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Wetland Mitigation Replacement Ratios

Defining Equivalency

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Wetland Mitigation Replacement Ratios: Defining Equivalency

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Executive Summary

This report was developed to assist efforts by Washington State agencies and local governments developing policies and standards for wetlands protection. The report summarizes and evaluates scientific literature, an agency survey, and a recent field study on wetland mitigation replacement ratios necessary to offset wetland losses due to filling and other wetland impacts.

Scientific Literature Review

Washington's wetlands are varied and complex, ranging from estuarine wetlands along the coastal and Puget Sound shorelines, to freshwater wetlands associated with lakes and rivers, to isolated wetlands whose water source is rainwater or snowmelt. Wetlands protection efforts usually require that unavoidable and necessary wetland losses be offset by replacing these natural wetlands with substitute wetlands either created, restored, or enhanced at the site of the loss or in some other location. Wetland restoration, enhancement, or creation is required on an areal basis, the goal being the replacement of lost acreage and functions of the impacted wetland.

Wetland replacement ratios are a regulatory tool used to standardize the areal extent of replacement, and are expressed as a ratio of wetland area replaced to wetland area lost.
There is a growing body of literature and scientific consensus recommending ratios greater than 1:1 in order to ensure full replacement of wetlands. These recommendations stem from research that demonstrates a significant rate of failure in current wetland replacement projects as well as a loss of wetland function over the time it takes for a created wetland to represent a fully functioning ecosystem. Some investigators doubt that created systems can ever reach the functional equivalent of a natural system.

Investigators have used a variety of techniques to measure the success or failure of mitigation projects. These range from confirming that projects were completed according to plans, to achieving stated goals and objectives, to comparing functional equivalency through quantitative evaluations with natural control or reference sites.

These follow-up studies indicate that the average rate of compliance with permit conditions was 50%. Common problems include inadequate design; failure to implement the design; lack of proper supervision; site infestation by exotic species; grazing by geese or other animals; destruction by floods, erosion, fires, or other catastrophic events; failure to adequately maintain water levels; and failure to protect projects from on-site and off-site impacts such as sediments, toxics, and off-road vehicles.

Investigators have found that in spite of current efforts to replace wetlands, many replacement projects result in lost acreage, wetland types, and wetland functions. Field-verified acreage replacement rates were sometimes lower due to inaccurate calculations of created wetland area (including buffers or side slopes in the calculation) as well as unsuccessful projects. Investigators also found that wetland types were lost through mitigation that tends towards construction of more easily created types or those that are perceived more desirable. Creation of open water systems was most common and most successful.

Forested systems were not replicated at all. The creation of a wetland that is functionally equivalent to its natural counterpart has never been documented. In a California study, functional equivalency of a created salt marsh was 60% of its natural counterpart after 5 years. It is unknown whether it will ever reach an equivalent state. In a qualitative study of the ability of some Puget Sound mitigation sites to reach functional equivalency, no sites were successful within the period they had been established, usually less than 5 years.

Time is a significant factor in assessing wetland loss. Losses occur over the time it takes for a replacement wetland to represent a fully functioning ecosystem. No estimates have been offered of the time it takes to achieve functional equivalency beyond general assumptions that it takes years or decades, during which time, many generations of organisms may be lost. The length of time that it will take depends, in part, on the type of vegetation. It may be possible to create marsh vegetation in a few years, whereas, a forested wetland will take far longer to mature. Structural equivalency, however, is not the same as functional equivalency, which may never be attained.

A number of factors influenced the rate of success of mitigation projects. These included our technical information concerning wetland mitigation, the adequacy of project planning and implementation, the wetland type(s) and function(s) being replicated, the type of mitigation (i.e., restoration, creation, or enhancement), and time. Our inadequate technical expertise regarding Pacific Northwest wetlands has hampered our ability to compensate for unavoidable wetland impacts. Mitigation projects are still considered experimental and wetland systems are complex and poorly understood, increasing the risk of failure. The likelihood of successful mitigation can be improved if projects include better planning and implementation, including improved project design, monitoring, and construction oversite. Mitigation attempts have been more successful for some wetland types, including emergent and open water wetlands. Other types have been very difficult or impossible to replicate, such as mature forested or bog systems, or wetlands that serve as habitat for sensitive wildlife species. Of the three types of mitigation generally utilized to compensate for unavoidable wetland impacts, the likelihood of success for restoration efforts is greatest because the restored wetland can often benefit from reestablishment of the original hydrology, one of the most difficult wetland parameters to reproduce. Given sufficient time, more mitigation projects will stabilize, increase their species diversity through natural recruitment of new plant species, and increase their complexity with age via competitive interactions, thus providing more of the functional values associated with older, natural wetland systems.

<u>Regulatory Requirements</u>

Planned replacement of lost wetland acreage in the Pacific Northwest is improving, although most projects have not accounted for risk of failure or wetland losses over time. Recent plans provide nearly equivalent acreage replacement established within permit conditions. In previous years, planned acreage replacement averaged 75% of permitted losses.

A survey was conducted of regulatory requirements for compensatory mitigation ratios in 16 states, six Washington counties, and 28 Washington cities. Of the 16 states reviewed in the survey, ten had compensatory mitigation ratio requirements either adopted or under review. Of the six Washington counties, three had compensatory mitigation ratio requirements. Of the 28 Washington cities, 16 had compensatory mitigation ratio requirements. Compensatory mitigation ratios ranged from 1:1 to 6:1, depending upon wetland values, location of the mitigation site, and type of wetland habitat.

Most jurisdictions lacked information on the administrative effectiveness of their respective regulatory programs. With the possible exceptions of King County and the City of Bellevue, the local wetland regulatory programs reviewed in this study are still early in the developmental phase. King County is not yet prepared to evaluate the effectiveness of its Sensitive Areas Ordinance, adopted in September, 1990. Even jurisdictions that had reviewed their wetland regulatory programs had no solid information on the effectiveness of their compensatory mitigation ratios in replacing lost wetland functions and values. Only the state of Oregon believed that the 1:1 habitat replacement ratio generally required for impacts to estuarine systems had been effective.

Field Study

A field study of eight sites assessed the effectiveness of mitigation replacement ratios to compensate for permitted wetland losses in King and Snohomish counties. During the course of the study, design components affecting compensation success were identified and discussed.

The study indicated that most sites met the stated compensation goals because they were written so generally that only total failure to create a wetland area could be interpreted as failure. None of the goal statements provided a quantifiable method of determining success, which provided no means for an agency to require remediation or contingency actions to provide additional functional value. In general, all compensation areas were providing a variety of wetland functions and values. However, the level or amount of function varied significantly depending on the functions and values present within the pre-existing wetland communities, and on how well the compensation was designed.

The investigators determined that elements of design, implementation, and monitoring of compensation plans were the most critical components of successful compensation. Beyond the design and follow-up of the compensation plans, the other most significant factor was time. Time may allow all of these systems to stabilize, to increase their species diversity, to increase their spatial complexity with age and natural attrition, and to provide more of the functional values associated with older natural wetland systems.

In conclusion, current mitigation practices are not satisfying goals that require no-net-loss of wetlands, maintenance of aquatic systems, or protection from adverse impacts. Replacement ratios of 2:1 or greater are necessary to compensate for our current rate of failure to achieve permit compliance or basic wetland community structural objectives within attempted mitigation projects, neither of which are accurate measures of functional equivalency. Some wetland habitats and some functions may not be replicated at all, including mature forested swamps, bogs, and threatened and endangered species habitat. It takes time for community structure to mature and for a wetland to achieve functional equivalency. Variable ratios based on vegetative type are an appropriate method to account for a portion of this time element.

There are no expressed formulas for calculating acreage replacement ratios based on evaluations to date. The extent to which adopted replacement ratios incorporate risk of failure, probability of success, and time factors is a policy decision that should be conservatively rendered, given the experiences with wetland mitigation thus far. The level of risk of mitigation failure depends on the standard of success. If the standard is to comply with permit conditions (i.e., to implement the project elements correctly and provide structural equivalency), the risk may be 50% or more. If the standard is to create a functionally equivalent wetland, the risk is far greater.

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Preface

Three significant developments relating to wetlands protection in Washington State occurred in 1990 and 1991. The first was the state legislature's adoption of the 1990 Growth Management Act that requires local governments to protect critical areas including wetlands. The second was Governor Booth Gardner's issuance of an Executive Order for wetlands protection. The third was a revision to the 1991 Puget Sound Water Quality Management Plan that recommends that local governments in the Puget Sound Basin adopt comprehensive wetlands protection programs to achieve a goal of no-net-loss of wetlands functions and values and a long term increase in wetland quantity and quality.

Washington's Growth Management Act was adopted by the state legislature in the final days of the 1990 legislative session. The provisions of the 1990 statute, as well as amendments adopted in 1991, require local governments throughout the state to identify and protect critical areas including wetlands. Interim development regulations are to be adopted by all jurisdictions no later than March 1992. Final development regulations are to be completed by 1994. Those local governments who have not already adopted regulations for critical area protection are now in various stages of developing their ordinances assisted by the Department of Community Development.

On April 21, 1990, Washington's Governor Booth Gardner issued Executive Order (EO) 90-04, Protection of Wetlands. The EO is directed at both state and local governments with specific requirements for state agencies and recommendations for local governments. All state agencies are required to protect wetlands under existing authorities to the extent legally permissible. Following a task in the EO, the Department of Ecology developed a model wetlands protection ordinance to provide guidance to local governments. The model ordinance was released in September 1990 and will be amended in the future to incorporate new information.

In the summer of 1991, the Puget Sound Water Quality Authority modified the wetlands protection element (W-4.1) of the 1991 Puget Sound Water Quality Management Plan. The modified element recommends local adoption of a comprehensive approach to wetlands protection using both regulatory and non-regulatory tools. The comprehensive approach is intended to complement the provisions of the Growth Management Act. The Plan amendments recommend that local development regulations address several elements, including wetlands mitigation. The amendments refer to Ecology's model ordinance for technical guidance on wetlands protection standards.

Each of these three actions has brought into focus the need for technical information upon which to base wetlands protection policies and standards. During the development of wetlands protection policies and regulations, information is sought on both the scientific basis for wetlands protection standards and on the actions of other regulatory decision-makers.

I. Introduction

This report was developed to assist efforts by the Washington State Department of Ecology (Ecology), other Washington State agencies, and local governments to develop policies and standards for wetlands protection within existing authorities. Specifically, the report summarizes and assesses information on wetlands mitigation in an effort to learn more about replacement ratios[1] necessary to offset losses in wetlands acreage and function due to filling and other wetland impacts. Information is provided from literature sources and agency surveys.

The report is organized into four sections accompanied by an executive summary, references, and appendices. The sections include:

- introductory information;
- a review of the existing literature;
- the results of an agency survey of existing regulatory requirements for mitigation acreage replacement ratios; and
- conclusions drawn from the literature review and agency survey.

Appendix A presents the results of a field study that provides a post-construction evaluation of the effectiveness of replacement ratios as a regulatory standard to compensate for permitted wetland losses. Several mitigation projects in King and Snohomish counties were assessed to determine if project designs were implemented, if they were successful over time, and which critical components most significantly affected success.

A companion document entitled <u>Wetland Mitigation Replacement Ratios: An Annotated Bibliography</u> is also available.

[1] "Replacement ratios" are numeric expressions of the wetland area replaced through restoration, creation, or enhancement to wetland area lost. For example, a ratio of 2:1 means that two wetland units (typically acres) must be restored, enhanced or created for each one unit of wetland altered or destroyed.

II. Scientific Literature review

Introduction

The scientific literature review is a compilation and analysis of the findings of a literature search for information on wetlands restoration, creation, or enhancement efforts undertaken to offset unavoidable wetland losses. The purpose of this review is to provide information on the rationale for standards governing the areal extent of wetland replacement necessary to offset permitted wetland losses.

Information was obtained from a review of published literature as well as from oral and written personal communications. Sources of information included computer search programs, on-line library collections, existing bibliographies, research centers, federal and state agencies, county and city planning departments, professional organizations, environmental organizations, and individuals. A specific list of information sources for this section is listed in Appendix B.

The review provides background information and discusses factors used in developing acreage replacement ratios, data on mitigation effectiveness, factors that influence success, and acreage replacement ratio recommendations from various authors.

Background

Wetlands have received increased attention in Washington State as a result of continuing wetland losses and the growing awareness that wetlands have many important functions and values. Estimates suggest that up to 50% of the state's wetlands have been lost, with localized losses in the urban areas up to 98% (Canning and Stevens, 1989). Wetland functions vary from site to site but may include fish and wildlife habitat, flood control, shoreline and riverbank stabilization, sediment and pollution control, surface water supply, aquifer recharge, and education and recreation opportunities.

Washington's Wetlands

Wetlands are important ecosystems that exhibit a unique combination of water-tolerant vegetation, hydric soils, and sufficient water to maintain hydrophytic vegetation and saturated soils. Washington's wetlands are varied and complex. They range from estuarine wetlands along coastal and Puget Sound shorelines, to freshwater wetlands associated with lakes, rivers, and other shorelines, to isolated wetlands whose water source is rainwater or snowmelt. Wetland types include bogs and fens that are nutrient poor, very sensitive to small changes in water quality and quantity, and form over a period of thousands of years (one inch of peat formed in 40 years in western Washington and one inch in 100 years in eastern Washington). Vernal ponds and playas form in the spring, provide important habitat for waterfowl and migratory birds, and dry up in the summer. Riparian systems are dynamic systems that rely on extreme flood events to maintain ecological dynamics. Surge plain wetlands form near the mouths of rivers flowing into tidal water and are formed by the backwater effect caused by freshwater flowing into high tidal waters. Tidal channels in surge plain wetlands form a convoluted micro-topography that is maintained by consistent flooding and tidal changes (Canning and Stevens, 1989). Some emergent marshes in urbanizing areas are more recent additions to the landscape, forming or expanding due to impermeable soil conditions and increased stormwater runoff. These are just a few examples of the various wetlands found in Washington.

Several factors influence wetland plant community structure. Climate, soils, elevation, aspect, fire history, human activities, and animal activities all act to influence plant communities. In wetland plant communities, the water source, frequency, and duration of inundation act together to significantly influence soil chemistry and pH, the stability or dynamics of the plant community over time, and plant species composition. The presence and abundance of a plant species in a particular wetland depends on its life history and adaptation to its local environment (Canning and Stevens, 1989).

Wetlands Protection

Wetlands protection efforts in Washington are occurring at the federal, state, and local levels and are driven by a variety of adopted policies. The goal of the federal Clean Water Act is to restore and maintain existing aquatic resources. A 1990 Memorandum of Agreement signed by the Environmental Protection Agency and the U.S. Army Corps of Engineers (U.S. Army Corps/EPA, 1990) endorses a national goal of no-net-loss of wetlands acreage and function that was first recommended by the National Wetlands Policy Forum in 1989. The state's Shoreline Management Act is designed to minimize damage to the ecology and environment of shoreline areas. The purpose of the state's Hydraulic Code is to protect fish life and fish habitat. The Puget Sound Water Quality Authority has adopted the no-net-loss goal into the Wetlands Protection Element of their management plan. The state's recent Growth Management Act establishes a number of planning goals for local governments, among them to protect the environment and enhance the state's quality of life.

In order to attain policies and goals that require that aquatic systems be "maintained", or that programs result in "no-net-loss," or that wetlands be "protected," it has become common practice to offset permitted wetlands losses and impacts by replacing natural wetlands with substitute wetlands. Commonly termed "mitigation," "compensatory mitigation" or "replacement mitigation," wetlands replacement is actually the final step in the sequence of mitigation actions defined by the Council on Environmental Quality (40 CFR 1508.20) and adopted in the implementing rules for Washington's State Environmental Policy Act. This step requires, as a part of the mitigation process, compensation for impacts by replacing or providing substitute resources or environments. For this report, "mitigation" is used to refer to the creation, restoration or enhancement of wetlands to offset unavoidable wetland impacts.

Replacement Ratios

An important issue in setting standards for mitigation is the amount of created, restored, or enhanced wetland that a permittee should be required to provide in order to ensure that wetland losses are adequately compensated. The required amount of mitigation is frequently established as a ratio of wetland area replaced to wetland area lost, and is termed "replacement ratio".

At first glance, the development of replacement ratios appears to be a relatively simple task: determine the number of acres of wetland being lost, and replace an equivalent number of acres using a 1:1 ratio. Wetland losses, however, are not measured merely in terms of acreage, but in terms of function, type, location, and time (Kusler, 1989). Scientists suggest that it takes a great deal of time for a created wetland to represent a fully functioning ecosystem and that these time losses should be reflected in replacement ratios. Many have remarked that risks and probability of success should also be included as a factor because unsuccessful projects lead to further wetland losses (Kruczynski, 1990b; Kusler and Kentula, 1990; Josselyn, 1990; Bill, 1991). Eliot (1985) felt that the determination of replacement ratios depends on:

- the lag time for complete habitat replacement;
- determination of a critical size to replace habitat;
- feasibility of fully restoring habitat; and
- the difficulty of predicting success of a given project.

In order to determine the extent that these factors should result in replacement ratios that exceed 1:1, it is helpful to understand the success or failure of mitigation projects to date and factors that influence success. Time is an element of both of these discussions.

Mitigation Effectiveness

Several researchers have reviewed mitigation projects in order to evaluate the success of projects to date, however, their evaluation techniques differ greatly. Various measures of success have been used, including compliance with permit conditions, replacing equivalent acreage, establishing vegetative communities or wetland types, and recreating wetland functions. Some measurements were qualitative and some were quantitative. Some evaluations were performed using the lost wetland as a reference and others used existing natural controls ("reference" wetlands). Many did not use references at all. The age of the evaluated projects varied, but most were less than five years old and only provide information on short-term success.

General

Follow-up studies of mitigation indicate that about half of the projects failed in one or more respects (Kusler, 1987). Common problems include inadequate design; failure to implement the design; lack of proper supervision; site infestation by exotic species; grazing by geese or other animals; destruction by floods, erosion, fires, or other catastrophic events; failure to adequately maintain water levels; and failure to protect projects from on-site and off-site impacts such as sediments, toxics, and off-road vehicles (Kusler and Kentula, 1990). Miller (1987), in her assessment of Pacific Northwest mitigation projects, cited some common reasons for failure as improper final grade, non-native plant species substituted for native species, improper planting techniques, inadequate water levels, human impacts, and wildlife predation.

Compliance

Many post-project evaluations of mitigation effectiveness have used compliance with permit conditions as a measure of success. Compliance measures were varied, including initiation of the project according to schedule, achieving the stated purpose according to permits, complying with design requirements, and replacing target vegetation.

In a study of 20 mitigation sites in western Washington, Bill (1991) found compliance problems at 50% of the sites that were completed. These problems included substitution of other plants for required species; inadequate density or location of plantings; inadequate construction of slopes, acreage, or structure; insufficient hydrology; and improper timing of the completion.

Sheldon and Dole (Appendix A, this report) evaluated eight mitigation sites in King and Snohomish counties in Washington. Sites were evaluated only if the mitigation had been constructed (i.e., initiation of the project was not used as a measure of success). The investigators found that most were implemented as planned with minor exceptions. Ornamental landscaping species were substituted for some native species at two sites, and planting density requirements were not met at one site. All had some wetland characteristics and functions, which was attributed to the proximity of all sites to existing or former wetlands. Most met their goals because the goals were general and sometimes vague, but they provided very limited "community functions" except those provided by the presence of the pre-existing wetland community. The limited success in replicating natural wetland communities was due to inappropriate design and implementation factors including soils, grading, water source, planting densities, and maintenance.

Baker (1984) examined ten projects in the San Francisco Bay area. Eight of those projects required some form of active restoration work, and only five of the eight had been fully implemented as required, even though four to five years had passed. Only two of these had good results and appeared to be meeting objectives. One additional site was partially successful and two sites were judged as failures. Baker felt that the consequences were not as disastrous as they appeared, since noncompliance was more common for small projects than for large projects.

Demgen (1988) examined 18 mitigation projects in the San Francisco Bay area and field-checked the sites for biological, physical, and hydrologic conditions. Success was defined as completing permit requirements of the mitigation projects. Thirty-three percent were judged to be fully successful and an additional 50% were judged partially successful (i.e. a majority of the permit requirements were met).

Gwin and Kentula (1990) evaluated freshwater mitigation sites in Oregon to determine if mitigation projects were in compliance with permit conditions, verify that wetlands were created according to their construction plans, and evaluate the design of those projects. They found that none of the wetlands were designed or constructed as permitted. In their evaluation of established vegetation, they found that 96% of the species on the created wetlands were volunteers while less than 4% were species found on the planting lists. They suggested that either planting did not take place, or that environmental conditions were not correct to ensure persistence.

Also monitoring wetland mitigation in Oregon, Shaich (1989) performed compliance inspections on 53 wetland project sites in Oregon permitted under Oregon's Removal-Fill Law. He found that 28 of the projects (almost 53%) had compliance problems. The most common problem was lack of the required vegetation. As with Gwin and Kentula, Shaich could not assess whether this was due to non-compliance or poor planting success. Other problems included improper grading, no required fencing, use by off-road vehicles, no hydrology, and problems with water control structures. Shaich felt that the findings should be applied cautiously because projects were selected with a bias towards larger projects that may have more problems due to size and complexity.

A common concern among evaluators who have used permit provisions as a reference for success is that mitigation plans have rarely contained enough information to perform an adequate and quantifiable evaluation of success (Eliot, 1985; Sheldon and Dole, [Appendix A, this report]).

Equivalent acreage

The extent of acreage replacement resulting from mitigation projects has been evaluated by several authors. While not used independently as a measure of success, acreage replacement is one of the measures of wetlands loss (or gain) that is more easily quantified.

Several studies in Washington indicate that for most of the last decade, acreage replacement required through the Section 404 permit process within project designs and permit requirements alone (i.e. independent of field verification of "success") resulted in a loss of wetland acreage. Kunz et al. (1988), in reviewing mitigation in Washington State required through Section 404 permits, found a planned replacement ratio of only 67% for the years 1980 to 1986. Updated information for these years indicated a ratio of 75% (Rylko and Storm, 1991). Rylko and Storm studied Seattle District Corps information and found that for the years between 1980 and 1990, only 1986, 1987 and 1989 realized an increase in the annual planned compensation acreage over the corresponding acreage lost. The average planned compensation from these three years resulted in acreage replacement of 107%. Bill (1991) evaluated mitigation sites required through SEPA in western Washington. She found an average 84% planned acreage replacement and suggested that this figure is a high representation of actual replacement of functioning wetland acreage.

