface runoff) from the basin to the pond. Click OK.

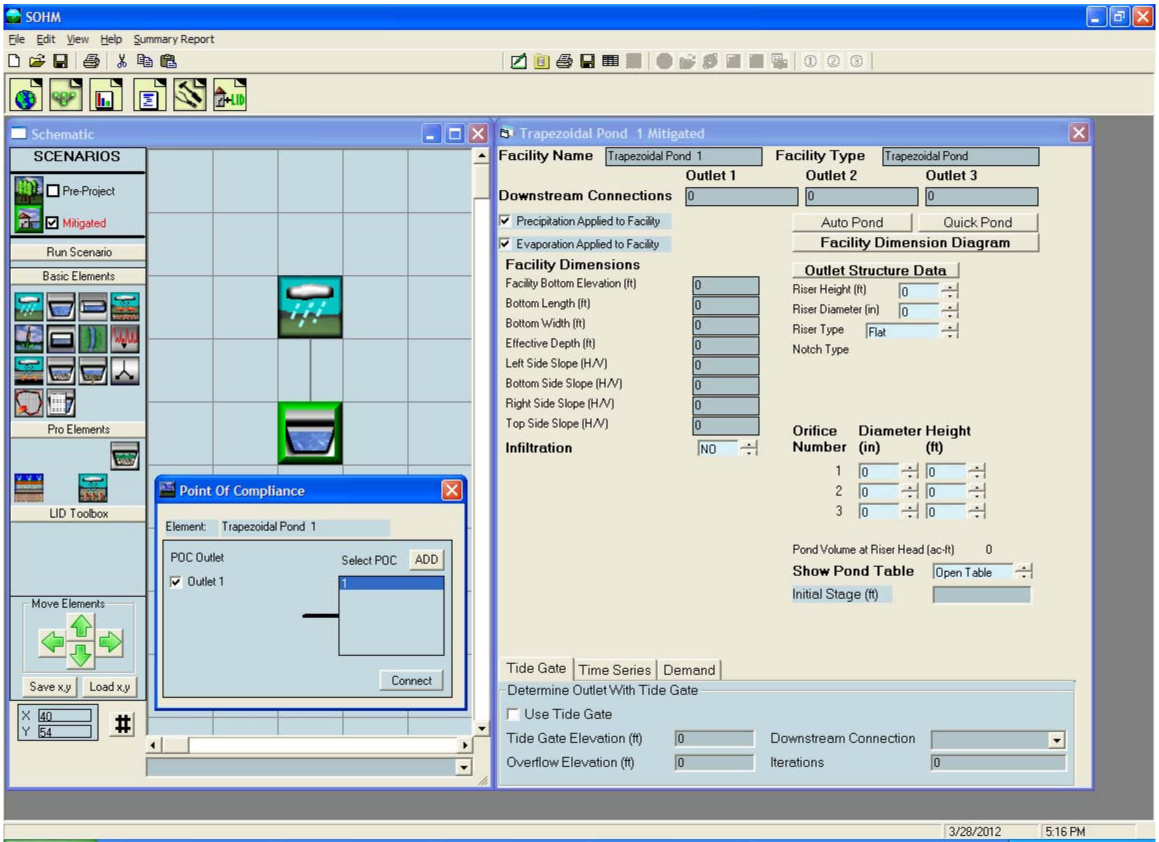




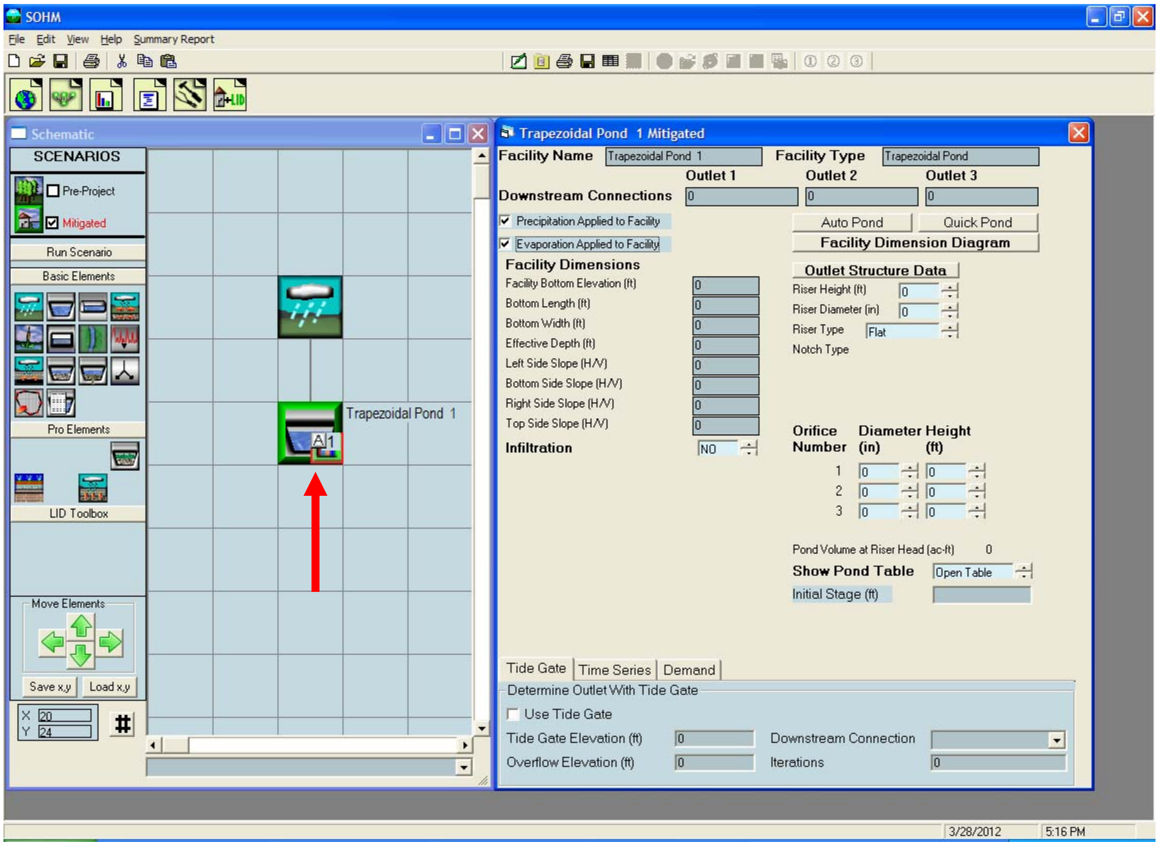
A line will connect the land use basin to the pond.



Right click on the trapezoidal pond element to connect the pond's outlet to the point of compliance. Highlight Connect to Point Of Compliance and click.



The Point of Compliance screen will be shown for the pond. The pond has one outlet (by default). The outflow from the pond will be compared with the Predevelopment runoff. The point of compliance is designated as POC 1 (SOCHM allows for multiple points of compliance). Click on the Connect button.

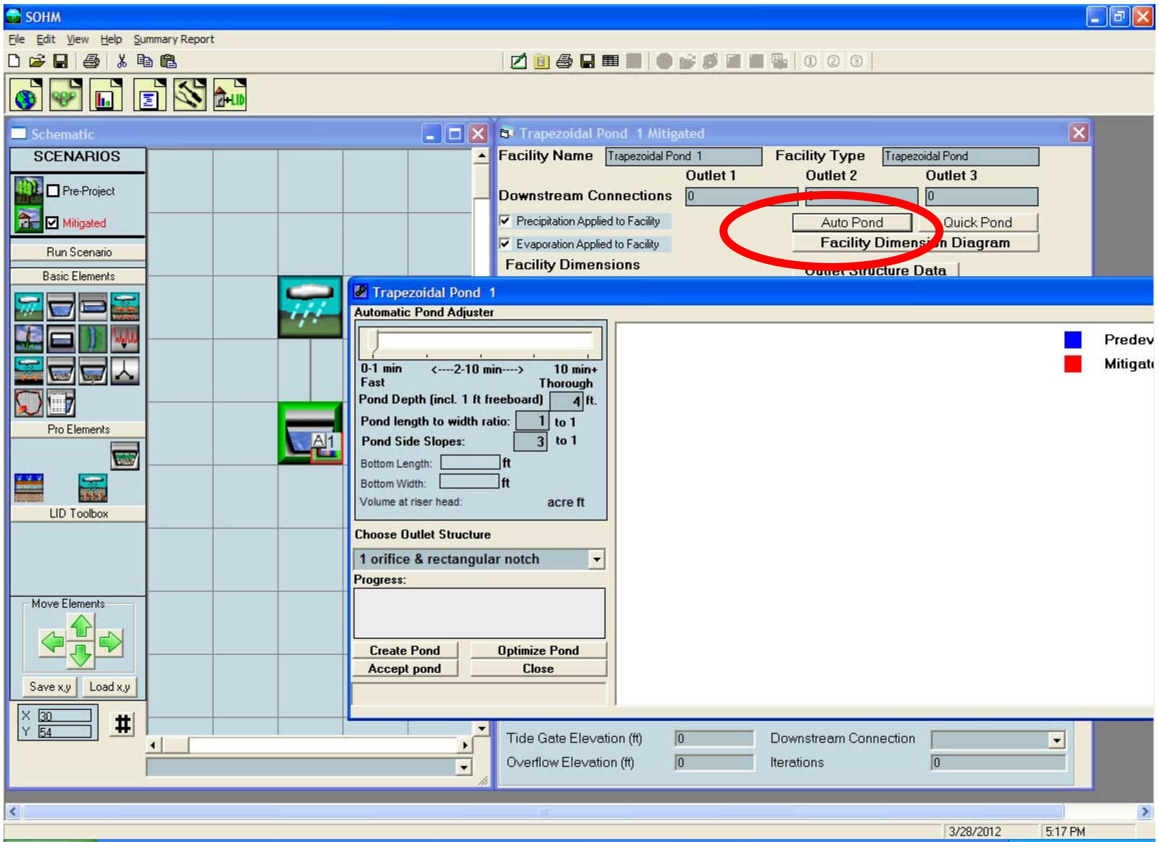


The point of compliance is shown on the pond element as a small box with the letter "A" and number 1 in the bar chart symbol in the lower right corner.

The letter "A" stands for Analysis and designates that this is an analysis location where flow and stage will be computed and the output flow and stage time series will be made available to the user. The number 1 denotes that this is POC 1.

You can have an analysis location without having a point of compliance at the same location, but you cannot have a point of compliance that is also not an analysis location.

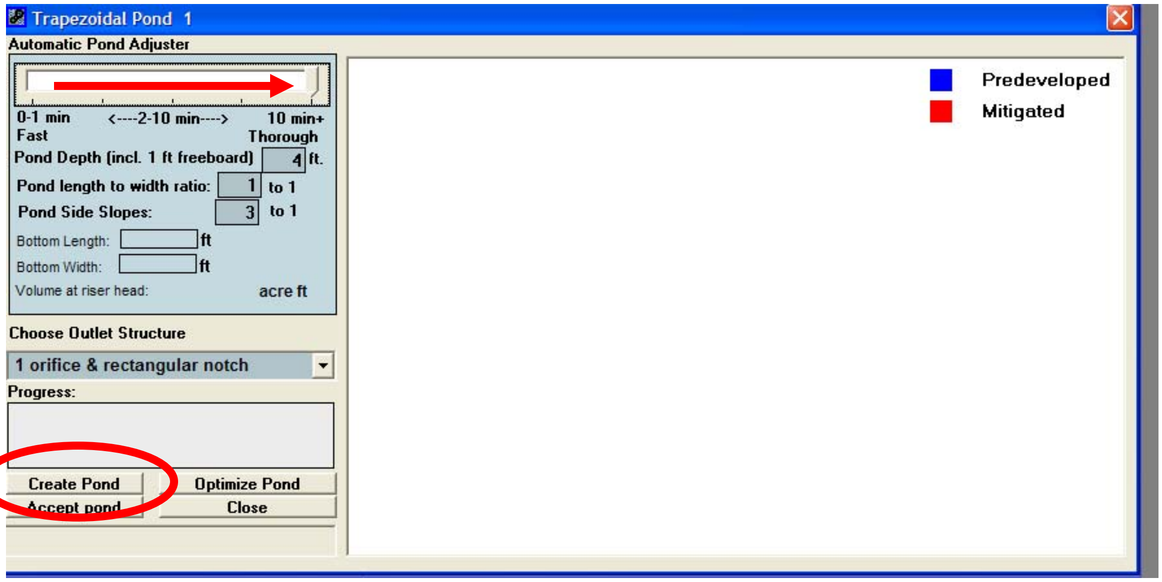
5. Sizing the pond.



A trapezoidal stormwater pond can be sized either manually or automatically (using AutoPond). For this example AutoPond will be used. (Go to page 48 to find more information about how to manually size a pond or other HMP facility.)

Click on the AutoPond button and the AutoPond screen will appear. The user can set the pond depth (default: 4 feet), pond length to width ratio (default: 1 to 1), pond side slopes (default: 3 to 1), and the outlet structure configuration (default: 1 orifice and riser with rectangular notch weir).

To optimize the pond design and create the smallest pond possible, move the Automatic Pond Adjuster pointer from the left to the right.



The pond does not yet have any dimensions. Click the Create Pond button to create initial pond dimensions, which will be the starting point for AutoPond's automated optimization process to calculate the pond size and outlet structure dimensions.

Running AutoPond automates the following SOCHM processes:

1. the 15-minute Predevelopment runoff is computed for the 40-60 years of record (it varies depending on the rain gage used),
2. the Predevelopment runoff flood frequency is calculated based on the partial duration peak flows,
3. the range of flows is selected for the flow duration (10% of the 2-year peak to the 10-year peak),
4. this flow range is divided into 100 increments, and
5. the number of 15-minute Predevelopment flow values that exceed each flow increment level (Predevelopment flow duration) are counted to create the flow duration curves and accompanying tabular results.

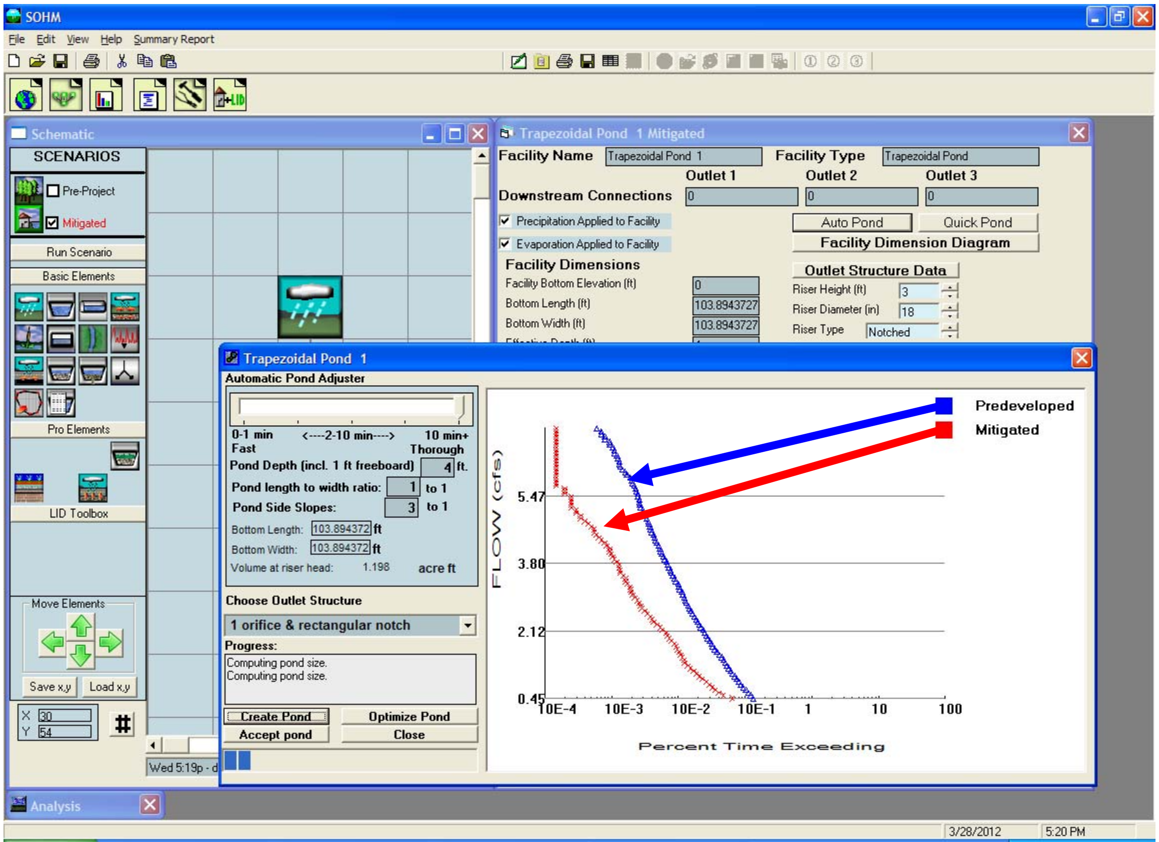
Next, SOCHM computes the post-project runoff (in the Mitigated scenario) and routes the runoff through the pond. But before the runoff can be routed through the pond the pond must be given dimensions and an outlet configuration. AutoPond uses a set of rules based on the Predevelopment and Mitigated scenario land uses to give the pond an initial set of dimensions and an initial outlet orifice diameter and riser (the riser is given a default rectangular notch). This information allows SOCHM to compute a stage-storage-discharge table for the pond.

With this initial pond stage-storage-discharge table SOCHM:

1. routes the 15-minute post-project runoff through the pond for the 40-60 years of record to create to the Mitigated flow time series,
2. counts the number of 15-minute Mitigated flow values that exceed each flow increment level (this is the Mitigated flow duration), and

3. computes the ratio of Mitigated flow values to Predevelopment flow values for each flow increment level (comparing the Predevelopment and Mitigated flow duration results).

If any of the 100 individual ratio values is greater than allowed by the flow duration criteria then the pond fails to provide an appropriate amount of mitigation and needs to be resized.



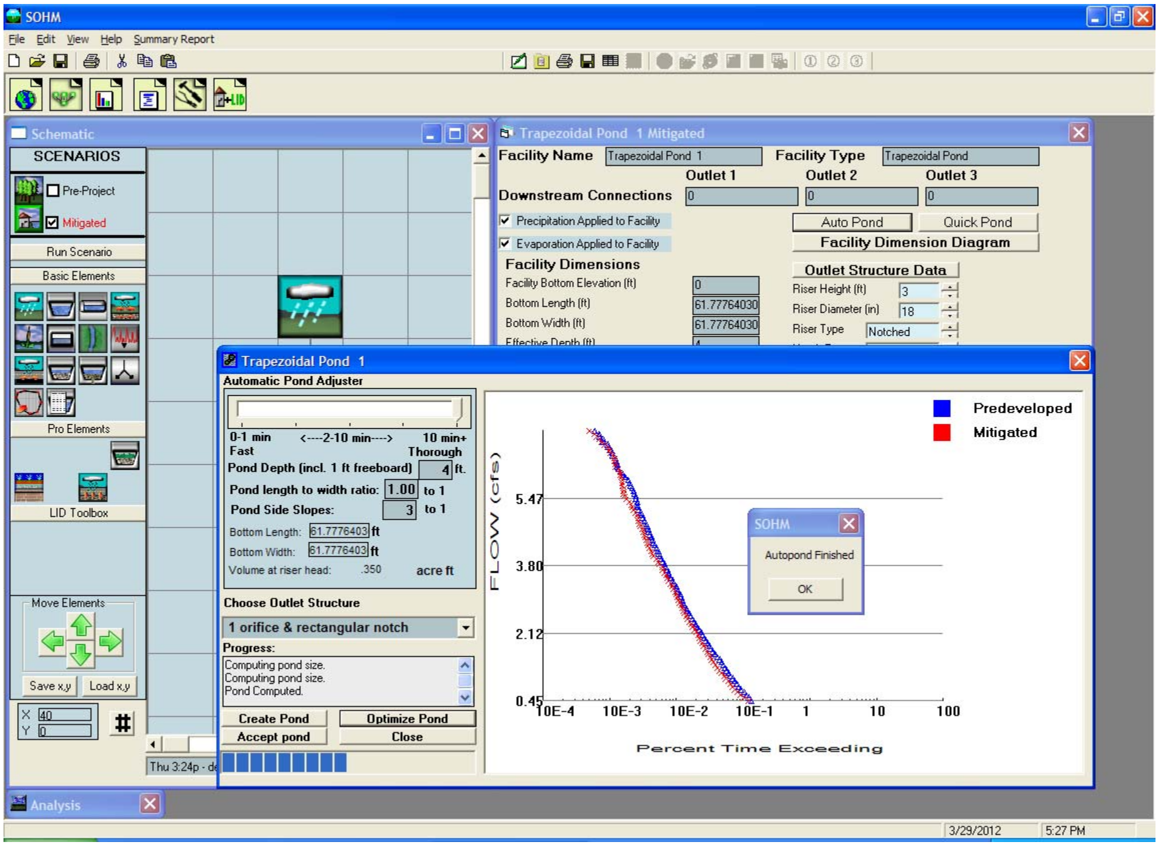
Flow duration results are shown in the plots above. The vertical axis shows the range of flows from 10% of the 2-year flow (0.45 cfs) to the 10-year flow (7.14 cfs). The horizontal axis is the percent of time that flows exceed a flow value. Plotting positions on the horizontal axis typical range from 0.001% to 1%, as explained below.

For the entire 40- to 60-year simulation period (depending on the period of record of the precipitation station used) all of the 15-minute time steps are checked to see if the flow for that time step is greater than the minimum flow duration criteria value (0.38 cfs, in this example). For a 50-year simulation period there are approximately 1,600,000 15-minute values to check. Many of them are zero flows. The 10% of the Predevelopment 2-year flow value is exceeded less than 1% of the total simulation period.

This check is done for both the Predevelopment flows (shown in blue on the screen) and the Mitigated flows (shown in red).

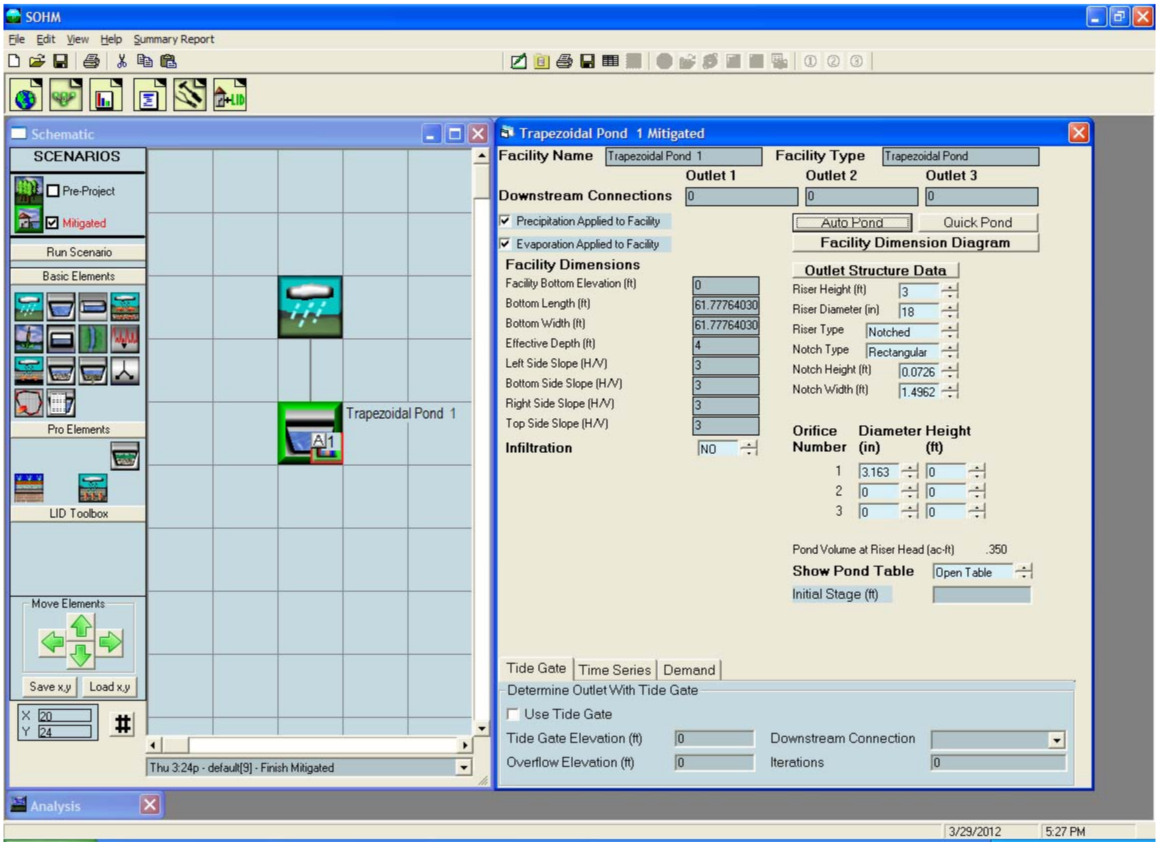
If all of the Mitigated flow duration values (in red) are to the left of the Predevelopment flow duration values (in blue) then the pond mitigates the additional erosive flows produced by the development.

If the Mitigated flow duration values (in red) are far to the left of the Predevelopment flow duration values (in blue) then the pond can be made smaller and still meet the flow duration criteria.



AutoPond goes through an iteration process by which it changes the pond dimensions and outlet configuration, then instructs SOCHM to again compute the resulting Mitigated runoff, compare flow durations, and decide if it has made the results better or worse. This iteration process continues until AutoPond finally concludes that an optimum solution has been found and the Mitigated flow duration values (in red) are as close as possible to the Predevelopment flow duration values (in blue).

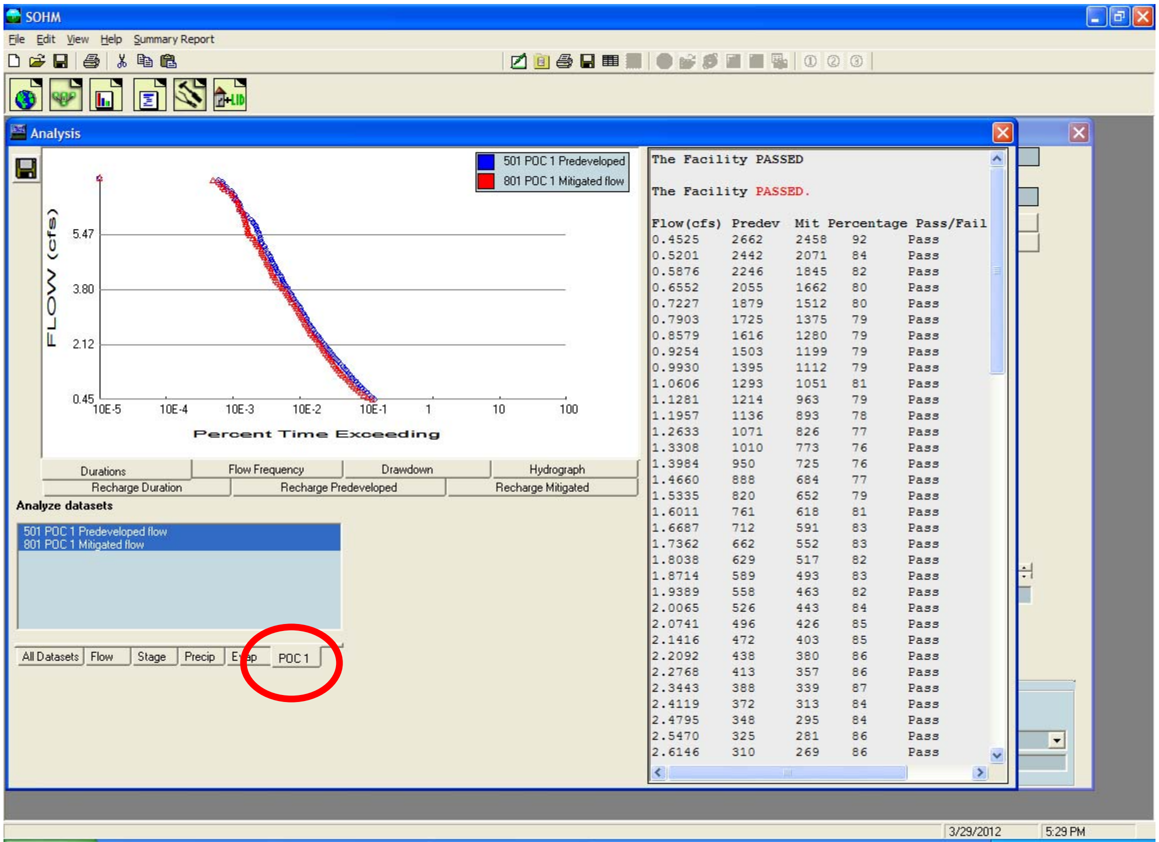
The user may continue to manually optimize the pond by manually changing pond dimensions and/or the outlet structure configuration. (Manual optimization is explained in more detail on page 48.) After making these changes the user should click on the Optimize Pond button to check the results and see if AutoPond can make further improvements.



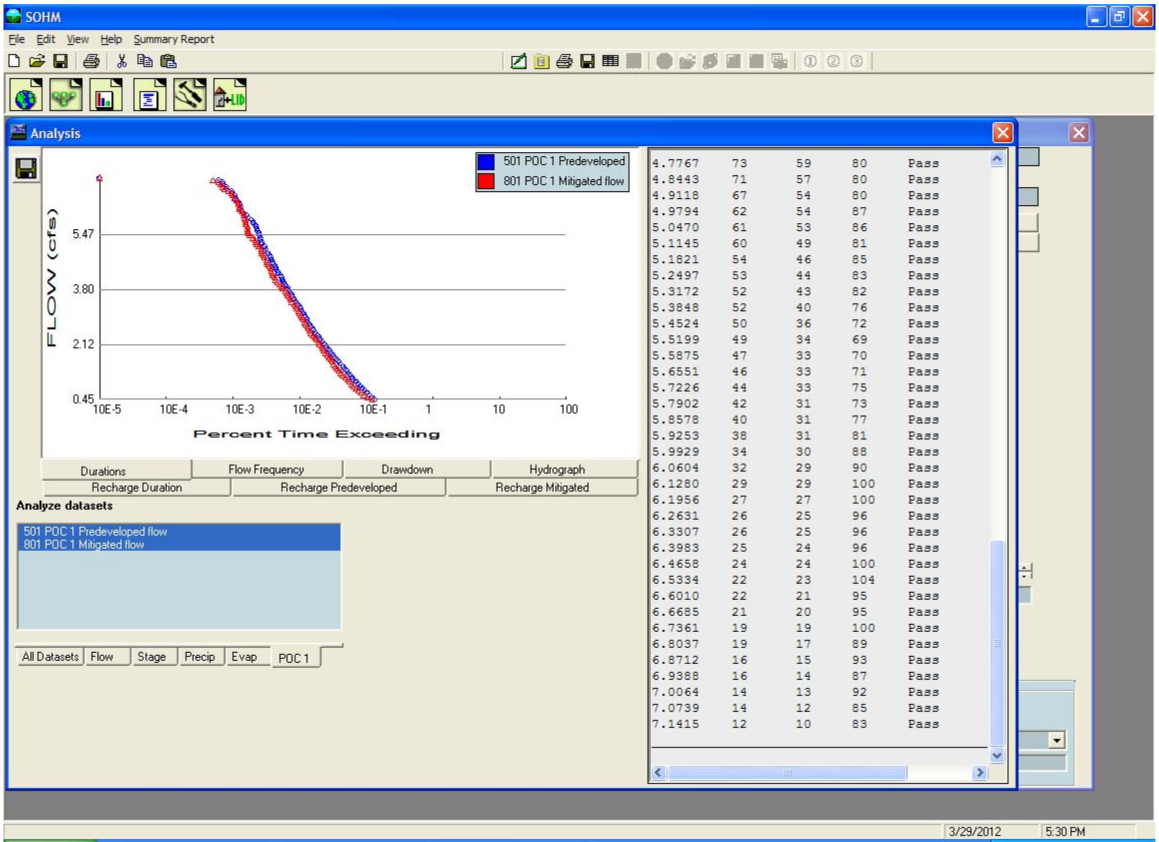
The final pond dimensions (bottom length, bottom width, effective pond depth, and side slopes) and outlet structure information (riser height, riser diameter, riser weir type, weir notch height and width, and orifice diameter and height) are shown on the trapezoidal pond screen to the right of the Schematic grid.

NOTE: If AutoPond selects a bottom orifice diameter smaller than the smallest diameter allowed by the local municipal permitting agency then the user has the option of specifying a minimum allowable bottom orifice diameter even if this size diameter is too large to meet flow duration criteria for this element. Additional mitigating BMPs may be required to meet local hydromodification control requirements. Please see Appendix C or consult with local municipal permitting agency for more details. For manual sizing information see page 48.

6. Review analysis.

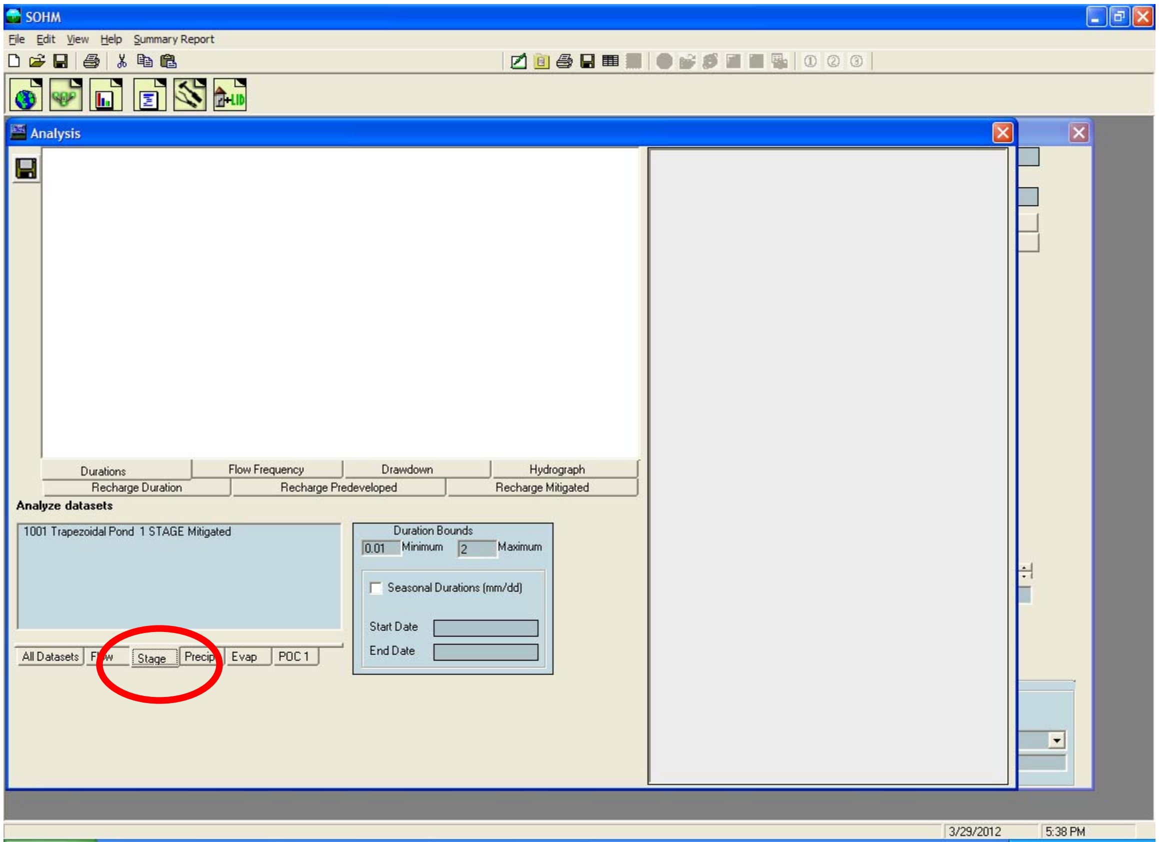


The Analysis tool bar button (third from the left) brings up the Analysis screen where the user can look at the results. Each time series dataset is listed in the Analyze Datasets box in the lower left corner. To review the flow duration analysis at the point of compliance select the POC 1 tab at the bottom and make sure that both the 501 POC 1 Predevelopment flow and 801 POC 1 Developed flow are highlighted.



The flow duration plot for both Predevelopment and Mitigated flows will be shown along with the specific flow values and number of times Predevelopment and Mitigated flows exceeded those flow values. The Pass/Fail on the right indicates whether or not at that flow level the flow control standard criteria were met and the pond passes at that flow level (in this example from 10% of the 2-year flow to the 10-year). If not, a Fail is shown; a single Fail fails the pond design.

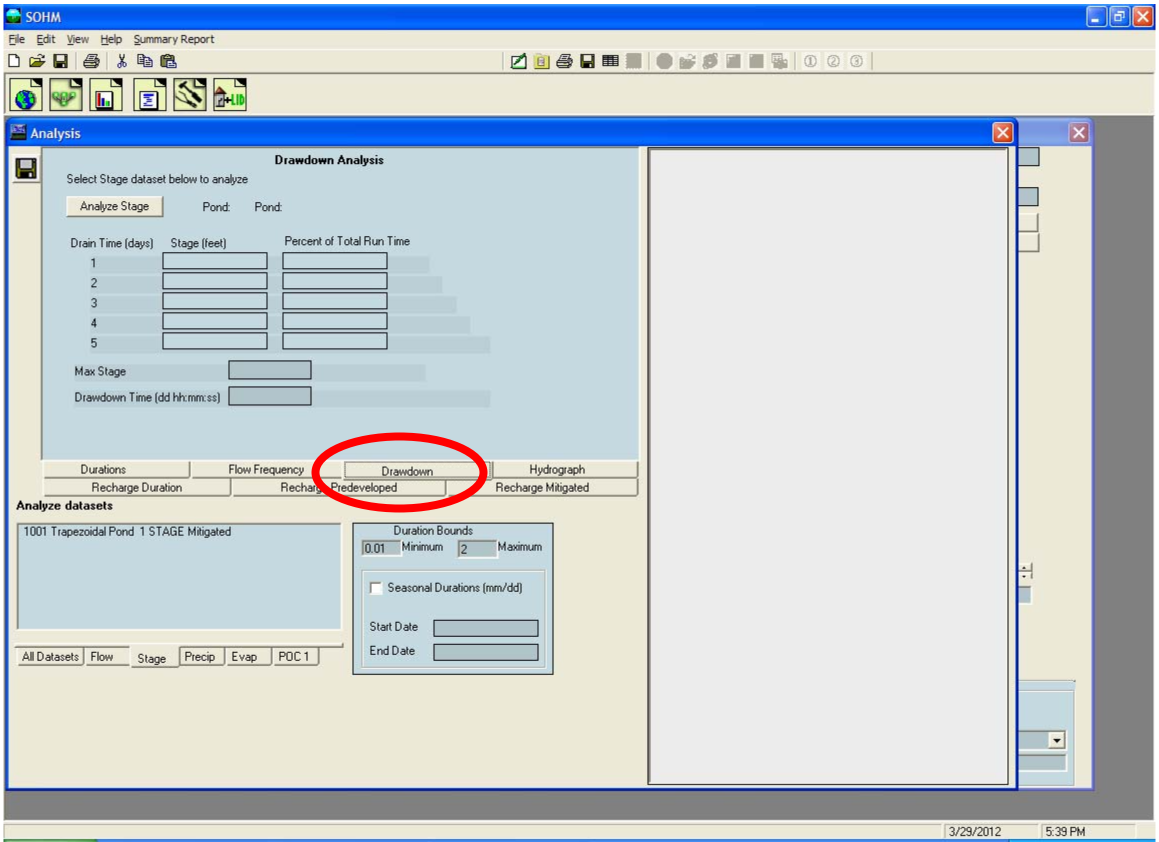
Note that there is a flow level (6.53 cfs) where the number of times the Mitigated flows exceeded that flow level is greater than the number of times the Predevelopment flows exceeded that same flow level (23 vs. 22). This produces a ratio of 104%. A maximum ratio of 110% is allowed for flows between the 5-year flow and the 10-year flow. Below the 5-year flow the maximum allowed ratio is 100%.



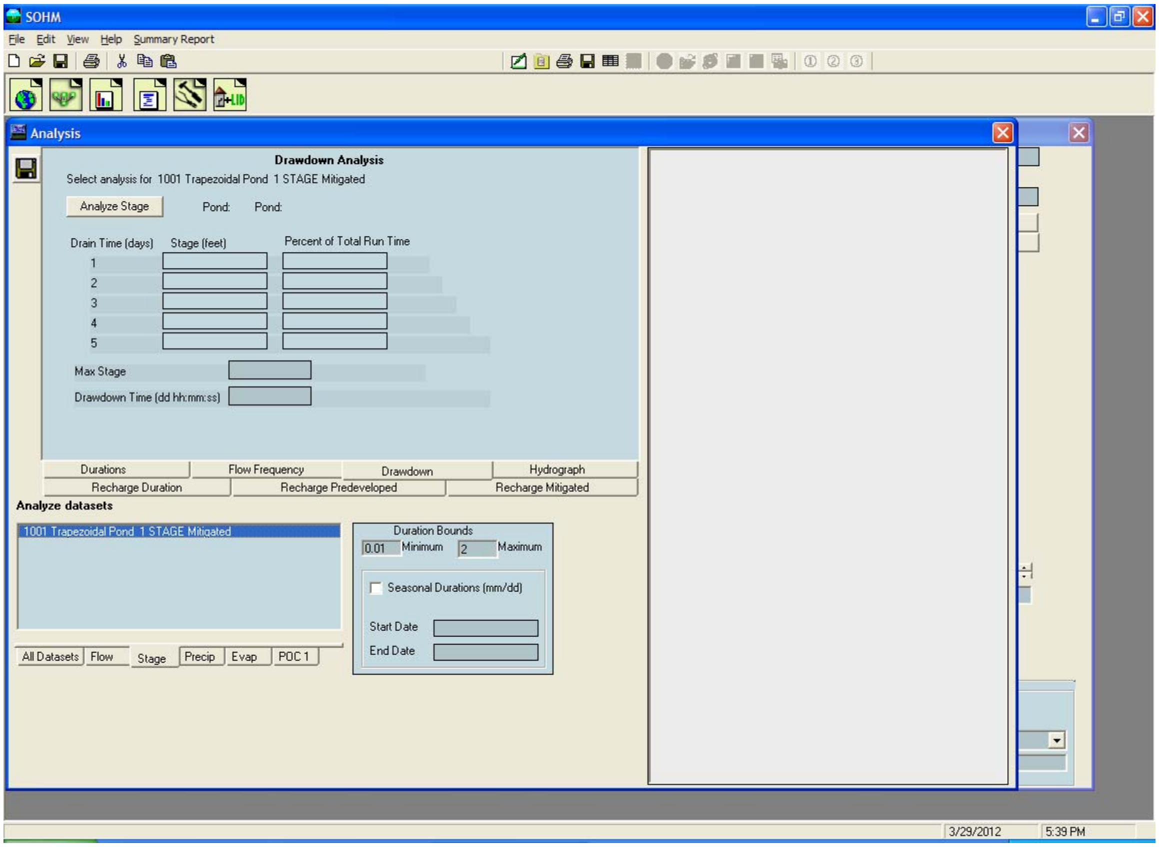
Pond drawdown/retention time is computed on the Analysis screen.

NOTE: This information is not required for basic sizing of the flow duration facility, but can assist the user in determining the overall suitability of the mitigated design in meeting additional, related requirements for treating stormwater runoff and minimizing risk of vector (mosquito) breeding problems. See page 104 for more descriptions of this SOCHM feature, and Appendix C for discussion and references for these requirements.

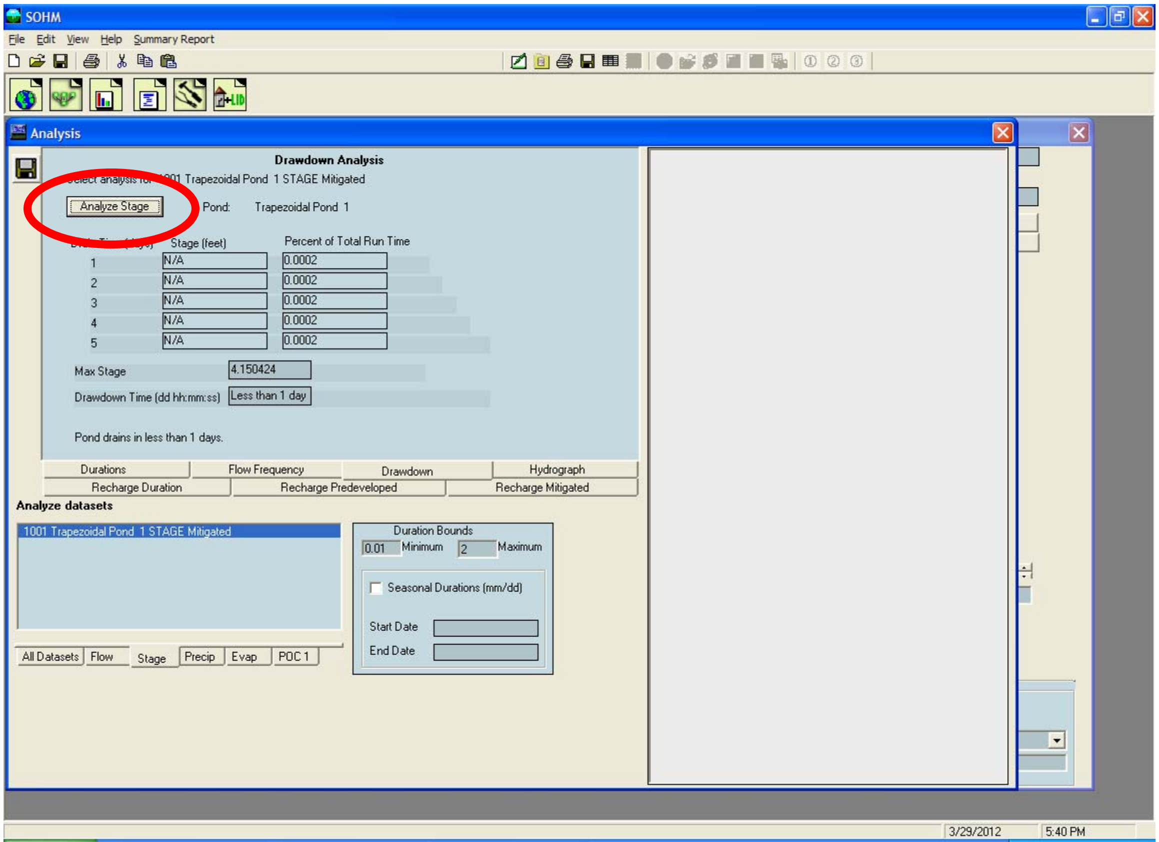
Click on the Stage tab at the bottom to get the Mitigated pond stage time series.



Click on the tab labeled Drawdown. This is where the pond drawdown/retention time results will be shown.



Select the pond you want to analyze for drawdown/retention time (in this example there is only one pond: Trapezoidal Pond 1) by clicking on the dataset and highlighting it.



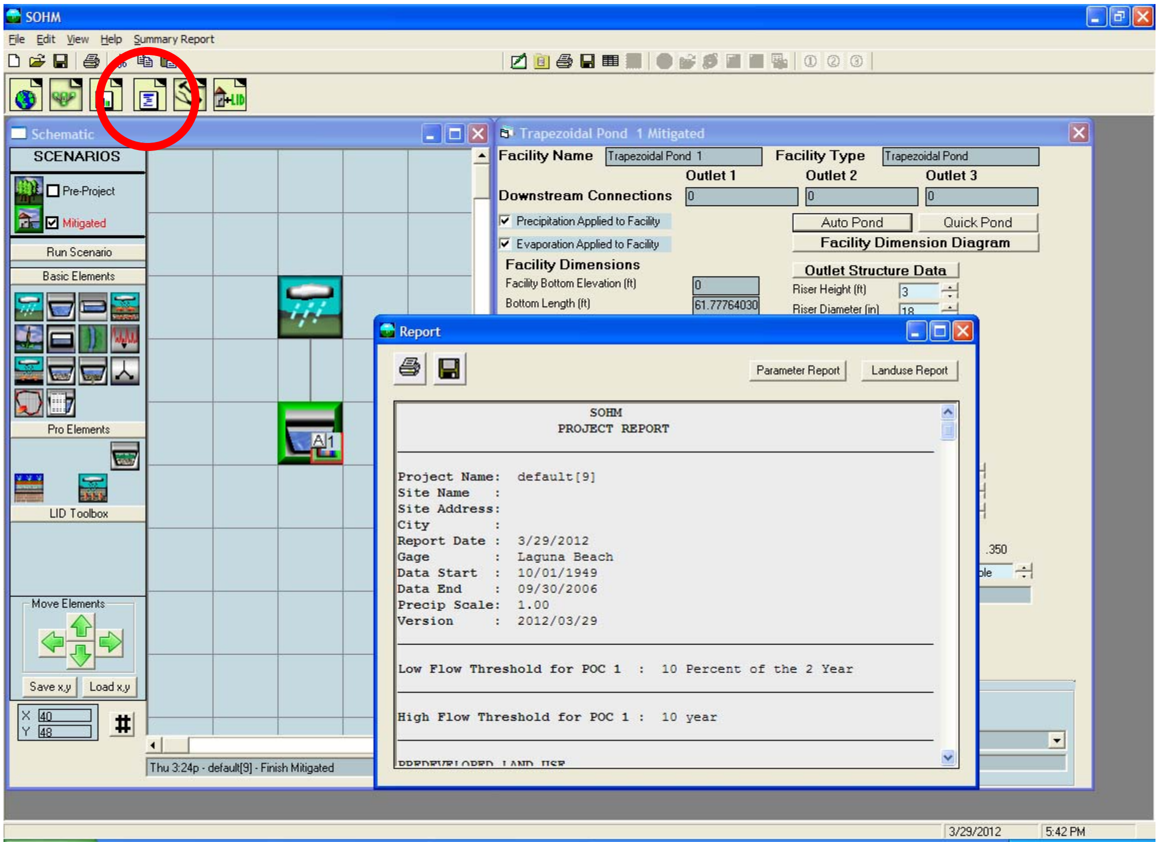
Click on the Analyze Stage button and the computed pond stages (pond water depths) are summarized and reported in terms of drain/retention time (in days).

For this example, the maximum stage computed during the entire 40-60 year simulation period is 4.15 feet. This maximum stage has a drawdown time of less than one day.

Ponds may have drain times in excess of the allowed maximum of hours. This can occur when a pond has a small bottom orifice. If this is not acceptable then the user needs to change the pond outlet configuration, manually run the Mitigated scenario, and repeat the analyze stage computations. A situation may occur where it is not possible to have both an acceptable pond drawdown/ retention time and meet the flow duration criteria.

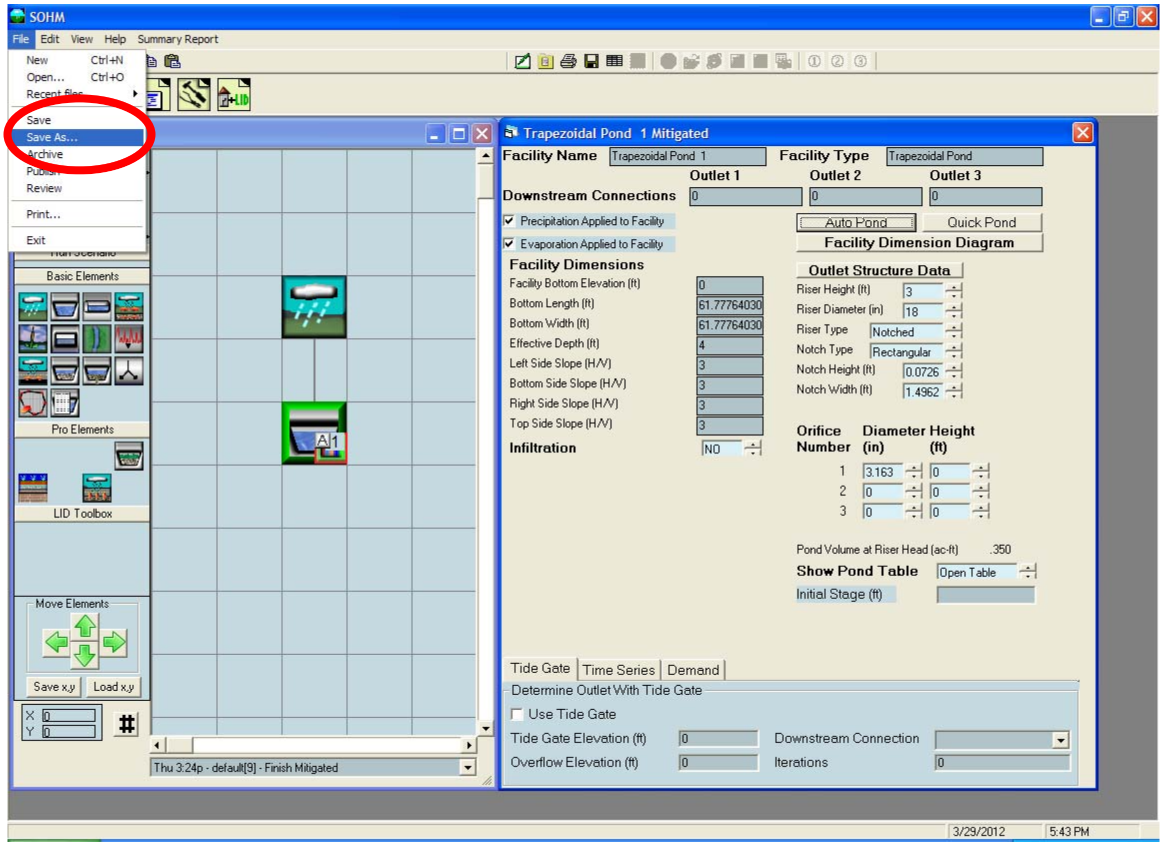
NOTE: See Appendix C or the local municipal permitting agency for an overview of other requirements that may apply regarding drawdown time, and suggestions for addressing situations where it is not possible to meet all drawdown/retention time guidelines and also meet the flow duration criteria. The guidance documentation assumes that the flow duration criteria take precedence unless the user is instructed otherwise by the local municipal permitting agency.

7. Produce report.

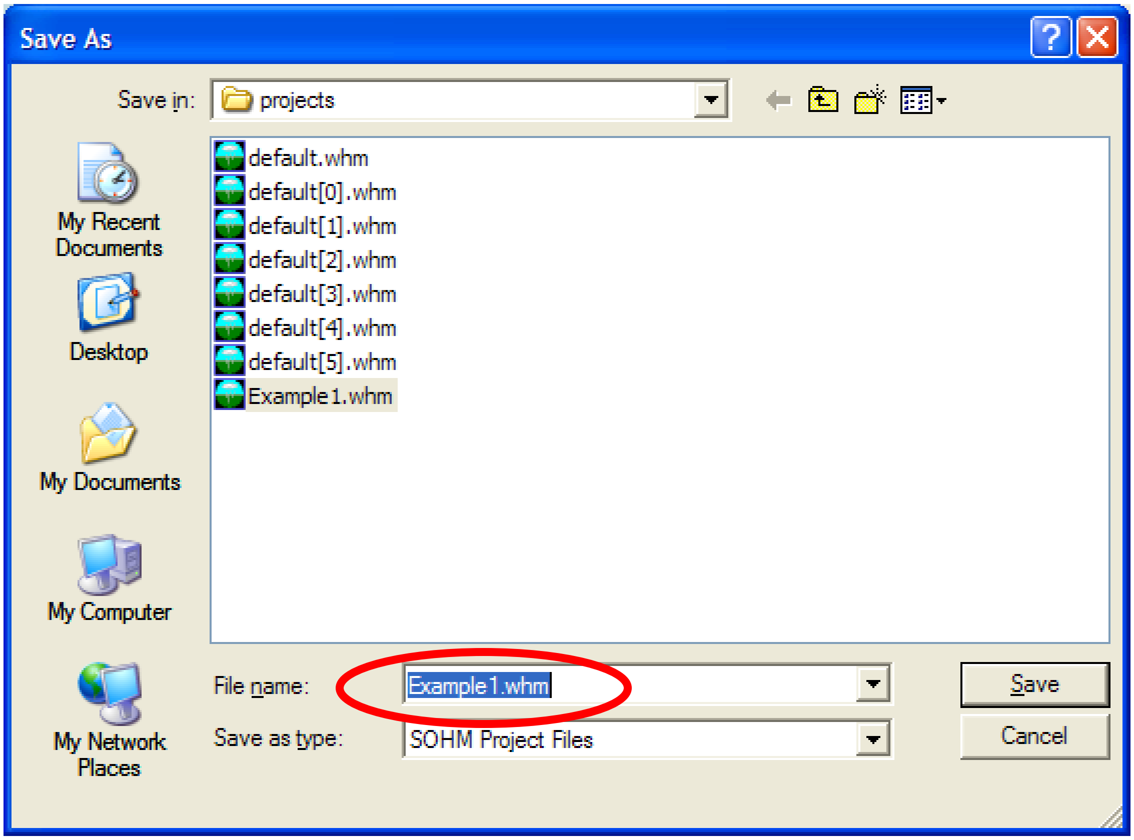


Click on the Reports tool bar button (fourth from the left) to generate a project report with all of the project information and results. Scroll down the Report screen to see all of the results.

8. Save project.

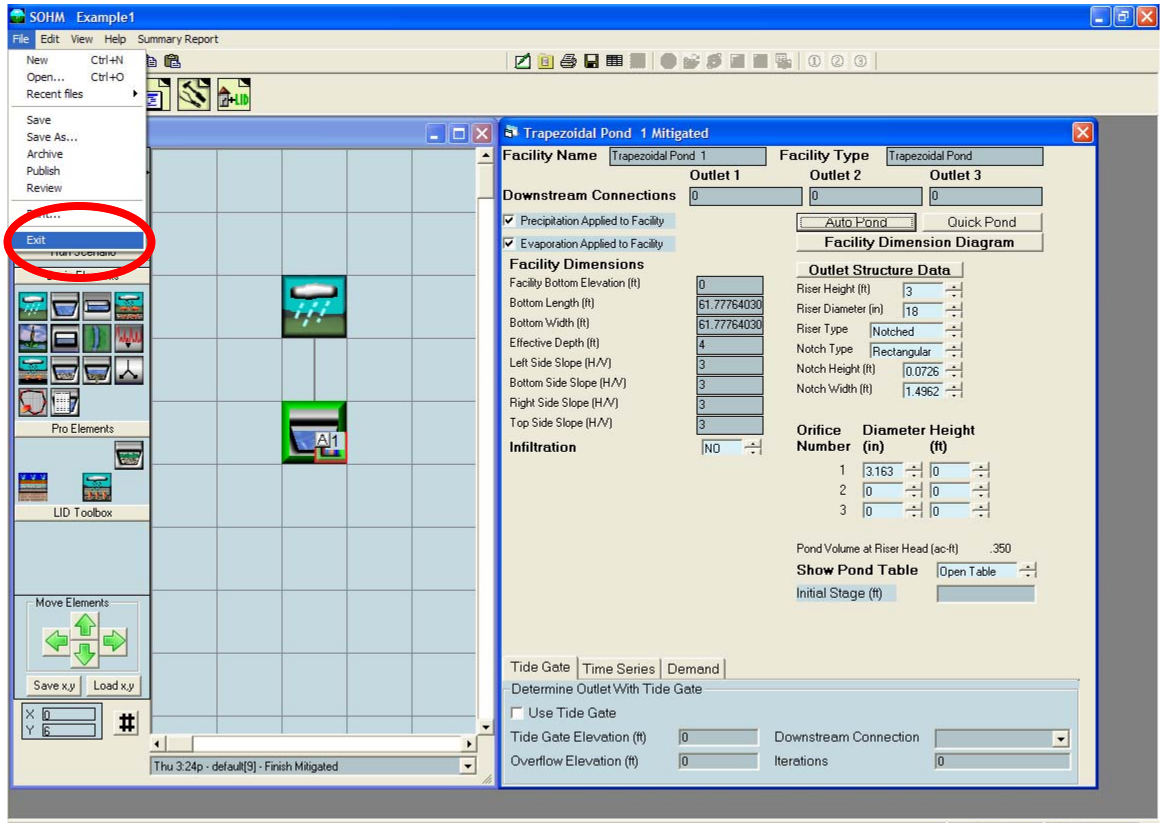


To save the project click on File in the upper left corner and select Save As.



Select a file name and save the SOCHM project file. The user can exit SOCHM and later reload the project file with all of its information by going to File, Open.

9. Exit SOCHM.



To exit SOCHM click on File in the upper left corner and select Exit. Or click on the X in the red box in the upper right hand corner of the screen.

