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NATURAL RESOURCES DEFENSE COUNCIL

Mary Nichols, Chair
California Air Resources Board
1001 "I" St. P.O. Box 2815
Sacramento, CA 95812

August 11, 2008

Re: ***AB 32 Draft Scoping Plan and Appendices – Water, Urban Reuse***

Dear Ms. Nichols:

We are writing today in support of the California Air Resources Board's ("CARB") inclusion of Low Impact Development ("LID") as a measure for reducing greenhouse gas ("GHG") emissions in California in the Draft Scoping Plan for AB 32, and to call on CARB to require its implementation at future development and redevelopment in the state. Attached, please find a copy of an analysis of LID's potential to reduce GHG emissions in the state, authored by the Natural Resources Defense Council, Dr. Robert Wilkinson, Director of the Water Policy Program at the UC Santa Barbara Bren School of Environmental Science and Management, and Dr. Richard Horner, member of the National Academy of Sciences-National Research Council (NASNRC) panel on Reducing Stormwater Discharge Contributions to Water Pollution. This analysis is submitted to substantiate the potential for implementation of LID practices to result in water savings, and corresponding reductions in energy use and GHG emissions, in California, and is intended as a supplement to comments submitted by NRDC on the Draft Scoping Plan's Water Sector on August 1, 2008.

LID represents a significant opportunity for climate response under AB 32, and CARB should ensure that use of LID practices is required statewide in order to achieve AB 32's goal of reducing GHG emissions in California.

Sincerely,

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NRDC COMMENT ON AB 32 SCOPING PLAN APPENDICES – WATER SECTOR

Executive Summary

Low Impact Development ("LID") represents a major opportunity for climate response under AB 32 because LID has the potential to significantly reduce California's demand for energy- and emissions-intensive imported and desalinated water. 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."[1] It 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 use in irrigation or graywater recycling systems. As a result, LID decreases the need to obtain water from imported sources or processes such as ocean desalination which require massive energy inputs. Thus, we support the California Air Resources Board's ("CARB") inclusion of LID as a measure under the Draft Scoping Plan, and encourage CARB to aggressively implement a regulatory structure to require the use of LID for future development in California.

NRDC, in cooperation with leading academics, has recently conducted a comprehensive study incorporating detailed analyses of land use, water supply patterns, and energy consumption of water systems in California. Based upon this study, 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 alone, 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, with increasing benefits thereafter). 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 future 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 reductions in greenhouse gas ("GHG") emissions—would additionally result from full application of LID practices statewide.

In this comment, we discuss LID in the context of the relationship between water supply, energy, and GHG emissions in California. We present the preliminary results of our study of the potential for LID to augment local water supplies and result in a reduction of energy use and GHG emissions in the state. The essence of LID is to eliminate—or at least 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, especially where it may provide a

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

preferred alternative to infiltration and groundwater recharge due to a limited availability of permeable soils or pervious surface.[2]

By preventing site runoff altogether in many situations, LID practices are often substantially more effective at protecting water quality than many types of 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. Environmental Protection Agency ("EPA") has stated that the "vast majority" of case studies suggest that implementing LID site designs is cost effective,[3] particularly in comparison to conventional methods. The EPA analysis was based solely on the costs of implementation, and their conclusion is strengthened considerably when economic externalities are considered; the use of LID practices can reduce strain on, and costs of, municipal storm water infrastructure, decrease the frequency and severity of combined sewer overflow events, and increase real estate values. (See section on Costs of LID, *infra*.) Since current federal and state regulatory policies already require that developed sites control post-construction stormwater runoff (see section on LID Site Design Principles and Benefits, *infra*), including LID as a measure in the Draft Scoping Plan and requiring its implementation under AB 32 presents an opportunity to reduce energy use and GHG emissions in California by simply requiring the most cost-effective means of complying with existing mandates of federal and state laws.

Because the primary goal of LID is widely viewed as the prevention of stormwater pollution, it has generally been overlooked as a means of augmenting energy-efficient, local water supplies. This has occurred despite the fact that water delivery now constitutes the largest use of electricity in California.[4] The California State Water Project ("SWP"), which pumps water a distance of 444 miles from the Sacramento-San Joaquin Delta to southern California, in the process lifting the water nearly 3000 feet over the Tehachapi Mountains,[5] is the single largest individual user of electricity in the state.[6] Further, as California confronts issues related to limited water supplies and a growing economy,[7] 20 ocean desalination plants have been proposed statewide, each of which would supply water at an energy cost comparable to the SWP.[8] By contrast, the energy required to supply groundwater can be five to ten times less than that required to supply water

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[2] 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

[3] EPA (December 2007) Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices, *available at* http://www.epa.gov/owow/nps/lid/costs07/; National Association of Home Builders (NAHB) (2002) Builder's Guide to Low Impact Development, *available at* http://www.lowimpactdevelopment.org/lid%20articles/Builder_LID.pdf. (The NAHB states "Ever wish you could simultaneously lower your site infrastructure costs, protect the environment, and increase your project's marketability? With LID techniques, you can.")

[4] California Energy Commission (2005). *Integrated Energy Policy Report*, November 2005, CEC-100-2005-007-CMF.

[5] DWR, State Water Project – Today, *available at* http://www.publicaffairs.water.ca.gov/swp/swptoday.cfm.

[6] Carrie Anderson (1999) Energy Use in the Supply, Use and Disposal of Water in California, Process Energy Group, Energy Efficiency Division, California Energy Commission.

[7] See, e.g., Jennifer Steinhauer, "Water-starved California slows development" New York Times, June 7, 2008 at A13.

[8] 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.

through the SWP or ocean desalination, and the energy required to harvest and reuse stormwater can be a minimum of two to six times less. (See section on energy of water supply, infra.) Since LID has the potential to offset a substantial portion of California's energy-intensive imported or desalinated water needs, it should be viewed as a vital component of AB 32's mandate to reduce GHG emissions.

LID's ability to reduce demand for imported or desalinated ocean water through infiltration and 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. California produces more groundwater—approximately 17 million acre-feet per year—than any other state in the country.[9] As much as 50 percent of the state's population receive some portion of their potable water supply from groundwater.[10] 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 of Southern California's ("MWD") member agencies' water supply consists of groundwater.[11] (See Figure 1, which depicts the source and relative volume of water supply for water agencies in southern California. Though energy-intensive, imported water forms an important supply for the region, groundwater represents a significant portion of each water agency's total supply.)

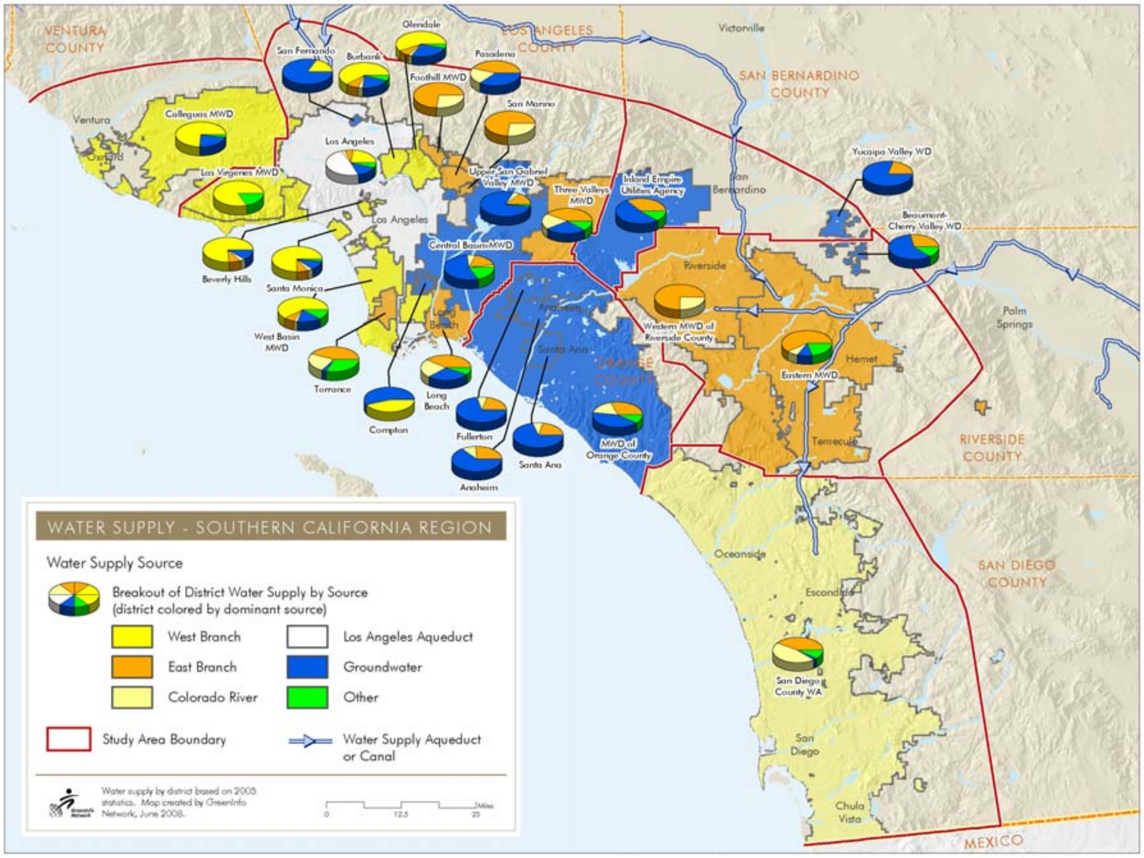

Figure 1. Water supply sources for southern California study area.

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[9] U.S. Geological Survey ("USGS") (March 2004, last revised February 2005) Estimated Use of Water in the United States in 2000, *available at* http://pubs.usgs.gov/circ/2004/circ1268/ (at Table 4).

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

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

By increasing the availability of groundwater supply through recharge, LID can reduce the need to import water through the SWP and other such water delivery projects, thereby greatly reducing energy use and related emissions in the state.

For areas of the state where surface soil conditions or water supply patterns favor water harvesting rather than groundwater recharge, the opportunities to capture water for reuse present an equally compelling potential for reducing energy use and GHG emissions. 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."[12] This is relevant for regions such as the San Francisco Bay Area, which has not traditionally included groundwater as a water source in significant volumes but has been proposed as the location of four ocean desalination plants. Implementing LID to harvest water for later reuse could substantially reduce the need to supply water through ocean 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, presents an exiting opportunity for the State to address the issue of climate change under AB 32. CARB should use the AB 32 process to ensure that regulatory structure in the State requires that LID practices be employed at all future commercial and residential development, with the possibility of expanding this requirement to include industrial and public use properties, to meet its goal of reducing GHG emissions statewide.

