

Guidance for Stormwater and Dry Weather Runoff

CAPTURE

(California Practices To Use Runoff Effectively)

AT SCHOOLS



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Office of Water Programs
at California State University, Sacramento

December
2018

Acknowledgements

Thank you to the many people who contributed to the creation of this document, including staff from the State Water Resources Control Board, Division of the State Architect, and California Department of Education.

Disclosure

The Guidance for Stormwater and Dry Weather Runoff CAPTURE at Schools is considered a living document that may be updated in response to evolving best design and use practices or regulations. It is recommended that public schools consider this guidance for voluntary implementation or in preparation for potential coverage under the National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer system (MS4) permit.

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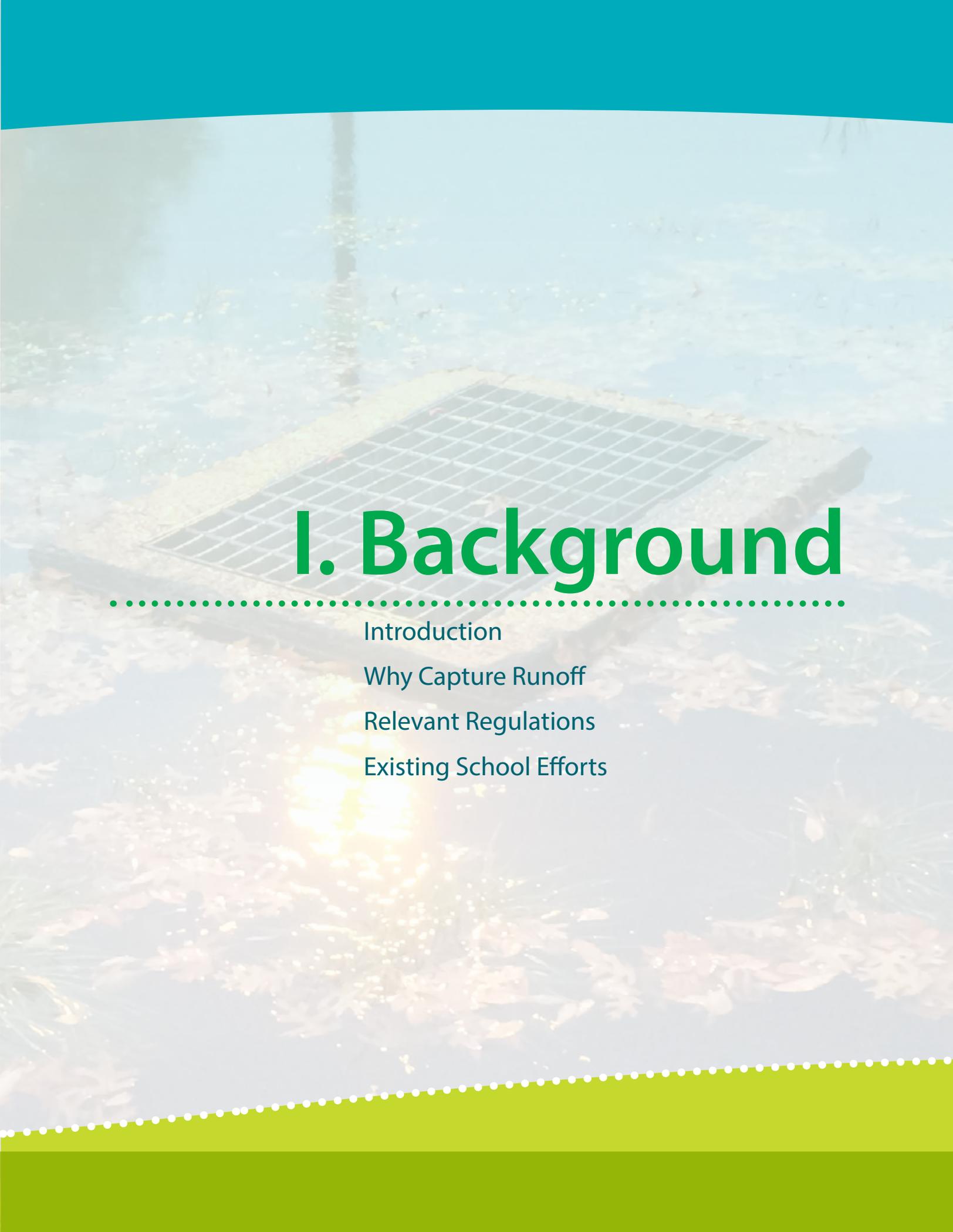
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ACRONYMS USED FREQUENTLY THROUGHOUT THIS GUIDANCE

BMPs	<u>BEST MANAGEMENT PRACTICES</u>
CASQA	<u>CALIFORNIA STORMWATER QUALITY ASSOCIATION</u>
CDE	<u>CALIFORNIA DEPARTMENT OF EDUCATION</u>
CGP	<u>CONSTRUCTION GENERAL PERMIT</u>
CWA	<u>CLEAN WATER ACT</u>
CWH	<u>COUNCIL FOR WATERSHED HEALTH</u>
DROPS	<u>DROUGHT RESPONSE OUTREACH PROGRAM FOR SCHOOLS</u>
DSA	<u>DIVISION OF THE STATE ARCHITECT</u>
DWR	<u>DEPARTMENT OF WATER RESOURCES</u>
IRWM	<u>INTEGRATED REGIONAL WATER MANAGEMENT</u>
IRWMP	<u>INTEGRATED REGIONAL WATER MANAGEMENT PLAN</u>
LID	<u>LOW IMPACT DEVELOPMENT</u>
MOA	MEMORANDUM OF AGREEMENT
MOU	MEMORANDUM OF UNDERSTANDING
MS4	<u>MUNICIPAL SEPARATE STORM SEWER SYSTEM</u>
NPDES	<u>NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM</u>
O&M	OPERATION AND MAINTENANCE
OWP	<u>OFFICE OF WATER PROGRAMS</u>
Phase II permit	<u>NPDES PERMIT FOR SMALL MS4S</u>
QSD	<u>QUALIFIED SWPPP DEVELOPMENT</u>
SCMs	<u>STORMWATER CONTROL MEASURE</u>
SFPUC	<u>SAN FRANCISCO PUBLIC UTILITY COMMISSION</u>
SFUSD	<u>SAN FRANCISCO UNIFIED SCHOOL DISTRICT</u>
SWPPP	<u>STORMWATER POLLUTION PREVENTION PLAN</u>
TMDLs	<u>TOTAL MAXIMUM DAILY LOADS</u>
TSS	<u>TOTAL SUSPENDED SOLIDS</u>
USEPA	<u>UNITED STATES ENVIRONMENTAL PROTECTION AGENCY</u>



I. Background

Introduction

Why Capture Runoff

Relevant Regulations

Existing School Efforts

I. Background

Introduction

These guidelines provide insights for the selection, design, and implementation of practices that can reduce runoff and pollutants that flow from school properties. These practices include minimizing impervious surfaces, increasing green space, promoting infiltration, and treating runoff on site.

In using these guidelines, school districts can achieve benefits that apply directly to schools, such as creating school yards that promote natural play and improve student health and well being, developing educational opportunities related to sustainability, and reducing the heat island effects of asphalt. This guidance also provides strategies school districts can use to help protect local watersheds, such as augmenting water supply, protecting against localized flooding, protecting and improving water quality, and reducing greenhouse gas emissions. In the face of climate change and the recent California drought, these concepts are particularly crucial to support sustainability— conserving current resources for future generations.

The guidelines are not requirements or standards. Instead, they provide background on and examples of stormwater management principles and common capture practices (Figure I-1). Notably, some information provided herein may become outdated as regulations, policies, and technologies evolve. Consequently, the guidelines direct the reader to other resources, such as the California Stormwater Quality Association (CASQA) and municipal stormwater programs and manuals, that will be updated to address these changes.

These guidelines provide school administrators, facility managers, and their design teams insight on the following elements related to runoff management and capture:

1. Background
2. Benefits
3. Practices
4. Planning and design
5. Construction
6. Maintenance
7. Costs
8. Regional collaboration
9. Codes and regulations
10. References

To better understand the context of the runoff prevention and capture material presented in this guidance, the remainder of this section summarizes why runoff is a concern and how it can be captured and used as a resource. Relevant regulations and examples of existing schools efforts are also provided.

A guide for runoff capture at schools

Chapter 811, Statute of 2017 (SB 541, Allen) requires the State Water Resources Control Board (State Water Board) to “recommend best design and use practices for stormwater and dry weather runoff capture practices that can generally be applied to all new, reconstructed, or altered public schools, including school grounds.” The intent of such practices is: “...to control water pollutants, pollutant loads, and water runoff volume exiting a site to the maximum extent feasible by minimizing impervious surface area and controlling runoff from impervious surfaces through infiltration, evapotranspiration, bioretention, treatment, and rainfall harvest.” (California SB 541 2017)



Figure I-1—Example of runoff capture implementation at a school in New York (San Francisco Public Utilities Commission)

Why Capture Runoff?

Urban development alters natural landscapes causing degradation of water resources.

Grasslands, forests, and other naturally occurring, pervious landscapes are replaced with impervious surfaces such as buildings, roads, and parking lots. The hardened surfaces reduce the amount of precipitation that can infiltrate into the soil, resulting in increased volumes and flow rates of runoff that are discharged to water bodies. This trend is referred to as **hydromodification** (Figure I-2).

Hydromodification

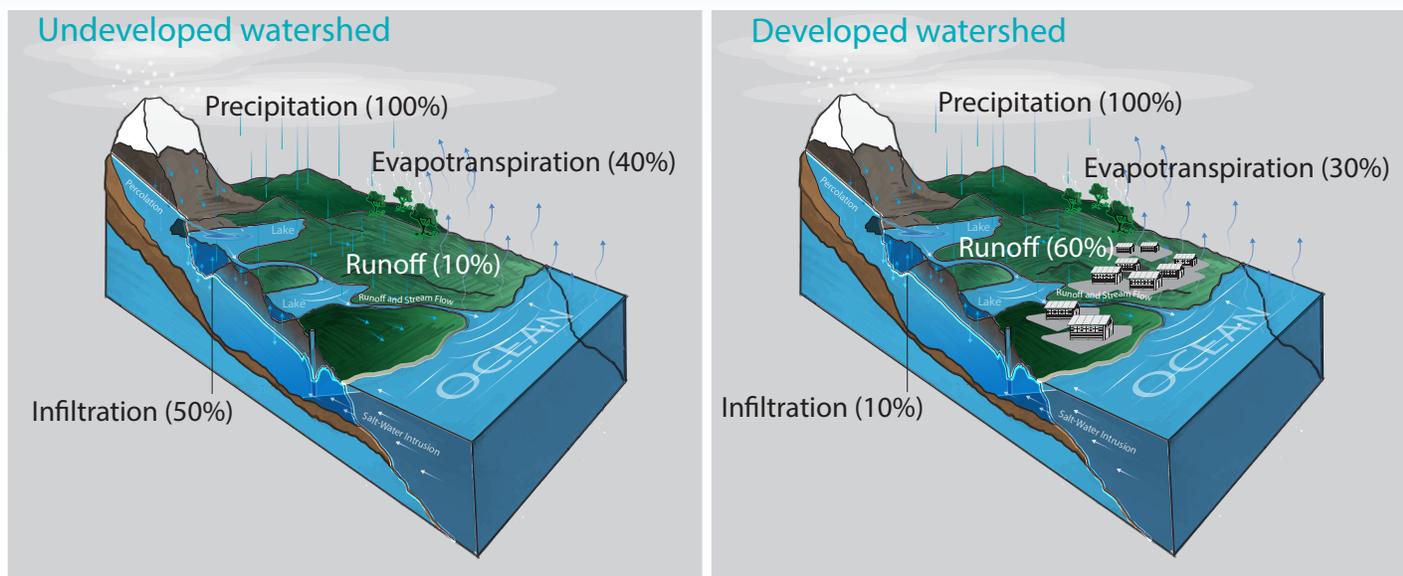


Figure I-2—Hydromodification: The alteration of flow characteristics through a landscape resulting in the degradation of water resources.

I. Background

Hydromodification exacerbates flooding and causes downstream erosion, which results in excess sediment transport into streams and disruption of natural drainage patterns, stream flows, and habitat (Figure 1-3).



Figure 1-3—Impacts of hydromodification (Clockwise from upper left: Stillwater Sciences, Soil Science on Flickr, State Water Board, Flickinpics on Flickr)

In addition, human activities have introduced pollutants, such as plastics, oils, greases, metals, and pesticides, which are transported across landscapes to downstream receiving waters (Figure I-4).



Figure I-4—Pollutant transport (left: Draper City UT; right: SW Washington Stormwater Partners)

These pollutants pose threats to a water body's beneficial uses. Such threats include damage to habitats and biotic integrity and degradation of water quality for consumption and recreation (Figure 1-5).



Figure 1-5— Impacts from pollutant discharges (clockwise from upper left: eutrofication&hypoxia on Flickr, Heal the Bay, Pixabay, Wikipedia Commons)

Dry weather runoff—excess irrigation water that drains from properties—combines with the stormwater runoff, exacerbating these impacts (Figure 1-6).



Figure 1-6— Dry weather runoff from excess irrigation or outdoor water use (City of College Station, TX)

I. Background

To address these issues, runoff practices today emphasize designs that reduce runoff volumes, flow rates, and pollutants discharged to receiving waters (Figure I-7). Such practices not only reduce detrimental impacts, but capture and use runoff as a resource to supplement water supply. These practices can also reduce flooding, enhance communities, and support climate change resiliency and adaptation.



Figure I-7— Runoff capture (clockwise from upper left: BASMAA, OWP, fireballsedai on Flickr, City of San Diego)

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“Stormwater is a resource and an asset and should not be treated as a waste product. Managing rainwater and stormwater at the source is a more effective and sustainable alternative to augmenting water supply, preventing impacts from flooding, mitigating stormwater pollution, creating green space, and enhancing fish and wildlife habitat. California encourages alternative, innovative, multi-objective solutions to help use and protect this valuable resource, while at the same time controlling pollution due to urban runoff.”

—State Water Resources Control Board, 2013

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Relevant Regulations

Discharging pollutants into surface waters is prohibited by the federal Clean Water Act (CWA), unless they are in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits regulate discharges from several programs, including stormwater discharges from municipal separate storm sewer systems (MS4s) and combined sewer overflows (CSOs). Figure 1-8 shows many examples of entities subject to NPDES permits.



Figure 1-8— Entities subject to NPDES permits. Sources: <https://www.maxpixel.net>, <https://www.flickr.com>, <https://commons.wikimedia.org>, <https://pixabay.com>, <https://en.wikipedia.org>, <https://sfec.cfans.umn.edu>, <https://www.ang.af.mil>, <https://picryl.com>

MS4 permits regulate runoff from an MS4—a conveyance or system of conveyances (e.g., roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains, 40 CFR 122.26(b)(8)). The permits address runoff from stormwater as well as dry weather flows. Stormwater permits were first issued for large municipalities having populations of 100,000 or greater, and

I. Background

are referred to as “Phase I permits”. In California, these permits are issued by the Regional Water Quality Control Boards. In 2003, the State Water Board issued the NPDES permit for small MS4s (the “Phase II permit”). The Phase II permit covers counties, cities, towns, etc., with populations of more than 10,000 but less than 100,000 people, as well as non-traditional facilities such as universities, colleges, state parks and beaches, transit authorities, prisons, and other state properties. The State Water Board also issues an NPDES permit to the California Department of Transportation (Caltrans) for stormwater discharges from their roadways and other facilities. The Phase I, Phase II, and Caltrans permits are updated and reissued every few years.

The NPDES permits include several minimum control measures for managing runoff.

- ▶ Education and outreach
- ▶ Public involvement and participation
- ▶ Illicit discharge detection and elimination
- ▶ Construction site stormwater runoff control
- ▶ Pollution prevention/good housekeeping
- ▶ Post-construction stormwater management for new and redevelopment
- ▶ Water quality monitoring
- ▶ Program effectiveness and assessment
- ▶ Total maximum daily load (TMDL) compliance

The guidance in this document mostly pertains to the post-construction stormwater management element of the permits. Post-construction requirements stipulate design practices and features that must be included in new development and redevelopment projects of a certain size to prevent and reduce runoff for the lifetime of the project. Section VIII (Regional Collaboration) offers suggestions for school districts to leverage expertise and support regional permittees in implementing some permit elements to support watershed health. A good example is the San Francisco Public Utility Commission's (SFPUC) Urban Watershed [Stewardship Grants for Schools](#) (Figure I-9). The SFPUC incentivizes schools to install green infrastructure, including runoff capture devices, which supports the city's permit compliance.



Figure I-9— Stewardship Grants For Schools

The State Water Board also issues a Construction General Permit (CGP) that specifies actions to be taken to prevent and reduce runoff and pollutant discharges generated during construction activities. These requirements are incorporated throughout this guidance document.

**See Section VIII (Regional Collaboration) for how school districts can leverage expertise and potential resources from municipal permittees.*

Existing School Efforts

Some school districts in California are actively engaged in managing runoff. They have done so for a variety of reasons. For example, school districts in San Diego and Los Angeles have worked with local communities to capture runoff and support regional water supply and water quality goals. Also, a few districts are named in NPDES permits for managing runoff and are actively managing runoff to address water quality issues. The Los Angeles Unified School District (LAUSD) is releasing a stormwater technical manual in 2019.

Some newly constructed or retrofitted schools in California have pursued certification through the [Collaborative for High Performance Schools](#) (CHPS) standards program, which incentivizes energy efficiency and green design practices, including runoff capture (Figure I-10). The LAUSD adopted CHPS standards for school designs in 2009.



Figure I-10— Opportunities through Collaboration for High Performance Schools (CHPS 2018)

Several school districts in Southern California have developed a Stormwater Pollution Prevention Plan (SWPPP) [internship program](#), which was first funded by the State Water Board's Drought Response Outreach to Schools (DROPS) grants. The program gives students hands-on educational opportunities related to water quality sampling and analysis, site evaluations, stormwater infrastructure design and construction, and more.

There have been some unique efforts exemplifying the possibilities for regional collaboration between schools and their communities in supporting runoff capture. [Green Schoolyards America](#) encourages and provides support to communities investing in school grounds to improve children's well-being, learning, and play while contributing to the ecological health and resilience of their cities (including incorporation of runoff capture practices). As another example, [TreePeople](#) collaborated with the Los Angeles Department of Water and Power (LADWP), the LA County Department of Public Works (LACDPW), the City's Bureau of Sanitation (LASAN), and other agencies to examine collaborative options that could allow for increased runoff capture projects on LAUSD campuses (TreePeople 2015).

I. Background

The SFPUC and the San Francisco Unified School District (SFUSD) completed a jointly funded “Stormwater Schoolyard” project at Robert Louis Stevenson Elementary School in October 2018 (Figure I-11). The project collects runoff from about one acre of impervious surface and diverts it to dry creek beds and a sunken amphitheater that uses permeable pavers for ground cover. Drought tolerant plants are incorporated throughout. The project prevents impacts from runoff, provides opportunities for outdoor education and play, and serves as a demonstration facility for other schools in the district. The SFPUC has also developed the [Green Infrastructure Grant Program](#) to further these types of runoff capture practices throughout San Francisco.

Beyond these examples, the majority of schools and school districts throughout the state do not have active runoff management programs. These guidelines will provide a foundational understanding of stormwater management strategies and a framework for developing projects on your own campus.



Figure I-11— Example of dry creek bed and signage installed at Robert Louis Stevenson Elementary School in San Francisco (SFUSD 2018)



II. Benefits

School Benefits

Regional Benefits

II. Benefits

School Benefits

Many runoff capture practices can be designed to incorporate features that enhance schoolyards beyond merely improving runoff management. This includes creating outdoor play, learning, and teaching spaces; increasing shade; increasing access to natural areas; and establishing drought tolerant habitat. By doing so, the schools can:

- ▶ Enhance educational opportunities
- ▶ Improve student health and well-being
- ▶ Create environmental benefits
- ▶ Leverage funding
- ▶ Share costs
- ▶ Reduce on-site flooding
- ▶ Engage communities
- ▶ Improve community reputation
- ▶ Support regional sustainability

drops **2017-18 WATER QUALITY PROJECT**

OLIVENHAIN PIONEER ELEMENTARY SCHOOL

With the help of a grant from the state, fifth and sixth-grade SWPPP interns are supervising the construction of a bioswale with a Low-Impact Development design. The bioswale will filter pollutants running off the parking lot all the way to Batiquitos Lagoon and the ocean at Ponto Beach.

SWPPP
INTERNSHIP™

FINAL PROJECT PLANS

LANDSCAPE PLANTING PLANS

IRRIGATION PLANS

INTERNATIONAL APPROVAL/PERMIT SECTION

PARKING LOT RECONSTRUCTION AREA SECTION

BIOSWALE PLANTING

PERMANENT PAVING OLIVENHAIN PIONEER ELEMENTARY SCHOOL, 10000 OLIVENHAIN DRIVE, SAN DIEGO, CA 92121

"For the parking lot project, we will be putting in permeable pavers so that the water can go into the ground and the TSS and oil and grease will not go down the storm drains to the ocean." - Miles

"For our DROPS project, we got to work with surveyors and landscape architects so that we could help plan out how the project would work and also what kind of plants will go in the bioswale. We learned that the plants help filter out the pollutants so the less pollutants will make it down the storm drain." - Sienna

"Our DROPS project will have curb cut outs, permeable pavers where the cars park and then a bioswale to soak up the stormwater. With all of these things, it will make less water going down the storm drain and will filter the water going into the ground. It is going to make the parking lot stormwater very clean!" - Savanna

WWW.SWPPPINTERNSHIP.COM

Figure II-1—An example of opportunities for education

Enhance Educational Opportunities: School districts that implement runoff minimizing practices can create projects that offer teachers and students opportunities in the science, technology, engineering, and mathematics (STEM) fields, and possibly other areas such as language arts, social studies, government, and arts. Projects can incorporate education regarding the beneficial uses of capturing runoff to sustain future supplies and reduce flood risks. A great example of an existing educational opportunity is the [SWPPP internship program](#) offered by some California school districts (Figure II-1). More broadly, schools that create green schoolyards (which can include runoff capture features) can be used to enhance educational opportunities across almost every subject at every grade level in a variety of ways.

