USGS

# WATER RESOURCES RESEARCH GRANT PROPOSAL

**Title:** Measuring Stormwater Impacts of Different Neighborhood Development Patterns, Ronald Kellett and Cyntia Girling, University of Oregon


## Abstract

This project will undertake stormwater modeling on two different proposed neighborhood plans for a site in Corvallis, Oregon. The two plans, both with the same net density, will demonstrate a similar mix of land use and housing types, but different street systems, stormwater and open space designs. One plan~includes a water quality-oriented stormwater system, the other a conventional piped system. The results will be used to develop a visual and interactive web site that demonstrates how land planning and design decisions impact water quality.


**Duration:** February 1, 2000 - January 31, 2001

**Fiscal Year 2000 Funds Requested:** Total $10,701
Direct $6,814 + $3,887 tuition
Indirect $0

**Matching Funds to be Allocated:** Total $24,391
Direct $10,697
Indirect $11,686

**Principal Investigator(s):**


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**Key Collaborators:**

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**Congressional District:** Oregon lt4

## Critical Need for Research

In the face of perilously low numbers of wild "saltnonid" species and their recent listing as endangered in many watersheds, Northwest communities face enormous diffficulties accommodating population growth while responding to mandates to improve fish habitats. News headlines in March, 1999 proclaimed the significance of these listings: "Federal Fisheries Agency Adds Nine Species of Pacific Coast Salmon to Endangered

Species List Action marks first time protection has extended to heavily urbanized areas. NOM News, Washington, March 16, 1999 and on the next day on Oregon, "Salmon, steelhead runs listed The burden of restoring fish will fall on everyone Nine runs were added to the list of endangered and threatened species." The Register Guard, Eugene, Oregon, March 17, 1999.

All three of Oregon's largest cities are located in these watersheds. These and other cities in listed watersheds must find means for reducing the impacts of urban areas on water-based habitat, including cleaning up stormwater runoff, enhancing streamside vegetation, curtailing the use of herbicides and pesticides and cutting back water usage (Register Guard, *3117199).* These same Oregon cities are growing more dense and several have recently elected to hold to existing urban growth boundaries rather than allow outward expansion. Portland, Corvallis and Eugene legislate or encourage more compact, higher density, mixed-use development. While there are clear advantages to more compact cities, such as land conservation, reduced transportation and related air pollution loads, reduced public infrastructure costs, there are concerns about the abilities of these cities to grow more dense while concurrently reducing environmental impacts such as on salmon habitat (Kitzhaber, 1997 *). It is* not yet clear how the water qualityoriented development practices that will follow the salmon listing can be integrated with growth management-oriented development practices.

We recently completed a comparison of different neighborhood development patterns against measures of land use, transportation, cost and environmental impact. Three alternative neighborhood plans were created for a demonstration site (about 400 acres of valley floor land in the mid-Willamette Basin near Corvallis, Oregon) then measured and compared. Each of the alternatives we measured represents a common neighborhood development pattern nation-wide. A conventional low density "Status Quo" (SQ) plan1 represents many subdivision developments. A more dense Neighborhood Village (NV) plan represents a more compact and mixed use new urbanist pattern and a lower environmental impact "Open Space" plan (OS) represents similar density and land use mixes to the NV plan with greater open space, urban forest and stormwater features. Each alternative preserves different amounts of open space and pursues different approaches to infrastructure, urban forests and stormwater management.

Representative land use cases derived from field measured data from an illustrated database developed by the Center for Housing Innovation (the Elements of Neighborhood') were assigned to each of the three alternatives. Each plan was then inventoried for summary data such as land use area, dwellings, densities, building coverage, paving coverage, forest, tree and turf cover, and so on. From these inventories, measures of land use, environmental impact (such as impervious surfaces, areas of landscape, forest and habitat preservation, stormwater runoff and water quality) and cost were created and compared. ClTYgreen (by American Forests) was used to estimate stormwater peak flows for both two year and ten year storm events. SUNOM (by the Center for Watershed Protection) was used to estimate annual water pollution loads associated with stormwater runoff.

The results of our initial measurements demonstrate that development pattern matters as much, if not more than density and land use mix on matters of water quaiity. The physical planning and design characteristics of three different alternatives shaped development patterns which in turn revealed significant differences in their impacts on stormwater quantities and quality. Two of the plans had the same numbers of dwellings on the site, yet one had *54%* impervious surfaces and increased peak flow rates of stormwater by *34%* (10 year storm) while the other, designed around a surface stormwater system, had *42%* impervious surface and increased peak flow rates by only *5%*. These results suggested that higher densities, mixed uses and greater vehicular and pedestrian connectivity now encouraged in Oregon can either compete with or complement goals of habitat protection and stormwater runoff reduction. To become complementary, strategic tradeoffs must be made between land dedicated to roads and parking and land dedicated to open space, urban forest and stormwater.

The NV development pattern, for example, may achieve many positive growth management impacts, such as improving the distribution and proximity of services, connectivity of both vehicular and pedestrian networks, creating cultivated urban forest opportunities and potentially reducing vehicle use and vehicle miles traveied. But, as this study also demonstrates, this development pattern can also increase impervious area, increase stormwater runoff and decrease water quality as much of the increased runoff volumes are associated with streets and carry common street-related pollutants. We also demonstrated that surface drainage systems and on-site water storage and filtration permit higher density patterns to perform at least as well as lower density patterns and better than New Urbanism-type patterns against measures of public open space, urban forest protection and stormwater runoff.