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[12] 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

Introduction to LID Site Design Principles and Benefits

By maximizing infiltration to increase groundwater recharge and by employing water harvesting techniques, LID can greatly augment the availability of local water supply and reduce the demand for energy-intensive supply from imported water sources or ocean desalination. This valuable result, and the attendant reduction in GHG emissions that LID can provide, support CARB's further development of LID as a measure under the Scoping Plan. In addition, however, LID provides exceptionally important benefits with respect to water quality, pollution abatement, and flooding and erosion control. LID practices, such as green roofs, can be designed to reduce the "urban heat island effect," thereby reducing the need for air conditioning and other energy-intensive residential and commercial uses of electricity. And by increasing green space in development projects, LID can also improve overall urban aesthetics and provide natural-looking, pleasing cityscapes. The additional open space created by LID site designs can be especially important for low-income communities otherwise disadvantaged with regard to usable urban outdoor areas.

Stormwater Runoff and Regulation

Urbanization and development increase the percentage of impervious cover (*i.e.*, surfaces such as roads, rooftops, and parking lots that prevent the infiltration of water into soil) in the landscape. Greater impervious cover, in turn, increases the volume, velocity, and duration of runoff that results from precipitation.[13] For example, a one-acre parking lot produces 16 times more runoff than a one-acre meadow.[14] This can lead to increasingly severe flooding and erosion[15] and can greatly increase levels of pollution in surface water bodies—when the increased volume of runoff flows over paved surfaces, it picks up proportionally higher levels of car wastes, pesticides, pet wastes, trash, and other contaminants, and carries them to receiving waters. In fact, EPA views urban runoff as one of the greatest threats to water quality in the country, and considers it "one of the most significant reasons that water quality standards are not being met nationwide."[16] According to EPA, "54 percent of California's impaired waterways are polluted by runoff."[17] Additionally, California experienced 4,736 beach closing and advisory days in 2007,[18] and "the largest identified pollution source" was "stormwater runoff from roads, roofs, lawns, construction sites, and other impervious surfaces."[19]

In order to prevent the pollution and other harms that result from urban runoff, the Clean Water Act requires municipalities, counties, and other dischargers to impose "controls to reduce the discharge of pollutants to the maximum extent practicable."[20] Dischargers must use

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[13] NRDC, (June 2006) Rooftops to Rivers, Green Strategies for Controlling Stormwater and Combined Sewer Overflows, *available at* http://www.nrdc.org/water/pollution/rooftops/contents.asp; California Water and Land Use Partnership, How Urbanization affects the Water Cycle, *available at* http://www.coastal.ca.gov/nps/watercyclefacts.pdf last visited July 13, 2008.

[14] Dana Beach (2002) Coastal Sprawl: The effects of urban design on aquatic ecosystems in the United States. Pew Oceans Commission, *available at* http://www.pewtrusts.org/our_work_report_detail.aspx?id=30037.)

[15] Prince George's County, *supra*, note 2.

[16] GAO (June 2001) Water Quality: Urban Runoff Programs, GAO-01-679, *available at* http://www.gao.gov/new.items/d01679.pdf.

[17] EPA (July 31, 2000) Officials Approve New California Poluted Runoff Program, *available at* http://yosemite.epa.gov/opa/admpress.nsf/8b75cea4165024c685257359003f022e/7340a18a132b249c852570d8005e13dd!OpenDocument.

[18] NRDC (July 2008) Testing the Waters 2008, *available at* http://www.nrdc.org/water/oceans/ttw/titinx.asp.

[19] NRDC (August 2007) Testing the Waters 2007, *available at* http://www.nrdc.org/water/oceans/ttw/titinx.asp.

[20] 33 U.S.C. § 1342(p)(3)(B)(iii).

"management practices, control techniques and system, design, and engineering methods, and such other provisions which are appropriate."[21] To meet these conditions, dischargers apply for permits under the National Pollutant Discharge Elimination System ("NPDES") program. Permittees in California have been increasingly required to apply controls on the volume of runoff that sites may generate in order to prevent further pollution to the state's waters.[22] For example, in 2001, the State Water Resources Control Board adopted Order WQ 2000-11, which "created objective and measurable criteria for the amount of runoff that must be treated or infiltrated," and established a requirement that treatment or infiltration occur for "85 percent of the runoff from specified categories of development."[23] One method of complying with such permit conditions has been to use conventional stormwater management practices, which involve applying structural engineering solutions to manage the increased volume of impervious runoff that occurs with development. With conventional practices, runoff is transported away from developed sites as quickly as possible—through systems of curbs, gutters, buried drainage pipes, and centralized combined sewer systems—to treatment facilities or directly to receiving waters.[24] However, because treatment occurs in this system, if at all, only after pollutants have already entered stormwater, conventional practices are often ineffective at removing pollution in urban runoff and mitigating its impacts on surface water bodies.[25]

LID Principles

In contrast, LID uses common sense and simple technology—strategically placed beds of native plants, rain barrels, "green roofs," porous surfaces for parking lots and roads, and other features—to reduce runoff by helping rainfall soak into the ground or otherwise retaining rainfall onsite, rather than polluting the nearest water body. In effect, LID mimics nature's own infiltration and filtering systems.[26] Runoff accumulates less pollution because it crosses less impervious surface, and bioswales, basins, trenches, and other infiltration devices use absorption, settling, and the soil's natural capacity to filter pollutants to achieve 70 to 98 percent contaminant removal.[27] The result is less water pollution from stormwater runoff, less flooding, replenished water supplies, and frequently more natural-looking, aesthetically pleasing cityscapes. Furthermore, LID strategies that preserve existing vegetation and include vegetated and grassy swales and tree-box filters can help sequester GHG emissions and reduce the "heat

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[21] 40 C.F.R. § 122.26(d)(2)(iv).

[22] See generally, 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, NPDES NO. CAS0108758) 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.

[23] Memo from Chief Counsel regarding State Water Board Order WQ 2000-11 (December 26, 2000), *available at* http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/stormwater/susmp/susmp_details.shtml.

[24] HUD, *supra*, note 2; Prince George's County, *supra*, note 2; NRDC, Rooftops to Rivers, *supra*, note 13.

[25] NRDC, Rooftops to Rivers, *supra*, note 13.

[26] See Larry S. Coffman (2000), "Low-impact development design: A new paradigm for stormwater management mimicking and restoring the natural hydrologic regime." Proceedings from the National Conference on Tools for Urban Water Resource Management and Protection, February 2000, *available at* http://www.epa.gov/ORD/WebPubs/nctuw/Coffman.pdf; Low Impact Development Center (December 2007) A Review of Low Impact Development Policies: Removing Institutional Barriers to Adoption, *available at* http://www.waterboards.ca.gov/lid/docs/ca_lid_policy_review.pdf.

[27] EPA (2001) Source Water Protection Practices Bulletin, Managing Storm Water Runoff to Prevent Contamination of Drinking Water, *available at* http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_stormwater.pdf.)

island" effect in urban areas. These strategies also increase green space and open land generally. This results in enhanced property values and an increased availability of open space for community residents, which is particularly valuable in low-income communities that may otherwise have scant access to outdoor recreational areas.

Although LID incorporates a number of varied practices and technologies aimed at reducing stormwater runoff, for the purposes of increasing local water supply aimed at reducing electricity use and GHG emissions, measures that maximize infiltration and groundwater recharge opportunities to the greatest extent possible should be promoted under the Scoping Plan. Where the density of urban development or the presence of impervious soils has the potential to reduce opportunities for infiltration, LID measures that emphasize stormwater harvesting should be selected as the preferred method for increasing water supply.

Because dischargers are already required to control post-construction stormwater runoff, requiring the implementation of LID practices represents the most commonsense means of complying with the law. Given these multiple benefits and the robust contributions that LID can make to reducing GHG emissions, CARB should ensure that LID practices that emphasize groundwater recharge and water harvesting are required for dischargers statewide.

Water, Energy, GHG Emissions and Opportunities for LID in California

California's Overall Water-Energy Picture

At the national level, water systems, or the extraction, conveyance, treatment, storage, distribution, end-use, and wastewater treatment, require an estimated 75 billion kilowatt-hours (kWh) of energy per year, or about 3% of the total electricity demand in the United States.[28] In California, water systems account for a staggering 19% of total electricity use and about 33% of the non-power plant natural gas use in the state.[29] Although the energy embodied in a unit of water varies with location and source, moving large quantities of water long distances and over significant topographical features, treating and distributing water within communities, use of water, and collecting and treating the resulting wastewater, are each energy intensive processes. Water is now recognized as the *largest electricity user* in California, and both the California Energy Commission ("CEC") and the California Public Utilities Commission ("CPUC") have concluded that the energy embedded in water presents large untapped opportunities for cost-effectively improving energy efficiency and reducing emissions of GHGs.[30] Indeed, our research has demonstrated that significant opportunities for savings may be realized simply by reducing the need for the most energy-intensive supply, and for the reasons already discussed, LID is one of the easiest and most effective means of tapping into these opportunities.

The Energy Intensity of Water in California

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. Certain interbasin transfer systems, such as California's SWP and the Colorado River Aqueduct ("CRA"), require large amounts of electrical energy to convey water for this reason.

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[28] Franklin L. Burton (1996) Water and Wastewater Industries: Characteristics and Energy Management Opportunities, Burton Engineering, Los Altos, CA, Report CR-106941, Electric Power Research Institute Report.
[29] California Energy Commission (November, 2005) Integrated Energy Policy Report, CEC-100-2005-007-CMF.
[30] *Id*.

Approximately 2,580 kWh are required to pump one acre-foot of SWP water from the Sacramento-San Joaquin Delta to Castaic on the West Branch of the SWP; 3,236 kWh/af are required to reach the Devil's Canyon Power Plant on the East Branch; and 5,418 kWh/af are required to reach Cherry Valley at the end of the East Branch. Additionally, approximately 2,000 kWh/af are required to pump Colorado River water to southern California.[31] The water from these systems is delivered raw (untreated) to those points. From there, conveyance continues by gravity or pumping to treatment and distribution systems within individual service areas. In general, service areas at higher elevations have higher energy requirements. Thus, at Cherry Valley and other locations near the terminus of the East Branch, raw water supplies are actually *more* energy intensive than estimates for desalinated ocean water (ocean desalination requires an estimated 4,400 kWh/af).

Seawater desalination has been viewed as the ultimate drought hedge, a virtually inexhaustible water source, but costs have prevented desalination from achieving widespread use. The salinity of ocean water varies, with the average generally exceeding 30 grams per liter (g/l). The Pacific Ocean is 34-38 g/l, while brackish water contains 0.5 to 3.0 g/l. Potable water salt levels, however, should be below 0.5 g/l. Using existing technologies to reduce salt levels from over 30 g/l to 0.5 g/l and lower (to meet drinking water standards) requires considerable amounts of energy for the pressure to drive water through extremely fine filters in the process of reverse osmosis. Recent improvements in energy efficiency have lessened the amount of pumping energy required for this process, but high energy-intensity is still an issue.

