To: **CARB Staff**
From: **Ronnie Cohen, Noah Garrison, NRDC**
(rcohen@nrdc.org)
Re: **Comments on Water in Draft Scoping Plan and Appendices**
Date: **August 1, 2008**
Via: **Electronic submission at**
http://www.arb.ca.gov/cc/scopingplan/spcomment.htm

On behalf of the Natural Resources Defense Council (NRDC), we submit the following comments on the *Climate Change Draft Scoping Plan*, June 2008 Discussion Draft (Scoping Plan). NRDC is a national nonprofit environmental organization with more than 1.2 million members and online activists, including more than 250,000 Californians.

Consistent with the request of the California Air Resources Board (CARB) that we submit separate comments for each sector included in the Scoping Plan, the following are NRDC's comments on the water sector. Comments on other sectors will be submitted separately. Our water comments will first address several cross-cutting issues that apply to several of the water strategies. We then offer our strategy-specific comments. Additionally, we intend to submit under separate cover, a recent NRDC analysis of the energy savings and greenhouse gas emission reduction potential from Low Impact Development (LID), a strategy included in the Scoping Plan. We believe this analysis will address some of the data gaps that CARB has identified.

I. General Comments

Overall, we are pleased that the Scoping Plan recognizes the energy intensity of water use in California, and incorporates strategies, including water efficiency, water recycling, and urban stormwater reuse, that can be used to decrease California's reliance on energy intensive water supplies. We strongly support inclusion of a Public Good Surcharge to provide sustained funding for these programs.

As the Scoping Plan recognizes, California's water systems are uniquely energy-intensive due in large part to the pumping requirements of major conveyance systems that move large volumes of water long distances and over thousands of feet in elevation. In the absence of aggressive efficiency, recycling, and LID programs, California's water supplies may become even more energy intensive. Seawater desalination has been viewed as the ultimate drought hedge, enabling water providers to augment water supplies with desalted ocean water, a virtually inexhaustible water source. As California confronts a limited water supply, 20 desalination plants have been proposed statewide, each of which would supply water at an energy cost comparable to the State Water Project.[1] Recent improvements in energy efficiency have lessened the amount of thermal and pumping energy required for the desalination processes, but the energy intensity of desalinated water remains high.

NRDC research has demonstrated that significant opportunities for energy savings may be realized by reducing the need for the most energy-intensive supplies, through implementation of water use efficiency, water recycling, and reusing urban runoff through low impact development (LID). To move beyond the water benefits of these measures and ensure that they are implemented in a way that maximize their energy savings and greenhouse gas reduction potential, the Scoping Plan should consider the following:

1) Existing programs are based only on the value of water savings. Economic benefits of energy and greenhouse gas reductions should be included in cost-effectiveness analyses and would justify increased investment in these strategies.

The Scoping Plan is correct that many of the water strategies included in the Scoping Plan are already being pursued because of their water quality and water supply reliability benefits. Once energy and greenhouse gas emission benefits are included, greater levels of water efficiency, recycling, and stormwater capture may be cost effective than if those measures were evaluated solely on the basis of water supply benefits. A recent study on water recycling by the California Sustainability Reliance[2] suggests including a proxy value for the energy and carbon benefits of recycled water, noting that:

> Adopting an interim proxy facilitates near-term investment decisions that fully consider the water, energy and carbon benefits of recycled water options on a holistic societal basis. Including consideration of these additional value streams increases the portfolio of cost-effective recycled water options.

Based on its investigations, the Alliance recommends a proxy of 3,400 kWh per acre foot of additional recycled water developed and used in Southern California and notes that at a levelized electricity price of $0.08/kWh, this equates to about $270 per acre-foot. The Alliance notes that “there is substantial precedent in California for employing proxies to allow important decisions to be made to minimize lost opportunities, while studies proceed in parallel to further refine data and methods.”

We would extend that recommendation to apply to all water measures in the Scoping Plan, including efficiency, recycling, and storm water capture, that reduce reliance on imported water supplies, though the actual proxy value may vary for the various strategies, as well as by location.

The Scoping Plan should target the most energy intensive water sources.

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[1] Heather Cooley, Peter H. Gleick, and Gary Wolff (June 2006) Desalination, with a grain of salt; A California Perspective, Pacific Institute, *available at* http://www.pacinst.org/reports/desalination/index.htm.

[2] California Sustainability Alliance, *The Role of Recycled Water in Energy Efficiency and Greenhouse Gas Reduction* (May, 2008)

Because there are great variations in the embedded energy and associated GHG emissions depending on source and location of water source and use, the Scoping Plan should identify means of prioritizing and reducing reliance on the most energy intensive water supplies.

