

Science Question 2 – How might Oregon accomplish the mission of the Oregon Plan in the face of an increasingly urbanized landscape?

In 1997, the State of Oregon established the Oregon Coastal Salmon Restoration Initiative Conservation Plan which later became the broader state-wide Oregon Plan for Salmon and Watersheds (i.e., the Oregon Plan). This mission of the Oregon Plan is to “*restore the watersheds of Oregon and to recover the fish and wildlife populations of those watersheds to productive and sustainable levels in a manner that provides substantial ecological, cultural and economic benefits*” (Oregon Revised Statute 541.405(2)(a)). The Oregon Plan focuses on factors that contribute to the decline of native salmonids and watershed health. While most measures and restoration actions have been focused on forest and agricultural resource lands, there is a growing recognition and effort to improve aquatic ecosystems and watersheds affected by urban and rural-residential areas. This section focuses on approaches to meeting the goals of the Oregon Plan that are unique to urban and rural-residential areas.

Section 9.0: Potential Contributions to the Oregon Plan

The potential for developed areas to contribute to the mission of the Oregon Plan should not be underestimated. Between 1950 and 2000, Oregon's human population increased 125% to 3.4 million residents and is projected to add another 1.5 million residents by 2030 (US Census Bureau 2005). Most of these new citizens will reside in urban areas (US Census Bureau 2003) located along streams, rivers, and estuaries that are important to the persistence and recovery of native salmonids, including a number of federally-listed species (see Section 1.31 of this report). Protecting or improving the condition of aquatic ecosystems within urban and rural-residential developments will help ensure that developed lands contribute to the persistence and recovery of salmonid populations across broader spatial scales. Unless proactive measures are taken to avoid or mitigate the effects of current and future development, however, it will be difficult to reverse or slow the impairment of aquatic habitat quality and function as Oregon's human population continues to increase.

In the literature previously reviewed by IMST (see Sections 2.0–7.0 of this report) and others (Paul & Meyer 2001; Allan 2004; Kaye *et al.* 2006), impaired water quality, degraded physical habitat, altered flow regimes, and blocked fish passage are commonly linked to the types of engineering and development practices used on developed lands, the patterns in which developments expand, the consumer products widely used in developed areas, and the trends in resource use and waste production on developed lands. Consequently, the outcomes of natural resource policies and management actions, such as the Oregon Plan, will be affected by the extent and location of rural-residential and urban development resulting from Oregon's future population growth (Kline *et al.* 2007; Bilby & Mollot 2008) and associated economic growth (e.g., Reed & Czech 2005).

In Science Question 2, IMST examines scientifically credible approaches to avoiding, minimizing, or mitigating the adverse effects of development with emphasis on concepts relevant to salmonid population persistence and recovery. The following sections provide:

- A review of futures analyses completed in the Pacific Northwest and the potential of such analyses to serve as planning tools.
- An overview of strategies and actions that could be used to guide the placement and construction of future developments in ways that are more protective of aquatic ecosystems.
- Selected examples of proactive measures underway in the Pacific Northwest.
- A summary of how the aquatic ecosystem response to developed land uses is currently monitored in Oregon.

Section 9.1: Futures Analysis as a Planning Tool

Minimizing aquatic ecosystem impairments while Oregon's human population and economy grow requires understanding where and how future development is likely to occur. Spatial models of future land use planning and socioeconomic trend data (e.g., past land use change, socioeconomic factors that drive land use change, contemporary housing and population trends) to characterize a range of landscape configurations possible under different policies, management actions, and development scenarios (Hulse *et al.* 2004; Kline *et al.* 2007). Such models are powerful tools for evaluating how land use policies and programs could drive the location and extent of future development (Kline 2005a, b). When model predictions of future land use configurations are made at appropriate spatial and temporal scales, they may also be used to predict potential consequences of different development scenarios on ecological processes, ecosystem condition, and the recovery or persistence of salmonid populations (Kline *et al.* 2007).

The accuracy of futures analyses depends on how well models represent the complex interactions among socioeconomic forces, changing landscapes, and ecological processes (Nilsson *et al.* 2003). Extrapolating aquatic ecosystem responses to future development requires the integration of multiple models parameterized with knowledge from diverse disciplines including economics, hydrology, geomorphology, and ecology (Nilsson *et al.* 2003). The capacity to construct and parameterize models that forecast ecological condition is limited by information gaps within each of these disciplines. Applying model results to natural resource management requires consideration of how socioeconomic trends and land use policies may change in the future (Kline *et al.* 2007; see Section 1.43 of this report). However, such changes are difficult to predict and can reduce the level of certainty associated with results from futures analyses.

In practice, efforts to model alternative futures are intended to demonstrate relative outcomes (as opposed to exact endpoints) of decisions made about the use of land and water resources (Baker *et al.* 2004; Burnett *et al.* 2007). Significant efforts have been made to model the location and density of future population growth and development in the Pacific Northwest and to characterize the implications of future land use change for aquatic and terrestrial habitat condition (Table 9-1). While the level of certainty associated with any individual extrapolation of aquatic ecosystem condition is low (e.g., Van Sickle *et al.* 2004), the majority of futures analyses conducted for Pacific Northwest landscapes indicate that future development could have moderate to severe consequences for riparian and aquatic habitat condition and aquatic biota (Table 9-1). These results mirror findings from a retrospective analysis of salmon distributions carried out in four river basins that drain to Puget Sound (Washington).

Table 9-1. Examples of Futures Analyses. These examples predict how human population growth and development may affect aquatic ecosystems in the Pacific Northwest.

Location	Spatial; Temporal Scale	Modeling Objectives Relevant to Natural Resource Management	Demographic Predictive Variable	Key Findings Relevant to Aquatic Ecosystem Management	Reference
Oregon	Willamette River Basin; 1850, 1990, 2050	Modeled future landscapes for three alternative development scenarios including current land use policies, a market-oriented approach, and prioritization of ecosystem protection and restoration. Endpoints evaluated included water availability, channel structure, riparian condition and fish species richness in the Willamette River; ecological condition of other streams; and terrestrial vertebrate populations.	Doubling of 1990 population by 2050	Continuation of current land use policies resulted in expansion of urban areas, but limited basin-wide effects on aquatic biota. Relaxation of current environmental policies had limited effects on aquatic biota primarily because most development occurred on land already highly modified by agricultural uses. Increased conservation measures significantly improved indicators of stream condition. Out of stream water uses increased by 40 to 60% under all three scenarios.	Baker <i>et al.</i> 2004
Oregon	Willamette River Basin; 1990 to 2050	Evaluated the impact of current approaches for water use on future water resource availability.	Doubling of 1990 population by 2050	A basin-wide approach is unnecessary for understanding many water management issues. Modest, comprehensive conservation efforts are insufficient for protecting instream flows. Increased urban water use does not seriously affect junior water right holders.	Dole & Niemi 2004
Oregon	Willamette River Basin; 1800's, 1990, 2050	Modeled future landscapes for three alternative development scenarios including current land use policies, a market-oriented approach, and prioritization of ecosystem protection and restoration. Endpoints evaluated included fish and aquatic invertebrate assemblages.	Doubling of 1990 population by 2050	Agricultural and urban land development occurring since the 1800's is associated with statistically significant reductions in the condition of aquatic biota. Conservation actions modeled have the potential to rehabilitate aquatic biota. Maintenance or relaxation of current environmental policies had limited effects on aquatic biota primarily because most development occurred on land already highly modified by agricultural uses.	Van Sickle <i>et al.</i> 2004
Oregon	Coastal Province; 1996 to 2096	Modeled the intrinsic potential for high quality rearing habitat for juvenile coho salmon and steelhead as a function of present and future landscape characteristics based on current land management policies.	Gravity Index (Kline <i>et al.</i> 2003)	Stream reaches with high intrinsic potential to support rearing habitat for coho salmon were disproportionately affected by developed land uses. Recovery of steelhead or coho populations likely depends on habitat improvements on private lands.	Burnett <i>et al.</i> 2007
Montana, Wyoming, Idaho	Greater Yellowstone Ecosystem; 1990-1999	Modeled affects of three rural-residential development scenarios on various habitat metrics, including riparian habitats.	Contemporary demographic trends	Rural-residential homes were more likely to be located in riparian habitats than what would be expected if new home constructions was distributed randomly.	Gude <i>et al.</i> 2007

Table 9-1, *continued*. Examples of Futures Analyses. These examples predict how human population growth and development may affect aquatic ecosystems in the Pacific Northwest.

Location	Spatial; Temporal Scale	Modeling Objectives Relevant to Natural Resource Management	Demographic Predictive Variable	Key Findings Relevant to Aquatic Ecosystem Management	Reference
Oregon: East of the Cascade Mountains	Northeast, Central, and Klamath regions analyzed separately; 2000 to 2025	<p>Predict extent and density of future development from known land use patterns and trends.</p> <p>Evaluate loss of forest, range and agricultural land to developments of varying density.</p> <p>Evaluate wildfire risk posed by future development.</p>	Modeled building counts and building count changes	<p>Data on past and current human population growth and land use trends may be insufficient to predict future development patterns.</p> <p>Spatial land use models should be used in conjunction with other economic data sources (e.g., increased tourism) to predict the probabilities and patterns of future development.</p> <p>Crook, Deschutes, Jefferson and northern Klamath counties are predicted to undergo the highest conversion of forest, range, and agricultural lands to more densely developed lands.</p>	Kline <i>et al.</i> 2007
California	Russian River Basin; 1994 to 2002; 2002 to 2010	Modeled the potential sediment response to land use change forecasts for agricultural, rural-residential and urban land uses.	Contemporary demographic and land use trends	<p>The total land area converted to rural-residential uses was greater than that converted to urban use.</p> <p>The location of future rural-residential development ranged into previously undisturbed areas more likely to contain high quality salmonid spawning habitats.</p> <p>Future increases in rural-residential development have greater potential to reduce the quantity and quality of existing salmonid spawning habitats.</p>	Lohse <i>et al.</i> 2008

Bilby & Molloy (2008) correlated changes in the spawning distribution of coho salmon with changes in land use that occurred between 1986 and 2001. Over this period, the portion of the study area covered by urban development increased from 7 to 13% and the area in rural-residential uses increased from 11 to 21% (Bilby & Molloy 2008). Coho salmon populations underwent rapid declines in the portions of the study area most affected by urban development.

As research in economics, hydrology, ecology, and other relevant disciplines fills critical knowledge gaps, the utility of futures analyses in evaluating and setting land use policies will increase. Ultimately, such analyses could become a very useful part of the routine toolset used by city-, county-, and state-level land managers (Baker *et al.* 2004). Such efforts are already underway in Oregon. The Metro regional government (northwestern Oregon), for example, modeled potential outcomes of four future growth patterns on land consumption and air quality (Metro 2000). More recently, resource managers in Benton County (western Oregon) completed a comprehensive analysis of future water demands (Benton County 2008). A significant effort currently underway to plan for Oregon's future water supply needs is the Oregon Water Supply and Conservation Initiative overseen by OWRD⁷⁰. The impetus and strategy for this initiative are detailed in the following section.

