ANALYSIS OF BARRIERS TO LOW IMPACT DEVELOPMENT IN THE NORTH COAST REDWOOD REGION, CALIFORNIA

by

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ABSTRACT

Analysis of Barriers to Low Impact Development in the
North Coast Redwood Region, California

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Stormwater runoff from development degrades receiving water bodies and alters their capacity to support life. Environmental planners are tasked with managing impacts from human land uses on ecosystem functions in order to meet water quality goals. However, conventional stormwater management practices aggravate development impacts, raising the need for a paradigm shift in stormwater management. Low Impact Development (LID) approaches to stormwater management can minimize impacts from runoff, and protect water quality and stream ecosystems by mimicking pre-development hydrology. Barriers to adoption, needs, and opportunities for LID on the North Coast of California were assessed through a comparative analysis of the North Coast and four other regions in the United States currently implementing LID. The analysis was based on literature review and on interviews with stormwater professionals in the five regions. The most significant barriers to LID found on the North Coast were institutionalized conventional practices, budget and staff constraints, and challenging local site conditions. The most significant regional needs identified to promote a shift toward LID were economic incentives, education and research, and regulatory and policy reform. Growing "regulatory-will" from the state and local level, and significant existing human capital

may provide opportunities to help spur LID uptake locally. Recommendations based on my study are that LID policy language be included in General Plans, codes, and ordinances. Standards and requirements for LID should be developed to be consistent on a regional scale. Additionally, local governments should take greater advantage of partnerships with local watershed groups, and universities to create LID educational opportunities.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Stormwater runoff is the leading cause of impairments to the country's waters (Environmental Protection Agency 2002a). Urbanization creates impervious surfaces, including roads, roofs, parking lots, and sidewalks, that disrupt watershed function by reducing infiltration and evapotranspiration, increasing runoff, and introducing pollutants to water resources (Water Environment Federation 1998). Land clearing and development activities compact or remove native soil, preventing infiltration and reducing water storage in the soil layer. Furthermore, vegetation removal reduces the amount of rain intercepted by the canopy and reduces evapotranspiration rates. A parking lot produces 20 to 90 times more surface runoff than a meadow or forest, respectively (Hinman 2005). As a result, given equal levels of precipitation, urban landscapes experience earlier storm peak flows of greater volume and velocity than undisturbed landscapes (Mount 1995, Water Environment Federation 1998).

Studies correlating impervious surfaces and watershed degradation have documented degradation impacts in stream channels with as little as 10% total impervious surface coverage in the watershed (Klein 1979, Booth et al. 2002, Moglen and Kim 2007). However, degradation can occur with any level of impervious surfaces depending on the geology, climate, biology, vegetation, topography, and land use in a watershed (Water Environment Federation 1998, Brabec et al. 2002, Booth et al. 2004,

Hershey et al. 2006). Stream degradation results from low-density rural development even where impervious surfaces are limited. Degradation can result from canopy removal and forestland conversion to pastures, lawns or agriculture, as loss of evapotranspiration and interception increase surface runoff (Booth et al. 2002). In rural areas with low-density development, changes in slope and canopy cover are better indicators of potential landscape degradation due to stormwater runoff than percentage of impervious cover (Water Environment Federation 1998, Gaffield et al. 2003). Understanding the impacts of land use change on watersheds is critical to stormwater management and to efforts to maintain natural drainage and healthy ecosystems (McHarg 1969, Booth et al. 2004).

All of the aforementioned impacts, when combined, can alter sediment supply and transport, increase temperatures and flooding, destabilize stream channels, and reduce summer base flows, leading to declines in biological health of aquatic systems (Mount 1995, Ward and Trimble 2004). At the same time, as indicated in Table 1, risks to public health increase because runoff often contains pathogens and chemicals that can contaminate seafood and recreational waters (Environmental Protection Agency 1994, Gaffield et al. 2003). For example, heavy metals, trash, and oil are commonly found pollutants from urban land use, whereas sediment, organic material, and high temperatures impair rural streams and rivers (CH2M Hill 2001).

Paradoxically, conventional stormwater management practices often exacerbate the problems caused by urbanization.

Table 1. Common pollutants found in stormwater runoff and typical pollutant sources (adapted from Environmental Protection Agency 1994)

Stormwater Pollutants	Sources
Coliforms, pathogens, bacteria	Human and animal waste
Cadmium	Fossil fuels, paint, batteries
Copper	Vehicle brake pads, pesticides, plumbing, gutters
Zinc	Tires, motor oil, galvanized iron
Lead	Vehicle exhaust, engines
Chromium	Air conditioning coolants, timber treatment
pH	Metals, cleaners
Sediments	Agriculture, construction sites, unpaved roads, timber harvest sites, sand and gravel storage
Nitrogen/ Phosphorous	Detergents, animal wastes, fertilizers, wastewater, organic matter
Oil/ Grease	Vehicles, industry, food preparation
Dioxin	Industry, pulp mills, lumber mills
Thermal pollution	Absorbed solar radiation on impervious surfaces

Conventional stormwater practices hail from the early twentieth century progressive era, when heavily engineered water systems emerged in the U.S., and focused on "taming the hydrologic cycle" (Gleick 1998). During this era, federal agencies such as the Army Corps of Engineers and the Bureau of Reclamation were charged with developing water resources for flood control, hydro-power, storage, and distribution (Mount 1995, Gerlak 2005). Water infrastructure engineering grew, especially in California, where by the 1970's, the majority of rivers had been dammed, levied, and channelized.

Conventional stormwater systems collect and convey water away from a site as quickly and efficiently as possible to reduce flooding hazards. Infrastructure, such as drain inlets, pipes, curbs, gutters, wet vaults, and outfalls quickly move storm flows into the nearest body of water. Such methods are readily implemented because they are reliable (Hinman 2005). Further, they are easy to model to ensure regulatory requirements are achieved. Installation and maintenance costs are standardized and easy to estimate. However, typical engineered stormwater infrastructure does not address either the on-site root causes of the problem, or impacts to aquatic health at the end of the pipe.

The emphasis on end-of-pipe treatments assumes that land use impacts on hydrologic function in a watershed can be accommodated and mitigated through engineered infrastructure. Yet collection and conveyance systems prevent infiltration and thus increase the peak volume and velocity of stormwater flows to receiving waters, with associated impacts including erosion, down-cutting of stream channels, downstream flooding and impairment of aquatic habitat, thus compounding the impacts of

development (Environmental Protection Agency 2002b, Rohrer et al. 2004). Degradation of receiving waters disrupts local economies dependent on productive fisheries and clean water for recreation. Ultimately, long-term costs of conventional stormwater management practices are shifted downstream (MacMullan and Reich 2007).

A more proactive approach would capture water on site, and thus reduce runoff volumes and pollutants in the first place. While this goal has not yet been achieved, the regulatory process has been moving in this direction. Under the Clean Water Act (Clean Water Act, Section 104, 33 U.S.C) that requires all waters to be "swimmable and fishable," Congress empowered the U.S. Environmental Protection Agency (Environmental Protection Agency), and subsequently the states, to implement programs to assess water bodies and guide planning to meet water quality standards. The National Pollutant Discharge Elimination System was included in the 1972 Clean Water Act amendments to regulate effluent from pollution point sources, such as industrial and municipal waste (Prahalad et al. 2007).

Under the 1972 Clean Water Act amendment, effluent standards for allowable amounts of pollutant discharge were set, but these standards only act to limit polluted discharges instead of eliminating them (Environmental Protection Agency 2002a). The 1987 amendments to the Clean Water Act authorized Environmental Protection Agency to address water quality impairments from nonpoint source pollution, including stormwater from construction, sewage treatment facilities, and municipal separate storm sewer systems (Parikh et al. 2005). The National Pollutant Discharge Elimination System stormwater program has operated in two phases. Phase I targeted large (> 100,000) urban

populations first and applied effluent standards as the regulatory tool. Then in 1999, Phase II extended National Pollutant Discharge Elimination System authority to address stormwater from cities and counties with populations under 100,000 that have municipal separate storm sewer systems, and construction sites of one acre or more (Barnard 2002). Phase II used a new regulatory approach by requiring management measures to be implemented, rather than applying effluent standards.

Each Phase II community is required to develop a comprehensive stormwater management plan that includes six minimum management measures: 1) public education and outreach; 2) public involvement; 3) illicit discharge detection and elimination; 4) construction site stormwater runoff control; 5) post-construction stormwater management in new and re-development; and 6) pollution prevention or good housekeeping for municipal operators (Nisenson and Molloy 2005). Municipalities must apply for a National Pollutant Discharge Elimination System stormwater permit every five years. While National Pollutant Discharge Elimination System Phase II program modifications began to focus on proactive approaches to reducing pollution, the program is an unfunded mandate, meaning that there is little funding support provided to municipalities to comply with the law (Keeley 2007). This is a significant problem for small governments with limited staff and funding.

The Clean Water Act is further limited in that it addresses stormwater quality and not stormwater quantity. Stormwater pollution is regulated by the pollutants found in runoff through limiting point source discharge through permits in the National Pollutant Discharge Elimination System program as described above, or through the Total

Maximum Daily Load Program. The Total Maximum Daily Load Program requires maximum concentration standards to be set for specific pollutants for a particular water body (Prahalad et al. 2007). The pollutant standards allow for a certain amount of pollution for each impaired water body. This regulatory approach is reactive in its focus on the quality of water bodies that are already impaired, when it is clear that stormwater runoff quantity and its associated pollutants are directly correlated with the type and intensity of land use in a watershed. However, land use is subject to state and local government authority and most federal government laws such as the Clean Water Act cannot directly regulate state, county, and municipalities' land use (Parikh et al. 2005).

For coastal states, there is additional legislation linking land use with nonpoint source pollution. In 1990, Congress enacted the Coastal Zone Reauthorization Amendments Section 6217, requiring coastal states to create nonpoint source pollution control plans for coastal watersheds with management measures for land use activities that degrade coastal waters and habitats (Environmental Protection Agency 2008). The Clean Water Act and the Coastal Zone Management Act together create a strong regulatory framework for protecting the nations' coastal waters, while allowing the states to choose how to comply with the law.

In California, the State Water Resources Control Board and the California Coastal Commission (Coastal Commission) have overlapping jurisdictions concerning coastal water pollution problems and oversee the management measures that work to reduce adverse impacts of stormwater runoff. The Porter-Cologne Water Quality Control Act is the State law that governs water quality and assigns overall responsibility for water

quality protection to the State Water Resources Control Board which in turn directs the nine statewide Regional Water Quality Control Boards to develop and enforce water quality standards within their boundaries. The Coastal Commission oversees compliance of actions in the coastal zone with the 1976 California Coastal Act. The Coastal Act provides resource protection within the coastal zone to prevent adverse impacts to marine resources, water quality, wetlands, and scenic resources. In 2000, the two agencies updated the statewide Nonpoint Source Pollution Control Plan in response to the Coastal Zone Reauthorization Amendments. This Plan, intended to comply with both Clean Water Act and Coastal Zone Reauthorization Amendments requirements, prescribes 61 management measures for controlling stormwater pollution by 2013 (State Water Resources Control Board 2000). The process is ongoing. Many major tasks have been addressed, but the agencies continue to identify areas for improvement as nonpoint source pollution continues to impair waterways (State Water Resources Control Board 2004).

Stormwater management has historically been implemented as an engineering undertaking. To address stormwater management practices comprehensively will require a paradigm shift from a dependence on conventional engineering approaches to ecological engineering which addresses both runoff quality and quantity (Graham et al. 2004). The conventional stormwater management paradigm emphasizes peak flow control to prevent on-site flooding. Ecological engineers, in contrast, focus on maintaining and emphasizing ecosystem services and using the least impacting means to achieve both ends. Differences in conventional and ecological engineering approaches

are presented in Table 2. Instead of the conventional mantra of "collect and convey" as the theme of stormwater runoff management with a focus on large storm events (e.g. 10-year or 100 year storm event), ecological engineers use volume control to "retain, detain, and convey" a range of precipitation events and manage the overall water budget. In addition, volume control is necessary to address the impacts caused by reduced infiltration and increased runoff (Graham et al. 2004).