Wetland losses have been found in field verification of permit requirements. In Oregon, Gwin and Kentula (1990) found that created wetlands were an average of 29% smaller than site plans had depicted. They attributed this difference to acreage calculations that did not differentiate between the wetland and the property boundary, and that included the areas of the upland side slopes and the transitional zone of created wetlands.

Baker's (1984) evaluation of projects in San Francisco Bay found that mitigation acreage replacement resulted in equal or greater acreage being created, ranging from 1:1 to 2:1 replacement. He also found that while acreage may have been maintained or increased, the emerging trend was for a disparity between the types of wetlands created and those that were lost.

Other evaluators found insufficient information in the project design or permit to assess the gains or losses in wetland acreage (Shaich, 1989; Sheldon and Dole, [Appendix A, this report]).

Wetland types

Replacement of specific wetland types is usually a stated objective in mitigation requirements. While not a precise measure of equivalency, it is important to restore lost habitat values (Kusler, 1987). This is particularly crucial in viewing the cumulative effects of compensation projects within a region over time. It is also important to note that many scientists feel that the replacement of some wetland types may be impossible (Hollands, 1990). This is particularly true for rare or complex habitat types (e.g., certain forested wetlands, bogs, fens).

In their evaluation of mitigation sites in King and Snohomish counties, Sheldon and Dole (Appendix A, this report) reviewed the success of replicating three wetland community types: emergent, scrub-shrub and forested. They found that:

> "although emergent communities were often present, they were too often severely limited in their extent and complexity, due to the limitations of the considerations during site design. Functional shrub communities were not found within many of the compensation sites, except where the presence of volunteer red alder and willow had filled amongst the planted specimens to provide the dense 'brushy' aspect found in more natural wetland communities.
>
> Forested communities did not exist in any of the compensation areas. In one site, where large cottonwood trees had been transplanted along a riparian corridor, the trees were surviving; however, no element of 'forest' was yet present. Tree plantings were provided in many sites; given the relative age of the sites, it is not possible for any forest functional element to have been created."

The open water components of the applicable projects were successful.

Most research demonstrates a trend towards an exchange of one wetland type for another, usually more "desirable" or easily created wetland type, representing a loss of wetland diversity. For example, Kunz et al. (1988) found that during a six-year period of mitigation projects in Washington, 2.1 habitat types were lost per project, while only 1.4 habitat types were restored through mitigation. They reported a tendency to try to create those wetlands that are more aesthetically pleasing (e.g., open water wetlands) or more acceptable to other special interests such as commercial and recreational fisheries, rather than replacing habitat for non-commercial wildlife. They also found that forested wetlands were not replicated at all. Bill (1991) found an increase in some wetland types and a decrease in others. Planned mitigation resulted in a 325% increase in palustrine open water wetlands and a 64% decrease in palustrine emergent wetlands. The planned open water wetlands were mostly small ponds created for stormwater detention or as visual amenities for the projects. She concluded that mitigation is generally planned to satisfy the needs of the developer. Eliot (1985) found that 45% of the 58 mitigation sites she reviewed in San Francisco Bay were cases where the mitigation habitat goals were different from the project habitat losses. Rylko and Storm (1991) found a planned replacement in the number of habitat types of 73% from 1980 through 1987, representing a net loss of diversity. From

1988 to 1990, this figure improved to a 97% planned replacement. The authors attribute the progress to the increased emphasis placed by agencies on replacing wetland function as well as acreage.

In a study of the creation and restoration of seagrass systems by Fonseca (1990) transplant survival reduced the real replacement ratio. Based upon a desired replacement ratio of greater than 1:1 and the available, suitable compensation sites, this resulted in a project-specific ratio of a 2.17:1 replacement. However, monitoring the survival of transplanted areas revealed that this 2.17:1 replacement effected only a 1.09:1 real replacement, after an approximately 50% survival in the restored community.

Wetland functions

How well do created wetlands replace the ecological functions of the wetlands that were destroyed? Answering this question is more complex than measuring compliance, acreage replacement, or habitat type replacement. We still know relatively little about wetland ecosystems, and methods for assessing wetland functions have not been standardized, especially in the Pacific Northwest. Mitigation plans are not consistent in providing baseline data on wetlands to be impacted or adequate monitoring to demonstrate functional replacement.

In their assessment of Section 404 permits authorized from 1980 to 1990, Rylko and Storm (1991) found that not all wetland functions were equally proposed for replacement. On a percentage basis, food chain support, flood storage, and fish habitat were most frequently targeted for replacement. Although substantial improvement was evident from 1987 to 1990, wildlife habitat was still not fully replaced.

Using functional and "perceptional" measures of success, a team in coastal California found about 65% of 120 restoration projects functioned like similar natural wetlands and were perceived as successful by local agency staff or wetland scientists (Zentner, 1988). Functional measurements included wildlife censuses and Wetland Evaluation Technique (Adamus and Stockwell, 1983) measurements over a three year period.

Sheldon and Dole (Appendix A, this report) used qualitative measures of "functional equivalency" in their study of King and Snohomish County mitigation projects. A project met the goal of functional equivalency if the target communities provided the same or better level of functional value as the pre-existing wetland on-site for five functions: stormwater attenuation, water quality, groundwater effects, aesthetics, and wildlife habitat. Where the pre-existing site was significantly degraded, equivalency was determined using a standard reference community. They found that, in general, all of the sites were providing some wetland functions. The level or amount of function varied significantly, depending on the functions present within the pre-existing wetland communities and on how well the compensation was designed. There was little success in replicating fully-functioning wetland communities that provided equivalent functions to established wetland communities within the one to six year age of the projects.

Zedler testified before the Domestic Policy Council Wetlands Task Force in 1990, characterizing her findings of a study conducted to assess the functions of an enhanced salt marsh in San Diego Bay compared to a natural reference salt marsh (Zedler and Langis, 1990). Using an index of functional equivalency developed for this project, the enhanced salt marsh resulted in less than 60% equivalency after five years. For five years, the marsh failed to replace the functions of the development site and it was unknown whether it will ever reach functional equivalency. Zedler pointed out that functions were also lost at the wetland enhancement site, where a high marsh was graded to a low marsh to attract the endangered light-footed clapper rail. As yet, the clapper-rail has not been attracted to the site.

There have been no successful transplants of wetland fauna to new restoration sites, although it has been attempted with the salt marsh harvest mouse in the San Francisco Bay and with rare beetles in the Tijuana Estuary. Resident species with restricted ranges are unlikely to become re-established in new locations, especially where development separates the various wetland habitats (Josselyn et. al., 1990).

Time factors

Time is an important element in assessing the effectiveness of mitigation in offsetting permitted losses. Time losses occur during the period it takes to complete construction of the mitigation site as well as the time it takes for the created site to behave like a natural wetland.

Those who reviewed time losses during implementation of the project found that nearly all projects resulted in at least temporary wetland losses. Kunz et al. (1988) found that time lags between project initiation and mitigation completion resulted in a loss of one to three growing seasons per project. Bill (1991) found that only 10% of the sites were completed before construction and subsequent elimination of the original wetlands. Eliot (1985) found that only 56% had been completed by the permit deadline and felt that noncompliance with permit conditions formed a weak link in the permit process. She commented that this was aggravated by the fact that regulatory staff are frequently overburdened.

A considerably greater but usually unknown amount of time passes before created wetlands assume the structure and function of the lost wetlands. Golet (1986) suggested that it might take "several decades" for functional equivalency to be reached in created wetlands. Demgen (1988) has pointed out that "there are many generations of organisms that are lost during the establishment phase of a mitigation project." Race and Christie (1982) echo this concern, noting that the creation of "a newly restored or created marsh is not the functional equivalent of a thousand-year-old marsh."

The length of time required for a created wetland to assume the desired vegetative structure depends, in part, on the type of vegetation. It may be possible to restore or re-create marsh vegetation in a few years, whereas forested wetland may take far longer (Kusler, 1987; Kunz et al., 1988). In Demgen's 1988 study of mitigation projects in San Francisco Bay, she found that some of the projects yielded the desired marsh rapidly (one to two years); others took longer (seven to ten years).

While successful vegetation establishment ensures that created wetlands resemble the originals, the long term hydrology, soils, and species use may be quite different (Kusler, 1987). Zedler and Langis' 1990 study demonstrated that combined measures of soil, vegetation and epibenthos indicated less than 60% equivalency to a natural reference wetland in five years. D'Avanzo's 1990 review of studies on sediment characteristics of created wetlands compared to natural controls cited work done by Cammen et al. (1976). Cammen et al. estimated that organic content of soils in created projects would reach reference concentrations in four to 26 years. Similarly, Craft et al. (1988) concluded that organic matter pools develop in 15 to 30 years but development of soil carbon, nitrogen, and phosphorus pools take much longer.

Factors That Influence Success

Many researchers have offered conclusions about various factors that influence the rate of success of current and future mitigation projects. They can generally be described in five categories. These include:

- technical and scientific information;
- project planning and implementation;
- wetland type;
- wetland functions;
- type of mitigation; and
- time.

Technical and scientific information

Creating a new wetland or restoring an historic wetland entails providing the proper shape, slopes, substrate level and type, supplying an appropriate hydrologic regime, and establishing vegetative communities (Gwin and Kentula, 1990; Kusler, 1987), all of which involve attempting to replicate systems that may have evolved over hundreds of years. The intricacy of these factors introduces considerable risk of failure. Most scientists agree, in fact, that naturally occurring wetlands cannot be duplicated or replicated exactly because of the complexity of natural systems (Kusler, 1987; Zedler and Weller, 1990).

Many researchers characterize wetland mitigation as "experimental" (Zedler, 1984; Rylko and Kentula, 1991; Bill, 1991). Miller (1987) commented that each mitigation project is altered according to the successes and failures of preceding projects. D'Avanzo (1990) noted, however, the difficulty of generalizing information about one wetland to other locales and habitats because of their complexity and sensitivity to variations in hydrologic regime.

The inadequacy of our scientific understanding about wetlands and wetland mitigation hampers our ability to successfully mitigate for wetland losses. Kusler and Kentula draw several conclusions about our science base in their executive summary of the 1990 document entitled, Wetland Creation and Restoration: The Status of the Science. First, practical experience and the science base on restoration and creation are limited for most types and vary regionally. Fewer projects have been implemented on the Pacific coast; thus there is a small literature base. Kentula's 1986 search of data bases for publications on the creation and restoration of wetlands located 277 items, of which nine apply to the Pacific Northwest (In Miller, 1987). None of these dealt with small freshwater wetlands. Second, most wetland mitigation projects do not have specified goals, complicating efforts to evaluate success and learn from those projects. Finally, monitoring of mitigation projects has been uncommon so that the potential information gained for future projects is lost.

Project planning and implementation

Most scientists recognize that the likelihood of successful mitigation could be improved if projects included better planning and implementation. Slocum (1987) concluded that 86% of the permits were successful when they contain specific conditions for mitigation, whereas only 44% without specific conditions could be considered so. Miller (1987) suggested that the level of success for mitigation projects is greater when there are detailed plans, biologists involved with construction and planting, and a monitoring plan and a contingency plan to modify the design if it is not successful. Kusler and Kentula (1990) agreed, stressing that experts with hydrologic, biological, botanical and engineering backgrounds as well as previous experience were highly desirable. They also felt that careful supervision of design implementation was important. Sheldon and Dole (Appendix A, this report), concluded that design, implementation, and monitoring of compensation plans are the most critical components in successful compensation functioning. Design considerations include: the analysis of soils, grading contours, water source and hydroperiod, and detailed landscaping plans including appropriate native species, planting densities, species groupings, and size of planting zones.

Josselyn et al. (1990) in reviewing evaluations by several authors of mitigation projects to date, summarized their recommendations for future projects as follows:

- detail on the habitat to be created with specific design objectives and features;
- more precise habitat evaluation of the development site versus the proposed mitigation site;
- improved monitoring;
- construction prior to or concurrently with project development to reduce non- compliance; and
- a uniform database for recording proposals.

Wetland type

Mitigation attempts have been more successful for some types of wetlands than others.
Most documented successful wetland compensation projects are those which mitigated impacts to emergent and open water wetlands (Quammen, 1986). This is because elevations are less critical than in forested or shrub wetlands, native seed stocks are often present, natural revegetation often occurs, and marsh vegetation quickly reaches maturity (Kusler and Kentula, 1990). Documented successful compensation for forested wetlands or bogs is rare (Golet, 1986; Walker, 1986; Kusler and Kentula, 1990; Carothers et al.; 1990), and some scientists feel that it may be virtually impossible to create functionally equivalent wetlands for these types (Zedler and Weller, 1990). Poor success for forested wetlands is partly due to their sensitive long term hydrologic requirements and because they reach maturity slowly (Kusler and Kentula, 1990).

Creating wetlands of the same type increases the probability of mitigation success because the original wetland can serve to guide the replacement effort and because it reduces the loss of habitat types (Kusler 1987). However, compensation off-site or out-of-kind is sometimes beneficial, particularly when viewing the cumulative impact of wetland loss on a landscape level. Mitigation may be occurring for permitted losses of highly degraded wetlands (e.g., emergent wetlands full of invasive non-native species) that could be improved by out-of-kind replacement. In these instances, relatively common wetland types could be replaced with less common types (Quammen, 1986). On a regional or watershed level, permitting authorities may view some compensation projects within this larger picture of wetland impacts in the context of cumulative impacts of development: past, present, and future (Good, 1987).

Gosselink and Lee (1986) also point out the importance of viewing the various ecological processes (functions, values) of wetlands within the entire watershed or landscape. They use the analogy of viewing the diminishing wetlands within the landscape as one would view an ancient mosaic mural from which many of the tiles have disappeared. In order to recreate the picture, it is important to give priority to the type and placement of tiles that will best restore the essence of the mural. In viewing watershed restoration in this manner, the important lessons are: (1) individual tiles are not as important as the pattern of tiles; and (2) pre-planning is necessary to conserve the pattern. This landscape approach to management of cumulative effects is outlined by Décamps et al. (1990) who, in reference to their work on land/water ecotones, recommend a three-point approach concentrating on: (1) ecotone functions (ie., edge effects, community composition, hydrologic and nutrient regimes); (2) relationships between ecotones and adjacent systems; and 3) management and human investment.

Wetland functions

Two elements related to replacing wetland functions are important to consider in a discussion of factors that influence success. One is that lost wetland functions are difficult to quantify; therefore, they are difficult to accurately reproduce. Another is that some functions are difficult to successfully replicate.

Efforts have been made to quantify wetland values for wetland inventories and to determine lost values for compensation and restoration projects. Snyder (1986), in an attempt to fine-tune a coastal restoration project, modeled the biotic and mechanical aspects of wetland systems to examine stresses to the systems and productivity responses. The purpose of this modeling was to go "beyond functional replacement or acreage calculations" in wetland mitigation. Other methods have also been developed for wetland and habitat value assessment, including the Wetland Evaluation Technique (WET) (Adamus et al., 1987) and the Habitat Evaluation Procedure (HEP).

Of the habitat value assessment techniques, WET is perhaps the most widely utilized method of evaluating wetland functions and values. The objectives of WET are to: (1) assess most of the recognized wetland functions and values; (2) apply over a wide variety of wetland types; (3) be reproducible and rapid (typically one day per wetland); and (4) be founded upon a sound technical basis in the scientific literature (Adamus et al. 1987). This method was designed to assess wetland habitat from a broad perspective.

WET lacks regional specificity, and is best calibrated for coastal and estuarine wetlands of the Gulf States. This limits its applicability, for example, to freshwater wetlands in Washington. Despite WET's popularity, some scientists have expressed reservations regarding its use. These reservations are based upon WET's inherent subjectivity. Because much of the data used for WET is subjective, WET analyses may vary from user to user, and this variability decreases WET's reliability. Furthermore, although WET assigns ratings of "high," "moderate," or "low" to wetland functions, WET is geared towards assigning "moderate" ratings for most functions unless relatively unusual conditions exist.

Regardless of the method used to measure functions, some are easier to reproduce and some may not be reproduced at all. Kusler (1987) offered the following illustrative examples. Flood storage and conveyance can be quantitatively evaluated and can be reproduced by proper grading. If created systems are protected from high rates of sedimentation, there is a high probability of successfully restoring these functions. Recharge/discharge functions are more difficult to evaluate and to design. Efforts to recreate recharge functions may be difficult where organic materials collect on the bottom of the wetland and seal its recharge capabilities. Quantitative methods exist for evaluating wetlands for waterfowl habitat and methods exist for recreating indicators of waterfowl habitat. There is a high probability of success for recreating these systems because of our experience and knowledge, and because marshes are relatively easily recreated. Endangered species habitat is more difficult to assess and there is a low probability of recreating these functions. Endangered species often require relatively undisturbed, well established habitat depending on the organism. For other wildlife species, the probability of success will vary depending on the species. Because of the difficulty in assessing pollution control potential, the probability of replacement is moderate. It is impossible to re-create heritage or archeological value.

Kusler (1987) also suggested that wetlands created for stormwater treatment and flood storage may be considered "high risk" wetlands and therefore should require higher replacement ratios. This is because they may receive high sediment and debris loading that destroy them in a short period of time or they may accumulate toxic materials to the point that they become dangerous to wildlife.

Type of mitigation

There are three types of mitigation generally recognized as acceptable methods to compensate for wetlands impacts: restoration, creation, and enhancement. Wetlands restoration refers to the reestablishment of a wetland in an area where a wetland historically existed but which now performs little or no wetland functions. Wetlands creation refers to the construction of a wetland in an area that was not a wetland in the recent past. Enhancement refers to increasing one or more functions of an existing wetland (Kruczynski, 1990b).

The likelihood of success for restoration efforts is greater because the restored wetland can often benefit from reestablishment of the original hydrology, one of the most difficult wetland parameters to reproduce. The site may also benefit from nearby seed stocks. Wetland creation presents increased risk since it involves an attempt to establish a new wetland at a site where none has existed. Continued maintenance is often needed (Kruczynski, 1990b; Kusler, 1987). Wetland enhancement, like restoration, has a greater likelihood of resulting in successful wetland establishment. There is a risk, however, that improvement of some functions will degrade or destroy others. Enhancement as a sole means of mitigation always leads to lost wetland acreage because permitted losses are only offset by gains or exchanges of function and not of area (Kruczynski, 1990b).

Time

Restoration or creation of particular functions is influenced by time. Those functions that do not depend on soils or vegetation may be quickly recreated. Waterfowl habitat may take a few years, and endangered species habitat may never be replaced (Kusler, 1987).

Some scientists feel that time may enable created systems to eventually reach the equivalent of a natural wetland, and that evaluations to date have been on projects that are too young to be judged successful (Baker, 1984; Sheldon and Dole, [Appendix A, this report]). Others feel that time may show that many projects that were judged earlier as successful may eventually fail.

Recommended Replacement Ratios

Authors and agencies have recommended various replacement ratios. Most are estimates based on known failures of compensatory mitigation rather than a calculation of what is necessary to guarantee full compensation. Josselyn et al. (1990) suggest that because total acreage has not been replaced in previous compensation projects, and because delays in implementing compensation projects result in immediate loss of habitat, "in no case should mitigation be permitted with less than a one-to-one replacement." Willard and Hiller (1990) recommend that wetlands be designed "well 'oversize' compared to the wetlands for which they compensate". Kruczynski (1990b) suggested a 1.5:1 ratio for wetland restoration, a 2:1 ratio for wetland creation, and a 3:1 ratio for wetland enhancement. These recommendations were based upon "the uncertainty that a particular project will be successful and to compensate partially for the length of time that the restored, planted wetland system takes before becoming completely functional." He suggested that these ratios could be lowered to 1:1 if compensation is completed "up front," that is, demonstrating successful functional equivalency prior to alteration to the original wetland. Similarly, Kantor and Charette (1986) suggest a 2:1 replacement, because created wetlands are not functionally equivalent to natural wetlands. Kusler (1986a) has also suggested ratios larger than 1:1 in cases where: (1) uncertainties exist as to the probable success of the proposed restoration or creation; (2) degradation or destruction will deprive society of various wetland values for a period of time until the restoration or creation is completed and functional; or (3) one or more functions cannot be restored or recreated. Zedler (1991) recommended ratios of 10:1 for low-quality replacement wetlands and 5:1 for moderate-quality replacement wetlands to help reduce risks.

Based upon follow-up of seagrass restoration projects, Phillips (1991) has recommended no less than a 4:1 replacement of these systems because planted plugs of seagrass might not coalesce, and even if they do, ecosystem function might not be viably replaced over the short term (Fonseca et al., 1988). This same concern over success of seagrass and other wetland habitat restoration has been expressed by Walker (1986); plant communities may indeed be restored, but faunal recolonization and other ecosystem functions may not be complete.

Washington Department of Wildlife Wetlands Policy (POL-3025) 7. states: "For wetland compensation projects involving a Hydraulic Project Approval (HPA), a minimum of 2:1 compensation to impacted area shall be required." Note that wetlands under the direct authority of Hydraulic Project Approval are below ordinary high water mark and are most frequently aquatic bed and emergent wetlands (Bob Zeigler, pers. comm. 2/6/92).

Ecology has provided recommendations for Washington's local governments in the form of the Model Wetlands Protection Ordinance (1990). The model has also been endorsed by the Puget Sound Water Quality Authority. Ecology's model suggests that replacement ratios include a 6:1 ratio for Category I wetlands, a 3:1 ratio for Category II and III forested wetlands, a 2:1 ratio for Category II and III scrub-shrub wetlands, a 1.5:1 ratio for Category II and III emergent wetlands, and a 1.25:1 ratio for Category IV wetlands. Criteria are provided for lowering the ratio.

III. Agency survey

Introduction

Purpose

The agency survey provides a review and synthesis of other state and Washington local government regulatory requirements for wetlands compensatory mitigation. The purpose of this review is to confirm the methods and standards for replacement ratios that have been legislatively adopted by regulatory agencies, and to provide information on standards that have been proposed or recommended by others.