SECTION 9.11: PLANNING FOR OREGON'S LONG-TERM WATER SUPPLY NEEDS

The Oregon Progress Board (2000) has identified inadequate water supply as one of the major environmental challenges facing the state. Oregon water law allocates available water resources across users who hold water rights. At any given time, prioritization of water use is determined by a seniority system established by the date OWRD received a user's application for the water right, the amount of water allocated to individual water rights, and the actual amount of water available (Dole & Niemi 2004). Presently, available surface water resources are either fully- or over-appropriated during low flow periods (i.e., summer and fall months) and pressure on groundwater resources is growing in many areas (Oregon Progress Board 2000; ISAB 2007b; Snell & Colbert 2007; Figures 9-1 and 9-2). Because shallow groundwater aquifers connect with and supplement surface water flows, an increased use of groundwater resources has the potential to further reduce surface water supplies (Snell & Colbert 2007).

Human population growth will increase the demands made on Oregon's existing water resources, particularly in the face of a changing climate (Houston *et al.* 2003). Technological innovations that increase water use efficiency may help offset the need to develop additional water resources to meet future demands (Houston *et al.* 2003). However, with limited water resources available for new uses, conflicts between in-stream (e.g., salmonids, maintaining adequate streamflows) and out-of-stream uses will increase. Such conflicts have the potential to become divisive and can be expensive to resolve (Snell & Colbert 2007). Increasing demands on water resources will present significant challenges as resource managers and policy makers weigh difficult tradeoffs among competing social, economic, and ecological uses. Resolution of such challenges requires an understanding of future water availability, water demands, and social priorities on water use (Jenerette & Larsen 2006).

Of the 18 western US states, only Oregon and Alaska have no plan for meeting future water requirements (Snell & Colbert 2007). Several steps have been taken by the State of Oregon to

⁷⁰ http://www.wrd.state.or.us/OWRD/LAW/owsci_info.shtml. Accessed December 16, 2009.

identify and meet future water needs. The Oregon Governor created the Headwaters to Ocean⁷¹ initiative with the goal to identify priorities and strategies for meeting future water needs in Oregon. The Headwaters to Ocean advisory council recommended an approach that consists of initiating investments in long-term efforts to collect data for planning purposes and addressing short-term concerns related to current water supplies, water conservation, pollution control and prevention, monitoring water use, and ecosystem services. OWRD identified 5 key components in its Oregon Water Supply and Conservation Initiative⁷² including:

- Assessing statewide water demands;
- Inventorying sites with the potential to increase above- and below-ground water storage;
- Identifying opportunities for conservation of water resources;
- Conducting analyses of basin-wide water yields; and
- Providing financial support to local communities engaged in water supply planning.

The budget passed by the Oregon Legislature for the 2009-2011 Biennium included \$3.5 million for activities and investments related to water resource management including:

- Development of an integrated water resource management strategy to be cooperatively overseen by OWRD and ODEQ (House Bill 3369);
- Expenditures for infrastructure projects that will increase water conservation (e.g., aquifer storage and recovery); and
- Expenditures to meet future water supply needs (including those of fish and wildlife) while also protecting ground and surface water quality.

In addition, OWRD is currently seeking to develop a long-term water supply strategy and has recently implemented a survey to gather information that will aid in forecasting future water demands and supplies through 2025 and 2050 at the county or river basin level⁷³. OWRD is also currently administering a \$1.6 million grant program that supports research into the feasibility of various water conservation, reuse or storage sites or technologies⁷⁴.

⁷¹ <http://governor.oregon.gov/Gov/GNRO/14jan09-h2o-strategy-home-page.shtml>. Accessed December 16, 2009.

⁷² www.wrd.state.or.us; <http://www.wrd.state.or.us/OWRD/LAW/owsci.shtml#Updates>. Accessed December 16, 2009.

⁷³ Reports derived from this survey can be downloaded at http://www.wrd.state.or.us/OWRD/LAW/owsci_info.shtml. Accessed December 16, 2009

⁷⁴ http://www.wrd.state.or.us/OWRD/LAW/conservation_supply.shtml. Accessed December 16, 2009

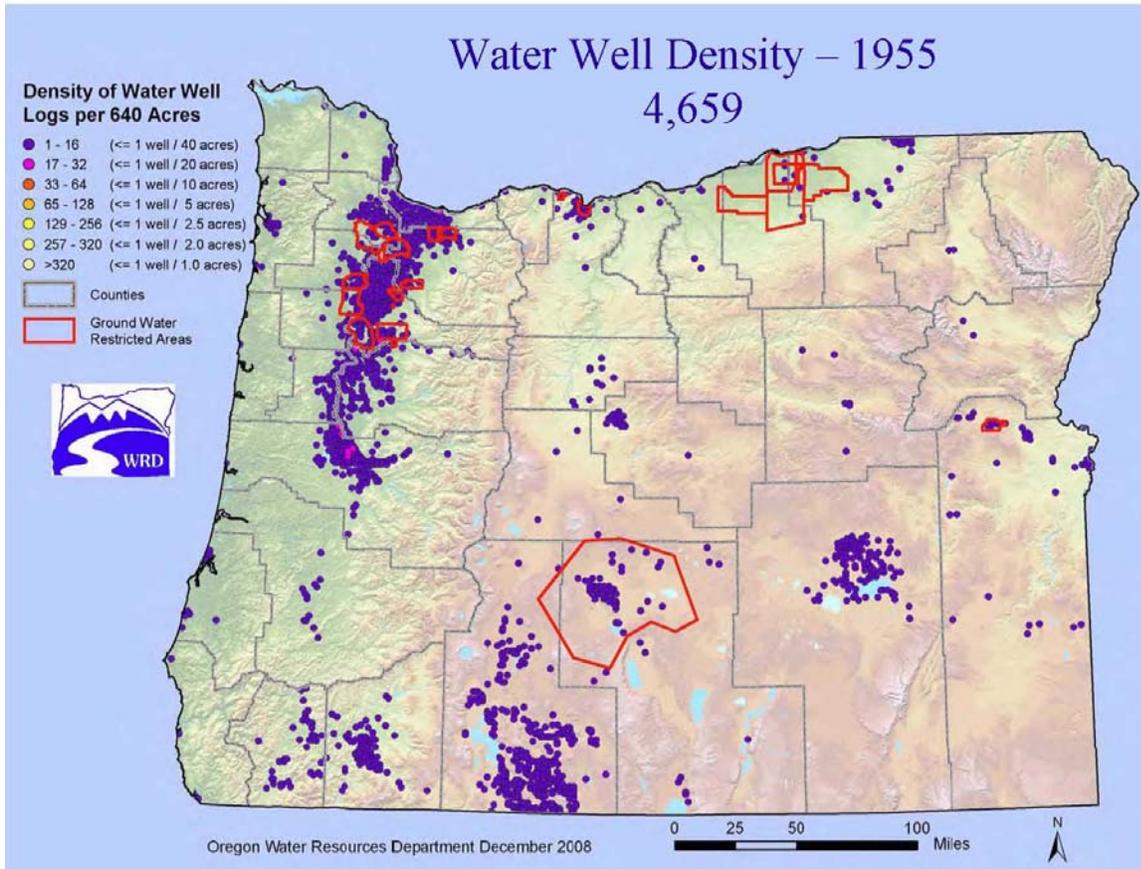


Figure 9-1. The density and distribution of permitted and exempt groundwater wells in Oregon during 1955. Figure is based on water well logs on file (excluding logs for well deepening, alteration, and abandonment) at the Oregon Water Resources Department OWRD. State regulations requiring that water well logs be submitted to OWRD for any new well construction or existing well modification were instituted in 1955. Only a few of the wells that existed prior to 1955 are represented in these figures. Groundwater restricted areas (depicted by red lines) represent areas with groundwater use restrictions, such as prohibition of new permits or, in some cases, restricted use of existing permits. In most cases, exempt uses are allowed in the restricted areas. Exempt uses include wells used for domestic purposes. These wells constitute a water right with a priority date but do not require the user to hold a permit from OWRD. Up to 15,000 gallons per day can be pumped from exempt wells. The amount of water actually withdrawn varies considerably among represented well localities. Figure provided by OWRD.

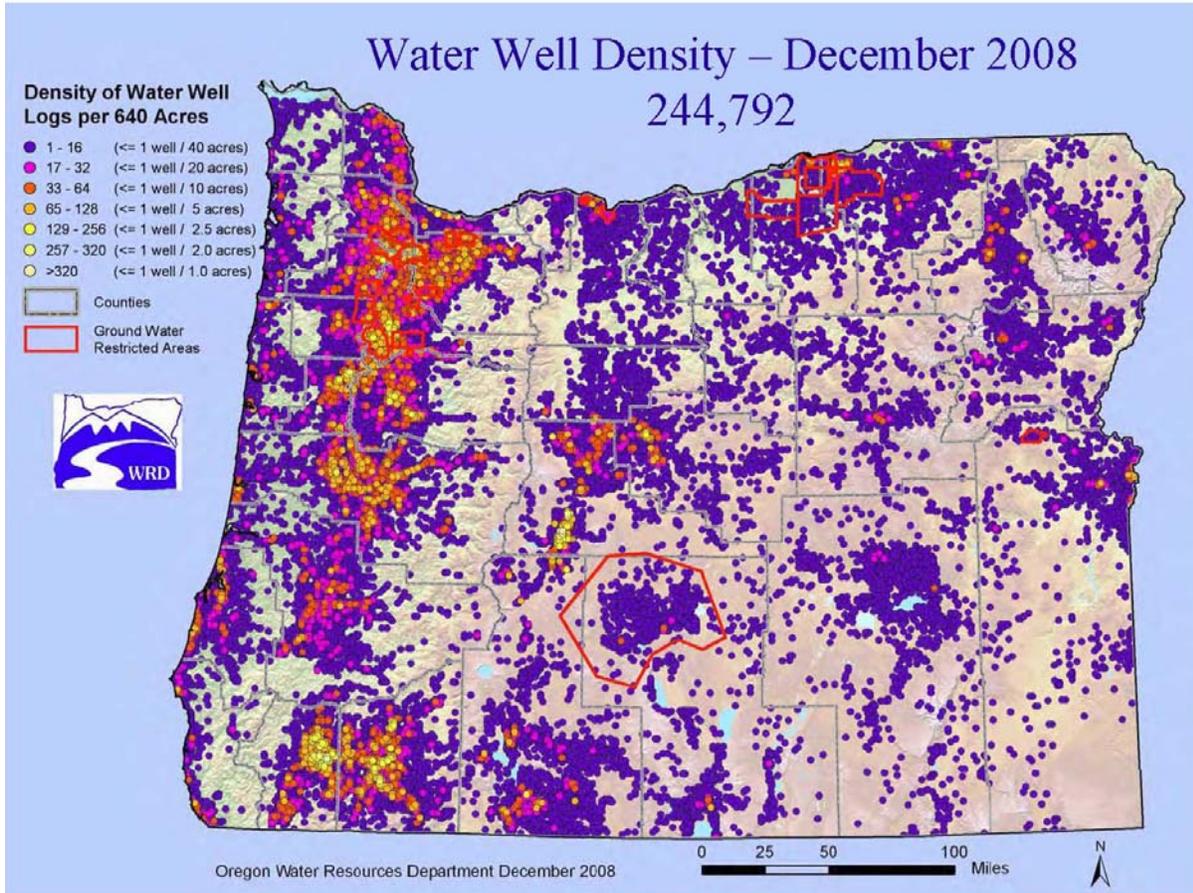


Figure 9-2. The density and distribution of permitted and exempt groundwater wells in Oregon during 2008. Figure is based on water well logs on file (excluding logs for well deepening, alteration, and abandonment) at the Oregon Water Resources Department OWRD. State regulations requiring that water well logs be submitted to OWRD for any new well construction or existing well modification were instituted in 1955. Only a few of the wells that existed prior to 1955 are represented in these figures. Groundwater restricted areas (depicted by red lines) represent areas with groundwater use restrictions, such as prohibition of new permits or, in some cases, restricted use of existing permits. In most cases, exempt uses are allowed in the restricted areas. Exempt uses include wells used for domestic purposes. These wells constitute a water right with a priority date but do not require the user to hold a permit from OWRD. Up to 15,000 gallons per day can be pumped from exempt wells. The amount of water actually withdrawn varies considerably among represented well localities. Figure provided by OWRD.