II. Strategy-Specific Comments

A. Urban Water Use Efficiency

The Scoping Plan recognizes the large GHG benefits that can come from water use efficiency. However, the measure identified in the Scoping Plan is to "continue" water efficiency programs. <u>Existing water efficiency programs and policies are not adequate to achieve the necessary levels of water savings.</u> We strongly urge that the Scoping Plan identify measures to expand and accelerate water efficiency programs, rather than assume the adequacy of existing efforts.

While many water agencies have made excellent progress in improving water efficiency, CARB should not assume that no additional action is necessary. On an aggregate basis, existing water use efficiency programs lag far behind their potential. Many analyses have identified shortcomings in California's existing water efficiency programs. The CEC noted that in comparison to the state's energy efficiency programs, water efficiency programs lag in policies and funding. In 2004, the California Bay-Delta Authority (CBDA) conducted a comprehensive review of the CALFED Water Use Efficiency Program. Part of the review included an assessment of urban water supplier implementation of the 14 voluntary conservation Best Management Practices (BMPs.) The CBDA report states that "rates of compliance with most BMPs remain low." It also states that "the MOU process is not working as intended and its impact on urban water use remains well below its full potential." Recent legislation has tied BMP compliance to eligibility for state grants, so there is hope of improved performance in the future, but the added imperative of assuring these savings to achieve the associated GHG reductions, warrants increased rigor.

Furthermore, relying on existing water efficiency policies and programs implicitly perpetuates the cost-effectiveness standard used in those programs. Yet, current water efficiency programs are based almost exclusively on the water supply benefits of the programs. As noted in the general comments above, if the energy savings and greenhouse gas reductions were included, a much higher level of investment in water efficiency could be justified. Indeed, the 2005 IEPR noted:

> Given the interconnectedness of water and energy resources in California, the fact that cost effectiveness is determined from the perspective of a single utility and a single resource creates barriers to achieving greater energy savings from water efficiency programs. Water utilities only value the cost of treating and delivering water. Wastewater utilities only value the cost of collection, treatment, and disposal. Electric utilities only value saved electricity. Natural gas utilities only value saved natural gas. This single focus causes underinvestment in programs

> that would increase the energy efficiency of the water use cycle, agricultural and urban water use efficiency, and generation from renewable resources by water and wastewater utilities. (2005 IEPR, p.158)

Pending legislation (AB 2175) would require the state to reduce per capita urban water use by 2020. However, the specific targets assigned to water agencies in the bill would not achieve the overall 20 percent target. Instead, the bill requires DWR to develop and submit to the legislature a plan to achieve the full 20 percent. The scoping plan should include measures that will assure that the state does indeed reach that 20 percent reduction. Approaches could include a statewide retrofit upon resale law for water efficient fixtures and appliances, and increased State Board enforcement under Section 275 of the Water Code. Also, there have been numerous laws passed in recent years that have called for the CEC to establish water efficiency standards for buildings, fixtures, appliances, and irrigation equipment, but the CEC has not yet initiated proceedings on any of these. We urge you to amend the Scoping Plan to include a schedule for development of these standards.

The Scoping Plan should also be revised to address the issue of water system losses. These losses are comprised of water that enters the distribution system, but never reaches the customer. Embedded energy in this water includes energy required for extraction, conveyance and water treatment as well as some portion of the energy used for local distribution. The losses likely vary widely by community, and may be as high as 20% in some communities, but the inadequacy of current approaches makes it impossible to quantify the potential savings. The United States lags behind several other countries, including Australia and England, with respect to how these losses are monitored and addressed. To protect against waste and unreasonable use the Scoping Plan should require urban water suppliers to conduct water loss audits in accordance with International Water Association procedures and to identify and develop a plan to reduce economically recoverable losses. This approach was adopted by the American Water Works Association as a best practice and a manual for water agencies will be released in 2009.

B. Agricultural Water Use Efficiency

The draft Scoping Plan does not include measures to address agricultural water use. We recognize that the energy use and greenhouse gas emission reductions associated with agricultural water use vary widely, and that any reductions in GHG emissions would depend on the location and disposition of the conserved water. However, as agriculture uses approximately 80% of the developed water in California, it is inappropriate to omit completely that sector of water use from the Scoping Plan.