The synthesis of existing regulations begins with other state programs and is followed by Washington county and city programs. This review addresses the following items for each jurisdiction:

- information on the overall regulatory program;
- specific replacement ratio requirements; and
- administrative effectiveness comments, if available.

The adopted replacement ratio requirements for states, counties, and cities are summarized in Table 1. The table identifies the presence or absence of a ratio requirement and specific ratios. "Yes", in the ratio requirement column of Table 1 acknowledges that a jurisdiction has specific ratio requirements in their regulations (those that evaluate proposals on a case-by-case basis may have mitigation requirements, but do not have a ratio requirement).

Rapid changes are occurring in Washington State and the nation in the formulation of growth strategies and wetland protection. Many jurisdictions that do not currently have regulations in place are in the process of drafting them, and some are in the process of amending regulations already in place (e.g., Thurston and Island counties). Information on proposed Washington county and city regulatory programs is not provided in the synthesis, however, proposed requirements for replacement ratios are summarized in Table 2.

Study process

The data used in this study were collected in March, April, May, and August 1991. Washington State local government data was updated in February 1992. The information was collected primarily by direct contact with state and local agencies, and by review of all relevant laws, regulations, and guidelines. The Washington State data was updated according to information currently available to Department of Ecology. Personal communications are cited only when the information provided was not contained in an official agency publication. Only those agencies that have adopted specific wetlands regulatory programs have been included in the regulatory synthesis. Table 2, the summary of proposed programs, includes as many programs as the investigators could find; it is not necessarily the exhaustive list and the proposed standards presented are changing rapidly. Overall, the review includes at least 16 states, 6 counties and 28 cities. Information is presented in alphabetical order by jurisdiction.

Background

No-Net-Loss

The Conservation Foundation convened the National Wetlands Policy Forum to take a broad look at wetland policy, and to recommend ways to better protect and manage wetlands (The Conservation Foundation, 1988). The Forum recommended establishing a national interim goal of achieving no overall net loss of the nation's wetlands base, and a long term goal of increasing the quantity and quality of the nation's wetland resource base. At the present time these goals are widely accepted by federal, state, and local governmental agencies. The no-net-loss goal is included in major wetland protection programs in the State of Washington.

Replacement ratios, codified as standards within wetlands creation and enhancement requirements, are critical components to both the short-term and long-term no-net-loss goals. Certainly, as wetlands alteration permits continue to be issued, the only way to achieve no-net-loss is to require at least an equivalent amount of replacement wetlands as compensation.

Mitigation Sequence

For at least the last two decades, a major policy objective of federal, state, and many local governments has been a consistent approach to wetland regulation based upon scientific information. In November 1989, the U. S. Army Corps of Engineers and the U.S. Environmental Protection Agency entered into a Memorandum of Agreement (MOA) for the determination of mitigation under the Clean Water Act Section 404(b)(1) Guidelines. This MOA clarified the standards for determining "appropriate and practicable" measures to offset unavoidable impacts. The MOA determined that "mitigation" includes avoiding, minimizing, or compensating for adverse wetland impacts. Mitigation then is defined, in order of preference, as: 1) avoidance, which does **not** include compensatory mitigation, allows permit issuance only for the least environmentally damaging practicable alternative; 2) minimization, which requires the consideration of appropriate steps to minimize the adverse impacts through project modifications and permit conditions; and 3) compensation, which is allowed only after all appropriate and practicable minimization has been considered.

Replacement ratios apply to wetland creation and enhancement efforts that are elements of compensation. Typically, these ratios are specified as standards within the compensatory mitigation section of an ordinance or regulation.

Current regulations and guidelines

Ecology is currently in the process of developing a consistent statewide approach for determining compensatory mitigation ratios. Other states, such as Oregon and Minnesota, are involved in a similar process. California was the first state to develop comprehensive regulatory guidance for wetlands that included a standard replacement ratio of 4:1 (California Coastal Commission, February 1981).

In Washington State, there are several key wetland regulatory and policy documents guiding local government wetlands protection efforts. Guidelines (Chapter 365-190 WAC, "Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands and Critical Areas") have been adopted by the Department of Community Development for use by local governments in compliance with the Growth Management Act. These guidelines encourage Washington State counties and cities to make their actions consistent with the intent and goals of Executive Orders 89-10 and 90-04 (Protection of Wetlands). They also encourage counties and cities to consider Ecology's model ordinance, and to consider the use of a wetlands rating system.

In the Puget Sound region of Washington, additional guidance is provided by another agency, the Puget Sound Water Quality Authority (PSWQA). In its recommendations for enhanced regulatory protection for wetlands by local government, PSWQA has outlined a comprehensive wetlands protection program and recommends use of Ecology's Model Wetlands Protection Ordinance.

National Survey of State Programs

At least sixteen states throughout the country utilize existing laws and regulations to protect wetlands. These are summarized below:

CALIFORNIA

Regulatory Program: The California Coastal Act of 1976 contains the only statewide requirements for wetland protection and management, and the act applies only to wetlands within California's coastal zone. In 1981, the California Coastal Commission adopted a comprehensive set of guidelines for assistance in determining the commission's wetland jurisdiction. The guidelines established permitted uses in wetland areas, provided specific functional criteria for establishing wetland buffers, and provided standards for determining compensatory wetland mitigation. The process of drafting and adopting the interpretive guidelines was long (nearly two years), very controversial, and relied extensively upon expert scientific opinion (Metz and DeLapa, 1980).

To provide a scientific basis for the guidelines, the Coastal Commission hired Dr. Christopher Onuf, a salt marsh ecologist, to prepare scientifically supportable standards for protecting wetlands from land use impacts (Onuf, 1979). The report issued by Onuf included two case studies assessing actual attempts by local governments to protect and manage wetlands in a manner consistent with California Coastal Act policies. The case studies included the City of Carlsbad's Agua Hedionda Specific Plan for protecting a coastal lagoon, and the City of Santa Barbara's Environmentally Sensitive Draft Report on the Goleta Slough for protecting a coastal slough. In addition, the commission convened a panel of federal and state agency wetland regulatory experts to review Onuf's recommendations.

The Coastal Act distinguishes between "wetlands" and "degraded wetlands". Under this Act, only "degraded" wetlands are candidates for any type of compensatory mitigation.

Compensatory Mitigation Ratios: If a wetland is determined to be "degraded", then four acres of degraded wetland must be restored for each one acre of degraded wetland destroyed (4:1 ratio). This compensation must be provided on-site, and in-kind. Off-site restoration is not an option. This Coastal Act provision was designed to exploit revenue produced from private marina developments to fund the restoration of degraded wetlands (as an exchange for allowing the marina to be built in the wetland).

Administrative Effectiveness of Regulatory Program: The wetland guidelines have now been in place for ten years. In 1986, the Coastal Commission staff convened a wetland task force and completed an internal assessment of the commission's wetland program and its effectiveness. The effectiveness of requirements for compensatory wetland mitigation have not been assessed. It is not generally known if required wetland mitigation plans have even been carried out. The guidelines have not been revised or amended since they were adopted in 1981, and they have not been followed consistently by the staff or the commission. This is due, in part, to the fact that there has not been a full-time wetland coordinator position at the agency since 1983 (Jim Raives, California Coastal Commission, pers. comm. April

1991). Consequently, there has been no overall coordination or technical assistance provided in the wetland area during the past seven years.

To help address these problems, the staff is preparing a wetland regulatory training manual to promote consistent wetland policy within the agency. The agency is also considering reinstating the wetland coordinator position. The task force report recommends that the agency adopt a pro-active wetland program designed to educate the public about wetlands, to reduce conflict with fish and wildlife agencies, and to continue to improve the program.

CONNECTICUT

Regulatory Program: The Connecticut Inland Wetlands & Watercourses Act was passed in 1972. This act and subsequent amendments required municipalities to establish inland wetland agencies to carry out the provisions of the act. These agencies are further obliged by the act to prepare "inventories of regulated areas", that are similar in nature to the National Wetland Inventory maps. While delegating this authority to the individual municipalities, the state has not mandated a specific regulatory program. The state Department of Environmental Protection has issued "Model Inland Wetlands and Watercourses Regulations" as a guide to assist in the implementation of municipal inland wetland regulatory programs. The Department of Environmental Protection acts as a technical advisory panel for the individual municipalities.

Compensatory Mitigation Ratios: There is no formal mitigation policy for Connecticut. A careful examination of long-term and short-term impacts to watershed functions is required, and compensation is loosely based on these findings. While there is no formal state mitigation policy, the regulations promote no-net-loss of wetland functions and values.

DELAWARE

Regulatory Program: Delaware regulates wetlands through the Tidal Wetlands Act of 1973, and the Sub Aqueous Law of 1986. The legislation does not contain specific requirements for buffers or compensation ratios. For this reason, the Delaware Department of Natural Resources and Environmental Control has developed a proposed Freshwater Wetlands Act that is currently in the legislative process. The bill is based closely on Delaware's Tidal Wetlands Act of 1973. The proposed bill would include replacement ratios and a five-tier rating system that includes a fifth class for human-made detention facilities.

Compensatory Mitigation Ratios: Compensation ratios for the proposed bill are 3:1 for Class 1 wetlands, 2:1 for Class 2, 1:1 for Class 3, and 0.5:1 for Class 4 and 5. Compensation ratios included in the pending Delaware bill are not scientifically-based, but reflect the experience of the Department of Natural Resources and Environmental Control personnel in dealing with past wetland issues.

ILLINOIS

Regulatory Program: The Interagency Wetland Policy Act of 1989 is the first piece of wetland protection legislation passed by the State of Illinois. This law establishes a no-net-loss goal for acreage and function and provides for enhancement of existing wetlands by conditioning state-funded projects. This Act established an Interagency Wetlands Committee to advise the State Department of Conservation in the development of administrative guidelines.

Compensatory Mitigation Ratios: The Act dictates the creation of wetland replacement ratios within the guidelines. At this time, the guidelines have not been prepared, and their development is hindered by the lack of available scientific justification (David Mick, Wetlands Program, DEC, pers. comm., March 1991).

LOUISIANA

Regulatory program: The State of Louisiana has no statewide wetland protection legislation. The Coastal Zone Management Act of 1990 has enabled the state to regulate land use in wetlands in a portion of southern Louisiana. Wetlands within the Coastal Zone Boundary are regulated by the Department of Natural Resources (DNR). The Coastal Zone Boundary is a political line that limits DNR jurisdiction and is not ecologically-based. Furthermore, only tidally-influenced wetlands (fresh or salt water) are covered under the act. This act requires compensatory mitigation for all wetland impacts and establishes the framework for mitigation banking programs. DNR is currently drafting detailed rules and regulations relating to mitigation policy and mitigation banking. DNR also has a division responsible for management of the Coastal Restoration Trust Fund that is supported directly by state oil and gas revenues. This Fund may also be utilized for restoration and creation of wetland areas deemed suitable by the state legislature.

Compensatory Mitigation Ratios: Compensation is required on a 1:1 basis for functions and values as defined by the Habitat Evaluation Procedure (HEP) model. HEP is also used for determining mitigation bank credits, monitoring mitigation projects, and enhancement. Because the delta wetlands have been actively eroding in recent years, compensation is directed towards reversing this trend by creating wetlands in areas of open water rather than on upland sites.

MAINE

Regulatory Program: Wetlands in the State of Maine are regulated by the Natural Resources Protection Act of 1988 (amended in 1990). The act is implemented by wetland protection rules developed in 1990 by the State Department of Environmental Protection. The rules establish minimum guidelines that must be adopted and administered by all municipalities. These standards include a regulatory definition of wetlands, and establish three wetland classes with associated compensatory mitigation ratio requirements.

Compensatory Mitigation Ratios: Compensatory mitigation is allowed in Maine and may include restoration, enhancement, creation or preservation. Mitigation ratios are 1:1 for Class 2 and 3 wetlands, and 2:1 for Class 1 wetlands. Preservation of land at an off-site location requires a compensatory mitigation ratio of 8:1. Land purchased under a preservation agreement is kept in perpetuity as a natural area, and must retain all of its significant functions.

MARYLAND

Regulatory Program: The State of Maryland passed the Non-tidal Wetland Protection Act in January of 1989 (based upon The Tidal Wetland Act of 1974). This act contains a no-net-loss policy for the state and establishes statewide buffer standards. A two-tier wetland rating system is employed in Maryland that includes "areas of special state concern," and all other wetlands.

Compensatory Mitigation Ratios: Wetland alterations of greater than 5000 square feet require compensatory mitigation based on acreage. Specifically, emergent wetlands are replaced on a 1:1 basis, forested and scrub-shrub wetlands on a 2:1 basis, and "areas of special state concern" on a 3:1 basis.

MICHIGAN

Regulatory Program: The Goemaere-Anderson Wetland Protection Act (1979) is the main piece of legislation governing land use in wetlands in the state of Michigan. Administrative Rules promulgated in 1988 enable the Michigan Department of Natural Resources (MDNR) to comprehensively administer the wetland management program. In August of 1984, this state became the first in the nation to assume 404 program responsibilities from the U.S. Army Corps of Engineers and expedites the permit application process. Built into the assumption rule is a 90-day time limit for permit review. All wetlands contiguous with lakes, streams, or ponds, and all isolated wetlands greater than five acres are covered under the state regulatory program.

Michigan has developed its own methodology for wetland identification that relies more heavily on the presence of hydrophytic vegetation than the methodology presented in the Federal Manual. There is no standardized rating system employed in this state. Wetlands are rated individually by MDNR staff and are given a ranking based on a state-developed ranking methodology that also utilizes a great deal of subjective habitat and functional determinations.

Compensatory Mitigation Ratios: Compensation ratios are applied on a case-by-case basis and are intended to replace wetland functions and values. Acreage replacement ratios are applied to achieve this goal, and they range from 1:1 to 4:1, depending on the impacted functions.

MINNESOTA

Regulatory Program: The Wetland Conservation Act of 1991 (H.F. 1) is Minnesota's main statute governing wetland areas. It includes several key elements: requiring the Board of Water and Soil Resources to adopt rules by 1993 to determine the public value of wetlands and to be the basis for assuring adequate wetland replacement; establishing a restoration and compensation program; establishing a no-net-loss goal for the state; and, requiring special protection for peatlands. The act protects all wetland types and sizes, with some exemptions; it does not include a wetlands rating system.

Compensatory Mitigation Ratios: During the interim period, January 1, 1992 through rules adoption by July 1993, the act requires that replacement ratios for creation or restoration be at least 1:1 for agricultural lands and 2:1 for non-agricultural lands. The act stipulates that replacement must restore or create wetlands of at least equal public value and the ratios can be modified. Replacement is not required for those wetlands with a general permit under the federal Clean Water Act; for activities in type 1 wetlands on agricultural lands, except bottomland hardwood wetlands; and activities in type 2 wetlands that are two acres or less in size.

NEW HAMPSHIRE

Regulatory Program: New Hampshire's enabling legislation for regulating wetlands is its Fill and Dredge in Wetlands Law (RSA 482-A). This statute provides the authority for the state's administrative rules that establish the New Hampshire Wetlands Board (Chapter Wt 100 through Wt 800). The board consists of the commissioners and directors, several state departments, and local government representatives. The board has developed and administers wetland protection rules and regulations for the state and also makes jurisdictional determinations. Regulated wetlands include fresh and salt water wetland areas as defined by the methodology presented in the 1989 Federal Manual for the Identification and Delineation of Jurisdictional Wetlands.

Compensatory Mitigation Ratios: The board requires compensatory mitigation at a ratio of 1:1.

NEW JERSEY

Regulatory Program: The State of New Jersey has three statutes that protect wetlands: the Coastal Zone Management Act of 1970 that regulates land use in all coastal wetlands; the Freshwater Protection Act of 1988 that provides protection for freshwater wetlands statewide; and a statute that governs activities in the New Jersey Pine Barrens.

Compensatory Mitigation Ratios: The Freshwater Protection Act applies a 2:1 ratio. The act also specifies that under no circumstances shall the mitigation area be smaller than the disturbed area. This implies that a 1:1 mitigation ratio will be used as a minimum standard.

NEW YORK

Regulatory Program: The New York Freshwater Wetlands Act of 1975 is the only statewide wetland legislation in New York. Under the act, the state regulates:

> ...wetlands greater than 12.4 acres in size; wetlands of unusual local significance; and Class 1 wetlands that are at or near a water body used primarily as a water supply.

Delineation of wetland boundaries is primarily based on vegetation indicators. Within the state of New York, the Adirondack Park Agency also regulates wetlands pursuant to the act on park agency land. The park agency requires a permit for any work in wetlands greater than one-half acre in size.

Wetlands regulated in the state of New York are placed into one of four classes. Class distinctions are based on habitat and vegetation associations, as well as values estimates related to flood control and water quality.

Compensatory Mitigation Ratios: No formal compensation policy currently exists, but a 1:1 replacement of wetland acreage is "suggested" (Patricia Rexinger, New York Dept. of Environmental Conservation, pers. comm., March 1991). Policy statements in the act attempt to provide a retention of wetland functions and values. Compensation ratios are determined on a case-by-case basis, and department staff attempt to formulate the most practicable alternative through an alternatives analysis.

Administrative Effectiveness of the Regulatory Program: The New York Freshwater Wetlands Act of 1975 was one of the first wetland protection measures initiated by any state. There have been no significant amendments to this statute since its inception.

OREGON

Regulatory Program: Oregon has a state removal/fill law that is administered by the Oregon Division of State Lands (ODSL) (ORS 541.605-541.695). A permit is required for removal from a waterway of 50 cubic yards or more of material from one location in any calendar year, or the filling of a waterway with 50 cubic yards or more of material at any one location at any time. The law also applies to "waters of the state" that include navigable and non-navigable rivers, bays, estuaries, permanent and certain intermittent streams, and salt and freshwater wetlands.

Oregon also has a mitigation law (ORS 541.626) that applies to fill or removal from wetlands. In addition, in 1989 the Oregon Legislature passed Senate Bill 3 that requires a statewide wetland inventory, and calls for local government preparation of wetland conservation plans. Senate Bill 3 is implemented by administrative rules on wetland inventory and wetland conservation plans (ORS 196.668-196.692).

ODSL is developing a broader-based functional methodology for all wetlands. The goal is to develop a habitat-based model, like that described below for estuarine systems, if there is sufficient information for freshwater wetlands.

The administrative rules for estuarine mitigation contain a habitat-based model for weighing relative values of selected estuarine habitat types. Two models exist, one for the Columbia River Estuary, and one for all other estuaries. Substrate, salinity regime, and vegetation are evaluated for relative habitat value, but the output is used only for calculating compensatory mitigation, not for determining buffer width. A comparison is made between values lost, and values replaced, with the goal of no overall net loss of estuarine surface area, productivity, diversity, or natural habitat areas.

Compensatory Mitigation Ratios: The mitigation models for estuaries, described above, are the state's only requirements for compensatory mitigation. Normally, the mitigation required is 1:1 (Ken Bierly, ODSL, pers. comm., April 1991).

Administrative Effectiveness of Regulatory Program: ODSL is generally satisfied that the 1:1 habitat replacement required for impacts to estuarine systems has been effective. Since the freshwater wetland regulatory program is not as well developed, the state has no information on the effectiveness of compensatory wetland mitigation for freshwater wetlands. Most freshwater wetland mitigation projects have been less than one acre in size.

PENNSYLVANIA

Regulatory Program: Pennsylvania does not currently have comprehensive wetland protection legislation at the state level. The only existing law that requires wetland protection is the Dam Safety and Encroachments Act of 1979. According to Section 105.17 of the proposed rules for Dam Safety and Waterway Management, which are administered by the Department of Environmental Resources, Pennsylvania rates wetlands using two categories: exceptional value wetlands and all other wetlands.

Compensatory Mitigation Ratios: The state is currently issuing proposed rule changes that will require 1:1 compensatory replacement for impacted wetlands. The Department of Environmental Resources' Wetlands Protection Action Plan issued in 1988 is the driving force behind the development of new regulations. This document recommends that a no-net-loss policy be adopted by the State of Pennsylvania.

RHODE ISLAND

Regulatory Program: The Rhode Island Freshwater Wetlands Act of 1971 is administered pursuant to the Department of Environmental Management Wetland Rules and Regulations (1989). The rules contain jurisdictional definitions and activities requiring permits. Activities included in this permit procedure include wetland fill, as well as water quality and flood water impacts.

The state employs a "Wetland-Wildlife Evaluation Model" as a method for determining affected areas (Models for Assessment of Freshwater Wetlands, University of Massachusetts at Amherst, Publication No. 32). This rating system is applied on a case-by-case basis and determines whether the wetland is "unique" or "valuable."

The Rhode Island Department of Environmental Management maintains maps of designated wetland areas that are regulated. Included on these maps is an additional 50-foot buffer area that is also regulated.

Compensatory Mitigation Ratios: No formal compensation ratios presently exist. Rhode Island may include compensatory mitigation as part of upcoming amendments to the Freshwater Wetlands Act (Dean Albro, Dept. of Environmental Management, pers. comm., March 1991).

VERMONT

Regulatory Program: The Vermont legislature passed a statewide wetland protection act in 1986. Vermont Wetland Rules, developed by the state's Water Resources Board, were adopted in 1990. The rules apply to all land identified as wetland by the 1989 Federal Manual for the Identification and Delineation of Jurisdictional Wetlands.

Compensatory mitigation ratios apply to three classes of wetlands described in the rules. Class determinations are based on habitat functions and values, as well as open space and aesthetic concerns.

Compensatory Mitigation Ratios: Compensatory mitigation is allowed on all classes of wetlands but only for identified "compensable functions" considered to be replaceable. Flood and surface water storage, waterfowl habitat, and aesthetic amenities are the only compensable features under these rules. Compensation ratios of 1:1 are required for replacement of impacted acreage and compensable functions.

Washington Survey of County Programs

Five counties (Clark, Island, King, Pierce, and Thurston) in Washington State have existing wetlands regulations in place. Of these, King County has by far the most fully-developed program protecting wetlands. Many of the other counties are in the process of developing wetlands programs for compliance with the state's Growth Management Act (GMA) of 1990. Washington's adopted county regulations are as follows:

CLARK

<u>Regulatory Program:</u> Following more than a year of public involvement and development, Clark County adopted a wetlands protection ordinance in February, 1992.