Key Findings: Futures analysis and planning

- Avoiding aquatic ecosystem impairments associated with future development requires understanding where and how future development is likely to occur.
- Spatial models of future land use (futures analyses) are powerful tools for estimating the location and extent of future development and for evaluating potential effects of different development scenarios on aquatic ecosystems. The science underlying futures analysis is an area of ongoing research and efforts to model alternative futures typically demonstrate relative outcomes, rather than exact endpoints, of different policies on land and water resource use.
- Individual model estimates of aquatic ecosystem condition have a low level of certainty; however, the majority of futures analyses conducted for Pacific Northwest landscapes indicate that future development could have moderate to severe consequences for riparian and aquatic habitat condition and aquatic biota.
- Oregon currently lacks an established long-term water management strategy but several initiatives have recently been undertaken to assess priorities and strategies for managing water sources in Oregon.

Section 9.2: What actions can be taken to protect salmonids in the face of a developing landscape?

This section describes a range of actions that could be taken to avoid or reduce the negative effects developments can have on aquatic ecosystems, or offset negative effects occurring in one location by investing in actions that avoid, mitigate, or remedy impacts elsewhere.

SECTION 9.21: AVOID FUTURE IMPACTS

The USEPA (2004c) recommends 75 proactive policies and actions that hold potential for avoiding the negative effects of development on aquatic ecosystems at both regional and site-level scales. Regional-level policies fall into the following categories (USEPA 2004c):

- *Discouraging development in strategic areas*: When communities inventory and clearly define areas they want to protect (e.g., headwaters, estuaries, wetlands, marshes, riparian corridors, and other lands with higher ecological value), development will shift to land with lower ecological value.⁷⁵
- *Environmental regulatory innovations including voluntary incentives*: The federal Clean Water Act (CWA) defines national water quality goals and standards and details procedural steps necessary to attain them. Individual states and tribes are given the authority to determine how they will meet federal standards outlined and enforced by the USEPA. Such delegated authority creates opportunity for state-level innovation in water

⁷⁵ For an example of how achieving such goals are being approached in Oregon, see the Riparian and Wetlands project underway (2009-2011) in Benton County. <http://www.co.benton.or.us/cd/riparian/advisory.php>. Accessed December 16, 2009.

quality and aquatic habitat management and can encourage cost-effective voluntary practices.

- *Education*: The effects of development on water resources are widespread and regulation alone has not proven effective in protecting aquatic ecosystems. Educating local officials, residents, business owners, developers, and other stakeholders on the many ways their actions affect aquatic ecosystems is critical to the success of the Oregon Plan.
- *Funding and fee structures*: Financial incentives are important tools for directing development in ways that protect aquatic ecosystems. Fees that reflect the true cost of water quality and physical habitat impairments caused by development encourage proactive actions (e.g., better stormwater control).

Site-level policies fall into the following categories:

- *Site planning*: Local governments focused on planning approaches that are compatible with protecting aquatic ecosystems can direct the location of new developments.
- *Strategies and technologies*: Site-specific strategies determine how developments function as livable places while also protecting aquatic ecosystems.
- *Education*: Outreach, training, and information about new development approaches and innovations can help encourage development patterns that protect aquatic ecosystems.
- *Ordinances and codes*: Ordinances and codes determine the type of development allowed at specific locations and advance standards to better manage water resources⁷⁶.

In the following sections IMST summarizes recent peer-reviewed literature relevant to many of the policies outlined by the USEPA (2004c).

SECTION 9.22: AVOID BUILDING IN SENSITIVE AREAS

While factors that impair aquatic ecosystem conditions are well documented (e.g., Paul & Meyer 2001; Allan 2004; Sections 2.0–7.0 of this report) comprehensive research on how best to protect streams and rivers from future development is still in its infancy and few examples exist for the effective conservation of freshwater ecosystems (Abell *et al.* 2007). Achieving a high level of conservation in river networks may require a hierarchical approach that incorporates freshwater protected areas (i.e., reserves similar to those used as conservation tools in terrestrial and marine ecosystems) into a mix of lands managed using ‘salmonid-friendly’ practices (Abell *et al.* 2007; Linke *et al.* 2008). The use of riparian buffer zones is a well-known strategy for protecting aquatic ecosystems adjacent to developed lands (e.g., Booth 2005). Some initiatives aimed at establishing freshwater protected areas are underway in the Pacific Northwest (e.g., North American Salmon Stronghold Partnership⁷⁷). Land acquisitions and similar conservation tools are also important components of many conservation plans in Oregon, including plans for

⁷⁶ Also see model ordinances to protect local resources: <http://www.epa.gov/owow/nps/ordinance/index.htm>; <http://www.lcd.state.or.us/>. Accessed December 16, 2009.

⁷⁷ http://www.wildsalmoncenter.org/programs/north_america/strongholds.php. Accessed December 16, 2009.

salmonid species (ODFW 2006). The following examples highlight programs that have either acquired land or directed development away from sensitive lands in Oregon.

- The **Metropolitan Greenspaces Program** (Metro & USFWS 2005) was jointly administered by the USFWS and Metro (northwestern Oregon) and involved stakeholders from non-profit organizations, local governments within Metro, and citizens. Metro is the elected government responsible for managing a regional urban growth boundary encompassing 25 cities and more than 60 special service districts within Washington, Multnomah and Clackamas counties. About 1.3 million people live within the approximately 400 sq. mi. (1036 sq. km) demarcated by the Metro UGB. The primary goal of the Metropolitan Greenspaces program was natural resource conservation implemented through natural area inventories, land acquisition, habitat restoration, environmental education, and public outreach. From 1991 through 2005 the program was funded by a \$135.6 million bond measure and other grants that allowed matching funds to be leveraged from federal agencies. The land acquisition component of the program resulted in the purchase of over 8,000 acres (3,237 ha) of high priority fish and wildlife habitat across the greater Portland Metro area. The program provides a nationally recognized example for conservation strategies implemented in and around urban areas.
- The Metro council of regional governments along with Clackamas, Multnomah, and Washington counties has initiated a process intended to shape the location and intensity of development occurring in the Portland metropolitan region between 2010 and 2060. Beginning in 2007 with Senate Bill 1011, the **Coordinated Reserves Work Program**⁷⁸ has resulted in proposals for a series of urban and rural reserves on lands currently outside the UGB for the Portland-Metro area. Under Oregon's land use laws, the UGB is intended to contain a twenty-year supply of developable land. Every five years Metro determines how much acreage is needed to meet the 20-year demand and expands the UGB accordingly. The Coordinated Reserves Work Program identifies urban reserves that contain lands suitable for future UGB expansions and urban development in advance of the 5-year UGB planning intervals. Rural reserves are intended to protect natural areas and features from development and to maintain lands for the production of agricultural and forest products. Proposed urban and rural reserves are being designed in compliance with Oregon's land use laws (e.g., DLCD Goals 5 and 6) and will undergo review by DLCD.
- The **West Eugene Wetland Partnership**⁷⁹ has acquired and protected a 3,000 acre (1,214 ha) complex of wetland and associated upland habitats through a combination of regulation, mitigation banking, land acquisition, restoration, and education. Since the early 1990's the Partnership has raised over \$20 million in state and federal funds for land acquisition and habitat restoration. The site also serves as a wetland mitigation bank for the city of Eugene and the surrounding area. City and county planners are also working to connect the wetland complex to other important natural resource sites acquired by the **Rivers to Ridges** program (Lane Council of Governments 2003). The

⁷⁸ <http://www.oregonmetro.gov/index.cfm/go/by.web/id=30155>, and http://library.oregonmetro.gov/files/reserves_work_program_overview_07-10-09.pdf. Accessed December 21, 2009

⁷⁹ <http://www.eugene-or.gov/portal/server.pt?open=512&objID=667&PageID=2543&cached=true&mode=2&userID=2>. Accessed December 17, 2009.

success of both the West Eugene Wetland Partnership and the Rivers to Ridges programs is credited in part to planners who engaged citizens, built a community vision for natural resource protection, and gained broad political support for protecting wetland resources.

Managing land use in ways that protect aquatic ecosystems requires consideration of lateral, longitudinal, and vertical connectivity (Linke *et al.* 2008). Because streams and rivers transport water, solutes, and sediments, distant land-use activities can affect water quality and physical habitat within reaches that might otherwise have high conservation value. Consequently, landscape features occurring over a broad area should be considered when determining the conservation value associated with protecting a particular river segment (Linke *et al.* 2008). The high mobility of many aquatic organisms also presents a difficult challenge for the design of freshwater protection strategies (Abell *et al.* 2007). Most salmonids have complex life histories that require several different habitats (e.g., spawning, rearing, refuge, and smolting) distributed over broad spatial extents (Table 1-5). This increases the likelihood that at least one of their critical habitats will fall outside of protected reaches.