In the Westland Water District, for example, groundwater pumping requires approximately 740 kWh/af, and deliveries from the Central Valley Project range from 435-763 kWh/af. Energy requirements also vary by irrigation practice. Flood irrigation without on-farm lift requires no supplemental irrigation, while low pressure sprinklers require 100 kWh/af and permanent set sprinklers require 205 kWh/af. Our analysis in

Energy Down the Drain (NRDC, 2004) revealed that retiring 200,000 acres of land in Westlands Water District and dedicating that water to environmental flows could save 121 million equivalent kWh/year. However, if that water were transferred to urban use, energy use would instead increase dramatically.

Despite large regional variations, and the need to clearly define, in an enforceable manner, the ultimate disposition of the conserved water, the potential for energy savings and reductions in GHG emissions from changes in agricultural water management are large and warrant analysis. The 2005 IEPR noted that: “Efficient irrigation techniques hold promise for substantially reducing the amount of water delivered. Agricultural water conservation can also increase on-farm energy demand, such as the energy required to pressurize drip and microspray irrigation systems, but this increase can be more than offset by greater on-farm irrigation system efficiency and operations, and by energy reductions associated with delivering less water.” (2005 IEPR, p.156)

We recommend instead that the Scoping Plan direct the Department of Water Resources and the State Water Board to identify areas where changes in agricultural water use, including improvements in agricultural water use efficiency, can reduce greenhouse gas emissions. The analysis should identify what steps are necessary to ensure that the changes in water management do in fact translate into reduced GHG emissions.

C. Water Recycling

Water recycling, as recognized in the scoping plan, is another important tool that can be used to reduce reliance on energy intensive imported water supplies. According to the California Sustainability Alliance study on the energy benefits of water recycling[3], about 415,000 acre feet of tertiary and secondary wastewater is being discharged by four water agencies in Southern California which could be used as a beneficial water supply. That number is higher – about 580,000 acre feet per year – when advanced primary effluent is included. The study goes on to note that: For the four agencies studied, the annual energy and carbon benefits of accelerated development of available tertiary and secondary recyclable water totals 1,400 gigawatt hours and 540,000 metric tons of CO2. A bill pending in the legislature (AB 224) would direct the State Board and DWR to evaluate the energy savings and GHG reductions from water recycling on a statewide basis.

We support the Scoping Plan recommendation that National Pollution Discharge Elimination System permits be amended to require preparation and implementation of water recycling plans at wastewater treatment plants in communities that rely on imported water supplies and communities where water recycling would otherwise require less energy than current water supplies.

The Alliance study notes some important obstacles to increasing water recycling in California, and makes policy recommendations to address these obstacles. We support the recommendations of that study, which include:

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[3] California Sustainability Alliance, *The Role of Recycled Water in Energy Efficiency and Greenhouse Gas Reduction* (May, 2008).

- Adopting an interim proxy for valuing the energy and carbon benefits of recycled water;
- Developing a California Recycled Water Blueprint that assesses the statewide recycled water potential by region;
- Convening a cross-cutting policy leadership group to develop and expedite remedies to significant recycled water barriers, including public perception and the high cost of dual plumbing;
- Increasing recycled water incentives;
- Creating streamlined approaches that expedite development of recycled water;
- Establishing market-based mechanisms to facilitate transfers of recycled water.

D. Low Impact Development

The Scoping Plan notes that ”although urban water reuse may have the potential to achieve energy and emission reductions by reducing the use of new water, information is not available at this time to accurately quantify the volume of water that could be captured and reused, or the energy savings that could be realized.” (p. C-85)

NRDC has completed an analysis of Low Impact Development (LID) that may provide some of this information. LID is a “comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds.”[4] LID employs cost-effective practices that can greatly increase the availability of local water supply through either the infiltration of urban runoff to recharge groundwater or the use of water harvesting to capture and store runoff from impervious surfaces for reuse in irrigation or graywater recycling systems. As a result, LID decreases the need to obtain water from imported sources or processes such as desalination which require massive energy inputs.

NRDC has recently conducted a comprehensive study in consultation with leading academics, incorporating detailed analyses of land use, water supply patterns, and energy consumption of water systems in California. We have concluded that through implementation of LID at new and redeveloped residential and commercial properties in the urbanized areas of southern California and limited portions of the San Francisco Bay Area, LID has the potential to result in savings of between 124,000 and 223,000 acre-feet (af) of water per year by 2020, with a corresponding electricity savings of 269,000 to 637,000 megawatt-hours (MWh) per year (227,500 to 408,000 af/year and 494,000 to 1,167,000 MWh/year by 2030). These results are likely conservative when compared to the water and energy savings that may actually be achieved by employing LID, as the analysis currently assumes a cautious figure for development rates, and, additionally, does not currently take into account the potential to implement LID practices at government, public use, and industrial sites, which account for a significant percentage of the total land use in the state. Far greater water and electricity savings—and associated

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[4] Low Impact Development Center, available at http://www.lowimpactdevelopment.org/ last visited July 13, 2008.

reductions in GHG emissions—would also result from full application of LID practices statewide.