<u>Compensatory Mitigation Ratios:</u> Replacement ratios are established for three compensation options: 1) in-kind, within the same year of impact; 2) in-kind, and prior to impact; and 3) enhanced replacement. Under the reduction criteria for enhanced replacement, it is possible to replace 10 acres of Category IV wetland with 6 acres of Category II wetland (a 0.6:1 ratio). Specific ratios for all three options are:

Rating	In-kind, Same year	In-kind, Prior	Enhanced
Category I	6:1	5:1	1:1
Category II	3:1	1.25:1	1:1
Category III			
Forested	3:1	1:1	1:1
Scrub-shrub 2:1	1:1	1:1	
Emergent	1.5:1	1:1	1:1
Category IV	1.25:1	1:1	1:1

ISLAND

<u>Regulatory Program:</u> Island County was one of the first counties in the state to adopt wetlands protection regulations. In 1984, the county adopted these wetland provisions as an overlay zone within the County's zoning ordinance. The regulations include a three-tier wetlands rating system (with category 3 wetlands exempt from regulation), buffers, and mitigation requirements. Regulated wetlands include those defined under the federal Clean Water Act with exemptions for smaller sized wetlands (dependent on category).

<u>Compensatory Mitigation Ratios:</u> No replacement ratios exist under the current ordinance although replacement is sometimes required. The draft wetlands ordinance revisions developed by the planning department (1991) do not specify ratios but instead propose that "mitigation projects shall restore or create equivalent or greater areas than those altered to compensate for wetlands losses".

Administrative Effectiveness of Regulatory Program: The Board of Island County Commissioners feels that their program is a responsible approach to wetlands protection. They support their approach of use of regulating two categories of wetlands because of its simplicity yet effectiveness.

KING

Regulatory Program: The King County Sensitive Areas Ordinance (KCSAO), passed by the county council in 1990, is in many ways a pioneering document. This ordinance attempts to define all areas of public concern, including wetlands, throughout the county. The accompanying map folio to the KCSAO includes all regulated land as it pertains to the KCSAO. Alteration of wetlands and required buffers is not allowed without an appropriate mitigation plan that enhances or protects the wildlife habitat, natural drainage, and/or other valuable functions of wetlands.

The ordinance contains a three-tier rating system for wetlands that is based exclusively on habitat, plant associations, and size.

Compensatory Mitigation Ratios: Strict requirements are included for wetland restoration, enhancement, and replacement. All altered wetlands are replaced or enhanced on-site using the following criteria: Class 1 and 2 wetlands are replaced on a 2:1 basis and Class 3 wetlands on a 1:1 basis.

Replacement must provide equal or greater biological values, including habitat value; and equivalent hydrological values, including storage capacity. Off-site wetland replacement or enhancement is allowed when the applicant can demonstrate that the off-site location is in the same drainage sub-basin and that greater biological and hydrological values will be achieved. Wet ponds established and maintained for control of surface water will not be considered replacement or enhancement for wetland alterations.

Administrative Effectiveness of the Regulatory Program: The County is finding that dividing the KCSAO into two separate documents would ease administration of the program. These documents would include a general policy statement and overview of the program, and an accompanying set of detailed regulations. Experience has shown that standards contained in the KCSAO are so complex, and affect so many departments within the county, that it frequently leads to confusion. Weekly meetings held by county staff are used to formalize interpretations of those ordinance provisions not clearly defined initially. Since the KCSAO has been enacted such a short time, it is premature to judge its effectiveness (Cindy Baker, King County SAO Implementation Coordinator, pers. comm., May 1991).

PIERCE

Regulatory Program: In January, 1992, the Pierce County Council adopted Ordinance No. 91-128S3, the Pierce County Wetland Management Regulations. The ordinance requires that by September 1, 1992, the director of Planning and Land Services shall report to the Council's Planning and Environment Committee on implementation of the ordinance.

Compensatory Mitigation Ratios: Wetland replacement ratios are specified as 3:1 for Category I, 2:1 for Category II or III forested, 1.5:1 for Category II or III scrub-shrub and emergent, and 1:1 for Category II or III open water and Category IV wetland. The ordinance does allow for a reduction in the ratios but requires that "in no case shall the department approve a ratio less than 1:1".

SNOHOMISH

Regulatory Program: In May of 1990, Snohomish County Council adopted the Aquatic Resource Protection Program (ARPP), consisting of policies and ordinances for the protection of aquatic resources (Freeman, 1990). A referendum petition placed the ARPP ordinances on the November 1990 ballot, and it was subsequently suspended. Until early 1991, the ARPP was administered as policy. However, in early 1991 the County Council voted to eliminate the ARPP for use even as a policy document.

Compensatory Mitigation Ratios: Compensatory mitigation ratio requirements under the Aquatic Resource Protection Program Policy were 1.5:1 on-site and 2:1 off-site. Currently, the County uses a standard policy consisting of 1:1 compensatory mitigation ratios for any wetland alteration projects.

Administrative Effectiveness of the Regulatory Program: The County employs six full-time and two part-time biologists who review wetland issues and permits. The Snohomish County Planning Department and Planning Committee are in the process of developing a new wetlands program (Marilynn Freeman, Snohomish County Planning, pers. comm. 5/91).

THURSTON

Regulatory Program: The Environmentally Sensitive Areas Chapter of the Thurston Regional Planning Council Comprehensive Plan, completed in 1988, regulates wetlands greater than one acre. Special plans are required for certain developments, and the County can also require "building and development coverage, setbacks, size of lots and development sites, height limits, density limits, restoration of ground cover and vegetation, or other measures for environmental protection". A wetlands map included in the Comprehensive Plan depicts the general outlines of wetland areas in the county. In November, 1990, the county drafted revisions to its Environmentally Sensitive Areas chapter.

Compensatory Mitigation Ratios: No specified compensatory mitigation policy exists at this time in Thurston County.

Washington Survey of City Programs

Since the Growth Management Act Guidelines were enacted, many Washington cities have, or are in the process of developing, regulations concerning development in and around wetlands. At least 28 Washington cities now require wetlands protection. The majority of these cities require compensation for lost wetland acreage, function and values in the form of replacement ratios.

ANACORTES

Regulatory Program: The City of Anacortes regulates wetlands through a subsection of the city's Zoning Ordinance No. 1917. This subsection, called "Non-tidal Wetland Protection", applies to all lands in, or within, 25 feet of a non-tidal wetland greater than 10,000 square feet. Non-tidal wetland permits are issued if an activity is determined in the public interest, is water-dependent, and meets other detailed requirements.

Compensatory Mitigation Ratios: None.

BAINBRIDGE

Regulatory Program: The City of Bainbridge adopted a wetlands protection ordinance in February, 1992.

Compensatory Mitigation Ratios: Replacement ratios are 6:1 for Category I wetlands, 3:1 for Category II or III forested wetlands, 2:1 for Category II or III scrub-shrub wetlands, 1.5:1 for Category II or III emergent wetlands, and 1.25:1 for Category IV wetlands.

BELLEVUE

Regulatory Program: The City of Bellevue regulates wetlands through the City of Bellevue Land Use Code, the City of Bellevue Comprehensive Plan, and the City of Bellevue Sensitive Areas Notebook. Bellevue's regulated wetlands are defined as follows:

> "Those sensitive areas transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of applying this definition wetlands must have one or more of the following three attributes: (1) At least periodically, the land supports predominantly hydrophytes; (2) The substrate is predominantly undrained hydric soil; (3) The substrate is non-soil and is saturated by water or covered by shallow water at some time during the growing season of each year."

Bellevue's rating system includes Type A, B, and C wetlands that are based on wetland size and relationship to riparian corridors.

Compensatory Mitigation Ratios: Compensatory mitigation ratios are determined on a case-by-case basis, although any alteration of Type A or B wetlands is greatly discouraged. Type C wetlands require compensation if they are regulated.

BELLINGHAM

Regulatory Program: In December, 1991, the City of Bellingham adopted Ordinance No. 10267, the Wetland and Stream Regulatory Chapter of the Municipal Code. The ordinance includes a three-tier rating system.

Compensatory Mitigation Ratios: No ratios are specified. Wetlands compensatory mitigation and mitigation banking projects are determined by the director on a case-by-case basis.

BONNEY LAKE

Regulatory Program: The City of Bonney Lake adopted a Sensitive Areas Ordinance in August 1991. The code has a wetlands protection element that regulates wetlands as defined in the federal Clean Water Act and ponds under 20 acres and their submerged aquatic beds. One of the key goals of the ordinance is for no-net-loss of wetlands functions and values. Sensitive Areas Permits and special studies are required for wetlands impacts. The ordinance utilizes Ecology's four-tier rating system with some deviation in size limitations, and is the basis for determining mitigation requirements.

Compensatory Mitigation Ratios: Impacts to Category I and II wetlands are not permitted, but require a 2:1 replacement ratio for violations. Replacement of Category III and IV wetlands requires a 1:1 minimum ratio.

BOTHELL

Regulatory Program: The City of Bothell adopted an interim critical areas ordinance in December 1991. The city uses King County's three-tier system, providing varying regulatory requirements for Categories 1, 2, and 3.

Compensatory Mitigation Ratios: The city uses the following ratios: 2:1 for Category 1, 1.5:1 for Category 2, and 1:1 for Category 3.

BURLINGTON

Regulatory Program: In August 1991, the City of Burlington adopted interim regulations for critical areas as an addition to the Municipal Code.

Compensatory Mitigation Ratios: There are no wetlands standards to address compensatory mitigation ratios or requirements.

CAMAS

Regulatory Program: The City of Camas added an environmentally sensitive areas chapter to the zoning code in August 1991. Prior to issuance of a SEPA threshold determination within identified wetlands areas, the applicant is required to submit a wetlands report that serves as the basis for wetlands protection requirements.

Compensatory Mitigation Ratios: The wetlands standards do not specify compensatory mitigation ratios or requirements.

DES MOINES

Regulatory Program: Wetlands within the City of Des Moines are subject to the regulations in Ordinance No. 853. All areas considered wetlands according to the 1989 Federal Manual for Identification and Delineation of Jurisdictional Wetlands are regulated within the city limits.

A wetland rating system has been developed that assigns each wetland into one of two categories; "significant" or "important". This two-tier rating system is based on the King County Wetland Inventory.

Compensatory Mitigation Ratios: Compensation is required for all approved alterations to wetlands. There is no defined compensatory mitigation ratio within the regulations, however, Section 9 of Ordinance No. 853 states that "the applicant shall create an area of wetland on-site and adjacent to the wetland edge of equal or greater size, functions, and values." If on-site compensation is not possible or environmentally superior, off-site compensation of greater size, functions, and values will be required, but must be within the same sub-watershed.

EATONVILLE

Regulatory Program: The city adopted a wetlands protection ordinance in September 1991.

Compensatory Mitigation Ratios: Replacement ratios are 3:1 for Category 1, 1.5:1 for Category II or III forested, 1.25:1 for Category II or III scrub/shrub, 1.1:1 for Category II or III emergent, and 1:1 for Category IV wetlands.

ENUMCLAW

Regulatory Program: The City of Enumclaw passed a Critical Areas Ordinance in January 1992 that provides wetlands protection regulations. The city uses Ecology's four-tier rating system.

Compensatory Mitigation Ratios: Wetlands creation ratios are 3:1 for Category I wetlands; 1.5:1 for Category II and III, except for forested wetlands (2:1); and 1:1 for Category IV. In addition, wetlands enhancement compensation can be allowed providing that acreage replacement ratios are doubled.

EVERETT

Regulatory Program: The wetland regulations found within Everett's Environmentally Sensitive Areas Ordinance, adopted in 1991, rate wetlands according to four categories based on wetland size, wetland class, and, to some degree, functions and values. The rating system is similar to King County's three-tier system.

Compensatory Mitigation Ratios: Wetland replacement is required according to the following ratios: 6:1 for Category I, 1.5:1 to 3:1 for Category II or III depending on vegetative class, and no ratio for Category IV, which requires payment to a mitigation bank fund.

FEDERAL WAY

Regulatory Program: The City of Federal Way's zoning code classifies and regulates wetlands and other sensitive areas. The code defines "regulated" wetlands, which include any wetland that has been mapped and classified by King County; any other wetland that is functionally related to a mapped wetland; or any wetland, whether or not mapped, that is, or has been, functionally related to a wetland that has any significant or valuable (not defined) functions.

Compensatory Mitigation Ratios: Federal Way does not address compensation ratios in the Federal Way Zoning Code. At this time, compensation for filled or altered wetlands is required and evaluated on a case-by-case basis, which is generally determined by functions and values.

KIRKLAND

Regulatory Program: Chapter 90 in the City of Kirkland Zoning Code contains wetland regulations. The city's definition of "regulated" wetlands is very similar to that which is used by The City of Federal Way (see above).

Compensatory Mitigation Ratios: Determined on a case-by-case basis.

Administrative Effectiveness of the Regulatory Program: The wetlands protection regulations are somewhat difficult to administer because they are open to interpretation (Joan Liebermann-Brill, City of Kirkland Planning Dept., pers. comm., March 1991).

LACEY

Regulatory Program: In July, 1991, the City of Lacey adopted a Wetlands Protection Ordinance. Streams are included in the definition of "regulated wetland" and are provided protection and buffers. Lacey uses Ecology's four-tier rating system except for added protection for streams (Category V wetlands). The criteria for Category V wetlands are all type 2 to 5 waters as defined by the Washington Forest Practice Rules and Regulations. Type 1 waters, within their ordinary high-water mark, as inventoried as "shorelines of the state," are specifically excluded from this category.

Compensatory Mitigation Ratios: Lacey utilizes the replacement ratios recommended in the model ordinance. In addition, the following ratios apply to the creation or restoration of Category V wetlands: type 2 waters require 6:1, type 3 waters require 3:1, type 4 waters require 2:1, and type 5 waters require 1.25:1.

LYNDEN

Regulatory Program: The City of Lynden passed a Sensitive Areas Ordinance that amended the Municipal Code in September 1991. Within the ordinance, the city declares that there is no land within the city limits that can be considered wetlands, except areas within the shorelines of the city that are protected through the Lynden Shoreline Master Program. There may be wetlands in the urban growth areas that could potentially be annexed by the city, but the ordinance leaves that issue to future consideration.

Compensatory Mitigation Ratios: None.

MILTON

Regulatory Program: Milton adopted Ordinance 1148 on August 6, 1991.

Compensatory Mitigation Ratios: The city requires wetland replacement according to the following ratios: 6:1 for Category I, 1.5:1 to 3:1 for Category II or III depending on vegetative class, and 1.25:1 for Category IV.

OLYMPIA

Regulatory Program: Olympia regulates activities in wetlands using its Environmentally Sensitive Areas Chapter of the zoning ordinance, which was recently amended. The ordinance incorporates Ecology's recommended four-tier rating system.

Compensatory Mitigation Ratios: The city requires wetland replacement according to the following ratios: 6:1 for Category I, 1.5:1 to 3:1 for Category II or III depending on vegetative class, and 1.25:1 for Category IV.

PORT ANGELES

Regulatory Program: In November, 1991, the City of Port Angeles adopted their Wetlands Protection Ordinance. The ordinance incorporates Ecology's recommended four-tier rating system.

Compensatory Mitigation Ratios: Acreage replacement ratios range from 1.25:1 for Category IV wetlands to 6:1 for Category I wetlands.

PUYALLUP

Regulatory Program: On September 3, 1991, the City of Puyallup adopted a new chapter of the Municipal Code entitled Wetlands Protection Regulations. The regulations include a four-tier rating system that is the basis for wetlands standards and requirements.

Compensatory Mitigation Ratios: When replacement of wetlands are proposed, the functions and values must be replaced or enhanced based upon an evaluation procedure such as Wetland Evaluation Technique (WET) or Habitat Evaluation Procedure (HEP). The following ratios are required:

Category I - no replacement;
Category II and III forested - 2:1;
Category II and III scrub/shrub and emergent - 1.5:1;
Category II and III open water - 1.25:1; and
Category IV - 1.25:1.

There are provisions that allow for a decreased ratio under certain conditions to a 1:1 minimum.

REDMOND

Regulatory Program: The City of Redmond is in the process of adopting a Critical Areas Ordinance that includes a comprehensive wetlands section. Because the development of the Critical Areas Ordinance has taken more time than anticipated, the city adopted an interim wetlands protection ordinance in September, 1991. The interim ordinance (Ordinance No. 1649) has no standards and states the following policy:

> "Retain and protect the important biological and hydrological functions of wetlands through conditions on new development to assure no-net-loss of wetland acreage, function, and value in the Redmond Planning area."

Compensatory Mitigation Ratios: None.

SEATTLE

Regulatory Program: In October 1990, the City of Seattle adopted interim regulations to protect critical areas. Wetlands protection is primarily limited to a provision for buffers. Wetlands reports or additional information for project review may be required by the Director to ensure more thorough analysis of alternatives.

Compensatory Mitigation Ratios: No mitigation ratios or standards are specified

SHELTON

Regulatory Program: Not available.

SNOQUALMIE

Regulatory Program: The City of Snoqualmie adopted a new sensitive areas chapter into their municipal code in August 1991. Wetlands protection regulations are a part of the package and include a three-tier rating system (similar to King County's), mitigation requirements, and buffers.

Compensatory Mitigation Ratios: Class 1 and 2 wetlands shall be replaced or enhanced at a 2:1 ratio while Class 3 wetlands must be replaced on a 1:1 basis with equal or greater biological values and equivalent hydrological values.

TACOMA

Regulatory Program: In February 1992, the Tacoma City Council adopted a Critical Areas Ordinance that includes wetlands protection.

Compensatory Mitigation Ratios: Mitigation ratios are based on functional value and require 1:1 replacement for creation, restoration, and enhancement activities. In addition, the ordinance allows applicants to pay a fee-in-lieu of on-site mitigation.

TUKWILA

Regulatory Program: On June 10 1991, the City of Tukwila passed a Sensitive Areas Ordinance with wetlands protection regulations. The ordinance uses the King County rating system to establish development standards and criteria.

Compensatory Mitigation Ratios: Only isolated Type 3 wetlands can be altered or relocated, and the applicant must clearly demonstrate that the changes would result in an improvement of wetland and buffer functions. A compensatory mitigation ratio of 1.5:1 is required.

TUMWATER

Regulatory Program: In August 1991, the City of Tumwater adopted a Conservation Plan as part of their Comprehensive Land Use Plan. The Plan addresses natural resource lands conservation and critical areas protection, including an element that specifies wetlands regulations. The regulations utilize Ecology's four-tier rating system.

Compensatory Mitigation Ratios: Tumwater requires mitigation ratios of 6:1 for Category I wetlands, 2:1 for Category II and III emergent wetlands, and 1.25:1 for Category IV wetlands.

WENATCHEE

Regulatory Program: Effective September 1, 1991, the City of Wenatchee passed a Resource Lands and Critical Areas Development Ordinance that includes wetlands regulations. The ordinance incorporates Ecology's recommended four-tier rating system.

Compensatory Mitigation Ratios: The development standards of the ordinance do not specify compensatory mitigation ratios or requirements.

TABLE 1
Adopted[2] Wetland Replacement Ratios

STATE	Ratio Requirement	Rating System	Ratio
California	yes	yes	4:1
Connecticut	no	no	none
Delaware	no	no	none
Illinois	no	no	none
Louisiana	yes	yes	1:1
Maine	yes	yes	1:1 to 8:1
Maryland	yes	yes	1:1 to 3:1
Michigan	no	no	case-by-case
Minnesota	yes	no	1:1 to 2:1
New Hampshire	yes	no	1:1
New Jersey	yes	yes	1:1 to 7:1
New York	no	no	case-by-case
Oregon	yes	yes	1:1
Pennsylvania	yes	yes	1:1 to 2:1
Rhode Island	no	no	case-by-case
Vermont	yes	yes	1:1

COUNTY	Ratio Requirement	Rating System	Ratio
Clark	yes	yes	1:1 to 6:1
Island	no	yes	none
King	yes	yes	1:1 to 2:1
Pierce	yes	yes	1:1 to 3:1
Thurston	no	no	none

CITY	Ratio Requirement	Rating System	Ratio
Anacortes	no	no	none
Bainbridge	yes	yes	1.25:1 to 6:1
Bellevue	no	yes	case-by-case
Bellingham	no	yes	case-by-case
Bonney Lake	yes	yes	1:1 to 2:1
Bothell	yes	yes	1:1 to 2:1
Burlington	no	no	none
Camas	no	no	none
Des Moines	no	yes	case-by-case
Eatonville	yes	yes	1:1 to 3:1

[2] State information contains proposed as well as adopted standards

Enumclaw	yes	yes	1:1 to 6:1
CITY (cont.)	Ratio Requirement	Rating System	Ratio
Everett	yes	yes	1:1 to 6:1
Federal Way	no	no	case-by-case
Kirkland	no	no	case-by-case
Lacey	yes	yes	1.25:1 to 6:1
Lynden	no	no	none
Milton	yes	yes	1.25:1 to 6:1
Olympia	yes	no	1:1
Port Angeles	yes	yes	1.25:1 to 6:1
Puyallup	yes	yes	1.25:1 to 6:1
Redmond	no	no	none
Seattle	no	no	none
Shelton	yes	yes	
Snoqualmie	yes	yes	1:1 to 2:1
Tacoma	yes	yes	1:1 (for
Tukwila	yes	yes	1.5:1
Tumwater	yes	yes	1.25:1 to 6:1
Wenatchee	no	yes	none

TABLE 2
Proposed Washington City and County Wetland Replacement Ratios

COUNTY	Ratio Requirement	Rating System	Ratio
Benton	yes	yes	1.25:1 to 6:1
Clallam	no	yes	none
Grant	no	yes	none
Jefferson	yes	yes	1.25:1 to 6:1
Kitsap	yes	yes	1.25:1 to 2:1
San Juan	yes	yes	1.25:1 to 6:1
Thurston	yes	yes	1.25:1 to 6:1
Whatcom	no	yes	none yet

CITY	Ratio Requirement	Rating System	Ratio
Auburn	yes	yes	1.25:1 to 6:1
Bainbridge	yes	yes	1.25:1 to 6:1
Blaine	no	yes	none
Bothell	yes	yes	2:1
Edmonds	yes	yes	1.25:1 to 6:1
Everson	no	yes	none
Ferndale	yes	yes	1:1 to 6:1
Fife	yes	yes	1.25:1 to 6:1
Fircrest	yes	yes	1.25:1 to 6:1
Gig Harbor	yes	yes	1:1 to 2:1
Hunts Point	no	no	none
Issaquah	yes	yes	1:1 to 2:1
Kent	yes	yes	1.5:1 to 3:1
Longview	yes	yes	1.25:1 to 6:1
Medina	no	no	none
Mill Creek	yes	yes	1.25:1 to 2:1* (*no ratio for Cat I)
Mt. Vernon	no	no	none
Nooksack	no	yes	none
Normandy Park	no	yes	none
North Bend	yes	yes	1.25:1 to 6:1
Port Townsend	yes	yes	1.25:1 to 6:1
Poulsbo	yes	yes	1.25:1 to 6:1
Redmond	yes	yes	1:1 to 2:1
Renton	yes	yes	1.5:1 to 3:1
Sedro-Woolley	no	yes	none
Steilacoom	yes	yes	1:1 to 3:1
Sumner	yes	yes	1.25:1 to 6:1
Winslow	yes	yes	1.25:1 to 6:1

IV. CONCLUSIONS

Replacement ratios are a regulatory tool used to quantify mitigation requirements for replacement wetlands. They are expressed as a ratio of wetland area replaced to wetland area lost. Evaluations of permit requirements indicate that, in the past, planned acreage replacement (ie. acreage replacement indicated in permit conditions or site plans) in the Pacific Northwest averaged 75% of permitted losses (0.75:1). Recent studies indicate that our record is improving to nearly equivalent acreage replacement (1:1 ratio). There is a growing body of literature and scientific consensus recommending greater than equivalent acreage replacement to ensure full replacement of wetlands. Scientists feel that the risks of project failure and the time it takes for a created wetland to represent a fully functioning ecosystem should be factored into replacement ratios which exceed 1:1.

