Draft Operational Guidebook to Assessment of Riverine, Slope and Depressional Waters/Wetlands Functions in the City of Mount Vernon, Washington

DRAFT

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Draft Operational Guidebook to Assessment of Riverine, Slope and Depressional Waters/Wetlands in the City of Mount Vernon, Washington

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Disclaimer

This document is an Operational Draft Guidebook developed specifically to assist in Hydrogeomorphic (HGM) assessment of ecosystem functions of riverine, slope and depressional waters/wetlands within the City of Mount Vernon, Washington. This document was adapted for the waters/wetlands in the City of Mount Vernon using best professional judgment and more than 50 years of local knowledge of the area, but is not based on a single reference dataset at this time. This document is intended to be used in quantifying ecosystem functions in waters/wetlands within the City of Mount Vernon consistent with the City's Critical Areas Ordinance.

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I. Introduction

A. Background

1. Administrative Context and Need for Assessment of the Functions of Waters/Wetlands Ecosystems in the City of Mount Vernon

The Clinton Administration's Wetland Plan (1993) expressed the need for improvement of rapid assessment techniques to allow for better consideration of the functions of waters/wetlands in the context of the clean Water Act (CWA) Section 404 process and in other federal and state programs that focus on waters/wetlands. The Section 404 process as outlined in the 404(b) (1) Guidelines (40 CFR Part 232 and 233) and the U.S. Army Corps of Engineers (Corps) regulations (33 CFR Parts 320-330) is generally comprised of 6 steps:

(1) Establishment of geographic jurisdiction over waters of the U.S.,
(2) Determination of water dependency,
(3) Evaluation of practicable alternatives,
(4) Impact assessment,
(5) Impact minimization, and
(6) Mitigation.

Over the last several years, approximately five percent of all 404 permit applications received nationally require analyses of impacts for proposed projects that invoke rigorous functional assessments.

The hydrogeomorphic (HGM) approach to assessment of wetland functions can be used in the 404 process (1) after waters/wetlands have been delineated on a site, and (2) after determination of water dependency and initial evaluation of practicable alternatives have been completed. Specifically, HGM can be used in comparing practicable alternatives and for impact assessment, impact minimization and mitigation (Brinson 1995, 1996). HGM can be used as an impact assessment and predictive too that can help permit specialists suggest and/or examine alternatives for proposed projects involving waters/wetlands. Furthermore, HGM can also be used to develop and/or condition restoration or creation project targets, and to trigger contingencies when creation or restoration project standards are in jeopardy (Brinson 1995, 1996, Brinson and Rheinhardt 1996).

2. Rationale for Selection of the Hydrogeomorphic Assessment Methodology – Operational Draft Guidebook Objectives

The HGM approach to assessing the functions of waters/wetlands has been developed over the last two decades as a technical tool with specific applications in land use planning, restoration design, implementation of restoration projects, permitting, and monitoring. Some common uses of the HGM approach are:

(1) Land use planning and land suitability assessment,
(2) Project impact assessment and impact minimization,
(3) Restoration design/ prioritization of restoration acquisitions and management, and
(4) Development of monitoring protocols and contingency measures for restoration projects (Brinson 1993a, Brinson et al. 1995).

HGM offers an objective metric to quantify effects of project implementation within a watershed. It serves as a mechanism to compare functional trade-offs of restoration decisions. Additionally, HGM has proven to be an effective tool for facilitating communication among individuals/ groups with divergent goals for management of aquatic resources. At this writing, and consistent with Washington State Department of Ecology guidance regarding implement of Critical Area Ordinances, the HGM approach represents the "Best Available Science" for rapid assessment of waters/wetlands ecosystem functioning.

B. Overview of the Hydrogeomorphic Approach to the Assessment of Functions of Waters/Wetlands

The HGM approach to assessment of functions of waters/wetlands has four essential elements (Brinson 1993a, 1993b, 1995, 1996):

1. Classification of waters/wetlands based upon hydrogeomorphic factors.
2. Identification, definition, and description of the functions for the subclass of waters/wetlands under consideration.
3. Development of a reference system that includes descriptive information about the subclass and the range of variation in structure and function observed within the subclass.
4. Development of assessment models, associated protocols, and definition of functional indices, which establish criteria for the background information necessary to perform a functional assessment.

Each of these four elements is described in the following sections (B.2 - B.5). The inter-agency "National Hydrogeomorphic Implementation Team" recommended procedures for development of regional guidebooks, which incorporates the essential elements of HGM and synthesizes them into a standardized assessment approach for a particular subclass of waters/wetlands (*e.g.*, Brinson 1993a, Smith *et al.* 1995, U.S. Army Corps of Engineers 1997; Federal Register: August 16, 1996 (Vol. 61, No. 160, Pages 42593-42603); Federal Register: June 20, 1997 (Vol. 62, No. 119, Pages 33607- 33620).

1. Classification of Waters/Wetlands – *First Essential Element of HGM*

The first essential element of the HGM approach is the classification of waters/wetlands based upon hydrogeomorphic factors (Brinson 1993a). The purpose of the HGM classification is to provide a characterization of waters/wetlands that is based upon their position in the landscape, geomorphic setting, dominant source of water, and flow and fluctuation of the water. Such intrinsic features are sources of natural variation within each class of waters/wetlands. Classification criteria are described in greater detail in Brinson (1993a).

Seven hydrogeomorphic classes have been identified: riverine, depression, slope, mineral soil flats, organic soil flats, estuarine fringe, and lacustrine fringe. Regional subclasses of waters/wetlands can also be identified (*e.g.*, the Riverine class can be subdivided into according to gradient and/or bed type). Variation within and between subclasses is often attributable to factors such as geomorphic setting, dominant water source, and hydrodynamics (Brinson 1993a). The Mount Vernon HGM models focus on the riverine, slope and depression waters/wetlands classes and subclasses.

2. Identification, Definition and Description of Functions – *Second Essential Element of HGM*

The second essential element of the HGM approach is the identification, definition, and description of the functions of the waters/wetlands of concern. For the purposes of HGM, functions are defined as "processes that are necessary for the maintenance of an ecosystem, such as primary production, nutrient cycling, decomposition, *etc.*" **In the context of HGM, the term "*functions*" is used primarily as a means to highlight the distinction of ecosystem functions from socioeconomic values. The term "*values*" is associated with society's perception of ecosystem functions.** Functions occur in ecosystems regardless of whether or not they have value to society. HGM guidebook authors typically choose to group functions according to broad categories such as hydrologic, biogeochemical, plant community, and faunal support/habitat.

3. Reference Systems – *Third Essential Element of HGM*

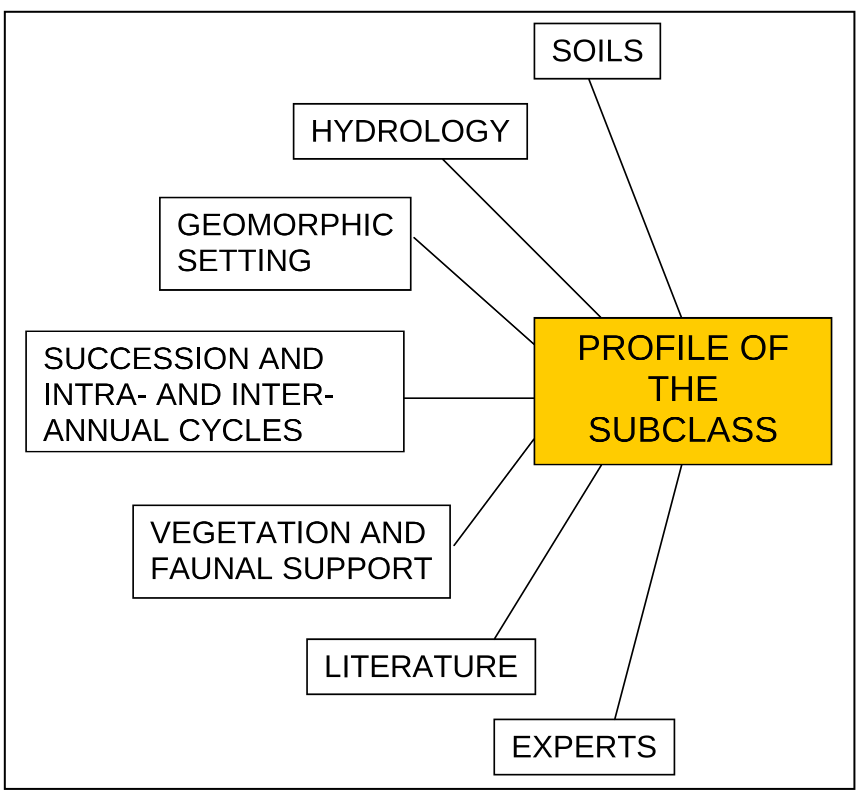
The third component of the HGM approach is establishment and use of a reference system (Brinson 1995, Brinson 1996). The structure of an HGM reference system is shown in Figure 1. To apply the use of reference systems in the context of HGM, it is important to understand the standard definitions presented in Table 1. To the extent possible, the authors have used HGM nomenclature in this Guidebook that is known to be consistent with developing national standards. However, a national HGM nomenclature is still evolving and use of some terms may be inconsistent from region to region.

The subclass profile (Figure 1) is the highest organizational element of the HGM reference system. Users of HGM reference systems commonly access information included in the subclass profile to establish standards for comparison among members of the subclass (*e.g.*, sites of the same subclass within the "Reference Domain" (Smith *et al.* 1995)). Typically HGM users use reference systems:

1. To apply HGM models and thus detect changes in waters/wetland ecosystem functioning,
2. As design templates, and
3. To set monitoring targets and specify contingency measures (Figure 2).

Reference systems are used in the context of HGM to set a standard of comparison and create relative rather than absolute measures to increase efficiency and consistency of measurements.

Figure 1. HGM Reference System Structure



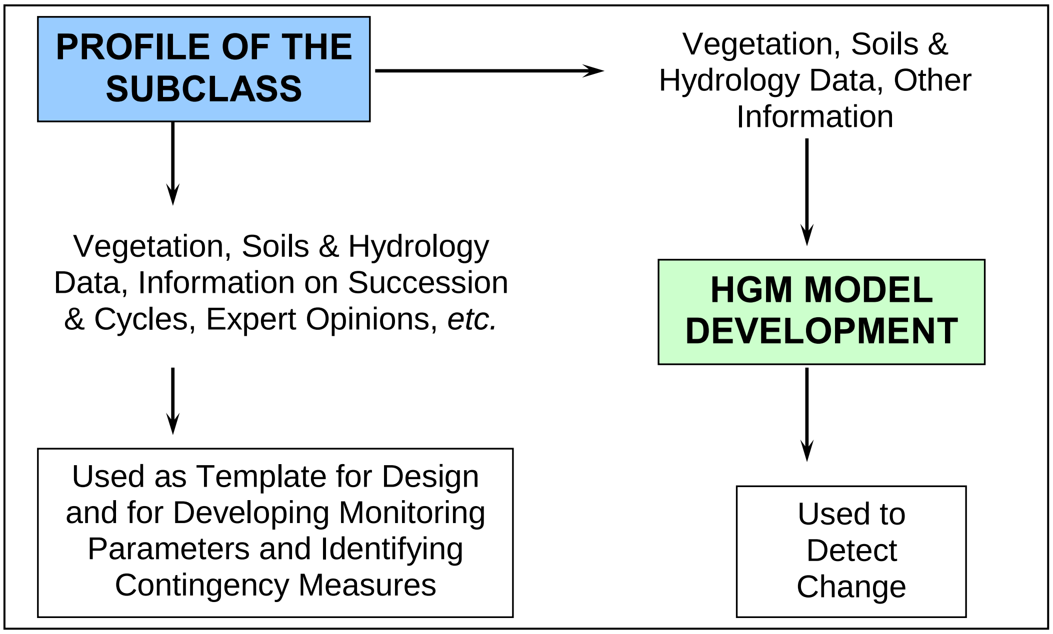
Standards and details concerning development of HGM reference systems are given in the National Reference Guidebook (Smith *et al.* 1995, Smith 2001, Clairain 2002). Briefly, to develop an HGM reference system, an interdisciplinary assessment team (A-team) visits reference sites in a range of conditions (*i.e.*, relatively pristine to highly degraded) in the same biogeographic region and hydrogeomorphic subclass. At each site, the team collects data on physical, hydrologic, biogeochemical, vegetation, and faunal support/habitat community attributes.

When synthesized, interpreted, and combined with the best scientific judgment of the interdisciplinary team, these data serve to indicate the range of ecosystem conditions, functions, and responses to perturbation witnessed by the team within the subclass.

Table 1. HGM Reference System Definitions (after Brinson *et al.* 1995)

REFERENCE TERM	DEFINITION
Reference Domain	All waters/wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass.
Reference Wetland	Waters/wetland sites within the reference domain that encompass the known variation of the subclass. Reference waters/wetlands are used to establish the ranges of variation.
Reference Standard Sites	Those sites within a reference waters/wetland data set from which reference standards are developed. Among all reference waters/wetlands, reference standard sites are judged by an interdisciplinary team to have the highest level of functioning.
Reference Standards	Conditions exhibited by a group of reference waters/wetlands that correspond to the highest level of functioning (highest sustainable capacity) across the suite of functions of the subclass. By definition, reference standard functions receive an index score of "1.0".
Site Potential	The highest level of functioning possible given local constraints of disturbance history, land use, and other factors. Site potential may be equal to or less than levels of functioning established by reference standards.
Project Target	The level of functioning identified or negotiated for a restoration or creation project. This target must be based on reference standards and site potential and be consistent with restoration or creation goals. Project targets are used to evaluate whether a project is developing toward reference standards and site potential.
Project Standards	Performance criteria and/or specifications used to guide the restoration or creation activities towards the project target. Project standards should include and specify reasonable contingency measures if the project target is not being achieved.

Figure 2. Use of HGM Subclass Profiles



In addition to developing a subclass profile, the A-team uses best scientific judgment to determine whether each site is a "reference standard site." Reference standard sites are those that are determined by the A-team to be functioning at the highest level (*i.e.,* highest sustainable capacity) across the suite of functions exhibited within the subclass. "Reference standards" are articulated from data collected at the reference standard sites. Reference standards are those conditions exhibited by the reference standard sites that correspond to the highest level of functioning. In the HGM approach, reference standards are used to construct functional profiles of the waters/wetlands subclass and to set the standards that allow development of HGM models.

Ideally, all of the waters/wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass constitute the *reference domain*. However, practical limitations of funding, personnel, and access usually do not allow sampling of all waters/wetlands within the defined region. Therefore, the reference domain is envisioned as both the actual waters/wetlands sampled to build the reference system, and the geographic area within which reference sites for a regional waters/wetlands subclass have been sampled. Where sampling of additional reference sites could be used reasonably to expand the sampled reference domain (*e.g.*, within a single biogeographic region), one can infer a "potential reference domain." The potential reference domain thus constitutes the sampled reference domain plus the pool from which additional reference sites might be selected to expand the sampled reference domain.

4. HGM Assessment Models, Protocols and Definition of Functional Indices – *Fourth Essential Element of HGM*

The fourth essential element of the HGM approach is development of assessment models for the HGM functions. After defining the ecosystem functions that waters/wetlands within a subclass perform, the assessment models and definitions of functional indices can be developed. A functional capacity index (FCI) is an estimate of the capacities of the waters/wetlands within a subclass to perform those functions (Smith *et al.* 1995). The assessment protocol is the how-to portion of the model, defining minimum information requirements and sampling techniques.

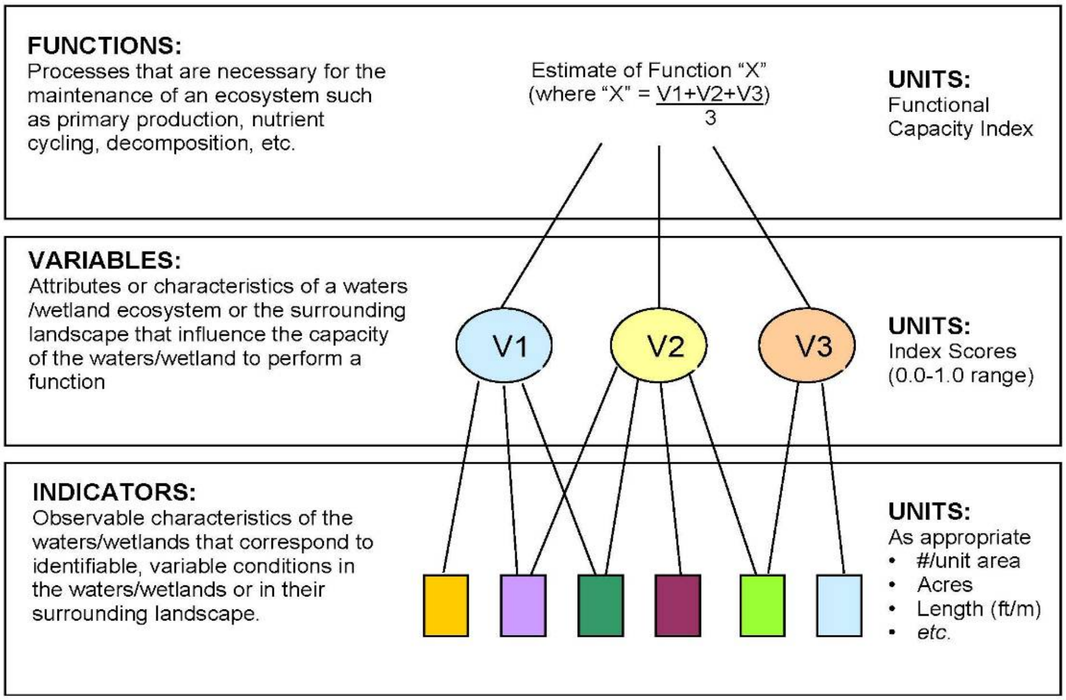
To develop assessment models for the functions associated with a regional waters/wetlands subclass, variables must be identified, defined, and scaled using data from the reference system. ***Variables* are defined as the attributes or characteristics of a waters/wetland ecosystem or the surrounding landscape that influence the capacity of a water/wetland to perform an ecosystem function or a set of functions.** For example, in sub-basins within Mount Vernon, the condition of the Flood Prone Area affects "channel and forest interactions." Whether the channel is constrained by levees, rip rap, *etc.* or not dramatically affects how natural channel migration processes function. At each project assessment area, a variable may be operating or expressed to a greater or lesser degree, depending upon land uses, degree of disturbance, *etc.* Hence, variables are usually observed to relate directly to the degree of anthropogenic perturbation on a particular site. In the field, variable conditions are either measured directly (*e.g.*, tree stem density) or indirectly through the use of "field indicators" (*e.g.*, microtopographic roughness as approximated by the number of pits of a certain size capable of storing ponded water). Specifically, field indicators are observable characteristics of the water/wetland that correspond to identifiable variable conditions in the water/wetland or in the surrounding landscape.

Finally, variables must be combined into assessment models. **An HGM model for a particular function is usually expressed as a simple formula that combines variables in certain ways to yield an estimate of a *functional capacity index* (FCI).** In a complete guidebook, the relationships among variables that are combined to develop an FCI have been clearly established, and they are based on analyses of reference data and best professional judgment for each subclass (Figure 3). By definition, FCI values range from 0.0 to 1.0, and reference standard sites yield FCI values of 1.0. Therefore, highly degraded waters/wetlands may yield an FCI of 0.0 (*i.e.*, unrecoverable loss of ecosystem function). Thus, an FCI is an estimate of the function performed by a water/wetland with respect to reference standard conditions.

5. Assessment Protocol

The final step in development of an assessment model is development of assessment protocols for users of the HGM model. The assessment protocol establishes criteria for the background information necessary to perform a functional assessment, and provides instructions for the measurement of variables in the field and subsequent calculation of FCI's. Use of assessment protocols establishes minimum requirements for valid use of models and thus helps ensure their unbiased, consistent application. More details on the assessment protocols developed in this guidebook are presented in the "HGM Applications" section (Chapter VI).

Figure 3. Structure of an HGM model.



C. Scope of the Draft Guidebook

1. Reference Domain ─ Definition and Geographic Extent

The geographic reference domain for this guidebook includes the area within the incorporated limits and growth management area of the City of Mount Vernon. Reference sites include riverine, slope and depressional waters/wetlands within this reference domain, encompassing the known variation of each subclass. Reference waters/wetlands are used to establish the ranges of variation.

2. Geographic Extent of Potential Reference Domain and Applicability of the Guidebook to Similar Regions

This Guidebook is designed for waters/wetlands within the City of Mount Vernon, but is potentially applicable in areas of similar terrain in the Puget Sound Lowlands.

II. Characterization of Waters/Wetlands Ecosystems within the City of Mount Vernon

A. Overview and Description of Mount Vernon

The City of Mount Vernon, Washington lies within the Skagit River Valley at elevations ranging up to approximately 200 feet above sea level. Mount Vernon occupies approximately 11 square miles (~7,260 acres) within the Skagit River watershed. Nine watershed sub-basins exist within the city: Carpenter Creek, Britt Slough, Kulshan Creek, Maddox Creek, Nookachamps Creek, Trumpeter Creek, Skagit River, Combined Sewer, and West Mount Vernon.

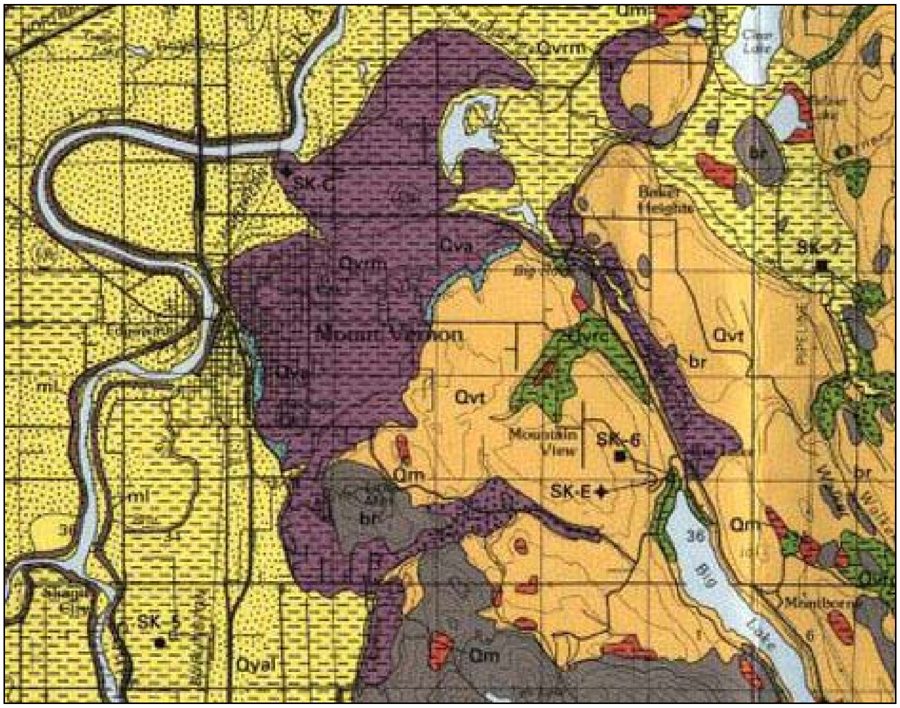
With an estimated population of over 28,000 people, the City of Mount Vernon is in the midst of an era of urbanization. Natural environments within the city face pressures of urbanization and growth from both past and current development, and the environmental conditions within the nine sub-basins reflect these patterns of growth. A range of watershed conditions exist across sub-basins. Common impacts of urbanization include decreasing buffer widths, decreasing canopy cover, decreasing woody debris in the understory, an increase in non-native species, and an increase in impervious surfaces. Three sub-basins (Carpenter Creek, Maddox Creek, and Nookachamps Creek) are currently relatively less disturbed than the others due primarily to lower population densities. The remaining six sub-basins have experienced more significant growth and are marked by greater environmental impacts.

1. Geomorphic Setting

The City of Mount Vernon is located in the Puget Sound Lowland domain. Major geologic influences in this area include plate tectonics, glacial advancement and recession, and volcanic activity. Dominant surface features and topography of the Puget Lowland can be attributed to the most recent ice-sheet advance (known as the Vashon stade of the Fraser glaciation) which culminated around 16,000 years ago. As glaciers receded from Washington around 13,000 years ago, glacial deposits 60 meters thick or more were left behind. Subsequently, post glacial modifications, primarily from fluvial processes, began creating the landscape features that are present today.

Much of the Puget Lowland is a glacial drift plain with Vashon till and glacial deposits at or near the surface. A *drift plain* is defined as an area where glacial deposits remained as the glacier retreated. Major geologic landforms within the City of Mount Vernon are composed of glacial till, recessional marine glacial deposits and alluvium (Pessl *et al.* 1989). Within Mount Vernon these three features lie roughly in this order in 3 bands according to elevation in a southeast to northwest direction (Figure 4). Glacial *till* refers to "unsorted sand, gravel, silt and clay deposited beneath the ice sheet" while *recessional deposits* refer to "well-sorted sand and gravel deposited by streams draining from the ice as the ice sheet receded, as well as silt and clay deposited in lakes dammed by the receding ice" (Booth *et al.* 2003).

Figure 4. Geological landscape in Mount Vernon.



(Abbreviations are as follows: Qyal = Younger alluvium (Holocene); Qvrm = Deposits of the Vashon Stade of the Fraser Glaciation, Recessional Marine Deposits; Qvrc = Deposits of the Vashon Stade of the Fraser Glaciation, Recessional Continental Deposits; Qvt = Deposits of the Vashon Stade of the Fraser Glaciation, Till; Qva = Deposits of the Vashon Stade of the Fraser Glaciation, Advance Outwash Deposits; Br = Bedrock)

Glacial drift (including till and recessional deposits) dominates higher elevations in the City of Mount Vernon. In this area, glacial till (Qvt) is composed of poorly sorted (unstratified) rock fragments along with finer components of silt, sand and clay that were deposited directly by the Vashon-age ice sheet. Till thickness probably averages between three and 15 meters (Pessl *et al.* 1989). This layer of till overlies raised bedrock formations; bedrock can be observed at the surface directly southeast of the city limits. Recessional marine deposits (Qvrm) are composed of fossil-bearing stony silt, sand, and clay and medium to well-sorted massive to laminated sand, silt and clay. This layer is approximately 15-18 meters thick near Mount Vernon along the border with alluvial bottomland (Pessl *et al.* 1989).

At lower elevations, alluvium within the Skagit River valley dominates the geological landscape. The Skagit River transports water from its mountainous watershed (Collins and Sheik 2003), through Mount Vernon to the Skagit River Delta where the water reaches the Puget Sound. In all, the Skagit River watershed covers approximately 7800 km^2. Alluvium (Qyal) along this flood plain consists of moderately well-sorted silt, clay and sand with some pebble gravel. Layering of particle sizes and organic matter within the alluvium depicts the fluvial history of the Skagit River. This alluvium layer ranges from one to ten meters deep near Mount Vernon. Paleogeography suggests that the Skagit River delta front was near Mount Vernon about 5,000 years ago and that the confluence with the Puget Sound has moved westward through time to where it currently lies today (Dragovich *et al.* 2002, and references therein). Lahar (pyroclastic material mixed with water) flows originating from Glacier Peak traveled through the Skagit River valley and extended the delta southward between 6,300 and 5,900 years ago.

Currently, the lower reach of the Skagit River is constrained by dikes and levees from just west of Sedro Woolley to the delta near Puget Sound. The residential areas and cropland on valley alluvium within the floodplain are protected from flooding which occurs approximately once every 14 years (Klungland and McArthur 1989).

2. Climate

The Puget Lowland has a mild maritime climate with cool and comparatively dry summers contrasted with wet and cloudy winters. In Mount Vernon, the average summer temperature is 61 °F while the average winter temperature is 40 °F (Klungland and McArthur 1989). The average daily minimum temperature is 73°F in summer and 34 °F in winter. The average relative humidity in the afternoon is about 60 percent and is typically somewhat higher at night averaging about 80 percent at dawn. Total average annual precipitation is 32 inches with only 30 percent of this falling between April and September during the growing season. Average snowfall is seven inches in Mount Vernon with snow remaining on the ground for only about four days per year. The sun shines 65 percent of the time in summer and 25 percent in winter. The prevailing wind is from the southwest. Average wind speed is less than ten miles per hour. In Mount Vernon, the growing season lasts from March 1 through November 14, a total of 257 days (NRCS 2002).

3. Soils

Mount Vernon lies within two general soil map units: the flood plain dominated Skagit-Sumas-Field soil unit and the upslope Bow-Coveland-Swinomish soil unit (Klungland and McArthur 1989). The Skagit-Sumas-Field soil map unit is composed of very deep, poorly drained and moderately well drained, level and nearly level soils (slope 0 - 3%) on the Skagit River floodplain. The Bow-Coveland-Swinomish soil map unit contains moderately deep and very deep, somewhat poorly drained and moderately well drained, level to steep soils on the terraces and hills. The distribution of soils as mapped by the Natural Resource Conservation Service (NRCS) is depicted in
Figure 5. Table 1 describes characteristics of soils found within the city of Mount Vernon.

Where development has not left a mosaic of fill and disturbed urban land soils, the parent material along the Skagit River floodplain is primarily alluvium and volcanic ash outfall. Parent material within the upper reaches of the sub-basins and along hill slopes includes volcanic ash and loess overlying glacial till and glaciolacustrine sediment. Till can be compacted and silica-cemented to form a relatively impermeable layer in the soil profile causing a perched water table which can result in depressional or slope wetlands. Many of the soils within this area are classified as hydric or are known to have hydric inclusions within the mapped unit (Table 2).

Figure 5. Soils classification for Mount Vernon (Klungland and McArthur 1989).
Note: Table 2 provides details of soil types displayed in this figure.

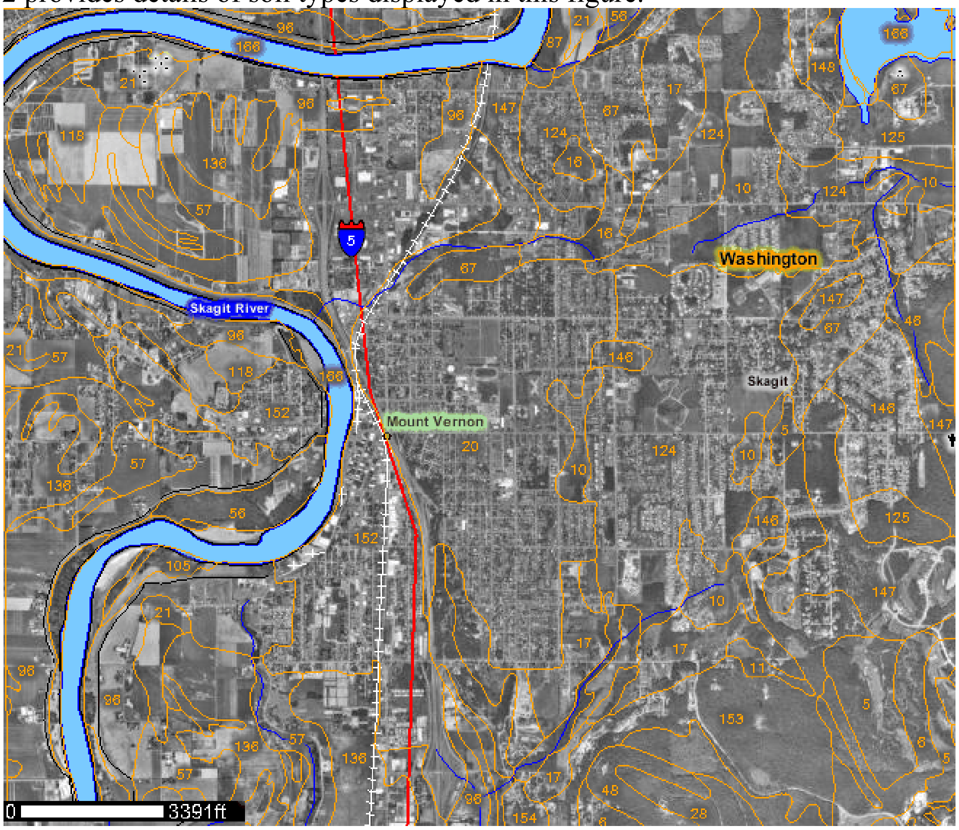


Table 2. Soil unit names and map unit designations of ten predominant soil units within the city of Mount Vernon.

Map Unit	Soil Unit Name and Description	Hydric soil
5, 6	Barneston gravelly loam, 0 to 8 percent slopes	Hydric Inclusions
10	Bellingham silt loam	Yes
17, 20	Bow-Urban land complex, 0 to 8 percent slopes	Yes
57	Field silt loam, protected	Hydric Inclusions
67	Hoogdal silt loam, 8 to 15 percent slopes	No
96	Mt. Vernon very fine sandy loam	No
124	Skipopa silt loam, 0 to 3 percent slopes	Hydric Inclusions
147	Tokul gravelly loam, 8 to 15 percent slopes	No
152	Urban land-Mt. Vernon-Field complex	No
153	Vanzandt very gravelly loam, 0 to 15 percent slopes	No

4. Vegetation Communities

Mount Vernon lies within the Western Hemlock Vegetation Zone as defined by Franklin and Dyrness (1973). The Western Hemlock Zone is dominated by the Western hemlock-Western red cedar climax community and the Douglas fir subclimax community. The *climax community* (*e.g.,* Western hemlock) is an ultimate steady state forest community that will not be replaced without non-natural disturbance; a *subclimax community* (*e.g.*, Douglas fir) may be replaced with Western hemlock over time. In other words, Douglas fir is an earlier successional species than Western hemlock; if sufficient time without disturbance is allowed, the Douglas fir dominated forest may transition to a forest dominated by western hemlock. Western red cedar is a common tree associate in wetter areas.

Within the Western Hemlock Vegetation Zone of the Puget Lowlands, a mosaic of specific plant community associations exists. A minimum of three major forest types can be described within the Western Hemlock Zone: Western Hemlock/Sword Fern, Western Hemlock/Cascade Oregon Grape, and Douglas Fir/Salal (Kruckeberg 1991). Depending on scale of classification and methodology, numerous other specific associations can be defined within the Western Hemlock Zone.

In the Mount Vernon area, red alder is prominent in forests areas which have been cleared in the past as red alder is quick to regenerate. Nearly all of the forests have been cut at some point in the past. Low gradient areas around Mount Vernon may be dominated by scrub-shrub forest combinations. Big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*) and flowering dogwood (*Cornus sericea*) are common floodplain and stream edge species that can also become established where fire or clearcutting disturb the coniferous canopy in more upland areas. Big leaf maple is also an early colonizing species in disturbed areas, but it is restricted to slopes and flats that are somewhat wet.

Some common understory shrub species include salal (*Gaultheria shallon*), Cascade Oregon grape (*Berberis nervosa*), salmon berry (*Rubus spectabilis*), red huckleberry (*Vaccinium parvifolium*), and Scouler's willow (*Salix scouleriana*). Common herbaceous species include sword fern (*Polystichum munitum*), giant horse tail (*Equisetum telmateia*), scouring rush (*Equisetum hymale*) and skunk cabbage (*Lysichitum americanum*).

Wetter areas can often be discovered by observing the dominant plant species. For example, western hemlock and western red cedar forests are commonly found adjacent to stream corridors. In the understory, salmon berry often occurs in wet areas, primarily on soils with a hard pan and in seeps. Extremely wet areas may have a dense covering of skunk cabbage. Redosier dogwood and black twinberry are indicators of very wet areas. Douglas fir is more common at slightly raised elevations and in hummocks.

5. Fish and Wildlife Resources

The Mount Vernon area hosts a wide range of estuary- and riparian-dependent species. Native fish found in streams and rivers near Mount Vernon include surf smelt, sand lance, Pacific herring, three-spine stickleback, lamprey; Chinook, pink, chum, coho, and sockeye salmon; sea-run cutthroat trout, steelhead, and bull trout (Garrett *et al*. 2006). The Skagit River is the only river system in Washington which supports all five species of salmon and steelhead. This river hosts six of the region's 22 populations of threatened Chinook salmon and the largest population of listed bull trout. In addition, the Skagit River hosts steelhead runs and the largest pink salmon stock in Washington.

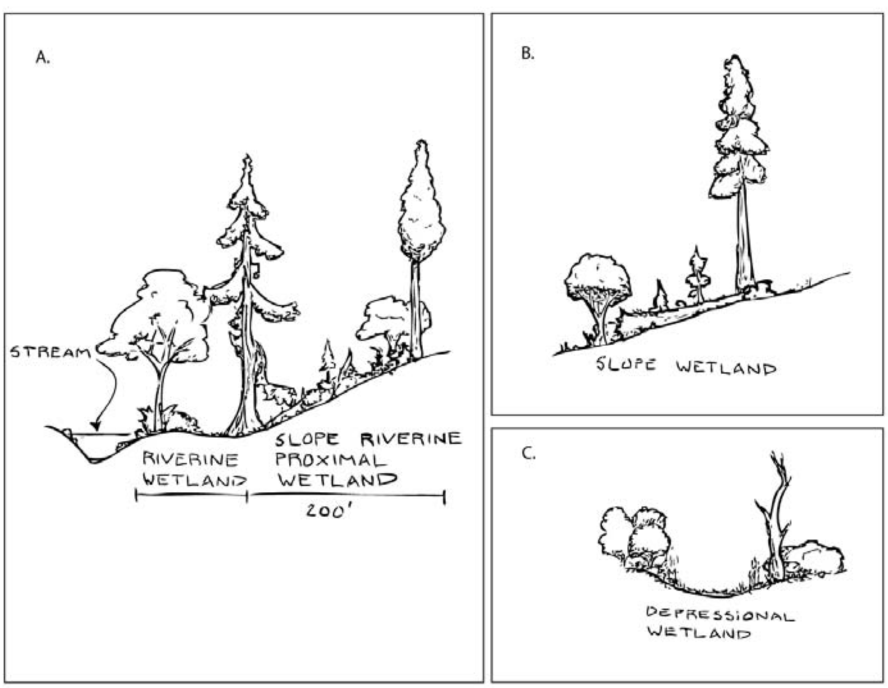
The Skagit River Valley is a major stop on the Pacific Flyway, supporting 190 species of birds (Garret *et al*. 2006). Wintering birds include bufflehead, ring-neck duck, greater and lesser scaup, pintail, mallard, gadwall, widgeon, green and blue wing teal and greater Canada goose, as well as trumpeter and tundra swans. Migrating waterfowl including snow geese, Brant, canvasbacks, grebes, and loons pass through the area annually. Many shorebirds also pass through the Mount Vernon area each year. Raptors including bald eagles, peregrine falcons, northern harriers, red-tailed and rough-legged hawks, short-eared and barn owls, and occasionally golden eagles, gyrfalcons, snowy owls, and merlins are attracted by the abundance of prey found in or near Mount Vernon (Garret *et al.* 2006).

Approximately 40 species of mammals live in the area, including black-tailed deer, coyote, raccoon, opossum, skunk, cottontail rabbit, bats, beaver, muskrat, river otter, red fox, weasels, mice, shrews, and moles (Garrett *et al.* 2006). A number of reptiles and amphibians reside in the area, including the garter snake, alligator lizard, western pond turtle, several species of salamander, rough-skinned newt, northwestern toad, and Pacific tree frog. Invertebrates found include various shrimp, clams, insects, and worms (Garrett *et al.* 2006).

B. Landscape Position of Riverine, Slope, and Depressional Wetland Ecosystems in the City of Mount Vernon

Three wetland classes have been identified in Mount Vernon: riverine wetlands, slope wetlands (including slope riverine proximal), and depressional wetlands (Figure 6). These wetlands differ in their position within the landscape, hydrology, and plant community. These wetland classes are described in detail below. A dichotomous key is provided in the next section to assist in identifying and distinguishing between wetland classes within the City of Mount Vernon (Table 3).

Figure 6. Wetland types observed within Mount Vernon.

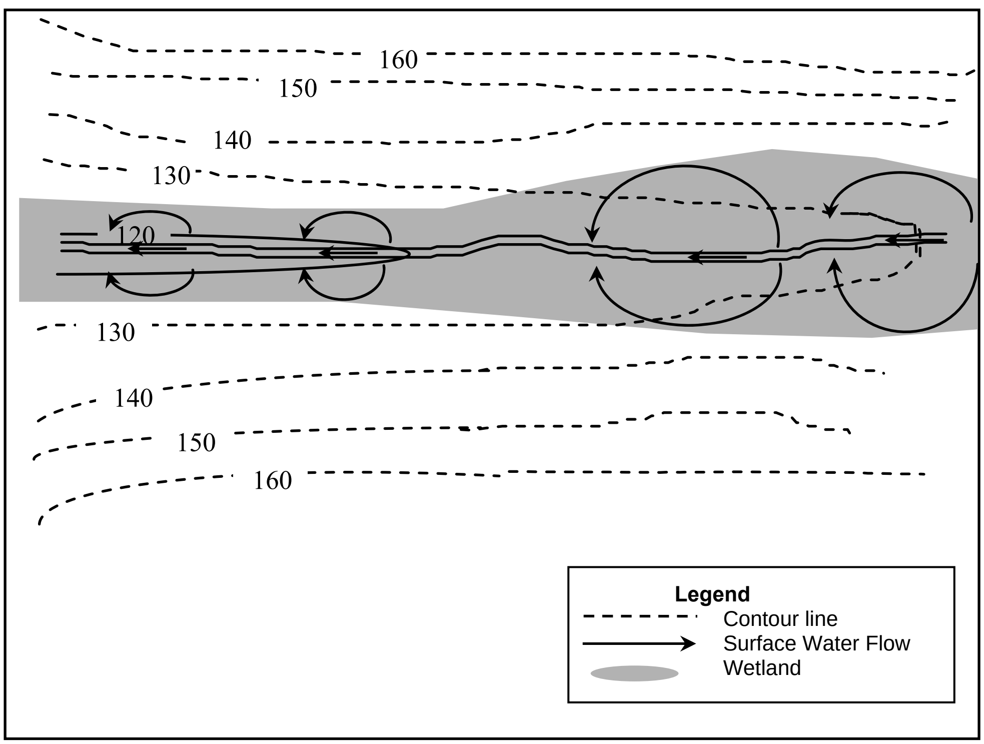


1. Riverine Wetlands

Riverine waters/wetlands occur in floodplains and riparian corridors in association with stream channels (Figure 6a and Figure 7). Riverine wetlands mediate flooding by detaining water during storm events and releasing it more slowly by flow through the saturated subsurface that discharges to the stream channel. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional water sources may be groundwater discharge from a surficial aquifer, overland flow from adjacent uplands and tributaries, and precipitation. When overbank flooding occurs, unidirectional horizontal flows dominate hydrodynamics. Streams mapped as solid or broken blue lines on U.S. Geological Survey 7.5 minute topographic maps (scale 1:24,000) usually are associated with riverine waters/wetlands.

Riverine wetlands occur within valley bottoms along the floodplain and along the riparian corridor. At their headward-most extension, riverine waters/wetlands often begin as depressional or slope wetlands where channel (bed) and bank disappear, or they may integrate with or transition from poorly drained flats or uplands.

Figure 7. Riverine wetland in a valley during a flood.



Within the City of Mount Vernon, riverine waters/wetland ecosystems are divided into four sub-classes based on gradient and channel geomorphology. The subclasses include:

1) Steep gradient (>10% slope) colluvial cascade reaches in the upper headwaters of each subbasin,
2) Moderate gradient (2-10%) step pool reaches which downcut through glacial till,
3) Low gradient (1-2%) plain bed, pool-riffle reaches of tributaries to the Skagit River, and
4) Low gradient (<1%), alluvial reaches in the mainstem of the Skagit River.

2. Slope Wetlands

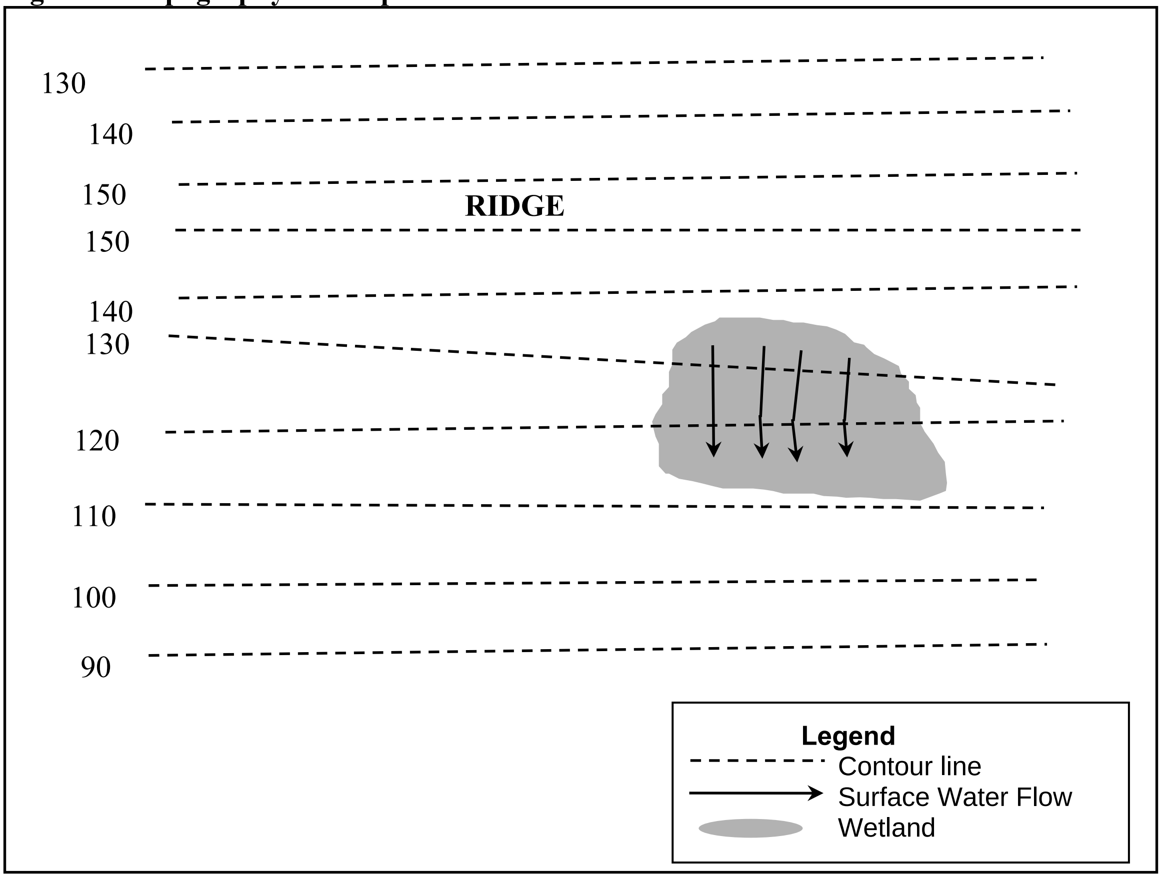
Slope wetlands occur where groundwater discharges toward the land surface. Slope wetlands occur on steep hillsides and on low gradient hillslopes to nearly flat slopes that are incapable of depressional storage because they lack closed elevation contours. Principal water sources are usually groundwater return flow, interflow from surrounding uplands, and precipitation. Hydrodynamics are dominated by down slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturation subsurface and surface flows and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Seeps and fens are common examples of slope wetlands.