The essence of LID is to eliminate—or at least significantly ameliorate—the problems generated by runoff from urban and suburban development, before they can develop, by exploiting the natural onsite infiltration and treatment abilities of soils and vegetation or by harvesting water for later reuse. LID practices include: maximizing infiltration, which recharges local and regional groundwater systems; providing retention areas and slowing runoff, which reduce flooding and erosion; minimizing projects' impervious footprint; directing runoff from impervious areas into landscaping; and harvesting water.[5] Thus, LID provides exceptionally important benefits with respect to water quality, pollution abatement, and flooding and erosion control.

By preventing site runoff altogether in many situations, LID practices are often substantially more effective at protecting water quality than conventional best management practices, which rely on structural treatment devices to remove a percentage of pollution after it has already entered stormwater runoff. Further, the U.S. EPA has stated that, "In the vast majority of cases… implementing well-chosen LID practices saves money for developers, property owners, and communities while protecting and restoring water quality."[6] Since current federal and state regulatory policies already require that developed sites control post-construction stormwater runoff,[7] requiring LID implementation under AB 32 simply represents an opportunity to reduce energy use and GHG emissions in California by requiring the most cost-effective means of complying with existing mandates of federal and state laws.

LID's ability to reduce demand for imported or desalinated water through groundwater recharge is particularly appropriate in light of the fact that many, if not most, areas of the state already have infrastructure in place for the extraction and distribution of groundwater. As much as 50 percent of the state's population receives some portion of their water supply from groundwater.[8] This includes the vast majority of the southern California area that receives water from the SWP, as nearly 50 percent of the Metropolitan Water District's ("MWD") member agencies' water supply consists of

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[5] See generally, Prince George's County, Maryland, Department of Environmental Resources (July 1999) Low Impact Development Hydrologic Analysis, *available at* http://www.lowimpactdevelopment.org/pubs/LID_Hydrology_National_Manual.pdf; US Department of Housing and Urban Development ("HUD") (July 2003) The Practice of Low Impact Development, *available at* http://www.huduser.org/publications/destech/lowImpactDevl.html

[6] EPA, (December 2007) Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices, *available at* http://www.epa.gov/owow/nps/lid/costs07/.

[7] See generally, (33 U.S.C. § 1342(p)(3)(B)(iii)); In the Matter of the Petitions of the Cities of Bellflower et al., the City of Arcadia, and Western States Petroleum Association, State Water Resources Control Board ("SWRCB") Order WQ 2000-11 (October 5, 2000); San Diego County Phase I MS4 Permit (California Regional Water Quality Control Board, San Diego Region, Order No. R9-2007-0001) at 20; Ventura County Draft Phase I MS4 Permit (California Regional Water Quality Control Board, Los Angeles Region, April 29, 2008) at 57; General Phase II MS4 Permit (SWRCB Order No. 2003-0005-DWQ); Resolution of the California Ocean Protection Council Regarding Low Impact Development, May 15, 2008.

[8] DWR (October 2003) California's Groundwater – Bulletin 118 Update 2003, *available at* http://www.groundwater.water.ca.gov/bulletin118/

groundwater.[9] By increasing the availability of groundwater supply extracted through environmentally sound, safe yield approaches, LID can reduce the need to import water through the SWP and other such water delivery projects, thereby greatly reducing energy use and related GHG emissions for a large portion of the state.

The opportunities to capture water for reuse present an equally compelling potential for reducing energy use and GHG emissions. In assessing LID site design practices for the San Francisco Bay Area, Dr. Richard Horner, a nationally recognized expert on stormwater runoff, stated that LID techniques that emphasize capture can "reduce annual runoff volumes by almost half to more than 3/4…with much of the water saved available for a beneficial use."[10] This is relevant for regions such as the San Francisco Bay, which have not traditionally included groundwater as a water source in significant volumes but have been proposed as the location of multiple desalination plants. Implementing LID to harvest water for later reuse could substantially reduce the need to supply water through seawater desalination, thus also reducing the energy use and GHG emissions that result from this highly energy-intensive process.

The potential for LID to reduce GHG emissions in California, coupled with the multiple benefits that LID provides, present an exiting opportunity for the State to address the issue of climate change under AB 32. Thus, we support CARB's inclusion of LID as a measure under the Scoping Plan, and encourage CARB to aggressively implement a regulatory structure to require the use of LID for future development in California. CARB should use the AB 32 process to ensure that regulatory structure in the State implements requirements that LID practices be employed to meet its goal of reducing GHG emissions statewide.