Typically, land acquisition budgets are insufficient for covering costs associated with purchasing and managing all desirable lands. Only protecting inexpensive sites that have a low probability of being developed will exclude areas with high conservation value. Alternatively, focusing on high-priced lands that provide large conservation benefits will likely only protect a small area (Newburn *et al.* 2006). The selection of areas for protection can be accomplished with greater efficiency if the process occurs before surrounding areas begin to undergo development (Costello & Polasky 2004; Newburn *et al.* 2006). Land values and threats to sensitive species constantly change as developments expand and thus present moving targets for conservation (Armsworth *et al.* 2006). The dynamic forces of land supply and demand help determine land value. As a result, the purchase of land for conservation purposes changes land supply and may influence the monetary value of nearby parcels and alter the likelihood that these parcels will be developed (Armsworth *et al.* 2006). Ultimately such dynamics can influence the conservation benefits gained by protecting certain parcels.⁸⁰

Avoiding the effects of future development also requires identifying lands that can be developed with minimal consequences for aquatic ecosystems. Selecting sites for either protection or development involves striking a balance between conflicting conservation and economic interests such as the ecological value of a parcel, monetary value of a parcel, and the likelihood that a parcel will be developed within a defined period (Armsworth *et al.* 2006; Newburn *et al.* 2006). Polasky *et al.* (2008) analyzed the economic and biological tradeoffs of alternate land use scenarios on rural 'working' lands (i.e., outside of protected areas and UGBs) in the Willamette River basin (Oregon). Using spatially explicit models that integrated information on land use patterns, economic returns from alternate land uses, and the habitat requirements of terrestrial vertebrates, Polasky *et al.* (2008) identified land use patterns that maximized both economic gains and conservation benefits. Conservation of wetland habitats adjacent to the Willamette River between Eugene and Corvallis substantially increased conservation benefits at minimal economic cost. While their analysis focused on terrestrial vertebrates, riparian wetland conservation would also benefit aquatic organisms and these results highlight the advantages of

⁸⁰ For examples of how open space can influence home sale values in Oregon see Lutzenhiser & Netusil (2001) and Mahan *et al.* (2000).

considering the spatial arrangement of various land uses (i.e., agriculture, forestry and rural-residential) in land use planning (Polasky *et al.* 2008).

SECTION 9.23: ENGINEERING & BIOENGINEERING SOLUTIONS

Stormwater derived from developments has strong influences on hydrology and channel morphology of streams, rivers, and estuaries, and has been identified as a significant source of diffuse (non-point) pollutant loads entering surface waters (USEPA 2004c, 2005; Trauth & Shin 2005; Dietz & Clausen 2008; see Section 2.0 of this report). To address stormwater-related issues in medium and large municipalities, the US Congress amended the CWA in 1990 and 1999 to include Phase I & II NPDES stormwater control measures (USEPA 2005). Approaches used to manage and treat stormwater in Oregon cities typically include 'end of pipe' techniques (e.g., stormwater detention ponds) that convey stormwater to large management facilities for treatment before it enters surface waters (USEPA 2000a, 2007; Zimmer *et al.* 2007). Such techniques are intended to regulate peak stormflow rates and control some pollutants but do not address alterations to stormflow or bankfull flow duration that are known to cause aquatic ecosystem impairments (USEPA 2000a, 2007; Booth *et al.* 2004; Dietz & Clausen 2008; see Section 2.0 of this report).

Continuing development will increase the difficulties many municipalities face in meeting NPDES permit obligations and other water quality regulations such as TMDL requirements (USEPA 2007). This will also result in the continuing impairment of Oregon's aquatic ecosystems and will hinder efforts to rehabilitate urban and rural-residential streams. The USEPA strongly supports two alternative approaches aimed at improving stormwater management on developed lands. *Low impact development* (LID), also known as Green Infrastructure⁸¹, is a site design strategy composed of techniques that minimize site disturbance and impervious surface area, that reduce reliance on 'end-of-pipe' stormwater treatment facilities, and that preserve or mimic natural (i.e., predevelopment) hydrologic processes within the boundaries of individual developments (USEPA 2000a, 2005, 2007; Dietz 2007; Zimmer *et al.* 2007; Godwin *et al.* 2008). Smart growth is a framework for planning the spatial pattern and density of developments at regional, watershed and site-level spatial scales (Nickerson 2001; APA 2002; Palmer *et al.* 2002; USEPA 2001b, 2005, 2006a; NOAA 2009).

Section 9.231: Low Impact Development

The LID concept evolved out of best management practices designed to meet NPDES stormwater permit requirements (USEPA 2005). Many LID techniques were pioneered in the northeastern and northwestern US (USEPA 2007; Zimmer *et al.* 2007) and can be incorporated into both existing and new developments (USEPA 2000a; Hinman 2005; Godwin *et al.* 2008). The primary goals of LID designs are to reduce surface runoff, increase groundwater recharge, and increase evapotranspiration by strategic placement of numerous stormwater management applications (Table 9-2) throughout a development (USEPA 2000a, 2007; Hinman 2005; Dietz 2007; Zimmer *et al.* 2007; Dietz & Clausen 2008; Godwin *et al.* 2008). Relative to older and more typical current procedures, LID techniques used in new and existing developments have

⁸¹ See USEPA Managing Wet Weather with Green Infrastructure, http://cfpub.epa.gov/npdes/home.cfm?program_id=298. Accessed December 17, 2009

been shown to increase stormwater infiltration, improve stream hydrology, and reduce the amount of stormwater-associated pollutants that reach surface waters (e.g., UNH Stormwater Center 2010). LID techniques are directed towards controlling stormwater runoff at its source, as opposed to downstream locations. This requires preservation or restoration of hydrologic processes such as interception and infiltration, and of natural topographic features (McCuen 2003). Such actions can lower the pollutant load transferred to surface waters, reduce erosion, and contribute to the preservation or rehabilitation of the natural hydrologic regime (USEPA 2004a, 2005; UNH Stormwater Center 2010). The following LID strategies improve the hydrologic function within individual developments (McCuen 2003, USEPA 2000a, 2004c, 2005, 2006a):

- Maximizing stormwater retention at the parcel-level;
- Preserving or emulating natural hydrologic processes during the construction of hard surfaces;
- Protecting (as opposed to paving or filling) small permanent and intermittent streams and associated riparian buffers and wetlands; and
- Regulating the volume, timing, and velocity of stormwater flows at many points throughout a watershed rather than at few downstream locations.

Table 9-2. Low Impact Development Practices. Shown are different categories of low impact development practices, their use, and examples of each (adapted from USEPA 2007).

Low Impact Development Practice/Design	General Purpose	Examples
Conservation design	preserve open space and minimize disturbance of vegetation and soils in new developments or infill	clustered development; open space protection; reduced street and sidewalk widths; shared and shorter driveways
Infiltration practices	capture and infiltrate runoff into soil	infiltration basins and trenches; porous pavement; disconnected downspouts; rain gardens; vegetated roofs
Runoff storage practices	capture runoff from impervious surfaces and store for reuse or gradual infiltration	storage basins associated with parking lots, streets, and sidewalks; rain barrels and cisterns; depression storage
Runoff conveyance practices	route excess runoff from large storm events out of LID structures through structures that regulate flow velocity, volume, and timing	eliminate curbs and gutters; grassed swales; roughened channels and surfaces; long flow paths over landscaped areas; terraces and check dams
Filtration practices	filter runoff through media designed to capture pollutants	bioretention/rain gardens; vegetated swales; vegetated filter strips or buffers
Low impact landscaping	select landscaping features and plants to serve LID functions	native plants; drought tolerant garden and landscaping plants; convert turf to shrubs or trees; soil amendment

Compared to conventional stormwater management techniques, LID can be less expensive to implement, although the costs of long-term maintenance remain unclear (USEPA 2000a, 2007). Relevant organizations such as the Oregon Environmental Council⁸², the Metro regional

⁸² <http://www.oeconline.org/our-work/rivers/stormwater/stormwater-report>. Accessed December 29, 2009.

government⁸³, the Bureau of Environmental Services at the City of Portland⁸⁴, the Puget Sound Action Team (Hinman 2005), and Oregon Sea Grant (Godwin *et al.* 2008) provide extensive guidance on the use of LID techniques to control stormwater.

Effectiveness of LID Techniques – There is a growing body of literature on the effectiveness of LID⁸⁵. The majority of studies available assess individual LID practices (e.g., vegetated roofs, permeable pavement) at relatively small spatial scales. Research findings indicate that individual LID practices effectively reduce stormwater runoff and sequester many types of freshwater pollutants (reviewed by USEPA 2000a; Dietz 2007, UNH Stormwater Center 2010). Dietz & Clausen (2008) assessed stormwater runoff and pollutant loads derived from two adjacent Waterford (Connecticut) subdivisions constructed using traditional and LID techniques. This study provides a more realistic view of LID effectiveness because it measured stormwater at the scale of entire developments and integrated the effects of multiple stormwater control techniques. Stormwater runoff, runoff rates, and pollutant loads in the LID subdivision did not increase with impervious surface area and were similar to those measured in nearby forested watersheds representing predevelopment conditions (Dietz & Clausen 2008). Research addressing whether LID techniques can achieve the desired level of protection for aquatic ecosystems at the watershed scale is limited (Dietz 2007; USEPA 2007). Zimmer *et al.* (2007) modeled the ability of LID techniques to reduce the effects of development on watershed-scale hydrology and demonstrated that LID techniques improved hydrologic conditions in both new and existing developments.

Common barriers to the implementation of LID techniques include resistance to change, limited opportunities, limited funding, restrictions imposed by existing codes and rules, maintenance issues, and lack of government staff and resources to implement policies and programs (USEPA 2000a; Godwin *et al.* 2008). Because LID techniques must be broadly distributed throughout a development they often require implementation on private property which complicates maintenance issues (USEPA 2000a). Existing codes may also prevent city land managers from implementing alternative strategies (e.g., restrictions against disconnecting downspouts). Limited staff at planning and public works departments have difficulty keeping pace with permitting demands imposed by rapidly growing cities (Godwin *et al.* 2008).

The suite of LID techniques in use is continually evolving along with the need to evaluate the effectiveness of both existing and new techniques (Dietz 2007). Results from the collective body of research reviewed by IMST indicate that LID techniques can reduce, to varying degrees, the negative effects that developments have on nearby streams, rivers, and estuaries. Overall, more research is needed to determine if LID reduces the deterioration of aquatic ecosystems and to identify specific land use policies that will effectively manage future growth in ways that protect water resources and aquatic ecosystems (USEPA 2007).

⁸³ <http://www.oregonmetro.gov/index.cfm/go/by.web/id=24592>. Accessed December 29, 2009.

⁸⁴ <http://www.portlandonline.com/bes/index.cfm?c=31892>. Accessed September 1, 2010.

⁸⁵ See International Stormwater BMP database - <http://www.bmpdatabase.org/BMPPerformance.htm>; Water Environment Research Foundation - <http://www.werf.org/net/search.aspx>. Accessed December 21, 2009.

Section 9.232: Smart Growth

The principles underlying *smart growth* were drafted by a coalition of preservation, development, academic, and governmental organizations that comprise the Smart Growth Network (USEPA 2006a). The smart growth concept is based on a set of 10 land-use principles (USEPA 2001b; Trauth & Shin 2005) intended to guide the development of livable cities in ways that preserve natural hydrologic processes, improve water quality, and increase water quantity (McCuen 2003; USEPA 2005, 2006a). At regional and watershed scales, land use policies informed by smart growth principles direct development away from contiguous tracts of land intended to protect the ecological condition of aquatic and riparian ecosystems. Once the locations of future development have been determined, appropriate techniques for managing stormwater (e.g., LID practices) can be implemented within individual developments (USEPA 2000a, 2007).