**Expected Results, Benefits, and Information**

This project is intended to educate the diverse constituency of landowners, neighbors, developers, planners, designers, elected officials and members of the public who initiate, regulate or influence neighborhood scale planning and design in their communities. Through this work, we intend to improve their awareness of the water quality implications and opportunities embedded in many of the planning and design decisions they will be called upon to make and, influence them toward choices with more positive water quality impact.

**Goals and Objectives**

1. To survey existing models for estimating stormwater runoff in residential neighborhoods and determine the most appropriate candidates; and

2. To estimate runoff for two different development pattern at a site in Corvallis, Oregon.

**Methods, Procedures, and Facilities**

Our previous project described above was adequate to indicate that different development patterns yield different stormwater impacts. However, the stormwater runoff quantity and quality analyses were coarse. ClTYgreen was utilized because it was an ArcView extension that was low cost and quick to assimilate and it provided some key indicator information about stormwater behavior. While sensitive to some development variables, such as impervious surfaces, its analysis routine is coarse and simplistic. For example, it recognizes only four different land covers: roofs, pavement, turf and forest and it assumes very conventional stormwater system design. The water quality model, an adaptation of Schueler's Simple Method, is designed for use in the US Northeast and assumes landscapes and land development patterns common to that region and pollution rates associated with land uses from 1980s national data (NURP).

Work outlined in this proposal builds on this substantial existing body of work and uses it to evaluate other available stormwater modeling tools, select one or more appropriate to the project, re-measure the NV and OS alternatives (the two that had similar net densities and land use mixes), iterate the modeling several times to isolate the potential benefit of particular best management practices and, create a visual, web-ready summary of the results.

The first task would find and evaluate more reliable and robust water quality modeling tools that would allow us to check and refine our prior findings and estimate the potential contribution of different BMP's to overall performance. Some of the shortcomings of our existing results have to do with the depth and sensitivity of the models used by ClTYgreen and SUNOM. For example, being able to use more detailed and better quality information about runoff quantity such as total annual rainfall and necessary flood control storage capacity would add depth and meaning to our plan comparisons. Also, with regard to water quality, being able to use Oregon-specific pollution reference data and being able to estimate suspended solids would be essential. To do so, we will need to acquire and evaluate other stormwater modeling software alternatives. Examples of candidates include: Boss International's WMS or StormSHED or Fuss and O'Neill's FO-AVSHED We will define our criteria for new software, conduct a search for what is available and cost effective, acquire up to three software packages and re-run the same stormwater quantity and quality numbers done in the previous project.

The second task of the project would re-measure the alternative plans using the selected tool(s) and exactly the same data and assumptions we used with ClTYgreen and SUNOM. We will compare the results and investigate the source of any significant anomalies.

The third task would use the more sophisticated modeling tool to learn more about how and how much different neighborhood planning and design strategies impact stormwater. This will involve iterating variations of the two plans and re-measuring them to answer questions about the degree to which planning and design variables can improve water

quality. For example, is there some target that might be set for the ratio of inipervious to pervious surface in residential neighborhoods, given certain assumptions about density and the stormwater system used? How much of the area of parks and open space on the OS plan can be replaced with other land uses before significant stormwater impacts are seen? How much of the difference in stormwater quantity is related solely to pond storage and how much might be attributable to the infiltration capabilities of the surface stormwater system? Can small scale reductions in street width and length, when multiplied over entire neighborhoods, create significant water quality benefits?

**Technology Transfer**

The results of the research will be developed into a web-ready content that will communicate these findings to the planning and development community (including regulators) in Oregon. In addition, as part of our normal academic and professional responsibilities, the principal investigators will write about this project and present the results at planning, landscape architecture and architecture conferences.

Our web site currently includes a brief and well-illustrated summary of the work upon which this proposal is based. The main site (aaa.uoregon.edu/~nec) describes the nature and character of our neighborhood scale planning and design work in general as well as the database of neighborhood elements that create the basis the plans we propose to compare. Two of the three links from that page (at the bottom) describe projects related to measured comparisons of the Corvallis. One, Demonstrating the Values of Urban Forests in New Community Development (aaa.uoregon.edu/~nucfac) emphasizes environmental impacts and the other Measuring Infrastructure in New Community Development (aaa.uoregon.edu/~dlcd) emphasizes land use, transportation and infrastructure cost. This site, with its water quality results could be linked to the OWRRI site.

A summary of, and findings from this proposed project would be added to this site as a new major link with the following new content:

· Detailed visual illustration and quantitative explanation of the type and character of the land use variables (the elements) that make up each of the plans. We will directly link images and data about these elements to the areas of each of each plan to which they pertain. Visitors to the site could place a cursor over a section of the plan and instantly retrieve an image, narrative and quantitative summary about the specific building or street or open space types assigned to that place. With this form of display, our audience would be able to relate quantitative variables and results to the character and quality of place reflected by them.

· A line-item summary of the potential, incremental benefit of different water quality related planning and design choices. Based on our iterative measurement of the plan alternatives with and without selected planning and design features, we can demonstrate the potential contribution of various BMP's (many small or fewer larger ponds or, narrower streets or porous pavements, for example) to measures of runoff and water quality. With this content and type of presentation, our audience would be able to compare the relative contribution of variows BMP's and estimate which might create the best opportunity in their communities.

· A visual and tabular summary of our review of available stormwater modeling software. We will summarize our criteria and evaluation of the water quality modeling software we compared to undertake the project and post them along with a side-by-side comparison of the modeling results we gained from using them. This would enable those members of our audience who will need to measure their own alternatives to compare available tools to do so.

· Finally, as we have done for other projects, we would link downloadable copies of papers and reports we create about this work directly available as .pdf documents.