ABSTRACT

Title: A GIS Evaluation of Land Use Zones and Water Quality for marine conservation site selection in Lincoln County, Oregon.

The leasing of submerged and submersible lands is emerging as a new marine conservation method. Using a geographic information system, this study:
(1) examines the suitability of estuary tideland sites for conservation leasing in Lincoln County, Oregon, and (2) explores the relationship between adjacent terrestrial land use zones and the chemical and physical water quality parameters of submerged lands. Pearson correlations between land use zones and estuarine water quality were performed at the 250 m, 500 m, 1000 m, 2000 m, and 4000 m scale. Significant Pearson correlations were found for six out of the nine land use zones studied. These results suggest bordering land use zoning can be used as an initial filter for site selection when water quality is a factor in conservation management for a site.
A GIS Evaluation of Land Use Zones and Water Quality for Marine Conservation Site Selection in Lincoln County, Oregon

by

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in partial fulfillment of the requirement for the degree of

Master of Science

Presented June 5, 2007
Commencement June 2008
ACKNOWLEDGEMENTS

I want to sincerely thank my advisor, Michael Harte, for providing assistance and support, especially during the last few time crunching weeks before my defense. I am also grateful to the members of my graduate committee, Dawn Wright and Hamilton Smillie. I appreciate Hamilton Smillie’s committed involvement, which included several coast to coast conference calls and extended periods of listening in through the “black box.”

I would like to acknowledge NOAA Coastal Services Center for providing me with an insightful and excellent opportunity as an intern during the summer of 2006. I would especially like to thank Joshua Murphy and Hamilton Smillie for contributing to my positive experience at NOAA Coastal Services Center. I gratefully recognize the funding source for my M.S. program, NOAA Coastal Service Center, Grant # NA04NOS4730181 to Dawn Wright and Jim Good.

Lastly, I would like to thank my fellow Marine Resource Management graduate students for their generous advice and support.
# TABLE OF CONTENTS

1 INTRODUCTION .............................................................................. 1  
   1.1 The Meaning and Mechanisms of Conservation: From Terrestrial to Marine Lands .................................................... 3

2 BACKGROUND INFORMATION .................................................... 6  
   2.1 Study Area: Estuaries of Lincoln County ........................................ 6  
   2.2 Water Quality Regulations and Monitoring .................................. 7  
      2.3 Water Quality Parameters ..................................................... 10  
      2.4 Land Use Zoning .................................................................. 11

3 LITERATURE REVIEW ............................................................. 13  
   3.1 Aquaculture and Conservation Site Selection ................................. 13  
   3.2 Effect of Landscape Characteristics and Human Development on Water Quality ......................................................... 15

4 METHODS ................................................................................. 19  
   4.1 Objective: Map ownership and use of Lincoln County estuary tidelands and their adjacent land use zones ......................... 19  
   4.2 Objective: Examine the statistical relationship between Lincoln County land use zones and water quality ......................... 20

5 RESULTS AND DISCUSSION .................................................... 29  
   5.1 Marine Land Mapping ............................................................ 29  
      5.2 Water Quality and Land Use Zone Correlations ......................... 30  
         5.2.1 Pearson correlations ..................................................... 30  
         5.2.2 Pollutant sources and pathways ....................................... 32  
         5.2.3 Marine conservation site selection .................................. 36

6 CONCLUSION .............................................................................. 39

REFERENCES CITED .................................................................... 42

APPENDICES ............................................................................... 48
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Map of DEQ water quality sampling stations utilized in the study</td>
<td>23</td>
</tr>
<tr>
<td>2.</td>
<td>A 500 m buffer zone around Yaquina Bay water quality stations</td>
<td>24</td>
</tr>
<tr>
<td>3.</td>
<td>Delineated buffer zones for a water quality station</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>Model Builder flow chart of processing steps</td>
<td>26</td>
</tr>
<tr>
<td>5.</td>
<td>Example attribute table joining water quality values to %age land use</td>
<td>27</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Summary of significant Pearson correlations between land use zones and water quality</td>
<td>30</td>
</tr>
<tr>
<td>2. Summary of significant Pearson correlations between land use zones and water quality. Pearson correlation values included</td>
<td>31</td>
</tr>
<tr>
<td>3. Summary of significant Pearson correlations for each buffer level</td>
<td>32</td>
</tr>
</tbody>
</table>
## LIST OF APPENDICES

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Land use zone classifications</td>
<td>48</td>
</tr>
<tr>
<td>2. Estuary tideland ownership</td>
<td>64</td>
</tr>
<tr>
<td>3. Water quality parameter samples</td>
<td>68</td>
</tr>
<tr>
<td>4. Pearson correlation tables</td>
<td>69</td>
</tr>
<tr>
<td>5. XY plots of water quality parameter values versus %age land use zone</td>
<td>73</td>
</tr>
</tbody>
</table>
# LIST OF APPENDIX FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tideland ownership in Salmon River estuary</td>
<td>64</td>
</tr>
<tr>
<td>2. Tideland ownership in Siletz Bay</td>
<td>65</td>
</tr>
<tr>
<td>3. Tideland ownership in Yaquina Bay</td>
<td>66</td>
</tr>
<tr>
<td>4. Tideland ownership in Alsea Bay</td>
<td>67</td>
</tr>
</tbody>
</table>
LIST OF APPENDIX TABLES

Table | Page
--- | ---
1. The number of DEQ stations monitoring the water quality parameters of interest, and the total number of samples utilized for each parameter | 68

Pearson correlation tables:
2. Fecal coliform dry season | 69
3. Fecal coliform rainy season | 69
4. Ammonia as N | 70
5. Dissolved orthophosphate as P | 70
6. Field dissolved oxygen | 71
7. Nitrate/nitrite as N | 71
8. % saturated field dissolved oxygen | 72
9. Total suspended solids | 72
1 INTRODUCTION

Increasing threats to the marine environment call for the development of new conservation strategies. In the past, terrestrial conservation techniques, such as the acquisition of land for preservation and restoration, were thought to be inapplicable to estuarine and marine systems. However, a similar framework exists in the marine environment, as many state-owned submerged\(^1\) and submersible\(^2\) lands* are available for lease or ownership. Although leasing is currently used for development purposes, such as for aquaculture, oil exploration, private docks, or public marinas, a change in policy could promote the leasing of lands for conservation purposes. For land-trust non-governmental organizations, such as The Nature Conservancy, acquiring submerged lands may be an alternative to or an addition to upland conservation activities. Submerged land leasing for the purpose of conservation has been implemented in Galveston Bay, Texas; Puget Sound, Washington; and Peconic Bay and Great South Bay, New York (Beck et al., 2004).

As the leasing of submerged and submersible lands becomes more popular, methods for selecting lands appropriate for restoration and preservation will gain importance. Adjacent terrestrial land uses are relevant during the site selection

\(^1\) Lands lying below the line of ordinary low water of all title navigable and tidally influenced waters within the boundaries of the State of Oregon. OAR 141-082-0020(65)

\(^2\) Lands lying between the line of ordinary high water and the line of ordinary low water of all title navigable and tidally influenced waters within the boundaries of the State of Oregon. OAR 141-082-0020(66)

*Throughout this report, “submerged lands” is used to refer to both submerged and submersible lands. “Marine lands” is used as a broader term, encompassing submerged and submersible lands. “Tidelands” is used interchangeably with “submersible lands”.

process due to their proximity and impact on the ecological quality of potential leased lands. Terrestrial land uses impact near shore water quality (Basnyat et al., 1999) through runoff delivery of sediments, nutrients, and pollutants (Detenbeck, 2001), although with smart land use planning these adverse effects can be minimized. For successful conservation management of the coastal zone, a unique intersection of water and land, one would aspire for compatibility between upland zoning and submerged land leases.

This study focuses on potential conservation lease site selection in Lincoln County, Oregon. Although Oregon does not currently have any marine conservation leases, the Oregon Department of State Lands issues leases, licenses, temporary-use permits and registrations for uses of state-owned submerged land (Oregon Department of State Lands, n.d.). Using a geographic information system (GIS), this study maps ownership and use of Lincoln County estuary tidelands in relation to adjacent land use zones. The correlation between land use zones and estuarine water quality parameters is then examined at varying scales, from directly adjacent land use zones (250 m and 500 m buffers), extending to a 1000 m, 2000 m, and 4000 m buffer. The specific aims of this study are to:

1. Identify the location of state-owned estuary tidelands as potential conservation lease sites, specifically characterizing their adjacent land use zones.

2. Examine the relationship between water quality of submerged lands and adjacent land use zones.
3. Identify land use zones that are most or less compatible with submerged land conservation that is dependent on water quality.

Although other physical, biological, and economic factors must be taken into consideration before final site selections are made, water quality is a critical environmental aspect of coastal conservation and provides a first discerning step in a GIS site selection model.

1.1 The Meaning and Mechanisms of Conservation: From Terrestrial to Marine Lands

The term “conservation” has been broadly applied, with much debate over its precise definition. The National Research Council’s Committee on Scientific and Technical Criteria for Federal Acquisition of Lands for Conservation (1993) defined conservation as “the management of land resources to sustain their productivity in the long term and to avoid losses of valuable components” (p. 27). Physical, biological, social, historical, agricultural, cultural, recreational, and aesthetic characteristics are all considered valid components for conservation. Several mechanisms have been used for land conservation, including the acquisition of property rights through buying full title to land parcels (acquisitions in fee), obtaining limited rights to land parcels (conservation easements, purchased or transferred development rights), and exercising eminent domain (Committee on Scientific and Technical Criteria for Federal Acquisition of Lands for Conservation, 1993).

This study addresses the acquisition of marine lands for conservation, with the primary focus on preserving ecological, biological, and recreational capacities.
Conservation goals for submerged lands include setting aside relatively undisturbed areas for scientific observation, protecting biological diversity, and restoring or maintaining ecosystem functions. Projects that take an active approach to conservation may involve activities such as marsh restoration, removal of invasive species, and the reestablishment of shellfish populations (Beck et al., 2004). A more passive approach to submerged land conservation is the acquisition of property rights simply to preclude other forms of development.

Water quality is an important component to many of the above mentioned marine conservation project goals, and may be used in two ways during the site selection process. The success of estuarine flora and fauna restoration projects hinge on water quality being at a minimum standard to support healthy growth, and projects with a recreational or oyster cultivation aspect must have water quality that meets certain health criteria. In these cases, sites with better water quality would be given higher priority. On the other hand, some projects’ main goal is to improve the condition of bays and estuaries with degraded water quality; in these cases, sites with poorer water quality would be sought out.

For conservation projects that restore oyster populations to support a sustainable commercial crop, fecal bacteria in the water must be closely monitored. In Oregon, where fecal coliform levels can pose a problem (Oregon DEQ, n.d. b), water quality would be a primary concern during site selection. Currently, The Nature Conservancy is in partnership with Oregon State University, Tillamook Estuary Partnership, and the Whiskey Creek Shellfish Hatchery to reintroduce native Olympia oysters in Netarts Bay, Oregon. Olympia oysters were
once dominant along the West Coast, but due to over harvesting, non-native predators, and habitat and water quality degradation, their population has severely declined. A successful Netarts Bay project could lead to native Olympia oyster reintroduction in other Oregon bays and estuaries, and once populations reach an adequate size, a sustainable native oyster commercial crop (The Nature Conservancy, n.d.).
2 BACKGROUND INFORMATION

2.1 Study Area: Estuaries of Lincoln County

Lincoln County, which lies within the mid-coast region of Oregon, is characterized by wet, stormy winters and relatively dry summers. Temperatures remain mild throughout the year with minimal snowfall. The county’s major coastal river basins are the Salmon River, Siletz River, Yaquina River, Alsea River, and Yachats River (Garono and Brophy, 2001). Where these rivers meet the ocean, estuaries create a highly productive habitat for many fish and wildlife species, including economically important juvenile salmonids (Johnson et al., 2007).

