Appendix A: Sources

INTRODUCTION

Wetlands provide valuable benefits to the ecosystems in which they exist. Each wetland serves some function that has some benefit, although the type and degree of benefit varies from wetland to wetland. Understanding and identifying these benefits and roles is currently limited to qualitative and semi-quantitative judgments and knowledge of potential functions and their benefits. Wetland functions and their assigned human-based values have been identified by many sources in the literature, Cowardin et al. (1979), Adamus et al. (1987), Mitsch and Gosselink (1995), Sather and Smith (1984), and Reppert et al. (1979). They include: ground water recharge and discharge; storm and flood water attenuation and flood peak desynchronization; sediment stabilization and erosion control; water quality improvement through biofiltration and retention of sediments, nutrients, and toxicants; high primary productivity and accumulation of organic material; important nutrient cycling and utilization; food chain support; habitat and structural diversity for fish and wildlife; refuge for threatened, endangered, and sensitive species; and passive and active recreation.

Table 2: Recommended references when planning field work.

Reference	**Source**
USGS topographic maps, 7.5 minute quad	U. S. Geologic Survey, Local libraries and commercial map vendors
NWI wetland inventories by USGS quad, USFW service, 1979.	Washington State Department of Natural Resources, Photo and Map Sales Unit, P.O. Box 47031, Olympia, WA 98504-7031 (360) 902-1234 fax (360) 902-1779
Local wetland inventories	County and City administrative offices, planning divisions
Private sector delineations	Public domain sources
Stream surveys	County and City administrative offices, planning divisions, public works departments
Aquatic resource maps	Washington Department of Fish and Wildlife
Natural Resources Conservation Service (NRCS) soil maps by County	County NRCS extension offices
Aerial photographs	Washington State DNR, Commercial vendors

1.0 FLOOD/STORM WATER CONTROL

Wetlands serve in flood/storm water control through the detention of peak flows within a wetland system and the slow discharge of the water to downstream receiving waters (Carter 1986, Gosselink and Turner 1978). The efficiency of a particular wetland system in performing runoff control is based upon the storage capacity and outlet discharge capacity of the wetland relative to the magnitude of the inflow (Marble 1992, Reinelt and Horner 1991, Stark and Brown 1987). The value of wetlands in reducing downstream flooding increases with an increase in wetland area, the magnitude of the flood, the proximity of the wetland to the flooded area, its position in the drainage, and the lack of other storage areas (Erwin 1990). The continual loss of wetlands within a drainage basin can, therefore, have a cumulative effect resulting in increased flooding (Preston and Bedford 1988). Thus, an important priority of mitigation within a drainage basin is to replace the flood storage capacity that may be lost.

2.0 BASEFLOW/ GROUNDWATER SUPPORT

Wetlands can recharge an aquifer, discharge to a downstream wetland, serve as groundwater discharge, and/or attenuate surface water flows (Erwin 1990). The benefit of groundwater exchange is not well-defined or understood, and the identification of this function usually necessitates intensive data collection (Erwin 1990). Determination of the groundwater exchange character of a wetland is a function of piezometric head relationships and the antecedent conditions including pore size and matrix potential (Hollands 1985), both of which are too detailed to discuss for the purposes of this methodology.

Past hydrologic studies indicate that the majority of wetlands serve predominantly for groundwater discharge (i.e., they are fed by groundwater) and that only a few are recharge systems. Some wetlands however, can function in both modes in some alternating pattern (Sather and Smith 1984). Recharge appears to be more important in small wetland systems where they can contribute significantly to regional groundwater (Mitsch and Gosselink 1993, Weller 1981).

It is known that wetland types can be defined by their hydrologic regime (Gosselink and Turner 1978, Marble 1992, Reinelt and Horner 1990). Changes to that regime result in drastic shifts in vegetation (Day and Megonigal 1993; Niering 1990; Taylor 1993; van der Valk 1994) and, consequently, wildlife composition (Carter 1986, Crawford and Rossiter 1982). Wetlands can provide groundwater recharge or discharge, or provide both, at different times of the year (Harvey et al. 1987). Groundwater recharge replenishes aquifers and filters water. With later discharge elsewhere, it provides a perennial water source for wetlands and provides dry season stream flow, benefitting stream dependent species such as fish (Mitsch and Gosselink 1993).

The degree of saturation or inundation of soils within a wetland is one of the most important factors in the development of wetland vegetation and consequently other biotic features (Reppert et al. 1979, Sather and Smith 1984, Taylor 1993). Vegetation responds to a specific hydrologic regime, described by the depth, degree, and duration of soil saturation. Highly organic soils increase flood storage capacity and likely affect groundwater recharge.