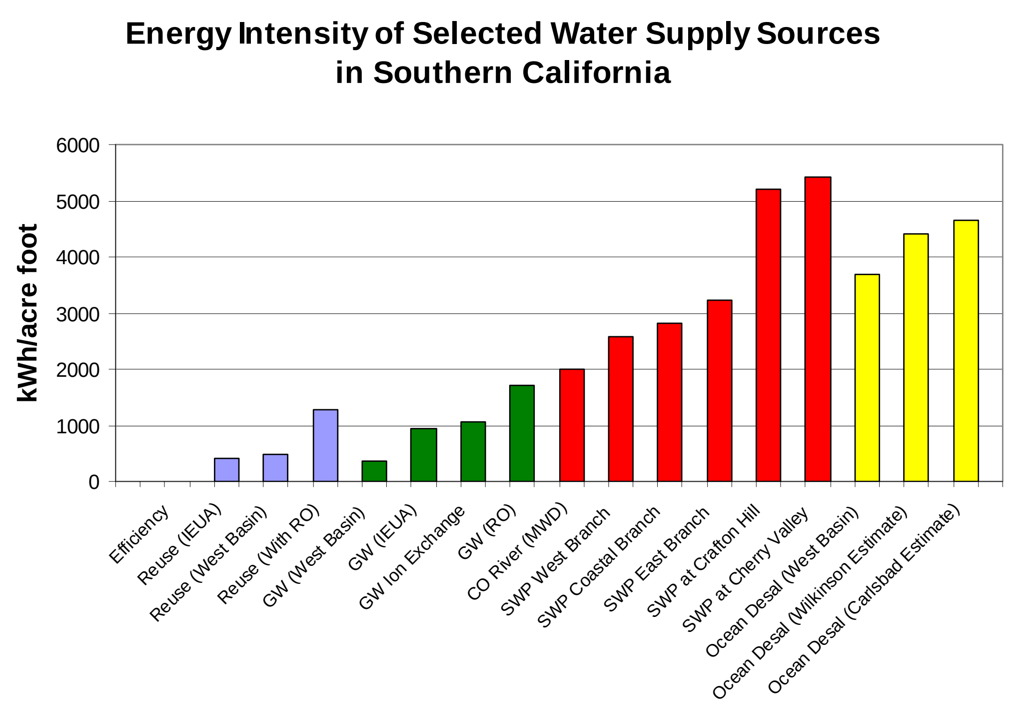

Figure 2. Based on data from IEUA, West Basin MWD, DWR, and desalination estimates.

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[31] MWD (1996) Integrated Resource Plan for Metropolitan's Colorado River Aqueduct Power Operations.

Figure 2 shows the energy intensity of major water supply options for inland and coastal locations in southern California. Each bar represents the energy intensity of a specific water supply source at selected locations in southern California. Water conservation—e.g., not using water in the first place—avoids additional energy inputs along all segments of the water use cycle and is consequently a superior option from an energy perspective where available. For all other water resources, there are ranges of energy inputs that depend on many factors, including the quality of source water, the energy intensity of the technologies used to treat the source water to standards needed by end-users, the distance water needs to be transported to reach end-users, and the efficiency of the conveyance, distribution, and treatment facilities and systems.[32]

Next to water conservation, recycled water and groundwater are lower energy intensity options than most other water resources, in many, if not most, areas of California.[33] Even with advanced treatment to remove salts and other contaminants, recycled water and groundwater (the blue and green bars) usually require far less energy than untreated imported water (red bars) and seawater desalination (yellow bars). The Chino desalter, which uses a reverse osmosis ("RO") treatment process to provide high-quality potable water from contaminated groundwater (Figure 2 above includes groundwater pumping and RO filtration), is far less energy intensive than any of the imported raw water. From an energy standpoint, greater reliance on reuse and groundwater provides significant energy benefits. From a GHG emissions standpoint, these energy benefits provide significant potential GHG emissions reduction benefits in direct proportion to their energy savings.

Groundwater pumping energy requirements vary depending on the lift required. While the CEC's Public Interest Energy Research - Industrial, Agriculture and Water program acknowledges that in many parts of the state, "[t]he amount of energy used in pumping groundwater is unknown due to the lack of complete information on well-depth and groundwater use," for other areas, the amount of energy used is well defined. "In the Tulare Lake area, with an average well depth of 120 feet, pumping would require 175 kWh per acre-foot of water. In the San Joaquin River and Central Coast areas, with average well depths of 200 feet, pumping would require 292 kWh per acre-foot of water."[34] Analysis of these different sources provides a reasonably consistent result: local groundwater and recycled water are far less energy intensive than imported water or ocean desalination.

By contrast, water pumping plants employed in the supply of imported water carry among the largest electrical loads in the state. For example, the SWP's Edmonston Pumping Plant, situated at the foot of the Tehachapi Mountains, pumps water up 1,926 vertical feet (the highest single lift of any pumping plant in the world) and is the largest *single user* of electricity in the state.[35] As

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[32] Robert C. Wilkinson, (2000) Methodology For Analysis of The Energy Intensity of California's Water Systems, and an Assessment of Multiple Potential Benefits Through Integrated Water-Energy Efficiency Measures, Exploratory Research Project, Ernest Orlando Lawrence Berkeley Laboratory, California Institute for Energy Efficiency, *available at* http://www.es.ucsb.edu/faculty/wilkinson.pdfs/Wilkinson_EWRPT01%20DOC.pdf.

[33] Laurie Park, Bill Bennett, Stacy Tellinghuisen, Chris Smith, and Robert Wilkinson, 2008 The Role of Recycled Water In Energy Efficiency and Greenhouse Gas Reduction, California Sustainability Alliance, *available at* http://www.sustainca.org/content/recycled_water_2.

[34] California Energy Commission (2006) Public Interest Energy Research - Industrial, Agriculture and Water, *available at* http://energy.ca.gov/pier/iaw/industry/water.html

[35] DWR (1996) Management of the California State Water Project, Bulletin 132-96, *available at* http://wwwswpao.water.ca.gov/publications/bulletin/96/b96home.html.

mentioned above, in total, the SWP *system* is the largest user of electricity in the state.[36] Because of such energy requirements, water use (based on embedded energy) is the second or third largest consumer of electricity in a typical southern California home after refrigerators and air conditioners.[37] The electricity required to support water service in the typical home in southern California is estimated to be between 14% to 19% of total residential energy demand.[38] In homes without air conditioning, this figure is even higher. The MWD estimates that energy requirements to deliver water to residential customers can equal as much as 33% of the total average household electricity use.[39] Nearly three quarters of this energy demand is for pumping imported water. Increasing the availability of energy-efficient local water supply, as LID implementation would do, could therefore result in a savings for individual end users and in an overall reduction in the energy required to supply water.

For the foregoing reasons, the Department of Water Resources has identified improvements in urban water use efficiency in its official State Water Plan as the largest new water supply for the next quarter century, followed by groundwater management and reuse. Figure 3 indicates the critical role water use efficiency, groundwater recharge and management, and reuse will play in California's water future.

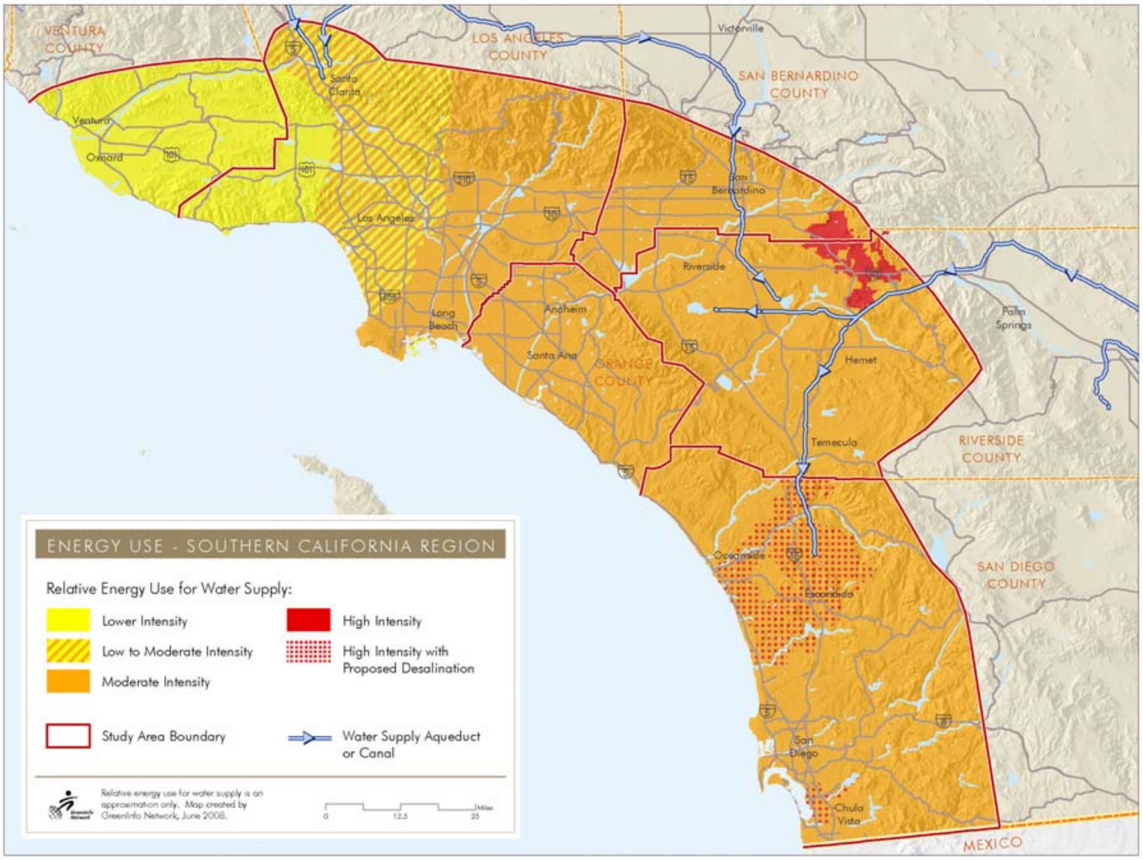

Figure 3. Energy intensity of supply by area.

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[36] Carrie Anderson, *supra*, note 6.
[37] Robert C. Wilkinson, *supra*, note 32.
[38] QEI, Inc. (1992) Electricity Efficiency Through Water Efficiency, Report for the Southern California Edison Company.
[39] MWD, *supra*, note 31.