• There is a significant risk that mitigation projects will fail to replace wetland losses with equivalent wetlands in terms of acreage, function and wetland type. This study documented that many, if not most, mitigation efforts have thus far failed to result in wetlands that are equivalent to the wetlands they were intended to replace. Wetland functions, acreage and types continue to be lost despite efforts to create, restore or enhance substitute wetlands.

> Investigators have used a variety of techniques to measure the success or failure of mitigation projects. These range from confirming that projects were completed according to plans, to achieving stated goals and objectives, to comparing functional equivalency through quantitative evaluations with natural control or reference sites.
>
> Failure rates for compliance with permit conditions varied from 0% to 62% within those studies that offered quantified results. The average compliance rate was 50%. Common problems include inadequate design; failure to implement the design; lack of proper supervision; site infestation by exotic species; grazing by geese or other animals; destruction by floods, erosion, fires or other catastrophic events; failure to adequately maintain water levels; and failure to protect projects from on-site and off-site impacts such as sediments, toxics and off-road vehicles.
>
> In some cases, improper calculations of created wetland area (including buffers or side slopes in the calculation) have resulted in further wetland losses.
>
> The creation of a wetland that is functionally equivalent to its natural counterpart has never been documented. Few studies have quantitatively assessed functional equivalency. In a California study, functional equivalency of a created salt marsh was 60% of its natural counterpart after 5 years. It is unknown whether it will ever reach an equivalent state. In a qualitative study of the ability of some Puget Sound mitigation sites to reach functional equivalency, no sites were successful within the period they had been established, usually less than 5 years.
>
> Wetland types are being lost through mitigation with a trend towards construction of more easily created types or those that are perceived more desirable. Creation of open water systems is most common and most successful.

• The probability or period of time that it will take for a created wetland to achieve functional equivalency is unknown. No estimates have been offered of the time it takes to achieve functional equivalency beyond general assumptions that it takes years or decades, during which time, many generations of organisms may be lost. The length of time that it will take depends, in part, on the type of vegetation. It may be possible to create marsh vegetation in a few years whereas a forested wetland will take far longer to mature. Structural equivalency, however, is not the same as functional equivalency.

• Our inadequate technical and scientific expertise on Pacific Northwest wetlands hampers our ability to mitigate wetland impacts. Mitigation projects are still considered experimental. Wetland systems are very complex and poorly understood, increasing the risk of failure. Few projects have adequate goals from which to measure and learn about success, and monitoring is uncommon.

• Proper planning, implementation, and monitoring are critical factors to improving the likelihood of successfully reproducing wetlands. The following components of compensatory mitigation plans are considered to be critical in attempting to achieve functional equivalency: design, implementation, monitoring, and maintenance. Design considerations should include soils analyses, grading contours, water source and hydroperiod, and detailed landscaping plans including appropriate native species, planting densities, species groupings, and size of planting zones. Implementation of the plan as designed determines if the construction of compensation sites will allow successful establishment of functionally equivalent wetlands. Regular monitoring and maintenance of created and restored wetlands maximizes the opportunity for the plan to succeed as designed and constructed.

• Open water wetlands and some marshes are easier to reproduce; forested systems and bogs may not be possible to replicate. Research demonstrates that elevations for emergent wetlands are less critical than for forested or shrub wetlands, and marsh vegetation quickly reaches maturity. There have been no successful attempts to replicate forested systems or bogs.

• Some wetland functions are more easily measured and replicated than others. Wetlands experts agree that some wetland functions may be quantified, for example, flood storage and conveyance. This leads to an increased probability that flood storage capabilities can be replicated. Other wetland functions, for example, groundwater interactions, may be impossible to quantify and may be impossible to replicate.

• Wetlands restoration has a higher probability of success than creation or enhancement. The likelihood of success for restoration efforts is greater because the restored wetland can benefit from the original wetland hydrology, one of the most difficult wetland parameters to reproduce. Wetland creation presents increased risk since it involves an attempt to establish a new wetland at a site where none has existed. Enhancement results in no substitute wetland acreage for permitted losses.

• Given time, more mitigation projects may be judged successful. Time is an important factor in successful mitigation. Given sufficient time, more mitigation projects will stabilize, increase their species diversity through natural recruitment of new plant species, and increase their complexity through competitive interactions, thus providing more of the functional values associated with older, natural wetland systems.

• Recommended or adopted ratios range from 1:1 to 10:1. The range of replacement ratios suggested by wetlands experts or adopted into regulation ranges from approximately 1:1 to 10:1. While many agencies have not incorporated replacement ratio standards into their regulatory programs, there is a growing trend to provide standards in order to provide predictability.

Current mitigation practices are not satisfying goals that require no-net-loss of wetlands, maintenance of aquatic systems, or protection from adverse impacts. Replacement ratios of 2:1 or greater are necessary to compensate for our current rate of failure to achieve permit compliance or basic wetland community structural objectives within attempted mitigation projects, neither of which are accurate measures of functional equivalency. Some wetland habitats and some functions may not be replicated at all, including mature forested swamps, bogs, and threatened and endangered species habitat.

It takes time for community structure to mature and for a wetland to achieve functional equivalency. Variable ratios based on vegetative type are an appropriate method to account for a portion of this time element.

There are no expressed formulas for calculating acreage replacement ratios based on evaluations to date. The extent to which adopted replacement ratios incorporate risk of failure, probability of success, and time factors is a policy decision that should be conservatively rendered, given the experiences with wetland mitigation thus far. The level of risk of mitigation failure depends on the standard of success. If the standard is to comply with permit conditions (i.e., to implement the project elements correctly and provide structural equivalency), the risk of failure may be 50% or more; if the standard is to create a functionally equivalent wetland, the risk is far greater.

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Appendix A: Replacement Ratios: a field assessment of mitigation replacement ratios in Puget Sound

REPLACEMENT RATIOS: A FIELD ASSESSMENT OF
MITIGATION REPLACEMENT RATIOS IN PUGET SOUND

Prepared for:

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EXECUTIVE SUMMARY

This study assessed the effectiveness of replacement ratios to compensate for permitted wetland losses and assessed functioning of designed compensation wetlands. During the course of the study, critical design components affecting compensation success were identified and discussed.

Local agency staff were contacted to assist in identifying appropriate compensation sites. Agency files were reviewed to identify sites that had permit requirements for compensatory mitigation and that had pre-existing site data available. Constructed sites were field checked and assessed by traversing and completing a data form.

A total of eleven potential compensation sites were identified in King and Snohomish Counties; eight of these sites were selected as study sites. Compensation implementation on the other three sites was too new to assess success.

The results of this study indicate the majority of compensation sites met their stated goals because the goals were written so broadly that only outright failure of a compensation could be interpreted as a failure to meet the goals. None of the goal statements provided a quantifiable method of determining success, thus they provided no means for an agency to assess success/failure or to require remediation.

The level of functional value of the compensation site was most often dependent upon the functional value of the pre-existing contiguous wetland communities.

Only one of the compensation areas was created on non-wetland substrate, all other compensation areas were constructed in pre-existing or historical wetlands. The compensation wetland substrate composition and hydroperiod were significant factors in determining success in compensation plans.

The elements of detailed design, implementation and monitoring of compensation plans are the most critical components in successful compensation. Time may be the most critical non-controllable component that allows these systems to stabilize, increase species diversity, increase spatial complexity through natural attrition, and provide more of the functions and values associated with older, natural wetland systems.

No measurable field data was found that would form the basis for establishing variable quantifiable replacement ratios. However, requiring variable replacement ratios as an incentive to not impact certain communities should not be ignored.

I. INTRODUCTION

Background

The Washington State Department of Ecology (Ecology) requested an evaluation of the effectiveness of wetland replacement ratios used in compensatory mitigation designs for permitted wetland losses. The evaluation consisted of a review and synthesis of existing literature, an agency survey of existing requirements within local, state and national regulatory programs; the development of an annotated bibliography of applicable literature; and a field analysis of mitigation replacement ratio effectiveness. The following is the compilation and analysis of data collected during the site specific field component of the study. Based on the analysis, a series of recommendations regarding critical components of successful site compensation are presented. For this portion of the study, the term "compensation" will be used to mean actions taken to replicate or compensate for permitted wetland losses.

Purpose

The purpose of the field study was to assess the effectiveness of replacement ratios in compensating for permitted wetland losses. Another objective identified during the course of the study was to assess the functioning of designed and constructed compensation wetlands. Specific study objectives were to:

- to assess the effectiveness of compensation in meeting no-net-loss of wetlands;
- to assess the effectiveness of requiring variable replacement ratios based on wetland vegetation community types; and
- to determine critical design components that affect compensation success.

To accomplish these objectives the following questions were tested:

- Was the compensation wetland implemented as designed?
- Was the compensation wetland successful over time?
- What were the critical components of compensation design and implementation that most significantly affected success?
- What additional questions need to be answered when assessing the effectiveness of compensation?

II. METHODOLOGY

Agency Contact and Permit Identification

Local governmental agency staff were contacted to assist in the identification of appropriate sites, especially those sites containing constructed compensation. Agency staff provided a list of potential sites identified by permit application. A list of agency and staff contacts is provided in Attachment 1.

Permit File Review and Site Selection

King County files for short plats, formal subdivisions, commercial permits, and wetlands were reviewed, along with SEPA files from the City of Kirkland, and the 404 permit files from the Army Corps of Engineers. Information from Snohomish County files examined during the course of a previous study was used as well. Over four years of permit files were reviewed.

Potential sites were identified based on the following criteria:

- presence of permit requirements for compensation;
- availability and thoroughness of pre-existing site data;
- availability of compensation planting plans;
- age of compensation projects;
- availability of photographic record for the site;
- location and accessibility of project; and
- agency staff or field personal knowledge of the site.

Field Data Sheet Development

Data needs for the site-specific assessment were identified, and individual field data sheets were developed. The field data sheets are located in Attachment 2.

The compensation data sheets were designed to collect consistent information on each site regarding pre-existing conditions, permit requirements, design goals and objectives, existing site conditions, and qualitative assessments of success and function of the compensation mitigation. Data sheets were structured to collect both permit file and field data in the following general categories of information:

Pre-existing site conditions

Pre-existing conditions, present before the compensation project was constructed, included plant species diversity, dominant species, community type, pre-existing wetland type and size, surrounding land use, and functioning of wetland. Pre-existing conditions information was obtained both from review of the files and from personal knowledge of the site by field personnel, or both.

Permit requirements and compensation goals
Permit requirements and goals information were obtained from review of files.

Construction/implementation of permit requirements
Construction details were obtained from review of the files. Implementation of permit requirements was assessed both from review of the files and from on-site analysis.

Existing wetland and compensation wetland conditions
Site conditions were separated into:

> **existing wetland**: any wetland on-site that had not been enhanced, created or restored, that was present prior to the construction of the compensation project;
>
> **compensation wetland**: any wetland specified in the compensation plan for restoration, enhancement or creation.

Site conditions for both existing and compensation wetlands included plant species diversity, dominant species, viability of species, community type, wetland type and size, buffer type and size, and surrounding land use. Site condition information was assessed on-site.

Compensation wetland functioning
Information gathered regarding functioning of the compensation wetland included: achievement of stated goals; evidence of wildlife use of the area; vigor and/or stability of planted vegetation species; and impacts to the compensation or pre-existing wetland. This information was gathered on-site.

Summary Assessment
The assessment included the identification of probable factors affecting compensation wetland functioning, and a general analysis of the wetland system. Summary information was gathered on-site and was based on site conditions and investigators' knowledge of Pacific Northwest wetlands.

Field Site Establishment and Assessment

Potential sites identified during permit review were field checked. Actual sites selected for analysis were a subset of the field checked sites. Selection of actual sites was based on the following criteria:

- construction and implementation of compensation project;
- ability to locate the site; and
- access to site.

Once a site was determined to be appropriate for inclusion in the study, the field assessment was conducted using the field data forms. Sites were assessed by traversing the area to locate the compensation area and the pre-existing area, and filling in the forms. A detailed description of the methodology that explains the basis for the field data form questions is provided in Attachment 3.

Data Analysis

Information collected in the field was reviewed and findings and conclusions were drawn from the information and assessments were recorded on the forms. Within this report, a clear distinction is made between findings based solely on the results of this study and those based on the findings of this study in conjunction with the professional experience of the project investigators.

III. FINDINGS

A total of eleven potential compensation sites, located in Snohomish and King Counties, were identified from agency permit files (Figure 1). One potential study site in Snohomish county was identified through the Puget Sound Wetlands and Stormwater Management Research Program, based on personal knowledge of the site and the availability of pre-existing site conditions.

Potential sites were field checked and several were eliminated from consideration. Sites were eliminated for several reasons. If the development project and/or wetland compensation had not yet been implemented, the site was eliminated. For several sites, the compensation had been implemented within the past year and no evaluation of success was possible. In order to attempt to determine success of the compensation it was necessary to use compensation sites that had been in place for as long as possible. One site was not used as it was not located.

Eight sites were selected as compensation study sites. Names and locations of the final study sites are summarized in Table 1, approximate locations are noted in Figure 1. The eight sites include two commercial-industrial sites, one commercial-business park site, and five residential sites.

On-site wetland compensation for the sites ranged from 0.07 to 14 acres (Table 2). One site had 14 acres of compensation; one site had 4 acres of compensation on-site with an additional off-site compensation area; and the remaining six sites had less than 2 acres of compensation each. Implementation dates for the compensation ranged from 1985 to 1990.

Five of the sites were partial compensation where a portion of a previously existing wetland was used to accomplish compensation. Three of the sites were total compensation where either the entire area was a newly-created wetland, or the compensation incorporated the entire area of a pre-existing wetland.

Two of the sites included wetland creation. One of these was entirely created and the other included a small, created scrub-shrub wetland as a part of a larger compensation. Of the remaining six sites, one consisted of restoring an historical wetland and the other five included a combination of enhancement and restoration.

Site information recorded on the field data forms is located in Attachment 4.

Figure 1. Location of Compensation Sites in the Study Area

King and Southern Snohomish Counties

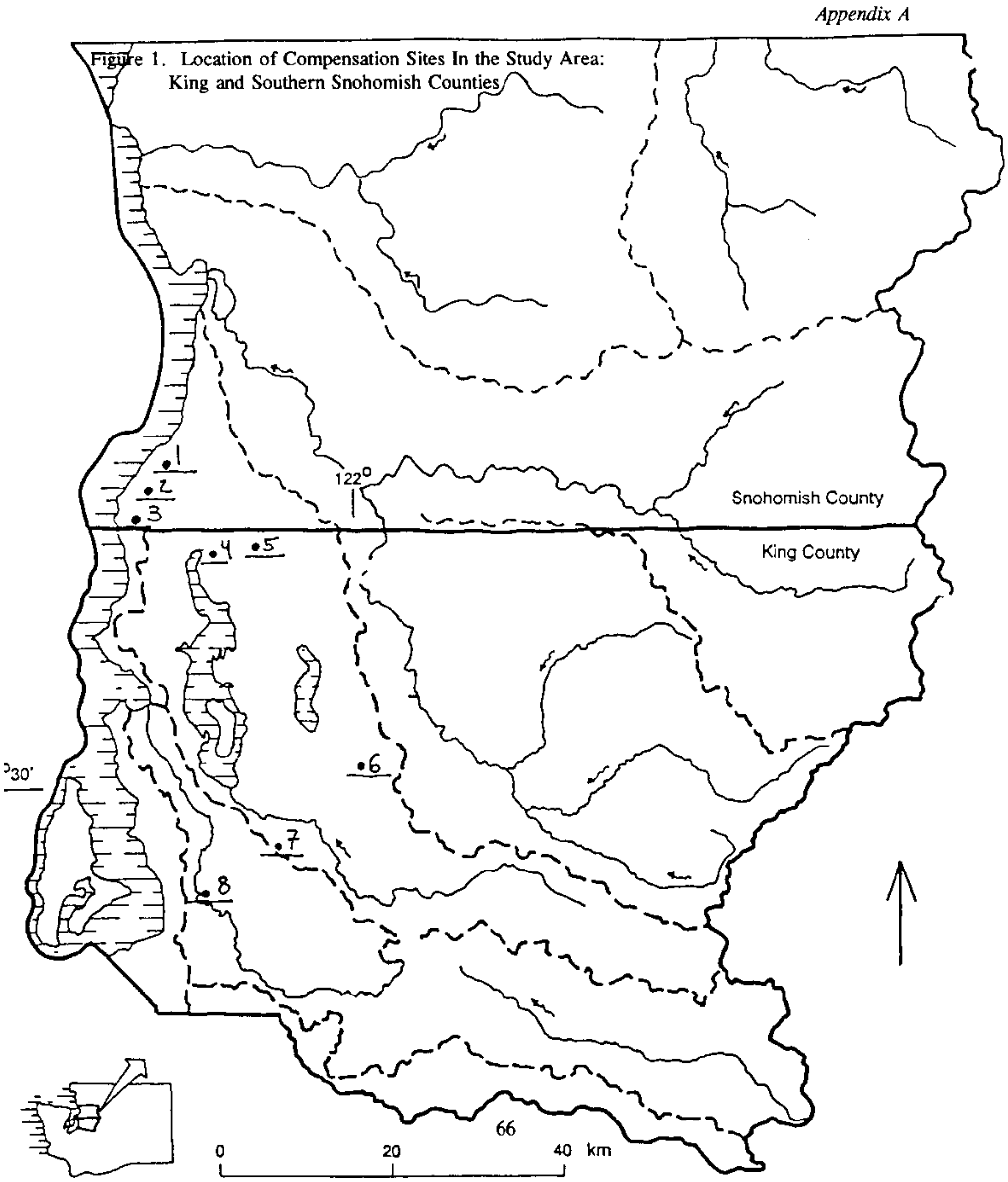

Table 1. Preliminary and Final Compensation Sites

Sites are arranged by County from North to South.

SITE LOCATION	COUNTY	COMPENSATION	SITE USED	IF NOT, WHY NOT	SITE#
Airport Road/ 100th Street SW NE quadrant	Snohomish	Yes	Yes		1
Airport Road South of West Casino Road SW quadrant	Snohomish	Yes	No	Comp. too young (fall of 1990)	
Harbor Point Blvd./ 55th Place West SW quadrant	Snohomish	Yes	Yes		2
83rd Avenue West/North of 224th Street West	Snohomish	Yes	Yes		3
South of 175th Street on the Sammamish Slough	King	Yes	Yes		4
North Creek Pkwy/ NE 195th Street	King	Yes	Yes		5
Issaquah Pine Lake Road/238th Way SE	King	Yes	Yes		6
148th Avenue SE/ SE 183rd Street	King	Yes	Yes		7
64th Avenue South/ James Street	King	Yes	Yes		8
SE 265th Street/ 117th Avenue SE	King	No	No	Comp. not built	
SE 265th Street/ 117th Avenue SE		No	No	Comp. not built	

Table 2. Compensation Site Characteristics.

SITE#	APPROX ACRES OF COMP	COMPENSATION TYPE*	YEAR IMPLMTD	DEVELOPMENT TYPE
1	<1 acre	P; C	1989	Commercial, Bus. Park
2	<1 acre	P; E	1989	Residential, Single Family
3	1-2 acres	P; R	1990	Residential, Single Family
4	<1 acre	P; R, E	1989	Commercial, Warehouse
5	14 acres	T; E, R	1985	Commercial, Business
6	1-2 acres	T; R, E	1986	Residential, Single Family
7	<1 acre	T; E	1990	Residential, Single Family
8	4 acres	P; E, C	1988	Residential, Multi Family

* Compensation Type

Restoration (R) - actions taken on an historical wetland that is not now a wetland to restore lost functions.

Creation (C) - design and construction of wetland where none historically existed.

Enhancement (E) - actions taken on a pre-existing wetland to improve some or all of its functional characteristics.

Partial (P) - Compensation uses only a portion of the pre-existing wetland.

Total (T) - Compensation includes all of the pre-existing wetland.