Improve Student Health and Well-Being: Many runoff capture practices can be used to create green spaces that support the physical and mental well-being of students. Project designs where large non-permeable areas in the main schoolyards are replaced with living materials and trees increase student activity levels and create shade, which reduces playground temperatures, and provide opportunities for children to be more active, improving their physical fitness and motor coordination. In addition, research indicates that students with views and access to trees and nature recover faster from stress and mental fatigue (Daniel et al 2018, Liang et al 2014, Lovasi et al 2008, Taylor & Kuo 2011), and improve their ability to pay attention, along with measurably improved test scores (Li and Sullivan 2016). [The Children and Nature Network](#) provides visual summaries of these benefits (Figure II-2).



Figure II-2— Children and Nature Networks downloadable infographics regarding the benefits of green schoolyards

II. Benefits

Create Environmental Benefits: Potential environmental benefits that can be realized from implementing runoff prevention and capture practices include providing shade and reducing heat island effects, lowering building energy demands, reducing smog and air pollution, improving health and well-being, sequestering carbon, increasing wildlife habitat, and reducing pollutant discharges.

Leverage Funding: Because preventing and capturing runoff provides many benefits, several agencies provide grant and low-interest loan programs to assist in funding these projects. These can be tied into existing school enhancement projects.

Share Costs: Schools districts can work with neighboring municipalities and other agencies on stormwater management to spread costs among collaborators.

Reduce On-Site Flooding: Preventing and reducing the runoff volume and flow rates discharged from school properties helps reduce the risk, frequency, and consequences of on-site flooding, in turn reducing capital and maintenance costs of runoff infrastructure.

Engage Communities: Embracing sustainability practices can draw interest from the school community (parents, teachers, maintenance staff, students, etc.) interest, creating further support and involvement and extending benefit opportunities. School communities can participate in the design of stormwater management elements to ensure that multiple needs of the school are met. This can encourage buy-in and support from the greater local community.

Improve Community Standing: The school benefits previously discussed as well as the regional benefits described next all improve a community's reputation and draw residents to the neighborhood and students to schools. This increased public support and enrollment can accentuate the community's existing pride, extending and expanding the benefits that are possible.

Support Regional Sustainability: Beyond the benefits that apply directly to schools, preventing and reducing runoff from school properties can support regional goals for managing watershed health and achieving sustainability. Such practices can supplement regional benefits related to water quality, water supply, flood control, communities, and other environmental systems (e.g., air quality or habitat condition), as well as climate change adaptation and resilience. Specific examples are provided later in this section.

Regional Benefits

Preventing and reducing runoff can contribute to regional goals of sustainability, including those related to:

- ▶ Water quality
- ▶ Environmental systems
- ▶ Water supply
- ▶ Communities
- ▶ Flood control
- ▶ Climate change

Improve Water Quality: Runoff capture practices prevent and reduce runoff volumes, flow rates, and pollutants discharged from a property to protect the beneficial uses of local water ways.

Augment Water Supply: Many of the runoff practices presented in this guidance document involve capturing runoff and allowing it to infiltrate into underlying soils where it often percolates down, recharging groundwater basins for future water supply. Other practices in this document capture and store runoff for direct use (e.g., irrigation), which can increase water supply by reducing demand on local surface water sources.



Figure II-3—Example of a regional project that improves water quality, alleviates flooding, recharges groundwater, and enhances public recreation.

II. Benefits

Support Flood Prevention: Runoff prevention and capture practices can reduce and slow the discharge of runoff, reducing risks and mitigating flooding. Localized flooding can be remedied by incorporating features such as pervious pavement, dry wells, vegetated landscapes that promote infiltration, or even sunken sports field that can serve as temporary detention basins. These practices, when distributed copiously throughout an area, can support other regional flood practices as well.

Protect Environmental Systems: Runoff capture practices that prevent and reduce runoff volumes and flow rates can protect or enhance wetlands, riparian zones, and other aquatic habitats by reducing the potential for 1) excess sediment transport to streams; 2) downstream erosion and sedimentation; 3) flooding; 4) disruption of natural drainage patterns, stream flows, and riparian habitat; 5) elevated water temperatures; and 6) transport of pollutants to these habitats. In addition, runoff capture and prevention can reduce the need for pumping and, therefore, the use of electricity and greenhouse gas emissions. Some stormwater capture measures (SCMs) can even provide carbon sequestration.

Enhance Communities: Minimizing imperviousness and incorporating vegetated runoff capture at schools can enhance communities by expanding education, involvement, and recreation opportunities. It can also make communities more beautiful, sustainable, and friendly to wildlife. Such gathering places provide ideal locations for educating visitors about the impacts of urbanization on their environment. This can lead to modifications in behavior to support or improve watershed health. Developing brochures, websites, mobile applications, and signage and conducting public outreach events are a few ways to educate communities.

Climate Change Adaptation and Resilience: Climate research and modeling indicate that, in future decades, weather events in California will grow more extreme. This includes more extreme precipitation events and prolonged drought periods (Dettinger 2011, Diffenbaugh 2015, Swain 2017). Storms in particular will likely increase in intensity, straining current stormwater drainage systems, but presenting opportunities for more capture and infiltration. Runoff prevention and capture practices provide opportunities to adapt and develop resiliency in the face of climate change by:

- ▶ Addressing increased precipitation volumes and intensities by increasing infiltration, reducing runoff volumes, and delaying peak runoff. This will help prevent erosion, water quality and habitat degradation, and flood damage
- ▶ Preparing for more extreme and frequent drought conditions by capturing and using runoff to reduce demand on water supplies, as well as recharging groundwater to increase groundwater supplies
- ▶ Reducing heat island effects by promoting incorporation of vegetated landscapes to the extent feasible
- ▶ Providing redundancy through distributed, small-scale measures



III. Practices

Small-scale Landscape Features

Design Strategies

Stormwater Control Measures

Additional Runoff Management Practices

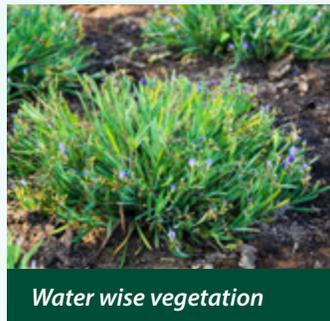
III. Practices

Small-Scale Landscape Features

There are several small-scale landscape features that can support runoff prevention and capture. These features involve fairly simple planning and modifications. The material needs for construction are often quite accessible, making them excellent candidates for low-cost features that offer educational opportunities for schools, such as engaging students in project designs, visualization of the rainfall-runoff process, or constructing new campus features. Figure III-1 shows some examples.

Water Wise Landscapes:

Using plants that require little water, especially native plants, can help reduce the water needs of revamped landscapes and promote more infiltration. Low-water plants often do not require spray irrigation, further reducing overwatering and dry weather runoff. [California's Model Water Efficient Landscape Ordinance](#) (MWELO) is a good resource for planning such landscapes. It specifies design, installation, and maintenance practices that meet an irrigation water budget based on climate parameters and site characteristics.



Water wise vegetation



Curb cuts



Downspout disconnects



Rain gardens



Above ground storage

Figure III-1—Small-scale landscape features (clockwise from left: OWP; OWP; CWH; Porter County, IN; OWP)

Curb Cuts:

These features allow runoff to flow from sidewalks or roads into swales, bioretention planters, and other infiltrating areas.

Downspout Disconnects: Disconnected downspouts direct roof runoff to cisterns, rain barrels, porous pavement, or other SCMs in lieu of discharging it untreated, to conveyance systems and ultimately receiving waters.

Rain Gardens: Rain gardens are depressed landscapes that capture runoff and allow it to pond and slowly infiltrate over time. Rain gardens are simple planters consisting of amended soils (to promote infiltration) and waterwise vegetation. Notably, rain gardens in California often require summer irrigation.

Rain barrels: Rain barrels are small containers that collect roof runoff for later use such as irrigation. They can be combined with down spout disconnects.

Many online tools and guidebooks exist for these features, such as CASQA's [LID Portal](#) as well as stormwater design manuals. The manuals can be identified by contacting MS4 permittees. See the [CA Phase II LID Sizing Tool](#) for a map of the permittees.

Design Strategies

Design strategies are tactics and principles incorporated during the planning and design stages of a project to help capture and prevent runoff. Such strategies are summarized in Figure III-2. Project designs should achieve multiple benefits.



Preserve, create, and enhance natural areas and features

- ▶ Design around existing trees and vegetated landscapes to promote infiltration
- ▶ Design new and natural areas that allow infiltration



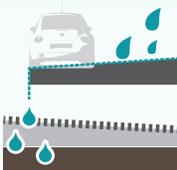
Minimize impervious surfaces

- ▶ Combine hardscape play areas with interactive green space if possible
- ▶ Design to replace impervious surfaces with pervious surfaces, such as porous pavement or green roofs
- ▶ Minimize building footprints with multi-story structures



Design with soils that promote infiltration

- ▶ Use compost and mulch to amend soils to both promote and enhance infiltration
- ▶ Minimize soil compaction in identified green spaces during construction



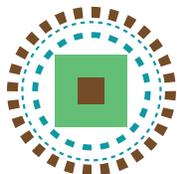
Arrange impervious surfaces to drain to permeable surfaces

- ▶ Drain runoff from impervious surfaces to pervious surfaces like vegetated landscapes to allow infiltration



Design areas to prevent irrigation runoff

- ▶ Select plants that require minimal watering
- ▶ Use non-spray systems, when possible
- ▶ Operate and maintain irrigation systems to minimize generation of runoff



Allocate space to stormwater control measures

- ▶ See the discussion on stormwater control measures on page 24 discussion later in this section



Incorporate visual stormwater features and learning opportunities

- ▶ Place SCMs in areas visible to students, staff, and visitors to increase awareness regarding runoff management
- ▶ Install signage, create brochures, offer tours, and create other opportunities to educate school communities on the need for, and function of, runoff capture features

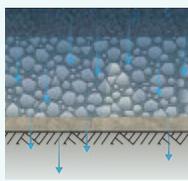
Figure III-2—Design strategies

III. Practices

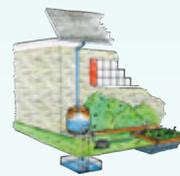
Stormwater Control Measures (SCMs)

SCMs are structural devices that reduce runoff volumes, flow rates, and pollutant transport. SCMs are referred to as structural best management practices (BMPs), and some qualify as [low impact development](#) (LID) devices. Note that some of the SCMs can be combined in series to create a “treatment train” that provides cumulative performance. This is especially useful when site layout is limited, but also allows creativity in site aesthetics related to SCM features. SCMs address runoff volumes, flow rates, and pollutants through a number of mechanisms, as shown in Figure III-3.

Capture and Treatment Mechanisms



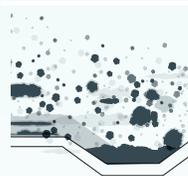
Infiltration (I): The movement of runoff downward from the ground surface through the unsaturated soils



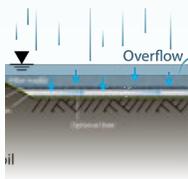
Rainfall Harvest (RH): Collecting and storing rainfall for later use. Check local ordinances for treatment requirements



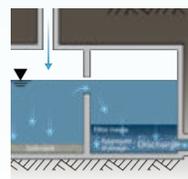
Trash Capture (T): Capturing trash in accordance with the State Water Board’s definition of a [Full Trash System](#) (State Water Board 2018e)



Sedimentation (S): Slowing the flow rate of runoff, allowing suspended particles to settle or deposit and be retained on a surface



Filtration and Adsorption (FA): Filtration involves passing runoff through a straining media (a filter) that traps and retains particulates but allows liquid and smaller suspended particles to pass through. Adsorption involves adherence of atoms, ions, or molecules in runoff to a solid



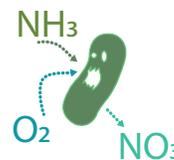
Flotation (F): Floating and trapping materials such as trash, oils, and grease, allowing heavier materials and fluids to flow through



Evapotranspiration (ET): A combination of processes by which water at or near the earth’s surface becomes atmospheric water vapor. It includes evaporation of water from surface waters, bare soil, and vegetative surfaces; evaporation from within the leaves of plants (transpiration); and sublimation from ice and snow surfaces (Dingman 1994)



Plant Uptake (P): Root plants taking up nutrients and other chemicals from runoff



Biochemical Transformation (B): Biological and chemical processes, such as biological nitrification, that convert molecules into different forms

Figure III-3—Capture and treatment mechanisms

Common SCMs are shown in Figure III-4. Appendix A provides factsheets summarizing their functions, advantages, limitations, and more. Additional information is available from CASQA's BMP Handbooks.



Figure III-4—Common SCMs

III. Practices

Additional Runoff Management Practices

In addition to the design strategies and SCMs presented in this guidance, there are several runoff management practices that prevent potential pollutants from coming into contact with runoff, as well as practices for evaluating and refining runoff management activities. Although not the focus of this document, these elements are crucial to preventing pollutants from entering waterways, and guidance on the related activities is provided from a variety of sources. The CASQA [New and Redevelopment BMP Handbook](#) is an excellent resource. Among publicly available material, EPA's [National Management Measures to Control Nonpoint Source Pollution from Urban Areas](#) is a highly regarded reference resource. Figure III-5 shows some examples.

Other Runoff Management Practices	
Education and outreach	
Public involvement and participation	
Illicit discharge detection and elimination	
Construction site runoff control	
Water quality monitoring	
Program effectiveness assessment and improvement	
Pollution prevention/good housekeeping related to:	
<ul style="list-style-type: none">▶ Outdoor storage of liquids and raw materials▶ Parking/storage area maintenance▶ Vehicle/equipment fueling and maintenance▶ Outdoor loading and unloading of materials	<ul style="list-style-type: none">▶ Sweeping and cleaning▶ Outdoor process equipment▶ Landscape maintenance▶ Trash storage▶ Evaluating irrigation system for intended operation



Interpretive signage

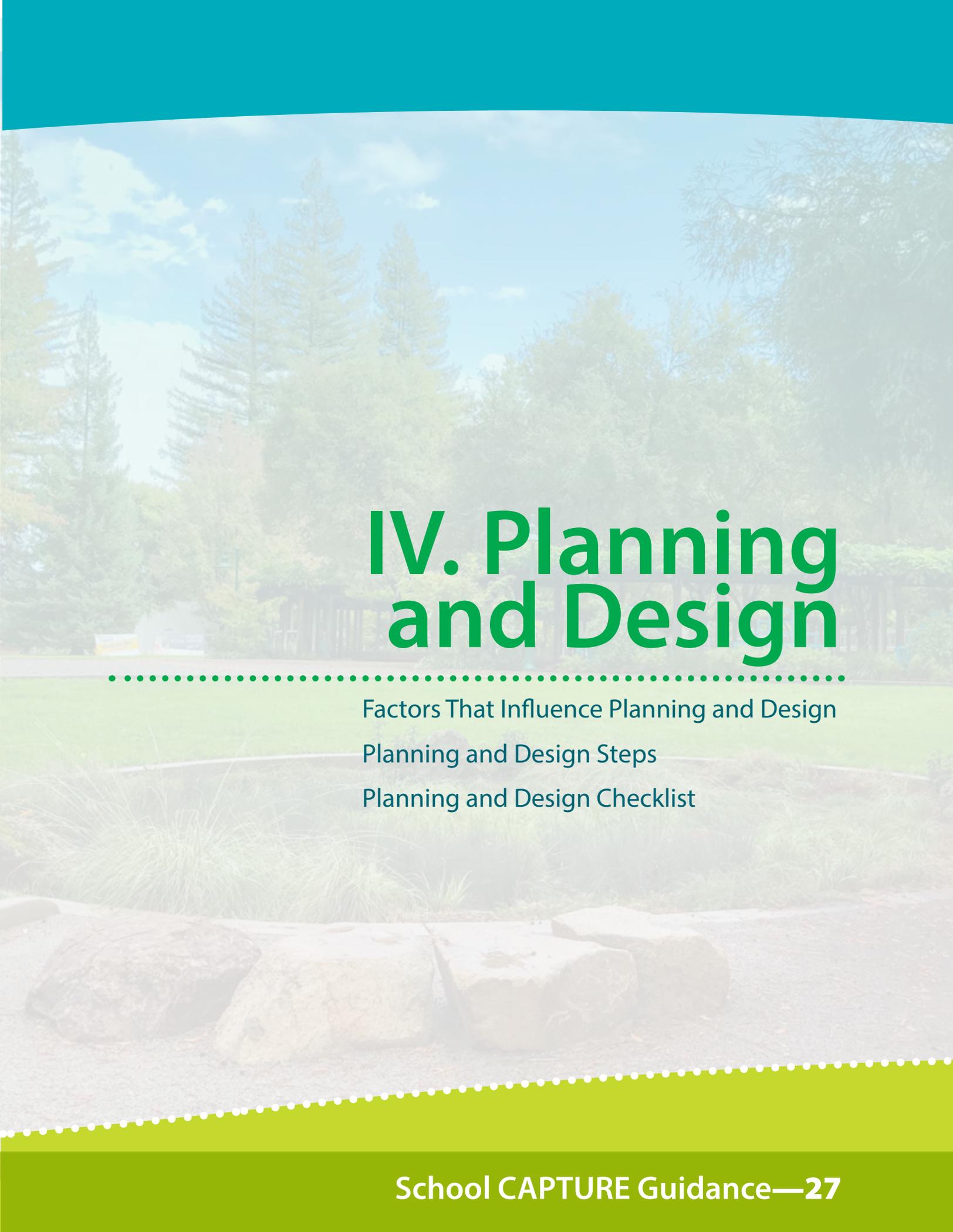


Straw waddles



Secondary containment

Figure III-5—Examples of other runoff management practices that help prevent degradation of water bodies.



IV. Planning and Design

Factors That Influence Planning and Design

Planning and Design Steps

Planning and Design Checklist

IV. Planning and Design

Factors That Influence Planning and Design

SCMs are designed to capture, retain, and treat a certain amount of runoff. In general, the amount of runoff to be captured is estimated using historic climate data, the area on which precipitation falls (drains from), and land cover characteristics that influence the amount of precipitation that becomes runoff. SCM selection and design also depend on the pollutants of concern, the desired performance (runoff volumes, flows, and pollutants discharged), the characteristics of existing soils, and the types of and proximity to surrounding infrastructure. Additional considerations for SCM design include vegetation, safety, maintenance, and permit requirements.

Climate

SCM designs are based on historic climate data. California has uniquely diverse climate systems, ranging from rainforest conditions with average rainfall depths exceeding 170 inches per year to desert zones having average rainfall depths of less than 1 inch per year (Figure IV-1).

Hydrologic data is easily available from several sources. Both [Basin Sizer](#) from the California Department of Transportation (Caltrans) and the [Phase II Sizing Tool](#) from the Office of Water Programs (OWP) include databases of precipitation data throughout California. The Phase II Sizing Tool also provides a map of municipal stormwater programs, which have local precipitation data.

Drainage Area

The area, or catchment, on which precipitation falls significantly influences the volume and flow rate of runoff generated during a storm event. Catchments are delineated based on topography, with runoff flowing down slopes and accumulating according to the grading of a site. In planning, grading should be designed to delineate drainages that flow toward areas where SCMs can be used. Drainage areas can be determined from topographic surveys or satellite imagery.

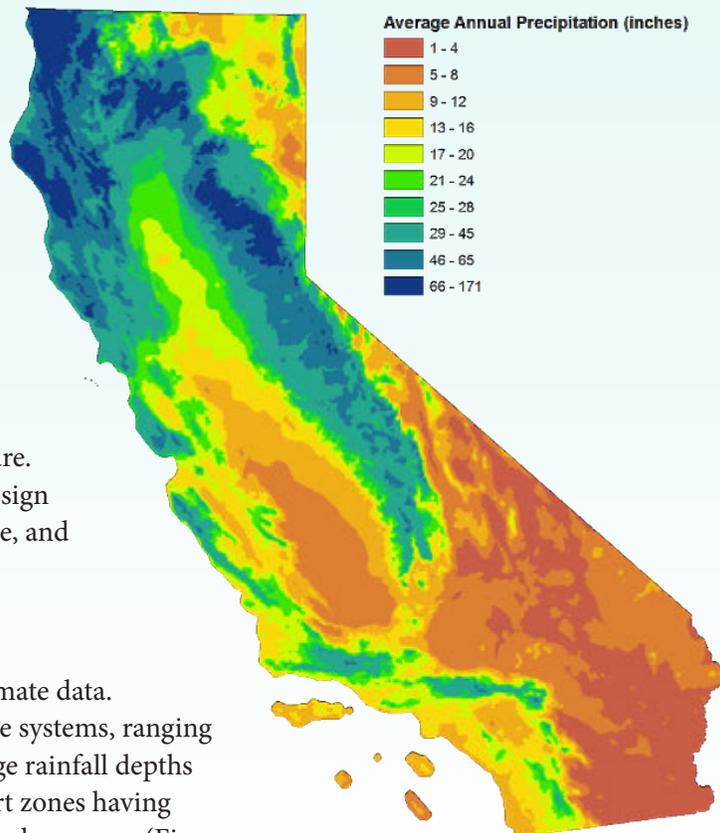


Figure IV-1. Annual average precipitation throughout California (USDA 2012)

Land Cover and Use

Land cover is the primary factor that determines the percentage of precipitation that becomes runoff. Areas with more impervious surfaces generally create more runoff because less precipitation is infiltrated and stored in soils, plants, and other pervious materials (Figure IV-2). Minimizing impervious surfaces and maintaining or increasing pervious surfaces can prevent the generation of runoff and reduce the discharge of runoff to water bodies. While all pervious surfaces can help promote infiltration and reduce runoff, their effectiveness varies. Surfaces with more and/or larger gaps between soil particles allow more infiltration. Many soils beneath developed properties are disturbed and have been compacted, reducing the space between soil particles, and therefore, infiltration. This increases the amount of precipitation that becomes runoff.