Comprehensive stormwater management will require a paradigm shift in land use planning as well as in water infrastructure engineering. Furthermore, it is necessary for upstream development to be downstream-conscious. Water policy integration into all aspects of land use could lay the framework needed for a paradigm shift for stormwater management. Essentially, this will entail shifting from hardscape engineering (e.g. using hard materials such as pavement, pipes, curbs, and outfalls) to ecological engineering. In other words, employing a preference for ecological services over human-made structures that intend to act as nature would, and promoting land uses that take into account the functional limits of the landscape.

Low Impact Development (LID) for stormwater management is a growing movement in the U.S. that acts to restore the hydrologic function in watersheds and manage stormwater. Although the term LID was coined in Prince Georges County, Maryland in the early 1990's, LID techniques have been used for decades under different names, such as conservative design, stormwater source control, or sustainable urban drainage systems (Graham et al. 2004). By minimizing impacts of stormwater runoff from new development and re-development, LID can restore and protect ecosystems.

Table 2. Some differences between ecological engineering and traditional engineering (modified from Barrett 1999).

Category/ characteristic	Traditional Engineering	Ecological Engineering
Project goal	Single purpose	Multiple benefits
Benefits to the ecosystem	Low priority	High priority
Structures	Concrete, steel, human-made, "hard"	Landscape/aquatic features, natural, "soft"
Energy source	Fossil fuel combustion, electricity	Solar, gravity, plants, animals
Material movement mechanisms	Pumps, blowers, conveyors	Convection/gravity, plant/microbial processes
Processes	Human-driven, human-regulated	Natural, self-regulated
Climate and landscape setting	Relatively unimportant	Critical
Useful lifespan	Relatively short	Relatively long
Performance	Controlled	More variable
Robustness	Often low	Usually high
Operation & Management costs	High	Low
Land requirements	Low	High

Multiple benefits include reduced runoff volume and velocity, pollutant removal, groundwater recharge, increased aesthetic value from more green space and reduction of downstream flooding and capital costs for water infrastructure, such as bridges or larger culverts (Graham et al. 2004, MacMullan and Reich 2007).

Low Impact Development applies on-site management approaches that mimic ecosystem function. Source controls, measures that preserve open space, native vegetation, canopy cover, soils, and wetlands, integrate stormwater management at the initial planning stage of development to reduce runoff and maintain hydrological function of the landscape (Hinman 2005). Impervious surface limits, imposed through codes and ordinances, require developers to cluster building sites, design narrower streets, and disconnect impervious areas (Graham et al. 2004, Keeley 2007). Engineered treatment techniques include green roofs, permeable pavement, vegetated swales, and bioretention to reduce effective impervious surfaces in a watershed while also providing treatment of runoff. These practices improve water quality by filtering pollutants, and reducing temperatures, peak flows, and volume more effectively than conventional tools such as simple detention ponds (University of New Hampshire 2005, Horner et al. 2004, MacMullan and Reich 2007).

While LID is very promising, adoption of this approach has been slow. Federal legislation has been moving toward LID (Weinstein and Kloss 2009). Local and state governments across the U.S., as well as the Environmental Protection Agency, are progressively incorporating LID strategies into stormwater ordinances, programs, and policies. The Environmental Protection Agency has officially endorsed LID practices.

New federal laws, such as the Energy Independence and Security Act, require federal development projects to maintain the pre-development hydrograph (Environmental Protection Agency 2007, Weinstein and Kloss 2009). Such federal agency adoption and congressional mandates direct government agency staff to develop standards and policy for local governments nationwide. Yet "one size fits all" regulations often lack the specificity that is required for effective local implementation. However, California state regulations mandating LID may be imminent.

The State Water Resources Control Board and the Ocean Protection Council, a policy group established by the 2004 California Ocean Protection Act, both passed resolutions in early 2008 endorsing LID and are committed to sustainable water resources management (Ocean Protection Council 2008, State Water Resources Control Board 2008). State Water Resources Control Board is now requiring LID for large cities such as San Diego in the new Phase I National Pollutant Discharge Elimination System stormwater permits (Lucera 2008). Planning ahead, before strict regulations are handed down, may ease the transition for smaller communities and allow for a learning process to take place to ensure optimum implementation.

Federal and state directed regulations are often resisted by local jurisdictions, especially in areas where resources are not perceived as currently at risk, but proactive measures can help to prevent degradation (Smith and Giraud 2006). On the local government level, there are several challenges yet to be overcome to implement LID. These challenges fall into three broad categories that essentially represent the phases necessary for a paradigm shift in stormwater management.

First, since new and redevelopment projects must be reviewed and approved by local governments, the local government level is appropriate for implementing the LID paradigm shift. Existing policy and regulatory barriers in local codes and ordinances may inhibit or restrict LID practices (Weinstein and Tippet 2003, Wulkan 2007, Godwin et al. 2008). Further, it is critical to assess constraints and opportunities that influence local governments' ability to promote LID. White and Boswell (2007) studied innovation in local governments' response to the National Pollutant Discharge Elimination System Phase II mandate and found that governments with few resources had more difficulty preparing and implementing the required plans. Other studies identified lack of funding, staff training, and vagueness of regulatory language as barriers (Jenkins 1997, Gearheart 2007, Godwin et al. 2008).

Once local governments begin to embrace the idea of LID, a second category of barriers to a paradigm shift includes short-term obstacles that arise while LID is first being vetted within a community. These barriers arise during the transition from the status quo practices of conventional paradigm and learning, exploring, and developing alternative, ecologically informed practices in the new paradigm. Local governments and their advisors, including planners, engineers, developers, and contractors, are often unaware of LID options for stormwater management (Godwin et al. 2008). Providing assistance to local communities through outside technical review and analysis of code and polices may be the extra impetus governments need to apply LID in stormwater programs (Bradford and Gharabaghi 2004, Wulkan 2007, Godwin et al. 2008). Stormwater management professionals and the general public need to be informed about

the problems associated with stormwater runoff and about LID approaches to addressing them (Field 1996, Booth et al. 2004, California Water and Land Use Partnership 2006, White and Boswell 2007, Wulkan 2007, Godwin et al. 2008). Returning to natural drainage systems to manage rainfall and runoff may aid local governments in adapting to changes in climate, which is an important consideration for planners. Guidance materials, such as technical information, are needed to illustrate how LID is applicable on a local scale.

Finally, in the third phase of the paradigm shift, once there is agreement on using LID, barriers to on-the-ground implementation specific to local conditions will arise, including questions about the suitability of specific LID approaches (California Water And Land Use Partnership 2006, Dietz 2007) and the local availability of technical expertise to implement them (Graham et al. 2004, Wulkan 2007, Godwin et al. 2008). Therefore, another component to advancing LID project implementation may include providing incentive programs for developers and homeowners.

Addressing local challenges, concerns, and needs may aid local governments in proactively and efficiently achieving the goals of federal and state directives. To better understand how LID can be encouraged and incorporated into local policy, plans, and development projects, a local perspective is needed to explain local challenges, opportunities, and needs. Local governments represent the culture of an area and provide "a frame of reference that helps to orient and steer behavior" (Buitelaar et al. 2007, p 894). Creating change on the local level requires an understanding of the ecological,

socio-cultural, and economic context of the area. This determines which new policies are appropriate for the community.

The purpose of this study is to assess barriers and opportunities for LID at the local level in the North Coast redwood region of California. To conduct this assessment, I focused on the following questions: (1) What are hallmarks of successful stormwater management programs that are implementing LID across the country? (2) How does stormwater management on the North Coast compare with LID stormwater programs? (3) What barriers exist to implementing LID strategies on the North Coast? And, (4) what are potential opportunities for implementing a paradigm shift to LID?

STUDY SITE

Northern California's coastal redwood region (North Coast) extends from the Oregon border through Del Norte County to southern Humboldt County (Figure 1). Humboldt Bay, located in Humboldt County, supports salmon, crab, and oyster fisheries and is the largest estuary between San Francisco Bay in California and Coos Bay, Oregon. The landscape includes coastal sand dunes, coastal wetlands, upland redwood and Douglas fir forests, rural farmlands and ranches, and urban development (Resources Agency of California 2008). The average annual rainfall is 114-178 centimeters, in Humboldt and Del Norte Counties respectively. Rain is most frequent in winter, with low to moderate intensity storms occurring from November to April (Sawyer et al. 2001, Konrad and Burges 2001). Fog is abundant in summer. According to Hinman (2005) approximately 50 percent of annual rainfall in the Pacific Northwest is evaporated or intercepted. The climate is cool, with little seasonal variation in temperature. Steep slopes primarily consisting of sandstone, mudstone, and assemblages of the Franciscan formation characterize the uplands (USDA 2008). The bottomlands are composed of non-marine and marine terraces, with drainages filled by more recent alluvium. The steep topography of the uplands combined with medium textured soils, and local climate, contribute to high erosion rates.

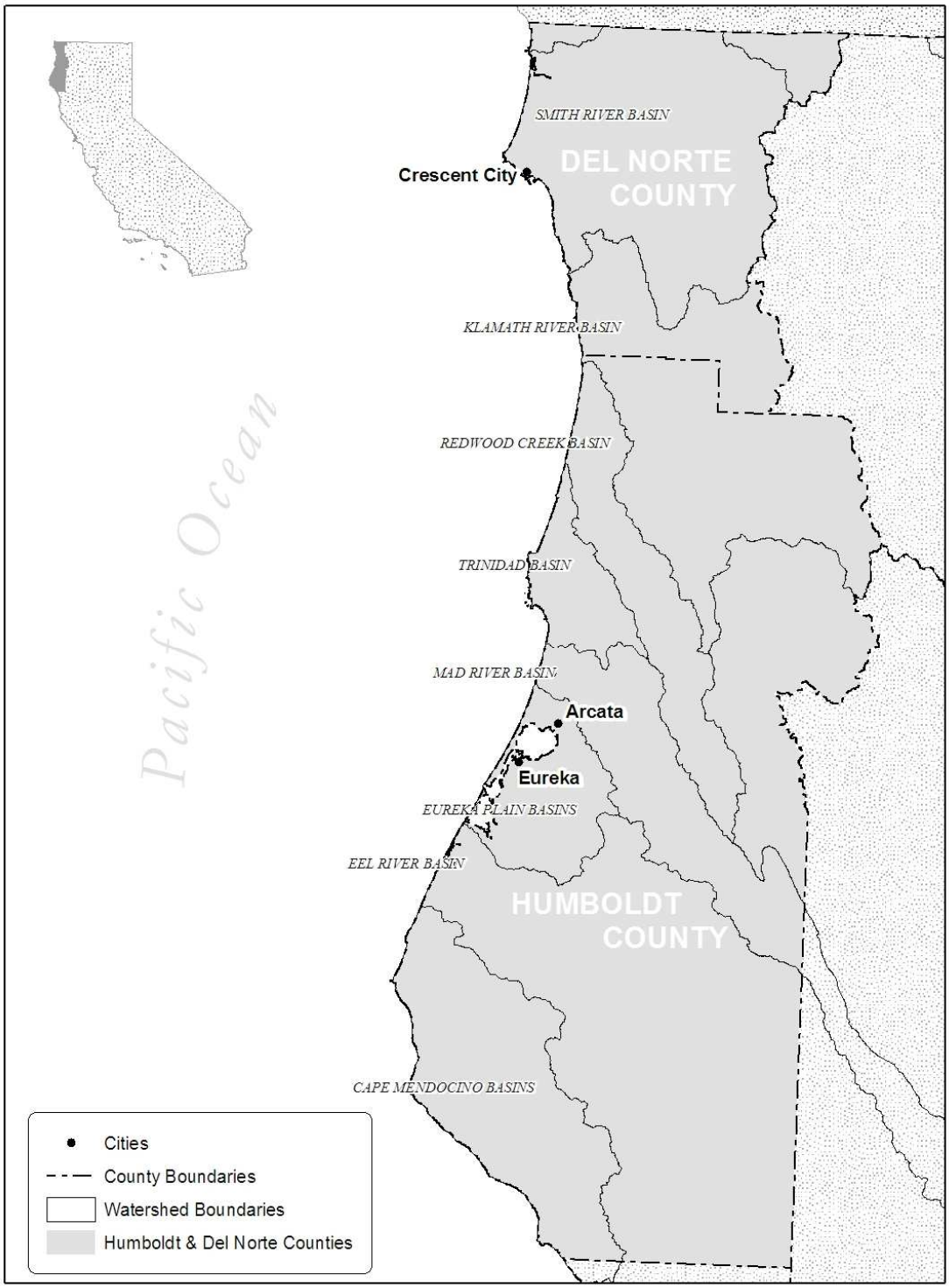

Figure 1. Map of North Coast Region (Map created by Brain Hugget).