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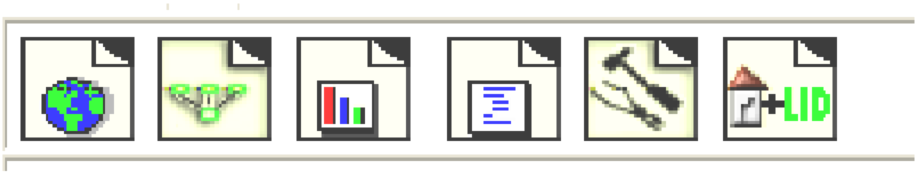
MAIN SCREENS



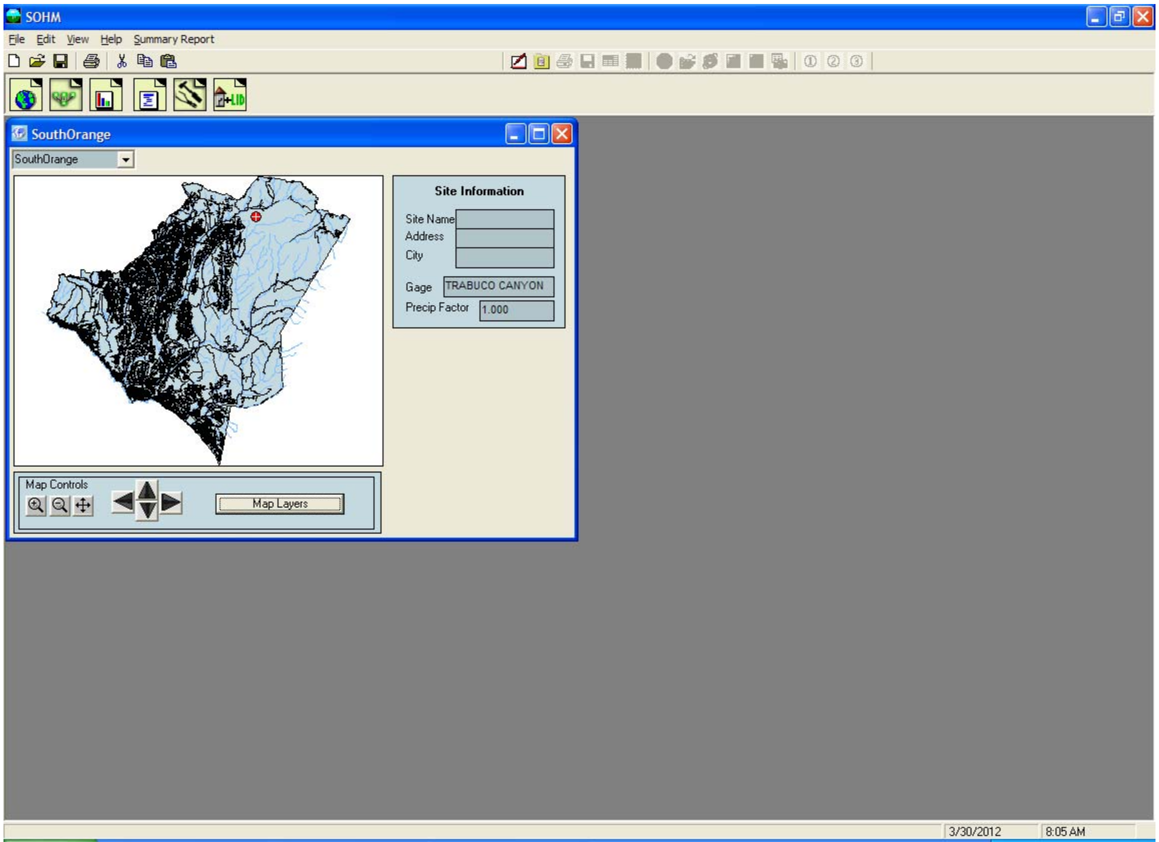
SOCHM has six main screens. These main screens can be accessed through the buttons shown on the tool bar above or via the View menu.

The six main screens are:

- Map Information
- General Project Information
- Analysis
- Reports
- Tools
- LID (Low Impact Development) Analysis

Each is discussed in more detail in the following sections.

MAP INFORMATION SCREEN



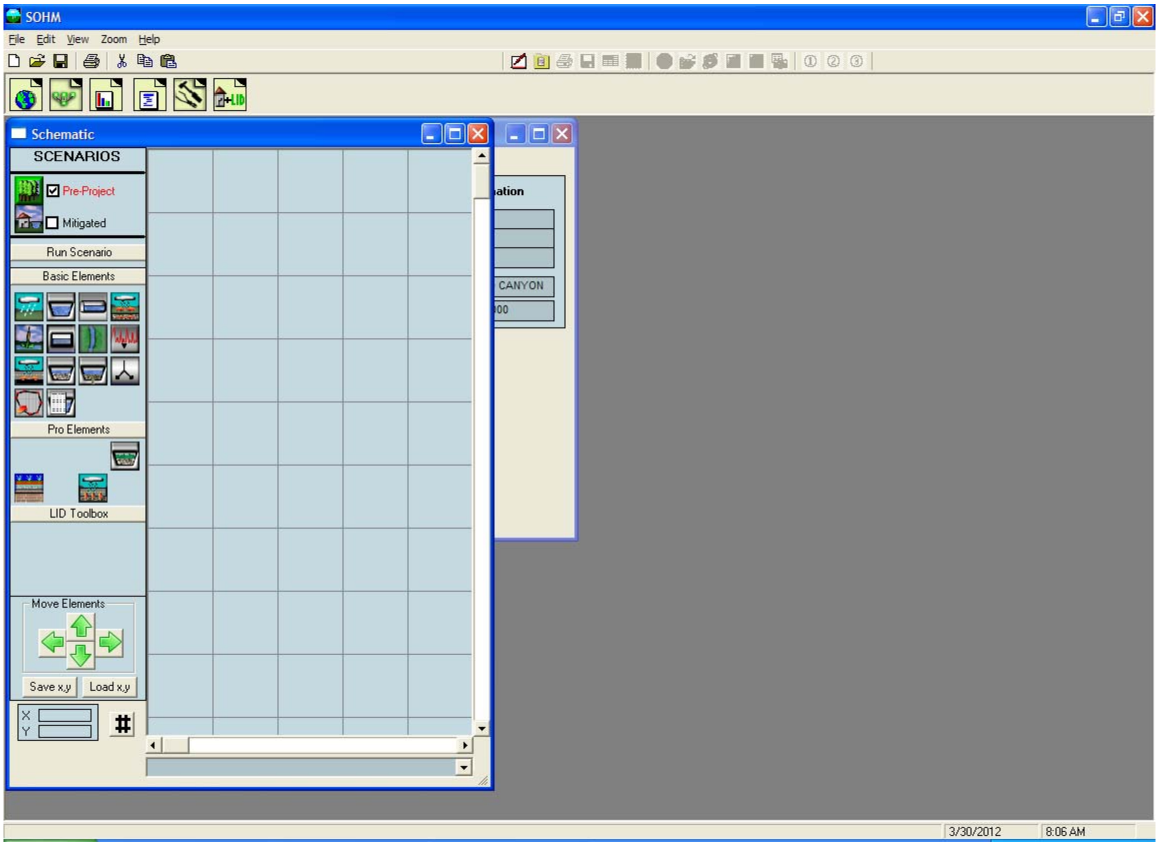
The Map Screen contains county information. The precipitation gage and precip factor are shown to the right of the map. They are based on the project site location.

The user can provide site information (optional). The site name and address will help to identify the project on the Report screen and in the printed report provided to the local municipal permitting agency.

The user locates the project site on the map screen by using the mouse and left clicking at the project site location. Right clicking on the map re-centers the view. The + and – buttons zoom in and out, respectively. The cross hair button zooms out to the full county view. The arrow keys scroll the map view.

The map layers allow the user to view different map information.

GENERAL PROJECT INFORMATION SCREEN



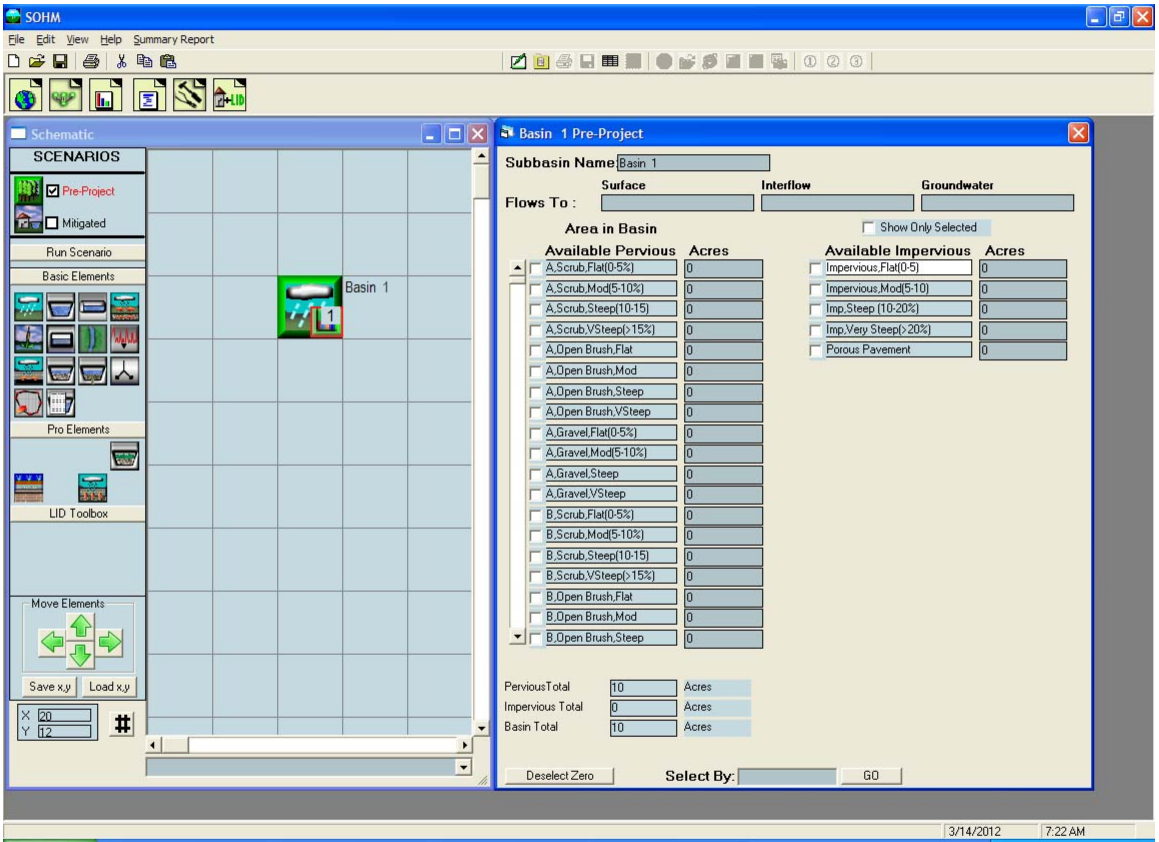
The project screen contains all of the information about the project site for the two land use scenarios: Predevelopment land use conditions and the Mitigated (developed) land use conditions. To change from one scenario to another check the box in front of the scenario name in the upper left corner of the screen.

Predevelopment is defined as the native land cover conditions prior to any land use development. Runoff from the Predevelopment scenario is used as the target for the Mitigated scenario compliance. The model will accept any land use for this scenario.

Mitigated is defined as the developed land use with mitigation measures (as selected by the user). Mitigated is used for sizing stormwater control and water quality facilities. The runoff from the Mitigated scenario is compared with the Predevelopment scenario runoff to determine compliance with flow duration criteria.

Below the scenario boxes are the Elements. Each element represents a specific feature (basin, pond, etc.) and is described in more detail in the following section.

SCHEMATIC EDITOR



The project screen also contains the Schematic Editor. The Schematic Editor is the grid to the right of the elements. This grid is where each element is placed and linked together. The grid, using the scroll bars on the left and bottom, expands as large as needed to contain all of the elements for the project.

All movement on the grid must be from the top of the grid down.

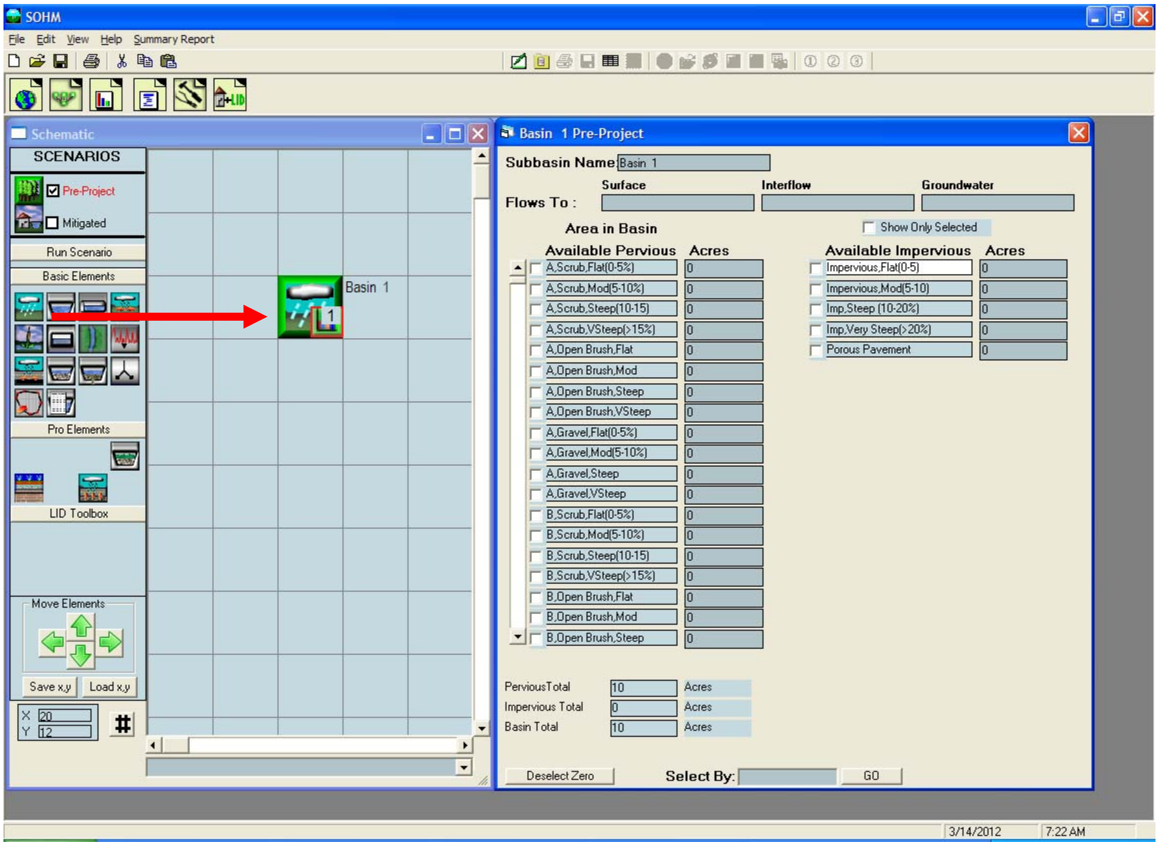
The space to the right of the grid will contain the appropriate element information.

To select and place an element on the grid, first left click on the specific element in the Elements menu and then drag the element to the selected grid square. The selected element will appear in the grid square.

The entire grid can be moved up, down, left, or right using the Move Elements arrow buttons.

The grid coordinates from one project can be saved (Save x,y) and used for new projects (Load x,y).

BASIN ELEMENT



The Basin element represents a drainage area that can have any combination of soils, land cover, and land slopes. A basin produces three types of runoff: (1) surface runoff, (2) interflow, and (3) groundwater. Surface runoff is defined as the overland flow that quickly reaches a conveyance system. Surface runoff mainly comes from impervious surfaces. Interflow is shallow, subsurface flow produced by pervious land categories and varies based on soil characteristics and how these characteristics are altered by land development practices. Groundwater is the subsurface flow that typically does not enter a stormwater conveyance system, but provides base flow directly to streams and rivers.

The user can specify where each of these three types of runoff should be directed. The default setting is for the surface runoff and interflow to go to the stormwater facility; groundwater should not be connected unless there is observed base flow occurring in the drainage basin.

Table 1 shows the different pervious land types represented in the Basin element.

Table 1. SOCHM Pervious Land Types

PERLND No.	Soil Type	Land Cover	Land Slope
1	A	Scrub	Flat (0-5%)
2	A	Scrub	Moderate (5-10%)
3	A	Scrub	Steep (10-15%)
4	A	Scrub	Very Steep (>15%)
5	A	Open Brush	Flat (0-5%)
6	A	Open Brush	Moderate (5-10%)
7	A	Open Brush	Steep (10-15%)
8	A	Open Brush	Very Steep (>15%)
9	A	Gravel	Flat (0-5%)
10	A	Gravel	Moderate (5-10%)
11	A	Gravel	Steep (10-15%)
12	A	Gravel	Very Steep (>15%)
13	B	Scrub	Flat (0-5%)
14	B	Scrub	Moderate (5-10%)
15	B	Scrub	Steep (10-15%)
16	B	Scrub	Very Steep (>15%)
17	B	Open Brush	Flat (0-5%)
18	B	Open Brush	Moderate (5-10%)
19	B	Open Brush	Steep (10-15%)
20	B	Open Brush	Very Steep (>15%)
21	B	Gravel	Flat (0-5%)
22	B	Gravel	Moderate (5-10%)
23	B	Gravel	Steep (10-15%)
24	B	Gravel	Very Steep (>15%)
25	C	Scrub	Flat (0-5%)
26	C	Scrub	Moderate (5-10%)
27	C	Scrub	Steep (10-15%)
28	C	Scrub	Very Steep (>15%)
29	C	Open Brush	Flat (0-5%)
30	C	Open Brush	Moderate (5-10%)
31	C	Open Brush	Steep (10-15%)
32	C	Open Brush	Very Steep (>15%)
33	C	Gravel	Flat (0-5%)
34	C	Gravel	Moderate (5-10%)
35	C	Gravel	Steep (10-15%)
36	C	Gravel	Very Steep (>15%)
37	D	Scrub	Flat (0-5%)
38	D	Scrub	Moderate (5-10%)
39	D	Scrub	Steep (10-15%)
40	D	Scrub	Very Steep (>15%)
41	D	Open Brush	Flat (0-5%)
42	D	Open Brush	Moderate (5-10%)
43	D	Open Brush	Steep (10-15%)
44	D	Open Brush	Very Steep (>15%)
45	D	Gravel	Flat (0-5%)
46	D	Gravel	Moderate (5-10%)
47	D	Gravel	Steep (10-15%)

48	D	Gravel	Very Steep (>15%)
49	A	Urban	Flat (0-5%)
50	A	Urban	Moderate (5-10%)
51	A	Urban	Steep (10-15%)
52	A	Urban	Very Steep (>15%)
53	B	Urban	Flat (0-5%)
54	B	Urban	Moderate (5-10%)
55	B	Urban	Steep (10-15%)
56	B	Urban	Very Steep (>15%)
57	C	Urban	Flat (0-5%)
58	C	Urban	Moderate (5-10%)
59	C	Urban	Steep (10-15%)
60	C	Urban	Very Steep (>15%)
61	D	Urban	Flat (0-5%)
62	D	Urban	Moderate (5-10%)
63	D	Urban	Steep (10-15%)
64	D	Urban	Very Steep (>15%)

The user does not need to know or keep track of the HSPF PERLND number. That number is used only for internal tracking purposes.

The user inputs the number of acres of appropriate basin land use information. Pervious land use information is in the form of soil, land cover, and land slope. For example, “A, Open Brush, Flat” means SCS soil type A, open brush vegetative cover, and flat (0-5%) land slope.

There are four basic soil types: A (well infiltrating soils), B (moderate infiltrating soils), and C (poor infiltrating soils), and D (really poor infiltrating soils).

There are four basic land cover categories: scrub, open brush, gravel, and urban landscaped vegetation.

Native land cover has been divided into scrub, open brush, and gravel and refers to the natural (non-planted) vegetation. In contrast, the developed landscape will consist of urban vegetation (lawns, flowers, planted shrubs and trees). Urban vegetation is irrigated in the model.

Land slope is divided into flat (0-5%), moderate (5-10%), steep (10-15%), and very steep (>15%) land slopes.

HSPF parameter values in SOCHM have been adjusted for the different soil, land cover, and land slope categories. SOCHM HSPF soil parameter values take into account the hydrologic effects of land development activities that result from soil compaction when “Urban” is specified.

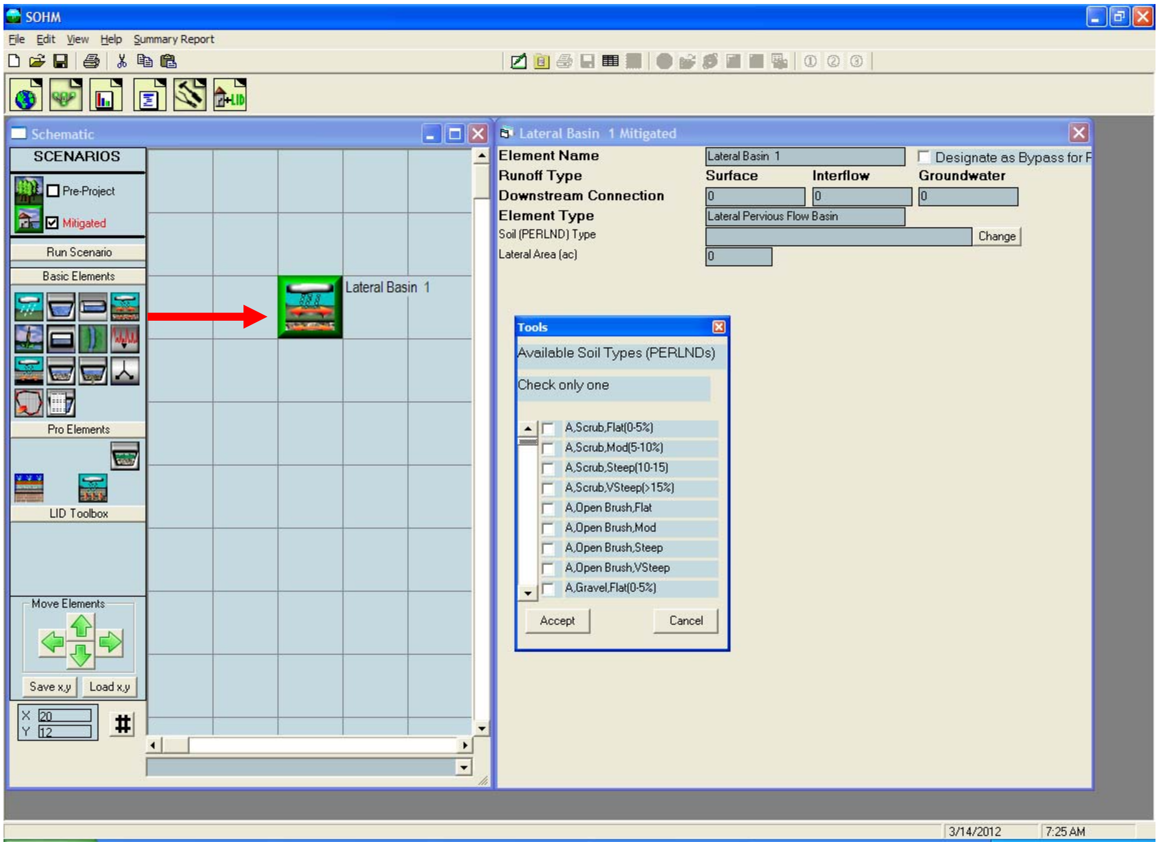
Impervious areas are divided into four different slopes (see Table 2). Impervious areas include roads, roofs, driveways, sidewalks, and parking. The slope categories are flat, moderate, steep, and very steep.

Table 2. SOCHM Impervious Land Types

IMPLND No.	IMPLND Name	Land Slope
1	Impervious	Flat (0-5%)
2	Impervious	Moderate (5-10%)
3	Impervious	Steep (10-15%)
4	Impervious	Very Steep (>15%)

The user does not need to know or keep track of the HSPF IMPLND number. That number is used only for internal tracking purposes.

LATERAL BASIN ELEMENT (Pervious)



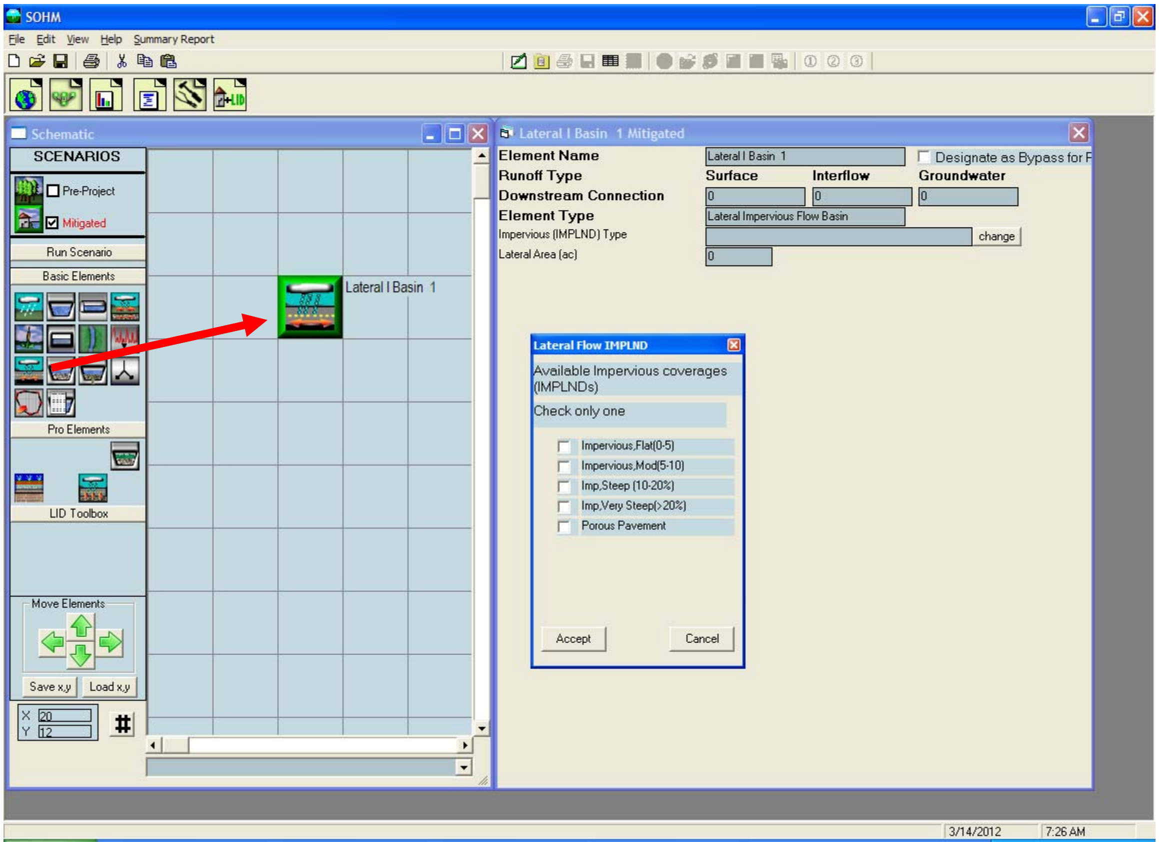
Runoff dispersion from impervious surfaces onto adjacent pervious land can be modeled using pervious and impervious lateral basins. For example, runoff from an impervious parking lot can sheet flow onto an adjacent lawn prior to draining into a stormwater conveyance system. This action slows the runoff and allows for some limited infiltration into the pervious lawn soil prior to discharging into a conveyance system.

The pervious lateral basin is similar to the standard basin except that the runoff from the lateral basin goes to another adjacent lateral basin (impervious or pervious) rather than directly to a conveyance system or stormwater facility. By definition, the pervious lateral basin contains only a single pervious land type. Impervious area is handled separately with the impervious lateral basin (Lateral I Basin).

The user selects the pervious lateral basin land type by checking the appropriate box on the Available Soil Types Tools screen. This information is automatically placed in the Soil (PERLND) Type box above. Once entered, the land type can be changed by clicking on the Change button on the right.

The user enters the number of acres represented by the lateral basin land type.
If the lateral basin contains two or more pervious land use types then the user should create a separate lateral basin for each.

LATERAL I BASIN ELEMENT (Impervious)



The impervious lateral basin is similar to the standard basin except that the surface runoff from the lateral impervious basin goes to another adjacent lateral basin (impervious or pervious) rather than directly to a conveyance system or stormwater facility. By definition, the impervious lateral basin contains only impervious land types. Pervious area is handled separately with the pervious lateral basin (Lateral Basin).

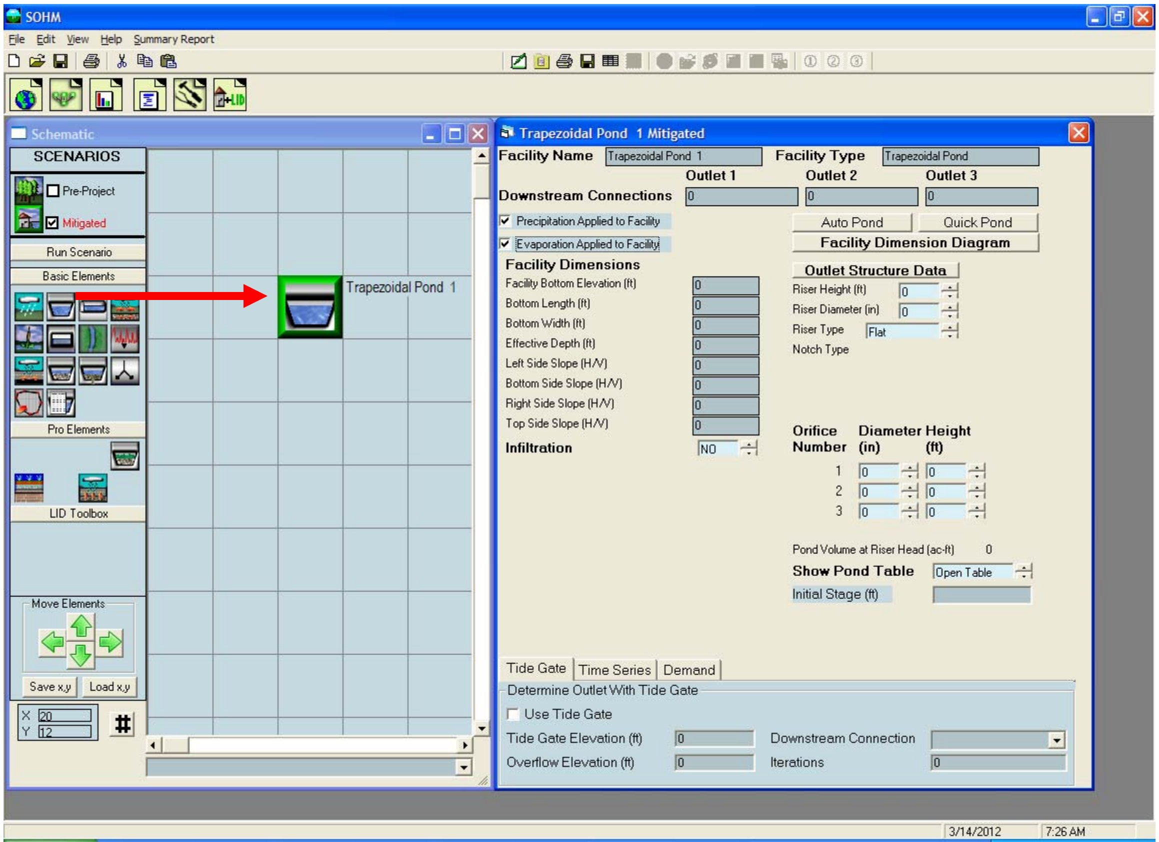
The user selects the impervious lateral basin land type by checking the appropriate box on the Available Impervious Coverages screen. This information is automatically placed in the Impervious (IMPLND) Type box above. Once entered, the land type can be changed by clicking on the Change button on the right.

The user enters the number of acres represented by the lateral impervious basin land type.

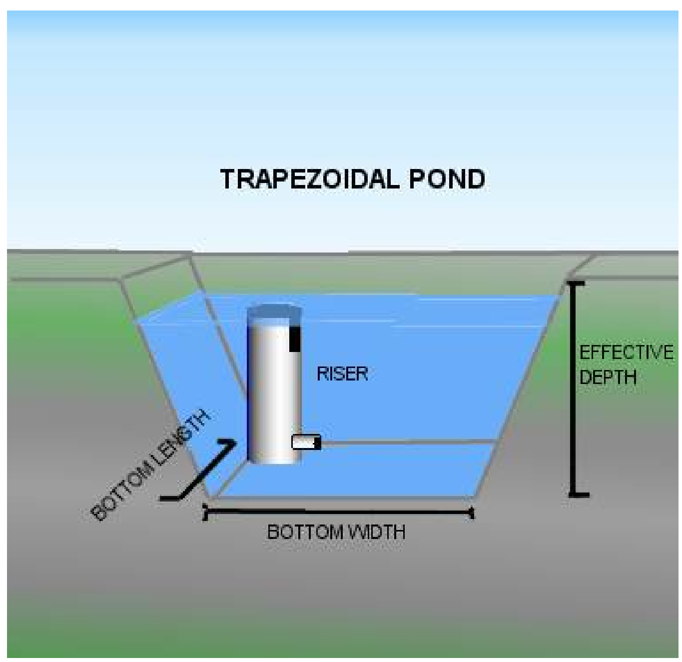
If the lateral impervious basin contains two or more impervious land use types then the user should create a separate lateral I basin for each.

To model parking lot runoff dispersion onto adjacent lawn connect the Lateral I Basin (the parking lot) to the Lateral Basin (the lawn). In the model's calculations surface runoff from the parking lot is added to the surface of the lawn (urban vegetation). The total runoff will then directed to a stormwater conveyance system by the user.

TRAPEZOIDAL POND ELEMENT



In SOCHM there is an individual pond element for each type of pond and stormwater control facility. The pond element shown above is for a trapezoidal pond. This is the most common type of stormwater pond.



A trapezoidal pond has dimensions (bottom length and width, depth, and side slopes) and an outlet structure consisting of a riser and one or more orifices to control the release of stormwater from the pond. A trapezoidal pond includes the option to infiltrate runoff, if the soils are appropriate and there is sufficient depth to the underlying groundwater table.

The user has the option to specify that different outlets be directed to different downstream destinations, although usually all of the outlets go to a single downstream location.

AutoPond will automatically size a trapezoidal pond to meet the required flow duration criteria. AutoPond is available only in the Mitigated scenario.

QuickPond can be used to instantly add pond dimensions and an outlet configuration without checking the pond for compliancy with flow duration criteria. QuickPond is sometimes used to quickly create a scenario and check the model linkages prior to sizing the pond. Multiple clicks on the QuickPond button incrementally increase the pond size.

The user can change the default name “Trapezoidal Pond 1” to another more appropriate name, if desired.

Precipitation and evaporation must be applied to the pond unless the pond is covered.

The pond bottom elevation can be set to an elevation other than zero if the user wants to use actual elevations. All pond stage values are relative to the bottom elevation. Negative bottom elevations are not allowed.

The pond effective depth is the pond height (including freeboard) above the pond bottom. It is not the actual elevation of the top of the pond.

Pond side slopes are in terms of horizontal distance over vertical. A standard 3:1 (H/V) side slope would be given a value of 3. A vertical side slope has a value of 0.

The pond bottom is assumed to be flat.

The pond outlet structure consists of a riser and zero to three orifices. The riser has a height (typically one foot less than the effective depth) and a diameter. The riser can have either a flat top or a weir notch cut into the side of the top of the riser. The notch can be either rectangular, V-shaped, or a Sutro weir. More information on the riser weir shapes and orifices is provided later in this manual.

After the pond is given dimensions and outlet information the user can view the resulting stage-storage-discharge table by clicking on the “Open Table” arrow in the lower right corner of the pond information screen. This table hydraulically defines the pond’s characteristics.

The user can use either AutoPond to size a pond or can manually size a pond. Follow the following steps for manual sizing a pond using an outlet configuration with one orifice and a riser with rectangular notch (this is usually the most efficient design):

1. Input a bottom orifice diameter that allows a discharge equal to the lower threshold (e.g., 10% of 2-year) Predevelopment flow for a stage equal to 2/3rds the height of the riser. This discharge can be checked by reviewing the pond’s stage-storage-discharge table.

2. Input a riser rectangular notch height equal to 1/3 of the height of the riser. Initially set the riser notch width to 0.1 feet.
3. Run Predevelopment and Mitigated scenarios.
4. Go to Analysis screen and check flow duration results.
5. If pond passes flow duration criteria then decrease pond dimensions.
6. If pond fails flow duration criteria then change (in order of priority) bottom orifice diameter, riser notch width, pond dimensions.
7. Iterate until there is a good match between Predevelopment and Mitigated flow duration curves or fatigue sets in.

Pond input information:
Bottom Length (ft): Pond bottom length.
Bottom Width (ft): Pond bottom width.
Effective Depth (ft): Pond height from pond bottom to top of riser plus at least 0.5 feet extra.
Left Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Bottom Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Right Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Top Side Slope (H/V): ratio of horizontal distance to vertical; 0 (zero) for vertical pond sides.
Riser Height (ft): Height of overflow pipe above pond bottom.
Riser Diameter (in): Pond overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the pond side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

A pond receives precipitation on and evaporation from the pond surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

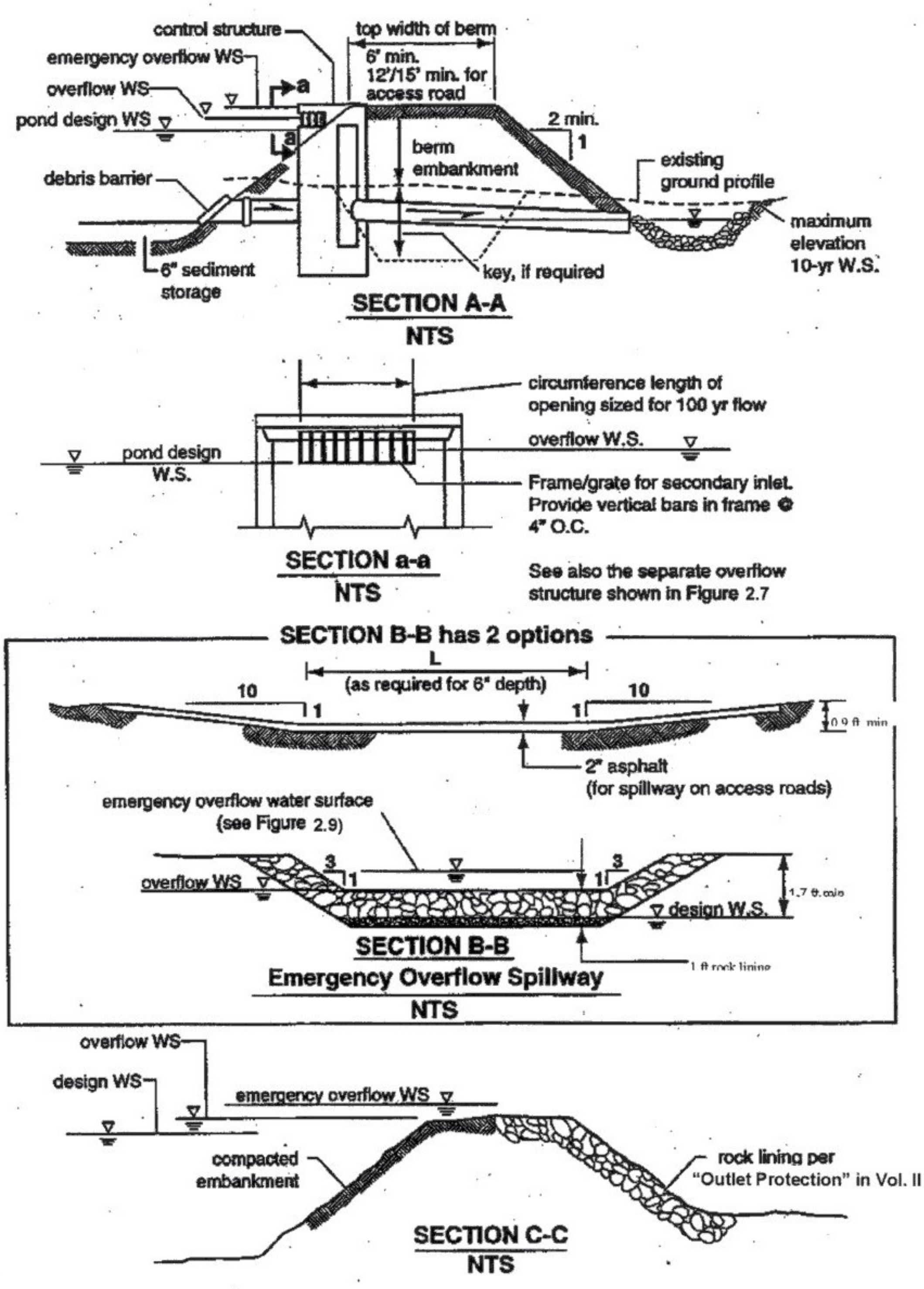
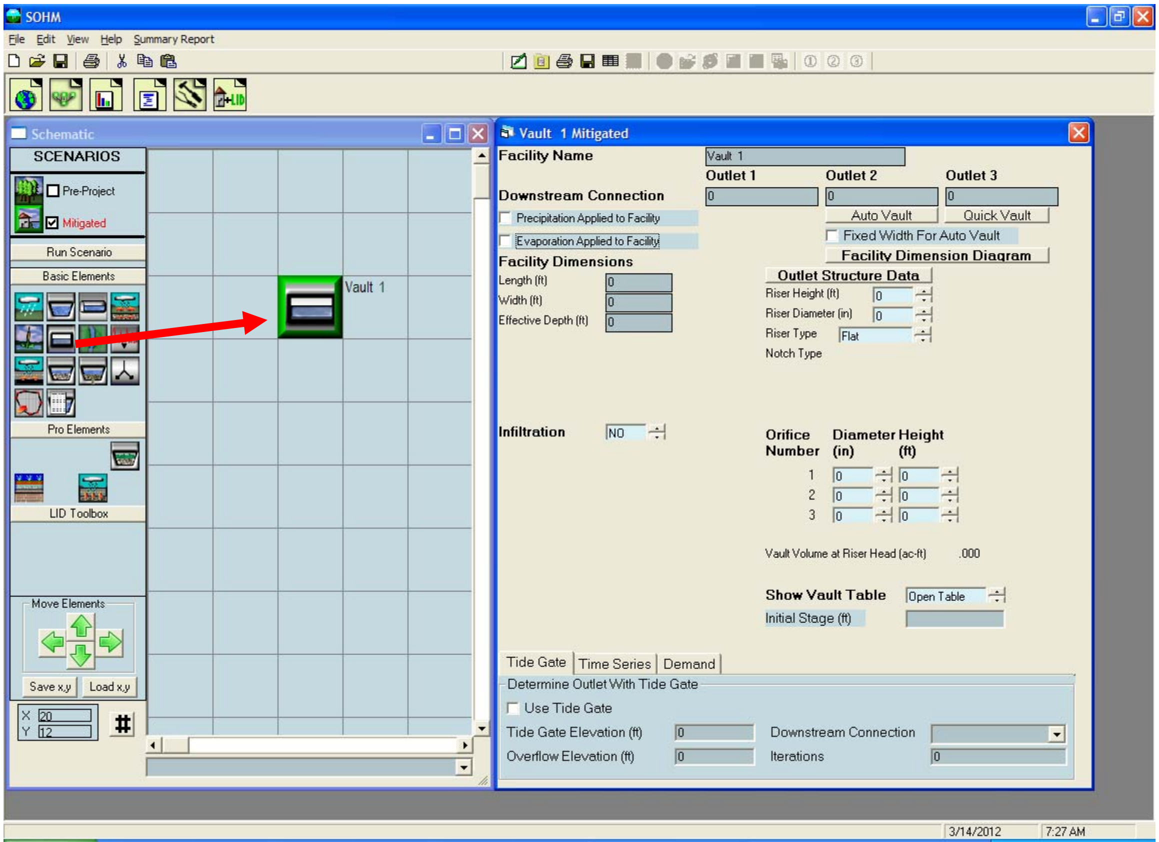


Figure 3.10 Typical Detention Pond Sections

NOTE: The detention pond section diagram shows the general configuration used in designing a pond and its outlet structure. This diagram is from the Washington State Department of Ecology's 2005 Stormwater Management Manual for Western Washington. *Consult with your local municipal permitting agency on specific design requirements for your project site.*

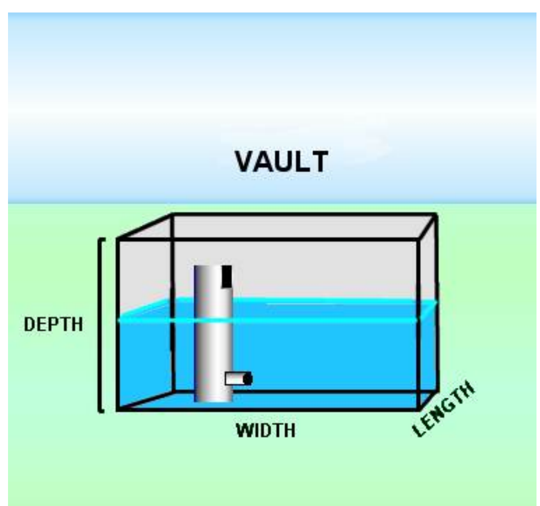
VAULT ELEMENT



The storage vault has all of the same characteristics of the trapezoidal pond, except that the user does not specify the side slopes (by definition they are zero) and the vault is assumed to have a lid (no precipitation or evaporation).

AutoVault and QuickVault work the same way as AutoPond and QuickPond. Go to page 48 to find information on how to manually size a vault or other HMP facility.

Vault input information:
Bottom Length (ft): Vault bottom length.
Bottom Width (ft): Vault bottom width.
Effective Depth (ft): Vault height from vault bottom to top of riser plus at least 0.5 feet extra.
Riser Height (ft): Height of overflow pipe above vault bottom.
Riser Diameter (in): Vault overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.



For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

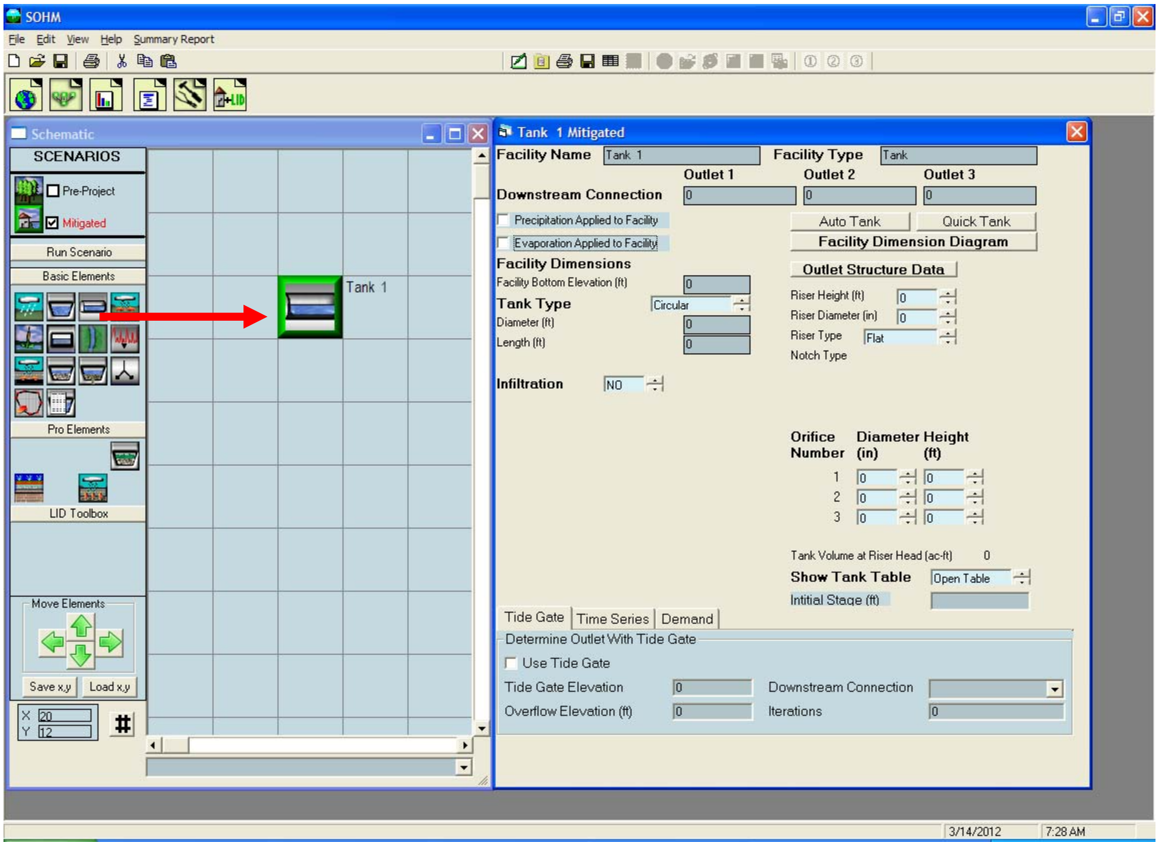
Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the vault sides is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

A vault is usually covered and does not receive precipitation on and evaporation from the vault surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should not be checked unless the vault top is open to the atmosphere.

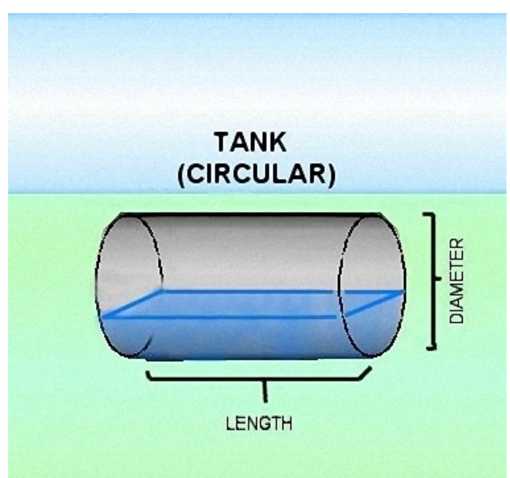
TANK ELEMENT



A storage tank is a cylinder placed on its side. The user specifies the tank's diameter and length.

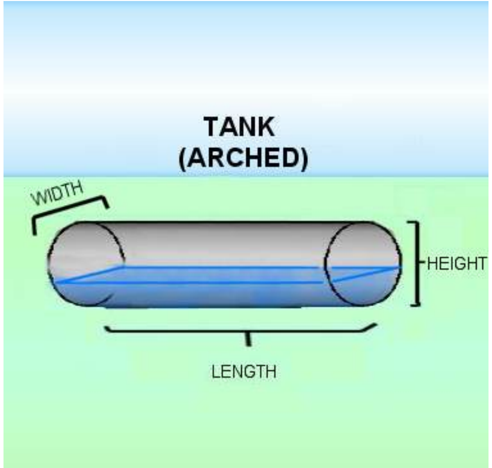
There is no AutoTank (automatic tank sizing routine). The user must manually size the tank to meet the flow duration criteria. Go to page 48 to find information on how to manually size a tank or other HMP facility.

There is a QuickTank option that creates a tank, but does not check for compliance with the flow duration criteria.



Tank input information:
Tank Type: Circular or Arched
For Circular:
Diameter (ft): Tank diameter.
Length (ft): Tank length.
For Arched:
Height (ft): Tank height.
Width (ft): Tank width (at widest point).
Length (ft): Tank length.

Riser Height (ft): Height of overflow pipe above tank bottom; must be less than tank diameter or height.
Riser Diameter (in): Tank overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.



For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

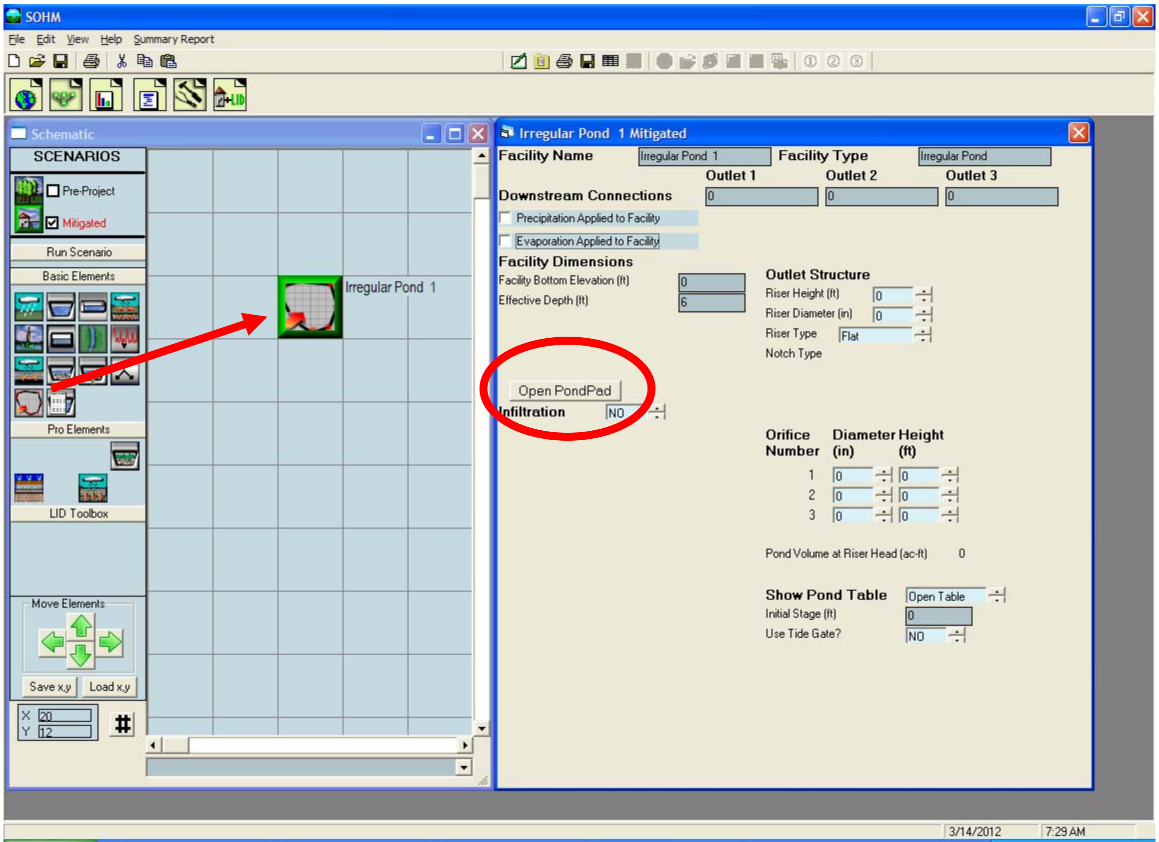
Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the tank sides is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

A tank is covered and does not receive precipitation on and evaporation from the tank surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should not be checked.

IRREGULAR POND ELEMENT

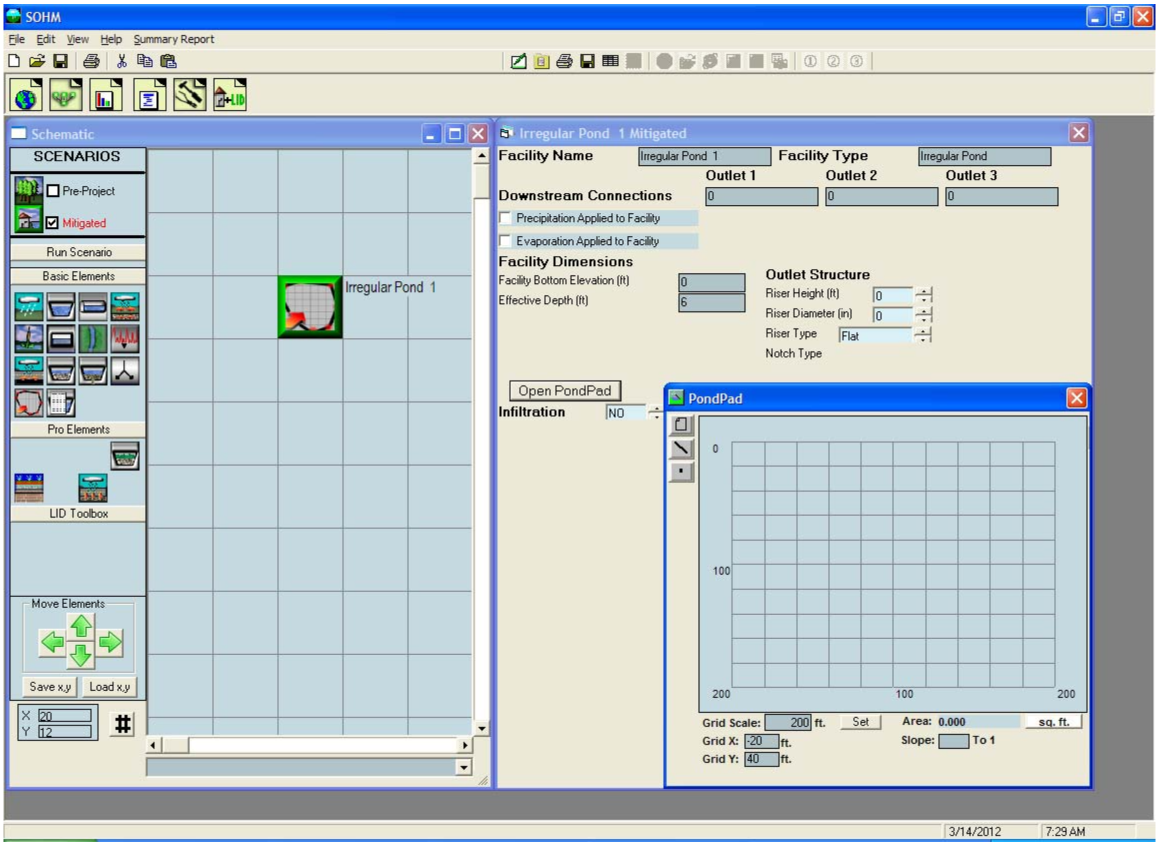


An irregular pond is any pond with a shape that differs from the rectangular top of a trapezoidal pond. An irregular pond has all of the same characteristics of a trapezoidal pond, but its shape must be defined by the user.

The AutoPond option is not available for an irregular-shaped pond. Go to page 48 to find information on how to manually size an irregular pond or other HMP facility.

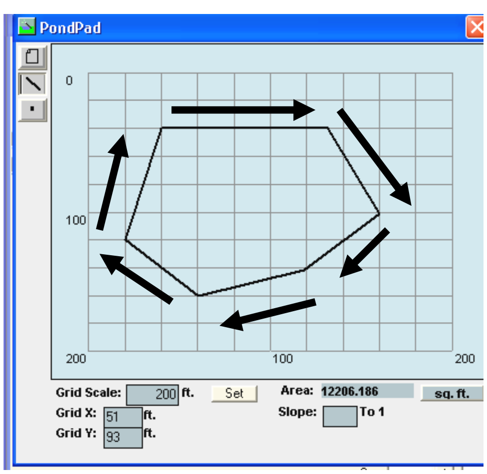
To create the shape of an irregular pond the user clicks on the “Open PondPad” button. This allows the user to access the PondPad interface (see below).

PondPad Interface

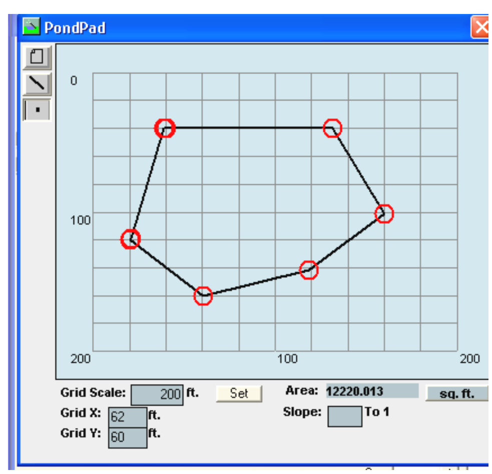


The PondPad interface is a grid on which the user can specify the outline of the top of the pond and the pond's side slopes.

The user selects the line button (second from the top on the upper left corner of the PondPad screen). Once the line button is turned on the user moves the mouse over the grid to locate the pond's corner points. The user does this in a **clockwise** direction to outline the pond's top perimeter. The user can select individual points by clicking on the point button immediately below the line button. Once selected, any individual point can be moved or repositioned.



The



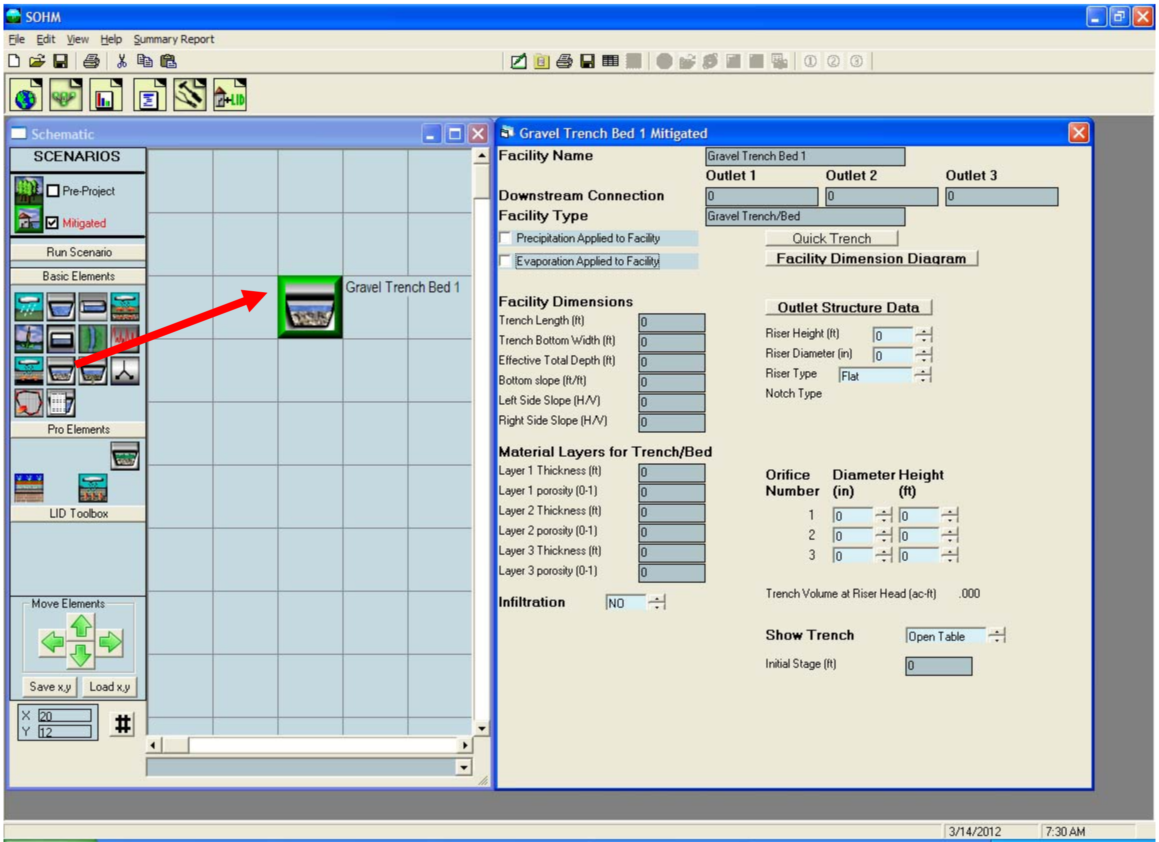
default side slope value is 3 (3:1). The side slopes can be individually changed by right clicking on the specific side (which changes the line color from black to red) and then entering the individual side slope value in the slope text box.