Slope wetlands occur where groundwater discharges toward the land surface. Typically, groundwater reaches the surface when soil layers have different permeability causing a perched water table and when a change in gradient brings the water to the surface. These commonly saturated areas are typically referred to as seeps. Slope wetlands provide a connection between uplands and wetlands. Therefore, maintenance of longitudinal connections and landscape connectivity for slope waters/wetlands is fundamental to maintaining their function.

Within the landscape in Mount Vernon, slope wetlands occur in two geomorphic positions: 1) slope riverine proximal wetlands and 2) slope wetlands. Slope riverine proximal wetlands are topographically and hydrologically adjacent to riverine wetlands (Figure 6a). By definition, slope riverine proximal wetlands extend 200 feet upslope beyond the boundary of riverine wetlands and have a surface or shallow subsurface hydrologic connection with the river. The lower extent of a slope riverine proximal wetland includes the portion of the landscape immediately above the flood prone area of the active river channel and/or the intergrade to the estuarine geomorphic subclass. Slope wetlands are isolated from riverine wetlands (meaning they are not functionally, hydrologically or topographically connected) and are beyond 200 ft upslope of riverine wetlands (Figure 6b, Figure 8).

Slope wetlands often form due to the geology and soil profile at a particular location. Within the city of Mount Vernon, *hard pans* (a layer with low permeability) are present in some soils (*i.e.* Tokul series). Silica-cemented glacial till with very low permeability is overlain by volcanic ash and loess with higher permeability. This hardpan causes a perched water table which may direct water toward the surface when slope gradients change resulting in a seep (a type of slope wetlands).

Figure 8. Topography of a slope wetland



3. Depressional Wetlands

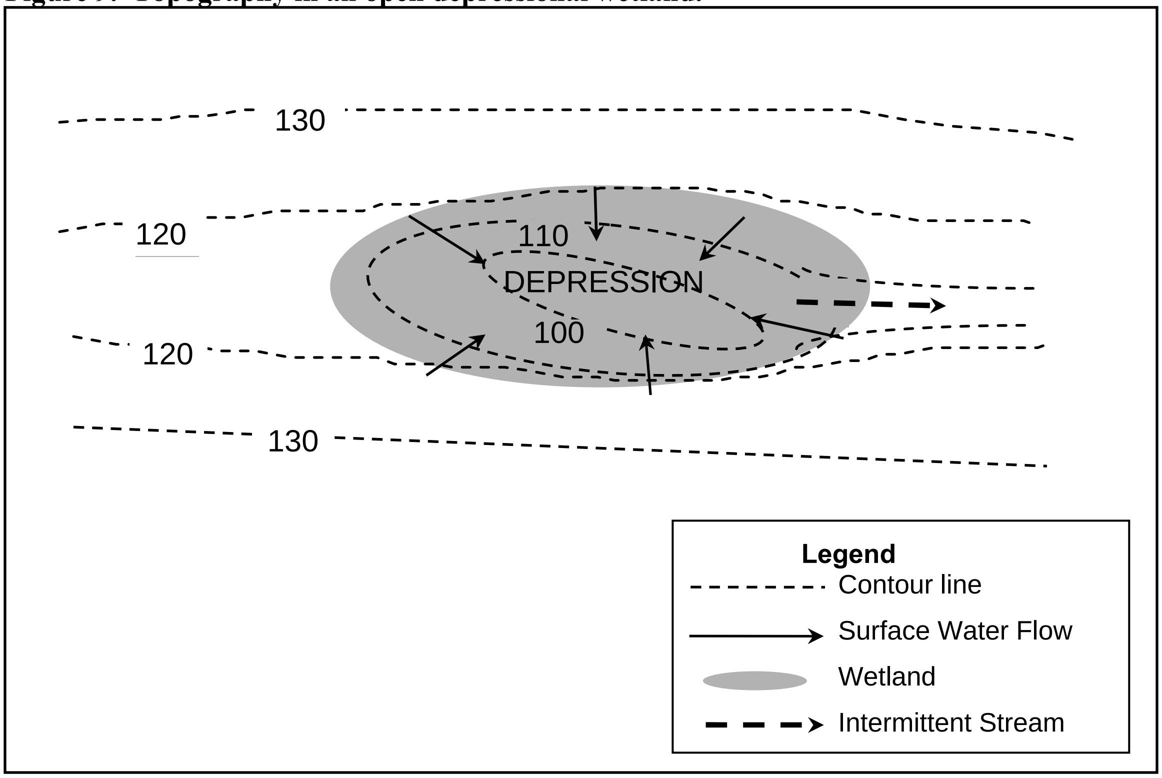
Depressional waters/wetlands occur in topographic depressions (Figure 6c). Dominant water sources are precipitation, groundwater discharge, and surface flow and interflow from adjacent uplands. The direction of flow is normally from the surrounding uplands toward the center (low point) of the depression. Elevation contours are closed, thus allowing the accumulation of surface water. Depressional waters/wetlands may have any combination of inlets and outlets or lack them completely. Dominant hydrodynamics are vertical fluctuations, primarily seasonal. Depressional waters/wetlands may lose water through intermittent or perennial discharge from an outlet, by evapotranspiration, and, if they are not receiving groundwater discharge, may slowly contribute to groundwater. Peat deposits may develop in depressional waters/wetlands. Prairie potholes are a common example of depressional waters/wetlands.

Depressional wetlands occur in two geomorphic positions within the City of Mount Vernon.

1) Along the low gradient Skagit River valley alluvium, depressional wetlands occur as either natural or excavated ponds.
2) Depressional wetlands are found at upper elevations of the triple boundary between Maddox Creek, Nookachamps Creek (*a.k.a.* Upper Golf Course Creek) and Trumpeter Creek. These natural depressions form the headward-most extent of small channel networks in the upper watershed above the three creeks.

Depressional wetlands can be closed depressions which lack a surface outlet or open, flow-through depressions. This terminology refers to the mechanisms of water loss. In closed depressions, water is lost only through evapotranspiration. Open depressions have some surface connection to downstream waters, as illustrated in Figure 9.

Figure 9. Topography in an open depressional wetland.



C. Classification of Riverine, Slope and Depressional Wetlands in the City of Mount Vernon

The first step to any HGM assessment is to determine the wetland class(es) and subclass(es) in which you are working. The following page provides a key that can be used to identify and distinguish between wetland classes and subclasses within the City of Mount Vernon (Table 3). An illustration to assist with this key is provided in Figure 10. Three different but related HGM assessment models have been developed to correspond with the three wetland classes in Mount Vernon (*i.e.,* riverine, slope and depression models). Slight variations exist for between subclasses (*i.e.*, several functions vary between the four riverine wetland sub-classes: steep gradient riverine, moderate gradient riverine, low gradient riverine, and low gradient Skagit River riverine wetlands). Scaling differs between some variables for open versus closed depressional wetlands. However slope and slope-riverine proximal wetlands are scaled in the same way at this time. The HGM model for the low gradient riverine wetlands along the Skagit River is not discussed in this manual.

Table 3. Key to City of Mount Vernon HGM Waters/Wetland Classes and Subclasses (Also see Figure 10)

1a. The project assessment area does not support and/or is not adjacent or contiguous with a jurisdictional water/wetland as defined in the City of Mount Vernon CAO at 15.40.090.B.1 - 3 and 15.40.110.A.1.. **Project assessment area is not a water/ wetland, or adjacent to, or contiguous with a waters/wetland. Guidebook is not applicable.**

1b. The assessment area is adjacent to and/or contiguous with a water/wetland as defined in the City of Mount Vernon CAO at 15.40.090.B.1 - 3 and 15.40.110.A.1.. **2**

RIVERINE WETLAND

2a. Water/wetland is associated with a stream channel or channel system and/or an active floodplain...................... **3 (Riverine Wetland Class)**

3a. Stream channel (longitudinal) slope <1%.................... **Low Gradient Skagit River Riverine (Dune-ripple, pool-riffle reach)**

3b. Stream channel (longitudinal) slope 1-2%.................. **Low Gradient Riverine (Pool-riffle, plain bed reach)**

3c. Stream channel (longitudinal) slope >2-8%................. **Moderate Gradient Riverine (Plain bed, step-pool reach)**

3d. Stream channel (longitudinal) slope 8-25%................. **Steep Gradient Riverine (Cascade reach)**

SLOPE WETLAND

2b. Water/wetland is not associated with a stream channel or channel system and/or active floodplain.......... **4**

4a. Water/wetland is located on a hillslope or, if it exists on nearly level terrain, the water/wetland exhibits sloped surface water or shallow subsurface (groundwater) profile... **5 (Slope Wetland Class)**

5a. Water/wetland is located on a hillslope ≤ 200 feet from a stream channel and has a past, present, or future hydrologic connection...................................... **Slope River Proximal**

5b. Water/wetland is located on a hillslope >200 feet from a stream channel and does not have a past, present or future hydrologic connection with a stream channel.. **Slope**

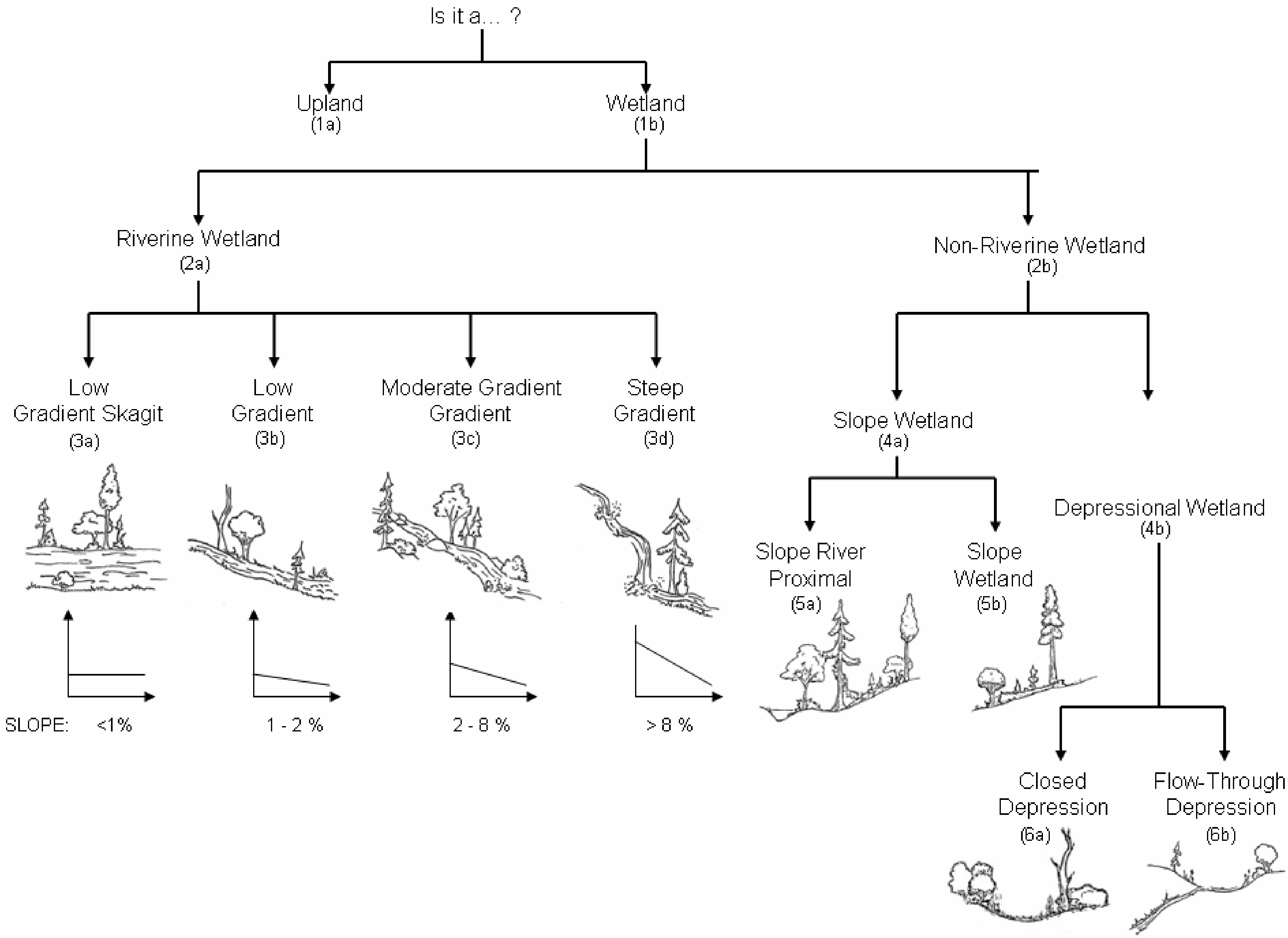
DEPRESSIONAL WETLAND

4b. Water/wetland is located in a topographic depression. Water/Wetland is not located on a hillslope or, if it exists on nearly level terrain, the water/wetland does not exhibit a sloped surface water or shallow subsurface (groundwater) profile…................................... **6 (Depressional Wetland Class)**

6a. Depression is closed and does not have a permanent or seasonal surface or shallow subsurface drainage outlet.. **Closed Depression**

6b. Depression is open and has one or more permanent and/or seasonal surface or shallow subsurface drainage outlets............................ **Flow-Through Depressions**

Figure 10. Pictorial Key to City of Mount Vernon HGM Waters/Wetland Classes and Subclasses (Table 3)



III. Waters/Wetland Functions and Assessment Models for Riverine Wetlands in the City of Mount Vernon

Note: The following Riverine Wetland HGM model was developed for Low, Moderate, and Steep Gradient subclasses. The Low Gradient Skagit Riverine Wetland Model is not included in the following section. Due to the widely varying conditions between the large, low gradient Skagit River and the smaller, hillslope channels within Mount Vernon, variables could not be scaled to match both types of systems. An additional model will be developed for wetlands directly associated with the Skagit River.

A. Overview of the HGM Riverine Wetland Model

We identified 14 functions performed by riverine waters/wetland ecosystems in the City of Mount Vernon. Consistent with guidance provided in the National Riverine Guidebook (Brinson *et al.* 1995), these functions fall into four groups: hydrology, biogeochemistry, plant community, and faunal support/habitat (Table 4). All of these functions are performed at some level at all sites within the reference domain.

We use a total of 24 variables to describe the 14 riverine ecosystem functions presented and discussed in this *Guidebook* (Table 5). Variables which we used to represent a given function sometimes differ among the riverine subclasses identified in this *Guidebook.* Four riverine wetland subclasses, defined according to the slope of the channel's longitudinal profile (*i.e.*, the steepness of the channel), occur in Mount Vernon. Changes in the variables that we used represent our best attempts to account for the unique functional characteristics of each subclass.

Fourteen ecosystem functions and 24 variables are fully described in the following sections. Table 6 identifies the relationship between variables and functions. Table 7 illustrates the formulas for each function. Descriptions of the 14 functions include the following information (Section III. B):

1. Definition
2. Rationale for describing or recognizing the function for riverine ecosystems in Mount Vernon
3. Listing of variables used to assess the function
4. The formulae used to estimate the functional capacity indices

Descriptions of the 24 variables include the following information (Section III.C):

1. Definition
2. Rationale for selection of the variable
3. Definition of the Variable Assessment Area (VAA)
4. Protocol for measuring the variable in the field
5. Scaling rationale
6. Scaling between 0 and 1

Please note that in describing functions or variables, we have used some terminology that allows us to address the project site to be assessed using HGM. The "Project Assessment Area" (PAA) refers to the waters, wetlands and their buffers which may be affected by the proposed project. The area that one needs to examine in the field to collect data necessary to score a variable is the "Variable Assessment Area" (VAA). Both PAA and VAA are defined in the Glossary. In addition, several of the figures that support presentation of variables illustrate graphically the extent of either PAA or VAA.

Table 4. List of Riverine Waters/Wetland Functions by Category

FUNCTION	DESCRIPTION
Hydrologic	
1. Surface and Ground Water Storage and Exchange	The retention and/or circulation of surface and ground water in the Flood Prone Area within the riverine ecosystem.
2. Surface Water Flow	The magnitude, frequency, duration, and timing of stream discharges that are dependent upon the ways in which water is delivered to, removed from, and passed through the Flood Prone Area within the riverine ecosystem.
3. Channel and Forest Interactions	The physical and biological processes that generate and maintain characteristic channel and floodplain structure and function. These include channel migration zone cross-section condition, flow characteristics, sediment/bedload characteristics, in-channel large wood and key pieces, and riparian forest condition.
Biogeochemical	
4. Cycling of Elements and Compounds	Abiotic and biotic processes that change elements and convert compounds (*e.g.*, nutrients and metals) from one form to another.
5. Retention and Detention of Imported Elements and Compounds	Delay or retardation of movement, and transformation or removal of imported nutrients, contaminants, and other element or compounds into, through, and out of the riverine ecosystem.
6. Retention and Detention of Particulates	Delay, retardation of movement, and removal of inorganic and organic particulates (>0.45 μm) from the water column, primarily through physical processes.
7. Organic Carbon Export	Leaching, flushing, displacement, and/or erosion of dissolved and particulate organic carbon from the waters/wetlands.
Plant Community	
8. Plant Community	The physical characteristics and ecological processes that maintain native riparian forests (living plant biomass).
9. Detrital System	The process of production, accumulation, and dispersal of dead plant biomass of all sizes.
Faunal Support /Habitat	
10. Spatial Structure of Habitats	The capacity of waters/wetlands to support animal populations within the habitat structure provided by hydrologic conditions, micro- and macrotopographic features, and living plant and detrital communities.
11. Interspersion and Connectivity of Habitats	The capacity of the water/wetland to allow aquatic, semi-aquatic, and terrestrial organisms to enter and leave a riverine ecosystem via large, contiguous patches.
12. Distribution and Abundance of Resident and Anadromous Fish	The capacity of the waters/wetland to support resident and anadromous fish.
13. Distribution and Abundance of Invertebrates	The capacity of waters/wetlands to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic, and terrestrial).
14. Distribution and Abundance of Vertebrates	The capacity of the water/wetland to maintain the density and spatial distribution of vertebrates (aquatic, semi-aquatic, and terrestrial).

Table 5. Riverine Wetland Variables

	VARIABLE	DESCRIPTION	DEFINITION
1.	$V_{BARRIER}$	Barriers to Fish Passage	Presence of man-made structures or other types of channel blockages that prevent fish passage upstream and downstream.
2.	$V_{FLOODTREE}$	Floodplain Forest Tree Composition	Coniferous and deciduous tree composition of floodplain forest.
3.	VFPAXS	Flood Prone Area Cross-Section	The condition of the channel and its adjacent floodplain, which are required to carry and discharge moderate frequency, moderate magnitude flood flows.
4.	$V_{GEOFORM}$	Geomorphic Form	Hydraulic resistance imparted by geomorphic features (*e.g.*, meanders, bars, wood jams, cobbles, steps) and complex micro- and macrotopographic surfaces (*e.g.*, secondary channels, pools) that can store surface water.
5.	V_{HERB}	Herbaceous Canopy Cover	Percent cover of herbaceous vegetation, specifically graminoids, forbs, ferns, and fern allies.
6.	V_{INLW}	In-Channel Large Wood	In-channel large wood (>4 inches diameter & > 6 feet in length) below OHW (*i.e.,* bank full width) within the VAA.
7.	$V_{KEYPIECE}$	Key Piece	In-channel large wood that is (1) independently stable (not functionally held by another factor, *e.g.*, pinned by another log, buried, trapped by a rock or bed form), and (2) retaining (or having the potential to retain) other pieces of large woody debris (WFPB 1997; Fox *et al.* 2003).
8.	V_{LITTER}	Litter and Fine Woody Debris	The cover class of leaf litter and dead and downed fine woody debris (< 3.0 inches diameter).
9.	$V_{LONGPROF}$	Longitudinal Profile	Integrity of the natural longitudinal profile of the channel within and/or upstream and downstream from the main channel cross section (channel slope and connectivity).
10.	V_{NATIVE}	Percentage of Native Plant Species	Percentage of the dominant plant taxa within the VAA that are native.
11.	$V_{OFFCHANWOOD}$	Off-Channel Large Wood	Volume of downed and dead trees and/or limbs (> 4" diameter) above OHW within the VAA.
12.	$V_{PATCHAREA}$	Patch Area	Relative area of habitat patches, as calculated from the Habitat Patch map, within a 1000 ft radius VAA.
13.	$V_{PATCHLATCON}$	Patch Lateral Contiguity	Lateral (*i.e.*, perpendicular to the general valley trend of channel) contiguity of habitat patches within the 1000 ft radius VAA.
14.	$V_{PATCHLONGCON}$	Patch Longitudinal Contiguity	Longitudinal (*i.e.*, along the channel) contiguity of habitat patches within the 1000 ft radius VAA.
15.	$V_{PATCHNUMBER}$	Patch Number	Number of habitat patches within the 1000 ft radius VAA surrounding the project site.
16.	V_{ROADS}	Road Density	Density of roads in upper watershed.
17.	$V_{RIPBUFFWIDTH}$	Riparian Buffer Width	Width and condition of the area extending 150 feet upslope from the flood prone area boundary.
18.	V_{SED}	Sediment Delivery	Assessment of existing and potential sediment transport into waters/wetlands due to human perturbations (*e.g.*, roads, trails).
19.	V_{SHADE}	Riparian Shade	Tree cover, shrub cover, and overhanging vegetative strata adjacent to the Ordinary High Water mark of the channel.
20.	V_{SHRUB}	Shrub Canopy Cover	Percent canopy cover of shrubs (multiple stemmed woody species).
21.	$V_{SLOPETREE}$	Hillslope Forest Tree Composition	Relative percent composition of conifer and deciduous trees in the hillslope forest.
22.	$V_{SOILINTEG}$	Soil Profile Integrity	A measure of the presence and condition of the soil profile (soil horizons) within the VAA.
23.	V_{STRATA}	Vegetation Strata	Number of distinct vegetation layers present in the PAA.
24.	V_{TREE}	Tree Canopy Cover	Percent canopy cover of trees (*i.e.*, single stem woody species with > 4" DBH and >10 feet height).

Table 6. Relationship of Variables to Functions in Riverine Wetlands

		Hydrologic			***Biogeochemical***				***Plant Community***		***Faunal Support / Habitat***				
		Surface and Ground Water Storage and Exchange	Surface Water Flow	Channel and Forest Interactions	Cycling of Elements and Compounds	Retention and Detention of Imported Elements and Compounds	Retention and Detention of Particulates	Organic Carbon Export	Plant Community	Characteristic Detrital System	Spatial Structure of Habitat	Interspersion and Connectivity of Habitat	Resident and Anadromous Fish Habitat	Distribution and Abundance of Vertebrates	Distribution and Abundance of Invertebrates
1.	$V_{BARRIER}$												X	**T**	**T**
2.	$V_{FLOODTREE}$								X				X	**O**	**O**
3.	V_{FPAXS}	X	X	X			X					X	X		
4.	$V_{GEOFORM}$						X				X		X	**B**	**B**
5.	V_{HERB}		X		X	X	X	X	X		X			**E**	**E**
6.	V_{INLW}			X						X			X		
7.	$V_{KEYPIECE}$			X						X			X	**D**	**D**
8.	V_{LITTER}				X					X				**E**	**E**
9.	$V_{LONGPROF}$		X								X			**T**	**T**
10.	V_{NATIVE}								X		X			**E**	**E**
11.	$V_{OFFCHANWOOD}$				X					X				**R**	**R**
12.	$V_{PATCHAREA}$											X		**M**	**M**
13.	$V_{PATCHLATCON}$											X		**I**	**I**
14.	$V_{PATCHLONCON}$											X		**N**	**N**
15.	$V_{PATCHNUMBER}$											X		**E**	**E**
16.	$V_{RIPBUFFWIDTH}$					X					X			**D**	**D**
17.	V_{ROADS}											X			
18.	V_{SED}				X	X	X								
19.	V_{SHADE}												X		
20.	V_{SHRUB}		X	X	X	X	X	X	X		X				
21.	$V_{SLOPETREE}$								X				X		
22.	$V_{SOILINTEG}$	X			X	X		X							
23.	V_{STRATA}								X		X				
24.	V_{TREE}		X	X	X	X	X	X	X		X		X		

Table 7. Indices of Functions for Low, Moderate, and Steep Gradient Riverine Waters/Wetlands in Mount Vernon, Washington

FUNCTION	FORMULAE
Hydrologic	**For Low, Moderate & Steep Gradient waters/wetlands, use:**
1. Surface and Ground Water Storage and Exchange	$(V_{FPAXS} + V_{SOILINTEG})/2$
2. Surface Water Flow	$[V_{FPAXS} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{LONGPROF}]/3$
3. Channel and Forest Interactions (low, moderate, & steep gradients)	$(V_{FPAXS} + V_{INLW} + V_{KEYPIECE} + V_{TREE} + V_{SHRUB})/5$
Biogeochemical	**For Low, Moderate & Steep Gradient waters/wetlands, use:**
4. Cycling of Elements and Compounds	$[V_{OFFCHANWOOD} + V_{LITTER} + (V_{SOILINTEG} + V_{SED})/2 + (V_{TREE} + V_{HERB} + V_{SHRUB})/2]/4$
5. Retention and Detention of Imported Elements and Compounds	$(V_{RIPBUFFWIDTH} + (V_{SOILINTEG} + V_{SED})/2 + (V_{HERB} + V_{SHRUB} + V_{TREE})/3)/3$
6. Retention and Detention of Particulates	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{SED} + V_{GEOFORM} + V_{FPAXS}]/4$
7. Organic Carbon Export	$[V_{SOILINTEG} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3]/2$
Plant Community	
8. Plant Community	**For Steep Gradient waters/wetlands, use:** $[(V_{SHRUB} + V_{TREE})/2 + V_{SLOPETREE} + V_{NATIVE} + V_{STRATA}]/4$ **For Low & Moderate Gradient waters/wetlands use:** $[(V_{SHRUB} + V_{TREE})/2 + V_{FLOODTREE} + V_{NATIVE} + V_{STRATA}]/4$
9. Detrital System	$(V_{LITTER} + V_{OFFCHANWOOD} + V_{KEYPIECE} + V_{INLW})/4$
Faunal Support/ Habitat	
10. Spatial Structure of Habitats	**For Steep Gradient waters/wetlands, use:** $((V_{SHRUB} + V_{HERB})/2 + V_{STRATA} + V_{NATIVE} + V_{RIPBUFFWIDTH} + V_{LONGPROF})/5$ **For Low & Moderate Gradient waters/wetland, use:** $((V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{NATIVE} + V_{STRATA} + V_{RIPBUFFWIDTH} + V_{GEOFORM} + V_{LONGPROF})/6$
11. Interspersion and Connectivity of Habitats	**For Low, Moderate, & Steep Gradient waters/wetlands, use:** $[V_{FPAXS} + (V_{PATCHNUMBER} + V_{PATCHAREA})/2 + (V_{PATCHLONGCON} + V_{PATCHLATCON})/2 + V_{ROADS}]/4$
12. Anadromous & Resident Fish Habitat	**For Steep Gradient waters/wetlands, use:** $[V_{BARRIER} + (V_{KEYPIECE} + V_{INLW})/2 + (V_{FPAXS} + V_{SHADE} + V_{TREE})/3]/3$ **For Moderate Gradient waters/wetlands, use**: $\{V_{BARRIER} + [V_{FPAXS} + V_{SHADE} + (V_{SLOPETREE} + V_{FLOODTREE}/2)]/3 + V_{GEOFORM} + V_{KEYPIECE} + V_{INLW}\}/5$ **For Low Gradient waters/wetlands, use**: $[V_{BARRIER} + (V_{FPAXS} + V_{SHADE} + V_{FLOODTREE})/3 + V_{GEOFORM} + V_{KEYPIECE} + V_{INLW}]/5$
13. Distribution and Abundance of Invertebrates	To Be Determined
14. Distribution and Abundance of Fish & Wildlife	To Be Determined

B. Description of Functions Identified in Riverine Waters/Wetlands Ecosystems

1. Hydrologic Functions

A) Surface and Ground Water Storage and Exchange (low, moderate, & steep gradient channels)

(1) Definition

The Surface and Ground Water Storage and Exchange function pertains to the retention and/or circulation of surface and ground water in the river network.

(2) Rationale for the Function

In Mount Vernon, the surface and ground water storage and exchange function is dependent upon surface and shallow subsurface connectivity among surface water in the Flood Prone Area, shallow ground water in alluvial deposits, and deeper ground water in regional ground water systems. Riverine ecosystems are one part of this integrated surface and ground water system. Water may be stored as and exchanged among surface water in the Flood Prone Area, soil moisture in the unsaturated zone, water within the capillary fringe, and ground water in the saturated zone. Surface water flowing within a specific reach is addressed in Surface Water Flow and Storage; however, deeper ground water in regional ground water systems cannot be adequately assessed by a rapid assessment procedure. Thus, focusing on the physical characteristics of the Flood Prone Area cross-section and alluvial deposits within a specific reach provides an indirect assessment of Surface and Ground Water Storage and Exchange.

(3) Variables Used to Assess Surface and Ground Water Storage and Exchange

We used the following variables to assess the surface and groundwater storage and exchange function for all subclasses:
a. Flood Prone Area Cross-Section (V_{FPAXS})
b. Soil Profile Integrity ($V_{SOILINTEG}$)

(4) Index of Function for All Subclasses

Index = $(V_{FPAXS} + V_{SOILINTEG})/2$

B) Surface Water Flow (low, moderate, & steep gradient channels)

(1) Definition

Surface Water Flow pertains to the frequency, magnitude, timing, and duration of stream discharges that are dependent upon the ways in which water is delivered to, removed from, and passed through the Flood Prone Area network within the riverine ecosystem.

(2) Rationale for the Function

Stream discharges are characterized by their frequency, magnitude, timing, and duration. Alterations to the Flood Prone Area can have substantial impacts on stream channel morphology and function. This concept is perhaps best understood by examining some characteristics of bank full discharges. Bank full discharge is the discharge that results in the maintenance of natural channel morphology (Leopold and Wolman 1957). Bank full discharge is considered by some to be the volume of flow that, on average and over many years, performs the majority of work (*i.e.,* transport of sediment and maintenance of channel morphology) in the channel system. Small discharges occur frequently but move small amounts of sediment; large discharges move large amounts of sediment but occur infrequently. Moderate discharges occur occasionally and move moderate amounts of sediment. It is the moderate discharges that typically dominate sediment transport and the concomitant maintenance of channel morphology over long periods of time (Wolman and Miller 1960). Changes in frequency, magnitude, timing, and duration of stream discharge will change bank full discharge, and therefore alter the form and function of the channel system. Smaller discharges are also important because they provide water to support plant and wildlife habitats in the late growing season, while larger discharges play critical roles in tree recruitment and persistence (McBride and Strahan 1984, Scott *et al.* 1998).

(3) Variables Used to Assess Surface Water Flow

We used the following variables to assess the surface water flow function for all riverine subclasses in Mount Vernon:

a. Flood Prone Area Cross-Section (V_{FPAXS})
b. Tree Canopy Cover (V_{TREE})
c. Shrub Canopy Cover (V_{SHRUB})
d. Herbaceous Canopy Cover (V_{HERB})
e. Longitudinal Profile ($V_{LONGPROF}$)

(4) Index of Function

Index = $(V_{FPAXS} + ((V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{LONGPROF})/3$

C) Channel and Forest Interactions (low, moderate, & steep gradient channels)

(1) Definition

The channel and forest interaction function includes an assessment of the channel and forest processes that generate and maintain low and moderate gradient channel and floodplain ecosystem structures and function. These include channel migration, flow characteristics, sediment/bedload characteristics, in-channel large wood, riparian forest large wood sources, channel dimensions, floodplain and stream bank vegetation, and other physical features (pools, side-channels).

(2) Rationale for the Function

Riverine waters/wetland landscapes in forested river valleys of the coastal Pacific Northwest are composed of primary, and in many cases secondary, river channels and floodplains, and floodplain and adjacent riparian hillslope forests. Primary processes generating and maintaining riverine waters/wetland ecosystem structures and functions include anthropogenically unimpeded channel migration and recruitment of floodplain and riparian hillslope forest large wood to the active channel and floodplain. The interactions of river channels and adjacent floodplain and riparian hillslope forests generate and maintain hydrologic, biogeochemincal, plant community, and faunal support/habitat functions.

(3) Variables Used to Assess Channel and Forest Interactions

We used the following variables to assess the channel and forest interaction function for all subclasses:
a. Flood Prone Area Cross-Section (V_{FPAXS})
b. In-Channel Large Wood (V_{INLW})
c. Key Pieces ($V_{KEYPIECE}$)
d. Tree Canopy Cover (V_{TREE})
e. Shrub Canopy Cover (V_{SHRUB})

(4) Index of Function

Index = $(V_{FPAXS} + V_{INLW} + V_{KEYPIECE} + V_{TREE} + V_{SHRUB})/5$

2. Biogeochemical Functions

A) Cycling of Elements and Compounds (low, moderate & steep gradient channels)

(1) Definition

This function includes abiotic and biotic processes that change elements and convert compounds (*e.g.*, nutrients and metals) from one form or valence to another.

(2) Rationale for the Function

Cycling of elements and compounds includes fundamental ecosystem processes mediated by both biotic and abiotic components of the environment. The biotic components of elemental cycling are net primary productivity, in which nutrients are taken up by plants, and detritus turnover, in which nutrients are released for renewed uptake by plants and microbes. Abiotic components are linked inextricably to the microbially mediated (biogeochemical) processes that drive the oxidation-reduction reactions that alter elements and compounds. Sources of these abiotic components are the soil profile, eolian processes that input nutrients and particulates, and hydrologic processes that input nutrients and particulates to the system. Net effects of elemental cycling are balanced between gains through import processes and losses through hydrologic export, efflux to the atmosphere, and long-term retention in soil, sediment, and persistent biomass. Retention/detention of elements and compounds onsite decreases the probability of their export to down-gradient aquatic ecosystems and diminishes nutrient loading. Elements and compounds detained onsite also contribute to water quality in waters/wetlands adjacent to and down gradient from the HGM project assessment area. This recycling of nutrients is critical to maintaining low concentrations of elements and nutrients in flowing water (Elder 1985).

(3) Variables Used to Assess Cycling of Elements and Compounds

The following variables represent biotic and abiotic components of the ecosystem that are involved in cycling of elements and compounds.
a. Off-Channel Large Wood ($V_{OFFCHANWOOD}$)
b. Litter and Fine Woody Debris (V_{LITTER})
c. Herbaceous Canopy Cover (V_{HERB})
d. Shrub Canopy Cover (V_{SHRUB})
e. Tree Canopy Cover (V_{TREE})
f. Soil Profile Integrity ($V_{SOILINTEG}$)
g. Sediment Delivery (V_{SED})

(4) Index of Function

Index = [$V_{OFFCHANWOOD}$ + V_{LITTER} + ($V_{SOILINTEG}$ + V_{SED})/2 + (V_{TREE} + V_{HERB} + V_{SHRUB})/3]/4

B) Retention and Detention of Imported Elements and Compounds (low, moderate & steep gradient channels)

(1) Definition

Retention and detention of imported elements and compounds includes processes which delay, retard, or prevent movement of imported nutrients, contaminants, and other elements or compounds into, through, and out of the riverine ecosystem.

(2) Rationale for the Function

The functioning of riverine waters/wetlands as interceptors of nonpoint source pollution is well documented (Peterjohn and Correll 1984). Studies have shown that wetland/riparian systems serve as sinks for nutrients and contaminants from upland sources (*e.g.,* Lowrance *et al.* 1984). Riverine waters/wetlands, particularly those in headwater positions, are strategically located to intercept nutrients and contaminants before they reach streams (Brinson 1988). The detention of imported elements and compounds is a function of (a) the timing, duration, and amount of water delivered to the riverine ecosystem, (b) the development and integrity of the soil profile, and (c) the development and integrity of the vegetation communities within the Flood Prone Area (Mayer *et al.* 2007). We use the term "detention" to imply the long-term accumulation, but not permanent loss of, elements and compounds from incoming water sources. Retention refers to uptake and incorporation into long-lasting woody and long-lived perennial herbaceous biomass. This function takes a very broad approach to both the elements and compounds of interest and the mechanisms by which they are removed. This is in contrast to most research on the topic, which is conducted on one element or mechanism at a time and often includes expensive and time-consuming methodologies that quantify the elements or compounds of interest. Elements herein include macronutrients essential to plant growth (nitrogen, phosphorus, potassium, *etc.*) as well as other elements such as heavy metals (zinc, chromium, *etc.*) that can be toxic at high concentrations. Compounds include herbicides, pesticides, and other imported materials. Soil, sediments, and vegetation are the main components of the function. Mechanisms of retention, removal, and detention include sorption, sedimentation, denitrification, burial, decomposition to inactive forms, microbial transformation, uptake and incorporation into vegetative biomass, and similar processes. The biotic components of riverine ecosystems detain elements and compounds through (a) uptake from soil and water, (b) biomass accumulation, and (c) and partitioning into soil organic matter. Physical processes which lead to detention and retention of elements and compounds influence the residence time available for biogeochemical processes to occur at a given site.

(3) Variables Used to Assess Detention of Imported Elements and Compounds

The following variables represent components of the ecosystem that are involved in biological and biogeochemical processes.

a. Herbaceous Canopy Cover (V_{HERB})
b. Shrub Canopy Cover (V_{SHRUB})
c. Tree Canopy Cover (V_{TREE})
d. Riparian Buffer Width ($V_{RIPBUFFWIDTH}$)
e. Sediment Deposition (V_{SED})
f. Soil Profile Integrity ($V_{SOILINTEG}$)

(4) Index of Function for all Subclasses:

Index = $[V_{RIPBUFFWIDTH} + ((V_{SOILINTEG} + V_{SED})/2) + (V_{HERB} + V_{SHRUB} + V_{TREE})/3]/3$

C) Retention and Detention of Particulates (low, moderate, & steep gradient channels)

(1) Definition

Retention and detention of particulates includes delay, retardation, and removal of inorganic and organic particulates (>0.45 μm) from the water column, primarily through physical processes.

(2) Rationale for the Function

Flooding is the major source of inorganic particulates for floodplains and riparian areas. Floodplains of smaller streams also receive sediments due to overland flow from adjacent uplands. Once waterborne sediment has been transported to a floodplain, velocity reduction normally occurs due to surface roughness and increasing cross-sectional area of discharge (Nutter and Gaskin 1989). This leads to a reduction in the capacity of water to transport suspended sediments, so particulates settle. Detention applies to particulates arising from both onsite and offsite sources, but excludes *in situ* production of organic matter. The Retention and Detention of Particulates function requires physical processes (*e.g.*, sedimentation and particulate removal) while the Cycling of Elements and Compounds and Retention/Detention of Imported Elements and Compounds primarily relies on chemical transformation. Sediment detention/ retention occurs through burial and chemical precipitation (*e.g.*, removal of phosphorus by Fe^{+3}). Dissolved forms may be transported as particles after undergoing sorption or chelation (*i.e.*, metals mobilized with organic compounds).

(3) Variables Used to Assess Retention and Detention of Particulates

The following variables are involved in physical and biological processes facilitating the detention of organic and inorganic particulates. The detention of organic and inorganic particulates from the water column is essentially a physical process. Retention and detention of particulates is a function of the (a) timing, duration, and amount of water delivered, (b) roughness elements within the riverine ecosystem, and (c) development and integrity of the vegetation communities within the stream buffer. The biotic components of riverine ecosystems contribute to the deposition and detention of organic and inorganic particulates by contributing properties of roughness to (a) the stream channel, (b) channel riparian areas, and (c) the associated floodplain. Abiotic components of riverine ecosystems contribute to the deposition and detention of organic and inorganic particulates by contributing physical properties of roughness to the stream channel and channel riparian areas.

a. Flood Prone Area Cross-Section (V_{FPAXS})
b. Tree Canopy Cover (V_{TREE})
c. Shrub Canopy Cover (V_{SHRUB})
d. Herbaceous Canopy Cover (V_{HERB})
e. Sediment Deposition (V_{SED})
f. Geomorphic Form ($V_{GEOFORM}$)

(4) Index of Function for all Subclasses

Index = $((V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{SED} + V_{GEOFORM} + V_{FPAXS})/4$

D) Organic Carbon Export (low, moderate & steep gradient channels)

(1) Definition

Organic carbon export assesses leaching, flushing, displacement, and/or erosion of dissolved and particulate organic carbon from the waters/wetlands.

(2) Rationale for the Function

Waters/wetlands export organic carbon at higher rates per unit area than terrestrial ecosystems (Mitsch and Gosselink 2000) in part because surface water has long contact time with organic matter in litter and surface soil. Organic carbon is exported from waters/wetlands in dissolved (≤ 0.45 μm) and particulate forms. Mechanisms of organic carbon export include leaching, displacement, and erosion. Sources of organic carbon include herbaceous vegetation in the water/wetland and in the buffer, as well as organic matter incorporated into the soil profile. Export of organic carbon from riverine waters/wetlands is dependent upon the condition of the hydrologic connection to down gradient waters/wetlands. While the molecular structure of most organic matter is not well known because of its chemical complexity (Stumm and Morgan 1981, Paul and Clark 1989), organic matter nevertheless plays important roles in geochemical and food web dynamics. For example, organic carbon can complex with a number of relatively immobile metal ions, which in turn facilitates their transport in soil (Schiff *et al.* 1990). Organic carbon is a primary source of energy for microbial food webs (Edwards and Meyer 1986) that form the base of the detrital food web in aquatic ecosystems. These factors, in combination with the close proximity of wetlands to aquatic ecosystems, make wetlands critical sites for supplying both dissolved and particulate organic carbon.

(3) Variables Used to Assess Organic Carbon Export

The following variables represent biotic and abiotic components of the ecosystem that are involved in the biological and physical processes that export organic carbon:

a. Soil Profile Integrity ($V_{SOILINTEG}$)
b. Shrub Canopy Cover (V_{SHRUB})
c. Herbaceous Canopy Cover (V_{HERB})
d. Tree Canopy Cover (V_{TREE})

(4) Index of Function

Index = $(V_{SOILINTEG} + (V_{SHRUB} + V_{HERB} + V_{TREE})/3)/2$

3. Plant Community Functions

A) Plant Community (low, moderate & steep gradient channels)

(1) Definition

The plant Community function assesses the physical characteristics and ecological processes that maintain indigenous living plant biomass.

(2) Rationale for the Function

Living plant biomass converts solar radiation and carbon dioxide into complex organic molecules that support organisms at all trophic levels. In addition to energy, plant species and assemblages of plants provide (a) compositional and structural diversity within the ecosystem, (b) corridors for migration and movement of faunal species among habitats, and (c) feeding, resting, hiding, thermal, and escape cover for migratory and resident animals. Finally, plants provide seeds and other propagules for regeneration and succession following catastrophic events such as fire, floods, and debris flows. Vegetation accounts for most of the biomass of riverine wetlands, and the physical characteristics of living and dead plants are closely related to ecosystem functions associated with hydrology, nutrient cycling, and the abundance and diversity of animal species, as mentioned above (Gregory *et al.* 1991). Removal or severe disturbance of riparian vegetation can lead to a change in the structure of macroinvertebrate communities (Hawkins *et al.* 1982), a decrease in the species diversity of stream ecosystems, a decline in the local and/or regional diversity of animals associated with riparian corridors, a deterioration of downstream water quality, and significant changes in river/stream hydrology (Gosselink *et al.* 1990). The Plant Community function considers the amount and type of vegetation present in the project site relative to reference standard conditions.