While discussing efficiency of hot and cold water use in homes and businesses, the California Energy Commission's 2005 *Integrated Energy Policy Report* ("IEPR") takes a position that is equally applicable to increasing the energy efficiency of water supplies: "[r]educing the demand for energy is the most effective way to reduce energy costs and bolster California's economy."[40] The CEC staff report notes that, "As California continues to struggle with its many critical energy supply and infrastructure challenges, the state must identify and address the points of highest stress. At the top of this list is California's water-energy relationship."[41] Thus, implementation of LID accords perfectly with the CEC's position, and CARB should aggressively adopt policies that mandate the use of LID under AB 32.

This finding is consistent with an earlier analysis that found that energy use for conveyance, including interbasin water transfer systems (systems that move water from one watershed to another) in California, accounted for about 6.9% of the state's electricity consumption.[42] Estimates by CEC's Public Interest Energy Research – Industrial, Agriculture and Water experts indicate that "total energy used to pump and treat this water exceeds 15,000 gigawatt-hours (GWh) per year, or *at least* 6.5 percent of the total electricity used in the state per year." The magnitude of these figures suggests that failing to tap energy savings derived from water efficiency improvements would be an opportunity lost.

Selection of Study Areas to Assess Potential Water, Energy, and GHG Emissions Savings
Although LID has previously been overlooked as a means of increasing local water supply, wherever water from energy-efficient sources such as groundwater extraction or rainwater recycling can be used in place of energy-intensive imported or desalinated water, LID presents a potential to reduce California's electricity usage and GHG emissions under AB 32 through recharging local aquifers or onsite water supplies. This potential exists throughout the state and can be realized at current and future development projects of virtually any scale or land use type. At present, LID is a vast, underutilized resource that the Scoping Plan should tap.

Though opportunities for augmenting water supply and decreasing energy usage and GHG emissions exist throughout the state, in deciding where to focus our analysis of LID's emissions reduction potential, we considered several factors to determine the study's geographical scope. Among these factors were:

1. Distribution of population: We selected populous locations to incorporate as many of the state's residents as possible.
2. Energy-intensity of water supply: We designed the study to include areas in the state that show the highest marginal energy use for water supply so that the greatest energy savings may be realized through the implementation of LID.
3. Adequate rainfall: We selected areas of study where rainfall is high enough to create a substantial supply of water that could be directed to infiltration or water harvesting

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[40] DWR (2005) California Water Plan Update 2005, Bulletin 160-05, *available at* http://www.waterplan.water.ca.gov/previous/cwpu2005/index.cfm.

[41] Gary Klein (November 2005) California Energy Commission, California's Water – Energy Relationship. Final Staff Report, Prepared in Support of the 2005 Integrated Energy Policy Report Proceeding, (04-IEPR-01E), CEC-700-2005-011-SF, *available at* http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF.

[42] Robert C. Wilkinson, *supra*, note 32.

practices in order to significantly reduce the amount of water drawn from energy-intensive sources.

4. Availability for infiltration and groundwater recharge or capture: We further selected the study areas based on either the presence of sufficient existing or potential pervious surface—including analyses of soil type and location of groundwater systems—to allow for infiltration, or the presence of sufficient development to allow for extensive water harvesting from rooftop runoff.

Following these parameters, our initial study has focused on urbanized southern California and portions of the San Francisco Bay Area. These areas incorporate the vast majority of the state's population—approximately 50 percent of the state's population resides in the counties located within the southern California study area, and an additional 20 percent live in the San Francisco Bay region.[43] These areas are also characterized by some of the highest energy use per unit of water delivered; imported water accounts for one-half or more of all domestic water supply, more than 2,000,000 acre-feet per year, in the southern California region.[44] (See Figures 1, 3. Water from the SWP, supplied at energy requirements of between 2,580 kWh/af (yellow areas) and 5,418 kWh/af (solid red areas), is used pervasively throughout this region.) The San Francisco Bay region, which historically used surface water almost exclusively, is the site of four proposed desalination plants, with an estimated capacity of between 35,800 and 108,700 af/year[45] and an embedded energy requirement of 4,400 kWh/af.[46] Further, the average rainfall throughout both regions is sufficient to result in significant runoff diversion through the use of LID; rainfall averages roughly 10 to 15 inches annually in most portions of the southern California study area, and from 18 to more than 30 inches annually in the San Francisco Bay region.[47] Finally, these areas are projected to see large scale population growth, accompanied by development that could be required, under AB 32, to implement LID practices that maximize groundwater recharge or stormwater harvesting. Thus, based on the four parameters outlined above, these two areas have some of the greatest potential to reduce energy usage and GHG emissions in California through the implementation of LID.

Southern California

The southern California study area includes San Diego County, Orange County, and portions of Ventura County, Los Angeles County, San Bernardino County and Riverside County. (See Figure 4, Map of Study Area, including a breakdown of land use designations. Of particular interest are the large tracts of residential and commercial land in which LID practices could be widely implemented.) Generally speaking, the urbanized communities of southern California are particularly well-suited to implementing LID to increase local water supplies through infiltration and groundwater recharge. Groundwater is already used in immense quantities in the region – more than 1.5 million acre-feet of groundwater are produced in areas supplied by member

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[43] California Department of Finance (May 2008) E-1 Population Estimates for Cities, Counties and the State with Annual Percent Change — January 1, 2007 and 2008, *available at* http://www.dof.ca.gov/research/demographic/reports/estimates/e-1_2006-07/

[44] NRDC review of MWD member agencies' Urban Water Management Plans.

[45] Heather Cooley et al., *supra*, note 8.

[46] Another five desalination plants, with a capacity of between 46,700 and 55,800 af/yr have been proposed for operation in neighboring Monterrey Bay, directly to the south of the northern California study area. *Id.*

[47] Based on Natural Resources Conservation Service ("NRCS"), Average Annual Rainfall, 1961-1990, analyzed by NRDC (2008).

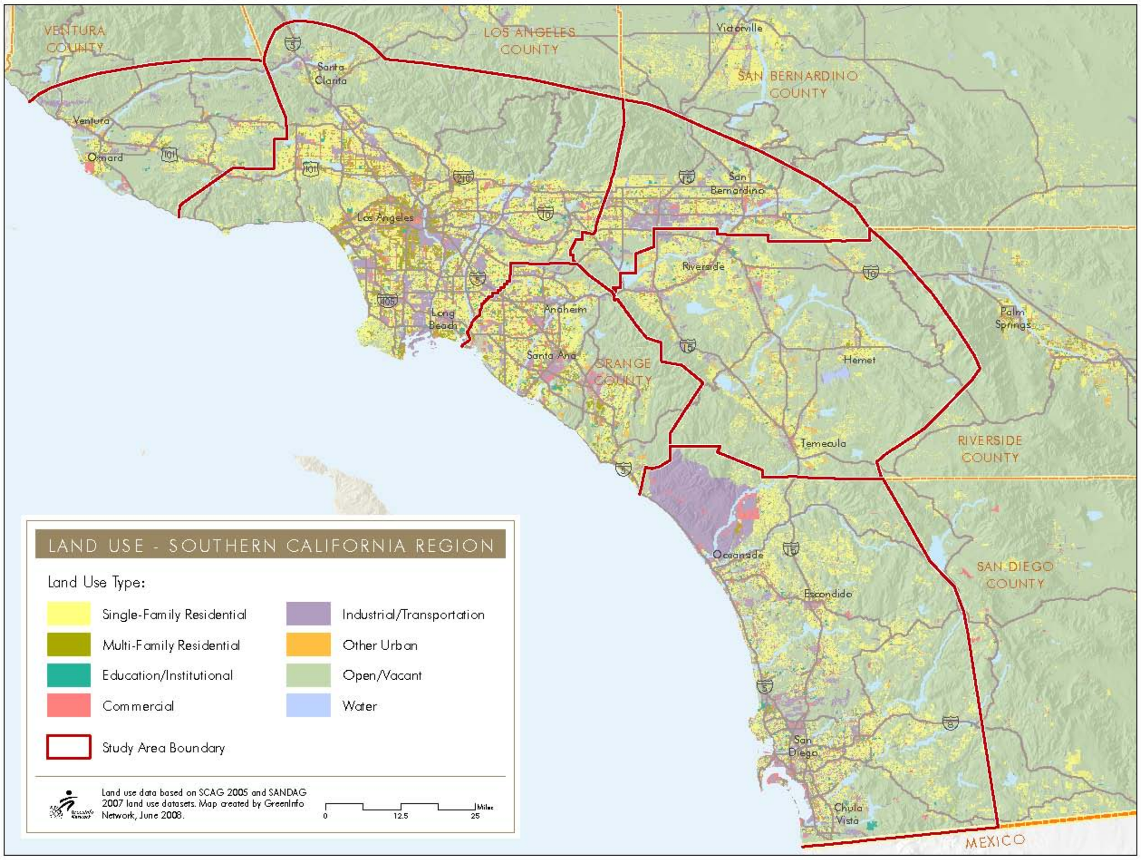

Figure 4. Map of southern California study area.

agencies of the MWD in an average year,[48] and in areas of Orange County, eastern Los Angeles County, and San Bernardino, groundwater extraction constitutes the principal source of water (see Figure 1).

Conditions for groundwater recharge are also generally favorable throughout the region. First, the regional climate includes a rainy winter season when water is relatively abundant and a lengthy dry summer season during which imported, captured, and recharge water is necessary to maintain supplies and sustain communities. Second, the geologic material underlying most of the region is highly permeable, allowing rapid infiltration into groundwater basins. For example, approximately 35-40 percent of developed lands identified as suitable for infiltration and groundwater recharge in the study overlie areas designated by the state as hydrologically vulnerable,[49] or amenable to rapid infiltration to regional aquifers that are used for potable water supply. (Figure 5.) Even outside these areas, as discussed in the section on groundwater below, there remain strong possibilities for groundwater recharge to benefit local water supply. Moreover, where soils or surface conditions are not amenable to infiltration, water harvesting can provide many of the same local water supply benefits. LID techniques favoring capture can

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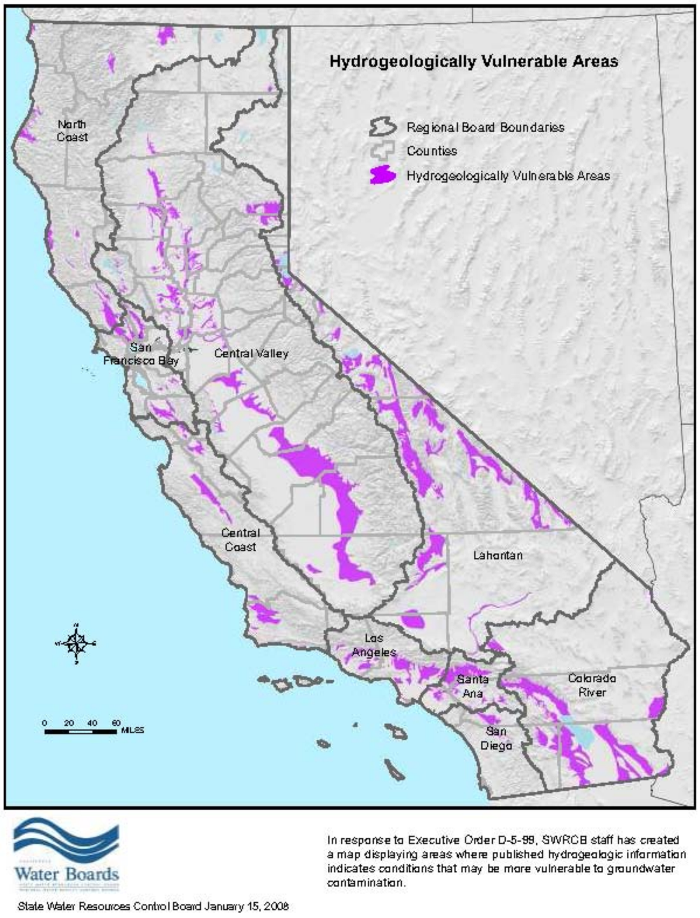
[48] MWD (September 2007) A Status Report on the Use of Groundwater in the Service Area of the Metropolitan Water District of Southern California, Report Number 1308, *available at* http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/GWAS.html Plate ES-2.