The Yaquina Bay estuary is Lincoln County’s largest estuary at approximately 4329 acres in area. The Alsea Bay, Siletz Bay, and Salmon River estuaries follow in size at 2516, 1461, and 438 acres, respectively. The Salmon River estuary is a bar built estuary with little freshwater input (Oregon Coastal Atlas, n.d. b; Oregon DLCD, 1987). The Yaquina Bay, Alsea Bay, and Siletz Bay estuaries are drowned river mouth estuaries (Oregon Coastal Atlas, n.d. a,b,c, and d) characterized by extensive salt marsh, eelgrass, and tidal flats (Good, 1999). In winter, sediment and freshwater inputs into the estuary are high, while in summer, seawater inflow dominates (Oregon DLCD, 1987). All the estuaries are subject to the mixed semi-diurnal tides of the North Pacific Ocean (Kentula and DeWitt, 2003).

Estuaries are particularly susceptible to negative impacts from human activities, and pressures on estuaries are increasing with rapidly growing coastal
development. Mid-coast region cities have grown at a faster rate than other Oregon cities (Garono and Brophy, 2001), with Depoe Bay, Lincoln City, Newport, and Waldport each increasing in population from 1990 to 2000 by 25.9%, 20.6%, 11.5%, and 22.2%, respectively (Proehl, 2007), all of which are adjacent to estuaries. Predominant landowners in the mid-coast region are private industrial timber companies, the US Forest Service, private non-industrial landowners, and the Bureau of Land Management (Garono and Brophy, 2001). Lumber, fishing, agriculture, and tourism are the principal industries of Lincoln County (Oregon Coastal Atlas, n.d. a).

During precipitation, flow from mid-coast lands leads to elevated levels of nitrates, phosphates, total solids, and biochemical oxygen demand in estuary waters. In the mid-coast basin, nitrate nitrogen is the primary degrader of water quality, with non-point source pollution being the most likely contributor (Cude, 1996). Water quality tends to deteriorate during the winter rainy season and improve during the summer (Cude, 1996).

2.2 Water Quality Regulations and Monitoring

Lincoln County’s inland and coastal water quality is regulated by the Clean Water Act whose directive is to “maintain and restore the chemical, physical, and biological integrity of our Nation’s waters” (Federal Water Pollution Control Act (Clean Water Act) of 1972). To meet this objective, water quality standards are established. Section 303(c) of the Clean Water Act mandates that water quality standards include designated uses for waters and that water quality criteria are of adequate stringency and breadth to protect those uses (U.S. EPA, 2006b; U.S.
EPA, 2004b). In accordance with section 304(a), the EPA publishes criteria to aid states and tribes in developing water quality standards (U.S. EPA, 2006a). States and tribes may adopt the EPA’s criteria, modify the criteria to fit site-specific conditions, or adopt their own criteria based on scientifically-defensible methods (U.S. EPA, 2006b). Criteria may be narrative or numeric, and may also include biological criteria (i.e., a description of the aquatic community), nutrient criteria, and sediment criteria (U.S. EPA, 2006b).

Section 303(d) requires states to identify water bodies that do not meet water quality standards, and establish a total maximum daily load (TMDL) of pollutants that will bring these waters into compliance (Copeland, 1997). Specifically applicable to Lincoln County’s estuaries, the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000 amended the Clean Water Act, requiring that states with coastal recreation waters adopt criteria for pathogens and pathogen indicators published under section 304(a) of the Clean Water Act (U.S. EPA, 2004b). The BEACH Act addresses the serious concern and health threat of fecal pollution contamination of coastal waters. Oregon did not meet the April 2004 deadline to enact protective bacteria criteria, and therefore, a November 8th final rule promulgated by the EPA put federal bacteria standards into effect for Oregon (U.S. EPA, 2004a; U.S. EPA, 2007a).

The mid coast basin’s designated beneficial uses for estuaries and adjacent marine waters include industrial water supply, fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, aesthetic quality, and commercial navigation and transportation (Oregon DEQ, 2003). For each water
body, federal law requires the protection of the most sensitive of these uses. The Oregon Department of Environmental Quality (DEQ) currently monitors the quality of estuaries through the Western Environmental Monitoring and Assessment Program (EMAP). As a part of this program, DEQ has sampled nearly 350 coastal and estuarine sites since 1999. Currently, DEQ samples 25 random Oregon estuarine sites per year. Sampling includes water column measurements, sediment contaminants and toxicity data, as well as benthic macroinvertebrate and demersal fish community data (U.S. EPA, 2007b). The inclusion of a biological assessment in EMAP is part of a national trend in recognizing the significance of biota and their habitat in gauging ecosystem health. EPA has developed methods for four core groups of biological indicator assemblages: benthic macroinvertebrates, fish, aquatic macrophytes, and phytoplankton, with benthic macroinvertebrates being the most widely sampled (U.S. EPA, 2000). In addition to EMAP sampling, DEQ also conducts target sampling in estuaries for the development of TMDLs (L. Caton, personal communication, April 5, 2007; C. Cude, personal communication, April 5, 2007).

In March of 2006, EPA’s Office of Environmental Assessment released an EMAP report of the “Ecological Condition of the Estuaries of Oregon and Washington.” The report drew conclusions about the health of estuaries from data on dissolved oxygen, nutrients, sediment characteristics, toxicity of fish tissue, and non-indigenous species. Benthic invertebrates were not used to assess estuarine health due to a lack of benchmark data.
2.3 Water Quality Parameters

EMAP physical and chemical water column data for fecal coliform, nutrients in the form of nitrogen and phosphorous, suspended solids, and dissolved oxygen were used in this study. Each parameter has specific environmental consequences that may be exaggerated or initiated by human activities and resulting non-point source pollution.

Fecal indicator bacteria groups, such as fecal coliform, are used worldwide as indicators of recreational and shellfish health hazards in coastal waters (Sanders et al., 2005). Their presence in water suggests fecal contamination and pathogens that cause human illnesses (e.g., gastroenteritis) (U.S. EPA, 2004b). Fecal bacteria originate from many sources, including failing or poorly sited septic systems, domesticated and wildlife feces, runoff from urban, residential, and agricultural lands, as well as discharges of untreated or poorly treated sewage (Oregon DEQ, 2006).

Nutrients are essential for healthy algal growth, but over-enrichment of nutrient levels can lead to algal blooms (Oregon DEQ, n.d. a). Two key nutrients, phosphorous and nitrogen, are artificially elevated in some estuaries due to human activities, such as fertilizer use in agriculture and residential lawns and gardens (Hayslip et al., 2006). Resulting algal blooms can cause waters to turn green and murky, and increase water pH, leading to human eye irritation. When blooms decompose, oxygen, which is necessary for fish and other aquatic organisms, is depleted in the estuary. Half of the surface waters in the US do not meet water quality objectives due to excess nutrients (U.S. EPA, 2006a).
Suspended solids in estuaries may either be local estuarine suspended particulate matter (SPM) from the estuary bed sediment, or they may be fine-grained SPM carried in by rivers and coastal waters (Uncles and Smith, 2005). Suspended materials typically include clay and silt soil particles, algae, and plankton; suspended solids may be heightened due to runoff from construction, logging, or agriculture practices (Hayslip et al., 2006). Elevated amounts of suspended solids may clog fish gills, as well as impair fish growth, resistance to disease, and egg and larval development. In addition, excess suspended solids may decrease visibility of predators, disrupt filter-feeding, transport toxins, and reduce oxygen levels in the water (Hayslip et al., 2006; Oregon DEQ, n.d. a).

2.4 Land Use Zoning

Land use zoning has the potential to direct human activity and development so as to minimize ill effects from non-point source pollution. The Oregon Land Use Act of 1973 is the primary legislation regulating statewide land use planning in Oregon. The land use planning program’s mission is to:

- Conserve farm land, forest land, coastal resources, and other important natural resources: encourage efficient development; coordinate the planning activities of local governments and state and federal agencies; enhance the state’s economy; and reduce the public costs that result from poorly planned development (Oregon State Archives, 2007).

Under this act, nineteen statewide planning goals were created to guide city and county comprehensive land use plans. As part of their comprehensive plans, cities and counties develop and implement land use zoning and land division
ordinances. Lincoln County’s *Comprehensive Plan and Zoning Regulations* outlines the county’s land use goals and policies.
3 LITERATURE REVIEW

As the leasing of submerged lands for conservation is a relatively new phenomenon, little research exists on the topic. However, several similar study topics are relevant, and are reviewed here. The use of submerged lands for aquaculture is a traditional practice with many examples available in the literature. Selection of sites best suited for aquaculture often reflects the process and priorities of site selection for conservation. Methods have also been developed for prioritizing estuaries and wetlands for conservation.

Many studies have examined land use and water quality, although the emphasis has been on freshwater systems. Several coastal studies are included in this review as well.

3.1 Aquaculture and Conservation Site Selection

GIS models have been used successfully in aquaculture site selection and often include water quality and coastal land use parameters. In a study in Maharashtra, India, Karthik et al. (2005) evaluated the suitability of intertidal areas for aquaculture based on engineering parameters, water quality parameters, soil quality parameters, infrastructure facility, meteorological parameters, and social restrictions. Specific water quality parameters included water temperature, salinity, pH, dissolved oxygen, NH$_3$, NO$_2$, NO$_3$, and PO$_4$ obtained from direct field and laboratory analysis. A weighted overlay of the various parameters in a GIS analysis divided the study area into highly suitable, suitable, moderately suitable, and unsuitable for aquaculture. Similarly, Perez et al. (2003) identified sites acceptable in the Canary Islands for marine fish cages using a GIS analysis of
temperature, turbidity, sewage, and bathymetry. Thematic maps were scored from one to eight, dependent upon their suitability for aquaculture. Arnold and Norris (1998) applied GIS technology along with information on water depth, water quality classification, upland land use, site accessibility, transportation corridors, the distribution and abundance of clams and submerged aquatic vegetation to assess site suitability for shellfish aquaculture in Florida. GIS suitability models were also employed in coastal aquaculture zoning in Sri Lanka (Angell, 1998) and clam aquaculture in Virginia (Hershner and Woods, 1999).

Edgar et al. (2000) employed GIS maps and field-collected data to identify nine distinct estuary groups in Tasmania, Australia for biodiversity conservation. Physical characteristics such as the presence of a seaward barrier, tidal range, salinity, estuary size, and river runoff were used as predictors of biological differences to separate the estuaries into nine categories. Human population, land use, and land tenure were then used to assign levels of anthropogenic disturbance within each estuarine group. Those estuaries with the least anthropogenic disturbance in each group were given the highest conservation priority.

Brophy (1999) analyzed Oregon’s Alsea and Yaquina basins in order to prioritize estuarine wetland sites for protection and restoration. Sites that received a highest priority ranking had “large acreage, known salmonid use, unusual plant communities, a single landowner, and simple restoration needs,” while lower priority sites were “of smaller size, disturbed condition, many landowners, and more complex restoration needs” (Brophy, 1999, p. 7).
Brophy’s (1999) assessment is a worthy guide for wetland protection and restoration, but as it excludes mudflats, eelgrass beds, and open water, it does not function as a priority guide for marine land conservation.

While both Edgar et al. (2000) and Brophy (1999) contribute valuable information to coastal conservation, this study fulfills a different role. Edgar et al. (2000) assessed conservation from a biological standpoint without including feasibility, economics, and policy. While that is necessary, managers have to consider many other factors during the implementation of conservation goals. This study first assessed estuary ownership to examine the availability and location of potential marine land lease sites. Lincoln County policy was then incorporated to identify predominant land use zones adjacent to marine land ownership classes. The correlation between adjacent terrestrial land use zones and water quality was defined, providing a “coarse-filter” site-selection tool: sites can be included or disregarded for specific conservation projects based upon adjacent land use zoning characteristics.