IV. DISCUSSION

The original two objectives of the field study were to assess the effectiveness of compensatory mitigation in achieving no-net-loss of wetlands, and to assess the effectiveness of requiring variable replacement ratios based on wetland vegetation community types to compensate for permitted wetland losses.

To assess the effectiveness of compensatory mitigation within the scope of this study, a qualitative measure of success or failure of compensation sites was needed. It was necessary to establish a qualitative assessment of functional equivalency. To determine whether the proposed compensation was successful or not, a series of questions were asked to establish pre-existing conditions, compensation goals, existing site conditions and to establish whether the goals were achieved. The preliminary set of questions generated a second series of questions related to the definition of success, functioning, and equivalency. Simply put, the main question became: if shrubs are planted in a wetland, has a shrub-scrub wetland community been created?

Detailed quantified studies have been conducted to define and determine what constitutes functional equivalency. For the purposes of this field study, it was assumed that a compensation project met the goal of functional equivalency if the target communities within the compensation zone provided the same or better level of functional value as the pre-existing wetland on-site, for the five functions outlined below. For certain sites, the pre-existing wetland may have been significantly degraded, in which case equivalency was determined by using a standard "reference" of the target community (e.g., a typical spirea/willow shrub, or cattail/water-plantain/sedge emergent community commonly found in the central Puget Trough area).

As a result of the questions developed for determining the effectiveness of compensatory mitigation, a series of critical components for compensation design, implementation, and monitoring were identified. A third objective was added to the study: to determine what criteria or critical design components significantly affect compensation "success."

Based on the results of this study, we address the appropriateness of requiring variable replacement ratios factored on wetland vegetation community types to compensate for permitted wetland losses. In addition, we provide a discussion of the adequacy of compensation plan goals to provide for creation of wetland communities.

Parameters of Success

In order to determine if the proposed compensation plans were successful in meeting their goals, a series of questions were asked at each site. The intent of the questions was to establish pre-existing conditions, to determine if the compensation project was constructed as it was designed, and to determine if the compensation site currently existed as was predicted within the compensation design.

Was a pre-site analysis completed?
Pre-site analyses of varying degrees of complexity were completed on all eight sites. These analyses were not all available within the files reviewed for this study; however, according to documentation or references located within the files, they were completed.

Because many of the pre-existing site assessments were not available for our review, no assessment of pre-compensation to post-compensation wetland conditions could be completed on a number of sites.

Was the compensation implemented as planned?
Most sites were implemented as planned, with minor exceptions. Ornamental landscaping species were substituted for some of the native species on two of the sites. Shrubs were planted at much lower densities than what was proposed on one large site.

Is the compensation mitigation site functioning?
All sites were functioning as wetland. However, it is critical to note that with one exception, all the sites used for compensatory mitigation were either wetlands (or portions thereof) prior to the compensation action, or were sites that were historically wetland that had been filled, and the compensation involved removal of fill to restore lost functions to the compensation portion.

All sites involved only a portion of a pre-existing wetland. In other words, the compensation wetland site was either contiguous with or adjacent to an existing, functioning wetland system. This physical relationship to a functioning wetland significantly improved the "functioning" of the compensation areas.

Were the compensation goals met?
In order to answer this question, a clear statement of goals defined at the outset of each project was needed. Most of the goal statements, if present, were general phrases such as "to create 0.2 acres of emergent marsh..." or "to create a scrub-shrub wetland." Given the general and sometime vague description of the goals, results of this study indicate that goals were met at these sites. Many of the compensation areas were providing wetland functions such as stormwater attenuation, biofiltration, sediment deposition, groundwater discharge, and species or habitat diversity. However, most of the compensation sites provided very limited wetland community functions, except that provided by the presence of the pre-existing adjacent wetland community.

Functioning of Compensation Sites

The last two questions above generated discussion and questions regarding the functioning of compensation wetlands. All compensation sites reviewed by this study were functioning as wetlands; however, not all target wetland communities were currently functioning as communities. As mentioned above, all the compensation areas were located adjacent to or contiguous with a pre-existing wetland, and many of the compensation sites were enhancements of portions of pre-existing wetlands.

Functional values associated with the compensation wetlands included stormwater attenuation, water quality, groundwater effects, aesthetics, and wildlife habitat.

Stormwater Attenuation

Six of the eight sites (sites 1, 3, 4, 5, 6 and 8) were designed to control stormwater, to act as flood backwaters, or had stormwater directed towards them as a source of water. Sites 3 and 6 were designed and engineered to provide stormwater retention/detention (R/D) and outlet structures were present to provide storage on these sites. Sites 4 and 5 were designed to collect backwater floods from adjacent riparian systems. Site 1 was designed to receive stormwater from an upland site approximately 1,000 feet away; stormwater was directed to the site to provide a source of water, not to provide storage.

The use of the compensation wetland areas for R/D has had a variety of impacts on the pre-existing wetland systems. Site 3 is a sphagnum bog, and the alteration in nutrient balance from incoming stormwater is adversely impacting the vegetation community within the bog. Site 6 provides for R/D within a dredged pond down gradient from the pre-existing mature forested system. The flood storage occurs primarily within the pond and no direct adverse impacts were readily visible within the forested community. However, no attempts were made to assess pre-construction and post-construction conditions within this forested community for the identification of species or community impacts.

Site 4 is a relatively low gradient backwater located on the Sammamish Slough. No evidence of excessive sedimentation or siltation within the backwater channel was observed; however, observations were limited to off-site viewing with binoculars.

Site 5, located on North Creek, was flooded repeatedly in the winter storms preceding this study. As a result, silt and debris from the flood waters covered the backwater area vegetation that consisted almost exclusively of reed canary grass. It is not known if the reoccurring flooding and deposition of sediment has influenced the viability of other species of the vegetation in the area. The area is providing a flood storage function within a riparian system where high levels of sedimentation are known to be a problem.

Water Quality

Water quality functions can be provided by biofiltration; of sediments within a system, by nutrient uptake within the vegetation system, and/or by providing a settling basin for the deposition of suspended solids.

The dense cover of dead winter reed canary grass provides very effective biomass for biofiltration; consequently, the North Creek compensation site (Site 5) provides excellent biofiltration and settling for suspended solids.

The other study sites were likely have minimal effect on water quality, as only minor amounts of degraded water enter the compensation area without first having passed through the pre-existing wetland. Several of the sites have no observable stormwater input.

Groundwater Effects

Wetlands can influence groundwater by acting as discharge and/or recharge points for shallow aquifers and/or adjacent streams. Wetlands can discharge water to deep aquifers by means of infiltration through deep hydric soil deposits and through pervious substrate beneath the body of the wetland allowing for the transport of surface water to subsurface aquifers. Wetlands may also function as discharge zones for groundwater, commonly referred to as spring-fed systems.

Wetlands may also provide a critical function for stream recharge, by metering stored open water or water within the soils out to down-gradient streams. Wetlands can extend the stream recharge over a longer period of time than impervious surfaces or upland soils. This function can have major significance for systems associated with salmonid streams with either perennial or seasonally intermittent flows.

Full study of the effects of compensation areas on groundwater was beyond the scope of this study; however, some general observations are provided. On sites 2, 3, 6 and 8, open water was created by excavating to expose groundwater. Creation of these open water ponds likely had no effect on deep aquifers, but may have served to increase evapotranspiration from the water surface. Site 5 is located on very deep organic peat deposits; occasional flooding of the compensation area likely provides recharge to the peat that then can release water to North Creek for a longer period of time. As a result of the flooding, the recharge function of the wetland may be improved over the pre-existing dredged farm ditch conditions.

Aesthetics

Wetlands can provide several solely human-identified values that are here termed aesthetics. Such values are associated with open space and views, with opportunities for passive recreation such as walking/birdwatching, and with opportunities for education (either formal or informal). Aesthetic developments within wetlands may include placing of trails in the wetland or buffer, placing observation decks or structures within or on the wetland edge, and/or planting of non-native ornamental species for their color, foliage, fruits, or blooms.

Sites 2, 3, 5, 6, 7 and 8 were designed to be incorporated into residential settings and/or to provide passive recreation and open space. Features designed to enhance aesthetics, such as colorful species, attractive blooms, trails, boardwalks and interpretive signs, were included. All of these sites are successfully providing aesthetic/open space values.

Site 3 is located within a public park and incorporates detailed interpretive signs, a walkway, and an overlook system. Site 5 is located in a commercial business park; an extensive walkway is provided, as well as interpretive signs.

Site 6 was designed to provide an "entrance statement" to a residential subdivision; the excavated pond was landscaped to provide views of the open water for passengers in vehicles entering the site. Maintenance of the aesthetic function is affecting other functions of this site. Planted and volunteer shrubs and trees located in the area that would block the view of the pond are mowed as part of an active maintenance program, thus eliminating a large part of the desired habitat diversity.

Incorporation of wetlands and compensation areas within residential areas provides opportunity for interpretation and interaction, however, it also provides for intrusion by humans and domestic animals. Walkways and trails on all sites were used by humans, some heavily, and domestic animals were observed in several sites during the field visits.

The perception that open water provides a more positive image than dense vegetation has promoted the dredging of ponds (sites 2, 6 and 7) within residential areas.

Wildlife Habitat

All eight site plans listed enhancement of wildlife habitat as a compensation goal. Habitat can be provided in a variety of ways, including increasing vegetation species diversity, increasing structural complexity, and providing missing habitat types such as open water, shrubs, or emergent zones. The discussion of vegetation community status is provided within this wildlife section because species diversity and community complexity can be a significant factor in wildlife use. Sites 2, 3, 4, 6, 7 and 8 each provided open water to increase wildlife habitat diversity and in some instances provide for R/D. Open water was created successfully at all sites by dredging out material to expose groundwater or capture adjacent surface waters.

Within the open water community, all six sites attempted to create an emergent vegetation community to provide increased species diversity. The emergent areas were planted in the margins of the dredged zones. The viability and vigor of the emergent vegetation plantings at the sites was varied (see the Design Component discussion below for more detail). Site 1 attempted to create an emergent community on former fill; at the time of this study, the compensation area was entering its second growing season and the vegetation appeared to be viable and at adequate densities. Site 4 (viewed from off-site) appeared to have established a complex and robust emergent community within a dredged portion of pre-existing wetland.

Sites 5 and 8 contained large portions of emergent wetland dominated by reed canary grass. On site 5, reed canary grass almost exclusively dominated the emergent zone; however, on site 8, an effort had been made to add structural diversity by planting various shrub and tree species within the existing reed canary grass emergent zone. Although the reed canary grass-dominated areas are technically emergent wetland communities, they were not providing species diversity or habitat complexity.

Emergent species were planted on the margins of the excavated ponds on sites 2, 3, 6, and 7. The extent of the emergent zone was limited by substrate and water depth on sites 2 and 6. Timing of the field work for this study and the young age of the emergent areas on sites 3 and 8 made an assessment of presence or viability of the emergent species impossible.

Shrub species had been planted to create scrub-shrub habitat on all sites. The survivability of the shrubs varied. At least half of the shrubs on site 1 died. Survivability seemed to be correlated to water regime, with those shrubs outside of the wetted zone not surviving.

Shrub species planted with appropriate hydrologic regimes had a much higher survival rate on sites 2, 5, 6 and 7. Some of the shrubs in sites 5 and 6, and most of the shrubs on site 2, were planted on steep, well-drained slopes; those species that did survive were stressed. Many of the shrubs on site 5 seemed to be outcompeted by the reed canary grass; in addition, shrub species were planted at a far lower density than called for in the plans. On site 6, ongoing maintenance (mowing) to assure views of the adjacent pond eliminates a significant portion of the proposed shrub community. Some portions of this site along the pond margin are not mowed, and are filling in with volunteer red alder saplings at high densities.

Although site 3 is too new for the assessment of survivability, the vegetation appeared to be planted at densities adequate for a dense shrub "community" over time. Vegetation on site 4 is surviving and is planted in appropriate locations; however, the density of plantings will not allow a shrub "community" to become established without the introduction of volunteer species overtime. Site 8 also contains pockets of shrub plantings that, although too young for the assessment of community structure, appear to have adequate densities.

Although trees were planted in many of the sites, only the large transplanted black cottonwood trees within the riparian zone of site 5 are currently providing any "tree functions"; trees on other sites are too new to provide structural complexity or, in some cases, even fruits. Within all sites providing open water, waterfowl use was observed. The most common species observed were mallards and Canada geese. The use of ponds by geese and mallards is ubiquitous in this region, and does not provide a good indicator of wildlife habitat.

Coots, blue-winged teal, widgeon, gadwall, and buffleheads were seen at sites 3, 5 and 6. Great blue heron were sighted at sites 5 and 6, and a green heron was observed in the riparian zone at site 5. Passerine birds were observed at all sites.

Beaver were actively harvesting trees and shrubs along the riparian corridor of site 5. An active dam structure and a possible bank den were observed.

Sites 2, 3, 5, 6, and 8 created elements of structural diversity within the wetland community that were not present prior to the compensation, primarily in the form of open water and edge habitat. Wildlife use of this habitat was variable, and assessment is limited by the single field observation of each site.

Functioning of the compensation wetlands, especially for wildlife habitat, was dependent upon the adjacent wetland. No assessment of the wildlife habitat functions of the compensation wetland in isolation from the pre-existing wetland was possible; indeed, such an assessment might be inappropriate.

Critical Compensation Plan Components

Critical components that contribute to the successful functioning of compensation wetlands are identified in Table 3. The components generally fall into four categories: design, implementation, maintenance, and time.

Design Components

Soil: Lack of appropriate substrate contributed to lowered functioning of portions of sites 2 and 6. The open water and emergent areas were created by dredging down to till. It appears that the planted emergent species are limited by lack of suitable substrate; growth is restricted, and an increase in the community beyond the planted specimens does not appear to be occurring.

Table 3. Components of Compensation Site Functioning

COMPONENTS OF COMPENSATION SITE FUNCTIONING

1.	Design	Soil	Presence Type Contours/Grading
		Hydrology	Source/Quality Hydroperiod Input Method
		Vegetation	Species Composition Species Diversity Planting Density Placement
2.	Implementation	Quality Control	Grading Contours Erosion Control Timing Species Use/Placement
3.	Maintenance	Type	Irrigation Mowing Replanting Control of Invasives
		Frequency	
4.	Time		

In contrast, vegetation on sites where existing or recovered hydric soils were used (Sites 3, 4, 5 and 8) was more robust. These sites are likely to expand and develop a more extensive community over time.

Hydrology: Inadequate site planning for hydroperiod and water source, including quality and method of conveyance to the wetland, lowered the success of compensation at several sites.

Site 1 receives limited amounts of stormwater from an upland warehouse located over 1,000 feet from the wetland. No direct contamination source exists at the source and the water passes through 300 feet of vegetation-lined ditch. Because the water quantity is limited, water levels within the wetland are very low during winter months, and no standing water is present during the summer season. It is unknown if this site will continue to function over time with this hydrologic regime.

Hydrologic cycles were considered in the design of Site 5; however, the design did not consider the unpredictable nature of deep organic soils. The compensation wetland site has "rebounded" above the designed elevations, thereby lying higher than the average floodplain elevation of the creek. The wetland seems to be under stress due to a lack of sufficient water.

Poorly constructed or designed side slopes and bottom contours in compensation areas has resulted in water regimes beyond the tolerance level of some hydrophytic species. Lack of extensive shallow water zones limits the extent of emergent habitat. Water levels consistently over two feet deep, or areas where the seasonal hydroperiod includes deep flooding to absolute drying, is resulting in species mortality.

Lack of appropriate water levels may be contributing to lack of a natural succession and species diversity within site 8. The area is characterized by deep hydric soil deposits; however, the soils appear quite dry, even during the field visit in the early spring of an exceptionally wet year. Lowering of the site elevation by only several inches might have increased the soil saturation to the level preferred by hydrophytic species. Planted species present are not stressed; however, the lack of saturation may provide for the continued presence and dominance of reed canary grass.

Hydrology at site 3 appears to be appropriate and, as a result, the plant community is developing and functioning well, even though it is very young.

Vegetation: Low planting densities contributed to a lowered potential for vegetation groupings' functioning as a community in sites 2, 4, 5, and 6. Although appropriate species were planted, the specimens were placed at extremely low densities and will likely never mature into a functioning shrub community, unless pioneering species such as red alder "fill in the gaps." There appeared to be a consistent pattern of providing appropriate shrub species, but not providing densities high enough to create a community over a reasonable time frame.

Shrub planting densities on site 5 were much lower than those specified in the plan, and as a result, the shrub community within the wetland has not developed. Species diversity on the emergent portion of this site was low when the site was constructed, and the compensation area has not significantly changed that composition. Reed canary grass totally dominates the emergent zone; other planted emergent species are present in very limited numbers, scattered throughout the area. Although the emergent wetland zone functions as an emergent zone, there appears to have been little increase in functional value, and the target communities were not created.

Appropriate use of plant densities and species diversity likely contributed to higher success of the compensation areas at sites 1, 3, 4, 6, and 8. Portions of site 8 are functioning as planned, specifically, the portions furthest from human disturbance and adjacent to the pre-existing wetland area.

Species placement in a design is critical; often wetland shrub and buffer species were placed on steep fill slopes surrounding the wetland area, so that survivability and success of these plantings is extremely limited, due to lack of appropriate substrate and availability of water.

Implementation Components

In general, implementation was as specified in the plans, with the exception of substitutions with non-native and ornamental species. It is not known how many of the sites were constructed with a wetland ecologist or landscape architect on-site to oversee construction.

Maintenance Components

Lack of proper type or level of maintenance following implementation contributed to lowered functioning of portions of several of the compensation wetlands.

Lack of irrigation at Site 1 likely resulted in some species mortality. Lack of control of invasive species at site 5 and 8 has contributed to limited community functioning.

Active site maintenance on sites 2 and 6 has adversely impacted the functioning of the target communities. Location of compensation sites within areas designed for aesthetics can result in maintenance activities that limit the functional value of the wetland communities.

Shrubs at site 6 are regularly being mowed and are not allowed to grow; elimination of this maintenance would result in development of the shrub area. Mowing, removal of shrubs, clearing of underbrush, and planting of ornamental species all impact functioning to varying degrees.

Time

One criteria for site selection was for sites that had been constructed for as long as possible. The two sites with the longest history (sites 5 and 6) have been constructed since 1986. Most of the other sites averaged less than 2 years; two sites had been constructed for only one year.

Time is a critical factor of compensation functioning that cannot be controlled by design. Most of the sites in this study would provide higher functional value over time if they were allowed to mature and develop complexity in response to natural determinants, not human maintenance activities.

Replacement Ratios

A primary objective of the study was to assess the effectiveness of requiring variable compensation replacement ratios based on the vegetation community type.

The results from this study of a small number of regional compensation sites indicate that while all of the compensation sites are providing some wetland functions, few sites are providing those functions exclusive of the contribution of the adjacent pre-existing wetland. The sites surveyed are a sub-set of compensation sites within the Puget Sound area; it is our opinion that they provide a representative sampling of compensation areas.

The field study found that there was little success in replicating fully-functioning wetland communities. Factors contributing to this lack of success were for the most part, controllable factors, except for one variable: time. All of the compensation areas will function more fully over time. Plant specimens will mature and stable communities will establish as planted and volunteer species combine.

Given the lack of long-term compensation projects to assess, there is no basis for providing a time-line of functional equivalency. The collected data does not allow conclusions regarding which wetland community type can be more easily replicated; as a result, no direction as to appropriate ratio assignments can be provided. A general assumption of wetland professionals is that emergent wetland communities are the easiest to replicate; however, this study did not test this hypothesis.

Because of the lack of quantified data on pre-existing conditions, it was not possible to deduce whether the amount of functional wetland allowed to be eliminated was replaced or compensated for within the compensation areas. In order to assess whether proposed replacement ratios are appropriate, wetland communities lost to development must be quantified and compared to wetland communities successfully created. As mentioned above; it was extremely difficult to find created wetland communities that were providing equivalent functions to established wetland communities.

Within the compensation sites there was often a mosaic of success, i.e., some portions of the compensation area were functioning, while some portions were not. Although all compensation areas were providing wetland functions, most compensation areas were not providing wetland community functional values.

V. CONCLUSIONS

One of the primary objectives of the field study was to determine the effectiveness of compensation in achieving no-net-loss of wetland resources. Effectiveness could be assessed by comparing existing wetland conditions before and after construction, and drawing conclusions as to the net gain or loss of functional value; or by comparison of the prescribed goals of the compensation plans to the achievement of those goals resulting in replication of equivalent functional values.

When assessing achievement of no-net-loss, it is important to consider whether the compensation project created wetland out of non-wetland; restored an area that was historically wetland (i.e., the area was filled or drained, and was no longer functioning as wetland); or enhanced an existing wetland area. Creation or restoration could result in a potential replacement or net gain in wetland area; enhancement may result in an increase of existing wetland functional value but no net gain in wetland area. If the goal is to provide for no-net-loss of wetland, and if a functional wetland is allowed to be eliminated by development proposals, then creation or restoration actions may be of higher priority than enhancement of existing wetland systems.

The compensation plans were proposed and implemented to provide for the replacement or improvement of wetland communities that were permitted to be eliminated. It was outside the scope of this field study to thoroughly determine pre-existing conditions or to determine whether the created compensations represent a replication or improvement of former wetland conditions. Therefore, this field study considered whether the constructed compensation plans met their proposed goals.

During the course of reviewing the proposed goals stated in the compensation plans, it became clear that the goal statements were so general and unspecified that only outright total failure of a compensation wetland area could be interpreted as a failure to meet the goals. Goal statements, when they existed, were generally written to specify the creation of certain habitat types, often with no reference as to size or functional level. Quantified areas were often provided for the entire compensation wetland; in few cases were the areas of target wetland community types broken into separate quantities.

None of the goal statements provided a quantifiable method of determining success. Because the goal statements did not define the target communities by their functional values and spatial dimensions such as species numbers, densities, spatial patterns, and growth patterns, there is no method to determine if the goals have been met.

This lack of clearly discernable and quantifiable goals resulted in an inability to determine "success" and, as a result, provided no means for an agency to request remediation or contingency actions to provide additional functional value.