(3) Variables Used to Assess Plant Community

The following variables are involved in assessing plant community maintenance:
a. Percent of Native Plant Species (V_{NATIVE})
b. Shrub Canopy Cover (V_{SHRUB})
c. Vegetation Strata (V_{STRATA})
d. Tree Canopy Cover (V_{TREE})
e. Floodplain Forest Tree Composition ($V_{FLOODTREE}$)
f. Hillslope Forest Tree Composition ($V_{SLOPETREE}$)

(4) Index of Function

a. For steep gradient streams:
$\text{Index} = ((V_{SHRUB} + V_{TREE})/2 + V_{SLOPETREE} + V_{NATIVE} + V_{STRATA})/4$

b. For low and moderate gradient streams:
$\text{Index} = ((V_{SHRUB} + V_{TREE})/2 + V_{FLOODTREE} + V_{NATIVE} + V_{STRATA})/4$

B) Detrital System (low, moderate, & steep gradient channels)

(1) Definition

Detrital system assesses the process of production, accumulation, and dispersal of dead plant biomass of all sizes.

(2) Rationale for the Function

Detrital matter contributes to the functioning of riverine ecosystems in multiple ways (Fontaine and Bartell 1983). For example, accumulations of detrital matter help to reduce soil erosion and can add significant amounts of organic carbon to soils (McPhee and Stone 1966). Decomposing detritus provides wildlife habitat and stores nutrients and water for use by both plants and animals (Franklin,*et al.* 1987; Harmon *et al.*1986; Stouder *et al.* 1997). In the riverine waters/wetlands of Mount Vernon, woody debris is a major source of energy for decomposers and other heterotrophs (Harmon *et al.* 1986; Seastedt *et al.* 1989). Throughout the watershed, detrital material (especially coarse woody debris and debris dams) plays an important role by influencing the development and persistence of floodplain surfaces and the plant communities that develop in flood prone areas and in other hydrologically active areas (Bilby 1981, Smock *et al.* 1989). The approach to assessing detrital functions in the riverine ecosystems of Mount Vernon requires evaluations of the amounts and distributions of detrital material (litter and woody debris) within a PAA.

(3) Variables Used to Assess Detrital System

The following variables are used to assess the Detrital system function for all Subclasses:
a. Litter and Fine Woody Debris (V_{LITTER})
b. Off-Channel Large Wood ($V_{OFFCHANWOOD}$)
c. Key Pieces ($V_{KEYPIECE}$)
d. In-Channel Large Wood (V_{INLW})

(4) Index of Function

Index = $(V_{LITTER} + V_{OFFCHANWOOD} + V_{KEYPIECE} + V_{INLW})/4$

4. Faunal Support/Habitat Functions

A) Spatial Structure of Habitats (low, moderate, & steep gradient channels)

(1) Definition

This function refers to the capacity of waters/wetlands to support animal populations within the habitat structure provided by hydrologic conditions, micro- and macro-topographic features, and living plant and detrital communities.

(2) Rationale for the Function

The spatial structure of habitats function is used to assess the suitability of hydrologic conditions, micro- and macro-topography, and living plant and detrital communities for sustaining characteristic animal populations in riverine ecosystems. While all ecosystem attributes are important for the maintenance of faunal habitat integrity, the horizontal and vertical structural complexity of plant communities that exist within the flood prone area largely determines habitat quality for resident and nonresidential animals. Generally, habitats with greater vegetative heterogeneity and structural complexity support more diverse faunal communities (Harris 1984, Findlay and Bourdages 2000, Gibbs 2000, Jones *et al.* 2000). Contiguous habitat structure provides opportunities for movement of migratory animals or resident faunal species with large range requirements into and out of waters/wetlands.

Vegetation of mature, intact riverine ecosystems reflects the constraints imposed by environmental conditions (climate, hydrologic regime, geomorphology, *etc.*), as well as the competitive interactions among plant populations. Plant communities have been shown to be relatively reliable indicators of current and past disturbances within riverine ecosystems (*i.e.*, past and ongoing anthropogenic alterations in hydrogeomorphic conditions). The goal of assessing the spatial structure of habitats for the HGM approach is to evaluate the structural complexity of dominant hydrologic, micro- and macro-topographic and vegetation conditions within a riverine ecosystem. This function is meant to be used as part of a rapid assessment technique for waters/wetland functions. It is not intended to replace more detailed procedures or long-term habitat studies.

(3) Variables Used to Assess Spatial Structure of Habitat

a. Geomorphic Form ($V_{GEOFORM}$)
b. Herbaceous Canopy Cover (V_{HERB})
c. Longitudinal Profile ($V_{LONGPROF}$)
d. Percentage of Native Vegetation (V_{NATIVE})
e. Shrub Canopy Cover (V_{SHRUB})
f. Vegetation Strata (V_{STRATA})
g. Tree Canopy Cover (V_{TREE})
h. Buffer Width ($V_{RIPBUFFWIDTH}$)

(4) Index of Function

For Steep Gradient waters/wetlands, use:
Index = $((V_{SHRUB} + V_{HERB})/2 + V_{STRATA} + V_{NATIVE} + V_{RIPBUFFWIDTH} + V_{LONGPROF})/5$

For Low & Moderate gradient waters/wetland, use:
Index = $((V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{STRATA} + V_{NATIVE} + V_{RIPBUFFWIDTH} + V_{GEOFORM} + V_{LONGPROF})/6$

B) Interspersion and Connectivity of Habitats (low, moderate & steep gradient channels)

(1) Definition

This function refers to the capacity of the riverine waters/wetlands to allow aquatic, semi-aquatic, terrestrial, and avian organisms to access and utilize habitats via contiguous patches.

(2) Rationale for the Function

Wetland ecosystems are used extensively by aquatic, semi-aquatic, terrestrial, and avian organisms to complete portions of their life cycles including reproduction, feeding, and growth. Adequate habitat corridors are required for connecting riverine ecosystems to other portions of the landscape (Forman and Godron 1986). Smaller, less mobile faunal species frequently require juxtaposition of habitat components or resources on scales consistent with their smaller home ranges (Opdam 1990). Studies of habitat fragmentation show reduced faunal species richness as patch sizes decrease (Harris 1984). Connections between habitats help maintain higher animal and plant diversity across the landscape (Brinson *et al.* 1995). Habitat Interspersion and Connectivity characterizes the spatial distribution of waters/wetlands within their landscape settings.

(3) Variables Used to Assess Interspersion and Connectivity of Habitats

We used the following variables to assess the habitat interspersion and connectivity function for all riverine subclasses in Mount Vernon:

a. Patch Number ($V_{PATCHNUMBER}$)
b. Patch Area ($V_{PATCHAREA}$)
c. Habitat Patch Longitudinal Contiguity ($V_{PATCHLONGCON}$)
d. Habitat Patch Lateral Contiguity ($V_{PATCHLATCON}$)

e. Road Density (V_{ROADS})
f. Flood Prone Area Cross-Section (V_{FPAXS})

(4) Index of Function

For all subclasses:

Index = $(V_{FPAXS} + (V_{PATCHNUMBER} + V_{PATCHAREA})/2 + (V_{PATCHLONGCON} + V_{PATCHLATCON})/2 + V_{ROADS})/4$

C) Distribution of Resident and Anadromous Fish

(1) Definition

This function refers to the capacity of the waters/wetlands to maintain characteristic distribution of resident and anadromous fish, including bull trout.

(2) Rationale for the Function

In general, at the reach and habitat unit levels, the greater the diversity of habitat structures, the greater the fish community diversity (Reeves *et al.* 1998). The Distribution of Resident and Anadromous Fish function assesses (1) whether the water/wetland is isolated by a fish barrier, and (2) the integrity of channel, floodplain, and vegetation elements of fish habitat.

(3) Variables Used to Assess Distribution and Abundance of Resident and Anadromous Fish

a. Flood Prone Area Cross-Section (V_{FPAXS})
b. In-Channel Large Wood (V_{INLW})
c. Key Pieces ($V_{KEYPIECE}$)
d. Tree Canopy Cover (V_{TREE})
e. Shrub Canopy Cover (V_{SHRUB})
f. Geomorphic Form ($V_{GEOFORM}$)
g. Floodplain Forest Tree Composition ($V_{FLOODTREE}$)
h. Fish Barrier ($V_{BARRIER}$)
i. Riparian Shade (V_{SHADE})
j. Hillslope Forest Tree Composition ($V_{SLOPETREE}$)

(4) Indices of Function

For Steep Gradient waters/wetlands, use:
Index = $[V_{BARRIER} + (V_{KEYPIECE} + V_{INLW})/2 + (V_{FPAXS} + V_{SHADE} + V_{TREE})/3]/3$

For Moderate Gradient waters/wetlands, use:
Index = $\{V_{BARRIER} + [V_{FPAXS} + V_{SHADE} + (V_{SLOPETREE} + V_{FLOODTREE})/2)]/3 + V_{GEOFORM} + V_{KEYPIECE} + V_{INLW}\}/5$

For Low Gradient waters/wetlands, use:
Index = $[V_{BARRIER} + (V_{FPAXS} + V_{SHADE} + V_{FLOODTREE})/3 + V_{GEOFORM} + V_{KEYPIECE} + V_{INLW}]/5$

D) Distribution and Abundance of Invertebrates

(1) Definition

This function refers to the capacity of waters/wetlands to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic, and terrestrial).

(2) Rationale for the Function

Invertebrates exploit almost every microhabitat available in waters/wetlands and may reach densities of thousands of individuals per square meter. Because invertebrates are so pervasive and partition habitats so finely, they are excellent indicators of ecosystem function (Karr 1991, Karr and Kerans 1992).

(3) Status of the Function in this *Draft Operational Guidebook*

At this stage of development of the City of Mount Vernon *Guidebook*, we are unable to provide reliable variables that would allow calculation of an index of function for invertebrates. This situation is due to the combination of a lack of reference data, lack of invertebrate expertise on the field/author team, and a limited scope and budget for this project. However, the invertebrate function has been included as a placeholder to signify (a) our recognition of the importance of invertebrate taxa in stream ecosystems, and (b) the potential to expand upon current efforts.

E) Distribution and Abundance of Vertebrates

(1) Definition

The capacity of waters/wetlands to maintain characteristic density and spatial distribution of vertebrates (aquatic, semi-aquatic and terrestrial).

(2) Rationale for the Function

Vertebrate distribution and abundance in any riverine ecosystem is extremely variable, and can change rapidly in space and time. For example, large mammalian species (Black bears, cougars, *etc.*) require vast tracts of land in order to sustain a population. Therefore, in any given riparian system, especially in the lower gradient positions, the level of use by these large mammals in an assessment area is episodic. In the highly urbanized environment within the City of Mount Vernon, large vertebrates are uncommon. Typically, many vertebrates are conspicuous users of waters/wetlands, and can have a strong influence on the dynamics of a riverine ecosystem. The goal in assessing this function is to compare reference and assessment site functions with respect to species composition and structure of vertebrate species associated with a water/wetland and the presence of necessary habitats to support common (or rare) vertebrate faunal populations. Rapid, direct measurements of vertebrates are difficult to perform in the field. Direct sightings or indirect indicators of animal use can be used to assess this function. The following are suggestions, given the expertise and scope of work, to measure this function accurately: (a) Perform complete surveys by vertebrate specialists and compare to reference standard conditions using similar indices, (b) Reference local species lists for mammals, birds, fish, amphibians, and reptiles, and (c) Compare to reference standard conditions using similar indices.

(3) Status of the Function in this *Draft Operational Guidebook*

At this stage of development of the City of Mount Vernon *Guidebook*, we are unable to provide reliable variables that would allow calculation of an index of function for vertebrates. This situation is due to the combination of a lack of reference data, lack of vertebrate expertise on the field/author team, and a limited scope and budget for this project. However, the vertebrate function has been included as a placeholder to signify (a) our recognition of the importance of vertebrate taxa in stream ecosystems, and (b) the potential to expand upon current efforts.

C. Detailed Description, Measurement Protocol, and Scaling of Variables for the Riverine Wetland HGM model

1. Barriers to Fish Passage ($V_{BARRIER}$)

A) Definition

Barriers to fish passage include the presence of man-made structures or other types of channel blockages that prevent fish passage upstream or downstream.

B) Rationale for Selection of Variable

Unrestricted access to suitable habitat within a reach increases the suitability of a reach for both resident and anadromous fish. Both upstream and downstream access can impact fish usage of a reach. $V_{BARRIER}$ is one indicator of habitat fragmentation and connectivity within a stream system.

C) Definition of VAA

In the field, the VAA for $V_{BARRIER}$ is the stream channel within the PAA and extending for 500 feet downstream and upstream from the PAA. The entire upstream and downstream reach of the stream is the VAA for the mapping exercise.

D) Measurement Protocol

(1) Consult City of Mount Vernon Planning Department for fish barrier locations on City fish distribution maps. Note barriers located upstream and/or downstream from the PAA. (2) In addition to consulting City fish barrier maps, walk the stream channel 500 feet upstream and downstream from the main PAA cross section. List any barriers to fish passage (such as culverts, wide spanned bridges, and temporary bridges) within 500 feet of the PAA in either direction. Record evidence of anthropogenic activities resulting in changes to characteristic channel habitat (*i.e.*, forest harvest operations, channel modifications). Note that field observations will supersede observations from the city fish barrier map.

E) Scaling Rationale

$V_{BARRIER}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{BARRIER}$	Index
a. **No** barriers to fish movement exist downstream or upstream of the VAA, **AND** b. There is **no** evidence of significant anthropogenic activities (*e.g.*, forest harvest operations or channel modifications) resulting in barriers within the VAA.	1.00
a. **No** barriers to fish movement exist downstream or upstream of the VAA, **BUT** b. There is **some** evidence of anthropogenic activities (*e.g.*, forest harvest operations or channel modifications) resulting in ***minor*** changes to cross-sectional and longitudinal geometry within the VAA.	0.75
a. Fish barriers exist **upstream** of the VAA, **AND** b. There is evidence of anthropogenic activities (*e.g.*, forest harvest operations, channel hardening, or culvert placements) resulting in ***significant*** changes to cross-sectional and/or longitudinal geometry within the VAA.	0.50
a. Fish barriers exist **downstream** of the VAA, **AND** b. There is evidence of anthropogenic activities (*e.g.*, forest harvest operations, channel hardening, culvert placements, untreated stormwater inputs, direct sediment inputs, *etc.*) resulting in ***significant*** changes to cross-sectional and/or longitudinal geometry within the VAA.	0.25
a. Fish barriers exist both **upstream** and **downstream** of the VAA, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Fish barriers exist **both upstream and downstream** or **downstream only** that are not removable with current development, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

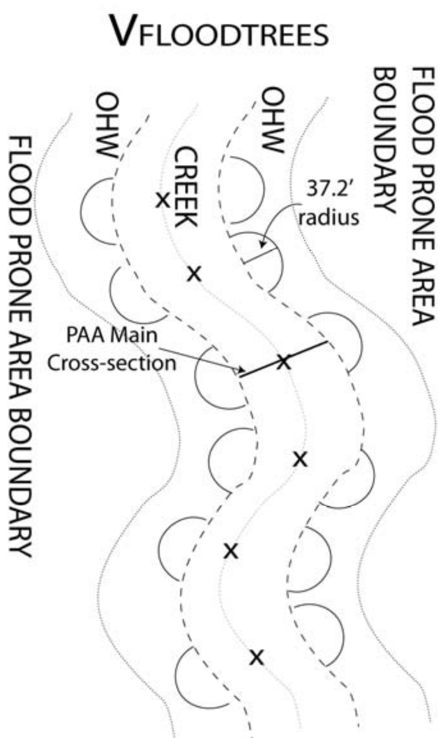
2. Flood Prone Area Tree Composition ($V_{FLOODTREES}$)

A) Definition

Flood Prone Area Tree Composition is defined as the percent composition of coniferous and deciduous trees (> 4” diameter) in the forest surrounding the creek.

B) Rationale for Selection of Variable

Coniferous trees located within the flood prone area are the major source of large wood to the channel. While deciduous trees are also a source of large wood for the channel, downed deciduous trees decay quickly. Therefore, deciduous trees are weighted with lower importance than coniferous trees.



C) Definition of VAA

The VAA for $V_{FLOODTREES}$ consists of a minimum of one and up to six plots (radius = 37.2 ft). One plot consists of two semi-circles which are centered at the OHW on each side of the stream along the main cross-section of the PAA. Ideally, six plots (six pairs of semi-circles) will be assessed. If only one plot (two semi-circles) will be established, it ***must*** be located in an area that is representative of the entire reach, and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Location of Plots

To establish the six plots (six pairs of semi-circles) for scaling $V_{FLOODTREES}$, begin at the PAA main cross-section (Figure 11). For each pair of semi-circles, stand along the OHW on stream right and then on stream left. From each side of the stream, visually extend an arc with a radius of 37.2 feet from this point (creating a 0.05 acre half circle). Establish additional plots centered at OHW upstream and downstream from the main PAA cross-section at 80 foot intervals. See Figure 11 for further clarification.

If vegetation plots can not be established according to the articulated HGM protocol because of extremely steep terrain, or a narrow riparian zone, then locate the six vegetation plots in accessible, but representative portions of the riparian zone. If the establishment of six plots is not possible at all, given hazardous or unsafe conditions, then the data required for the vegetation variables should be estimated from a remote location (*e.g.*, from the creek bed).

Measurements for $V_{FLOODTREES}$

Within each vegetation plot (Figure 12), count the number of conifers and deciduous (broadleaf) trees. Count only the trees which are rooted within the boundary of the flood prone area. If the width of the flood prone area is less than 37.2 feet, do not include trees beyond this boundary in your count. Trees are defined as having a stem diameter greater than 4 inches. Determine the percent of tree stems that are coniferous and the percent of stems that are deciduous in each semi-circle. Record these percentages on the Minimal Submittal Worksheets. Average the twelve measurements of percent conifer and percent deciduous to calculate the final estimate.

E) Scaling Rationale

$V_{FLOODTREES}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Low and moderate gradient channels

Measurement or Condition for $V_{FLOODTREES}$	Index
Of the total number of tree stems counted within the VAA, more than 60% are conifers	1.00
Of the total number of tree stems counted within the VAA, between 41% and 60% are conifers	0.75
Of the total number of tree stems counted within the VAA, between 10% and 40% are conifers	0.50
Of the total number of tree stems counted within the VAA, less than 10% are conifers	0.25
a. There were no conifers within the VAA **but** deciduous trees were observed, **AND** b. The variable is recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. There is no tree canopy cover, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Steep gradient channels

Measurement or Condition for $V_{FLOODTREES}$	Index
Of the total number of tree stems counted within the VAA, more than 90% are conifers	1.00
Of the total number of tree stems counted within the VAA, between 71% and 90% are conifers	0.75
Of the total number of tree stems counted within the VAA, between 51% and 70% are conifers	0.50
Of the total number of tree stems counted within the VAA, between 1% and 50% are conifers	0.25
a. There were no conifers within the VAA **but** deciduous trees were observed, **AND** b. The variable condition is recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. There is no tree canopy cover, **OR** only deciduous trees were observed, **AND** b. The variable condition is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

Figure 11. Protocol for establishing sample plot layout for vegetation variables in the Project Assessment Area (PAA).

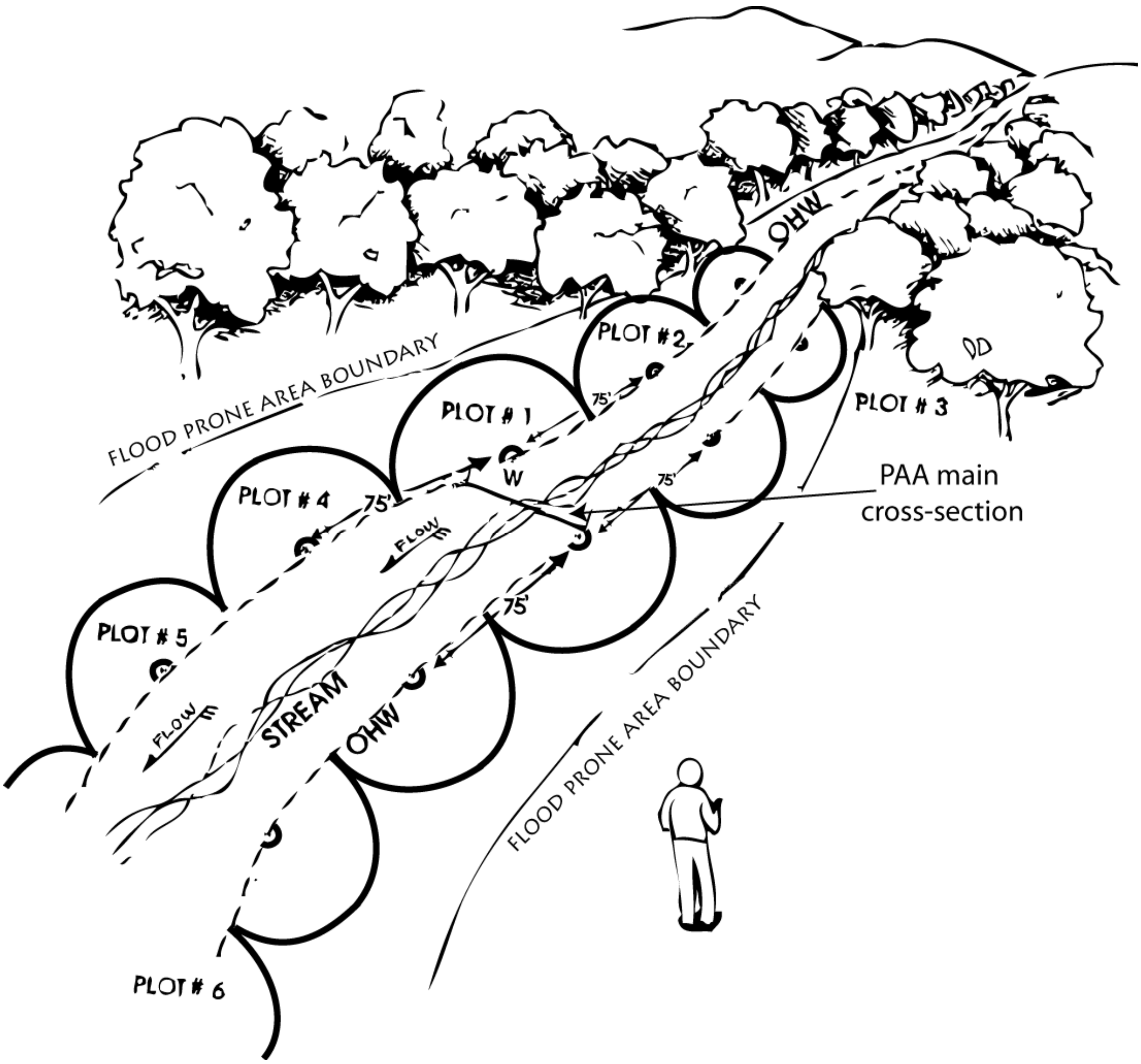
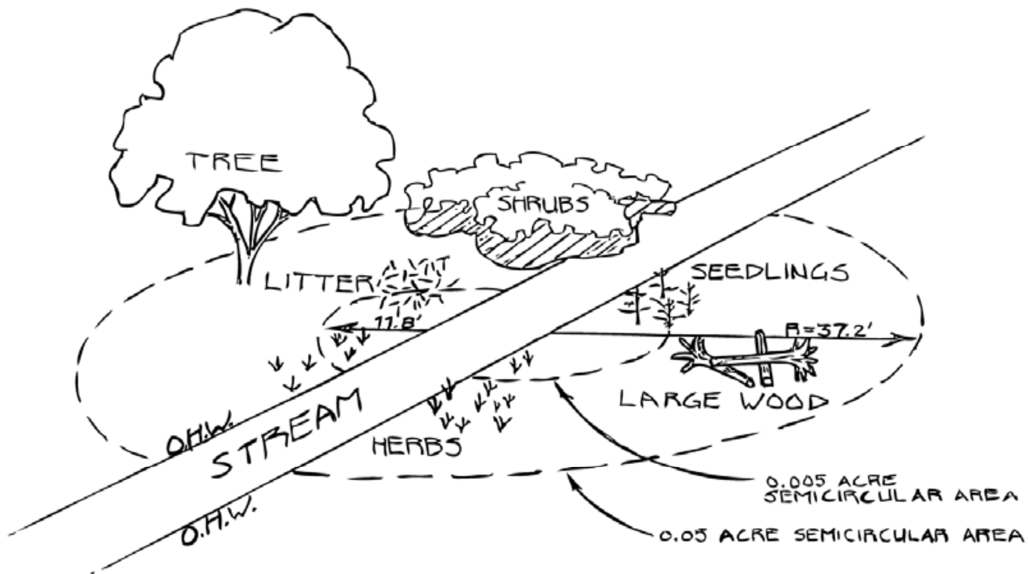


Figure 12. Measurement protocol for the tree, shrub and herb vegetation canopy and stem count variables in the Variable Assessment Area (VAA).



__**Variables measured in 0.05 acre (37.2 ft radius) semi-circle:**__

a) Flood Prone Area Trees ($V_{FLOODTREES}$)
b) Shrub Canopy Cover (V_{SHRUB})
c) Tree Canopy Coverage (V_{TREE})
d) Off-Channel Large Wood ($V_{OFFCHANWOOD}$)

__**Variables measured in 0.005 acre (11.8 ft radius) semi-circle:**__

a) Herbaceous Cover (V_{HERB})
b) Litter and Fine Woody Debris (V_{LITTER})

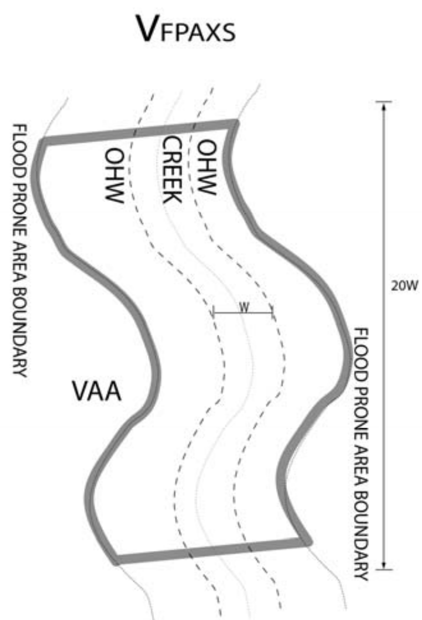
3. Flood Prone Area Cross-Section (V_{FPAXS})

A) Definition

Flood Prone Area Cross-Section refers to the condition of the channel and those parts of the floodplain adjoining the channel, which are required to carry and discharge moderate frequency, moderate magnitude flood flows.

B) Rationale for the Selection of the Variable

Mount Vernon stream ecosystems can convey large amounts of water and sediment, especially during episodic events. However, human activities and alterations to watersheds result in impacts on sources and/or the timing, rate, and amount of water delivery to riverine ecosystems. Channels that have been disconnected from their former floodplains by roads, culverts, bridges, and development are unable to dissipate flow volumes and energy on their floodplains. Human induced changes in the water delivery dynamics of riverine ecosystems usually have negative impacts on all classes of ecosystem functions (*i.e.,* hydrologic, geochemical, plant community and faunal support/habitat functions) (Ward and Stanford 1979). Too much or too little water in contact with the flood prone area and associated riverine ecosystems can have large effects on the productivity and diversity of *in situ* faunal communities and on downstream faunal communities that depend on maintenance of the integrity of upstream habitats and food webs (Platts and Megahan 1975, Bestcha and Platts 1986).



C) Definition of VAA

The VAA for V_{FPAXS} is defined laterally and longitudinally at the main PAA cross-section. Laterally, the VAA is defined as the flood prone area width (*i.e.,* the active channel and those parts of the floodplain adjoining the channel that are engaged during moderate frequency, moderate magnitude flood flows) (Figure 13). Longitudinally, the VAA is defined as 20 times the OHW channel width centered at the main cross-section (*i.e.,* 10 channel widths upstream and downstream from the main cross-section) (Figure 14).

D) Measurement Protocol

The measurement protocol for V_{FPAXS} is to walk the VAA (the channel for a length 20 times the OHW width), making note of the condition of the channel and flood prone area, as described in the next paragraph. If visibility is poor, add lateral transects as needed to ensure that the entire VAA is considered for the purposes of scaling V_{FPAXS}.

To scale V_{FPAXS}, consider both direct and indirect impacts to the topography and structure of the flood prone area. Direct impacts to the channel and flood prone area include, but are not limited to development, placement of fill, rip-rap, levees, cultivation, roads, culverts, bridges, *etc.* Indirect impacts to the channel/flood prone area can be more subtle, and include channel incision, rapid lateral migration, in-channel aggradation, *etc.* It is important to observe evidence of out-of-bank flow, including sand splay features, wrack lines, and secondary channels. These indicators can provide some context of the magnitude, frequency, and duration of floodplain inundation within the VAA.

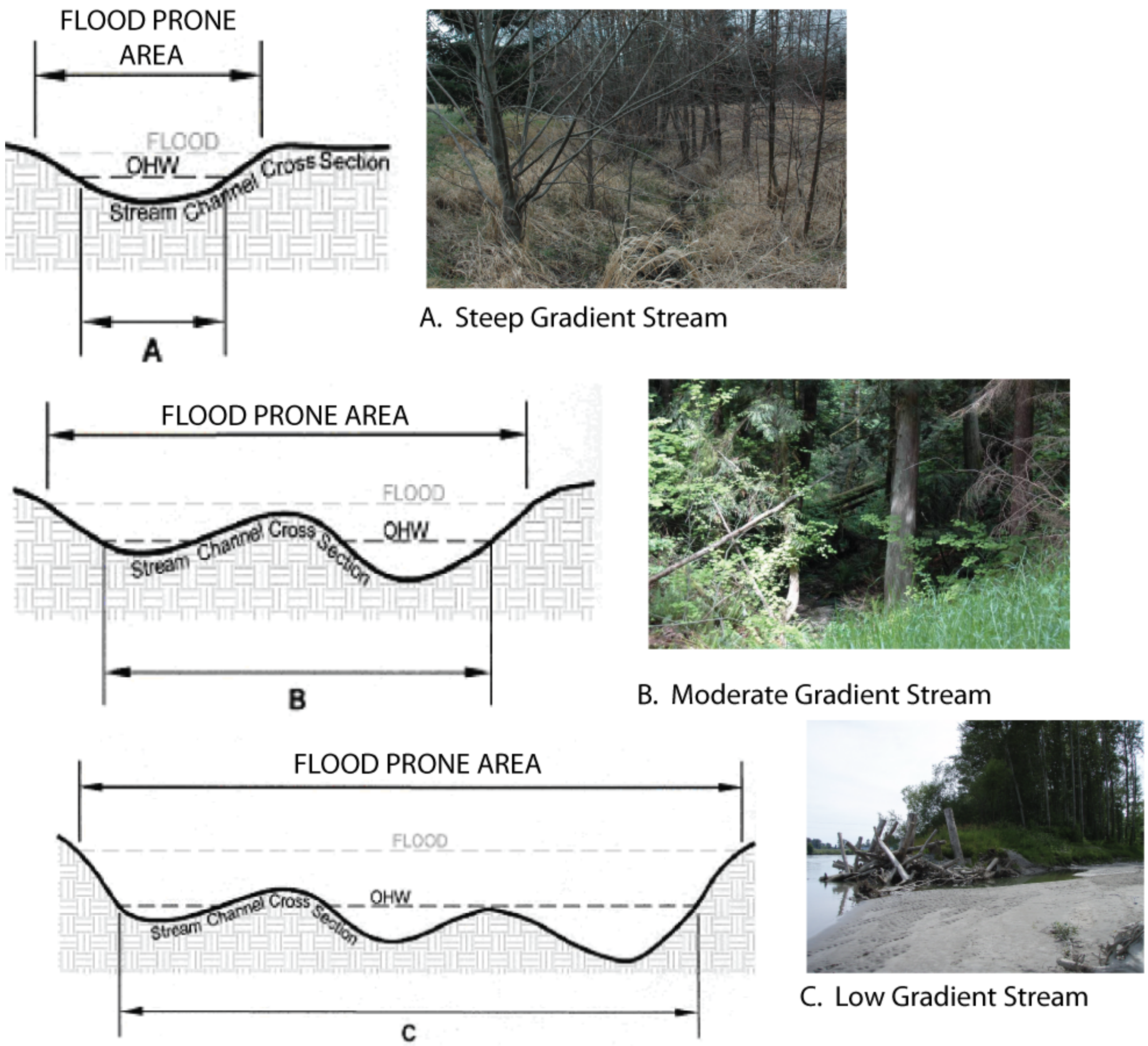
E) Scaling Rationale

V_{FPAXS} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling for all Subclasses

Measurement or Condition for V_{FPAXS}	Index
The flood prone area is **not** laterally constrained at any point within the VAA by anthropogenic activities (*e.g.*, culturally-accelerated entrenchment, levees, rip-rap, roads, large accumulations of fill or debris).	1.00
At some point within the VAA the flood prone area **is** laterally constrained on **one** side **OR** at **one** cross-section by anthropogenic activities (*e.g.*, levees, rip-rap, roads, large accumulations of fill or debris).	0.75
a. Flood prone area is constrained on **both** sides **OR** at more than one cross-section by anthropogenic activities (*e.g.*, culturally-accelerated entrenchment, levees, rip-rap, large accumulations of fill or debris, heavy grazing). b. **However**, flood prone area is still able to convey large flood flows as evidenced by large width and complex micro- and macrotopographic relief (*e.g.*, meanders, depositional bars, secondary channels, floodplains, wide bridge crossings).	0.50
a. Flood prone area is constrained on **both** sides by anthropogenic activities (*e.g.*, culturally accelerated entrenchment, levees, rip-rap, large accumulations of fill or debris), **AND** b. Flood prone area is **not** able to convey large flood flows, as evidenced by narrow and/or relatively homogeneous surfaces that lack micro- and macrotopographic relief (*e.g.,* channel has been straightened and/or smoothed).	0.25
a. Flood prone area is constrained on **both** sides by anthropogenic activities (*e.g.*, culturally accelerated entrenchment, levees, large accumulations of fill or debris) **AND** b. Flood prone area is hardened in places via placement of rip-rap, gabions, concrete, *etc.*, **AND** c. The variable **is** recoverable and sustainable through natural processes if the existing land use is discontinued and restoration measures are applied.	0.10
a. Flood prone area is constrained on **both** sides by anthropogenic activities (*e.g.*, culturally accelerated entrenchment, levees, large accumulations of fill or debris) **AND** b. Flood prone area is completely filled or hardened with concrete/asphalt, *etc;* **AND** c. The variable condition is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

Figure 13. Channel cross-sections showing Ordinary High Water and flood prone area on channels of varying gradients.



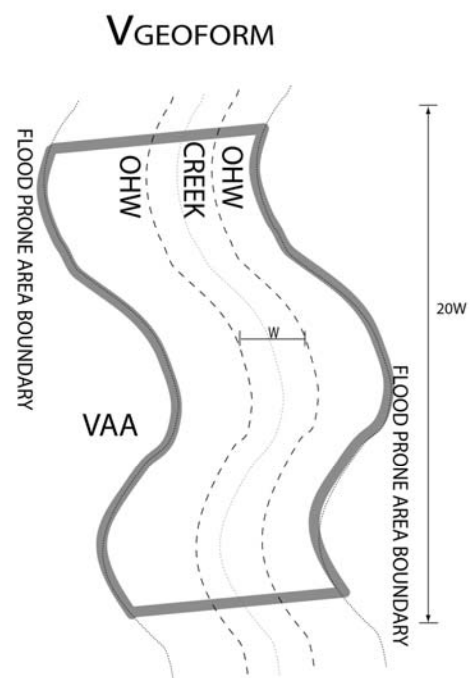
4. Geomorphic Form ($V_{GEOFORM}$)

A) Definition

Geomorphic form refers to hydraulic resistance or roughness imparted to the channel system by geomorphic structures (*e.g.,* meanders, bars) and complex micro- and macrotopographic surfaces (*e.g.,* secondary channels and pools) that can slow down, store, or deflect surface water.

B) Rationale for the Selection of the Variable

Geomorphic features (*e.g.,* meanders and bars), and complex micro and macro topographic features (*e.g.,* secondary channels and pools) provide roughness and thus hydraulic resistance within riverine ecosystems. Hydraulic resistance is closely related to the timing and amount of water storage that can occur within the flood prone area. In Mount Vernon, human activities (*e.g.,* channel straightening or removal of riparian vegetation for flood control) decrease the structural complexity and roughness of natural surfaces within riverine ecosystems. This smoothing and straightening leads to less short and long-term storage of water within flood prone area reaches, and thus results in faster conveyance of water and sediment downstream.



C) Definition of VAA

The VAA for $V_{GEOFORM}$ is defined laterally and longitudinally at the main PAA cross-section. Laterally, the VAA is defined as the flood prone area width (*i.e.,* the active channel and those parts of the floodplain adjoining the channel that are engaged during **moderate** frequency, **moderate** magnitude flood flows) (Figure 12). Longitudinally, the VAA is defined as **7 times the OHW channel width** centered at the main cross-section (*i.e.,* 10 channel widths upstream and downstream from the main cross-section) (Figure 14).

D) Measurement Protocol

To measure $V_{GEOFORM}$, walk the entirety of the VAA. Select a representative cross-section and walk across the entire VAA making note of all of the micro- and macrotopographic features (Figure 14 and Figure 15). Micro- and macro-topographic features include secondary channels and pools, depressions, channel meanders and side channel bars.

Figure 14. Measurement protocol for Flood Prone Area Cross-Section and Geomorphic Form.

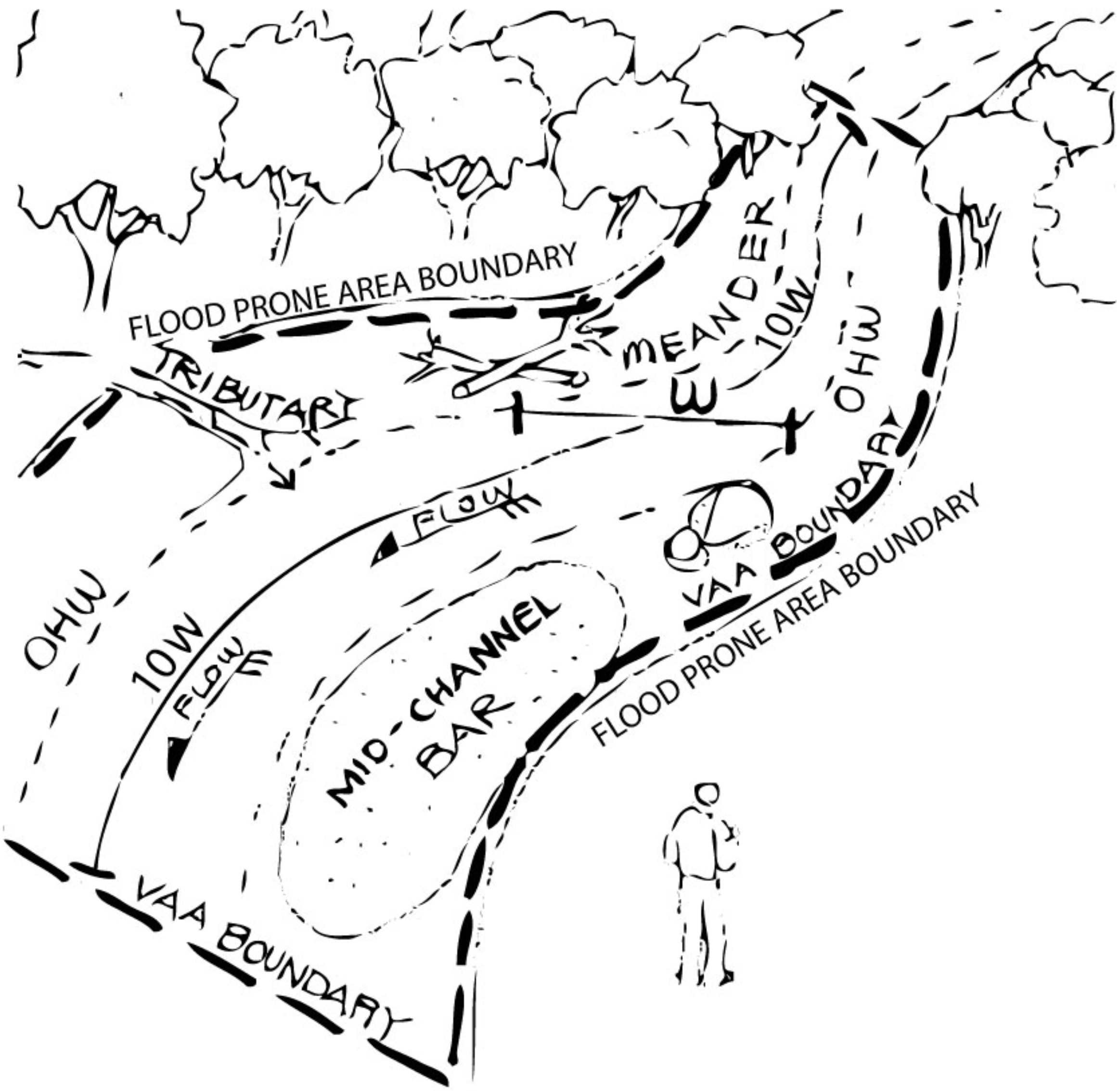
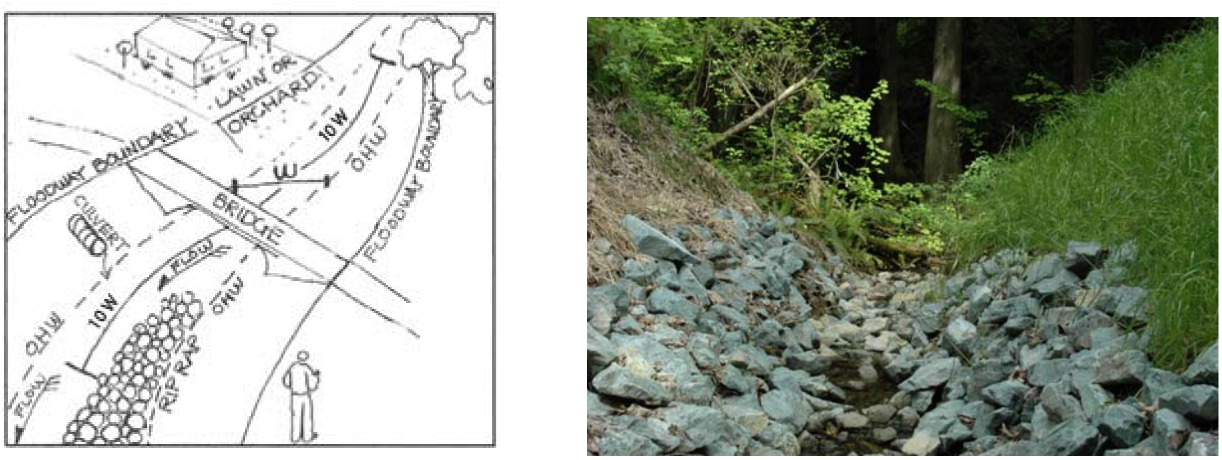


Figure 15. Examples of increasing human disturbance to the geomorphic form of stream channels.

A. VAA reach without human disturbance

B. VAA reach with moderate human disturbance



C. VAA reach with extensive human disturbance

E) Scaling Rationale

$V_{GEOFORM}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1) Low and Moderate Gradient Riverine Subclasses

Measurement or Condition for $V_{GEOFORM}$	**Index**
a. Flood prone area is characterized by complex and intact micro- and macrotopographic relief (*e.g.*, meanders, depositional bars, and secondary channels), **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Flood prone area is characterized by complex micro- and macrotopographic relief (*e.g.*, meanders, depositional bars, and secondary channels) **and** b. There **is** evidence of anthropogenic disturbance (*e.g.,* culvert headwalls, rip-rap, gabions, minor berms or partial levees).	0.75
a. Flood prone area is characterized partially by complex micro- and macrotopographic relief, (*e.g.*, meanders, depositional bars, and secondary channels), **AND** b. **Small portions** of the VAA are dominated by relatively homogeneous surfaces that lack micro- and macrotopographic relief (*e.g.,* gabion walls, rip-rap, berms, levees, *etc.*).	0.50
a. VAA is **dominated** by relatively homogeneous surfaces that lack micro- and macrotopographic relief (*e.g.*, meanders, depositional bars, and secondary channels), **AND** b. VAA has been hardened, straightened and/or smoothed.	0.25
a. Flood prone area is characterized by relatively homogeneous surfaces that lack micro- and macrotopographic relief, **AND** b. VAA has been hardened, straightened and/or smoothed, **AND** c. The variable **is** recoverable and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Flood prone area is hardened and completely filled with impervious material (*e.g.*, concrete, asphalt, grouted rip-rap, *etc.*), **AND/OR** b. The variable is **not** recoverable or sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2) Steep Gradient Riverine Subclass

Measurement or Condition for $V_{GEOFORM}$	Index
a. Flood prone area is characterized by complex and intact micro- and macro-topographic relief (*e.g.*, meanders, depositional bars, secondary channels, and boulders), **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Flood prone area is characterized by complex micro- and macro-topographic relief (*e.g.*, meanders, depositional bars, and secondary channels and boulders), **AND** b. There **is** evidence of anthropogenic disturbance (*e.g.,* culvert headwalls, rip-rap, gabions, minor berms or partial levees).	0.75
a. Flood prone area is characterized partially by complex micro- and macro-topographic relief, (*e.g.*, meanders, depositional bars, secondary channels, and boulders), **AND** **b. Small portions** of the VAA are dominated by relatively homogeneous surfaces that lack micro- and macrotopographic relief (*e.g.,* gabion walls, rip-rap, berms, levees, *etc.*).	0.50
a. VAA is **dominated** by relatively homogeneous surfaces that lack micro- and macro-topographic relief (*e.g.*, meanders, depositional bars, secondary channels, and boulders), **AND** b. VAA has been hardened, straightened and/or smoothed.	0.25
a. Flood prone area is characterized by relatively homogeneous surfaces that lack micro- and macro-topographic relief, **AND** b. VAA has been hardened, straightened and/or smoothed; **AND** c. The variable **is** recoverable and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Flood prone area is hardened and completely filled with impervious material (*e.g.*, concrete, asphalt, grouted rip-rap, *etc.*); **AND/OR** b. The variable is **not** recoverable nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

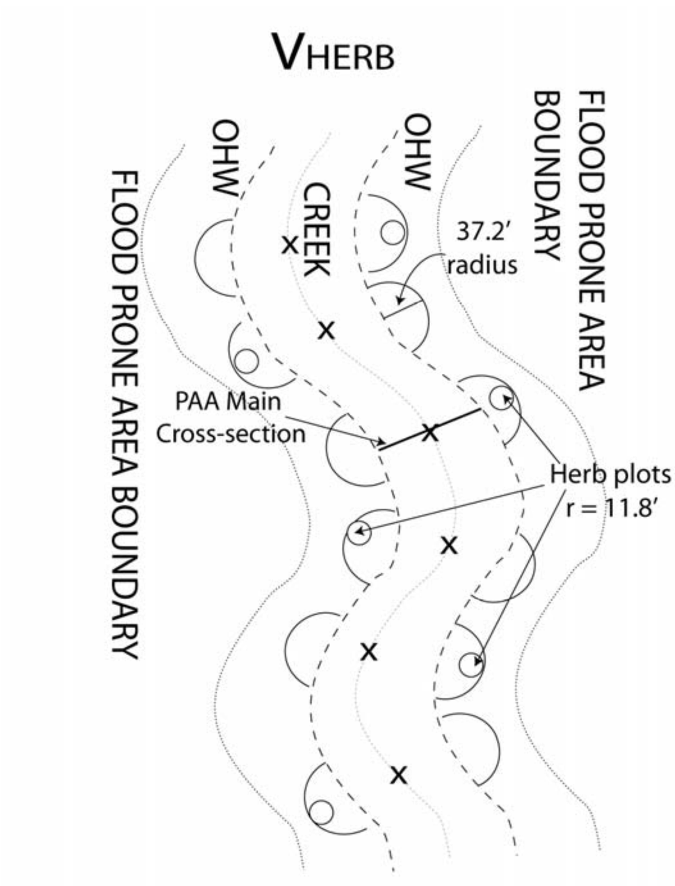
5. Herbaceous Cover (V_{HERB})

A) Definition

Herbaceous cover is defined as the percent cover of herbaceous vegetation, specifically graminoids, forbs, ferns, and fern allies within the VAA.