3.2 Effect of Landscape Characteristics and Human Development on Water Quality

GIS, aerial photography, and remote sensing have aided research on the relationship between landscape characteristics and water quality. These studies employ various methodologies, with most using GIS for initial stages of land characterization, and then exporting data to a statistical analysis package. Stream and inland watershed studies dominate the literature, but coastal studies have been performed as well. Many of the principles in freshwater studies are also applicable to coastal studies.
Bolstad and Swank (1997) examined the impact of basin and near-stream land use on water quality in a western North Carolina mountain stream. Water quality parameters sampled included pH, $\text{HCO}_3^-$, conductivity, $\text{NO}_3^-$-$\text{N}$, $\text{NH}_4^+$-$\text{N}$, $\text{PO}_4^{3-}$-$\text{P}$, $\text{Cl}^-$, $\text{Na}^+$, $\text{K}^+$, $\text{Ca}^{2+}$, $\text{Mg}^{2+}$, $\text{SO}_4^{2-}$, $\text{SiO}_2$, turbidity, temperature, dissolved oxygen, total and fecal coliform, and fecal streptococcus. GIS buffers from 50 to 300 m were utilized to represent the near-stream zone. Simple linear regression models related water quality (dependent variable) to landscape parameters (independent variable). Basnyat (1999) also examined land use and stream water quality at varying scales. A multiple regression was performed to determine the relationship between non-point source pollutants (nitrates and sediments) and land use. Land use was examined at three scales: the entire basin, the “contributing zone” for each stream, and the stream bank buffer.

Richards and Host (1994) assessed the relationship between watershed land use and stream habitat quality. Principal component and correlation analyses were used to identify physical stream habitat and land use associations. Detenbeck et al. (2001) investigated wetland influence as a land-cover on stream water quality. They used GIS to estimate proximity-weighted wetland areas hydrologically connected to each stream sampling point.

Coastal fecal coliform abundance in relation to land use was addressed by Mallin et al. (2000) and Kelsey et al. (2004). Mallin et al. (1999) examined five estuarine watersheds for a correlation between fecal coliform abundance and watershed demographic and land use factors. The land use factors employed were %age development and %age impervious surface. Kelsey et al. (2004) looked at a
single South Carolina estuary to determine land use characteristics that contributed
to fecal coliform pollution. Both environmental and land use variables were
included in a regression model to explain fecal contamination. Land use variables
were distance from water sampling locations to population density, housing unit
density, total population, total number of housing units, area of developed and
undeveloped land, number of septic tanks, sewage system lift stations, roads,
boating intensity, boat landings and marinas.

Several studies have examined land use and fecal coliform conditions in the
Tillamook Bay watershed, located in Tillamook County, the coastal county
directly north of Lincoln County, Oregon. The levels of fecal contamination in
Tillamook Bay and its tributaries frequently exceed mandated standards, posing a
threat to the oyster shellfish industry and public recreational use (Jackson and
Glendening, 1982). Sullivan et al. (2005) utilized data from the Tillamook Bay
National Estuary Project to assess fecal coliform bacteria, total suspended solids,
and nutrients in the watershed. In four Tillamook basin rivers, water quality
samples were collected at a downstream site near the bay and at an upstream site
near the agriculture/forest land use transition. As the uplands in Tillamook Bay
watershed are primarily forested, and the lowlands areas are agriculture, the
contributions from each land use could be quantified.

The methodology used in some of the stream/river water quality and land use
assessments parallel the steps of this estuarine water quality analysis, in Chapter 4,
Methods, below. The 250 and 500 m buffers constructed around each estuary
water quality sampling station in this study are comparable to a streamside buffer,
as they encompass directly adjacent lands. The expanding buffer zones (1000 m, 2000 m, and 4000 m) used in this study can be thought of as an attempt to capture “contributing zones,” where the 4000 m buffer approaches the 7th Field HUC catchment of the US Geological Survey’s classification.

The land use zone categories utilized in this study encompass many of the landscape variables discussed in the studies above. Impervious surfaces, human development, and urbanization are captured in land use zones such as city, commercial, industrial, and residential; while zones like resource include agriculture and timberlands.

Although land use and water quality has been the interest of many researchers, the exact relationship between the two remains unclear (Basnyat, 1999). There is much to be learned about pollutant transport processes and linkages to landscape (Howarth et al., 2002).
4 METHODS

4.1 Objective: Map ownership and use of Lincoln County estuary tidelands and their adjacent land use zones.

To assist with the spatial identification of tideland ownership and terrestrial land use zones, a geodatabase of relevant coastal data was created. Physical, biological, and jurisdictional boundary data were aggregated in a GIS for coastal Lincoln County, Oregon. Oregon Department of State Lands provided an estuary ownership shapefile classifying submersible land (tidelands) as state-owned, privately-owned, or other. Oregon’s federal and state marine managed areas, including national wildlife refuges, national or state estuarine research reserves, conservation zones, and marine gardens, were mapped from data accessed at www.mpa.gov. Shellfish plat lease locations in Lincoln County, specifically Yaquina Bay, were digitized from Oregon Department of Agriculture (ODA) hardcopy records. Digital land use zoning data obtained from Lincoln County were classified into the following categories: city, commercial, dredged material disposal, industrial, marine, public facilities, residential, resource, and rural residential (Appendix 1 provides a full description of zone classifications and permitted uses). Many other data layers, such as hydrology and shoreline protection structures, served as supplemental information in the geodatabase, but because they were not explicitly used in data analysis, they are not described here.

As state-owned tidelands are of primary interest to those pursuing conservation leasing, this study examined the relative proportion of tidelands that were owned by the state versus other or privately-held tidelands. The relative area of the three estuary groups was calculated: state-owned, privately-owned, and
“other” estuaries that were neither state nor privately owned (Appendix 2). ArcGIS calculate areas tool was used to calculate the area for each polygon in the estuary ownership shapefile. The ArcGIS dissolve tool was then used to aggregate the polygons and summarize the tideland area by ownership group. The area (in m²) for each ownership group was divided by the total area of the estuary ownership shapefile, to give the relative %age tideland area held by each ownership group.

The geographic location of the three estuary ownership groups, as well as estuary uses for aquaculture (ODA shellfish plat leases), and marine managed areas were examined in relation to adjacent land use zones. For each estuary ownership group and for aquaculture and marine managed areas, the bordering land use zones were manually selected. The selected records were then exported to create a separate attribute table for every land use zone bordering each ownership and use group. The ArcGIS calculate areas tool and the summary statistics for the area field were used to obtain the total area of each land use zone located next to the ownership or use of interest. The area for each land use zone was divided by the total area of land use zones bordering a specific ownership and use group, to obtain a relative %age composition of the surrounding land use zones.

4.2 Objective: Examine the statistical relationship between Lincoln County land use zones and water quality.

Water quality monitoring data for Lincoln County’s estuaries was accessed from DEQ’s online monitoring database, the Laboratory Analytical Storage and Retrieval (LASAR) Web Application (http://deq12.deq.state.or.us/lasar2/). Random estuary site sampling is part of the EPA’s Environmental Monitoring and Assessment Program. Details on technical sampling procedures and quality
assurance controls can be found on DEQ’s website:

http://www.deq.state.or.us/lab/techrpts/technicaldocs.htm

As a result of data availability and coverage, as well as applicability to research goals, sampling records from 1999 to 2005 were retained for the following water quality parameters: ammonia as N (mg/L), dissolved orthophosphate as P (mg/L), fecal coliform (CFU/100 mL), field dissolved oxygen (mg/L), nitrate/nitrite as N (mg/L), % saturation field dissolved oxygen (%), total suspended solids (mg/L). Only samples classified as “surface water” or “Bay/Estuary/Ocean” sampling matrix were utilized. All water quality parameters were monitored by 16 or more stations and had at least 48 samples recorded in the database (see Figure 1 and Appendix 3).

In Oregon, the dramatic difference in precipitation between the rainy season and dry season can lead to seasonal variations in water quality parameters (Sullivan et al., 2005). Spring and summer coastal upwelling, which delivers nutrients from the ocean into the estuary, may also cause seasonal variability in nutrient concentrations (Fry et al., 2003; Colbert and McManus, 2003). To mitigate this effect, the sampling data was pooled by season: the rainy season from October through April, and the dry season from May through September. Rainy season samples were only available for fecal coliform. All other parameters were sampled solely during dry season.

Tidal fluctuations also introduce variability in estuarine water quality (DiLorenzo et al., 2004). To assess and then moderate tidal influences, the tidal stage at time of sampling was first determined. NOAA Tides & Currents
(http://tidesandcurrents.noaa.gov) historic tide data were used to classify the water monitoring records by tide condition. A six minute water level was converted to tidal stage by calculating the sign (positive or negative) of the difference between successive water levels. A positive sign corresponded to flood tide, while a negative sign corresponded to ebb tide. Slack tides (high slack and low slack) were assigned a one hour period, centered around high and low tide, with the least amount of water level change. This methodology was adapted from Wyeth et al. (2006).

After sampling data were pooled by season and tide, multiple values occurring at each station were averaged over the years 1999 to 2005 in order to obtain one water parameter value (for each seven parameters) per station point within seasonal and tidal categories. In order to produce one mean seasonal water parameter value for each station with reduced variability from tidal fluctuations, a poststratification, weighted average method suggested by DiLorenzo et al. (2004) was employed. Each tidal stage value for a station was weighted by the fraction of time it composed of the 12.42 h tidal cycle. The one-hour of low slack and high slack tide values were each weighted 0.08, while flood tide and ebb tide were each weighted 0.42, to give one mean seasonal value. If a station was missing a certain tidal stage value (e.g., no sampling data for low slack), the other tidal stage weights were scaled up accordingly.
Figure 1. DEQ water quality sampling stations used in this study.
In ESRI’s ArcGIS 9.1, each water quality station was given a 250 m, 500 m, 1000 m, 2000 m, and 4000 m buffer which overlaid Lincoln County’s land use zones layer (Figures 2 and 3). The 250 and 500 m buffers capture directly adjacent land use zones, while the extended buffers (1000 m, 2000 m, and 4000 m) capture contributing zones and were adapted from methods used to assess land use and water quality relationships in stream and inland watershed studies (Bolstad and Swank, 1997; Basnyat, 1999).

Figure 2. A 500 m buffer zone around Yaquina Bay water quality stations.
Figure 3. Delineated buffer zones for a water quality station.
To capture the relative %age of different land use zones surrounding each water quality station, the following methods were repeated for all five buffer sizes (Figure 4): buffers were intersected with Lincoln County land use zoning. The area of each land use zone within a buffer was calculated, and the resulting layer was
dissolved by the fields sampling station ID and land use zone with a summary statistic field for area. A field named “Percent” was added to the attribute table. “Percent” field values were calculated by dividing the area of a land use zone by the total area contained within one buffer size.

A table joining water quality parameter values to %age land use zone by the common field, sampling station ID, was created for each land use zone (Figure 5). The tables were then exported to the statistical package S-plus, where a Pearson Product Moment Correlation was performed to examine the relationship between water quality and relative land use zone composition for a series of buffer sizes.

Figure 5. Example GIS attribute table showing the result of a join operation between dry season fecal coliform values and the %age of resource land use within a buffer. Each water quality station is a separate record (i.e., a row in the table).
A Pearson Product Moment Correlation, the most common measure of correlation (Lane, 2007), assesses the degree of linear relationship between two quantitative, continuous variables. It is a measure of the strength of the association between the two variables, with a correlation of +1 representing a perfect positive linear relationship, a correlation of -1 representing a perfect negative linear relationship, and a correlation of 0 means that there is no relationship. A Pearson’s correlation, as opposed to a regression analysis, was chosen because this study’s objectives focus on identifying a relationship between land use zones and water quality for management site selection purposes, and not the development of a predictive water quality model, nor the elucidation of the complex pathways and sources of marine pollutants.