The grid scale can be changed by entering a new value in the grid scale box. The default value is 200 feet.

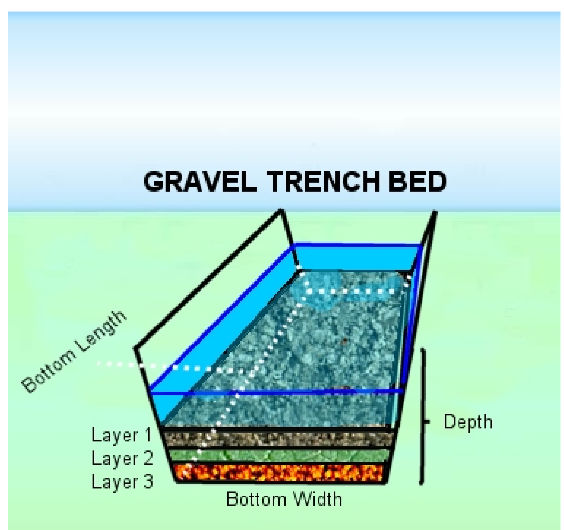
PondPad Controls and Numbers

Clear:	The Clear button clears all of the lines on the grid.
Line:	The Line button allows the user to draw new lines with the mouse.
Point:	The Point button allows the user to move individual points to alter the pond shape and size.
Sq Ft:	Converts the computed pond area from square feet to acres and back.
Grid Scale:	Changes the length of a grid line. Default grid scale is 200 feet.
Grid X:	Horizontal location of the mouse pointer on the grid (0 is the upper left corner).
Grid Y:	Vertical location of the mouse pointer on the grid (0 is the upper left corner)
Area:	Top area of the pond (either in square feet or acres).
Slope:	Side slope of the selected line (side of the pond).

GRAVEL TRENCH BED ELEMENT



The gravel trench bed is used to spread and infiltrate runoff, but also can have one or more surface outlets represented by an outlet structure with a riser and multiple orifices.



The user specifies the trench length, bottom width, total depth, bottom slope, and left and right side slopes.

The material layers represent the gravel/rock layers and their design characteristics (thickness and porosity).

QuickTrench will instantly create a gravel trench bed with default values without checking it for compliancy with flow duration criteria.

The gravel trench bed input information:

Trench Length (ft): Trench bed length.
Trench Bottom Width (ft): Trench bed bottom width.

Effective Total Depth (ft): Height from bottom of trench bed to top of riser plus at least 0.5 feet extra.
Bottom Slope of Trench (ft/ft): Must be non-zero.
Left Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical trench bed sides.

Right Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical trench bed sides.
Infiltration Rate (in/hr): Trench bed gravel or other media infiltration rate.
Layer 1 Thickness (ft): Trench top media layer depth.
Layer 1 Porosity: Trench top media porosity.
Layer 2 Thickness (ft): Trench middle media layer depth (Layer 2 is optional).
Layer 2 Porosity: Trench middle media porosity.
Layer 3 Thickness (ft): Trench bottom media layer depth (Layer 3 is optional).
Layer 3 Porosity: Trench bottom media porosity.
Riser Height (ft): Height of trench overflow pipe above trench surface.
Riser Diameter (in): Trench overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

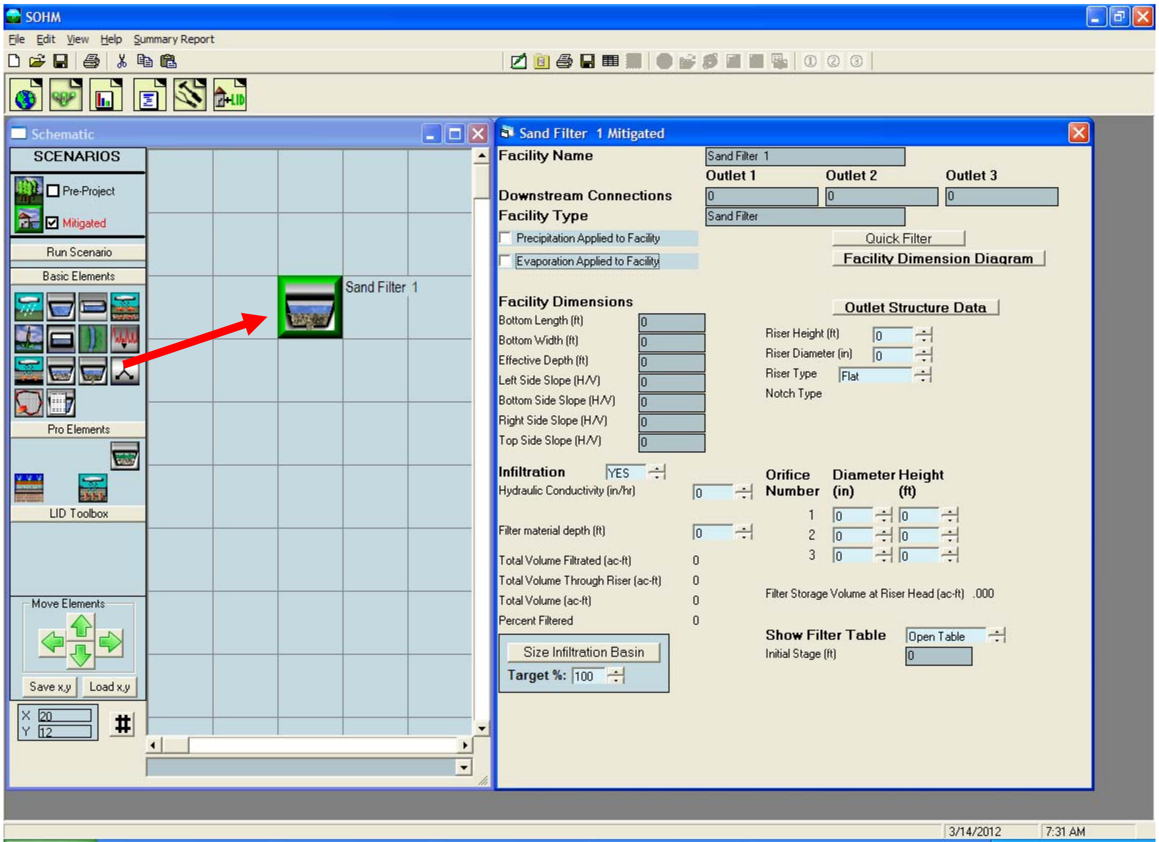
Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the trench side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

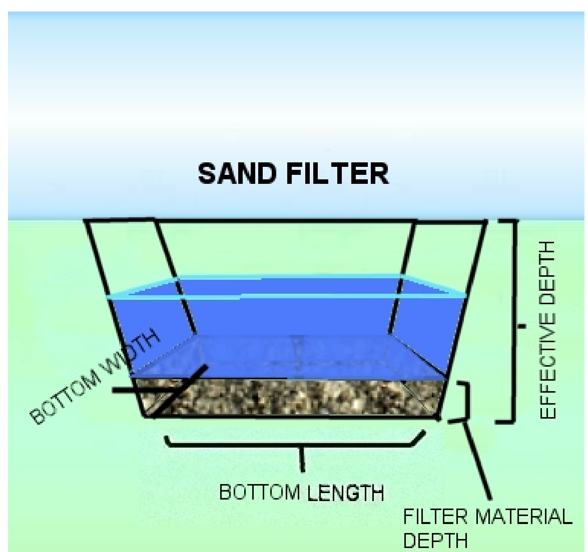
NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

Gravel trench bed receives precipitation on and evaporation from the trench surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

SAND FILTER ELEMENT



The sand filter is a water quality facility. It does not infiltrate runoff, but is used to filter runoff through a medium and send it downstream. It can also have one or more surface outlets represented by an outlet structure with a riser and multiple orifices.



The user must specify the facility dimensions (bottom length and width, effective depth, and side slopes. The hydraulic conductivity of the sand filter and the filter material depth are also needed to size the sand filter (default values are 1.0 inch per hour and 1.5 feet, respectively).

NOTE: When using the sand filter element check with Appendix C or the local municipal permitting agency to determine the required treatment standard (percent of the total runoff volume treated by the sand filter).

The filter discharge is calculated using the equation Q = K*I*A, where Q is the discharge in cubic feet per second (cfs). K equals the hydraulic conductivity (inches per hour). For sand filters K = 1.0 in/hr. Sand is the default medium. If another filtration material is used then the design engineer should enter the appropriate K value supported by documentation and approval by the reviewing authority.

Design of a sand filter requires input of facility dimensions and outlet structure characteristics, running the sand filter scenario, and then checking the volume calculations to see if the Percent Filtered equals or exceeds the treatment standard percentage. If the value is less than the treatment standard percentage then the user should increase the size of the sand filter dimensions and/or change the outlet structure. The sand filter input information:

Bottom Length (ft): Sand filter bottom length.
Bottom Width (ft): Sand filter bottom width.
Effective Depth (ft): Height from bottom of sand filter to top of riser plus at least 0.5 feet extra.
Left Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Bottom Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Right Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Top Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical sand filter sides.
Riser Height (ft): Height of sand filter overflow pipe above sand filter surface.
Riser Diameter (in): Sand filter overflow pipe diameter.
Riser Type (options): Flat or Notched
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

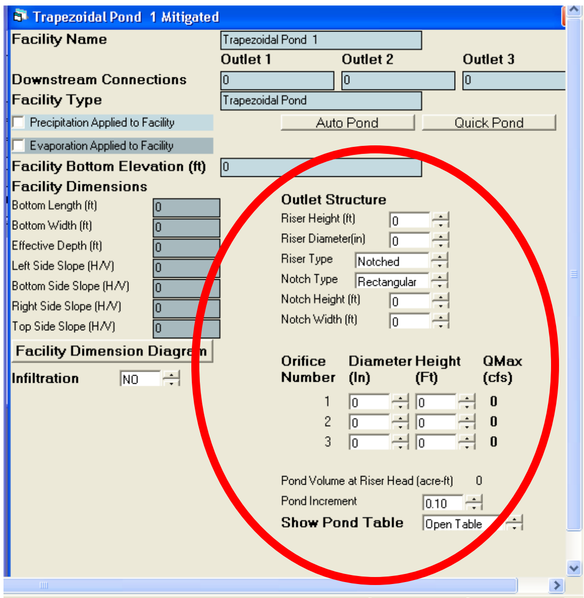
For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.

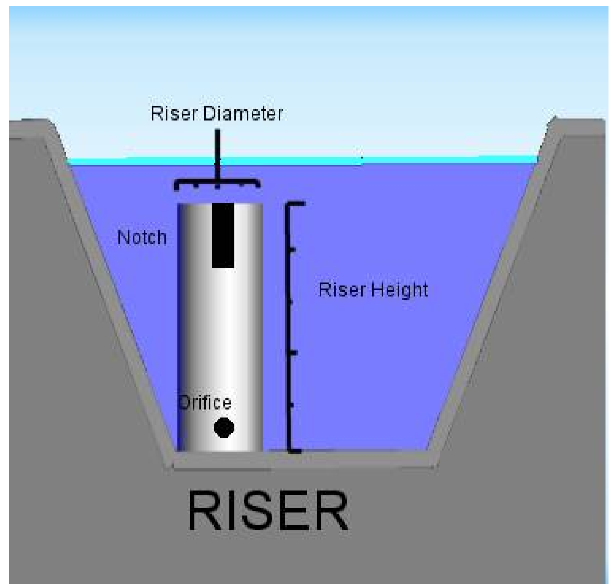
Infiltration: Yes (infiltration through the filter material)
Hydraulic Conductivity (in/hr): Filtration rate through the sand filter.
Filter material depth (ft): Depth of sand filter material (for runoff filtration).

Sand filter receives precipitation on and evaporation from the sand filter surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

OUTLET STRUCTURE CONFIGURATIONS

The trapezoidal pond, vault, tank, irregular pond, gravel trench bed, and sand filter all use a riser for the outlet structure to control discharge from the facility.

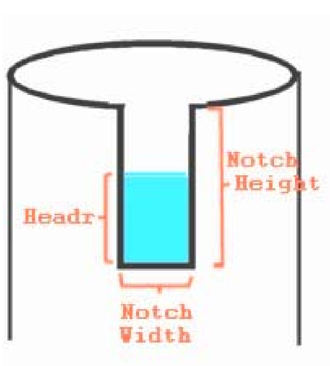




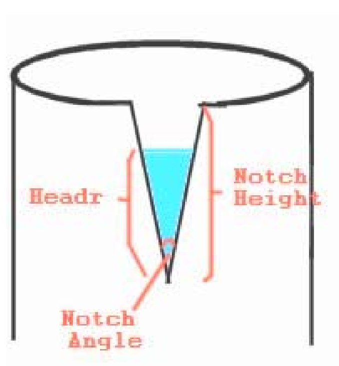
The riser is a vertical pipe with a height above pond bottom (typically one foot less than the effective depth). The user specifies the riser height and diameter.

The riser can have up to three round orifices. The bottom orifice is usually located at the bottom of the pond and/or above any dead storage in the facility. The user can set the diameter and height of each orifice. The model will automatically calculate the maximum orifice discharge value, QMax (cfs), if the pond dimensions have already been defined.

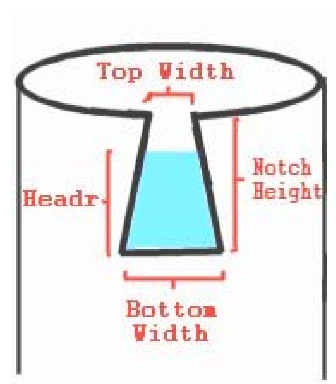
The user specifies the riser type as either flat or notched. The weir notch can be either rectangular, V-notch, or a Sutro weir. The shape of each type of weir is shown below.



Rectangular Notch



V-Notch



Sutro

By selecting the appropriate notch type the user is then given the option to enter the appropriate notch type dimensions.

Riser and orifice equations used in SOCHM are provided below.

Headr = the water height over the notch/orifice bottom.
q = discharge

Riser Head Discharge:

Head = water level above riser
q = 9.739 * Riser Diameter * Head ^ 1.5

Orifice Equation:
q = 3.782 * (Orifice Diameter) ^ 2 * SQRT(Headr)

Rectangular Notch:
b = NotchWidth *- (1- 0.2 * Headr)
where b >= 0.8
q = 3.33 * b * Headr ^ 1.5

Sutro:
Wh = Top Width + {(Bottom Width- Top Width)/Notch Height }* Headr
Wd = Bottom Width - Wh (the difference between the bottom and top widths)

Q1 = (rectangular notch q where Notch Width = Wh)
Q2 = (rectangular notch q where Notch Width = Wd)

q = Q1 + Q2 / 2

V-Notch:
Notch Bottom = height from bottom of riser to bottom of notch
Theta = Notch Angle

a = 2.664261 - 0.0018641 * Theta + 0.00005761 * Theta ^2
b = -0.48875 + 0.003843 * Theta - 0.000092124 * Theta ^2
c = 0.3392 - 0.0024318 * Theta + 0.00004715 * Theta ^2

YoverH = Headr / (NotchBottom + Headr)
Coef = a + b * Headr + c * Headr ^2

q = (Coef * Tan(Theta / 2)) * (Headr ^ (5 / 2))

These equations are provided from the Washington State Department of Ecology's 2005 *Stormwater Management Manual for Western Washington.* The outlet designs are shown below. They have been reproduced from Volume III of the *Stormwater Management Manual for Western Washington* which has more information on the subject.

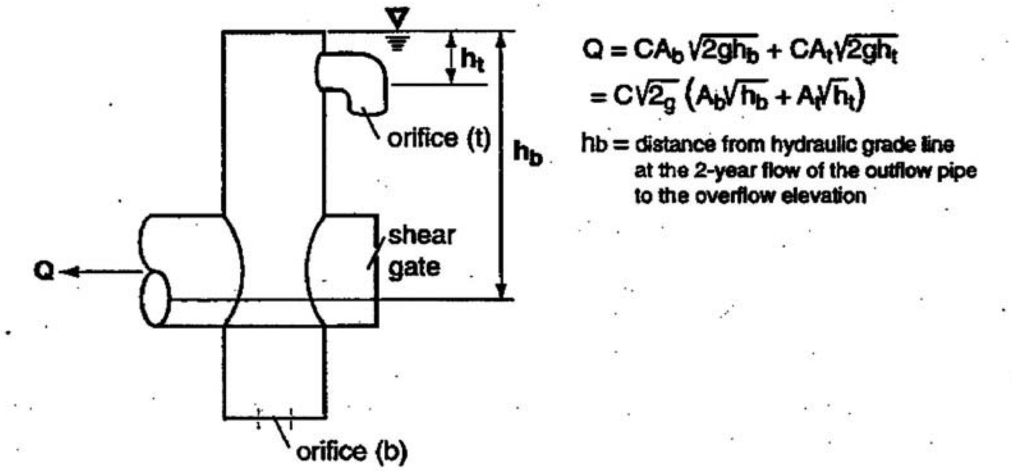


Figure 3.20 Simple Orifice

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \qquad \text{(equation 5)}$$

where d = orifice diameter (inches)
Q = flow (cfs)
h = hydraulic head (ft)

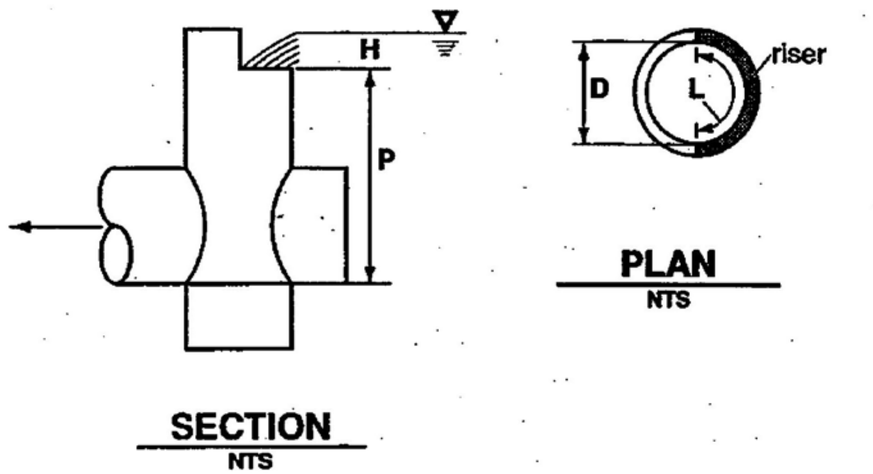


Figure 3.21 Rectangular, Sharp-Crested Weir

$Q=C\ (L - 0.2H)H^{3/2}$ (equation 6)

where Q = flow (cfs)
C = 3.27 + 0.40 H/P (ft)
H, P are as shown above
L = length (ft) of the portion of the riser circumference as necessary not to exceed 50 percent of the circumference
D = inside riser diameter (ft)

Note that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.

The physical configuration of the outlet structure should include protection for the riser and orifices to prevent clogging of the outlet from debris or sediment. Various outlet configurations are shown below. They have been reproduced from Volume III of the *Stormwater Management Manual for Western Washington* which has more information on the subject.

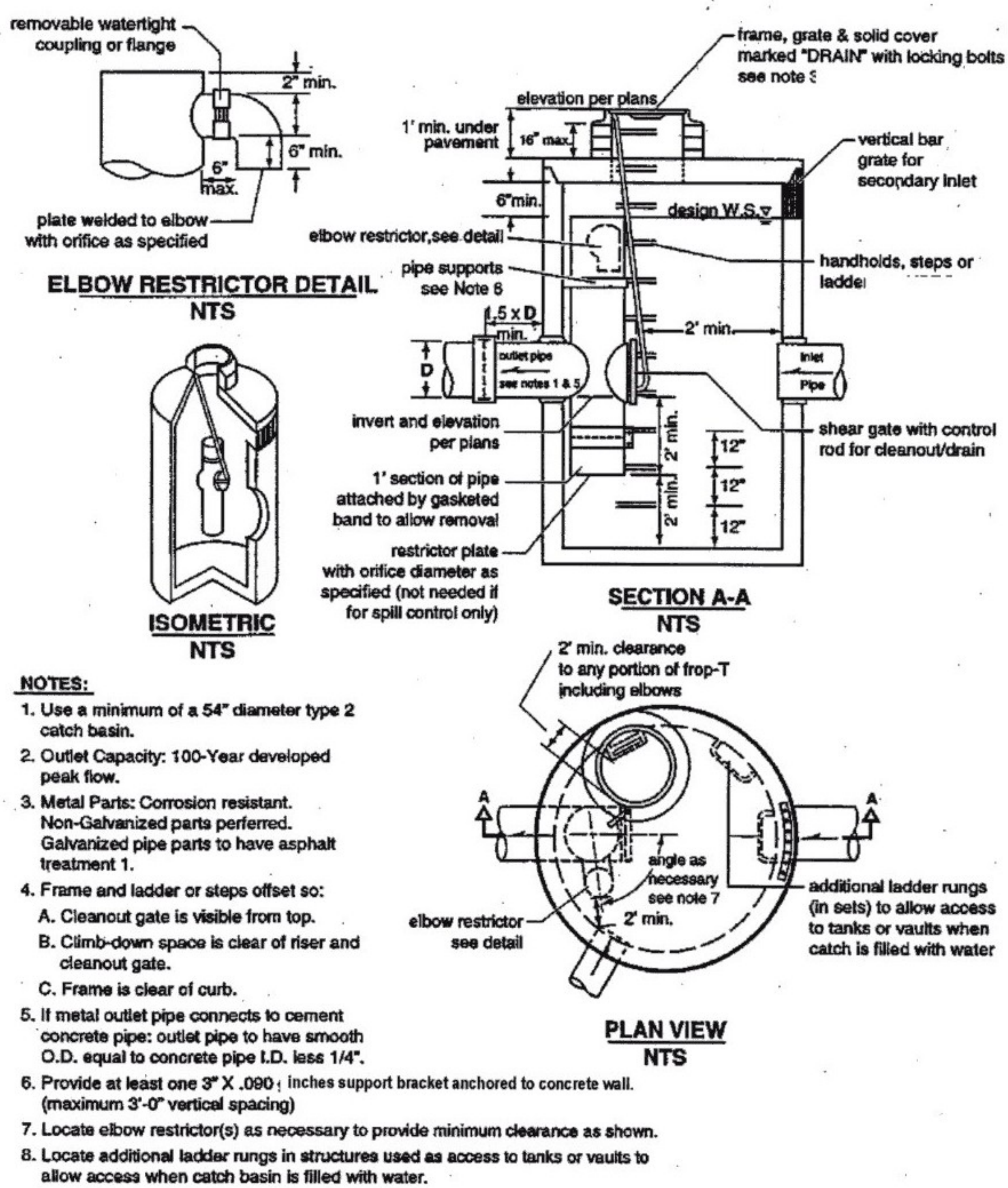


Figure 3.17 Flow Restrictor (TEE)

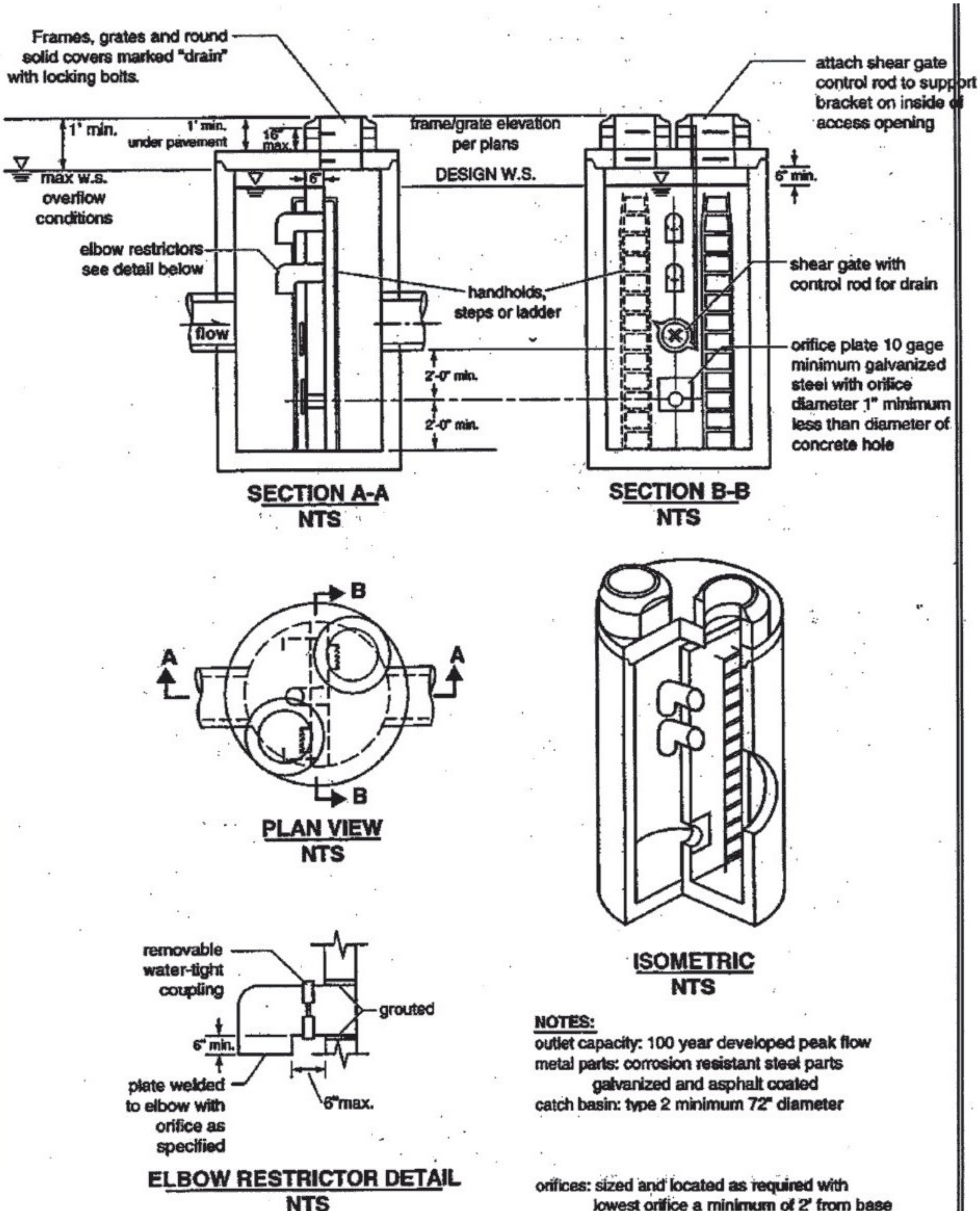


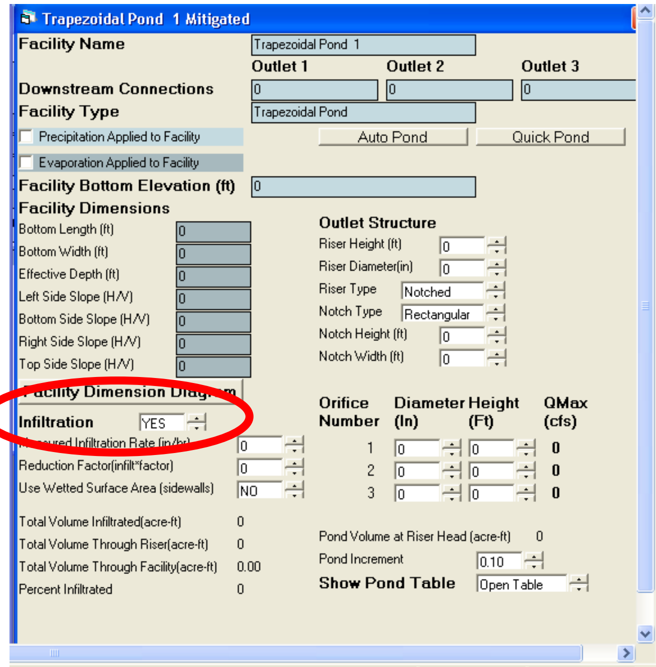
Figure 3.18 Flow Restrictor (Baffle)

Riser protection structures. Diagrams courtesy of Washington State Department of Ecology.

INFILTRATION

Infiltration of stormwater runoff is a recommended solution if certain conditions are met. These conditions include: a soils report, testing, groundwater protection, pre-settling, and appropriate construction techniques.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.



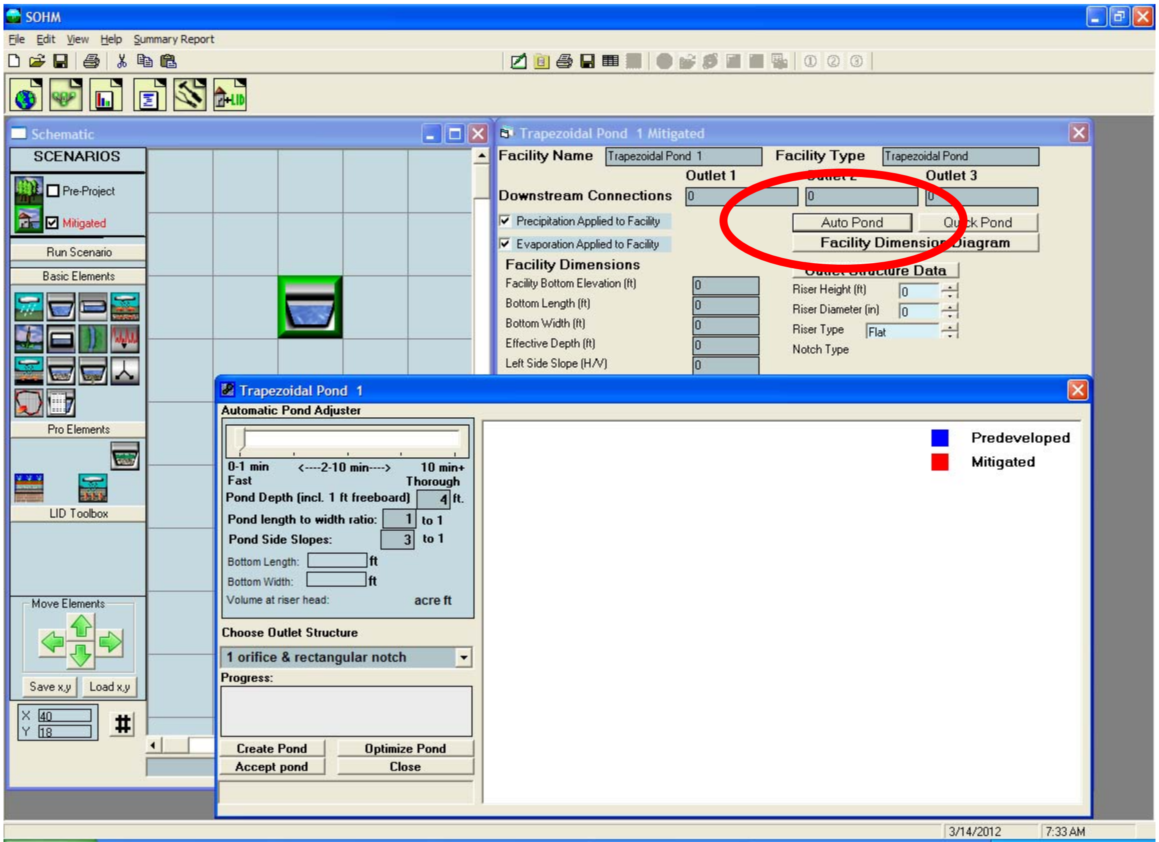
The user clicks on the Infiltration option arrow to change infiltration from NO to YES. This activates the infiltration input options: measured infiltration rate, infiltration reduction factor, and whether or not to allow infiltration through the wetted side slopes/walls.

The infiltration reduction factor is a multiplier for the measured infiltration rate and should be less than one. It is the same as the inverse of a safety factor. For example, a safety factor of 2 is equal to a reduction factor of 0.5.

Infiltration occurs only through the bottom of the facility if the wetted surface area option is turned off. Otherwise the entire wetted surface area is used for infiltration.

After the model is run and flow is routed through the infiltration facility the total volume infiltrated, total volume through the riser, total volume through the facility, and percent infiltrated are reported on the screen. If the percent infiltrated is 100% then there is no surface discharge from the facility. The percent infiltrated can be less than 100% as long as the surface discharge does not exceed the flow duration criteria.

AUTOPOND



AutoPond automatically creates a pond size and designs the outlet structure to meet the flow duration criteria. The user can either create a pond from scratch or optimize an existing pond design.

AutoPond requires that the Predevelopment and Mitigated basins be defined prior to using AutoPond. Clicking on the AutoPond button brings up the AutoPond window and the associated AutoPond controls.

AutoPond controls:

Automatic Pond Adjuster: The slider at the top of the AutoPond window allows the user to decide how thoroughly the pond will be designed for efficiency. The lowest setting (0-1 min) at the left constructs an initial pond without checking the flow duration criteria. The second setting to the right creates and sizes a pond to pass the flow duration criteria; however, the pond is not necessarily optimized. The higher settings increase the amount of optimization. The highest setting (farthest right) will size the most efficient (smallest) pond, but will result in longer computational time.

Pond Depth: Pond depth is the total depth of the pond and should include at least one foot of freeboard (above the riser). The pond's original depth will be used when optimizing an existing pond; changing the value in the Pond Depth text box will override any previous set depth value. The default depth is 4 feet.

Pond Length to Width Ratio: This bottom length to width ratio will be maintained regardless of the pond size or orientation. The default ratio value is 1.0

Pond Side Slopes: AutoPond assumes that all of the pond's sides have the same side slope. The side slope is defined as the horizontal distance divided by the vertical. A typical side slope is 3 (3 feet horizontal to every 1 foot vertical). The default side slope value is 3.

Choose Outlet Structure: The user has the choice of either 1 orifice and rectangular notch or 3 orifices. If the user wants to select another outlet structure option then the pond must be manually sized.

Create Pond: This button creates a pond when the user does not input any pond dimensions or outlet structure information. Any previously input pond information will be deleted.

Optimize Pond: This button optimizes an existing pond. It cannot be used if the user has not already created a pond.

Accept Pond: This button will stop the AutoPond routine at the last pond size and discharge characteristics that produce a pond that passes the flow duration criteria. AutoPond will not stop immediately if the flow duration criteria have not yet been met.

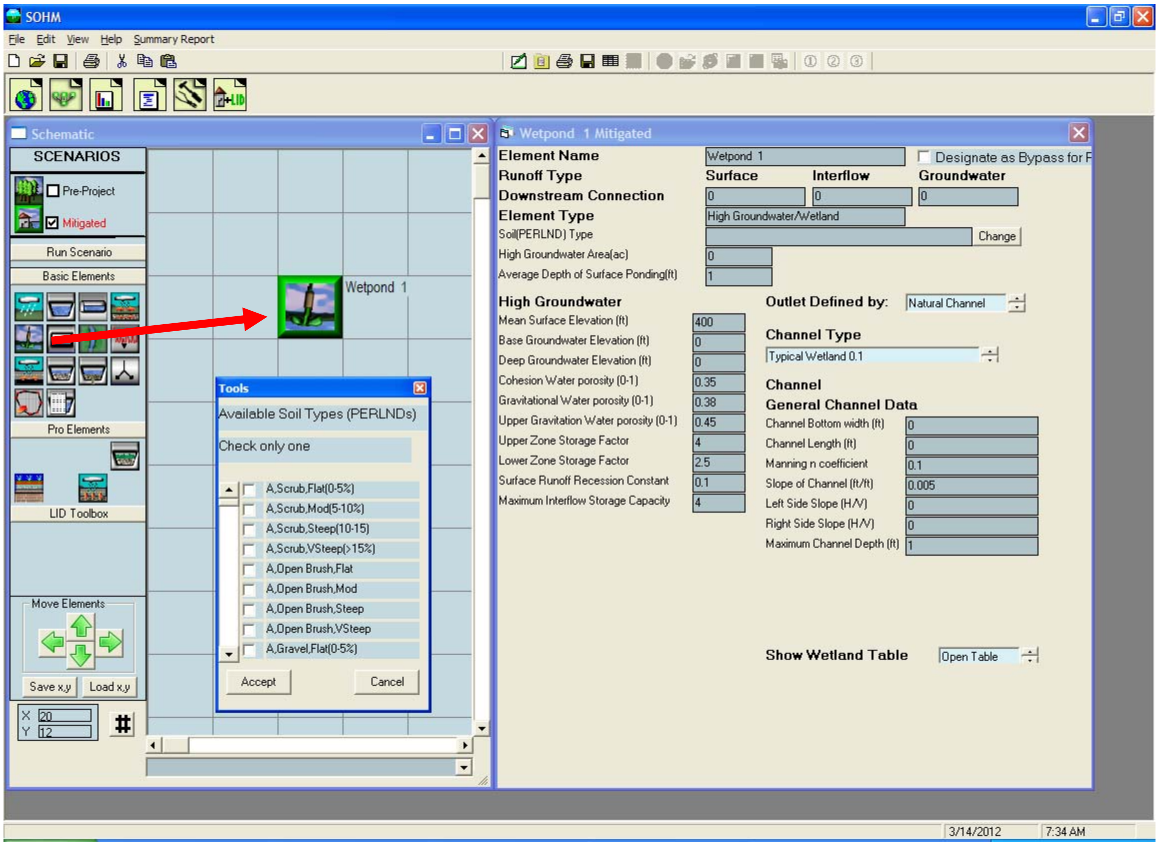
The bottom length and width and volume at riser head will be computed by AutoPond; they cannot be input by the user.

AutoVault operates the same way as AutoPond.

There are some situations where AutoPond (or AutoVault) will not work. These situations occur when complex routing conditions upstream of the pond make it difficult or impossible for AutoPond to determine which land use will be contributing runoff to the pond. For these situations the pond will have to be manually sized. Go to page 48 to find information on how to manually size a pond or other HMP facility.

NOTE: If AutoPond selects a bottom orifice diameter smaller than the smallest diameter allowed by the local municipal permitting agency then additional mitigating BMPs may be required to meet local hydromodification control requirements. Please see Appendix C or consult with local municipal permitting agency for more details. For manual sizing information see page 48.

HIGH GROUNDWATER/WETLAND ELEMENT



The High Groundwater/Wetpond element is a complex element that should only be used in special applications by advanced SOCHM users. The purpose of the high groundwater/ wetpond element is to model hydrologic conditions where high groundwater rises to the surface (or near the surface) and reduces the ability of water to infiltrate into the soil.

The element can be used to represent wetland conditions with surface ponding where the discharge from the wetland is via a surface release. The user is given the choice of using either a natural channel, berm/weir, or control structure to determine the release characteristics.

The element provides default values for some of the parameters, especially as they relate to high groundwater. The user should be fully familiar with these parameters and the appropriate values for their site prior to attempting to use this element. The high groundwater parameter definitions are shown below.

Cohension water porosity: soil pore space in micropores.

Gravitational water porosity: soil pore space in macropores in the lower and groundwater layers of the soil column.

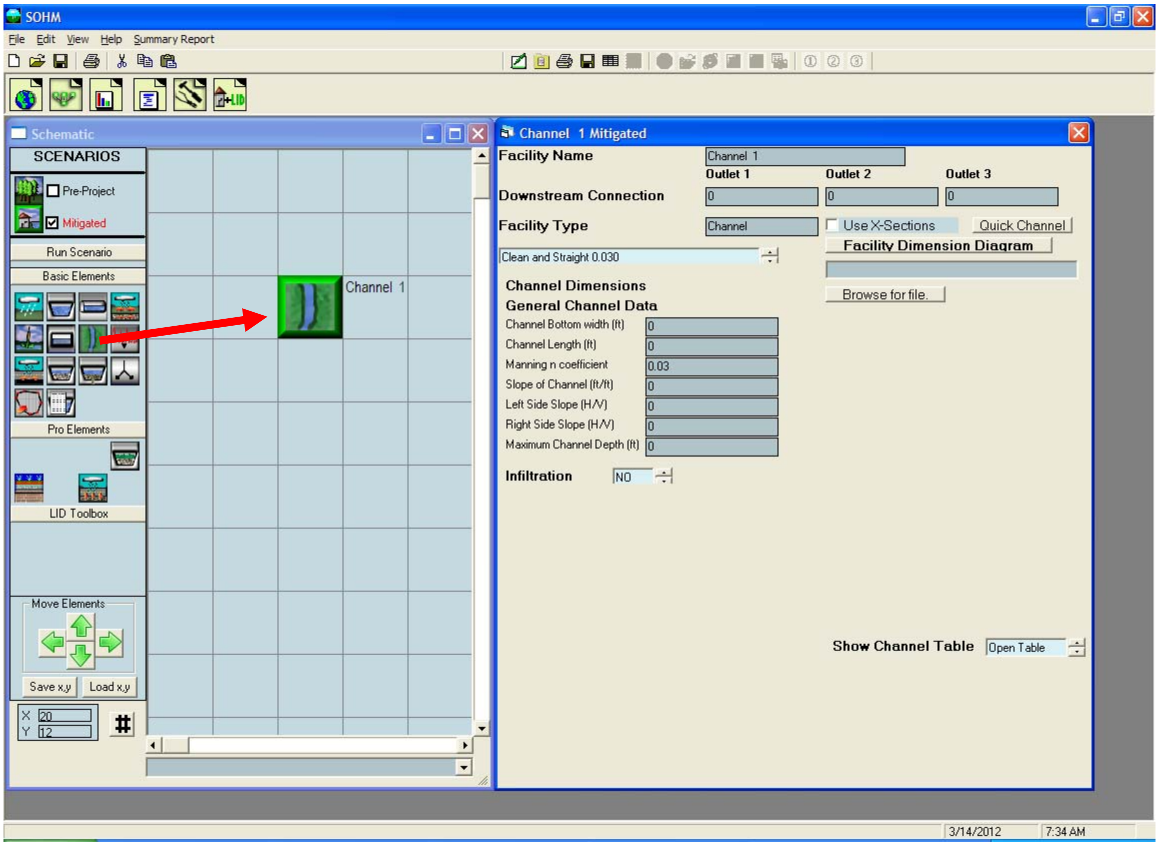
Upper gravitation water porosity: soil pore space in macropores in the upper layer of the soil column.

Upper zone storage factor: portion of the water stored in macropores in the upper soil layer which will not surface discharge, but will percolate, evaporate or transpire.

Lower zone storage factor: portion of the water stored in micropores in the lower soil layer which will not gravity drain, but will evaporate or transpire.

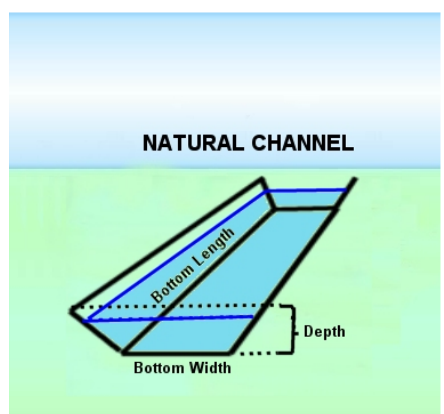
NOTE: Due to permit restrictions on infiltration for stormwater treatment measures in areas of high groundwater, consult with the local municipal permitting agency regarding any project conditions that might involve using this element.

CHANNEL ELEMENT



The Channel element allows the user to route runoff from a basin or facility through an open channel to a downstream destination.

The channel cross section is represented by a trapezoid and is used with Manning's equation to calculate discharge from the channel. If a trapezoid does not accurately represent the cross section then the user should represent the channel with an independently calculated SSD Table element or use the Use X-Sections option.



The user inputs channel bottom width, channel length, channel bottom slope, channel left and right side slopes, maximum channel depth, and the channel's roughness coefficient (Manning's n value). The user can select channel type and associated Manning's n from a table list directly above the Channel Dimension information or directly input the channel's Manning's n value.

The channel is used to represent a natural or artificial open channel through which water is routed. It can be used to connect a basin to a pond or a pond to a pond or multiple channels can linked together.

Channel input information:

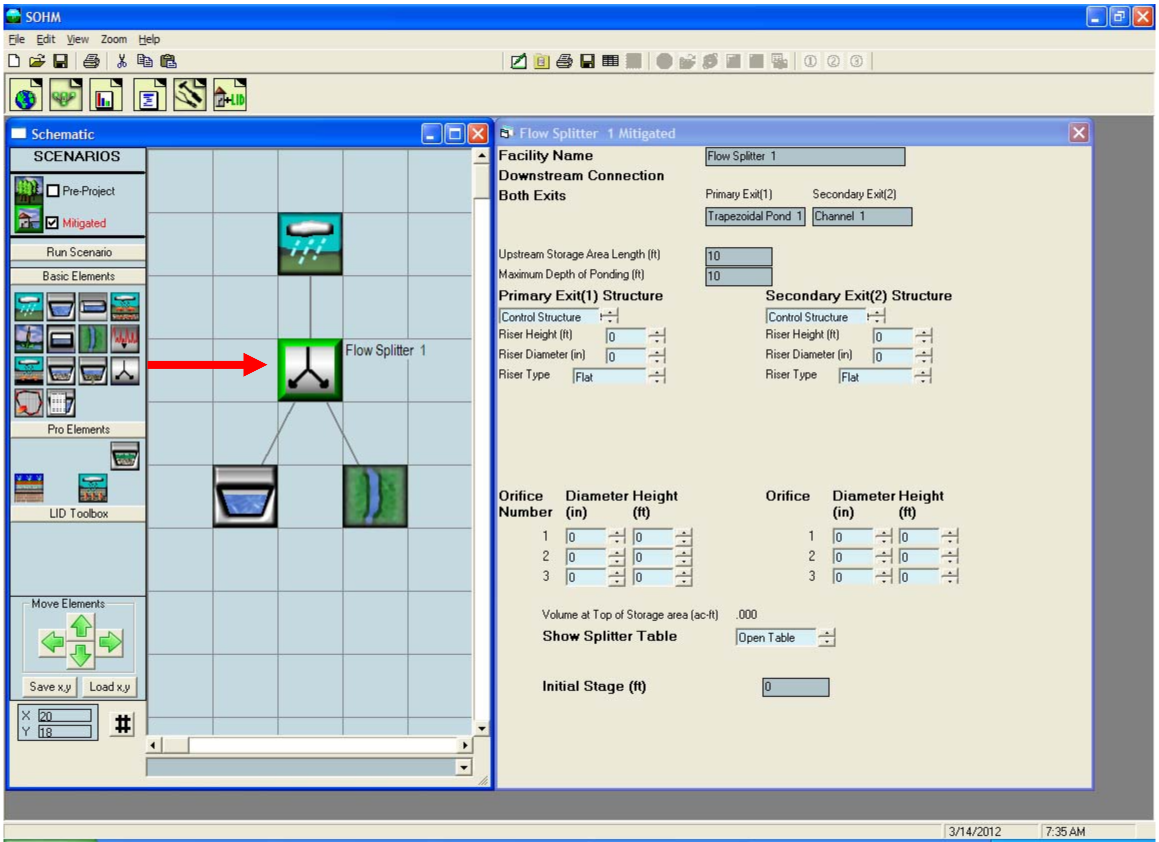
Channel Bottom Width (ft): Open channel bottom width.
Channel Length (ft): Open channel length.
Manning's n coefficient: Open channel roughness coefficient (user menu selected or input).
Slope of Channel (ft/ft): Open channel bottom slope.
Left Side Slope of Channel (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical channel sides.
Right Side Slope of Channel (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical channel sides.
Maximum Channel Depth (ft): Height from bottom of channel to top of channel bank.

Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the channel side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

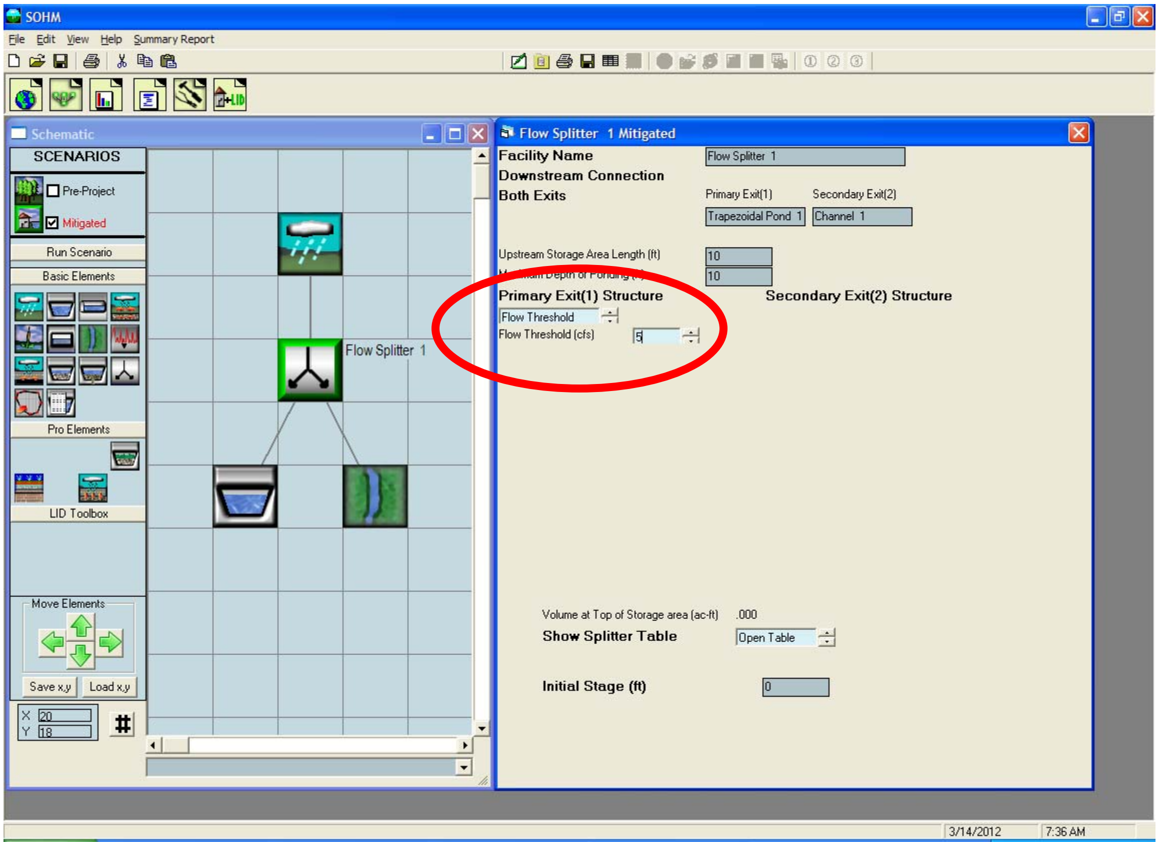
FLOW SPLITTER ELEMENT



The flow splitter divides the runoff and sends it to two difference destinations. The splitter has a primary exit (exit 1) and a secondary exit (exit 2). The user defines how the flow is split between these two exits.

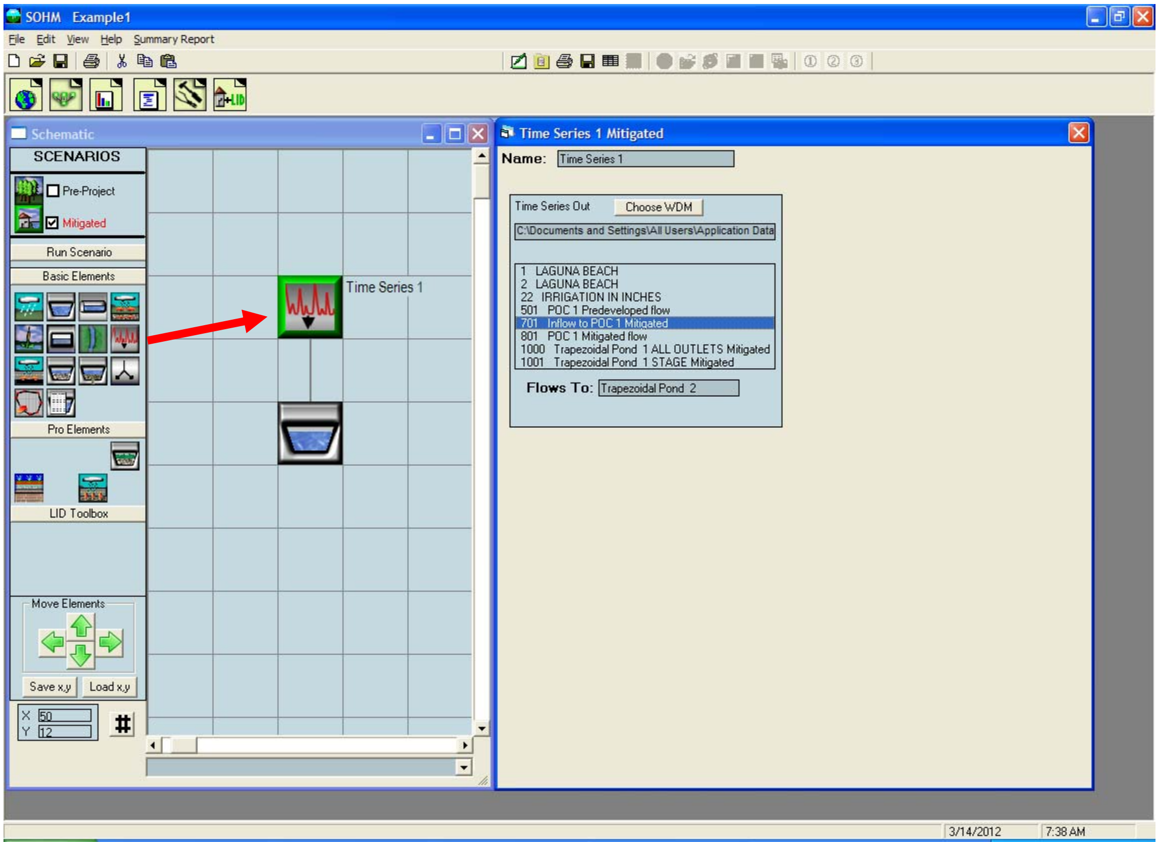
The user can define a flow control structure with a riser and one to three orifices for each exit. The flow control structure works the same way as the pond outlet structure, with the user setting the riser height and diameter, the riser weir type (flat, rectangular notch, V-notch, or Sutro), and the orifice diameter and height.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.



The second option is that the flow split can be based on a flow threshold. The user sets the flow threshold value (cfs) for exit 1 at which flows in excess of the threshold go to exit 2. For example, if the flow threshold is set to 5 cfs then all flows less than or equal to 5 cfs go to exit 1. Exit 2 gets only the excess flow above the 5 cfs threshold (total flow minus exit 1 flow).

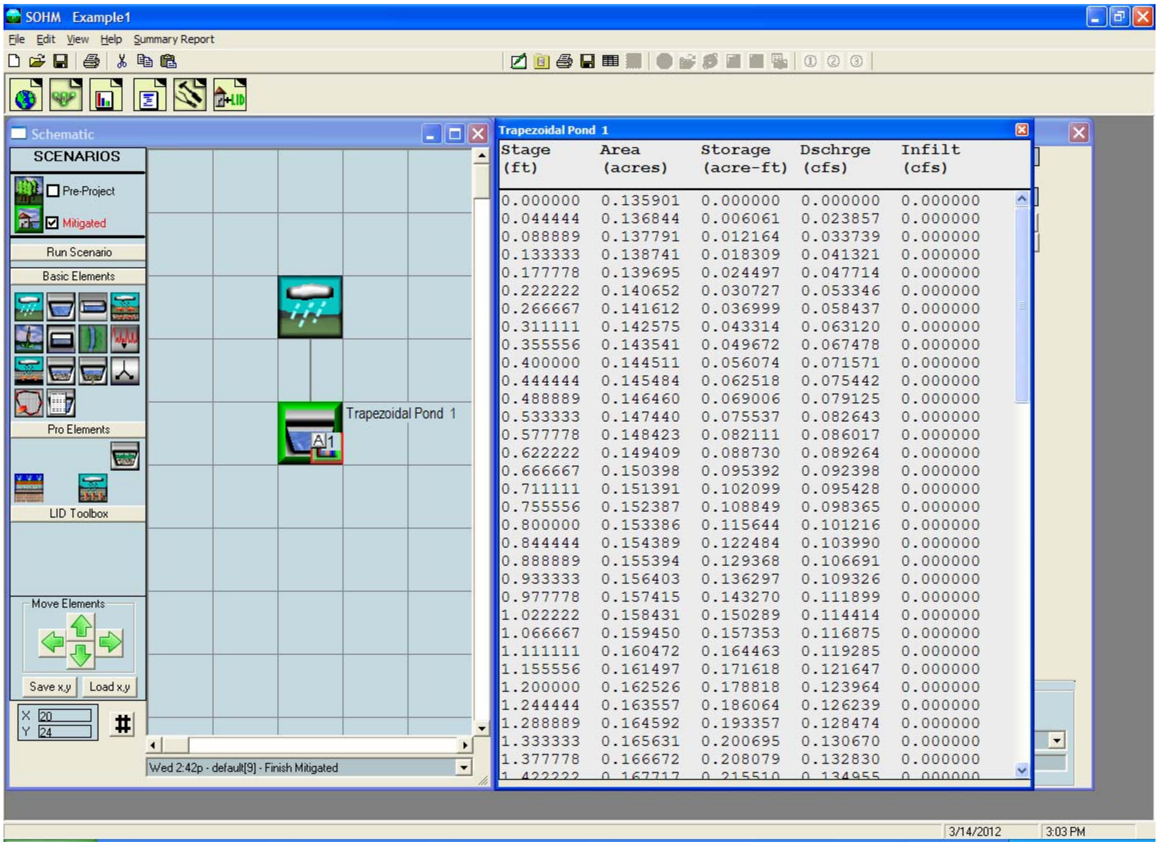
TIME SERIES ELEMENT



SOCHM uses time series of precipitation, evaporation, and runoff stored in its database (HSPF WDM file). The user has the option to create or use a time series file external from SOCHM in SOCHM. This may be a time series of flow values created by another HSPF model. An example is offsite runoff entering a project site. If this offsite runoff is in an existing WDM file and is the same period as SOCHM data and the same simulation time step (15-minute) then it can be linked to SOCHM model using the Time Series element.

To link the external time series to SOCHM the user clicks on the Choose WDM button and identifies the external WDM file. The external WDM's individual time series files are shown in the Time Series Out box. The selected input dataset is the time series that will be used by SOCHM.

STAGE-STORAGE-DISCHARGE TABLE

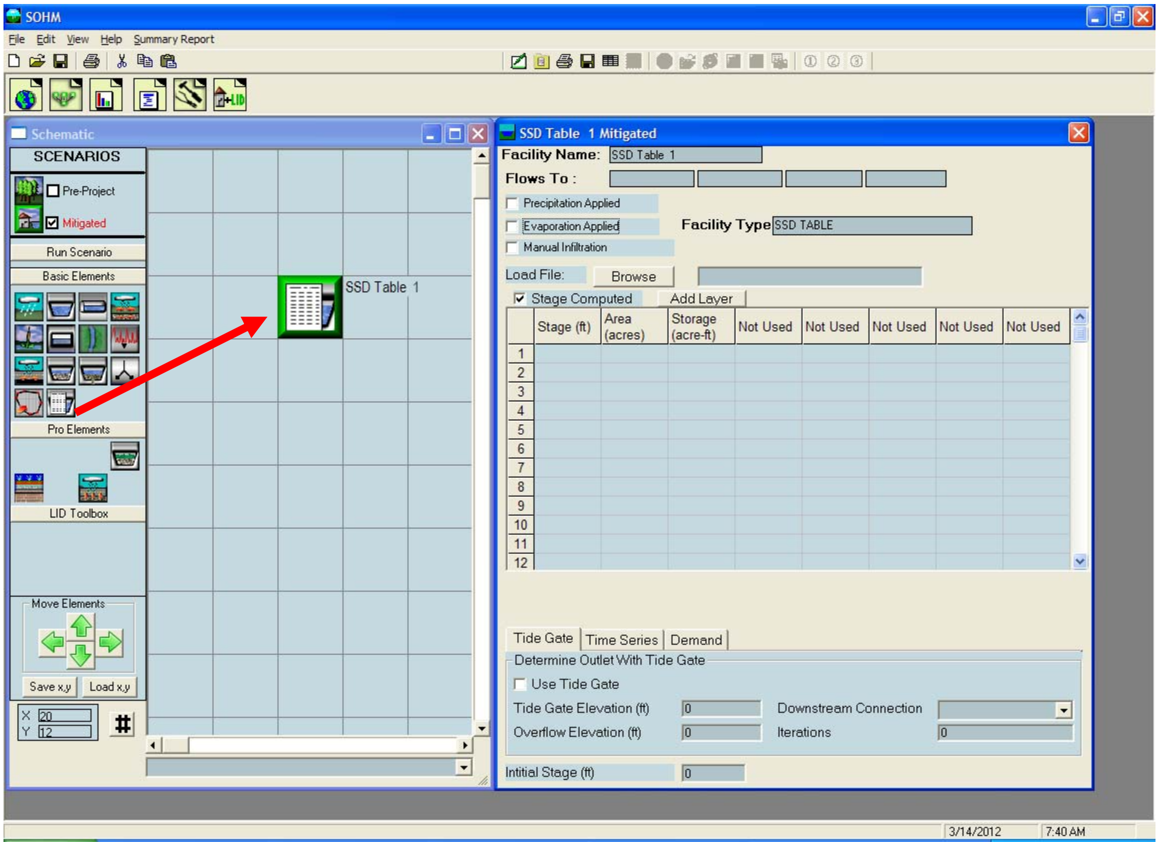


The stage-storage-discharge table hydraulically represents any facility that requires stormwater routing. The table is automatically generated by SOCHM when the user inputs storage facility dimensions and outlet structure information. SOCHM generates 91 lines of stage, surface area, storage, surface discharge, and infiltration values starting at a stage value of zero (facility bottom height) and increasing in equal increments to the maximum stage value (facility effective depth).