B) Rationale for Selection of the Variable

Cover of herbaceous vegetation typical of reference standard conditions indicates the presence and maintenance of native plant communities. Low herbaceous cover is characteristic of late succession, undisturbed reference standard conditions in the majority of plant communities found throughout the watershed. High percent cover of herbs in communities can indicate an early stage of the forested waters/wetlands in Mount Vernon. A high percentage of herbaceous cover also can indicate recent, intense, and/or frequent disturbance by human activities.



C) Definition of VAA

The VAA for V_{HERB} consists of a minimum of 1 and up to six circular plots located within the flood prone area between the OHW and boundary of the flood prone area. Each circular plot should cover 0.01 acre (radius = 11.8 feet). Establish one herb plot within the semi-circles along the PAA main cross-section. The other five plots should be located within the semi-circular plots established for tree and shrub variables that are spaced at increments of 80 feet upstream and downstream. Half of the plots should be located on each bank of the stream. If only one plot is established, it must be located in an area that is representative of the entire reach. Ideally, six plots will be assessed.

D) Measurement Protocol

At each of the six plot centers; define a 0.01 acre (radius = 11.8 feet) circular plot on stream right and stream left (Figure 12). Within each of the six circular plots, make visual estimates of the percent cover for the herbaceous stratum (including graminoids, forbs, ferns, and fern allies) using midpoints of standard canopy cover classes (Table 8). Record these estimates of percent cover on the Minimal Submittal Worksheets. Average the six measurements of herbaceous canopy cover to calculate the final estimate of herbaceous cover.

E) Scaling Rationale

V_{HERB} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling for all Subclasses

1. Tree (Forest) Community is Dominant Within the VAA:

Measurement or Condition for V_{HERB}	**Index**
a. Average herbaceous cover is ≥ 25% and < 50%, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Average herbaceous cover is ≥ 25% and < 50%, **AND** b. There is evidence of anthropogenic disturbance within the VAA.	0.75
Average herbaceous cover is ≥ 15% and < 25%	0.50
a. Average herbaceous cover is ≥ 1% and < 15%, **OR** **b.** Average herbaceous cover is ≥ 50%.	0.25
a. Average herbaceous cover is < 1% **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Average herbaceous cover is < 1% **AND** b. the variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Shrub and/or Herbaceous Community is Dominant within the VAA:

Measurement or Condition for V_{HERB}	**Index**
a. Average herbaceous cover is ≥ 75%, **AND** . b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Average herbaceous cover is ≥ 75%, **AND** b. There **is** evidence of anthropogenic disturbance within the VAA.	0.75
Average herbaceous cover is ≥ 50% and < 75%	0.50
Average herbaceous cover is ≥ 10% and < 50 %	0.25
a. Average herbaceous cover is < 10% **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Average herbaceous cover is < 10%, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

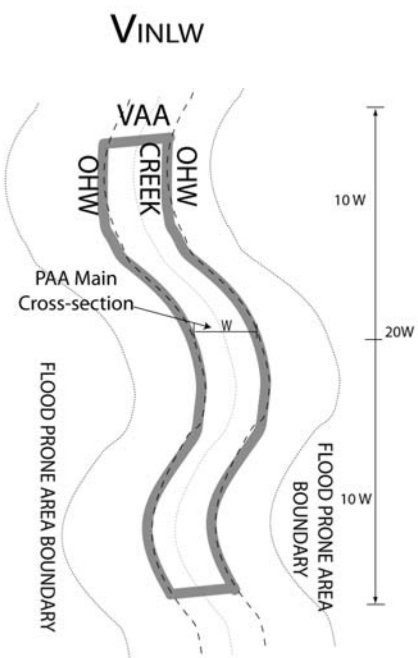
6. In-Channel Large Wood (V_{INLW})

A) Definition

In-Channel Large Wood is the number of pieces of large wood (> 4 inches average diameter and ≥ 6 feet length) per 330 feet of channel below OHW. Large wood does not include dimension lumber or rounds (*i.e.* telephone poles and fence posts).

B) Rationale For Selection of Variable

In-channel large wood (LW) in the Puget Sound Lowland provides resistance to flow (*i.e.,* roughness) and hydraulic complexity in the channel reach. Movement of water over, under, or around LW dissipates hydraulic energy and can reduce average flow velocities within the channel, and increase the complexity of the flow regime or flow pathways (*e.g.*, turbulence, low velocity eddies) (Swanson and Lienkaemper 1978, Keller and Swanson 1979, Frear 1982, Beschta 1983, Harmon *et al.* 1986, Sedell *et al.* 1988, Van Sickle and Gregory 1990, and Nakamura and Swanson 1993). During moderate to high flow conditions, LW can become mobilized and form LW jams, which further increase the hydraulic complexity and provide resistance to flow. In both relatively undisturbed and degraded channel systems, LW jams affect the development and maintenance of cross sectional and longitudinal geometry. LW provides important fish and wildlife habitat within the riverine ecosystem. Additionally, LW in various states of decomposition contributes organic carbon (detritus) to terrestrial and aquatic ecosystems. This organic carbon serves as an energy source that provides the basis for numerous ecosystem processes (*e.g.,* decomposition, nutrient cycling, energy transfer, *etc.*).



C) Definition of VAA

The VAA for V_{INLW} consists of a channel reach length that is twenty (20) times the OHW width of the main PAA cross section. The VAA is centered on the main PAA cross section, so that 10 OHW channel widths are upstream and 10 OHW channel widths are downstream from the main PAA cross section.

D) Measurement Protocol

To develop a measure of the V_{INLW} start at the PAA cross section. Walk upstream 10 OHW channel widths and downstream 10 channel widths. During these walks, count the number of pieces of LW > 4 inches diameter and ≥ 6 feet in length located below OHW. If any large wood intersects the OHW line, but extends above OHW, count it. Convert the number of pieces of wood in the surveyed channel length to the number of pieces per 330 feet (Formula 1).

FORMULA 1

$$\frac{\text{\# pieces}}{\text{330 feet}} = (330\text{ ft}) \times \frac{\text{number of pieces}}{\text{\# feet surveyed}}$$

Record your results on the Minimum Submittal Worksheets.

E) Scaling Rationale

The in-channel wood loading guidelines used in scaling Mount Vernon V_{INLW} were developed for western Washington streams by Fox *et al.* (2003).

F) Scaling

Note that channel width is the distance between Ordinary High Water (OHW) marks on either side of the channel. Round large wood counts to the nearest whole number.

For low, moderate, and steep gradient channels

Measurement or Condition for V_{INLW}	**Index**
For channel widths ≤ 19 feet: > 30 pieces / 330 feet **For channels widths 20 - 98 feet:** > 63 pieces / 330 feet **For channels widths > 98 - 328 feet:** > 208 pieces / 330 feet	1.00
For channels widths ≤ 19 feet: 26 - 30 pieces / 330 feet **For channels widths 20 - 98 feet:** 29 - 63 pieces / 330 feet **For channels widths > 98 - 328 feet:** 57 - 208 pieces / 330 feet	0.50
For channels widths ≤ 19 feet: 10 - 25 pieces / 330 feet **For channels widths 20 - 98 feet:** 10 - 28 pieces / 330 feet **For channels widths > 98 - 328 feet:** 10 - 56 pieces / 330 feet	0.25
For channels widths ≤ 19 feet: 1 - 9 pieces / 330 feet ` **For channels widths 20 - 98 feet:** 1 - 9 pieces / 330 feet **For channels widths > 98 - 328 feet:** 1 - 9 pieces / 330 feet	0.10
For channels widths ≤ 19 feet: 0 pieces / 330 feet **For channels widths 20 - 98 feet:** 0 pieces / 330 feet **For channels widths > 98 - 328 feet:** 0 pieces / 330 feet	0.00

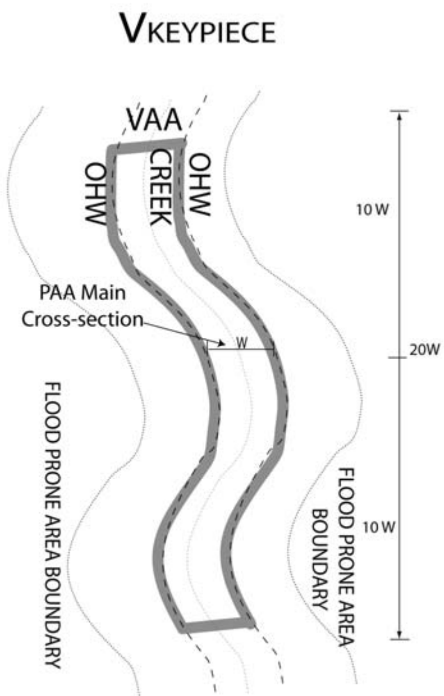
7. Key Piece ($V_{KEYPIECE}$)

A) Definition

Key pieces are defined as in-channel large wood that is (1) independently stable (not functionally held by another factor, *e.g.*, pinned by another log, buried, trapped by a rock or bed form), and (2) retains (or has potential to retain) other pieces of large woody debris (WFPB 1997; Fox *et al.* 2003). Key pieces are characteristically >20 inches in diameter and often have root wads attached.

B) Rationale for Selection of Variable

Large wood key pieces form primary structural elements of stable wood jams and channel steps.



C) Definition of VAA

The VAA for $V_{KEYPIECE}$ consists of a channel reach length that is twenty (20) times the OHW width of the main PAA cross section. The VAA is centered on the main PAA cross section, so that 10 OHW channel widths are upstream and 10 OHW channel widths are downstream from the main PAA cross section.

D) Measurement Protocol

To develop a measure of the $V_{KEYPIECE}$, start at the PAA cross section. Walk upstream 10 OHW channel widths and downstream 10 channel widths. During these walks, count the number of key pieces of LW below OHW. If any key piece intersects the OHW line, but extends above OHW, count it. Convert the number of pieces of wood per channel length to number of pieces per 330 feet (*e.g.*, Formula 1).

FORMULA 1

$$\frac{\#\ \text{pieces}}{330\ \text{feet}} = (330\ \text{ft}) \times \frac{\text{number of pieces}}{\#\ \text{feet surveyed}}$$

Record your results on the Minimum Submittal Worksheets.

E) Scaling Rationale

The instream wood loading guidelines used in scaling Mount Vernon $V_{KEYPIECE}$ were developed for western Washington streams by Fox *et al.* (2003).

F) Scaling

Note that channel width is the distance between Ordinary High Water (OHW) marks on either side of the channel. Round key piece counts to the nearest whole number.

For low, moderate, and steep gradient channels

Measurement or Condition for $V_{KEYPIECE}$	**Index**
For channel widths 0 - 33 feet: > 4 key pieces / 330 feet **For channels widths > 33 - 100 feet:** > 11 key pieces / 330 feet	1.00
For channels widths 0 - 33 feet: > 1 - 4 key pieces / 330 feet **For channels widths > 33 - 100 feet:** > 4 - 11 key pieces / 330 feet	0.50
For channels widths 0 - 33 feet: 1 key piece / 330 feet **For channels widths > 33 - 100 feet:** 1 - 4 key pieces / 330 feet	0.25
For channels widths 0 - 33 feet: 0 pieces / 330 feet **For channels widths > 33 - 100 feet:** 0 pieces / 330 feet	0.00

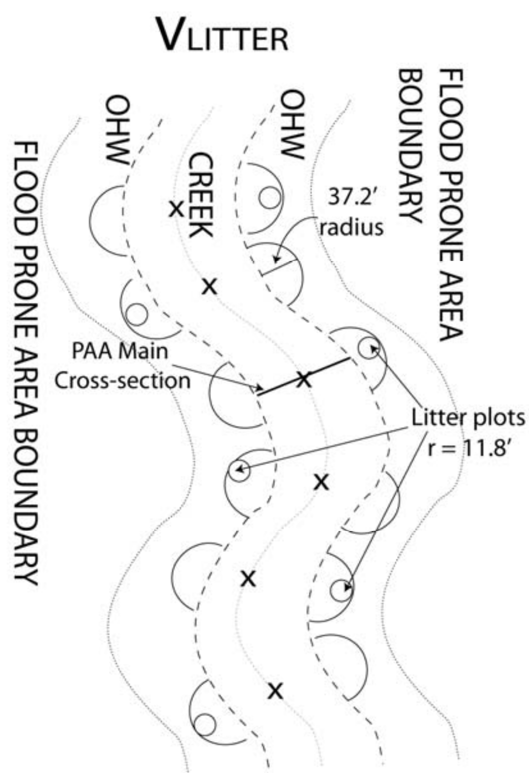
8. Litter and Fine Woody Debris (V_{LITTER})

A) Definition

Litter and fine woody debris is defined as the cover class of leaf litter and dead and downed fine woody debris (< 3 inches diameter) within the VAA.

B) Rationale for Selection of Variable

Tree branches and twigs (< 3 inches diameter) as well as leaves on the floodplain, terrace, and forest floor represent litter and fine woody debris. Fine woody debris (FWD) in various states of decomposition and leaf litter contributes organic carbon (detritus) to terrestrial and aquatic ecosystems. Organic carbon serves as an energy source that provides the basis for numerous ecosystem processes (*e.g.,* decomposition, nutrient cycling, energy transfer, *etc.*). Fine woody debris and litter also provides an important substrate for many phases of invertebrate life cycles (*e.g.*, feeding, nesting, and rearing habitat), and habitat for small vertebrates.



C) Definition of VAA

The VAA for V_{LITTER} consists of a minimum of 1 and up to six circular plots located within the flood prone area between the OHW and boundary of the flood prone area. Each circular plot should cover 0.01-acre (radius = 11.8 feet). Establish one herb plot within the semi-circles along the PAA main cross-section. The other five plots should be located within the semi-circular plots established for tree and shrub variables that are spaced at increments of 80 feet upstream and downstream. Half of the plots should be located on each bank of the stream. If only one plot is established, it must be located in an area that is representative of the entire reach. Ideally, six plots will be assessed.

D) Measurement Protocol

At each of the six plot centers; define a 0.01 acre (radius = 11.8 feet) circular plot on stream right and stream left (Figure 12). Within each of the circular plots, make visual estimates of the percent cover of fine woody debris and leaf litter using midpoints of standard canopy cover classes (Table 8). Record these estimates of percent cover on the Minimal Submittal Worksheets.

Table 8. Midpoint of Cover Classes

Percent (%) Cover	Midpoint
<1	0
1-5	3
6-15	10.5
16-25	20.5
26-50	38
51-75	63
76-95	85.5
96-100	98

E) Scaling Rationale

V_{LITTER} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For low, moderate and steep gradient channels

Measurement or Condition for V_{LITTER}	Index
a. Cover by litter/FWD is ≥ 90%. b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
Cover by litter/FWD is ≥ 90%. b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
Cover by litter/FWD is ≥ 75 and < 90%	0.50
Cover by litter/FWD is ≥ 25% and < 75%	0.25
a. Cover by litter/FWD is < 25%, **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Cover by litter/FWD is < 25%, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

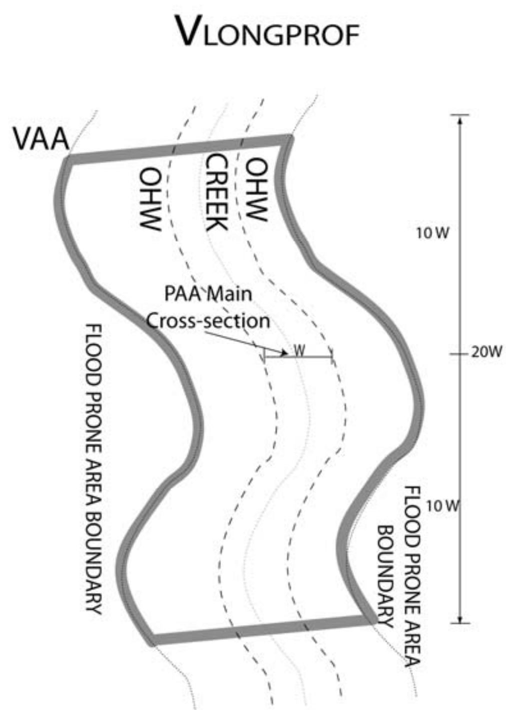
9. Longitudinal Profile ($V_{LONGPROF}$)

A) Definition

Longitudinal profile refers to the integrity of the natural longitudinal profile of the channel within and/or upstream and downstream from the main channel cross section with emphases on channel slope and connectivity to downstream reaches.

B) Rationale for the Selection of the Variable

Maintenance of the integrity of the natural longitudinal profile of channel systems is a fundamental physical feature that, when combined with features such as channel width, depth, water volume, and bedload materials, defines the ability of the channel system to perform work (Dunne and Leopold 1978, Leopold 1994). Manipulation of the longitudinal profile of channel systems (*e.g.,* installation of in-channel dams or diversion structures, water bars, bridges, culverts, *etc.*) immediately leads to adjustments in the ability of the channel system to allocate kinetic energy. Thus, changes in channel slope will lead to changes in cross sectional and longitudinal channel geometry (*e.g.,* width, depth, degree of entrenchment, sinuosity, *etc.*) These responses have important direct and collateral effects on the ability of the riverine ecosystem to maintain characteristic hydrologic processes through all phases of the hydrograph, and thus to support characteristic geochemical, plant community, and faunal support/habitat functions. For example, manipulation of channel slopes can have immediate effects on water residence times, sediment transport, and the degree to which water can contact floodplain surfaces. Plant community and faunal support/habitat functions in riverine ecosystems are directly influenced by channel slope, because water residence time, water turnover (flux/storage), and characteristics of the channel cross section and sediment dynamics are all largely controlled by longitudinal slope and variations in slope. The longitudinal gradient is delicately adjusted in a natural channel to most efficiently transport sediment in a natural channel. Any change causes readjustment through deposition or erosion of the bed and banks.



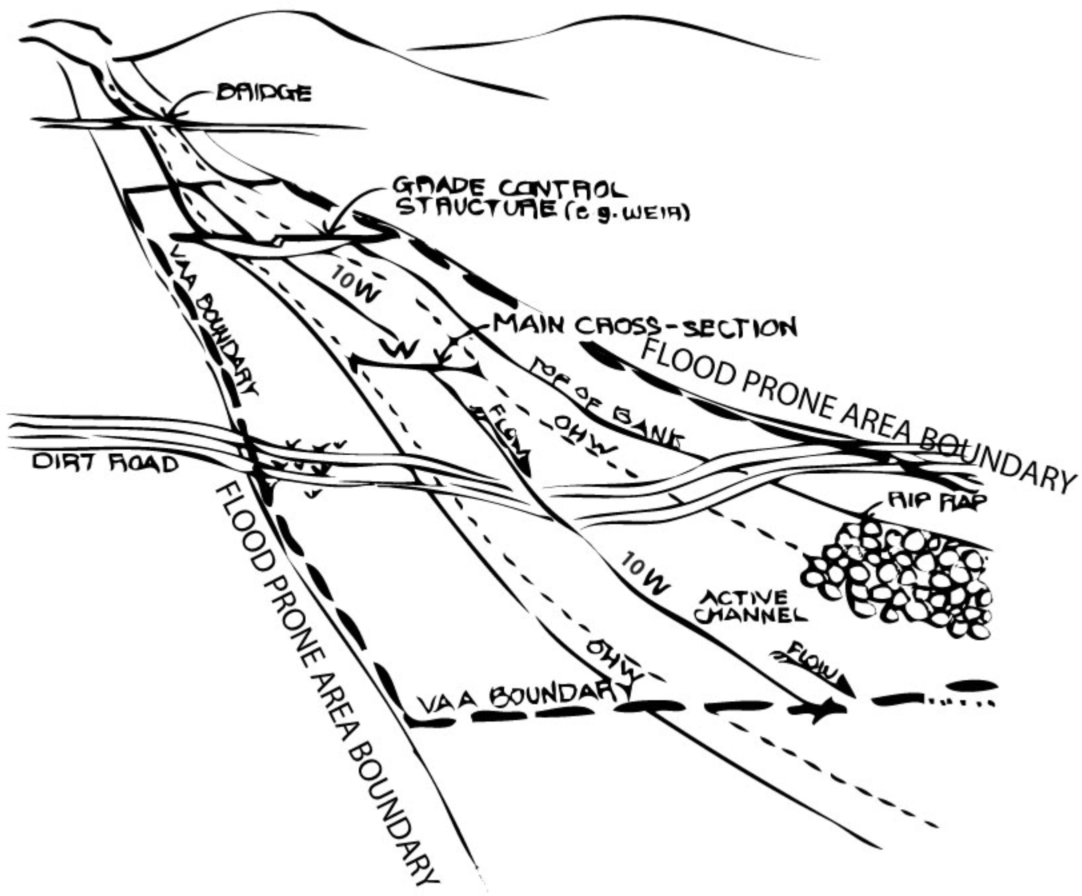
C) Definition of VAA

The VAA for $V_{LONGPROF}$ is the flood prone area (Figure 13) (*i.e.*, the channel and those parts of the floodplain adjoining the channel that are reasonably required to carry and discharge moderate frequency, moderate magnitude flood flows) for a distance equal to 20 times the OHW channel width at the main cross section and centered at the main cross section (*i.e.,* 20 widths up and downstream of the main cross-section).

D) Measurement Protocol

To measure $V_{LONGPROF}$, walk the VAA study reach (Figure 15). Carefully note all of the physical changes to the slope and/or upstream and downstream connectivity such as road crossings, culverts, check dams, or other grade control structures.

Figure 16. Measurement protocol for Longitudinal Profile Variable.



E) Scaling Rationale

$V_{LONGPROF}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For low, moderate, and steep gradient channels

Measurement or Condition for $V_{LONGPROF}$	**Index**
a. No change is evident in longitudinal slope and upstream and downstream connectivity within the VAA, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Channel longitudinal slope and upstream or downstream connectivity have been altered by anthropogenic activities, **BUT** b. These activities **have not** resulted in development of hardened, engineered civil structures (*e.g.,* culvert wingwalls, temporary road or foot trail crossings, limited, temporary construction activities, rip-rap, sills, *etc.*)	0.75
a. Channel longitudinal slope **AND** upstream or downstream connectivity have been altered by anthropogenic activities, b. These activites have resulted in: 1) changes in channel longitudinal slope **OR** in upstream and downstream connectivity, **BUT NOT** 2) development of hardened, engineered civil structures in channel (*e.g.,* clearing of vegetation, temporary road or foot trail crossings, limited, temporary construction activities, *etc.*).	0.50
a. Channel longitudinal slope and upstream or downstream connectivity have been altered by anthropogenic activities. b. These activites have resulted in: 1) changes in channel longitudinal slope **OR** in upstream and downstream connectivity, **AND** 2) development of hardened, engineered civil structures in channel (*e.g.,* clearing of vegetation, temporary road or foot trail crossings, limited, temporary construction activities, *etc.*).	0.25
a. Channel longitudinal slope and upstream or downstream connectivity have been altered by anthropogenic activities. b. These activities have resulted in: 1) changes in channel longitudinal slope **AND** 2) changes in upstream and downstream connectivity **AND** 3) development of hardened, engineered civil structures in channel (*e.g.,* clearing of vegetation, temporary road or foot trail crossings, limited, temporary construction activities, *etc.*), **AND** c. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Channel is completely hardened by filling with impervious materials (*e.g.*, concrete trapezoids, concrete weirs and ramps, grouted rip rap, *etc.*), **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

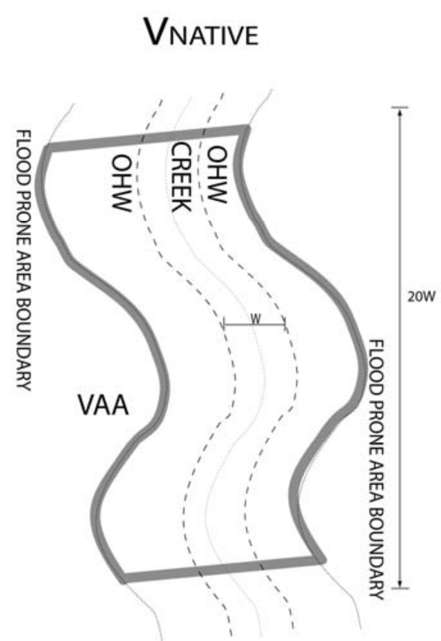
10. Percentage of Native Vegetation (V_{NATIVE})

A) Definition

The percentage of native vegetation is defined as the proportion of the dominant (top five) plant taxa within the VAA that are native.

B) Rationale for Selection of Variable

Native plant species dominate reference standard conditions. Anthropogenic disturbances provide opportunities for nonnative weedy taxa to enter and to become established within the disturbed portions of the community. However, it has been suggested that most nonnative species have little or no effect on native species within the invaded community (Simberloff 1981). Some nonnative species, such as Japanese Knotweed (*Polygonum japonica)*, can and do interact with native species in ways that may be detrimental. Nonnative taxa may hybridize with closely related species (Thompson 1991, Abbot 1992); outcompete natives (see Parker and Reichard 1998 for a review); alter ecosystem processes such as nitrogen fixation (Vitousek *et al.* 1987), site water balance (Carman and Brotherson 1982), and mycorrhizal interactions (Goodwin 1992); and, they may negatively affect the use of the native communities by wildlife (Neill 1983, Olson and Knopf 1986). Therefore, the percentage of native plant species to nonnative plant species in an assessment area is a measure of the degree to which native plant communities have departed from reference standard conditions as a result of anthropogenic activities.



C) Definition of VAA

The VAA for V_{NATIVE} is defined laterally and longitudinally at the main PAA cross-section. Laterally, the VAA is defined as the flood prone area width (*i.e.*, the active channel and those parts of the floodplain adjoining the channel that are engaged during moderate frequency, moderate magnitude flood flows) (Figure 12). Longitudinally, the VAA is defined as 20 times the OHW channel width centered at the main cross-section (*i.e.,*10 channel widths upstream and downstream from the main cross-section) (Figure 13).

D) Measurement Protocol

To develop a measurement for V_{NATIVE}, start at the main cross section. Thoroughly walk the VAA. During your walk of the VAA, determine the five dominant species for each of the three vegetation strata (*i.e.*, tree, shrub, and herb) (see Figure 12). Vines are considered to be shrubs. If five species are not present within a stratum, list all species that do occur. For example, if only *Rubus discolor* and *Rubus spectabilis* occur in the shrub stratum within the VAA, then only record these two species. Record all dominant species for all three strata on the Minimum Submittal Worksheets.

If you encounter problems in determining the dominant species within the VAA for a particular stratum, begin by assigning a cover class midpoint value (Table 7) for all species that occur in that stratum. Then select the five species from that stratum with the highest cover class values. For all dominant species, identify their indigenous status (native or non-native) using *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1990). Count the number of native, non-native (including ornamental and cultivated) species from this list of dominant species. Divide the number of native species by the total number of identified dominant species and multiply by 100 to obtain a percentage of native species. Record the percentage on the Minimum Submittal Worksheets.

E) Scaling Rationale

V_{NATIVE} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For low, moderate, and steep gradient channels

Measurement or Condition for V_{NATIVE}	**Index**
a. > 90% of the dominant species are native, **AND** b. There is **no** evidence of anthropogenic disturbance	1.00
a. ≥ 75 % and < 90% of the dominant species are native, **AND** ` b. There is **some** evidence of anthropogenic disturbance	0.75
≥ 50% and < 75% of the dominant species are native	0.50
≥ 25% and < 50% of the dominant species are native	0.25
a. < 25% of the dominant species are native, **AND** b. the variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. < 25 % of the dominant species are native, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

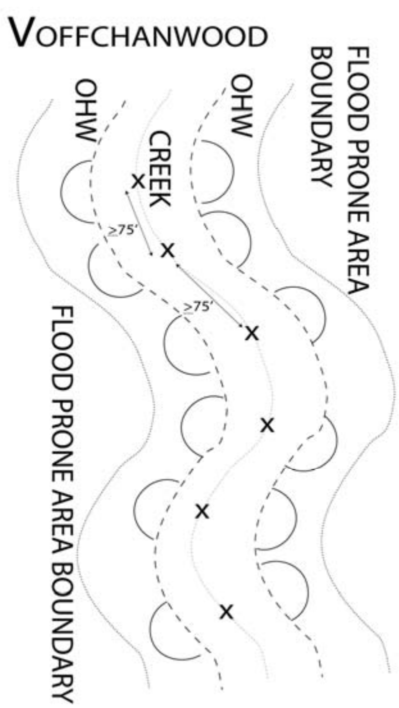
11. Off-Channel Large Wood ($V_{OFFCHANWOOD}$)

A) Definition

Off-Channel Large Wood is the number of downed and dead trees or limbs (> 4 inches diameter and > 6 feet in length) above OHW and within the VAA.

B) Rationale for Selection of Variable

Large wood (LW) that occurs above OHW in the Puget Sound Lowland has direct effects on hydrologic, geochemical, plant community, and faunal support/habitat functioning both within and outside the influence of the active stream channel. During moderate to high flow conditions and wind storms, off-channel LW can become mobilized and transported into the channel and deposited below OHW. Off-channel LW inputs below OHW increase the hydraulic complexity of the channel, floodplain, and channel roughness within the PAA. During moderate to high flow conditions, mobile LW also has the potential to form many different types of debris jams. These jams can have direct and indirect effects on the development and maintenance of cross sectional and longitudinal channel geometry, diversity of on and off channel habitat conditions, *etc.* Off channel LW provides important plant and animal habitat and cover within riparian ecosystems. Additionally, off channel LW in various states of decomposition contributes organic carbon (detritus) to terrestrial and aquatic ecosystems. This organic carbon serves as an energy source that provides the basis for numerous ecosystem processes (decomposition, nutrient cycling, energy transfer, *etc.*).



C) Definition of VAA

The VAA for $V_{OFFCHANWOOD}$ consists of a minimum of one and up to six plots (radius = 37.2 ft). One plot consists of two semi-circles which are centered at the OHW on each side of the stream along the main cross-section of the PAA. Ideally, six plots (six pairs of semi-circles) will be assessed. If only one plot (two semi-circles) will be established, it ***must*** be located in an area that is representative of the entire reach, and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

<u>Location of Plots</u>

To establish the six plots (six pairs of semi-circles) for scaling $V_{OFFCHANWOOD}$, begin at the PAA main cross-section (Figure 11). Stand at OHW on stream right and then on stream left. From each side of the stream, visually extend an arc that is 37.2 feet radius from this point (creating a 0.05 acre half circle). Establish additional plots centered at OHW upstream and downstream from the main PAA cross-section at 80 foot intervals. See Figure 10 for further clarification.

If vegetation plots can not be established according to the articulated HGM protocol because of extremely steep terrain, or a narrow riparian zone, then locate the six vegetation plots in accessible, but representative portions of the riparian zone. If the establishment of six plots is not possible at all, because of hazardous or unsafe conditions, then the data required for the vegetation variables should be estimated from a remote location (*e.g.*, from the creek bed).

Variable Measurement

Count all down wood and dead trees and/or limbs (> 4 inches diameter and > 6 feet in length) within the VAA. Note that downed wood must be at an angle of repose greater than 45 degrees from vertical. It can be either dead or alive.

All pieces of LW that intersect the sample VAA perimeters should be recorded. If a piece of off channel large wood is found in the VAA and it extends beyond the plot boundary and into the active channel (*i.e.*, below OHW), count it. Record your results on the Minimum Submittal Worksheets.

E) Scaling Rationale

Scaling for $V_{OFFCHANWOOD}$ is based on data from 196 stands in the Cascade and coastal ranges in Washington and Oregon collected by Spies *et al.* (1988).

F) Scaling

Measurement or Condition for $V_{OFFCHANWOOD}$	**Index**
On average, there are greater than 15 pieces of large wood per 0.1 acre plot.	1.00
On average, there are between 8 and 15 pieces of large wood per 0.1 acre plot.	0.75
On average, there are between 5 and 7 pieces of large wood per 0.1 acre plot.	0.50
On average, there are between 2 and 4 pieces of large wood per 0.1 acre plot.	0.25
On average, there are 1 or 2 pieces of large wood per 0.1 acre plot.	0.10
There is no large wood within the VAA.	0.00

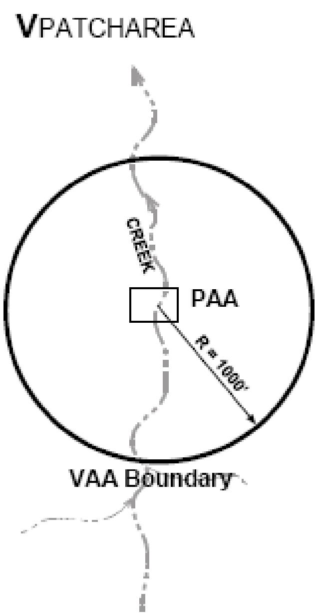
12. Patch Area ($V_{PATCHAREA}$)

A) Definition

Patch area is the percent of the area covered by habitat patches, as calculated from the Habitat Patch map, within the 1000 ft radius VAA.

B) Rationale for Selection of the Variable

The relative area (measured as a percentage of the 1000 ft VAA ring) of patches is an indicator of the site's capacity to function as habitat for faunal communities. The relative area, in combination with a measure of the total number of patches (*i.e.*, $V_{PATCHNUMBER}$), is an indicator of the number and size distribution of the habitat patches available for utilization by faunal communities. Large habitat patches have low edge-to-interior ratios and thus a diversity of interior niches that are critical for resting, hiding, escape, thermal, and feeding dynamics. For aquatic dependent species with both large and small home ranges, large intact habitat patches are critical for completion of their lifecycles. In addition, habitat patch size affects the maintenance of native vegetation communities through factors such as seed dispersal, light, and temperature regulation.



C) Definition of the VAA

The variable assessment area (VAA) for $V_{PATCHAREA}$ is the 1000 ft radius VAA ring centered on the project area (*i.e.* area where development is planned to occur).

D) Measurement Protocol

Using GIS, display or print an area map showing the watershed that contains the PAA of interest. Using a ruler and compass, or an equivalent technique in the mapping software, plot a circle with a 1000 ft radius around the centroid of the project area.

To score this variable, three habitat conditions have been identified in Mount Vernon:

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers),
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Using a 1:24,000 mapping scale grid, or an equivalent GIS technique (*e.g.* "Tabulate Area" in Arc/Info Spatial Analyst), measure the relative areas of the habitat patches that are within the 1000 ft VAA ring. Habitat patches that extend beyond the 1000 ft VAA ring should be truncated and only the area within the 1000 ft VAA ring should be included in the area measurement in order to produce a relative area measurement. If a patch has a width less than 35 feet, include this area with the adjacent habitat type.

Using these calculations, sum the patch areas to calculate the total patch area for Excellent and Good condition habitat within the 1000 ft VAA ring. Divide the patch areas by the area of the 1000 ft VAA ring

(3,140,000 ft^2 [*i.e.*, 1000 ft x 1000 ft x 3.14]) and multiply by 100 to calculate the relative percentage of the 1000 ft VAA ring in each habitat patch class. If necessary, convert the habitat patch areas from m^2 to ft^2 to maintain consistency of units. Use the relative area of the habitat patches in the 1000 ft VAA ring to scale the $V_{PATCHAREA}$ variable. Print and include an electronic copy of the map used for the calculation in final reports.

E) Scaling Rationale

$V_{PATCHAREA}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

<u>Habitat Types</u>

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Measurement or Condition for $V_{PATCHAREA}$	**Index**
≥ 95% of the VAA is covered by excellent habitat	1.00
≥ 95% of the VAA is covered by excellent or good habitat	0.75
50 to 94% of the VAA is covered by excellent or good habitat	0.50
10 to 49% of the VAA is covered by excellent or good habitat	0.25
a. 0 to < 10 %% of the VAA is covered by excellent or good habitat, **AND** b. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. 0 to < 10 %% of the VAA is covered by excellent or good habitat, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

13. Habitat Patch Lateral Contiguity ($V_{PATCHLATCON}$)

A) Definition

The lateral contiguity (perpendicular to the general valley trend of channel) of habitat patches within the 1000 ft radius VAA.

B) Rationale for Selection of the Variable

The lateral contiguity of habitat patches within the VAA is an indicator of the site's capacity to function as habitat for faunal communities. In Mount Vernon, less disturbed riparian ecosystems are connected laterally through a contiguous forest vegetation community. Lateral connectivity decreases with human disturbance (roads, urbanization, agriculture, grazing, land clearing, *etc.*) and thus influences the ability of faunal communities to locate, access, utilize, and disperse from a variety of habitat types.

C) Definition of the VAA

The variable assessment area (VAA) for $V_{PATCHLATCON}$ is a 2000 ft transect that crosses the centroid of the project area (PAA; *i.e.*, area where development will occur) and that is oriented perpendicular to the primary gradient of the slope.

D) Measurement Protocol

Within GIS, display or print a map showing the watershed that contains the PAA of interest. From the centroid (approximate center) of Project Area, draw a line 1000 ft in each direction (2000 ft total) that is perpendicular to the primary gradient of the slope. Count and record the number of habitat changes crossed by this line. Count a habitat class change only if some portion of the new habitat class is visible on either side of the transect.

Record your results on the Minimum Submittal Worksheet. Print and include an electronic copy of the map used for the calculation.

E) Scaling Rationale

$V_{PATCHLATCON}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For low, moderate, and steep gradient channels

Measurement or Condition for $V_{PATCHLATCON}$	**Index**
a. Habitat along the VAA is entirely Excellent Habitat (forest), **AND** b. There are 0 habitat class changes	1.00
a. There are 1 – 3 habitat class changes along the VAA, **AND** b. Excellent habitat is present within the VAA.	0.75
a. There are ≥ 3 – 6 habitat class changes along the VAA, **AND** b. Excellent habitat is present within the VAA.	0.50
a. There are ≥ 6 – 9 habitat class changes along the VAA, **AND** b. Excellent habitat is present within the VAA.	0.25
a. There is no Excellent habitat (forest) along the VAA, **OR** b. There are ≥ 10 habitat class changes in the VAA, **AND** c. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. There is no Excellent habitat (forest) along the VAA, **OR** b. There are ≥ 10 habitat class changes in the VAA, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

14. Habitat Patch Longitudinal Contiguity ($V_{PATCHLONGCON}$)

A) Definition

The longitudinal contiguity (*i.e.*, along the channel) of habitat patches within the 1000 ft radius VAA.

B) Rationale for Selection of the Variable

The longitudinal contiguity of habitat patches within the VAA is an indicator of the site's capacity to function as habitat for faunal communities. In Mount Vernon watersheds, undisturbed riparian ecosystems have no habitat class changes. Moderately impacted areas have between 1 and 6 habitat class changes while highly degraded areas have more than 6 class changes. along the 1:24,000 scale stream channel network within the VAA. Longitudinal contiguity decreases (*i.e.*, increasing number of habitat class changes) with increasing human disturbance (*i.e.,* grazing, land clearing, roads, urbanization, agriculture *etc.*) and thus influences the ability of faunal communities to locate, access, utilize, and disperse from a variety of habitat types.

C) Definition of the VAA

The variable assessment area (VAA) for $V_{PATCHLONGCON}$ is the stream channel located within a 1000 ft radius circle centered on the Project Area.

D) Measurement Protocol

Using GIS, display or print a map of the project site at 1:24,000 scale. Locate and plot the location of the project site on the map and generate a 1000 ft VAA ring centered on the PAA). Identify the dominant stream channel (*i.e.*, drains the largest area) that passes through the 1000 ft VAA.

Start from the farthest up-gradient point on the stream channel (*i.e.*, where the channel intersects or enters the 1000 ft VAA ring) and count the number of habitat class changes that occur along the stream channel until you reach the down-gradient point where the channel exits the 1000 ft VAA ring. Use the number of habitat class changes that occur along the stream channel in the 1000 ft VAA to score the $V_{PATCHLONGCON}$ variable.

Count habitat class changes when the stream channel (arc/line) enters or touches a new habitat type. Count a habitat class change only if some portion of the new habitat class is visible on either side of the stream channel. Where the stream channel (arc/line) evenly splits pixels of two different habitat classes from the class you are currently in, switch habitat classes to a) the first class encountered, or b) when both are encountered at the same point, switch to the larger of the two patches encountered. Record your results on the Minimum Submittal Worksheet. Print and or include an electronic copy of the map used for this calculation.

E) Scaling Rationale

$V_{PATCHLONGCON}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For low, moderate, and steep gradient channels

Measurement or Condition for $V_{PATCHLONGCON}$	Index
a. Habitat within the VAA is entirely Excellent habitat; there are 0 habitat class changes, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. There are between 1 and 4 habitat class changes within the VAA, **AND** b. Excellent habitat is present within the VAA, **AND** c. There is **SOME** evidence of anthropogenic disturbance within the VAA.	0.75
a. There are between 4 and 6 habitat class changes within the VAA, **AND** b. Excellent habitat is present within the VAA.	0.50
a. There are more than 6 habitat class changes within the VAA, **AND** b. Excellent habitat is present within the VAA.	0.25
a. No Excellent habitat is present within the VAA, **BUT** b. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. No Excellent or Good habitat is present within the VAA, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

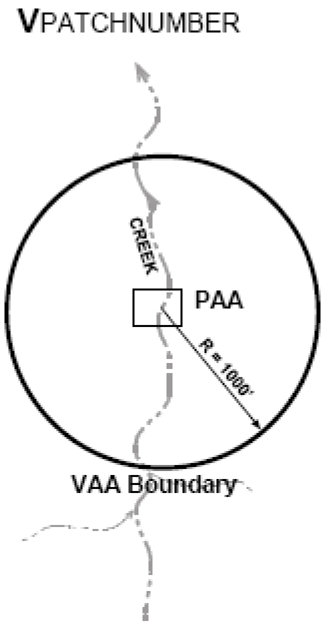
15. Patch Number ($V_{PATCHNUMBER}$)

A) Definition

The number of habitat patches, calculated from the Habitat Patch map, within the 1000 ft radius VAA ring surrounding the project site.

B) Rationale for Selection of the Variable

The number of habitat patches within a 1000 ft radius VAA on the project site is an indicator of the site's capacity to function as habitat for faunal communities. The number of patches increases with human disturbance and thus influences the ability of faunal communities to locate, access, utilize, and disperse from a variety of habitat types. The access and utilization of habitat patches by faunal communities is essential for population dynamics such as resting, hiding, escape, thermal regulation, and feeding.



C) Definition of the VAA

The variable assessment area (VAA) is the 1000 ft radius VAA ring centered on the project area (*i.e.,* area where development is planned to occur).

D) Measurement Protocol

Using GIS, display or print an area map showing the watershed that contains the PAA of interest. Locate the Project Area. Using a ruler and compass, or an equivalent technique in the GIS software, plot a circle with a 1000 ft radius around the centroid of the project area.