Mallin et al. (2000) used Pearson’s correlations in their examination of the effect of human development on bacteriological water quality. They performed correlation analysis on mean fecal coliform abundance and watershed demographic and land use factors. Richards and Host (1994) used Pearson’s correlations to assess the relationship between land use and physical stream habitat for macroinvertebrates.
5 RESULTS AND DISCUSSION

5.1 Marine Land Mapping

Estuary tidelands in Lincoln County are predominantly owned by the state of Oregon, followed by private ownership, and “other” ownership, comprising 47%, 28%, and 12% of tideland area, respectively. State-owned tidelands are typically adjacent to residential or city land use zones, with 49% of adjacent land use zone area occupied by residential zoning and 37% occupied by city zoning. Resource land use zoning is 12% of the adjacent land use zone area for state-owned tidelands, and rural residential and commercial zones are also present in small percentages. Privately-owned tidelands are bordered most often by resource land use zones, composing 57% of the adjacent land use zone area, and rural residential zones, composing 30% of the zone area. City, dredged material disposal, and residential zoning is also present.

There are two marine managed areas in the coastal waters of Lincoln County: the Siletz Bay National Wildlife Refuge and the Oregon Islands National Wildlife Refuge. Refuge areas are bordered by an assortment of land use zones including city, commercial, public facilities, resource, residential, and rural residential. There appears to be no clear preference or pattern to land use zoning adjacent to the marine managed areas. ODA aquaculture lease sites are located next to dredged material disposal, resource, and rural residential land use zones.
5.2 Water Quality and Land Use Zone Correlations

5.2.1 Pearson correlations

Six out of the seven water quality parameters tested had a significant Pearson correlation with one or more land use zones (Table 1). Dissolved orthophosphate as P was most sensitive to variations in land use zones, with the strongest correlations to the most land use zones (Table 2). Nitrate/nitrite as N had no significant Pearson correlations within the tested buffer ranges (Table 2). All Pearson correlations results can be found in Appendix 4.

Table 1. Pearson correlations between land use zones and water quality parameters. Cells marked with x have a significant (at p < 0.1) Pearson correlation for at least one of the buffer sizes.

<table>
<thead>
<tr>
<th></th>
<th>City</th>
<th>Comm¹</th>
<th>DMD²</th>
<th>Indus³</th>
<th>Marine</th>
<th>PFacil⁴</th>
<th>Resid⁵</th>
<th>Resour⁶</th>
<th>RRes⁷</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC dry</td>
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<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>FC rainy</td>
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<td></td>
<td></td>
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<td>x</td>
<td>x</td>
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<td>NH₃-N</td>
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<tr>
<td>OP-P</td>
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<td>NO₃-N; NO₂-N</td>
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</table>

¹ = commercial, ² = dredged material disposal, ³ = industrial, ⁴ = public facilities, ⁵ = residential, ⁶ = resource, ⁷ = rural residential.
Table 2. Pearson correlations between land use zones and water quality parameters. Only the land use zones with significant correlations (at p < 0.1) to water quality are included. Bold values have significance at p < 0.05. P indicates a correlation to poorer water quality, while B indicates a correlation to improved water quality. The strongest correlations from the various buffer scales are shown.

<table>
<thead>
<tr>
<th></th>
<th>City</th>
<th>Indus(^1)</th>
<th>PFacil(^2)</th>
<th>Resid(^3)</th>
<th>Resour(^4)</th>
<th>RRes(^5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC dry</td>
<td>P(0.514)</td>
<td>P(0.360)</td>
<td>(0.283)</td>
<td></td>
<td></td>
<td>P(0.328)</td>
</tr>
<tr>
<td>FC rainy</td>
<td>P(0.527)</td>
<td>P(0.424)</td>
<td></td>
<td></td>
<td>P(0.284)</td>
<td></td>
</tr>
<tr>
<td>NH(_3)-N</td>
<td>P(0.692)</td>
<td>P(0.589)</td>
<td></td>
<td>P(0.364)</td>
<td>B(-0.734)</td>
<td>B(-0.413)</td>
</tr>
<tr>
<td>OP-P</td>
<td>(-0.470)</td>
<td>B(0.587)</td>
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<tr>
<td>DO</td>
<td>(-0.549)</td>
<td>P(-0.449)</td>
<td>B(0.448)</td>
<td>B(0.590)</td>
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<tr>
<td>%DO</td>
<td>P(0.401)</td>
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<tr>
<td>TSS</td>
<td>P(0.401)</td>
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</table>

\(^1\) = industrial, \(^2\) = public facilities, \(^3\) = residential, \(^4\) = resource, \(^5\) = rural residential.

In comparison to other land use zones, city land use zone had a significant Pearson correlation with the greatest number of studied water quality parameters (Table 2). An increase in city land use zone had a moderate correlation to poorer water quality in all cases. Industrial land use zone, as well, had a low to moderate correlation to poorer water quality in all cases.

Residential land use zones had a significant correlation with four water quality parameters. An increase in residential land use zone had a weak correlation to higher dissolved orthophosphate as P and dry season fecal coliform, but a moderate correlation to improved dissolved oxygen concentrations. Resource land use zone had a strong correlation to lowered dissolved orthophosphate as P and a moderate correlation to lower total suspended solids.

When all water quality parameters are considered, the most frequent and strongest correlations between land use zone and water quality occur at the 4000 m buffer, followed sequentially by 2000 m, 1000 m, 500 m, and 250 m buffers.
(Table 3). Fecal coliform, dissolved orthophosphate as P, and % saturation field dissolved oxygen have the strongest correlation to land use zones at the 4000 m buffer level. Total suspended solids is tied at the 2000 m and 4000 m buffer level for the strongest correlation. Field dissolved oxygen (mg/L) has the strongest correlation at the 2000 m level, while ammonia as N has the strongest correlation at the 500 m level.

Table 3. The buffer levels with the strongest significant Pearson correlation for each land use zone are marked with x.

<table>
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<tr>
<th></th>
<th>250 m</th>
<th>500 m</th>
<th>1000 m</th>
<th>2000 m</th>
<th>4000 m</th>
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<tr>
<td>FC dry</td>
<td>x</td>
<td>x</td>
<td>xx</td>
<td></td>
<td></td>
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<tr>
<td>FC rainy</td>
<td>x</td>
<td>xx</td>
<td>xx</td>
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<td>NH₄-N</td>
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<td>OP-P</td>
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<td>DO</td>
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<td>NO₃-N</td>
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<td>NO₂-N</td>
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</table>

To assess whether Pearson correlation results were representative of all Lincoln County estuaries, or whether correlations deviated by individual estuary, xy plots of water quality parameter values versus %age land use zone were examined. There appeared to be no clustering of individual estuary points above or below the trendline, indicating that an analysis aggregating all estuaries was appropriate (see Appendix 5 for a sample of the xy plots).

5.2.2 Pollutant sources and pathways

The water quality parameters used have varying sources and transport pathways that can impact their correlations with land use zones, and may dictate the geographical buffer zone at which they have the greatest influence.
Phosphorous inputs into U.S. surface waters are dominated by nonpoint sources resulting from application of inorganic fertilizers and manure (Howarth et al., 2002). Historically, farms have been a sink for phosphorous due to local recycling of manure as a fertilizer to meet crop phosphorous requirements. The specialization, and separation, of crop and animal operations has led to a net export of phosphorous from grain to animal areas, where excess manure saturates the soil with nutrients (Howarth et al., 2002). Phosphorous is transported into coastal waters through erosion, surface run-off, and subsurface flow. A small portion of the landscape during a storm is typically responsible for the majority of phosphorous export (Sharpley et al., 2001). Phosphorous is much less mobile than nitrogen and is largely associated with sediments (Berka et al., 2001; Howarth et al., 2002). The contribution of subsurface flow P is generally small (Sharpley et al., 2001). Biological uptake and regeneration of nutrients in estuaries may influence the concentration of both phosphorous and nitrogen (Colbert and McManus, 2003; Sullivan et al., 2005). In addition, the coastal upwelling of oceanic waters can be a source of estuarine nutrients (Fry et al., 2003; Colbert and McManus, 2003).

The reduced mobility of phosphorous, and its dominant transport by erosion and run-off, may explain its stronger correlations with land use zones in this study. As phosphorous export is associated with relatively small problem areas of the landscape, adjacent land use zoning could play a larger role in phosphorous levels. Due to its limited mobility, phosphorous would tend to show correlations in
a small-scale buffer study, such as this one, as opposed to a basin analysis of water quality, where trends in nitrogen levels might become more apparent.

Nitrogen inputs are also dominated by nonpoint sources, although the pathway of nitrogen to coastal waters is more complicated than that of phosphorous. Nitrogen can reach estuaries by atmospheric deposition, surface runoff, or through ground water transport. Inorganic fertilizers, livestock waste, and fossil-fuel combustion are the primary contributors. Nitrogen applied as fertilizer leaches into ground and surface waters, and also volatilizes as ammonia (Howarth et al., 2002). Almost 40% of livestock waste is volatilized as ammonia (Bouwman et al., 1997), while runoff carries additional waste directly into surface waters. Nitrogen from fossil fuel combustion volatilizes to NOₓ. Once in the atmosphere, the lifetime of nitrogen is fairly short, and it is typically deposited near the source. Nitrogen can be deposited terrestrially and then runoff into estuaries, or be directly deposited onto surface waters (Howarth et al., 2002). The dynamic and highly mobile pathway of nitrogen may make correlations between immediately adjacent land use zones and water quality less likely, with trends being observable on a more regional level.

Rainy season fecal coliform values were positively correlated with city, industrial, and public facility land use zones. As fecal coliform input to today’s coastal waters is primarily through runoff and non-point surface water flow, the impervious surfaces located in the above land use zones allow for rapid and concentrated transport of fecal coliform during rain events (Mallin et al., 2000; Weiskel et al., 1996; Mallin et al., 2001). Dry season fecal coliform values were
positively correlated with residential, resource, and rural residential, as well as public facilities again. These land use zones may comprise more rural areas where sedimentation and erosion can transport fecal coliform (Mallin et al., 2001).

Several confounding environmental factors complicate the use of fecal coliform as an indicator organism. Changes in temperature, salinity, levels of nutrients, toxic compounds, and UV exposure may all cause stress on the microbe. If conditions are favorable in coastal waters, it is possible for fecal coliform to reproduce, introducing a secondary source of contamination. In addition, water fowl fecal pellets may contribute to fecal coliform levels, although it has been shown that there is limited dispersal from these pellets (Weiskel et al., 1996).

Dissolved oxygen is also a complex water quality indicator. Dissolved oxygen is influenced by a combination of variables, not just factors like excess nutrients and organic matter decomposition, that can be linked to land uses. Dissolved oxygen levels vary with water temperature and photosynthetic activity. Fast moving rivers and streams entrain more oxygen, bringing elevated levels into estuaries; incoming ocean water also delivers higher levels of oxygen. A pycnocline or unique bathymetric features can cause decreased mixing in an estuary, leading to lowered dissolved oxygen (Chesapeake Bay Program, 2005).

Suspended solids may act as carriers for certain pollutants. Specifically, fecal coliform and phosphorous transport are associated with suspended solids (Mallin et al., 2000). In this study, resource land use zoning, probably because of its increased vegetation cover, was negatively correlated with total suspended solids. Resource land use zoning was also negatively correlated with rainy season
fecal coliform and dissolved orthophosphate as P. This may indicate that the lack of total suspended solids exported from resource land use zones reduced the amount of fecal coliform and phosphorous transported from resource zones into estuaries. City land use zoning, which was positively correlated with suspended solids, was also positively correlated with rainy season fecal coliform and dissolved orthophosphate as P.