Additionally, different land uses

affect the types of pollutants in runoff. Pollutants generated on school properties would include those typical for residential and commercial properties (sediments, nutrients, metals, pesticides, oil and grease, bacteria and pathogens, and trash) and possibly organic compounds and other hazardous chemicals if used on site for maintenance or industrial purposes. If off-site runoff is captured on or diverted through school grounds, additional pollutant types may be present according to the land cover and uses of the contributing drainage.

Soil Characteristics

For infiltrating capture devices, soil type is an important design consideration. Soils with significant amounts of sand and gravel have higher rates of infiltration, while less porous soils such as clay and silts have lower infiltration rates. The infiltration rates will influence the size and configuration of the device.

There are several ways to classify soils, but for runoff capture planning, the US Geological Survey (USGS) categorizations are most common, consisting of four different groupings (see tabulation on the next page). Infiltrating SCMs that are implemented in areas with better infiltrating soils (A and B hydrologic soil groups) can have smaller footprints than those implemented in areas with soils having poor infiltration rates (groups C and D). Different soil groups have different ranges of saturated hydraulic conductivity, which is often used to represent overall infiltrations.

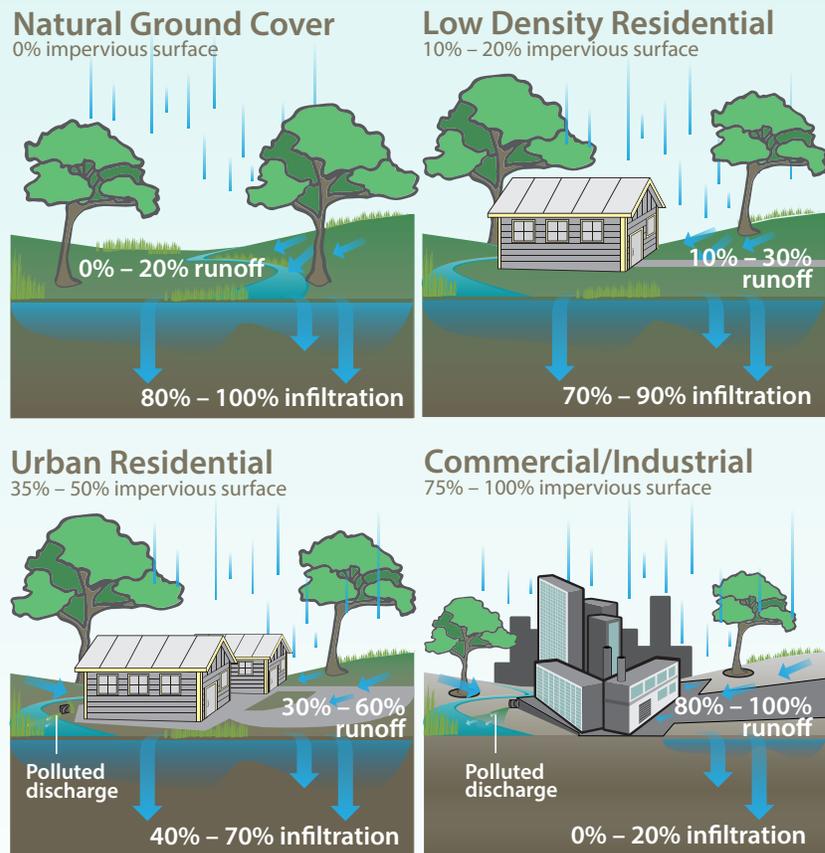


Figure IV-2. Changes in land cover and use impact runoff and infiltration

IV. Planning and Design

USGS hydrologic soil groups

USGS Hydrologic Soil Groups	Description	Saturated Conductivity (in/hr)
A	Sandy and loamy soils with low runoff potential and high infiltration rates	>1.42
B	Silty and loamy soils with some infiltration potential but can reduce with saturation	0.57-1.42
C	Sandy clay loam soils that are less advantageous for infiltration	0.06-0.57
D	Clay loam, silty clay loam, sandy clay, or clay soils with limited infiltration capacity	<0.06

USDA NRCS 2007

Soil types vary across latitude, longitude, and depth, with any particular location comprised of many subsurface soil layers, each of varying composition. Figure IV-3 shows how soils and infiltration rates can vary within the subsurface. Often a soil type provided for a particular location represents a weighted-average of the multiple types of soils that exist within the subsurface. The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) hosts a web map, the [Web Soil Survey](#), that depicts hydrologic soil groups throughout the country, using this weighted average representation. The NRCS also publishes its Soil Survey Geographic Database (SSURGO) dataset that shows soil groups at specific depths (Figure IV-4).

The Web Soil Survey and SSURGO are based on extrapolations of historical soil investigations. Given the spatial variability of soil types, these resources should be used for planning and preliminary design only. Final designs should be based on an on-site soil survey that involves collecting soil cores to characterize soil types and saturated conductivities laterally and vertically within the subsurface.

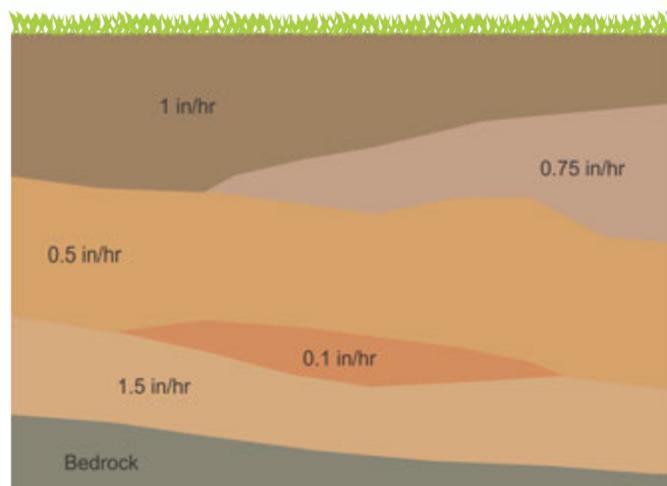
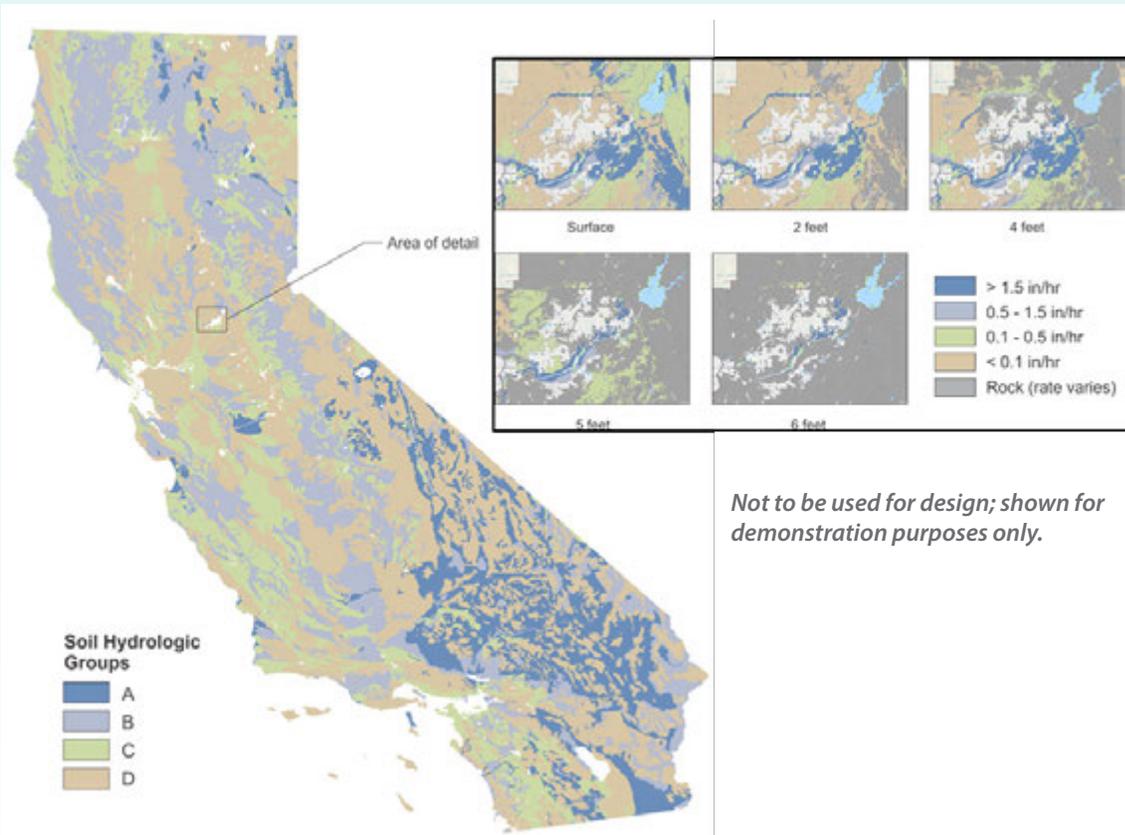


Figure IV-3. Example of how soil layers and infiltration rates can vary within the subsurface



Not to be used for design; shown for demonstration purposes only.

Figure IV-4. Hydrologic soil groups throughout California (left) and infiltration rate (represented by saturated hydraulic conductivity) variations with depth in Sacramento (right). (NRCS 2018)

Existing Standards

Many municipalities throughout California have been subject to runoff permit requirements for several years and have already established design standards for preventing and minimizing runoff. The standards provide specifications for the technical aspects of runoff management, including types of materials to be used; numerical retention, treatment, and hydromodification design criteria and tools; and required maintenance activities. These standards were developed with specific regional interests in mind, and can serve as resources for design specifications for schools in the interest of regional sustainability and consistency. When adopted into local drainage ordinances, compliance is required per [Government Code §53097](#). The CA [Phase II LID Sizing Tool](#) includes a map of school properties and municipalities that can be used to identify permittees with existing stormwater design manuals and standards that may be useful for schools.

IV. Planning and Design

Pollutants of Concern

Pollutants of concern vary by water body, and are influenced by land cover and use as previously explained. These pollutants can be used to prioritize treatment of typical school runoff pollutants. Generally, the pollutants in runoff include sediment, nutrients, metals, pesticides, oil and grease, bacteria, pathogens, and trash (Figure IV-5). A list of typical pollutants, their sources, and impacts are tabulated by municipalities and other entities regulated by NPDES permits. They must also comply with regional and local water quality standards (WQS), such as United States Environmental Protection Agency's (USEPA's) 303(d) program. The program lists TMDLs, which stipulate the maximum amount of contaminant discharges to water bodies that are allowed. The 303(d) list, TMDLs, and other WQS may be used to identify pollutants of concern in water bodies receiving runoff from schools. An assessment of land cover and use helps indicate whether these pollutants can be targeted for reduction by SCMs. The 303(d) water bodies, pollutants, and TMDLs are posted on the State Water Board's [Impaired Water Bodies](#) website.

Typical pollutant concentrations in runoff from various land types can be estimated from either regional data (often available from local municipalities) or the [National Stormwater Quality Database](#). The type and concentrations of pollutants generated can inform selection of SCMs.



Figure IV-5. An outfall below a neighborhood and golf course discharging multiple pollutants.

Typical pollutants of concern in urban runoff (adapted from CASQA 2003)

Pollutant Category	Example Constituents	Land Use Categories								Example Sources	Impacts
		Global/Regional Aerial Deposition	Agriculture	Commercial	Construction	Industrial	Residential	Transportation	Undeveloped		
Sediment	TSS Turbidity	X	X	X	X	X	X	X	X	Erosion Excavation	Habitat destruction Reservoir storage loss Increased water treatment costs
Nutrients	Nitrogen Phosphates		X	X	X	X	X	X		Fertilizers Farm animal waste Septic systems	Algae blooms Habitat destruction Fish kills
Bacteria and Pathogens	Fecal coliform <i>E. Coli</i>		X	X	X	X	X	X	X	Domestic sewage Pet waste Wildlife waste	Odors Toxicity Beach closures
Oils and greases	Total oil & grease Total petroleum Hydrocarbons			X		X		X		Vehicles Solvents & degreasers Crude oil	Visually unappealing Toxicity
Organic pollutants	PAHs ¹ VOCs ²			X		X		X		Illicit discharges Asphalt sealants Insecticides Varnishes & paints	Toxicity
Metals	Lead Zinc Copper	X		X	X	X	X	X	X	Industrial waste Mining Vehicles	Toxicity
Pesticides	Pyrethroids Chlorpyrifos Fipronil Diazinon		X	X	X	X	X	X	X	Residential landscape Agriculture Vegetated roadsides	Toxicity
Trash and particulates	Cigarette butts Paper bags Leaf litter			X	X	X	X	X	X	Schools Shopping centers Landscapes Fugitive trash ³ Vehicle accidents	Visually unappealing Habitat destruction Odors

¹Polyaromatic hydrocarbons

²Volatile organic compounds

³Fugitive trash released from landfills, transfer stations, garbage trucks, personal vehicles, trash receptacles, and industries

IV. Planning and Design

SCM Performance

SCMs have varying performance capabilities, as shown on the following page. Some SCMs can reduce runoff volumes, flow rates, and pollutant loads; some do not reduce volumes (only flow rate and pollutants); and some merely remove pollutants. Some SCMs are better at removing particular pollutants of concern, and some provide more volume or flow rate reduction. Design variations within the same SCM type can also affect performance. For example, bioretention planters that include an elevated underdrain can have better nitrate removal than those without an elevated underdrain—storing water within the gravel allows time for denitrification.

Selecting SCMs that maximize infiltration or on-site use is often the best way to address the many pollutants common in runoff. SCMs that include infiltration (see the SCM factsheets) will provide water quality treatment and volume reduction, while most of those without infiltration will provide water quality treatment only. The [International BMP Database](#) provides data and assessments of SCM performance reported by others.

Individual School Needs

Each school will have needs that can be met by projects designed for multiple purposes. Schools that need new sports fields, practice fields, or interactive play areas can plan these projects to include capturing runoff as part of the recreation infrastructure.

School District Requirements

School districts have specific requirements related to many elements of runoff capture design, as dictated by the California Code of Regulations, the California Department of Education (CDE), and the Division of State Architect (DSA). Examples include compliance with the Americans with Disabilities Act (ADA), excavations near existing structures, and geotechnical design for infiltration and runoff capture. Section IX summarizes many of the regulatory codes that may impact the SCM design.

Safety and Access

SCM implementation cannot create a condition that violates safety and access requirements in the DSA code requirements. In particular, limitations on SCM selection or design and incorporation of safety features may be needed for the following conditions:

- ▶ SCMs with a grade drop of more than 4 inches
- ▶ SCMs with confined spaces or standing water
- ▶ SCMs near fire access or emergency egress from any building

“In spite of the high voids content, properly placed pervious concrete pavements can achieve flexural strengths of more than 500 psi ... more than adequate for most low-volume pavement applications, including high axle loads for garbage trucks and emergency vehicles such as fire trucks.”— Perviouspavement.org

Environmental Compliance

There are several environmental regulatory compliance considerations for SCM installations, including the California Environmental Quality Act (CEQA) and the CGP. These are discussed further in [Identify Relevant Regulations and Programs](#) later in this section.

Maintenance Needs

SCMs are investments. To maximize these investments, operation and maintenance (O&M) needs must be considered and addressed during the project planning and design. Available funding and staffing, required equipment and materials, and aesthetics and function should be considered in SCM selection and design. Engaging maintenance staff in planning is particularly crucial to incorporate their insight and experience in easing future maintenance, and to address concerns regarding worker safety and changes to job descriptions or expectations. These and other O&M aspects are further discussed in [Identify Long Term Maintenance Needs](#) later in this section, and in Section VI (Maintenance).

Pollutants addressed by various SCMs | ¹ Assumes runoff is fully retained, ² Total metals only (does not address dissolved metals), ³ SCM comes in lined or unlined variations. Volume is retained only in unlined SCMs that allow infiltration

SCM	Parameter Addressed								
	Sediments	Nutrients	Pathogens & Bacteria	Oils & Grease	Organic Pollutants	Metals	Pesticides	Trash	Volume
Aboveground Storage ¹	X	X	X	X	X	X	X	X	X
Bioretention Planter	X		X		X	X	X	X	X ³
Constructed Wetland	X		X			X	X	X	X ³
Detention Basin	X					X ²	X	X	X ³
Drain Inlet Insert	X					X ²		X	
Dry Well ¹	X	X	X	X	X	X	X	X	X
Green Roof	X	X			X	X	X	X	
Hydrodynamic Separator	X	X	X	X	X	X	X	X	
Infiltration Basin ¹	X	X	X	X	X	X	X	X	X
Infiltration Gallery ¹	X	X	X	X	X	X	X	X	X
Infiltration Trench ¹	X	X	X	X	X	X	X	X	X
Media Filter	X					X	X	X	X ³
Oil Water Separator	X			X		X ²		X	
Porous Pavement	X	X	X	X	X	X	X	X	X ³
Underground Storage ¹	X	X	X	X	X	X	X	X	X
Vegetated Buffer Strip	X	X			X	X	X	X	X
Vegetated Swale	X	X			X	X	X	X	X
Wet Pond	X					X	X	X	X ³

IV. Planning and Design

Surrounding Infrastructure

Surrounding infrastructure is an important component of SCM design.

Proximity to buildings is important for SCMs that infiltrate, because moisture can damage foundations and basements. Guidance for SCMs often specifies a separation of 10 feet between buildings and infiltrating devices (Figure IV-6). Alternatively, a geotechnical engineer can be consulted. Additional measures, such as the use of a vertical moisture barrier, underdrains, or trench drains, can help route water away from buildings and structures.

The location of existing underground utilities also affects SCM siting and construction. Subsurface electric, gas, phone, and cable infrastructure must all be identified to prevent damage from excavations or long-term corrosion from habitual saturation. Upon request, public utilities staff will come to the site to delineate utility lines. Property owners should also be contacted to locate privately installed utilities, such as underground wiring for parking lot lights.

For redevelopment or retrofit projects, and even some new development projects, tapping into existing drainage infrastructure can be a good cost-savings approach. SCMs could be connected to or built around existing drain inlets, grading, surface conveyance (e.g., valley gutters), and subsurface conveyance piping to either direct runoff to the SCM or provide a means of discharge for excess runoff (i.e., overflows). Figure IV-7 shows an example.

Vegetative Health

Erosion control and irrigation needs, weed suppression, sun exposure, saturated soils, drought conditions, and maintenance requirements all affect vegetation selection. Several documents guide the selection and siting of plants within green infrastructure. Most contemporary landscape guidance documents emphasize the use of native plants for their drought adaptive traits and contributions to local habitat such as supporting pollinators. The County of San Diego's [LID handbook](#) includes detailed, species-specific information on plant water needs, sun requirements, climate zones, and, uniquely, ideal locations within SCM landscapes where inundation varies. Some plants are suitable for areas of sustained inundation such as lower areas within an SCM, while others do better in drier areas of SCMs, such as the upper slope of a rain garden. Similar considerations should govern the species of trees that are chosen for planting. Smaller trees may establish faster and be hardier, easing landscaping and maintenance needs.



Figure IV-6. A lined bioretention planter prevents infiltration impacts to building foundation



Figure IV-7. Tying a bioretention planter into existing drainage infrastructure



Figure IV-8. Use of hardier drought resistant plant species is appropriate for SMCs

Input from the School Community

To maximize the benefits from a capture project, teachers, parents, maintenance staff, and even students can provide unique insight and ideas related to how their school grounds could better serve their curriculum as well as their recreational, educational, and environmental needs.

In California’s climate, plants located in SCMs may need seasonal irrigation during vegetation establishment—even native plants located in a bioretention planter or similar feature—especially when not protected by tree canopy cover. In regions of the state with hot summer

months, new plantings are best done in the fall or early winter to provide plants time to establish root systems, which is critical for drought tolerance. Most newly planted vegetation, even native species, benefit from watering during the first several months as they become established. Figure IV-9 shows some varieties of plants used in bioretention planters in Sacramento.



*Figure IV-9. Left to right: Feather Reed Grass, Sticky Monkey Flower, Douglas Iris, Deer Grass, Blue-Eyed Grass, Spreading Rush, California Coffee Berry, Sawleaf Zelkova (Images acquired through Wikimedia Commons, <https://commons.wikimedia.org>; Sticky Monkey Flower, *Mimulus aurantiacus*: Image by Curtis Clark, Creative Commons Attribution-Share Alike 2.5 Generic, Douglas Iris: Image by Curtis Clark, Creative Commons Attribution-Share Alike 2.5 Generic)*

IV. Planning and Design

Planning and Design Steps

Planning and design activities are essential to implementing a project that meets its intended objectives and is sensitive to cost and other feasibility constraints. The following activities should be integrated into the planning activities for any project adding or replacing impervious surfaces. They can also be useful in planning stand-alone projects for SCM implementation. Planning and design activities can be categorized as follows:

- ▶ Step 1—Conduct a site reconnaissance
- ▶ Step 2—Establish the Project Team
- ▶ Step 3—Identify Relevant Regulations and Programs
- ▶ Step 4—Develop the Project Concept
- ▶ Step 5—Plan the Implementation Components
- ▶ Step 6—Finalize the Design and Cost Estimate

The [Guidance for Design and Construction of Vegetated Low Impact Development Projects](#) (Figure IV-10), developed as part of the State Water Board's [DROPS](#) effort, provides many additional planning and design suggestions that supplement the information provided in this document.