The North Coast's natural resources are valued and have received special designations including: Areas of Special Biological Significance, International Biosphere Reserve, Critical Coastal Areas, wildlife reserves, refuges, wild and scenic rivers, and national and state parks (Resources Agency of California 1995, Resources Agency of California 2008). These designations are in place to protect, preserve, and enhance unique ecosystems and biota such as redwood forests, anadromous fish, offshore kelp beds, and migrating birds. Yet critical environmental concerns remain.

The region is plagued with impaired waters listed under the 303(d) section of Clean Water Act. Timber harvesting, the legacy impacts from thousands of miles of logging roads developed on highly erodible soils, agriculture, industry, mining, and urbanization have significantly increased the amount of sediment and pollutants released to rivers and the ocean. High water temperatures in streams are also a concern and reduced flows due to dams or diversions compound the problem. Tribal, subsistence, commercial, and sport fishing industries are dependent on Trinity and Klamath River salmon, as the annual population estimates for this fishery are a major factor in determining state and regional allowable harvest (Coon 2003). Fisheries, along with timber harvesting and milling, agriculture, aggregate mining, tourism, and restoration, drive the economy (Resources Agency of California 2008).

Decision-making on the local scale is, in part, driven by state mandates. The counties and municipalities on the North Coast are required to meet North Coast Regional Water Quality Control Board requirements for stormwater permits as well as water quality standards (State Water Resources Control Board 2009). The Coastal

Commission also has requirements for coastal water quality and habitat (California Coastal Commission 2002). Local governments must address coastal zone policies and standards in their general plans, or corresponding planning documents, to ensure compliance. Government staff and consultants develop the language for policies. The public, as well as the regulating agencies, have the opportunity to review and comment on proposed plans. It is up to local elected officials to approve policies and codes. Enforcement and compliance are delegated to appropriate government departments. In the case of stormwater, the Public Works, Engineering, Planning, and Community Development Departments all have a hand in management (Godwin et al. 2008).

Fortunately, the North Coast has relatively low human populations, with approximately 29,000 people living in Del Norte County and 132,000 in Humboldt County. The majority of people live in cities (California Department of Finance 2007). Low population density could allow for sound environmental policy to be set in place before major development occurs. To maintain, restore, and enhance the North Coast's water bodies, local governments must plan to manage future growth. Low Impact Development has been slow to infiltrate the North Coast' policies. While it is gaining recognition, challenges remain for full implementation. In communities across the U.S. where technical help has been provided to local governments, LID has been readily adopted and incorporated into practice. Such an approach would be timely as several North Coast municipalities and Humboldt and Del Norte Counties are currently updating their General Plans and Local Coastal Programs as well as developing stormwater programs to comply with federal and state mandates.

METHODS

In order to learn if and how local governments are making the shift from conventional stormwater management to LID, I reviewed literature on state and local government stormwater programs that have incorporated LID (Shoemaker et al. 2008). I selected four regions of the United States that share characteristics in common with the North Coast: 1) Puget Sound, Washington; 2) Florida; 3) Chesapeake Bay, Maryland; and 4) New England. These are referred as "model regions" in this study. Through comparative analysis of the literature, I identified key characteristics shared by stormwater programs promoting LID in the four model regions. While these may not be the only characteristics of successful programs, it is likely that they are factors that contribute to these programs' success. They are discussed in more detail below. The characteristics or factors were then assigned to the appropriate phases of paradigm change. The first phase, in which there is recognition that an existing paradigm is no longer working is labeled "policy development" to describe government uptake of LID. The second phase of exploring new practices is labeled "transition" to the new paradigm. Finally, in the third phase, there is acceptance of the new paradigm, and this is labeled "implementation". The allocation of successful stormwater program characteristics to paradigm shift phases created an analytical framework through which to assess successful LID adoption and implementation. Next, the relative significance of the analytical framework characteristics identified through the literature review was explored in a series

of six phone interviews with stormwater managers in the model regions. Interviews in the model regions served to validate the analytical framework and to identify operative barriers, needs, and opportunities related to the paradigm shift phases of LID policy development, transition, and implementation experienced in the model regions. This analytical framework was then used as a basis for evaluating stormwater management practices on the North Coast of California.

To identify barriers to and opportunities for LID policy development, transition, and implementation on the North Coast, I analyzed and reviewed stormwater plans, codes, and policies for North Coast jurisdictions. The jurisdictions included the cities of Arcata, Eureka, Fortuna, Ferndale, Trinidad, Crescent City, and Humboldt and Del Norte counties. Local codes including zoning, parking, stormwater, and land use requirements were reviewed. The Codes and Ordinance Worksheet developed by the Center for Watershed Protection was used as a reference tool (Appendix A, Center for Watershed Protection 1998). The Commonwealth of Massachusetts has developed a similar tool to guide review of local land use codes (Metropolitan Area Planning Council 2008). Both worksheets provide specific stormwater policies and standards to look for in documents. This includes requirements to collect and convey runoff or allow infiltration, or the design and appropriate number of parking stalls.

Finally, qualitative interviews with open-ended questions were used to gain insights into how local government staff and consultants charged with managing stormwater and policy development view their work, and how LID might be regulated and accepted within the community (Humboldt State University Institutional Review

Board Approval 07-57). Interview participants were chosen based on their professional experience working on stormwater management practices and policies. Government staff were targeted in the study areas, as well as developers and consultants. Thirteen participants from the North Coast were interviewed by phone or in person.

The interview guide approach was used to ask participants open-ended questions, such as "What barriers do you see to LID?" to allow participants to explain their own knowledge and experiences (Appendix B) (Patton 1990, Lofland and Lofland 1995). Follow-up questions to clarify responses were used when necessary and participants were allowed to guide the interview based on what was important to them. However, all interviews covered the same topics (Patton 1990). Interview durations ranged from 25 minutes to two hours.

Local interviews conducted in person were taped and transcribed. Comprehensive notes were taken during phone interviews and then written up immediately. Interview responses were systematically coded by hand and categorized to analyze themes, identifying broad commonalities, patterns, and differences (Lofland and Lofland 1995). Inductive content analysis was applied to interview responses based on recurring phrases, ideas, or themes. All interviews were coded in the same manner. Code consistency was maintained through repeated review and cross-validation of the data (Patton 1990).

Content codes were categorized into broader themes as either (1) barriers to LID acceptance, (2) needs or inputs necessary to overcome barriers, and (3) opportunities that support the shift toward LID. These categories were then grouped by the corresponding element of the analytical framework. Themes were tallied for frequency and then ranked

by the percentage of participants that named the theme in the interviews. Analysis of the differences between the North Coast stormwater management context and programs and LID programs in the model regions provided a basis for recommendations regarding LID implementation opportunities on the North Coast.

RESULTS

Model Regions Analysis

The model regions share several stormwater related problems. All four regions have polluted coastal waters, and recognize this as a significant problem to which stormwater run-off contributes. In addition, Puget Sound and Chesapeake Bay estuaries provide special habitat for species endemic to their regions. New England and Florida also have critical ocean fisheries. The recognition of a significant water pollution problem is developed by localities identifying reduced water quality, declining fisheries, and (or) reduced health and safety from contact with the water body. The model regions have combined sewer overflow systems that link sewer and stormwater infrastructure. This design allows wastewater to overflow into receiving water bodies when flows exceed capacity. These systems are different from the municipal separate storm sewer systems found in the North Coast, in which sewer and stormwater pipes are separated, sewer lines go to a wastewater treatment plant while stormwater pipes go to the nearest stream. The Environmental Protection Agency used this difference in infrastructure to prioritize implementation of strict regulation for the model regions to prevent sewage overflow into water bodies.

Through analysis of the literature and interviews with experts, seven factors were identified that are shared by all of the model regions that have been successful in achieving a paradigm shift in stormwater management. These factors are regulations,

funding mechanisms, human capital, research and technical development, collaborative partnerships, infrastructure, and incentives. Each factor and its relevance are briefly discussed below.

In all four regions, strong policies and regulations driving stormwater management have been put in place through state mandates and entities with authority to manage stormwater runoff. In both Florida and Washington, growth management acts drive planning. This type of act requires local governments to prepare local comprehensive plans, implement land development regulations, and efficiently use infrastructure (Planning Association of Washington 2006, Florida Department of Environmental Protection 2008).

Maryland has a state law requiring comprehensive land use plans. It also requires local jurisdictions to include their future plans for stormwater in their comprehensive land use plans. Maryland also requires an "As-Built" plan certification after construction of all stormwater management facilities to ensure projects were constructed to function as intended, as specified in the Maryland Stormwater Guidelines for State and Federal Projects (Maryland Department of Environment 2001). In addition, the Maryland Stormwater Management Act of 2007 requires "environmental site design," which entails using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources (Maryland Department of Environment 2007). All four regions have state departments that are responsible for carrying out the requirements of the Clean Water Act. In addition, the Puget Sound has the Puget Sound

Partnership, a non-regulatory agency charged with improving water quality conditions and promoting LID.

Funding was found to be essential to promoting LID. Local governments must be able to seek out, receive, and distribute funding to implement LID demonstration projects. Funds are needed to bring in technical expertise, to revise codes and regulations, and for LID implementation. The model regions have received funding from Environmental Protection Agency grants as well as from their respective states. Research funding also comes from programs such as Cooperative Institute for Coastal and Estuarine Environmental Technology (Traver 2007, University of New Hampshire 2005). Taxation is another option. Florida was one of the first states to implement stormwater utility fees to fund its stormwater management programs. Credits or fee reduction are offered if runoff is reduced (Lienhart 2003).

Human capital is especially important to drive the paradigm shift to LID. Human capital refers to individuals' capacity to lead and strengthen community, and to apply technical and interpersonal skills, and values (Flora and Flora 2008). People are needed to bring new ideas to the table, to take on the tasks of improving water quality, and lead the transformation in stormwater management. Innovation through human capital is a means to promote paradigm shifts, or changes in policy, since the decision- making process in government is iterative and can be time consuming. Jordan and Greenaway (1998) discussed 'policy oriented learning,' where paradigm shifts occur in an environment where current practices are failing to alleviate an identified problem. New information is gathered based on logic and values, and the "interplay and importance" of

bureaucracy and politics are used to solve the problem. The bases of policy development are the combination of learning and "networks of interaction" creating research and technical expertise to begin to break down the existing paradigm (Jordan and Greenaway 1998, p 670). The human capital component of the analytical framework refers to staff or other persons dedicated to promoting LID. The human capital category has overlap with the partnerships and technical development factors, as people are necessary for both.

In the Puget Sound, many people within cities, counties, state, and home builder associations have stepped up to promote and implement LID. Many Puget Sound counties have a LID coordinator as a staff position. Local conservation districts' staff provides landowners with free technical assistance on how they can improve the quality and quantity of runoff from their land using LID techniques (Puget Sound Partnership 2008).

In the Chesapeake Bay region, the former Director of Prince George's County Department of Environment developed LID concepts and practices together with the directors of the Low Impact Development Center, and the Center for Watershed Protection (Prince George's County 1999). In addition, many more forward thinking individuals in this region have made considerable contributions to the stormwater/water quality field (Schueler 2008).

In Florida, there is a statewide Stormwater Association and Task Force (Florida Stormwater Association 2006). In addition, researchers at several universities focus on LID. There are educational programs and government departments that employ staff who

promote LID (University of Florida 2009, Florida Department of Environmental Protection 2008).

New England is home to Nonpoint Education for Municipal Officials. Started at the University of Connecticut, Nonpoint Education for Municipal Officials is a national network dedicated to providing research and education linking land use and resource protection (Nonpoint Education for Municipal Officials 2008). In New England, universities and partnership groups provide leadership, research, and technical expertise. Massachusetts' Coastal Zone Management is employing smart growth techniques through the promotion of LID. Smart growth practices reduce impacts from development through compact development, reduced impervious surfaces and improved water detention, safeguarding environmentally sensitive areas, mixing land uses (e.g., homes, offices, and shops), transit accessibility, and better pedestrian and bicycle amenities (Environmental Protection Agency 2009).