E. Public Good Surcharge

We strongly support the Scoping Plan call for a public goods surcharge on water. This approach has been a critical element of California's remarkable success with energy efficiency programs. Funding for water efficiency has lagged woefully behind.

A dedicated funding source for water efficiency would greatly facilitate the state's efforts to achieve the 20 percent per capita reduction. We believe that a per unit fee, rather than a per connection fee, would better serve the dual purpose of directly reducing GHG emissions though demand reduction, while also providing a funding source for efficiency programs. However, we recognize that this approach presents a greater administrative challenge than a flat per connection fee, and would support a per connection fee as a suitable way to initiate the program.

We also support the stated intention for ARB to "develop protocols for monitoring , tracking and reporting performance to ensure that the GHG reductions are real, permanent, quantifiable, verifiable and enforceable." (p. C-87)

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[9] Based on NRDC review of MWD member agencies' Urban Water Management Plans.

[10] Richard R. Horner (2007) Supplementary Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for the San Francisco Bay Area, Attached as Appendix A

III. Conclusions

California is presented with an unprecedented opportunity to address the issues of climate change and its impacts on our state. California should, and must, act rapidly under AB 32 and include the broadest possible palate of measures, including water-related measures, to reduce GHG emissions. We appreciate the opportunity to offer these comments and look forward to working with CARB and other agencies to develop and implement the necessary policies and programs to achieve the goals of AB 32.

APPENDIX A

SUPPLEMENTARY INVESTIGATION OF THE FEASIBILITY AND BENEFITS OF LOW-IMPACT SITE DESIGN PRACTICES ("LID") FOR THE SAN FRANCISCO BAY AREA

Richard R. Horner[†]

ABSTRACT

The Clean Water Act NPDES permit that regulates municipal separate storm sewer systems (MS4s) in the San Francisco Bay Area, California will be reissued in 2007. The draft permit includes general provisions related to low impact development practices (LID) for certain kinds of development and redevelopment projects. Using eight representative development project case studies, based on California building records, the author investigated the practicability and relative benefits of LID options for the portion of the region having soils potentially limiting to infiltration. A principal LID option applicable in this situation is roof runoff harvesting, supplemented by dispersion of the roof water in single-home sites. Other site runoff would be treated by conventional stormwater best management practices (BMPs), as specified in the permit. The results showed that combining LID techniques with conventional BMPs where infiltration opportunities are limited can: (1) reduce annual runoff volumes by almost half to more than 3/4, depending on land use characteristics, with much of the water saved available for a beneficial use; and (2) decrease mass loadings of pollutants to receiving waters by 63 to over 90 percent, depending on pollutant and land use.

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INTRODUCTION

Background

A report titled, "Initial Investigation of the Feasibility and Benefits of Low-Impact Development Practices ("LID") for the San Francisco Bay Area" used six representative development project case studies, based on California building records, to investigate the practicability and relative benefits of LID options for the majority of the region having soils potentially suitable for infiltration either in their natural state or after amendment using well recognized LID techniques. The results demonstrated that: (1) LID site design and source control techniques are more effective than conventional best management practices (BMPs) in reducing runoff rates; and (2) in each of the case studies, LID methods would reduce site runoff volume and pollutant loading to zero in typical rainfall scenarios.

For a broad regional assessment of relatively large scale use of soil-based, infiltrative LID practices, the initial report covered areas having soils in Natural Resources Conservation Service (NRCS) Hydrologic Soil Groups A, B, or C as classified by the Natural Resources Conservation Service (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx). This supplementary report covers locations with group D soils, which are generally not amenable to infiltration, again depending on the specific conditions on-site. A minority but still substantial fraction of the Bay Area has group D soils (39.3, 68.0, 18.3, and 50.1 percent of the mapped areas of Alameda, Contra Costa, San Mateo, and Santa Clara Counties, respectively). Regarding any mapped soil type, it is important to keep in mind that soils vary within small distances and thus projects within areas classified as having D soils may, in practice, be hospitable to infiltration.