Figure IV-10. Guidance for Design and Construction of Vegetated Low Impact Development Projects (CWH 2016)

Step 1: Conduct a Site Reconnaissance

Identify existing issues at the site, such as flooding that needs to be addressed, natural play and learning areas that are desired, and increased shade and greening. From this information, identify the project's objectives, which should be multifaceted to maximize the potential benefits, as described in Section II.

Step 2: Establish a Project Team

A good project starts with a good team, and a good team can assist in identifying and understanding critical planning and design factors. When soliciting an architectural and engineering firm, consider requesting particular expertise as identified in the [DROPS Guidance](#) (Appendix B). The project team should consist of appropriate personnel. Design staff, maintenance staff, teachers, and parents can serve as key proponents and provide brainstorming ideas (Figure IV-11). This will ensure that district and school site needs and requirements (budgetary limits, ADA access, fire lanes, etc.) will be addressed. Plumbing and landscape staff should also be consulted regularly to ensure they will approve any proposed additions or modifications that will require code approvals as well as maintenance.



Figure IV-11—Teachers and parents participated in a brainstorming event for the Robert Lewis Stevenson Elementary School stormwater schoolyard project in San Francisco SFPUC

Step 3: Identify Relevant Regulations and Programs

Identify regulatory requirements that may need to be addressed, including:

California Environmental Quality Act (CEQA): All projects in California that propose new development and structures are subject to the requirement to prepare an environmental impact report (EIR) before construction of projects. A certified environmental planner will review the project and determine EIR requirements. The California Natural Resources Agency provides introductory material for understanding basic guidelines and procedures related to [CEQA requirements](#).

Capital Improvement Programs: Runoff prevention and capture practices can easily be incorporated into capital improvement program (CIP) projects, as most CIP projects will involve site grading and runoff management. Verify that drainage for school CIP projects incorporate runoff prevention and capture practices covered in this document.

IV. Planning and Design

Construction General Permit (CGP): For any construction project that disturbs more than one acre of soil, coverage under the [CGP](#) from the State Water Board is required to mitigate the effects of construction site runoff (State Water Board 2018b). To fulfill the requirements, a SWPPP must be developed that outlines measures to prevent debris, trash, and sediment from entering runoff. The plan must be written by a Qualified SWPPP Developer ([QSD](#)). The CGP also contains post-construction runoff management requirements, which can be addressed by use of SCMs that promote infiltration.

CWA Sections 401 and CA Porter Cologne Water Quality Control Act: CWA Section 401 and California’s Porter Cologne Act protect wetlands from development. The State Water Board’s [CWA Section 401 program](#) regulates discharges of fill and dredged material to all waters of the state (including wetlands) through protection of special-status species and control of hydromodification impacts. Actively managed runoff detention facilities are generally not subject to these development and permitting requirements, as they are not naturally-occurring wetlands. Active management must include record keeping that details regular trash removal, inspections, erosion control, and mowing and weeding. For sites that contain endangered species, much stricter management and protection requirements apply (WRA 2015).

DSA approval: Plans meeting certain minimum thresholds for scope and cost must also be reviewed by DSA. Section IX summarizes many regulatory codes that relate to runoff capture practices. Examples of features requiring approval are tabulated below.

<p>CCR Title 24 Part 2 (CBC) §1803A.1</p>	<p>Water retention basins and/or vaults anywhere on a school site that will regenerate (percolate) localized ground water will require DSA approval. A geotechnical report from a CA-registered geotechnical engineer evaluating the effect of the water level on the soil bearing and lateral resisting capacity of any nearby structures will be required.</p> <p>Any basin or vault located close to an existing structure will require a geotechnical report and DSA approval. The bearing capacity of the structure’s foundations may be affected, and open trenches may result in settlement of the structure during installation.</p>
<p>CAC Part 1 §4-302 CCR Title 24 Part 2 (CBC) §1601A, 1604A, & 1803A.1</p>	<p>Basins, vaults, culverts, and porous pavement must be designed to support heavy vehicle traffic (fire-fighting trucks and equipment) and will require DSA approval. A geotechnical report may be required to determine the effect on bearing .</p> <p>Surface structural elements, including but not limited to site walls, fences, covered walkways, pedestrian bridges, solar or shade structures, covered parking, retaining walls, planters, and retention ponds will require DSA approval.</p>
<p>CAC Part 1 §4-302 & §4-314</p>	<p>New and/or rerouted plumbing and electrical utility lines and systems will require DSA approval.</p>
<p>EDC § 17280 – 17317 CCR Title 24, Part 1 (CAC) (Chapter 4, Groups 1 - 3)</p>	<p>Plans, specifications, and/or calculations shall be prepared by CA-licensed architects or professional engineers registered for their scope of work and will require approval by DSA prior to contracts being let to contractors and the start of any construction. Project inspection and material testing will be required during construction.</p>

CCR: CA Code of Regulations; CBC: CA Building Code; CAC: CA Administrative Code; EDC: Education Code;

Incentive Programs and Grants: Runoff capture projects can often qualify for funding through grants, loans, or regional collaboration. Refer to Section VII (Costs and Funding) for more detailed descriptions of these opportunities. Runoff capture projects can also be used to develop education programs on sustainability, such as the [SWPPP internship program](#) implemented by several school districts in southern California. Informing teachers, principals, and even parents and guardians of plans for runoff capture may help create incentives.

Monitoring and reporting requirements: Any of the above regulations may require monitoring and/or reporting. In addition, monitoring or reporting may be required by Sections 13267 or 13383 of the CA water code, which allows the State Water Board and Regional Water Boards to establish monitoring, inspection, entry, reporting, and recordkeeping requirements. Check with the State Water Board and Regional Water Boards to inquire if monitoring would be required. The State Water Board hosts the [Stormwater Multiple Application and Report Tracking System](#) (SMARTS), a platform for submitting and storing relevant runoff monitoring and reporting information.

National Pollutant Discharge Elimination System (NPDES) Permits: Some locations may be subject to [NPDES permits](#) for MS4s. Such permits could be applicable through local drainage ordinances or a statewide MS4 permit. These permits contain SCM performance criteria and monitoring and reporting requirements.

Other Requirements: Additional requirements could include zone variances and local drainage ordinances (See [Title 5 §53097](#)).

Step 4: Develop the Project Concept

Step 4a: Create a Preliminary Site Plan

Using input from the stakeholders engagement (Step 1), identify general ideas of what project elements are needed and where they can be placed. This involves determining where small-scale landscape and SCM features can be used to achieve the multiple objectives and benefits identified in Step 1.

Step 4b: Estimate Existing Metrics

Estimate the runoff volumes and flow rates that will be generated from the post-construction project site and identify the pollutants of concern. Various methods and models for estimating runoff volumes and flow rates are available as discussed in [Step 4e and Appendix B](#). Types and concentrations of pollutants can be determined using the resources described previously in [Pollutants of Concern](#).

Step 4c: Select SCM Type(s)

Select the SCM type(s) based on the requirements from [Step 3](#), the estimated metrics from Step 4, the on-site soil characteristics, available space, slope, and other considerations that are described in the SCM factsheets (Appendix A).

IV. Planning and Design

Step 4d: Conduct Preliminary Sizing

Determine a rough estimate of the dimensions of the selected SCMs. This is needed to perform subsequent planning tasks such as permitting, site layout, and traffic routing. The practices presented in [SCM Sizing Methods](#) can be used for preliminary sizing, but with a less rigorous estimation of the variables.

Site selection should consider the area available, funding constraints, and site hydrology. Constraints such as endangered species habitat, protected vegetation, archaeological resources, and maintenance and access needs and concerns should be assessed during site selection. Low areas, oddly configured areas, or otherwise unbuildable locations might present opportunities for siting SCMs.

This step, like many, may be an iterative process. If appropriate space is not available, grading or facility location adjustments can be used to increase sustainability.

Step 4e: Estimate the Expected Performance

Quantify the expected performance of the SCM in terms of volume and/or pollutants. Performance can be established as:

- ▶ Percent retained, for example:
 - ▶ 90% volume retained annually
 - ▶ 90% total suspended solids (TSS) retained annually
- ▶ Amount discharged, for example:
 - ▶ 1 acre-foot of runoff discharged annually
 - ▶ 100 kg of TSS discharged annually
- ▶ Difference retained, for example:
 - ▶ 9 acre-feet of runoff retained annually
 - ▶ 1,200 kg of TSS reduced annually

There are many models and tools, as well as simple hand calculation methods, that can be used to estimate volume and pollutant reductions and discharges based on specified SCM design elements. Some may have been used during preliminary sizing. Some tools evaluate volume reduction performance, such as the [USEPA National Stormwater Calculator](#) (Figure IV-12) and the [CA Phase II LID Sizing Tool](#) (Figure IV-13). These volume reductions can be combined with water quality treatment performance data from local municipalities or the [International Stormwater BMP Database](#) to estimate pollutant load reductions. These tools provide estimations for individual catchments. Separate simulations are required to evaluate overall performance for a particular site or region consisting of many catchments. Other models such as [GreenPlanIT](#) or the Tool to Estimate Load Reductions ([TELRL](#)) are available for regional planning and include pollutant load reduction estimates.

Step 4f: Compare the Expected Performance to the Desired Performance

Comparing expected performance to the desired performance helps check whether the conceptual design of the SCM meets the target objectives. The desired performance may come from NPDES permit criteria or other regulations mentioned in the [Step 3](#). If the expected performance does not meet the desired performance, the SCM may need to be resized, or additional or alternative SCMs may be needed.

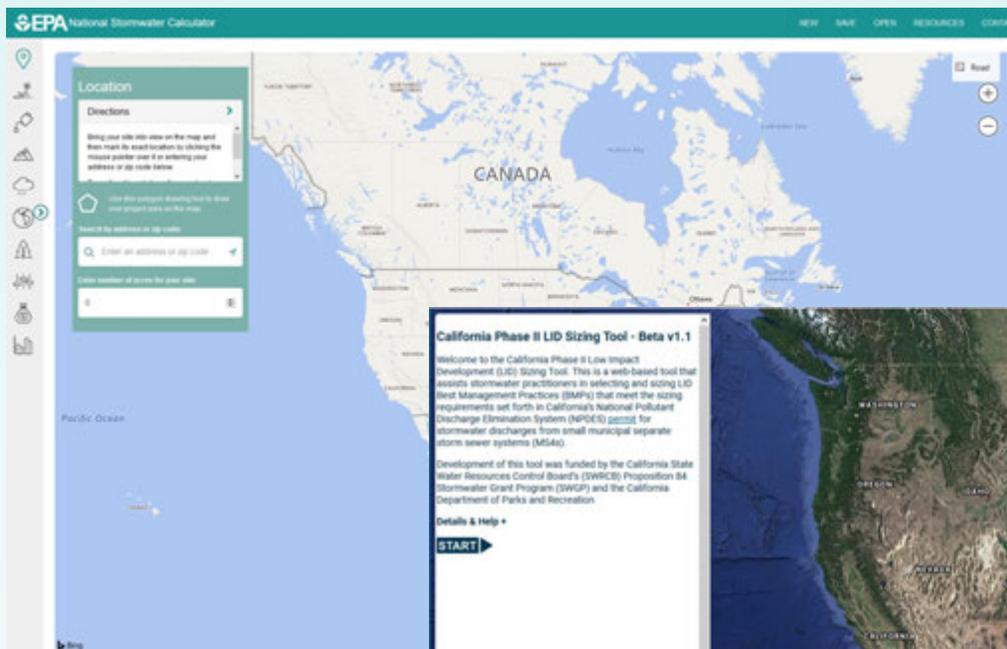


Figure IV-12— USEPA National Stormwater Calculator



Figure IV-13— CA Phase II LID Sizing Tool

Step 4g: Identify Long-Term Maintenance Needs

Determine O&M activities that will be required after construction and throughout the expected life of the SCMs. “Design with maintenance in mind” is a valuable strategy for managing costs and feasibility of a project. Fortunately, guidance already exists. For instance, DeepRoot Green Infrastructure posted an insightful blog breaking down maintenance aspects to be considered during project design and planning ([DeepRoot 2018](#)). In many cases, incorporating features that reduce long-term maintenance efforts and costs may be well worth any additional capital cost investments.

Maintenance staff should be engaged early in the planning and design process to incorporate their insight and experience as well as address any concerns regarding potential changes in job descriptions or expectations. See Section VI (Maintenance) for details.

If maintenance will be handled by an external entity, maintenance agreements should be developed. An O&M plan should be created to document responsibilities, activities, and schedules, and then included in the maintenance agreement. See Section VI (Maintenance) for information regarding maintenance activities, including a template for an O&M plan.

IV. Planning and Design

Design with maintenance in mind

Maintenance Considerations

Funding: Establish a maintenance budget specific to the selected SCMs. Section VII (Costs and Funding) provides resources for estimating these costs and acquiring funding.

Equipment: Identify what equipment is needed and available for O&M. Examples include commonly-owned equipment (leaf blowers and power washers) and specialty items (weed burners or vacuum sweepers). Exclude SCMs for which proper maintenance equipment is not or will not be available. Design SCM elements to “fit” the equipment. For example, curb cut openings should be sized to fit a shovel or allow street sweeping.

Materials: Verify that materials needed for maintenance will be available. Example materials include familiar supplies (bark or mulch) or specialty materials (bioretention soil or pervious concrete). Ensure there will be means for maintaining an inventory and condition schedule, as well as communicating where equipment can be procured and accessed.

Appropriate Staff: Determine which personnel have the authority and capability to maintain the SCMs as needed and whether training or addition of staff is needed.

Aesthetic vs Function: Establish the desired aesthetics and relevant level of effort and maintenance required to maintain that aesthetic.

(adapted from DeepRoot 2018)

Step 4h: Document Final Concept

Documentation of the final concept facilitates its use to gather input from stakeholders, develop cost estimates, and inform final design and funding. The document can also be offered to teachers, providing them a resource for learning opportunities.

Developing the SCM project concept is an iterative process. As information is developed and evaluated throughout the planning period, the concept may be adjusted to meet project constraints. Advantages and constraints that were identified to develop the final concept should be recorded, along with preliminary details and schematics with respect to SCM type, siting, dimensions, and infrastructure proximity or tie-ins. Share the conceptual plan with the stakeholders identified in Step 1 for potential additional ideas or limitations.

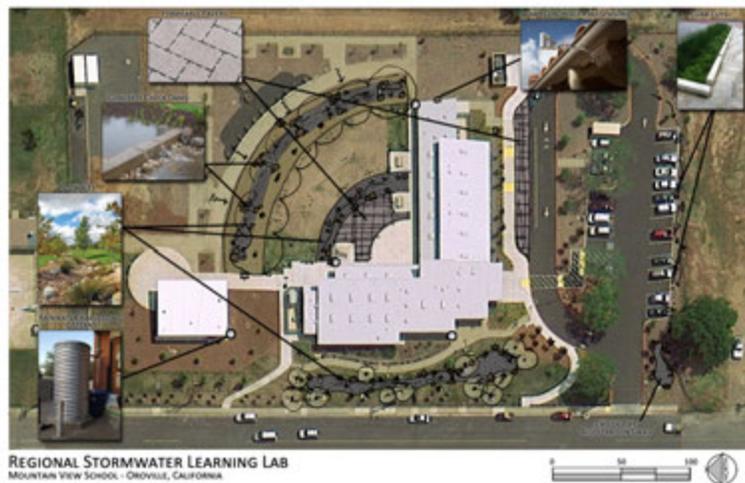


Figure IV-14. Example of a conceptual plan for SCM installations at a school (provided by DROPS program)

Step 5: Plan the Implementation Components

Step 5a: Develop a Vegetation Plan

A number of runoff capture practices (e.g., tree planting, bioswales, bioretention planters, and wetlands) include vegetation. Maintaining vegetation health throughout the life of the SCM is essential for adequate performance. Upfront planning will identify resources needed to successfully establish vegetation and long-term maintenance. This includes staff responsible for and committed to the establishment and maintenance of vegetation, and access to water (and nutrients, if needed). If possible, allow for plant establishment prior to letting children access areas where there is significant investment in plant materials. Council for Watershed Health (CWH) [DROPS Guidance](#) provides good tips for using appropriate plants and landscaping materials and determining an irrigation approach. The county of San Diego's [LID Handbook](#) also provides good information

Step 5b: Evaluate Pedestrian and Traffic Routing

Implementing SCM projects may disrupt pedestrian traffic patterns if the footprint impinges on walkways, bike lanes, roads, or other transportation corridors on the school campus. Therefore, site SCMs to ensure that foot, bike, and car traffic patterns can be maintained after construction. This could involve rerouting traffic or development of alternative routes to maintain traffic flow. If porous pavement is an element of a proposed SCM, the porous pavement needs to be constructed to manage the vehicle traffic loads. Avoid designs that re-route foot traffic and try to keep existing pathways in place. Pathways that are replaced by vegetation may continue to be used, risking damage to the new installations. CWH's [DROPS Guidance](#) provides further insight regarding pedestrian circulation and use (Figure IV-15).

Step 5c: Coordinate Construction Staging

When scheduling construction activities, consider both the school's daily and seasonal schedules. It may be less disruptive if construction activities occur in the summer or at other times when school is not in session. Also, if the project involves excavations (e.g., detention basins or bioretention planters), work will be more difficult in the rainy season, when runoff to the construction site must be managed. If the SCM involves planting of vegetation, the planting schedule should consider weather to ensure that plants have an optimal chance for establishing healthy growth, as discussed previously in Step 5a.

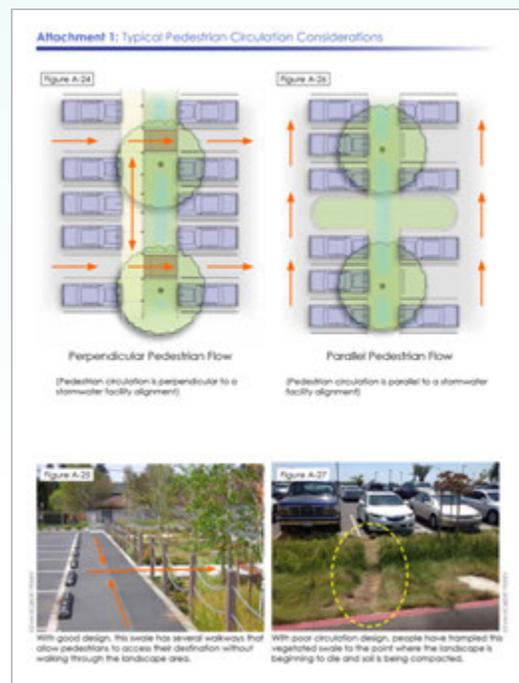


Figure IV-15. Pedestrian circulation considerations from DROPS (CWH 2016)

IV. Planning and Design

Step 5d: Develop a Plan for Waste Disposal

Installation and maintenance of some SCMs may generate waste materials that require disposal. For example, plant material may need to be periodically removed from some SCMs, such as biostrips, bioswales, and bioretention planters. Additionally, dry wells, infiltration basins, and detention basins must be periodically cleaned of soils and settled solids. Grates and drains must be cleaned of debris and material that can impact optimum performance. These waste materials will generally be inert and non-hazardous, but plans should be put in place to characterize any waste streams that could possibly be defined as hazardous under California regulations. Hazardous wastes require more stringent storage and disposal procedures. A plan for waste disposal should be put in place before SCM construction.

Step 5e: Develop a Monitoring Plan

Once the SCM is constructed, monitoring (if required) may be performed to assess its performance. Monitoring may also help demonstrate compliance with regulatory requirements, if applicable (see monitoring and reporting requirements in the [Identify Relevant Regulations and Programs](#) step). This monitoring can take the form of visual inspections, runoff sampling, flow measurements, or water quality analysis and evaluation.

Step 5f: Estimate Costs and Secure Funding

Estimate the costs and identify sources of funding for initial planning, design, and construction activities as well as for future O&M. Section VII (Costs and Funding) describes several resources for estimating SCM capital and O&M costs as well as funding sources.

Step 5g: Document the Implementation Details

For simpler projects with fewer stakeholders and planning tasks, the activities discussed above can be documented through informal communication among the project team. For more complex projects, it may be useful to prepare a written document describing all activities and selected strategies. This can be used to inform stakeholders and allow them to understand the project elements and decision process, as well as provide input.

Step 6: Finalize the Design and Cost Estimate

Step 6a: Refine and Finalize the Design

Refine the design plans and specifications. A few versions of the plans and specifications should be developed prior to finalization, with each progressively more detailed and accurate. The conceptual plan conceived during the [Develop the Project Concept](#) step can be considered a preliminary draft design, as it includes simple elements such as what SCMs are to be installed, where they are to be located, and their approximate dimensions. Multiple drafts may be needed before finalizing the design. Each draft should incorporate and adjust the components considered during the implementation planning step, namely the vegetation plan, traffic routing, construction staging, and waste disposal.