Human capital is critical to research and technical development, as researchers complete the tasks necessary under this component of the analytical framework. Universities and other research entities are increasingly addressing local area research needs, monitoring effectiveness, and implementing adaptive management. These institutions also provide technical and scientific resources and education and training opportunities. In all four regions, university extension branches have taken on the applied research necessary for LID implementation. University of New Hampshire has established a Stormwater Center that researches LID best management practices on-site, and provides performance results compared with conventional practices (University of

New Hampshire 2009). Research entities produce technical guidance manuals, provide technical assistance programs to local governments, define goals and objectives, and maintain stormwater resources web pages with up-to-date research, information, and maintenance guidance (Puget Sound Partnership 2008, Nonpoint Education for Municipal Officials 2008, University of Florida 2009, University of New Hampshire 2009).

Model regions use strategic and collaborative partnerships to promote LID. Partnerships at the local level may include a wide range of stakeholders from public and private sectors who are involved in or may influence stormwater management. Together stakeholders discuss and identify issues and concerns, and build consensus on best management practices. Stakeholders can also use partnerships to leverage resources. For example, this can be done by combining funding and sharing staff time.

The Puget Sound Partnership exemplifies this collaborative approach. The Puget Sound Partnership includes local governments, tribes, watershed groups, home builders associations, universities, the public, and other participants. Kitsap County Home Builders Foundation has convened a leadership team. The leadership team includes planners, engineers, scientists, and other professionals from nearby jurisdictions who are charged with making decisions as to the structure and contents of the LID standards draft ordinance (Kitsap Home Builders Foundation 2008). Organizations discussed above under human capital also represent partnerships within their respective regions with local governments.

Infrastructure needs for LID refers to readily available supplies, such as permeable concrete or pavers, and compost to amend soils for bioretention systems -

essentially, materials used to construct LID systems. Infrastructure also refers to the need for designers and installers able to construct engineered LID treatments correctly. In the urbanized areas of the model regions, many products are likely available. For example, soil amendments for bioretention are used to increase soil permeability and have location-specific ingredients, requiring research to achieve the right specifications. In the Puget Sound, the University of Washington has created a compost mix that is widely available for the region. Training for installers is available and ongoing in all regions. However, in the Puget Sound, the effort is very focused and directed with continuous trainings offered to installers for LID implementation (Puget Sound Partnership 2008).

Incentives are means to encourage installation of LID instead of conventional systems. Examples of incentives may include faster permit review time, density bonuses that allow more development on a lot than standard zoning, or stormwater utility fee reduction. Washington, for example, uses strict flow control regulations. This means that to meet regulatory standards using conventional stormwater management, a developer would be required to install expensive and space consuming detention ponds on a site. Using LID, small, distributed stormwater treatments would be applied that consume less land than conventional stormwater management. Stormwater credits to reduce stormwater utilities are another form of incentive (Lienhart 2003, Bradford and Gharabaghi 2004). The Puget Sound Partnership has developed a table of incentive options that local governments may offer for LID including public recognition programs, property tax reduction, and reduced application fees for development permits (Puget Sound Partnership 2005).

These seven factors shared by the model regions' stormwater management programs suggest an analytical framework for a paradigm shift from conventional practices to LID for stormwater management. In Figure 2 the phases of the paradigm shift are overlaid with the seven factors of the analytical framework. As illustrated, the phases of the paradigm shift overlap with the components of a successful program. Overlap of paradigm shift phases is due to the fact that several components play a part in different phases. For example, funding mechanisms and human capital are part of the initial policy development phase of recognizing that the existing paradigm of stormwater management is no longer working. These same factors are also part of the transitional phase that requires exploration into new practices as funding and human capital are necessary to drive change at the policy level, and to continue to bring change during the transition to a new practice. Research and technical development and partnerships components are part of the transition phase of the paradigm shift as well as the implementation phase of the new paradigm, as research and technical development are necessary to provide information for the transition, as well as improve implementation measures. Partnerships are necessary during the transition phase to bring interested parties together who will bring about the paradigm shift, as well as to maintain the shift and ensure information is distributed throughout the learning and implementation process.

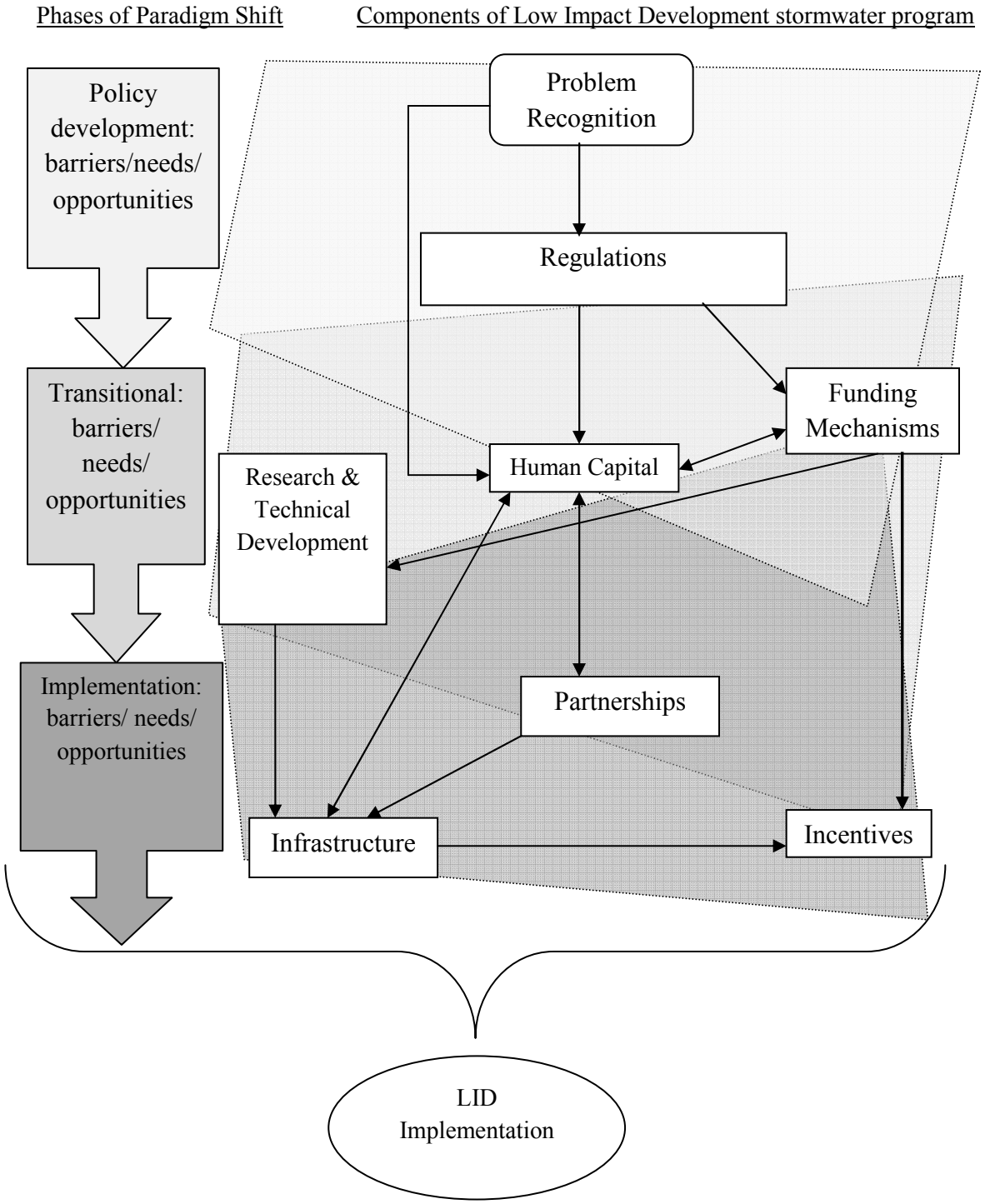

Figure 2. Analytical framework used to assess Low Impact Development stormwater programs overlaid by the phases of a paradigm shift. Elements of the framework were derived from model region LID programs.

Model Regions and North Coast Interview Results

The model regions' interviews validated the components of the analytical framework. Interview participants from the model regions worked for government departments implementing LID programs, non-governmental organizations researching LID, and a home builders association. North Coast participants also worked for government departments that were charged with managing stormwater, as well as stormwater consultants, and a building contractor. The same key themes that were identified in the model regions were identified in the interviews with stormwater experts on the North Coast. However, the significance rating for the themes varied. Interview themes were grouped by components of the analytical framework and further categorized as barriers, needs, or opportunities to the paradigm shift. The tables provided represent broad themes discussed during the interviews and compare the results from the model regions and the North Coast.

Themes which correspond with the regulation category of the analytical framework are found in Table 3. Bureaucratic processes that prohibit, or make LID difficult to incorporate into project designs were reported by five of six of the model regions respondents as a highly significant barrier, whereas seven of the 13 North Coast respondents reported the same barrier. Regulations or codes that prohibit or inhibit LID practices were again reported by five of six of the model regions respondents as a highly significant barrier. Five of the 13 North Coast participants reported regulations as a low significance barrier.

Table 3. Comparison table of model regions and North Coast regulation themes regarding Low Impact Development for stormwater management.

	Model Regions			North Coast		
Themes	Relevance[a]	Frequency[b]	Significance level[c]	Relevance[a]	Frequency[b]	Significance level[c]
Barriers						
Bureaucratic Barriers	83%	14	High	54%	17	Medium
Regulatory Barriers	83%	13	High	38%	12	Low
Conventional practices institutionalized	66%	8	High	69%	20	High
Jurisdictional Barriers	33%	4	Low	31%	6	Low
Needs						
Regulations and/or Guidance	83%	19	High	62%	32	Medium
Opportunities						
Growing regulatory will	83%	10	High	69%	21	High

[a]: Percentage of interview participants that discussed theme.
[b]: Number of times theme was discussed throughout all interviews.
[c]: More than 65% of participants discussed theme = high; less than 65% and more than 45% of participants discussed theme = medium; less than 45% of participants discussed theme = low

The barrier that conventional practices are institutionalized within the current regulatory framework and standard stormwater practices is an aspect of bureaucratic process that was specifically mentioned by four of the six respondents from the model regions; nine of North Coast respondents also reported and frequently discussed this same barrier. Finally, while not as significant as the regulatory and bureaucratic barriers, two model regions' respondents and four North Coast respondents also indicated that jurisdictional boundaries could be challenging. Jurisdictional barriers arise where political boundaries do not correspond to their underlying watersheds or where there is jurisdictional overlap between various government agencies.

Five of six model regions' participants and eight of 13 North Coast participants identified the need for regulations that encourage and promote LID over conventional practices. They noted that along with regulations, guidance on implementation for local communities is needed if regulations come down from the top levels of government. Clearly defined LID rules and standards are needed because, as I heard several times, "developers just want to know what to do and what the rules are." All but one of the model regions' participants and nine of the North Coast participants described opportunities for LID through growing regulatory-will, which provides opportunities for LID implementation as government agencies and departments recognize the benefits of LID and wish to see it incorporated into projects and policies.

Funding was mentioned but was not a highly significant concern for respondents from the model regions. Two of the six model regions' respondents identified funding

barriers in terms of staff and budget constraints because shifting to LID requires staff time and money to plan and implement (Table 4). Nine of the North Coast participants frequently discussed budget and staff constraints as a significant barrier. Participants recognized the difficulties small governments with limited budgets have in updating plans and codes to incorporate LID. Maintenance requirements were mentioned but were not perceived as a significant barrier in the model regions as only one participant mention this barrier. Six North Coast participants discussed maintenance requirements as a barrier.

Model regions' respondents discussed the *need* for funding more often than funding as a barrier, whereas five of the North Coast participants discussed funding needs versus the nine participants that discussed budget constraints. The semantics of funding as a need or barrier are subtle but important. As an illustrative example, a participant that discussed funding as a barrier would in general say "we do not have funding to implement LID programs", alternatively another would say "we need funding to implement LID"; the subtle difference being that the participant discussing the barrier of funding may see a shift to LID as relatively hopeless in contrast to the participant who seems ready to implement LID while recognizing a challenge in the need for funding.

Table 4. Comparison table of model regions and North Coast funding themes regarding Low Impact Development for stormwater management.