Table 3: Fish species and their sensitivity to low stream flows.

Species Name	Flow Sensitivity
coho salmon	high
freshwater mussels	high
cutthroat trout	moderate

3.0 EROSION/SHORELINE PROTECTION

Erosion control is closely linked with other wetland functions and is most often of concern in wetland systems with water flow sufficient to re-suspend and transport sediments, or in wetlands that have been physically disturbed. Decreased water velocity, vegetative structure, soil root-binding properties and substrate type will lessen the effect of water-related erosion (Carter 1986; Greeson et al. 1979; Sather and Smith 1984). This function is especially present in shallow, flood plain wetlands where velocities are slow and vegetation is dense. Such vegetation is composed of species that are effective traps of sediments, and which impede or slow water flow so that sediments settle out. Erosion and shoreline protection is especially important in riparian corridors where the vegetation can have strong root systems to hold sediments together and prevent loss of stream banks (Erwin 1990, Reppert et al. 1979). This function is not present in isolated wetlands which do not have water flowing through them.

4.0 WATER QUALITY IMPROVEMENT

The morphology of freshwater wetlands provides simple physical processes that remove sediment (Clairain et al. 1985). Flood plain morphology, the length and width of the wetland, landscape characterization, vegetation community structure, and productivity have a great influence on water velocity, type of sedimentation and rate of sedimentation (Mitsch and Gosselink 1993). Particulate materials are removed through settling, which is controlled by water velocity, particle size, the residence time of water in the wetland, physical filtration by vegetation, and substrate (Sather and Smith 1984).

Wetlands remove excessive nutrients, heavy metals, and certain organic compounds through a variety of physical and biological processes (Sather and Smith 1984 and Zedler et al. 1990). The ability of a wetland to perform these functions varies with the nature of the wetland, the degree of disturbance of the wetland (Hemond and Benoit 1988), and according to unusual events and seasonal cycles.

The ability of a wetland system to remove excess nutrients, heavy metals and toxic organic compounds is closely related to other functions such as sediment removal, water quality parameters

(Azous and Horner 2000), wetland hydrology (Day and Megonigal 1993, Lundin and Bergquist 1990), and vegetation community composition, density, richness, structure, and productivity (Kuenzler 1989, Sather and Smith 1984). Water quality parameters such as dissolved oxygen (DO), pH, and total suspended solids (TSS) influence the chemical form and fate of nutrients, metals and organic compounds in wetland systems (Busnardo et al. 1992, Kadlec and Kadlec 1978, Mitsch and Gosselink 1993). Nutrients and other pollutants often bind with suspended sediments and are incorporated into the soils through sedimentation. Nutrients, metals and organics stored in the soils are taken up by vegetation and converted to biomass, which is buried in the sediments as peat is deposited, or exported out of the wetland (Miller et al. 1983).

5.0 NATURAL BIOLOGICAL SUPPORT

Wetlands generally are characterized by high primary productivity (food production that fuels the food chain), compared to adjacent upland and deep water habitats. Food chains are well developed in mature wetlands, species diversity is high and many habitats and feeding niches occur (Erwin 1990). Primary production within wetlands can be important to wildlife and fish that spend part or all of their lives within wetlands. The cycling of nutrients into plant tissues and the export of the photosynthetic byproducts can also be an important source of energy to the different trophic levels of the food chain (Brinson et al. 1981). There are two major energy flow patterns in wetlands: the grazing food chain which involves the consumption of living green plants, and the detrital food chain composed of organisms that depend on detritus and/or organic debris for their food source (Erwin 1990; Zedler et al. 1988). Areas with surface water flow have the potential to export decomposed photosynthetic products beyond the boundary of the wetland (Sather and Smith 1984). Seasonally dry wetlands can also contribute significant biomass to herbivores when they draw down during the dry season. Some wetlands are sinks for the biomass material. Wetlands such as bogs and some fens accumulate plant material and do not contribute the biomass to surrounding systems (Mitsch and Gosselink 1993).

Nutrient cycling in wetlands occurs in both the plants and the sediments. Nutrients can be stored in the sediments by being bound to organic compounds and clays (Mitsch and Gosselink 1993). Saturated/inundated conditions in the sediments prevent the release of nutrients or prolong their residence in sediments (Devito and Dillon 1993). On the other hand, anaerobiosis (lack of oxygen) accompanying saturation is often responsible for releasing phosphorus in a soluble form. Nutrients which are incorporated into plant tissues are unavailable to the ecosystem as long as the plant material is alive. Annual growth in deciduous plants usually dies back at the end of the growing season, and the biomass ends up falling to the ground. The biomass either decomposes and releases the nutrients as dissolved compounds, or stays bound to the organic matter in saturated conditions until the electrochemical conditions become conducive for decomposition. Once the nutrients are released, they become available for uptake by other plants, can be lost to the wetland via discharge downstream from the wetland, or can remain in storage in the sediments, and the cycle continues. The export of vegetative matter can be an important source of nutrients in aquatic systems which are commonly nutrient-limited. Pulses of nutrients, metals and organics occur on a seasonal basis (decomposition during the fall senescent period or erosion during storm events) (Sather and Smith 1984).