The [DROPS guidance](#) (CWH 2016) serves as an excellent resource for design, particularly for ensuring that runoff can enter and exit the project, protecting adjacent structures, using ponding depth and check dams to enhance infiltration, and avoiding sediment and erosion problems. It also has extensive appendices with pictures of good design practices, as well as poorly implemented SCMs. The DROPS guidance includes a discussion on sizing aspects of design, focusing on a simple method, although there are other methods that may reduce the required SCM size and, therefore, costs. To supplement the DROPS guidance, common design (sizing) methods are presented in [SCM Sizing Methods](#) (Appendix B).

SCM design tips from DROPS (CWH 2016)

Design Topics
Ensure runoff can enter and exit the project
Protect adjacent structures from runoff intrusion
Use ponding depth and check dams to enhance infiltration
Avoid sediment and erosion problems

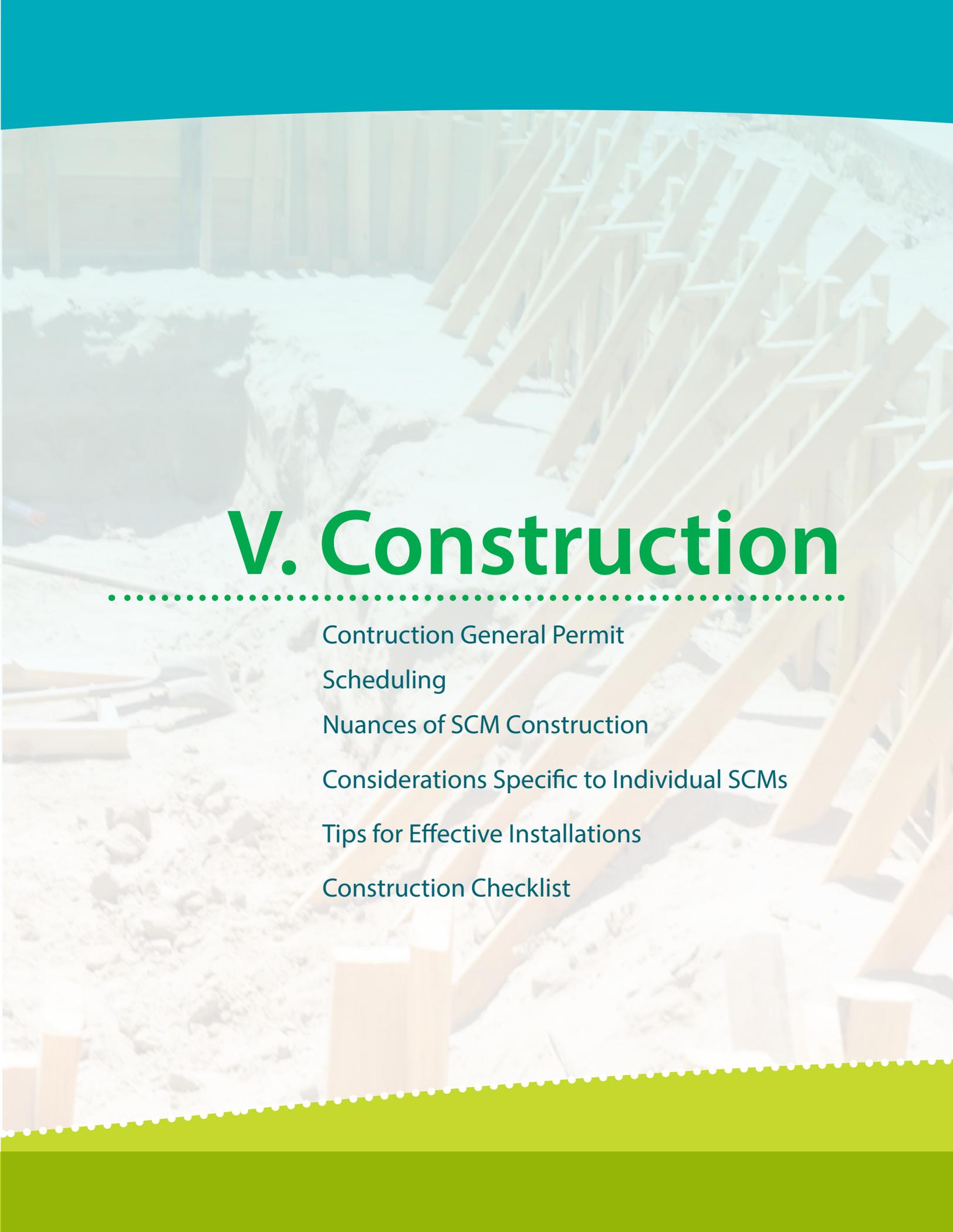
Step 6b: Update the Cost Estimate

Update the cost estimate to reflect the final design plans and specifications. Refer to Section VII (Costs and Funding) for relevant resources.

Planning and design checklist

The table below can be used to ensure that appropriate objectives of each planning and design step have been addressed.

Step	Question	Y/N
1	Has a site reconnaissance been conducted to identify the site needs, project objectives, and ways multiple benefits can be achieved?	
2	Has the project team been established, with members having appropriate knowledge of and experience with the project objectives?	
3	Have relevant regulations and programs that may limit or support various project elements been identified?	
4a	Has a preliminary site plan been developed that identifies where improvements are needed and where infrastructure can be placed to meet the project objectives?	
4b	Have the pre-project metrics been estimated, including runoff volumes, flow rates, and pollutant loads?	
4c	Have SCMs and design strategies been selected based on the relevant regulations and programs, existing metrics, on-site soils, available space, slope, and other considerations?	
4d	Have the SCMs been sized appropriately based on relevant regulations, available space, funding constraints, site hydrology, etc?	
4e	Has the expected performance for the project been estimated in terms of a percent retained, a difference retained, or an amount discharged?	
4f	Does the expected performance meet the desired performance?	
4g	Have long-term maintenance needs been identified, including maintenance staff concerns, specialty equipment needs, funding, scheduling, and an O&M plan?	
4h	Has the conceptual design been documented and shared with relevant stakeholders?	
5a	Has a vegetation plan been developed, with selection of plants that are drought and inundation tolerant, along with an irrigation plan for vegetation establishment and long-term maintenance?	
5b	Has pedestrian and traffic routing been evaluated to ensure patterns and flow will meet required needs after construction?	
5c	Has a general construction schedule been developed, taking into consideration school functions and how seasons impact certain construction aspects (e.g., avoid rainy season for deep excavations, avoid planting in hot weather)?	
5d	Has a plan for disposal of waste materials such as excavated soils, vegetation, and underground infrastructure components been developed?	
5e	Has the project team determined if monitoring is required for the project, and if so has a monitoring plan been developed?	
5f	Have costs and funding sources for planning, design, construction activities, and future O&M been estimated and identified?	
5g	Have the implementation details addressing all items of this checklist been documented for future reference?	
6a	Has the design been refined and finalized to meet the project objectives and constraints?	
6b	Has the cost estimate been updated to reflect the final design plans and specifications?	



V. Construction

Construction General Permit

Scheduling

Nuances of SCM Construction

Considerations Specific to Individual SCMs

Tips for Effective Installations

Construction Checklist

V. Construction

Construction General Permit

Construction activities that disturb a specified area of land (i.e., clearing, grading, excavating, and stockpiling—including installation of SCMs) are subject to requirements in the California [CGP](#). The requirements include development of a SWPPP. The SWPPP must be created by a QSD and implemented by a qualified SWPPP practitioner (QSP). The SWPPP must include potential pollutant sources; pollution prevention/good housekeeping practices; construction BMPs (e.g., swaddles, drain inlet covers); inspections, maintenance, and repair of pollution prevention equipment; spill response; and other elements.

Scheduling

As cornerstones of communities, schools are busy places that often host a variety of activities during non-classroom hours, ranging from after-school camps and scout meetings to parent-teacher conferences, festivals, and recreational sports. Scheduling when and where various construction activities can occur to minimize activity disruptions is challenging. For some schools, summer may be an ideal time for construction, although the long, dry summers typical of much of California can be difficult for plant establishment, even if irrigation is provided. So, the sequencing and staging of construction activities should be considered during the planning stages of the project and confirmed during design and at the start of construction.

Nuances of SCM Construction

Compared to conventional drainage infrastructure, the runoff management practices featured in this document focus on capture, retention, and treatment of small storms. This is a relatively new concept to many contractors and developers. The Central Coast LID Initiative developed a useful and concise [Technical Assistance Memo](#) (TAM) that informs practitioners on the nuances of LID implementation, such as avoiding compaction of soils to allow runoff to infiltrate (Figures V-1 and V-2). The Water Environment Federation's National Career Infrastructure Certification Program also provides training on the special details needed for green infrastructure installations.



Figure V-1. Keep heavy equipment off areas intended for infiltration

Low Impact Development (LID) For Contractors and Developers

LIDI Technical Assistance Memo (TAM)

Low Impact Development, or LID, is required for many new and redevelopment projects, including public projects. It is an approach to managing stormwater by mimicking natural landscapes. LID integrates design features (e.g., specially designed landscapes, permeable hardscapes, and rainwater catchment systems) on-site to meet post-construction stormwater controls. In contrast to post-construction flood control infrastructure (e.g., vaults and detention ponds) LID focuses on infiltration of small storm events to meet water quality requirements for watershed protection and to support water supply objectives. Although projects with LID features may look like conventional development projects, there are key differences for contractors and developers to understand as part of bidding or cost estimating, construction, and maintenance. The goal of this TAM is to give contractors and developers who are new to LID pointers to help identify aspects of LID implementation that impact cost, affect project schedule, or require special construction procedures.

UNDERSTANDING PROJECT DESIGN

It is important to carefully review construction documents (CDs) and specifications for design elements, construction methods, special phasing, and new materials related to LID features that may impact implementation or cost. Subcontractors should also review CDs with this in mind. For public projects, contractors and subcontractors should attend the pre-bid meeting, which is an opportunity to obtain valuable information for bidding the LID features. Additional considerations to better understand the LID project include:

- LID features typically involve excavation. Ensure that potholing is included in the cost estimate where utilities are expected to be present.
- Account for protection of LID features from compaction as identified in CDs and specifications.
- Account for additional sediment and erosion control effort. LID features are designed to intercept stormwater and are often at low points. However, during construction stormwater should be diverted away from LID features until the site is stabilized.
- LID features often require special construction, such as deepened curbs that cannot be built as extruded.
- Verify that suppliers can meet the specifications for LID materials. Substitutions may be limited, or in some cases not allowed.

CONSTRUCTION Sequencing and Schedule

- Understand the unique needs for construction sequencing of LID features. LID features need protection from compaction, erosion, sedimentation, and construction runoff. Plan to sequence construction of LID features for the least amount of conflict with other aspects of construction.
- Avoid excavation and other work in LID features during wet or saturated conditions.
- Consider lead times and associated submittals on specialized LID materials (e.g., impermeable liner, bioretention aggregate, bioretention soil mix, plants for ponded area of bioretention facility, mulch).



Source: Cannon

CONSTRUCTION

Excavation and Infrastructure

- Excavations for LID features may create utility conflicts. Pothole first. Is there still adequate cover? Are there conflicts? Do utilities need temporary relocation or protection from equipment and compaction?
- Provide clear signs/barriers to prevent entrance and compaction of LID features.
- Meet and walk the property with equipment operators regularly to clarify construction boundaries.
- Machinery performing excavation should be adjacent to, not inside of, the LID facility whenever possible.
- When machinery must operate in the LID facility due to size or location, consult the soils engineer for strategies to minimize compaction, and re-scarification requirements.
- Grading of LID features is non-traditional and assumptions and changes to grades shown on plans should not be made without consulting the designer. Ask questions if grading design is not clear.



LID For Contractors and Developers

page 2

Excavation and Infrastructure (continued)

- Curbs and gutters may have unique details for the purpose of directing stormwater to LID features. Don't overlook these details. Ask questions if a detail is unclear or not provided.
- Do you understand the functional intent of the LID feature? What is the stormwater ponding depth and where is the overflow location?
- Drainage overflow structures (e.g., catch basins and raised area drains), their locations in the facility, and inlet elevations are intentional for stormwater ponding. Do not make field adjustments to overflow structures; clarify the design intent if an elevation looks wrong.



Source: David Hertz

- Understand where infiltration is desired and where it is not. Road base, utilities trenches, and building foundations must be protected as noted per plans and specifications. Deep curbs, underdrains, impermeable liners, and trench dams keep infiltration away from these undesired locations.
- Filter fabric is not recommended in LID infiltration features. It can clog with sediment and cause the system to fail. Do not substitute or install filter fabric without consulting the designer.
- When underdrains are used, their placement and the orientation of their pipe holes are intentional, and may vary for facilities on the same site. Underdrains at the lowest elevation of the LID facility drain the maximum amount of water. Underdrains installed at a higher elevation allow retention and infiltration of stormwater into underlying soils.

Technical Resources

More information, including standard details and technical specifications for LID design is available on LIDI's website at: centralcoastlidi.org/technical

Legal Disclaimer: This Technical Assistance Memo (TAM) is intended as guidance only and should not be used as a substitute for design and engineering. Applicants are responsible for compliance with all code and rule requirements whether or not described in this TAM.

Soil and Landscape

- Are plans and specifications clear on soil placement and compaction for LID features? Compaction for LID is not like traditional compaction. Systems are designed to infiltrate. Over compaction of underlying or engineered soils inhibits infiltration. Over-compacted soils must be rescarified to a depth identified by the soils engineer to return soils to their desired infiltration rates.
- Are plans and specifications clear on plant locations and spacing? Installation must accurately match landscape plans because special plants are selected to tolerate the ponding areas.
- The contractor should coordinate with the landscape contractor to ensure that final grades are maintained upon completion of plant and mulch installation.
- LID landscapes can receive erosive stormwater flows; inlets should be blocked or otherwise protected until plants establish enough to withstand stormwater flows. Look for direction in the plans and specifications.



Source: Cannon

VERIFICATION

- The Regional Water Board may require field verifications of LID features by the municipality or a third party during construction. Coordinate with the inspector at appropriate construction phases to ensure compliance and avoid re-excavation.
- Obtain approval for submittals/substitutions from the designer or owner's representative before ordering.

MAINTENANCE/WARRANTY

- LID features often require additional maintenance (e.g., sediment and debris removal from inlets and overflows, periodic vacuuming of void spaces within permeable hardscapes). Be sure to clarify what is required for projects that include a maintenance and/or warranty period.

Figure V-2. LID for Contractors and Developers Technical Assistance Memo (LIDI 2018)

Considerations Specific to Individual SCMs

The SCM factsheets in Appendix A note construction considerations specific to each SCM.

Examples include:

- ▶ Following proper confined space entry practices
- ▶ Conducting leak detection
- ▶ Preventing sediment from entering SCM
- ▶ Scheduling vegetation establishment to minimize irrigation needs and plant loss/damage
- ▶ Mitigating plant damage
- ▶ Field verifying soil characteristics
- ▶ Following manufacturer guidelines

V. Construction

Pitfalls of SCM Construction

- ▶ Installing overflow risers flush to the ground rather than raising them
- ▶ Swapping specified bioretention soil mix with a mix not designed for water quality treatment
- ▶ Allowing heavy equipment and compaction on areas intended for infiltration
- ▶ Actual on-site soils having lower infiltration potential than intended design
- ▶ Sloping curb cuts away from SCMs
- ▶ Planting when weather is too hot

Tips for Effective Installations

SCM installation activities include those typical for many construction projects: staging, surface preparation, excavation, infrastructure placement, regrading, planting, and vegetation. But, designs may differ slightly from those that contractors typically follow. The [DROPS guidance](#) effort provides many details for effective installations:

- ▶ Reviewing the project design with the construction team
- ▶ Preparing for different construction techniques and material requirements
- ▶ Ensuring that proper protections are in place and checking the native soil conditions
- ▶ Excavating sites, placing materials, and setting elevations

Construction Checklist

Items to be checked to help support successful SCM construction are tabulated below

#	Question	Y/N
1	Has a SWPPP been developed by a QSD? Does it include measures and practices intended to address requirements of the CGP?	
2	Is the contractor prepared to implement devices and practices outlined in the SWPPP?	
3	Has a project team member been delegated to provide continuity and support during construction?	
4	Has the project team met with the contractor and reviewed the project, including the nuances of SCM construction and considerations specific to each SCM?	
5	Is the correct planting, bioretention, media mix, or other fill material being used and placed correctly?	
6	Is the infrastructure being installed at the proper depths and alignment, including underdrains, raised inlets, and conveyance piping?	
7	Have all final grades all been checked, reviewed, and set correctly?	
8	Are the materials, systems, and practices needed for vegetation establishment in place, particularly plant placements, irrigation schedule, and maintenance plans?	
9	Has an O&M plan been developed and reviewed with maintenance staff, with their concerns properly addressed?	

A worker in a yellow safety vest and blue cap is bent over, working on a pipe in a field. The field is filled with potted plants, and the background shows a fence and more vegetation. The scene is overlaid with a semi-transparent green filter.

VI. Maintenance

.....

The Value of Maintenance

Types of Maintenance Activities

Engaging Maintenance Staff

Developing an O&M Plan



VI. Maintenance

The Value of Maintenance

SCMs require investments in planning, design, and construction. Maintenance can maximize these investments. Installations have an effective life of 20 or more years, if properly maintained.

Most maintenance activities involve simple inspections or preventive measures, with occasional corrective actions, to reduce the risk of premature failures. The consequences of ineffective maintenance or neglect can include clogging or short circuiting of the systems, often well before they reach their intended effective life. Engaging with maintenance crews during planning, design, and construction and developing an O&M plan can ensure that maintenance activities and any follow-up actions are completed.

Types of Maintenance Activities

Typical maintenance activities include those listed below. Refer to the [O&M template](#) for descriptions of the activities and the SCMs they apply to.

- ▶ Inspect adjacent landscaping and pavement
- ▶ Inspect for erosion
- ▶ Inspect inlet conveyance infrastructure
- ▶ Inspect irrigation system
- ▶ Inspect outlet conveyance infrastructure
- ▶ Inspect overflow system
- ▶ Inspect for permanent pool
- ▶ Inspect for ponding
- ▶ Inspect porous/pervious pavement structure
- ▶ Inspect pumps
- ▶ Inspect SCM structure
- ▶ Inspect vegetative health
- ▶ Clean/vactor sediment
- ▶ Perform integrated pest management
- ▶ Prune vegetation
- ▶ Remove accumulated debris
- ▶ Replace fill material
- ▶ Replace mulch
- ▶ Weed



Flooding Due to Broken Sprinkler Head



Erosion in Vegetated Swale (EPA 2016)



Porous/Pervious Pavement in Need of Maintenance vs. Clean



Leaves Clogging Inlet Pipe



Leaf Debris Covering Overflow



Sand and Sediment Entering SCM Drainage Area

Figure VI-1. Examples of SCM maintenance needs

VI. Maintenance

Engaging Maintenance Staff

Maintenance staff should be engaged during planning and design activities to incorporate their insights and experiences in easing future maintenance, as well as to address concerns regarding any changes to job descriptions or expectations. Most maintenance activities are straight-forward and similar to those typical for landscaped areas, but maintenance staff may have concerns about issues like:

- ▶ Extra training required for integrated pest management, porous pavement cleaning, and other activities
- ▶ More weeding (especially during vegetation establishment) due to restrictions on herbicide use
- ▶ Seasonal hand pruning instead of using powered shears
- ▶ Concerns of exposure to potential pollutants

Throughout SCM planning, design, and construction, project planners must engage maintenance crews, and perhaps any associated unions, to discuss and resolve potential concerns, including changes to job descriptions.

In addition to obtaining maintenance staff insight and addressing any concerns, training crews on the particulars of SCM maintenance can be valuable. The lack of proper and regular maintenance can result in loss of performance and aesthetics, and ultimately expensive repairs. For example, tasks such as weeding and irrigating can often be postponed or forgotten, resulting in the need to replace vegetation. Purchasing plants, directing repairs, and conducting mitigation can be costly. A good training program for maintenance of green infrastructure is available from the [Water Environment Federation's National Green Infrastructure Certification Program](#) (NGICP).

Developing an O&M Plan

O&M plans must describe the SCMs to be maintained, specific maintenance activities and schedules, training, recordkeeping, and safety considerations.

The State Water Board website offers an [O&M plan template](#) with standard language. Recommended activities, including the frequency for each activity, are provided for common SCMs. Any SCMs that are not applicable can simply be deleted. The template uses a color highlighting system to indicate fields where information needs to be added or deleted or to give other instructions.

Inspection form templates are provided for each SCM as attachments to the O&M plan template. The template also allows for attaching vegetation plans, preferred species lists, and/or material specifications used for SCM design and construction. The intent of attaching this information is to provide a starting point for making decisions regarding what is an intended plant versus a weed, and what type of fill material could be used for replacements, if needed.

Example of maintenance frequency table for a specific SCM

Frequency	Activity
Monthly	Inspect Inlet Conveyance Infrastructure ¹
Semi-Annually	Inspect Adjacent Landscaping and Pavement
	Inspect Outlet Conveyance Infrastructure
	Clean/Vactor Sediment
	Remove Accumulated Debris
Annually	Inspect SCM Structure

¹ *Inspect monthly during leaf fall season and once outside of leaf fall season*

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VII. Costs and Funding

Costs

Funding



VII. Costs and Funding

Costs

While runoff prevention and capture practices have numerous benefits, there is a monetary expense associated with planning, design, construction, and O&M. These costs vary according to region, types of practices, design features, and industry demand.

Balancing Capital and Maintenance Expenses

The “design with maintenance in mind” concept presented in Section IV (Planning and Design) can help manage the costs of O&M activities during the planning and design stages. Project details should be evaluated in the interest of minimizing maintenance and repair costs. Given the ongoing limitations of funding for schools, investing in higher, upfront costs for more sustainable capital infrastructure and features that reduce the maintenance burden may be more cost-effective over the life of the SCM.