In field checking the constructed sites, another primary objective was to note whether the created wetland compensation areas were providing wetland functions and whether the proposed target communities were functioning as communities. In general, it was found that all of the compensation areas were providing a variety of wetland functions and values. As noted in the text, the level or amount of function varied significantly, depending on the functional values present within the pre-existing wetland communities and on how well the compensation was designed.

Within this field study, it was not always possible to clearly isolate certain functions provided by the compensation area from those provided by the pre-existing wetland. Wildlife habitat and use was the most critical function that seemed dependent upon the pre-existing wetland and adjacent land uses. For other functions and values (e.g., flood attenuation, water quality impacts, and aesthetics), it was easier to differentiate between those provided by the compensation area from the pre-existing wetland, depending upon the site. Location of the compensation wetland in relation to the source of floodwaters, degraded surface water, or human view, affected the degree and significance of its functioning.

It was important to define what was meant as "functional equivalency" for this study, in order to set some parameters for a qualitative comparison. For the purposes of this field study, it was assumed that a compensation project met the goal of functional equivalency if the target communities within the compensation zone provided the same or better level of functional value as the pre-existing wetland on-site; or the on-site wetland, though degraded, met the functional value of a "representative wetland" community. Using this definition, it was most often found that the target wetland communities were not created, except for the open water components.

Although emergent communities were often present, they were too often severely limited in their extent and complexity, due to the limitations of the considerations during site design. Functional shrub communities were not found within many of the compensation sites, except where the presence of volunteer red alder and willow had filled amongst the planted specimens to provide the dense "brushy" aspect found in more natural wetland communities.

Forested communities did not exist in any of the compensation areas. In one site, where large cottonwood trees had been transplanted along a riparian corridor, the trees were surviving; however, no element of "forest" was yet present. Tree plantings were provided in many sites, but given the relative age of the sites, it is not possible for any forest functional element to have been created.

The study found that the design, implementation, and monitoring of compensation projects are the most critical components in successful compensation functioning. Design considerations include the analysis of soils, grading contours, water source and hydroperiod, and detailed landscaping plans including appropriate native species, planting densities, species groupings, and size of planting zones.

Implementation, monitoring and maintenance of compensation projects was found to be critical for the long-term functions of the site. Routine maintenance of some communities within residential settings was found to significantly reduce the function of the compensation wetland for wildlife habitat.

Beyond the design and follow-up of the compensation plans, the other most significant factor was time. Time may allow many of these systems to stabilize, to increase their species diversity by natural inclusion of volunteers, to increase their spatial complexity with age and natural attrition, and to provide more of the functional values associated with "older" natural wetland systems.

The significance of the time factor should not be diminished; it is an important element that may provide for "success" to be achieved. The passage of time will allow pioneer species to volunteer within a compensation area and to mask the limitations of the planted zones. The natural process of succession and change will occur within the created systems in spite of certain design limitations.

It is critical to note that only one of the eight compensation areas was created on non-wetland substrates. All others were either constructed in existing wetlands or in areas that were historically wetlands. The wetland substrate composition may be a very significant factor in determining ultimate success in compensation plans. Volunteer native species may only colonize sites that have appropriate hydroperiods on appropriate substrates. The one exception was a well-establishing emergent community created on tight compacted upland fill soils; it is not known how this community will function over time.

The level of detailed design contained within the sites reviewed covers a range of compensation designs from the last five years. The design plans ranged from simple bubble diagrams with target community types shown on the drawings and an accompanying list of proposed vegetation species within a text or table; to detailed assessments with engineered calculations of grades, floodplains, and hydroperiod, as well as species composition and position. Unfortunately, the reviewed site that entailed some of the most detailed engineering design was constructed on a deep peat system and did not calculate the natural substrate rebounding within the system; therefore, although the design utilized detailed quantified analysis, a critical factor was overlooked and the site is not functioning as proposed.

It is the opinion of the investigators that with more detailed compensation designs incorporating as many site variables possible, there would be an increased likelihood of success of compensation plans. By providing detailed plans (i.e., grading contours, substrate composition, hydroperiod, species composition, spatial arrangement, nursery species types and conditions, timing of construction and planting), the created systems can more accurately approximate a natural system. If the compensation wetland more accurately mimics a natural system, especially in species composition, extent, and density, then over a reasonable time period, the compensation area will likely begin to approximate more closely the functional values of natural systems.

The results of this field study provide little basis for establishing quantified, variable replacement ratios based on measurable field data. This is due to the failure, in our opinion, of the compensation sites to provide for replacement or replication of the functional values present within a mature wetland community. It is understood that the assessment of failure could likely be reversed over time as sites mature and volunteer species fill in the gaps present in the compensation areas.

Because of the lack of adequate pre-existing data analysis and the lack of quantifiable "success" of the compensation designs, this study does not provide quantified justification for variable replacement ratios. But the lack of quantified justification cannot eliminate the recognition that certain communities require a longer period of establishment before beginning to achieve any functional equivalency. Created forested and shrub communities are limited in their inherent functional equivalency because of the physical complexity required internally before they provide wetland community functions.

The findings of this study of a small sub-set of sites within the central Puget Trough area, does not imply that a 1:1 replacement ratio is appropriate for the goal of no-net-loss of wetland functional value. To the contrary, the findings illustrate that the achievement of functional equivalency, using the methods of these compensation designs and over relatively short time periods, has not occurred. The study further illustrates that due to the inability of many of the compensation sites to achieve functional equivalency, there is an overall net loss of wetland resources.

The one clear effect of requiring variable replacement ratios is the incentive to not impact certain wetland community types. Those communities requiring the greatest ratio of replacement will be the ones most likely to be avoided by applicants where possible, because of the implications of cost and space on a project.

VI. RECOMMENDATIONS

The following recommendations are based on the findings and results of this field study and on the professional experience of the authors. In addition to this study, there are other field studies that corroborate the findings, conclusions, and recommendations of this study. Citations of those studies are included within the references.

The recommendations are formulated based on several consistent findings: first, that a pre-existing conditions assessment is often not conducted or is incomplete; and second, that compensation goals must be provided in some quantifiable manner that allows an accurate determination of subsequent success or failure.

Pre-existing Conditions Assessment

A pre-existing conditions assessment must be conducted for the wetland communities proposed to be eliminated and for the wetland community (if present) located within the proposed compensation zone. This provides a reference, in the future, of the wetland community types eliminated. It also provides for a characterization of the pre-existing wetland (if any) within the compensation zone to assess any change in functions and values. Finally, a detailed assessment of the communities proposed to be lost can provide the quantified description of the target communities to be created.

The assessment must be conducted in a process that <u>quantifies</u> the existing wetland characteristics. For each wetland community present within the wetland, a sample plot large enough to provide for a representative sampling must be established. Within each plot the following data should be collected:

- vegetation listed by percent presence and presence within the community (groundcover, emergent, shrub, sub-canopy, canopy; sapling, mature, dead, dormant, etc.). All species present within the plot or within the greater wetland should be noted, not just species of 20% presence or greater.

- relative spacing of species within the plot; i.e., red-osier shrubs present at approximately 2 feet on center, spirea present in a continuous coverage, Sitka spruce at 12-foot centers;

- relative heights of the vegetation, community complexity, vegetative edge complexity. Relationships of the various vegetation canopy and community compositions; i.e., skunk cabbage located under a red alder canopy, or under a salmonberry/devil's club sub-canopy with an overstory of mixed red cedar and hemlock.

The hydroperiod of the wetland must be determined on a seasonal basis to determine the water fluctuations to which the existing species are adapted. A thorough hydrological analysis, including the source of the water within the system, the method by which it enters the wetland (e.g., surface sheetflow, pipe, stream, subsurface) and whether or not the wetland is a closed depression. Water quality conditions should be established based on field observation of sources, sediment input, and existing or documented conditions.

Soil conditions within the wetland must be established, dealing with whether the system contains parent material or fill, whether it is primarily mineral or organic in origin, relative depths of organic deposits, and the presence or absence of an impervious layer that may be allowing surface water to be perched and exposed.

The functional value of the wetland proposed to be eliminated and within the proposed compensation site (if present) must be provided. At a minimum, the five functions as outlined in this report should be assessed.

A detailed quantified analysis of the square footage proposed to be eliminated, by wetland community type, must be provided. By providing the quantities of wetland communities proposed to be lost, it would be possible to ascertain the success of replacement over time.

By establishing measurable characteristics of the wetland proposed to be eliminated, or, if appropriate, the pre-existing wetland within the compensation zone, one can create a quantified description of the wetland communities targeted to be created within the compensation zone.

If replication of the wetland communities existing on site is proposed, then one must provide a detailed quantified assessment of those communities in order to determine if the compensation goals have been met. If the wetland communities on site are degraded, it may be more appropriate to provide a detailed quantified characterization of an identifiable representative wetland community located off-site, but within the vicinity.

Establishing Compensation Goals and Objectives

The goals and objectives of the compensation must be provided in a manner that allows for the determination of success or failure. As noted, most goal statements are written so broadly as to virtually assure compliance. In order to provide a quantifiable goal, the target communities proposed to be created must be described in detail. The detail is provided by the pre-existing site assessment as described above. The goal is to replicate either the pre-existing wetlands on-site, or the wetlands identified as a representative community (if on-site wetlands are already degraded).

Goals and objectives must include square footage by wetland community type, by plant community species composition percentage, and by relative density (stem spacing or amount of coverage).

Given the fact that success of compensation is determined by time as well as design, a proposed time line should be provided (i.e., years to establish specific height and density, years to replicate specific community). It is understood that such time approximations will be speculative at first, but as the data collection for this science accrues, it will allow for the refinement of these time estimates.

Compensation Plan Design

Based on the assessment of the target community, the compensation design should attempt to replicate that target community to every extent possible. The design must incorporate detailed analysis of substrate composition, grades and elevations, hydroperiod, source of hydrology, potential water quality impacts, sediment sources, and vegetation community composition.

As noted repeatedly, vegetation community composition must include species, and spatial design (percentage of presence, density of plantings, community structure).

Designs must include detailed grading plans, hydrologic analysis and landscaping plans that include planting specifications, sources of material, and a guarantee of plant material availability for large projects.

Implementation

Appropriate timing for planting and construction depends upon site conditions. Obvious factors include grading during the dry season and irrigation during the first growing season. The wetland ecologist and/or landscape architect responsible for the design should be on-site during construction and implementation. Planting of certain materials should be undertaken at optimum seasons, e.g., late fall for woody species to stabilize them before the dormant winter season; spring for some emergent species and for some species that are seeded, to eliminate winter foraging by birds. Timing of plantings is species-specific and site-specific.

Control of erosion and sediment movement during construction and post-construction can be crucial for certain projects.

Maintenance

Follow-up and maintenance should be outlined within the plan. Maintenance may include control of invasive non-natives, irrigation, shrub pruning to promote certain growth habits, removal of dead specimens, planting of quick-growing species to provide shade for less tolerant target species (e.g., planting alder or cottonwood saplings to provide shade for red cedar saplings until the cedar becomes established, and then removing the deciduous trees if desired).

Monitoring

Establish a quantifiable monitoring program that relies on quantified targets: percentage of survivability, percentage of relative species composition within a target community (assuring that the targeted 60% dogwood/40% vine maple has not become 80% willow /20% spirea), and achievement of relative densities.

By establishing quantified standards at the outset, and a relative time-line of compliance, the monitoring element should be able to assess relative success of the compensation plan in achieving its goals.

To summarize, in order to be able to determine whether the goal of replacement has been achieved, it is necessary to establish a quantified assessment of the wetland communities targeted to be created. This assessment is also necessary if the proposed action is to enhance an already existing wetland community. One must be able to describe, in a quantifiable manner, the community that one is attempting to replicate.

Existing stable, functionally diverse wetland communities should be used as models in the establish of standards for the target communities to replicate.

VII. STUDY LIMITATIONS

This field study has provided some valuable insights into the effectiveness of wetland compensation. However, inherent in a study of this size and scope are several limitations.

The compensation sites assessed in this study are a small subset of available compensation sites present only within the Puget Sound Basin. It was outside the scope of this study to field check sites located in the major portion of the state of Washington. It is the opinion of the field investigators that the compensation sites visited actually represent a relatively realistic sample of "typical" freshwater compensation sites designed in the late 1980's within the central Puget Sound region.

The geographic scope of the study was limited by time and resources to the west side of the Cascade Mountains, and was also was limited within the Puget Trough to those areas easily accessible within two days field work (total) and on which pre-existing permit information was readily available.

No attempt was made during the study to review all available development permit files or to identify all possible compensation sites; the number of sites chosen was limited by available field time and a realistic travel radius.

In addition, as noted within the body of the report, site selection was conducted to assess those sites that had been in place as long as possible and for which adequate background data was readily available in the files. Some older compensation sites exist within the study area, but were not assessed due to the lack of readily available background and/or permit data.

Assessments were conducted on a qualitative scale only, as it was beyond the scope of the study to provide for any quantitative assessment of functioning.

Sites were visited only once during this study. Sites were assessed during March, when many plant species are still dormant or just beginning to break dormancy. As a result, ability to assess health of the system, as well as viability and robustness of some species, was limited.

Assessment of the functioning of various plant groups within the entire wetland was limited and might have been different if the site were visited later in the year. For example, shrub functioning may have been underestimated in some wetlands because the shrubs were not leafed out. Evaluations of site functioning over time are speculative and are based on site conditions during the visit and investigator expertise.

Study sites consisted for the most part of younger sites (less than or equal to 2 years of age); very few older sites with adequate background material were located within the current files. A more long-term study would allow the accessing of archived files from the agencies, which would allow for the incorporation of more older sites. The limited number of sites more than two years old with adequate

background data limited the thorough assessment of compensation development and functioning over time.
This age limitation is a reflection of the relatively young "science" presented as wetland compensation. The presence of very broadly defined goals within the compensation plans results in general conclusions that many compensation plans were successful in meeting their goals; this is a reflection of the undefined nature of the goals themselves, and the lack of consensus as to what constitutes functioning.

Although the conclusions that can be drawn from this study are limited, the critical components of important compensation wetland functioning identified during this study are appropriate to be considered during the permitting and design phases of future wetland compensation projects.

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Attachments

Attachment 1: Agency and staff contacts

The following agencies and staff were contacted to provide a list of potential sites:

KING COUNTY, Building and Land Development
Technical Services Section
Tina Miller, Heather Stout, Laura Kaye
Subdivision Products Section
Howard Haemmerle

CITY OF KIRKLAND,
Joan Brill

CITY OF BELLEVUE,
Toni Craemer

ARMY CORPS OF ENGINEERS,
Michelle Walker

Attachment 2 - Compensation Site Field Data Forms

Investigator(s) ______________________ Date _____________

________________________________ County ____________

________________________________ Weather ____________

Site/Project Name ____

Site Location/Address ______________________________________

Was a Buffer Form completed for this site? Y / N When?

1. **PERMIT REQUIREMENTS**

A. Was a pre-existing conditions assessment done? Y / N
Was a report prepared?

B. **PRE-EXISTING VEGETATION SPECIES/COMMUNITY DIVERSITY**

COMMUNITY TYPE	Dominant Species	Comments/Conditions
POW		
PAB		
PEM		
PSS		
shrubs		
herbs		
PFO		
canopy		
sub-canopy		
shrubs		
herbs		

How was the information listed above determined?

C. **TYPE OF COMPENSATION REQUIRED**

	Partial	Entire	Describe
Enhancement			
Creation			
Restoration			

2. **IMPLEMENTATION**

A. Was the compensation implemented? Y / N

B. When?

3. **CONSTRUCTION DETAILS**

A. Was the compensation implemented as specified in the permit? Y / N

B. How much (acreage) compensation was specified? What type of wetland was to be created?

SOILS

C. Were hydric soils used? Y / N

D. If used were they:

a) in situ
b) placed on upland soils

c) recovered from under fill

E. Comments on soil conditions/use.

HYDROLOGY

F. Is the hydrological regime within the Compensation wetland natural or created? If created, describe how.

G. Does the hydrological regime seem appropriate? Why or why not?

H. Is the Compensation Wetland being used for detention/retention purposes? Y / N

I. Was the Compensation Wetland created to provide detention/retention? Y / N

VEGETATION

J. Was the vegetation design appropriate? Why or why not?

K. Were native vegetation species planted within the Compensation Wetland?

L. Was the density of plantings appropriate for compensation? Y / N
Comments.

4. **CONDITIONS ADJACENT TO WETLAND** (within 200 feet)

A. **SIZE OF BASIN**

	Small	Medium	Large
Size of Basin			

B. **LOCATION OF WETLAND IN BASIN**

	Upper third	Middle third	Lower third
Location of wetland in basin			

C. **CURRENT LAND USE ADJACENT TO WETLAND**

Zoning	Use	Percent	Comments/Conditions
Residential			
single family			
multi family			
Commercial			
Industrial			
Business Park			
Agriculture			
Native Vegetation			

D. Historical Land Use Adjacent to Wetland. How was the historical land use determined?

5. **<u>EXISTING</u> WETLAND CONDITIONS** (non compensation wetland)

A. **EXISTING WETLAND TYPE AND SIZE**

Community Type	% Total Wetland	Size of wetland (acres)
POW		
PEM		
PSS		
PFO		
PAB		

B. DOE Wetland Category:

C. **EXISTING WETLAND VEGETATION**

Strata	Species (listed by dominance)
Canopy	
Subcanopy	
Shrubs	
Herbs	
Grasses/sedges	

6. **<u>COMPENSATION</u> WETLAND CONDITIONS**

A. COMPENSATION WETLAND TYPE AND SIZE

Community Type	% Total Wetland	Size of wetland (acres)
POW		
PEM		
PSS		
PFO		
PAB		

B. DOE Wetland Category:

C. **COMPENSATION WETLAND VEGETATION**

Strata	Species (listed by dominance)
Canopy	
Subcanopy	
Shrubs	
Herbs	
Grasses/sedges	

D. **COMPENSATION WETLAND FUNCTIONS**

Wetland Functions	Pre-existing	Goal	Existing
Biofiltration/sediment			
Nutrient uptake			
Habitat Diversity			
Aesthetics			
Flood storage			
Veg. Comm. Diversity			

E. **COMPENSATION WETLAND CONDITIONS**

	Yes	No	Specifics/Comments
Runoff to Wetland/Buffer			
point source			
non point source			
chemical			
physical			
Turbidity in wetland			
Oil/grease			
Erosion			
Siltation (low, med, high)			
Wildlife use			
birds			
mammals			
fish			
amphibian/reptiles			
prey species			
Habitat Features			
snags/cavities			

brush/cover			
food species			
vegetation complexity			

7. **COMPENSATION WETLAND SUCCESS**

A. Are there invasive species present? Y / N Are they competing with the target species? Y / N Describe:

B. Which species appear to be robust, stable?

C. Which species appear to be stressed? Probable cause:

D. Is there debris in the area? (i.e. trash, tires) Describe type and level:

E. Are there other impacts to the compensation wetland? Y / N Probable cause:

F. How much of the compensation wetland is functioning? Describe:

G. Is the compensation community functioning as a viable entity? Y / N

as a community? Y / N

as a part of the larger system? Y / N

H. Were the compensation wetland goals met? Why or why not?

8. **SUMMARY**

A. What aspects appear to be functioning in the compensation wetland? What aspects do not appear to be functioning?

B. What variables were not addressed in the design?

C. Suggestions for improving functioning?

Additional Comments:

Attachment 3 - Field form methodology

The compensation data sheets were designed to collect consistent information on each site regarding pre-existing conditions, permit requirements, design goals and objectives, existing site conditions, and qualitative assessments of success and functioning of the compensation sites. Data sheets were structured to collect both permit file and field data, however all portions of the field data sheets were recorded <u>on site</u>.

Preliminary information was entered into the data sheet before proceeding to the remainder. This information included investigators name(s), date, site name and site location.

<u>Section 1</u> was designed to assess permit requirements and conditions present before the compensation project was constructed. This information was obtained primarily from the permit files, however, in several cases where the investigator was familiar with the site, the information was known.

Pre-existing wetland community types were identified (according to the Cowardin classification), as well as the dominant species present in each strata, if known. This information was obtained from the descriptions of pre-existing site conditions in the permit files.

<u>Sections 2 and 3</u> were designed to describe implementation and construction details. Soil, hydrology and vegetation aspects of the <u>planned</u> compensation were described. This information was also obtained from the permit files.

Several questions in sections 2 and 3 were designed to elicit the opinion of the investigators as to the appropriateness of the various aspects of the proposed compensation. This was strictly an assessment based on the investigators expertise and site conditions.

<u>Section 4</u> was designed to assess land use within 200 feet of the wetland. Basin information can be obtained from USGS topographic maps. Current land use was identified by viewing at the surrounding area.

<u>Section 5</u> addresses existing wetland conditions. The existing wetland was defined as any wetland on site that had not been enhanced, created or restored that was present prior to the construction of the compensation project. If no pre-existing wetland existed, this was noted on the field form and section 6 was left blank. If a pre-existing wetland was present, major community types and dominant plant species within each strata were identified. Total existing wetland size was estimated.

<u>Section 6</u> addresses compensation wetland conditions. The compensation wetland was defined as any wetland specified in the compensation plan for restoration, enhancement or creation. Information described above for the existing wetland was gathered.

This section was also designed to assess functions and conditions of the compensation wetland. Wetland functions existing before the compensation wetland was constructed and the goals of the compensation were obtained from the files (or if the site was known, from investigators expertise). If goals were not specifically outlined in the plan, they were surmised from the information given. Existing wetland functions were identified based on type and conditions of the wetland and the expertise of the investigator.

Conditions of the compensation wetland were assessed by identifying potential or actual runoff to the site, water quality, sediment input, turbidity or erosion. Probable causes were noted. Comments were made regarding each item, if needed.

Wildlife habitat features such as snags, logs, beaver dams, brush, and forage were noted. Actual wildlife use was identified on the basis of observed wildlife, tracks, holes or nests. Some assumptions regarding wildlife use were made based on site conditions. Additional detail was provided when needed.

Section 7 consists of general questions designed to assimilate data collected on the field form and make some assessments of the site. This portion of the form was filled in based on investigators expertise.

Section 8 is a summary section. Probable factors affecting compensation wetland functioning were identified and a general analysis of the wetland system was given. This section provided an opportunity for further comments not solicited from specific questions on the form.