When the user or SOCHM changes a facility dimension (for example, bottom length) or an orifice diameter or height the model immediately recalculates the stage-storage-discharge table.

The user can input to SOCHM a stage-storage-discharge table created outside of SOCHM. To use a stage-storage-discharge table created out of SOCHM the SSD Table element is required. See the SSD Table element description below for more information on how to load such a table to SOCHM program.

SSD TABLE ELEMENT



The SSD Table is a stage-storage-discharge table externally produced by the user and is identical in format to the stage-storage-discharge tables generated internally by SOCHM for ponds, vaults, tanks, and channels.

The easiest way to create a SSD Table outside of SOCHM is to use a spreadsheet with a separate column for stage, surface area, storage, and discharge (in that order). Save the spreadsheet file as a space or comma-delimited file. A text file can also be created, if more convenient.

The SSD Table must use the following units:
Stage: feet
Surface Area: acres
Storage: acre-feet
Discharge: cubic feet per second (cfs)

A fifth column can be used to create a second discharge (cfs). This second discharge can be infiltration or a second surface discharge.

Certain rules apply to the SSD Table whether it is created inside or outside of SOCHM. These rules are:

1. Stage (feet) must start at zero and increase with each row. The incremental increase does not have to be consistent.

2. Storage (acre-feet) must start at zero and increase with each row. Storage values should be physically based on the corresponding depth and surface area, but SOCHM does not check externally generated storage values.

3. Discharge (cfs) must start at zero. Discharge does not have to increase with each row. It can stay constant or even decrease. Discharge cannot be negative. Discharge should be based on the outlet structure's physical dimensions and characteristics, but SOCHM does not check externally generated discharge values.

4. Surface area (acres) is only used if precipitation to and evaporation from the facility are applied.

To input an externally generated SSD Table, first create and save the table outside of SOCHM. Use the Browse button to locate and load the file into SOCHM.

BIORETENTION/RAIN GARDEN ELEMENT

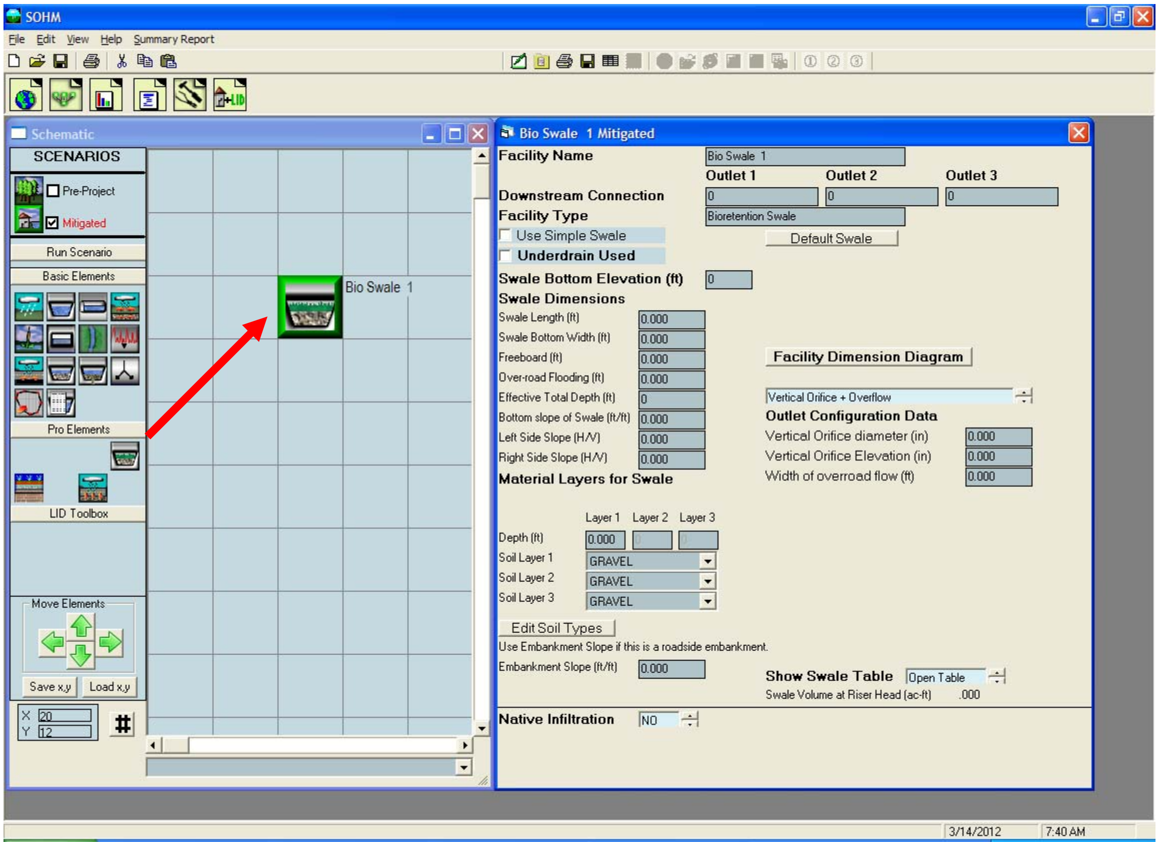
The bioretention swale element is also known as a landscape swale or rain garden. The SOCHM bioretention swale element is a special conveyance feature with unique characteristics. The element uses the HSPF hydraulic algorithms to route runoff, but the HSPF routing is modified to represent the two different flow paths that runoff can take. The routing is dependent on the inflow to the swale and the swale soil capacity to absorb additional runoff. HSPF Special Actions is used to check the swale soil capacity to determine the appropriate routing option.

A bioretention swale is a swale in which the native soils have been excavated and replaced with amended soil. At the downstream end of the swale a weir controls the surface discharge from the swale and detains runoff, encouraging it to infiltrate into the amended soil. Infiltration from the amended soil to the native soil is also possible, depending on the properties of the native soil. Swales can include an underdrain pipe.

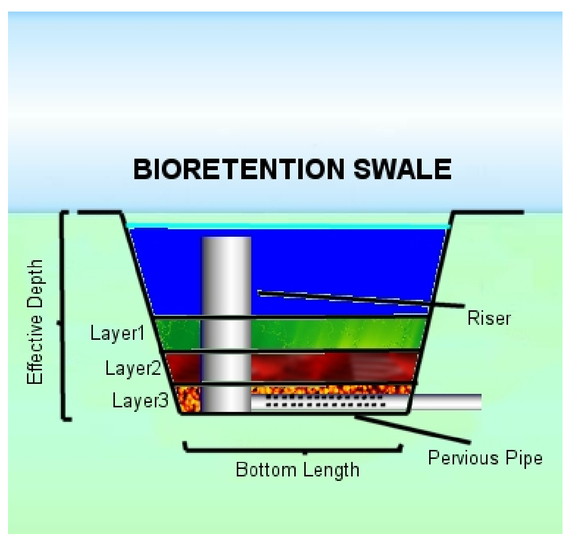
The amended soil placed in the swale is assumed to have storage capacity equal to its porosity and volume. Runoff infiltrates from the surface of the swale to the amended soil at an infiltration rate set by the user. The infiltration rate cannot exceed the available storage capacity of the amended soil. The available storage capacity is determined each time step by HSPF Special Actions. Once the amended soil is saturated then water has the opportunity to infiltrate into the underlying native soil at the native soil's infiltration rate. The native soil infiltration is input by the user and is assumed to be constant throughout the year.

Inflow to the swale can exceed the amended soil infiltration rate. When this occurs the extra water ponds on the surface of the swale. The extra water can then infiltrate into the soil during the next time step or can flow out of the swale through its surface outlet if the ponding exceeds the surface outlet's storage.

Runoff in both the surface storage and amended soil storage is available for evapo-transpiration. Surface storage evapotranspiration is set to the potential evapo-transpiration; the amended soil evapotranspiration pan evaporation factor is set to 0.50 to reflect reduced evapotranspiration from the amended soil.



The user is required to enter the following information about the bioretention swale:



The bioretention swale dimensions are specified in terms of swale length, bottom width, freeboard, over-road flooding, effective total depth, bottom slope, and left and right side slopes.

Swale Length (ft): length dimension of swale surface bottom.
Swale Bottom Width (ft): width dimension of swale surface bottom.
Freeboard (ft): depth of surface ponding before weir/street overflow occurs.
Over-road Flooding (ft): maximum depth of flow over weir/street.
Effective Total Depth (ft): the total depth of the amended soil layer(s) plus freeboard plus over-road flooding plus vertical orifice elevation plus vertical orifice diameter; effective total depth is computed by SOCHM.
Bottom Slope of Swale (ft/ft): the slope of the swale length; must be greater than zero.
Left Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical swale sides.

Right Side Slope (ft/ft): H/V ratio of horizontal distance to vertical; 0 (zero) for vertical swale sides.

In the amended soil water movement through the soil column is dependent on soil layer characteristics and saturation rates for different discharge conditions.

Consider a simple two-layered bioretention facility designed with two soil layers with different characteristics. As water enters the facility at the top, it infiltrates into the soil based on the modified Green Ampt equation (Equation 1). The water then moves through the top soil layer at the computed rate, determined by Darcy's and Van Genuchten's equations. As the soil approaches field capacity (i.e., gravity head is greater than matric head), we can determine when water will begin to infiltrate into the second layer (lower layer) of the soil column. This occurs when the matric head is less than the gravity head in the first layer (top layer).

Since the two layers have different soil characteristics, water will move through the two layers at different rates. Once both layers have achieved field capacity then the layer that first becomes saturated is determined by which layer is more restrictive. This is determined by using Darcy's equation to compute flux for each layer at the current level of saturation. The layer with the more restrictive flux is the layer that becomes saturated for that time step. The next time step the same comparison is made.

The rate and location of water discharging from the soil layer is determined by the discharge conditions selected by the user.

There are four possible combinations of discharge conditions:

1. There is no discharge from the subsurface layers (except for evapotranspiration). This means that there is no underdrain and there is no infiltration into the native soil. Which this discharge condition is unlikely, we still need to be able to model it.

2. There is an underdrain, but no native infiltration. Discharge from the underdrain is computed based on head conditions for the underdrain. The underdrain is configured to have an orifice. (It is possible for the orifice to be the same diameter as the underdrain.) With a maximum of three soil layers determining head conditions for the orifice is complicated. Each modeled layer must overcome matric head before flow through the underdrain can begin. Once matric head is overcome by gravity head for all of the layers then the underdrain begins to flow. The flow rate is determined based on the ability of the water to move through the soil layers and by the discharge from the orifice, whichever is smaller. Head conditions are determined by computing the saturation level of the lowest soil layer first. Once the lowest soil layer is saturated and flow begins then the gravity head is considered to be at the saturation level of the lowest soil layer. Once the lowest soil layer is saturated completely then the head will include the gravity head from the next soil layer above until gravity head from all soil layers is included. Gravity head from ponding on the surface is included in the orifice calculations only if all of the intervening soil layers are saturated.

3. There is native infiltration but no underdrain. Discharge (infiltration) into the native soil is computed based a user entered infiltration rate in units of inches per hour. Specific head conditions are not used in determining infiltration into the native soil. Any impact due to head on the infiltration rate is considered to be part of the determination of the native soil infiltration rate. Because it is possible to have a maximum of three soil layers, each modeled layer must overcome matric head before infiltration to the native soil can begin. Once matric head is overcome by gravity head for all modeled layers then infiltration begins at a maximum rate determined either by the ability of the water to move through the soil layers or by the ability of the water to infiltrate into the native soil, whichever is limiting.

4. There is both an underdrain and native infiltration. Underdrain flow and native infiltration are computed as discussed above. However, there is one other limitation to consider. In the case where the flow through the soil layer is less than the sum of the discharge through the underdrain and the native infiltration then the flow through the soil layer becomes the limiting flow and must be divided between the native infiltration and the underdrain. This division is done based on the relative discharge rates of each.

Note that wetted surface area can be included in the discharge calculations by adding the infiltration through the wetted surface area to the lower soil layer and the upper surface layer individually. This is done by computing the portion of the wetted surface area that is part of the upper surface layer and computing the infiltration independently from the portion of the wetted surface area that is part of the lower soil layers.

There are several equations used to determine water movement from the surface of the bioretention facility, through the soil layers, and into an underdrain or native infiltration. The water movement process can be divided into three different zones:

1) Surface ponding and infiltration into the top soil layer (soil layer 1)
2) Percolation through the subsurface layers
3) Underdrain flow and native infiltration

The modified Green Ampt equation (Equation 1) controls the infiltration rate into the top soil layer:

$$f = K\left(1 + \frac{(\phi - \theta)(d + \varphi)}{F}\right) \qquad \text{(Equation 1)}$$

f = soil surface infiltration rate (cm/hr)
ϕ = soil porosity of top soil layer
θ = soil moisture content of top soil layer
φ = suction head at the wetting front (cm)
F = soil moisture content of the top soil layer (cm)
d = surface ponding depth (cm)
K = hydraulic conductivity based on saturation of top soil layer (cm/hr)

K (relative hydraulic conductivity) can be computed using the following Van Genuchten approximation equation:

Van Genuchten approximation of relative hydraulic conductivity

$$\frac{K(\theta)}{K_{sat}} = \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{1/2}\left[1 - \left(1 - \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{1/m}\right)^m\right]^2 \qquad \text{(Equation 2)}$$

where $K(\theta)$ = relative hydraulic conductivity,
K_{sat} = saturated hydraulic conductivity,
θ = water content, θ_r = residual water content,
ϕ = porosity, α = constant, n = constant, m = constant

A few issues arise when dealing with multiple subsurface soil layers. The K value used in Equation 1 must be computed from the top soil layer. Infiltration into the upper soil layer must not exceed the lesser of the maximum percolation rates for each of the soil layers. Finally, the rate of percolation of the top layer may be reduced because the layer or layers beneath the top layer cannot accept the percolation flux because of existing saturation levels.

Water storage and movement through the three subsurface layers will be computed using Darcy's equation as shown below:

$$q = -K \frac{\partial h}{\partial z} \qquad \text{(Equation 3)}$$

Where:

q = Darcy flux (cm/hr)

K = hydraulic conductivity of the porous medium (cm/hr)

h = total hydraulic head (cm)

z = elevation (cm)

The total head, h, is the sum of the matric head, ψ, and the gravity head, z:

$$h = \psi + z \ . \qquad \text{(Equation 4)}$$

Substituting for h yields:

$$q = -K \frac{d(\psi + z)}{dz} \ . \qquad \text{(Equation 5)}$$

Hydraulic conductivity and matric head vary with soil moisture content. These values can be computed by solving the Van Genuchten's equation (Equation 6) for both values. Note that $\psi = 0$ when the soil is saturated.

Van Genuchten Equation to calculate total head

$$h = -\frac{1}{\alpha}\left[\frac{1}{SE^{1/m}} - 1\right]^{1/n} + z \qquad \text{(Equation 6)}$$

where h = total hydraulic head, α = constant, SE = effective saturation, m = constant, n = constant, and z = elevation head

Effective saturation (SE) can be computed using the following Van Genuchten equation:

Van Genuchten Equation to calculate effective saturation

$$\frac{\theta - \theta_r}{\phi - \theta_r} = \left[\frac{1}{1 + (\alpha\psi)^n}\right]^m = SE \qquad \text{(Equation 7)}$$

where θ = water content, θ_r = residual water content,
ϕ = porosity,
$\alpha = \text{constant} = y_b - 1$,
$n = \text{constant} = \lambda + 1$,
$m = \text{constant} = 1 - \frac{1}{\lambda + 1}$,
λ = pore size distribution index,
y_b = bubbling pressure
ψ = pressure head = h-z, h = total hydraulic head,
z = elevation head, and SE = effective saturation

Ignoring z (elevation head) results in h = hm (matric head).

Evapotranspiration is an important component of the bioretention facility's hydrologic processes. Evapotranspiration removes water from bioretention surface ponding and the soil column during non-storm periods. The routine will satisfy potential evapo-transpiration (PET) demands in the same sequence as implemented in HSPF:

1. Water available from vegetation interception storage
2. Water available from surface ponding
3. Water available from the bioretention soil layers (top layer first)

Water will be removed from vegetation interception storage and surface ponding and the bioretention soil layers (starting at the top layer) down to the rooting depth at the potential rate. Water is taken from the soil layers below the rooting depth based on a percentage factor to be determined. Without this factor there will be no way to remove water from below the rooting depth once it becomes completely saturated.

The user inputs:

Layer Thickness (feet): depth of amended soil.
Type of amended soil: 24 different soil types are included; the user can also create their own soil type using the Edit Soil Type button.

Note that there can be a maximum of three different amended soil layers.

Infiltration to the native soil can be turned on by setting Native Infiltration to YES. The parameters for native soil infiltration are:

Measured Infiltration Rate (inches per hour): infiltration rate of the native soil.
Infiltration Reduction Factor: between 0 and 1 (1/Native soil infiltration rate safety factor (see page 69).
Use Wetted Surface Area (sidewalls): YES or NO; YES allows infiltration to the native soil through the sidewalls of the swale; otherwise all infiltration is through the bottom only.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

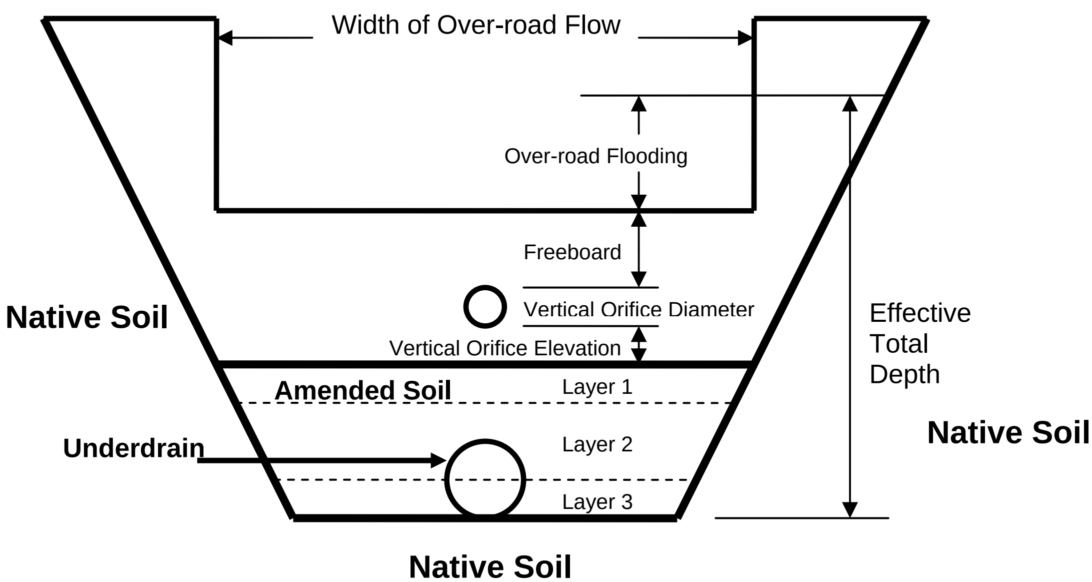
NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

The user has two swale surface outlet configuration choices: (1) vertical orifice + overflow or (2) riser outlet structure.

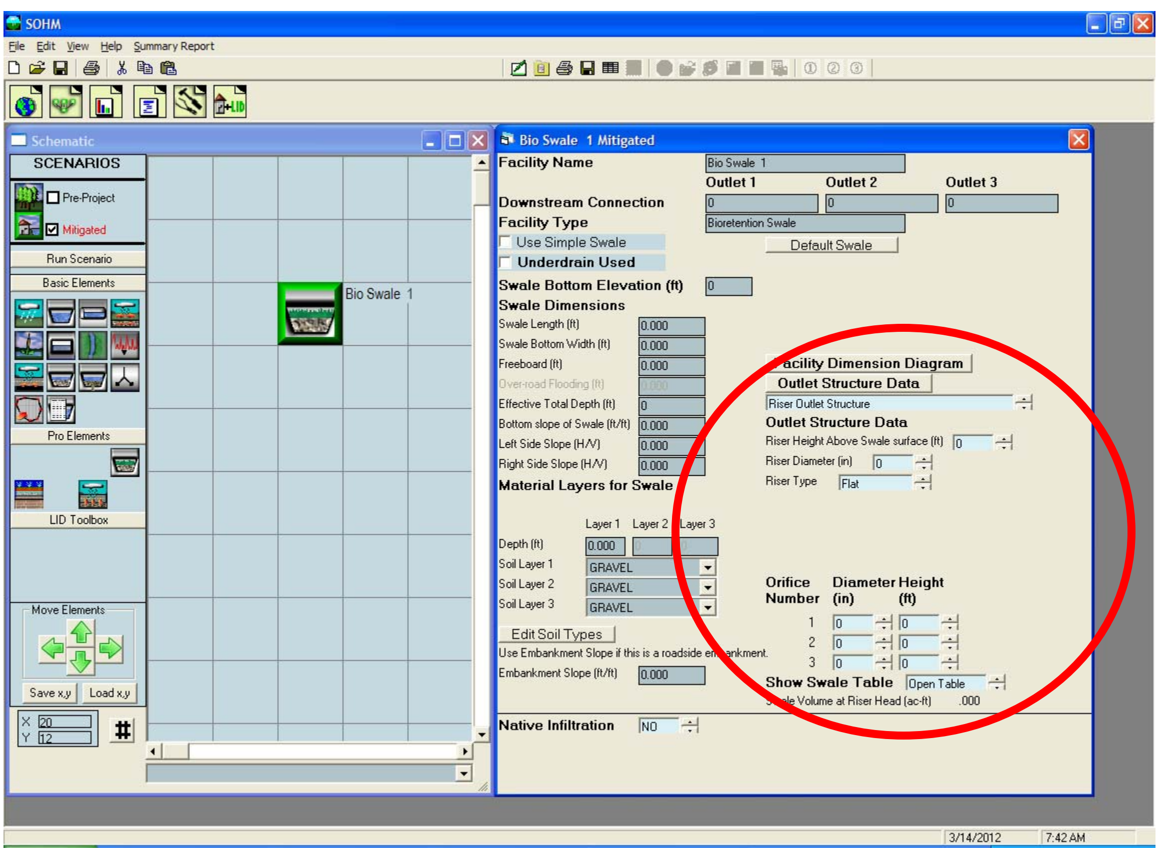
The input information required for the vertical orifice plus overflow is:

Vertical Orifice Diameter (inches): diameter of vertical opening below the weir.
Vertical Orifice Elevation (inches): vertical distance from the top of the amended soil surface to the bottom of the vertical orifice.
Width of Over-road Flow (feet): weir/street length.

Diagram of bioretention swale with vertical orifice plus overflow:



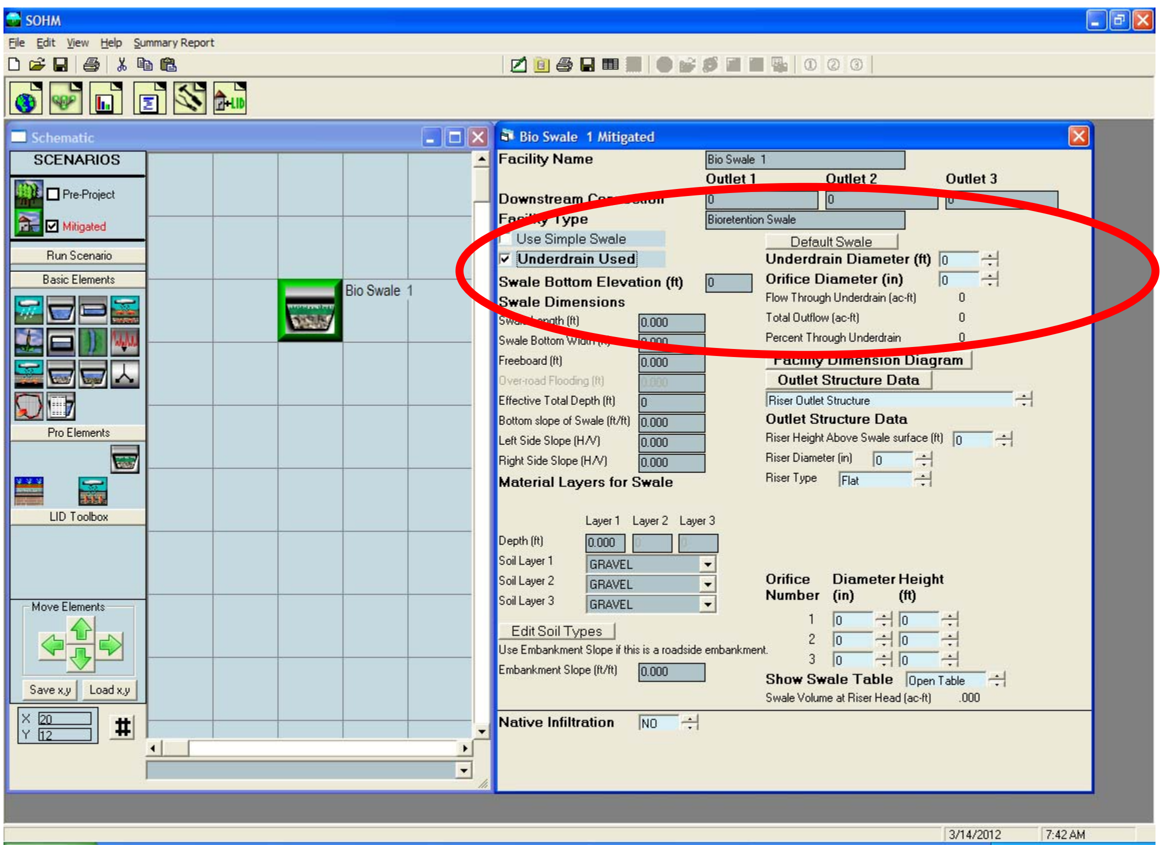
Riser outlet structure option:



The input information required for the riser outlet structure is:

Riser Height above Swale Surface (feet): depth of surface ponding before the riser is overtopped.
Riser Diameter (inches): diameter of the stand pipe.
Riser Type: Flat or Notched.
Notch Type: Rectangular, V-Notch, or Sutro.
For a rectangular notch:
Notch Height (feet): distance from the top of the weir to the bottom of the notch.
Notch Width (feet): width of notch; cannot be larger than the riser circumference.

For more information on riser notch options and orifices see discussion in OUTLET STRUCTURE CONFIGURATIONS section.



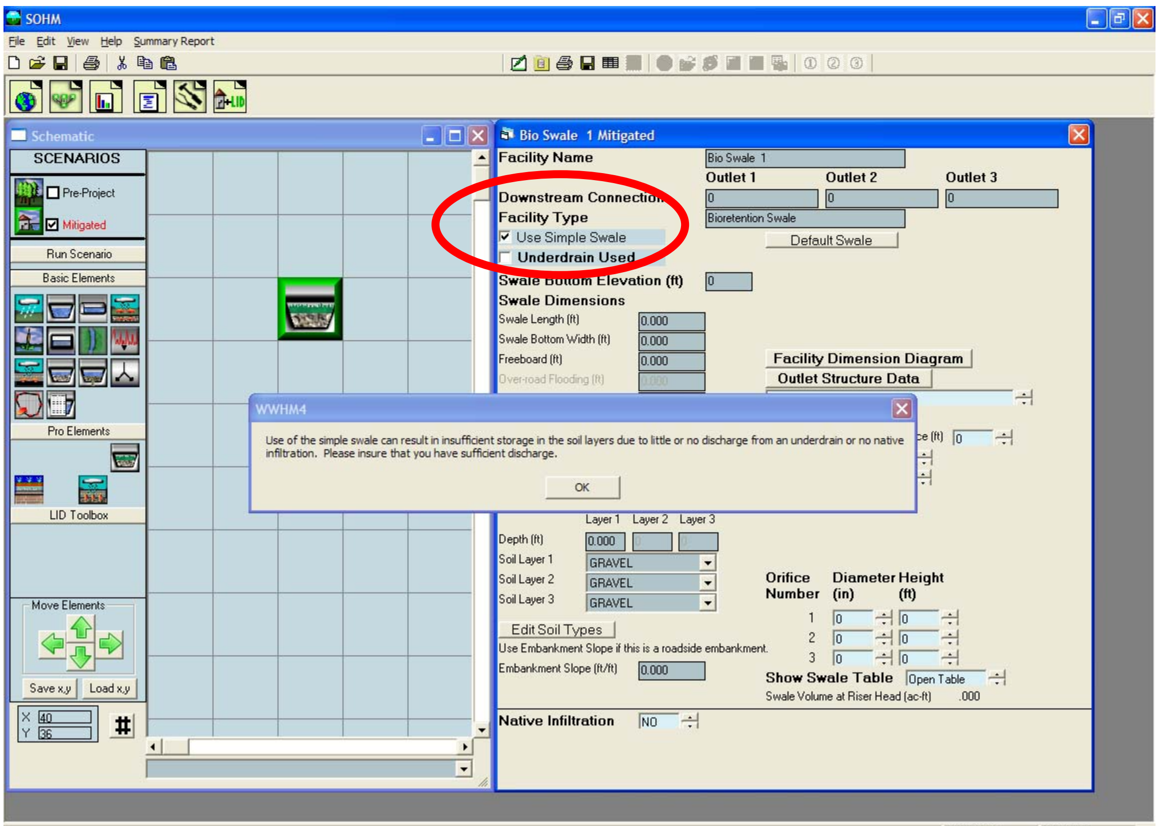
To use the underdrain click the Underdrain Used box and input an underdrain pipe diameter (feet) and underdrain outlet orifice diameter (inches). The bottom of the underdrain pipe is assumed to be at the bottom of the amended soil layer.

The amended soil layer fills with stormwater from the top on down to where it can drain to the native soil (if Native Infiltration is set to YES) and/or the underdrain pipe (if Underdrain Used box is checked).

Water enters the underdrain when the amended soil becomes saturated down to the top of the underdrain. The underdrain pipe fills and conveys water proportionally to the depth of amended soil saturation. When the amended soil is fully saturated the underdrain pipe is at full capacity. Discharge from the underdrain pipe is controlled by the underdrain orifice diameter.

If native infiltration is turned on then native infiltration will start when/if:

1. Water starts to fill the underdrain (if an underdrain is used).
2. Water enters the amended soil (if Use Wetted Surface Area (sidewalls) is set to YES).
3. Water saturates the amended soil layer(s) to 2/3rds of the total amended soil depth (if there is no underdrain and Wetted Surface Area is set to NO).



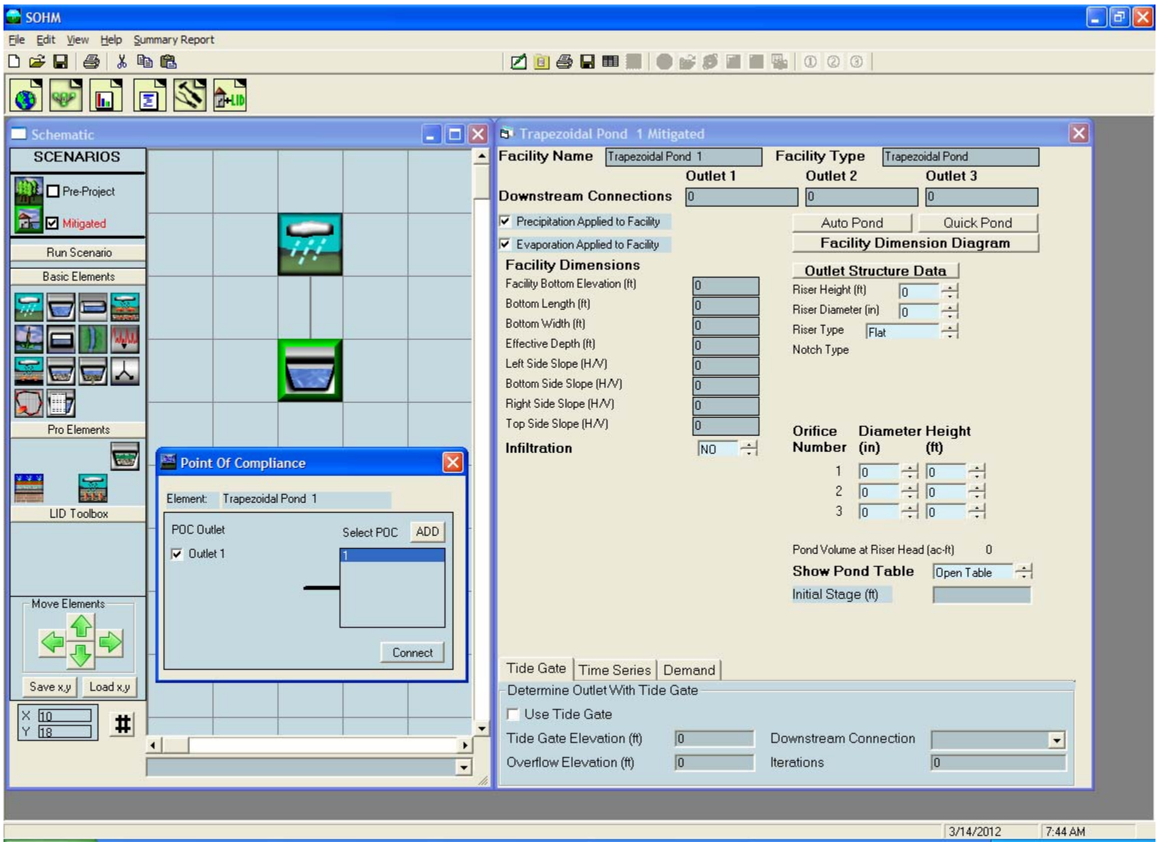
There is a simple swale option. It is computationally much faster than the standard bioretention swale. Before using the simple swale option read the note on the screen and the information below to understand the limitations of the simple swale.

The standard bioretention swale routine uses HSPF Special Actions to check the available amended soil storage and compares it with the inflow rate. Because of the check done by HSPF Special Actions simulations using bioretention swales take much longer than simulations not using bioretention swales. Simulations that normally take only seconds may take multiple minutes when one or more bioretention swales are added, depending on the computational speed of the computer used.

One solution to this problem is to use the simple swale option (check the Use Simple Swale box). The simple swale does not include HSPF Special Actions. It is less accurate than the standard swale. Tests have shown that the simple swale option should only be used when the swale area (and volume) is relatively small compared to the contributing basin area. If in doubt, model the bioretention swale both ways and see how close the simple swale answer is to the standard swale method. The standard swale method will always be more accurate than the simple swale.

POINT OF COMPLIANCE

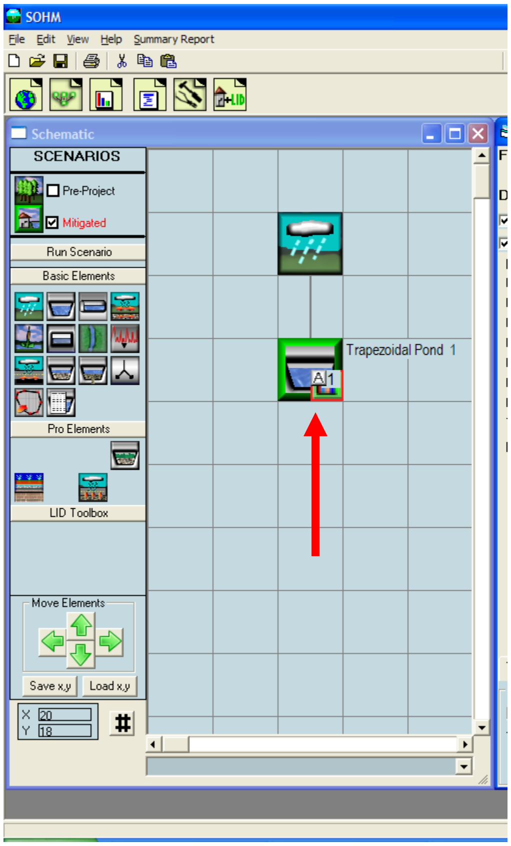
SOCHM allows for multiple points of compliance (maximum of 59) in a single project. A point of compliance is defined as the location at which the Predevelopment and Mitigated flows will be analyzed for compliance with the flow control standard.



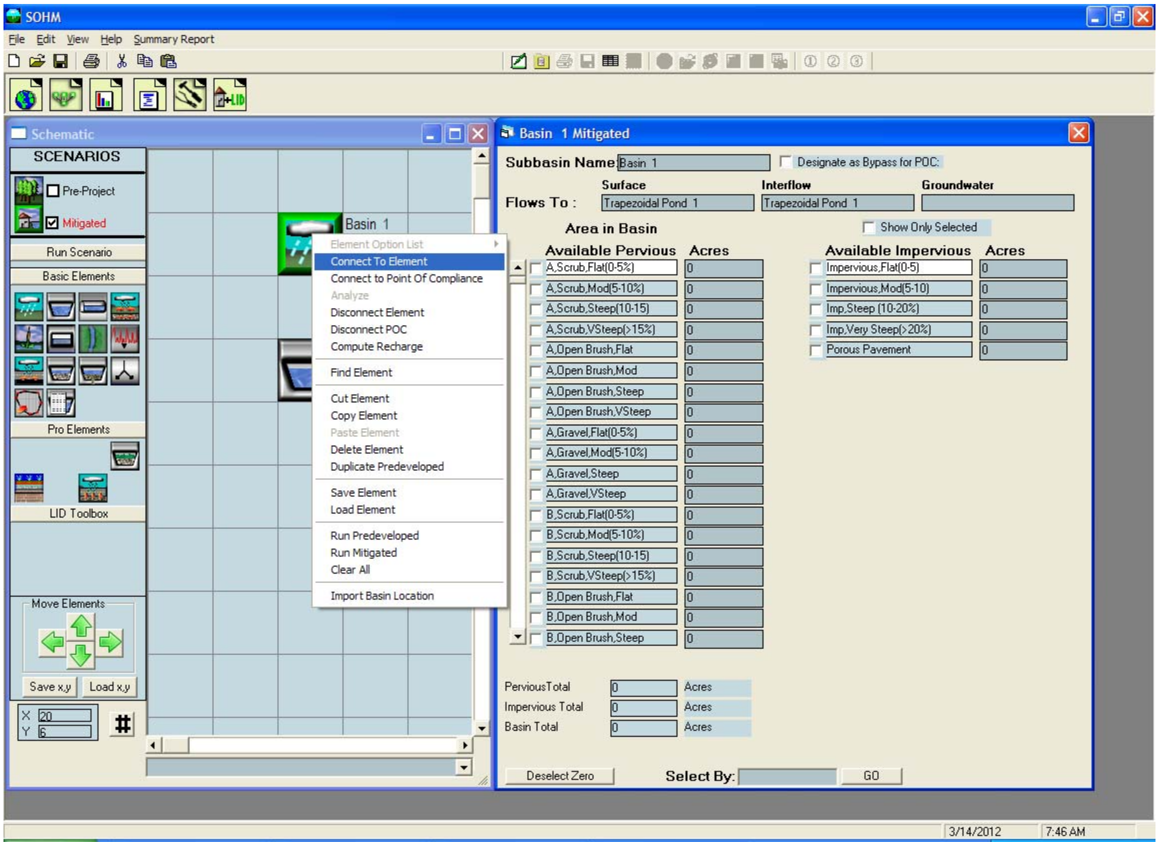
The point of compliance is selected by right clicking on the element at which the compliance analysis will be made. In the example above, the point of compliance analysis will be conducted at the outlet of the trapezoidal pond.

Once the point of compliance has been selected the element is modified on the Schematic screen to include a small box with the letter “A” (for Analysis) in the lower right corner. This identifies the outlet from this element as a point of compliance.

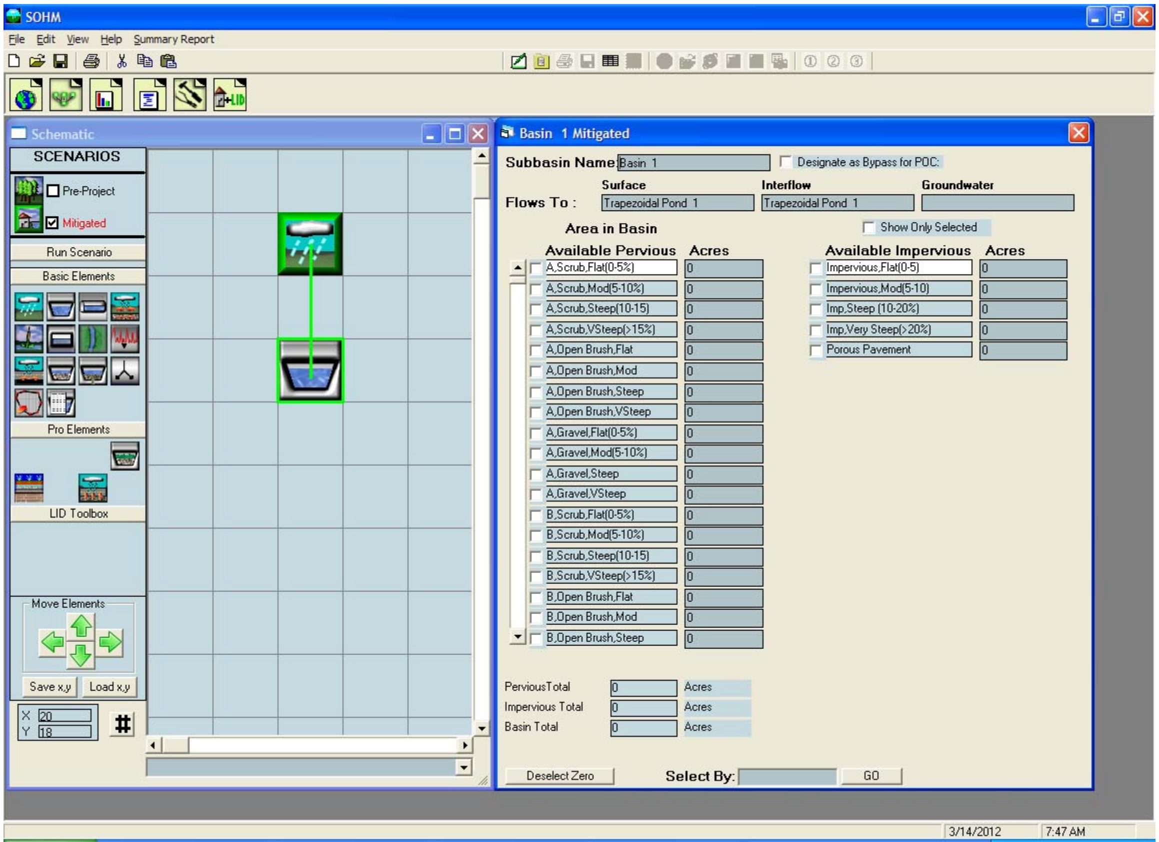
The number 1 next to the letter “A” is the number of the POC (POC 1).



CONNECTING ELEMENTS

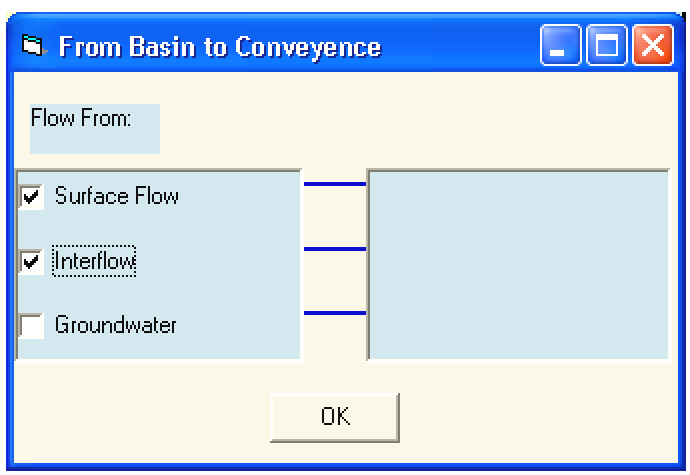


Elements are connected by right clicking on the upstream element (in this example Basin 1) and selecting and then left clicking on the Connect To Element option. By doing so SOCHM extends a line from the upstream element to wherever the user wants to connect that element.

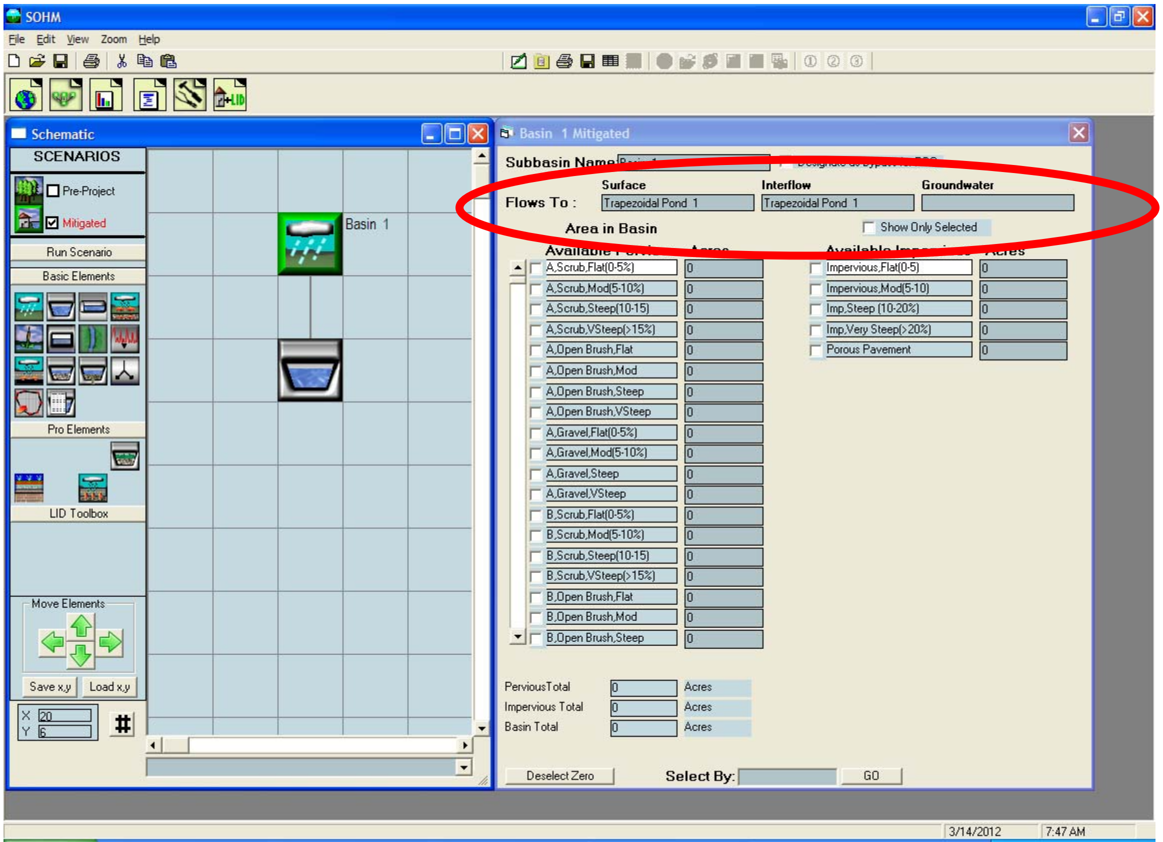


The user extends the connection line to the downstream element (in this example, a pond) and left clicks on the destination element. This action brings up the From Basin to Conveyance box that allows the user to specify which runoff components to route to the downstream element.

Stormwater runoff is defined as surface flow + interflow. Both boxes should be checked. Groundwater should not be checked for the standard land development mitigation analysis. Groundwater should only be checked when there is observed and documented base flow occurring from the upstream basin.

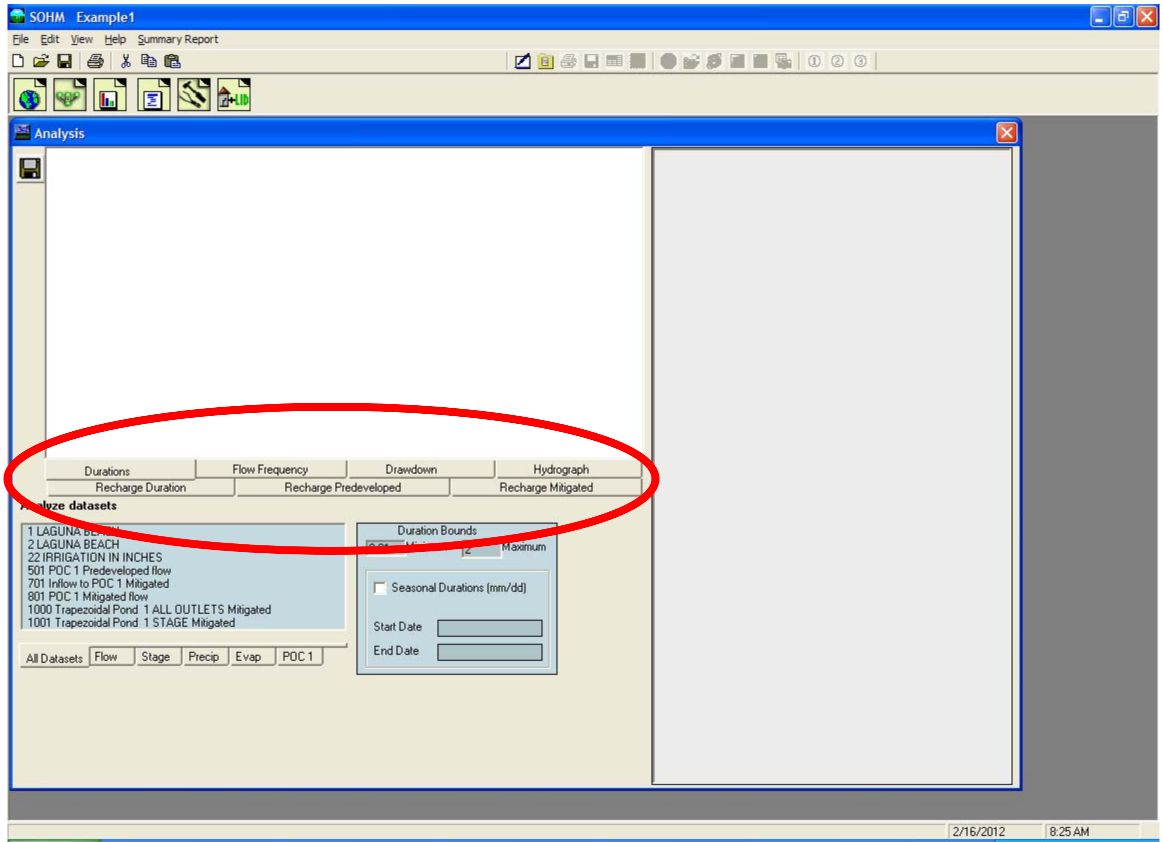


After the appropriate boxes have been checked click the OK button.



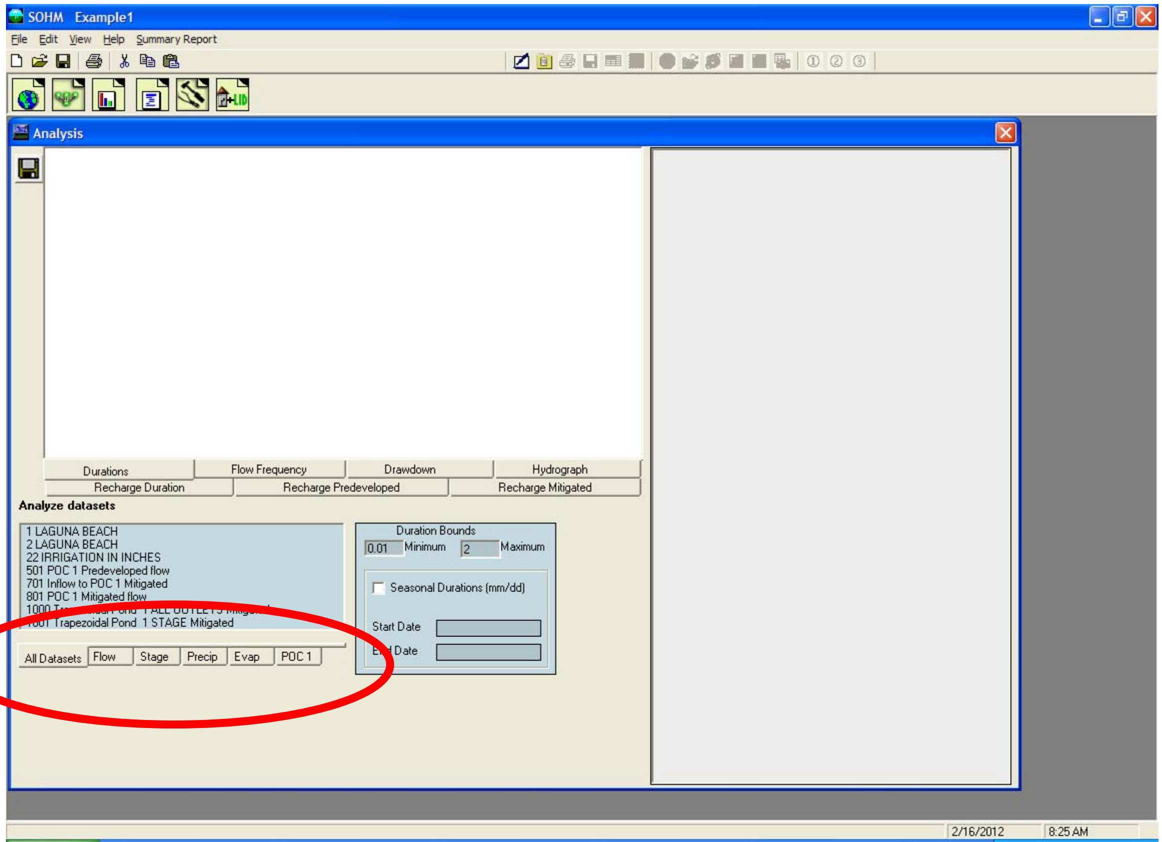
The final screen will look like the above screen. The basin information screen on the right will show that Basin 1 surface and interflow flows to Trapezoidal Pond 1 (groundwater is not connected).

ANALYSIS SCREEN



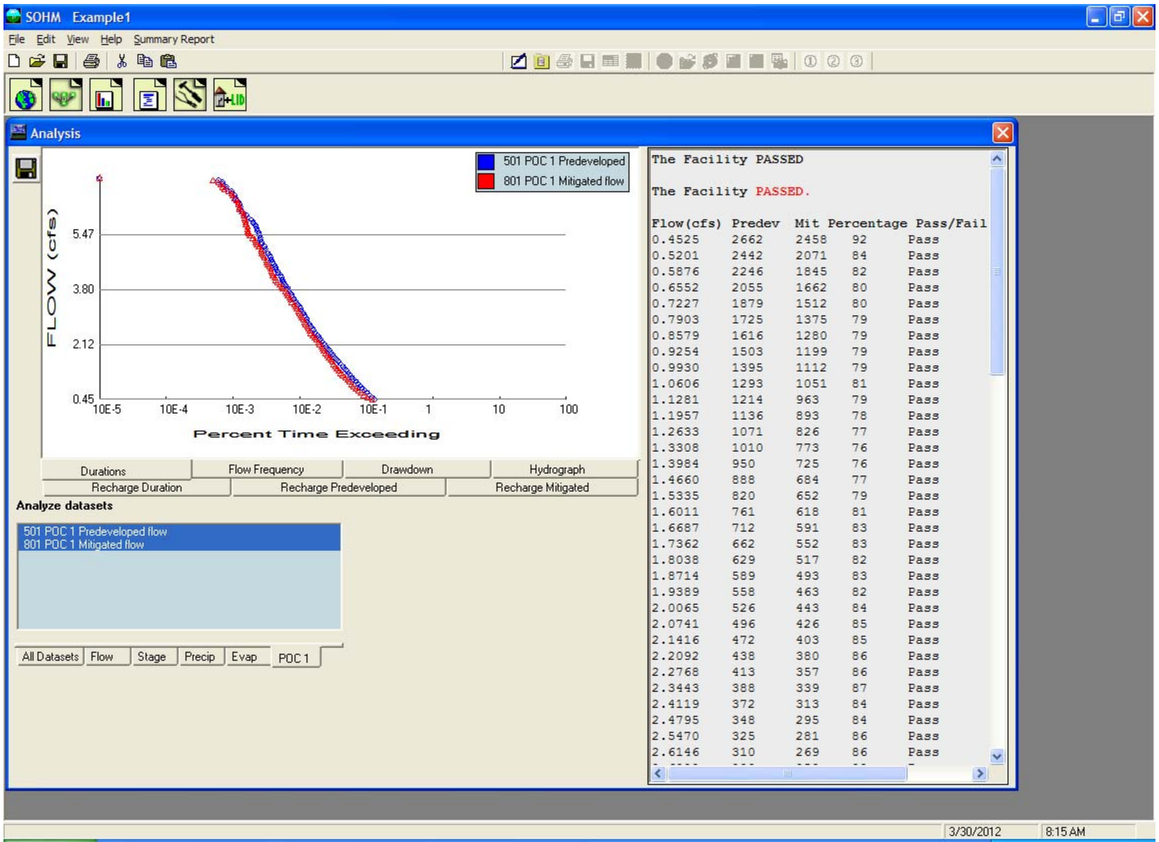
The Analysis tool bar button (third from the left) brings up the Analysis screen where the user can look at the results of the Predevelopment and Mitigated scenarios. The Analysis screen allows the user to analyze and compare flow durations, flow frequency, drawdown times, and hydrographs.

The recharge tabs are for the optional analysis of determining Predevelopment and Mitigated recharge to the groundwater.



The user can analyze all time series datasets or just flow, stage, precipitation, evaporation, or point of compliance (POC) flows by selecting the appropriate tab below the list of the different datasets available for analysis.

FLOW DURATION



Flow duration at the point of compliance (POC 1) is the most common analysis. A plot of the flow duration values is shown on the left, the flow values on the right.

The flow duration flow range is from the lower threshold flow frequency value (10% of the 2-year value) to the upper threshold flow frequency value (10-year value). As shown in the flow duration table to the right of the flow duration curves, this flow range is divided into approximately 100 levels (flow values).

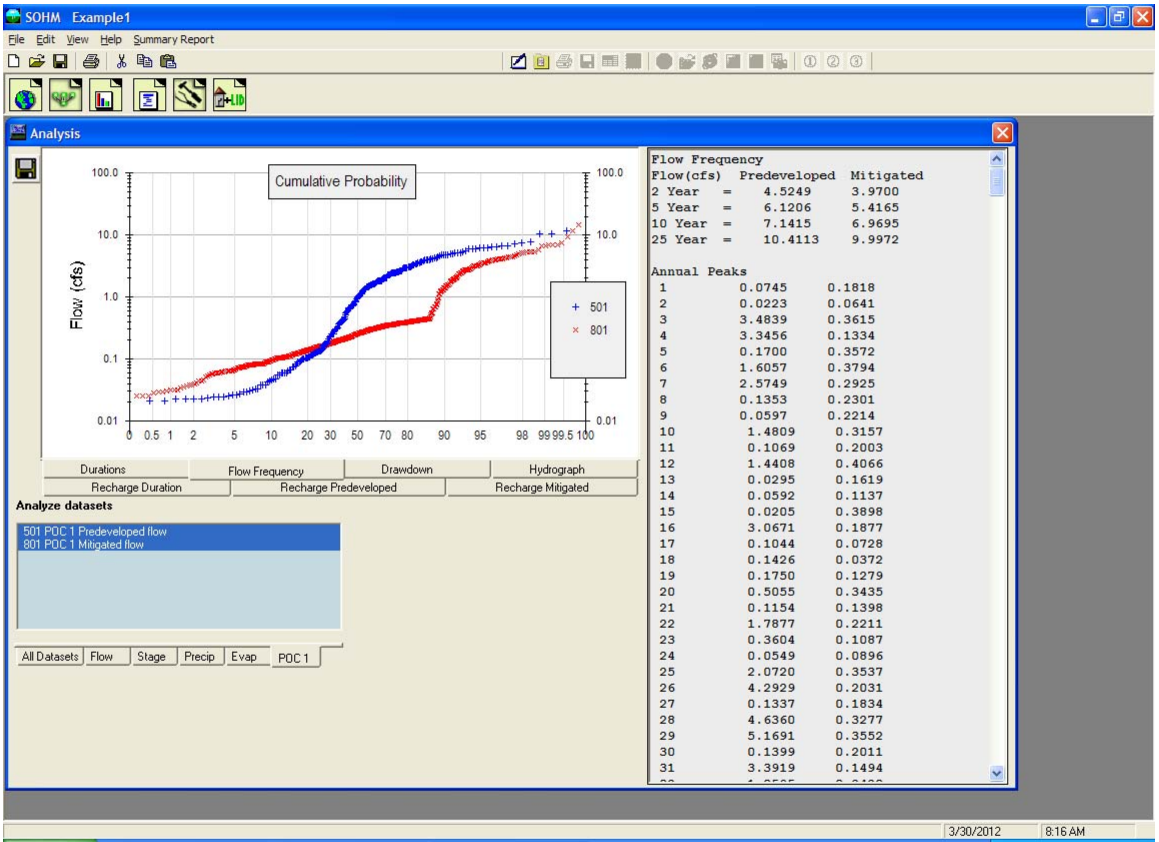
The division of the flow range into a large number of levels is important to make sure that the erosive flows do not increase between the lower threshold (10% of the 2-year flow) and the 2-year flow frequency value and between increasing flow frequency levels (3-year, 4-year, 5-year, etc.). The majority of the erosive flows occur between the 10% of the 2-year flow value and the 2-year flow frequency value. It is important to divide the flow levels in that range into multiple level steps to not miss any occasions when the mitigated flows exceed the predevelopment flows.