The use of smart growth concepts in regional- and watershed-scale land use planning concentrates growth on smaller land areas (compared to traditional developments) and protects the condition of aquatic ecosystems (USEPA 2004c, 2007) by doing the following:

- Avoiding development near areas with high ecological value,
- Maximizing use of existing infrastructure,
- Concentrating future development in existing developments, and
- Regulating the quantity and distribution of impervious surfaces at the watershed level, rather than at the parcel or development level.

The USEPA has produced extensive guidance on smart growth including policy actions that provide an explicit framework for incorporating smart growth principles into land use planning at regional, watershed, or site-level scales (USEPA 2004c, 2005, 2007; Trauth & Shin 2005).

In traditional developments, impervious surfaces lead to numerous detrimental effects on aquatic ecosystems (see Section 2.0 of this report). Because impervious surfaces have been repeatedly linked to poor water quality, local governments sometimes set limits on the maximum impervious area allowed within a zoning district (Jones *et al.* 2005; USEPA 2005). While the intention of such regulations is to protect aquatic resources, limiting impervious surface areas can result in low-density developments spread over larger land areas and may actually increase water quality problems at the watershed scale (Trauth & Shin 2005). In contrast, the smart growth framework proposes clustered, high-density developments that could dramatically increase impervious surfaces in selected areas of a watershed if these areas were developed using traditional methods (Trauth & Shin 2005). Under the smart growth framework, however, increased stormwater runoff from intensely developed lands is reduced through the application of LID techniques (USEPA 2000a, 2005, 2006a).

Several authors (e.g., Jones *et al.* 2005; USEPA 2004c; 2006b) assert that high development densities hold greater potential to protect water resources when these developments are placed in appropriate locations. This argument is based on the premise that low development densities do not necessarily alleviate the ecological consequences of increasing population growth; they simply determine the spatial patterning of development (USEPA 2006b). For example, low development densities often require more infrastructure such as roads and can increase the amount of impervious surfaces outside of residential parcels (Trauth & Shin 2005; USEPA

2006b). To better understand the relationship between development density and water quality, USEPA scientists modeled the volume of stormwater runoff generated by three different development scenarios at three different scales (USEPA 2006b). Model results indicated that the volume of stormwater runoff generated *per house* would be consistently lower in higher density developments (USEPA 2006b). The volume of stormwater runoff produced by an equivalent number of homes was a function of development pattern, with lower development densities affecting more area within the modeled watershed and collectively generating more stormwater (USEPA 2006b). These findings indicate that high development densities may provide superior protection for aquatic ecosystems and that increasing development density in appropriate areas is one viable strategy for minimizing the negative effects development can impose on aquatic ecosystems (USEPA 2004b, 2006c).

The quantity of water required by developing cities also depends on where and how growth takes place (USEPA 2006a). For example, residents living on larger parcels often use more water than those dwelling in homes situated on smaller lots. A study of residential developments in Seattle (Washington) demonstrated that residents living on 6,500 square foot (0.15 acres) lots used 60% less water than residents living on 16,000 square foot (0.37 acres) lots (USEPA 2006a). Implementing smart growth design strategies (e.g., compact neighborhood layouts) may increase the efficiency with which municipalities use water resources (USEPA 2006a).

Section 9.233: LID and Smart Growth Implementation in the Pacific Northwest

A recent ruling made by the State of Washington's Pollution Control Hearing Board illustrates the role that LID may play in future development in the Pacific Northwest. The August 2008 ruling⁸⁶ represents the first decision in the US to require LID implementation in new developments in order to meet NPDES Phase I stormwater permit requirements. This ruling determined that the use of LID techniques is necessary to meet CWA standards stating that stormwater be managed to the 'maximum extent practicable' using 'all known and reasonable technologies'. Jurisdictions and municipalities affected by the ruling cover a large area in Washington including Clark, King, Pierce, and Snohomish counties and the cities of Seattle and Tacoma (Locklear 2009).

In Oregon, NPDES permits currently in effect do not require the use of LID techniques. Phase I NPDES permits are, however, currently undergoing review and reissuance. Revised permits will likely require the use of LID in new development or redevelopment projects unless a municipality identifies a significant barrier that would make the use of such techniques inappropriate (Benninghoff 2009 pers. comm.⁸⁷). These changes would likely apply to only the largest municipalities in Oregon and to only to new development or redevelopment projects. Phase II NPDES permits that apply to cities with populations under 100,000 also do not currently require the use of LID but will undergo reissuance in 2012.

⁸⁶ Pollution Control Hearings Board. PSA vs. Ecology, Findings of Fact, Conclusions of Law, and Order Phase I PCHB Nos. 07-021, 07-026, 07-027 07-028, 07-029, 0-030, 07-037 August 2008, <http://www.eho.wa.gov/searchdocuments/2008%20archive/pchb%2007-021,07-026,07-027,07-028,07-029,07-030,07-037%20phase%20i%20final.pdf>.

See also <http://www.stormh2o.com/july-august-2009/washington-state-decision.aspx>. Both accessed December 31, 2009.

⁸⁷ Benjamin Benninghoff, Oregon Department of Environmental Quality, Portland, Oregon, personal communication, December 2, 2009.

Many Oregon cities have not yet adopted LID practices for areas undergoing development. As a result, the stormwater generated by ongoing development still has a significant capacity to impair aquatic ecosystems. While changes to the NPDES Phase I permits will reduce the stormwater generated by new development in Oregon's largest and most rapidly growing cities, these changes will not apply to numerous small municipalities throughout the state. The cumulative effects of existing and new developments that are not regulated by the NPDES permitting process could be significant for Oregon's aquatic ecosystems. Rural-residential and urban developments can make substantial contributions to the mission of the Oregon Plan, but it is critical to ensure that continuing development does not perpetuate the damage already inflicted on Oregon's aquatic ecosystems. It is far more effective to invest in preventing such damage rather than attempting to rehabilitate aquatic ecosystems after damage has already occurred (i.e., after a stream has been placed on the 303d list because of impairments caused by stormwater runoff).

Oregon's land use laws already embody many smart growth principles. The urban growth boundary, first implemented in Oregon during the 1970s, protects resource lands by restricting the location of high-density development. Ongoing efforts in the Portland metropolitan region to articulate the 2040 growth concept⁸⁸ and to identify urban and rural reserves outside of the current UGB also integrate many smart growth principles. Such efforts have resulted in the long-standing maintenance of large uninterrupted tracts of forest and agricultural land and have likely provided some protection to Oregon's aquatic resources over the past 35 years. For example, implementation of DLCD's Goal 5⁸⁹ within Oregon's UGBs has resulted in the inventory and protection of riparian and aquatic habitats that might otherwise have been diminished by development.

However, the primary focus of Oregon's land use laws is to protect economically important agricultural and forest resource lands by containing urban sprawl; aquatic habitats are a secondary focus (Wiley 2001). The land use program is implemented within landscapes dominated by human activities that are partitioned according to ownership and government jurisdiction. Also, the language of land use goals (i.e., DLCD Goals 5, 6, 7, 15) that could achieve a significant level of protection for aquatic resources is broad and leaves individual jurisdictions with significant latitude on how to interpret and implement goals. Consequently, the level of protection derived from these land use goals depends on how they are interpreted and implemented within any given jurisdiction (Punton 2009 pers. comm.⁹⁰). This system can result in differing levels of protection of the same resource across individual jurisdictions (Wiley 2001).

The proper functioning of aquatic ecosystems depends on components and processes that overlap and interact within and across different spatial and temporal scales. Natural features and processes important to the conservation of aquatic ecosystems often span jurisdictional boundaries subject to Oregon's land use laws. The focus of Oregon's land use laws on individual resources within human-defined jurisdictions limits the degree to which these laws can be used to address regional conservation priorities (e.g., recovery of ESA-listed salmonids). Increased coordination among jurisdictions and an increased focus on functional landscapes (e.g.,

⁸⁸ <http://www.oregonmetro.gov/index.cfm/go/by.web/id=25104>. Accessed December 28, 2009.

⁸⁹ <http://www.oregon.gov/LCD/docs/goals/goal5.pdf>. Accessed December 31, 2009.

⁹⁰ Amanda Punton, Department of Land Conservation and Development, Portland, Oregon, personal communication, November 2009.

watershed-scale processes) during the implementation of Oregon's land use laws could afford greater protection to aquatic ecosystems. Sufficient protection of aquatic ecosystems may also require augmentation of land use laws with additional tools such as land acquisitions, conservation easements, tax incentives, and land owner education programs. Coordinated implementation of such an array of actions could allow the development of a multi-tiered approach to address the habitat needs of salmonids in developed lands.

Key Findings: Engineering & bioengineering solutions

- New development will result in the continuing impairment of Oregon's aquatic ecosystems and will hinder efforts to rehabilitate urban and rural-residential streams. Rural-residential and urban developments could make significant contributions to the mission of the Oregon Plan by ensuring that new development does not perpetuate the damage already inflicted on Oregon's aquatic ecosystems by existing development.
- Protecting sensitive lands through land acquisitions and designation of freshwater reserves and improving stormwater management on developed lands are strategies that could be used to avoid or minimize the effects of future development.
- Spatially explicit models that integrate information on land use patterns, economic returns from alternate land uses, and the habitat requirements of sensitive species can be used to identify locations where increased conservation benefits can be achieved with minimal economic cost.
- When incorporated into existing or new developments, low impact development (LID) techniques can reduce pollutant loads transferred to surface waters, reduce erosion, and preserve or rehabilitate the pre-development hydrologic regime. Many Oregon cities have not yet adopted LID practices. As a result, the stormwater generated by existing and ongoing development impairs aquatic ecosystems.
- Smart growth is based on a set of land use policies that direct development away from contiguous tracts of land intended to protect the ecological condition of aquatic and riparian ecosystems. Literature reviewed by IMST indicates that constructing high-density developments in appropriate locations is a viable strategy to minimize the negative effects of development.
- Oregon's land use laws embody many smart growth principles and have resulted in the long-term maintenance of large uninterrupted tracts of forest and agricultural land which has afforded some protection to Oregon's aquatic resources. The focus of Oregon's land use laws on individual resources within human-defined jurisdictions limits the degree to which they can be used to address regional or watershed-scale conservation priorities.

Section 9.3: Offsetting Impacts of New Development

Even with the use of smart growth and LID practices, the negative impacts developments have on aquatic ecosystems cannot be completely avoided. Oregon's governments, communities and businesses expend substantial resources on environmental rehabilitation and mitigation projects aimed at offsetting the effects of development (INR 2008). Mitigation or rehabilitation projects implemented 'on-site' may not be effective in regional conservation efforts because individual projects tend to be costly and only protect or rehabilitate small, spatially dispersed areas near developed lands (Sudol & Ambrose 2002; BenDor & Brozović 2007; Primožich & Vickerman 2007; INR 2008). In response to perceived shortcomings of on-site rehabilitation and mitigation actions, various market-based trading strategies have been proposed or developed as economically and ecologically sound alternatives (e.g., Breetz *et al.* 2004; USEPA 2004c; Morgan & Wolverson 2005; Trauth & Shin 2005; BenDor & Brozović 2007; Primožich & Vickerman 2007; Shabman & Stephenson 2007; Willamette Partnership 2007a).