5.2.3 Marine conservation site selection

There is no over-arching solution to selecting sites for marine conservation. Water quality is only one aspect of a conservation project, and each conservation project may have specific goals which alter the suitability of a submerged land site. GIS can be an effective tool to assess the marine land options available and weigh the environmental characteristics of a particular site location. In this study, some land use zones were correlated with poorer overall water quality or better overall water quality, whereas other land use zones had both positive and negative correlations, dependent upon the water quality parameter. When selecting a marine site for conservation, one must consider the goals of the particular conservation project, as well as the problem pollutants for the area.

As mentioned previously, state-owned estuary tidelands which could potentially be available for conservation leasing are adjacent, for the most part, to residential and city land use zones, with a smaller portion adjacent to resource land use zones. According to the results of this study, if a high water quality standard was a key requirement in site-selection, it would not be advisable to locate next to
city land use zoning. Generally, resource land use zoning would provide a better option.

When assessing land use zones that have both positive and negative correlations with water quality criteria, it is helpful to identify the particular water quality problems of an area. For example, from river mile 0 (the mouth) to 23.1, Salmon River is water quality limited and 303(d) listed for fecal coliform. It violates the criteria set for shellfish growing: fecal coliform median of 14 organisms per 100 ml; no more than 10% of samples greater than 43 organisms per 100 ml. From river mile 0 to 4.9, Alsea River is limited in water quality and violates Section 303(d) of the Clean Water Act for fecal coliform. It violates the same criteria set for shellfish growing. Yaquina River, from river mile 0 to 56.8, also violates Section 303(d) for fecal coliform, as it pertains to safe conditions for shellfish growth. If selecting conservation sites in these areas, one would want to avoid city and public facility land use zones, as they have the strongest positive correlations with fecal coliform. Yaquina River violates Section 303(d) and has poor water quality along these same river miles for dissolved oxygen. The criteria for dissolved oxygen is set to protect cold-water aquatic life and must not be less than 8.0 mg/l or 90% of saturation (Oregon DEQ, n.d. b). For site-selection possibilities in Yaquina River, one might want to include residential land use zones, as this would most likely minimize dissolved oxygen problems.

As the most and strongest correlations between land use zone and water quality parameters occurred at the 4000 m buffer, it appears as if managers will have to look beyond directly adjacent land use zones for an accurate assessment of
water quality threats. The 500 m buffer, which only captures directly adjacent land use zones, was seldom the strongest correlation, with the exception of ammonia. The 2000 m and 4000 m buffers seemed to be the zones of greatest influence. The 4000 m buffer approached the size of the US Geological Survey’s 7th Field Hydrologic Unit “Catchment”, but was still substantially smaller than the USGS watershed classification. When examining estuary adjacent land use zones for site selection purposes, it would be best to recreate a 4000 m buffer or physically survey a 4000 m buffer around candidate sites.
6 CONCLUSION

The acquisition of submerged and submersible lands is a promising marine conservation strategy that has been implemented effectively in Texas, Washington, and New York (Beck et al., 2004), and is being explored by other coastal states. Once acquired, these marine lands can be used to protect vital habitat, remove invasive species, restore fish and invertebrate populations, and preserve overall ecological function (Beck et al., 2004).

To ensure that marine lands utilized for conservation achieve their maximum potential, project goals should be matched with suitable submerged land sites. GIS can be valuable during the site-selection process and is a key step towards informed decision-making. This study demonstrated that terrestrial land use zoning can be used as an initial site selection screen to ensure compatibility between conservation goals and water quality conditions.

In Oregon, the Department of State Lands issues leases for state-owned submerged and submersible lands, providing a possible framework for marine land conservation leasing. This study found that in Lincoln County, Oregon, the state of Oregon is the predominant owner of estuary tidelands. These state-owned lands are typically located next to residential and city land use zones. Unfortunately, city land use zone had a correlation with deteriorated water quality for six out of the eight studied water quality parameters. Sites located next to city land use zones are likely poor options for those projects that have high water quality as a key requirement in site-selection. Residential and rural residential zones offer better options. Resource land use zone appears to be the best overall option to have as an
upland use in site selection. Although, resource land use zoning is only 12% of the adjacent land use zone area for state-owned tidelands. This study has shown that managers should consider land use zoning within a 4000 m buffer to most accurately assess marine land site options.

It is possible that other marine land conservation methods, in addition to the lease of state-owned marine lands, could be employed in Lincoln County. Privately-owned tidelands could be a promising target for conservation, as privately-owned tidelands are predominantly bordered by resource and rural residential land use zones.

Not all water quality parameters have the same correlations to land use zones. It is helpful to identify the particular water quality problems of an area when assessing land use zones that have both positive and negative correlations with water quality criteria. In this way, one can select a land use zone that mitigates the problem pollutant in the water body of interest. However, this study showed that using land use zoning as a site-selection tool may be ineffective for controlling nitrogen levels, as nitrogen parameters had little to no significant Pearson correlations to land use zones within the tested buffer ranges. On the other hand, phosphorous levels were moderately to highly correlated with five out of the nine land use zones.

The results of this study may be combined with other research and policy efforts to obtain the most compatible uses of submerged and terrestrial lands. Oregon Statewide Planning Goal 16 directed the Land Conversation and Development Commission to establish a classification system of estuaries: natural,
conservation, shallow draft development, and deep draft development. These classifications set a limit upon the amount and type of development within an estuary. In addition, individual estuary plans assign natural, conservation, and development management units within each estuary. Management units are determined primarily by habitat and extent of past alterations to the estuary (Oregon DLCD, 1987). This study indicates that land use zones extending 4000 meters around estuarine sites would be another important factor to include in estuary management decisions.

A GIS model is only as accurate as the data used. Future studies can increase the useful management applications of this study by incorporating several data improvements. Water sampling should be conducted in the rainy season for all water quality parameters, not just fecal coliform. This would provide a more complete view of land use and water quality correlations, ensuring site selection decisions were valid for both the rainy and dry season. The land use zones utilized in this analysis could be broken down into more detailed categories. Specifically, by separating resource land use zone into agriculture and forested uses, the relationship between these uses and water quality could be defined more precisely.

The water quality data and analysis used in this study are not limited to submerged land conservation applications. Equipped with a similar geodatabase, governmental agencies or researchers could address a myriad of other environmental issues in the state. A more detailed investigation of pollutant pathways and sources could lead to new discoveries and strategies for coastal management.
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Appendix 1
Land use zone classifications

City Zone
Commercial Zones
   (a) Tourist Commercial C-T
   (b) Retail Commercial C-1
   (c) General Commercial C-2

Dredge Material Disposal Zone

Industrial Zones
   (a) Planned Industrial I-P

Marine Zone

Public Facilities Zone
   (a) Public Facilities P-F

Residential Zones
   (a) Residential R-1
   (b) Residential R-1-A
   (c) Residential R-2
   (d) Residential R-3
   (e) Residential R-4

Resource Zones
   (a) Agricultural Conservation A-C
   (b) Timber Conservation T-C

Rural Residential Zones
   (a) Rural Residential RR1-2
   (b) Rural Residential RR-5
Appendix 1 continued
Permitted uses in land use zones. Adapted from the 2007 Lincoln County Code published by the Office of Lincoln County Legal Counsel.

General Commercial: This area is provided to accommodate the normal range of business activities and meet the day-to-day needs of the community. Uses such as retail store, repair shop, barber shop, beauty shop, motel, community hall are primary. Secondary use such as service stations or drive-ins and outdoor amusement center may be included by County review.

Tourist Commercial Zone C-T

(1) Uses Permitted Outright:
(a) A use permitted outright in the R-4 zone.
(b) Automobile service station, including minor repair provided it is conducted entirely within an enclosed building.
(c) Barber or beauty shop.
(d) Boat launching or moorage facility, marina, boat charter service.
(e) Car wash.
(f) Clinic.
(g) Club, lodge, or fraternal organization.
(h) Food store.
(i) Gift shop.
(j) Hotel, motel, or resort, when served by a public or community sewer system.
(k) Indoor commercial amusement or recreation establishment such as bowling alley, theater, or pool hall.
(L) Laundromat.
(m) Office.
(n) Private museum, art gallery, or similar use.
(o) Restaurant, bar, or tavern.
(p) Retail sale of sporting goods, or bait.

(2) Conditional Uses Permitted:
(a) A use permitted as a conditional use in the R-4 zone.
(b) Recreational vehicle park.
(c) Outdoor recreation development.
(d) Outdoor commercial amusement or recreation establishment such as miniature golf course or drive-in theater, but not including uses such as race track or automobile speedway.
(e) Automobile repair garage provided all repair shall be conducted entirely within an enclosed building.
(f) Signs, advertising.
(g) Heliport.
(h) Pilings, piers, docks, and similar in water structures.
(i) Mini-storage.

**Retail Commercial Zone C-1**

1) **Uses Permitted Outright:**
   
   (a) A use permitted outright in the R-4 zone.
   
   (b) Retail store or shop such as food store, drug store, apparel store, hardware store, furniture store, or similar establishment.
   
   (c) Repair shop for the type of good offered for sale in those retail trade establishments permitted in a C-1 zone provided, all repair and storage shall occur entirely within an enclosed building.
   
   (d) Personal or business service establishment such as barber or beauty shop, laundry or dry cleaning establishment, tailor shop, or similar establishment.
   
   (e) Clinic.
   
   (f) Financial institution.
   
   (g) Club, lodge, or fraternal organization.
   
   (h) Hotel, when served by a public or community sewer system.
   
   (i) Indoor commercial amusement or recreation establishment such as bowling alley, theater, or pool hall.
   
   (j) Mortuary.
   
   (k) Newspaper office, print shop.
   
   (L) Office.
   
   (m) Private museum, art gallery, or similar facility.
   
   (n) Restaurant, bar, or tavern.
   
   (o) Beachfront protective structures.

2) **Conditional Uses Permitted:**
   
   (a) A use permitted as a conditional use in the R-4 zone.
   
   (b) Recreational vehicle park.
   
   (c) Outdoor commercial amusement or recreation establishment such as miniature golf course or drive-in theater, but not including uses such as race track or automobile speedway.
   
   (d) A use permitted outright or a conditional use permitted in the C-1 zone with drive-in service facilities such as an automobile service station or a drive-in restaurant.
   
   (e) Signs, advertising.
   
   (f) Heliport.
   
   (g) Pylons, piers, docks, and similar in water structures.
   
   (h) Mini-storage.

**General Commercial Zone C-2**

1) **Uses Permitted Outright**
   
   (a) A use permitted outright in the C-1 zone.
   
   (b) Automobile, truck, or trailer sales, service, storage, rental, or repair.
   
   (c) Boat launching or moorage facility, marine boat charter service.
(d) Boat or marine equipment sales, service, storage, rental, or repair.
(e) Cabinet or similar woodworking shop.
(f) Cold storage or ice processing plant.
(g) Feed or seed store.
(h) Implement, machinery, or heavy equipment sales, service, storage, or rental.
(i) Laboratory for experiment or research.
(j) Lumber or building materials sales and storage.
(k) Machine, welding, sheet metal, or similar metal working shop.
(L) Outdoor commercial amusement or recreation establishment such as miniature golf course or drive-in theater, but not including uses such as race track or automobile speedway.
(m) Plumbing, heating, electrical, or paint contractors' storage, repair, or sales shop.
(n) Processing, packing, or storage of food or beverage, excluding those products involving distillation, fermentation, rendering of fats or oils or slaughtering.
(o) Tire sales, repair, retreading, or vulcanizing.
(p) Truck terminal, freight depot.
(q) Upholstery shop.
(r) Warehouse or storage area.
(s) Wholesale establishment.
(2) **Conditional Uses Permitted:**
(a) A use permitted as a conditional use in the C-1 zone.
(b) Animal hospital.
(c) Heliport.
(d) Pilings, piers, docks, and similar in water structures.
(e) Mini-storage.