General Assessment Methods

The assessment for group D soils reported herein emphasizes the use of standard, representative LID practices appropriate in areas with relatively restrictive soils, supplemented by conventional stormwater management practices implemented at fully practicable, high levels of effectiveness. The assessment was performed in a manner analogous to the analysis for the other soil groups and as described in the initial report. To recap briefly, with respect to each of several development case studies, three assessments were undertaken: a baseline scenario incorporating no stormwater management controls; a second scenario employing conventional BMPs; and a third development scenario employing LID stormwater management strategies supplemented by conventional BMPs. In each assessment, annual stormwater runoff volumes were estimated, as well as concentrations and mass loadings (the products of concentrations times flow volumes) of four pollutants: (1) total suspended solids (TSS), (2) total recoverable copper (TCu), (3) total recoverable zinc (TZn), and (4) total phosphorus (TP). The results of the second and third assessments were expressed in terms of the extent to which the management practices would reduce pollutant concentrations and loadings and runoff volumes, converting stormwater discharge to a potentially beneficial use (direct consumption or, in the case of group A, B, C soil areas, groundwater recharge).

Eight case studies were selected to represent a range of urban development types considered to be representative of the Bay Area. The majority of the case studies are carried forward from the Initial Investigation report previously submitted to the Regional Water Board. These case studies involved: a large commercial development (COMM), a multi-family residential complex (MFR), a relatively small-scale (23 homes) single-family residential development (Sm-SFR), a restaurant (REST), an office building (OFF), a relatively large (1000 homes) single-family residential development (Lg-SFR), a single home (SINGLE), and an urban infill redevelopment project (REDEV). The land cover types for these various land uses were derived from building permit and other public records from the Bay Area or elsewhere in California.

Adaptation of Methods for Areas with Group D Soils

A key LID technique in a setting with soils relatively restrictive to infiltration is water harvesting, which can be applied at larger scales in commercial and light industrial developments and at smaller residential scales using cisterns or rain barrels. Harvesting has been successful in reducing runoff discharged to the storm drain system and conserving water in applications at all scales. For example, in downtown Seattle the King County Government Center collects enough roof runoff to supply over 60 percent of the toilet flushing and plant irrigation water requirements, saving approximately 1.4 million gallons of potable water per year (http://www.psat.wa.gov/Publications/LID_studies/rooftop_rainwater.htm, http://dnr.metrokc.gov/dnrp/ksc_tour/features/features.htm). A much smaller public building in Seattle, the Carkeek Environmental Learning Center, drains roof runoff into a 3500-gallon cistern to supply toilets (http://www.harvesth2o.com/seattle.shtml). Collecting drainage from individual dwellings for household use is a standard technique around the world, particularly in areas deficient in rainfall and without affordable alternative sources.

An additional general category of LID practices for poorly infiltrating locations, applicable especially at single homes and other relatively small-scale developments, is runoff dispersion for storage in vegetation and soil until evapotranspiration and some infiltration occurs. Section C.3.c of the California Regional Water Quality Control Board San Francisco Bay Region "Administrative Draft" NPDES Municipal Regional Stormwater Permit ("the Permit") requires all single-family home projects that create and/or replace 5,000 square feet or more of impervious surface to implement one or more stormwater lot-scale BMPs from a selection of: (1) diverting roof runoff to vegetated areas; (2) directing paved surface runoff flow to vegetated areas; and/or (3) installing driveways, patios, and walkways with pervious material such as pervious concrete or pavers. Another way of distributing and dissipating roof runoff used successfully in varied soils in the state of Washington is the downspout dispersion system, consisting of a splash block or gravel-filled trench serving to spread roof runoff over a vegetated area (Washington Department of Ecology 2005 [Volume III, Section 3.1.2]).

The basis of the group D soils assessment was harvesting roof runoff, supplemented in smaller-scale developments by runoff dispersion methods. The report asserts that, through these LID BMPs, it is practicable to prevent the entrance of any roof runoff into the municipal storm drain system in any soils setting in the Bay Area. In order to make the analysis conservative, this analysis also presume that, in group D soils, infiltration likely cannot be relied upon to reduce runoff from other portions of developments, such as walkways, driveways, parking lots, access roads, and landscaping. Some water loss would undoubtedly occur, especially through evapotranspiration and at least some infiltration of runoff generated on or directed to landscaping. The analysis presented in this report does not take account of these losses and hence, in this connection also, is conservative in estimating benefits.

As required by the Permit, any runoff not attenuated by harvest, evapotranspiration, or infiltration would be subject to quality controls. The initial report investigating LID for A, B, and C soils presented estimates of benefits for EDBs, swales, and filter strips, along with continuous deflective separation (CDS) units, a practice that effectively captures only large particulate pollutants. For brevity, this follow-up report focuses on extended-detention basins (EDBs) and CDS units as the supplement to LID. EDBs are one of several general-purpose, conventional stormwater BMPs available for this service, others being wet ponds, constructed wetlands, sand or other media filters, and biofiltration swales and filter strips. In performance, EDBs tend to fall between swales and filter strips for total suspended solids, slightly lower than the other two BMP types for metals, and either between the two or comparable to swales for total phosphorus. The California Department of Transportation (Caltrans, 2004) tested the performance of all of these practices in its BMP Retrofit Pilot Program, conducted in San Diego and Los Angeles Counties.