Three habitat types have been identified in Mount Vernon:
1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Using a 1:24,000 mapping scale grid, or an equivalent GIS technique (*e.g.*, "Tabulate Area" in Arc/Info Spatial Analyst), measure the relative areas of the habitat patches that are within the 1000 ft radius VAA ring. Habitat patches that extend beyond the 1000 ft radius VAA ring should be truncated and only the area within the 1000 ft VAA ring should be included in the area measurement in order to produce a relative area measurement. If a patch has a width less than 35 feet, include this area with the adjacent habitat type. Count the number of Excellent and Good Habitat patches that are within the 1000 ft radius VAA ring. Habitat patches that are intersected by, but also extend beyond, the 1000 ft VAA ring should also be included in the count of habitat patches. Count habitat patches separately if they do not share a common edge, or are connected only diagonally on the map. Count a habitat patch only once even if the patch intersects the 1000 ft VAA ring at more than one location. Print and or include an electronic copy of the map used for the calculation. Record your results on the Minimum Submittal Worksheet.

E) Scaling Rationale

$V_{PATCHNUMBER}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

<u>Habitat Types</u>

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

For low, moderate, and steep gradient channels

Measurement or Condition for $V_{PATCHNUMBER}$	**Index**
a. The 1000 ft radius VAA ring contains 1 – 2 Excellent habitat patches, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA	1.00
a. The 1000 ft radius VAA ring contains 3 – 5 Excellent habitat patches, **AND** b. There is **some** evidence of anthropogenic disturbance within the VAA	0.75
a. The 1000 ft radius VAA ring contains 6 – 10 Excellent **and/or** Good habitat patches, **AND** b. Excellent habitat is present within the VAA.	0.50
a. The 1000 ft radius VAA ring contains 11 – 20 Excellent **and/or** Good habitat patches, **AND** b. Excellent habitat is present within the VAA	0.25
a. The 1000 ft radius VAA ring contains more than 20 Excellent and Good habitat patches, **OR** b. No Excellent habitat is present within the VAA, **BUT** c. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. No Excellent or Good habitat is present within the VAA, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

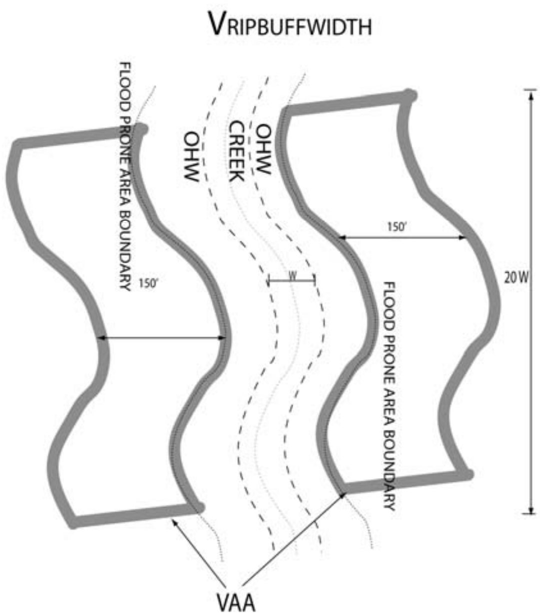
16. Riparian Buffer Width ($V_{RIPBUFFWIDTH}$)

A) Definition

Riparian buffer width is the condition of the plant community extending across the flood prone area and 150 feet up slope from the edge of the flood prone area.

B) Rationale for Selection of Variable

Intact plant communities are critical to the functioning of the riverine ecosystem. They provide stream temperature control, source of LWD recruitment, microclimate control, erosion control and sediment removal, nutrient and pollutant removal and fish and wildlife habitat. Riparian Buffer Width is used in the Faunal Support/Habitat functions and is scaled to provide a riparian buffer width of approximately one site potential tree height (approximately 150 feet).



C) Definition of the VAA

The VAA for $V_{RIPBUFFWIDTH}$ extends upslope in a line perpendicular from the creek, beginning at the edge of the flood prone area for 150 feet. Note that the flood prone area can be variable in width on different banks and also along the same bank. The length of the VAA for $V_{RIPBUFFWIDTH}$ is 20 times the width of the channel at OHW. The VAA is centered on the PAA cross section so that 10 OHW channel widths are upstream, and 10 OHW channel widths are downstream from the main PAA cross section.

D) Measurement Protocol

To measure $V_{RIPBUFFWIDTH,}$ begin at the edge of the flood prone area and walk upslope in a line perpendicular to the stream channel. Measure the width of contiguous forest canopy upslope from the flood prone area boundary. Multiple measurements may be necessary to determine an average width of contiguous canopy for the VAA. Complete measurements on each side of the stream; average the results to scale the variable.

E) Scaling Rationale

$V_{RIPBUFFWIDTH}$ was scaled according to the expected height of a site potential tree (potential height of trees expected at this site) that can contribute to the riparian zone (May 2003; Table 9).

Table 9. Recommendations on Riparian Management Zones (RMZ) for Streams (May 2003).

Riparian Function	General Range of Effective Widths (meters)	Minimum Recommended Width (meters)	Minimum Recommended Width (feet)	Notes on Riparian Functions
Sediment and Erosion Control	8 – 183	30	98	80% sediment removal
NPS Pollutant Removal	4 – 262	30	98	80% nutrient (P/N) and FC removal
Large Woody Debris Recruitment	10 - 100	1 SPTH (~50 m)	164	SPTH = site potential tree height; based on long- term natural levels of LW
Water Temperature Regulation	11 - 43	30	98	Based on adequate shade
Wildlife Habitat	10 - 300	100	328	Coverage for a majority but not all species of concern
Microclimate	45 - 200	100	328	Optimum function

Note: Recommended minimum effective widths are based on a review of scientific literature. Full riparian function is the goal. A larger RMZ and buffer may be required in specific cases including but not limited to areas with steep slopes, active flood plain systems, and streams contiguous with wetlands. Larger buffers may also be required for riparian corridors where surrounding land-use activity is potentially harmful or where human encroachment is likely (indicated by a wide range of effective widths in this table.

F) Scaling

For low, moderate, and steep gradient channels

Measurement or Condition for $V_{RIPBUFFWIDTH}$	Index
a. Riparian buffer width with contiguous forest canopy cover is greater than 150 feet, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Riparian buffer width with contiguous forest canopy cover is greater than 150 feet, **AND** b. There is **some** evidence of anthropogenic disturbance.	0.75
Riparian buffer width with contiguous forest canopy cover is between 76 and 150 feet.	0.50
Riparian buffer width with contiguous forest canopy cover is between 10 and 75 feet.	0.25
a. Riparian buffer width with contiguous forest canopy cover is between 0 and 10 feet beyond the flood prone area boundary, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. There is no contiguous forest cover beyond the flood prone area boundary, **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

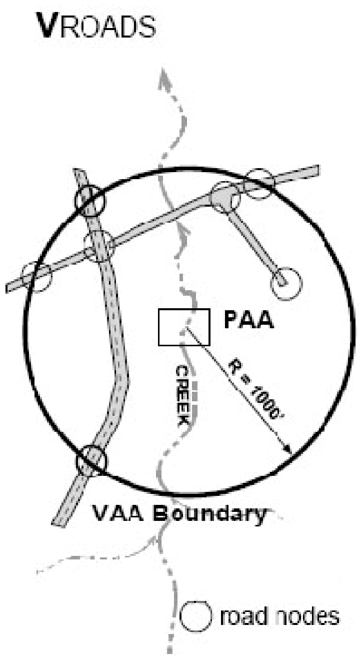
17. Road Density (V_{ROADS})

A) Definition

The density of highways and roads, as calculated from the Mount Vernon map road overlay, within the 1000 ft radius VAA ring surrounding the project site.

B) Rationale for Selection of the Variable

The density of highways and roads within a 1000 ft radius of the project site is an indicator of the site's capacity to function as habitat for faunal communities (Riitters and Wickham 2003). For example, the density of highways and roads can have a direct influence on the mortality rates of faunal communities (Trombulak and Frissell 2000). In Mount Vernon watersheds, the density of roads influences the ability of faunal species to locate, access, utilize, and disperse from a variety of habitat types. Uninterrupted (by roads and/or traffic) access and utilization of habitat by faunal species is essential for maintenance of faunal populations via reproduction, and for providing food and cover resources.



C) Definition of the VAA

The variable assessment area (VAA) for the V_{ROADS} variable is a 1000 ft ring centered on the project assessment area (PAA).

D) Measurement Protocol

Display or print a map with the road overlay that contains the project assessment area (PAA) of interest. Include the road overlay on the map. Plot the location of the PAA on the map. Using 1:24,000 mapping scale circles, or an equivalent GIS technique, generate a 1000 ft radius VAA ring centered on the PAA.

Count the number of road and highway nodes that are within the 1000 ft VAA ring or that intersect the 1000 ft VAA ring. A road/highway node is defined as: 1) the point where two roads/highways intersect, 2) the point where a road/highway terminates, or 3) the point where a road/highway intersects the 1000 ft VAA ring.

Record your results on the Minimum Submittal Worksheet.

E) Scaling Rationale

V_{ROADS} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for V_{ROADS}	**Index**
There are no roads in the 1000 ft radius VAA.	1.00
There are 2 to 5 road nodes in the 1000 ft radius VAA.	0.75
There are 6 to 9 road nodes in the 1000 ft radius VAA.	0.50
There are 10 to 12 road nodes in the 1000 ft radius VAA.	0.25
There are 12 to 15 road nodes in the 1000 ft radius VAA.	0.10
There are more than 15 road nodes in the 1000 ft radius VAA.	0.00

18. Sediment Delivery (V_{SED})

A) Definition

Sediment Delivery refers to the sources and amount of sediment delivery and deposition to waters/wetland from upgradient landscape positions.

B) Rationale for the Selection of the Variable

Urban watersheds in Mount Vernon characteristically convey large amounts of sediment. Human activities often result in impacts on the sources and/or the timing, rate, and amount of sediment delivery and deposition to riverine waters/wetlands (*i.e.,* significant increases or decreases over reference standard conditions). Human induced changes in sediment dynamics of riverine ecosystems usually have negative impacts on all classes of ecosystem functions (*i.e.*, hydrologic, geochemical, plant community, and faunal support/habitat functions) (Ward & Stanford 1979). For example, alteration of channel geometry and hydraulic roughness due to either accelerated rates of sediment deposition or elimination of sediment (*e.g.,* installation of debris basins) can inhibit or enhance conveyance of flood flows. Similarly, sediment accumulations from developed up-gradient source areas can be the mechanism by which riverine ecosystems and downstream ecosystems are chronically loaded with nutrients, organic matter, and contaminants. Too much or too little sediment moving through riverine ecosystems can have large effects on the productivity of in situ faunal communities (Bestcha & Platts 1986) and on downstream faunal communities that depend on maintenance of the integrity of upstream habitats and food webs.

C) Definition of VAA

The VAA for V_{SED} consists of the stream channel and flood prone area within the PAA and extending for 500 feet downstream and upstream from the PAA.

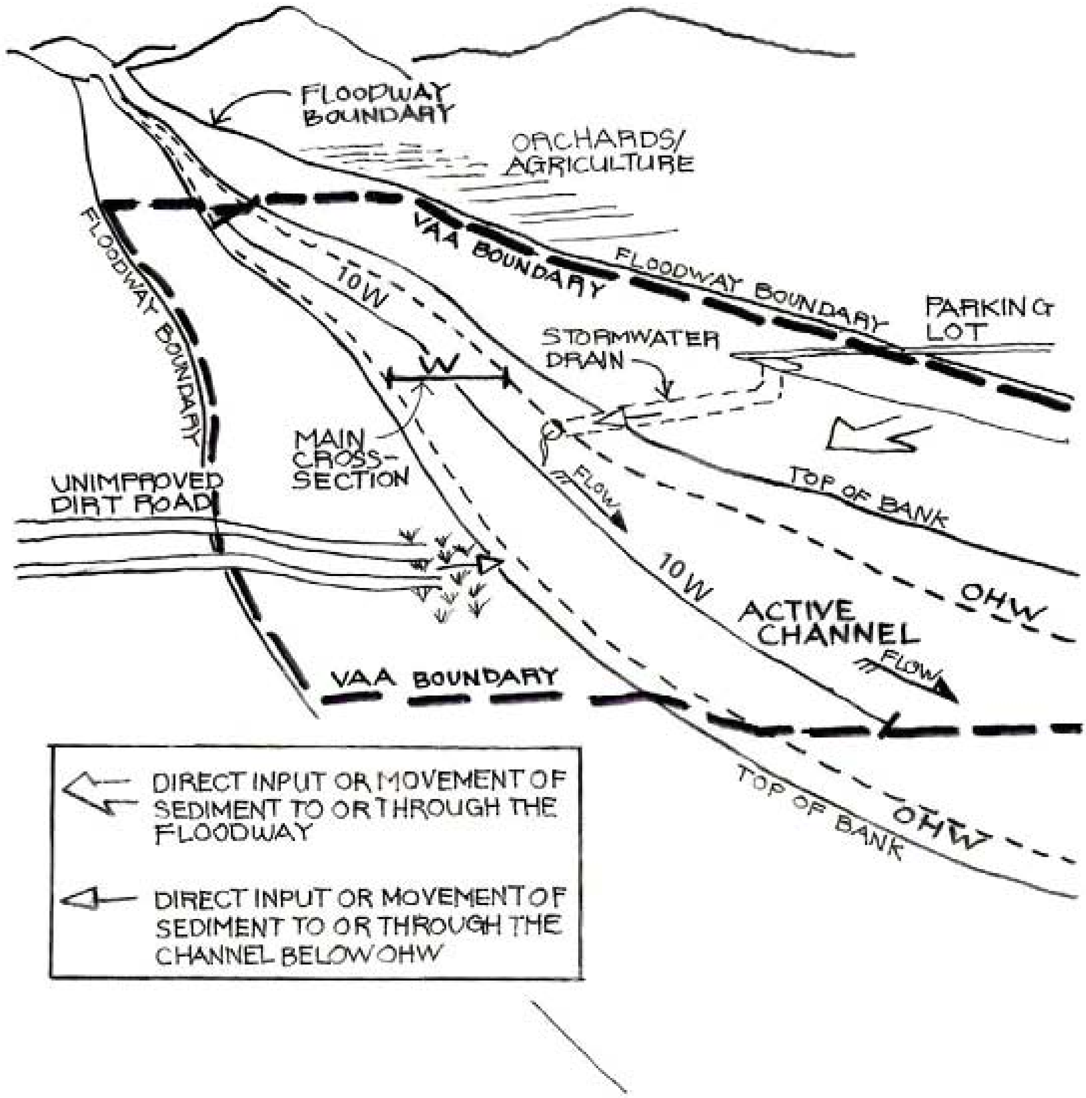
D) Measurement Protocol

To measure V_{SED}, walk the VAA study reach (Figure 17). Identify and count the number and type of natural and/or anthropogenic sources of sediment delivery or accumulation, or movement of sediment to or through the stream channel system below OHW, or direct input, accumulation, or movement of sediment to or through the buffer area. Examples of anthropogenic sources of disturbance that may impact sediment inputs into the stream channel and/or buffer areas are clearing of vegetation, bank instability, grading and/or dredging of the channel bed, recreational trails and/or dirt roads, public roads, parking lots and other impervious surfaces, drains, agriculture, construction activities lacking proper sediment and erosion control measures, *etc.*

E) Scaling Rationale

V_{SED} was scaled using a combination of field observations, literature, and best scientific judgment.

Figure 17. Measurement protocol for Sediment Delivery.



F) Scaling

For low, moderate, and steep gradient channels

Measurement or Condition for V_{SED}	Index
a. There are **no** direct sources of sediment delivery or deposition into waters/wetlands or their associated buffers within the VAA, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. There are 1 or 2 direct sources of sediment delivery or deposition into waters/wetlands or their associated buffers within the VAA. Evidence of moderate sources may include bank instability, drains, recreational trails and/or dirt roads, public roads, *etc.*, **AND** b. Mitigation for the sediment source(s) is in place and functioning properly. This mitigation can include drain filters, revegetation efforts on unstable banks, *etc.*, **AND** c. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
a. There are 1 or 2 point sources of sediment delivery and deposition into waters/wetlands or their associated buffers within the VAA. Evidence of moderate sources may include bank instability, drains, *etc.*, **AND** b. There is **no** mitigation for these sediment source(s) in place or it is not functioning properly. Examples of mitigation include drain filters, revegetation efforts on unstable banks, *etc.*	0.50
a. There are **more than 2** point or non-point sources of sediment delivery and deposition into waters/wetlands or their associated buffers within the VAA. Evidence of point sources may include bank instability, drains, *etc.* N on-point sources include clearing of vegetation, grading and/or dredging of the channel bed, recreational trails and/or dirt roads, public roads, parking lots and other impervious surfaces, agriculture, construction activities lacking proper sediment and erosion control measures, *etc.*	0.25
a. Sources and/or amount of sediment delivery and deposition into waters/wetlands within the VAA are significantly altered due to the presence of hardened engineered structures (within the VAA and/or up or down gradient) that are specifically designed and maintained to alter and permanently control the amount and rate of sediment delivery to or through the VAA (*e.g.,* debris basins), **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Sources and/or amount of sediment delivery and deposition into waters/wetlands within the VAA are significantly altered due to the presence of hardened engineered structures (within the VAA and/or up or down gradient) that are specifically designed and maintained to alter and permanently control the amount and rate of sediment delivery to or through the VAA (*e.g.,* debris basins), **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

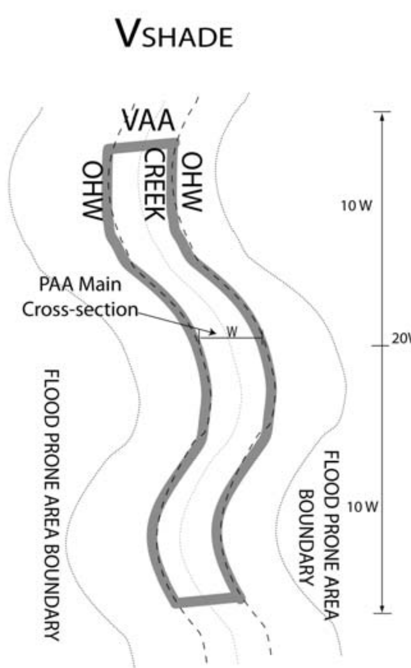
19. Shade over the Stream Channel (V_{SHADE})

A) Definition

Shade over the stream channel is the percent cover of tree and shrub vegetation canopies overhanging the active stream channel.

B) Rationale for Selection of Variable

Trees and shrubs that overhang the stream channel and cast shade below OHW have been shown to have important influences on a wide range of riparian ecosystem processes (Martin *et al.* 1986). The presence or absence of riparian shade has particularly important influences on (1) stream temperatures; (2) quality and quantity of food and cover resources available for vertebrate and invertebrate faunal species, and (3) riparian microclimatic conditions (Gregory *et al.* 1991). For example, regulation of stream water temperatures by riparian tree, shrub, and herb canopy shade is important to the maintenance of aquatic and semi-aquatic vertebrate and invertebrate faunal assemblages. Specifically, it has been shown that dramatic fluctuations in diurnal and diel water temperature (and thus dissolved oxygen content) can have deleterious short and long term effects on essential components of aquatic and semi-aquatic species' life cycles (incubation of eggs and/or larvae). Vegetation that overhangs stream channels provides direct inputs of organic matter to the stream ecosystem, and thus to aquatic food webs (Beschta and Platts 1986, Gregory *et al.* 1991). The presence or absence of riparian shade can have significant influences on (1) the movement of faunal species within or to riparian zones, and (2) species use of riparian habitat for feeding, escape, reproductive, or thermal cover.



C) Definition of the VAA

The VAA for V_{SHADE} consists of a channel reach length that is **twenty (20) times the OHW channel width** at the PAA cross section. The VAA is centered on the main PAA cross section so that 10 OHW channel widths are upstream, and 10 OHW channel widths are downstream from the main PAA cross section. The width of the VAA extends from OHW on stream right to OWH on stream left.

D) Measurement Protocol

To develop a measure for V_{SHADE}, begin at the main PAA cross section. Look upstream on stream right a total distance of 10 times the OHW channel width. Identify the OHW mark along this reach. Make a visual estimate of the average percent canopy cover of trees and shrubs that are overhanging the channel below OWH. Along the same reach, (upstream, stream right), measure the average perpendicular distance of tree and shrub overhang from OHW towards the center of the channel within the upstream channel reach. Record the canopy cover estimate and overhang distance measure on the Minimum Submittal Worksheets. The same set of measurements should be made for (1) upstream left, (2) downstream left, and (3) downstream right. You will thus have a total of four sets of measurements. Using these four sets of measurements, calculate the average canopy cover over the active channel and the average overhang distance.

E) Scaling Rationale

V_{SHADE} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Channels greater than or equal to 20 feet wide (width at OHW)

Measurement or Condition for V_{SHADE}	Index
a. Greater than 10 feet of vegetation overhangs the channel from OHW, **AND** b. 75-100 % tree and/or shrub canopy cover at or below OHW, **AND** c. There is **no** evidence of anthropogenic disturbance.	1.00
a. Greater than 10 feet of vegetation overhangs the channel from OHW, **AND** b. 75-100 % tree and/or shrub canopy cover at or below OHW, **AND** c. There is **some** evidence of anthropogenic disturbance.	0.75
a. 5 to 10 feet of vegetation overhang the channel, **AND** b. 50 to < 75% tree and/or shrub canopy cover at or below OHW.	0.50
a. < 5 feet of vegetation overhang over the channel from bankfull stage; **AND** b. 20% to < 50% tree and/or shrub canopy cover at or below OHW.	0.25
a. < 20% tree and shrub canopy cover, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. No shade provided by trees and shrubs, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Channels less than 20 feet wide (width at OHW)

Measurement or Condition for V_{SHADE}	Index
a. Channel is 95 - 100% covered by tree and/or shrub layers, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Channel is 95 - 100 % covered by tree and/or shrub layers, **AND** b. There is **some** evidence of anthropogenic disturbance.	0.75
Channel is 75 - 94% covered by tree and/or shrub layers.	0.50
Channel is 25 - 74% covered by tree and/or shrub layers.	0.25
a. Channel is less than 25% shaded by tree and/or shrub layers. Extensive anthropogenic activities have resulted in removal of the near-stream forest, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. No shade provided by trees and shrubs and extensive anthropogenic activities have resulted in removal of the near-stream forest, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

20. Shrub Canopy Cover (V_{SHRUB})

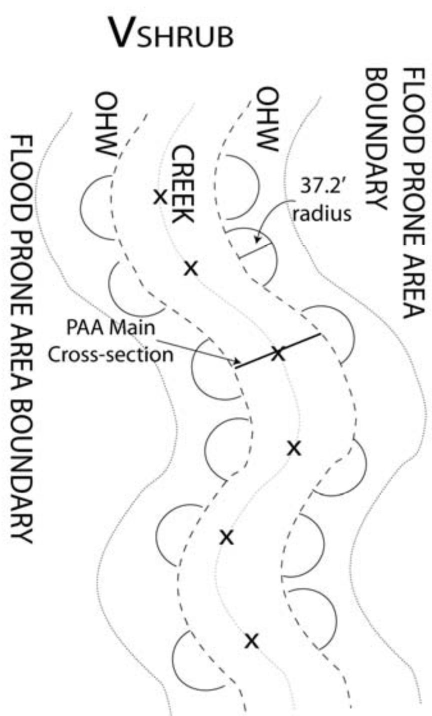
A) Definition

Shrub canopy cover is defined as the percent cover of shrubs (multiple-stemmed woody species) within the VAA.

B) Rationale for Selection of Variable

Shrub canopy coverage is one measure of vegetation that indicates maintenance of native plant community structure and function. As such, shrub canopy cover can be used along with other measures of vegetative cover to indicate the potential for a site to support characteristic ecosystem processes, such as maintenance of native and nonnative plant communities, faunal communities and faunal support/habitat, *etc.* The presence of shrubs (along with that of trees) contributes to roughness and topographic variation on floodplain and channel sites. Roughness provides a mechanism to slow water flows and thus provides static and dynamic storage of flood flows as well as cover for aquatic and terrestrial fauna. Shrubs, along with trees, maintain channel morphology by increasing bank shear strength through the production and maintenance of fine root biomass. Shrubs also function as structural elements that limit and/or control development and maintenance of channel geometry.

Shrubs provide significant inputs of labile and refractory organic carbon to riverine ecosystems. In addition, the shrub canopies alter microclimatic conditions in riparian forests (*e.g.*, moisture, nutrients, light, temperature, wind speed, *etc.*). Microclimatic alterations caused by the presence of shrubs is important in maintaining several ecosystem functions, such as biomass production, maintenance of site water balance, nutrient conservation, habitat structure, *etc.* Furthermore, shrubs, along with trees, are instrumental in soil genesis, elemental cycling, and successional processes (Hooper and Vitousek 1997). These successional processes include the dispersal and establishment of plant propagules that support plant and animal species diversity and turnover (Tilman 1982, Huston and Smith 1987, Cohen and Levin 1991, Tilman and Pacala 1993).



C) Definition of VAA

The VAA for V_{SHRUB} consists of a minimum of one and up to six plots (radius = 37.2 ft). One plot consists of two semi-circles which are centered at the OHW on each side of the stream along the main cross-section of the PAA. Ideally, six plots (six pairs of semi-circles) will be assessed. If only one plot (two semi-circles) will be established, it ***must*** be located in an area that is representative of the entire reach, and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Location of Plots

To establish the six plots (six pairs of semi-circles) for scaling V_{SHRUB}, begin at the PAA main cross-section (Figure 10). Stand along the OHW on stream right and then on stream left. From each side of the stream, visually extend an arc that is 37.2 feet radius from this point (creating a 0.05 acre half circle). Establish additional plots centered at OHW upstream and downstream from the main PAA cross-section at 80 foot intervals. See Figure 10 for further clarification.

If the vegetation plots can not be established according to the articulated HGM protocol because of extremely steep terrain, or a narrow riparian zone, then locate the six vegetation plots in accessible, but representative portions of the riparian zone. If the establishment of six plots is not possible at all, given hazardous or unsafe conditions, then the data required for the vegetation variables should be estimated from a remote location (*e.g.*, from the creek bed).

Variable Measurement

To measure V_{SHRUB}, utilize the six plot centers within the stream channel. On stream right and stream left at each plot center define a 0.05 acre (radius 37.2 feet) arc (half-circle) plot. Within each of the arcs, make visual estimates of the percent cover for the shrub stratum (Figure 11) using midpoints of standard canopy cover classes (Table 7). Note that vines are defined as shrubs. Record these estimates of percent cover on the Minimal Submittal Worksheets. Average the measurements of shrub canopy cover to calculate the final estimate of shrub cover.

E) Scaling Rationale

V_{SHRUB} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Shrub Community is Dominant within the VAA:

Measurement or Condition V_{SHRUB}	**Index**
a. Average shrub canopy cover is ≥ 75%, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Average shrub canopy cover is ≥ 75%, **AND** b. There is some evidence of anthropogenic disturbance.	0.75
Average shrub canopy cover is ≥ 50% and < 75%.	0.50
Average shrub canopy cover is ≥ 25% and < 50%.	0.25
a. Average shrub canopy cover is < 25%, **AND** b. The variable condition **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average shrub canopy cover is < 25%, **AND** b. The variable condition is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Trees (Forests) are Dominant within the VAA:

Measurement or Condition V_{SHRUB}	**Index**
a. Average shrub canopy cover is ≥ 45% and ≤ 75%, **AND** b. There is no evidence of anthropogenic disturbance.	1.00
a. Average shrub canopy cover is ≥ 45% and < 75%, **AND** b. There is some evidence of anthropogenic disturbance.	0.75
Average shrub canopy cover is ≥ 25% and < 45%.	0.50
a. Average shrub canopy cover is ≥ 15% and < 25%, **OR** b. Average shrub canopy cover is > 75%	0.25
a. Average shrub canopy cover is < 15%**, AND** b. The variable is recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average shrub canopy cover is < 15% **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

21. Hillslope Trees ($V_{SLOPETREE}$)

A) Definition

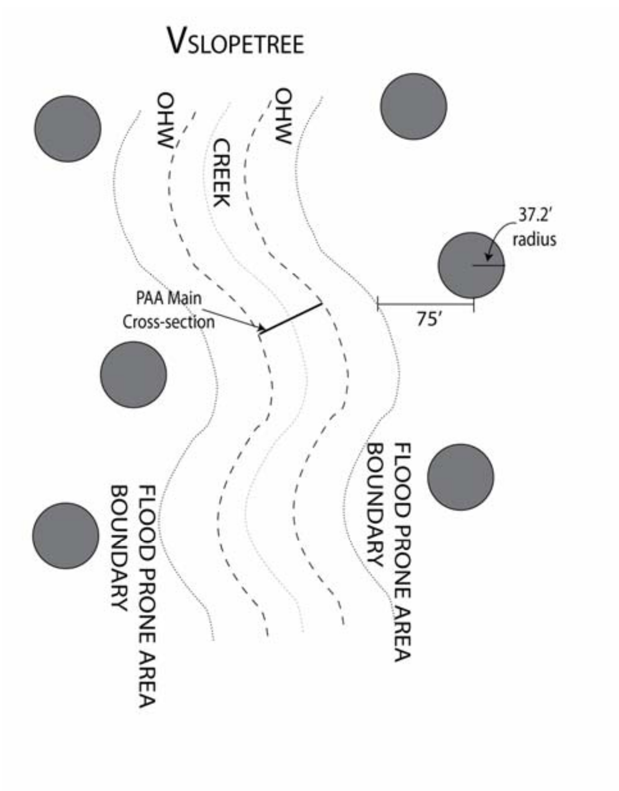
Hillslope trees is defined as the percent composition of conifers and deciduous trees on the slopes adjacent to riverine wetlands. This variable is scored for steep gradient channels. Trees are defined as having diameter at breast height of 4 inches or greater and standing over 10 feet tall.

B) Rationale for Selection of Variable

Coniferous trees located within the vicinity of the river can be a source of large wood to the channel. While deciduous trees are also a source of large wood for the channel, deciduous trees decay more quickly. Therefore, deciduous trees are weighted with lower importance than coniferous trees. Undisturbed reference forests are dominated by conifers but have some interspersed deciduous trees. The scaling of this variable is designed to represent this mixture of coniferous and deciduous trees.

C) Definition of the VAA

The VAA for $V_{SLOPETREES}$ consists of six 0.1-acre circular plots (radius = 37.2 feet) established at 80 foot intervals located on stream right and stream left hillslopes (3 plots on each side of the stream).



D) Measurement Protocol

<u>Location of Plots</u>

To establish the six 0.1-acre circular plots that are required to scale $V_{SLOPETREES}$, begin at the main assessment area cross-section (Figure 12). Visually extend the cross section upslope, perpendicular to the stream channel flow. On both sides of the stream at approximately 75 feet upslope from the edge of the flood prone areas, establish a circular plot (radius = 37.2 ft).

From the midpoints of these plots, establish the two additional plot centers 80 feet upstream and downstream from the PAA cross section midpoints each side of the stream. If the establishment of six plots is not possible at all, given hazardous or unsafe conditions, then the data required for the vegetation variables should be estimated from a remote location (*e.g.*, from the creek bed).

<u>Variable Measurement for $V_{SLOPETREE}$</u>

Within each vegetation plot (Figure 11), count the number of conifers and deciduous (broadleaf) trees. Trees are defined as having a stem diameter > 4 inches. Determine the percent of tree stems that are coniferous, and the percent of stems that are deciduous in each semi-circle. Record these percents on the Minimal Submittal Worksheets. Average the twelve measurements of percent conifer and percent deciduous to calculate the final estimate.

E) Scaling Rationale

$V_{SLOPETREE}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For low, moderate, and steep gradient channels (using canopy cover estimates).

Measurement or Condition for $V_{SLOPETREE}$	Index
a. Proportion of conifer stems is ≥ 60% but less than 80% of total stems observed, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Proportion of conifer stems is ≥ 60% but less than 80% of total stems observed, **AND** b. There is **some** evidence of anthropogenic disturbance.	0.75
Proportion of conifer stem density is > 80% of the total number of stems observed	0.50
Proportion of conifer stems is between 40% and < 60%.	0.25
a. Proportion of conifer stems is < 40%, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Proportion of conifer stem density < 40%, **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

22. Soil Profile Integrity ($V_{SOILINTEG}$)

A) Definition

This variable is a measure of the presence and condition of the soil profile (soil horizons) within the VAA.

B) Rationale for Selection of Variable

The integrity of the soil profile, through linkages with site hydrology, exerts strong control on the ecosystem functions that occur in high, middle, and low marsh fringing waters/wetlands. These functions include biogeochemical processes affecting nutrient cycles and storage, and the establishment and maintenance of plant communities. In particular, finer textured soils that occur within the riparian/transition areas are rare, given past and current land uses. Where they occur, they exhibit increased profile development, structure, and organic carbon accumulation. Thus, when compared to the sandy skeletal soils that are characteristic of adjacent high and medium gradient riverine subclasses, the finer textured soils in low gradient landscape positions have higher cation exchange and assimilative capacities.

Maintenance of intact soils in low gradient riverine waters/wetland is especially important in the Mount Vernon landscape, because water movement through low gradient sites exhibits lower kinetic energy and longer residence time when compared to high and medium gradient subclasses (*i.e.,* diminished infiltration rates and hydraulic conductivities). Increased time of contact of water with soil mineral particles and organic matter, plant roots, microbes, *etc.*, facilitates retention and transformation of nutrients, organic matter and contaminants. These soil processes are critically important to the maintenance of water quality.

C) Definition of the VAA

The VAA for $V_{SOILINTEG}$ consists of a channel reach length that is **twenty (20) times the OHW channel width** at the PAA cross section and the width of the flood prone area. The VAA is centered on the main PAA cross section so that 10 OHW channel widths are upstream, and 10 OHW channel widths are downstream from the main PAA cross section. The width of the VAA extends from OHW on stream right to OWH on stream left.

D) Measurement Protocol

Describe the modal soil within the PAA. To accomplish descriptions, excavate soil pits in representative locations within the PAA. Excavate the soil pits to the depth of excess water, impenetrable debris (*e.g.* boulders, stones, cobbles) or to a depth of approximately 3 ft, whichever is encountered first. Closed-bucket or Dutch augers are useful below approximately 2 feet. After excavation of the soil pit, carefully scrape the face of the bank or pit (a dull knife works well) to remove weathered or smeared material on the face of the soil profile. Clean the face of the profile until the different soil horizons (if present) are clearly exposed. Separate the different soil horizons within the profile by changes in color and/or texture. Describe the different textures by feel, and color consistent with guidelines provided in Munsell Soil Color Charts (Munsell 1994). Many soil colors will not exactly match any one Munsell color chip. In these cases, use the Munsell chip closest in color to the soil sample. All soil colors should be from a moist sample and read in direct sunlight if possible. Measure the thickness and depth of each horizon. Record the presence and location of any additional features or activities that might be important (*e.g.,* land use, any disturbances to the soil profile, the presence of redoximorphic features within the profile, depth to water, abundant organic matter, faunal habitat, *etc.*). Take photographs and/or samples for later identification of unknown or confusing features.

Identification, nomenclature, and description of soil horizons should be consistent with guidance provided by the USDA Natural Resource Conservation Service (Schoeneberger *et al.* 1998). All soil depths are measured from the soil surface (usually an A horizon), excluding any litter or duff layers that may have accumulated on the soil surface. Live vascular and non-vascular plant materials are **not** included in measurements of soil depths.

E) Scaling Rationale

The authors used best scientific judgment and, secondarily, empirical field data from reference sites to scale this variable. The scaling presented herein is based on the presence, condition, and color (organic carbon content) of organic and/or mineral horizons and the degree of disruption that has occurred from direct manipulation of the riparian areas, and/or wetland (*e.g.*, rip-rap, revetments, fenced cobble and stone banks, *etc.*). For all soils present within the PAA, the soil profile integrity variable is scaled down proportional to the degree of anthropogenic disturbance or disruption of the soil profile.

E) Scaling for all Subclasses:

Measurement or Condition for $V_{SOILINTEG}$	**Index**
a. The modal soil profile(s) (mineral or organic soils) is/are well developed (*i.e.,* different horizons are discernable), and intact within the upper 24 inches, **AND** b. The surface and shallow subsurface deposits and depositional features **have not** been altered by anthropogenic activities (*e.g.* roads, agriculture, fills, *etc*.).	1.00
a. Modal soil profile(s) is/are present within the VAA, **BUT** b. Surface and shallow subsurface deposits and depositional features **have** been altered by anthropogenic activities resulting in **minor** changes to the soil profile Alterations may include, but are not limited to, fill, excavation, earthwork, recreation, foot traffic, and clearing of brush.	0.75
a. Modal soil types are present within the VAA, **BUT** b. Surface and shallow subsurface deposits and depositional features **have** been altered by anthropogenic activities. For both mineral and organic soils, soil surface horizons are impacted (*e.g.,* compaction, light erosion, placement of limited fill, grazing, plowing, or disking) and as a consequence, they exhibit some diminished structure, thickness, and/or organic carbon content. Alterations may include, but are not limited to, fill, excavation, and/or earthwork, **AND** c. Modal organic soil profile is essentially intact except for evidence of some plowing or disking within the top 15", or some compaction due to livestock grazing, vehicular traffic, *etc.*	0.50
a. The soil profile is no longer entirely intact due to human activities, **AND** b. The surface horizon was removed or buried by human activities and the subsurface horizon(s) are either buried, or exposed and altered, (*e.g.,* disturbance by roads, debris basins, construction), **AND** c. Soil structure in the upper part of the profile is weak or absent and organic carbon content is diminished (*e.g.,* moist color value and chroma > 3))	0.25
a. Soil profile is no longer entirely intact and is significantly disturbed by human activities, **AND** b. The surface horizon has been buried **or** removed by human-induced activities and the subsurface horizon(s) are exposed, highly eroded, and subject to failure or continued erosion and deterioration (*e.g.*, soil is buried by fill, has areas of slope failure, heavy vehicle traffic, disturbance by roads, construction, or agriculture), **OR** c. Soil structure is weak or absent and vegetation, root biomass, and organic carbon content are greatly diminished or absent (*e.g.*, moist color value and chroma > 3), **AND** d. The soil profile can be recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Soil profile is no longer intact as a result of human activities, **AND** b. The surface and subsurface horizons are generally absent due to removal **or** burial as a result of human activities (*e.g.,* the placement of fill, roads, concrete or asphalt, construction, debris basins, revetments, concrete weirs or trapezoids), **OR** c. Soil structure, vegetation, root biomass, and organic carbon are virtually absent (*e.g.,* moist color value and chroma > 3), **AND** d. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

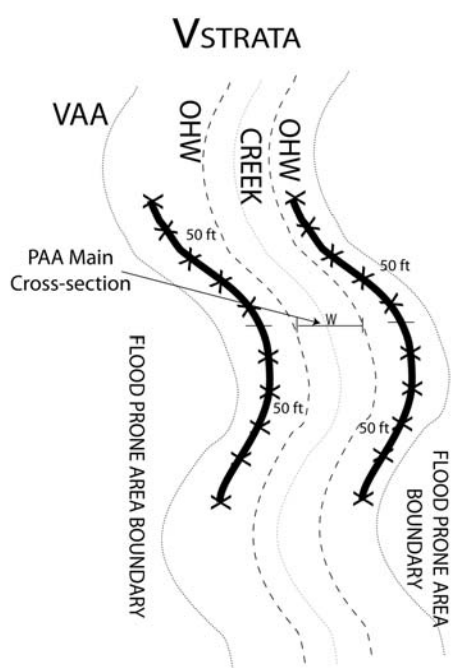
23. Vegetative Strata (V_{STRATA})

A) Definition

Vegetative strata are defined as the number of distinct layers present within the VAA. Vegetative strata are recognized within the Mount Vernon landscape as trees (single stem woody species with > 4" DBH and a height of > 10 ft), shrubs (multiple stemmed woody species including vines), and herbs (including forbs, graminoids, ferns, and fern allies).

B) Rationale for Selection of Variable

Multiple vegetative strata (*e.g.*, trees, shrubs, and/or herbs) are often good indicators of the development and maintenance of plant communities, habitat structure, and channel bank stability (Tilman 1994). For example, the number of strata can be correlated with the habitat structure and complexity necessary to support characteristic faunal assemblages, *e.g.*, those typical of the Mount Vernon watershed. Similarly, the number and types of vegetation strata combine to provide the diversity of faunal habitat, as well as the types and quantity of food and cover resources available.



C) Definition of the VAA

The VAA for V_{STRATA} consists of two 100 ft vegetation transects, one on stream right and one on stream left. Each 100 ft transect should be centered at on the PAA main channel cross section so that the transect extends 50 ft upstream and 50 feet downstream.

D) Measurement Protocol

To develop a measure for V_{STRATA}, begin 50 ft downstream from the midpoint of the first transect (*i.e.*, 40 ft downstream from main channel cross section). Walk upstream along the transect, stopping to observe the number of vegetative strata at every 10 ft interval. At each interval, determine the number of vegetation layers (*i.e.,* strata) at that point. Record the total number of strata (*i.e.,* herb, shrub, and tree) that intersect the transect at each stopping point.

Calculate an average number of vegetation strata for the assessment area using all 20 data points. Record these values on the Minimum Submittal Worksheet.

E) Scaling Rationale

V_{STRATA} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Shrub Community is Dominant within the VAA:

Measurement Condition for V_{STRATA}	**Index**
a. Average number of strata is ≥ 1.5, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Average number of strata is ≥ 1.0 and < equal to 2.0 **AND** b. There is **some** evidence of anthropogenic disturbance.	0.75
Average number of strata is ≥ 0.5 and < 1.0.	0.50
Average number of strata is ≥ 0 and < 0.5.	0.25
a. The average number of strata is 0, **AND** b. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.10
a. The average number of strata is 0, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures applied.	0.00

2. Forest Community is Dominant within the VAA:

Measurement Condition for V_{STRATA}	**Index**
a. Average number of strata is 3, **AND** b. There is no evidence of anthropogenic disturbance.	1.00
a. Average number of strata is ≥ 2 and <3, **AND** b. There is some evidence of anthropogenic disturbance.	0.75
Average number of strata is ≥ 1.0 and < 2.	0.50
Average number of strata is ≥ 0 and < 1.	0.25
a. The average number of strata is 0, **AND** b. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.10
a. The average number of strata is 0, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.00

24. Tree Canopy Coverage (V_{TREE})

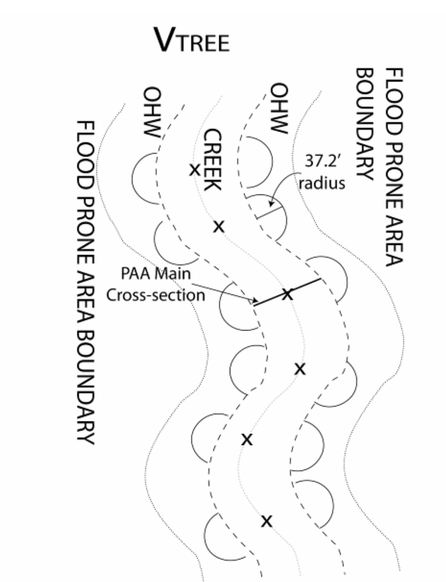
A) Definition

Tree canopy cover is defined as the percent canopy cover of trees (*i.e.*, single stem woody species with > 4" diameter at breast height and > 10 feet in height) within the VAA.

B) Rationale for Selection of Variable

Tree canopy coverage is traditionally used as a measure of species distribution and biomass (Clements 1916, Avery 1975, Mueller-Dombois and Ellenberg 1974). As such, canopy cover can indicate the potential for a site to support characteristic ecosystem processes such as maintenance of native and nonnative plant communities and faunal support/habitat. Trees also contribute to roughness and topographic variation on floodplain and channel sites. Roughness provides a physical mechanism that slows water flows and thus provides static and dynamic storage of flood flows and cover for aquatic and terrestrial fauna. Trees maintain channel morphology by increasing bank shear strength through the production and maintenance of fine root biomass. Trees also function as structural elements that limit and/or control development and maintenance of channel geometry.

Trees provide allochthonous inputs of labile and refractory organic carbon to riverine ecosystems. In addition, the presence of tree boles and canopies alter microclimatic conditions in riparian forests (*e.g.*, moisture, nutrients, light, temperature, wind speed, *etc.*). Microclimatic alterations caused by the presence of trees is important in maintaining several ecosystem functions such as biomass production, maintenance of site water balance, nutrient conservation, habitat structure, *etc.* Furthermore, trees are instrumental in soil genesis, elemental cycling, and successional processes (Hooper and Vitousek 1997). These successional processes include the dispersal and establishment of plant propagules, support plant and animal species diversity and turnover (Tilman 1982, Huston and Smith 1987, Cohen and Levin 1991, Tilman and Pacala 1993).



C) Definition of VAA

The VAA for V_{TREE} consists of a minimum of one and up to six plots (radius = 37.2 ft). One plot consists of two semi-circles which are centered at the OHW on each side of the stream along the main cross-section of the PAA. Ideally, six plots (six pairs of semi-circles) will be assessed. If only one plot (two semi-circles) will be established, it ***must*** be located in an area that is representative of the entire reach, and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Location of Plots

To establish the six plots (six pairs of semi-circles) for scaling V_{TREE}, begin at the PAA main cross-section (Figure 11). Stand along the OHW on stream right and then on stream left. From each side of the stream, visually extend an arc that is 37.2 feet radius from this point (creating a 0.05 acre half circle). Establish additional plots centered at OHW upstream and downstream from the main PAA cross-section at 80 foot intervals. See Figure 10 for further clarification.

If the vegetation plots can not be established according to the articulated HGM protocol because of extremely steep terrain, or a narrow riparian zone, then locate the six vegetation plots in accessible, but representative portions of the riparian zone. If the establishment of six plots is not possible at all, given hazardous or unsafe conditions, then the data required for the vegetation variables should be estimated from a remote location (*e.g.*, from the creek bed).