**Industrial:** This area is provided to accommodate the more intensive and large scale commercial enterprises and industrial uses. Uses such as implement sales, storage or repairs, lumber or building materials sales and storage, and tire sales and repair are primary. Uses which require special standards such as quarrying pulp mill, gas or petroleum manufacturing, airport, and auto wrecking may be included by County review.

**Planned Industrial Zone I-P**
(1) **Uses Permitted Outright:**
(a) Farm use.
(b) Forestry, including the management, production, and harvesting of forest products and of related natural resources in forest areas and including rock extraction and processing for use in forest access roads.
(c) Residence for caretaker or night watchman.
(d) Beachfront protective structures.
(2) **Conditional Uses Permitted:**
(a) A use involving manufacture, research, repair, assembly, processing, fabricating, packing, distribution, warehousing, wholesaling, mini-storage, or storage provided that the use does not create a public nuisance, noise, smoke, odor, or dust, or because it constitutes a fire, explosion, or other physical hazard.
(b) Heliports and related uses.
(c) Animal hospital.
(d) Automobile, truck, or trailer sales, service, storage, rental, or repair.
(e) Automobile speedway, race track.
(f) Automobile wrecking yard, junk yard.
(g) Boat launching or moorage facility, marina, boat charter service.
(h) Boat or marine equipment sales, service, storage, rental, or repair.
(i) Extraction and processing of rock, sand, gravel, or other earth product.
(j) Feed or seed store.
(k) Governmental structure or use of land.
(L) Implement, machinery, heavy equipment sales, service, storage, rental or repair.
(m) Lumber or building materials sales and storage.
(n) Newspaper office, printing shop.
(o) Plumbing, heating, electrical, or paint contractors storage, repair, or sales shop.
(p) Public park, playground, golf course, or similar recreation area.
(q) Public utility facility.
(r) Radio or television transmitter or tower.
(s) Restaurant, bar, or tavern.
(t) Solid waste transfer station.
(u) Solid waste debris site or facility complying with provisions.
(v) Tire sales, repair, retreading, or vulcanizing.
(w) Signs, advertising.
(x) Bank and similar lending institutions.
(y) Theater/performing arts center.
(z) Pilings, piers, docks, and similar in-water structures.

(3) **Prohibited Uses:**
The following uses are prohibited:
(a) Cement, lime gypsum, or plaster of Paris manufacturer.
(b) Explosives storage or manufacture.
(c) Fertilizer manufacture.
(d) Gas manufacture.
(e) Glue manufacture.
(f) Petroleum or petroleum refining.
(g) Pulp mill.
(h) Rendering plant.
(i) Smelting or refining of metallic ore.
(j) Other uses similar to the above.
Public Facilities: Historically, few if any public facilities were available in the rural areas of Lincoln County. As demand for recreational development increased, various services have developed in the unincorporated areas. Through the formation of special districts, water, fire protection and in some cases, sanitary sewer services has been provided. The delivery of these services has been localized, and the networks have developed in a largely uncoordinated fashion.

Public Facilities Zone P-F

1) Uses Permitted Outright
   (a) Public parks and playgrounds, swimming pools, golf courses or similar recreation facility intended for use by the public.
   (b) Public schools and associated facilities.
   (c) Hospitals.
   (d) Government use.
   (e) Solid waste disposal site.
   (f) Beach front protective structures.

2) Conditional Uses Permitted
   (a) Public park and playground, golf course, swimming pool or similar recreation facility.
   (b) Public schools and associated facilities.
   (c) Hospitals.
   (d) Government use.
   (e) Solid waste disposal site.
   (f) Conversion of one outright use to another outright use.

Suburban Residential: Primary uses are single-family residential, multi-family residential where urban facilities and services are available, and existing public recreation facilities. Secondary uses such as community facilities, new public recreation facilities, government uses and similar uses may be included by County review.

Residential Zone R-1

1) Uses Permitted Outright:
   (a) A one-family dwelling unit excluding single wide mobile homes;
   (b) Duplex on a corner lot each unit fronting on a separate street;
   (c) A recreational vehicle or other approved temporary housing to be used for dwelling purposes during the construction of a single-family residential dwelling unit for which a building permit has been issued. The use shall not exceed a period of one year;
   (d) Farm and forest use: Livestock and primary processing or forest products are prohibited;
   (e) Beach front protective structures.

2) Conditional Use Permitted:
(a) Cemetery;
(b) Church, non-profit religious or philanthropic use;
(c) Community center;
(d) Day nursery, nursery school-kindergarten, day care center, or similar facility;
(e) Governmental structure or use of land;
(f) Home occupation;
(g) Hospital, nursing home, retirement home or similar facility;
(h) Golf course and ancillary uses, but excluding golf driving range, miniature golf course or similar facility;
(i) Mobile home park;
(j) Private, non-commercial recreation club, such as archery, swimming or tennis;
(k) Private school;
(L) Public park, playground, swimming pool or similar recreation facility;
(m) Public or private utility facility;
(n) Radio or television transmitter or tower;
(o) Temporary real estate office;
(p) Excavating, filling, dredging or wetland drainage;
(q) Single-wide mobile home;
(r) Recreational vehicle park;
(s) Keeping of livestock;
(t) Pilings, piers, docks, and similar in-water structures;
(u) Heliports;
(v) Transfer stations;
(w) Bed and breakfast inns.

Residential Zone R-1-A

(1) **Uses Permitted Outright:**
(a) A use permitted outright in the R-1 zone, but excluding duplexes on corner lots.

(2) **Conditional Uses Permitted:**
(a) A use permitted as a conditional use in the R-1 zone, excluding single-wide manufactured dwellings and bed and breakfast inns.

Residential Zone R-2

(1) **Uses Permitted Outright:**
(a) A use permitted outright in the R-1 zone.
(b) Two-family dwelling.

(2) **Conditional Uses Permitted:**
(a) A use permitted as a conditional use in the R-1 zone.
(b) Recreational vehicle on an individual lot.
Residential Zone R-3
(1) Uses Permitted Outright:
(a) A use permitted outright in the R-2 zone.
(b) Multi-family dwelling.
(2) Conditional Uses Permitted:
(a) A use permitted as a conditional use in the R-2 zone.
(b) Mobile home park.

Residential Zone R-4
(1) Uses Permitted Outright:
(a) A use permitted outright in the R-3 zone.
(2) Conditional Uses Permitted:
(a) A use permitted as a conditional use in the R-3 zone.
(b) Clinic.
(c) Club, lodge, or fraternal organization.
(d) Hotel, motel, or resort, when served by a public or community sewer system, with accessory commercial uses provided that:
(A) They are located within the main building or buildings.
(B) They are limited to gift shops, eating and drinking establishments, and similar facilities.
(C) They do not exceed 10% of the total floor area of the main use.
(e) Private museum, art gallery, or similar facility.
(f) Professional office.

Agriculture Lands: Agricultural lands represent nearly 2% of the lands in Lincoln County. These ownerships lie along the river and creek valleys and are mainly used for grazing and small gardens with some commercial agriculture. The primary use of these properties is intended to be agricultural to maintain their current resource value. Uses such as agriculture, forestry, dwellings necessary for farm use and existing public recreation facilities are primary. Secondary uses such as farm help residences, quarrying, new recreation facilities, and similar uses may be included by County review.

Agricultural Conservation Zone A-C
(1) Uses Permitted Outright:
(a) Farm use as defined in ORS 215.203.
(b) Other buildings customarily provided in conjunction with farm use.
(c) Propagation and harvesting of a forest product.
(d) Creation, restoration and enhancement of wetlands.
(e) A winery as defined in ORS 215.452.
(f) Operations for the exploration of geothermal resources as defined by ORS 522.005, oil and gas as defined by ORS 520.005, or minerals as defined by
ORS 517.750.

(g) Climbing and passing lanes within a highway right of way existing as of July 1, 1987.

(h) Reconstruction or modification of public roads and highways, not including the addition of travel lanes, where no removal or displacement of structures would occur, and no new land parcels would be created.

(i) Temporary public road and highway detours that will be abandoned and restored to original condition when no longer needed.

(j) Minor betterment of existing public roads and highway related facilities, such as maintenance yards, weigh stations and rest areas within right of way existing as of July 1, 1987, and contiguous public-owned property utilized to support the operation and maintenance of public roads and highways.

(k) Alteration, restoration or replacement of a lawfully established dwelling

(2) **Conditional Uses Permitted:**

(a) One single family dwelling customarily provided in conjunction with farm use, subject to provisions.

(b) One single family dwelling not provided in conjunction with farm use, subject to provisions.

(c) A farm help dwelling.

(d) A medical hardship dwelling.

(e) Primary processing of forest products.

(f) Public or private schools, including all buildings essential to the operation of a school, except that no such use may be authorized within three miles of an urban growth boundary, unless an exception is approved pursuant to ORS 197.732 and OAR chapter 660, division 4, and further that no such use may be authorized on high value farmland.

(g) Churches and cemeteries in conjunction with churches, except that no such use may be authorized within three miles of an urban growth boundary, unless an exception is approved pursuant to ORS 197.732 and OAR chapter 660, division 4, and further that no such use may be authorized on high value farmland.

(h) Utility facilities necessary for public service, excluding commercial utility facilities for the purpose of generating power for public use by sale and transmission towers over 200 feet in height. A facility is necessary if it must be situated in an A-C zone in order for the service to be provided.

(i) A replacement dwelling to be used in conjunction with farm use if the existing dwelling has been listed in a county inventory as historic property and is listed on the National Register of Historic Places.

(j) Processing, as defined by ORS 517.750, of aggregate into asphalt or Portland cement, except that asphalt production shall not be permitted within two miles of a producing vineyard of 40 acres or more which is planted as of the date that the application for asphalt production is filed.

(k) Farm stands.

(l) Facility for the processing of farm crops.

(3) **Additional Conditional Uses Permitted that are Subject to OAR 660**
-33-130(5):
(a) Propagation, cultivation, maintenance, and harvesting of aquatic species.
(b) Residential home as defined in ORS 197.675 in an existing dwelling.
(c) Commercial activities in conjunction with farm use.
(d) Home occupation.
(e) Dog kennels, except that such uses are prohibited on high value farmland.
(f) Operations for the production of geothermal resources as defined in ORS 522.005, and oil and gas as defined in ORS 520.005.
(g) Operations conducted for the mining, crushing or stockpiling of mineral, aggregate and other subsurface resources subject to ORS 215.298.
(h) Personal use airports and heliports, including associated hangars and maintenance and service facilities.
(i) Private parks, playgrounds, hunting and fishing preserves and campgrounds, except that such uses are prohibited on high value farmland.
(j) Parks and playgrounds
(k) Community centers owned by a governmental agency or nonprofit community organization and operated primarily by and for residents of the local rural community.
(L) Golf courses, except that such uses are prohibited on high value farmland.
(m) Transmission towers over 200 feet in height.
(n) Commercial utility facilities for the purpose of generating power for public use by sale. A power generation facility shall not preclude more than 12 acres of high value farmland or 20 acres of other land from commercial farm use unless an exception is approved pursuant to OAR chapter 660, division 4.
(o) A site for the disposal of solid waste approved by a city or county governing body and for which a permit has been granted by the Department of Environmental Quality under ORS 459.245, including the equipment, facilities, and buildings necessary for its operation, except that such uses are prohibited on high value farmland.
(p) Construction of additional passing and travel lanes requiring the acquisition of right of way, but not resulting in the creation of new land parcels.
(q) Reconstruction or modification of public roads and highways involving the removal or displacement of structures, but not resulting in the creation of new land parcels.
(r) Improvement of public roads and highway related facilities such as maintenance yards, weigh stations, and rest areas, where additional property or right of way is required, but not resulting in the creation of new land parcels.
(s) Propagation, cultivation, maintenance and harvesting of aquatic or insect species.
(t) Operations for the extraction and bottling of water.
(4) **Requirements for Conditional Uses Subject To OAR 660-33-130(5):** Approval of uses subject to the requirements of this subsection requires
findings that such uses:
(a) Will not force a significant change in accepted farm or forest practices on surrounding lands devoted to farm or forest use; and
(b) Will not significantly increase the cost of accepted farm or forest practices on lands devoted to farm or forest use.