	Model Regions			North Coast		
Themes	Relevance[a]	Frequency[b]	Significance level[c]	Relevance[a]	Frequency[b]	Significance level[c]
Barriers						
Budget and staff constraints	33%	3	Low	69%	25	High
Maintenance requirements	17%	3	Low	46%	14	Medium
Needs						
Funding	66%	10	High	38%	11	Low

[a]: Percentage of interview participants that discussed theme.
[b]: Number of times theme was discussed throughout all interviews.
[c]: More than 65% of participants discussed theme = high; less than 65% and more than 45% of participants discussed theme = medium; less than 45% of participants discussed theme = low.

Four of the six model regions' respondents and nine of 13 North Coast respondents recognized human capital explicitly as a significant element in LID efforts (Table 5). Human capital was discussed only as an opportunity, no barriers, or needs were identified. Participants described available human capital as the means used to create partnerships to collaborate with public and private sectors to effectively and efficiently promote LID.

Barriers to expanding focused LID research and development focused on LID stem from the fact that LID is still new and untested in many areas, according to four of six model regions' respondents and eight of 13 North Coast respondents (Table 6). Participants explained that since stormwater management has focused on conventional methods, many questions and technical difficulties arise when implementing LID. These include at a very basic level: What is LID? Where is LID appropriate? How are LID techniques best designed and to what specifications? An additional factor noted was that site-specific conditions, such as high groundwater, and soil types may initially deter LID until technical expertise overcomes local challenges. The LID unknowns lead naturally to the need for education and research as recognized by all participants in the model regions and by 10 of the 13 North Coast participants. All of the model regions' participants and nine of the North Coast participants discussed the need to engage stormwater professionals on stormwater problems. Five out of six model regions' participants specifically identified engineers as slow to change from conventional practices. This theme was not discussed by the North Coast participants.

Table 5. Comparison table of model regions and North Coast human capital themes regarding Low Impact Development for stormwater management.

	Model Regions			North Coast		
Themes	Relevance[a]	Frequency[b]	Significance level[c]	Relevance[a]	Frequency[b]	Significance level[c]
Opportunities						
Human capital available	66%	10	High	69%	28	High

[a]: Percentage of interview participants that discussed theme.
[b]: Number of times theme was discussed throughout all interviews.
[c]: More than 65% of participants discussed theme = high; less than 65% and more than 45% of participants discussed theme = medium; less than 45% of participants discussed theme = low.

Table 6. Comparison table of model regions and North Coast research and technical development themes regarding Low Impact Development for stormwater management.

	Model regions			North Coast		
Themes	Relevance[a]	Frequency[b]	Significance level[c]	Relevance[a]	Frequency[b]	Significance level[c]
Barriers						
LID unknowns	66%	10	High	62%	22	Medium
Site specific characteristics	66%	7	High	62%	18	Medium
Needs						
Education and research needed	100%	35	High	77%	33	High
Stormwater fields to engage	100%	16	High	69%	23	High
A. Engineers	83%	8	High	-Theme not found	-	-
Information and process on how to implement	83%	18	High	46%	12	Medium
Opportunities						
Documents and actions in place	50%	10	Medium	54%	19	Medium

[a] Percentage of interview participants that discussed theme.
[b] Number of times theme was discussed throughout all interviews.
[c] More than 65% of participants discussed theme = high; less than 65% and more than 45% of participants discussed theme = medium; less than 45% of participants discussed theme = low.

Half of the model regions' participants and seven North Coast participants discussed the opportunity of 'documents and actions in place' which describe LID guidance tools, or activities such as programs to help local governments update codes, and research identifying how and where LID is appropriate on a local scale.

Participants identified partnerships as critical, requiring people to work together, rather than as individuals, to bring about the transition to, and implementation of LID (Table 7). All of the model regions' participants discussed establishing partnerships as a major need that requires use of human capital to increase communication and coordination among stakeholders. Seven of the North Coast participants also discussed the need to communicate and coordinate with stakeholder to establish partnerships. All of the model regions' participants indicated that collaboration among public and private sectors created opportunities to bring diverse groups to the table to discuss and explore LID. The opportunity of collaboration was not discussed by the North Coast participants. Barriers to partnerships were not discussed.

All model regions' respondents and six of the North Coast participants noted that infrastructure demonstration models are critical to the shift toward LID (Table 8). Four of the six model regions' participants also noted the importance of LID treatment systems being installed correctly, as badly constructed LID can discourage its use and acceptance. Carrying out inspections during all phases of construction, and requiring contractors to be certified through local programs were also identified. The North Coast participants did not discuss this theme.

Table 7. Comparison table of model regions and North Coast partnership themes regarding Low Impact Development for stormwater management.

	Model Regions			North Coast		
Themes	Relevance[a]	Frequency[b]	Significance level[c]	Relevance[a]	Frequency[b]	Significance level[c]
Needs						
Communication and coordination	100%	16	High	54%	16	Medium
Opportunities						
Collaboration among government, private, and public	100%	25	High	Theme not found		

[a] Percentage of interview participants that discussed theme.
[b] Number of times theme was discussed throughout all interviews.
[c] More than 65% of participants discussed theme = high; less than 65% and more than 45% of participants discussed theme = medium; less than 45% of participants discussed theme = low.

Table 8. Comparison table of model regions and North Coast infrastructure themes regarding Low Impact Development for stormwater management.

	Model Regions			North Coast		
Themes	Relevance[a]	Frequency[b]	Significance level[c]	Relevance[a]	Frequency[b]	Significance level[c]
Needs						
Demonstration to prove LID	100%	11	High	46%	17	Medium
Need for LID treatments to be properly installed	66%	4	High	Theme not found		
Opportunities						
Potential means to implement LID	66%	11	High	77%	31	High

[a] Percentage of interview participants that discussed theme.
[b] Number of times theme was discussed throughout all interviews.
[c] More than 65% of participants discussed theme = high; less than 65% and more than 45% of participants discussed theme = medium; less than 45% of participants discussed theme = low.

Four of the six model regions' respondents noted that opportunities to implement LID have been created through capital improvement programs, new staff positions, incentive programs, and strategic partnerships. Ten North Coast participants discussed the potential for LID to be implemented through the same means described by the model regions' participants.

Half of the model regions' participants recognized a lack of incentives as a barrier to LID, and all specifically identified the need for an economic driver to encourage implementation of LID (Table 9). Participants explained that simply informing developers that LID can reduce construction expenses for gutters, pipes, and land area for ponds can go a long way. More formal incentives such as density bonuses for development may also work in some cases. North Coast participants did not discuss the barrier of lack incentives but 10 did discuss the need for an economic driver to encourage LID. Four of the six model regions' respondents noted that local governments are realizing multiple benefits from LID implementation. Reduced runoff for example, alleviates stress on aging infrastructure. As model regions create more opportunities, local governments are realizing multiple benefits from LID implementation. Additionally, LID was also identified in model regions interviews as a means to help meet Total Maximum Daily Load requirements for impaired watersheds under the Clean Water Act, as well as a means to increase groundwater recharge, and mitigate for climate change. The opportunity of multiple benefits was not discussed by the North Coast respondents.

Table 9. Comparison table of model regions and North Coast incentive themes regarding Low Impact Development for stormwater management.

	Model Regions			North Coast		
Themes	Relevance[a]	Frequency[b]	Significance level[c]	Relevance[a]	Frequency[b]	Significance level[c]
Barriers						
Lack of incentives	50%	3	Medium	Theme not found		
Needs						
Need economic driver	100%	15	High	77%	25	High
Opportunities						
Multiple benefits received from implementing LID	66%	14	High	Theme not found		

[a] Percentage of interview participants that discussed theme.
[b] Number of times theme was discussed throughout all interviews.
[c] More than 65% of participants discussed theme = high; less than 65% and more than 45% of participants discussed theme = medium; less than 45% of participants discussed theme = low.

North Coast Regulatory Document Review

The review of representative local governments' policies and stormwater plans, specifically three municipalities, one unincorporated town, and both Humboldt and Del Norte Counties, indicated that conventional stormwater management approaches dominate on the North Coast. However, there are several exceptions in which cities are beginning to allow and even encourage LID. On the North Coast, the National Pollutant Discharge Elimination System municipal and construction permits are the critical drivers enforcing stormwater management. However, low population densities on the North Coast limit the reach of the National Pollutant Discharge Elimination System permit regulations. Several of the local governments, such as the cities of Eureka, Arcata, Fortuna, and unincorporated McKinleyville, and Shelter Cove are included in Phase II of National Pollutant Discharge Elimination System. However, Del Norte County and the smaller cities and towns in Humboldt County fall below the urban requirement and are not so closely regulated. Yet Del Norte County's stormwater infrastructure is at capacity and county representatives indicated that they are considering LID as a means to reduce impacts on their aging system.

The North Coast Regional Water Quality Control Board requires Humboldt State University and College of the Redwoods to develop Stormwater Management Plans per National Pollutant Discharge Elimination System as non-traditional Phase II entities. The North Coast Regional Water Quality Control Board also promotes and recommends LID to all North Coast National Pollutant Discharge Elimination System permit holders and

has informed the permittees that LID best management practices will be expected in the next round of permitting.

Although California requires all counties and municipalities to complete a general plan, water planning is optional (California Governor's Office of Planning and Research 2003). Nevertheless, several local governments have developed drainage plans in addition to general plans. Drainage plans are primarily examples of conventional stormwater management focused on flood control using conveyance, pipes, culverts, and outfalls.

Initial steps towards LID are being undertaken. The city of Eureka has recently adopted a LID guidance manual. The cities of Eureka and Arcata have reviewed their codes and ordinances to allow LID in projects, yet curbs and gutters were still required. Other communities have policies that range from ignoring stormwater runoff completely, to not inhibiting LID, to requiring conventional practices.

Del Norte County and its major municipality, Crescent City, are currently undergoing general plan updates but maintain codes which require curbs and gutters to collect and convey stormwater runoff. Humboldt County's General Plan was being updated with a water element. One of the three policy language options currently considered for the Humboldt County General Plan contains policies that encourage LID. However, even this option does not name or encourage all LID-like policies or requirements such as canopy cover retention. The other proposed policy options open for consideration do not mention LID. None of the communities require LID in their policies or codes.

DISCUSSION

The North Coast results indicated that momentum was building to create a shift to LID. This was shown through the high percentage of respondents indicating growing regulatory will, available human capital, and potential means to implement LID. It was also clear that there are some key differences in assessment of barriers to LID and needs and opportunities for LID between the model regions that have already shifted toward implementing LID, and the North coast communities that were embarking on this path. Local communities of the North Coast viewed the relatively clean waters, salmon populations, as well as the rural character of the region, as an asset (Humboldt County Planning Division 2008, Del Norte County 2003). This perception encourages stream restoration, which has become a significant contributor to the local economy (Baker 2004), but does not necessarily drive stormwater management. Although, there were examples where restoration and stormwater management overlap, such as floodplain restoration to reduce stormwater flooding.

On the North Coast, the most significant barrier under the regulation themes found in Table 3 was that conventional practices are institutionalized. While bureaucratic and regulatory barriers were found to be most significant with the model regions' participants, regulatory barriers were rated as low significance by North Coast participants. These differences between the North Coast and model regions were likely due to the level of progress in undergoing the paradigm shift to LID. Conventional

stormwater practices are a well-established practice on the North Coast, and these practices remain embedded within codes and standards practiced by the local jurisdictions.

The model regions are beginning to overcome the institutionalization of conventional practices and work towards LID. The model regions are required to comply with strict standards set by Phase I of the National Pollutant Discharge Elimination System program. Strict regulations have prompted these regions to act quickly to change how stormwater is managed. With their lead on innovative programs, the model regions have experience that can be transmitted to the North Coast. Bureaucratic and regulatory barriers may become more apparent on the North Coast as local jurisdiction grapple with how to permit, review, and codify LID once conventional practices begin to lose ground as standard practice.

Jurisdictional barriers, while currently perceived as low significance by both model regions and North coast respondents, may in fact become a more significant barrier in the long term. Currently, water planning responsibilities are fragmented amongst agencies and levels of government. Water policy implemented on appropriate geographic scales relates to hydrological function and socio-cultural regions. Integrating land use and water policy is most appropriate for managing land use impacts, as the two issues are highly correlated (Booth et al. 2004, Environmental Protection Agency 2007, Woltjer and Al 2007). Low Impact Development is not in itself a silver bullet for mitigating development impacts, rather it must be part of a broader effort of recognizing what level of development and land use is appropriate geographically. Incorporation of

LID into numerous policy topics and educational forums, as well as building institutional relationships across the public and private sectors could effectively integrate LID (CH2M Hill 2001, New South Wales Department of Environment and Conservation 2004). Planners can help promote changes by emphasizing water quality concerns in spatial planning (Woltjer and Al 2007). This will be important in the future on the North Coast as hill slope development is a growing trend and has the potential to further impact water resources if headwater streams and slopes are not protected. Proactive policies and actions can help to prevent irreversible degradation, while maintaining working landscapes. The difficulties lie in developing specific LID standards and rules for specific regions or watersheds.