Many species of wildlife are adapted to or require wetland habitats for at least a portion of their life cycle (Reppert et al. 1979). The variety of vegetation, substrate types, hydrologic regimes, and the sizes and characteristics of the edge between habitat types are critical factors for wildlife (Sather and Smith 1984). The association between adjacent habitats is especially important in riparian areas which are crucial to many species of wildlife.

Table 4. Wetland community types (Cowardin et al. 1979)

Wetland Type: **(after Cowardin et al. 1979)**	**Wetland type description**
PAB	palustrine aquatic bed
POW	palustrine open water
PEM	palustrine emergent (herbs, grasses, sedges, rushes)
PSS (includes bogs)	palustrine scrub-shrub
PFO	palustrine forested
EST	estuary

Table 5. Invasive Plant species in wetlands and their buffers. (Nomenclature after Cooke, 1998). [Check against King County Noxious Weeds list]

Scientific name	**Common name**
Cirsium vulgare, C. arvense	Common and bull thistle
Convolvulus spp.	Morning glory
Cytisus scoparius	Scot's broom
Hedera helix	English ivy
Ilex aquifolia	Holly
Juncus effusus	Soft rush
Lotus corniculatus	Birdsfoot trefoil
Lysimachia thyrsiflora	Yellow loosestrife
Lythrum salicaria	Purple loosestrife
Phalaris arundinaceae	Reed canary grass
Ranunculus repens	Creeping buttercup
Rubus armeniacus (R. discolor)	Himalayan blackberry
R. laciniatus	Evergreen blackberry
Tanacetum vulgare	Tansy ragwort

Table 6. Productivity of typical Northwest wetland habitats.

Community Types	Productivity
Forested	Low
Forested/ Scrub Shrub	Low
Forested/ Scrub Shrub/Emergent	Moderate
Scrub Shrub	Moderate
Scrub/Shrub/Emergent	Moderate
Emergent	High

6.0 Overall Habitat Functions

Plant species do not occur randomly in wetlands; rather, they occur in distinct communities that are identifiable and often repeated across the landscape. Most species of both plant and wildlife have preferred habitats in specific zones associated with physical gradients such as light, moisture, hydrologic regime and elevation (Adamus 1988; Brinson 1993; Kusler and Kentula 1989; Reppert et al. 1979). High plant species richness is often associated with areas that have multiple habitats in close proximity. Mature wetland systems are characterized by the presence of many niches accounting for high plant and animal diversity. Life cycles of most organisms are long and complex (Zedler et al. 1988). High plant and animal diversity is usually correlated to greater wildlife diversity (Crawford and Rossiter 1982; Greeson et al. 1979; Lesica 1993). Niering (1985) reports that North America has 150 species of birds and 200 species of wildlife that are wetland dependent for at least some stage of their life cycle. This high number reflects the large variety and high diversity of wetlands.

Rare, large or unusual habitats are valuable and should be set aside as sanctuaries. The individual species present may be rare, or the plant community assemblages can be rare (Mitsch and Gosselink 1993, Sather and Smith 1984). The rareness of a wetland community "type" may be due to the lack of particular set of environmental factors, or species distributions in a particular watershed or region. The rarity of a wetland-associated species may be due to the fact that the species is adapted to a specific set of environmental conditions, which may only be present in few places. The opportunity for the species to have appropriate living conditions may therefore be rare. Wetlands may also be differentially lost and rare in a region because particular wetland types have experienced more development pressure or are especially sensitive to human impacts (Stevens and Vanbianchi 1993, Strickland 1986).

7.0 Specific habitat functions

Specific habitat functions relate to habitat for a particular type of plant or creature. In this category, the form questions are self-explanatory.

8.0 Cultural/Socioeconomic

Cultural and socioeconomic characteristics are evaluated from a purely value-based perspective. Establishing the cultural and socioeconomic values of wetlands is probably the easiest assessment performed. Most of the human-use opportunities can be quantified by determining the ownership of the wetland and associated buffer, and the proximity of the wetland to humans who could potentially use the wetland for recreational, or commercial purposes.

9.0 References

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