For each flow level/value SOCHM counts the number of times that the flow at the Point of Compliance for the Predevelopment scenario (Predev) exceeds that specific flow level/value. It does the same count for the Mitigated scenario flow (Mit). The total number of counts is the number of simulated hours that the flow exceeds that specific flow level/value.

The Percentage column is the ratio of the Dev count to the Predev count. This ratio must be less than or equal to 100% for flow levels/values between the lower threshold (10% of the 2-year flow) and the 5-year flow and 110% for flow levels/values between the 5-year flow and the upper threshold value.

If the percentage value does not exceed this maximum ratio (100% for the lower threshold to the 5-year flow value and 110% for the 5-year flow value to the 10-year value) then the Pass/Fail column shows a Pass for that flow level. If they are exceeded then a Fail is shown. A single Fail and the facility fails the flow duration criteria. The facility overall Pass/Fail is listed at the top of the flow duration table.

FLOW FREQUENCY



Flow frequency plots are shown on the left and the 2-, 5-, 10-, and 25-year frequency values are on the right. Flow frequency calculations are based on selecting partial duration flow values and ranking them by their Cunnane Plotting Position.

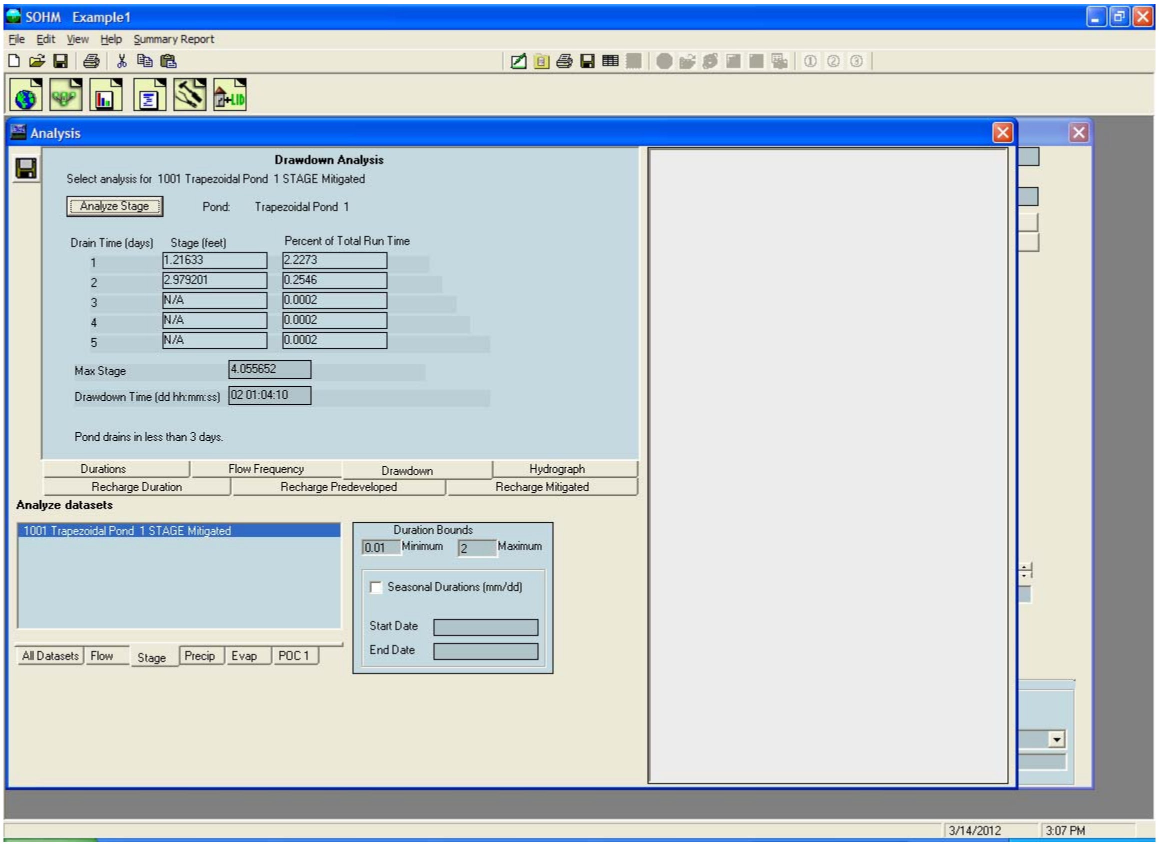
The Cunnane Plotting Position formula is:

Tr = (N+a)/(m-b) where Tr = return period (years)
m = rank (largest event, m = 1)
N = number of years
a = 0.2
b = 0.4

Probability = 1/Tr

The return period value, Tr, is used in SOCHM to determine the 2-year, 5-year, 10-year, and 25-year peak flow values. If necessary, the 2-year, 5-year, 10-year, and 25-year values are interpolated from the Tr values generated by Cunnane.

DRAWDOWN



The drawdown screen is used to compute pond stages (water depths). These stages are summarized and reported in terms of drain/retention time (in days).

For this example, the maximum stage computed during the entire 40-60 year simulation period is 4.05 feet. This maximum stage has a drawdown time of 2 days, 1 hour, 4 minutes, 10 seconds (approximately 49 hours).

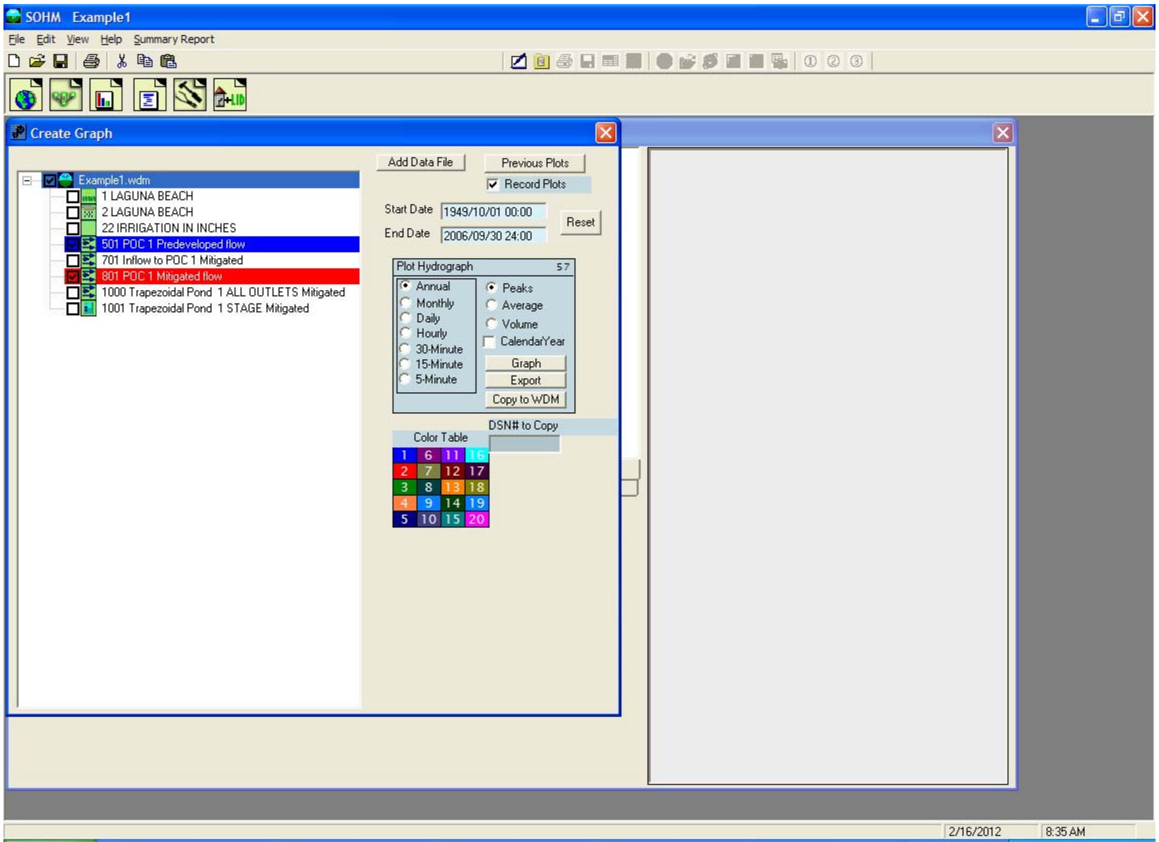
The 1-day (24-hour) drain time is needed to drain the pond when it is at a stage of 1.22 feet. This stage occurs 2.23% of the total simulation time.

The 2-day (48-hour) drain time is needed to drain the pond when it is at a stage of 2.98 feet. This stage occurs 0.25% of the total simulation time.

Ponds may have drain times in excess of the allowed maximum. This can occur when a pond has a small bottom orifice. If this is not acceptable then the user needs to change the pond outlet configuration, manually run the Mitigated scenario, and repeat the analyze stage computations. A situation may occur where it is not possible to have both an acceptable pond drawdown/ retention time and meet the flow duration criteria.

NOTE: The flow duration criteria take precedence unless the user is instructed otherwise by Appendix C or the local municipal permitting agency.

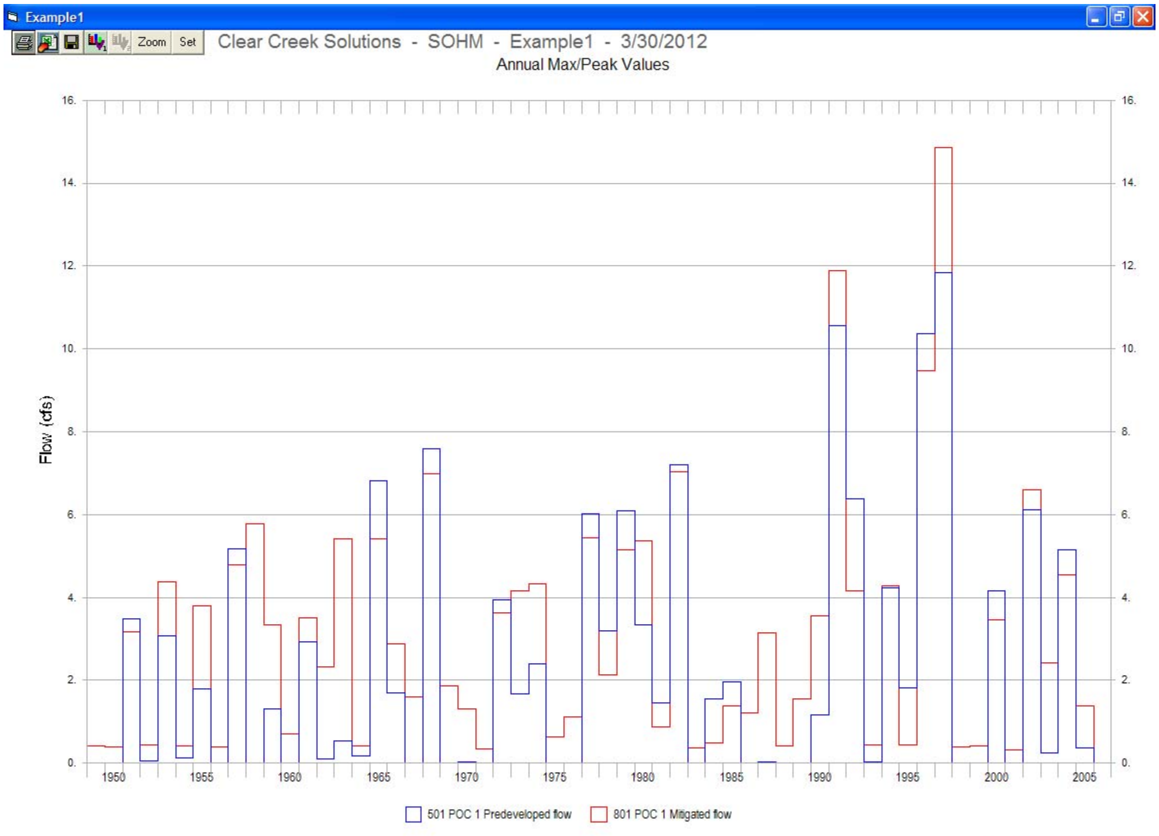
HYDROGRAPHS



The user can graph/plot any or all time series data by selecting the Hydrograph tab. The Create Graph screen is shown and the user can select the time series to plot, the time interval (yearly, monthly, daily, or 15-minute), and type of data (peaks, average, or volume).

The following numbering system is used for the flow time series:
500-599: Predevelopment flow (Predevelopment scenario)
700-799: Inflow to the POC (Mitigated runoff entering the BMP facility)
800-899: POC flow (Mitigated flow exiting the BMP facility)

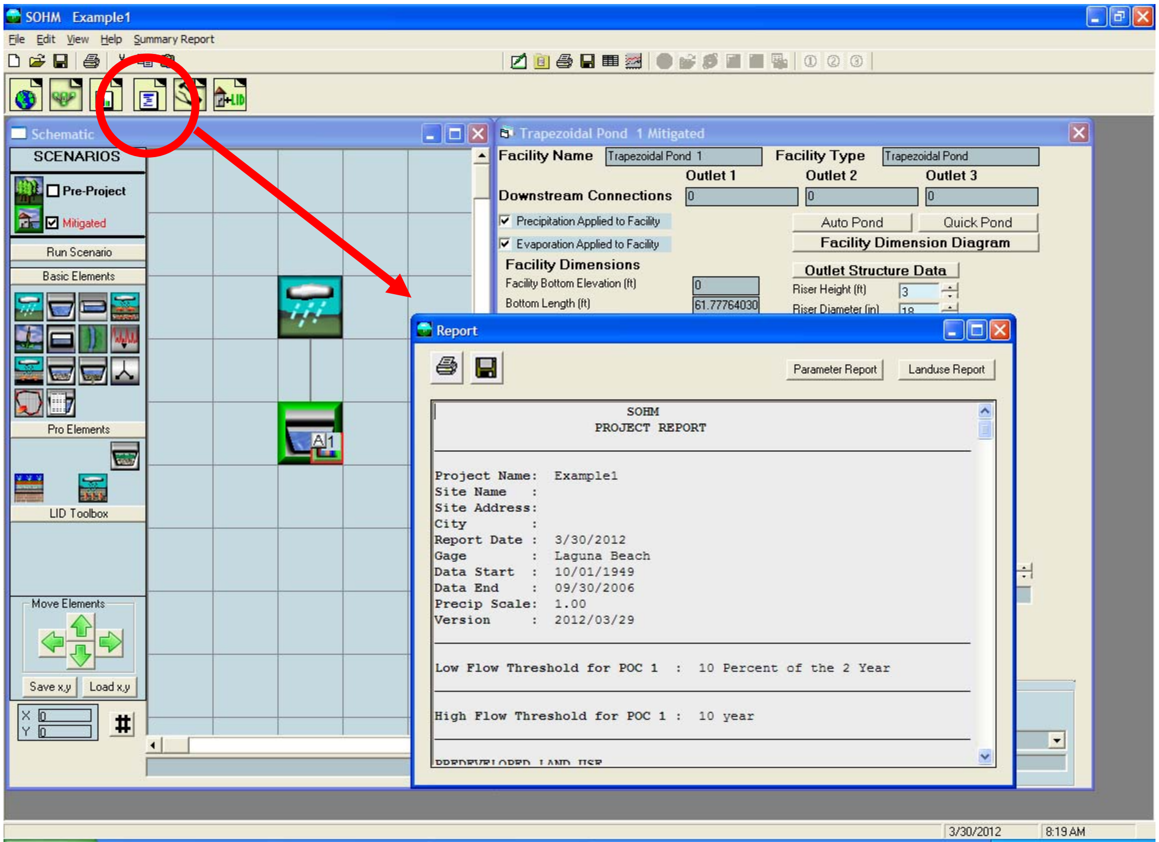
The selected time series are shown. To graph the selected time series the user clicks on the Graph button.



The hydrograph shows the yearly maximum/peak flow values for each time series for the entire simulation period (in this example, from 1949 through 2005).

The graph can be either saved or printed.

REPORTS SCREEN



The Reports tool bar button (fourth from the left) brings up the Report screen where the user can look at all of the project input and output. The project report can be saved or printed.

The project report contains the project input information provided by the user and a summary of the project output information produced by SOCHM. The saved project report file can be read by Microsoft Word or any text-editing program.

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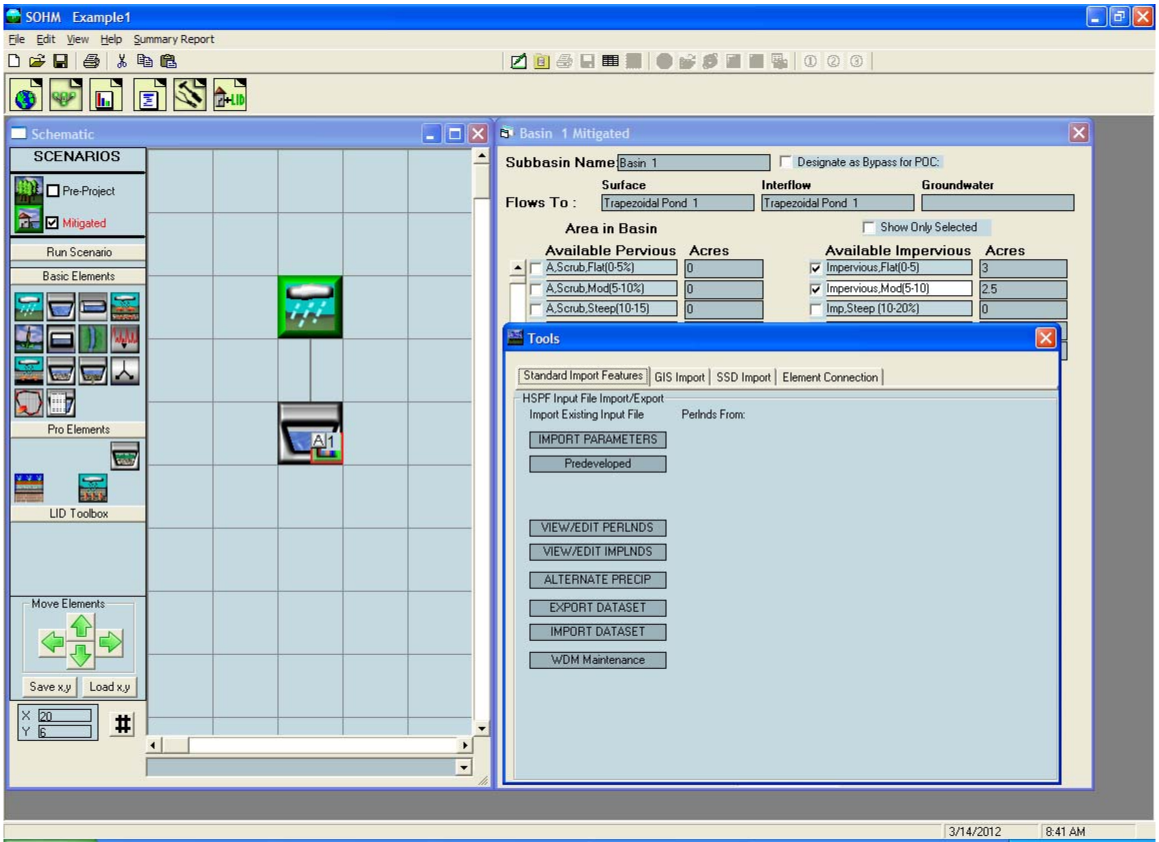
TOOLS SCREEN

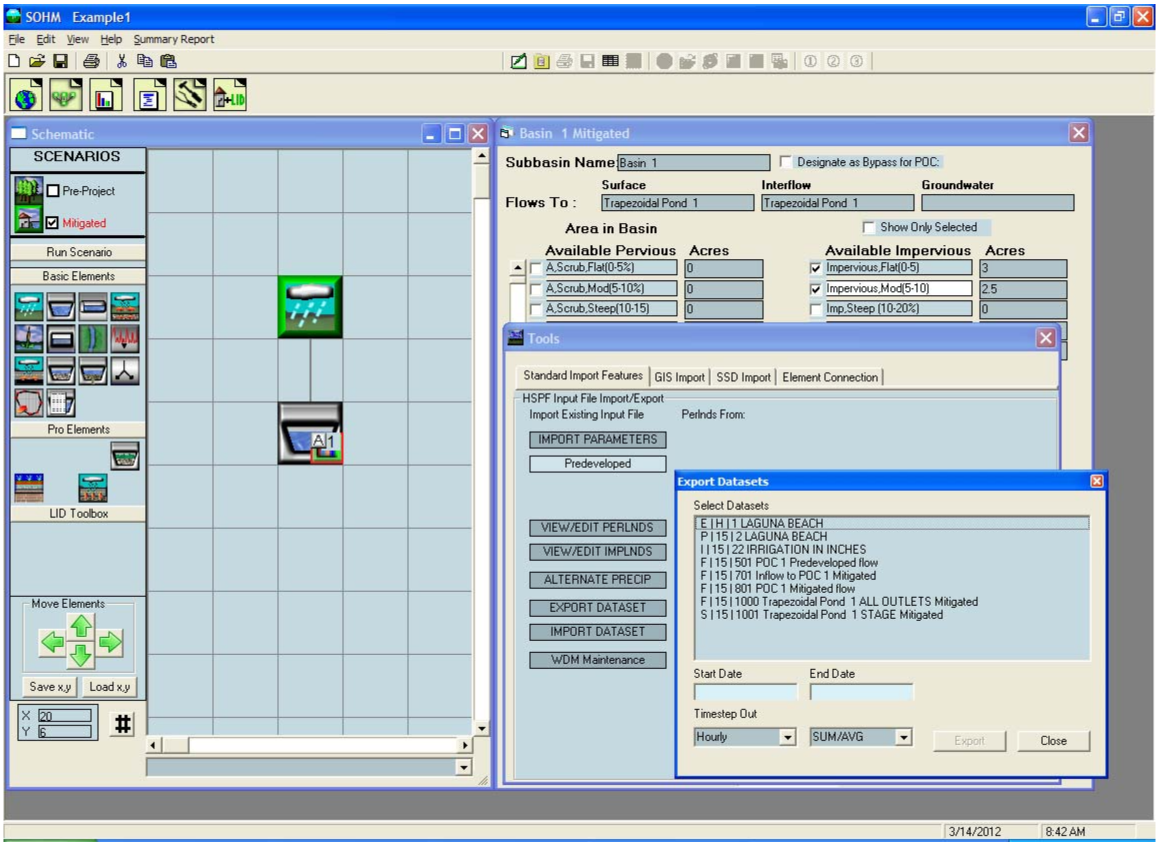


The Tools screen is accessed with the Tools tool bar (second from the right). The two purposes of the Tools screen are:

(1) To allow users to import HSPF PERLND parameter values from existing HSPF UCI files and/or view and edit SOCHM PERLND parameter values.

(2) To allow users to export time series datasets.

To export a time series dataset click on the Export Dataset box.



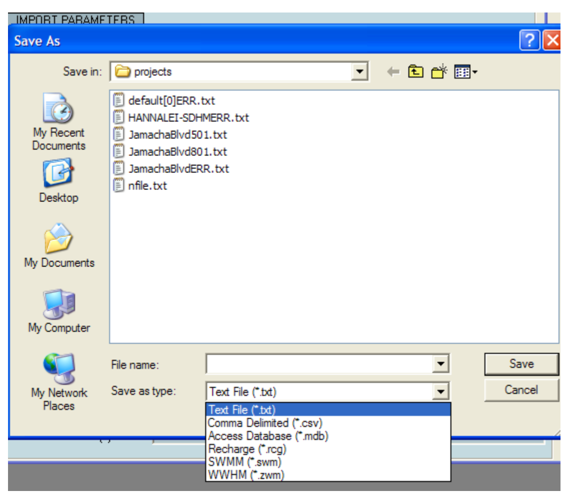
The list of available time series datasets will be shown. The user can select the start and end dates for the data they want to export.

The time step (15-minute, daily, monthly, yearly) can also be specified. If the user wants daily, monthly, or yearly data the user is given the choice of either selecting the maximum, minimum, or the sum of the 15-minute values.

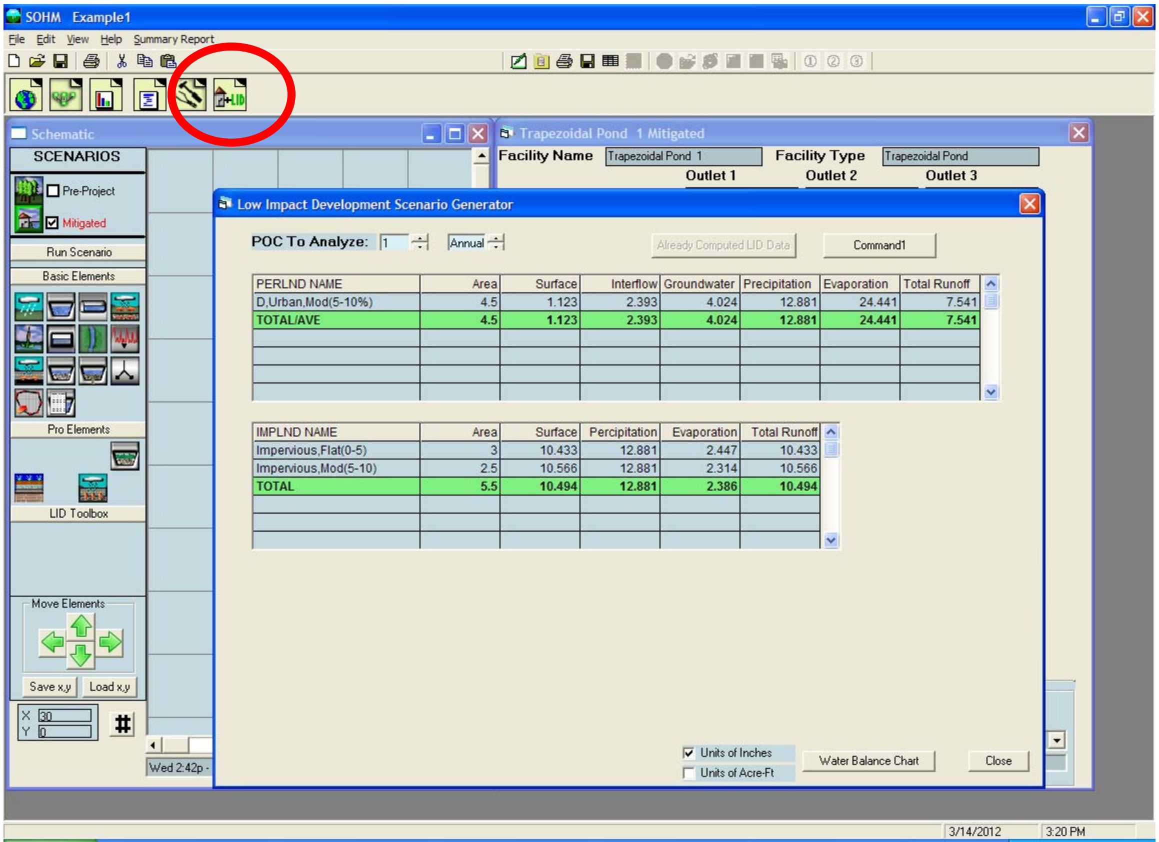
Click the Export button.

The user provides a file name and the format or type of file. The file type can be ASCII text, comma delimited, Access database, recharge, SWMM, or WWHM.

Click Save to save the exported time series file.



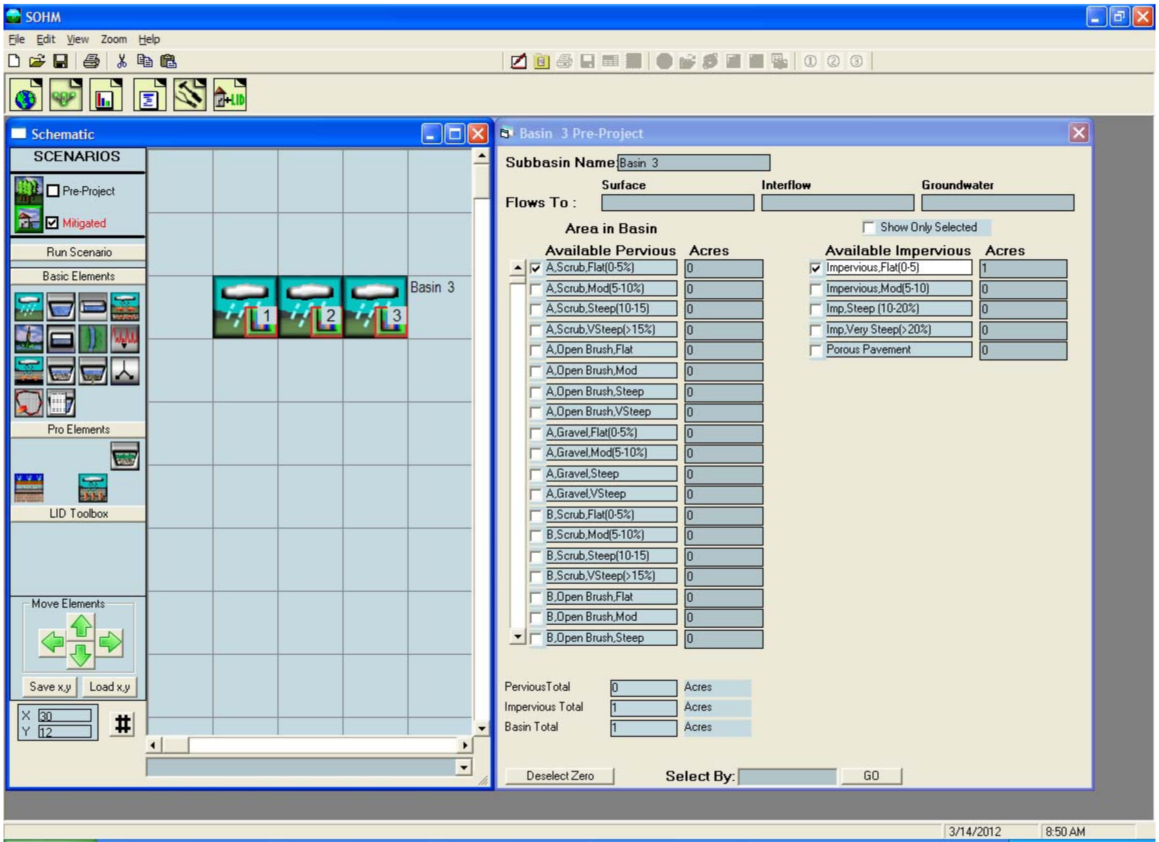
LID ANALYSIS SCREEN



The LID tool bar button (farthest on the right) brings up the Low Impact Development Scenario Generator screen.

The LID scenario generator can be used to compare the amount of runoff from different land types and combinations. The user can quickly see how changing the land use affects surface runoff, interflow, groundwater, and evapotranspiration.

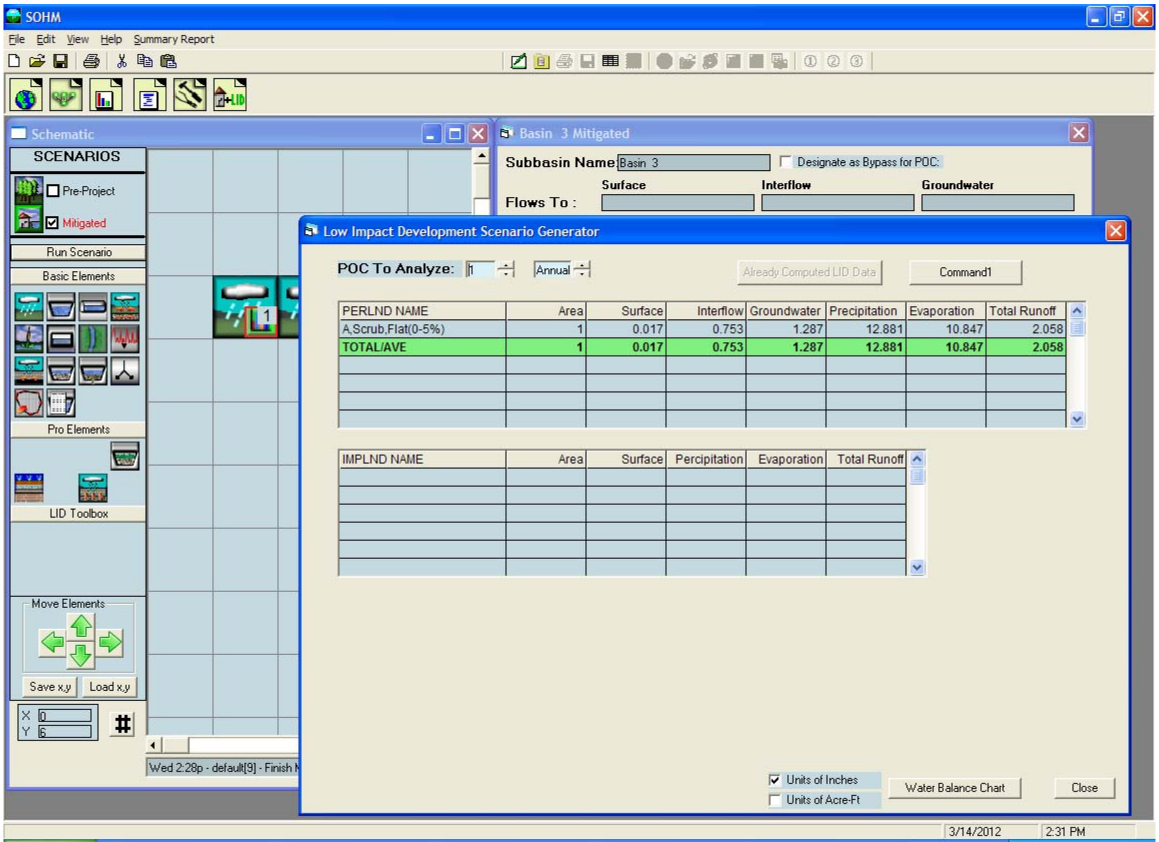
NOTE: The LID scenario generator works only in the Mitigated scenario.



The easiest way to compare different land use scenarios is to place all of them on the same Schematic Editor screen grid. Each basin can then represent a different land use scenario. Because the LID scenario generator only compares runoff volume there is no need to do any routing through a conveyance system or stormwater facility.

For this example the three basins are assigned the following land uses:
Basin 1: 1 acre A, Scrub, Flat
Basin 2: 1 acre D, Gravel, Steep
Basin 3: 1 acre Impervious, Flat

Each basin is assigned a different POC (point of compliance) for the LID analysis.



Click on the Compute LID Base Data button to generate the LID analysis data and summarize the surface runoff, interflow, groundwater, precipitation, evaporation, and total runoff for all of the basins. The results will be shown for each basin in terms of its POC.

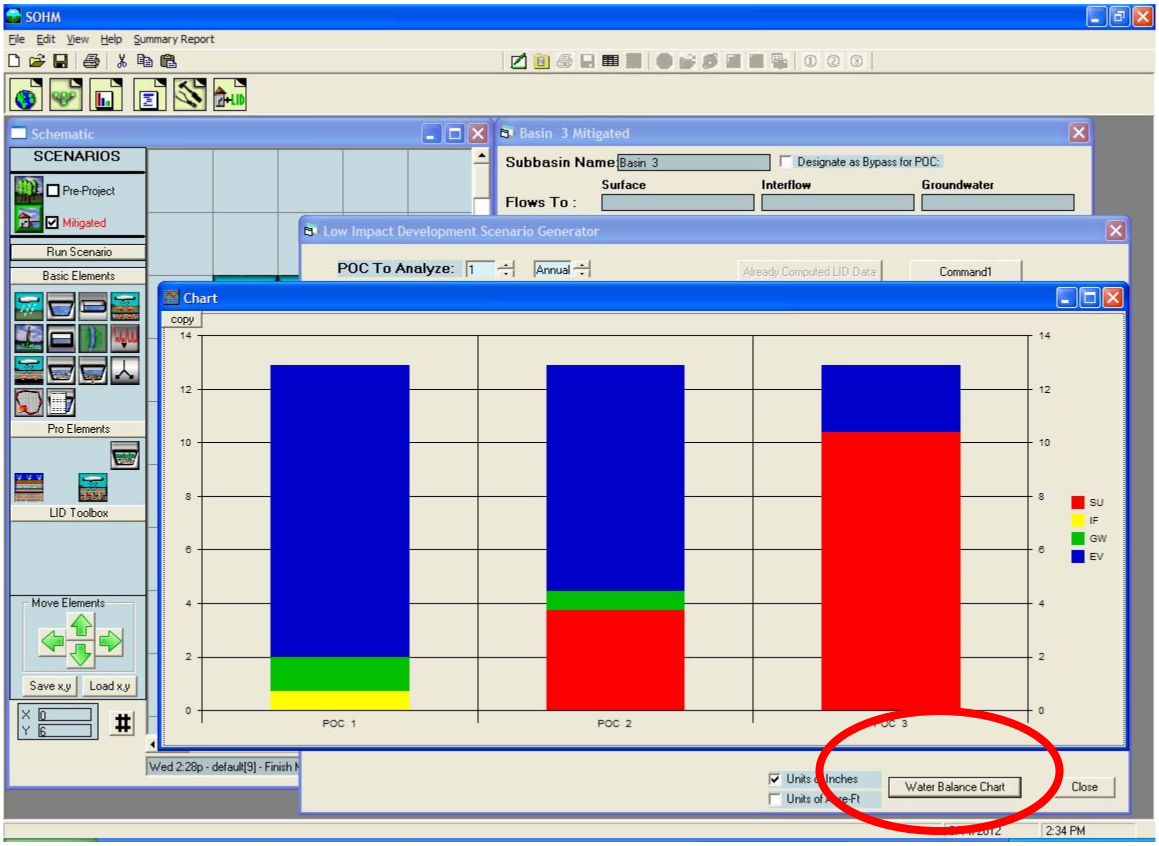
For Basin 1 (1 acre of A, Scrub, Flat) the distribution of the precipitation is:
Surface runoff = 0.017 inches per year
Interflow = 0.753 inches per year
Groundwater = 1.287 inches per year
Evaporation = 10.847 inches per year

The sum of the surface runoff + interflow + groundwater + evaporation equals 12.90 inches per year. The precipitation at this site equals 12.88 inches per year. The difference is the initial soil water storage at the start of the simulation period.

To look at the other basins click on the Select POC To arrow and select the basin of interest.

The LID analysis results can be presented in terms of either inches per year or acre-feet per year by checking the appropriate box in the lower right portion of the LID analysis screen.

To compare the different scenarios side-by-side in a graphical format click on the Display Water Balance Chart.

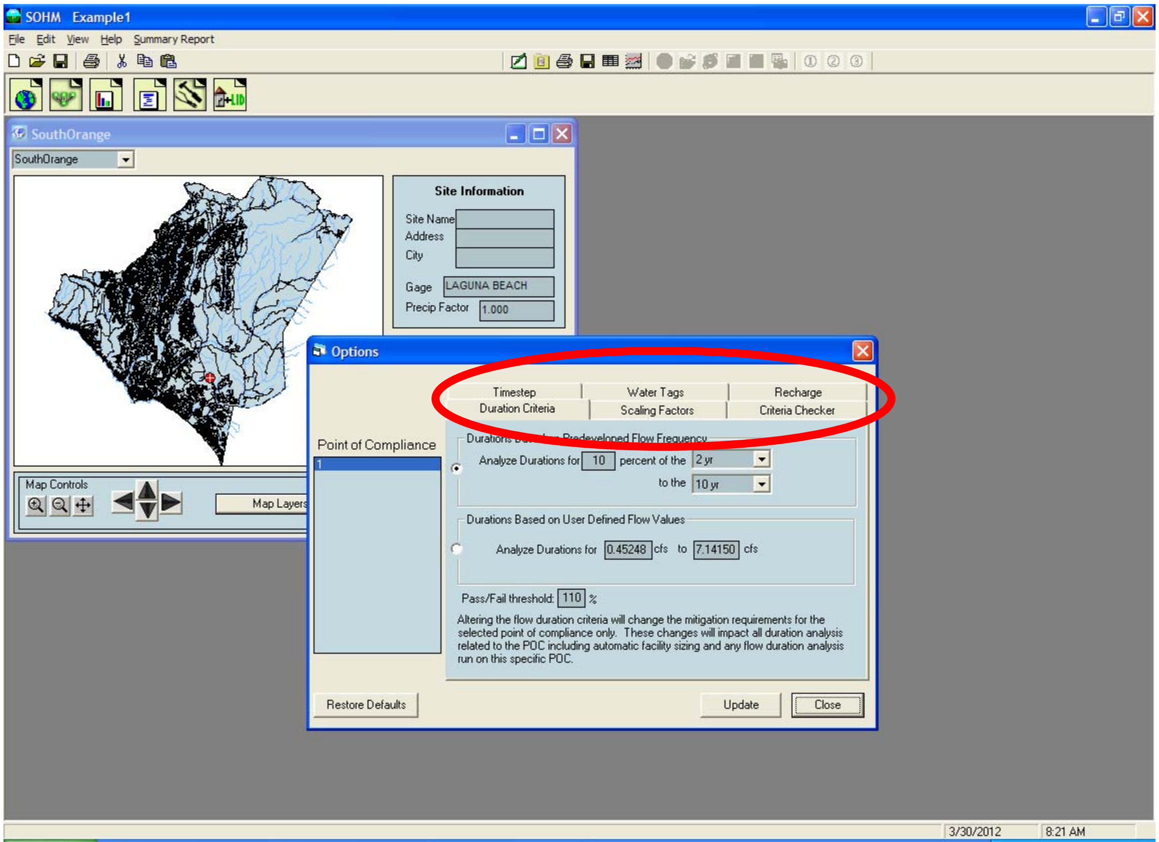


The water balance chart graphically displays the runoff distribution for all three land use scenarios side-by-side.

The bottom red is the surface runoff. Above in yellow is interflow; then green for groundwater and blue for evaporation. Basin 1 (Scenario 1) is an A soil with scrub land cover on a flat slope and produces the least amount of surface runoff and interflow (the sum of surface and interflow is the total stormwater runoff). Basin 2 is a D soil with gravel land cover on a steep slope; it produces more surface runoff and interflow than Basin 1. Basin 3 is impervious and produces the largest amount of surface runoff and interflow and the smallest amount of evaporation.

A maximum of seven scenarios can be graphed at one time.

OPTIONS



Options can be accessed by going to View, Options. This will bring up the Options screen and the ability to modify the built-in default duration criteria for flow duration matching and scaling factors for climate variables.

DURATION CRITERIA

The flow duration criteria are:

1. If the post-development flow duration values exceed any of the predevelopment flow levels between the lower threshold (10% of the two-year) and five-year predevelopment peak flow values then the flow duration standard has not been met.

2. If the post-development flow duration values exceed any of the predevelopment flow levels between the 5-year and the upper threshold (100% of the ten-year) predevelopment peak flow values more than 10 percent of the time (110 Percent Threshold) then the flow duration standard has not been met.

3. If more than 10 percent of the flow duration levels exceed the 100 percent threshold then the flow duration standard has not been met.

The duration criteria in SOCHM can be modified by the user if appropriate and the local municipal permitting agency allows (see NOTE below).

The user can conduct the duration analysis using either (1) durations based on Predevelopment flow frequency, or (2) durations based on user defined flow values.

If using durations based on Predevelopment flow frequency, the percent of the lower limit can be changed from the default of the 10% of the 2-year flow event to a higher or lower percent value. The lower and upper flow frequency limits (2-year and 10-year) also can be changed.

If using durations based on user defined flow values, click on that option and input the lower and upper flow values.

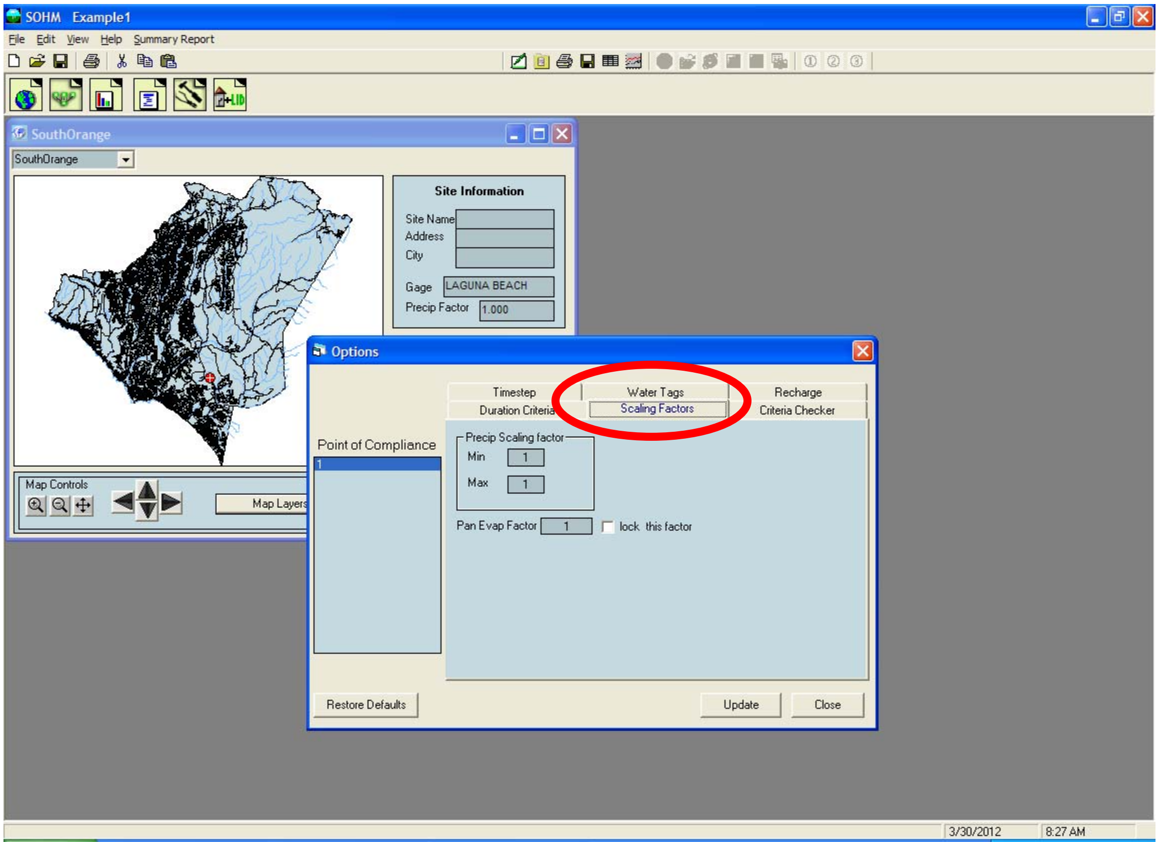
The default pass/fail threshold is 100% for the flows between 10% of the 2-year and 5-year flow. This value cannot be changed by the user.

The default pass/fail threshold is 110% for the flows between the 5-year and 10-year flow. This value can be changed by the user.

The duration criteria can be changed for a single point of compliance. Click on the Update button once all of the changes have been made. To return to the default values click on the Restore Defaults button.

NOTE: Any change(s) to the default duration criteria must be approved by the appropriate local municipal permitting agency or specified in Appendix C.

SCALING FACTORS



The user can change the scaling factors for precipitation (minimum and maximum) and pan evaporation.

NOTE: Any change in default scaling factors requires approval by the local municipal permitting agency or Appendix C.

Click on the Update button once all of the changes have been made. To return to the default values click on the Restore Defaults button.

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TIPS AND TRICKS FOR LID PRACTICES AND FACILITIES

There are many different tips and tricks that can be used to tailor SOCHM to solve different stormwater problems. This section presents only a fraction of the tricks that we and others have found and used, but it should give you a good idea of the options and flexibility built into SOCHM.

The tips and tricks show how different LID/BMPs (Low Impact Developments/Best Management Practices) can be represented by SOCHM elements.

LID/BMP practices and facilities reduce the need for and the size of stormwater control facilities. LID/BMP practices and facilities typically try to mimic the natural environment and provide source control and storage of runoff. Specific LID/BMP practices and facilities described in this section are shown in Table 1.

Table 1. LID/BMP Practices and Facilities and Equivalent SOCHM Elements

BMP Category	**BMP Title**	**SOCHM Model Element**
HSC-1	Localized on-lot infiltration	Bioretention swale
HSC-2	Impervious area dispersion	Lateral flow impervious area + Lateral flow soil basin
HSC-3	Street trees	Bioretention swale
HSC-4	Rain barrels	Storage vault
HSC-5	Green roof/brown roof	Green roof
HSC-6	Blue roof	Storage vault
INF-1	Infiltration basin	Trapezoidal pond or Irregular-shaped pond
INF-2	Infiltration trench	Gravel trench/bed
INF-3	Bioretention with no underdrain	Bioretention swale
INF-4	Bioinfiltration	Bioretention swale
INF-5	Dry well	Storage vault or Gravel trench/bed or Dry well
INF-6	Permeable pavement	Porous pavement
INF-7	Underground infiltration	Storage vault or Storage tank
HU-1	Above-ground cisterns	Storage vault
HU-2	Underground detention	Storage vault or Storage tank
BIO-1	Bioretention with underdrain	Bioretention swale
BIO-2	Vegetated swale	Bioretention swale or Natural channel or Vegetated swale
BIO-3	Vegetated filter strip	Bioretention swale or Lateral flow impervious area + Lateral flow soil basin
BIO-4	Wet detention basin	Trapezoidal pond or Irregular-shaped pond
BIO-5	Constructed wetland	Combination of elements
BIO-6	Dry extended detention basin	Trapezoidal pond or Irregular-shaped pond
BIO-7	Proprietary biotreatment	Bioretention swale or Planter box
TRT-1	Sand filter	Sand filter

TRT-2	Cartridge media filter	SSD Table
PRE-1	Hydrodynamic separation device	SSD Table
PRE-2	Catch basin insert	SSD Table

NOTE: Many of these LID/BMP practices and facilities rely on infiltration into native soils. See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of an infiltration reduction factor, where appropriate.

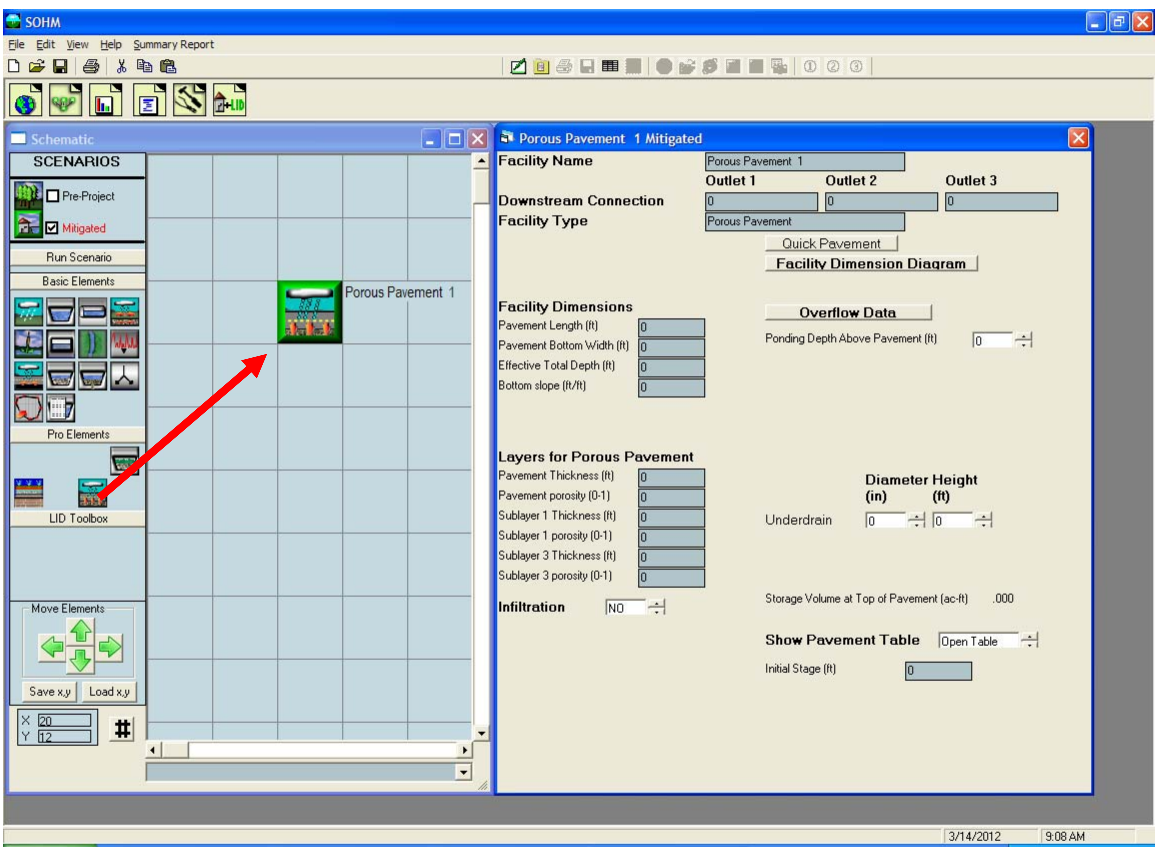
PERMEABLE PAVEMENT

Permeable pavement LID options include porous asphalt or concrete and grid/lattice systems (non-concrete) and paving blocks. The use of any of these LID options requires that certain minimum standards and requirements are met related to subgrade, geotextile material, separation or bottom filter layer, base material, wearing layer, drainage conveyance, acceptance testing, and surface maintenance.

NOTE: Permeable pavement can be used in place of conventional pavement for roadways, sidewalks, driveways, and parking lots. Check with Appendix C or the local municipal permitting agency to find out under what conditions permeable pavement is allowed.

Permeable pavement can be represented by the porous pavement element in SOCHM if the following three conditions are met:

1. The infiltration rate of the permeable pavement is greater than the peak rainfall rate.
2. The infiltration rate of the permeable pavement is greater than the underlying native soil.
3. There is subgrade layer of crushed rock/gravel between the permeable pavement and the native soil.



The porous pavement dimensions and parameters are:

Pavement Length (ft): Roadway length.
Pavement Bottom Width (ft): Roadway width.
Effective Total Depth (ft): Height from bottom of permeable pavement subgrade to top of pavement plus at least 0.5 feet extra.
Bottom Slope (ft/ft): Roadway slope or grade.
Pavement Thickness (ft): Permeable pavement layer depth.
Pavement Porosity: Permeable pavement porosity.
Sublayer 1 Thickness (ft): Subgrade gravel layer depth.
Sublayer 1 Porosity: Subgrade gravel porosity.
Sublayer 3 Thickness (ft): Sand layer depth (if appropriate).
Sublayer 3 Porosity: Sand porosity.
Ponding Depth above Pavement (ft): Height at which surface runoff occurs.

NOTE: Check with Appendix C or the local municipal permitting agency to find out if ponding on the surface of the pavement is allowed.

Underdrain Diameter (inches) and Height (feet) above bottom layer-native soil interface. The underdrain is optional.

Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).

If infiltration is used then the user should consult the Infiltration discussion on page 69.

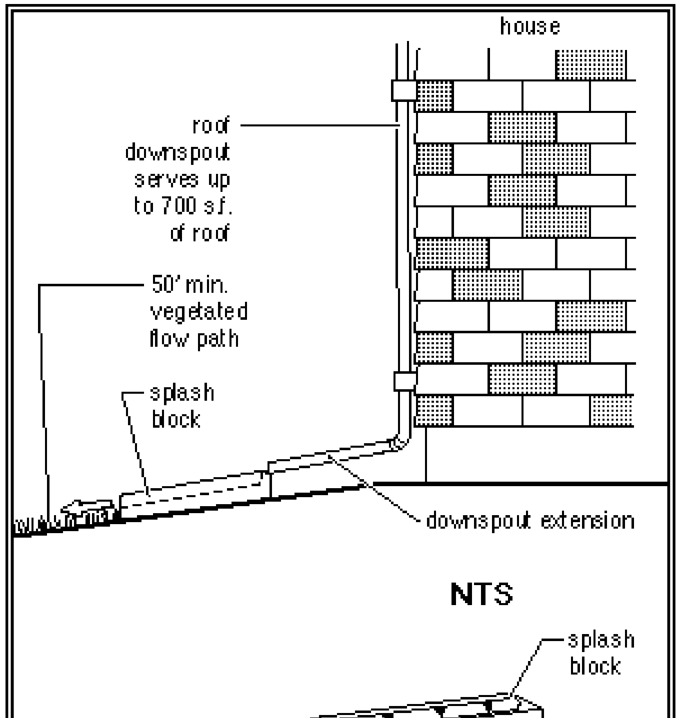
NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

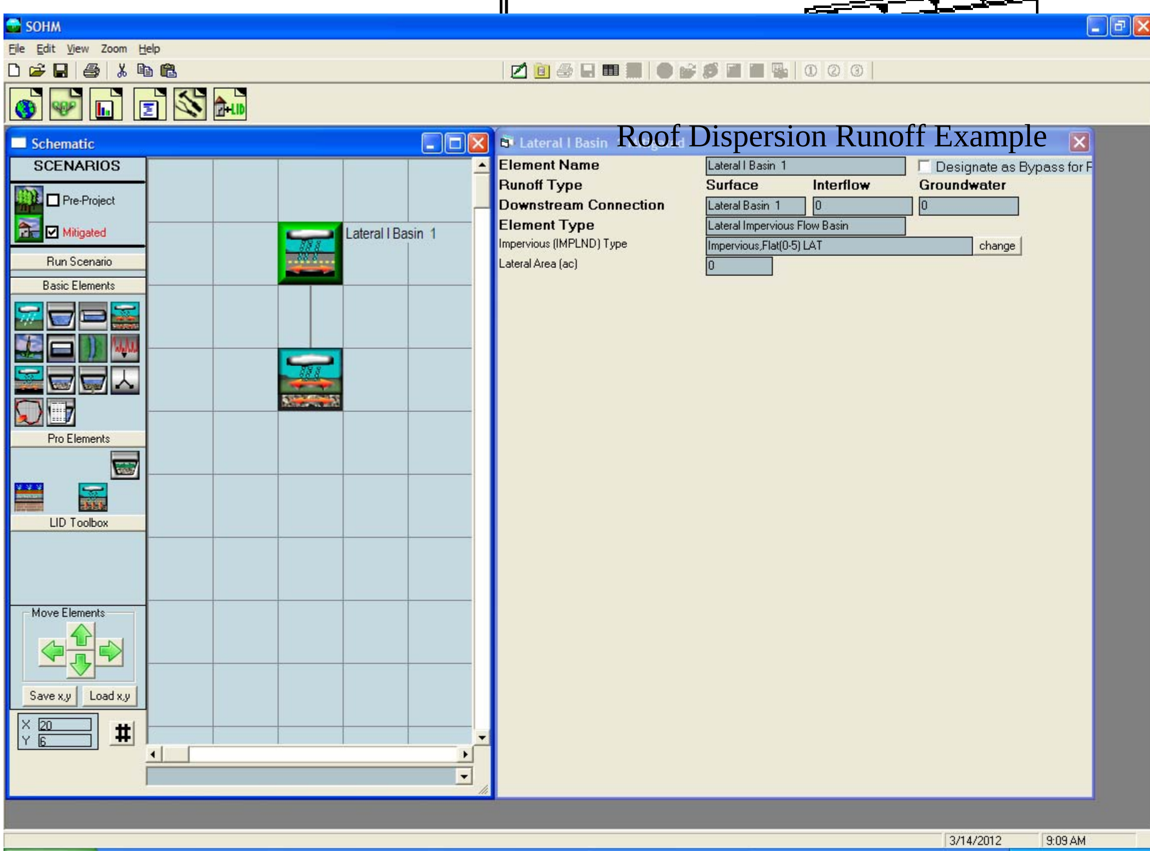
DISPERSION

LID Dispersion practices can include roof runoff dispersion onto adjacent yard area, parking lot runoff onto adjacent lawn area, and reverse slope sidewalks draining onto adjacent vegetated areas.

NOTE: Specific minimum requirements and standards must be met to allow dispersion (see Appendix C and the local municipal permitting agency for details).

Dispersion is represented in SOCHM with lateral flow basin elements.