State governments have directed local governments in the model regions to start revising codes to allow LID projects. In California, state agencies such as the State and Regional Water Boards and the California Coastal Commission, are increasing their efforts to promote LID through education and outreach with the promise of regulation to follow. North Coast communities at the very least may need to revise codes and regulations to allow LID. The Coastal Commission is currently reviewing Del Norte County, Crescent City, and Humboldt County General Plan updates and may make recommendations or modifications encouraging LID-compatible policies and ordinances. If LID policies are incorporated into land use plans this may go a long ways towards overcoming the regulatory barriers and addressing the institutionalization of conventional practices as standard procedure. The North Coast participants did discuss the need for clear regulations and guidance to establish LID, although the significance rating was

slightly lower than in the model regions. As LID becomes more prevalent or desired on the North Coast, the need for clear regulations and guidance will likely meet the significance found in the model regions to ensure that LID is applied consistently. Development of local LID codes will require partnerships and coordination to lead the transition and implementation phases of the paradigm shift. A paradigm shift is rarely as linear as a flowchart would suggest. Rather such a transition follows an incremental path of trial and error, implementation, and policy adaptation, until LID is either mandated as a requirement by government codes and standards, or becomes standard practice encouraged by local governments and applied by developers. From North Coast stormwater managers, I heard that if the state required LID it would make their job easier.

> "In some ways it's easier to get people to comply when you say well it's the state it's not us… because the people can also be offended by what they can perceive as too much regulatory enforcement that will put them out of business" (North Coast municipal employee).

One participant suggested this as a solution:

> "We should have really one Humboldt County wide, say LID program, so that whether somebody is working in Shelter Cove or Willow Creek or Arcata, they are going to be held to the same requirements, and they would be requirements that are applicable and relevant to our area and requirements that will take into consideration resources that are available locally and also hydrology, soils…"(North Coast municipal employee).

North Coast participants recognized that state agencies encourage LID and therefore see LID as the future direction of stormwater management.

State and local governments on the North Coast were thus initiating the policy and growing regulatory will that represent one of the first phases of the paradigm shift. Beginning the transition and implementation phase of the paradigm shift, all of the North Coast local staff interviewed were aware of LID, and several jurisdictions were beginning to implement LID projects, such as permeable pavement and bioswales, and completing LID guidance manuals.

A major hurdle lies in funding. With California's budget in a crisis, state and county governments are already understaffed and expecting more cuts to come. While this hurdle is high, it is also hopefully temporary. Model regions have been successful in acquiring large amounts of federal funding and it is possible that this avenue will be available to the North Coast as well. The model regions success with acquiring funding for stormwater management and LID correlates with the low significance the respondents attributed to budget and staff constraints barriers in Table 4. Funding deficiencies on the North Coast may translate to a lack of local government assistance for government employees to update codes, or propose new LID ordinances, as well as a lack of financial assistance for developers to incorporate LID into projects.

North Coast participants discussed the fact that the National Pollutant Discharge Elimination System was an unfunded mandate. Small governments were limited in their ability to hire new personnel to deal with the new requirements, creating more work piled on already overworked staff. For the smaller communities not required to manage runoff quality under National Pollutant Discharge Elimination System, stormwater was left as a flood control issue. The lack of funding made transitioning to new technologies such as

LID a challenge. Examples of participants' description of the work environment included:

> "And then most people will tell you I'm busy, I'm overworked, too much work to do. And then there's people who always say we don't have money to hire another person, so that's just, I guess staffing is just always a challenge" (North Coast municipal employee)

> "Local governments are just like state governments, overworked, not enough staff, not enough time, so they do the best they can with limited resources" (California state employee).

In California, funding has been provided through voter propositions for water quality programs. Proposition 50 brought money into Humboldt County for stormwater education, awareness, and outreach (Arroyo 2009, personal communication). The North Coast Regional Water Quality Control Board has created opportunities for LID through violation fines and encouraging LID project implementation in lieu of payments (Metz 2008, personal communication). Though violation fines were not a stable source of funding, they were spawning LID project development in Humboldt County in the form of LID project proposals.

Maintenance requirements for LID were seen as cost-prohibitive on the North Coast. However, this was not the case in the model regions. This perception on the North Coast may have been related to the need for technical expertise and demonstration projects to understand the maintenance requirements. The same could be said for the local site-specific barriers noted under the research and technical development element. Once implemented, LID maintenance can be incorporated with landscaping maintenance

needs, or good housekeeping practices such as street sweeping. For example, the city of Seattle developed partnerships with neighborhoods to maintain vegetated bioswales in the public right-of-way (Lilly 2007). While it took time and effort on the City's part to establish this maintenance agreement, the effort created public buy-in and support for these types of LID systems.

Both the model regions and North Coast results were quite similar in that both areas have human capital available. If LID is to take hold within a community, it will need broad support and understanding. Elected officials, department heads, and planning commissions will all need to support LID and direct staff to work LID into local codes and projects. Builders will need assurances from local governments that LID is supported and will receive a positive review in the permit process. Top-down regulations may drive the paradigm shift, however, successful implementation will need bottom-up support of LID from all stormwater practitioners and the public.

While LID codes and standards are being determined, information and educational opportunities are needed to train and inform stormwater practitioners in every field. Even in Maryland, where the idea and practice of LID have caught on, the lack of proper training of all consultants and contractors has led in some cases to poorly designed and constructed LID techniques leading to failure (Weinstein 2008). Model regions respondents were all well aware of the significance of this issue as a critical need for properly functioning LID techniques and stormwater management (Table 6). Many, but not all of the interview participants on the North Coast recognized the significance of the need for education and training opportunities. Overcoming conventional practices

requires training and education, funding, and effort – needs identified in the North Coast and model regions results under the research and technical development element.

Partnerships were found to be highly significant in the model regions. The literature indicates that effective partnerships should include all stakeholders and will involve the human capital, technical development, and partnerships elements of the analytical framework. Shandas and Messer (2008, p 410) found "effective collaboration integrates key interests and technical expertise that is more likely to lead to evidence based solutions that meet local values". Collaborative processes are used in the Puget Sound, and in Massachusetts as a means to bring stakeholder concerns to the forefront early in the LID planning process where they can be addressed and consensus can be built for implementation.

The city of Seattle, ready with newly adopted LID codes, used a major redevelopment project as an opportunity to partner with the local housing authority and implement LID on a large scale development project (Johnson and Staeheli 2007). This partnership was able to work through zoning requirements, permitting, and project design, creating a model of development for the city and demonstrating that LID on a large scale is feasible. Van Roon et al. (2005) identified the importance of interdisciplinary partnerships as a means to tackle barriers to LID in New Zealand. Partnerships increase effectiveness and efficiencies of stormwater management through building institutional relationships, possibly leading to bottom-up support for LID and behavior change (CH2M Hill 2001, New South Wales Department of Environment, and Conservation 2004, Godwin et al. 2008).

Communication and coordination was a medium significance need, and collaboration was not discussed at all by the North Coast participants. This difference from the model regions may be due to a lack of experience in tackling a paradigm shift in stormwater management or due to lack of resources to dedicate staff time to the shift. However, tremendous potential exists for partnerships to promote LID on the North Coast. There are numerous water and natural resources related non-profit organizations, a community college and a university, a homebuilders association, and green building organizations located locally. These organizations could potentially be employed to help lead the paradigm shift through education, outreach, and implementation. In addition, local jurisdictions in Humboldt County have convened the North Coast Stormwater Coalition that focuses mainly on public outreach, but could potentially be another forum to lead the paradigm shift.

All of the model regions' participants discussed the need for demonstration projects to lead the paradigm shift as highly significant. Areas in the Puget Sound have invited stormwater professionals to view LID implementation during construction, providing peer education and a low-cost option to showcase projects, while raising local familiarity with LID. All model regions have implemented LID demonstration projects on large and small scales, through partnerships with the local government and developers. The need for demonstration projects on the North Coast was discussed as a medium significance need. The participants that discussed the need explained that demonstration projects can help to bridge the credibility gap for LID, making LID techniques more familiar.

> "Well, you need to make it familiar to people and show what it is and how it can work. Because I think people are reticent to try something, unless they see someone else is doing it…" (North Coast municipal employee). "

> …it's just the familiarity of the city engineer for the type of project that might be proposed and the comfort level of people who are contractors who know how to design a normal parking lot without a bioretention swale… We still need local demonstration projects that we could go out and take a look at" (North Coast municipal employee).

Model regions' participants discussed the importance of ensuring LID systems are properly installed. They indicated that this requires vigilance from local governments to make sure LID systems are designed properly, and then installed properly. This entails proper training of design consultants as described above, but also permit review, inspections during construction phases, and follow-up post-construction. The bureaucratic process of reviewing development and land use proposals will require cross-departmental communication and coordination to ensure LID is widely understood and accepted by government staff. This theme was not discussed by North Coast participants, as LID systems are just starting to be installed locally. North Coast jurisdictions could implement LID through capital improvement projects. However, this would involve LID being incorporated at the initial design phase, also requiring LID buy-in by all departments involved. Capital improvement projects would provide an opportunity for local governments to lead by example, and enter into the final paradigm shift phase of implementation.

Model regions' participants discussed that a lack of incentives to promote LID can act as a barrier (Table 9). As LID was a relatively new concept on the North Coast, this theme was not discussed here. Model regions and the North Coast identified economic incentives as significant needs. The practice of LID can be used as an economic driver as capital cost savings can be realized with implementation as well as environmental benefits (Environmental Protection Agency 2007). Studies comparing costs and benefits of LID and conventional systems have found that LID is less expensive and provides more benefits than conventional systems. Simply comparing maintenance costs of LID versus conventional systems does not take key factors into account, for example LID systems can handle more volume of runoff than conventional systems, and reduce costs of controlling downstream erosion from conventional systems (MacMullan and Reich 2007). Not taking into account environmental benefits from LID systems or effectiveness provides a one-sided analysis, or rather a simple cost-analysis as opposed to a cost-benefit analysis. The same is true when comparing installation costs of LID and conventional systems, which can vary significantly from site to site (Environmental Protection Agency 2007). For example, a development site that needs significant soil amendments for an LID infiltration system may have higher initial construction/installation costs, but looking at the installation costs alone does not take into account the environmental benefits that this system provides including treatment and groundwater recharge (MacMullan and Reich 2007). Likewise, if a site has good porous soils, LID may reduce stormwater management costs by not requiring hard infrastructure for curbs, gutters, drain inlets, and pipes. Low Impact Development provides multiple

benefits, while conventional systems provide the single benefit of conveying runoff away from a site.

The North Coast findings were similar to those found in other areas across the U.S. attempting to shift to LID. Godwin et al. (2008) conducted needs assessment workshops in three Oregon communities to identify needs and barriers to LID planning. Using partnerships, the workshops were facilitated by Nonpoint Education for Municipal Officials staff and Oregon State University in 2006. Notable barriers identified included: LID was not allowed by current codes; government staff was not able to take on more responsibility pertaining to new practices; there was resistance to change; concerns over maintenance requirements for LID projects; limitations regarding site-specific conditions; and permit delays caused by longer government review for LID projects. These barriers are consistent with the model regions and the North Coast results, indicating that these barriers are typical of communities beginning the paradigm shift. The Nonpoint Education for Municipal Officials study also affirms the usefulness of partnerships and universities, and the role of universities in taking on locally applicable research for LID.

A stakeholder study conducted in Washington State to assess barriers and opportunities to an efficient and effective stormwater management program identified key themes as "management coordination, effectiveness, costs and funding, and technical assistance, outreach, and education" (CH2M Hill 2001). These themes correspond well with the analytical framework factors identified in this study. The Washington State stakeholders focused on the significant need for coordination among stormwater professionals and stormwater programs. Essentially, stormwater management is an

interdisciplinary challenge, requiring interaction between regulators, engineers, developers, water quality scientists, biologists, land managers, and the public. Stakeholder coordination enables problem solving, and facilitates partnerships. The need for broad stakeholder outreach, support, and understanding highlights the multi-disciplinary nature of stormwater management and the unique challenge of creating a paradigm shift within several disciplines.