Forest Lands: Forest lands represent nearly 90% of Lincoln County, and are its major resource. These are mainly held in large ownership patterns and covered by commercial stands of Douglas fir, true fir, hemlock, cedar, and spruce. Uses such as raising and harvesting of the forest crop and existing recreation facilities are primary. Secondary uses such as new recreation facilities, public and private utilities, and dwellings may be included by county review.

Timber Conservation Zone T-C
(1) Uses Permitted Outright:
(a) Forest operations or forest practices including, but not limited to, reforestation of forest land, road construction and maintenance, harvesting of a forest tree species, application of chemicals, and disposal of slash.
(b) Temporary on-site structures which are auxiliary to and used during the term of a particular forest operation. As used in this paragraph, "auxiliary" means a use or alteration of a structure or land which provides help or is directly associated with the conduct of a particular forest practice. An "auxiliary structure" is located on-site, temporary in nature, and is not designed to remain for the forest's entire growth cycle from planting to harvesting. An auxiliary use is removed when a particular forest practice has concluded.
(c) Physical alterations to the land auxiliary to forest practices, including but not limited to, those made for purposes of exploration, mining, commercial gravel extraction and processing, landfills, dams, reservoirs, road construction or recreational facilities.
(d) Uses to conserve soil, air and water quality and to provide for wildlife and fisheries resources.
(e) Farm use as defined in ORS 215.203.
(f) Local distribution lines, such as electric, telephone and natural gas, and accessory equipment, such as electric distribution transformers, poles, meter cabinets, terminal boxes, pedestals, or equipment which provides service hookups, including water service hookups.
(g) Temporary portable facility for the primary processing of forest products. The facility shall not be placed on a permanent foundation and shall be removed at the conclusion of the forest operation requiring its use.
(h) Temporary forest labor camps limited to the duration of the forest operation requiring the use.
(i) Exploration for, and production of, geothermal, gas, oil, and other associated hydrocarbons, including the placement and operation of
compressors, separators and other customary production equipment for an individual well adjacent to the well head as defined in ORS chapters 517 and 520.

(j) Caretaker residences for public parks and fish hatcheries.
(k) Private hunting and fishing operations without any accommodations.
(L) Exploration for mineral and aggregate resources as defined in ORS chapter 517.
(m) Towers and fire stations for forest fire protection.
(n) Widening of roads within existing rights-of-way in conformance with the transportation element of acknowledged comprehensive plans, including public road and highway projects as described in ORS 215.213(1)(L) through (o) and ORS 215.283(1)(k) through (n).
(o) Water intake facilities, canals and distribution lines for farm irrigation and ponds.
(p) Uninhabitable structures accessory to fish and wildlife enhancement.
(q) Alteration, restoration or replacement of a lawfully established dwelling

2) Conditional Uses Permitted:
(a) Permanent facility for the primary processing of forest products.
(b) Permanent logging equipment repair and storage.
(c) Log scaling and weigh stations.
(d) Disposal site for solid waste approved by the governing body of a city or county or both and for which the Department of Environmental Quality has granted a permit under ORS 459.245, together with equipment, facilities or buildings necessary for its operation.
(e) Parks and campgrounds.
(f) Mining and processing of oil, gas, or other subsurface resources, as defined in ORS chapter 520, and not otherwise permitted under paragraph (i) of subsection (1) of this section, such as compressors, separators and storage serving multiple wells, and mining and processing of aggregate and mineral resources as defined in ORS chapter 517.
(g) Television, microwave and radio communication facilities and transmission towers.
(h) Fire stations for rural fire protection.
(i) Utility facilities for the purpose of generating power. A power generation facility shall not preclude more than 10 acres from use as a commercial forest operation unless an exception is taken pursuant to OAR 660, Division 4;
(j) Aids to navigation and aviation.
(k) Water intake facilities, related treatment facilities, pumping stations, and distribution lines.
(L) Reservoirs and water impoundments.
(m) Firearms training facility.
(n) Cemeteries.
(o) Private seasonal accommodations for fee hunting operation, subject to provisions
(p) New electric transmission lines with right-of-way widths of up to 100 feet
as specified in ORS 772.210. New distribution lines, such as gas, oil and geothermal, with rights-of-way 50 feet wide or less in width.

(q) Temporary asphalt and concrete batch plants as accessory uses to specific highway projects.

(r) Home occupations.

(s) Medical hardship dwelling.

(t) Expansion of existing airports.

(u) Public road and highway projects as described in ORS 215.213(2)(p) through (r) and ORS 215.283(2)(p) through (r).

(v) Private accommodations for fishing occupied on a temporary basis, subject to provisions

(w) Forest management research and experimentation facilities as defined by ORS 526.215 or where accessory to forest operations.

(x) One single-family dwelling on a tract meeting certain qualifications

(y) Non-forest dwelling, subject to provisions

(z) One single family dwelling on a tract of 160 or more contiguous acres and located on a lawfully created lot or parcel or at least 200 acres in one ownership that are not contiguous but are within Lincoln County, Lane County, Benton County, Polk County or Tillamook County and are zoned for forest use.

(3) Limitations on Conditional Uses:

The Planning Director or Commission shall determine whether a use other than a dwelling authorized by subsection (2) of this section meets the following requirements. These requirements are designed to make the use compatible with forest operations and agriculture, and to conserve values found on forest lands:

(a) The proposed use will not force a significant change in, or significantly increase the cost of, accepted farming or forest practices on agriculture or forest lands;

(b) The proposed use will not significantly increase fire hazard, significantly increase fire suppression costs, or significantly increase risks to fire suppression personnel; and

(c) A written statement recorded with the deed or written contract with the county or its equivalent is obtained from the land owner which recognizes the rights of adjacent and nearby land owners to conduct forest operations consistent with the Forest Practices Act and paragraphs (e), (l), (r), (s) and (v) of subsection (2) of this section.

Dispersed Residential: Uses such as forestry, farming and rural residential subdivisions, and existing public recreation facilities, quarrying, sanitary land fills, government uses and similar uses may be included by County review.

Rural Residential Zone RR-1

(1) Uses Permitted Outright:
(a) One single-family dwelling unit.
(b) Farm and forest use.
(c) A recreational vehicle or other approved temporary housing to be used for dwelling purposes, during the construction of a single-family residential dwelling unit for which a building permit has been issued. The use shall not exceed a period of one year.
(d) Beachfront protective structures.

(2) **Conditional Uses Permitted:**
   (a) Cemetery.
   (b) Church, non-profit religious or philanthropic center.
   (c) Community center.
   (d) Day nursery, nursery school-kindergarten, day care center, or similar facility.
   (e) Governmental structure or use.
   (f) Home occupation.
   (g) Nursing home, retirement home or similar facility.
   (h) Golf course and ancillary uses, but excluding golf driving range, miniature golf course or similar facility.
   (i) Private school.
   (j) Public or private utility facility.
   (k) Radio or television transmitter or tower.
   (L) Transfer station.
   (m) Excavating, filling, dredging or wetland drainage.
   (n) Recreational vehicle on an individual lot.
   (o) Aquaculture facilities.
   (p) Mining.
   (q) Boarding of horses for profit.
   (r) Pilings, piers, docks, and similar in-water structures.
   (s) Heliports.
   (t) Recreational vehicle park.
   (u) Bed and Breakfast Inns.

### Rural Residential Zone RR-2

(1) **Use Permitted Outright:**
   (a) One single-family dwelling unit, including single-wide mobile home.
   (b) Farm and forest use.
   (c) A recreational vehicle or other approved temporary housing to be used for dwelling purposes, during the construction of a single-family residential dwelling unit for which a building permit has been issued. The use shall not exceed a period of one year.
   (d) Beachfront protective structures.

(2) **Conditional Uses Permitted:**
   (a) Cemetery.
   (b) Church, non-profit religious or philanthropic center.
(c) Community center.
(d) Day nursery, nursery school-kindergarten, day care center, or similar facility.
(e) Governmental structure or use.
(f) Home occupation.
(g) Nursing home, retirement home or similar facility.
(h) Golf course and ancillary uses, but excluding golf driving range, miniature golf course or similar facility.
(i) Private school.
(j) Public or private utility facility.
(k) Radio or television transmitter or tower.
(L) Recreational vehicle park.
(m) Transfer station.
(n) Excavating, filling, dredging or wetland drainage.
(o) Recreational vehicle on an individual lot.
(p) Aquaculture facilities.
(q) Mining.
(r) Boarding of horses for profit.
(s) Pilings, piers, docks, and similar in-water structures.
(t) Heliports.
(u) Bed and breakfast inns.

**Rural Residential Zone RR-5**

1. **Uses Permitted Outright:**
   (a) One single-family dwelling unit.
   (b) Farm and forest use.
   (c) A recreational vehicle or other approved temporary housing to be used for dwelling purposes, during the construction of a single-family residential dwelling unit for which a building permit has been issued. The use shall not exceed a period of one year.
   (d) Beachfront protective structures.
2. **Conditional Uses Permitted:**
   (a) Cemetery.
   (b) Church, non-profit religious or philanthropic center.
   (c) Community center.
   (d) Day nursery, nursery school-kindergarten, day care center, or similar facility.
   (e) Governmental structure or use.
   (f) Home occupation.
   (g) Nursing home, retirement home or similar facility.
   (h) Golf course and ancillary uses, but excluding golf driving range, miniature golf course or similar facility.
   (i) Private school.
   (j) Public or private utility facility.
(k) Radio or television transmitter or tower.
(L) Transfer station.
(m) Excavating, filling, dredging or wetland drainage.
(n) Recreational vehicle on an individual lot.
(o) Aquaculture facilities.
(p) Mining.
(q) Boarding of horses for profit.
(r) Pilings, piers, docks, and similar in-water structures.
(s) Heliports.
(t) Recreational vehicle park.
(u) Bed and Breakfast Inns.
Appendix 2
State-owned, privately-owned, and other-owned estuary tidelands in Lincoln County, Oregon.