Variable Measurement

Within each of the arcs, make visual estimates of the percent cover for the tree stratum (Figure 11) using midpoints of standard canopy cover classes (Table 7). When making this estimate, canopy cover within the tree stratum sums to 100%. Record these estimates of percent cover on the Minimal Submittal Worksheets. Average all of the measurements of canopy cover to calculate the final estimate of tree canopy cover.

Please note that this variable is not to be scored in communities where shrubs are the dominant landscape matrix.

E) Scaling Rationale

V_{TREE} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For Tree (Forest) communities within the VAA:

Measurement or Condition for V_{TREE}	Index
a. Average percent cover of trees is ≥ 95%, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Average percent cover of trees is ≥ 75%, **AND** b. There is **some** evidence of anthropogenic disturbance.	0.75
Average percent cover of trees is ≥ 50% and < 75%.	0.50
Average percent cover of trees is ≥ 25% and < 50%.	0.25
a. Average percent cover of trees is < 25%, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average percent cover of trees is < 25%, **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

IV. Waters/Wetlands Ecosystem Function and Assessment Models for Slope and Slope Riverine Proximal Wetlands in the City of Mount Vernon

A. Overview of the Slope Wetland HGM Model

We identified 11 functions performed by slope water/wetland ecosystems in the City of Mount Vernon. These functions fall into four groups: hydrology, biogeochemistry, plant community, and faunal support/habitat (Table 10). All of these functions are performed at some level at all sites within the reference domain.

We used a total of 17 variables to describe 11 wetland ecosystem functions presented and discussed in this *Guidebook* (Table 11). Two subclasses were identified in Slope wetlands within the City of Mount Vernon: Slope and Slope Riverine Proximal Wetlands. Variables which we used to represent a given function sometimes differed between the slope and slope riverine proximal subclasses. Changes in the variables that we used represent our best attempts to account for the unique functional characteristics of each subclass.

Each of the 11 ecosystem functions and each of the 17 variables are fully described in the following sections. Table 12 illustrates the relationship between variables and functions. Table 13 illustrates the formulas for each function. Descriptions of the 11 functions include the following information (Section IV. B):

1. Definition
2, Rationale for describing or recognizing the function for slope wetland ecosystems in Mount Vernon
3. Listing of variables used to assess the function, and
4. The formulae used to estimate the functional capacity indices.

Descriptions of the 17 variables include the following information:

1. Definition
2. Rationale for selection of the variable
3. Definition of the Variable Assessment Area (VAA)
4. Protocol for measuring the variable in the field
5. Scaling rationale
6. Scaling between 0 and 1

Please note that in describing functions or variables, we have used some terminology that allows us to address the project site that shall be assessed using HGM. The “Project Assessment Area” (PAA) refers to the waters, wetlands and their buffers which may be affected by the proposed project. Similarly, the area that one needs to examine in the field to collect data necessary to score a variable is the “Variable

Assessment Area" (VAA). Both PAA and VAA are defined in the Glossary. In addition, several of the figures that support presentation of variables illustrate graphically the extent of either PAA or VAA.

Table 10. List of Slope Functions by Category

FUNCTION	DESCRIPTION
Hydrologic	
1. Surface and Subsurface Water Storage and Exchange	Retention and transfer of water between the wetland and down gradient streams or groundwater.
2. Landscape Hydrologic Connections	Contiguity of surface and shallow subsurface water flow between up gradient sources, slope wetlands, and down gradient ecosystems.
Biogeochemical	
3. Cycling of Elements and Compounds	Abiotic and biotic processes that change elements and convert compounds (*e.g.*, nutrients and metals) from one form to another. Cycling includes retention and detention of elements and compounds, including nutrients.
4. Retention and Detention of Particulates	Delay or retardation of movement of inorganic and organic particulates (>0.45 µm) from the water column, primarily through physical processes.
5. Organic Carbon Export	Leaching, flushing, displacement, and/or erosion of dissolved and particulate organic carbon from the waters/wetlands.
Plant Community	
6. Plant Community	The physical characteristics and ecological processes that maintain native forests (living plant biomass).
7. Detrital System	The process of production, accumulation, and dispersal of dead plant biomass of all sizes.
Faunal/Habitat Support	
8. Spatial Structure of Habitats	The capacity of waters/wetlands to support animal populations within the habitat structure provided by hydrologic conditions, micro- and macrotopographic features, and living plant and detrital communities.
9. Interspersion and Connectivity of Habitats	The capacity of the water/wetland to allow aquatic, semi-aquatic, and terrestrial organisms to enter and leave the ecosystem via large, contiguous patches.
10. Distribution and Abundance of Invertebrates	The capacity of waters/wetlands to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic and terrestrial).
11. Distribution and Abundance of Vertebrates	The capacity of the water/wetland to maintain the density and spatial distribution of vertebrates (aquatic, semi-aquatic, and terrestrial).

Table 11. Slope Variables

	VARIABLE	DESCRIPTION	DEFINITION
1.	$V_{BUFFWIDTH}$	Buffer Width	Width of the area extending 150 feet from the boundary of the slope wetland.
2.	$V_{BUFFCOND}$	Buffer Condition	Condition of the area extending 150 feet from the boundary of the slope wetland.
3.	$V_{BUFFCONTIG}$	Buffer Contiguity	Proportion of buffer extending 150 feet from the boundary of the slope wetland that has been disturbed
4.	V_{HERB}	Herbaceous Canopy Cover	Percent cover of herbaceous vegetation, specifically graminoids, forbs, ferns, and fern allies within the VAA.
5.	V_{LWOOD}	Large Wood	Large wood (> 4 inches diameter & 6 feet length) on the hillslope within the VAA.
6.	V_{LITTER}	Litter and Fine Woody Debris	Cover class of leaf litter and dead and down fine woody debris (< 3.0 inches diameter) within the VAA.
7.	V_{MICRO}	Microtopographic Relief	Degree of surface roughness, including relief and frequency of dissection.
8.	V_{NATIVE}	Percentage of Native and Non-Native Plant Species	Percentage of the dominant plant taxa within the VAA that are native as compared to nonnative plant taxa.
9.	$V_{PATCHAREA}$	Patch Area	The relative area of habitat patches within a 1000 ft radius VAA ring surrounding the PAA.
10.	$V_{PATCHLATCON}$	Patch Lateral Contiguity	The lateral (*i.e.* perpendicular to the slope) contiguity of habitat patches within the 1000 ft radius VAA.
11.	$V_{PATCHNUMBER}$	Patch Number	The number of habitat patches within the 1000 ft radius VAA ring surrounding the PAA.
12.	V_{SHRUB}	Shrub Canopy Cover	Percent canopy cover of shrubs (multiple stemmed woody species) within the VAA.
13.	$V_{SOILINTEG}$	Soil Profile Integrity	A measure of the presence and condition of the soil profile (soil horizons) within the VAA.
14.	V_{STRATA}	Vegetation Strata	Number of distinct vegetation layers present in the PAA. Vegetation strata are defined as trees (single stem woody species with > 4" DBH and > 10' tall); shrubs (multiple stemmed woody species); and, herbs including forbs, graminoids, ferns and fern allies.
15.	V_{SUBOUT}	Subsurface Outflow	Contiguity of the down gradient subsurface hydrologic connections to the adjacent landscape.
16.	V_{SURFIN}	Surface Inflow	Hydrologic connections into the VAA from the adjacent landscape.
17.	V_{TREE}	Tree Canopy Coverage	Percent canopy cover of trees (*i.e.*, single stem woody species with > 4" DBH and > 10 feet in height).

Table 12. Relationship of Variables to Functions

	Hydrologic		**Biogeochemical**			**Plant Community**		**Faunal Support / Habitat**			
	Surface and Subsurface Water Storage and Exchange	Landscape Hydrologic Connections	Cycling of Elements and Compounds	Retention and Detention of Particulates	Organic Carbon Export	Plant Community	Detrital System	Spatial Structure of Habitats	Interspersion and Connectivity of Habitat	Distribution and Abundance of Invertebrates	Distribution and Abundance of Vertebrates
1. $V_{BUFFWIDTH}$		X	X	X	X			X	X	**T**	**T**
2. $V_{BUFFCOND}$		X	X	X	X			X	X	**O**	**O**
3. $V_{BUFFCONTIG}$		X	X	X	X			X	X		
4. V_{HERB}	X		X	X	X	X	X	X		**B**	**B**
5. V_{LWOOD}			X				X			**E**	**E**
6. V_{LITTER}			X		X		X				
7. V_{MICRO}	X	X		X				X		**D**	**D**
8. V_{NATIVE}						X				**E**	**E**
9. $V_{PATCHAREA}$									X	**T**	**T**
10. $V_{PATCHLATCON}$									X	**E**	**E**
11. $V_{PATCHNUMBER}$									X	**R**	**R**
12. V_{SHRUB}	X		X	X	X	X	X	X		**M**	**M**
13. $V_{SOILINTEG}$	X	X			X					**I**	**I**
14. V_{STRATA}						X		X		**N**	**N**
15. V_{SUBOUT}	X	X								**E**	**E**
16. V_{SURFIN}	X	X		X						**D**	**D**
17. V_{TREE}	X		X	X	X	X	X	X			

Table 13. Indices of Functions for Slope Wetlands in Mount Vernon, Washington

FUNCTION	FORMULAE
Hydrologic	
1. Surface and Subsurface Water Storage and Exchange	$[V_{SOILINTEG} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{MICRO} + (V_{SURFIN} + V_{SUBOUT})/2]/4$
2. Landscape Hydrologic Connections	$[(V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + V_{SOILINTEG} + V_{MICRO} + V_{SURFIN} + V_{SUBOUT}]/5$
Biogeochemical	
3. Cycling of Elements and Compounds	$[V_{LWOOD} + V_{LITTER} + (V_{TREE} + V_{HERB} + V_{SHRUB})/3 + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$
4. Retention and Detention of Particulates	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{MICRO} + V_{SURFIN} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$
5. Organic Carbon Export	$[V_{LITTER} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{SOILINTEG} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$
Plant Community	
6. Plant Community	$[(V_{SHRUB} + V_{HERB} + V_{TREE})/3 + V_{NATIVE} + V_{STRATA}]/3$
7. Detrital System	$[V_{LITTER} + V_{LWOOD} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3]/3$
Faunal Support/ Habitat	
8. Spatial Structure of Habitats	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{STRATA} + V_{MICRO} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$
9. Interspersion and Connectivity of Habitats	$[(V_{PATCHNUMBER} + V_{PATCHAREA})/2 + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + V_{PATCHLATCON}]/3$
10. Distribution and Abundance of Invertebrates	**To Be Determined**
11. Distribution and Abundance of Vertebrates	**To Be Determined**

B. Description of 11 Functions Identified in Slope and Slope-Riverine Proximal Waters/Wetlands Ecosystems

1. Hydrologic Functions

A) Surface and Subsurface Water Storage and Exchange

(1) Definition

The Surface and Subsurface Water Storage and Exchange function pertains to the retention and/or circulation of surface and subsurface water in the wetland ecosystem.

(2) Rationale for the Function

Water is retained and stored within wetlands through surface water, soil moisture in the unsaturated zone, water within the capillary fringe, and ground water in the saturated zone. Vegetation aids in surface water exchange through evapotranspiration. Surface water flowing within a wetland area is addressed in this function; however, deeper ground water in regional ground water systems cannot be adequately assessed by a rapid assessment procedure. Measurement of this function focuses on the physical characteristics of the wetland to provide an indirect assessment of Surface and Subsurface Water Storage and Exchange.

(3) Variables Used to Assess Surface and Subsurface Water Storage and Exchange

We used the following variables to assess the surface and groundwater storage and exchange function for all subclasses:
a. Tree Canopy Cover (V_{TREE})
b. Shrub Canopy Cover (V_{SHRUB})
c. Herbaceous Canopy Cover (V_{HERB})
d. Soil Profile Integrity ($V_{SOILINTEG}$)
e. Microtopography (V_{MICRO})
f. Surface Water Inflow (V_{SURFIN})
g. Subsurface Water Outflow (V_{SUBOUT})

(4) Index of Function for All Subclasses

$$\text{Index} = [V_{SOILINTEG} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{MICRO} + (V_{SURFIN} + V_{SUBOUT})/2]/4$$

B) Landscape Hydrologic Connections

(1) Definition

The Landscape Hydrologic Connections function refers to contiguity of surface and shallow subsurface water flow between up gradient sources, slope wetlands, and down gradient ecosystems.

(2) Rationale for the Function

The rate and volume of water transferring between wetlands, uplands, and riverine ecosystems affects the flooding magnitude and frequency, the residence time available for biogeochemical transformations within the wetland environment, and the overall condition of a slope wetland. This function is measured by variables which effect the movement of water into, through and out of the wetland. Scaling for variables represents the fact that, historically, forested slope wetlands were dominated by sub-surface water flows with very little surface flow.

(3) Variables Used to Assess Landscape Hydrologic Connections

a. Buffer width ($V_{BUFFWIDTH}$)
b. Buffer Contiguity ($V_{BUFFCONTIG}$)
c. Buffer Condition ($V_{BUFFCOND}$)
d. Soil Profile Integrity ($V_{SOILINTEG}$)
e. Surface Water Inflow (V_{SURFIN})
f. Subsurface Water Outflow (V_{SUBOUT})
g. Microtopography (V_{MICRO})

(4) Index of Function for All Subclasses

$$Index = [(V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + V_{MICRO} + V_{SOILINTEG} + V_{SURFIN} + V_{SUBOUT}]/5$$

2. Biogeochemical Functions

A) Cycling of Elements and Compounds

(1) Definition

Cycling of Elements and Compounds refers to abiotic and biotic processes that change elements and convert compounds (*e.g.,* nutrients and metals) from one form or valence to another.

(2) Rationale for the Function

Cycling of Elements and Compounds is a fundamental ecosystem process mediated by biotic and abiotic components. The biotic components of elemental cycling are net primary productivity, in which nutrients are taken up by plants, and detritus turnover, in which nutrients are released for renewed uptake by plants and microbes. Abiotic components are linked inextricably to the microbially mediated (biogeochemical) processes that drive the oxidation-reduction reactions that alter elements and compounds. Sources of these abiotic components are the soil profile, eolian processes that input nutrients and particulates, and hydrologic processes that input nutrients and particulates to the system.

(3) Variables Used to Assess Cycling of Elements and Compound

a. Tree canopy Cover (V_{TREE})
b. Shrub Canopy Cover (V_{SHRUB})
c. Herbaceous Canopy Cover (V_{HERB})
d. Large Wood (V_{MICRO})
e. Litter and Fine Woody Debris (V_{LITTER})
f. Buffer Width ($V_{BUFFWIDTH}$)
g. Buffer Contiguity ($V_{BUFFCONTIG}$)
h. Buffer Condition ($V_{BUFFCOND}$)

(4) Index of Function for All Subclasses

Index = [V_{LWOOD} + V_{LITTER} + (V_{TREE} + V_{HERB} + V_{SHRUB})/3+ ($V_{BUFFWIDTH}$ + $V_{BUFFCONTIG}$ + $V_{BUFFCOND}$)/3]/4

B) Retention and Detention of Particulates

(1) Definition

Retention and Detention of Particulates refers to the delay, retardation or prevention of movement of inorganic and organic particulates (>0.45 μm) in the water column, primarily through physical processes.

(2) Rationale for the Function

Wetlands receive sediments in overland flow from adjacent uplands and may create sediment loading if erosion is occurring within the wetland boundary. Flooding and overland flow is the major source of inorganic particulates to floodplains and riparian areas. Velocity reductions due to surface roughness and increasing cross-sectional area of discharge in wetlands can decrease the amount of sediment that is suspended in the water column (Nutter and Gaskin 1989). Reduced water velocities leads to a reduction in the capacity of water to transport suspended sediments, causing particulates to settle. Sediment detention/ retention occurs through burial and chemical precipitation (*e.g.*, removal of phosphorus by Fe^{+3}).

(3) Variables Used to Assess Detention of Particulates

a. Tree Canopy Cover (V_{TREE})
b. Shrub Canopy Cover (V_{SHRUB})
c. Herbaceous Canopy Cover (V_{HERB})
d. Microtopography (V_{MICRO})
e. Surface Water Inflow (V_{SURFIN})
f. Buffer Width ($V_{BUFFWIDTH}$)
g. Buffer Contiguity ($V_{BUFFCONTIG}$)
h. Buffer Condition ($V_{BUFFCOND}$)

(4) Index of Function for All Subclasses

Index = [(V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{MICRO} + V_{SURFIN} + ($V_{BUFFWIDTH}$ + $V_{BUFFCONTIG}$ + $V_{BUFFCOND}$)/3]/4

C) Organic Carbon Export

(1) Definition

Organic Carbon Export assesses the tendency for leaching, flushing, displacement, and/or erosion of dissolved and particulate organic carbon from the waters/wetland.

(2) Rationale for the Function

Waters/wetlands export organic carbon at higher rates per unit area than terrestrial ecosystems (Mitsch and Gosselink 2000) in part because surface water has greater contact time with organic matter in litter and surface soil. Organic carbon is exported from waters/wetlands in dissolved (≤ 0.45μm) and particulate forms. Mechanisms of organic carbon export include leaching, displacement, and erosion. Sources of organic carbon include herbaceous vegetation both in the water/wetland and in the buffer, as well as organic matter incorporated into the soil profile. While the molecular structure of most organic matter is not well known because of its chemical complexity (Stumm and Morgan 1981, Paul and Clark 1989), organic matter nevertheless plays important roles in geochemical and food web dynamics. For example, organic carbon can complex with a number of relatively immobile metal ions, which in turn facilitates their transport in soil (Schiff *et al.* 1990).

Organic carbon is a primary source of energy for microbial food webs (Edwards and Meyer 1986) that form the base of the detrital food web in aquatic ecosystems. These factors, in combination with the close proximity of wetlands to aquatic ecosystems, make wetlands critical sites for supplying both dissolved and particulate organic carbon.

(3) Variables Used to Assess Organic Carbon Export

a. Tree Canopy Cover (V_{TREE})
b. Shrub Canopy Cover (V_{SHRUB})
c. Herbaceous Canopy Cover (V_{HERB})
d. Litter and Fine Woody Debris (V_{LITTER})
e. Soil Profile Integrity ($V_{SOILINTEG}$)

(4) Index of Function for All Subclasses

$$\text{Index} = [V_{LITTER} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{SOILINTEG} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$$

3. Plant Community Functions

A) Plant Community

(1) Definition

The Plant Community function refers to the physical characteristics and ecological processes that maintain the indigenous living plant biomass.

(2) Rationale for the Function

Living plant biomass converts solar radiation and carbon dioxide into complex organic molecules that support organisms at all trophic levels. In addition to energy, plant species and assemblages of plants provide (a) compositional and structural diversity within the ecosystem, (b) corridors for migration and movement of faunal species among habitats, and (c) feeding, resting, hiding, thermal, and escape cover for migratory and resident animals. Finally, plants provide seeds and other propagules for regeneration and succession following catastrophic events such as fire, floods, and debris flows. Vegetation accounts for most of the biomass in wetlands, and the physical characteristics of living and dead plants are closely related to ecosystem functions associated with hydrology, nutrient cycling, and the abundance and diversity of animal species, as mentioned above (Gregory *et al.* 1991). Removal or severe disturbance of wetland buffer vegetation can lead to a change in the structure of macro invertebrate communities (Hawkins *et al.* 1982), a decrease in the species diversity of wetland ecosystems, a decline in the local and/or regional diversity of animals, a deterioration of down gradient water quality, and significant changes in downstream hydrology (Gosselink *et al.* 1990). The Plant Community function considers both the amount and type of vegetation relative to reference standard conditions.

(3) Variables Used to Assess Plant Community

The following variables are involved in assessing plant community maintenance:
a. Herbaceous Canopy Cover (V_{HERB})
b. Percent of Native and Non-Native Vegetation (V_{NATIVE})
d. Shrub Canopy Cover (V_{SHRUB})
e. Vegetation Strata (V_{STRATA})
f. Tree Canopy Cover (V_{TREE})
g. Buffer Width ($V_{BUFFWIDTH}$)
h. Buffer Contiguity ($V_{BUFFCONTIG}$)
i. Buffer Condition ($V_{BUFFCOND}$)

(4) Index of Function

Index = $[(V_{SHRUB} + V_{HERB} + V_{TREE})/3 + V_{NATIVE} + V_{STRATA}]/3$

B) Detrital System

(1) Definition

Detrital System estimates the processes effecting production, accumulation, and dispersal of dead plant biomass of all sizes.

(2) Rationale for the Function

Detrital matter contributes to the functioning of wetland and riverine ecosystems in multiple ways (Fontaine and Bartell 1983). For example, accumulations of detrital matter help to reduce soil erosion and can add significant amounts of organic carbon to soils (McPhee and Stone 1966). Decomposing detritus provides wildlife habitat and stores nutrients and water for use by both plants and animals (Franklin *et al.* 1987; Harmon *et al.*1986; Stouder *et al.* 1997). Woody debris is a major source of energy for decomposers and other heterotrophs (Harmon *et al.* 1986; Seastedt *et al*. 1989). Throughout the watershed, detrital material (especially coarse woody debris, debris dams) plays an important role by influencing the development and persistence of plant communities that develop in wetlands and other hydrologically active areas (Bilby 1981, Smock *et al.* 1989). The approach to assessing detrital functions in the slope and slope riverine proximal wetland ecosystems of the Mount Vernon requires evaluations of the amounts and distributions of detrital material (litter and woody debris) within a PAA.

(3) Variables Used to Assess Detrital System

a. Herbaceous Canopy Cover (V_{HERB})
b. Shrub Canopy Cover (V_{SHRUB})
c. Tree Canopy Cover (V_{TREE})
d. Litter and Fine Woody Debris (V_{LITTER}):
e. Large Wood (V_{LWOOD})

(4) Index of Function

Index = $[V_{LITTER} + V_{LWOOD} + (V_{TREE} + V_{SHRUB} + V_{HERB})/2]/3$

4. Faunal Support/Habitat Functions

A) Spatial Structure of Habitat

(1) Definition

The capacity of waters/wetlands to support animal populations within the habitat structure provided by hydrologic conditions, micro- and macro-topographic features, and living plant and detrital communities.

(2) Rationale for the Function

Spatial structure of habitats assesses the suitability of hydrologic conditions, micro- and macro-topography, and living plant and detrital communities for sustaining characteristic animal populations in wetland ecosystems. While all ecosystem attributes are important for the maintenance of faunal habitat integrity, the horizontal and vertical structural complexity of plant communities that exist within the wetland largely determines habitat quality for resident and nonresidential animals. Generally, habitats with greater vegetative heterogeneity and structural complexity support more diverse faunal communities (Harris 1984, Findlay and Bourdages 2000, Gibbs 2000, Jones *et al.* 2000). Contiguous habitat structure provides opportunities for movement of migratory animals or resident faunal species with large range requirements into and out of waters/wetlands.

(3) Variables Used to Assess Spatial Structure of Habitats

a. Herbaceous Canopy Cover (V_{HERB})
b. Shrub Canopy Cover (V_{SHRUB})
c. Vegetation Strata (V_{STRATA})
d. Tree Canopy Cover (V_{TREE})
e. Buffer Width ($V_{BUFFWIDTH}$)
f. Buffer Condition ($V_{BUFFCOND}$)
g. Buffer Contiguity ($V_{BUFFCONTIG}$)
h. Microtopography (V_{MICRO})

(4) Index of Function

$$\text{Index} = [(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{STRATA} + V_{MICRO} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$$

B) Interspersion and Connectivity of Habitats

(1) Definition

Interspersion and Connectivity of Habitats refers to the capacity of the waters/wetlands to allow aquatic, semi-aquatic, terrestrial, and avian organisms to access and utilize habitats via contiguous patches.

(2) Rationale for the Function

Wetland ecosystems are used extensively by aquatic, semi-aquatic, terrestrial, and avian organisms to complete portions of their life cycles that include reproduction, feeding, growth, *etc.* Adequate habitat corridors are required for connecting wetland and upland ecosystems within the landscape (Forman and Godron 1986). Smaller, less mobile faunal species frequently require juxtaposition of habitat components or resources on scales consistent with their smaller home ranges (Opdam 1990). Studies of such habitat fragmentation show reduced faunal species richness as patch sizes decrease (Harris 1984). Connections between habitats help maintain higher animal and plant diversity across the landscape (Brinson *et al.* 1995).

(3) Variables Used to Assess Habitat Interspersion and Connectivity

We used the following variables to assess the habitat interspersion and connectivity function for all riverine subclasses in Mount Vernon:

a. Patch Number ($V_{PATCHNUMBER}$)
b. Patch Area ($V_{PATCHAREA}$)
c. Patch Lateral Contiguity ($V_{PATCHLATCON}$)
d. Buffer Width ($V_{BUFFWIDTH}$)
e. Buffer Condition ($V_{BUFFCOND}$)
f. Buffer Contiguity ($V_{BUFFCONTIG}$)

(4) Indices of Function

$$Index = ((V_{PATCHNUMBER} + V_{PATCHAREA})/2 + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + V_{PATCHLATCON})/3$$

C) Distribution and Abundance of Invertebrates

(1) Definition

The Distribution and Abundance of Invertebrates refers to the capacity of waters/wetlands to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic and terrestrial).

(2) Rationale for the Function

Invertebrates exploit almost every microhabitat available in waters/ wetlands and may reach densities of thousands of individuals per square meter. Because invertebrates are so pervasive and partition habitats so finely, they are excellent indicators of ecosystem function (Karr 1991, Karr and Kerans 1992).

(3) Status of the Function in this *Draft Operational Guidebook*

At this stage of development of the City of Mount Vernon *Guidebook*, we are unable to provide reliable variables that would allow calculation of an index of function for invertebrates. This situation is due to the combination of a lack of reference data, lack of invertebrate expertise on the field/author team, and a limited scope/budget for this project. However, the invertebrate function has been included as a "placeholder" to signify (a) our recognition of the importance of invertebrate taxa in wetland ecosystems, and (b) the potential to expand upon current efforts.

D) Distribution and Abundance of Vertebrates

(1) Definition

The Distribution and Abundance of Vertebrates function refers to the capacity of waters/wetlands to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic and terrestrial).

(2) Rationale for the Function

Vertebrate distribution and abundance in any wetland ecosystem is extremely variable, and can change rapidly in space and time. Many vertebrates are conspicuous users of waters/wetlands, and can have a strong influence on the dynamics of a riverine ecosystem. The goal in assessing this function is to compare reference and assessment site functions with respect to species composition and structure of vertebrate species associated with a water/wetland and the presence of necessary habitats to support common (or rare) vertebrate faunal populations. Rapid, direct measurements of vertebrates are difficult to perform in the field. Direct sightings, as well as indirect indicators of animal use can both be used assess this function. The following are suggestions, given the expertise and scope of work, to accurately measure this function: (a) Perform complete surveys by vertebrate specialists and compare to reference standard conditions using similar indices, (b) Reference local species lists for mammals, birds, fish, amphibians, and reptiles, and (c) Compare to reference standard conditions using similar indices.

(3) Status of the Function in This *Draft Operational Guidebook*

At this stage of development of the City of Mount Vernon *Guidebook*, we are unable to provide reliable variables that would allow calculation of an index of function for vertebrates. This situation is due to the combination of a lack of reference data, lack of invertebrate expertise on the field/author team, and a limited scope/budget for this project. However, the vertebrate function has been included as a "placeholder" to signify (a) our recognition of the importance of vertebrate taxa in wetland ecosystems, and (b) the potential to expand upon current efforts.

C. Description of 17 Variables Used in Slope and Slope-Riverine Proximal Waters/Wetlands Ecosystems

1. Buffer Width ($V_{BUFFWIDTH}$)

A) Definition

The wetland buffer width is the width of the plant community extending perpendicularly from the boundary of the slope wetland.

B) Rationale for Selection of Variable

Intact plant communities are critical to the functioning of wetland ecosystems. Vegetated buffers provide erosion control and sediment removal, temperature control, nutrient/pollutant removal and a suite of microclimate habitats for a variety of wildlife. Buffer Width is used in the Spatial Structure of Habitats Function, but contributes also to improved retention of nutrients and sediments and the cycling of elements and compounds.

C) Definition of the VAA

The VAA for $V_{BUFFWIDTH}$ includes an area extending perpendicularly out from the wetland boundary and surrounding the entire wetland. The VAA consists of the "standard" (default) buffer width as determined using (Table 14). Standard buffer widths shown in Table 14 were derived using the Washington Wetland Rating System (DOE Wetlands Rating System 2004) and the City of Mount Vernon Critical Areas Ordinance (15.40.110 C.6.a. Pg 40).

Table 14. Standard buffer widths according to wetland rating.

Wetland Rating	Standard Buffer (ft.)
I	200
II	100
III	75
IV	50

D) Measurement Protocol

At a representative location along the wetland, walk in a straight line away from the boundary of the slope wetland and measure (1) the width of contiguous forest canopy surrounding the wetland boundary, and/or (2) the width of contiguous shrub and herb canopy surrounding the wetland boundary within the standard buffer zone. If the buffer width conditions are variable, repeat this protocol to derive an average and representative width of contiguous canopy within the VAA.

E) Scaling Rationale

$V_{BUFFWIDTH}$ was scaled using regulatory guidance combined with field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{BUFFWIDTH}$	Index
a. Wetland buffer width with forest canopy is equal to the standard buffer width for the wetland class (Table 14), **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Wetland buffer width with forest canopy cover is > 75% of the standard buffer width for the wetland class (Table 14), **AND/OR** b. There is **some** evidence of anthropogenic disturbance within the standard buffer width.	0.75
a. Wetland buffer width with forest canopy cover is between > 25% and ≤ 75% of the standard buffer width for the wetland class (Table 14) , **OR** b. Wetland buffer width with herbaceous or shrub cover is > 75% of the standard buffer width for the wetland class.	0.50
a. Wetland buffer width with forest canopy cover is between > 10 and ≤ 25% of the standard buffer width for the wetland class (Table 14) , **OR** b. Wetland buffer width with herbaceous or shrub cover is > 25% and ≤ 75% of the standard buffer width for the wetland class.	0.25
a. Wetland buffer width with forest canopy cover is between 0 and ≤ 10% of the standard buffer width for the wetland class (Table 14), **OR** b. Wetland buffer width with forest canopy cover is between 0 and ≤ 25% of the standard buffer width for the wetland class, **AND** c. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. Wetland buffer width with forest canopy cover is between 0 and 10% of the standard buffer width for the wetland class (Table 14), **OR** b. Wetland buffer width with forest canopy cover is between 0 and ≤ 25% of the standard buffer width for the wetland class, **AND** c. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.00

2. Buffer Condition ($V_{BUFFCOND}$)

A) Definition

Buffer Condition is the predominant land use and condition of the area perpendicular to and outward from the slope water/wetland boundary.

B) Rationale for Selection of Variable

Intact plant communities are critical to the functioning of wetland ecosystems. Vegetated buffers provide erosion control and sediment removal, temperature control, nutrient/pollutant removal and a suite of microclimate habitats for a variety of wildlife. Wetland buffers contribute to improved retention of nutrients and sediments and the cycling of elements and compounds. In the HGM model for slope wetlands, Buffer Condition is used in conjunction with Buffer Contiguity and Buffer Width to describe the extent and function of the wetland buffer.

C) Definition of the VAA

The VAA for $V_{BUFFCOND}$ includes an area extending perpendicularly out from the wetland boundary and surrounding the entire wetland. The VAA consists of the "standard" (default) buffer width as determined using (Table 14). Standard buffer widths shown in Table 14 were derived using the Washington Wetland Rating System (DOE Wetlands Rating System 2004) and the City of Mount Vernon Critical Areas Ordinance (15.40.110 C.6.a. Pg 40).

Table 14. Standard buffer widths according to wetland rating.

Wetland Rating	Standard Buffer (ft.)
I	200
II	100
III	75
IV	50

D) Measurement Protocol

Determine Buffer Condition in conjunction with measuring Buffer Width and Buffer Contiguity within the VAA (Table 14). At representative locations along the wetland boundary, walk a transect that consists of a straight line of travel directly away from the boundary of the wetland. Along this transect, determine the vegetation cover type(s) (*e.g.*, tree canopy, shrubs, or herbs), the amount of impervious surface, and the relative percent cover of each cover type within the VAA. Walk enough transects at right angles around the wetland so that the buffer condition is assessed up gradient, down gradient and at each side of the slope wetland.

E) Scaling Rationale

$V_{BUFFCOND}$ was scaled using regulatory guidance combined with field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{BUFFCOND}$	**Index**
a. 100% of this buffer is dominated by intact **tree (forest) canopy, AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. 100% of this buffer is covered by **tree (forest) canopy**, **BUT** b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
a. > 50% of this buffer is dominated by tree canopy cover and the remaining buffer area is dominated by either shrubs or herbs. b. None of the VAA is covered by impervious surfaces.	0.50
a. The buffer is dominated by herb and/or shrub canopy cover, **AND** b. ≤ 10 % of the VAA is covered by impervious surfaces.	0.25
a. > 10 % but < 25% of the VAA is covered by impervious surfaces, **AND/OR** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. > 25% of the VAA is covered by impervious surfaces, **AND/OR** b. The variable **is not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.00

3. Buffer Contiguity ($V_{BUFFCONTIG}$)

A) Definition

Wetland buffer contiguity is the percent of the water/wetland boundary surrounded by an intact vegetated buffer.

B) Rationale for Selection of Variable

Intact plant communities are critical to the functioning of wetland ecosystems. Vegetated buffers provide erosion control and sediment removal, temperature control, nutrient/pollutant removal and a suite of microclimate habitats for a variety of wildlife. Intact buffers contribute to improved retention of nutrients and sediments and the cycling of elements and compounds. In the HGM model for slope wetlands, Buffer Contiguity is used in conjunction with Buffer Condition and Buffer Width to describe the extent and function of the wetland buffer.

C) Definition of the VAA

The VAA for $V_{BUFFCONTIG}$ includes an area extending perpendicularly out from the wetland boundary and surrounding the entire wetland. The VAA consists of the "standard" (default) buffer width as determined using (Table 14). Standard buffer widths shown in Table 14 were derived using the Washington Wetland Rating System (DOE Wetlands Rating System 2004) and the City of Mount Vernon Critical Areas Ordinance (15.40.110 C.6.a. Pg 40).

Table 14. Standard buffer widths according to wetland rating.

Wetland Rating	Standard Buffer (ft.)
I	200
II	100
III	75
IV	50

D) Measurement Protocol

Determine Buffer Contiguity in conjunction with measuring Buffer Width and Buffer Condition within the standard buffer width (Table 14). Estimate the percentage of the wetland surrounded by an **"intact"** forested and/or vegetated buffer. Please note: For the purposes of scaling this variable, buffers less than 15 feet in width are considered "**not intact**."

E) Scaling Rationale

$V_{BUFFCONTIG}$ was scaled using regulatory guidance combined with field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{BUFFCONTIG}$	**Index**
a. 100% of the water/wetland edge is bounded by an "intact" **forested** buffer, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. > 75% to 100% of the water/wetland edge is bounded by an intact **forested** buffer, **AND** b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
> 50% to ≤ 75% of the water/wetland edge is bounded by an intact **vegetated** buffer	0.50
> 25% to ≤ 50% of the water/wetland edge is bounded by an intact **vegetated** buffer	0.25
a. 0% to ≤ 25% of the water/wetland edge is bounded by an intact **vegetated** buffer, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. 0% to ≤ 25% of the water/wetland edge is bounded by an intact **vegetated** buffer, **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.00

4. Herbaceous Cover (V_{HERB})

A) Definition

Herbaceous cover is defined as the percent cover of herbaceous vegetation, specifically graminoids, forbs, ferns, and fern allies within the VAA.

B) Rationale for Selection of the Variable

Cover of herbaceous vegetation typical of reference standard conditions indicates the presence and maintenance of native plant communities. Low percent herbaceous cover is characteristic of late succession, undisturbed reference standard conditions in the majority of plant communities found throughout the watershed. High percent cover of herbs in communities can indicate an early stage of the forested waters/wetlands in Mount Vernon. A high percentage of herbaceous cover also can indicate recent, intense, and/or frequent disturbance by human activities.

C) Definition of VAA

The VAA for V_{HERB} consists of a minimum of 1 and up to three circular plots located within a representative area of the slope wetland (Figure 18). Each circular plot should cover 0.01-acre (radius = 11.8 feet). Establish one herb plot within the each tree/shrub survey plot (r = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Within each circular plot, make visual estimates of the percent cover for the herbaceous stratum (including graminoids, forbs, ferns, and fern allies) using midpoints of standard canopy cover classes (Table 15). Record these estimates of percent cover on the Minimal Submittal Worksheets. Average the three measurements of herbaceous canopy cover to calculate the final estimate of herbaceous cover.

Please note: Scaling of this variable assumes herbaceous canopy coverage percentages at or near peak floristic development (late June through July of any given year). If sampling is completed in “off” season intervals, adjust estimates of canopy coverage to reflect peak conditions.

E) Scaling Rationale

V_{HERB} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling for all Subclasses

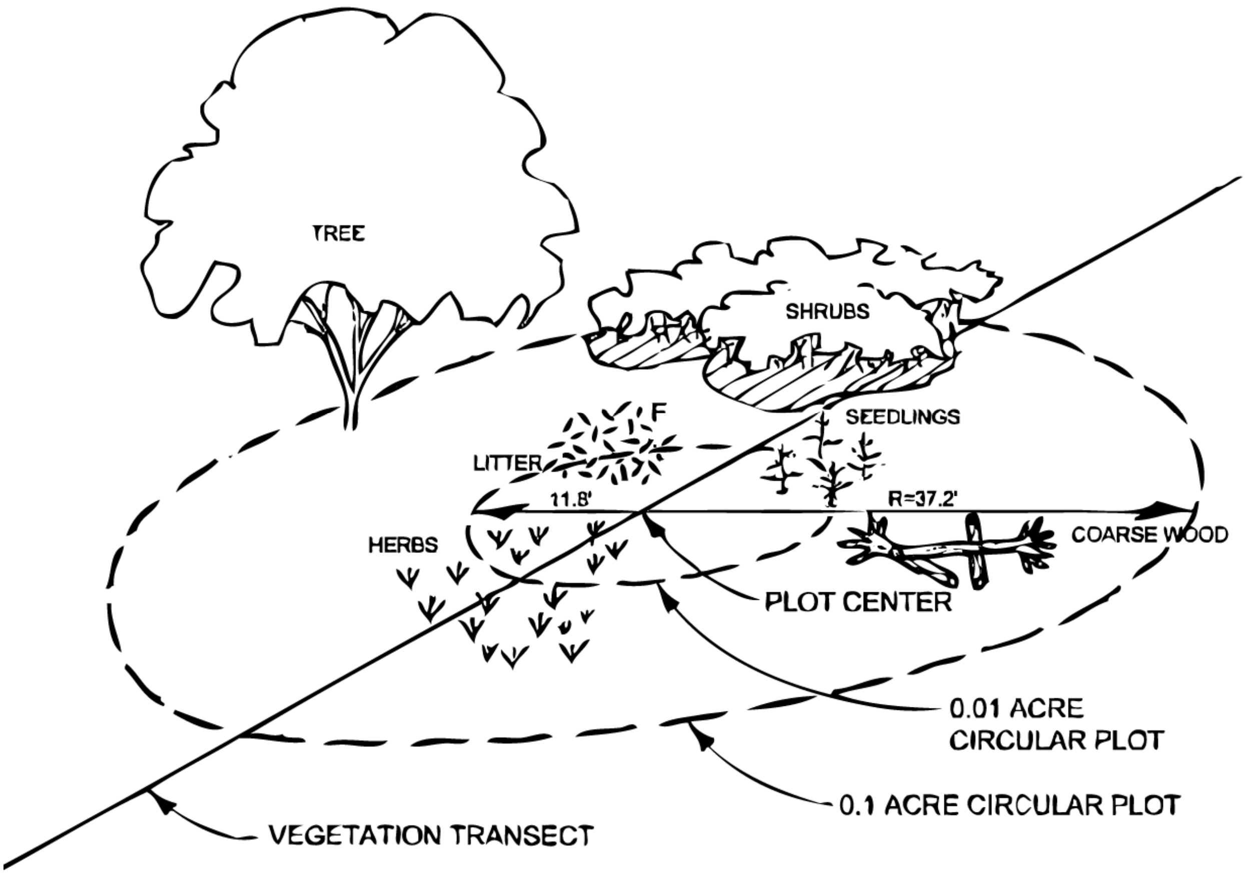
1. Shrub and/or Herbaceous Community is Dominant Within the VAA:

Measurement or Condition for V_{HERB}	Index
a. Average herbaceous cover is ≥ 90%, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Average herbaceous cover is ≥ 90%, **AND** b. There is evidence of anthropogenic disturbance within the VAA.	0.75
Average herbaceous cover is ≥ 50% and < 90%	0.50
a. Average herbaceous cover is ≥ 10 % and < 50%, **OR**	0.25
a. Average herbaceous cover is < 10% **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Average herbaceous cover is < 10% **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Tree (Forest) Community is Dominant within the VAA:

Measurement or Condition for V_{HERB}	Index
a. Average herbaceous cover is ≥ 25% and < 40%, **AND** . b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Average herbaceous cover is ≥ 25% and < 40%, **AND** b. There **is** evidence of anthropogenic disturbance within the VAA.	0.75
Average herbaceous cover is ≥ 15% and < 25%	0.50
Average herbaceous cover is ≥ 5% and < 15%	0.25
a. Average herbaceous cover is < 5% **OR** ≥ 40%, **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Average herbaceous cover is < 5 % **OR** ≥ 40%, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

Figure 18. Survey Protocol for Scaling Slope Variables



<u>Variables measured in 0.1 acre (37.2 ft radius) circle</u>

a) Percentage of Native and Non-Native Plant Species (V_{NATIVE})
b) Shrub Canopy Cover (V_{SHRUB})
c) Tree Canopy Coverage (V_{TREE})
d) Large Wood (V_{LWOOD})
e) Microtopography (V_{MICRO})

<u>Variables measured in 0.01 acre (11.8 ft radius) circle</u>

a) Herbaceous Cover (V_{HERB})
b) Litter and Fine Woody Debris (V_{LITTER})

<u>Variables measured along the 100 ft transects</u>
a) Number of Strata (V_{STRATA})

5. Litter and Fine Woody Debris (V_{LITTER})

A) Definition

Litter and fine woody debris is defined as the cover class of leaf litter and dead and down fine woody debris (< 3 inches diameter) within the VAA.

B) Rationale for Selection of Variable

Tree branches and twigs (< 3 inches diameter) as well as leaves on the floodplain, terrace and forest floor represent litter and fine woody debris. Fine woody debris (FWD) in various states of decomposition and leaf litter contributes organic carbon (detritus) to terrestrial and aquatic ecosystems. Organic carbon serves as an energy source that provides the basis for numerous ecosystem processes (*e.g.*, decomposition, nutrient cycling, energy transfer, *etc.*). Fine woody debris and litter also provides an important substrate for many phases of invertebrate life cycles (*e.g.*, feeding, nesting, and rearing habitat), and habitat for small vertebrates.

C) Definition of VAA

The VAA for V_{LITTER} consists of a minimum of 1 and up to three circular plots located within a representative area of the slope wetland (Figure 18). Each circular plot should cover 0.01-acre (radius = 11.8 feet). Establish one herb plot within the each tree/shrub survey plot (r = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Within each circular plot, make visual estimates of the percent cover of fine woody debris and leaf litter using midpoints of standard canopy cover classes (Table 15). Record these estimates of percent cover on the Minimal Submittal Worksheets.

Please note: Scaling of this variable assumes litter coverage percentages after the previous year's litterfall and not during peak litterfall intervals. If sampling is completed in "off" season intervals, adjust estimates of litter to reflect average conditions.

Table 15. Conversion Table for Percent Cover to Cover Class Midpoint

Percent (%) Cover	Midpoint
<1	0
1-5	3
6-15	10.5
16-25	20.5
26-50	38
51-75	63
76-95	85.5
96-100	98

E) Scaling Rationale

V_{LITTER} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for V_{LITTER}	**Index**
a. Cover by litter/FWD is ≥ 90%. b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
Cover by litter/FWD is ≥ 90%. b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
Cover by litter/FWD is ≥ 75 and < 90%	0.50
Cover by litter/FWD is ≥ 25% and < 75%	0.25
a. Cover by litter/FWD is < 25%, **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Cover by litter/FWD is < 25%, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

6. Large Wood (V_{LWOOD})

A) Definition

Large Wood is the average number of pieces of large wood (> 4 inches average diameter & > 6 feet length) per 0.1 acre. Large wood does not include dimension lumber or rounds (*i.e.* telephone poles and fence posts).

B) Rationale for Selection of Variable

Large Wood has direct effects on hydrologic, geochemical, plant community, and faunal support/habitat functioning. Large Wood contributes organic carbon (detritus) to terrestrial and aquatic ecosystems as it proceeds through the stages of decomposition. This organic carbon serves as an energy source that provides the basis for numerous ecosystem processes (*e.g.*, decomposition, nutrient cycling, energy transfer, *etc.*). Large wood provides key habitat micro-sites ideal for colonization by trees and shrubs.

Large wood provides substrate for plant recruitment in wetlands.

C) Definition of VAA

The VAA for V_{LWOOD} consists of a minimum of 1 and up to three circular plots located within a representative area of the slope wetland (Figure 18). Each circular plot should cover 0.10-acre (radius = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Within each 0.1-acre circular plot, count all down wood and dead trees and/or limbs (> 4 inches diameter and > 6 feet in length) within the VAA. Note that "down wood" is at an angle of repose greater than 45 degrees from vertical. The wood can be either dead or alive.