Roof Dispersion Runoff Example

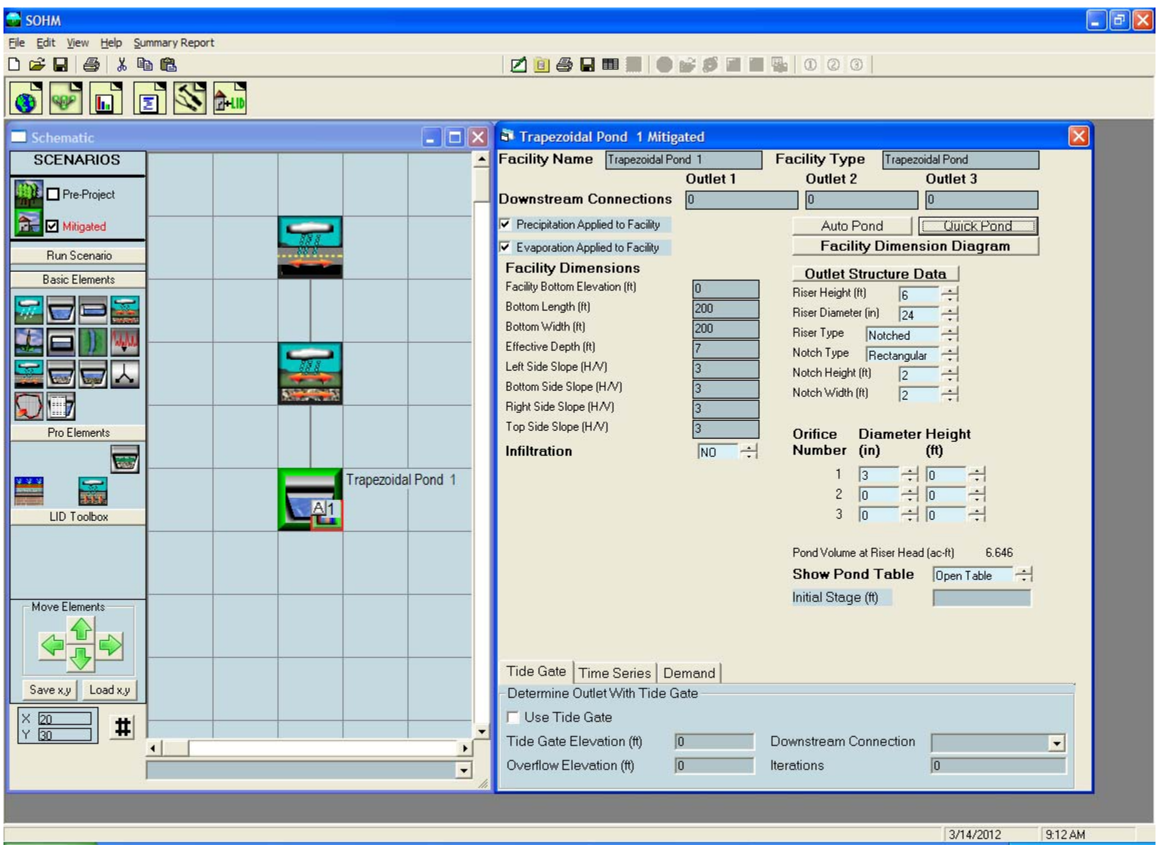
The impervious lateral basin (Lateral I Basin 1 in the above scenario) is connected to the pervious lateral basin (Lateral Basin 1). All of the runoff generated by impervious roof Lateral I Basin 1 is distributed onto pervious urban Lateral Basin 1 before routing to a stormwater control facility (pond, vault, etc.).

The lateral basin dimensions and parameters to adjust to represent dispersion are:

Impervious (IMPLND) type: select flat or moderate slope.

Soil (PERLND) type: select one of the 40 different pervious land types based on soil, land cover, and slope. A and B soils will provide more dispersion benefits than C or D soils because of their ability to infiltrate more runoff.

Lateral Area: size of contributing or receiving area (acres).

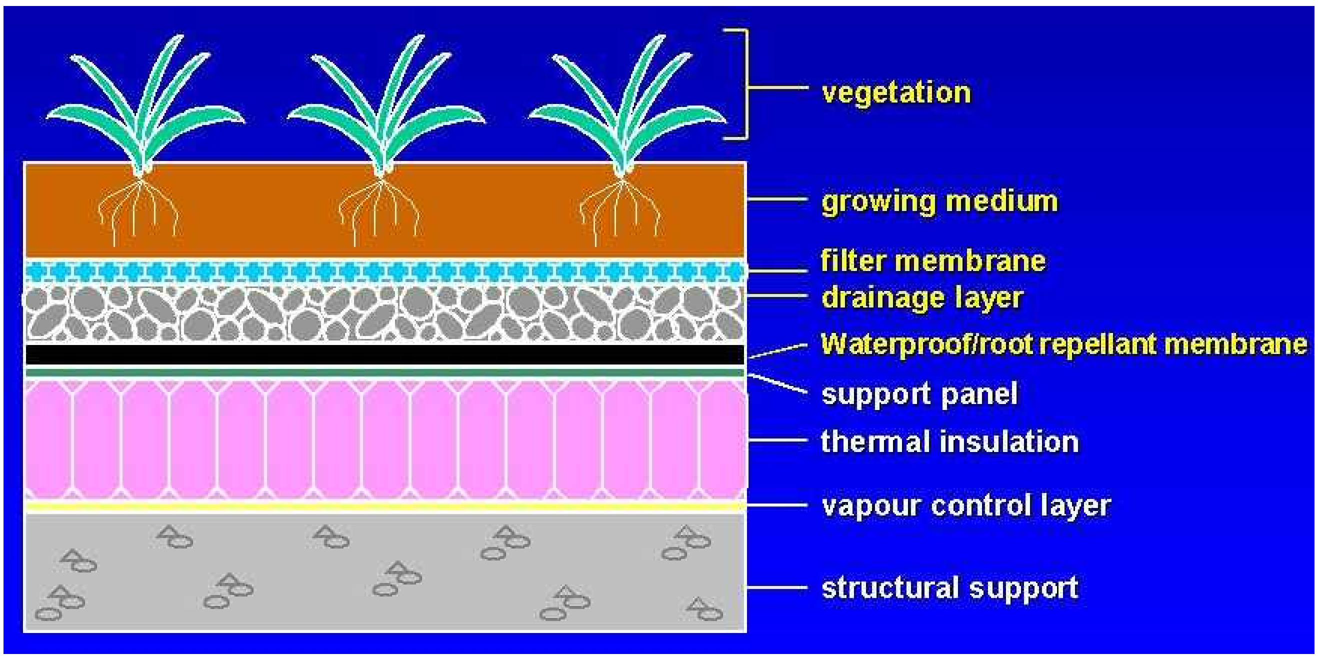


Dispersion will decrease the total runoff, but probably will not totally eliminate the need for a stormwater control facility. A pond can be connected to the discharge from the pervious lateral basin to provide the final required mitigation.

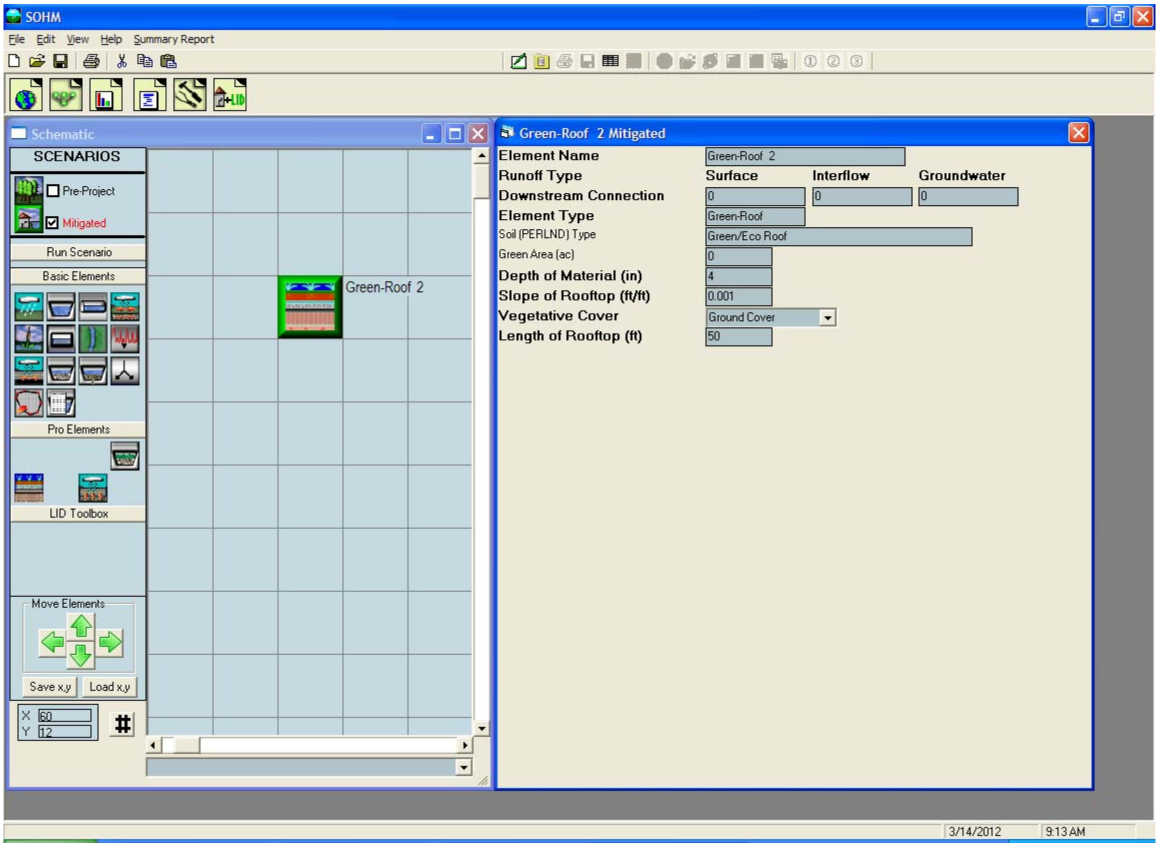
GREEN ROOF

A green roof is roof covered with vegetation and a growing medium (typically an engineered soil mix). Green roofs are not always green and are also known as vegetated roofs or eco-roofs.

The advantage of a green roof is its ability to store some runoff on the plants' surfaces and in the growing medium. Evapotranspiration by the plants and growing medium reduces the total runoff. Runoff movement through the growing medium slows down the runoff and reduces peak discharge during storm events.



A green roof is represented by the green roof element.



The dimensions and parameters to represent a green roof are:

Green Area (ac): Green roof area.
Depth of Material (in): Depth or thickness of soil/growing medium on top of roof.
Slope of Rooftop (ft/ft): Slope of roof in the direction of surface flow.
Vegetative Cover: ground cover, shrubs, or trees.
Length of Rooftop (ft): Maximum distance runoff travels to a roof drain.

RAINWATER HARVESTING

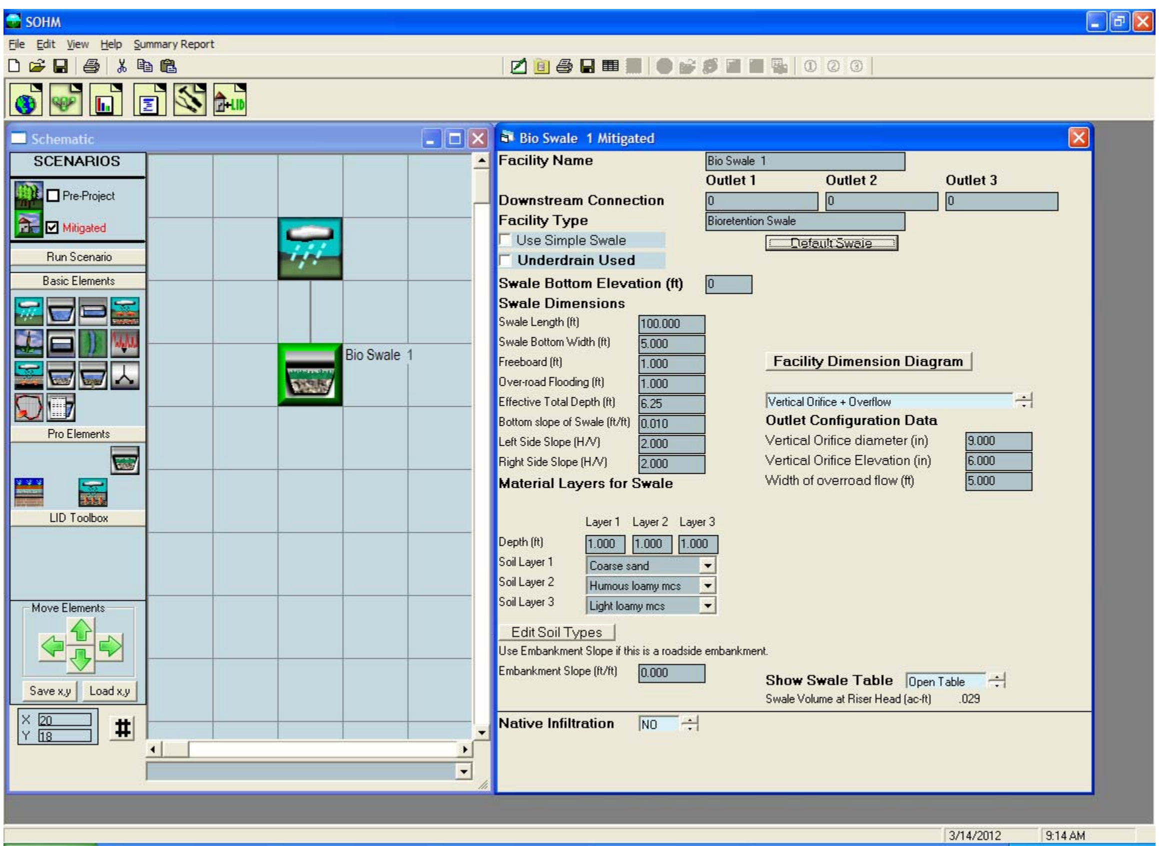
Rainwater harvesting involves water collection, storage, and reuse for residential outdoor use. The LID credit is pretty simple: the drainage area for which there is 100% capture does not have to be included in the SOCHM Mitigated land use scenario.

RAIN GARDEN

A rain garden is another name for a bioretention swale (also called a landscape swale). The rain garden is a depression partially filled with top or amended soil over the native soil. The top soil provides biofiltering and water storage.

Water is allowed to infiltrate into the native soil underlying the top soil of the bioretention area if the native soils have sufficient infiltration capacity. Stormwater enters the rain garden above ground and then infiltrate through the soil layers. An underdrain discharge pipe is optional.

In SOCHM the rain garden is represented by the bioretention swale element. If the native soil is an A or B soil then no underdrain is needed; if the soil is a C or D soil then an underdrain should be included.



The bioretention swale dimensions and parameters to adjust to represent rain garden are described on page 83.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

No underdrain should be used for A or B soils; there is no native infiltration should be included for C or D soils.

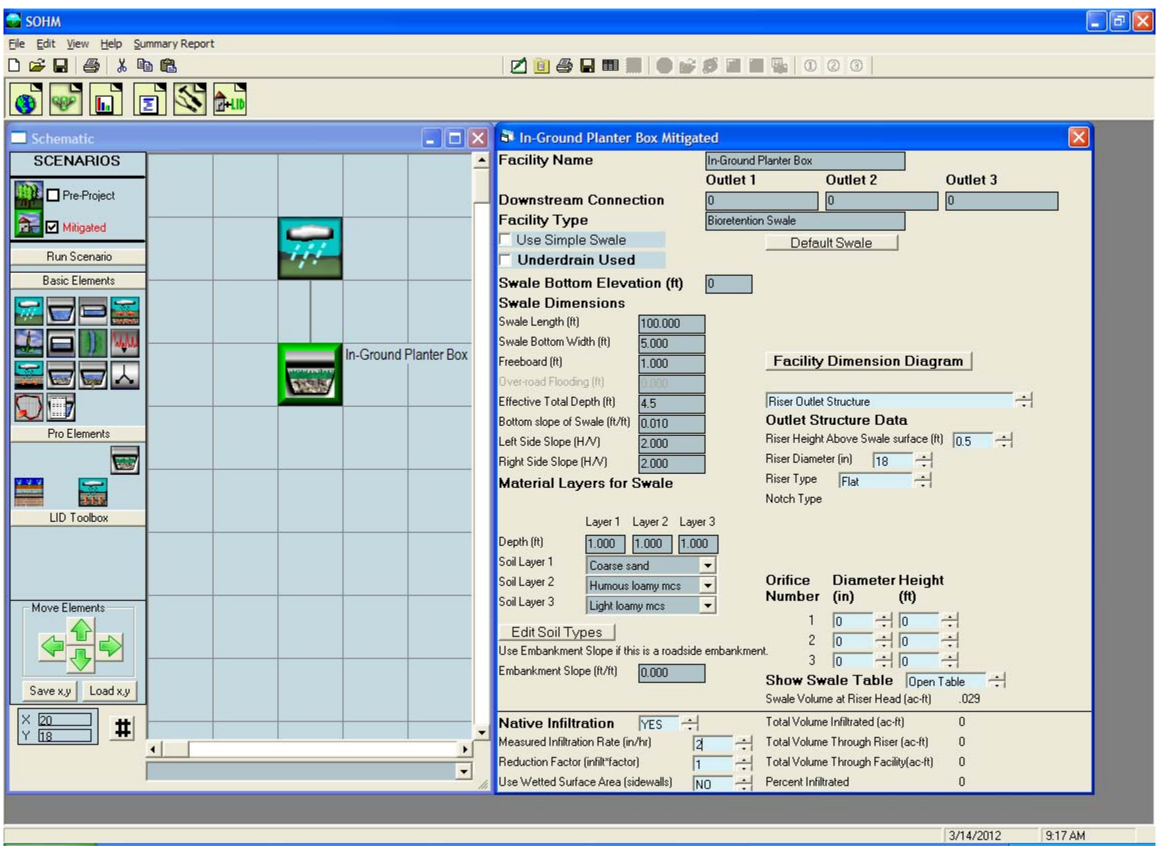
IN-GROUND (INFILTRATION) PLANTER

An in-ground planter allows stormwater to enter the planter above ground and then infiltrate through the soil and gravel storage layers before exiting through a discharge pipe. Water can also infiltrate into the native soil beneath the planter.

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.

In-Ground (Infiltration) Planter

In SOCHM the in-ground planter is represented by the bioretention swale element.



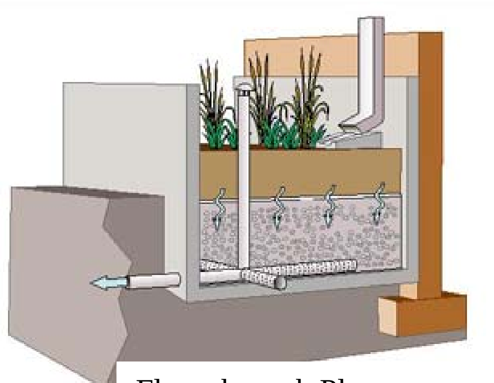
The bioretention swale dimensions and parameters to adjust to represent an in-ground (infiltration) planter are discussed on page 83.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

FLOW-THROUGH PLANTER

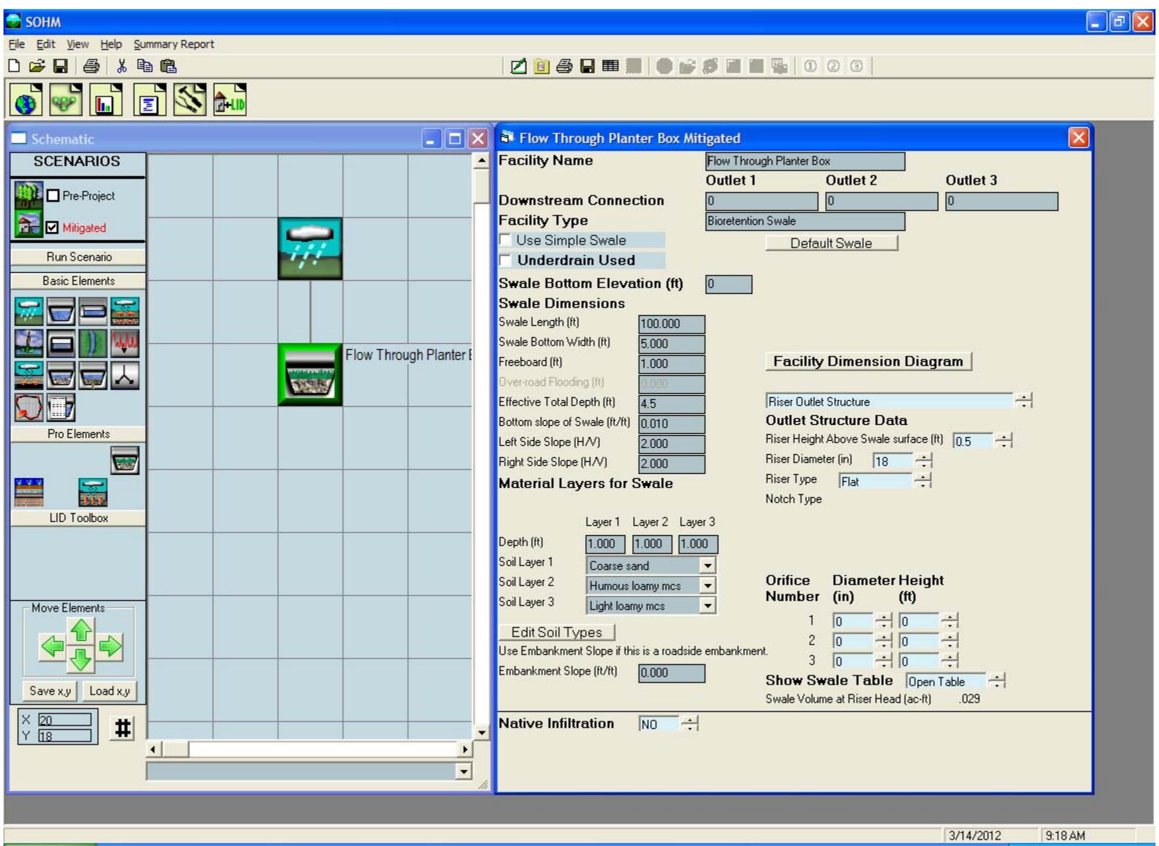
A flow-through planter is similar to the in-ground (infiltration) planter, except that water is not allowed to infiltrate into the native soil underlying the gravel layer of the planter. This is due to the native soil having poor infiltration capacity. As with the in-ground planter, stormwater enters the planter above ground and then infiltrate through the soil and gravel storage layers before exiting through a discharge pipe.



Flow-through Planter

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.

In SOCHM the flow-through planter is represented by the bioretention swale element.



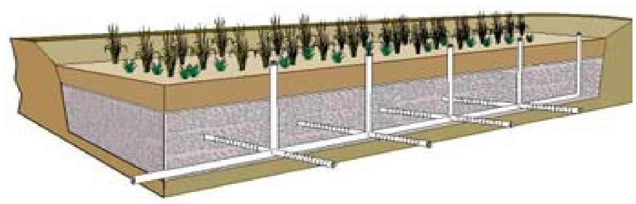
The bioretention swale dimensions and parameters to adjust to represent a flow-through planter are discussed on page 83.

Native Infiltration: No (no infiltration into the underlying native soil)

The only difference between an in-ground (infiltration) planter and a flow-through planter is whether or not native infiltration is included.

BIORETENTION AREA

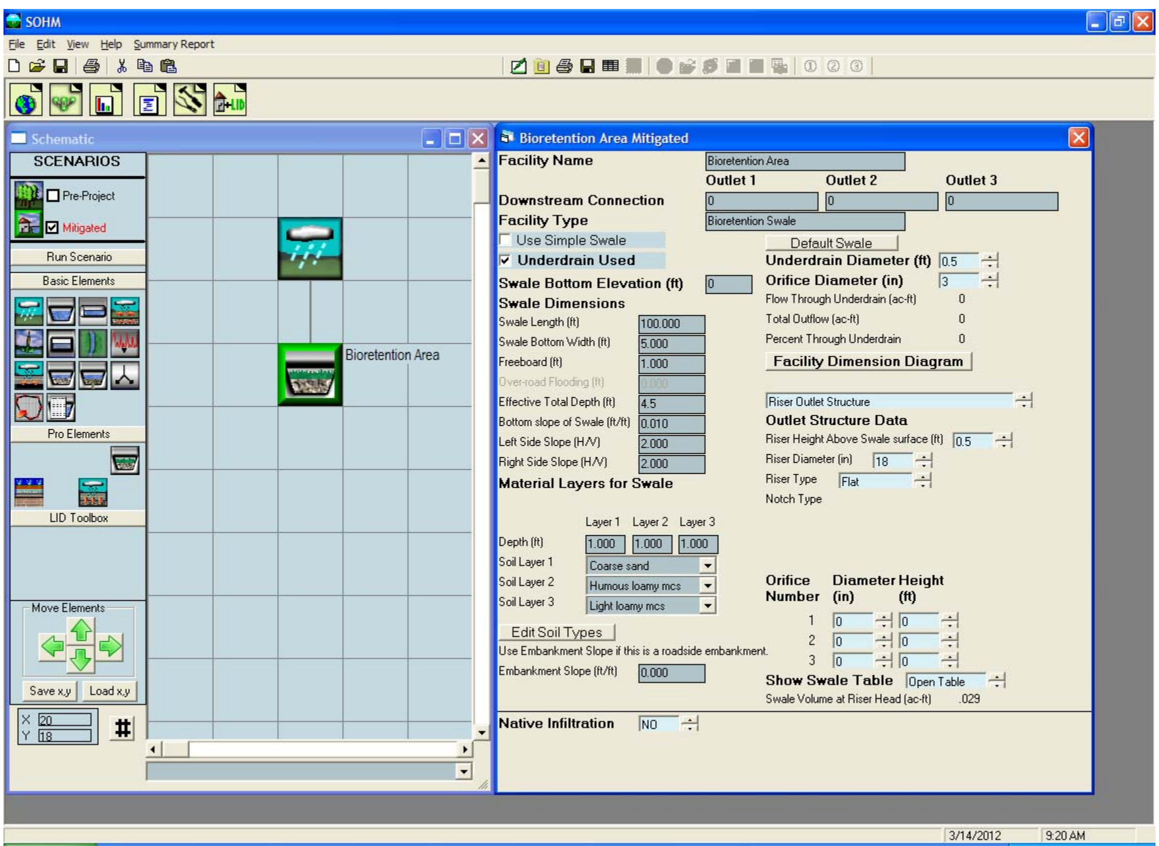
A bioretention is similar to the in-ground (infiltration) planter. Water is allowed to infiltrate into the native soil underlying the gravel layer of the bioretention area if the native soils have sufficient infiltration capacity. As with the in-ground planter, stormwater enters the planter above ground and then infiltrate through the soil and gravel storage layers before exiting through an underdrain discharge pipe.



Bioretention Area

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.

In SOCHM the bioretention area is represented by the bioretention swale element. If the native soil is an A or B soil then no underdrain is needed; if the soil is a C or D soil then an underdrain should be included.



The bioretention swale dimensions and parameters to adjust to represent bioretention area are discussed on page 83.

Native Infiltration: Yes if A or B soil (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).

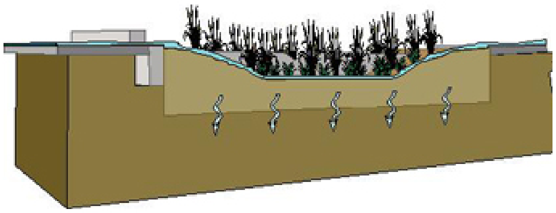
If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

There is no underdrain for A or B soils; there is no native infiltration for C or D soils.

VEGETATED OR GRASSY (DRY) SWALE

A vegetated or grassy (dry) swale is similar to the bioretention area. The major difference between a vegetated swale and a bioretention area is that when the vegetated swale overflows it produces surface runoff via weir flow out of the swale; a bioretention area discharges to an overflow pipe instead.

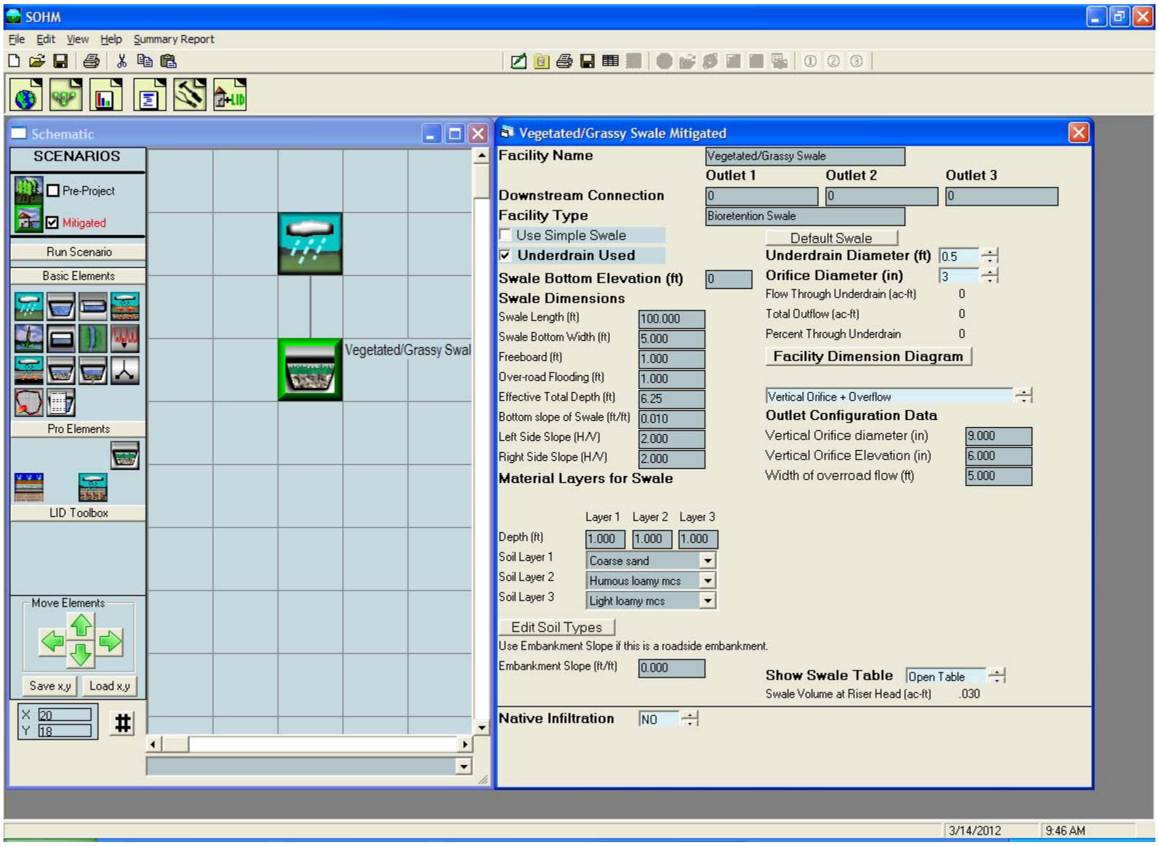


Vegetated or Grassy (Dry) Swale

If the swale is on A or B soils then there is no bottom discharge pipe or underdrain. Water must infiltrate into the native soil underlying the vegetated swale. The native soil must have sufficient infiltration capacity to infiltrate all of the stormwater.

If the swale is on C or D soils then an underdrain must be used.

In SOCHM the vegetated or grassy (dry) swale can be represented by the bioretention swale element or the channel element.



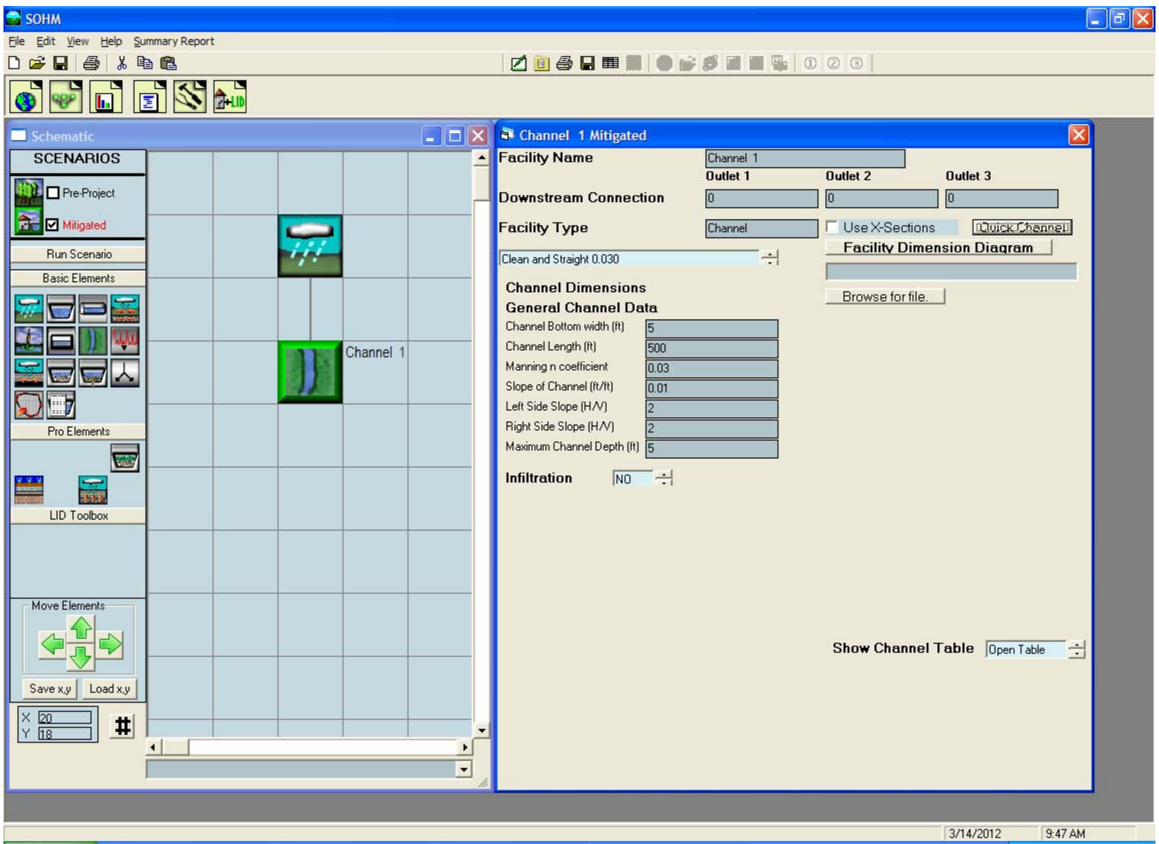
The bioretention swale dimensions and parameters to adjust to represent a vegetated/grassy swale are discussed on page 83.

Native Infiltration: Yes if A or B soil (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

There is no underdrain for A or B soils; there is no native infiltration for C or D soils.



Simple vegetated or grassy (dry) swales without an underdrain can be represented by the channel element.

The channel dimensions and parameters to adjust to represent a vegetated/grassy swale are:

Channel Bottom Width (ft): Vegetated/grassy swale width.
Channel Length (ft): Vegetated/grassy swale area length.
Manning's coefficient: Vegetated/grassy swale overland flow roughness coefficient.
Slope of Channel (ft/ft): Must be non-zero.
Left Side Slope of Channel (ft/ft): H:V Vegetated/grassy swale left side slope.

Right Side Slope (ft/ft): H:V Vegetated/grassy swale right side slope.
Maximum Channel Depth (ft): Height from bottom to top of vegetated/grassy swale side slopes.

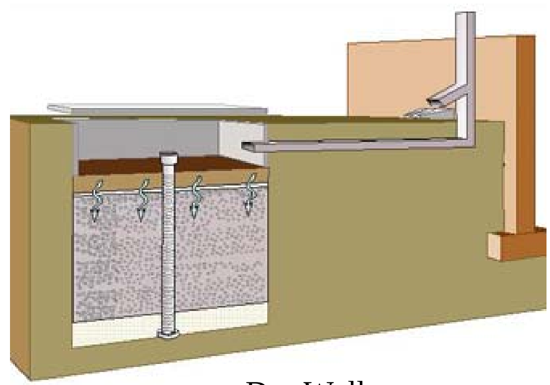
Infiltration: Yes (infiltration into the underlying soil through the swale bottom)
Infiltration Rate (in/hr): Vegetated/grassy swale channel bottom infiltration rate.
Infiltration Reduction Factor: 1/native soil infiltration rate safety factor (see page 69).

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

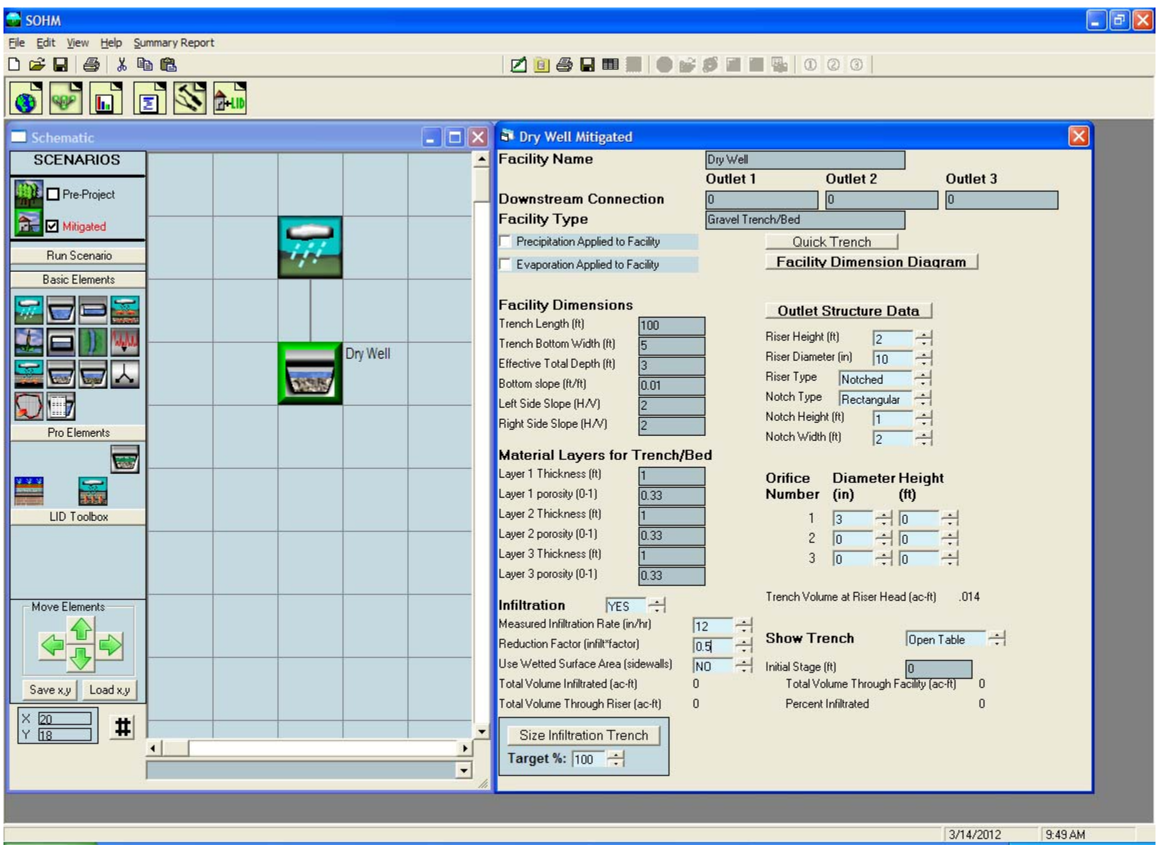
DRY WELL

A dry well is similar to the in-ground (infiltration) planter, except that there is no bottom discharge pipe or underdrain. Water must infiltrate into the native soil underlying the gravel layer of the planter. The native soil must have sufficient infiltration capacity to infiltrate all of the stormwater.

In SOCHM the dry well is represented by the gravel trench bed element.



Dry Well



The gravel trench bed dimensions and parameters to adjust to represent a dry well are:

Trench Length (ft): Dry well length.
Trench Bottom Width (ft): Dry well width.
Effective Total Depth (ft): Dry well height from bottom of dry well to top of riser plus at least 0.5 feet extra.
Bottom Slope of Trench (ft/ft): Must be non-zero.
Left Side Slope (ft/ft): 0 (zero) for vertical dry well sides.
Right Side Slope (ft/ft): 0 (zero) for vertical dry well sides.

Infiltration Rate (in/hr): Dry well soil infiltration rate.
Layer 1 Thickness (ft): Dry well soil layer depth.
Layer 1 Porosity: Dry well soil porosity.
Layer 2 Thickness (ft): Dry well gravel layer depth.
Layer 2 Porosity: Dry well gravel porosity.
Riser Height (ft): Height of dry well overflow pipe above dry well bottom.
Riser Diameter (in): Dry well overflow pipe diameter.
Riser Type: Flat

Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).

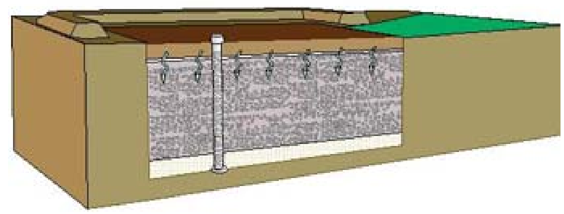
If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

Note that the dry well is covered; there is no precipitation on or evaporation from the dry well. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be left unchecked.

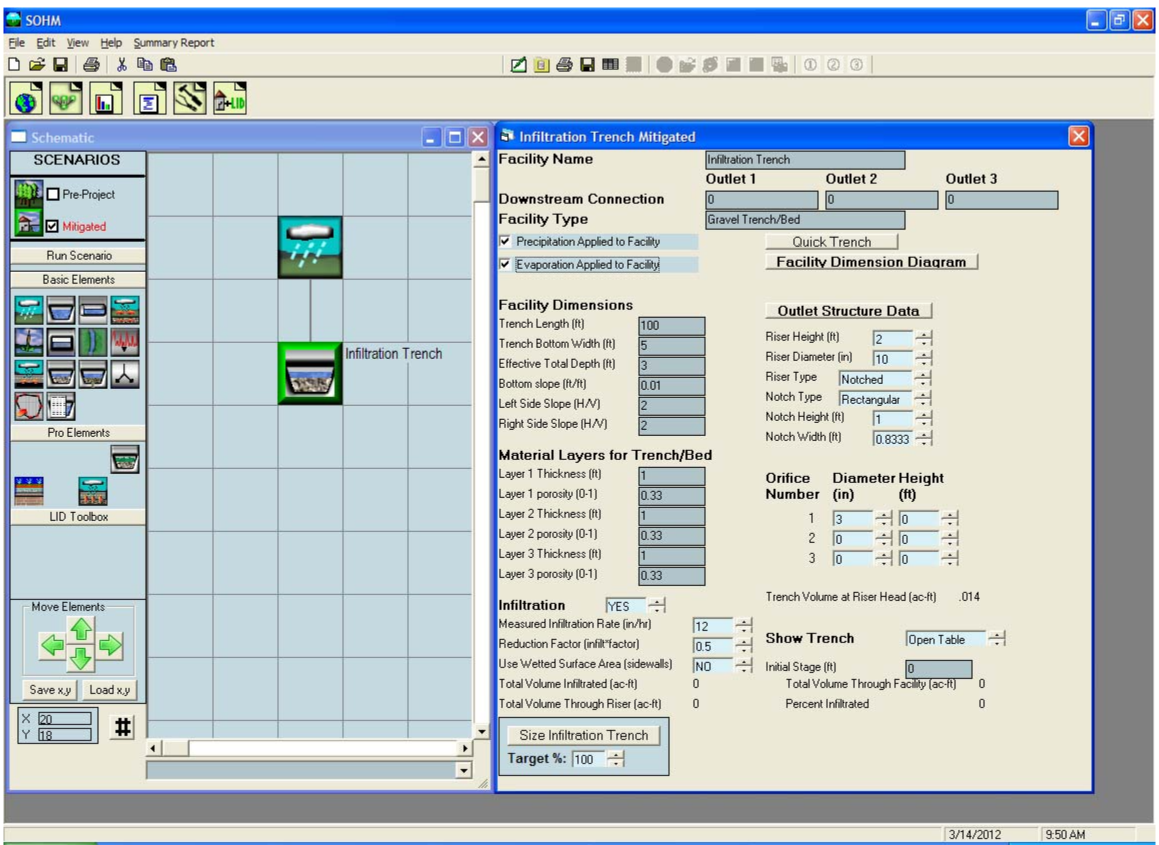
INFILTRATION TRENCH

An infiltration trench is similar to the dry well. There is no bottom discharge pipe or underdrain. Water must infiltrate into the native soil underlying the gravel layer of the planter. The native soil must have sufficient infiltration capacity to infiltrate all of the stormwater.



Infiltration Trench

In SOCHM the infiltration trench is represented by the gravel trench bed element.



The gravel trench bed dimensions and parameters to adjust to represent an infiltration trench are:

Trench Length (ft): Infiltration trench length.
Trench Bottom Width (ft): Infiltration trench width.
Effective Total Depth (ft): Infiltration trench height from bottom of trench to top of riser plus at least 0.5 feet extra.
Bottom Slope of Trench (ft/ft): Must be non-zero.
Left Side Slope (ft/ft): 0 (zero) for vertical infiltration trench sides.

Right Side Slope (ft/ft): 0 (zero) for vertical infiltration trench sides.
Infiltration Rate (in/hr): Infiltration trench soil infiltration rate.
Layer 1 Thickness (ft): Infiltration trench soil layer depth.
Layer 1 Porosity: Infiltration trench soil porosity.
Layer 2 Thickness (ft): Infiltration trench gravel layer depth.
Layer 2 Porosity: Infiltration trench gravel porosity.
Riser Height (ft): Height of infiltration trench overflow pipe above trench bottom. If a weir is preferred instead of a riser then set the riser height to the weir height and set the riser diameter to the weir length.
Riser Diameter (in): Infiltration trench overflow pipe diameter.
Riser Type: Flat

Native Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).

If infiltration is used then the user should consult the Infiltration discussion on page 69.

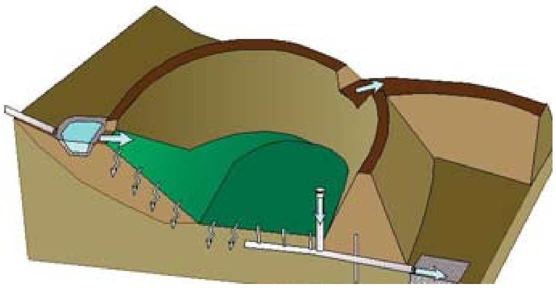
NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

Note that, unlike the dry well, the infiltration trench receives precipitation on and evaporation from the trench surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

INFILTRATION BASIN/POND

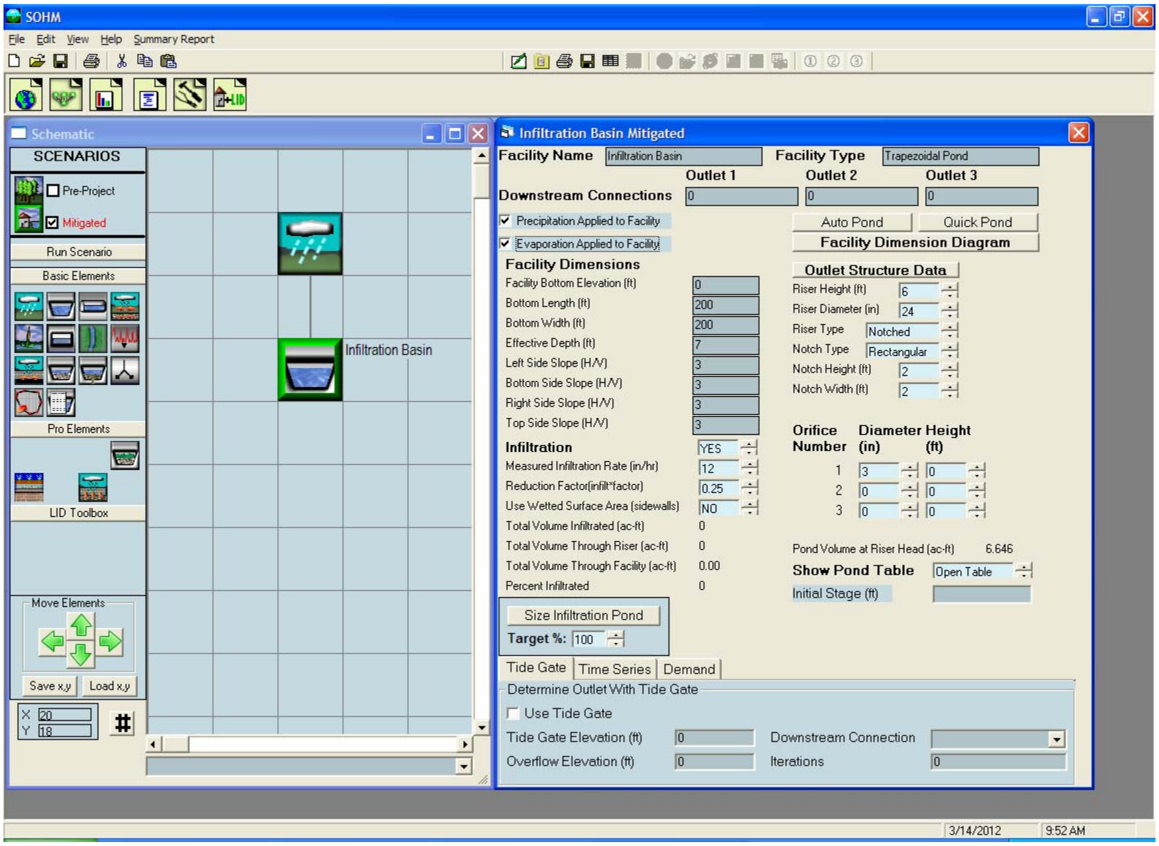
An infiltration basin/pond allows stormwater to enter the basin/pond above ground and then infiltrate through the bottom of the basin/pond before exiting through a discharge pipe. Water can also infiltrate into the native soil beneath the basin/pond.

For the purpose of flow control the discharge from the pipe should not exceed the predevelopment discharge from the project site for the flow duration range specified by the local jurisdiction.



Infiltration Basin/Pond

In SOCHM the infiltration basin/pond is represented by the trapezoidal or irregular-shaped pond element.



The pond dimensions and parameters to adjust to represent an infiltration basin are:

Bottom Length (ft): Infiltration basin/pond length.
Bottom Width (ft): Infiltration basin/pond width.

Effective Depth (ft): Infiltration basin height from basin/pond bottom to top of riser plus at least 0.5 feet extra.
Left Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Bottom Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Right Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Top Side Slope (H/V): ratio of horizontal distance to vertical for infiltration basin/pond sides.
Riser Height (ft): Height of infiltration basin/pond overflow pipe above basin/pond soil surface.
Riser Diameter (in): Infiltration basin/pond overflow pipe diameter.
Riser Type: Flat

Infiltration: Yes (infiltration into the underlying native soil)
Measured Infiltration Rate (in/hr): Native soil infiltration rate.
Infiltration Reduction Factor: 1/Native soil infiltration rate safety factor (see page 69).
Use Wetted Surface Area (sidewalls): Yes, if infiltration through the basin/pond side slopes is allowed.

If infiltration is used then the user should consult the Infiltration discussion on page 69.

NOTE: See Appendix C or consult with the local municipal permitting agency for additional considerations regarding infiltration and determination of the appropriate infiltration reduction factor.

An infiltration basin/pond receives precipitation on and evaporation from the basin/pond surface. The Precipitation Applied to Facility and Evaporation Applied to Facility boxes should be checked.

APPENDIX A: DEFAULT SOCHM HSPF PERVIOUS PARAMETER VALUES

The default SOCHM HSPF pervious parameter values are found in SOCHM file defaultpers.uci.

HSPF parameter documentation is found in the document:
Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. Hydrological Simulation Program – Fortran, User's Manual for Version 12. AQUA TERRA Consultants. Mountain View, CA.

Table 1. SOCHM Pervious Land Types

PERLND No.	Soil Type	Land Cover	Land Slope
1	A	Scrub	Flat (0-5%)
2	A	Scrub	Moderate (5-10%)
3	A	Scrub	Steep (10-15%)
4	A	Scrub	Very Steep (>15%)
5	A	Open Brush	Flat (0-5%)
6	A	Open Brush	Moderate (5-10%)
7	A	Open Brush	Steep (10-15%)
8	A	Open Brush	Very Steep (>15%)
9	A	Gravel	Flat (0-5%)
10	A	Gravel	Moderate (5-10%)
11	A	Gravel	Steep (10-15%)
12	A	Gravel	Very Steep (>15%)
13	B	Scrub	Flat (0-5%)
14	B	Scrub	Moderate (5-10%)
15	B	Scrub	Steep (10-15%)
16	B	Scrub	Very Steep (>15%)
17	B	Open Brush	Flat (0-5%)
18	B	Open Brush	Moderate (5-10%)
19	B	Open Brush	Steep (10-15%)
20	B	Open Brush	Very Steep (>15%)
21	B	Gravel	Flat (0-5%)
22	B	Gravel	Moderate (5-10%)
23	B	Gravel	Steep (10-15%)
24	B	Gravel	Very Steep (>15%)
25	C	Scrub	Flat (0-5%)
26	C	Scrub	Moderate (5-10%)
27	C	Scrub	Steep (10-15%)
28	C	Scrub	Very Steep (>15%)
29	C	Open Brush	Flat (0-5%)
30	C	Open Brush	Moderate (5-10%)
31	C	Open Brush	Steep (10-15%)
32	C	Open Brush	Very Steep (>15%)
33	C	Gravel	Flat (0-5%)
34	C	Gravel	Moderate (5-10%)
35	C	Gravel	Steep (10-15%)
36	C	Gravel	Very Steep (>15%)
37	D	Scrub	Flat (0-5%)
38	D	Scrub	Moderate (5-10%)
39	D	Scrub	Steep (10-15%)
40	D	Scrub	Very Steep (>15%)
41	D	Open Brush	Flat (0-5%)
42	D	Open Brush	Moderate (5-10%)
43	D	Open Brush	Steep (10-15%)
44	D	Open Brush	Very Steep (>15%)
45	D	Gravel	Flat (0-5%)
46	D	Gravel	Moderate (5-10%)
47	D	Gravel	Steep (10-15%)

48	D	Gravel	Very Steep (>15%)
49	A	Urban	Flat (0-5%)
50	A	Urban	Moderate (5-10%)
51	A	Urban	Steep (10-15%)
52	A	Urban	Very Steep (>15%)
53	B	Urban	Flat (0-5%)
54	B	Urban	Moderate (5-10%)
55	B	Urban	Steep (10-15%)
56	B	Urban	Very Steep (>15%)
57	C	Urban	Flat (0-5%)
58	C	Urban	Moderate (5-10%)
59	C	Urban	Steep (10-15%)
60	C	Urban	Very Steep (>15%)
61	D	Urban	Flat (0-5%)
62	D	Urban	Moderate (5-10%)
63	D	Urban	Steep (10-15%)
64	D	Urban	Very Steep (>15%)

Table 2. SOCHM HSPF Pervious Parameter Values – Part I

PERLND No.	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
1	5.20	0.090	400	0.05	0.80	0.955
2	4.80	0.070	350	0.10	0.80	0.955
3	4.50	0.045	300	0.15	0.80	0.955
4	4.20	0.030	250	0.20	0.80	0.955
5	5.20	0.090	400	0.05	0.80	0.955
6	4.80	0.070	350	0.10	0.80	0.955
7	4.50	0.045	300	0.15	0.80	0.955
8	4.20	0.030	250	0.20	0.80	0.955
9	2.60	0.045	400	0.05	0.80	0.955
10	2.40	0.035	350	0.10	0.80	0.955
11	2.20	0.022	300	0.15	0.80	0.955
12	2.00	0.018	250	0.20	0.80	0.955
13	5.00	0.070	400	0.05	0.80	0.955
14	4.70	0.055	350	0.10	0.80	0.955
15	4.40	0.040	300	0.15	0.80	0.955
16	4.10	0.025	250	0.20	0.80	0.955
17	5.00	0.070	400	0.05	0.80	0.955
18	4.70	0.055	350	0.10	0.80	0.955
19	4.40	0.040	300	0.15	0.80	0.955
20	4.10	0.025	250	0.20	0.80	0.955
21	2.50	0.035	400	0.05	0.80	0.955
22	2.30	0.028	350	0.10	0.80	0.955
23	2.10	0.020	300	0.15	0.80	0.955
24	1.90	0.015	250	0.20	0.80	0.955
25	4.80	0.045	400	0.05	0.80	0.955
26	4.50	0.040	350	0.10	0.80	0.955
27	4.20	0.030	300	0.15	0.80	0.955
28	3.90	0.015	250	0.20	0.80	0.955
29	4.80	0.045	400	0.05	0.80	0.955
30	4.50	0.040	350	0.10	0.80	0.955
31	4.20	0.030	300	0.15	0.80	0.955
32	4.00	0.015	250	0.20	0.80	0.955
33	2.40	0.022	400	0.05	0.80	0.955
34	2.20	0.020	350	0.10	0.80	0.955
35	2.00	0.015	300	0.15	0.80	0.955
36	1.80	0.010	250	0.20	0.80	0.955
37	4.60	0.040	400	0.05	0.80	0.955
38	4.30	0.035	350	0.10	0.80	0.955
39	4.00	0.025	300	0.15	0.80	0.955
40	3.70	0.012	250	0.20	0.80	0.955
41	4.60	0.040	400	0.05	0.80	0.955
42	4.30	0.035	350	0.10	0.80	0.955
43	4.00	0.025	300	0.15	0.80	0.955
44	3.70	0.012	250	0.20	0.80	0.955
45	2.30	0.020	400	0.05	0.80	0.955
46	2.10	0.018	350	0.10	0.80	0.955
47	1.90	0.012	300	0.15	0.80	0.955

48	1.70	0.008	250	0.20	0.80	0.955
49	5.00	0.070	400	0.05	0.80	0.955
50	4.70	0.055	350	0.10	0.80	0.955
51	4.40	0.040	300	0.15	0.80	0.955
52	4.10	0.025	250	0.20	0.80	0.955
53	4.80	0.070	400	0.05	0.80	0.955
54	4.50	0.055	350	0.10	0.80	0.955
55	4.20	0.040	300	0.15	0.80	0.955
56	4.00	0.025	250	0.20	0.80	0.955
57	4.60	0.045	400	0.05	0.80	0.955
58	4.30	0.040	350	0.10	0.80	0.955
59	4.00	0.030	300	0.15	0.80	0.955
60	3.70	0.015	250	0.20	0.80	0.955
61	4.40	0.040	400	0.05	0.80	0.955
62	4.10	0.035	350	0.10	0.80	0.955
63	3.90	0.025	300	0.15	0.80	0.955
64	3.60	0.012	250	0.20	0.80	0.955

LZSN: Lower Zone Storage Nominal (inches)
INFILT: Infiltration (inches per hour)
LSUR: Length of surface flow path (feet)
SLSUR: Slope of surface flow path (feet/feet)
KVARY: Variable groundwater recession
AGWRC: Active Groundwater Recession Constant (per day)

Table 3. SOCHM HSPF Pervious Parameter Values – Part II

PERLND No.	INFEXP	INFILD	DEEPFR	BASETP	AGWETP
1	2.0	2.0	0.0	0.03	0.00
2	2.0	2.0	0.0	0.03	0.00
3	2.0	2.0	0.0	0.03	0.00
4	2.0	2.0	0.0	0.03	0.00
5	2.0	2.0	0.0	0.03	0.00
6	2.0	2.0	0.0	0.03	0.00
7	2.0	2.0	0.0	0.03	0.00
8	2.0	2.0	0.0	0.03	0.00
9	2.0	2.0	0.0	0.03	0.00
10	2.0	2.0	0.0	0.03	0.00
11	2.0	2.0	0.0	0.03	0.00
12	2.0	2.0	0.0	0.03	0.00
13	2.0	2.0	0.0	0.03	0.00
14	2.0	2.0	0.0	0.03	0.00
15	2.0	2.0	0.0	0.03	0.00
16	2.0	2.0	0.0	0.03	0.00
17	2.0	2.0	0.0	0.03	0.00
18	2.0	2.0	0.0	0.03	0.00
19	2.0	2.0	0.0	0.03	0.00
20	2.0	2.0	0.0	0.03	0.00
21	2.0	2.0	0.0	0.03	0.00
22	2.0	2.0	0.0	0.03	0.00
23	2.0	2.0	0.0	0.03	0.00
24	2.0	2.0	0.0	0.03	0.00
25	3.0	2.0	0.0	0.03	0.00
26	3.0	2.0	0.0	0.03	0.00
27	3.0	2.0	0.0	0.03	0.00
28	3.0	2.0	0.0	0.03	0.00
29	3.0	2.0	0.0	0.03	0.00
30	3.0	2.0	0.0	0.03	0.00
31	3.0	2.0	0.0	0.03	0.00
32	3.0	2.0	0.0	0.03	0.00
33	3.0	2.0	0.0	0.03	0.00
34	3.0	2.0	0.0	0.03	0.00
35	3.0	2.0	0.0	0.03	0.00
36	3.0	2.0	0.0	0.03	0.00
37	4.0	2.0	0.0	0.03	0.00
38	4.0	2.0	0.0	0.03	0.00
39	4.0	2.0	0.0	0.03	0.00
40	4.0	2.0	0.0	0.03	0.00
41	4.0	2.0	0.0	0.03	0.00
42	4.0	2.0	0.0	0.03	0.00
43	4.0	2.0	0.0	0.03	0.00
44	4.0	2.0	0.0	0.03	0.00
45	4.0	2.0	0.0	0.03	0.00
46	4.0	2.0	0.0	0.03	0.00
47	4.0	2.0	0.0	0.03	0.00
48	4.0	2.0	0.0	0.03	0.00