These practices were applied to the same six case studies used in the initial analysis and described in Table 1 of the first report. Two additional case studies were defined for the assessment reported here: a sizeable commercial retail installation (COMM) and an urban redevelopment (REDEV). The hypothetical COMM scenario consists of a building with a 2-acre footprint and 500 parking spaces. Parking spaces were estimated to be 176 sq ft in area, which corresponds to 8 ft width by 22 ft length dimensions. A simple, square parking lot with roadways around the four sides and a square building with walkways also around the four sides were assumed. Roadways and walkways were taken to be 20 ft and 6 ft wide, respectively. The REDEV case was taken from an actual project in Berkeley involving a remodel of an existing structure, built originally as a corner grocery store with apartments above and a large side yard, and the addition of a new building on the same site to create a nine-unit, mixed-use, urban infill project. Table 1 summarizes the characteristics of these two case studies. The table also provides the recorded or estimated areas in each land use and cover type.

Table 1. Characteristics and Land Use and Land Cover Areas of Added Case Studies

	COMM[a]	REDEV[a]
No. buildings	1	1
Total area (ft^2)	226,529	5,451
Roof area (ft^2)	87,120	3,435
No. parking spaces	500	2 uncovered
Parking area (ft^2)	88,000	316 uncovered
Access road area (ft^2)	23,732	-
Walkway area (ft^2)	7,084	350
Driveway area (ft^2)	-	650
Landscape area (ft^2)	20,594	700

[a] COMM—retail commercial; REDEV—commercial/residential infill

The assessment for group D soils employed the same methods as the earlier analysis to estimate annual stormwater runoff volumes and pollutant discharges. Please refer to the initial report for details on those methods. The Natural Resource Conservation Service (NRCS, 1986) methodology cited in that report was applied to estimate that infiltration in group D soils would be roughly 60 percent of the amount through landscaping or the bed of a conventional BMP in C soils, which were the basis for establishing runoff coefficients in the first analysis. While that initial analysis was performed for both 14- and 20-inch average annual runoff zones, typical of different Bay Area locations, this supplementary work covered only the former condition. This simplification was made in the interest of brevity in this report, given that the first analysis showed almost no difference in conclusions between the two situations.

RESULTS OF THE ANALYSIS

Table 2 provides a comprehensive summary of the results. Rows shaded in gray compare runoff and pollutant discharges with and without treatment by CDS units, which can capture relatively large solids but have no mechanisms for dissolved substances and the finer particles. Having no soil contact and very limited residence time for evaporation, this BMP cannot reduce runoff volume at all. It can achieve some substantial reductions in TSS and TP for land uses relatively high in landscaped area but little removal of metals, especially copper.

The blue-shaded rows show the performance of conventional EDBs. In the group D soils considered in this analysis, they were estimated to reduce annual runoff volumes by 13-23 percent, the higher values for land uses with relatively small impervious footprints (OFF and REST). These BMPs can capture the majority of the long-term mass loading of most pollutants from most land uses in these soils, falling below 50 percent in reducing metals in stormwater flowing from residential developments.

Rows shaded in green present the results of applying LID BMPs appropriate for group D soils, roof runoff harvesting supplemented by dispersion in single-home land uses, plus treating the remaining runoff with EDBs, which, as noted above, provide a mid-level degree of performance compared to other conventional BMPs. Comparing annual runoff volumes with and without LID, it can be seen that removing roof runoff from the storm drain system affords very significant benefits in reducing surface discharge and putting much of that water to productive use. Compared to directing all site runoff to EDBs, LID is expected to reduce volume by almost 10 times in the REDEV case, by about five times for the various residential land uses, 3.6 times for the large commercial development, and around twice for the OFF and REST cases. This management strategy can recover over 3/4 of the stormwater that would otherwise go down the drain in the intense redevelopment case, approximately 2/3 for the multi- and single-family residential cases, over half in the COMM development, and almost half in the office and restaurant cases with relatively small roof footprints. Use of conventional BMPs with performance similar to EDBs, as a supplement to roof runoff retention, would provide roughly similar results.

Reduction of volume also translates to decreases in pollutant loadings. The combination of LID and EDB treatment is estimated to raise copper and zinc reductions to about 70 to over 90 percent in all except the developments with relatively low roof proportions (60-65 percent in these cases). TSS predictions come in at a quite consistent 75-82 percent across land uses. Total phosphorus estimates are a similarly consistent 63-71 percent, a bit higher in the highly impervious REDEV case.