All pieces of LW that intersect the sample VAA perimeters should be recorded. If a piece of large wood is found in the VAA and it extends beyond the plot boundary (*i.e.*, below OHW), count it. Record your results on the Minimum Submittal Worksheets. To scale this variable, determine an average number of pieces of large wood per 0.1 acre plot.

E) Scaling Rationale

Scaling is based on Spies *et al.* (1988) with 196 forested stands in the Cascade and coastal ranges in Washington and Oregon.

F) Scaling

Measurement or Condition for V_{LWOOD}	**Index**
a. On average, there are greater than 15 pieces of large wood per 0.1 acre plot, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA	1.00
On average, there are between 8 and 15 pieces of large wood per 0.1 acre plot. b. There is **some** evidence of anthropogenic disturbance within the VAA	0.75
On average, there are between 5 and 7 pieces of large wood per 0.1 acre plot.	0.50
On average, there are between 2 and 4 pieces of large wood per 0.1 acre plot.	0.25
On average, there are 1 or 2 pieces of large wood per 0.1 acre plot.	0.10
There is no large wood within the VAA.	0.00

7. Microtopography (V_{MICRO})

A) Definition

Microtopography refers to surface features and roughness within a slope wetland imparted by natural processes including hummocks and down wood that can 1) slow down, store, or deflect surface water and 2) provide colonization zones for the plant community.

B) Rationale for the Selection of the Variable

Geomorphic features and complex micro and macro topographic features (*e.g.,* ruts, mounds, logs, and hummocks) influence wetland hydrology, physicochemistry, and habitat variability (Moser *et al*. 2007). These features provide roughness and thus hydraulic resistance within wetland ecosystems. Hydraulic resistance is closely related to the timing and amount of water storage that can occur within the wetland. In Mount Vernon, human activities (*e.g.,* surface leveling, disking, and removal of vegetation for development or flood control, grazing, or haying) decrease the structural complexity and roughness of natural surfaces. This smoothing leads to less short and long-term storage of water within wetland, and thus results in faster conveyance of water and sediment down gradient and lower retention rates for nutrients, sediments or other pollutants that may be suspended in runoff.

C) Definition of VAA

The VAA for V_{MICRO} consists of a minimum of 1 and up to three circular plots located within a representative area of the slope wetland (Figure 18). Each circular plot should cover 0.10-acre (radius = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Within each 0.10 acre plot, note evidence of anthropogenic surface changes such as logging, fire history, land use, grazing, disking, and leveling, *etc*. Note evidence of surface microtopography such as hummocks, down wood, bunch grasses, frost heaves, microdepressions, *etc.*

E) Scaling Rationale

V_{MICRO} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for V_{MICRO}	Index
a. Microtopographic variation exists in the form of windthrow, logs, hummocks, microdepressions, bunch grasses, *etc.*, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Microtopographic variation exists in the form of windthrow, logs, hummocks, microdepressions, bunch grasses, *etc.*, **AND** b. There is **minor** evidence of anthropogenic disturbance.	0.75
a. There is **moderate** evidence of human alterations including **historical** logging, burning, disking, grazing, **BUT** b. **Some** microtopographic variation exists within the VAA.	0.50
a. There is **moderate** evidence of human alterations including **historical** logging, burning, disking, grazing, **AND** b. **Little or no** microtopographic variation exists within the VAA.	0.25
a. The VAA has **prominent** evidence of human alterations including recent logging, burning, disking, grazing, *etc.* **OR** b. The area is covered by semi-impervious surfaces (*i.e.* lawn, grading, surface leveling), **AND** c. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. The VAA is covered by impervious surfaces (*i.e.* pavement, asphalt, *etc.*), **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

8. Percentage of Native Vegetation (V_{NATIVE})

A) Definition

The Percentage of Native Vegetation function is defined as the proportion of native species in the dominant (top 5) plant taxa within the VAA.

B) Rationale for Selection of Variable

Native plant species dominate reference standard conditions. Anthropogenic disturbances provide opportunities for nonnative weedy taxa to enter and typically, to become established within the disturbed portions of the community. However, it has been suggested that most nonnative species have little or no effect on native species within the invaded community (Simberloff 1981). Some nonnative species, such as Japanese Knotweed (*Polygonum japonica)*, can and do interact with native species in ways that may be detrimental. Nonnative taxa may hybridize with closely related species (Thompson 1991, Abbot 1992); out compete natives (see Parker and Reichard 1998 for a review); alter ecosystem processes such as nitrogen fixation (Vitousek *et al.* 1987), site water balance, and mycorrhizal interactions (Goodwin 1992); and, they may also negatively affect the use of the native communities by wildlife (Olson and Knopf 1986, Carey and Wilson 2001). Therefore, the percentage of native vegetation to nonnative plant species in an assessment area is a general measure of the degree to which native plant communities have departed from reference standard conditions as a result of anthropogenic activities.

C) Definition of VAA

The VAA for V_{NATIVE} consists of a minimum of 1 and up to three circular plots located within a representative area of the slope wetland (Figure 18). Each circular plot should cover 0.10-acre (radius = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Thoroughly walk the VAA. Determine the five dominant species for each of the three vegetation strata (*i.e.*, tree, shrub, and herb) (see Figure 18). Vines are accounted as shrubs. If five species are not present within a stratum, list all species that do occur. For example if only *Rubus discolor* and *Rubus spectabilis* occur in the shrub stratum within the VAA, then only record these two species. Record all dominant species for all three strata on the Minimum Submittal Worksheets.

If you encounter problems in determining the dominant species within the VAA for a particular stratum, begin by assigning a cover class midpoint value (Table 15) for all species that occur in that stratum. Then select the five species from that stratum with the highest cover class values. For all dominant species, identify their indigenous status (native or non-native) using *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1990). Count the number of native, non-native (including ornamental and cultivated) species from this list of dominant species. Divide the number of native species by the total number of identified dominant species and multiply by 100 to obtain a percent of native species. Record the percentages and scaling on the Minimum Submittal Worksheets (Appendix A).

E) Scaling Rationale

V_{NATIVE} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for V_{NATIVE}	**Index**
a. Between ≥ 90% to 100% of the dominant species are native, **AND** b. There is **no** evidence of anthropogenic disturbance	1.00
a. ≥ 75 % and < 90% of the dominant species are native, **AND** b. There is **some** evidence of anthropogenic disturbance	0.75
≥ 50% and < 75% of the dominant species are native	0.50
≥ 25% and < 50% of the dominant species are native	0.25
a. < 25% of the dominant species are non-native, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. < 25 % of the dominant species are non-native, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

9. Patch Area ($V_{PATCHAREA}$)

A) Definition

Patch area is the percent of the area covered by habitat patches, as calculated from the Habitat Patch map, within the 1000 ft radius VAA.

B) Rationale for Selection of the Variable

The relative area (measured as a percentage of the 1000 ft VAA ring) of patches is an indicator of the site's capacity to function as habitat for faunal communities. The relative area, in combination with a measure of the total number of patches (*i.e.*, $V_{PATCHNUMBER}$), is an indicator of the number and size distribution of the habitat patches available for utilization by faunal communities. Large habitat patches have low edge-to-interior ratios and thus a diversity of interior niches that are critical for resting, hiding, escape, thermal, and feeding dynamics. For aquatic dependent species with both large and small home ranges, large intact habitat patches are critical for completion of their lifecycles. In addition, habitat patch size affects the maintenance of native vegetation communities through factors such as seed dispersal, light, and temperature regulation, *etc.*

C) Definition of the VAA

The variable assessment area (VAA) for $V_{PATCHAREA}$ is a 1000 ft radius VAA ring centered on the project area (PAA; *i.e.,* area where development is planned to occur).

D) Measurement Protocol

Within the GIS, display or print an area map showing the watershed that contains the PAA of interest. Using a ruler and compass, or an equivalent technique in the GIS, plot a circle with a 1000 ft radius around the centroid of the project area.

To score this variable, three habitat conditions have been identified in Mount Vernon:

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Using a 1:24,000 mapping scale grid, or an equivalent GIS technique (*e.g.* "Tabulate Area" in Arc/Info Spatial Analyst), measure the relative areas of the habitat patches that are within the 1000 ft VAA ring. Habitat patches that extend beyond the 1000 ft VAA ring should be truncated and only the area within the 1000 ft VAA ring should be included in the area measurement in order to produce a relative area measurement. If a "patch" has a width less than 35 feet, include this area with the adjacent habitat type.

Using these calculations, sum the patch areas to calculate the total patch area for Excellent Habitat and 2 within the 1000 ft VAA ring. Divide the patch areas by the area of the 1000 ft VAA ring (3,140,000 ft^2 [*i.e.*, 1000 ft x 1000 ft x 3.14]) and multiply by 100 to calculate the relative percentage of the 1000 ft VAA ring in each habitat patch class. If necessary, convert the habitat patch areas from m^2 to ft^2 to maintain consistency of units. Use the relative area of the habitat patches in the 1000 ft VAA ring to scale the $V_{PATCHAREA}$ variable. Print and/or include an electronic copy of the map used for the calculation.

E) Scaling Rationale

$V_{PATCHAREA}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Habitat Conditions

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Measurement or Condition for $V_{PATCHAREA}$	**Index**
> 95% of the VAA is covered by excellent habitat	1.00
> 95% of the VAA is covered by excellent or good habitat	0.75
50 to 94% of the VAA is covered by excellent or good habitat	0.50
10 to 49% of the VAA is covered by excellent or good habitat	0.25
a. 0 to < 10 %% of the VAA is covered by excellent or good habitat, **AND** b. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. 0 to < 10 %% of the VAA is covered by excellent or good habitat, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

10. Habitat Patch Lateral Contiguity ($V_{PATCHLATCON}$)

A) Definition

The lateral (*i.e.*, perpendicular to the general valley trend) contiguity of habitat patches within the 1000 ft VAA.

B) Rationale for Selection of the Variable

The lateral contiguity of habitat patches within the VAA is an indicator of the site's capacity to function as habitat for faunal communities. In Mount Vernon, less disturbed wetland ecosystems are connected laterally through a contiguous forest vegetation community. Lateral connectivity decreases with human disturbance (roads/urbanization, agriculture, grazing/land clearing, *etc.*) and thus influences the ability of faunal communities to locate access, utilize, and disperse from a variety of habitat types.

C) Definition of the VAA

The variable assessment area (VAA) for $V_{PATCHLATCON}$ is a 2000 ft transect that crosses the centroid of the project area (PAA; *i.e.,* area where development will occur) and that is oriented perpendicular to the primary gradient of the slope.

D) Measurement Protocol

Within GIS, display or print a map showing the watershed that contains the PAA of interest. From the centroid (approximate center) of Project Area, draw a line 1000 ft in each direction (2000 ft total) that is perpendicular to the primary gradient of the slope.

Three habitat types have been identified in Mount Vernon:

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Count and record the number of habitat changes crossed by this line. Count a habitat class change only if some portion of the new habitat class is visible on both sides of the transect.

Record your results on the Minimum Submittal Worksheet. Print and include an electronic copy of the map used for the calculation.

E) Scaling Rationale

$V_{PATCHLATCON}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{PATCHLATCON}$	**Index**
a. The Habitat type within the VAA is entirely Excellent condition habitat (forest), **AND** b. There are 0 habitat class changes.	1.00
a. There are 1- 3 habitat class changes in the VAA, **AND** b. Excellent habitat is present along the VAA.	0.75
a. There are ≥ 3 - 6 habitat class changes in the VAA, **AND** b. Excellent habitat is present along the VAA.	0.50
a. There are ≥ 6 – 9 habitat class changes in the VAA, **AND** b. Excellent condition habitat is present along the VAA.	0.25
a. There is no Excellent condition habitat (forest) along the VAA, **OR** b. There are ≥ 10 habitat class changes in the VAA, **AND** c. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. There is no Excellent condition habitat (forest) along the VAA, **OR** b. There are ≥ 10 habitat class changes in the VAA, **AND** c. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

11. Patch Number ($V_{PATCHNUMBER}$)

A) Definition

The number of habitat patches, calculated from the Habitat Patch map, within the 1000 ft radius circle VAA surrounding the project site.

B) Rationale for Selection of the Variable

The number of habitat patches within a 1000 ft radius (VAA) of the project site is an indicator of the site's capacity to function as habitat for faunal communities. The number of patches increases with human disturbance and thus influences the ability of faunal communities to locate, access, utilize, and disperse from a variety of habitat types. The access and utilization of habitat patches by faunal communities is essential for population dynamics such as resting, hiding, escape, thermal, and feeding.

C) Definition of the VAA

The variable assessment area (VAA) is the 1000 ft radius VAA ring centered on the project area (PAA; *i.e.* area where development is planned to occur).

D) Measurement Protocol

Within the GIS, display or print an area map showing the watershed that contains the PAA of interest. Locate the Project Area. Using a ruler and compass, or an equivalent technique in the GIS, plot a circle with a 1000 ft radius around the centroid of the project area.

Three habitat conditions have been identified in Mount Vernon:

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Using a 1:24,000 mapping scale grid, or an equivalent GIS technique (*e.g.* "Tabulate Area" in Arc/Info Spatial Analyst), measure the relative areas of the habitat patches that are within the 1000 ft VAA ring. Habitat patches that extend beyond the 1000 ft VAA ring should be truncated and only the area within the 1000 ft VAA ring should be included in the area measurement in order to produce a relative area measurement. If a "patch" has a width less than 35 feet, include this area with the adjacent habitat type. Count the number of Excellent Habitat and Good condition habitat patches that are within the 1000 ft radius VAA ring. Habitat patches that are intersected by, but also extend beyond, the 1000 ft VAA ring should also be included in the count of habitat patches. Count habitat patches separately if they do not share a common edge, or are connected only diagonally on the map. Count a habitat patch only once even if the patch intersects the 1000 ft VAA ring at more than one location. Print and or include an electronic copy of the Habitat Map used for the calculation. Record your results on the Minimum Submittal Worksheet.

E) Scaling Rationale

$V_{PATCHNUMBER}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Habitat Conditions

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Measurement or Condition for $V_{PATCHNUMBER}$	**Index**
a. The 1000 ft radius VAA ring contains 1 – 2 Excellent condition habitat patches, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA	1.00
a. The 1000 ft radius VAA ring contains 3 – 5 Excellent condition habitat patches, **AND** b. There is **some** evidence of anthropogenic disturbance within the VAA	0.75
a. The 1000 ft radius VAA ring contains 6-10 Excellent **and/or** Good condition habitat patches, **AND** b. Excellent condition habitat is present within the VAA.	0.50
a. The 1000 ft radius VAA ring contains 11-20 Excellent **and/or** Good condition habitat patches, **AND** b. Excellent habitat is present within the VAA	0.25
a. The 1000 ft radius VAA ring contains more than 20 Excellent and Good condition habitat patches, **OR** b. No Excellent condition habitat is present within the VAA, **BUT** c. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. No Excellent or Good condition habitat is present within the VAA, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

13. Shrub Canopy Cover (V_{SHRUB})

A) Definition

Shrub canopy cover is defined as the percent cover of shrubs (multiple-stemmed woody species) within the VAA.

B) Rationale for Selection of Variable

Shrub canopy cover is one measure of vegetation that indicates maintenance of native plant community structure and function. As such, shrub canopy cover can be used along with other measures of vegetative cover to indicate the potential for a site to support characteristic ecosystem processes, such as maintenance of native and nonnative plant communities, faunal communities and faunal support/habitat, *etc.* The presence of shrubs along with that of trees, contributes to roughness and topographic variation. Roughness provides a mechanism to slow water flows and thus provides static and dynamic storage of flood flows as well as cover for aquatic and terrestrial fauna. Shrubs, along with trees, decrease the potential for erosion through the production and maintenance of fine root biomass. Shrubs also function as structural elements that increase habitat diversity.

Shrubs provide significant inputs of labile and refractory organic carbon to wetland ecosystems. In addition, the shrub canopies alter micro-climatic conditions in forests (*e.g.*, moisture, nutrients, light, temperature, wind speed, *etc.*). Microclimatic alterations caused by the presence of shrubs is important in maintaining several ecosystem functions, such as biomass production, maintenance of site water balance, nutrient conservation, habitat structure, *etc.* Furthermore, shrubs, along with trees, are instrumental in soil genesis, elemental cycling, and successional processes (Hooper and Vitousek 1997). These successional processes include the dispersal and establishment of plant propagules that support plant and animal species diversity and turnover (Tilman 1982, Huston and Smith 1987, Cohen and Levin 1991, Tilman and Pacala 1993).

C) Definition of VAA

The VAA for V_{SHRUB} consists of a minimum of 1 and up to three circular plots located within a representative area of the slope wetland (Figure 18). Each circular plot should cover 0.10-acre (radius = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

To measure V_{SHRUB}, stand in the center of the plot and make visual estimates of the percent cover for the shrub stratum (Figure 17) using midpoints of standard canopy cover classes (Table 15). Note that vines are defined as shrubs. Record these estimates of percent cover on the Minimal Submittal Worksheets. Average the measurements of shrub canopy cover to calculate the final estimate of shrub cover.

E) Scaling Rationale

V_{SHRUB} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Shrub or Herb Community is Dominant within the VAA:

Measurement or Condition V_{SHRUB}	**Index**
a. Average shrub canopy cover is ≥ 75%, **AND** b. There is **no** evidence of anthropogenic disturbance	1.00
a. Average shrub canopy cover is ≥ 75%, **AND** b. There is some evidence of anthropogenic disturbance	0.75
Average shrub canopy cover is ≥ 50% and < 75%.	0.50
Average shrub canopy cover is ≥ 25% and < 50%.	0.25
a. Average shrub canopy cover is < 25%, **AND** b. The variable condition **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average shrub canopy cover is < 25%, **AND** b. The variable condition is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Trees (Forests) are Dominant within the VAA:

Measurement or Condition V_{SHRUB}	**Index**
a. Average shrub canopy cover is ≥ 45% and < 75%**, AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Average shrub canopy cover is ≥ 45% and < 75%, AND b. There is **some** evidence of anthropogenic disturbance.	0.75
Average shrub canopy cover is ≥ 25% and < 45%.	0.50
Average shrub canopy cover is ≥ 15% and < 25%.	0.25
a. Average shrub canopy cover is < 15% OR > 75%, **AND** b. The variable is recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average shrub canopy cover is < 15% OR >75%, **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

14. Soil Profile Integrity ($V_{SOILINTEG}$)

A) Definition

This variable is a measure of the presence and condition of the soil profile (soil horizons) within the VAA.

B) Rationale for Selection of Variable

The integrity of the soil profile, through linkages with site hydrology, exerts strong control on the ecosystem functions including biogeochemical processes affecting nutrient cycles and storage, and the establishment and maintenance of plant communities. Maintenance of intact soils in slope waters/wetland is especially important in the hilly Mount Vernon landscape. Sites with intact soil profiles typically exhibit higher infiltration rates and hydraulic conductivities than do disturbed and compacted soils. Increased time of contact of water with soil mineral particles and organic matter, plant roots, microbes, *etc.*, facilitates retention and transformation of nutrients, organic matter and contaminants.

C) Definition of the VAA

The VAA for Soil Profile Integrity consists of a transect across a representative section of the slope wetland.

D) Measurement Protocol

Describe the modal soil within the VAA. To accomplish descriptions, excavate soil pits in representative locations. Excavate the soil pits to the depth of excess water, impenetrable debris (*e.g.* boulders, stones, cobbles) or to a depth of approximately 3 ft, whichever is encountered first. Closed-bucket or Dutch augers are useful below approximately 2 feet. After excavation of the soil pit, carefully scrape the face of the bank or pit (a dull knife works well) to remove weathered or smeared material on the face of the soil profile. Clean the face of the profile until the different soil horizons (if present) are clearly exposed. Separate the different soil horizons within the profile by changes in color and/or texture. Describe the different textures by feel, and color consistent with guidelines provided in Munsell Soil Color Charts (Munsell 1994). All soil colors should be from a moist sample and read in direct sunlight if possible. Measure the thickness and depth of each horizon. Record the presence and location of any additional features or activities that might be important (*e.g.* land use, any disturbances to the soil profile, the presence of redoximorphic features within the profile, depth to water, abundant organic matter, faunal habitat, *etc.*). Take photographs and/or samples for later identification of unknown or confusing features.

Identification, nomenclature, and description of soil horizons should be consistent with guidance provided by the USDA Natural Resource Conservation Service (Schoeneberger *et al.* 1998). All soil depths are measured from the soil surface (usually an A horizon), excluding any litter or duff layers that may have accumulated on the soil surface. Live vascular and non-vascular plant materials are **not** included in measurements of soil depths.

E) Scaling Rationale

The authors used best scientific judgment and, secondarily, empirical field data from reference sites to scale this variable. The scaling presented herein is based on the presence, condition, and color (organic carbon content) of organic and/or mineral horizons and the degree of disruption that has occurred from direct manipulation of the wetlands. For all soils present within the PAA, the soil profile integrity variable is scaled down proportional to the degree of anthropogenic disturbance or disruption of the soil profile.

F) Scaling for all Subclasses:

Measurement or Condition for $V_{SOILINTEG}$	Index
a. The modal soil profile(s) (mineral or organic soils) is (are) well developed (*i.e.* different horizons are discernable), and intact within the upper 24 inches, AND b. The surface and shallow subsurface deposits and depositional features **have not** been altered by anthropogenic activities (*e.g.* roads, agriculture, fills, *etc.*).	1.00
a. The modal soil profile(s) (mineral or organic soils) is (are) present (*i.e.* different horizons are discernable), and intact within the upper 24 inches, **BUT** b. Surface and shallow subsurface deposits and depositional features **have** been altered by anthropogenic activities resulting in **minor** changes to the soil profile Alterations may include, but are not limited to, fill, excavation, earthwork, recreation, foot traffic, and clearing of brush.	0.75
a. Modal soil types are present within the VAA, **BUT** b. Surface and shallow subsurface deposits and depositional features **have** been altered by anthropogenic activities. For both mineral and organic soils, soil surface horizons are impacted (*e.g.*, compaction, light erosion, placement of limited fill, grazing plowed or disked) and as a consequence, they exhibit some diminished structure, thickness, and/or organic carbon content. Alterations may include, but are not limited to, fill, excavation, and/or earthwork, **AND** c. The soil profile description reveals the following characteristics: (1) Modal mineral soil profile has a well developed A horizon or an Ap horizon and, in most cases, a clear and prominent B horizon with well defined structure (*i.e.*, aggregation of soil particles into larger units, or peds) and a moist color value **and** chroma ≤ 2, **or** (2) Modal organic soil profile is essentially intact except for evidence of some plowing or disking within the top 15", or some compaction due to livestock grazing, vehicular traffic, *etc.*	0.50
a. The soil profile is no longer entirely intact due to human activities, **AND** b. The surface horizon was removed or buried by human activities and the subsurface horizon(s) are either buried, or exposed and altered, (*e.g.,* disturbance by roads, debris basins, construction), **AND** c. Soil structure in the upper part of the profile is weak or absent and organic carbon content is diminished (*e.g.,* moist color value and chroma > 3)	0.25
a. Soil profile is no longer entirely intact and is significantly disturbed by human activities, **AND** b. The surface horizon has been buried **or** removed by human-induced activities and the subsurface horizon(s) are exposed, highly eroded, and subject to failure or continued erosion and deterioration (*e.g.*, soil is buried by fill, has areas of slope failure, heavy vehicle traffic, disturbance by roads, construction, or agriculture), **OR** c. Soil structure is weak or absent and vegetation, root biomass, and organic carbon content within the soil are greatly diminished or absent (*e.g.*, moist color value and chroma > 3), **AND** d. The soil profile can be recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Soil profile is no longer intact as a result of human activities, **AND** b. The surface and subsurface horizons are generally absent due to removal **or** burial as a result of human activities (*e.g.,* the placement of fill, roads, concrete or asphalt, construction, debris basins, revetments, concrete weirs or trapezoids), **or** c. Soil structure, vegetation, root biomass, and organic carbon within the soil profile are virtually absent (*e.g.,* moist color value and chroma > 3), **AND** d. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

15. Vegetation Strata (V_{STRATA})

A) Definition

Vegetation strata are defined as the number of distinct layers present within the VAA. Vegetation strata are recognized within the Mount Vernon landscape as trees (single stem woody species with > 4" DBH and a height of > 10 ft), shrubs (multiple stemmed woody species including vines), and herbs (including forbs, graminoids, ferns, and fern allies).

B) Rationale for Selection of Variable

Multiple vegetative strata (*e.g.*, trees, shrubs, and/or herbs) often are good indicators of the development and maintenance of plant communities, habitat structure, and soil stability (Tilman 1994). For example, the number of strata can be correlated with the habitat structure and complexity necessary to support characteristic faunal assemblages, *e.g.*, those typical of the Mount Vernon watershed. Similarly, the number and types of vegetation strata combine to provide the diversity of faunal habitat, as well as the types and quantity of food and cover resources available.

C) Definition of the VAA

The VAA for V_{STRATA} consists of a 100 ft vegetation transect situated at a representative location within the slope wetland.

D) Measurement Protocol

To develop a measure for V_{STRATA}, walk along the 100 ft vegetation transect, stopping to observe the number of vegetative strata at 10 ft intervals. Record the total number of strata (*i.e.,* herb, shrub, and tree) that intersect the transect at each stop.

For example, an HGM user may identify the presence of only the herb stratum at a given sampling point. He or she would therefore record only one stratum as present. The HGM user would conduct this measurement at 10 points each transect.

Calculate an average number of vegetation strata for the assessment area using all 10 data points. Record these values on the minimum submittal sheet.

E) Scaling Rationale

V_{STRATA} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Shrub Community is Dominant within the VAA:

Measurement Condition for V_{STRATA}	**Index**
a. Average number of strata is 2, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Average number of strata is 2, **AND** b. There is **some** evidence of anthropogenic disturbance	0.75
Average number of strata is ≥ 1 and < 2.	0.50
Average number of strata is ≥ 0.5 and < 1.	0.25
a. The average number of strata is < 0.5, **AND** b. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.10
a. The average number of strata is < 0.5, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.00

2. Forest Community is Dominant within the VAA:

Measurement Condition for V_{STRATA}	**Index**
a. Average number of strata is 3, **AND** b. There is no evidence of anthropogenic disturbance	1.00
a. Average number of strata is 3, **AND** b. There is some evidence of anthropogenic disturbance	0.75
Average number of strata is ≥ 2 and < 3	0.50
Average number of strata is ≥ 1 and < 2.	0.25
a. The average number of strata is 0 to < 1, **AND** b. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.10
a. The average number of strata is 0 to < 1, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.00

16. Subsurface Water Out (V_{SUBOUT})

A) Definition

Subsurface Water Out refers to the hydrologic connections from the slope wetland to the adjacent down gradient landscape.

B) Rationale for Selection of Variable

Subsurface flows that are processed through slope wetlands provide a source of nutrients and organic carbon to receiving riverine wetlands, which support important biogeochemical and habitat functions as well as contributing to base flow.

C) Definition of VAA

The VAA for Subsurface Water Out consists of 500 feet down gradient of the slope wetland boundary.

D) Measurement Protocol

Identify the condition of the connection between the slope wetland and down gradient landscape (dry slope or riverine wetland). Record any channels, seeps, springs, *etc.* that occur at the down slope interface of the slope wetland. In addition, record presence of anthropogenic alterations such as berms, channels, and ditches along the down gradient boundary of the wetland.

In slope wetlands with no down gradient outlet, flow returns subsurface at the base of the wetland. In slope riverine proximal wetlands, the down gradient connection is a transition to riverine wetland at 200 feet from the flood prone area. In your survey, remember that the down gradient connection may have been altered or severed by anthropogenic activities such as through placement of a berm or through construction of a ditch or channel.

E) Scaling Rationale

V_{SUBOUT} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement Condition for V_{SUBOUT}	**Index**
a. The transition area between the slope wetland and down gradient ecosystem is predominantly undisturbed with native soils and native plant communities, **AND** b. Direct evidence of subsurface flow is observed (or inferred) along the transition (*e.g.*, seeps, upwellings, iron-floc discharge points, *etc.*), **BUT** c. No incised channels exist along the transition to down gradient ecosystem, **AND** d. There is **no** evidence of anthropogenic disturbance	1.00
a. The transition area between the slope wetland and down gradient ecosystem is predominantly undisturbed with native soils and native plant communities, **AND** b. Direct evidence of subsurface flow is observed (or inferred) along the interface (*e.g.*, seeps, upwellings, iron-floc discharge points, *etc.*), **AND** c. No incised channels exist along the transition to down gradient ecosystem, **BUT** d. There is **some** evidence of anthropogenic disturbance	0.75
a. The transition area between the slope wetland and down gradient ecosystem is predominantly undisturbed, native soils, and plant communities, **AND** b. No direct evidence of subsurface flow along the interface is observed or incised channels exist along the transition to the down gradient ecosystem.	0.50
The transition area between the slope wetland and down gradient ecosystem is predominantly disturbed.	0.25
a. The transition area between the slope wetland and down gradient ecosystem predominantly hard surfaces or fill, **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.10
a. A The transition area between the slope wetland and down gradient ecosystem are predominantly hard surfaces or fill, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.00

16. Surface Water In (V_{SURFIN})

A) Definition

Surface Water In refers to the hydrologic connections into the VAA from the adjacent landscape.

B) Rationale for Selection of Variable

The type and number of surface water connections between upland and slope wetland indicates the potential for the wetland ecosystem to maintain intact hydrologic, geochemical, plant community and faunal support/habitat functions (Brinson *et al.* 1995). For example, intact surface water connections mediate runoff from surrounding landscapes. Surface water connections are vital in allowing biogeochemical processes associated with particulate detention, elemental cycling, and organic carbon export (both dissolved and particulate) to occur.

Intact surface water connections help maintain diverse native plant communities in wetland ecosystems. They provide relatively moist microsites that are transitional habitats among (relatively wet) wetland and (relatively dry) upland habitats. The relatively moist transitional sites associated with surface water connections (a) support complex tree canopies and understory structure, (b) contribute significantly to plant species diversity in wetland ecosystems, and (c) act as corridors for dispersal of plant propagules within and between wetland, upland, and riparian ecosystems.

C) Definition of VAA

The VAA for Surface Water In consists of 500 feet up-gradient of the slope wetland boundary.

D) Measurement Protocol

Identify the number and type of all permanent, seasonal and ephemeral surface water connections that run across the wetland boundary from the surrounding landscape. Characterize the condition of the source area landscape as being relatively natural/undisturbed, low, moderate or high density housing, malls, parking lots, industrial, *etc.* Examples of surface water connections include drains, ditches, stormwater outflow, culverts, *etc.*

E) Scaling Rationale

V_{SURFIN} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for V_{SURFIN}	**Index**
a. Surface hydraulic connections into the wetland from the adjacent landscape are unaltered by human activities, **AND** b. There are no manipulations of the surface hydraulic connections leading to, or within the VAA.	1.00
Limited anthropogenic alteration of the natural surface hydraulic connections is evident (*e.g.,* road crossings, low density housing and residential runoff)	0.75
Surface hydraulic connections into the wetland from the adjacent landscape have been: a. Altered by human activity (*e.g.* low gradient ditches or swales, inputs from low or moderate density residential areas or open space parks or urban inputs), **AND** b. Achieved through a combination of natural tributaries and non-hardened engineered structures (*e.g.* through unlined ditches or swales with or without culvert outfalls, and/or engineered structures delivering treated storm water.	0.50
Surface hydraulic connections into the wetland are: a. Altered by moderate to intense human activity, **AND** b. Achieved **partially** through hardened engineered structures (*e.g.* culverts with headwalls, buried pipes, lined ditches, sheet flow over concrete or asphalt) that convey flow from areas of moderate density residential (*i.e.* 1 house/5 acres), or service industry installations (*e.g.* <2 acres malls, parking lots, *etc.*),	0.25
Surface hydraulic connections into the wetland from the adjacent landscape have been: a. **Significantly** altered by human activity such as high density suburban, urban or industrial inputs b. Achieved **primarily** through hardened engineered structures that drain runoff from urban, large industrial portions of the landscape proximate to the VAA. These structures could easily be removed or replaced with natural drainage paths, **THEREFORE** c. The variable is somewhat recoverable to reference standard conditions and sustainable through natural processes, if the existing land use is discontinued and no restoration measures are applied.	0.10
Surface hydraulic connections into the wetland from the adjacent landscape have been: a. **Significantly** altered by human activity such as high density suburban, urban or industrial inputs b. Achieved through hardened engineered structures that drain runoff from urban, large industrial portions of the landscape proximate to the VAA. These structures could **not** be removed without extensive re-engineering to address substantial threats to public safety, **THEREFORE** c. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes, if the existing land use is discontinued and no restoration measures are applied.	0.00

17. Tree Canopy Coverage (V_{TREE})

A) Definition

Tree canopy cover is defined as the percent canopy cover of trees (*i.e.*, single stem woody species with > 4" DBH and > 10 feet in height) within the VAA.

B) Rationale for Selection of Variable

Tree canopy coverage traditionally is used as a measure of species distribution and biomass (Clements 1916, Avery 1975, Mueller-Dombois and Ellenberg 1974). As such, canopy cover can indicate the potential for a site to support characteristic ecosystem processes such as maintenance of native and nonnative plant communities and faunal support/habitat. Trees also contribute to roughness and topographic variation. Roughness provides a physical mechanism that slows water flows and thus provides static and dynamic storage of flood flows and cover for aquatic and terrestrial fauna. Trees decrease the potential for erosion through the production and maintenance of fine root biomass.

Trees provide allochthonous inputs of labile and refractory organic carbon to wetland ecosystems. In addition, the presence of tree boles and canopies alter micro-climatic conditions in forests (*e.g.*, moisture, nutrients, light, temperature, wind speed, *etc.*). Microclimatic alterations caused by the presence of trees is important in maintaining several ecosystem functions such as biomass production, maintenance of site water balance, nutrient conservation, habitat structure, *etc.* Furthermore, trees are instrumental in soil genesis, elemental cycling, and successional processes (Hooper and Vitousek 1997). These successional processes include the dispersal and establishment of plant propagules, support plant and animal species diversity and turnover (Tilman 1982, Huston and Smith 1987, Cohen and Levin 1991, Tilman and Pacala 1993).

C) Definition of VAA

The VAA for V_{TREE} consists of a minimum of one and up to three 0.10-acre circular plots (radius = 37.2 ft). If the site is relatively homogenous, variables may be scaled using a single plot, but it ***must*** be located in an area that is representative of the entire reach. Justification showing that the plot location is representative of the wetland should be recorded.

D) Measurement Protocol

Within each plot, make visual estimates of the percent cover for the tree stratum (Figure 18) using midpoints of standard canopy cover classes (Table 15). When making this estimate, canopy cover within the tree stratum sums to 100%. Record these estimates of percent cover on the Minimal Submittal Worksheets. Average all of the measurements of canopy cover to calculate the final estimate of tree canopy cover.

Please note that this variable is not to be scored in communities where shrubs dominate the wetland plant community. The wetland plant community may differ from the plant community in the buffer.

E) Scaling Rationale

V_{TREE} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For Tree (Forest) communities within the VAA:

Measurement or Condition for V_{TREE}	**Index**
a. Average percent cover of trees is ≥ 95%, **AND** b. There is **no** evidence of anthropogenic disturbance	1.00
a. Average percent cover of trees is ≥ 75%, **AND** b. There is **some** evidence of anthropogenic disturbance	0.75
Average percent cover of trees is ≥ 50% and < 75%.	0.50
Average percent cover of trees is ≥ 25% and < 50%.	0.25
a. Average percent cover of trees is < 25% **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average percent cover of trees is < 25% **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

V. Water/Wetland Functions and Assessment Models for Depressional Wetlands in the City of Mount Vernon

A. Overview of the Depressional Wetland HGM Model

We identified 9 functions performed by depressional water/wetland ecosystems in the City of Mount Vernon. These functions fall into four groups: hydrology, biogeochemistry, plant community, and faunal support/habitat (Table 15). All of these functions are performed at some level at all sites within the reference domain.

We use a total of 14 variables to describe the 9 wetland ecosystem functions presented and discussed in this *Guidebook* (Table 16). Two subclasses were identified in depressional wetlands within the City of Mount Vernon: Open and Closed Depressional wetlands. The scaling of variables sometimes differed slightly between these subclasses. Changes in the variable scaling represent our best attempts to account for the unique functional characteristics of each subclass.

The 9 ecosystem functions and 14 variables are fully described in the following sections. Table 17 illustrates the relationship between variables and functions. Table 18 illustrates the formulas for each function. Descriptions of the 9 functions include the following information (Section V. B.):

1. Definition
2. Rationale for describing or recognizing the function for riverine ecosystems in Mount Vernon
3. Listing of variables used to assess the function, and
4. The formulae used to estimate the functional capacity indices.

Descriptions of the 14 variables include the following information:

1. Definition
2. Rationale for selection of the variable
3. Definition of the Variable Assessment Area (VAA)
4. Protocol for measuring the variable in the field
5. Scaling rationale
6. Scaling between 0 and 1

Please note that in describing functions or variables, we have used some terminology that allows us to address the project site that shall be assessed using HGM. The "Project Assessment Area" (PAA) refers to the waters, wetlands and their buffers which may be affected by the proposed project. Similarly, the area that one needs to examine in the field to collect data necessary to score a variable is the "Variable

Assessment Area" (VAA). Both PAA and VAA are defined in the Glossary. In addition, several of the figures that support presentation of variables illustrate graphically the extent of either PAA or VAA.

Table 16. List of Depressional Wetland Functions by Category

FUNCTION	DEFINITION
Hydrology	
1. Surface and Shallow Subsurface Water Storage and Exchange	Processes of retention and/or circulation of surface and shallow subsurface water within depressional wetlands.
Biogeochemistry	
2. Cycling of Elements and Compounds	Abiotic and biotic processes within waters/wetlands that control the transformation of compounds (*e.g.*, nutrients and metals) from one form to another.
3. Retention and Detention of Particulates	Removal of inorganic and organic particulates (>0.45 μm) from flowing and standing waters, primarily through physical processes.
4. Retention and Detention of Imported Elements and Compounds	Reduction in flux of imported nutrients, contaminants, and other elements or compounds into, through, and out of depressional waters/wetlands.
Plant Community	
5. Plant Community	Physical and ecological processes that maintain living plant biomass. The ability of a wetland to support a native plant community of characteristic species composition.
6. Detrital System	Processes of production, accumulation, and dispersal of dead plant biomass of all sizes.
Faunal Support / Habitat	
7. Spatial Structure of Habitats	Vertical and horizontal animal habitat structure, including hydrologic conditions, micro- and macro-topographic features, plant communities, and detrital system.
8. Distribution and Abundance of Invertebrates	The capacity of waters/wetlands to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic and terrestrial).
9. Distribution and Abundance of Vertebrates	The capacity of the water/wetland to maintain the density and spatial distribution of vertebrates (aquatic, semi-aquatic, and terrestrial).

Table 17. Depressional Water/Wetland Variables

	VARIABLE	DESCRIPTION	DEFINITION
1.	$V_{BUFFWIDTH}$	Buffer Width	Width of the area extending 150 feet from the boundary of the depressional wetland.
2.	$V_{BUFFCOND}$	Buffer Condition	Condition of the area extending 150 feet from the boundary of the depressional wetland.
3.	$V_{BUFFCONTIG}$	Buffer Contiguity	Proportion of buffer extending 150 feet from the boundary of the depressional wetland that has been disturbed
4.	V_{HERB}	Herbaceous Canopy Cover	Percent cover of herbaceous vegetation, specifically graminoids, forbs, ferns, and fern allies within the VAA.
5.	V_{LITTER}	Litter and Fine Woody Debris	Cover class of leaf litter and dead and down fine woody debris (< 3.0" diameter) within the VAA.
6.	V_{NATIVE}	Percentage of Native and Non-Native Plant Species	Percentage of the dominant plant taxa within the VAA that are native as compared to nonnative plant taxa.
7.	V_{OUT}	Outlet	Presence or absence and elevation of a natural or constructed surface and shallow subsurface water outlet.
8.	$V_{PATCHAREA}$	Patch Area	The relative area of habitat patches, as calculated from the Habitat Patch map, within a 1000 ft radius VAA ring surrounding the PAA.
9.	$V_{PATCHNUMBER}$	Patch Number	The number of habitat patches within the 1000 ft radius VAA surrounding the project site.
10.	$V_{SEDIMENT}$	Sediment Deposition	Assessment of existing and potential sediment transport into waters/wetlands due to human perturbations (e.g., roads, trails).
11.	V_{SHRUB}	Shrub Canopy Cover	Percent canopy cover of shrubs (multiple stemmed woody species) within the VAA.
12.	$V_{SOILINTEG}$	Soil Profile Integrity	Soil integrity provides a measure of the presence and condition of the soil profile (soil horizons) within the VAA.
13.	V_{STRATA}	Vegetation Strata	Number of distinct vegetation layers present in the PAA within the Puget Sound Lowland region. Vegetation strata are defined as trees (single stem woody species with > 4" DBH and > 10' tall); shrubs (multiple stemmed woody species); and, herbs including forbs, graminoids, ferns and fern allies.
14.	V_{TREE}	Tree Canopy Cover	Percent canopy cover of trees (*i.e.*, single stem woody species with > 4" DBH and > 10 feet in height).

Table 18. Relationship of Variables to Functions in Depressional Wetlands

	Hydrologic	Biogeochemical			Plant Community		Faunal Support/ Habitat		
	Surface and Shallow Subsurface Water Storage and Exchange	Cycling of Elements and Compounds	Retention and Detention of Particulates	Retention and Detention of Imported Elements and Compounds	Plant Community	Detrital System	Spatial Structure of Habitats	Distribution and Abundance of Invertebrates	Distribution and Abundance of Vertebrates
1. $V_{BUFFWIDTH}$	X	X	X	X			X	**T**	**T**
2. $V_{BUFFCOND}$	X	X	X	X			X	**B**	**B**
3. $V_{BUFFCONTIG}$	X	X	X	X			X	**D**	**D**
4. V_{HERB}	X				X	X	X		
5. V_{LITTER}		X				X			
6. V_{NATIVE}					X				
7. V_{OUT}	X		X						
8. $V_{PATCHAREA}$							X		
9. $V_{PATCHNUMBER}$							X		
10. $V_{SEDIMENT}$		X	X						
11. V_{SHRUB}	X				X	X	X		
12. $V_{SOILINTEG}$	X	X		X		X			
13. V_{STRATA}					X				
14. V_{TREE}	X				X	X	X		

Table 19. Indices of Functions for Depressional Waters/Wetlands in Mount Vernon

FUNCTION	FORMULAE
Hydrologic	
1. Surface & Shallow Subsurface Water Storage & Exchange	$[V_{SOILINTEG} + V_{OUT} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + (V_{HERB} + V_{SHRUB} + V_{TREE})/3]/4$
Biogeochemical	
2. Cycling of Elements and Compounds	$[V_{SEDIMENT} + V_{SOILINTEG} + V_{LITTER} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$
3. Retention and Detention of Particulates	$[V_{OUT} + V_{SEDIMENT} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/3$
4. Retention and Detention of Imported Elements & Compounds	$[V_{SOILINTEG} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/2$
Plant Community	
5. Plant Community	$[(V_{SHRUB} + V_{HERB} + V_{TREE})/3 + V_{NATIVE} + V_{STRATA}]/3$
6. Detrital System	$[V_{LITTER} + V_{SOILINTEG} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3]/3$
Faunal Support/ Habitat	
7. Spatial Structure of Habitats	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{STRATA} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + (V_{PATCHAREA} + V_{PATCHNUMBER})/2]/4$
8. Distribution and Abundance of Invertebrates	**To Be Determined**
9. Distribution and Abundance of Vertebrates	**To Be Determined**

B. Description of 9 Functions Identified in Depressional Waters/Wetlands Ecosystems

1. Hydrologic Functions

A) Surface and Shallow Subsurface Water Storage and Exchange

(1) Definition

The Surface and Shallow Subsurface Water Storage and Exchange function pertains to the retention and/or circulation of surface and ground water in the depression.

(2) Rationale for the Function

This function refers to the capacity of a water/wetland (1) to collect and detain surface and shallow subsurface water as static water above the soil surface, pore water in the saturated zone, and soil moisture in the unsaturated zone, and (2) to allow for the exchange of water between surface and shallow subsurface compartments. The land use and condition of the contributing area and the buffer affect the timing, duration, and amount of surface and shallow subsurface water flowing into the water/wetland. The presence or absence and elevation of an outlet affect the amount of surface and shallow subsurface water a water/wetland can detain. An intact soil profile is critical to this function since (1) perching above the restrictive layer is the primary mechanism of surface and shallow subsurface water storage, and (2) exchange of water occurs between surface and shallow subsurface compartments (*i.e.,* between the pool and the upper part of the soil. Fine root turnover maintains soil pore space for shallow subsurface water storage and maintains soil permeability to allow for the exchange of water between surface and shallow subsurface compartments. Vegetation aids in surface water exchange through evapotranspiration. Sediment input changes the soil pore space characteristics and, therefore, alters the way in which shallow subsurface water is stores and exchanged.