[49] State Water Resources Control Board (January 15, 2008) Map of Hydrologically Vulnerable Areas.

"reduce annual runoff volumes by almost half to more than 3/4…with much of the water saved available for a beneficial use."[50] Consequently, regardless of the method used, there is tremendous potential in the southern California Study Area to increase local water supply and therefore, to reduce reliance on imported or desalinated water sources that generate considerable GHG emissions.



In response to Executive Order D-5-99, SWRCB staff has created a map displaying areas where published hydrogeologic information indicates conditions that may be more vulnerable to groundwater contamination.

State Water Resources Control Board January 15, 2008

Figure 5. Hydrologically vulnerable areas of California. State Water Resources Control Board, January 15, 2008.

Groundwater

Our analysis has shown that groundwater recharge has the largest potential under AB 32 to increase local water supply and thus to reduce GHG emissions, so the process of infiltration to groundwater through LID warrants discussion. Groundwater is water beneath the earth's surface that completely saturates the small spaces and voids in rocks or between grains of sediment and other unconsolidated material.[51] In simple terms, groundwater forms when precipitation falling on land infiltrates the soil and other unconsolidated surface materials and percolates to depth, forming aquifers over millions of years. In the natural hydrologic regime, up to 40 or 50 percent of this precipitation is lost to evapotranspiration, a combination of evaporation from the soil and transpiration by plants, and up to 10 percent is converted to surface runoff that does not

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[50] Richard R. Horner, *supra*, note 12.

[51] See generally, Freeze and Cherry, Groundwater 1979 at 1.

infiltrate.[52] This still leaves up to 50 percent or more of the precipitation to infiltrate the ground surface, either as shallow infiltration or as deep percolation reaching the water table. However, since development has spread throughout the state, impervious cover, such as roads, rooftops, and parking lots that prevent the infiltration of water into the soil, has increased dramatically. As impervious cover increases, water is prevented from penetrating the ground surface, the volume of runoff increases, and the volume of infiltration decreases.[53] When impervious cover reaches 75 percent and above, as it does in many dense, urban centers, this may result in a more than five-fold increase in surface runoff and a corresponding 70 percent drop in infiltration, with the greatest decrease seen in the quantity of water that percolates to sufficient depths to recharge groundwater.[54]

This reduction in potential recharge is particularly relevant for California as the nation's largest producer of groundwater. The 17 million acre-feet withdrawn in the state per year account for nearly 20 percent of all groundwater extracted in the United States each year.[55] From these extractions, approximately 30 percent of California's urban and agricultural water needs are supplied by groundwater in an average year, a figure that rises to 40 percent or more during periods of draught.[56] As such, groundwater is rightfully called "one of California's greatest natural resources,"[57] and its continued supply is integral to California's environmental, economic, and social wellbeing.

This is especially true for southern California, which relies on groundwater to supply nearly one-half of the water used by approximately 50 percent of the state's population.[58] Groundwater has been used in the southern California region for about 150 years,[59] and "the story of the growth of the region becomes the story of the utilization and application of its available waters."[60] However, since settlers drilled the first groundwater wells, an ever-increasing percentage of the landscape has been paved and covered with impervious surfaces, drastically altering the hydrologic regime that forms and replenishes the groundwater upon which the region depends. Historic land use maps of the Chino Basin in San Bernardino County exemplify this phenomenon, highlighting the type of rapid and intense urban development that has occurred in the State over the last 75 years. (Figure 6, showing a pronounced shift from agrarian to urban and residential uses.)

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[52] EPA (August 1999) Preliminary Data Summary of Urban Storm Water Best Management Practices, *available at* http://www.epa.gov/waterscience/guide/stormwater/#report.

[53] Chester L. Arnold, Jr. and James Gibbons (June 1996) "Impervious Surface Coverage: The Emergence of a Key Environmental Indicator," *J. of the Amer. Planning Assoc.* vol. 62 pages 243-258 at 244.

[54] *Id*.

[55] USGS, *supra*, note 9.

[56] DWR, *supra*, note 10.

[57] *Id*.

[58] *Id*.

[59] USGS (2003) Geohydrology, Geochemistry, and Ground-Water Simulation-Optimization of the Central and West Coast Basins, Los Angeles County, California, Water-Resources Investigations Report 03-4065, *available at* http://pubs.usgs.gov/wri/wrir034065/wrir034065.html.

[60] W.D. Mendenhall (1905) Development of underground waters in the central coastal plain region of southern California: U.S. Geological Survey Water Supply Paper 138

Land-Cover and Land-Use in the Chino Basin
1933-1993

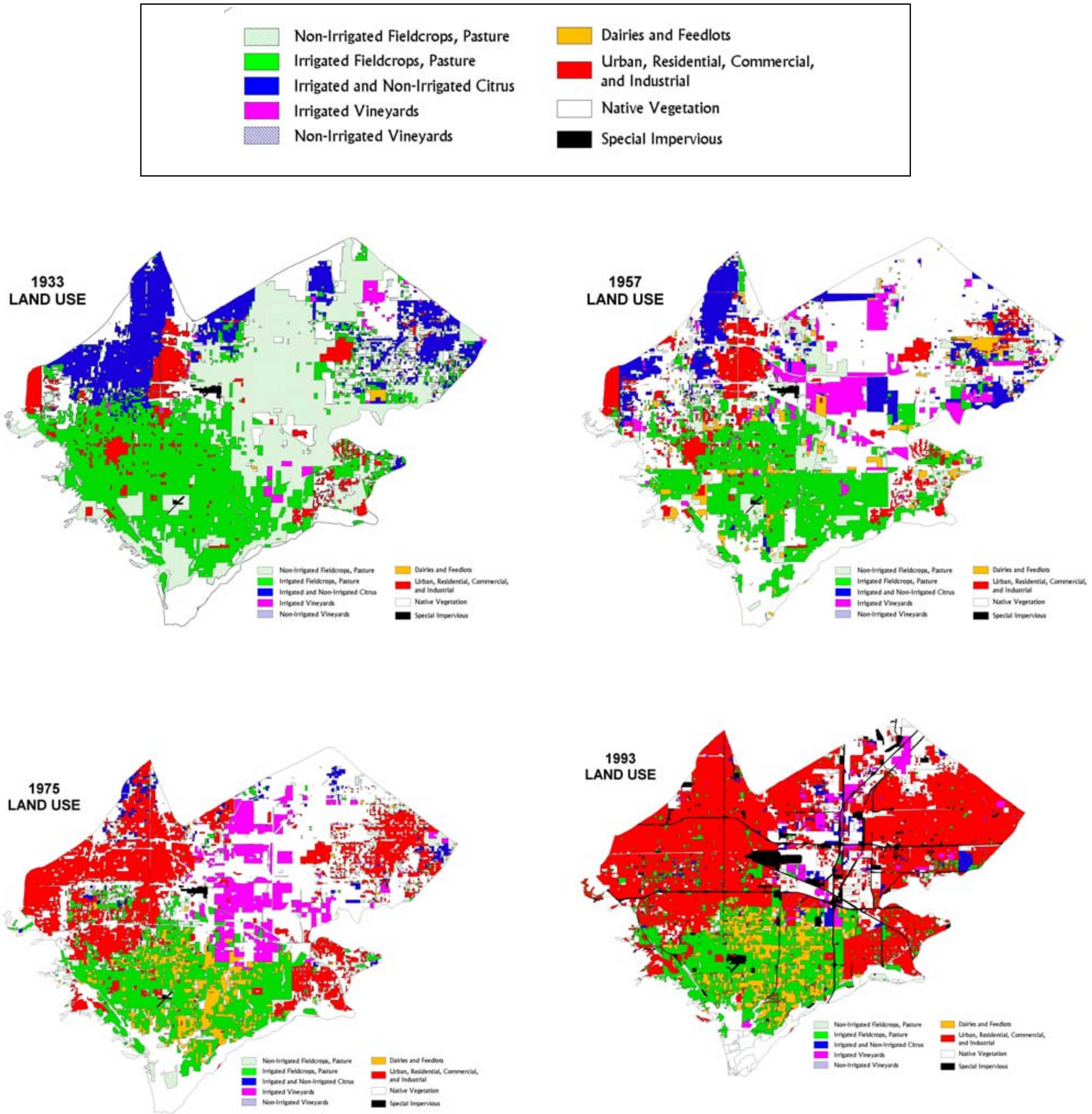

Figure 6. Source: Wildermuth Environmental[61]

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[61] Wildermuth Environmental, Inc. (August 19, 1999) Optimum Basin Management Program, Draft Phase I Report, prepared for Chino Basin Watermaster, *available at* http://www.cbwm.org/docs/engdocs/obmpphas1rep/Text/OBMP_Ph1_Report.pdf.

The large-scale shift from agrarian or open land to urban development depicted here is characteristic of large areas of the state, which has seen its population grow from 5.7 million in 1930, to over 36.5 million in 2006.[62] As discussed above, the accompanying increase in impervious surface unbalances the normal hydrologic regime, diverts precipitation from the ground surface, and threatens regional groundwater supply. However, LID practices that maximize infiltration can greatly reduce the threat to groundwater supplies, allow for natural recharge to resume, and augment local supplies of water. As a result, despite increased development and impervious cover, LID's ability to restore natural recharge conditions can offset the need for energy-intensive imported sources of water that might otherwise be required absent the implementation of LID.