Market-based strategies are used in situations where actions that impair environmental conditions (e.g., release of water pollutants, destruction of habitat) can be treated as tradable commodities and managed in ways that increase environmental gains and reduce overall financial costs of offsetting environmental impacts (Shabman & Stephenson 2007). Trading strategies are based on the premise that individual companies or agencies operating within a defined area (e.g., a watershed) incur different costs to comply with the same environmental regulation. Established trading programs allow entities that incur high financial costs to meet regulatory obligations by purchasing environmental credits from another entity capable of meeting the same regulatory obligation at a lower cost (INR 2008). As a result, environmental regulations are met by all involved parties at a lower overall financial cost. An added benefit is that market-based strategies create incentives for those involved in trading to seek innovations that improve the efficiency and reduce the cost of meeting environmental regulations (Shabman & Stephenson 2007).

For market-based programs to operate effectively, there must be an adequate demand for the environmental commodity to be purchased, a stable supply of marketable credits, and a structure for transactions that make the cost associated with trading affordable (INR 2008). These requirements set up an important interplay between the spatial extent in which a program operates and viability of the program (Farrow *et al.* 2005; Obropta & Rusciano 2006; BenDor *et al.* 2009). Trading programs operating within large spatial areas may result in large distances between sites affected by development and sites where credits are created. Such a situation may allow extensive damage to occur in one location while offsets occur in distant location with little ecological connection to the area disturbed by development. Trading programs operating in small spatial areas may not be able to produce a viable trading market because the land area is not large enough to create a stable supply of credits (e.g., acres of habitat in mitigation banks). These trade-offs should be considered carefully when setting the spatial area for market-based trading programs (BenDor *et al.* 2009).

The implementation framework used for market-based programs depends on the parties involved, the commodity traded, and the location where the program is implemented. Consequently, there is substantial variation in programs currently proposed or operating in the US (Breetz *et al.* 2004; Morgan & Wolverson 2005; Shabman & Stephenson 2007). Several programs are underway or under development by organizations and agencies in Oregon such as the Climate Trust, The Freshwater Trust, Deschutes River Conservancy, and Clean Water

Services (see INR 2008 for a recent overview of programs; Table 9-3). In addition to these organizations, the Willamette Partnership⁹¹ is developing a framework for a market that integrates a number of environmental commodities such as wetlands, water pollutants, water quantity, endangered species habitat, and carbon. The following sections summarize how two general types of market-based strategies operate, provide examples of strategies that have been implemented or are under development in Oregon, and review the benefits and shortcomings identified with the implementation of such strategies.

SECTION 9.31: MARKET-BASED TRADING

Market-based trading involves the establishment of a credit system that is used to regulate actions that impair ecosystem function. The majority of trading programs address water pollution limits set by TMDL requirements and many focus on a single pollutant such as phosphorus, nitrogen, or temperature (Morgan & Wolverton 2005; Obropta & Rusciano 2006). Programs for carbon trading are also under development nationwide (e.g., Western Climate Initiative⁹²). Typically, a watershed-based limit defined by a TMDL or other regulatory structure (e.g., a NPDES permit) stimulates a demand for trading credits by capping the total pollutant discharge allowed within the watershed (Shabman & Stephenson 2007). Supply can be created by allocating the allowable pollutant load among the group of traders that release the pollutant within the watershed. Trading ratios are typically used to address several complexities that arise during the management of water quality trading programs. The collective trading group typically sets rules regarding how pollution loads are allocated among traders and designs a framework for pollutant allocation and trading that maintains total pollutant loads below the level set by the regulatory authority. Market frameworks, transaction costs, trading ratios, and other aspects of the trading schemes vary considerably among programs (Breetz *et al.* 2004; Morgan & Wolverton 2005).

Trading ratios are generally used to standardize pollution credits based on likely environmental effects or to account for uncertainty in trading program effectiveness (Farrow *et al.* 2005; Morgan & Wolverton 2005). For example, both point and non-point pollution releases can be managed under market-based trading systems, but it is often difficult to incorporate non-point pollution sources into trading programs because these sources are dispersed and not easily quantified (Obropta & Rusciano 2006; Shabman & Stephenson 2007). When trades involving both point and non-point pollution sources are made, the point-source trader is typically held responsible if the non-point source trader fails to reduce its pollution discharges by the amount agreed upon (Shabman & Stephenson 2007). A point source trader interested in purchasing credits from a non-point source trader might be required to purchase a credit amount that is double the actual pollution discharge increase (i.e., a 2:1 trading ratio).

The effectiveness of market-based trading in controlling pollution may depend on how environmental regulations shape trading markets (Shabman & Stephenson 2007). In programs where pollutant loads are fully capped at a fixed level by a regulatory agency, any interested entity would have to be assigned a discharge allowance (i.e., trading credits) from the existing fixed supply to legally discharge the pollutant. Trading programs that operate under full (and

⁹¹ <http://www.mwvcog.org/WillamettePartnership/WillamEcoMarket.asp>. Accessed December 31, 2009.

⁹² <http://www.westernclimateinitiative.org/>. Accessed December 31, 2009.

Table 9-3. Existing and emerging markets for environmental credit trading and banking in the Willamette River basin. Adapted from Willamette Partnership (2007b).

Scheme	Mandate	Agencies	Description	Potential
Wetland mitigation banking	Section 404 fill permits from the CWA, and Section 10 of the Rivers and Harbors Act	Federal regulating agencies: USACE; USEPA Oregon regulating agencies: DSL Others involved: USFWS; NOAA; NMFS; ODF; members of the mitigation banking review team.	When land developers fill or otherwise alter a wetland they may buy offsets from a mitigation banker. The mitigation banker restores or creates an area of wetland (or multiple sites under an umbrella agreement) to generate credits.	High: already active with growing demand along I-5 corridor and Washington County. First stream mitigation bank approved in 2006. DSL is exploring building a state clearinghouse or wetland mitigation credits tied to industrial site development.
Endangered species conservation banking	Section 7 (consultations) and Section 10 (incidental take) of the ESA.	Federal regulating agencies: USFWS; NMFS Oregon regulating agencies: None determined Others involved: Future members of the conservation banking review team.	The conservation banking market is a biodiversity offset system that allows for the sale and purchase of endangered species credits to offset negative impacts to endangered species and their habitats. USFWS and NMFS are each responsible for conservation banking for their species.	Medium: USFWS has approved the first conservation banks for Oregon chub for ODOT. NMFS has approved a salmon bank in California. There is no formal process for conservation bank approval. There are no standards for anadromous fish banking.
Water quality trading	NPDES permits; TMDLs; MS4 permits	Federal regulating agencies: USEPA Oregon regulating agencies: ODEQ	Most water quality markets are established to assist industrial and municipal waste water dischargers that must reduce the amount of pollutants they release.	High: already active in the Tualatin River basin with grant monies in place to expand temperature trading in the Willamette. There is a need to authorize other trading for pollutants.
Water supply trading	Water quality goals under the CWA; ESA; other water supply needs.	Oregon regulating agencies: OWRD	Most water quantity trades have involved urban water users leasing water from agricultural water rights holders in the western US. Trading for environmental purposes has increased in the Columbia River basin and California. Flows are also getting attention related to meeting water quality goals and stormwater discharge requirements.	High: Already active throughout the country. Trading for environmental purposes has been facilitated by the Oregon Water Trust which acquires, purchases, and develops agreements to provide water in-stream.
Stormwater trading	Local regulations, MS4 permit, CWA	Federal regulating agencies: USEPA Oregon regulating agencies: ODEQ Others involved: Municipal governments, special districts	The City of Portland is conducting a stormwater trading feasibility study; cannot trade directly within the bounds of their MS4 permit; are using a local ordinance focusing on flows . Trading might occur around impervious pavement, where a green street installation might create credits that could be traded to developers in the same watershed.	Low: Portland may be creating the first stormwater trading program, but it may be unique to Portland. The regulatory drivers are not very clear and much work with ODEQ and USEPA is needed to facilitate trading.

Acronyms used in the table: CWA – Clean Water Act; DSL – Dept. of State Lands (Oregon); ESA – Endangered Species Act; MS4 – municipal separate storm sewer system; NMFS – National Marine Fisheries Service; NOAA – National Oceanic and Atmospheric Administration; ODEQ – Oregon Dept. of Environmental Quality; ODOT – Oregon Dept. of Transportation; OWRD – Oregon Water Resources Dept.; NPDES –National Pollutant Discharge Elimination System; TMDL – total maximum daily load; USACE – US Army Corps of Engineers; USEPA – US Environmental Protection Agency; USFWS- US Fish and Wildlife Service.

fixed) pollution caps are more likely to ensure that water quality will not be continually degraded when new discharge sources arise as economies and human populations grow (Shabman & Stephenson 2007). Programs where pollutant loads are not fully capped (i.e., only a subset of discharge sources are regulated) are less likely to be effective at protecting aquatic resources because only a fraction of the total pollution load is managed by trading (Shabman & Stephenson 2007). Under partially capped programs, water-quality degradation is likely to continue if unregulated discharge sources continued to grow and their pollution loads are not mitigated by reductions in the pollution contributed by the regulated fraction of discharge sources or by other regulatory mechanisms.

SECTION 9.32: MITIGATION BANKING

Environmental mitigation banks also establish a system of credits that can be purchased to offset the adverse effects of development. Credit purchases typically represent acres of habitat that mitigate habitat impaired or destroyed elsewhere. State rules address issues such as where mitigation credits can be used and the compensation that would be required for various types of impacts. Mitigation banks offer the following advantages over on-site mitigation activities (Brown & Lant 1999; USEPA 2001a; BenDor & Brozović 2007; BenDor *et al.* 2009):

- Large areas of wetland and other habitats can be established, conserved, and rehabilitated.
- Mitigation banks may do a better job of protecting ecosystem function compared to the fragmented habitats that can result from on-site rehabilitation efforts.
- Developers can be made aware of the costs associated with mitigation early in the development planning process.
- Mitigation banks create an economy of scale favorable to small development operations that might not be able to afford on-site mitigation costs.
- Mitigation banks potentially create greater assurance of long-term conservation of ecologically important lands.