Cost-Benefit Considerations

The SCMs presented in this document, as a subset of green infrastructure practices, are often identified as cost-effective in comparison to traditional gray infrastructure alternatives. A number of studies comparing the costs of green and gray infrastructure are tallied in USEPA’s [Green Infrastructure Cost-Benefit Resources](#). However, evaluating cost alone does not fully represent economic feasibility or potential for a project. Cost analyses alone “... ignore the differences in performance between green infrastructure and gray infrastructure. As a result, they provide an incomplete basis for decision-making,” according to the USEPA (2018a). As an alternative, cost-benefit analysis “...provides a more complete basis for decision-making. It considers costs as well as environmental, social, and public health outcomes of alternative management approaches. The result is more complete information on the benefits associated with different stormwater control options.” (USEPA 2018). The webpage above cites and describes cost-benefit studies, as well as tools for gathering information to initiate conversations with stakeholders regarding the benefits and costs of green infrastructure, including SCMs.

Cost-benefit analysis “...provides a more complete basis for decision-making. It considers costs as well as environmental, social, and public health outcomes of alternative management approaches. The result is more complete information on the benefits associated with different stormwater control options.” (USEPA 2018)

Another forthcoming resource for cost-benefit analysis is the Water Research Foundation’s [Community Enabled](#)

[Lifecycle Analysis of Stormwater Infrastructure Costs](#) (CLASIC). This project is currently developing a life-cycle analysis framework and publically accessible tool to assist in selection of green and gray infrastructure.

Cost Resources

Summaries of costs for various runoff projects are well documented, although local social, economic, political, and other conditions will drive actual contracted rates. In addition, project scale can impact costs. For example, implementing projects at many schools within a district can have an economy of scale benefit.

Some resources include CASQA's [New Development and Redevelopment BMP Handbook](#), which provides capital and O&M costs for many SCMs. Literature on the cost of runoff capture practices throughout the U.S. are provided in Appendix C.

The best resource may be local municipalities that are subject to NPDES permits and have likely implemented similar projects. Permittees within the vicinity of schools and school districts can be identified through the [CA Phase II LID Sizing Tool](#). Other resources include cost books and online data centers that provide line-item cost estimates. Examples include [RSMMeans](#) and [Sierra West Group](#), the latter of which is used by the [Office of Public School Construction](#) to verify costs for their state-wide grant program, which funds new construction and modernization (but not necessarily stormwater features—see the [funding](#) discussion later in this section). Such materials are updated annually or every few years.

In 2019, the [Sacramento State Environmental Finance Center](#) (EFC) will begin hosting a stormwater cost estimating tool, developed using existing literature and data, along with statewide surveys of capital and O&M costs for green and gray infrastructure. The tool will also provide suggested methods for best practices in stormwater management accounting.

Tips for Estimating Costs

- ▶ A design engineer typically develops a cost estimate based on the quantities specified in the final plans and local pricing, so having the project design team on board early is helpful for cost planning.
- ▶ Resources such as costing books and on-line data centers can help estimate line-item cost estimates. Such materials are updated annually or every few years. Searching “construction cost estimate resources” through an internet browser will provide multiple such projects. Examples include [RSMMeans](#) and [Sierra West Group](#).
- ▶ Estimates will need to include a contingency amount intended to account for unknown occurrences, such as increased labor rates, material expenses, or unexpected field conditions requiring design alternations.
- ▶ Design with maintenance in mind to balance capital and long-term maintenance costs. In many cases, incorporating features that reduce long-term maintenance efforts and costs may be well worth additional capital cost investments.

VII. Costs and Funding

Funding

Grants and Loans

There are a number of federal, state, and local grants and loans available for SCM projects, some directly targeting stormwater management practices and green infrastructure and others encouraging one or multiple goals for ecosystem protection, air quality, water supply, flood control, and community enhancement.

The State Water Board's [Stormwater Grant Program](#) promotes the beneficial use of stormwater and dry weather runoff through multiple-benefit projects. Runoff capture projects must be part of a [regional stormwater resource plan](#) (SWRP) to be eligible for this funding. The Board's [Division of Financial Assistance](#) (DFA) administers these and several other grant and loan programs.

DWR's [Integrated Regional Water Management \(IRWM\) Grant program](#) offers grants for planning and implementation of projects developed in collaboration with other projects and programs related to water resources in a region. Projects that support disadvantaged communities are highly encouraged. To receive funds, schools can collaborate with their regional IRWM group and municipalities to develop multi-benefit projects.

The California Natural Resources Agency's [Urban Greening Grant Program](#) also provides opportunities for funding runoff capture projects. To be eligible, projects must achieve multiple benefits and be part of a SWRP.

The [Office of Public School Construction](#) administers a \$42 billion voter-approved school facilities construction program. The funds support new school construction and modernization. In some cases, runoff management features may be eligible.

The USEPA hosts the [Water Finance Clearinghouse](#) with a repository of qualitative and quantitative information on funding water infrastructure in the U.S. Additionally, CASQA hosts the [Stormwater Funding Resource Portal](#) that includes current grant and loan funding opportunities.

Regional Collaboration

Because many municipalities in California are subject to NPDES permits for runoff discharges, they are motivated to collaborate with other regional entities in developing and implementing runoff capture projects. Section VIII (Regional Collaboration) of this document provides background on the types of projects schools might partner on as well as tips for optimizing school and school district benefits.

VIII. Regional Collaboration

A stylized sunburst background with a hand icon. The sunburst consists of numerous thin, light green rays radiating from the center. The hand icon is a simple, white outline of a hand with fingers slightly curled, set against a light green background. The overall design is clean and modern, with a focus on collaboration and community.

Existing Regional Efforts

Incentives for Collaboration

Types of Collaboration

Maximizing Benefits for Schools

Potential Barriers

Developing Cooperative Agreements

VIII. Regional Collaboration

Existing Regional Efforts

Spurred by existing regulations, there are many ongoing regional activities underway for managing runoff. For example, most municipalities in the U.S. are subject to NPDES permits that regulate runoff discharges from stormwater as well as dry weather flows. In response to these requirements, most NPDES permittees have fairly well-established runoff management programs. The programs address permit elements such as education and outreach, illicit discharge detection and elimination, water quality monitoring, and TMDL compliance. TMDL compliance often involves development of projects intended to reduce pollutants and discharge volumes through large regional SCMs, many distributed site-scale SCMs, or both. As part of their programs, permittees have developed stormwater design manuals that provide SCM standards and specifications.

Many permittees are also collaborating with water purveyors, wastewater facilities, and environmental stewardship groups through integrated regional watershed management plans ([IRWMPs](#)), supported by grants from the Department of Water Resources (DWR). The plans outline processes for meeting regional watershed goals related to water supply, water quality, flood control, environmental and community health, and climate change adaptation and resiliency. A subset of IRWMPs are [stormwater resource plans](#) (SWRPs, Figure VIII-1) that focus on regional efforts for capturing runoff to achieve multiple benefits. Projects that are part of a SWRP may be eligible for grants from the State Water Board. School districts can coordinate with these local and regional entities to capitalize on expertise, sharing the resources needed to manage runoff contributing to sustainable regional development efforts.

Incentives for Collaboration

With over 130,000 acres throughout California being managed by school districts, incentives exist for school districts to engage in jointly managing runoff with other local entities, particularly NPDES permittees. MS4 permittees often consider these properties ideal for implementing SCMs, as part of a vision of regional runoff capture facilities distributed throughout an urban area. Such coverage can go a long way in achieving permit compliance. Given this motivation, permittees may be willing to support runoff capture practices at schools through funding and resources.

Schools and their districts, then, can benefit from this assistance. In addition to the advantages described in Section II (Benefits), further incentives for schools to participate in regional efforts include leveraging resources and expertise, sharing costs, and delegating efforts, as described in this section.

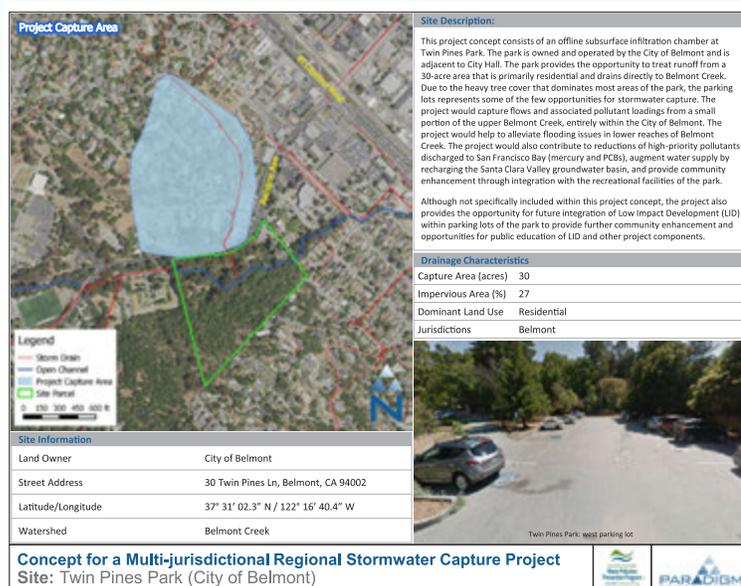


Figure VIII-1. Example of a regional project from the San Mateo SWRP.

Leveraging resources and expertise—Schools can leverage the expertise and existing resources of local permittees with ongoing program activities and trained personnel. Current school and district staff could learn from these professionals through joint workshops and planning or directly engage local runoff managers to help scope and plan projects and relevant activities. Additionally, local municipal permittees have existing stormwater management design manuals, which specify local development regulations for new and existing properties. These include runoff management requirements, hydrologic design approaches, best practices, LID requirements, and others.

Sharing costs—Rather than starting a new program, schools could work with a local permittee to streamline resources needed for planning, design, construction, and other activities like outreach, administration, and monitoring. If a school property drains to a large-scale, existing (or planned) municipal SCM, diverting runoff to that SCM could be cheaper than building multiple SCMs. Alternatively, school districts could partner with local permittees and land owners to build new infrastructure that manages runoff from multiple contributing areas. This would also reduce costs to the school district.

Delegating activities—Schools can benefit from working with local permittees by entering into agreements that delegate activities needed for managing runoff. The organization to which responsibilities are delegated is referred to as a separate implementing entity (SIE). In this arrangement, a school district that designates a local municipality as an SIE would devise an arrangement to compensate the local entity for managing runoff, perhaps through monetary payments or in-kind services.

Types of Collaboration

School districts can work with local agencies in several ways:

Joint use projects—School districts and other entities can implement runoff capture projects together. It may involve collecting runoff from several sites in a single project or moving runoff across jurisdictional boundaries (e.g., municipal property to school grounds).

Joint program activities—Local entities and school districts can merge or delegate responsibilities for necessary program activities such as maintenance, education and outreach, or publishing design and procedural manuals through cooperative agreements. For example, school districts might assign responsibilities to a local government permittee with a current runoff program. Cooperative agreements for joint use projects and joint program activities take many forms. They can be formalized through memorandums of understanding (MOUs), maintenance agreements, and memorandums of agreement (MOAs). While MOUs are typically non-binding, maintenance agreements and MOAs can be used to formally delineate responsibilities between partner organizations. The document contents might include descriptions and examples of activities, which are described in more detail in the [Developing Cooperative Agreements](#) section.

VIII. Regional Collaboration

Joint Use Projects

There are generally two configurations for joint use projects. First, schools could accept runoff from offsite areas. The municipality benefits by demonstrating compliance with runoff mitigation requirements, while the school district benefits by receiving new infrastructure or compensation, among the other benefits cited in Section II (Benefits) and the [Incentives for Collaboration](#) identified previously. Second, schools can send runoff generated on school property to an offsite SCM. In these arrangements, the school benefits by demonstrating that its runoff is mitigated at a downstream site, while other agencies benefit by lowering unit costs of infrastructure or supporting enhanced groundwater recharge.

Regional projects that involve multiple agencies tend to capture and retain or treat runoff from larger catchment areas. No clear classifications of project sizes exist, but regional projects generally involve capturing runoff from catchments larger than a property or site, which could translate to catchment areas larger than an acre. However, projects could comprise thousands of acres.

Projects Accepting Regional Runoff on School Properties

A variety of project designs can fit requirements for regional projects. For larger projects, detention basins, infiltration galleries, and subsurface cisterns can be good options within or beneath parking lots or sports fields. Figure VIII-2 shows an example of a sunken soccer field used as a detention basin at Leonardo Da Vinci Elementary School in Sacramento, CA. For this project, the city contracted with the local school district to divert municipal runoff to the basin. In exchange, the city paid for several school improvements (see list below.)

Improvements provided by the City of Sacramento as part of a joint use project at a local elementary school

- ▶ New soccer field (improved grading)
- ▶ New baseball diamond
- ▶ New irrigation systems
- ▶ Amphitheater-style seating
- ▶ New pathways
- ▶ Improved site drainage

This proposed project directs runoff to two recharge basins beneath sports fields for groundwater recharge.



Figure VIII-2. Regional detention basin built with a soccer field at Leonardo Da Vinci Elementary School, Sacramento

Projects Diverting School Runoff to Other Sites

Alternatively, rather than moving off-site runoff to school grounds, runoff from schools can be diverted to other sites. For example, as part of its Green Solutions Project, Los Angeles-based Community Conservation Solutions created conceptual plans (Figure VIII-3) to redevelop a regional park with wetlands that infiltrate runoff from the neighboring area, including from an adjacent charter school. The wetlands remove trash and pollutants, and bioswales address runoff that would otherwise flow untreated to the Los Angeles River.

VIII. Regional Collaboration

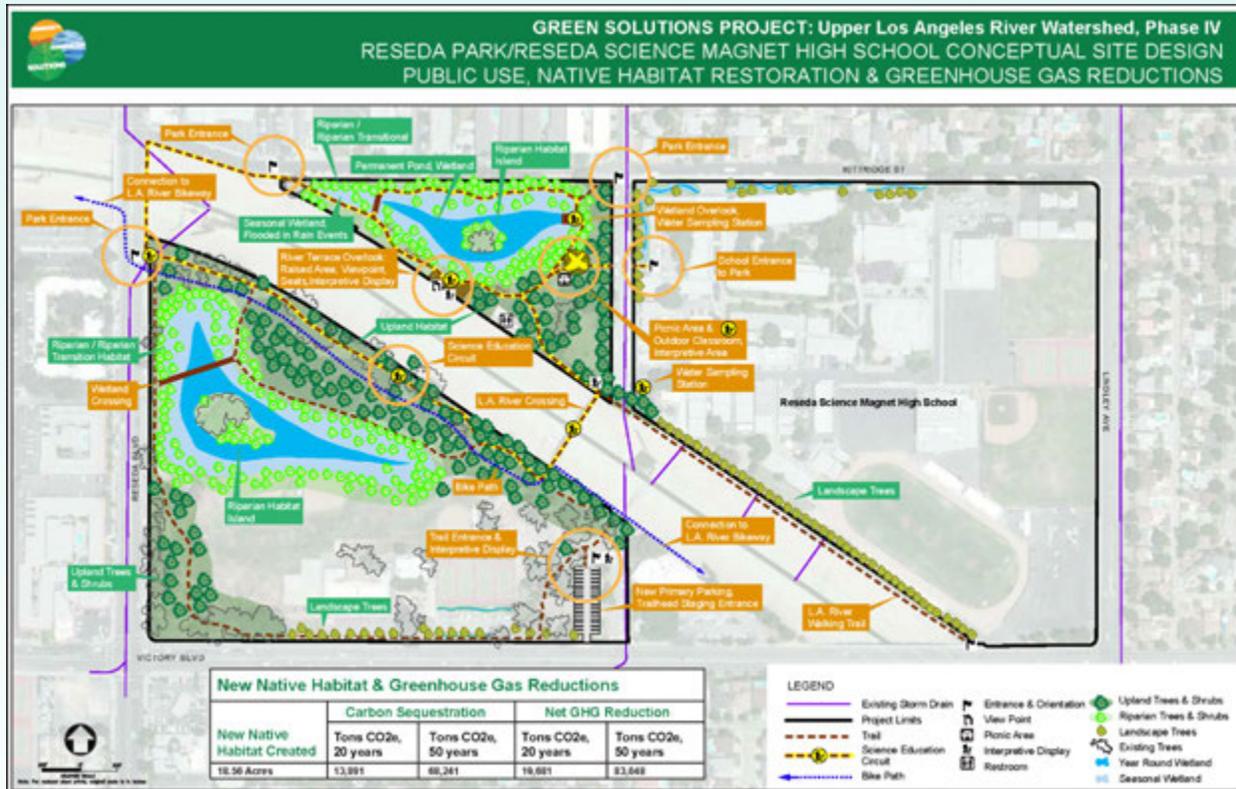


Figure VIII-3. Conceptual design for a regional project diverting runoff from a school site to offsite green infrastructure (Source: Community Conservation Solutions, 2016. Reprinted with Permission).

Joint Program Activities

Beyond collaborating on implementation of projects, school districts can coordinate with regional groups for other programmatic activities related to runoff management, including:

- ▶ Education and outreach
- ▶ Public involvement and participation
- ▶ Illicit discharge detection and elimination
- ▶ Construction site stormwater runoff control
- ▶ Pollution prevention/good housekeeping
- ▶ Post-construction stormwater management for new and redevelopment
- ▶ Water quality monitoring
- ▶ Program effectiveness and assessment
- ▶ TMDL compliance

A good example is an education and outreach program that the Sacramento Stormwater Quality Partnership funds. The program provides classroom presentations to 3rd through 6th grade students. During the presentations, the students are taught about water quality, stormwater pollution, and creek stewardship (Figure VIII-4).



Figure VIII-4. Students participating in stormwater workshops sponsored by the Sacramento Stormwater Quality Partnership (SSQP)

There are a variety of possible joint efforts between school districts and municipalities. For example, municipalities could develop and execute plans and inspections required by the CGP for projects that benefit both entities. Municipalities could also conduct illicit discharge inspections and identify mitigations on school sites, if required by an NPDES permit, and will be good resources for practices that prevent pollutants from coming into contact with rainwater and runoff, including standard plans and specifications for SCM design. Finally, municipal programs have monitoring and program effectiveness protocols and experience that schools could use.

Maximizing Benefits for Schools

Schools and schools districts that work with local agencies on joint programs and projects must identify benefits that will accrue from the partnerships. Collaborative activities are most likely when all parties realize benefits, and outlining expectations as part of the planning process offers a greater likelihood of long-term success for multi-agency regional projects.

VIII. Regional Collaboration

For such efforts, school district administrators, utility managers, and planning department staff will likely be working with local municipalities, consultants, and regulators. School district staff will need to assess the potential value of proposed collaborative projects, as well as promote school district interests, as part of any agreement.

The discussions below provide information that school district staff should be aware of in regards to large-scale watershed projects and regional collaboration, beyond the planning, design, construction, maintenance, and cost/funding resources presented in Sections IV through VII.

Design Approaches

In designing joint use projects, many of the same considerations described in Section IV (Planning and Design) apply, but in the context of multiple contributing catchments, which collectively comprise a watershed that will drain to the regional SCM to be constructed. In particular, methods for establishing the amount and quality of runoff generated will differ slightly from the catchment-scale methods discussed in Section IV.

As runoff moves and collects through a watershed (consisting of several catchments), its volume and flow rates increase. These metrics are driven by the intensity and duration of precipitation, as well as the characteristics of the watershed (soil type, land cover and use, etc.). Several methods are used to estimate the flow of runoff at various locations within the watershed at points in time, such as the rational method and the modified rational method. The methods estimate flow over surfaces and in pipes, gutters, and channels at particular locations and times, which are plotted as a hydrograph (Figure VIII-5). Municipal runoff design manuals often provide guidance and templates for performing hydrograph and routing calculations, as well as flows through pipes to design downstream flooding and water quality mitigation systems, including SCMs.

Common runoff pollutants from schools include sediment, trash, and others as described in Section IV. Runoff from off-site sources will likely have all these pollutants, but in greater amounts. Off-site runoff may also contain other pollutants such as oils and organic pollutants. As such, understanding the characteristics of the contributing watershed is an important step for ensuring an SCM project is properly designed to protect school interests. Land use characteristics influence the types and toxicity of runoff. Common land use types include single- and multi-family residential, commercial, light and heavy industrial, government, and institutions. Within these general categories, some land uses are of greater concern for managing risks associated with runoff pollutants. Ideally, each contributing catchment within the watershed should be assessed individually for potential pollutant contributions, although some guidelines exist to generally associate land uses and runoff pollutants (see the following table).

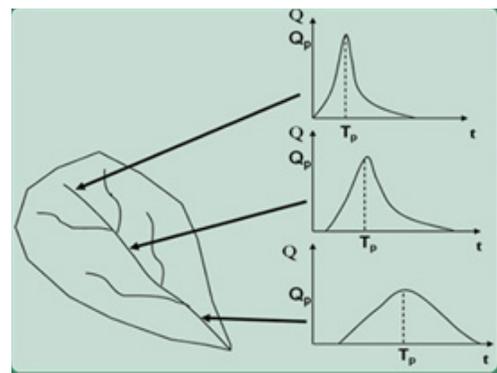


Figure VIII-5. How flow (Q_p) and its time of occurrence (T_p) change as runoff moves downstream through a watershed.