Even in areas not traditionally viewed as having ideal conditions for groundwater recharge, LID can supplement local supply through infiltration. In the Los Angeles-Orange County coastal plain aquifer system, which the Los Angeles and Orange County Water Districts and the U.S. Geological Survey have characterized in detail by drilling wells, contrasting layers of highly permeable gravels and finer-grained deposits control the region's hydrologic characteristics and have resulted in large deposits of relatively shallow groundwater separated from the deeper, regional groundwater systems by the relatively finer-grained deposits.[63]

Generally, water purveyors have ignored the shallow aquifers that characterize portions of the basin, and "because of low yields and poor water quality, little water is pumped" from them.[64] But, the continually increasing need for viable water supplies has begun to shift thinking on the potential for obtaining water from these aquifers. According to Ted Johnson, Chief Hydrogeologist at the Water Replenishment District of Southern California, the water has not generally been used for domestic or irrigation supply in recent years, "but it could be done...the water could be extracted and treated as needed for use...reverse osmosis may be needed if the water is too mineralized, or activated carbon if there is volatile organic contamination, but these technologies exist. There are entities pumping out shallow groundwater right now for dewatering purposes and we are looking at putting that water to beneficial use instead of losing it to the ocean."[65]

For areas of southern California, such as large sections of San Diego County (where in addition to supply from the SWP, a desalination plant has recently been conditionally permitted for operation), that overlie relatively impermeable soils or that do not generally contain usable regional groundwater aquifers, the greatest potential water and energy savings may be realized by implementing water harvesting practices to offset the need for imported or desalinated water. This method, discussed below in the context of northern California, offers a widely applicable means of supplementing local water supply and reducing the need for imported water and its associated GHG emissions. Thus, regardless of the LID technique utilized, LID's potential to address issues of climate change argues for its required implementation under AB 32.

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[62] U.S. Census Bureau, *available at* www.census.gov.

[63] R. Yerkes, T. McCulloh, J. Schoellhamer, and J. Vedder (1965) Geology of the Los Angeles basin, California – An introduction: U.S. Geological Survey Professional Paper 420-A, 57 p.

[64] USGS, Water-Resources Investigations Report 03-4065, *supra*, note 59.

[65] Personal communication, email, July 10, 2008.

Northern California

The northern California study area includes all or portions of San Francisco County, Marin County, Contra Costa County, Alameda County, Santa Clara County, and San Mateo County. (See Figure 7, general region of northern California study area.) As the map in Figure 8 shows, desalination plants have been proposed to supplement water supply in areas supplied by agencies including the East Bay Municipal Utilities District, Contra Costa Water Agency, San Francisco Public Utilities Commission, and Santa Clara Valley Water District. The locations served by these Water Districts offer the greatest potential for energy savings because water supply from four planned desalination plants in the study area could be offset by using LID-based water harvesting practices, and form the focus of our northern California analysis. However, additional opportunities to use LID to reduce energy usage and GHG emissions exist throughout the San Francisco Bay Area, including in Napa County and Sonoma County, as well as to the south in the Monterrey Bay region (where an additional five desalination plants are currently proposed).[66]

Figure 7. Map of land use in northern California.

The potential use of ocean desalination represents a significant influx of energy-intensive water supply, the need for most or perhaps all of which could be obviated through the implementation

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[66] Heather Cooley et al., *supra*, note 8.

of LID. With limited exceptions (principally in Santa Clara County), water harvesting is more appropriate than infiltration in these areas for two main reasons. First, within the San Francisco Bay study area, except for Santa Clara County, water purveyors do not currently use groundwater as a large component of their supplies. Groundwater accounts for only about 5 percent (or 68,000 af/year) of the entire region's average annual water supply for irrigation and domestic use.[67] Extensive groundwater production does occur in the Santa Clara Valley,[68] where substantial opportunity for additional recharge exists. However, generally speaking there is no developed infrastructure to supply groundwater in the region, so implementing LID to supplement groundwater storage would not result in a near-term increase in water supply. Second, relatively impermeable soils underlie a substantial fraction of the San Francisco Bay Area,[69] and while local variation is likely to allow for some groundwater recharge to occur, in many instances, water harvesting would allow for greater water savings (and consequently greater energy savings) than infiltration.

Planned Seawater Desalination Plants as of 2006

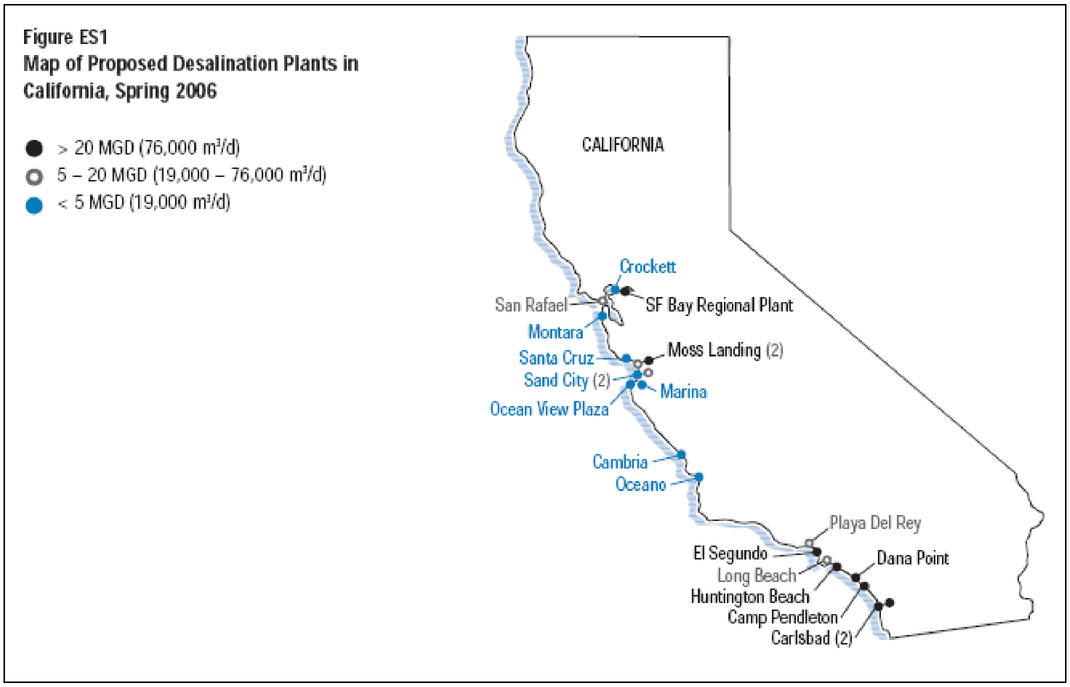

Figure 8. Source: Cooley, Heather, Peter H. Gleick, and Gary Wolff, 2006.[70]

Water harvesting is typically, though not exclusively used to capture rooftop runoff and can be applied at larger scales in commercial developments and residential subdivisions and at smaller scales using cisterns or rain barrels. Importantly for our analysis, studies have shown that

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[67] DWR, *supra*, note 10.

[68] *Id.*

[69] Richard R. Horner, *supra*, note 12. (Based on a survey of soils classified under the Natural Resources Conservation Service (NRCS) Hydrologic Soils Groupings, 39.3, 68.0, 18.3, and 50.1 percent of Alameda, Contra Costa, San Mateo, and Santa Clara Counties, respectively, are classified as having D type soils that are not generally amenable to infiltration.)

[70] Heather Cooley et al., *supra*, note 8.

harvesting is successful at reducing runoff discharged to storm drain systems and at conserving water for reuse at all scales and under a variety of conditions. For example, the King Street Center in downtown Seattle uses water captured from roof runoff to supply over 60 percent of the building's toilet flushing and irrigation requirements, saving approximately 4.3 acre-feet of potable water per year.[71] On a much smaller scale, the Carkeek Environmental Learning Center in Seattle drains rooftop runoff into a 3500-gallon cistern to supply toilets.[72] Given that the average roof at a residential or commercial development accounts for at least 40 to 60 percent of the site's total impervious surface area (and therefore 40 to 60 percent of impervious surface runoff), vast quantities of water are available for harvesting to offset the need for other, more energy-intensive sources of water.

Methodology and Results of NRDC Study

Our analysis found that, in the urbanized areas of southern California and limited portions of the San Francisco Bay Area alone, LID has the potential to result in savings of between 124,000 and 223,000 acre-feet of water per year by 2020, with a corresponding annual electricity savings of between 269,000 and 637,000 megawatt-hours (MWh). These figures increase to water savings of 227,500 to 408,000 af/year, and associated energy savings of 494,000 to 1,167,000 MWh/year by 2030, with savings continuing to increase thereafter with continued development. These savings represent a substantial opportunity to reduce GHG emissions under AB 32 given the practicable nature of LID, and the fact that current state and federal laws already require that discharges address the issue of stormwater runoff, in some fashion, even before any additional regulatory framework is implemented by the AB 32 process.

Methodology

The volume of water and associated energy savings and GHG emissions reductions were calculated based on separate analyses of both urbanized southern California and portions of the San Francisco Bay Area. The analysis evaluated land use data for all commercial and residential development within both study areas, and determined the average percentage of impervious surface for each designated land use type. (See, e.g., Figure 9, Map of impervious surface in southern California. Note the increased impervious coverage in areas such as downtown Los Angeles, Santa Monica, and San Diego.) Though LID practices are ultimately applicable to any land use or development type, we have limited our initial analysis of the potential water savings that may be realized to commercial and residential development due to the availability of data regarding future and re-development rates, discussed below. Impervious surface runoff from commercial and residential development was calculated based on average rainfall compiled from the NRCS 1961-1990 data set, averaged across each of the designated land uses, in order to determine the total volume of annual impervious surface runoff from the current distribution of specified land use types within the study area. Runoff was calculated based on a runoff coefficient for impervious areas of $C = (0.009) * I + 0.05$, where I is the impervious percentage (with I = to 100 percent for fully impervious areas).