A key component of effective mitigation banking is that the acres of habitat banked be fully interchangeable with those lost to development. Uncertainty that the banking program will result in 1:1 exchanges of lost to gained habitats is typically addressed by implementing a mitigation ratio where a developer is required to purchase credits representing a habitat area larger than the area actually destroyed (BenDor 2009). Purchases are usually restricted to service areas within the same watershed⁹³. Cross-watershed transfers of habitat (i.e., habitat affected in one watershed is mitigated in another watershed) do occur depending on federal, state, or county-level regulations (see BenDor & Brozović 2007; BenDor *et al.* 2009 for examples from Illinois and North Carolina). As with wetlands and as is the objective of the Clean Water Act, it may be advantageous for Oregon to develop a no-net-loss approach for aquatic ecosystem area, structure and/or function. The following list provides examples of the types of mitigation banks currently in operation (Primožich & Vickerman 2007; Willamette Partnership 2007b):

⁹³For examples of the spatial scales of watersheds serviced by wetland mitigation banks in Oregon visit http://www.oregon.gov/DSL/PERMITS/mitbank_status.shtml. Accessed December 14, 2009.

- Wetland mitigation banks are formed in response to federal, state, or local regulations (e.g., Section 404 of the CWA, and Section 10 of the Rivers and Harbors Act) that require developers to compensate for any actions resulting in loss of wetland acreage or function. Wetland credit banks are derived from landowners restoring wetlands in off-site locations. As of 2002, there were 219 wetland mitigation banks established across the US (Spieles 2005) and more under development (USEPA 2001a).

In Oregon, there are currently 20 wetland mitigation banks in operation with several more under development⁹⁴. All of Oregon's mitigation banks service areas west of the Cascade Mountains. DSL⁹⁵ provides significant guidance on the operation of mitigation banks in Oregon. Wetland mitigation banking is typically conducted within spatial areas encompassed by 4th field hydrologic units⁹⁶ and transfer of wetland habitats beyond areas serviced by mitigation banks is strongly discouraged unless there is an ecologically sound reason (Field 2010 pers. comm.⁹⁷).

- Endangered species/conservation banks exist where landowners that maintain habitat for endangered species are monetarily compensated for the cost of their property and its continued management. Regulatory drivers of such programs include Sections 7 and 10 of the ESA.
- Water supply banks involve water leasing agreements, typically between water right holders and urban municipalities. Agreements aimed at increasing instream flows for environmental purposes have increased in recent years particularly in California, the Columbia River basin, and the Great Lakes region. Regulatory drivers include the CWA and ESA.

SECTION 9.33: EFFECTIVENESS OF WETLAND MITIGATION BANKING

More effort has been expended toward evaluating wetland mitigation banking success than other types of mitigation banks because they have been in use the longest. The literature reviewed by IMST indicates that mitigation banking is a conservation tool with considerable potential if implemented, monitored, and managed properly. However, it is also clear that poor implementation of mitigation banking strategies leads to inadequate replacement of habitats that are degraded or destroyed elsewhere. For example, Kentula *et al.* (2004) found that natural wetlands were traded for ponds with very different ecological function. Also, the information required for landscape-scale analyses of the size and type of mitigation purchases may be lacking (BenDor & Brozović 2007, BenDor 2009). An overriding goal of federal policies that drive wetland mitigation markets is to achieve 'no net loss' of the wetland acreage or function remaining in the US (BenDor 2009). The overall effect of a mitigation banking framework on wetland acreage and function can create complexities that require resolution if the 'no net loss' policy is to be achieved (Brown & Lant 1999). The following bullets list examples of issues and research needs raised in the literature reviewed by IMST:

⁹⁴ http://www.oregon.gov/DSL/PERMITS/mitbank_status.shtml. Accessed December 14, 2009.

⁹⁵ Wetland Mitigation Guidebook for Oregon, http://www.oregon.gov/DSL/PERMITS/mit_guidebook_intro.shtml. Accessed January 7, 2010.

⁹⁶ Hydrologic units are not watersheds or basins, but rather map units used to delineate polygons in the US.

⁹⁷ Dana Field, Department of State Lands, Salem, Oregon, personal communication, January 11, 2010.

- The protection of wetlands provided by mitigation banks may be insufficient when regulatory guidelines are insufficient or are not followed (e.g., Brown & Lant 1999).
- Specific mitigation ratios used to compensate for uncertainty in how well a banking program protects wetlands have not been adequately determined. For example, it is not always clear how much mitigation acreage is required to capture the biological diversity or hydrologic functions that were lost to development. In several locations within the US insufficient mitigation ratios have resulted in net loss of wetland area (Brown & Lant 1999; BenDor 2009; Rubec & Hanson 2009).
- Banking wetland habitats alters the type, position, and distribution of wetlands across the landscape (BenDor & Brozović 2007, BenDor *et al.* 2009). The ecological consequences of such landscape-scale changes have not been adequately researched (Brown & Lant 1999; BenDor *et al.* 2009).
- Certain situations can create a lag between the loss and gain of functional wetlands (BenDor 2009). Restoration or creation of wetland acreage requires extended periods during which vegetation communities, soil structure, and hydrologic function become established (Craft *et al.* 2002; Gutrich & Hitzhusen 2004; BenDor 2009). Wetland mitigation credits are sometimes sold before the wetland acreage on which the credits are based has established full ecological function (Robertson 2006).

Key Findings: Offsetting impacts of development

- Market-based strategies have been proposed as economically and ecologically sound techniques for offsetting aquatic ecosystem impairments caused by development. These strategies manage actions that impair environmental conditions as commodities that can be purchased or traded.
- To begin to achieve positive outcomes, market-based programs at a minimum require an adequate demand for an environmental commodity, a stable supply of marketable credits, and a structure for transactions that make the associated costs affordable. These requirements set up important tradeoffs between the spatial extent in which a program operates and the viability of the program.
- The effectiveness of market-based trading in controlling pollution may depend on how environmental regulations shape trading markets.
- Mitigation banks can allow the establishment and long-term conservation of large areas of habitat and allow developers to determine the costs associated with mitigation early in the development process. Purchases are usually restricted to service areas within the same watershed however mitigation banking can change the type, position, and distribution of habitats across the landscape. The ecological consequences of such landscape-scale changes have not been adequately researched.
- Banks established to mitigate wetland loss have been in use the longest and have received a greater research effort to evaluate their success. The literature reviewed by IMST indicates that mitigation banking is a conservation tool with positive potential if implemented, monitored, and managed properly; however, it is also clear that poor implementation of mitigation banking strategies could lead to a net loss of habitats at the landscape-scale.

Section 9.4: Determining the Effectiveness of Actions Taken to Minimize or Offset the Effects of Development on Aquatic Ecosystems

Achieving the goals of the Oregon Plan requires an understanding of how different land uses and mitigation measures contribute to the recovery or decline of watershed condition. Developing such an understanding requires adequate monitoring of aquatic resources affected by different land uses. Rural-residential and urban lands physically occupy only a small fraction of the total land area in Oregon (see Section 1.4 of this report). If statewide monitoring efforts are allocated according to the area covered by various land uses, rural-residential and urban lands will be inadequately monitored. In addition, the ecological effects of developed areas (i.e., their ecological footprints) extend well beyond their physical boundaries (e.g., Sanderson *et al.* 2002; Rees 2003; Venetoulis *et al.* 2004; Leu *et al.* 2008).

In the western US, the majority of developments have been established and expanded along rivers and estuaries. As a result, lands adjacent to rivers are disproportionately affected by the ecological footprint of developed lands (Leu *et al.* 2008). The ecological footprint includes not only the physical area directly affected by development but also lands that produce goods and services consumed by city residents, lands that assimilate waste generated by city residents, and lands affected by the extended infrastructure (e.g., road networks, shipping channels, power lines, power generation facilities) that support developed areas (Rees 2003; Venetoulis *et al.* 2004; Leu *et al.* 2008). As Oregon's human population grows, the extent and intensity of the ecological footprint will also increase, especially if the per capita consumption of goods and services continues to increase. Considering how the ecological footprint of developed lands affects salmonid habitats and overall watershed condition may yield a more accurate understanding of how well entire watersheds or river basins can support viable salmonid populations (Leu *et al.* 2008; Polasky *et al.* 2005, 2008).

The following sections summarize recovery and monitoring efforts undertaken on Oregon's developed lands and assess how well these efforts address the ecological condition of developed lands and lands affected by the ecological footprint of development. Because it is unique to Oregon, IMST places special emphasis on efforts carried out under the Oregon Plan.

SECTION 9.41: FEDERAL EFFORTS

- The federal Clean Water Act (CWA) has historically focused its regulations on water quality, particularly from point source dischargers. Sections of the CWA relevant to developed areas include the NPDES (402), removal/fill permits (404), identification of 'water quality limited' watercourses (303d), and biennial water quality reports to Congress (305b). The CWA is largely implemented by the USEPA, which invests heavily in stormwater and wastewater treatment infrastructure and treatment in urban areas. Regulation and effectiveness monitoring are delegated to ODEQ which directs site monitoring by dischargers (see Sections 2.0 and 3.0 of this report). Implementation of CWA regulations results in individual dischargers collecting and submitting a considerable amount of monitoring data to ODEQ. However few of those data are available in electronic format. As a result, the usefulness of those data in determining the collective effectiveness of stormwater and wastewater management techniques is limited.

- The federal Endangered Species Act (ESA) constitutes a regulatory framework used to protect threatened and endangered species. Specific protections directed towards listed species include designation and protection of critical habitat, development and implementation of recovery plans, and protection from any harassment, harm, or mortality that constitute 'take' (Taylor *et al.* 2005). Substantial federal funds from ESA permitting agencies (i.e., USFWS, NMFS) and land management agencies (including US Forest Service, Bureau of Land Management, National Park Service, USFWS) are expended for habitat improvement projects. All four land management agencies plus the NMFS have implemented effectiveness monitoring programs to assess the results of their investments⁹⁸. The focus of those monitoring programs is on federal lands, some of which are affected by the ecological footprint of developed areas. IMST could not locate any information on how those agencies monitor the effectiveness of ESA protections within developed areas.
- The USEPA's National Aquatic Resource Survey⁹⁹ was implemented to assess status and trends of aquatic and coastal systems at state, ecoregion (Hughes *et al.* 2004), and national (Paulsen *et al.* 2008) scales. In 2008-2009, USEPA intensified its sampling to insure sufficient monitoring of urban streams (Olsen 2009 pers. comm.¹⁰⁰).
- The USGS's National Water-Quality Assessment Program¹⁰¹ lacks a regulatory or management role, but it has evaluated the effects of urban development in 11 urban centers including Portland (Oregon) (Waite *et al.* 2008; Brown *et al.* 2009) and Seattle (Washington). For each urban center, physical, chemical, and biotic responses to varying levels of development are characterized in 28 to 30 river-reaches.

Although sharing common goals and some common indicators, the efforts described above do not share common sampling protocols, data management, analyses, or reporting units, and only the latter two survey urban waterways. This lack of coordination would make it difficult to determine the sufficiency of efforts to protect salmonids and their habitats on lands affected by rural-residential or urban lands (See IMST 2009 and Roper *et al.* 2010 for further discussion of issues related to the synthesis of disparate data sets).

⁹⁸ Currently, there are two large effectiveness monitoring programs being conducted on federal lands in Oregon: The Aquatic-Riparian Effectiveness Monitoring Program is a joint US Forest Service/Bureau of Land Management program focused on monitoring physical habitat structure of wadeable streams and landscape condition on the federal lands within the range of the Northern spotted owls (*Strix occidentalis caurina*) (Gallo *et al.* 2005).