49	2.0	2.0	0.0	0.03	0.00
50	2.0	2.0	0.0	0.03	0.00
51	2.0	2.0	0.0	0.03	0.00
52	2.0	2.0	0.0	0.03	0.00
53	2.0	2.0	0.0	0.03	0.00
54	2.0	2.0	0.0	0.03	0.00
55	2.0	2.0	0.0	0.03	0.00
56	2.0	2.0	0.0	0.03	0.00
57	3.0	2.0	0.0	0.03	0.00
58	3.0	2.0	0.0	0.03	0.00
59	3.0	2.0	0.0	0.03	0.00
60	3.0	2.0	0.0	0.03	0.00
61	4.0	2.0	0.0	0.03	0.00
62	4.0	2.0	0.0	0.03	0.00
63	4.0	2.0	0.0	0.03	0.00
64	4.0	2.0	0.0	0.03	0.00

INFEXP: Infiltration Exponent
INFILD: Infiltration ratio (maximum to mean)
DEEPFR: Fraction of groundwater to deep aquifer or inactive storage
BASETP: Base flow (from groundwater) Evapotranspiration fraction
AGWETP: Active Groundwater Evapotranspiration fraction

Table 4. SOCHM HSPF Pervious Parameter Values – Part III

PERLND No.	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
1	see Table 8	0.90	0.30	4.00	0.70	see Table 9
2	see Table 8	0.70	0.30	3.20	0.45	see Table 9
3	see Table 8	0.50	0.30	2.60	0.40	see Table 9
4	see Table 8	0.30	0.30	1.30	0.30	see Table 9
5	see Table 8	0.80	0.25	4.00	0.70	see Table 9
6	see Table 8	0.65	0.25	3.20	0.45	see Table 9
7	see Table 8	0.45	0.25	2.60	0.40	see Table 9
8	see Table 8	0.25	0.25	1.30	0.30	see Table 9
9	see Table 8	0.60	0.20	1.50	0.70	see Table 9
10	see Table 8	0.50	0.20	1.40	0.45	see Table 9
11	see Table 8	0.40	0.20	1.20	0.40	see Table 9
12	see Table 8	0.20	0.20	1.00	0.30	see Table 9
13	see Table 8	0.90	0.30	3.00	0.70	see Table 9
14	see Table 8	0.70	0.30	2.40	0.45	see Table 9
15	see Table 8	0.50	0.30	1.60	0.40	see Table 9
16	see Table 8	0.30	0.30	1.00	0.30	see Table 9
17	see Table 8	0.80	0.25	3.00	0.70	see Table 9
18	see Table 8	0.65	0.25	2.40	0.45	see Table 9
19	see Table 8	0.45	0.25	1.60	0.40	see Table 9
20	see Table 8	0.25	0.25	1.00	0.30	see Table 9
21	see Table 8	0.60	0.20	1.40	0.70	see Table 9
22	see Table 8	0.50	0.20	1.30	0.45	see Table 9
23	see Table 8	0.40	0.20	1.10	0.40	see Table 9
24	see Table 8	0.20	0.20	0.80	0.30	see Table 9
25	see Table 8	0.90	0.30	2.00	0.70	see Table 9
26	see Table 8	0.70	0.30	1.20	0.45	see Table 9
27	see Table 8	0.50	0.30	0.80	0.40	see Table 9
28	see Table 8	0.30	0.30	0.40	0.30	see Table 9
29	see Table 8	0.80	0.25	2.00	0.70	see Table 9
30	see Table 8	0.65	0.25	1.20	0.45	see Table 9
31	see Table 8	0.45	0.25	0.80	0.40	see Table 9
32	see Table 8	0.25	0.25	0.40	0.30	see Table 9
33	see Table 8	0.60	0.20	1.30	0.70	see Table 9
34	see Table 8	0.50	0.20	0.90	0.45	see Table 9
35	see Table 8	0.40	0.20	0.60	0.40	see Table 9
36	see Table 8	0.20	0.20	0.30	0.30	see Table 9
37	see Table 8	0.90	0.30	1.00	0.70	see Table 9
38	see Table 8	0.70	0.30	0.80	0.45	see Table 9
39	see Table 8	0.50	0.30	0.60	0.40	see Table 9
40	see Table 8	0.30	0.30	0.30	0.30	see Table 9
41	see Table 8	0.80	0.25	1.00	0.70	see Table 9
42	see Table 8	0.65	0.25	0.80	0.45	see Table 9
43	see Table 8	0.45	0.25	0.60	0.40	see Table 9
44	see Table 8	0.25	0.25	0.30	0.30	see Table 9
45	see Table 8	0.60	0.20	0.65	0.70	see Table 9
46	see Table 8	0.50	0.20	0.45	0.45	see Table 9
47	see Table 8	0.40	0.20	0.30	0.40	see Table 9
48	see Table 8	0.20	0.20	0.20	0.30	see Table 9

49	see Table 8	0.70	0.25	3.00	0.70	see Table 9
50	see Table 8	0.50	0.25	2.40	0.45	see Table 9
51	see Table 8	0.35	0.25	1.60	0.40	see Table 9
52	see Table 8	0.20	0.25	1.00	0.30	see Table 9
53	see Table 8	0.70	0.25	3.00	0.70	see Table 9
54	see Table 8	0.50	0.25	2.40	0.45	see Table 9
55	see Table 8	0.35	0.25	1.60	0.40	see Table 9
56	see Table 8	0.20	0.25	1.00	0.30	see Table 9
57	see Table 8	0.70	0.25	3.00	0.70	see Table 9
58	see Table 8	0.50	0.25	2.40	0.45	see Table 9
59	see Table 8	0.35	0.25	1.60	0.40	see Table 9
60	see Table 8	0.20	0.25	1.00	0.30	see Table 9
61	see Table 8	0.70	0.25	3.00	0.70	see Table 9
62	see Table 8	0.50	0.25	2.40	0.45	see Table 9
63	see Table 8	0.35	0.25	1.60	0.40	see Table 9
64	see Table 8	0.20	0.25	1.00	0.30	see Table 9

CEPSC: Interception storage (inches)
UZSN: Upper Zone Storage Nominal (inches)
NSUR: Surface roughness (Manning’s n)
INTFW: Interflow index
IRC: Interflow Recession Constant (per day)
LZETP: Lower Zone Evapotranspiration fraction

Table 5. SOCHM HSPF Pervious Parameter Values – Part IV

PERLND No.	MELEV	BELV	GWDATM	PCW	PGW	UPGW
1	400	0	0	0.35	0.38	0.45
2	400	0	0	0.35	0.38	0.45
3	400	0	0	0.35	0.38	0.45
4	400	0	0	0.35	0.38	0.45
5	400	0	0	0.33	0.35	0.42
6	400	0	0	0.33	0.35	0.42
7	400	0	0	0.33	0.35	0.42
8	400	0	0	0.33	0.35	0.42
9	400	0	0	0.31	0.33	0.40
10	400	0	0	0.31	0.33	0.40
11	400	0	0	0.31	0.33	0.40
12	400	0	0	0.31	0.33	0.40
13	400	0	0	0.30	0.32	0.40
14	400	0	0	0.30	0.32	0.40
15	400	0	0	0.30	0.32	0.40
16	400	0	0	0.30	0.32	0.40
17	400	0	0	0.28	0.26	0.37
18	400	0	0	0.28	0.26	0.37
19	400	0	0	0.28	0.26	0.37
20	400	0	0	0.28	0.26	0.37
21	400	0	0	0.26	0.28	0.35
22	400	0	0	0.26	0.28	0.35
23	400	0	0	0.26	0.28	0.35
24	400	0	0	0.26	0.28	0.35
25	400	0	0	0.20	0.23	0.28
26	400	0	0	0.20	0.23	0.28
27	400	0	0	0.20	0.23	0.28
28	400	0	0	0.20	0.23	0.28
29	400	0	0	0.18	0.20	0.25
30	400	0	0	0.18	0.20	0.25
31	400	0	0	0.18	0.20	0.25
32	400	0	0	0.18	0.20	0.25
33	400	0	0	0.15	0.18	0.20
34	400	0	0	0.15	0.18	0.20
35	400	0	0	0.15	0.18	0.20
36	400	0	0	0.15	0.18	0.20
37	400	0	0	0.20	0.23	0.28
38	400	0	0	0.20	0.23	0.28
39	400	0	0	0.20	0.23	0.28
40	400	0	0	0.20	0.23	0.28
41	400	0	0	0.18	0.20	0.25
42	400	0	0	0.18	0.20	0.25
43	400	0	0	0.18	0.20	0.25
44	400	0	0	0.18	0.20	0.25
45	400	0	0	0.15	0.18	0.20
46	400	0	0	0.15	0.18	0.20
47	400	0	0	0.15	0.18	0.20
48	400	0	0	0.15	0.18	0.20

49	400	0	0	0.35	0.38	0.45
50	400	0	0	0.35	0.38	0.45
51	400	0	0	0.35	0.38	0.45
52	400	0	0	0.35	0.38	0.45
53	400	0	0	0.30	0.32	0.40
54	400	0	0	0.30	0.32	0.40
55	400	0	0	0.30	0.32	0.40
56	400	0	0	0.30	0.32	0.40
57	400	0	0	0.20	0.23	0.28
58	400	0	0	0.20	0.23	0.28
59	400	0	0	0.20	0.23	0.28
60	400	0	0	0.20	0.23	0.28
61	400	0	0	0.20	0.23	0.28
62	400	0	0	0.20	0.23	0.28
63	400	0	0	0.20	0.23	0.28
64	400	0	0	0.20	0.23	0.28

MELEV: Mean surface elevation of the land segment (feet)
BELV: Base elevation for active groundwater (feet)
GWDATM: Datum for the groundwater elevation (feet)
PCW: Cohesion Water Porosity (fraction)
PGW: Gravitational Water Porosity (fraction)
UPGW: Upper Gravitational Water porosity (fraction)

Table 6. SOCHM HSPF Pervious Parameter Values – Part V

PERLND No.	STABNO	SRRC	SREXP	IFWSC	DELTA	UELFAC	LELFAC
1	1	0.1	0	4	0.2	4	2.5
2	1	0.1	0	4	0.2	4	2.5
3	1	0.1	0	4	0.2	4	2.5
4	1	0.1	0	4	0.2	4	2.5
5	1	0.1	0	4	0.2	4	2.5
6	1	0.1	0	4	0.2	4	2.5
7	1	0.1	0	4	0.2	4	2.5
8	1	0.1	0	4	0.2	4	2.5
9	1	0.1	0	4	0.2	4	2.5
10	1	0.1	0	4	0.2	4	2.5
11	1	0.1	0	4	0.2	4	2.5
12	1	0.1	0	4	0.2	4	2.5
13	1	0.1	0	4	0.2	4	2.5
14	1	0.1	0	4	0.2	4	2.5
15	1	0.1	0	4	0.2	4	2.5
16	1	0.1	0	4	0.2	4	2.5
17	1	0.1	0	4	0.2	4	2.5
18	1	0.1	0	4	0.2	4	2.5
19	1	0.1	0	4	0.2	4	2.5
20	1	0.1	0	4	0.2	4	2.5
21	1	0.1	0	4	0.2	4	2.5
22	1	0.1	0	4	0.2	4	2.5
23	1	0.1	0	4	0.2	4	2.5
24	1	0.1	0	4	0.2	4	2.5
25	1	0.1	0	4	0.2	4	2.5
26	1	0.1	0	4	0.2	4	2.5
27	1	0.1	0	4	0.2	4	2.5
28	1	0.1	0	4	0.2	4	2.5
29	1	0.1	0	4	0.2	4	2.5
30	1	0.1	0	4	0.2	4	2.5
31	1	0.1	0	4	0.2	4	2.5
32	1	0.1	0	4	0.2	4	2.5
33	1	0.1	0	4	0.2	4	2.5
34	1	0.1	0	4	0.2	4	2.5
35	1	0.1	0	4	0.2	4	2.5
36	1	0.1	0	4	0.2	4	2.5
37	1	0.1	0	4	0.2	4	2.5
38	1	0.1	0	4	0.2	4	2.5
39	1	0.1	0	4	0.2	4	2.5
40	1	0.1	0	4	0.2	4	2.5
41	1	0.1	0	4	0.2	4	2.5
42	1	0.1	0	4	0.2	4	2.5
43	1	0.1	0	4	0.2	4	2.5
44	1	0.1	0	4	0.2	4	2.5
45	1	0.1	0	4	0.2	4	2.5
46	1	0.1	0	4	0.2	4	2.5
47	1	0.1	0	4	0.2	4	2.5
48	1	0.1	0	4	0.2	4	2.5

49	1	0.1	0	4	0.2	4	2.5
50	1	0.1	0	4	0.2	4	2.5
51	1	0.1	0	4	0.2	4	2.5
52	1	0.1	0	4	0.2	4	2.5
53	1	0.1	0	4	0.2	4	2.5
54	1	0.1	0	4	0.2	4	2.5
55	1	0.1	0	4	0.2	4	2.5
56	1	0.1	0	4	0.2	4	2.5
57	1	0.1	0	4	0.2	4	2.5
58	1	0.1	0	4	0.2	4	2.5
59	1	0.1	0	4	0.2	4	2.5
60	1	0.1	0	4	0.2	4	2.5
61	1	0.1	0	4	0.2	4	2.5
62	1	0.1	0	4	0.2	4	2.5
63	1	0.1	0	4	0.2	4	2.5
64	1	0.1	0	4	0.2	4	2.5

STABNO: User's number for the FTABLE in the FTABLES block which contains the outflow properties from the surface storage
SRRC: Surface Runoff Recession Constant (per hour)
SREXP: Surface Runoff Exponent
IFWSC: Maximum Interflow Storage Capacity when the groundwater elevation is greater than the upper influence elevation (inches)

DELTA: groundwater tolerance level used to determine transition between regions when high water table conditions are being simulated
UELFAC: multiplier on UZSN which gives the upper zone capacity
LELFAC: multiplier on LZSN which gives the lower zone capacity

The selection of the Table 5 and Table 6 default parameter values is based on limited application of these parameters in California by the staff of Clear Creek Solutions, Inc.

NOTE: The parameter values should be used with caution and only after consultation with the appropriate local municipal permitting agency or guidance in Appendix C. Different values should only be selected following detailed local soil analysis, a thorough understanding of the parameters and algorithms, and consultation with the appropriate local municipal permitting agency.

Table 7. SOCHM HSPF Pervious Parameter Values – Part VI

PERLND No.	CEPS	SURS	UZS	IFWS	LZS	AGWS	GWVS
1	0.00	0.00	0.090	0.00	1.040	0.30	0.01
2	0.00	0.00	0.070	0.00	0.960	0.30	0.01
3	0.00	0.00	0.050	0.00	0.900	0.30	0.01
4	0.00	0.00	0.030	0.00	0.840	0.30	0.01
5	0.00	0.00	0.080	0.00	1.040	0.30	0.01
6	0.00	0.00	0.065	0.00	0.960	0.30	0.01
7	0.00	0.00	0.045	0.00	0.900	0.30	0.01
8	0.00	0.00	0.025	0.00	0.840	0.30	0.01
9	0.00	0.00	0.060	0.00	0.520	0.30	0.01
10	0.00	0.00	0.050	0.00	0.480	0.30	0.01
11	0.00	0.00	0.040	0.00	0.440	0.30	0.01
12	0.00	0.00	0.020	0.00	0.400	0.30	0.01
13	0.00	0.00	0.090	0.00	1.000	0.30	0.01
14	0.00	0.00	0.070	0.00	0.940	0.30	0.01
15	0.00	0.00	0.050	0.00	0.880	0.30	0.01
16	0.00	0.00	0.030	0.00	0.820	0.30	0.01
17	0.00	0.00	0.080	0.00	1.000	0.30	0.01
18	0.00	0.00	0.065	0.00	0.940	0.30	0.01
19	0.00	0.00	0.045	0.00	0.880	0.30	0.01
20	0.00	0.00	0.025	0.00	0.820	0.30	0.01
21	0.00	0.00	0.060	0.00	0.500	0.30	0.01
22	0.00	0.00	0.050	0.00	0.460	0.30	0.01
23	0.00	0.00	0.040	0.00	0.420	0.30	0.01
24	0.00	0.00	0.020	0.00	0.380	0.30	0.01
25	0.00	0.00	0.090	0.00	0.960	0.30	0.01
26	0.00	0.00	0.070	0.00	0.900	0.30	0.01
27	0.00	0.00	0.050	0.00	0.840	0.30	0.01
28	0.00	0.00	0.030	0.00	0.780	0.30	0.01
29	0.00	0.00	0.080	0.00	0.960	0.30	0.01
30	0.00	0.00	0.065	0.00	0.900	0.30	0.01
31	0.00	0.00	0.045	0.00	0.840	0.30	0.01
32	0.00	0.00	0.025	0.00	0.800	0.30	0.01
33	0.00	0.00	0.060	0.00	0.480	0.30	0.01
34	0.00	0.00	0.050	0.00	0.440	0.30	0.01
35	0.00	0.00	0.040	0.00	0.400	0.30	0.01
36	0.00	0.00	0.020	0.00	0.360	0.30	0.01
37	0.00	0.00	0.090	0.00	0.920	0.30	0.01
38	0.00	0.00	0.070	0.00	0.860	0.30	0.01
39	0.00	0.00	0.050	0.00	0.800	0.30	0.01
40	0.00	0.00	0.030	0.00	0.740	0.30	0.01
41	0.00	0.00	0.080	0.00	0.920	0.30	0.01
42	0.00	0.00	0.065	0.00	0.860	0.30	0.01
43	0.00	0.00	0.045	0.00	0.800	0.30	0.01
44	0.00	0.00	0.025	0.00	0.740	0.30	0.01
45	0.00	0.00	0.060	0.00	0.460	0.30	0.01
46	0.00	0.00	0.050	0.00	0.420	0.30	0.01
47	0.00	0.00	0.040	0.00	0.380	0.30	0.01
48	0.00	0.00	0.020	0.00	0.340	0.30	0.01

49	0.00	0.00	0.070	0.00	1.000	0.30	0.01
50	0.00	0.00	0.050	0.00	0.940	0.30	0.01
51	0.00	0.00	0.035	0.00	0.880	0.30	0.01
52	0.00	0.00	0.020	0.00	0.820	0.30	0.01
53	0.00	0.00	0.070	0.00	0.960	0.30	0.01
54	0.00	0.00	0.050	0.00	0.900	0.30	0.01
55	0.00	0.00	0.035	0.00	0.840	0.30	0.01
56	0.00	0.00	0.020	0.00	0.800	0.30	0.01
57	0.00	0.00	0.070	0.00	0.920	0.30	0.01
58	0.00	0.00	0.050	0.00	0.860	0.30	0.01
59	0.00	0.00	0.035	0.00	0.800	0.30	0.01
60	0.00	0.00	0.020	0.00	0.740	0.30	0.01
61	0.00	0.00	0.070	0.00	0.880	0.30	0.01
62	0.00	0.00	0.050	0.00	0.820	0.30	0.01
63	0.00	0.00	0.035	0.00	0.780	0.30	0.01
64	0.00	0.00	0.020	0.00	0.720	0.30	0.01

CEPS: Initial interception storage (inches)
SURS: Initial surface runoff (inches)
UZS: Initial Upper Zone Storage (inches)
IFWS: Initial interflow (inches)
LZS: Initial Lower Zone Storage (inches)
AGWS: Initial Active Groundwater storage (inches)
GWVS: Initial Groundwater Vertical Slope (feet/feet)

Table 8. SOCHM HSPF Pervious Parameter Values: Monthly Interception Storage (inches)

PERLND No.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
3	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
4	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
5	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
6	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
8	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
9	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
16	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
17	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
18	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
19	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
20	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
21	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
22	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
23	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
24	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
25	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
26	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
27	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
28	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
29	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
30	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
31	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

32	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
33	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
34	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
35	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
36	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
37	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
38	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
39	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
40	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
41	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
42	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
43	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
44	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
45	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
46	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
47	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
48	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
49	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
50	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
51	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
52	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
53	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
54	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
55	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
56	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
57	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
58	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
59	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
60	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
61	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
62	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
63	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
64	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

Table 9. SOCHM HSPF Pervious Parameter Values: Monthly Lower Zone Evapotranspiration

PERLND No.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
2	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
3	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
4	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
5	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
6	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
7	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
8	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
9	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
10	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
11	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
13	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
14	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
15	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
16	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
17	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
18	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
19	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
20	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
21	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
22	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
23	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
24	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
25	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
26	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
27	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
28	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
29	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
30	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
31	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40

32	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
33	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
34	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
35	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
36	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
37	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
38	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
39	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
40	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
41	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
42	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
43	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
44	0.40	0.40	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.45	0.40
45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
46	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
47	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
48	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
49	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
50	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
51	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
52	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
53	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
54	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
55	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
56	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
57	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
58	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
59	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
60	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
61	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
62	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
63	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50
64	0.50	0.50	0.50	0.60	0.65	0.65	0.65	0.65	0.65	0.65	0.55	0.50

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APPENDIX B: DEFAULT SOCHM HSPF IMPERVIOUS PARAMETER VALUES

The default SOCHM HSPF impervious parameter values are found in SOCHM file defaultpers.uci.

HSPF parameter documentation is found in the document:
Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. Hydrological Simulation Program – Fortran, User's Manual for Version 12. AQUA TERRA Consultants. Mountain View, CA.

Table 1. SOCHM Impervious Land Types

IMPLND No.	IMPLND Name	Land Slope
1	Impervious	Flat (0-5%)
2	Impervious	Moderate (5-10%)
3	Impervious	Steep (10-15%)
4	Impervious	Very Steep (>15%)

Table 2. SOCHM HSPF Impervious Parameter Values – Part I

IMPLND No.	LSUR	SLSUR	NSUR	RETSC
1	100	0.05	0.10	0.10
2	100	0.10	0.10	0.09
3	100	0.15	0.10	0.08
4	100	0.20	0.10	0.07

LSUR: Length of surface flow path (feet) for impervious area
SLSUR: Slope of surface flow path (feet/feet) for impervious area
NSUR: Surface roughness (Manning's n) for impervious area
RETSC: Surface retention storage (inches) for impervious area

Table 3. SOCHM HSPF Impervious Parameter Values – Part II

IMPLND No.	RETS	SURS
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00

RETSC: Initial surface retention storage (inches) for impervious area
SURS: Initial surface runoff (inches) for impervious area

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APPENDIX C: ADDITIONAL GUIDANCE FOR USING SOCHM

Scope and Purpose: This appendix includes guidance and background information that are not incorporated into the SOCHM software, but which the user needs to know in order to use SOCHM for designing projects in the participating jurisdictions. The three main topic areas in this appendix are flagged in the main guidance documentation text by specially formatted notes under the SOCHM elements or software features to which they are related:

Appendix C Topic	**Relevant Sections in Guidance documentation**
Infiltration Reduction Factor	Infiltration, page 69; applicable when specifying characteristics of a facility (pond, vault, tank, some LID elements) if "yes" is selected as the Infiltration option.
Flow Duration Outlet Structures (includes sizing of low-flow orifice and alternative configurations)	Outlet Structure Configurations, pages 63-68; applicable when specifying characteristics of a flow duration facility.
Drawdown (drain) time for flow duration facilities	Drawdown (Analysis screen), page 104.

This guidance was originally created by the stormwater programs of Alameda, Santa Clara, and San Mateo counties. Please consult with the local municipal permitting agency for additional considerations.

Additional guidance and references are also discussed at the end of this appendix.

Infiltration Reduction Factor

The Western Washington Hydrology Model included this factor to reflect the requirement in the *Stormwater Management Manual for Western Washington* (SMMWW), to incorporate a Correction Factor (CF) to determine long-term infiltration rates; the inverse of the CF is the Infiltration Reduction Factor in SOCHM. The SMMWW gives three methods for determining CF: 1) a table providing empirical correlations between long-term infiltration rates and USDA Soil Textural Classification; 2) ASTM gradation testing at full-scale infiltration facilities; or 3) In-situ infiltration tests, preferably using a Pilot Infiltration Test specified in an appendix of the SMMWW.

Application of a CF or safety factor attempts to account for clogging and the reduction in infiltration over time, which might apply to the bottom of a flow duration pond or the top layer of a bioretention facility. However, a safety factor is also used to account for uncertainties in the available estimate of in-situ infiltration rates. The SMMWW notes that its suggested CF values, which range from 2 to 4, "represent an average degree of long-term facility maintenance, TSS reduction through pretreatment, and site variability in the subsurface conditions", and that increases or decreases to these factors should be considered for unusual situations.

Suggested safety factors in other texts and guidance generally range from 1 to 4. South Orange County stormwater permits may require some form of tracking and verification for treatment and hydromodification facilities. In addition, designers should not be overly conservative in selecting a very high safety factor, since this might lead to over-controlled (lower) post-project flows and an increase risk of causing impacts from deposition or sedimentation in the receiving channels. In the absence of other guidance, it is suggested that the SOCHM Infiltration Reduction Factor not be less than 0.25 or greater than 0.5.

Note: South Orange County stormwater programs may also restrict the use of infiltration for treatment purposes in certain conditions; since the flow duration facilities are also performing some treatment, designers should discuss treatment measure design with the applicable jurisdiction.

Flow Duration Outlet Structures – Practical Design Considerations

Low-flow Orifice Sizing

The diameter of the low-flow (bottom) orifice is an important design parameter for flow duration facilities, since flows discharged through this outlet should be at or below the project threshold for controlled flows (Qcp). However maintenance and/or other practical considerations may dictate a practical limit to how small this orifice may be, which may be larger than the optimal theoretical diameter determined by AutoPond. As an example, the SWMMWW specifies a minimum orifice diameter of 0.5 inches, for flow restrictor assemblies that are within protective enclosures that screen out large particles and also have 1-2 ft of sump below the orifice to allow for some sediment accumulation.

While the user can manually set a minimum size for the low-flow orifice, doing so before running AutoPond is not recommended as this may impair the program's ability to optimize the pond configuration. The following general approach is suggested for designing a pond when there is a small value for the low end of the flow matching range:

1. First estimate the minimum pond volume allowing AutoPond to freely determine the diameter and placement of all orifices.
2. Then manually accept all of the pond settings except low-flow orifice diameter. Set the low-flow orifice to the desired minimum size, after consulting the local municipal permitting agency.
3. Manually run the mitigated scenario as described on page 48 and review the Analysis screen to check if the revised mitigated flow still passes the flow-duration criteria for curve matching. If so, proceed with the pond design using the revised outlet.
4. If the revised design shows Fail scoring at one or more flow levels, excess flow

durations may be reduced somewhat by reducing the depth of the pond which lowers the head above the orifice (SWMMWW recognizes a practical minimum of 3 feet of live storage if pond shallowing is required at the minimum orifice size. As an alternative, further mitigation can be applied to the low-flow orifice flow by adding an additional infiltration measure downstream. This can be sized either approximately by estimating an average excess flow from the orifice or with the help of SOCHM by returning to the screen for the Pond characteristics and specifying a different Downstream Connection for the bottom orifice, which is then connected to an additional element. With this revision to the post project scenario, the Point of Compliance for the system would then be located at the downstream end of the additional low-flow mitigation.

Alternative Outlet Configurations

SOCHM has two default types of outlet configurations (multiple orifice or orifice plus weir notch) based on a standpipe riser structure detailed in the SMMWW. The entire standpipe is usually within a cylindrical enclosure or manhole to exclude trash and larger particles that could clog the outlet. The SMMWW notes that orifices can also be placed on a tee section or a vertical baffle within the same type of enclosure. An alternative configuration is a flat headwall with orifices and or notches, protected by racks or gratings. This may be fabricated from a large steel plate, similar in construction to the extended detention outlets specified in the Denver (Colorado) manual referenced below. This alternative outlet can be simulated in the SOCHM as a very large diameter standpipe, where the width of the top notch is equal to the overflow width at the top of the plate between its supports.

Drawdown time and treatment/vector considerations

Flow duration control facilities are designed to detain stormwater on-site for an extended period of time. The drawdown time is a concern to designers in relation to three areas of design besides hydromodification management:

1. Standing water for extended periods provides a potential habitat in which mosquitoes can breed. Orange County stormwater programs work with their local mosquito abatement or vector control agencies to develop guidelines for stormwater facility design; these generally recommend that design detention times not exceed 96 hours. Provisions for access and inspection by vector control personnel are also required. Contact the local permitting agency for details of local vector control provisions, which apply to both treatment measures and flow duration facilities.

2. Stormwater that is detained also undergoes water quality treatment through settling and/or infiltration of pollutants. The focus of water quality management is reducing mean annual loads and typical concentrations of pollutants in

receiving waters, so treatment design focuses on typical storms which contain the bulk of annual runoff volume. Stormwater permits and guidance documents describe the local design criteria for volume based treatment measures, which apply to a wider range of projects than the hydromodification management requirements. Recommended drawdown times for detention structures are typically at least 48 hours, but not to exceed 96 hours.

3. Flood control design is intended to control peak flows for large sized storms (with expected recurrence intervals such as 25, 50 or 100 years). Flood control facilities typically require capture and detention of a specified volume of stormwater, which then is discharged out at flows that can be safely conveyed by downstream channels without undue risk of flooding. Flood control facilities usually are required to drain within 24 hours after the end of the design storm in order to be empty for the next storm event. This concern that flood control storage remain available for large events has led flood control agencies to require that any storage volume for water quality not be credited for flood control, a feature that is sometimes referred to as “dead storage”.

Although many factors affect the drawdown time, the suggestions below may help SOCHM users in evaluating these other requirements. If flow duration control is required for a project site, it is recommended that the design process start with by using SOCHM to obtain a preliminary design for the flow duration pond, vault, or tank. Then check the performance of the facility for vector control concerns, and against treatment and/or flood control design criteria as appropriate. The latter are both based on the concept of a single empirical “design storm” which does not directly correspond to the flow duration approach using frequency analysis in a long-term simulation. Stormwater treatment design requires the use of volume-based runoff coefficients, which although similar in concept to runoff coefficients used for flood control, are determined differently. Runoff coefficients used for flood control were derived for large storms with some conservatism built-in to estimates of peak flow rates and water surface elevations. Runoff coefficients for stormwater treatment have been adjusted to reflect runoff from small storms where a greater percentage of the rainfall is held within the catchment.

Vector Management

If the maximum allowed drawdown is seldom or never exceeded over the simulation period, then likelihood of mosquito breeding in the facility is very low and the design for the pond, vault or tank does not need to be modified. If a maximum allowed drawdown time is exceeded then the system may need to be redesigned to reduce the drawdown time. The designer should consider additional reductions in impervious area and/or LID elements to help reduce the facility size.

To evaluate the frequency and distribution of larger events in more detail, use the Hydrograph tool (page 105) to plot monthly peaks for several years at a time of the mitigated (post-project) scenario to get an idea of how often the discharge that corresponds to the maximum allowed drain time would be exceeded during warmer months, when mosquito development times are shortest.

Treatment Credit

Use the applicable design criteria to determine the minimum treatment volume for the post-project scenario. Look at the pond volume representing a 2-day drawdown in the SOCHM's flow duration drawdown table. If this is larger than the calculated treatment volume, no further treatment design is needed. If the pond volume is less than the treatment volume, or always drains in less than 2 days, most or all of the water quality criteria may still be met if the combination of infiltration loss and detainment captures 80% of the runoff from the site. Infiltration loss for each pond stage is shown in the Stage-Storage-Discharge table, accessed by selecting the "Open Table" option at the bottom of the main Pond screen.

Flood Control Detention

Local flood control design criteria must be obtained from the appropriate agency, as well as any other policies or restrictions that may apply to drainage design. A single design storm event can be imported as a time series (page 78) and applied to the post-project scenario instead of the simulated precipitation record. If additional live storage is needed, it may be added to upper levels of the same facility or provided elsewhere on the site.

Guidance by Other Agencies

Some agencies in other parts of the United States have developed extensive guidance for design of stormwater management measures. Two manuals are discussed below that provide detailed discussions or examples that may be helpful to users of SOCHM, although the suitability of these recommendations for South Orange County conditions has not been verified. These documents can help provide context and ideas for users for SOCHM, but adapting these ideas requires the exercise of professional engineering judgment. **Mention of the procedures and details in these documents does not imply any endorsement or guarantee that they will be appropriate for addressing the Hydromodification Management Standards in South Orange County jurisdictions.**

Stormwater Management Manual for Western Washington (SMMWW) was prepared by the Washington Department of Ecology for implementation in 19 counties of Western Washington. The latest (2005) edition in 5 volumes is on the Web at: http://www.udfcd.org/downloads/down_critmanual.htm

Design recommendations from this manual were the basis for many features of the WWHM that have been carried over into SOCHM. Portions of Volume 3 (Hydrology) that may be of interest to project designers include:

- Pages 3-2 through 3-18 illustrate several types of roof downspout controls, simple pre-engineered designs for infiltrating and/or dispersing runoff from roof areas in order to reduce runoff volume and/or increase potential groundwater recharge.

- Pages 3-50 to 3-63 discuss outlet control structures, their maintenance and source equations modeled into WWHM and SOCHM
- Pages 3-75 to 3-93 regarding Infiltration Reduction Factor

Urban Storm Drain Criteria Manual by the Denver Urban Drainage and Flood Control District is on the Web at:
http://www.udfcd.org/downloads/down_critmanual.htm

Volume 3 covers design of stormwater treatment measures, including extended detention basins on pages S-66 through S-77 and structural details shown on pages SD-1 to SD-16. Although these designs are not presented for hydromodification management control, the perforated plate design concept allows fine-tuning of drawdown times and is adaptable for use in flow duration facilities.

APPENDIX D: SOCHM REVIEWER CHECKLIST

SOCHM Reviewer Checklist:	**Yes**	**No**
1. Received SOCHM project (WHM and WH2) files?		
2. Received SOCHM WDM (WDM) file?		
3. Received SOCHM report (DOC) file?		
4. Project (WHM) file loads okay?		
5. Project location matches location on SOCHM screen?		
6. Predevelopment scenario runs okay?		
7. Mitigated scenario runs okay?		
8. Compare SOCHM Report screen with report file:		
a. Project location descriptions match?		
b. Precipitation gages match?		
c. Precipitation scales match?		
d. Flow frequency results match?		
e. All flow duration values PASS?		
f. Any pervious (PERLND) land use changes?		
g. Any impervious (IMPLND) land use changes?		
h. Any scaling factor changes?		
i. Any duration criteria changes?		
j. pond dimensions match?		
k. pond outlet structure info matches?		
9. SOCHM pond dimensions match drawings?		
10. Infiltration set to YES for infiltration pond?		
11. Total SOHCM drainage area matches drainage maps/drawings?		
12. Mitigated drainage area(s) match Predevelopment?		
13. Predevelopment vegetation correct?		
14. Mitigated land use areas correct?		
15. Routing correct?		
16. Check facility drawdown (if included):		
a. Used POC Mitigated stage?		
b. Drawdown times okay?		
17. Options set to default values?		
18. Other issues?		
SOCHM submittal APPROVED?		

APPENDIX D

Conducting a Site-Specific Hydromodification Analysis

A project proponent may choose to develop a site specific hydromodification mitigation analysis in lieu of using the continuous simulation tool provided by the south Orange County Hydromodification Management Plan (HMP). The site specific analysis must be developed to demonstrate that the project will not adversely impact the receiving stream through either changes in the receiving stream hydrograph, or changes in bed material load supply to the stream.

The following items are not intended to be an approach to complete the analysis, rather, they are provided for information as suggestions for the engineering analysis. Each project will have unique conditions and will require a customized approach for analysis. A site specific analysis may or may not be ultimately approved by the reviewing agency. It is the responsibility of the engineer to assess the potential for an analysis to successfully demonstrate that the project is consistent with the guidelines of this HMP.

1. It is recommended that the applicant develop a study approach and outline, and review it with the local agency prior to beginning the full study.
2. The study must demonstrate that the project is consistent with the requirements of the south Orange County NPDES Permit and this HMP.
3. Site specific information to characterize bed sediment gradation, flow and rainfall data, and watershed hydrologic parameters will be required. Continuous simulation is required.
4. An objective of the study may be to determine if the loss of bed material load from the project site to the receiving stream can be partially or fully mitigated by additional mitigation of the runoff discharge from the project site.
5. Sediment transport modeling has inherent uncertainty. The agency may not approve a site specific analysis if it is apparent that the change in conditions that will be modeled are about the same magnitude as the model uncertainty.

The selected lower flow threshold shall correspond to the critical channel flow that produces the critical shear stress that initiates channel bed movement or that erodes the toe of channel banks of a comparable soft-bottom channel.

The method of analysis, including the specific modeling program, the sediment transport function, the reach of the receiving water to be modeled, the method of determining bed material discharge in the receiving stream, the method of determining bed material discharge from the project site, the period of record for continuous simulation and other parameters are left to the discretion of the engineer. The study report should document and justify the approach, selected models and methods, data requirements, analysis method and results for review.

APPENDIX E

HSPF Pervious Land Parameters

Pervious Land Hydrology (PWATER) Parameters

The HSPF hydrology parameters of PWATER are divided into four sections, titled PARM1-4. PARM1 is a series of checks to outline any monthly variability versus constant parameter values within the simulated algorithm; whereas, PARM2 and 3 are a series of climate, geology, topography, and vegetation parameters that require numerical values to be input.

PARM2 involves the basic geometry of the overland flow, the impact of groundwater recession, potential snow impact due to forest cover and the expected infiltration and soil moisture storage. The main parameters of groundwater recession are KVARY and AGWRC. The infiltration and soil moisture storage parameters are INFILT and LZSN.

PARM3 involves the impact of climate temperature during active snow conditions, a wide range of evaporation parameters due to the variability of the onsite soil and existing vegetation and subsurface losses due to groundwater recharge or the existing geology. The main evaporation parameters are INFEXP, INFILD, BASETP, and AGWETP. The parameter for subsurface loss is DEEPFR, which accounts for one of only three major losses from the PWATER water balance (i.e., in addition to evaporation, and lateral and stream outflows).

PARM4 involves the flow and hydrograph characteristics, the expectation of rain interception due to the inherent moisture storage capacity from existing vegetation, land use and/or near surface soil conditions and evaporation due to the root zone of the soil profile. The main interception parameters are CEPSC and UZSN. The parameter for evaporation as a primary function of vegetation is LZETP.

PARM2

KVARY. Groundwater recession flow parameter used to describe non-linear groundwater recession rate (/inches) (initialize with reported values, then calibrate as needed).
KVARY is usually one of the last PWATER parameters to be adjusted; it is used when the observed groundwater recession demonstrates a seasonal variability with a faster recession (i.e., higher slope and lower AGWRC values) during wet periods, and the opposite during dry periods. Value ranges are shown in Table A-4. Values that are representative of the conditions in south Orange County have been selected for the SOCHM. Plotting daily flows with a logarithmic scale helps to elucidate the slope of the flow recession.

AGWRC. Groundwater recession rate, or ratio of current groundwater discharge to that from 24 hours earlier (when KVARY is zero) (/day) (estimate, then calibrate).

The overall watershed recession rate is a complex function of watershed conditions, including climate, topography, soils, and land use. Hydrograph separation techniques can be used to estimate the recession rate from observed daily flow data (such as plotting on a logarithmic scale).

INFILT. Index to mean soil infiltration rate (in/hr); (estimate, then calibrate).
In HSPF, INFILT is the parameter that effectively controls the overall division of the available moisture from precipitation (after interception) into surface runoff. Since INFILT is not a maximum rate nor an infiltration capacity term, its values are normally much less than published infiltration rates, percolation rates (from soil percolation tests), or permeability rates from the literature.

INFILT is primarily a function of soil characteristics, and value ranges have been related to SCS hydrologic soil groups (Donigian and Davis, 1978, p.61, variable INFIL) as follows (Table A-1):

Table E-1: SCS Hydrologic Soil Group Characteristics

SCS Hydrologic Soil Group	INFILT Estimate		Runoff Potential
	(in/hr)	(mm/hr)	
A	0.4 – 1.0	10.0 – 25.0	Low
B	0.1 – 0.4	2.5 – 10.0	Moderate
C	0.05 – 0.1	1.25 – 2.5	Moderate to High
D	0.01 – 0.05	0.25 – 1.25	High

An alternate estimation method that has not been validated is derived from the premise that the combination of infiltration and interflow in HSPF represents the infiltration commonly modeled in the literature (e.g., Viessman et al., 1989, Chapter 4). With this assumption, the value of 2.0*INFILT*INTFW should approximate the average measured soil infiltration rate at saturation, or mean permeability.

LZSN. Lower zone nominal soil moisture storage (inches).

LZSN is related to both precipitation patterns and soil characteristics in the region. Viessman, et al, 1989, provide initial estimates for LZSN in the Stanford Watershed Model (SWM-IV, predecessor model to HSPF) as one-quarter of the mean annual rainfall plus four inches for arid and semiarid regions, or one-eighth annual mean rainfall plus 4 inches for coastal, humid, or subhumid climates.

PARM3

INFEXP. Exponent that determines how much a deviation from nominal lower zone storage affects the infiltration rate (HSPF Manual, p. 60).

Variations of the Stanford approach have used a POWER variable for this parameter; various values of POWER are included in Donigian and Davis (1978, p. 58). However, the vast majority of HSPF applications have used the default value of 2.0 for this exponent.

INFILD. Ratio of maximum and mean soil infiltration capacities.

In the Stanford approach, this parameter has always been set to 2.0, so that the maximum infiltration rate is twice the mean (i.e., input) value; when HSPF was developed, the INFILD parameter was included to allow investigation of this assumption. However, there has been very little research to support using a value other than 2.0.

DEEPFR. The fraction of infiltrating water which is lost to deep aquifers (i.e., inactive groundwater), with the remaining fraction (i.e., 1-DEEPFR) assigned to active groundwater storage that contributes baseflow to the stream.

It is also used to represent any other losses that may not be measured at the flow gauge used for calibration, such as flow around or under the gauge site. Watershed areas at high elevations, or in the upland portion of the watershed, are likely to lose more water to deep groundwater (i.e., groundwater that does not discharge within the area of the watershed), than areas at lower elevations or closer to the gauge.

BASETP. ET by riparian vegetation as active groundwater enters streambed; specified as a fraction of potential ET, which is fulfilled only as outflow exists.

If significant riparian vegetation is present in the watershed then non-zero values of BASETP are typically applied. If riparian vegetation is significant, a generic BASETP value of 0.2 is typically representative of the evapotranspiration conditions in the San Juan Hydrologic Unit. This value was established in conjunction with a satisfactory annual water balance.
AGWETP. Fraction of model segment (i.e., pervious land segment) that is subject to direct evaporation from groundwater storage, e.g., wetlands or marsh areas, where the groundwater surface is at or near the land surface, or in areas with phreatophytic vegetation drawing directly from groundwater. This is represented in the model as the fraction of remaining potential ET (i.e., after base ET, interception ET, and upper zone ET are satisfied), that can be met from active groundwater storage.

A value of 0.05 has been selected for inclusion into the SOCHM. This value was adjusted and calibrated in the Aliso Creek watershed HSPF model based on adjustment of the low-flow simulation, and ultimately the annual water balance.

PARM4

CEPSC. Amount of rainfall, in inches, which is retained by vegetation, that never reaches the land surface, and is eventually evaporated (estimate, then calibrate). Typical guidance for CEPSC for selected land surfaces is provided in Donigian and Davis (1978, p. 54, variable EPXM) (**Table A-2**).

Table E-2: CEPSC for Selected Land Surfaces

Land Cover	Maximum Interception (in)
Grassland	0.10

Cropland	0.10 – 0.25
Forest Cover, light	0.15
Forest Cover, heavy	0.20

LZETP. Index to lower zone evapotranspiration (unitless).

LZETP is a coefficient to define the ET opportunity; it affects evapotranspiration from the lower zone, which represents the primary soil moisture storage and root zone of the soil profile. LZETP behaves much like a "crop coefficient" with values mostly in the range of 0.2 to 0.7; as such, it is primarily a function of vegetation. Typical and possible value ranges are shown in **Figure 4-3**, and the following ranges for different vegetation are expected for the "maximum" value during the year (**Table E-3**):

Table E-3: LZETP Value Ranges

Land Cover Type	Input Coefficient
Forest	0.6 – 0.8
Grassland 0.4	0.4 - 0.6
Row Crops 0.5	0.5 – 0.7
Barren 0.1	0.1 – 0.4
Wetlands 0.6	0.6 – 0.9

Table E-4: Typical permanent channel cross-section with benchmark locations and points of measurement – Rosgen (1996)

HSPF HYDROLOGY PARAMETERS AND VALUE RANGES

NAME	DEFINITION	UNITS	RANGE OF VALUES TYPICAL MIN	TYPICAL MAX	POSSIBLE MIN	POSSIBLE MAX	FUNCTION OF ...	COMMENT
PWAT - PARM2								
FOREST	Fraction forest cover	none	0.0	0.50	0.0	0.95	Forest cover	Only impact when SNOW is active
LZSN	Lower Zone Nominal Soil Moisture Storage	inches	3.0	8.0	2.0	15.0	Soils, climate	**Calibration**
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.50	Soils, land use	**Calibration**, divides surface and subsurface flow
LSUR	Length of overland flow	feet	200	500	100	700	Topography	Estimate from high resolution topo maps or GIS
SLSUR	Slope of overland flow plane	ft/ft	0.01	0.15	0.001	0.30	Topography	Estimate from high resolution topo maps or GIS
KVARY	Variable groundwater recession	1/inches	0.0	3.0	0.0	5.0	Baseflow recession variation	Used when recession rate varies with GW levels
AGWRC	Base groundwater recession	none	0.92	0.99	0.85	0.999	Baseflow recession	**Calibration**
PWAT - PARM3								
PETMAX	Temp below which ET is reduced	deg. F	35.0	45.0	32.0	48.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temp below which ET is set to zero	deg. F	30.0	35.0	30.0	40.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0.0	0.20	0.0	0.50	Geology, GW recharge	Accounts for subsurface losses
BASETP	Fraction of remaining ET from baseflow	none	0.0	0.05	0.0	0.20	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0.0	0.05	0.0	0.20	Marsh/wetlands extent	Direct ET from shallow GW
PWAT - PARM4								
CEPSC	Interception storage capacity	inches	0.03	0.20	0.01	0.40	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.10	1.0	0.05	2.0	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Manning's n (roughness) for overland flow	none	0.15	0.35	0.05	0.50	Surface conditions, residue, etc.	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1.0	3.0	1.0	10.0	Soils, topography, land use	**Calibration**, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.7	0.3	0.85	Soils, topography, land use	Often start with a value of 0.7, and then adjust
LZETP	Lower zone ET parameter	none	0.2	0.7	0.1	0.9	Vegetation type/density, root depth	**Calibration**

Source: U.S. EPA BASINS Technical Note 6

Model assumptions for stream reach infiltration rates were derived through calibration based on data collected within the reaches of Aliso Creek (11 stations) and Rose Creek (6 stations). In the model, infiltration rates vary by soil type. Stream infiltration was calibrated by adjusting a single infiltration value, which was varied for each soil type by factors established from literature ranges (U.S. EPA 2000) of infiltration rates specific to each soil type. The final resulting infiltration rates were 1.368 in/hr (Soil Group A), 0.698 in/hr (Soil Group B), 0.209 in/hr (Soil Group C) and 0.084 in/hr (Soil Group D). The infiltration rates for Soil Groups B, C, and D are within the infiltration range given in literature (Wanielisata et al. 1997). The result for Soil Group A is below the range given in Wanielisata et al. (1997); however, this result only represented one watershed in this TMDL study.

APPENDIX F

Jurisdictional Exemption Maps

The exemption maps provided in Appendix F are for planning purposes and more detailed maps can be found at the County's Georesearch website.