Land use and impervious surface runoff totals were additionally calculated based on the underlying soil type from a combination of U.S. Department of Agriculture STATSGO soil data and NRCS SSURGO soil data, in order to determine infiltrative capacity of soil underlying each

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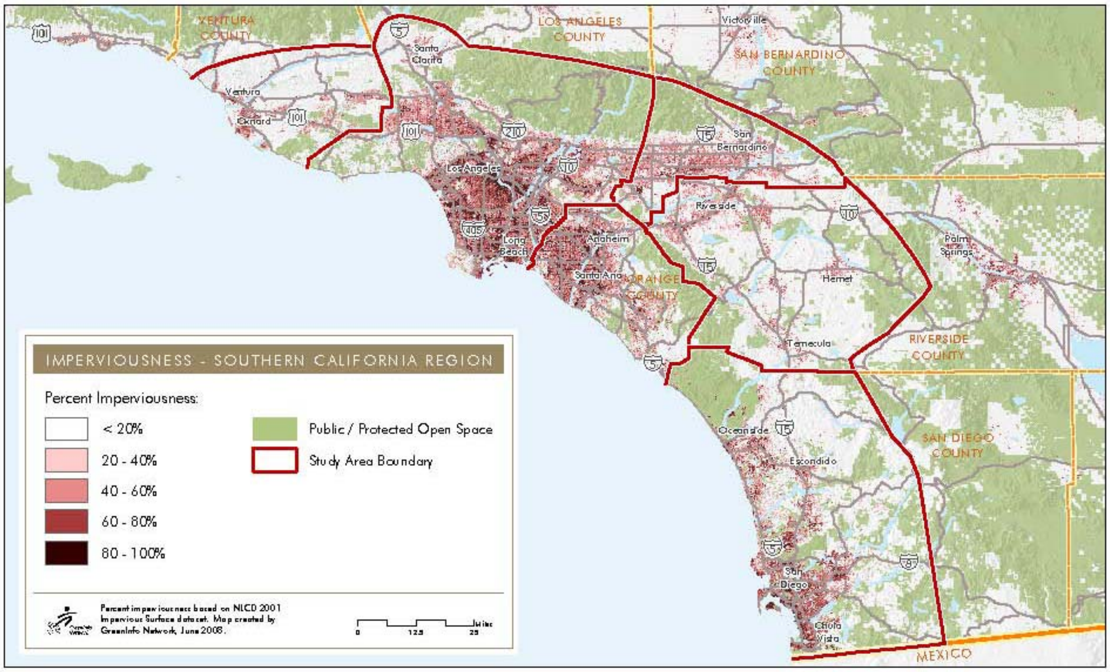
[71] *Id.*; see also http://www.psat.wa.gov/Publications/LID_studies/rooftop_rainwater.htm, http://dnr.metrokc.gov/dnrp/ksc_tour/features/features.htm.
[72] Anitra Accetturo (2005) Seattle Highlights Rainwater Harvesting at ARCSA 2005, *available at* http://www.harvesth2o.com/seattle.shtml.

land use type. Where infiltration and groundwater recharge was selected as the preferred method for increasing local supply, the study assumes that with adequate conditions, 100% of impervious surface runoff can be infiltrated to the ground surface (though depending on the estimate used, also assumes that a portion of this water will be lost to evapotranspiration). Where impervious surface runoff occurred over areas characterized as having D soils, or soils interpreted as not ideally suited for infiltration, water harvesting of rooftop runoff, rather than groundwater recharge was assumed to result in the greatest potential savings. Water from rooftop runoff was also used as the basis for calculating the potential water savings in areas of high impervious surface content, defined as areas greater than 10 acres in size containing contiguous impervious cover of greater than 80%. (E.g., downtown Los Angeles and San Francisco, both of which are characterized by high percentage of impervious cover.) Though these areas may in many instances encompass sufficient pervious cover to infiltrate a large percentage, if not the total volume of associated impervious surface runoff, we have assumed a conservative bias in characterizing the potential opportunities for groundwater recharge, and selected water harvesting as the preferred method under these conditions.



Percent imperviousness based on NLCD 2001 Impervious Surface dataset. Map created by GreenInfo Network, June 2008.

Figure 9. Map of impervious surface percentage in southern California study area.

In addition to precipitation based runoff, dry weather runoff stemming from human activities such as landscape irrigation and car washing was calculated within the southern California study area and Santa Clara portion of the northern California study area.   Dry weather runoff was calculated based on a figure of 0.152 gallons per acre of pervious surface per minute for residential and commercial land use types likely to include landscaped cover. This figure was derived from the “Residential Runoff Reduction Study” performed by the Irvine Ranch Water District,[73] and extrapolated to include commercial development for this study.

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[73] *Available at* http://www.irwd.com/Conservation/water_conservation_research.php.

Water savings for 2020 and 2030 were then calculated based on projected commercial and residential development rates for each county included within the study area. Development projections were provided by the Southern California Area Governments,[74] San Diego Association of Governments,[75] Association of Bay Area Governments,[76] California Department of Finance,[77] and national scale land use data.[78] Redevelopment rates were calculated based on an annual national "loss rate" of 1.37% for commercial buildings and 0.63% for residential structures.[79] These numbers are likely conservative, as the rate of development in the selected study areas exceeds national rates. This is particularly the case in light of the fact that the report forming the basis for these estimates states that, "In 2030, about half of the buildings in which Americans live, work, and shop will have been built after 2000."[80] However, based on these estimates, NRDC's study assumes that 100% of future development and redevelopment of commercial and residential property would be constructed using LID practices.

Energy savings were calculated based on reducing the volume of supply from the marginal, or highest, energy intensity source of water for each area within the southern California study area, and by reducing the use of ocean desalination water in northern California. In each instance, the volume of imported or desalination water to be offset was calculated to be reduced by the volume of water predicted to be either infiltrated for groundwater recharge or harvested through use of LID practices. In southern California, the marginal water source was determined based on a review of MWD member agency Urban Water Management Plans. The marginal source was determined to be the West Branch of the State Water Project for Ventura and one-half of Los Angeles County, and the East Branch of the State Water Project for one-half of Los Angeles County, Orange County, San Bernardino County, Riverside County, and San Diego County. Energy savings were thus calculated by determining the total amount of water to be recharged or harvested within the study area, then calculating the energy required to supply the same volume of water through the marginal supply source, less the energy required to supply the volume of water through either groundwater pumping or graywater recycling.

It should be noted that the estimates for both water savings and resultant energy savings presented here are conservative when compared to the actually available savings that may be achieved by employing LID, as the current analysis 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. Finally, the study does not take into account the loss rate for water supplied through the State Water Project or Colorado River Aqueduct. Both of these systems lose as much as 5 percent of the total water conveyed through a combination of evaporation and leakage during the course of transport, and the additional energy required to transport or pump this water has not been factored into the above calculations. There exists both

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[74] (2008) Integrated Growth Forecast, *available at* http://www.scag.ca.gov/forecast/index.htm.

[75] Demographics, *available at* http://www.sandag.cog.ca.us/index.asp?classid=26&fuseaction=home.classhome.

[76] See, e.g., ABAG Projections 2007: Regional Projections, *available at* http://www.abag.ca.gov/planning/currentfcst/regional.html.

[77] (July 2007) Population Projections for California and Its Counties 2000-2050, *available at* http://www.dof.ca.gov/HTML/DEMOGRAP/ReportsPapers/Projections/P1/P1.php.

[78] See, e.g., Arthur C. Nelson (2004) Toward a New Metropolis: The Opportunity to Rebuild America, Brookings Institution, Washington, DC, *available at* www.brookings.edu/dybdocroot/metro/pubs/20041213_RebuildAmerica.pdf.

[79] *Id*.

[80] *Id*.

a significant potential to expand the estimated volume of savings, and significant potential that the actual energy savings are greater than those presented here. As a result, these estimates should be considered to be an accurate, though conservative estimate of the total savings that would result from implementation of this measure.

Assumptions and Variables in Estimates of Water and Energy Savings Due to LID

Following from the above methodology, we present a low, medium, and high estimate for the potential water and energy savings that LID can produce under AB 32. This range reflects the unknowns and potential variability of individual factors that may affect both infiltrative and harvest capacity, as well as the energy requirements of local supply. However, we have assumed overall a conservative rate of development for the study areas and further limited our analysis to only commercial and residential properties. Thus, all of these estimates represent conservative values for the potential savings that widespread implementation of LID practices could achieve in California. Within that framework, we have considered the following factors in developing the estimates of water and energy savings:

- Percentage of runoff directed to infiltration and groundwater recharge but lost to evapotranspiration: A study currently being conducted by the Los Angeles-San Gabriel Rivers Watershed Council ("LASGRWC"), based on an infiltration model created by the U.S. Bureau of Reclamation, has shown that the evapotranspiration loss of water retained for onsite infiltration and groundwater recharge is minimal across various soil types and development patterns, often on the order of only 10 percent of the retained flow.[81] For the most conservative estimate, we have assumed that 30 percent of the water infiltrated onsite will be lost through evapotranspiration (reflecting a situation closer to pre-development conditions, in which 40 to 50 percent of water may be lost). For our middle estimate, we have assumed a 20 percent loss rate, and for the high estimate, a 10 percent loss rate.
- Percentage of roads to be developed as greenstreets: Surface roads and sidewalks account for as much as 20 percent of the total impervious cover in residential and commercial developments within the study area. As a result, the use of "greenstreets," or streetscapes designed according to LID principles, can significantly increase the volume of water available to augment local water supply through infiltration and recharge. In our low-end estimate, we assume that 50 percent of roads constructed in areas of new development will be engineered according to LID principles. In the medium estimate, we assume that 65 percent of roads in areas of new development and 25 percent of roads in areas of redevelopment will be engineered or resurfaced according to LID principles. In the high estimate, we assume that 80 percent of roads in areas of new development and 50 percent of roads in areas of redevelopment will be engineered using LID principles.
- Percentage of retrofitted development employing LID principles: In addition to calculating a rate of redevelopment within the study areas, we include an estimate for properties that will undergo a substantial retrofit or redesign that does not include a complete rebuild or re-construction of existing structures. We have assumed the rate of retrofitting of existing development to occur at the same rate as overall redevelopment within each of the study areas. However, in the conservative estimate we assume that only 25 percent of these structures will employ LID practices, while in the medium and

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[81] See generally, LASGRWC Water Augmentation Study, *available at* http://www.lasgrwc.org/WAS.htm.

high end estimates we assume that 50 percent of the retrofitted structures are re-engineered to incorporate LID practices.