The analysis has demonstrated that harvesting the roof runoff stream, supplemented by ground dispersion techniques, shows strong promise to reduce the majority of flow inputs to municipal storm drain systems while conserving water. Moreover, this strategy can also stem the majority of solids, copper, zinc, and phosphorus transport to receiving waters.

Table 2. Runoff Volume and Pollutant Loading Reductions with Conventional and Low-Impact Development (LID) Best Management Practices (BMPs) for Eight Land Use Case Studies in Hydrologic Group D Soils

	COMM[a]	OFF[a]	REST[a]	REDEV[a]	MFR[a]	Lg-SFR[a]	Sm-SFR[a]	SINGLE
Total annual runoff with no BMPs (ac-ft)	5.29	0.80	0.47	0.12	8.57	75.66	1.74	0.10
Total annual runoff with CDS units (ac-ft) [reduction][b]	5.29 [0.0%]	0.80 [0.0%]	0.47 [0.0%]	0.12 [0.0%]	8.57 [0.0%]	75.66 [0.0%]	1.74 [0.0%]	0.10 [0.0%]
Total annual runoff with conventional BMPs (ac-ft) [reduction][c]	4.43 [16.3%]	0.63 [21.3%]	0.36 [23.2%]	0.11 [8.1%]	7.48 [12.7%]	65.27 [13.7%]	1.50 [13.7%]	0.09 [13.3%]
Total annual runoff with LID + conventional BMPs (ac-ft) [reduction][c, d]	2.22 [58.0%]	0.44 [45.0%]	0.28 [40.4%]	0.03 [78.9%]	2.80 [67.3%]	26.72 [64.8%]	0.61 [64.8%]	0.04 [65.7%]
TSS reduction with CDS units[b, e]	19.4%	44.8%	33.9%	22.1%	27.1%	37.1%	37.1%	37.7%
TCu reduction with CDS units[b, e]	0.4%	11.0%	4.2%	0.9%	2.7%	7.3%	7.3%	7.6%
TZn reduction with CDS units[b, e]	25.3%	29.1%	25.5%	25.5%	24.1%	25.6%	25.6%	25.9%
TP reduction with CDS units[b, e]	25.9%	63.7%	54.3%	35.7%	46.7%	57.6%	57.6%	58.2%
TSS reduction with conventional BMPs[c, e]	64.7%	78.1%	74.9%	66.5%	62.8%	70.3%	70.3%	70.9%
TCu reduction with conventional BMPs[c, e]	57.9%	51.6%	56.4%	53.2%	51.4%	43.5%	43.5%	43.6%
TZn reduction with conventional BMPs[c, e]	57.6%	49.6%	48.9%	58.1%	48.5%	47.7%	47.7%	48.0%
TP reduction with conventional BMPs[c, e]	44.4%	67.6%	63.3%	52.8%	56.3%	64.4%	64.4%	64.7%
TSS reduction with LID + conventional BMPs[c, d, e]	74.6%	80.3%	77.0%	81.5%	79.4%	81.3%	81.3%	81.8%
TCu reduction with LID + conventional BMPs[c, d, e]	71.9%	60.3%	62.2%	82.3%	73.8%	68.9%	68.9%	69.5%
TZn reduction with LID + conventional BMPs[c, d, e]	79.7%	65.1%	60.9%	92.3%	78.9%	76.4%	76.4%	77.0%
TP reduction with LID + conventional BMPs[c, d, e]	63.1%	69.8%	66.0%	75.2%	69.4%	70.8%	70.8%	71.1%

[a] COMM—retail commercial; OFF—office building; REST—restaurant; REDEV—commercial/residential redevelopment; MFR—multi-family residential; Lg-SFR—large-scale single-family residential; Sm-SFR—small-scale single-family residential; SINGLE—single family home

[b] CDS—continuous deflective separation; reduction—comparison with no BMPs

[c] Conventional BMPs—extended-detention basins, biofiltration swales and filter strips, wet ponds, constructed wetlands, sand or other media filters (Calculations were based on exteneded-detention basins for illustration.); reduction—comparison with no BMPs

[d] LID—roof runoff harvesting for COMM, OFF, REST, REDEV, AND MFR; harvesting supplemented by dispersion of roof runoff for Lg-SFR, Sm-SFR, and SINGLE; treatment of remaining runoff with conventional BMPs; reduction—comparison with no BMPs

[e] TSS—total suspended solids; TCu—total recoverable copper; TZn—total recoverable zinc; TP—total phosphorus

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