Attachment 4 - Field data site summaries

SITE # 1 **LOCATION:** Airport Road/100th St. SW
THOMAS BROS. PAGE: 42, Snohomish **DRAINAGE:** Pigeon Creek

TYPE OF DEVELOPMENT: Commercial; Warehouse **APPROX. ACRES OF COMP.:** <1

PRE-EXISTING SITE CONDITIONS: Graded compacted upland fill adjacent to existing open water and emergent marshes. No water entering the site except for precipitation and limited sheet flow. Species predominantly weedy pioneers. Hydroseed including scots broom, white clover, thistle, fescue and brome grasses. Within wheel ruts in the fill, trace specimens of cattail, toadrush and daggerleaf rush were present.

COMPENSATION REQUIREMENTS: Remove fill to lower grade by 6-12"; direct stormwater from distant proposed warehouse site through grass-lined swale into wetland; maintain distinct berm between compensation wetland and adjacent existing wetland to west. Plant emergent area with native emergent plugs and seed. Plant transitional shrubs along three sides of wetland to provide buffer from upland.

COMPENSATION GOALS: Create emergent wetland with seasonal shallow water plus protective shrub buffer zone. To NOT provide waterfowl habitat because of the adjacency of Paine Field Airport.

PLANT SPECIES PROPOSED:
EMERGENT: small fruited bulrush, water plantain, smooth rush
SHRUB: red-osier dogwood, willows, spirea

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1989-1990

IMPLEMENTED AS PLANNED? Yes

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Most species called for are present. Site is new, difficult to assess establishment and viability of species.

Does not appear to be any water source to the site.

Microtopography appears highly important on this site. Depressional areas with access to water allow more robust growth of plants.

CRITICAL COMPONENTS OF FUNCTIONING: Shrub and emergent loss in those areas out of the seasonally flooded zone. Plantings most likely not dense enough.

WERE THE COMPENSATION GOALS MET? Yes, except shrub buffer is not robust and provides little buffer at this time.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Yes, an emergent seasonally wet wetland was created; volunteer species are present including daggerleaf rush and american speedwell, narrow leaved cattail, and slough sedge. Shrub zone is stressed and not providing shrub community buffering functions.

SITE # 2 LOCATION: Harbor Pt. Blvd/55th Place W.
THOMAS BROS. PAGE: 47, Snohomish County **DRAINAGE:** Puget Sound

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TYPE OF DEVELOPMENT: Single family residence **APPROX. ACRES OF COMP.:** <1

PRE-EXISTING SITE CONDITIONS: Forested and scrub-shrub wetland area dominated by red alder, western red cedar, willow, red-osier dogwood, douglas spirea, labrador tea, salal, evergreen blackberry.

COMPENSATION REQUIREMENTS: Create open water and emergent wetland by dredging to expose water table.

COMPENSATION GOALS: To increase habitat diversity and provide an open water and emergent wetland component.

PLANT SPECIES PROPOSED: Unknown

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?**

IMPLEMENTED AS PLANNED Unknown

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Open water with scrub-shrub and emergent component consisting of willow, red-osier dogwood, common cattail, and soft rush.

Heavy nutrient input into the system.

Area was dredged to till and as a result the emergent area may never develop to the extent desired.

CRITICAL COMPONENTS OF FUNCTIONING: Lack of hydric soil in emergent zone, high nutrient input into small system.

WERE THE COMPENSATION GOALS MET? Yes, the area is providing habitat and vegetation community diversity.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Yes, they were created, however, the emergent area may never function well due to lack of hydric soil.

SITE # 3 LOCATION: 83rd Ave West/North of 224th St. West
THOMAS BROS. PAGE: 58, Snohomish **DRAINAGE:** Lake Ballinger

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TYPE OF DEVELOPMENT: Single Family Residential **APPROX. ACRES OF COMP.:** 1-2

PRE-EXISTING SITE CONDITIONS: Site was previously fill and historically a sphagnum peat bog. No pre-existing data available.

COMPENSATION REQUIREMENTS: No compensation requirements were available.

COMPENSATION GOALS: Unknown

PLANT SPECIES PROPOSED:
FORESTED: western red cedar, red alder, western hemlock, pine spp.
SHRUBS: willow, evergreen huckleberry, common snowberry, salal, douglas spirea
EMERGENT: labrador tea, sphagnum, swamp laurel, pacific silverweed, common cattail, slough sedge, slender rush, soft rush, lady fern, eleocharis

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1989-1990

IMPLEMENTED AS PLANNED? Not known. Soils were recovered from under fill. Hydrologic function was created to provide flood storage.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Open water, scrub-shrub and forested wetland areas are present. The open water is connected to a relatively undisturbed existing peat bog.

Plant species present are for the most part natives, although several landscaping species are present.

Although the wetland is new, it appears healthy and given similar environmental conditions for a few more years will function very well.

CRITICAL COMPONENTS OF FUNCTIONING: Age of site.

WERE THE COMPENSATION GOALS MET? Unknown. Currently the site is providing biofiltration/sediment retention, habitat diversity, aesthetics, flood storage and community diversity.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Unknown. However emergent and the scrub-shrub areas will probably work given time.

SITE # 4 LOCATION: South of N.E. 175th St. on the Samm. Slough
THOMAS BROS. PAGE: 3, King County **DRAINAGE:** Sammamish River

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TYPE OF DEVELOPMENT: Commercial; Warehouse **APPROX. ACRES OF COMP.:** <1

PRE-EXISTING SITE CONDITIONS: Open water of the slough, emergent and scrub-shrub wetland area totalling 1-2 acres. The wetland was dominated by red-osier dogwood, reed canary grass, and rushes. A portion (.07 acres) of this wetland was filled during construction.

COMPENSATION REQUIREMENTS: Replace and enhance filled wetland by recovering hydric soils from under fill and replanting the area.

COMPENSATION GOALS: To increase species diversity, storm and flood water storage.

PLANT SPECIES PROPOSED:
FORESTED: black cottonwood, western red cedar, western hemlock, vine maple
SHRUB: hazelnut, willow, red-osier dogwood, red elderberry, snowberry, thimbleberry, salal, oregon grape, salmonberry
EMERGENT: yellow flag, soft rush, common cattail, slough sedge, hardstem bulrush

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1989

IMPLEMENTED AS PLANNED? Yes

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
It was not possible to physically access the site, therefore observations were made from an area adjacent to the site. The enhanced area of the wetland consisted of a small dredged area dominated by iris and limited open water. The wetland is still dominated by reed canary grass and the planted shrub species are at such low density that a functional shrub community is not present. Vegetation diversity within the emergent zone may be more extensive than what was able to be determined from a distance. An open water channel was present out to the slough.

CRITICAL COMPONENTS OF FUNCTIONING: The lack of adequate planting densities to create the target communities. The scattered shrubs and several sapling trees will not mature into a shrub/forested community due to the distance between specimens and the competition provided by invasive species such as reed canary grass. Lack of adequate design densities to create the target community.

WERE THE COMPENSATION GOALS MET? Partially; species diversity was introduced, some shallow water emergent community was created, and some structural diversity was provided.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Not completely. The emergent community was functioning by providing habitat for species other than reed canary grass; shallow water was present. The shrub and "forested buffer" community was not present and does not appear likely to be able to develop over time due to lack of species density and competition from aggressive plant species.

SITE # 5 LOCATION: North Creek Parkway and N.E. 195th St.
THOMAS BROS. PAGE: 4, King County **DRAINAGE:** North Creek

TYPE OF DEVELOPMENT: Commercial; Business Park **APPROX. ACRES OF COMP.:** 14

PRE-EXISTING SITE CONDITIONS: Scrub-shrub wetland of willow and black cottonwood on deep organic peat soils. Additional species included reed canary grass, creeping buttercup, velvet grass, orchard grass, brome grass, himalayan blackberry.

COMPENSATION REQUIREMENTS: Realign North Creek through the site, develop an associated riparian border, a scrub-shrub wetland and an emergent wetland. Fill portions of the compensation wetland with peat from other areas on-site to elevate wetland so that salmonids are not stranded during high water events. Compensation acreage totals 14 acres.

COMPENSATION GOALS: The stream and its riparian border were to be developed to provide fish and wildlife habitat and stream shading. The adjacent wetland was to be a rush/sedge/grass marsh that would provide flood storage and wildlife habitat.

PLANT SPECIES PROPOSED:
FORESTED AND SCRUB-SHRUB: willow, red osier dogwood, black cottonwood
EMERGENT: creeping spike sedge, liverwort, Glyceria, common water-plantain, pacific silverweed, water smartweed, slough grass, bent grass

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1986

IMPLEMENTED AS PLANNED? Yes, except several native tree species were replaced with ornamentals; shrubs were not planted at the designed densities within the wetland shrub zone.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
The creek and riparian zone appear to be functioning as designed. The stream bed is developing some diversity and structural integrity, especially with the presence of active beaver dams. The emergent wetland community is totally dominated by reed canary grass to the relative exclusion of all other species. The emergent wetland is essentially dry, except for occasional flooding during extremely large flood events. Planted shrubs are severely stressed or dead, outcompeted by the reed canary grass or the dry conditions. Buffer and transitional species planted along the steep berm sides are severely stressed due to the overdrained conditions. The backwater flooding design element appears to be non-functional except in extreme floods, therefore the emergent community is essentially dry. The emergent wetland community is not functioning as a wetland; species diversity is limited to the extent that the community is essentially monotypic reed canary grass. The shrub community has not developed within the wetland although the riparian zone is filling in and diversifying. Some flood storage is provided within the backwater area, and sediment removal and subsequent water quality improvement does take place. The stream itself has a high sediment load present due to upstream conditions.

CRITICAL COMPONENTS OF FUNCTIONING: Lack of control of final elevations within the proposed emergent wetland. No control on the reed canary grass so that it is so invasive and persistent that even planted woody species have not apparently been able to compete. The extremely well drained conditions on the steep berm slopes has not been conducive to transitional species viability. The shrub zones were not planted at the designed densities, and survival has been severely limited. Irrigation may have been a necessary component in early stages.

WERE THE COMPENSATION GOALS MET? Partially. The stream is more diverse and productive than the historic dredged ditch on site. However, the goal of creating a diverse emergent and shrub wetland community has not been met.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
No. Technically an emergent wetland community was created with dense reed canary grass on deep organic peats. The soil

saturation is likely at the surface with enough frequency to meet the criteria as wetland. However, the area probably provided greater functional value prior to the attempted enhancement.

SITE # 6 LOCATION: Issaquah-Pine Lake Road and 238th Way S.E.
THOMAS BROS. PAGE: 30, King County **DRAINAGE:** East Lake Sammamish

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TYPE OF DEVELOPMENT: Single family residential **APPROX. ACRES OF COMP:** 1-2

PRE-EXISTING SITE CONDITIONS: Area of compensation was formerly wet pasture with likely some shrub community present. Historically grazed and hayed.

COMPENSATION REQUIREMENTS: Dredge old wet pasture, and use recovered hydric soils to create an open water pond, emergent wetland and surrounding open grassy areas. Retain existing forested and scrub-shrub wetland areas.

COMPENSATION GOALS: To provide wildlife habitat, wetland community diversity, flood storage and aesthetics. Use pond for retention/detention.

PLANT SPECIES PROPOSED:
FORESTED AND SCRUB-SHRUB: western hemlock, western red cedar, willow, western crabapple, red-osier dogwood, indian plum, red-flowering currant, evergreen huckleberry
EMERGENT: common cattail, slough sedge, spatterdock, american water-lily, yellow flag
GRASS: colonial bent grass, red fescue, perennial rye grass, white clover

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1986

IMPLEMENTED AS PLANNED? Yes, except that several native tree species were replaced with ornamentals; native species required to be placed in addition to the ornamentals.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
All species required in the plan are present. Many of the wetland and transitional shrubs species are planted on the steep side slope above the wetted zone on the north and east sides of the pond. Most of these are regularly cut down and mowed so the majority of planted shrubs are no longer alive due to impacts of mowing and perhaps lack of water. No scrub-shrub wetland has developed on the north and east edges of the pond margins. The emergent wetland is present as a very restricted band (less than 3 feet wide on average) on portions of the pond margin. Appears that the edge of the pond has a very steep gradient as a result of the dredging, and little if any organic substrate is present in the emergent zone. The open water provides a habitat element that was not present previously, waterfowl and Blue Heron were present. The existing forested and scrub-shrub wetland remain intact to the south. Some emergent portions of the wetland are functioning.

CRITICAL COMPONENTS OF FUNCTIONING: Dredging of the pond did not leave a graduated shallow margin for emergent species to colonize. Deep water near the pond margins may have precluded emergent vegetation. In addition, the soils near the margins are quite gravelly and lack any strong organic component for rooting. Site maintenance has severely impacted the buffer shrub community by repeated mowing and clearing that has now killed the majority of the planted shrubs. Shrub removal may be intentional in order to maintain a view of the open water pond to people driving into the development. Cedar snags left for habitat niches were removed within the first year of the compensation.

WERE THE COMPENSATION GOALS MET? Yes. The pond is providing open water wildlife habitat that was not previously present, the open pond is maintained for its aesthetics, and the wetland area is providing flood storage for portions of the development.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Partially. The open water pond component is present and is being used by wildlife species. The emergent community is present along the very margins of the pond, provides extremely limited habitat value due to small size. The shrub community is not establishing on the majority of the pond margin, however it is present on the west and south pond margins where red alder has colonized. No created forested component is present.

SITE # 7 LOCATION: 148th Avenue SE/SE 183rd Street
THOMAS BROS. PAGE: 42, King **DRAINAGE:** Lower Cedar River

TYPE OF DEVELOPMENT: Single family residential **APPROX ACRES OF COMP:** <1

PRE-EXISTING SITE CONDITIONS: Several small scrub-shrub and emergent wetland areas in a drainage swale dominated by willow, skunk cabbage, slough sedge, douglas spirea, devil's club, pacific water-parsley, lady-fern and creeping buttercup.

COMPENSATION REQUIREMENTS: Construct a 5 to 10-foot wide, 60 to 70-foot long meandering drainage swale to convey 100-year storm events. Enhance drainage swale and allow for wetland development by placing four log weir control structures to provide back-up flow. Over excavate the swale, line with impervious membrane and backfill with peat.

COMPENSATION GOALS: Provide for conveyance of the 100 year storm event, allow development of wetlands and provide biofiltration and sediment removal.

PLANT SPECIES PROPOSED:
SHRUBS: vine maple, red-osier dogwood, black cottonwood, willow, western red cedar, red flowering currant, snowberry
EMERGENT: slough sedge, velvetgrass, soft rush, skunk cabbage, creeping buttercup, red fescue, colonial bent grass

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1990

IMPLEMENTED AS PLANNED? No. Species were substituted and the swale was not constructed to meander; it is straight. Area was not backfilled with peat.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Swale is straight and not undulating as required. Does not allow sediment trapping.

Site is very dry and the densities of plantings is sparse with lots of mortality.

CRITICAL COMPONENTS OF FUNCTIONING: Hydrology is inappropriate, too dry, high mortality, density of plantings is too low.

WERE THE COMPENSATION GOALS MET? Partially. The area is providing flood storage, however the wetlands are not developing and the straight channel does not allow much sediment removal. No species diversity.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
No. Site is very dry and wetlands are not developing as planned.

SITE # 8 LOCATION: 64th Avenue South/James Street
THOMAS BROS. PAGE: 48, King **DRAINAGE:** Lower Green River

TYPE OF DEVELOPMENT: Multi family residential **APPROX. ACRES OF COMP:** 4

PRE-EXISTING SITE CONDITIONS: 12.87 acres of forested, scrub-shrub, emergent and open water wetlands occurring in patches. Dominant species included black cottonwood, red alder, willow, red-osier dogwood, douglas spirea, velvet grass, reed canary grass, creeping buttercup, soft rush, horsetail, spike rush, red-top, bluegrass, and marsh cinquefoil.

COMPENSATION REQUIREMENTS: Enhance 3.54 acres of wetland and create .54 acres of scrub-shrub and open water wetland. Dredge existing soils to create open water. In addition, off-site compensation was required.

COMPENSATION GOALS: Increase wildlife habitat, storage of flood water, and increase the aesthetic value of the site.

PLANT SPECIES PROPOSED:
FORESTED: black cottonwood, red alder, western red cedar, douglas fir, white angel crabapple, red-twig dogwood, willow, yellow twig dogwood, spirea, salmonberry, red flowering currant, vine maple
EMERGENT: yellow flag, common cattail, hardstem bulrush, white waterlily, redtop bent grass, red fescue, meadow foxtail, tall fescue
GRASS: colonial bent grass, red fescue, perennial rye, tall fescue, annual rye, white clover, orchard grass, california poppy

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1988

IMPLEMENTED AS PLANNED? Yes

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Most of the species required in the plan are present. Most of the site wetlands appear to be robust.

CRITICAL COMPONENTS OF FUNCTIONING: Lack of water to a portion of the site, flooding of the littoral area.

WERE THE COMPENSATION GOALS MET? Yes. The wetland is functioning as wildlife habitat, floodwater storage and is providing aesthetic value.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Partially. Scrub-shrub enhancements will probably for the most part be functional. However, the creation may not ever fully function due to elevation of site.

Attachment 5 - Species list

Trees

Alnus rubra - Red Alder
Populus trichocarpa - Black Cottonwood
Pseudotsuga menziesii - Douglas' Fir
Thuja plicata - Western Red Cedar
Tsuga heterophylla - Western Hemlock
Pyrus fusca - Western crabapple
Salix spp. - Willow
Pinus spp. - Pine

Shrubs

Acer circinatum - Vine Maple
Cornus stolonifera - Red Osier Dogwood
Gaultheria shallon - Salal
Ledum groenlandicum - Labrador Tea
Rubus spectabilis - Salmonberry
Sambucus racemosa - Red Elderberry
Spirea douglasii - Douglas' Spirea
Symphoricarpos albus - Snowberry
Rubus discolor - Himalayan blackberry
Ledum groinlandicum - Indian plum
Berberis nervosa - Oregon grape
Rubus laciniatus - Evergreen blackberry
Vaccinium ovatum - Evergreen huckleberry
Cyutisus scoparius - Scots broom
Corylus cornuta - Hazelnut
Rives sanguinieum - Red flowering currant
Cornus spp. - Yellowtwig dogwood

Ferns/Horsetails

Athyrium felix-femina - Lady Fern

Herbs

Lysichitum americanum - Western Skunk Cabbage
Ranunculus repens - Creeping Buttercup
Iris pseudachorus - Yellow Flag
Alisima plantago-aquatica - Common water plantain
Trifolium spp. - White clover
Cirsium spp. - Thistle
Sphagnum spp. - Sphagnum

Potentilla pacifica - Pacific silverweed
Nuymphaia odorata - American water lily
Nuphar polysepalum - Spatterdock
Eschscholzia californica - California poppy
Ricciocarpus nutans - Liverwort

Grasses/Sedges and Rushes

Typha latifolia - Common cattail
Typha augustifolia - Narrow leaf cattail
Agrostis stolinifera - Red-top
Holcul lanatus - Velvet grass
Juncus effusus - Smooth rush
Phalaris arundinaceae - Reed canary grass
Scirpus microcarpus - Small-fruited bulrush
Agrostis tenuis - Colonial bentgrass
Beckmannia syzigachne - Sloughgrass
Polygonum spp. - Water smartweed
Dactylis blomerata - Orchard grass
Scirpus acutus - Hardstem bulrush
Juncus tenuis - Slender rush
Juncus effusus - Soft rush
Festuca rubra - Red fescue
Bromus spp. - Brome grass
Carex obnupta - Slough sedge
Festuca arundinaceae - Tall fescue
Alopecurus pratensis - Meadow foxtail
Poa spp. - Bluegrass
Eleocharis spp. - Spike rush
Equisetum arvense - Horsetail
Lolium perenne - Perennial ryegrass
Lolium tremulentum - Annual rye
Glyceria spp. - Manngrass

Appendix B - Information Sources

Information was obtained from a review of published literature as well as from oral and written personal communications. The following sources of information were utilized:

a. Computer search programs.
AFSA; Enviroline; Water Resources; NTIS; Pollution; Life Sciences; AGRICOLA; and Biosis.

b. On-line library collections.
University of Washington libraries: Natural Sciences; Fisheries; Forestry; Engineering; and Architecture.

c. Existing bibliographies.
King County Sensitive Areas Ordinance Bibliography (1990); "Wetland Buffers: An Annotated Bibliography (Castelle et al., 1992a); "Wetland Compensatory Mitigation Replacement Ratios: An Annotated Bibliography (Castelle et al., 1992b); "Wetlands Protection" (USEPA Bibliographic Series, 1988)

d. Research centers.
Natural Resources Research Institute (Duluth, MN); Center for Wetlands (University of Florida, Gainesville); School for Oceanography (Louisiana State University, Baton Rouge); College of Forest Resources (University of Washington, Seattle); College of Forestry (Oregon State University, Corvallis).

e. Washington state agencies.
Department of Ecology; Puget Sound Water Quality Authority; Department of Fisheries; Department of Transportation.

f. Federal agencies.
Federal Highway Administration; U.S. Fish and Wildlife Service; U.S. Soil Conservation Service; U.S. Forest Service; Environmental Protection Agency; and the U.S. Army Corps of Engineers.

g. State agencies.
California Department of Fish and Game; Oregon Department of Transportation; Idaho Transportation Department; Maryland Department of Natural Resources; Delaware Department of Wetlands & Aquatic Protection.

h. County planning departments.
King; Kitsap; Pierce; San Juan; Snohomish; Thurston; Whatcom.

i. City planning departments.
Auburn; Bellevue; Bellingham; Des Moines; Everett; Federal Way; Kirkland; Redmond; Renton; Tukwila.

j. Professional organizations.
Association of State Wetland Managers; Environmental Law Institute.

k. Environmental organizations.
Audubon Society; Conservation Foundation; Geraldine R. Dodge Foundation.

l. Individuals contacted.
J. Hoffmann, URS Consultants, Cleveland, Ohio; G. Rollins, California Dept. of Fish and Game; P. Dykman, Oregon Dept. of Transportation; D. Evans, City of Eugene Public Works; R.B. Tiedemann, Idaho Transportation Dept.