- Percentage of impervious surface comprised of rooftop: While we calculate our results based on 100 percent recovery of water generated as rooftop runoff (with the remaining site runoff either directed to available pervious surface for infiltration or diverted to conventional storm sewer systems), the percentage of impervious cover present as rooftop surface area at any individual site varies significantly. However, an analysis of six different case studies of building permits in southern California found that rooftop surface averaged between approximately 40 percent and 60 percent of total impervious surface area at a given site.[82] As a result, our low end estimate assumes that water harvesting will occur from 40 percent of the impervious surface area onsite, the medium estimate assumes a 50 percent rooftop scenario, and the high estimate 60 percent of impervious surface as rooftop area.
- Energy required for extraction of infiltrated water by groundwater pumping: The energy required to pump and produce potable water through groundwater supply is determined by numerous factors, including depth of pumping and presence of salts or other mineral contaminants that may require treatment. As a result, there a wide uncertainty exists in calculating the energy requirements for augmenting water supply through groundwater recharge. Whereas pumping groundwater from large portions of the state, including the Tulare Lake region or West Basin of Los Angeles require only a few hundred kWh/af, groundwater production may require greater than 1500 kWh/af in the Chino Basin. As a result, we have assumed a moderate-to-high overall embedded energy requirement for groundwater production overall. For the low estimate, we assume a requirement of 750 kWh/af, and for the middle and high estimates, 500 kWh/af.
- Energy required for recycling of rooftop water harvesting: As with groundwater production, a wide range of potential energy requirements exists in order to provide water through rooftop recycling. We have reviewed a variety of graywater recycling systems, and find that, at low volumes for single family residences, recycling may require as much as 1,650 kWh/af, while at higher volumes, or for large scale commercial application, 700 kWh/af or less. It should be noted that in many situations, such as where water is harvested by gravity feed for subsequent use in subsurface irrigation, the net energy requirements of the system will be negligible, if not zero. However, and in order to maintain a conservative approach, for our low end estimate we assume an energy requirement of 1,650 kWh/af, for the medium estimate, 1,200 kWh/af, and for the high estimate, 700 kWh/af in order to produce recycled water for irrigation or toilet flushing.
- Local variation in soil type and infiltrative capacity: As a final variable, we recognize that there may be areas that we have identified as having the greatest potential savings supplied through infiltration and groundwater recharge (not including those areas designated as having a high percentage of impervious surface), for which water harvesting may ultimately prove to be a preferred method for augmenting water supply. In order to demonstrate that LID is capable of achieving substantial water savings and corresponding reductions in energy use and GHG emissions regardless of what LID practice is employed, we assume, in our low estimate, that 50 percent of Los Angeles County within the study area will augment water supply through infiltration, with the remaining 50 percent employing water harvesting to augment water supply. The medium

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[82] Richard R. Horner, *supra*, note 12.

estimate assumes 75 percent infiltration and 25 percent capture, and the high estimate assumes 100 percent use of LID practices that emphasize infiltration.

Again, we highlight that the assumptions made here reflect a conservative bias, and even in the high estimate, an accurate, possible scenario for real-world application of LID principles under AB 32.

Results of Study
Utilizing the methodology and factors detailed above, we present the following estimates for water savings and associated energy savings within the southern California and San Francisco Bay Area study areas:

PREDICTIONS FOR SOUTHERN CALIFORNIA
AND SAN FRANCISCO BAY REGION
COMBINED WATER SAVINGS
(Acre-feet per year, af/yr)

	2020	2030
Low	124,000	227,500
Med	172,000	315,000
High	223,000	408,000

PREDICTIONS FOR SOUTHERN CALIFORNIA
AND SAN FRANCISCO BAY REGION
COMBINED ENERGY SAVINGS
(Megawatt-hours per year, MWh/yr)

	2020	2030
Low	269,000	494,000
Med	439,000	804,000
High	637,000	1,167,000

Under these scenarios, and in light of the assumptions made in calculating each estimate, it can be seen that the ratio of energy saved per unit of water increases significantly from the low end estimate (2,170 kWh saved per acre-foot) to the high end estimate (2,860 kWh saved per acre-foot). This difference results from the lower requirements of energy supply for groundwater or water harvesting assumed in the high estimate, which we consider to more accurately reflect likely real-world conditions based on the research presented herein. However, and regardless of the difference in total water savings, total energy savings, or energy saved per unit of water, the results compel the same conclusion to be drawn—the use of LID presents a significant, and currently untapped opportunity to reduce the use of energy required to supply water in California, and should be strongly supported by CARB in the Scoping Plan under AB 32.

Cost of LID
Finally, we call attention to the potential cost savings that may result through the implementation of LID practices, and that LID presents a cost effective method for reducing GHG emissions under AB 32. The CEC commented in its 2005 *Integrated Energy Policy Report* that: "The Energy Commission, the Department of Water Resources, the CPUC, local water agencies, and

other stakeholders should explore and pursue cost-effective water efficiency opportunities that would save energy and decrease the energy intensity in the water sector."[83] By virtually every metric considered, LID has proven to be a cost-effective method of controlling stormwater runoff. "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."[84] Implementing LID practices also results in a suite of positive externalities, as "LID…provides ecosystem services and associated economic benefits that conventional stormwater controls do not."[85] Overall, LID easily meets AB 32's mandate to employ cost-effective measures for reducing GHG emissions, providing further reason for its inclusion in the Draft Scoping Plan.

Traditional stormwater management practices involve the construction of complex systems of curbs, gutters, buried drainage pipes, and centralized sewers. Since, as described above, LID attempts to mimic the pre-development hydrology of a site, emphasizing onsite treatment, infiltration, and use of a site's existing drainage conditions, "[c]ost savings are typically seen in reduced infrastructure because the total volume of runoff to be managed is minimized."[86]

Costs of LID implementation may still vary greatly, depending on site and/or project conditions, the capabilities and experience of the project's designers, and the specific practices or techniques implemented.[87] However, with only "a few exceptions," EPA found that, "Total capital cost savings ranged from 15 to 80 percent when LID methods were used" instead of conventional stormwater management techniques.[88] The savings identified in the studies documented by EPA are all the more remarkable considering that they consider only the costs of installation for LID and conventional controls; the savings do not reflect or in any way monetize the additional economic benefits that LID may provide, which may further reduce the cost of LID in relation to conventional controls. The EPA study fully acknowledged this fact and stated, for one of the "few exceptions" in the report, that "The significant cost for the rooftop rainwater collection systems" installed at the site "was assumed to be offset somewhat by savings on stormwater utility bills" that were not calculated into the cost of the project.[89]

As detailed in the section above, LID practices provide multiple benefits and advantages over conventional stormwater controls. While the majority of case studies and economic assessments of stormwater management, like the EPA survey, have focused solely on the installation costs of LID, there are numerous examples of the economically beneficial externalities that result from LID, including the following:

<u>Reduced Costs of Municipal Infrastructure/Control of Combined Sewer Overflows</u>

- A 2007 ECONorthwest study highlighted a 2004 report by Brewer and Fisher that detailed four case studies of LID projects, including two residential projects, a commercial development, and an elementary school. The 2004 report found that at all

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[83] California Energy Commission, *supra*, note 29.
[84] EPA, *supra*, note 3.
[85] ECONorthwest (November 2007) The Economics of Low-Impact Development: A Literature Review, *available at* http://www.econw.com/reports/ECONorthwest_Low-Impact-Development-Economics-Literature-Review.pdf.
[86] EPA, *supra*, note 3; HUD *supra*, note 2.
[87] ECONorthwest, *supra*, note 85.
[88] EPA, *supra*, note 3.
[89] *Id*.

four sites LID designs managed a significantly greater volume of stormwater than conventional controls, which resulted in reduced strain on and expenditures for the local municipal stormwater system.[90] For all four locations, the economic value of the additional stormwater storage provided by LID, which ranged from $17,424 to $167,270 per project, was significantly greater than any net cost to the developer.[91]

- A case study of the Beecher Water District in Flint, Michigan showed that, by disconnecting downspouts from home sites connected to the sanitary sewer, which cost the water district a total of $15,000, and allowing the water to infiltrate into the ground naturally, the mean volume of sewer flows measured across all precipitation events decreased by 26 percent. The program saved the water district $8,000 per month in stormwater fees, reduced the costs of managing combined sewer overflows ("CSOs"), and paid for itself in just two months.[92]
- An analysis of the effectiveness of LID practices in New York City determined that, per $1,000 invested, use of greenstreets controlled more than six times the volume of water, and capturing stormwater in rain barrels controlled nearly four times the volume of water, as did construction of conventional controls such as storage tanks and other traditional CSO measures.[93]

Increased Value of Real Estate

- In a residential subdivision constructed in Sherwood, Arkansas, using LID site designs preserved natural drainage areas, increased open space from the originally planned 1.5 acres to 23.5 acres, and allowed the developer to reduce street widths from 36 to 27 feet. The design techniques enabled the development of 17 additional lots, and lots in the subdivision subsequently sold for $3,000 more than comparable lots developed with conventional controls. This generated a profit of over $1.5 million for the developer, in addition to the $678,500 cost savings of LID compared to conventional designs.[94]

Further, the operation and maintenance costs of LID are low, and have been estimated at 3-7% of the total installation costs annually.[95] Much of the maintenance of LID features can be combined with or undertaken in the course of normal landscape maintenance. According to Neil Weinstein, executive director of the Low Impact Development Center, "The misrepresentation is that LID techniques are difficult to maintain and will fail if they aren't. But most of these techniques really require minimal to no maintenance, and still function very well if they aren't maintained."[96]

All of these aspects of LID implementation indicate that the GHG emission reduction potential of LID site designs can be realized practicably and cost-effectively, thus actually saving money for those involved with its implementation. The benefits as they currently stand would argue in favor of requiring LID implementation under the Scoping Plan. But, because LID practices still

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[90] ECONorthwest, *supra*, note 85.

[91] *Id.*

[92] *Id.*; M.M. Kaufman and M. Wurtz (1997) "Hydraulic and Economic Benefits of Downspout Diversion," *J. of the Amer. Water Resources Assoc.* vol. 33, pages 491-497.

[93] ECONorthwest, *supra*, note 85.

[94] EPA, *supra*, note 3; HUD, *supra* note 2.

[95] EPA, *supra*, note 3.

[96] Asa Foss (May/June 2005) Low Impact Development: An Alternative Approach to Site Design, PAS Memo, American Planning Association, *available at*, http://www.pathnet.org/si.asp?id=1592.

represent a new technology that has previously resulted in increased costs for learning, initial design, and installation,[97] "[a]s with any new approach, the cost of implementing LID will decrease as institutional experience increases and the benefits of using LID are realized in practice."[98] This future cost savings is exemplified by a recent City of Seattle greenstreet pilot project, which cost $850,000 to implement but included an "extensive budget for design and consulting with residents."[99] The manager of the City's surface water program stated, "You could take $200,000 off the price just from what we didn't know… The pilot phases that we are currently in are more expensive, but as the project becomes institutionalized, all the costs will come down. Even still, these projects are less expensive than standard projects."[100] LID will become only more cost-effective with time.

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 to reduce GHG emissions. To that end, LID, which has the potential to greatly augment local water supplies through infiltration to recharge groundwater and harvesting and thereby reduce the need to rely on energy-intensive imported or desalinated water, should be aggressively implemented under AB 32.

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[97] ECONorthwest, *supra*, note 85.

[98] U.S. Department of Defense (2004) Unified Facilities Criteria – Design: Low Impact Development Manual, Unifie Facilities Criteria 3-210-10, *available at* http://www.wbdg.org/ccb/DOD/UFC/ufc_3_210_10.pdf.

[99] Asa Foss, *supra*, note 96.

[100] *Id*.