The PacFish/InFish Biological Opinion, a similar joint Bureau of Land Management/US Forest Service program but with different indicators and sampling methods, is directed at monitoring streams and riparian zone condition in the upper Columbia River basin (Henderson *et al.* 2005).

⁹⁹ <http://www.epa.gov/owow/monitoring/nationalsurveys.html>. Accessed January 14, 2010.

¹⁰⁰ Tony Olsen, USEPA, Corvallis, Oregon, personal communication, 2009.

¹⁰¹ http://water.usgs.gov/nawqa/studies/regional_assessments.html and <http://water.usgs.gov/nawqa/urban/html/studydesign.html>. Accessed January 14, 2010.

SECTION 9.42: OREGON PLAN FOR SALMON AND WATERSHEDS

In Oregon, OWEB funds watershed assessments, rehabilitation and enhancement projects, and monitoring throughout the state. OWEB and the Oregon Plan Monitoring Team manager provided IMST with information pertaining to the proportion of rehabilitation and monitoring efforts occurring on rural-residential and urban lands statewide and how information collected on these projects will be used to determine the effectiveness of the Oregon Plan within these land use categories. IMST also asked OWEB staff to summarize specific information on the number of OWEB-funded projects implemented on rural-residential and urban lands, the total number of projects funded by OWEB, and the number of projects on developed lands that included effectiveness monitoring. Summaries received by IMST covered information submitted to OWEB as of December 2008. OWEB responses to these information requests¹⁰² are summarized below.

At the watershed scale, rehabilitation and monitoring efforts funded by OWEB are determined by various stakeholder groups, often working within the organizational structure of a watershed council. Specific activities are prioritized by a multipart process that includes a watershed assessment to identify rehabilitation and monitoring needs and development of an action plan. Distribution of projects across various land uses are affected by the extent and distribution of different land uses within the watershed, the importance placed on environmental work within different land uses by local watershed councils and stakeholder groups, plus land owner interest and cooperation.

OWEB has tracked information (including land use categories) characterizing fish habitat restoration projects since 1997 through the Oregon Watershed Restoration Inventory¹⁰³ (OWRI). Currently, reporting for the OWRI is mandatory for all projects receiving grant money from OWEB. Reporting information includes completed project location on a 1:24,000 map scale, duration, spatial extent, goals, cost, treatment details, and implementation monitoring (effectiveness monitoring is not required by grants or for reporting). In 2002, OWEB added a section on 'urban' projects to its reporting form with the intent to better characterize projects carried out on urban lands. However, OWEB staff relayed that few urban projects have been reported to date; instead urban projects may be reported under specific project types (e.g., road, passage).

Presently, there is no mechanism to directly obtain an integrated (across all Oregon Plan agency and voluntary efforts) analysis of rehabilitation and monitoring efforts undertaken within particular land uses. With the assistance of OWEB staff, the OWRI database can be used to determine the distribution of OWEB-funded restoration projects on rural-residential and urban lands with high spatial and temporal resolution. However, determining the strategy or distribution (with respect to land use) of rehabilitation or monitoring projects carried out by state agencies or other Oregon Plan partners requires individual information requests directed to specific Oregon Plan partners.

As of December 2008, approximately 138 (4%) of 3,400 OWEB funded rehabilitation projects have been completed within urban growth boundaries. This number does not include projects in rural-residential areas or any information on project size (i.e., spatial extent, duration). OWEB staff reported that, as of December 2008, effectiveness monitoring had not been conducted on

¹⁰² November 15, 2007 letter from IMST to OWEB and the Oregon Plan Monitoring Team.

¹⁰³ <http://willametteexplorer.info/mappingtools/maps.aspx?Res=16660>. Accessed January 14, 2010

any projects within Oregon urban growth boundaries. However, this assessment did not include urban projects reported under other project types. Completed projects are not distributed in all urban areas of the state, and it is unlikely that they adequately address rural-residential or urban effects that extend beyond development boundaries.

The location and nature of monitoring efforts associated with rural-residential and urban rehabilitation projects (or projects on any other land use types) are difficult to determine. OWEB does not track monitoring locations in OWRI or in any other way that would allow determination of an aquatic ecosystem response to rehabilitation projects carried out on rural-residential and urban lands. The Oregon Plan Monitoring Team developed and is currently implementing (in coordination with the Oregon Plan Core Team and the Governor's Natural Resource Office) a monitoring strategy adopted by OWEB (OWEB 2003b). Since 2000, OWEB has required that all funded restoration projects include monitoring of project implementation (typically 1 to 3 years but can extend up to 10 years). Documentation of implementation monitoring activities is stored as hard copy files. Consequently, information pertaining to implementation monitoring or any other type of monitoring (e.g., compliance, effectiveness) is not reported or included in the electronic OWRI database.

The data on rehabilitation projects entered into the OWRI database could be used to design effectiveness monitoring strategies. Exchange of information about rehabilitation and monitoring projects among Oregon Plan agencies and local entities (e.g., watershed councils, soil and water conservation districts, local governments) occurs through the OWRI and specific directives within OWEB grant agreements that pertain to data sharing and storage. OWEB has developed contracts with ODFW's Natural Resource Information Management Program and the Institute for Natural Resource's Oregon Explorer (Oregon State University) to aid in the management and analysis of watershed assessment, rehabilitation project and monitoring project data. While exceptions exist, data collected by municipalities and local government agencies (e.g., cities, counties) are currently under-represented in the OWRI database and in efforts undertaken by others to create an integrated database of assessments, monitoring, and rehabilitation information. As of February 2009 an integrated monitoring database managed by OWEB remains under development.

SECTION 9.43: OTHER STATE-LEVEL MONITORING EFFORTS

Several additional entities such as watershed councils and city governments carry out monitoring projects in Oregon's streams, rivers and estuaries. Some of these entities have adopted common sampling protocols and environmental indicators from the USEPA's Generalized Random Sampling Design or the Environmental Monitoring and Assessment Program. As a result, the data from different monitoring programs can be aggregated and used to characterize the effects of current land uses and outcomes of land management policies. Recently the ODEQ aggregated and summarized monitoring data collected at 450 sites by 12 different monitoring programs implemented in the Willamette River basin, including the Oregon Plan. The resulting report (Mulvey *et al.* 2009) represents significant progress towards characterizing the effects of agricultural, urban and forestry land uses on the chemical, physical, and biological condition of aquatic ecosystems.

Key Findings: Determining effectiveness of efforts

- Achieving the goals of the Oregon Plan requires an understanding of how different land uses and mitigation measures contribute to the recovery or decline of watershed condition. Developing such an understanding requires adequate monitoring of aquatic resources affected by different land uses.
- Considering how the ecological footprint of developed lands affects salmonid habitats and overall watershed condition may yield a more accurate understanding of how well entire watersheds or river basins can support viable salmonid populations.
- Federal and state efforts to monitor the effects of land use on aquatic ecosystems share common goals and some common indicators, but these efforts rarely share common sampling protocols, data management, analyses, or reporting units. This lack of coordination hinders determining the sufficiency of efforts to protect salmonids and their habitats on lands affected by rural-residential or urban lands.

Section 9.5: Spatial Scale and Regional Planning

Actions that avoid or offset (mitigate) the impacts of development on aquatic ecosystems operate across stream reaches, watersheds and river basins. However, there is considerable variation in the scale of influence of such actions, for example:

- Smart growth and associated planning efforts are intended to operate at the watershed scale in ways that impart benefits from stream reach to river basin levels.
- Mitigation strategies are typically regulated at watershed or river basin scales depending on the partners involved in trading strategies. Individual stream reaches may benefit if a mitigation bank is located nearby.
- Market-based trading strategies are also regulated at watershed or river basin scales.
- On-site ordinances, building codes and similar regulations affect stream reaches with potential cumulative benefits at watershed and river basin levels.

Watershed or river basin scale planning involves many interrelated activities (Booth *et al.* 2001; USEPA 2004c; Trauth & Shin 2007) including assessment of existing watershed and water quality conditions, identification of areas containing high-quality habitat, development of futures scenarios, direction of future development toward areas that have the lowest ecological value, and the implementation of LID techniques in areas where future development occurs. This mosaic of activities and spatial effects across the landscape means that managing the effects of development may be more effective if coordinated through an integrated regional or basin planning framework (USEPA 2004c).

Section 9.6: A Role for Education

Advanced planning and mitigation actions alone are unlikely sufficient to minimize the numerous effects development can have on aquatic ecosystems (Booth *et al.* 2001; USEPA 2004c). Achieving Oregon Plan goals on developed lands will also require education of state and county officials, land and business owners, developers, and other local stakeholder groups regarding the effects development can have on aquatic ecosystems. The large number of federal, state, municipal, watershed council and private actions undertaken under the Oregon Plan across land uses means education can also help stakeholders better understand the goals and objectives of the Oregon Plan and coordinate their actions to assist smart growth and environmental mitigation actions.

A recent study by Montgomery & Helvoigt (2006) demonstrated that Oregonians became less supportive of salmon recovery and salmon recovery efforts between 1996 and 2002. Establishing educational opportunities that promote environmentally responsible behaviors can potentially slow or even halt further declines in water quality and salmonid habitat condition (USEPA 2004c). Therefore, educating Oregonians about the importance of various activities aimed at the recovery of salmonid populations appears to be important if recovery goals are to be achieved. Booth *et al.* (2004) recommended implementing landowner stewardship programs that highlight the roles that property owners have in improving aquatic ecosystem condition. The USEPA (2004c) suggests that municipalities and watershed councils organize community events that demonstrate the importance of individual behavior. For example, the non-profit organization Oregon Trout conducts a program called Salmon Watch that integrates salmon viewing into K-12 educational curricula addressing salmonid biology and stream ecology. Salmon Watch students participate in field trips organized by volunteers and fish biologists and view salmon spawning, measure water quality (i.e., temperature, pH, dissolved oxygen), sample aquatic macroinvertebrates, and learn about riparian vegetation. In 2006, the program served 86 schools, 119 teachers, and more than 4,500 students with 152 streamside trips involving 269 volunteers¹⁰⁴. In 2002 evaluations administered by classroom teachers immediately following the program resulted in a 47% gain in perceived knowledge by students (Schmidt 2008 pers. comm.¹⁰⁵).

Dunn *et al.* (2006) suggest that urban populations increasingly experience nature primarily in urban areas. Research on the phenomenon of 'place attachment' demonstrated that exposure to natural settings influences the interest of individuals in environmentally responsible behavior (Vaske & Kobrin 2001). Such findings imply that long-term support for salmonid conservation efforts will be strongly influenced by what people experience and learn about nature in urban areas.

¹⁰⁴ www.healthywatersinstitute.org/salmonWatch.html. Accessed January 14, 2010.

¹⁰⁵ Mary Ann Schmidt, Oregon Trout, Portland, Oregon, personal communication, 2008.