General runoff pollution risk categories associated with land use types

Risk Category	Description	Example Land Uses
Insignificant	Little to no risk of contaminated runoff that would not be mitigated through normal treatment measures.	<ul style="list-style-type: none"> ▶ Residential rooftops
Low	Low risk of contaminated runoff that would not be mitigated through normal treatment measures. Sites should be assessed for any specific sources of contamination that would increase risk.	<ul style="list-style-type: none"> ▶ Residential properties ▶ Office parks ▶ Small retail shops with limited parking ▶ Streets with <15,000 AADT¹
Medium	Increased risk of some contaminants, such as higher concentrations of trash, fertilizers, oils, greases, and metals from automobiles, and increased sediment associated with greater impervious surfaces.	<ul style="list-style-type: none"> ▶ Medium- and high-density residential ▶ Institutional and commercial land uses ▶ Major retail and offices ▶ Large parking lots ▶ Streets with 15,000 – 30,000 AADT¹
High	High risk of contaminated runoff that would not be mitigated through normal treatment measures.	<ul style="list-style-type: none"> ▶ Industrial land uses ▶ Gas stations, plant nurseries, car washes, automobile repair stations and shops ▶ Streets with >30,000 AADT¹

OWP 2018a

¹annual average daily traffic (AADT)

In addition to these general categories, some properties require special considerations. Brownfields and properties with hazardous contaminants from past activities should have special mitigation plans in place for runoff management. Searchable databases of identified brownfield sites are available through the State Water Board’s [Geotracker](#) website (State Water Board 2018d), along with the California Department of Toxic Substances Control [EnviroStor](#) website (DTSC 2018). These databases can be used to identify any potential properties of concern in the contributing watershed for a joint use project.

VIII. Regional Collaboration

Funding Considerations

A critical part of the planning process for joint use projects is identifying funding responsibilities. In particular, how will the new infrastructure be paid for and by whom? Will parties share costs equally through an agreed-upon arrangement, or will one party provide the majority of funding? How will various parties alternatively support capital and long-term maintenance costs?

In joint use projects to date, various financing options have been proposed, including:

- ▶ Joint grant applications—All project participants apply together. These grants can pay for some or all of the project costs. Funding programs through the California Department of Transportation, along with statewide General Obligation Bonds, are potential sources for joint grants.
- ▶ Catchment-based funding allocations—The percentages of funding contributions closely match the assessed runoff contributions of all parties to the device. For instance, if a new joint use project will capture runoff from a 100-acre catchment and the participating parties own 75 and 25 acres, respectively, a 75/25 funding scheme may be appropriate. Alternatively, funding amounts could be adjusted if some land uses in the catchment are higher risk.
- ▶ Mutually-agreed upon allocations—Each of the parties agrees to contribute according to the value it expects to gain. In many cases, local and regional runoff quality control agencies may contribute a large percentage of the capital costs, while school districts agree to fund long-term maintenance and upkeep as part of regular activities.

Funding arrangements can include the monetary value of cash contributions for design and construction together with the assessed value of land in determining cost-sharing. One strategy is to compare municipal and school district capital improvement project plans, looking for projects that help meet both. These will have funding streams readily available. Ultimately, the proper funding scheme for a project will involve detailed negotiations among parties and could be part of broader capital improvement projects on school grounds. Refer to Section VII of this guidance document for specific funding resources.

Operations and Maintenance

One of the most important benefits of joint use stormwater projects for schools is capitalizing on the expertise and resources of partners for operations and maintenance. School districts will benefit from partner agencies that have existing maintenance plans and perform regular staff training. An implemented maintenance program will help lengthen the life of any investments made by school districts and partner agencies in SCMs.

Like all SCMs, joint use projects need maintenance plans. Guidelines and templates for maintenance plans for joint use projects relevant to schools are presented in Section VI (Maintenance). In addition to the information provided in these resources, joint use project maintenance plans must allocate maintenance responsibilities among participating parties, specifically identifying the responsible party for each activity.

Municipalities regularly use maintenance agreements to assign maintenance responsibilities to parties other than the named stormwater permittee. For instance, a municipality might develop a standard maintenance agreement for private landowners who agree to build and maintain SCMs as part of a new or redevelopment project. Maintenance agreements would outline:

- ▶ Routine performance activities
- ▶ Maintenance schedules
- ▶ Inspection requirements
- ▶ Personnel access to SCMs for maintenance
- ▶ Consequences of failing to maintain SCMs
- ▶ Recordkeeping requirements for operations and maintenance

In addition, maintenance agreements should include a description of the system and a map of assets so that all involved parties understand what needs to be maintained or inspected. [Developing Cooperative Agreements](#), presented later in this section, provides some example agreements.

VIII. Regional Collaboration

Potential Barriers

A number of potential barriers to joint use projects have been identified through existing partnerships and processes. Such barriers can be overcome through teamwork and creativity in the planning process. In 2015, the non-profit TreePeople published a summary of a collaborative fact-finding workshop that identified barriers for school districts in working with regional agencies on joint use projects. TreePeople then worked with regional experts to explore these barriers and identify potential solutions. The barriers and solutions are summarized below.

Potential barriers and solutions for implementing joint use projects

Potential Barrier	Description	Potential Solution
Health risks	Accepting off-site runoff could expose students and faculty to health risks from contaminants	Use monitoring to demonstrate risk exposure and work with local public health officials to assess potential exposure risks.
Regulatory issues	Schools may not be allowed to accept off-site runoff due to environmental and water quality standards	While California state agencies (e.g., Department of Toxic Substance Control) could prohibit such transfers, no current regulations exist that prohibit the transfer of runoff to schools from another site.
Land-use limitations	Developing runoff facilities, such as subsurface infiltration, could inhibit future development of those areas	Runoff planning and design processes on school sites should include school district and site-specific master plans to ensure that SCMs do not conflict with long-term infrastructure upgrades.
Training and labor agreements	Implementing and managing green infrastructure on public school grounds will require additional training for facilities personnel and faculty, and may conflict with existing labor agreements if personnel from other municipal agencies or water districts are engaged to maintain SCMs	Existing programs in LA, supported through the DROPS program, have devised training programs on runoff management with separate components for faculty, students, facility managers, and the broader community. Agreements can be organized to allocate duties for maintenance among school district staff and other personnel.
Additional maintenance requirements	Green infrastructure for managing runoff requires more maintenance than existing ground cover, such as asphalt	Long-term funding and worker training should incorporate the requirements of maintenance plans. State and local funding streams that promote green infrastructure should be adapted to allow for such expenses as well as long-term, life-cycle considerations. Emerging research indicates the benefits of more diverse school grounds that are not just hardscape. School maintenance activities, and associated funding, must be adjusted to promote better student experiences.
Liability	School districts could be vulnerable to lawsuits concerning the risks of health exposure, personal injury, subsidence from saturated soils, soil contamination, or other long-term environmental consequences of infiltrating runoff on-site	Liability considerations can be discussed as part of negotiations. Mechanisms such as indemnification agreements exist that could protect schools from such lawsuits. Notably, in surveying stakeholders and existing research for this report, liability concerns arose in examples of larger school districts, but were not raised in discussions about site-level projects. Statewide legislation could alleviate such concerns, which would support the regulatory efforts to include school districts in the Phase II MS4 permits by offering an avenue for schools to meet permit requirements through regional collaboration.

Adapted and augmented from a study in Los Angeles by TreePeople (2015).

Notably, for all these challenges, smart designs can alleviate concerns. For instance, at a school site, off-site runoff could be captured, retained, and infiltrated and/or released only on peripheral areas where students and faculty are not exposed. This would pose exposure similar to any retention and infiltration-based SCM implemented within a municipality, which is increasingly common. Additionally, designs can emphasize subsurface SCMs, where no captured runoff is exposed at the surface. While more expensive, such projects have been proposed in California with no associated safety or liability risks raised during design discussions.

Developing Cooperative Agreements

Any agreements among schools, school districts, and other local agencies should be codified in writing. Several types exist, ranging in formality and commitments:

1. **Maintenance agreements** specify a commitment by a party, such as a private landowner, to operate and maintain stormwater infrastructure. Municipalities use maintenance agreements with partner agencies and private parties to delegate the responsibilities of long-term SCM upkeep for meeting local drainage and development codes. The agreements among parties are binding, and municipalities may be expected to undertake regular inspections to verify compliance.
2. **Memorandums of understanding (MOUs)** specify the agreed-upon terms for entities to collaborate; share; or exchange goods, services, data, or other resources. While MOUs are not binding agreements and do not have legal standing, they can serve as the basis for continued collaboration.
3. **Memorandums of agreement (MOAs)** specify agreed-upon terms for entities to work together in some capacity. Unlike MOUs, MOAs are binding and used to formalize arrangements, similar to contracts. The MOAs will specify relevant stipulations (sometimes called “recitals”), such as relevant regulatory requirements or consent decrees of participating parties, and the terms (for instance, “mutual covenants”) by which both parties agree to participate for the term of the MOA.

Each of these arrangements may be relevant for a joint use project among school entities and local agencies, though MOAs would be a likely mechanism to formalize long-term arrangements and contingencies for the parties to share resources and duties on a project.

Schools throughout California work with local municipalities on a variety of joint use activities. For instance, many schools have agreements to open school grounds to community groups or municipal departments after school hours. These recreational facilities are the school’s asset that it is agreeing to share in return for use, payment, safety and security precautions, maintenance, liability, and any other terms. These agreements stipulate the permitted uses of school property and identify the terms of the agreement.

VIII. Regional Collaboration

Example Agreements

A number of [example agreements](#) are available for easy reference. Cities such as Philadelphia, Boston, and San Francisco have developed model agreements to work with many types of parties on joint stormwater-related activities. In addition, joint use agreements were developed by an Oakland non-profit, Public Health Law & Policy, as a template for schools and local groups to facilitate use of school grounds after school hours. These templates (Figure VIII-6), available at the website of [ChangeLab Solutions](#), can be usefully adapted for joint use stormwater management projects, drawing on the other stormwater-specific examples to identify key terms that should be included.

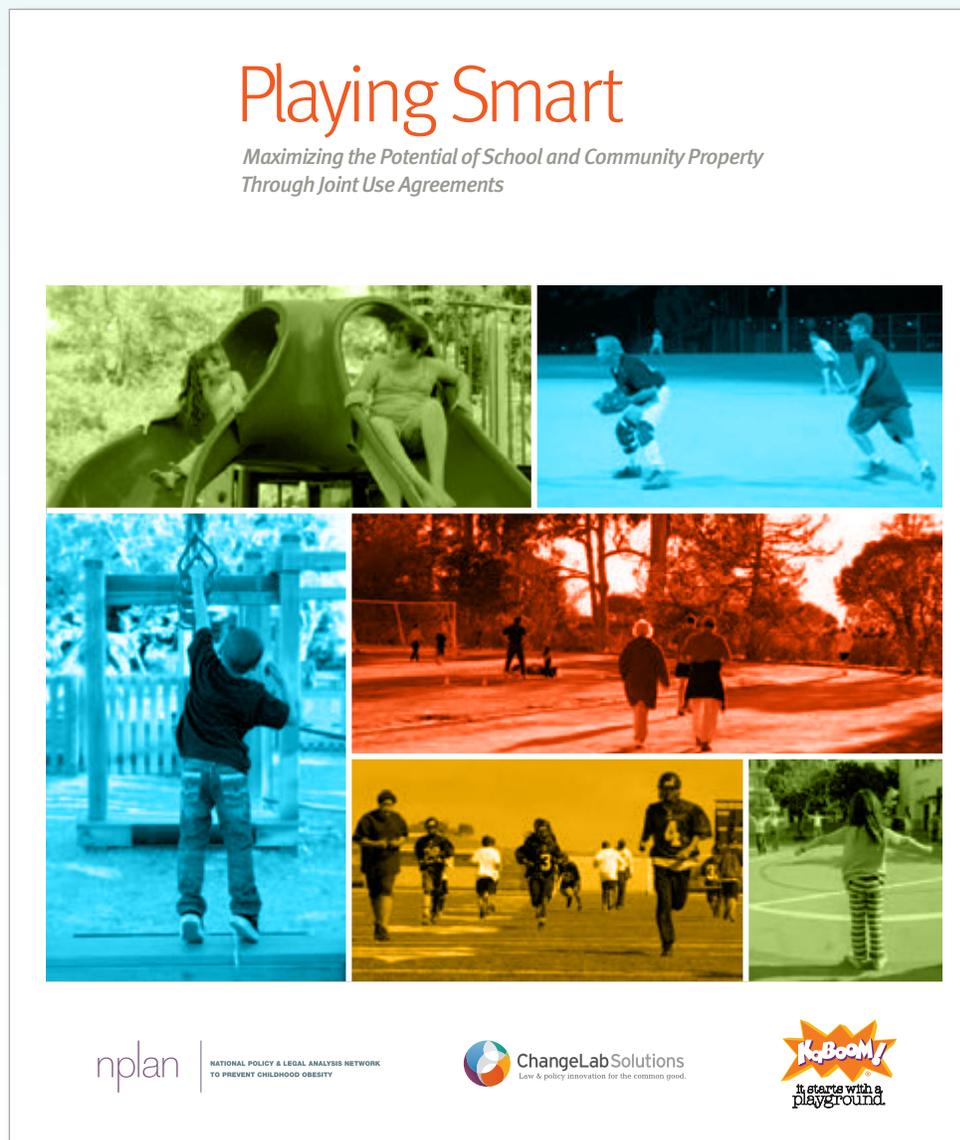
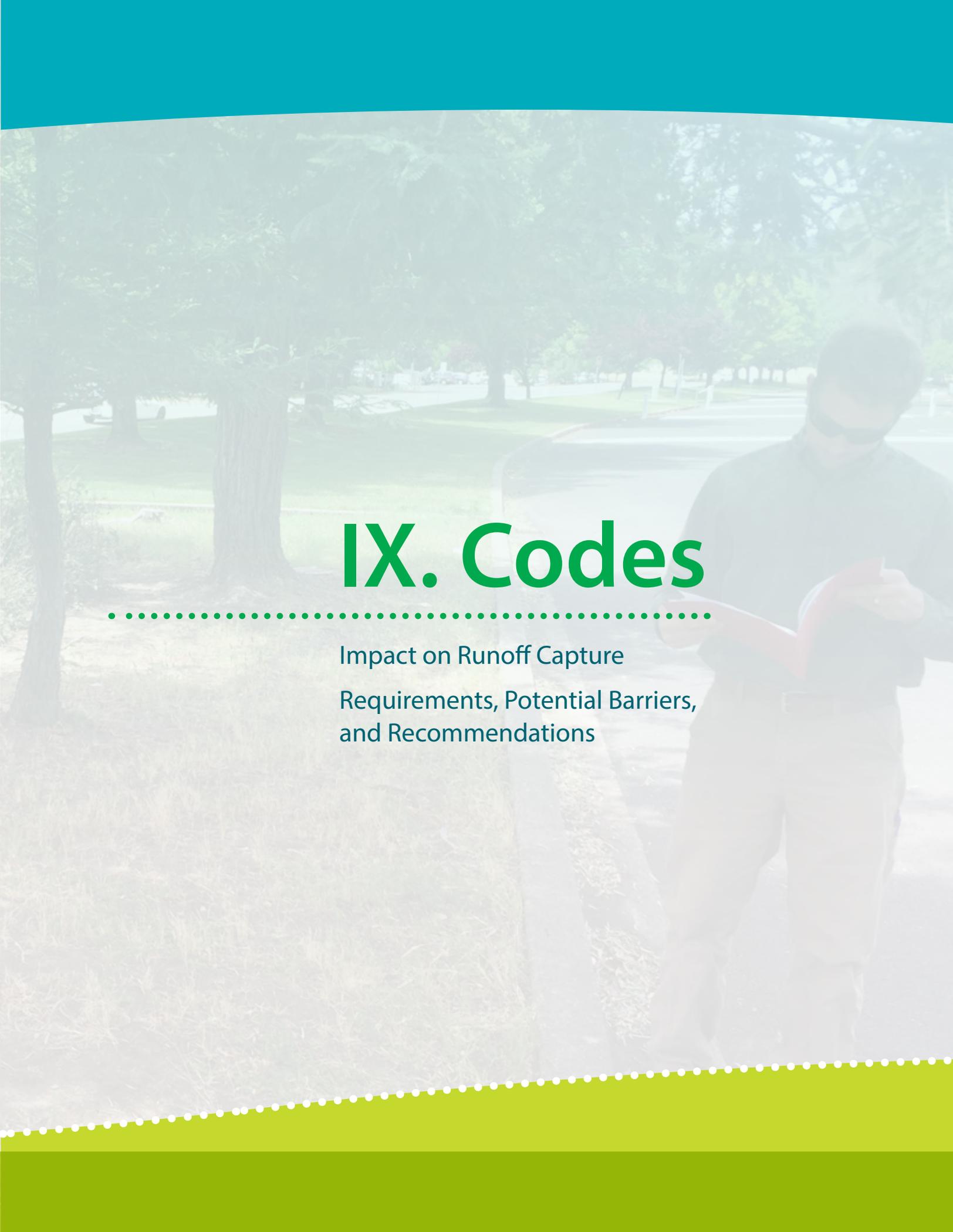


Figure VIII-6. Joint use agreement guidance by ChangeLab Solutions (2018)

A person wearing a dark long-sleeved shirt, sunglasses, and light-colored pants is standing in a park-like setting. They are holding a red folder or book and looking down at it. The background shows a grassy area with several trees and a paved path. The image is overlaid with a semi-transparent white filter.

IX. Codes

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Impact on Runoff Capture

Requirements, Potential Barriers,
and Recommendations

IX. Codes

Impact on Runoff Capture

California law, originating from the legislature as statute or by promulgation by a state agency through regulation, influences whether runoff minimization and runoff capture measures are feasible for a site.

Location, design, construction, and rehabilitation of school district infrastructure can fall under the jurisdiction of several entities, including CDE, DSA, State and Regional Water Boards (CCR), and local drainage authorities, and the requirements of those entities should be considered early in the planning process to successfully integrate stormwater measures. Some affect drainage directly, while others specify minimum infrastructure requirements that can affect how much impervious surface is used. The key requirements and the roles and authority for these agencies are:

- ▶ All school districts must meet the standards in California Code of Regulations, Title 5, section 14001 et seq. in selecting new school sites and in designing new schools. Those requesting state capital funding assistance must submit projects for review by CDE. CDE has an early role in advising districts on proposed school locations and site programming and design. New schools are to be located consistent with the district's adopted facility master plan and local land use planning, although a district's governing board has statutory authority to exempt a project from certain local standards. CDE convenes regional meetings to inform districts of policy updates.
- ▶ As authorized in sections 17280 and 81130 of the California Education Code, DSA has an active role in the design and construction of K–12 public schools, community colleges, and essential services buildings. As the enforcement entity, DSA provides plan review and construction oversight of new construction and alterations to buildings and facilities for conformance to Title 24 California Building Standards Code. To ensure compliance, DSA certifies project inspectors who are hired by the school district to oversee construction projects. The division also reviews California State University and University of California projects and state-funded construction for accessibility compliance. DSA has the authority, in the state of California, to promulgate regulations related to public school construction, and accessibility regulations for public accommodations, commercial buildings, public buildings, and public housing.
- ▶ State and Regional Water Boards have designation authority for stormwater permit enrollment, a delegated federal authority. Regardless of permit designation, the Water Boards have broader authority via sections 13267 and 13383 in the California Water Code to investigate pollutant sources and require landowners to report on those occurrences.
- ▶ Local drainage authorities can set local drainage standards via ordinance, and according to CCR Title 5 (section 53097), school districts must conform to local ordinances.

One example of codes that must be considered during design is the California statutes and regulations that impact the placement of vehicle-bearing surfaces. However, they do not always specify that impervious surfaces must be used. These requirements, and how they impact runoff prevention and capture practices, are presented in this section, along with a discussion of whether the requirements are a significant barrier to runoff prevention and capture measures, or merely a design consideration. This section also recommends improvements or changes to existing requirements or policy to improve use of the design strategies and SCMs presented in this document. Guidelines that could be improved for better stormwater planning are also listed.

Requirements, Barriers, and Recommendations

Requirements and Barriers

The following pages tabulate regulations relevant to minimizing impervious surfaces through runoff capture practices. No modifications to support compliance with runoff regulations, without compromising safety or learning objectives, were identified.

The following areas were thought to have regulations affecting runoff capture implementation. However, during investigations as part of the development of this document no impact was found.

- ▶ Minimum shade
- ▶ Covered lunch areas
- ▶ Security or barriers around standing water

Finally, some policies support consideration of SCMs and regional projects. For example, California Education Code, section 35275 requires meeting with appropriate local government, recreation, and park authorities to consider possible joint use of the grounds and buildings and to coordinate the design to benefit the intended users. Such collaboration could also provide a platform for regional urban runoff projects.

Recommended Changes in Policy or Regulation

Recommendations for modifying policies, laws, regulations, and guidance to better promote implementation of the design strategies and SCMs at school properties, as described in the guidelines, are included in the table in this section. In addition to this list, the [CDE Blueprint for Environmental Literacy](#) supports environmental protection efforts, and serves as a useful resource for incorporating sustainable runoff management into school district curriculums and activities.