Figure F-1: Aliso Viejo Exemption Map

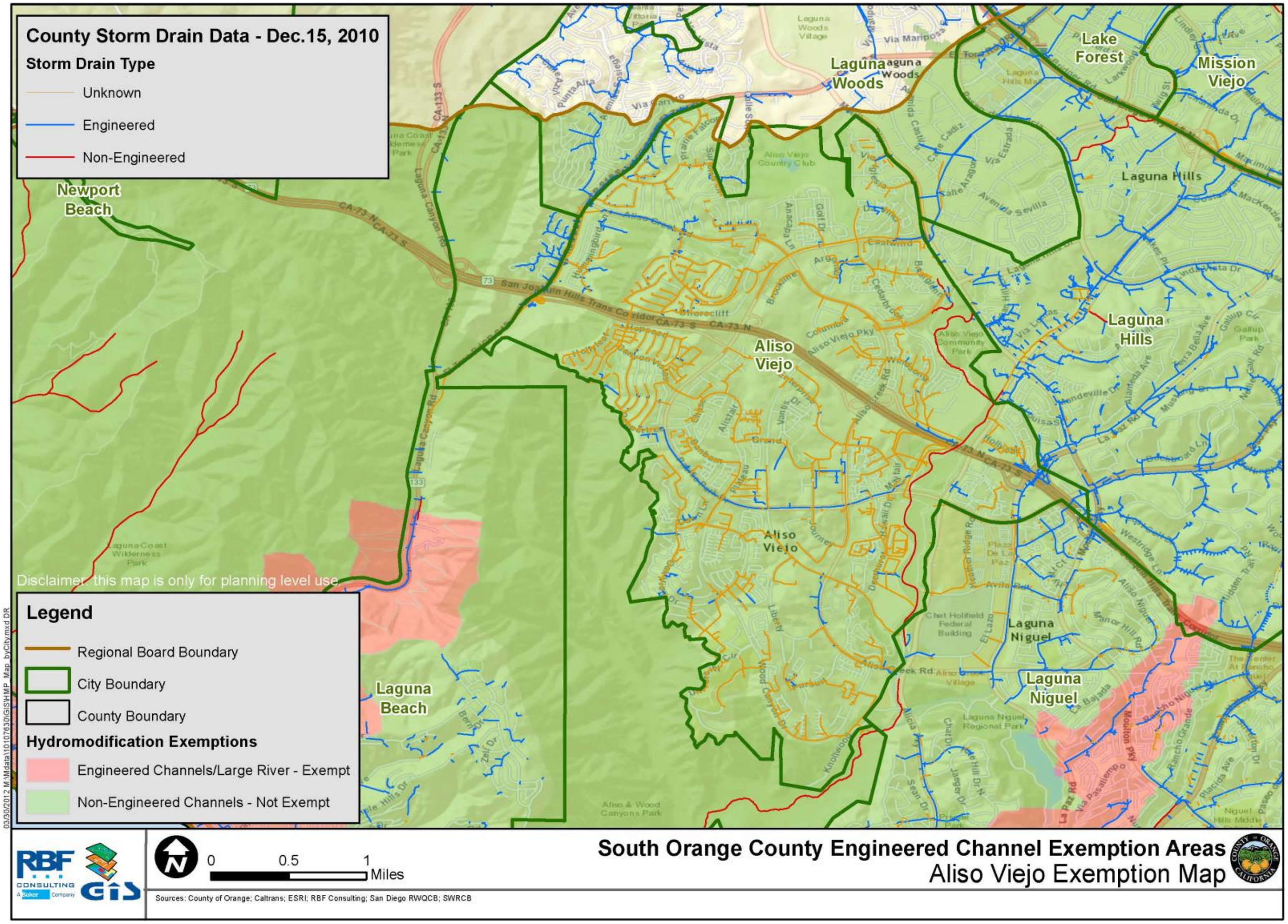


Figure F-2: Dana Point Exemption Map

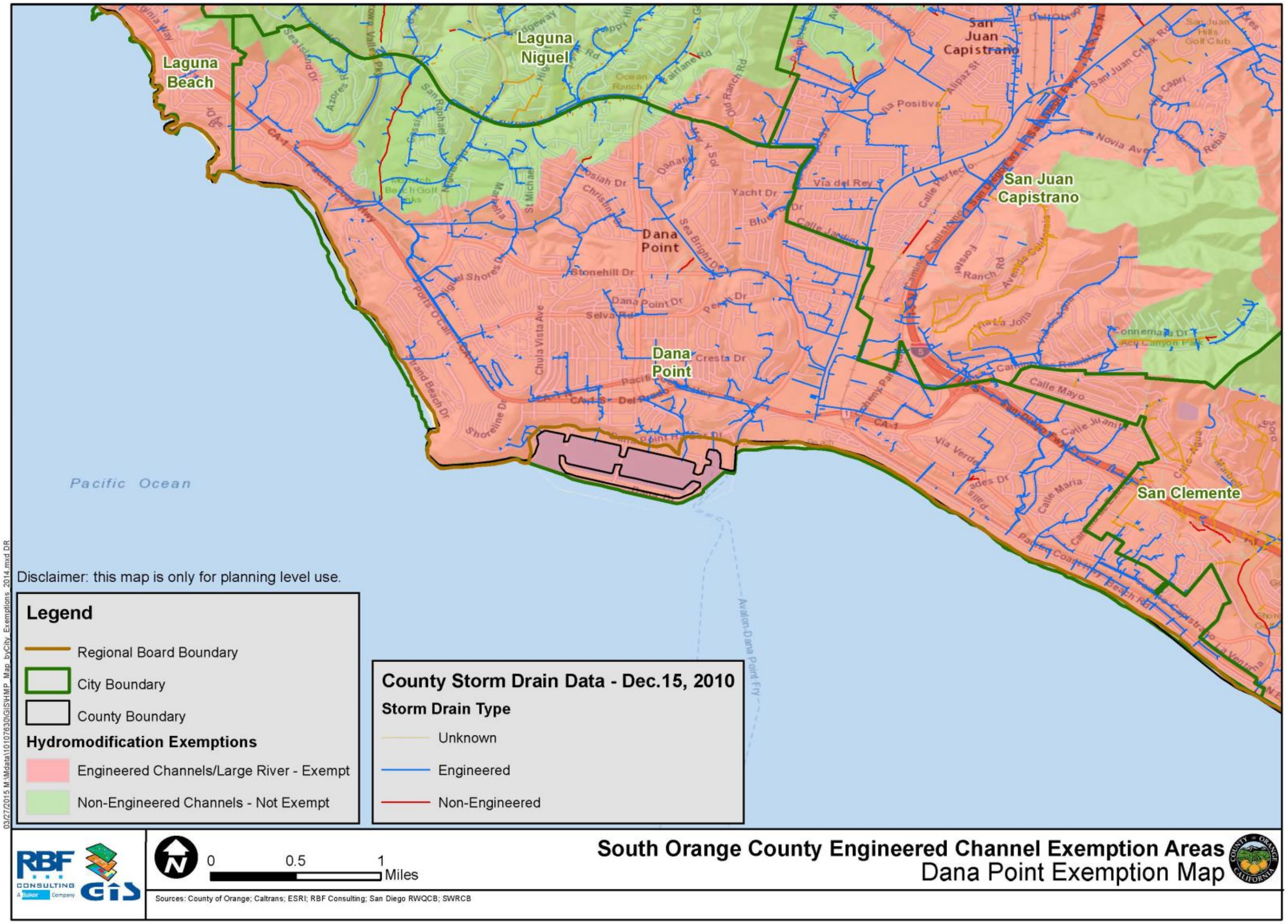


Figure F-3: Ladera Ranch Exemption Map

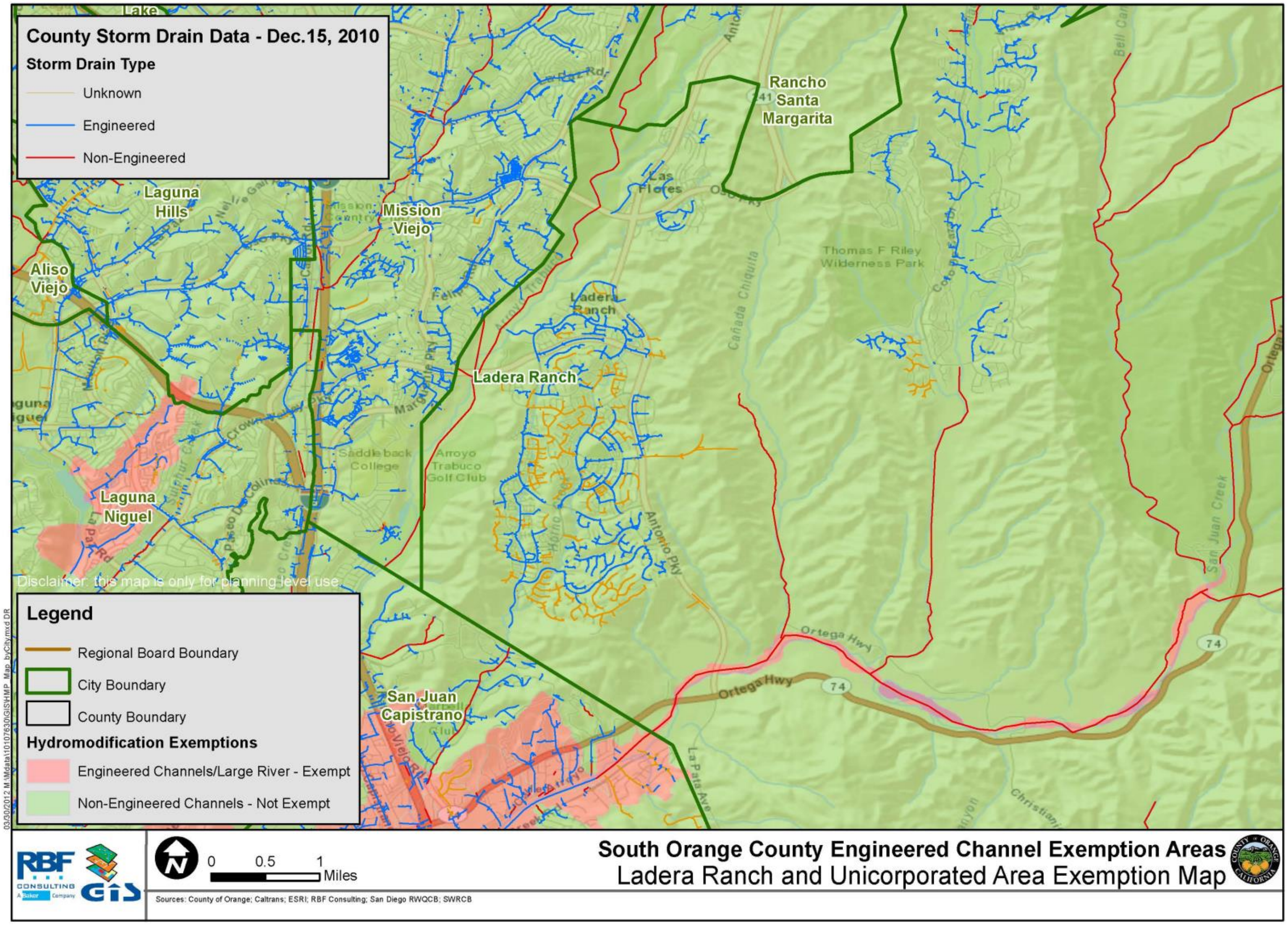


Figure F-4: Laguna Beach Exemption Map

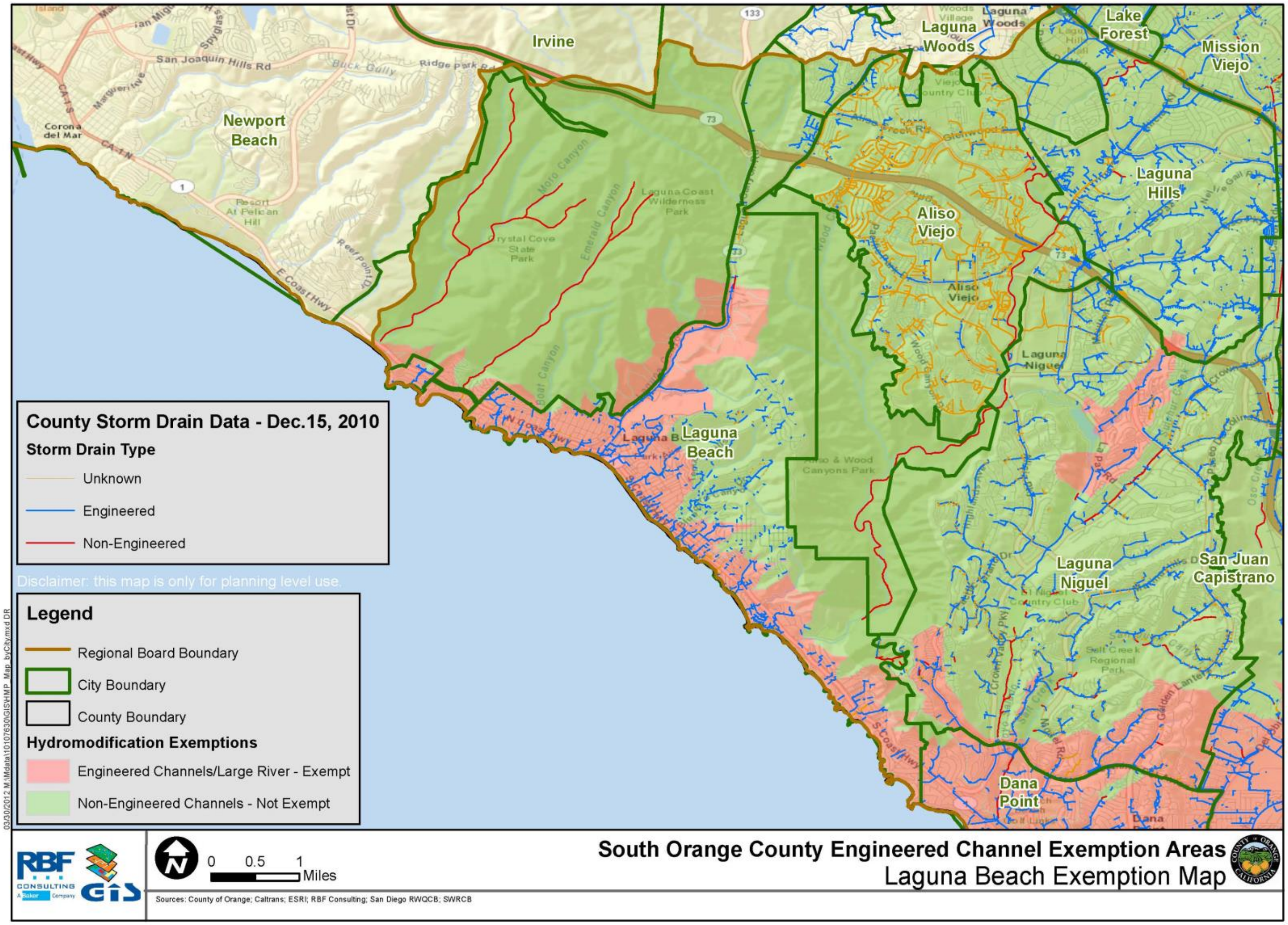


Figure F-5: Laguna Hills Exemption Map

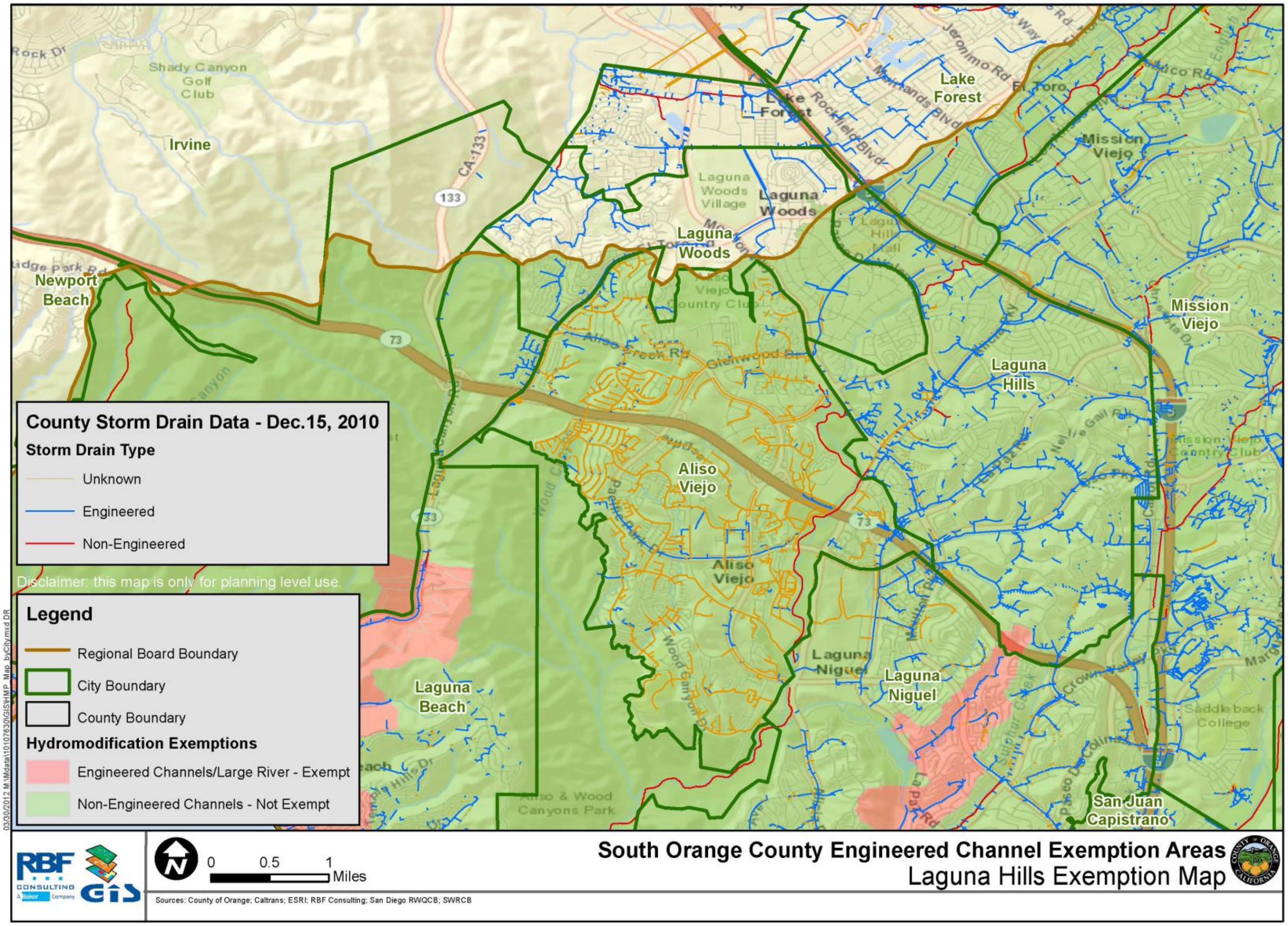


Figure F-6: Laguna Niguel Exemption Map

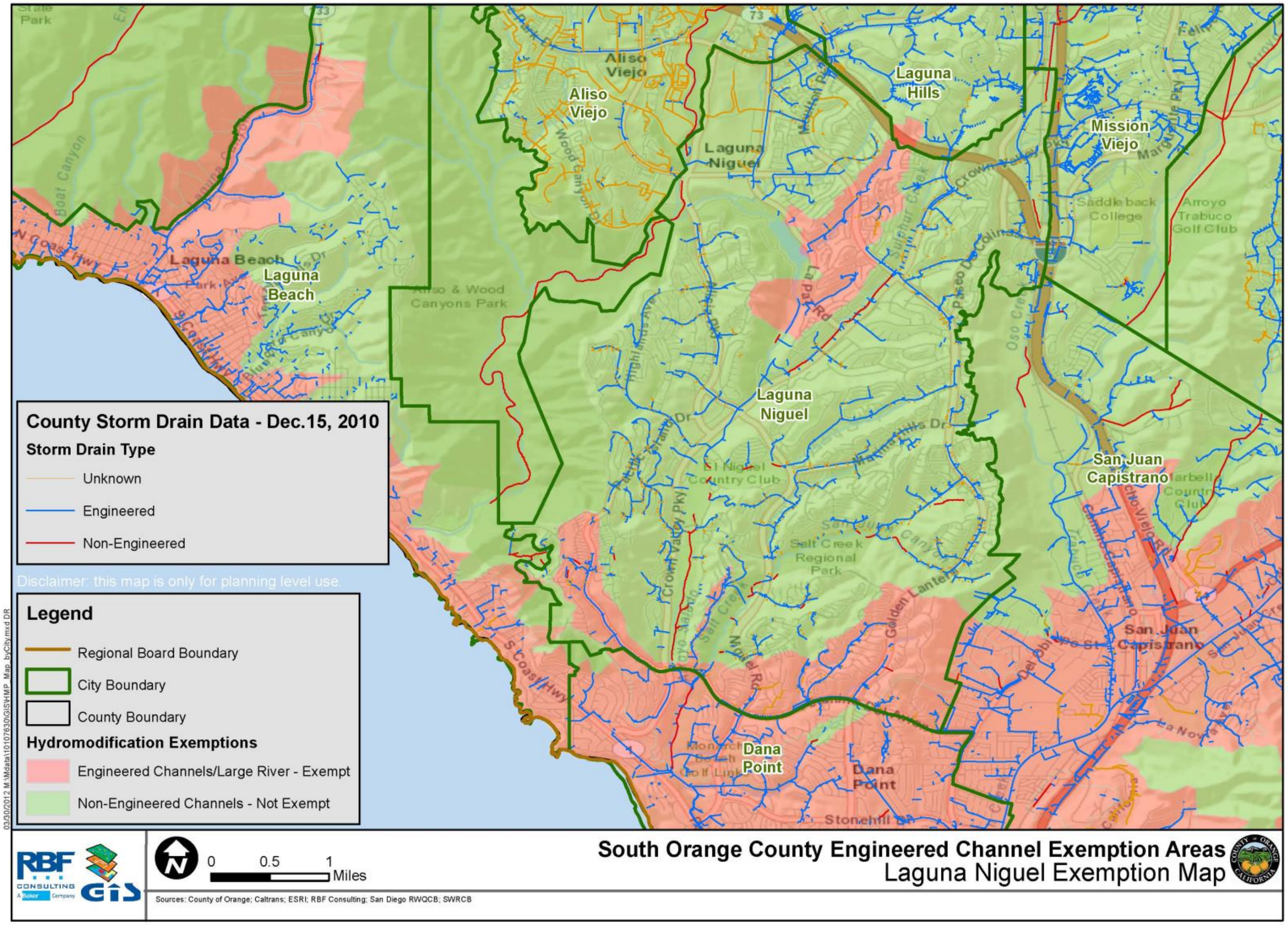


Figure F-7: Laguna Woods Exemption Map

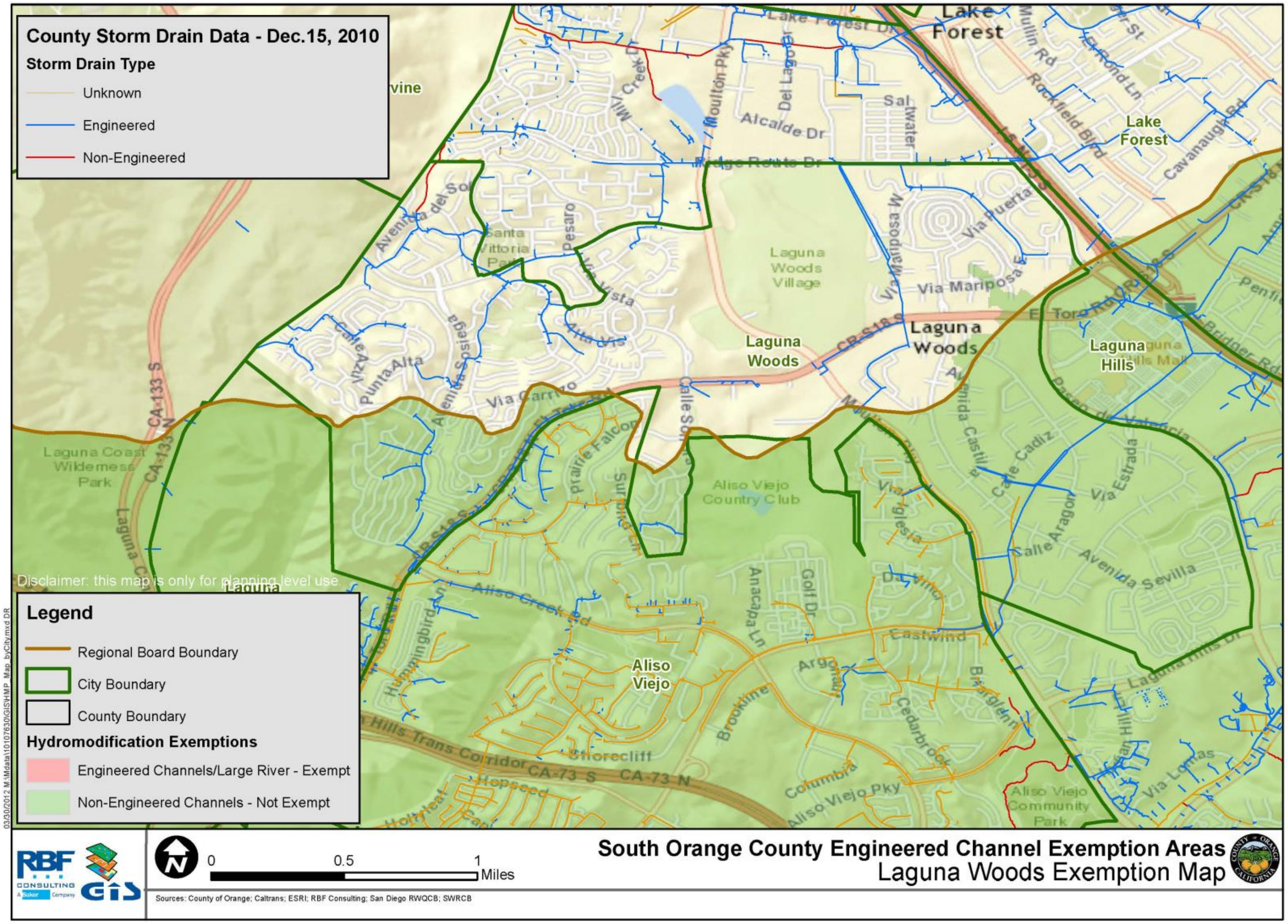


Figure F-8: Mission Viejo Exemption Map

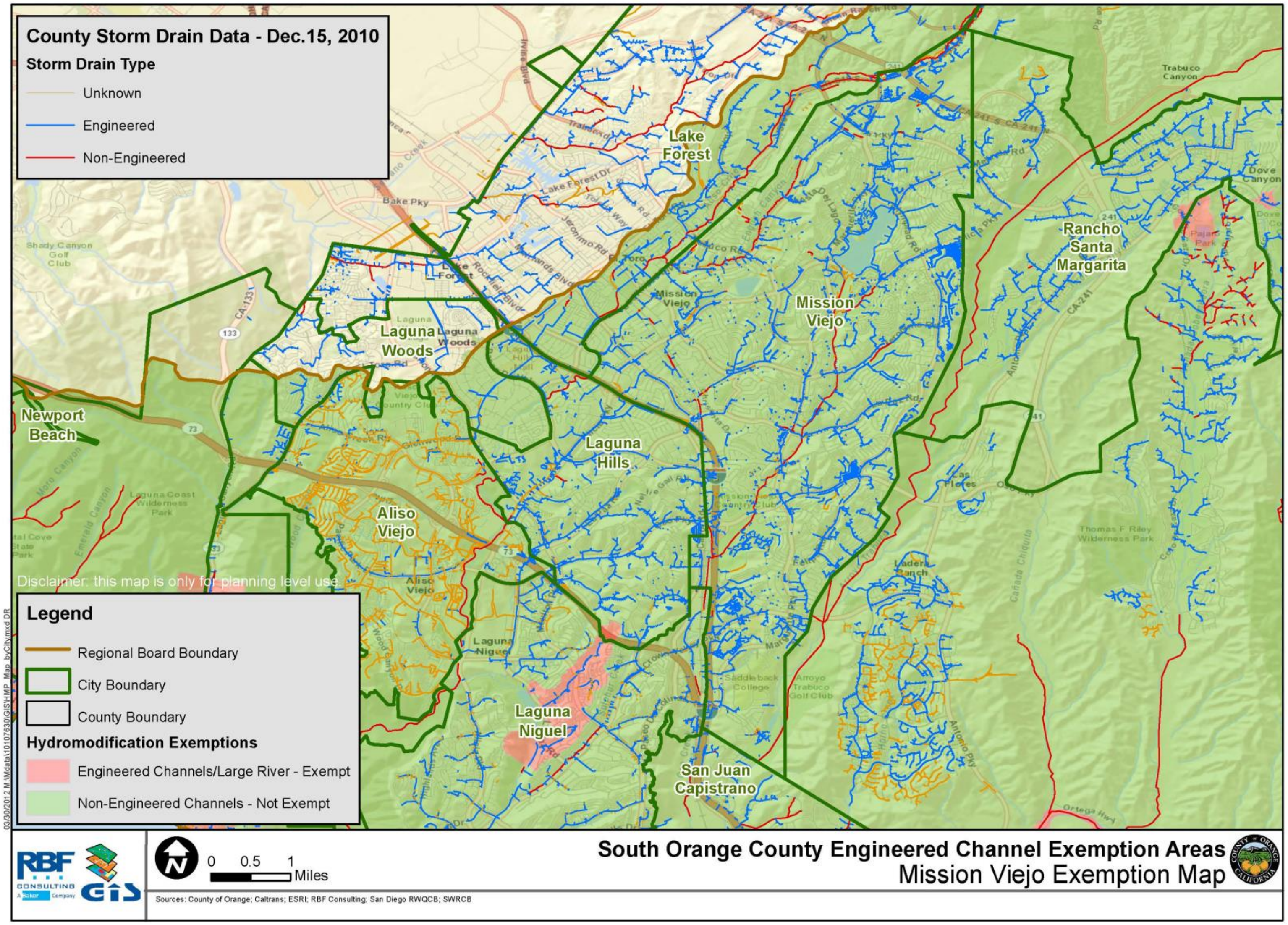


Figure F-9: Rancho Santa Margarita Exemption Map

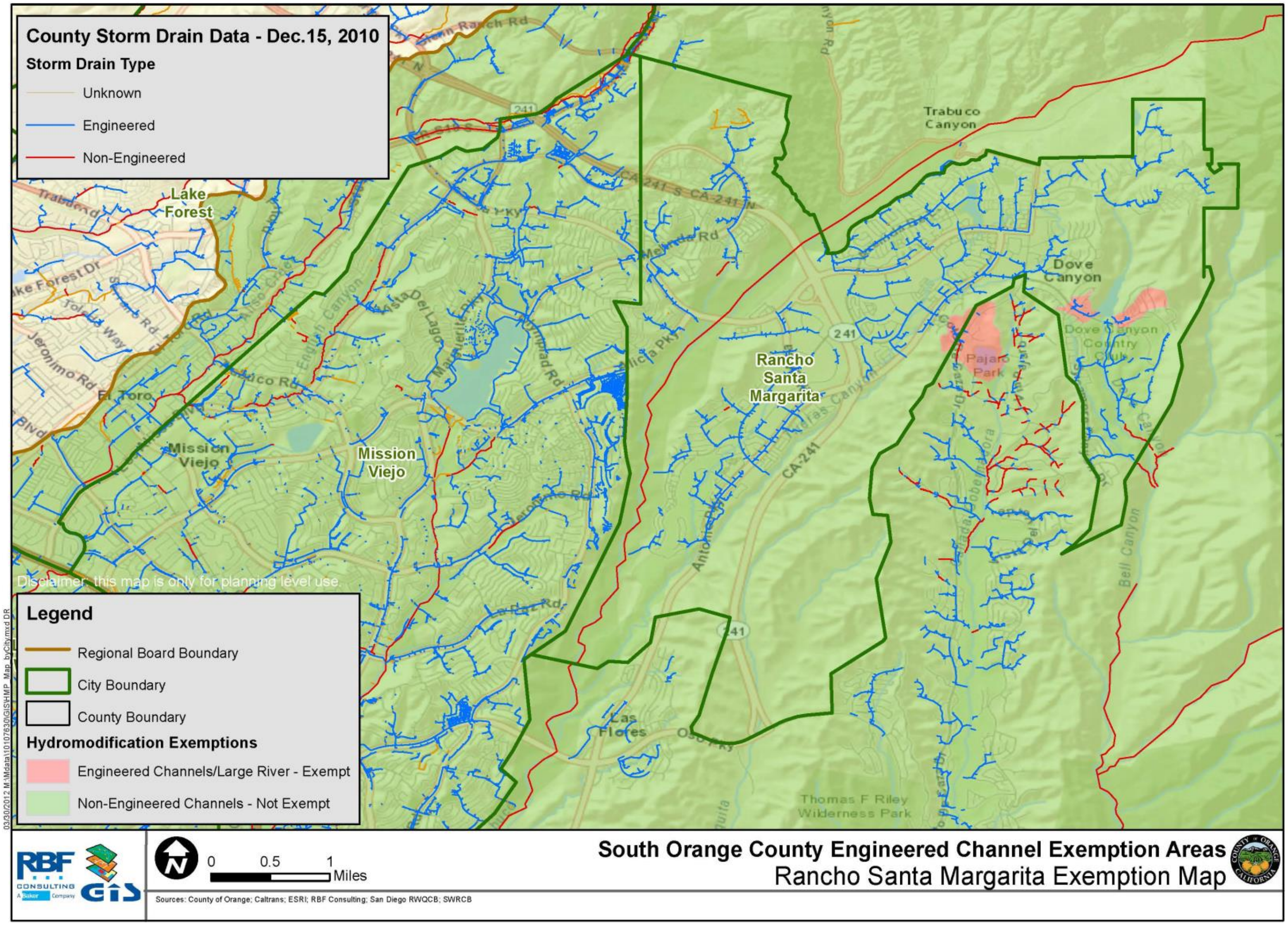


Figure F-10: San Clemente Exemption Map

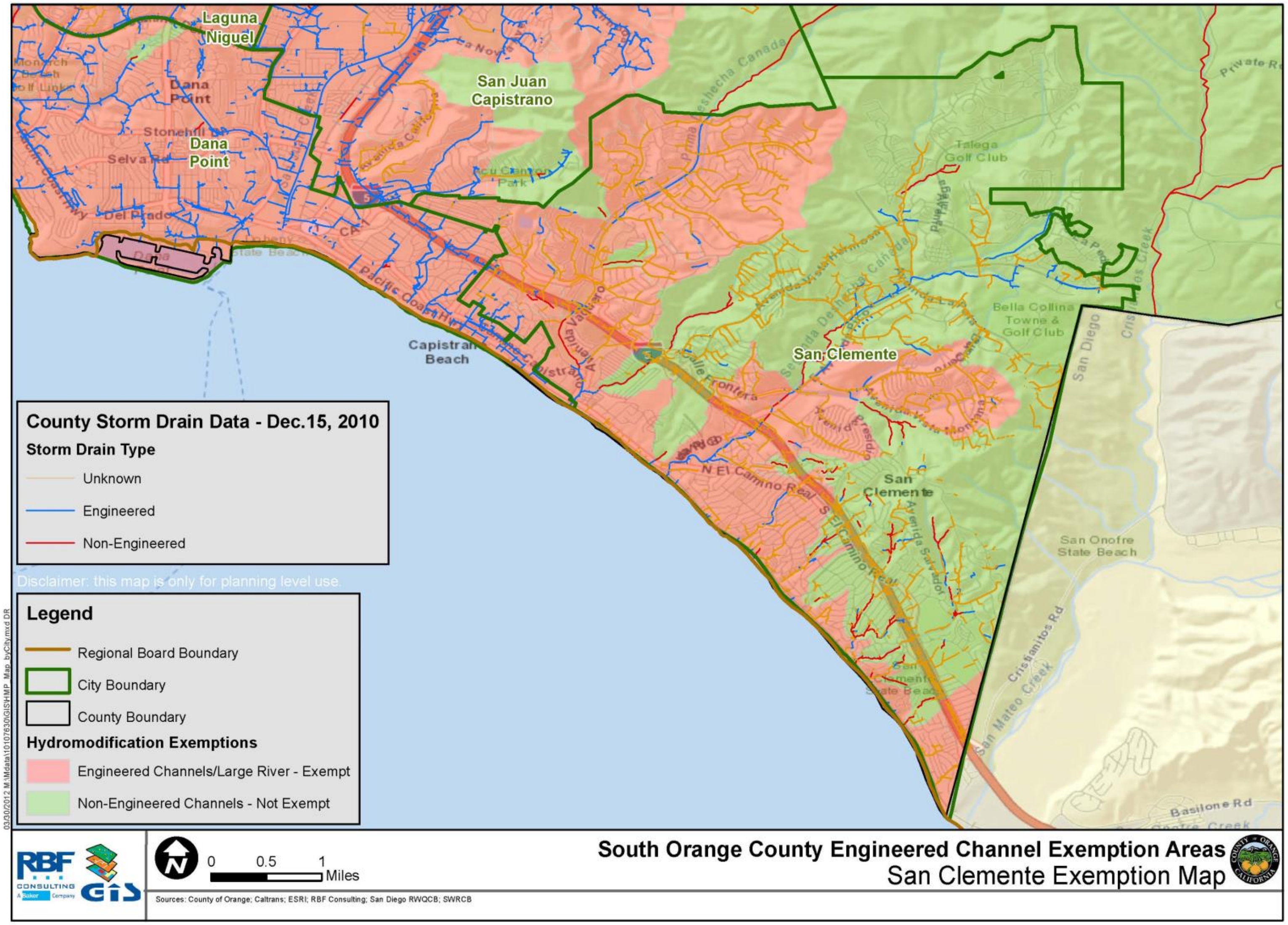
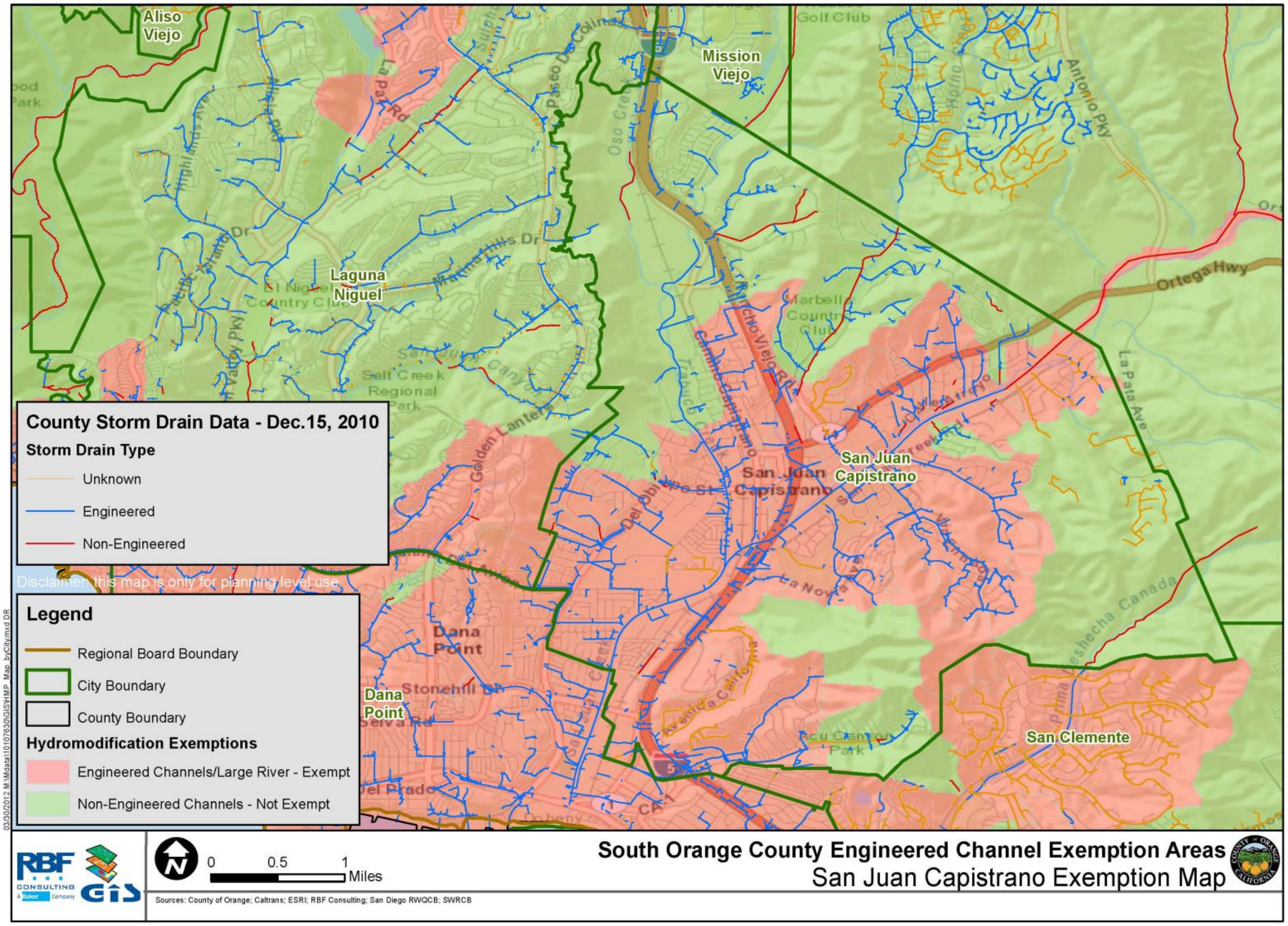


Figure F-11: San Juan Capistrano Exemption Map



APPENDIX G

Bioassessment

G.1 Historical Hydromodification Impacts and IBI Scoring

Order R9-2009-0002 Permit Section F.1.h.(1)(f) required the identification of areas within the San Juan hydrologic unit where historical hydromodification has resulted in negative impacts to benthic macroinvertebrate communities. The upper part of the San Juan hydrologic unit (HU 901) is located in Orange County. A Surface Water Ambient Monitoring Program (SWAMP) was prepared in July 2007 for this portion of the hydrologic unit by the Southern California Coastal Water Research Project (SCCWRP, 2007). Findings of the 2007 SWAMP report indirectly identify such areas that are associated with the negative impact to benthic macroinvertebrate and benthic periphyton. These areas are characterized by low (poor) or very low (very poor) Index of Biotic Integrity (IBI) scores. This reporting effort was completed under the supervision of the SDRWQCB. SWAMP monitoring efforts are conducted every five years.

The bioassessment analysis included monitoring data from the following historical monitoring programs:

- California Department of Fish and Game (1998-2000)
- Orange County NPDES (2002-2006)
- Camp Pendleton (2004-2005)

The Southern California IBI is computed as a composite of seven metrics summed and scaled from 0 to 100, as follows:

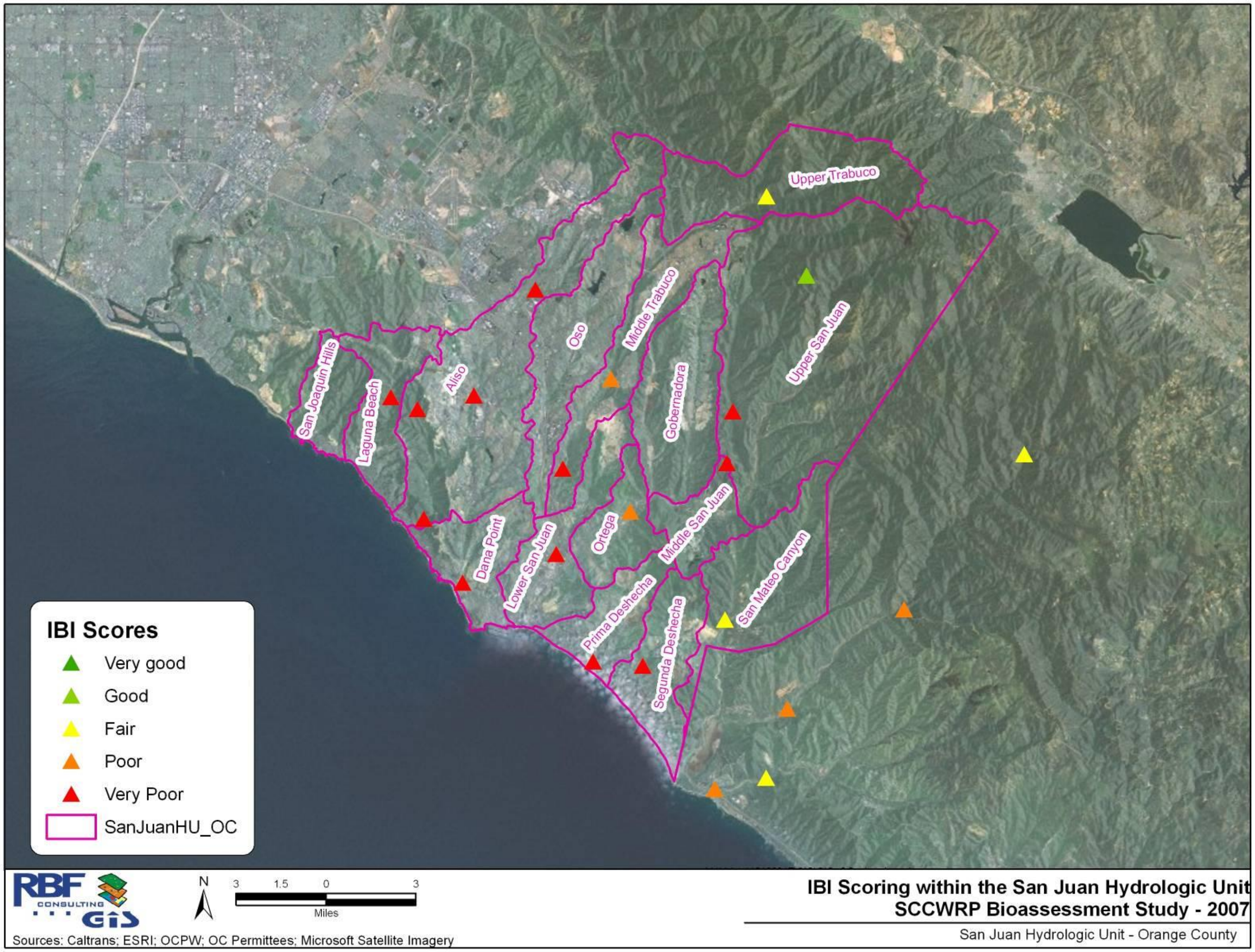
- 0–19 (very poor condition)
- 20–39 (poor condition)
- 40–59 (fair condition)
- 60–79 (good condition)
- 80–100 (very good condition)

Seventeen monitoring stations are located within the Orange County boundaries. **Error! Reference source not found.** shows the location of these stations, as well as their associated IBI scoring category. Associated IBI scores were derived from the statistical analysis of monitoring data that was collected over several seasons (winter, spring, summer, and fall) and different hydrologic conditions.

The SWAMP study considers three monitoring locations as unimpacted by anthropogenic development in the hydrologic unit. They are characterized as reference monitoring locations. The three reference stations and their associated IBI scores are

- Bell Creek (64)
- Cold Spring Creek (34)
- Arroyo Trabuco Creek (68)

Figure G-4: IBI Scoring within the San Juan Hydrologic Unit



Overall, benthic macroinvertebrate communities may have been impacted by hydromodification in several coastal and foothill subwatersheds that exhibit very poor IBI scores. These include the following subwatersheds: Laguna Beach, Aliso Creek, Dana Point, Lower San Juan, Prima Deshecha, Segunda Deshecha, Middle San Juan subwatersheds, as well as the lower portion of the Middle Trabuco subwatershed. Similarly, benthic macroinvertebrate communities may have been impacted to a lesser level in the Middle Trabuco and Ortega subwatersheds. One of the reference monitoring stations, Cold Creek, exhibits poor IBI scores. Conversely, benthic macroinvertebrate communities of the following subwatersheds may have been not impacted by hydromodification: San Mateo Canyon, Upper Trabuco, and Upper San Juan. Developments in these subwatersheds are limited.

No monitoring stations are available in the Gobernadora, Oso, and San Joaquin Hills subwatersheds. Impacts of hydromodification on IBI scores were not extrapolated to these subwatersheds because of the geographic variability of environmental conditions.

G.2 Assessment of Watercourses

Hydromodification impacts from development projects and/or maintenance activities may have led to the impairment of state and federal waters and wetlands. U.S. EPA reports three major types of hydromodification activities: channelization and channel modification, dams, and streambank and shoreline erosion (U.S. EPA, 2007). Studies suggest a link between the value of physical habitat/structure and IBI values. Waterbodies that are impacted by hydromodification may have lower IBI scores due to direct and indirect impacts of upstream development.

Accelerated impacts occur to natural or earthen drainages from projects that increase in runoff flow rates and duration. Such impacts to aquatic species may include changes in flow, increased sedimentation, higher water temperatures, lower dissolved oxygen, degradation of biotic structure and decreased water quality (U.S. EPA 2007). Once these environmental stressors are present, subsequent direct and indirect impacts occur, especially to aquatic life. For example, increased sediment loading can decrease fish spawning and reduce macro-invertebrate communities. Hydromodification generally increases the transport of sediment and associated constituents (nitrates, sulfates, metals, turbidity), which impacts water quality to the point where aquatic life thresholds may be exceeded (SCCWRP 2007). Studies suggest a link between the value of physical habitat/structure and IBI values. Waterbodies that are impacted by hydromodification would be expected to have lower IBI scores from direct and indirect impacts of upstream development. It should be noted, however, that low IBI scores may be caused by natural variability.

The second aspect to consider is the reduction of wash load, which is generally viewed as favorable to benthic health. “Natural” discharge of course material (bed material) is beneficial, but colloidal material, clay, and silt are unfavorable. Stabilization of the watershed, particularly of areas generating turbidity in runoff, is the goal. The reduction of wash load during construction activities may be accomplished with the implementation of the requirements of the Construction General Permit.

The impacts of potential hydrograph changes can be assessed through the SWAMP monitoring program, as presented in **Appendix H**. In addition, records of channel morphology can be taken at selected monitoring locations.

APPENDIX H

HMP & Bioassessment Monitoring Effectiveness

The following section defines the monitoring approach and the performance protocol that can be implemented to verify the effectiveness of the South Orange County HMP. The section presents technical concepts and defines approaches to monitor the effectiveness of the HMP as identified by provisions F.1.h. (1)(g) and F.1.h. (1)(l) of Regional Board Order No. R9-2009-0002 and is consistent with the requirements of Section D.1.c.(6) of Regional Board Order R9-2013-0001 as amended by Order No. R9-2015-0001
Section F.1.h.(1)(g) of Permit Order No. R9-2009-0002 required the definition of a protocol to evaluate the potential hydrograph change impacts to downstream watercourses from PDPs. The protocol must include the use of IBI scores. Section F.1.h.(1)(l) of Permit Order No. R9-2009-0002 also required a description of pre- and post- project monitoring and other program evaluation, including IBI score, to assess the effectiveness of the HMP.

The defined performance protocol addresses the requirements of provisions F.1.h.(1)(k) of Permit Order No. R9-2009-0002, including a description of inspections and maintenance of hydrologic controls and sediment supply management measures, as well as a protocol to address potential hydromodification impacts.

The hydrologic and sediment performance standards established by this HMP are based on the most recent state of the hydromodification management science (SCCWRP, 2012). The level of uncertainty associated with the variables influencing the geomorphology and the biological integrity of receiving streams may only be reduced through monitoring. The implementation of the hydromodification monitoring approach along with the performance protocol can operate on the basis of adaptive management principles. The frequency and geographical distribution of the proposed monitoring actions is optimally selected upon identification of the scientifically-observed seasonal and geographical patterns of hydromodification and in-stream biological activity. The findings of the monitoring plan can trigger refinements improving the hydrologic and sediment performance standards, to ensure that the geomorphology and the biological integrity of receiving streams are protected or enhanced.

H.1 Technical Concepts

H.1.1 HMP Monitoring Measures

H.1.1.1 Stream Benthic Community

A stream benthic community is a metric for assessing the condition of a stream. Biological communities represent the health of a portion of the benthic stream community. This is explained by the fact that biological organisms, especially benthic macroinvertebrate and periphyton communities, integrate exposure over time and respond to cumulative stressors (SCCWRP, 2011). The IBI integrates several populations of organisms, and as such the combination of organisms offers a differential sensitivity to stressors, allowing for early detection of potential degradation (SCCWRP, 2011). Bioassessment may only be conducted from May to July and only if water is present; however, samples that are collected late spring may provide the most representative results, as vegetation cover and flow conditions are usually optimal. This is particularly true for non-perennial streams of the San Juan Hydrologic Unit. Seasonal variability in benthic communities is typical for non-perennial streams; however, the current IBI has almost exclusively been calibrated for perennial streams (SCCWRP, 2011). SCCWRP is in the process of developing a Benthic Macroinvertebrate Index (BMI) that would account for the typical seasonal variability of non-perennial streams.

H.1.1.2 Channel incision and widening

The most obvious way to assess changes due to scour or deposition is to physically measure the pre-project and post-project cross sections, and determine if the channel is incising and/or widening over time. This is accomplished by conducting geomorphic assessments and channel surveys downstream of a planned development before and after construction. In addition to physical measurements, comparison of current and historical photos, aerial photography, and site inspection for signs of channel degradation can provide important supporting evidence.

H.1.2 Temporal and Spatial Variability of Monitoring Locations

H.1.2.1 Temporal variability

The single most important factor affecting the temporal variability inherent to measuring stream degradation is variable inter-annual rainfall frequency and intensity. Droughts in California can last years, with little to no rainfall occurring in Southern California. During El Niño years, anomalously high storm frequencies and intensities can result in sudden geomorphic changes. Rainfall intensity also varies intra-annually. Accordingly, the value of the monitoring program will be derived only over the long-term. Significant trends will likely require many years to identify. IBI scores may be a correlating variable to geomorphic changes in streams.. However, the method used to compute the index is specifically for perennial streams, and does not account for the typical seasonal variability associated with non-perennial streams, as it exists in the San Juan Hydrologic Unit.

H.1.2.2 Spatial variability

Sampling a representative set of streams is important to capture the range of watershed conditions and biological organisms present in the permit coverage area. Other important factors that affect stream responses to hydromodification include channel grade, watershed area, vegetated cover, and stream sinuosity. In addition to channel and watershed features, location within the watershed is an important consideration. Monitoring stations should be located in the watershed headwaters just downstream of a development project of sufficient size, so that hydromodification effects from the proposed development can be isolated for comparison purposes to the maximum extent practicable. Upper watershed sites provide more definitive measures of HMP effectiveness because they can more directly correlate effects to specific development projects.

Middle watershed and lower watershed sites would be influenced by confounding variables (such as mass wasting and impacts from natural tributary confluences and other existing development projects), including phased developments over many years, in the watershed. Therefore, middle and lower watershed monitoring sites would require much more time to assess overall program effectiveness, if achievable.

The concept of providing hydromodification effectiveness measurements in the watershed headwaters is supported by SCCWRP. Research by SCCWRP has shown that hydromodification effects of a development project become muted with increasing distance from the development site (defined by SCCWRP as the Domain of Effect). To the extent practicable, monitoring locations detailed in this plan will be distributed throughout the San Juan Hydrologic Unit to provide for geographic and climatic variability across south Orange County.

H.2 Approaches Selected to Assess HMP Effectiveness

One option is for the development of an HMP Effectiveness Plan

An examination of benthic macroinvertebrate organisms can be conducted to assess both biological and geomorphologic health of the streams. Additionally, channel assessment cross sections at selected locations, coincident with the IBI sampling locations, can be selected.

The South Orange County Permittees would seek cost-effective methods to implement any HMP Effectiveness Plan developed. Stream bioassessment for the purpose of HMP effectiveness should be coupled with the Urban Stream Bioassessment. Several bioassessment monitoring sites already exist for both the SWAMP, which is developed on a five-year cycle, and the annual PEA. At each of these existing sites, historical bioassessment data is readily available for the establishment of pre-project conditions. Several reference monitoring sites are also readily available including, but not limited to, three urban bioassessment sites. The ultimate selection of bioassessment sites should consider integrating one or several of these existing sites consistent with the objectives of the HMP Effectiveness Plan.

Considering the constraints and technical approach detailed above, the following approaches are recommended for HMP monitoring.

Evaluate the HMP effectiveness by monitoring benthic macroinvertebrate communities. Biological organisms provide essential information to the overall health of a stream. The evolution of benthic macroinvertebrate communities may be the precursor to an impacted or improved stream. Benthic communities should be monitored once a year, preferably in late spring, at defined monitoring stations. Bioassessment should be done by computing the IBI score and comparing it to historical levels in the same stream. Ultimately, the Benthic Macroinvertebrate Index (BMI) could be used once it has been developed by SCCWRP, however at this time there is no estimated date as far as completion.

Complete a stream channel survey at each of the selected channel sections on an annual basis. The stream channel survey consists of collecting topographic and bathymetric measurements along each cross-section to characterize morphology and longitudinal slope of the stream segment. Four parameters will be surveyed: the floodprone width, the bankfull width, the bankfull depth, and the longitudinal slope. In addition to these four parameters, to meet the requirements of Section D.1.c.(6) of Regional Board Order R9-2013-0001 as amended by Order No. R9-2015-0001the following information will be collected for each long-term receiving water monitoring station at least once during the term of Order R9-2013-0001 as amended by Order No. R9-2015-0001Channel conditions, including: channel dimensions, hydrologic and geomorphic conditions, and presence and condition of vegetation and habitat

- Location of discharge points
- Habitat integrity
- Photo documentation of existing erosion and habitat impacts, with location, latitude and longitude, where photos were taken
- Measurement or estimate of dimensions of any existing channel bed or bank eroded areas, including length, width, and depth of any incisions
- Known or suspected cause(s) of existing downstream erosion or habitat impact, including flow, soil, slope, and vegetation conditions, as well as upstream land uses and contributing new and existing development

Each surveyed stream segment will be subsequently classified per the simplified Rosgen system of channel classification (Rosgen, 1996). **Figure** H-1 shows the different types of channels per Rosgen channel classification (Rosgen, 1996).

Figure H-5: Simplified Rosgen Channel Classification

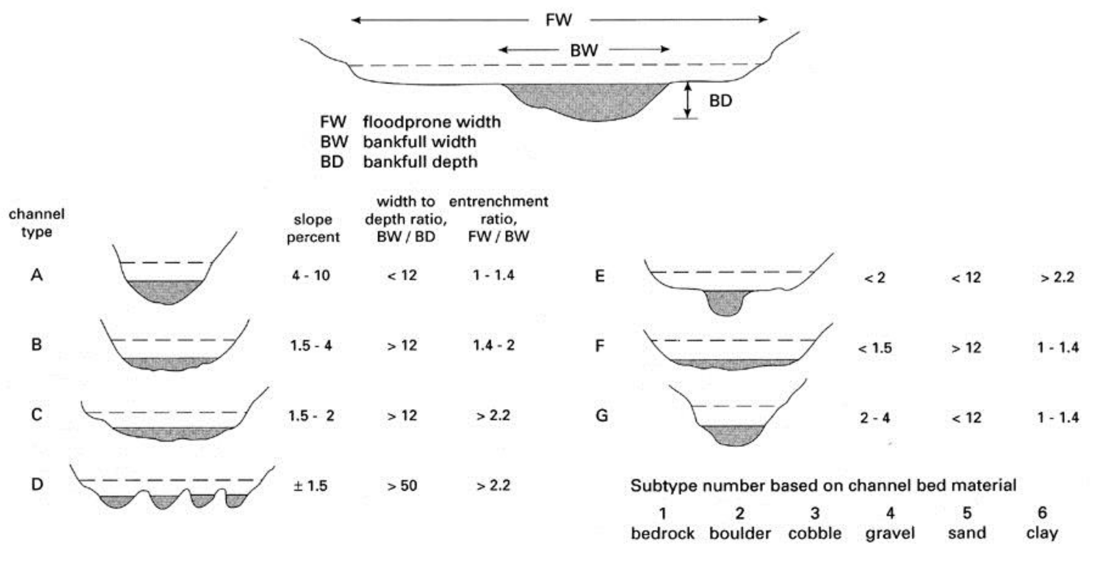


Figure 1.12 The Rosgen system of channel classification.

(Rosgen, 1996)

The temporal evolution in geomorphology, if any, of the surveyed stream segment will be compared to the six-stage Channel Evolution Model defined by Simon, as well as the previous year cross section data, to correlate any potential impacts of urbanization to this change of stream channel geomorphology (Simon et al., 1992). The geomorphologic evolution of a stream segment, if any, will also be compared to the annual bioassessment to determine if the observed aggradation or degradation is associated with changes in the benthic macroinvertebrate communities. **Error! Reference source not found.** illustrates the six-stage sequence of incised channel evolution (Simon et al., 1992). A stream segment will be considered stable over time if features of the stream segment (such as dimension, pattern, and profile) are maintained, and the stream system neither aggrades nor degrades.

Stream Classification Procedure

The procedure derives from the "Stream Stability Validation" approach that is described by Rosgen (1996). Stream stability over time may be assessed by monitoring the stream channel for five factors: (1) aggradation (2) degradation (3) shifting of particle sizes of stream bed materials (4) changing the rate of lateral extension through accelerated bank erosion (5) morphological changes following the CEM (Simon et al., 1992). If any hydrological changes or disturbance occurs in the watershed, the five elements defined above are critical to analyze the channel response to the implementation of HMP mitigation measures.

One reference stream station will be used for comparison purposes and should coincide with the station selected for the bioassessment. The reference station should be located in a stream that shows the same lithology, sediment regime, and morphometric parameters as the study stream stations. Annual comparisons of channel stability will be carried out at the same time of the year, at the end of the spring season, thus maximizing the chances to monitor similar weather patterns.

Channel stability will be evaluated, on an annual basis, at selected cross-sections in the San Juan hydrologic unit. Evaluation of the vertical or bed stability will serve as the reference method to understand the geomorphological changes of a channel stream over time. Vertical or bed stability will be evaluated at each of the identified cross-sections: this field method will identify a potential aggradation or degradation, if any, of the stream. Rate, magnitude, and direction of vertical change, if any, will be quantified.

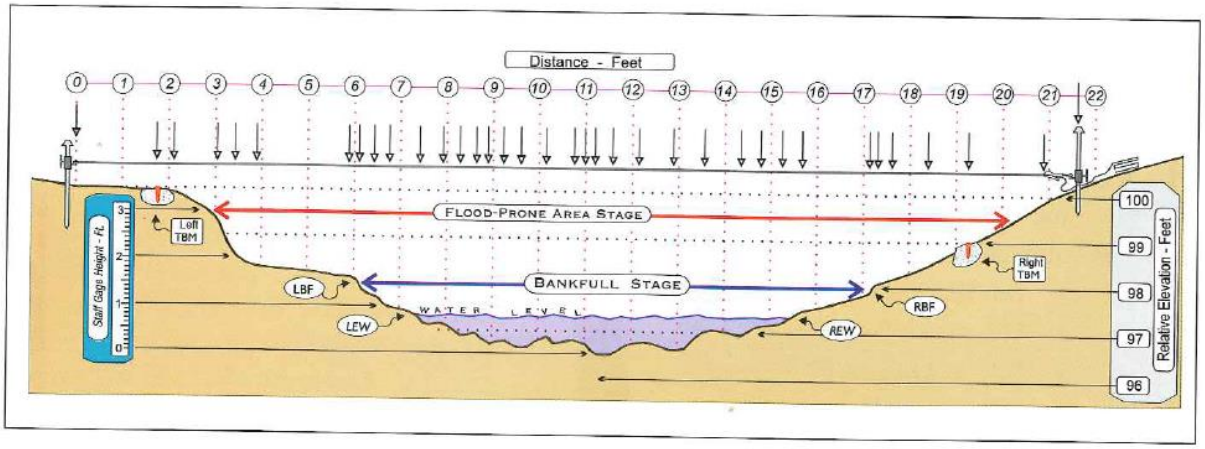
Vertical or bed stability:

Rosgen (1996) has documented a couple methods including one, known as the "Monumented cross-sections method". At each selected site, the method consists of setting permanently monumented cross-sections that are located on a riffle and pool segment (or step/pool segment), i.e., two monumented cross-sections per site. Annual measurements at the two monumented cross-sections per site will be compared to the reference elevations taken during the initial survey.

Initially, one permanent bench mark should be installed on each bank of the stream: a left temporary bench mark and a right temporary bench mark. These should be made permanent by digging a hole in which a 10-inch stove bolt will be set up by a pad of concrete. The intent is to avoid vandalism damage. These two bench marks will be located at the cross-section on a stable site above and away from the bankfull channel. Additionally, an elevation cross-section is often needed if the left or right side of the cross-section is located on an unstable slope. An elevation bench mark is established and often does not represent a true representation, but rather a relative elevation set at 100 feet.

During each cross-section survey, a leveled tape line is set above the stream channel. Measurements originate from the intercept of the rod with the leveled tape line (**Figure H-2**).

Figure H-2: Typical permanent channel cross-section with benchmark locations and points of measurement – Rosgen (1996)



Simple measurements are made with the measuring tape and elevation rod method as described by Rosgen (1996):

- Locate the permanent bench mark on both sides of the stream (or, if on one side, a bearing for the transect is needed)
- Stretch the tape very tight with spring clamp and tape level
- Locate tape at same elevation as reference bolt on bench mark
- Read distance and elevation reading of rod intercept with tape
- Measure major features, such as:
    - Left bench mark (LBM)
    - Left terrace/floodplain (LT, LFP)
    - Left bankfull (LBF)
    - Left bank (LB)
    - Left edge of water (LEW)
    - Various bed features, bars, etc.
    - Thalweg (TW)
    - Inner berm features (IB)
    - Right edge of water (REW)
    - Right bank (RB)
    - Right bankfull (RBF)
    - Right terrace/floodplain (RT, RFP)
    - Right benchmark (RBM)

Measurements must include the floodplain, terraces, and stream adjacent slopes. Other surveying procedures such as auto or laser levels and total station surveys may be adapted from the described "measuring tape and elevation rod" method. If technically feasible, any exceptional event associated with level higher than the bankfull level needs to be marked and indicated on the cross-section. The cross-section needs to be plotted for each measurement and compared to previous cross-sections to evaluate bed stability.

Finally, the longitudinal slope will be assessed based on measurements taken at two consecutive cross-sections. Rosgen (1996) also recommends developing a vicinity map and detailed site map indicating the locations of monumented cross-sections, as well as upstream and downstream photographs for site documentation. Channel dimensions for stream classification need to be correlated in order to document morphological comparisons for extrapolation.

Each stream segment being surveyed will be classified on an annual basis per the simplified Rosgen system of channel classification (Rosgen, 1996). Classification will be possible upon identification of the following parameters: floodprone width, bankfull width, bankfull depth, and longitudinal slope. **Figure H-3** shows the different types of channels per Rosgen channel classification (Rosgen, 1996).

Figure H-3: Simplified Rosgen Channel Classification (Rosgen, 1996)

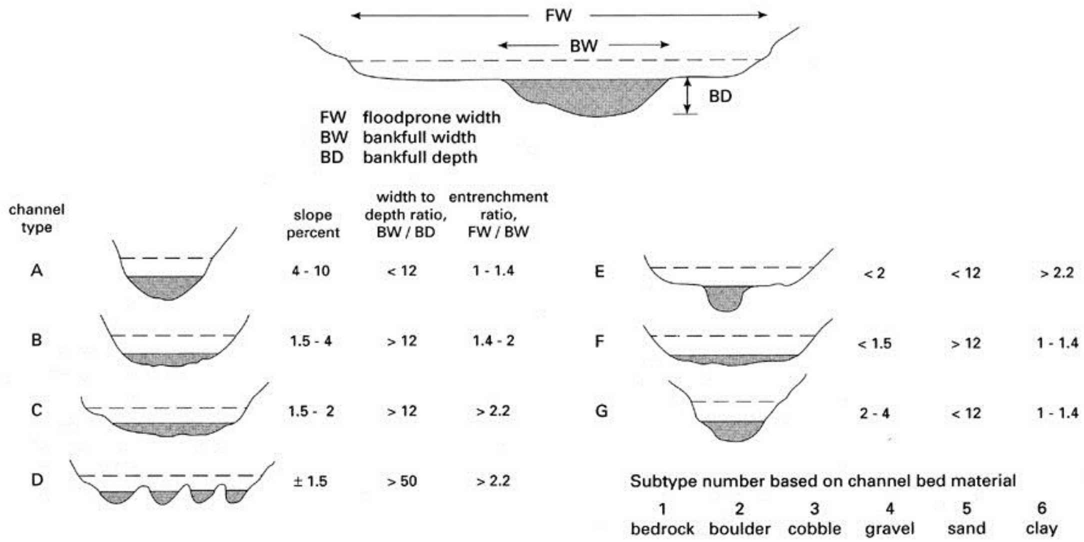
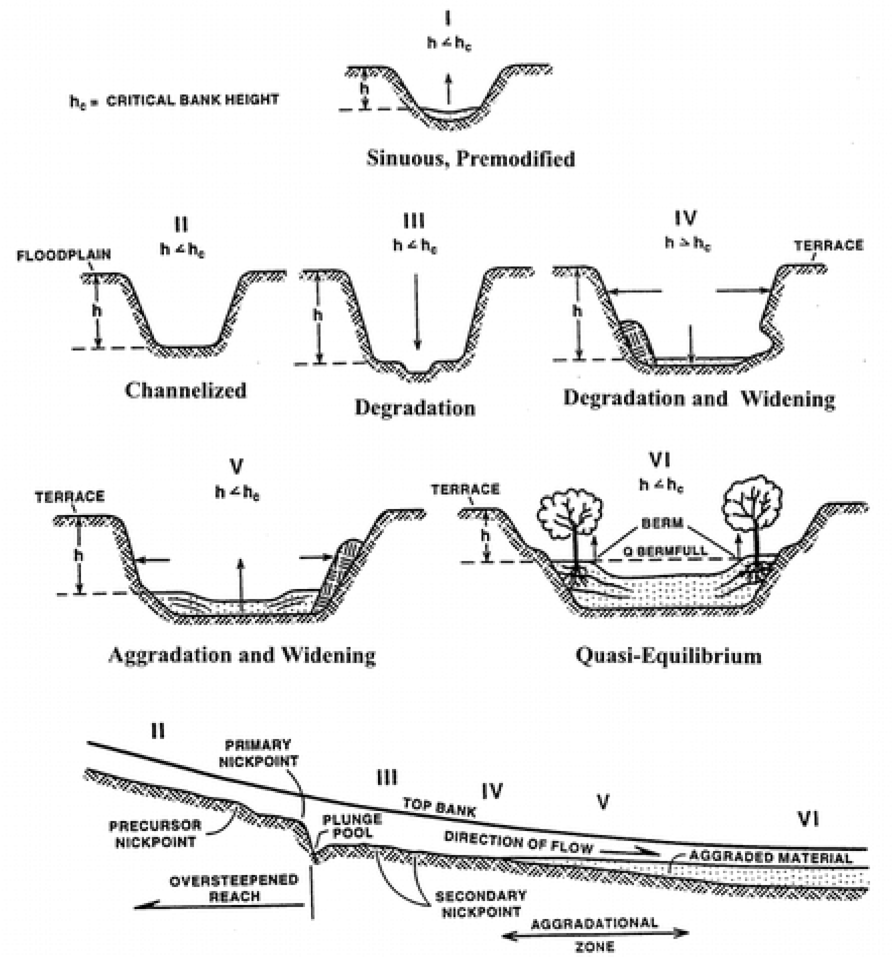


Figure 1.12 The Rosgen system of channel classification.

Figure H-4: Six-Stage Channel Evolution Model



(Simon et al, 1992)

H.2.1.1 Monitoring in the upper watershed

Upper watershed monitoring (channel surveys) is recommended to eliminate confounding lower watershed variables that would skew the analysis and minimize the potential for reaching meaningful conclusions.

H.2.1.2 Monitor three representative locations and one reference station

Providing three geographically representative stations would be sufficient to account for spatial and temporal variability of the conditions present in South Orange County. The reference monitoring station would be located in a watershed for which no upstream development (existing or future) is anticipated, preferably where historical bioassessment has been carried out. Data from the reference stations can be used to supplement pre-project condition data obtained at the representative monitoring sites, since the amount of pre-project condition data that can be obtained at such sites is dependent on the land development process. Providing three representative stations balances the need to characterize spatial variability against the cost of monitoring.

H.3 HMP Effectiveness Evaluation

The effectiveness of the HMP can be evaluated according to the following:

- BMP inspections and maintenance
- Performance protocol

H.3.1 BMP Inspections and Maintenance

One key component of the implementation of the HMP is to ensure hydrologic controls and sediment supply management measures perform effectively. PDPs are conditioned to verify inspections and maintenance operations as defined in the approved Local WQMP. The list of such inspections and maintenance operations shall be included in the WQMP submitted by the applicant. Maintenance activities shall ensure that the systems are properly controlling flow rates and durations.

H.3.2 Performance Protocol

Channel section surveys and IBI scores can be monitored on a regular basis at representative locations in the San Juan Hydrologic Unit. If a significant degradation of a stream segment has been detected, a hydrologic analysis can be performed. A significant degradation of the stream segment will be subjectively interpreted by the analyst as a sudden decline in the IBI, or a rapid change of the morphology of the channel (cross-section). A drastic change in IBI scores may indicate that flow conditions have consequently changed. A significant improvement of the IBI scores may validate the approach taken in this HMP.

The hydrologic analysis, if required, shall determine if the significant degradation of the stream segment is associated to geomorphically significant flows (10% of the 2-year storm event to the 10-year storm event). A significant difference between the expected and the observed flow duration curves for the identified flow range would automatically trigger a performance protocol. The objective of the performance protocol is to correct any performance deficiencies in the existing hydrologic controls and sediment supply management measures. If the stream degradation was caused by flows outside the critical range (a relatively rare storm event), the extensive hydrologic analysis may terminate and no further investigation is needed.

The performance protocol consists of investigating the tributary area of the impacted stream segment to identify the potential source(s). Hydrologic controls and sediment supply management measures of one or several PDPs will be examined to determine if they are under-performing due to a lack of maintenance or poor design. In this case, the lack of performance may appear to be directly responsible for the drastic change in stream conditions (IBI score, morphology). Rehabilitation of the stream segment may be required. It is expected that initial conclusions regarding the effectiveness of the HMP will be drawn after a minimum of five years of observations.

H.4 Summary and Conclusions

The HMP Effectiveness Plan, if developed, can include the following specific activities:

Baseline Monitoring Plan Requirements:

- Development of QAPP
- Bioassessment monitoring station analysis and installation
-
- Mid-term evaluation of the HMP Effectiveness after review of initial findings
- Report preparation (final report to be prepared in 2020)

Monitoring stations:

- Four monitoring locations – three representative stations monitoring exclusively areas in development located in the upper part of the San Juan Hydrologic Unit, and one reference station.
- Bioassessment conducted once a year

Bioassessment

- Annual sampling, preferably during spring season – similar to annual PEA and SWAMP

Channel Assessments:

- Geomorphic assessments and cross-section survey at each monitoring location to assess channel condition and response, once for each monitoring location (2015–2020)

Cross-section surveys consist of recording, on an annual basis, the vertical elevations of all significant geomorphic features (bankfull, bank top, bank toe, bar tops, edge of water, thalweg, bank failure, and others) and of all changes in slope breaks at the monumented cross-sections. Annual geomorphic assessments consist of characterizing, on an annual basis, the rate of change, if any, of bed material encountered, vegetation, and bed and bank lateral and longitudinal profiles that are derived from cross-section surveys. The geomorphic survey will also be coupled with monitoring data from the bioassessment stations to ensure that the HMP is effective in protecting the geomorphic and biological integrity of receiving streams.