Figure 1. Ownership in Salmon River estuary.
Figure 2. Ownership in Siletz Bay.
Figure 3. Ownership in Yaquina Bay.
Figure 4. Ownership in Alsea Bay.
Appendix 3
Water quality parameter samples

Table 1. The number of DEQ stations monitoring the parameters of interest, as well as the total number of samples taken and utilized for the study.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Stations</th>
<th>Total Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia as N</td>
<td>23</td>
<td>48</td>
</tr>
<tr>
<td>Dissolved orthophosphate as P</td>
<td>23</td>
<td>48</td>
</tr>
<tr>
<td>Fecal coliform</td>
<td>36</td>
<td>1404</td>
</tr>
<tr>
<td>Field dissolved oxygen</td>
<td>16</td>
<td>88</td>
</tr>
<tr>
<td>Nitrate/nitrite as N</td>
<td>23</td>
<td>48</td>
</tr>
<tr>
<td>% saturation field dissolved oxygen</td>
<td>16</td>
<td>88</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>23</td>
<td>48</td>
</tr>
</tbody>
</table>
Appendix 4
Pearson correlation tables

Table 2. Fecal coliform (CFU/100 mL) dry season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>-0.008</td>
<td>0.027</td>
<td>-0.051</td>
<td>-0.095</td>
<td>-0.263</td>
</tr>
<tr>
<td>Commercial</td>
<td>-0.016</td>
<td>0.002</td>
<td>-0.032</td>
<td>-0.103</td>
<td>-0.012</td>
</tr>
<tr>
<td>DMD(^1)</td>
<td>-0.082</td>
<td>0.063</td>
<td>-0.053</td>
<td>-0.158</td>
<td>-0.157</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.030</td>
<td>0.085</td>
<td>0.253</td>
<td>0.224</td>
<td>-0.075</td>
</tr>
<tr>
<td>Marine</td>
<td>-0.019</td>
<td>-0.032</td>
<td>0.001</td>
<td>-0.015</td>
<td>-0.071</td>
</tr>
<tr>
<td>Public</td>
<td>-0.070</td>
<td>0.210</td>
<td>0.283*</td>
<td>0.016</td>
<td>-0.054</td>
</tr>
<tr>
<td>Public Facilities</td>
<td><strong>0.360</strong></td>
<td><strong>0.301</strong></td>
<td>0.210</td>
<td>0.068</td>
<td>0.054</td>
</tr>
<tr>
<td>Resource</td>
<td>0.196</td>
<td>0.138</td>
<td>0.046</td>
<td>0.114</td>
<td>0.284*</td>
</tr>
<tr>
<td>Rural</td>
<td>-0.048</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, \(^1\) = dredged material disposal.

Table 3. Fecal coliform (CFU/100 mL) rainy season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>0.159</td>
<td>0.361*</td>
<td>0.451*</td>
<td>0.514*</td>
<td>0.420*</td>
</tr>
<tr>
<td>Commercial</td>
<td>-0.158</td>
<td>-0.146</td>
<td>-0.161</td>
<td>-0.123</td>
<td>-0.233</td>
</tr>
<tr>
<td>DMD(^1)</td>
<td>0.053</td>
<td>0.174</td>
<td>0.099</td>
<td>0.056</td>
<td>0.067</td>
</tr>
<tr>
<td>Industrial</td>
<td>-0.020</td>
<td>-0.019</td>
<td>0.088</td>
<td>0.169</td>
<td>0.364*</td>
</tr>
<tr>
<td>Marine</td>
<td>-0.207</td>
<td>-0.177</td>
<td>-0.173</td>
<td>-0.199</td>
<td>-0.059</td>
</tr>
<tr>
<td>Public</td>
<td>-0.211</td>
<td>-0.197</td>
<td>-0.102</td>
<td>0.122</td>
<td>0.424*</td>
</tr>
<tr>
<td>Public Facilities</td>
<td>-0.142</td>
<td>-0.214</td>
<td>-0.167</td>
<td>0.138</td>
<td>0.101</td>
</tr>
<tr>
<td>Resource</td>
<td>-0.087</td>
<td>-0.143</td>
<td>-0.228</td>
<td>-0.264*</td>
<td>-0.164</td>
</tr>
<tr>
<td>Rural</td>
<td>-0.036</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, \(^1\) = dredged material disposal.
Table 4. Ammonia as N (mg/L) dry season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>0.413*</td>
<td>0.527**</td>
<td>0.372*</td>
<td>0.167</td>
<td>0.145</td>
</tr>
<tr>
<td>Commercial</td>
<td>-0.065</td>
<td>0.177</td>
<td>-0.025</td>
<td>0.080</td>
<td></td>
</tr>
<tr>
<td>DMD¹</td>
<td></td>
<td>-0.108</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>-0.290</td>
<td>-0.269</td>
<td>-0.303</td>
<td>-0.188</td>
<td>-0.181</td>
</tr>
<tr>
<td>Marine</td>
<td>0.270</td>
<td>0.252</td>
<td>-0.011</td>
<td>-0.030</td>
<td>0.009</td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td>-0.171</td>
<td>-0.254</td>
<td>-0.274</td>
<td>0.038</td>
<td>-0.078</td>
</tr>
<tr>
<td>Residential</td>
<td>-0.111</td>
<td>-0.110</td>
<td>-0.092</td>
<td>-0.189</td>
<td>-0.294</td>
</tr>
<tr>
<td>Rural</td>
<td>0.128</td>
<td>0.038</td>
<td>0.028</td>
<td>-0.106</td>
<td>-0.134</td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, ¹ = dredged material disposal.

Table 5. Dissolved orthophosphate as P (mg/L) dry season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>0.016</td>
<td>0.318</td>
<td>0.511**</td>
<td>0.652**</td>
<td>0.692**</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.136</td>
<td>0.084</td>
<td>0.181</td>
<td>0.164</td>
<td></td>
</tr>
<tr>
<td>DMD¹</td>
<td>0.005</td>
<td>-0.147</td>
<td>-0.030</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>-0.020</td>
<td>0.077</td>
<td>0.113</td>
<td>0.139</td>
<td>0.195</td>
</tr>
<tr>
<td>Marine</td>
<td>-0.092</td>
<td>-0.005</td>
<td>-0.005</td>
<td>0.341</td>
<td>0.285</td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>-0.226</td>
<td>-0.111</td>
<td>0.032</td>
<td>0.030</td>
<td>0.365*</td>
</tr>
<tr>
<td>Resource</td>
<td>-0.519**</td>
<td>-0.555**</td>
<td>-0.640**</td>
<td>-0.734**</td>
<td>-0.710**</td>
</tr>
<tr>
<td>Rural</td>
<td>-0.385*</td>
<td>-0.413*</td>
<td>-0.339</td>
<td>-0.078</td>
<td>0.065</td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, ¹ = dredged material disposal.
Table 6. Field dissolved oxygen (mg/L) dry season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>-0.322</td>
<td>-0.397</td>
<td>-0.426</td>
<td>-0.470*</td>
<td>-0.406</td>
</tr>
<tr>
<td>Commercial</td>
<td>-0.050</td>
<td>-0.050</td>
<td>-0.234</td>
<td>-0.150</td>
<td></td>
</tr>
<tr>
<td>DMD&lt;sup&gt;1&lt;/sup&gt;</td>
<td>-0.362</td>
<td>-0.367</td>
<td>-0.367</td>
<td>-0.326</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td></td>
<td></td>
<td>-0.266</td>
<td>-0.411</td>
<td></td>
</tr>
<tr>
<td>Marine</td>
<td>0.048</td>
<td>-0.017</td>
<td>0.035</td>
<td>0.014</td>
<td>-0.191</td>
</tr>
<tr>
<td>Public Facilities</td>
<td>0.031</td>
<td></td>
<td>-0.306</td>
<td></td>
<td>0.349</td>
</tr>
<tr>
<td>Residential</td>
<td>0.104</td>
<td>0.272</td>
<td>0.408</td>
<td>0.587**</td>
<td>0.199</td>
</tr>
<tr>
<td>Resource</td>
<td>-0.121</td>
<td>-0.144</td>
<td>-0.056</td>
<td>0.224</td>
<td>0.308</td>
</tr>
<tr>
<td>Rural</td>
<td>-0.284</td>
<td>0.280</td>
<td>0.220</td>
<td>0.106</td>
<td>-0.282</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, <sup>1</sup> = dredged material disposal.

Table 7. Nitrate/nitrite as N (mg/L) dry season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>-0.88</td>
<td>0.093</td>
<td>0.253</td>
<td>0.229</td>
<td>0.136</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.301</td>
<td></td>
<td>0.131</td>
<td>-0.078</td>
<td></td>
</tr>
<tr>
<td>DMD&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td>-0.205</td>
<td></td>
<td>-0.120</td>
<td>-0.054</td>
</tr>
<tr>
<td>Industrial</td>
<td>-0.055</td>
<td>0.010</td>
<td>-0.002</td>
<td>0.037</td>
<td>0.005</td>
</tr>
<tr>
<td>Marine</td>
<td>0.047</td>
<td>0.191</td>
<td></td>
<td>-0.072</td>
<td>-0.253</td>
</tr>
<tr>
<td>Public Facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>-0.210</td>
<td>0.006</td>
<td>0.149</td>
<td>-0.213</td>
<td>-0.047</td>
</tr>
<tr>
<td>Resource</td>
<td>-0.207</td>
<td>-0.302</td>
<td>-0.293</td>
<td>-0.321</td>
<td>-0.266</td>
</tr>
<tr>
<td>Rural</td>
<td>-0.099</td>
<td>-0.044</td>
<td>-0.042</td>
<td>0.067</td>
<td>-0.078</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, <sup>1</sup> = dredged material disposal.
Table 8. Percent saturated field dissolved oxygen (%) dry season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>-0.267</td>
<td>-0.343</td>
<td>-0.550*</td>
<td>-0.509*</td>
<td>-0.377</td>
</tr>
<tr>
<td>Commercial</td>
<td>-0.084</td>
<td>-0.084</td>
<td>-0.151</td>
<td>-0.057</td>
<td></td>
</tr>
<tr>
<td>DMD$^1$</td>
<td>-0.190</td>
<td>-0.197</td>
<td>-0.193</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td></td>
<td>-0.199</td>
<td>-0.449*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine</td>
<td>0.195</td>
<td>0.106</td>
<td>0.150</td>
<td>0.106</td>
<td>-0.058</td>
</tr>
<tr>
<td>Public Facilities</td>
<td>0.006</td>
<td></td>
<td>-0.225</td>
<td>0.448*</td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>0.114</td>
<td>0.190</td>
<td>0.324</td>
<td>0.590*</td>
<td>0.246</td>
</tr>
<tr>
<td>Resource</td>
<td>0.061</td>
<td>0.067</td>
<td>0.149</td>
<td>0.374</td>
<td>0.399</td>
</tr>
<tr>
<td>Rural Residential</td>
<td>-0.132</td>
<td>0.252</td>
<td>0.207</td>
<td>0.117</td>
<td>-0.111</td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, $^1$ = dredged material disposal.

Table 9. Total suspended solids (mg/L) dry season.

<table>
<thead>
<tr>
<th>Land Zones</th>
<th>250m</th>
<th>500m</th>
<th>1000m</th>
<th>2000m</th>
<th>4000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>-0.014</td>
<td>0.151</td>
<td>0.356*</td>
<td>0.401*</td>
<td>0.355*</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.228</td>
<td></td>
<td>0.147</td>
<td>-0.073</td>
<td>0.110</td>
</tr>
<tr>
<td>DMD$^1$</td>
<td></td>
<td>-0.091</td>
<td>-0.141</td>
<td>-0.048</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>-0.161</td>
<td>-0.160</td>
<td>-0.178</td>
<td>-0.080</td>
<td>0.061</td>
</tr>
<tr>
<td>Marine</td>
<td>-0.040</td>
<td></td>
<td>-0.064</td>
<td>0.204</td>
<td>0.054</td>
</tr>
<tr>
<td>Public Facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>-0.195</td>
<td>-0.121</td>
<td>-0.177</td>
<td>-0.222</td>
<td>0.235</td>
</tr>
<tr>
<td>Resource</td>
<td>0.321</td>
<td>-0.288</td>
<td>-0.305</td>
<td>-0.423*</td>
<td>-0.506*</td>
</tr>
<tr>
<td>Rural Residential</td>
<td>-0.223</td>
<td>-0.154</td>
<td>-0.135</td>
<td>-0.140</td>
<td>-0.040</td>
</tr>
</tbody>
</table>

* significant at p < 0.1, ** significant at p < 0.05, $^1$ = dredged material disposal.
Appendix 5
Samples of: XY plots of water quality parameter values versus %age land use zone within varying buffers.