Two resources, College of the Redwoods and Humboldt State University, could be targeted to lead the research and technical development factor of the paradigm shift on the North Coast. These institutions train and reach the future generations, and they already offer courses that relate to LID. College of the Redwoods offers construction technology programs to students who will be the region's future builders. Educating the upcoming workforce on new practices, such as LID provides hands on training that could also encourage innovation while developing human capital. Humboldt State University could be a LID research center with a multidisciplinary program focused on LID. Offering Environmental Engineering, Watershed Management, Natural Resources Planning, Political Science, and Fisheries programs in one university provides an ideal opportunity and a forum for innovation. These schools could be used to showcase public LID demonstration projects as both schools have many construction projects occurring. However, use of these institutions is dependent on support for faculty with an interest in LID, and establishment of curriculum linking the above named programs with LID.

In critique of my study, a wider range of interviews on the North Coast might have raised additional issues and opportunities. A more specific focus on Coastal Act

compliance and development review within the North Coast's jurisdictions might have derived more specific opportunities and recommendations for regulatory oversight. Additionally, a broader international analysis of regions, such as Europe or New Zealand, that have been employing LID for many decades could offer additional insight as to how to overcome barriers or an understanding of longer-term issues that arise from LID implementation.

Overall, the North Coast appears to be shifting in the direction of LID. There are identified examples of growing regulatory-will, with available human capital and potential means to implement LID on the North Coast. Education, research, partnerships, and economic drivers are needed to overcome the identified barriers and support local opportunities. Identified barriers may be overcome through recognition of local needs combined with directed and dedicated efforts to shift to LID. Funding can relieve staff and budget constraints, leading to updating of codes and regulations, forums for training, and local research. Partnerships can efficiently make use of limited resources creating opportunities for demonstration projects and information sharing. Further exploration of LID on the local scale will advance the phases of the paradigm shift, as the initial phase of local governments recognizing a new practice for stormwater management on the North Coast is occurring. Transitional components of the analytical framework are the next phase that will need directed efforts. Specifically, the needs identified will be a starting point to lead to regular implementation of LID.

To energize the transition phase of the paradigm shift, a region-wide program to establish LID standards and rules that are consistent on a watershed and regional basis is

suggested. This program should incorporate public and private stakeholders, and be founded on research previously completed in model regions and supplemented with local research. Opportunities for LID lie within potential strategic partnerships that could be broadened to focus on LID implementation.

The Puget Sound Partnership in Washington or the Bay Area Stormwater Management Agencies Association can provide a model for partnership development. The Bay Area Stormwater Management Agencies Association formed when local governments in the San Francisco Bay region decided to band together, share resources, and prevent each jurisdiction from individually re-inventing stormwater management (Bay Area Stormwater Management Agencies Association 2009). A region-wide program that pulls together staff from local jurisdictions in planning, engineering, public works, transportation, as well as other related departments, would gather expertise. The assembly of interested staff would create a forum for consultation to determine criteria for project development and review. Integrating these departments into the process will be essential to establishing LID and promoting its use.

The region-wide program should be comprehensive, with rules to follow LID implementation throughout the whole development process, such as design, review, construction, and final approval. Additionally, LID could be a means to attain Coastal Act compliance. Incorporating LID into local coastal programs can offer consistency while achieving Coastal Act and Clean Water Act compliance. Creative funding opportunities should be explored, especially the concept of raising or creating stormwater utility fees that reflect actual management costs while also offering incentives to

landowners to reduce stormwater runoff through LID techniques. Technology, such as geographical information systems, could also be shared across local jurisdictions to track land uses, LID systems, and watershed characteristics. Monitoring constructed LID systems would also be relevant to adaptive management and to further refine local LID standards, rules, and applications.

Multiple benefits which improve local conditions can be received from LID, from runoff control and treatment to landscape amenities. Art can be incorporated as a design element, native plants can be showcased as educational opportunity, and green roofs used as sky parks. Energy use can be decreased through use of certain LID practices such as green roofs and rain barrels, creating opportunities for climate change mitigation. Pooling resources through partnerships may help to bridge the funding gap until a dedicated funding source is identified.

Opportunities are available on the North Coast to implement the paradigm shift in stormwater management and create a holistic and comprehensive land use and water management program. This will take a directed and coordinated effort that should focus on 1) partnerships; 2) ongoing training and outreach; 3) review and revision of local codes to promote LID on a watershed scale over conventional stormwater practices; 4) incentive programs that offer economic benefits to those willing to try LID; 5) implementation of public demonstration projects; and finally 6) monitoring of LID systems and adaptation of techniques for local effectiveness. These steps will help achieve a local paradigm shift in the stormwater management field by working through the top levels of local government and building bottom-up support.

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Appendix A. Center for Watershed Protection: codes and ordinances worksheet

The Code and Ordinance Worksheet allows an in-depth review of the standards, ordinances, and codes (i.e., the development rules) that shape how development occurs in your community. You are guided through a systematic comparison of your local development rules against the model development principles. Institutional frameworks, regulatory structures and incentive programs are included in this review. The worksheet consists of a series of questions that correspond to each of the model development principles. Points are assigned based on how well the current development rules agree with the site planning benchmarks derived from the model development principles.

The worksheet is intended to guide you through the first two steps of a local site planning roundtable.

Step 1: Find out what the Development Rules are in your community.

Step 2: See how your rules stack up to the Model Development Principles.

The homework done in these first two steps helps to identify which development rules are potential candidates for change.

PREPARING TO COMPLETE THE CODE AND ORDINANCE WORKSHEET

Two tasks need to be performed before you begin in the worksheet. First, you must identify all the development rules that apply in your community. Second, you must identify the local, state, and federal authorities that actually administer or enforce the development rules within your community. Both tasks require a large investment of time. The development process is usually shaped by a complex labyrinth of regulations, criteria, and authorities. A team approach may be helpful. You may wish to enlist the help of a local plan reviewer, land planner, land use attorney, or civil engineer. Their real-world experience with the development process is often very useful in completing the worksheet.

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Identify the Development Rules

Gather the key documents that contain the development rules in your community. A list of potential documents to look for is provided in Table 1. Keep in mind that the information you may want on a particular development rule is not always found in code or regulation, and maybe hidden in supporting design manuals, review checklists, guidance document or construction specifications. In most cases, this will require an extensive search. Few communities include all of their rules in a single document. Be prepared to contact state and federal, as well as local agencies to obtain copies of the needed documents.

Table 1: Key Local Documents that will be Needed to Complete the COW
Zoning Ordinance
Subdivision Codes
Street Standards or Road Design Manual
Parking Requirements
Building and Fire Regulations/Standards
Stormwater Management or Drainage Criteria
Buffer or Floodplain Regulations
Environmental Regulations
Tree Protection or Landscaping Ordinance
Erosion and Sediment Control Ordinances
Public Fire Defense Masterplans
Grading Ordinance

Identify Development Authorities

Once the development rules are located, it is relatively easy to determine which local agencies or authorities are actually responsible for administering and enforcing the rules. Completing this step will provide you with a better understanding of the intricacies of the development review process and helps identify key members of a future local roundtable. Table 2 provides a simple framework for identifying the agencies that influence development in your community. As you will see, space is provided not only for local agencies, but for state and federal agencies as well. In some cases, state and federal agencies may also exercise some authority over the local development process (e.g., wetlands, some road design, and stormwater).

USING THE WORKSHEET: HOW DO YOUR RULES STACK UP TO THE MODEL DEVELOPMENT PRINCIPLES?

Completing the Worksheet

Once you have located the documents that outline your development rules and identified the authorities responsible for development in your community, you are ready for the next step. You can now use the worksheet to compare your development rules to the model development principles. The worksheet is presented at the end of this chapter. The worksheet presents seventy-seven site planning benchmarks. The benchmarks are posed as questions. Each benchmark focuses on a specific site design practice, such as the minimum diameter of cul-de-sacs, the minimum width of streets, or the minimum parking ratio for a certain land use. You should refer to the codes, ordinances, and plans identified in the first step to determine the appropriate development rule. The questions require either a yes or no response or specific numeric criteria. If your development rule agrees with the site planning benchmark, you are awarded points.

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Calculating Your Score

A place is provided on each page of the worksheet to keep track of your running score. In addition, the worksheet is subdivided into three categories:

- Residential Streets and Parking Lots (Principles No. 1 - 10)
- Lot Development (Principles No. 11 - 16)
- Conservation of Natural Areas (Principles No. 17 - 22).

For each category, you are asked to subtotal your score. This "**Time to Assess**" allows you to consider which development rules are most in line with the site planning benchmarks and what rules are potential candidates for change.

The total number of points possible for all of the site planning benchmarks is 100. Your overall score provides a general indication of your community's ability to support environmentally sensitive development. As a general rule, if your overall score is lower than 80, then it may be advisable to systematically reform your local development rules. A score sheet is provided at end of the Code and Ordinance Worksheet to assist you in determining where your community's score places in respect to the Model Development Principles. Once you have completed the worksheet, go back and review your responses. Determine if there are specific areas that need improvement (e.g., development rules that govern road design) or if your development rules are generally pretty good. This review is key to implementation of better development: assessment of your current development rules and identification of impediments to innovative site design. This review also directly leads into the next step: a site planning roundtable process conducted at the local government level. The primary tasks of a local roundtable are to systematically review existing development rules and then determine if changes can or should be made. By providing a much-needed framework for overcoming barriers to better development, the site planning roundtable can serve as an important tool for local change.

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Table 2: Local, State, and Federal Authorities Responsible for Development in Your Community				
Development Responsibility		State/Federal	County	Town
Sets road standards	Agency:			
	Contact Name:			
	Phone No.:			
Review/approves subdivision plans	Agency:			
	Contact Name:			
	Phone No.:			
Establishes zoning ordinances	Agency:			
	Contact Name:			
	Phone No.:			
Establishes subdivision ordinances	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/establishes stormwater management or drainage criteria	Agency:			
	Contact Name:			
	Phone No.:			
Provides fire protection and fire protection code enforcement	Agency:			
	Contact Name:			
	Phone No.:			
Oversees buffer ordinance	Agency:			
	Contact Name:			
	Phone No.:			
Oversees wetland protection	Agency:			
	Contact Name:			
	Phone No.:			
Establishes grading requirements or oversees erosion and sediment control program	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves septic systems	Agency:			
	Contact Name:			
	Phone No.:			
Review/approves utility plans (e.g., water and sewer)	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves forest conservation/ tree protection plans	Agency:			
	Contact Name:			
	Phone No.:			

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*
1. Street Width	
What is the minimum pavement width allowed for streets in low density residential developments that have less than 500 daily trips (ADT)?	_____ feet
*If your answer is between **18-22 feet**, give yourself **4** points* • •	
At higher densities are parking lanes allowed to also serve as traffic lanes (i.e., queuing streets)?	YES
*If your answer is **YES**, give yourself **3** points* • •	
Notes on Street Width (include source documentation such as name of document, section and page #):	
2. Street Length	
Do street standards promote the most efficient street layouts that reduce overall street length?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Notes on Street Length (include source documentation such as name of document, section and page #):	
3. Right-of-Way Width	
What is the minimum right of way (ROW) width for a residential street?	_____ feet
*If your answer is **less than 45 feet**, give yourself **3** points* • •	
Does the code allow utilities to be placed under the paved section of the ROW?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Notes on ROW Width (include source documentation such as name of document, section and page #):	
4. Cul-de-Sacs	
What is the minimum radius allowed for cul-de-sacs?	_____ feet
*If your answer is **less than 35 feet**, give yourself **3** points* • •	
*If your answer is **36 feet to 45 feet**, give yourself **1** point* • •	
Can a landscaped island be created within the cul-de-sac?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Are alternative turnarounds such as "hammerheads" allowed on short streets in low density residential developments?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Notes on Cul-de-Sacs (include source documentation such as name of document, section and page #):	