IX. Codes

Relevant regulations

Authority/ Regulation ¹	Requirement	Imperviousness Required	Recommended Change ²
CCR Title 5 §14001 (& forward)	Overall minimum facility size: <ul style="list-style-type: none"> • For kindergarten and grades one through six: 59 square feet (sq ft) per pupil • For grades seven and eight: 80 sq ft per pupil • For grades nine through twelve: varies from 91.5 sq ft per pupil for an enrollment of 2,400 to 127 sq ft per pupil for an enrollment of 400 	Yes	None ¹
CCR Title 5 §14030	Site layout: parking, loading, drop off	No ³	None
	Playground & field areas: adequate physical education stations (includes hardcourts)	Yes ⁴	None ¹
	Classroom size: grades one through twelve may not be less than 960 sq ft	Yes	None ¹
	Kindergarten classroom size for permanent structures may not be less than 1350 sq ft	Yes	None ¹
	New school speech and language program: at least 200 sq ft.	Yes	None ¹
	Science and home economic labs: at least 1300 sq ft	Yes	None ¹
	Library space proportional to maximum planned school enrollment: at least 960 sq ft	Yes	None ¹
Computer laboratory: at least 960 sq ft	Yes	None ¹	
CCR Title 5 §14030 EDC §17747(a) ¹	New school resource specialist program: at least 240 sq ft	Yes	None ¹
CCR Title 24, Part 2 (CBC) Chapt 11B ¹	Americans with Disabilities Act (ADA) as incorporated into Title 24 CBC for sidewalk widths and parking stall widths	No ⁵	None
CCR Title 19 (PS) §3.05(a) ¹	Fire access: all-weather hard-surfaced at least 20 feet in width	No	None
CCR Title 24, Part 9 (CFC) §503.4 CCR Title 19 (PS) §3.05(a) ¹	All parking: faculty, staff, students, visitors	No	None
CCR Title 24, Part 11 (CalGreen) §5.106.12 ⁹	Shade trees: plant in parking lots, landscaped areas, and landscaped areas at percentages specified in code	No	None

Authority/Regulation ¹	Requirement	Imperviousness Required	Recommended Change ²
CCR Title 24, Part 9 (CFC) §503.4 CCR Title 19 (PS) §3.05(a) VEH §22500 (i), 22500.1, and 22500.5 ¹	Bus drive aisles serving as the required fire apparatus emergency vehicle access must be maintained free and clear of obstruction at all times. Stopping for short periods for the purposes of unloading, where the bus driver remains in the vehicle would be permitted. Stopping/parking where the driver shuts the bus off and leaves the vehicle would not be permitted (additional area would be required to accommodate bus parking).	No	None
DSA Policy PL 07-03	Minimum 30-foot width when student drop-off/loading zones are incorporated with required fire apparatus access roadways (fire lanes)	No	None
CCR Title 24, Part 2 (CBC) §1015 ¹	Requires 42" high guards ⁶ along open-sided walking surfaces that are located more than 30 inches (measured vertically) to the grade below at any point within 36 inches horizontally to the edge of the open side	No ⁷	None
CCR Title 19 (PS) ¹	Shade material	No ⁸	None

¹ EDC: Education Code; CCR: CA Code of Regulations; CBC: CA Building Standards Code (2016); PS: Public Safety; CFC: CA Fire VEH: Vehicle Code;

² Assumes modifications to regulations that require minimum impervious surface areas but would compromise safety or learning objectives; so no modifications are recommended.

³ Could impact SCM placement

⁴ Hardcourt minimums vary by grade and number of pupils

⁵ Impacts minimum widths and turning radii, but allows pervious surfaces if compliant with Title 24, Part 9 and with approval from the local fire authority

⁶ Design detail: Guards shall not have openings which allow passage of a sphere 4 inches in diameter from the walking surface to the required guard height

⁷ Does impact SCM design feature

⁸ Not specific restriction on use of pervious materials, but other restrictions apply for fire safety

⁹ Proposed for adoption in January 2019, with effective date of Jan 1, 2020

IX. Codes

Potential actions to promote runoff capture at school properties¹

Entity to Take Action	Recommendation
CDE	Include runoff capture as an objectives for strengthening relationships between schools and communities with those previously identified in CDE's Re-Visioning School Facility Planning and Design for the 21st Century Roundtable Report (CDE 2008).
Legislature/DSA	DSA project review thresholds per Education Code §17280 (K-12) and 81133 (post-secondary) are currently based on project cost estimate greater than \$100,000. Add additional thresholds based on amounts of impervious surface created or replaced as cited in the Phase II MS4 Permit for post-construction measures
CDE	Expand Education Code §35275 to require consultation specifically on local water capture projects that could be colocated with joint recreation facilities.
CDE	Update the Schools of the Future Report (CDE 2011) to include green infrastructure for stormwater runoff management.
CDE	Update Item 9 in Vision for California School Facilities (CDE 2015) to include "limit runoff".
CDE	Update CDE Sample Form 1.02b - Plot Plan of Site and Buildings (from Guide to Development of Long Range Facilities Plan, CDE 1986) to include SCMs.
DSA	Add stormwater management information to the DSA's Water Resources page for Sustainable Schools (DSA 2018) or where appropriate.
CDE	Update the Guide for Planning Educational Facilities (COEFP 1991) to include runoff capture information. Although this document states to consult state and local "Water Pollution Control" codes, Phase II stormwater regulations were only promulgated in 1990, so detailed information should not be expected. Consequently, the guidance needs updating or this document could also be listed within CCR Title 5, §14034 (Planning Guides).
CDE	CCR Title 5, §14031, Plan Approval Procedures for State-Funded School Districts, Part b states, "Each state-funded school district shall submit final plans including grading, site utilization, elevation, floor, lighting, and mechanical working drawings and any alterations to the educational specifications to the California Department of Education for approval." The regulation could be updated so that grading plans are required to include post-construction SCMs (compliant with current CGP and future Phase II requirements).
CDE	Update Healthy Children Ready to Learn: Facilities Best Practices (CDE 2006) to reference these SB 541 guidelines.
CDE	Update Guide to School Site Analysis and Development (CDE 2000) to incorporate SCM footprint requirements for impervious roofs, hardcourts, and other impervious surfaces (that do not use pervious alternatives).
USEPA	Update School Siting Guidelines (EPA 2011) to address concerns with colocation of regional stormwater projects that would manage offsite urban runoff. Also, expand list of tools for water quality mitigation provided on page 51 of those guidelines.

¹These potential actions may not be the only solution and the identified agencies may require time and resources to explore the most efficient solution

X. References

X. References

Andrews, H. O. A., and Lampe, L. K. (Andrews and Lampe 2005). *Post-Project Monitoring of BMPs/SUDS to Determine Performance and Whole Life Costs*. Proceedings of the Water Environment Federation, 2005(11), 4886-4909. 2005.

Blecken, G. T., Hunt, W. F., Al-Rubaei, A. M., Viklander, M. and Lord, W. G. (Blecken et al. 2017). *Stormwater Control Measure (SCM) Maintenance Considerations to Ensure Designed Functionality*. Urban Water Journal, 14:3, 278-290, DOI: 10.1080/1573062X.2015.1111913. 2017.

Brown, J.N., Peake, B.M. (Brown and Peake 2006). *Sources of Heavy Metals and Polycyclic Aromatic Hydrocarbons in Urban Stormwater Runoff*. Science of the Total Environment 359:145–155. doi: 10.1016/j.scitotenv.2005.05.0162. 2006.

Brown, W., and Schueler, T. (Brown and Schueler 1997). *The Economics of Storm Water BMPs in the Mid-Atlantic Region*. Center for Watershed Protection. Ellicott City, MD. 1997.

California Building Standards Commissions. (CBSC 2014). *California 2013 Green Building Standards Code California Code of Regulations Title 24, Part 11*. Effective date January 1, 2014.

California Department of Education. (CDE 2008). *Re-Visioning School Facility Planning and Design for the 21st Century Creating Optimal Learning Environments Roundtable Proceedings Report*. October 15 - 16, 2008.

California Department of Education. (CDE 1986). *Guide to Development of Long Range Facilities Plan*. 1986 edition.

California Department of Education. (CDE 2000). *Guide to School Site Analysis and Development*. 2000 edition.

California Department of Education. (CDE 2006). *Healthy Children Ready to Learn: Facilities Best Practices*. 2006.

California Department of Education. (CDE 2011). *Schools for the Future Report*. September 2011.

California Department of Education. (CDE 2015). *Vision for California Public School Facilities*. January 2015.

California Division of State Architect. (DSA 2018). *The Division of the State Architect's Sustainable Schools Resources – Water Resources*. Accessed July 2018.

<https://www.dgsapps.dgs.ca.gov/DSA/SustainableSchools/sustainabledesign/water/water.html>

California Natural Resources Agency. (NRCA 2018). *CEQA: The California Environmental Quality Act*. Accessed July 2018. <http://resources.ca.gov/ceqa/>

California Regional Water Quality Control Board Central Valley Region. (Central Valley Regional Water Board 2016). Order No. R5-2016-0040. NPDES No. CAS0085324. *National Pollutant Discharge Elimination System Permit and Waste Discharge Requirements General Permit for Discharges from Municipal Separate Storm Sewer Systems*. 2016.

California Senate Bill 541, Chapter 811, Allen. *Water: School Facility Water Capture Practices. Adding Section 189.3 to the Water Code, relating to water*. (Approved by Governor October 14, 2017. Filed with Secretary of State October 14, 2017.)

California State Water Resources Control Board. (State Water Board 2018a). *Storm Water Program*. Accessed July 2018. https://www.waterboards.ca.gov/water_issues/programs/stormwater/

California State Water Resources Control Board. (State Water Board 2018b). *Storm Water Program 2009-0009-DWQ Construction general permit*. Accessed July 2018. https://www.waterboards.ca.gov/water_issues/programs/stormwater/constpermits.shtml

California State Water Resources Control Board. ([State Water Board 2018c](#)). *Strategy to Optimize Resource Management of Stormwater Staff Report Project 4b: Eliminate Barriers to Funding Stormwater Programs and Identify Funding for Stormwater Capture and Use Projects*. 2018.

California State Water Resources Control Board. (State Water Board 2018d). *Geotracker*. Accessed July 2018. <http://geotracker.waterboards.ca.gov/>

California State Water Resources Control Board. (State Water Board 2018e). *Stormwater Program – Trash Implementation Program*. Accessed September 2018. https://www.waterboards.ca.gov/water_issues/programs/stormwater/trash_implementation.html

California Stormwater Quality Association. (CASQA 2003). *Best Management Practices Handbook for New and Redevelopment*. 2003.

California Stormwater Quality Association. (CASQA 2018a). *Draft Best Management Practices Handbook for New and Redevelopment*. 2018.

California Stormwater Quality Association. (CASQA 2018b). *Stormwater Funding Resource Portal*. Accessed July 2018.

X. References

Center for Neighborhood Technology. (Center for Neighborhood Technology 2009). *National Green Value Calculator Methodology*. 2009.

<http://greenvalues.cnt.org/national/downloads/methodology.pdf>

Center for Neighborhood Technology. (Center for Neighborhood Technology 2018). *Cost Sheet*.

Accessed 2018. http://greenvalues.cnt.org/national/cost_detail.php

Center for Watershed Health. (CHW 2016). *Drought Response Outreach Program for Schools (DROPS) Guidance for Planning and Executing Vegetated LID Projects*. March 2016.

Central Coast Low Impact Development Initiative. (LIDI 2018). *Central Coast LIDI*. Accessed July 2018.

<https://www.centralcoastlidi.org/>

City of Los Angeles. (City of Los Angeles 2009). *Green Infrastructure for Los Angeles: Addressing Urban Runoff and Water Supply through Low Impact Development*. April 17, 2009.

Clary, J., and Piza, H. (Clary and Piza 2017). *Cost of Maintaining Green Infrastructure*. 2017.

Community Conservation Solutions. (Community Conservation Solutions 2016). *Green Solutions Project*. 2016.

Council of Educational Facility Planners. (COEFP 1991). *Guide for Planning Educational Facilities*. 1991.

County of San Diego. (County of San Diego 2014). *Low Impact Development Handbook Stormwater Management Strategies*. July 2014.

Daniel, E. and Raney, M.A. (2018). Playground greening results in persistent improvements in physical activity levels among LAUSD elementary school students. *Southwest American College of Sports Medicine Conference Proceedings*, 17.

DeepRoot Green Infrastructure. (DeepRoot 2018). *What to Consider When Designing Green Stormwater Systems*. May 31, 2018.

Department of Toxic Substances Control. (DTSC 2018). *Envirostor*. Accessed July 2018.

<https://www.envirostor.dtsc.ca.gov/public/>

Dettinger, M.D. (2013) *Atmospheric Rivers as Drought Busters on the U.S. West Coast*. *Journal of Hydrometeorology*, 14 (6): 1721–32. 2013.

Diffenbaugh, N.S., Swain, D.L., and Touma, D. (2015). *Anthropogenic Warming has Increased Drought Risk in California*. *Proceedings of the National Academy of Sciences*, 112(13), 3931–3936. 2015.

<https://doi.org/10.1073/pnas.1422385112>

Dingman, S. L. (Dingman 1994). *Physical Hydrology*. 1994.

Duncan, H.P. (Duncan 1995). *A Bibliography of Urban Stormwater Quality*. Cooperative Research Centre for Catchment Hydrology. 1995.

Duncan, H.P. (Duncan 1999) *Urban Stormwater Quality: A Statistical Overview*. Cooperative Research Centre for Catchment Hydrology. 1999.

Ellis, H.C. (Ellis 1986). *Pollutional Aspects of Urban Runoff*. In: Marsalek J, Desbordes M (eds) Urban runoff pollution. Springer-Verlag, Berlin; New York. 1986.

Hollis, G.E. (Hollis 1975). *The Effect of Urbanization on Floods of Different Recurrence Interval*. Water Resources Research, 11:431. doi: 10.1029/WR011i003p00431. 1975

Houle, J. J., Roseen, R. M., Ballesteros, T. P., Puls, T. A., and Sherrard Jr, J. (Houle et al. 2013). *Comparison of Maintenance Cost, Labor Demands, and System Performance for LID and Conventional Stormwater Management*. Journal of Environmental Engineering, 139(7), 932-938. 2013.

Juneau Watershed Partnership. (Juneau Partnership 2018). Juneau Watershed Partnership. Accessed September 2018. <http://www.juneauwatersheds.org/stormwater.html>

Knight, R., Kadlec, R., Reed, S., Ruble, R., Waterman, J., and Brown, D. (Knight et al. 1994). *North American wetlands for water quality treatment database*. 1994.

Liang, J., Matheson, B. E., Kaye, W. H., and Boutelle, K. N. (2014). *Neurocognitive correlates of obesity and obesity-related behaviors in children and adolescents*. *International Journal of Obesity*, 38(4), 494–506.

Los Angeles Unified School District. (LAUSD 2009). Los Angeles Unified School District (LAUSD) *Stormwater Technical Manual*. October 2009.

Lovasi, G. S., Quinn, J. W., Neckerman, K. M., Perzanowski, M. S., and Rundle, A. (2008). Children living in areas with more street trees have lower prevalence of asthma. *Journal of Epidemiology and Community Health*, 62(7), 647–649.

Migliore, M. (Migliore 2014). *Stormwater Solutions*. September 12, 2014. <https://www.flowcontrolnetwork.com/stormwater-solutions/>

National Resource Conservation Survey. (NRCS 2018). *Soil Survey*. Accessed July 2018. <https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/>

X. References

Office of Water Programs at California State University, Sacramento. (OWP 2018a). *The American River Basin Stormwater Resource Plan*. May 2018.

Office of Water Programs at California State University, Sacramento. (OWP 2018b). *CA Phase II LID Sizing Tool*. Accessed July 2018. <http://www.owp.csus.edu/LIDTool/Start.aspx>

Office of Water Programs at California State University, Sacramento. (OWP 2018c). *The American River Basin Stormwater Resource Plan – Web Map*. Accessed July 2018. <http://www.owp.csus.edu/ARBSWRP/map.htm>

O’Geen, A., Saal, M., Dahlke, H., Doll, D., Elkins, R., Fulton, A., Fogg, G., Harter, T., Hopmans, J., Ingels, C. and Niederholzer, F. (O’Geen et al. 2015). *Soil suitability index identifies potential areas for groundwater banking on agricultural lands*. California Agriculture, 69(2), pp.75-84. 2015.

Roesner, L., Bledsoe, B. P., and Brashear, R. W. (Roesner et al. 2001). *Are Best-Management-Practice Criteria Really Environmentally Friendly?*. May/June 2001.

Rossmann, L. A., and Bernagros, J. T. (Rossmann and Bernagros 2014). *National Stormwater Calculator User’s Guide – Version 1.2.0.1*. 2014.

RSMeans Company. (RSMeans 2018). *Building Construction Costs with RSMeans Data 2018*. Means Building Construction Cost Data. 76 ed. 2018.

Sacramento Stormwater Quality Partnership. (SSQP). 2013. *Sacramento Stormwater Quality Partnership Hydromodification Management Plan*. Revised February 2013.

Schueler, T. (Schueler 1994). *The Importance of Imperviousness*. Watershed Protection Techniques 1:100–111. 1994.

Southeastern Wisconsin Regional Planning Commission. (SWRPC 1991). *Costs of Urban Nonpoint Source Water Pollution Control Measures*. 1991.

Stormwater Equipment Manufacturers Association. (SEMA 2018). *Templates for Maintenance Ordinance and Maintenance Agreements*. Accessed July 2018. <https://www.stormwaterassociation.com/templates-maintenance-agreement-ordinance>

Swain, D.L., Horton, D.E., Singh, D., and Diffenbaugh, N.S. (2016) *Trends in Atmospheric Patterns Conducive to Seasonal Precipitation and Temperature Extremes in California*. Science Advances, 2(4), e1501344–e1501344. 2016. <https://doi.org/10.1126/sciadv.1501344>

Taylor, A.F., and Kuo, F. E. M. (2011). *Could exposure to everyday green spaces help treat ADHD? Evidence from children's play settings*. *Applied Psychology: Health and Well-Being*, 3(3), 281–303.

Taylor, S. (Taylor 2014). *Long-term Performance and Life-cycle Costs of Stormwater Best Management Practices*. Washington, DC: Transportation Research Board of the National Academies. 2014.

Torno, H. (Torno 1984). *The EPA Nationwide Urban Runoff Program (NURP)*. Paper presented at the Proceeding of la 3ème International Conference on Urban Storm Drainage, Göteborg. 1984.

TreePeople. (TreePeople 2015). *Unlocking Collaborative Solutions to Water Challenges in the Los Angeles Region: The Power of Schools*. January 2015.

University of California, Davis. (UC Davis 2018). *Soil Agricultural Groundwater Banking Index*. Accessed July 2018. <https://casoilresource.lawr.ucdavis.edu/sagbi/>

United States Department of Agriculture. (USDA 2012). *National Resource Conservation District. National Geospatial Center of Excellence. 1981-2010 Annual Average Precipitation by State*. 2012.

United States Department of Agriculture Natural Resource Conservation Survey. (NRCS 2018). *Web Soil Survey*. Accessed July 2018. <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>

United State Environmental Protection Agency. (USEPA 1999). *Preliminary Data Summary of Urban Storm Water Best Management Practices*. 1999.

United States Environmental Protection Agency. (USEPA 2004). *Stormwater Best Management Practice Design Guide: Volume 1 General Considerations*. September 2004.

United States Environmental Protection Agency. (USEPA 2005a). *National Management Measures to Control Nonpoint Source Pollution from Urban Areas*. November 2005.

United States Environmental Protection Agency. (USEPA 2005b). *Stormwater Phase II Final Rule Pollution Prevention/Good Housekeeping Minimum Control Measures*. December 2005.

United State Environmental Protection Agency. (USEPA 2013). *Case Studies Analyzing the Economic Benefits of Low Impact Development and Green Infrastructure Programs*. 2013.

United States Environmental Protection Agency. (USEPA 2017). *Watershed Ecology Modules: Introduction to Watershed Ecology*. Accessed November 2017. https://www.epa.gov/watershedacademy/online-training-watershed-management#watershed_ecology

X. References

United States Environmental Protection Agency. (USEPA 2018a). *Green Infrastructure Cost-Benefit Resources*. Accessed July 2018.

<https://www.epa.gov/green-infrastructure/green-infrastructure-cost-benefit-resources>

United States Environmental Protection Agency. (USEPA 2018b). *Water Quality Criteria*. Accessed July 2018. <https://www.epa.gov/wqc>

United States Environmental Protection Agency. (USEPA 2018c). *Water Quality Standards Regulations: California*. Accessed July 2018.

<https://www.epa.gov/wqs-tech/water-quality-standards-regulations-california>

United States Global Change Research Program. (US Global Change 2018). *The National Climate Assessment*. Accessed July 2018. <https://nca2014.globalchange.gov/>

University of New Hampshire. (UNH 2018). *Fact Sheet LID as a Climate Change Adaptation Tool*. Accessed July 2018. <https://www.unh.edu/unhsc/forging-link-topics>

Urban Drainage and Flood Control District. (UDFCD 2018). *BMP-REALCOST Software*. Accessed 2018. <https://udfcd.org/software>

Urbanas, B. (Urbanos 2002). *Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation*. 2002.

WRA Environmental Consultants. (WRA 2015). *Maintenance Plan Key to Avoid Stormwater to Wetland Conversion*. May 2005. Accessed July 2018.

<https://wra-ca.com/maintenance-plan-key-avoid-stormwater-wetland-conversion>

Water Research Foundation, American Society of Civil Engineers, Environmental and Water Resources Institute, United States Environmental Protection Agency, U.S. Department of Transportation, American Public Works Association, Wright Water Engineers Inc., and Geosyntech Consultants. (WERF et al. 2018). *International Stormwater BMP Database*. Accessed July 2018. <http://www.bmpdatabase.org/index.htm>

Weiss, P. T., Gulliver, J. S., and Erickson, A. J. (Weiss and Erickson 2007). *Cost and Pollutant Removal of Stormwater Treatment Practices*. *Journal of Water Resources Planning and Management*, 133(3), 218-229. 2007.

Wossink, A., and Hunt, B. (Wossink and Hunt 2003). *An Evaluation of Cost and Benefits of Structural Stormwater Best Management Practices*. North Carolina Cooperative Extension Service Fact Sheet. November, 2003.