Code and Ordinance Worksheet *Subtotal Page 5* 0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*
5. Vegetated Open Channels	
Are curb and gutters required for most residential street sections?	YES
*If your answer is **NO**, give yourself **2** points* • •	
Are there established design criteria for swales that can provide stormwater quality treatment (i.e., dry swales, biofilters, or grass swales)?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Notes on Vegetated Open Channel (include source documentation such as name of document, section and page #):	
6. Parking Ratios	
What is the minimum parking ratio for a professional office building (per 1000 ft^2 of gross floor area)?	spaces
*If your answer is **less than 3.0 spaces**, give yourself **1** point* • •	
What is the minimum required parking ratio for shopping centers (per 1,000 ft^2 gross floor area)?	spaces
*If your answer is **4.5 spaces or less**, give yourself **1** point* • •	
What is the minimum required parking ratio for single family homes (per home)?	spaces
*If your answer is **less than or equal to 2.0 spaces**, give yourself **1** point* • •	
Are your parking requirements set as maximum or median (rather than minimum) requirements?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Notes on Parking Ratios (include source documentation such as name of document, section and page #):	
7. Parking Codes	
Is the use of shared parking arrangements promoted?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Are model shared parking agreements provided?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Are parking ratios reduced if shared parking arrangements are in place?	YES
*If your answer is **YES**, give yourself **1** point* • •	
If mass transit is provided nearby, is the parking ratio reduced?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Notes on Parking Codes (include source documentation such as name of document, section and page #):	

Code and Ordinance Worksheet *Subtotal Page 6* 0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*
8. Parking Lots	
What is the minimum stall width for a standard parking space?	feet
*If your answer is **9 feet or less**, give yourself **1** point* • •	
What is the minimum stall length for a standard parking space?	feet
*If your answer is **18 feet or less**, give yourself **1** point* • •	
Are at least 30% of the spaces at larger commercial parking lots required to have smaller dimensions for compact cars?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Can pervious materials be used for spillover parking areas?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Notes on Parking Lots (include source documentation such as name of document, section and page #):	
9. Structured Parking	
Are there any incentives to developers to provide parking within garages rather than surface parking lots?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Notes on Structured Parking (include source documentation such as name of document, section and page #):	
10. Parking Lot Runoff	
Is a minimum percentage of a parking lot required to be landscaped?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Is the use of bioretention islands and other stormwater practices within landscaped areas or setbacks allowed?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Notes on Parking Lot Runoff (include source documentation such as name of document, section and page #):	

Code and Ordinance Worksheet *Subtotal Page 7* 0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*

• • **Time to Assess:** Principles 1 - 10 focused on the codes, ordinances, and standards that determine the size, shape, and construction of parking lots, roadways, and driveways in the suburban landscape. There were a total of **40** points available for Principles 1 - 10. What was your total score?

Subtotal Page 5 [0] + Subtotal Page 6 [0] + Subtotal Page 7 [0] = [0]

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

11. Open Space Design

Are open space or cluster development designs allowed in the community? *If your answer is **YES**, give yourself **3** points • •* *If your answer is **NO**, skip to question No. 12*	YES
Is land conservation or impervious cover reduction a major goal or objective of the open space design ordinance? *If your answer is **YES**, give yourself **1** point • •*	YES
Are the submittal or review requirements for open space design greater than those for conventional development? *If your answer is **NO**, give yourself **1** point • •*	YES
Is open space or cluster design a by-right form of development? *If your answer is **YES**, give yourself **1** point • •*	YES
Are flexible site design criteria available for developers that utilize open space or cluster design options (e.g., setbacks, road widths, lot sizes) *If your answer is **YES**, give yourself **2** points • •*	YES

Notes on Open Space Design (include source documentation such as name of document, section and page #):

Code and Ordinance Worksheet *Subtotal Page 8* [0]

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*
12. Setbacks and Frontages	
Are irregular lot shapes (e.g., pie-shaped, flag lots) allowed in the community?	YES
*If your answer is **YES**, give yourself **1** point • •*	
What is the minimum requirement for front setbacks for a one half (½) acre residential lot?	_____ feet
*If your answer is **20 feet or less**, give yourself **1** point • •*	
What is the minimum requirement for rear setbacks for a one half (½) acre residential lot?	_____ feet
*If your answer is **25 feet or less**, give yourself **1** point • •*	
What is the minimum requirement for side setbacks for a one half (½) acre residential lot?	_____ feet
*If your answer is **8 feet or less**, give yourself **1** points • •*	
What is the minimum frontage distance for a one half (½) acre residential lot?	_____ feet
*If your answer is **less than 80 feet**, give yourself **2** points • •*	
Notes on Setback and Frontages (include source documentation such as name of document, section and page #):	
13. Sidewalks	
What is the minimum sidewalk width allowed in the community?	_____ feet
*If your answer is **4 feet or less**, give yourself **2** points • •*	
Are sidewalks always required on both sides of residential streets?	YES
*If your answer is **NO**, give yourself **2** points • •*	
Are sidewalks generally sloped so they drain to the front yard rather than the street?	YES
*If your answer is **YES**, give yourself **1** point • •*	
Can alternate pedestrian networks be substituted for sidewalks (e.g., trails through common areas)?	YES
*If your answer is **YES**, give yourself **1** point • •*	
Notes on Sidewalks (include source documentation such as name of document, section and page #):	
14. Driveways	
What is the minimum driveway width specified in the community?	_____ feet
*If your answer is **9 feet or less (one lane) or 18 feet (two lanes)**, give yourself **2** points • •*	

Code and Ordinance Worksheet *Subtotal Page 9* 0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*
Can pervious materials be used for single family home driveways (e.g., grass, gravel, porous pavers, etc)?	YES
*If your answer is **YES**, give yourself **2** points • •*	
Can a "two track" design be used at single family driveways?	YES
*If your answer is **YES**, give yourself **1** point • •*	
Are shared driveways permitted in residential developments?	YES
*If your answer is **YES**, give yourself **1** point • •*	

Notes on Driveways (include source documentation such as name of document, section and page #):

15. Open Space Management

Skip to question 16 if open space, cluster, or conservation developments are not allowed in your community.

Does the community have enforceable requirements to establish associations that can effectively manage open space?	YES
*If your answer is **YES**, give yourself **2** points • •*	
Are open space areas required to be consolidated into larger units?	YES
*If your answer is **YES**, give yourself **1** point • •*	
Does a minimum percentage of open space have to be managed in a natural condition?	YES
*If your answer is **YES**, give yourself **1** point • •*	
Are allowable and unallowable uses for open space in residential developments defined?	YES
*If your answer is **YES**, give yourself **1** point • •*	
Can open space be managed by a third party using land trusts or conservation easements?	YES
*If your answer is **YES**, give yourself **1** point • •*	

Notes on Open Space Management (include source documentation such as name of document, section and page #):

16. Rooftop Runoff

Can rooftop runoff be discharged to yard areas?	YES
*If your answer is **YES**, give yourself **2** points • •*	
Do current grading or drainage requirements allow for temporary ponding of stormwater on front yards or rooftops?	YES
*If your answer is **YES**, give yourself **2** points • •*	

Notes on Rooftop Runoff (include source documentation such as name of document, section and page #):

Code and Ordinance Worksheet *Subtotal Page 10* 0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*

• • **Time to Assess:** Principles 11 through 16 focused on the regulations which determine lot size, lot shape, housing density, and the overall design and appearance of our neighborhoods. There were a total of **36** points available for Principles 11 - 16. What was your total score?

Subtotal Page 8 0 + Subtotal Page 9 0 + Subtotal Page 10 0 = 0

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

17. Buffer Systems

Is there a stream buffer ordinance in the community? YES

*If your answer is **YES**, give yourself **2** points • •*

If so, what is the minimum buffer width? feet

*If your answer is **75 feet or more**, give yourself **1** point • •*

Is expansion of the buffer to include freshwater wetlands, steep slopes or the 100-year floodplain required? YES

*If your answer is **YES**, give yourself **1** point • •*

Notes on Buffer Systems (include source documentation such as name of document, section and page #):

18. Buffer Maintenance

If you do not have stream buffer requirements in your community, skip to question No. 19

Does the stream buffer ordinance specify that at least part of the stream buffer be maintained with native vegetation? YES

*If your answer is **YES**, give yourself **2** points • •*

Does the stream buffer ordinance outline allowable uses? YES

*If your answer is **YES**, give yourself **1** point*

Code and Ordinance Worksheet *Subtotal Page 11* 0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*
Does the ordinance specify enforcement and education mechanisms?	YES
*If your answer is **YES**, give yourself **1** point* • •	

Notes on Buffer Systems (include source documentation such as name of document, section and page #):

19. Clearing and Grading

Is there any ordinance that requires or encourages the preservation of natural vegetation at residential development sites?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Do reserve septic field areas need to be cleared of trees at the time of development?	YES
*If your answer is **NO**, give yourself **1** point* • •	

Notes on Buffer Maintenance (include source documentation such as name of document, section and page #):

20. Tree Conservation

If forests or specimen trees are present at residential development sites, does some of the stand have to be preserved?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Are the limits of disturbance shown on construction plans adequate for preventing clearing of natural vegetative cover during construction?	YES
*If your answer is **YES**, give yourself **1** point* • •	

Notes on Tree Conservation (include source documentation such as name of document, section and page #):

21. Land Conservation Incentives

Are there any incentives to developers or landowners to conserve non-regulated land (open space design, density bonuses, stormwater credits or lower property tax rates)?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Is flexibility to meet regulatory or conservation restrictions (density compensation, buffer averaging, transferable development rights, off-site mitigation) offered to developers?	YES
*If your answer is **YES**, give yourself **2** points* • •	

Notes on Land Cons. Incentives (include source documentation such as name of document, section and page #):

Code and Ordinance Worksheet *Subtotal Page 12* 0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued).

Development Feature	*Your Local Criteria*
22. Stormwater Outfalls	
Is stormwater required to be treated for quality before it is discharged?	YES
*If your answer is **YES**, give yourself **2** points* • •	
Are there effective design criteria for stormwater best management practices (BMPs)?	YES
*If your answer is **YES**, give yourself **1** point* • •	
Can stormwater be directly discharges into a jurisdictional wetland without pretreatment?	YES
*If your answer is **NO**, give yourself **1** point* • •	
Does a floodplain management ordinance that restricts or prohibits development within the 100-year floodplain exist?	YES
*If your answer is **YES**, give yourself **2** points* • •	

Notes on Stormwater Outfalls (include source documentation such as name of document, section and page #):

Code and Ordinance Worksheet *Subtotal Page 13* 0

• • **Time to Assess:** Principles 17 through 22 addressed the codes and ordinances that promote (or impede) protection of existing natural areas and incorporation of open spaces into new development. There were a total of 24 points available for Principles 17 - 22. What was your total score?

Subtotal Page 11 0 + Subtotal Page 12 0 + Subtotal Page 13 0 = 0

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

To determine final score, add up subtotal from each • **Time to Assess**

Principles 1 - 10 (Page 8)	0
Principles 11 - 16 (Page 11)	0
Principles 17 - 22 (Page 13)	0
TOTAL	0

Appendix A. Center for Watershed Protection: codes and ordinances worksheet (continued)

SCORING (A total of **100** points are available):		
Your Community's Score		
90- 100	•	• Congratulations! Your community is a real leader in protecting streams, lakes, and estuaries. Keep up the good work.
80 - 89	•	• Your local development rules are pretty good, but could use some tweaking in some areas.
79 - 70	•	• Significant opportunities exist to improve your development rules. Consider creating a site planning roundtable.
60 - 69	•	• Development rules are inadequate to protect your local aquatic resources. A site planning roundtable would be very useful.
less than 60	•	• Your development rules definitely are not environmentally friendly. Serious reform of the development rules is needed.

Appendix B. Interview guide.

1. How are stormwater policies developed?
2. What are your goals for stormwater policies and management?
3. How do you incorporate new technologies/practices into your management?
4. How are these new technologies/practices vetted?
5. How easy or difficult is it to change policy in your department?
6. What is the process of changing a policy?
7. How would you rate the communication level within you department/organization?
8. To what extent is LID discussed in your department/organization?
9. Do you see LID strategies as a viable solution to dealing with non-point source pollution?
10. To what extent is LID being implemented in the community?
11. Any LID project success or failures?
12. Do you think community members would embrace this method?

Appendix B. Interview guide (continued).

13. What are the barriers to implementing LID?

14. What is needed to incorporate LID strategies more extensively in stormwater planning policies?

15. Are the existing policies clear and understandable by project developers?

16. Would incentives work in this community?

17. What incentive ideas do you have?

18. Are other departments on board?

19. Are there any LID training opportunities for staff?