(3) Variables Used to Assess Surface and Shallow Subsurface Water Storage and Exchange

We used the following variables to assess the surface and groundwater storage and exchange function for all subclasses:

a. Tree canopy Cover (V_{TREE})
b. Shrub Canopy Cover (V_{SHRUB})
c. Herbaceous Canopy Cover (V_{HERB})
d. Soil Profile Integrity ($V_{SOILINTEG}$)
e. Buffer width ($V_{BUFFWIDTH}$)
f. Buffer Contiguity ($V_{BUFFCONTIG}$)
g. Buffer Condition ($V_{BUFFCOND}$)
h. Outlet (V_{OUT})

(4) Index of Function for All Subclasses

$$Index = [V_{SOILINTEG} + V_{OUT} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + (V_{HERB} + V_{SHRUB} + V_{TREE})/3]/4$$

2. Biogeochemical Functions

A) Cycling of Elements and Compounds

(1) Definition

Cycling of Elements and Compounds refers to abiotic and biotic processes that change elements and convert compounds (*e.g.,* nutrients and metals) from one form or valence to another.

(2) Rationale for the Function

Cycling of Elements and Compounds is a fundamental ecosystem process mediated by biotic and abiotic components. The biotic components of elemental cycling are net primary productivity, in which nutrients are taken up by plants, and detritus turnover, in which nutrients are released for renewed uptake by plants and microbes. Abiotic components are linked inextricably to the microbially mediated (biogeochemical) processes that drive the oxidation-reduction reactions that alter elements and compounds. Sources of these abiotic components are the soil profile, eolian processes that input nutrients and particulates, and hydrologic processes that input nutrients and particulates to the system.

(3) Variables Used to Assess Cycling of Elements and Compounds

a. Sediment Movement ($V_{SEDIMENT}$)
b. Litter and Fine Woody Debris (V_{LITTER})
c. Soil Profile Integrity ($V_{SOILINTEG}$)
d. Buffer width ($V_{BUFFWIDTH}$)
e. Buffer Contiguity ($V_{BUFFCONTIG}$)
f. Buffer Condition ($V_{BUFFCOND}$)

(4) Index of Function for All Subclasses

Index = $[V_{SEDIMENT} + V_{SOILINTEG} + V_{LITTER} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$

B) Retention and Detention of Particulates

(1) Definition

Retention and Detention of Particulates refers to the delay, retardation or prevention of movement of inorganic and organic particulates (> 0.45 μm) from the water column, primarily through physical processes.

(2) Rationale for the Function

Wetlands receive sediments in overland flow from adjacent uplands and may create sediment loading if erosion is occurring within the wetland boundary. Flooding and overland flow is the major source of inorganic particulates to floodplains and riparian areas. In tact, up-gradient wetlands retain and delay water and thereby decrease the frequency and severity of flooding. Velocity reductions due to surface roughness and increasing cross-sectional area of discharge in wetlands can decrease the amount of sediment that is suspended in the water column (Nutter and Gaskin 1989). Reduced water velocities leads to a reduction in the capacity of water to transport suspended sediments, causing particulates to settle.

Sediment detention/retention occurs through burial and chemical precipitation (*e.g.*, removal of phosphorus by Fe^{+3}).

(3) Variables Used to Assess Retention and Detention of Particulates

a. Outlet (V_{OUT})
b. Sediment Movement ($V_{SEDIMENT}$)
c. Buffer Width ($V_{BUFFWIDTH}$)
d. Buffer Contiguity ($V_{BUFFCONTIG}$)
e. Buffer Condition ($V_{BUFFCOND}$)

(4) Index of Function for All Subclasses

Index = $[V_{OUT} + V_{SEDIMENT} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]3$

3. Plant Community Functions

A) Plant Community

(1) Definition

The Plant Community function is defined by physical characteristics and ecological processes that maintain the indigenous living plant biomass.

(2) Rationale for the Function

Living plant biomass converts solar radiation and carbon dioxide into complex organic molecules that support organisms at all trophic levels. In addition to energy, plant species and assemblages of plants provide (a) compositional and structural diversity within the ecosystem, (b) corridors for migration and movement of faunal species among habitats, and (c) feeding, resting, hiding, thermal, and escape cover for migratory and resident animals. Finally, plants provide seeds and other propagules for regeneration and succession following catastrophic events such as fire, floods, and debris flows. Vegetation accounts for most of the biomass in wetlands, and the physical characteristics of living and dead plants are closely related to ecosystem functions associated with hydrology, nutrient cycling, and the abundance and diversity of animal species, as mentioned above (Gregory *et al.* 1991). Removal or severe disturbance of vegetation can lead to a change in the structure of macroinvertebrate communities (Hawkins *et al.* 1982), a decrease in the species diversity of stream ecosystems, a decline in the local and/or regional diversity of animals associated with large patches and corridors, a deterioration of downstream water quality, and significant changes in river/stream hydrology (Gosselink *et al.* 1990). The Plant Community function considers both the amount and type of vegetation relative to reference standard conditions.

(3) Variables Used to Assess Plant Community

The following variables are involved in assessing plant community maintenance:
a. Herbaceous Canopy Cover (V_{HERB})
b. Percent of Native and Non-Native Plant Species (V_{NATIVE})
d. Shrub Canopy Cover (V_{SHRUB})
e. Vegetation Strata (V_{STRATA})
f. Tree Canopy Cover (V_{TREE})

(4) Index of Function

Index = $[(V_{SHRUB} + V_{HERB} + V_{TREE})/3 + V_{NATIVE} + V_{STRATA}]/3$

B) Detrital System

(1) Definition

The Detrital System function refers to the process of production, accumulation, and dispersal of dead plant biomass of all sizes.

(2) Rationale for the Function

Detrital matter contributes to the functioning of riverine ecosystems in multiple ways (Fontaine and Bartell 1983). For example, accumulations of detrital matter help to reduce soil erosion and can add significant amounts of organic carbon to soils (McPhee and Stone 1966). Decomposing detritus provides wildlife habitat and stores nutrients and water for use by both plants and animals (Franklin *et al.* 1987; Harmon *et al.*1986; Stouder *et al.* 1997). In the riverine waters/wetlands of Mount Vernon, woody debris is a major source of energy for decomposers and other heterotrophs (Harmon *et al.* 1986; Seastedt *et al.* 1989). Throughout the watershed, detrital material (especially coarse woody debris, debris dams) plays an important role by influencing the development and persistence of the forested plant communities (Bilby 1981, Smock *et al.* 1989). The approach to assessing detrital functions in the riverine ecosystems of the Mount Vernon requires evaluations of the amounts and distributions of detrital material (litter and woody debris) within a PAA.

(3) Variables Used to Assess Detrital System

a. Herbaceous Canopy Cover (V_{HERB})
b. Shrub Canopy Cover (V_{SHRUB})
c. Tree Canopy Cover (V_{TREE})
d. Litter and Fine Woody Debris (V_{LITTER})
e. Soil Profile Integrity ($V_{SOILINTEG}$)

(4) Index of Function

Index = $[V_{LITTER} + V_{SOILINTEG} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3]/3$

4. Faunal Support/Habitat Functions

A) Spatial Structure of Habitats

(1) Definition

Spatial Structure of Habitats refers to the capacity of waters/wetlands to support animal populations within the habitat structure provided by hydrologic conditions, micro- and macro-topographic features, and living plant and detrital communities.

(2) Rationale for the Function

Spatial structure of habitats assesses the suitability of hydrologic conditions, micro and macro topography, and living plant and detrital communities for sustaining characteristic animal populations in water/wetland ecosystems. While all ecosystem attributes are important for the maintenance of faunal habitat integrity, the horizontal and vertical structural complexity of plant communities that exist within the water/wetland largely determines habitat quality for resident and nonresidential animals. Generally, habitats with greater vegetative heterogeneity and structural complexity support more diverse faunal communities (Harris 1984, Findlay and Bourdages 2000, Gibbs 2000, Jones *et al.* 2000). Contiguous habitat structure provides opportunities for movement of migratory animals or resident faunal species with large range requirements into and out of waters/wetlands.

(3) Variables Used to Assess Spatial Structure of Habitats

a. Herbaceous Canopy Cover (V_{HERB})
b. Shrub Canopy Cover (V_{SHRUB})
c. Vegetation Strata (V_{STRATA})
d. Tree Canopy Cover (V_{TREE})
e. Buffer Width ($V_{BUFFWIDTH}$)
f. Buffer Condition ($V_{BUFFCOND}$)
g. Buffer Contiguity ($V_{BUFFCONTIG}$)
h. Patch Area ($V_{PATCHAREA}$)
i. Patch Number ($V_{PATCHNUMBER}$)

(4) Index of Function

$$\text{Index} = [(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{STRATA} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + (V_{PATCHAREA} + V_{PATCHNUMBER})/2]/4$$

B) Distribution and Abundance of Invertebrates

(1) Definition

Distribution and Abundance of Invertebrates is defined as the capacity of waters/wetlands to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic and terrestrial).

(2) Rationale for the Function

Invertebrates exploit almost every microhabitat available in waters/ wetlands and may reach densities of thousands of individuals per square meter. Because invertebrates are so pervasive and partition habitats so finely, they are excellent indicators of ecosystem function (Karr 1991, Karr and Kerans 1992).

(3) Status of the Function in this *Draft Operational Guidebook*

At this stage of development of the City of Mount Vernon *Guidebook*, we are unable to provide reliable variables that would allow calculation of an index of function for invertebrates. This situation is due to the combination of a lack of reference data, lack of invertebrate expertise on the field/author team, and a limited scope/budget for this project. However, the invertebrate function has been included as a placeholder to signify (a) our recognition of the importance of invertebrate taxa in stream ecosystems, and (b) the potential to expand upon current efforts.

C) Distribution and Abundance of Vertebrates

(1) Definition

Distribution and Abundance of Vertebrates refers to the capacity of waters/wetlands to maintain characteristic density and spatial distribution of vertebrates (aquatic, semi-aquatic and terrestrial).

(2) Rationale for the Function

Vertebrate distribution and abundance in any wetland ecosystem is extremely variable, and can change rapidly in space and time. Many vertebrates are conspicuous users of waters/wetlands, and can have a strong influence on the dynamics of a riverine ecosystem. The goal in assessing this function is to compare reference and assessment site functions with respect to species composition and structure of vertebrate species associated with a water/wetland and the presence of necessary habitats to support common (or rare) vertebrate faunal populations. Rapid, direct measurements of vertebrates are difficult to perform in the field. Direct sightings, as well as indirect indicators of animal use can both be used assess this function. The following are suggestions, given the expertise and scope of work, to accurately measure this function: (a) Perform complete surveys by vertebrate specialists and compare to reference standard conditions using similar indices, (b) Reference local species lists for mammals, birds, fish, amphibians, and reptiles, and (c) Compare to reference standard conditions using similar indices.

(3) Status of the Function in This *Draft Operational Guidebook*

At this stage of development of the City of Mount Vernon *Guidebook*, we are unable to provide reliable variables that would allow calculation of an index of function for vertebrates. This situation is due to the combination of a lack of reference data, lack of invertebrate expertise on the field/author team, and a limited scope/budget for this project. However, the vertebrate function has been included as a placeholder to signify (a) our recognition of the importance of vertebrate taxa in stream ecosystems, and (b) the potential to expand upon current efforts.

C. Description of 15 Variables Used in Depressional Water/Wetland Ecosystems

1. Buffer Width ($V_{BUFFWIDTH}$)

A) Definition

The wetland buffer width is the width of the intact plant community perpendicular to and outward (up gradient) from the boundary of the depressional wetland.

B) Rationale for Selection of Variable

Intact plant communities are critical to the functioning of wetland ecosystems. Vegetated buffers provide erosion control and sediment removal, temperature control, nutrient/pollutant removal and a suite of microclimate habitats for a variety of wildlife. Buffer Width is used in conjunction with Buffer Contiguity and Buffer Condition to describe the extent and function of the buffer. Buffer Width is used in the Spatial Structure of Habitats Function, but contributes also to improved retention of nutrients and sediments and the cycling of elements and compounds.

C) Definition of the VAA

The VAA for $V_{BUFFWIDTH}$ includes an area extending perpendicularly out from the wetland boundary and surrounding the entire wetland. Standard buffer widths shown in Table 20 were derived using the Washington Wetland Rating System (DOE Wetlands Rating System 2004) and the City of Mount Vernon Critical Areas Ordinance (15.40.110 C.6.a. Pg 40).

Table 20. Standard buffer widths according to wetland rating.

Wetland Rating	Standard Buffer (ft.)
I	200
II	100
III	75
IV	50

D) Measurement Protocol

At a representative location along the wetland, walk in a straight line away from the boundary of the depressional wetland and measure (1) the width of contiguous forest canopy surrounding the wetland boundary and (2) the width of contiguous shrub and herb canopy surrounding the wetland boundary within the standard buffer zone. If the buffer width conditions are variable, repeat this protocol to determine an average width of contiguous canopy for the VAA. Figure 19 provides an example of the range of buffer conditions.

E) Scaling Rationale

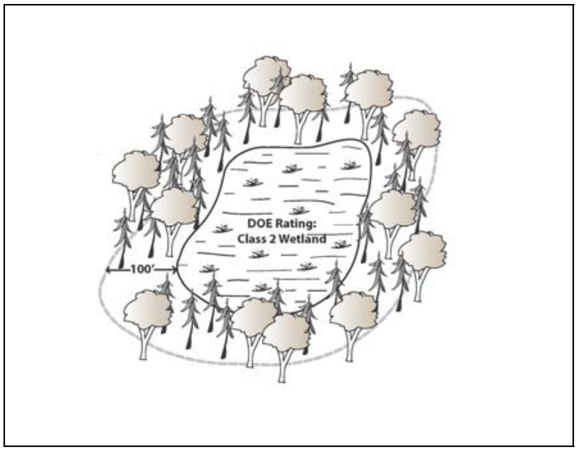
$V_{BUFFWIDTH}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{BUFFWIDTH}$	Index
a. Average wetland buffer width with forest canopy is equal to the standard buffer width for the wetland class (Table 19), **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Average wetland buffer width with forest canopy cover is > 75% of the standard buffer width for the wetland class (Table 19), **AND/OR** b. There is **some** evidence of anthropogenic disturbance within the standard buffer width.	0.75
a. Average wetland buffer width with forest canopy cover is between > 25% and ≤ 75% of the standard buffer width for the wetland class (Table 19) , **OR** b. Average buffer width with herbaceous or shrub cover is > 75% of the standard buffer width for the wetland class.	0.50
a. Average wetland buffer width with forest canopy cover is between > 10 and ≤ 25% of the standard buffer width for the wetland class (Table 19) , **OR** b. Average wetland buffer width with herbaceous or shrub cover is > 25% and ≤ 75% of the standard buffer width for the wetland class.	0.25
a. Average wetland buffer width with forest canopy cover is between 0 and ≤ 10% of the standard buffer width for the wetland class (Table 19), **OR** b. Average wetland buffer width with herbaceous or shrub canopy cover is between 0 and ≤ 25% of the standard buffer width for the wetland class, **AND** c. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. Average wetland buffer width with forest canopy cover is between 0 and ≤ 10% of the standard buffer width for the wetland class (Table 19), **OR** b. Average wetland buffer width with herbaceous or shrub canopy cover is between 0 and ≤ 25% of the standard buffer width for the wetland class, **AND** c. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.00

Figure 19. Examples of scaling for buffer condition, buffer width and buffer contiguity variables

A. Buffer with high index scaling for all 3 variables

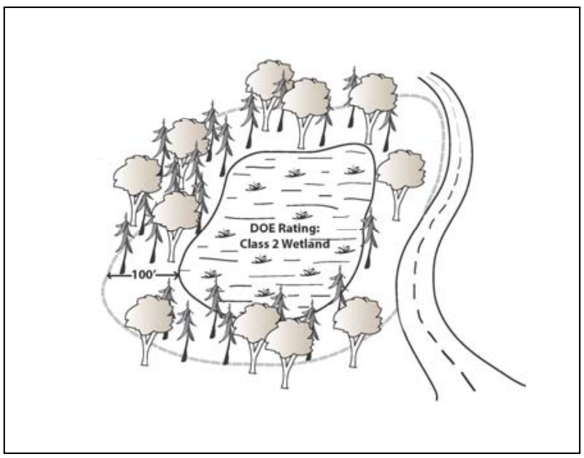


$V_{BUFFWIDTH}$ 1.0

$V_{BUFFCOND}$ 1.0

$V_{BUFFCONTIG}$ 1.0

B. Buffers variables in moderate condition

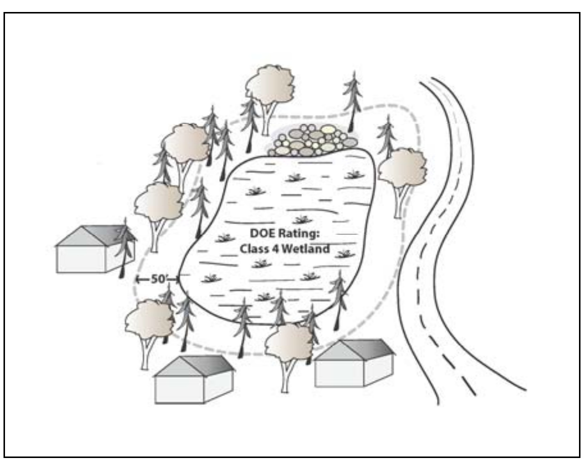


$V_{BUFFWIDTH}$ 0.5

$V_{BUFFCOND}$ 0.5

$V_{BUFFCONTIG}$ 0.5

C. Buffer variables in poor condition



$V_{BUFFWIDTH}$ 0.1

$V_{BUFFCOND}$ 0.0

$V_{BUFFCONTIG}$ 0.1

2. Buffer Condition ($V_{BUFFCOND}$)

A) Definition

Buffer Condition is the predominant land use or condition of the area perpendicular to and outward from the depressional water/wetland boundary.

B) Rationale for Selection of Variable

Intact plant communities are critical to the functioning of wetland ecosystems. Vegetated buffers provide erosion control and sediment removal, temperature control, nutrient/pollutant removal and a suite of microclimate habitats for a variety of wildlife. Wetland buffers contribute to improved retention of nutrients and sediments and the cycling of elements and compounds. In the HGM model for depressional wetlands, Buffer Condition is used in conjunction with Buffer Contiguity and Buffer Width to describe the extent and function of the wetland buffer.

C) Definition of the VAA

The VAA for $V_{BUFFCOND}$ includes an area extending perpendicularly out from the wetland boundary and surrounding the entire wetland. Standard buffer widths shown in Table 20 were derived using the Washington Wetland Rating System (DOE Wetlands Rating System 2004) and the City of Mount Vernon Critical Areas Ordinance (15.40.110 C.6.a. Pg 40).

Table 20. Standard buffer widths according to wetland rating.

Wetland Rating	Standard Buffer (ft.)
I	200
II	100
III	75
IV	50

D) Measurement Protocol

Determine Buffer Condition in conjunction with measuring Buffer Width and Buffer Contiguity within the VAA (Table 14 20). At representative locations along the wetland boundary, walk a transect that consists of a straight line of travel directly away from the boundary of the wetland. Along this transect, determine the vegetation cover type(s) (*e.g.*, tree canopy, shrubs, or herbs), the amount of impervious surface, and the relative percent cover of each cover type within the VAA. Walk enough transects at right angles around the wetland so that the buffer condition is assessed up gradient, down gradient and at each side of the slope wetland. Figure 19 provides an example of the range of buffer conditions.

E) Scaling Rationale

$V_{BUFFCOND}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For buffers naturally dominated by tree (forest) community

Measurement or Condition for $V_{BUFFCOND}$ (Tree community)	**Index**
a. 100% of the VAA (area within the standard buffer width) is covered by intact tree (forest) canopy, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. 100% of the VAA (area within the standard buffer width has **tree (forest) canopy, BUT** b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
a. > 50% of the VAA (area within the standard buffer width) has tree (forest) canopy cover and the remaining buffer area is dominated by either shrubs or herbs, **AND** b. None of the area within the standard buffer width is covered by impervious surfaces.	0. 50
a. > 10% but < 50% of the VAA (area within the standard buffer width) has tree (forest) canopy cover and the remaining buffer area is dominated by either shrubs or herbs, **AND** c. ≤ 10% of the area within the standard buffer width is covered by impervious surfaces.	0.25
a. < 10% of the VAA (area within the standard buffer width) has tree (forest) canopy b. > 10 % but < 25% of the area within the standard buffer width is covered by impervious surfaces, **AND** c. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. < 10% of the VAA (area within the standard buffer width) has tree (forest) canopy, **AND** b. > 10% of the area within the standard buffer width is covered by impervious surfaces, **AND** c. The variable **is not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.00

For buffers naturally dominated by a shrub community

Measurement or Condition for $V_{BUFFCOND}$ (Shrub community)	Index
a. 100% of the VAA (area within the standard buffer width) is covered by intact **shrub canopy, AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. 100% of the VAA (area within the standard buffer width has shrub canopy, **BUT** b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
a. > 50% of the VAA (area within the standard buffer width) has shrub canopy cover and the remaining buffer area is dominated by herbs, **AND** b. None of the area within the standard buffer width is covered by impervious surfaces.	0. 50
a. > 10% but < 50% of the VAA (area within the standard buffer width) has shrub canopy cover, **AND** b. ≤ 10% of the area within the standard buffer width is covered by impervious surfaces.	0.25
a. < 10% of the VAA (area within the standard buffer width) has shrub canopy cover, **AND** b. > 10 % of the area within the standard buffer width is covered by impervious surfaces, **AND** c. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. < 10% of the VAA (area within the standard buffer width) has shrub canopy cover, **AND** b. > 10 % of the area within the standard buffer width is covered by impervious surfaces, **AND** c. The variable **is not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.00

3. Buffer Contiguity ($V_{BUFFCONTIG}$)

A) Definition

The wetland buffer contiguity is the proportion of the distance (*i.e.,* circumference) around the water/wetland edge that is bounded by an intact buffer divided by the total distance around the water/wetland edge. Entirely intact buffers are characterized as (1) greater than or equal to the standard buffer for the wetland rating class (Table 19), and (2) vegetated. In order for a buffer to exist for this variable, the vegetated buffer width must be at lest 15 feet.

B) Rationale for Selection of Variable

Intact plant communities are critical to the functioning of wetland ecosystems. Vegetated buffers provide erosion control and sediment removal, temperature control, nutrient/pollutant removal and a suite of microclimate habitats for a variety of wildlife. Intact buffers contribute to improved retention of nutrients and sediments and the cycling of elements and compounds. In the HGM model for depressional wetlands, Buffer Contiguity is used in conjunction with Buffer Condition and Buffer Width to describe the extent and function of the wetland buffer.

C) Definition of the VAA

The VAA for $V_{BUFFCONTIG}$ includes an area extending perpendicularly out from the wetland boundary and surrounding the entire wetland. Standard buffer widths shown in Table 14 were derived using the Washington Wetland Rating System (DOE Wetlands Rating System 2004) and the City of Mount Vernon Critical Areas Ordinance (15.40.110 C.6.a. Pg 40) (Table 20).

Table 20. Standard buffer widths according to wetland rating.

Wetland Rating	Standard Buffer (ft.)
I	200
II	100
III	75
IV	50

D) Measurement Protocol

Determine Buffer Contiguity in conjunction with measuring Buffer Width and Buffer Condition within the standard buffer width (Table 14). Estimate the percentage of the wetland surrounded by an **"intact"** forested and/or vegetated buffer. Please note: For the purposes of scaling this variable, buffers less than 15 feet in width are considered "**not intact**." Figure 19 provides an example of the range of buffer conditions.

E) Scaling Rationale

$V_{BUFFCONTIG}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{BUFFCONTIG}$	Index
a. 100% of the water/wetland edge is bounded by an "intact" **forested** buffer, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. > 75% to 100% of the water/wetland edge is bounded by an intact **forested** buffer, **AND** b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
> 50% to ≤ 75% of the water/wetland edge is bounded by an intact **vegetated** buffer	0.50
> 25% to ≤ 50% of the water/wetland edge is bounded by an intact **vegetated** buffer	0.25
a. 0% to ≤ 25% of the water/wetland edge is bounded by an intact **vegetated** buffer, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.10
a. 0% to ≤ 25% of the water/wetland edge is bounded by an intact **vegetated** buffer, **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied	0.00

4. Herbaceous Cover (V_{HERB})

A) Definition

Herbaceous cover is defined as the percent cover of herbaceous vegetation, specifically graminoids, forbs, ferns, and fern allies within the VAA.

B) Rationale for Selection of the Variable

Cover of native herbaceous vegetation typical of reference standard conditions indicates the presence and maintenance of native plant communities. Low herbaceous cover is characteristic of late succession, undisturbed reference standard conditions in the majority of plant communities found throughout the watershed. High percent cover of herbs in communities can indicate an early stage of the forested waters/wetlands in Mount Vernon. In forested communities, a high percentage of herbaceous cover also can indicate recent, intense, and/or frequent disturbance by human activities or invasions by non-native species. In shrub-dominated communities, herbaceous cover is often high, but should be by native species only.

C) Definition of VAA

The VAA for V_{HERB} consists of a minimum of 1 and up to three circular plots located within a representative area of the depressional wetland (Figure 20). Each circular plot should cover 0.01-acre (radius = 11.8 feet). Establish one herb plot within the each tree/shrub survey plot (r = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Within each circular plot, make visual estimates of the percent cover for the herbaceous stratum (including graminoids, forbs, ferns, and fern allies) using midpoints of standard canopy cover classes (Table 21). Record these estimates of percent cover on the Minimal Submittal Worksheets. Average the three measurements of herbaceous canopy cover to calculate the final estimate of herbaceous cover.
Note that if beaver activity is current or recent (*i.e.*, dam building which raises water levels and changes herbaceous canopy cover), this variable will be scored differently than if anthropogenic activities have caused changes in vegetation patterns.

E) Scaling Rationale

V_{HERB} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling for all Subclasses

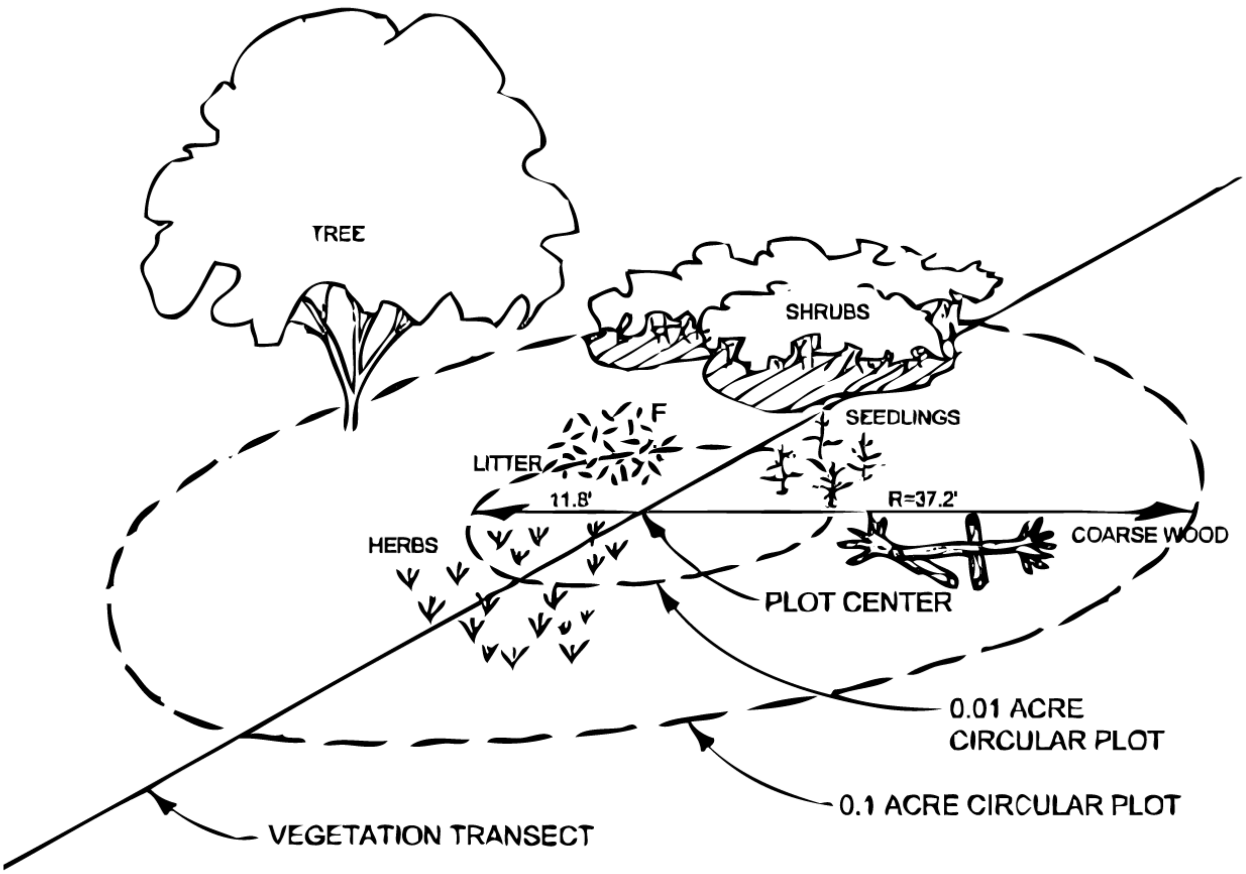
1. Shrub and/or Herbaceous Community is Dominant Within the VAA:

Measurement or Condition for V_{HERB}	Index
a. Average herbaceous cover by native species is ≥ 90% **OR** herbaceous canopy cover is ≥ 50% if beaver activity has raised water elevations, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Average herbaceous cover by native species is ≥ 90%, **OR** herbaceous canopy cover is ≥ 50% due to elevated water elevations from beaver activity but not due to anthropogenic manipulations, **AND** b. There is evidence of anthropogenic disturbance within the VAA.	0.75
Average herbaceous cover by native species is ≥ 50% and < 90%	0.50
Average herbaceous cover by native species is ≥ 10 % and < 50%, **OR**	0.25
a. Average herbaceous cover by native species is < 10% **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Average herbaceous cover by native species is < 10% **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Tree (Forest) Community is Dominant within the VAA:

Measurement or Condition for V_{HERB}	Index
a. Average herbaceous cover by native species is ≥ 25% and < 40%, **AND** . b. Average herbaceous cover by non-native species is < 5%, **AND** c. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. Average herbaceous cover by native species is ≥ 25% and < 40%, **AND** b. Average herbaceous cover by non-native species is < 5%, **AND** c. There **is** evidence of anthropogenic disturbance within the VAA.	0.75
a. Average herbaceous cover is ≥ 15% and < 25%, **AND** b. Average herbaceous cover by non-native species is < 15%	0.50
Average herbaceous cover is ≥ 5% and < 15%	0.25
a. Average herbaceous cover by native species is < 5% **OR** ≥ 40%, **OR** average herbaceous cover by non-native species is ≥ 15%, **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Average herbaceous cover by native species is < 5 **OR** ≥ 40%, **OR** average herbaceous cover by non-native species is ≥ 15%, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

Figure 20. Survey Protocol for Scaling Variables in Depressional Waters/Wetlands



Variables measured in 0.1 acre (37.2 ft radius) circle

a) Percentage of Native and Non-Native Plant Species (V_{NATIVE})
b) Shrub Canopy Cover (V_{SHRUB})
c) Tree Canopy Coverage (V_{TREE})

Variables measured in 0.01 acre (11.8 ft radius) circle

a) Herbaceous Canopy Cover (V_{HERB})
b) Litter and Fine Woody Debris (V_{LITTER})

Variables measured along the 100 ft transects

a) Vegetation Strata (V_{STRATA})

5. Litter and Fine Woody Debris (V_{LITTER})

A) Definition

Litter and fine woody debris is defined as the cover class of leaf litter and dead and down fine woody debris (< 3.0 inches diameter) within the VAA.

B) Rationale for Selection of Variable

Tree branches and twigs (< 3 inches diameter) as well as leaves on the forest floor represent litter and fine woody debris. Fine woody debris (FWD) in various states of decomposition and leaf litter contributes organic carbon (detritus) to terrestrial and aquatic ecosystems. Organic carbon serves as an energy source that provides the basis for numerous ecosystem processes (*e.g.,* decomposition, nutrient cycling, energy transfer, *etc.*). Fine woody debris and litter also provides an important substrate for many phases of invertebrate life cycles (*e.g.*, feeding, nesting, and rearing habitat), and habitat for small vertebrates.

C) Definition of VAA

The VAA for V_{LITTER} consists of a minimum of 1 and up to three circular plots located within a representative area of the depressional wetland (Figure 18). Each circular plot should cover 0.01-acre (radius = 11.8 feet). Establish one herb plot within the each tree/shrub survey plot (r = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Within each circular plot, make visual estimates of the percent cover of fine woody debris and leaf litter using midpoints of standard canopy cover classes (Table 21). Record these estimates of percent cover on the Minimal Submittal Worksheets.

Table 21. Conversion Table for Percent Cover to Cover Class Midpoint

Percent (%) Cover	Midpoint
<1	0
1-5	3
6-15	10.5
16-25	20.5
26-50	38
51-75	63
76-95	85.5
96-100	98

E) Scaling Rationale

V_{LITTER} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for V_{LITTER}	**Index**
a. Cover by litter/FWD is ≥ 90%. b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
Cover by litter/FWD is ≥ 90%. b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
Cover by litter/FWD is ≥ 75 and < 90%	0.50
Cover by litter/FWD is ≥ 25% and < 75%	0.25
a. Cover by litter/FWD is < 25%, **AND** b. The variable **is** recoverable to reference standard conditions and sustainable through natural processes if the existing land is discontinued and no restoration measures are applied.	0.10
a. Cover by litter/FWD is < 25%, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

6. Percentage of Native Vegetation (V_{NATIVE})

A) Definition

The "percentage of native vegetation" is defined as the proportion of the dominant (top 5) plant taxa within the VAA that are native.

B) Rationale for Selection of Variable

Native plant species dominate reference standard conditions. Anthropogenic disturbances provide opportunities for nonnative weedy taxa to enter and typically, to become established within the disturbed portions of the community. However, it has been suggested that most nonnative species have little or no effect on native species within the invaded community (Simberloff 1981). Some nonnative species, such as Japanese Knotweed (*Polygonum japonica)*, can and do interact with native species in ways that may be detrimental. Nonnative taxa may hybridize with closely related species (Thompson 1991, Abbot 1992); out compete natives (see Parker and Reichard 1998 for a review); alter ecosystem processes such as nitrogen fixation (Vitousek *et al.* 1987), site water balance (Carman and Brotherson 1982), and mycorrhizal interactions (Goodwin 1992); and, they may also negatively affect the use of the native communities by wildlife (Neill 1983, Olson and Knopf 1986). Therefore, the percentage of native vegetation to nonnative plant species in an assessment area is a general measure of the degree to which native plant communities have departed from reference standard conditions as a result of anthropogenic activities.

C) Definition of VAA

The VAA for V_{NATIVE} consists of a minimum of 1 and up to three circular plots located within a representative area of the depressional wetland (Figure 18). Each circular plot should cover 0.10-acre (radius = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

Thoroughly walk the VAA. Determine the five dominant species for each of the three vegetation strata (*i.e.*, tree, shrub, and herb) (see Figure 18). Vines are accounted as shrubs. If five species are not present within a stratum, list all species that do occur. For example if only *Rubus discolor* and *Rubus spectabilis* occur in the shrub stratum within the VAA, then only record these two species. Record all dominant species for all three strata on the Minimum Submittal Worksheets.

If you encounter problems in determining the dominant species within the VAA for a particular stratum, begin by assigning a cover class midpoint value (Table 20) for all species that occur in that stratum. Then select the five species from that stratum with the highest cover class values. For all dominant species, identify their indigenous status (native or non-native) using *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1990). Count the number of native, non-native (including ornamental and cultivated) species from this list of dominant species. Divide the number of native species by the total number of identified dominant species and multiply by 100 to obtain a percent of native species. Record the percentage on the Minimum Submittal Worksheets.

E) Scaling Rationale

V_{NATIVE} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for V_{NATIVE}	**Index**
a. > 90% of the dominant species are native, **AND** b. There is **no** evidence of anthropogenic disturbance	1.00
a. ≥ 75 % of the dominant species are native, **AND** b. There is **some** evidence of anthropogenic disturbance	0.75
≥ 50% and < 75% of the dominant species are native	0.50
≥ 25% and < 50% of the dominant species are native	0.25
a. < 25% of the dominant species are non-native, **AND** b. the variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. < 25 % of the dominant species are non-native, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

7. Outlet (V_{OUT})

A) Definition

Outlet refers to the presence or absence and elevation of a natural or constructed surface and shallow subsurface water outlet.

B) Rationale for Selection of the Variable

The hydrological function of depressional wetlands is dependent upon intact connections with surrounding landscape. Closed depressions developed in a system with no surface connection to the surrounding landscape. Sub-surface and groundwater connections may exist. However, alterations by humans often lead to ditching, or draining closed depressions by creating one or more outlets. Hydrology of open depressions may be altered by raising or lowering the elevation of the outlet resulting in draining or ponding. Effects of natural alterations such as dams created by beaver should be considered separately from effects of anthropogenic alterations to the wetland outlet for this variable.

C) Definition of the VAA

The VAA for V_{OUT} consists of the outlet, if one is present, of the wetland.

D) Measurement Protocol

Determine the presence or absence of a hydrologic outlet in the depressional wetland and thus if the depressional water/wetland is an isolated or flow-through depression. If an outlet is absent, the depression is thus isolated and scores a 1.0 on the variable scaling. If an outlet is present, determine if the outlet has been altered (*i.e.*, raised or lowered) and whether anthropogenic activities (*i.e.,* ditching, culvert placement, berm) or natural activities (*i.e.*, beaver dam) have caused this alteration. If the outlet has be artificially raised it scores a .75 on the variable scaling. If the outlet has been lowered from its original elevation (*i.e.*, excavated), measure the relative elevation of the excavated outlet. Compare the elevation of the excavated outlet to the elevation of the maximum depth of the depression. Compare to all the descriptions provided in the scaling for the V_{OUT} and choose the lowest score that appropriately describes the elevation of the excavated outlet.

E) Scaling Rationale

V_{OUT} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. For Closed Depressions:

Measurement or Condition for V_{OUT}	Index
a. No outlet is present, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. No outlet is present, **AND** b. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
Outlet is present. Outlet has been excavated to a depth of up to 50% of the depression depth.	0.50
Outlet is present. Outlet has been excavated to a depth of greater than 50% but less than the maximum depth of the depression.	0.25
a. Outlet has been excavated to the maximum depth of the depression. Depression drains and does not store water. b. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Outlet has been excavated to the maximum depth of the depression. Depression drains and does not store water. b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. For Open Depressions:

Measurement or Condition for V_{OUT}	Index
Outlet is present . Elevation of the outlet has not been modified by anthropogenic activities. Changes in elevation may be present but are due to beaver activity not anthropogenic activity.	1.00
Outlet is present. Outlet elevation has been raised resulting in surface water impoundment.	0.75
Outlet is present. Outlet has been excavated to a depth of up to 50% of the depression depth.	0.50
Outlet is present. Outlet has been excavated to a depth of greater than 50% but less than the maximum depth of the depression.	0.25
a. Outlet has been excavated to the maximum depth of the depression. Depression drains and does not store water, **AND** b. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Outlet has been excavated to the maximum depth of the depression. Depression drains and does not store water, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

8. Patch Area ($V_{PATCHAREA}$)

A) Definition

Patch area is the percent of the area covered by habitat patches, as calculated from the Habitat Patch map, within the 1000 ft radius VAA.

B) Rationale for Selection of the Variable

The relative area (measured as a percentage of the 1000 ft VAA ring) of patches is an indicator of the site's capacity to function as habitat for faunal communities. The relative area, in combination with a measure of the total number of patches (*i.e.*, $V_{PATCHAREA}$), is an indicator of the number and size distribution of the habitat patches available for utilization by faunal communities. Large habitat patches have low edge-to-interior ratios and thus a diversity of interior niches that are critical for resting, hiding, escape, thermal, and feeding dynamics. For aquatic dependent species with both large and small home ranges, large intact habitat patches are critical for completion of their lifecycles. In addition, habitat patch size affects the maintenance of native vegetation communities through factors such as seed dispersal, light, and temperature regulation, *etc.*

C) Definition of the VAA

The variable assessment area (VAA) for $V_{PatchArea}$ is the 1000 ft radius VAA ring centered on the project area (i.e. area where development is planned to occur).

D) Measurement Protocol

Within the GIS, display or print an area map showing the watershed that contains the PAA of interest. Using a ruler and compass, or an equivalent technique in the GIS, plot a circle with a 1000 ft radius around the centroid of the project area.

Three habitat types have been identified in Mount Vernon:

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Using a 1:24,000 mapping scale grid, or an equivalent GIS technique (*e.g.,* "Tabulate Area" in Arc/Info Spatial Analyst), measure the relative areas of the habitat patches that are within the 1000 ft VAA ring. Habitat patches that extend beyond the 1000 ft VAA ring should be truncated and only the area within the 1000 ft VAA ring should be included in the area measurement in order to produce a relative area measurement. If a "patch" has a width less than 35 feet, include this area with the adjacent habitat type.

Using these calculations, sum the patch areas to calculate the total patch area for Excellent Habitat and 2 within the 1000 ft VAA ring. Divide the patch areas by the area of the 1000 ft VAA ring (3,140,000 ft^2 [i.e., 1000 ft x 1000 ft x 3.14]) and multiply by 100 to calculate the relative percentage of the 1000 ft VAA ring in each habitat patch class. If necessary, convert the habitat patch areas from m^2 to ft^2 to maintain consistency of units. Use the relative area of the habitat patches in the 1000 ft VAA ring to scale the $V_{PATCHAREA}$ variable. Print and/or include an electronic copy of the map used for the calculation.

E) Scaling Rationale

$V_{PATCHAREA}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Habitat Types

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Measurement or Condition for $V_{PATCHAREA}$	**Index**
> 95 % of the VAA is covered by excellent habitat	1.00
> 95 % of the VAA is covered by excellent or good habitat	0.75
50 to 94 % of the VAA is covered by excellent or good habitat	0.50
10 to 49 % of the VAA is covered by excellent or good habitat	0.25
a. 0 to < 10 %% of the VAA is covered by excellent or good habitat, **AND** b. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. 0 to < 10 % of the VAA is covered by excellent or good habitat, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

9. Patch Number ($V_{PATCHNUMBER}$)

A) Definition

The number of habitat patches, calculated from the Habitat Patch map, within the 1000 ft radius VAA surrounding the project site.

B) Rationale for Selection of the Variable

The number of habitat patches within a 1000 ft radius (VAA) of the project site is an indicator of the site's capacity to function as habitat for faunal communities. The number of patches increases with human disturbance and thus influences the ability of faunal communities to locate, access, utilize, and disperse from a variety of habitat types. The access and utilization of habitat patches by faunal communities is essential for population dynamics such as resting, hiding, escape, thermal, and feeding.

C) Definition of the VAA

The variable assessment area (VAA) is the 1000 ft radius VAA ring centered on the project area (*i.e.,* area where development is planned to occur)..

D) Measurement Protocol

Within the GIS, display or print an area map showing the watershed that contains the PAA of interest. Locate the Project Area. Using a ruler and compass, or an equivalent technique in the GIS, plot a circle with a 1000 ft radius around the centroid of the project area.

Three habitat types have been identified in Mount Vernon:
1) Excellent: forest and shrub communities with apparent vertical structure,
2) Good: grass and lawn with no vertical structure, and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Using a 1:24,000 mapping scale grid, or an equivalent GIS technique (*e.g.,* "Tabulate Area" in Arc/Info Spatial Analyst), measure the relative areas of the habitat patches that are within the 1000 ft VAA ring. Habitat patches that extend beyond the 1000 ft VAA ring should be truncated and only the area within the 1000 ft VAA ring should be included in the area measurement in order to produce a relative area measurement. If a "patch" has a width less than 35 feet, include this area with the adjacent habitat type. Count the number of Excellent and Good Habitat patches that are within the 1000 ft radius VAA ring. Habitat patches that are intersected by, but also extend beyond, the 1000 ft VAA ring should also be included in the count of habitat patches. Count habitat patches separately if they do not share a common edge, or are connected only diagonally on the map. Count a habitat patch only once even if the patch intersects the 1000 ft VAA ring at more than one location. Print and or include an electronic copy of the Habitat Map used for the calculation. Record your results on the Minimum Submittal Worksheet.

E) Scaling Rationale

$V_{PATCHNUMBER}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Habitat Types

1) Excellent: forest and shrub communities with complex vertical structure, (*e.g.*, greater than or equal to 3 canopy layers)
2) Good: grass and/or turf with simple vertical structure (*e.g.,* 1 canopy layer), and
3) Poor: any and all developed areas including buildings, roads, asphalt and concrete, *etc*.

Measurement or Condition for $V_{PATCHNUMBER}$	Index
a. The 1000 ft radius VAA ring contains 1 – 2 Excellent habitat patches, **AND** b. There is **no** evidence of anthropogenic disturbance within the VAA	1.00
a. The 1000 ft radius VAA ring contains 3 – 5 Excellent habitat patches, **AND** b. There is **SOME** evidence of anthropogenic disturbance within the VAA	0.75
a. The 1000 ft radius VAA ring contains 6-10 Excellent **and/or** Good habitat patches, **AND** b. Excellent habitat is present within the VAA.	0.50
a. The 1000 ft radius VAA ring contains 11-20 Excellent **and/or** Good habitat patches, **AND** b. Excellent habitat is present within the VAA	0.25
a. The 1000 ft radius VAA ring contains more than 20 Excellent and Good habitat patches, **OR** b. No Excellent habitat is present within the VAA, **BUT** c. The variable **is** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. No Excellent or Good habitat is present within the VAA, **AND** b. The variable is **not** recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

10. Sediment Deposition ($V_{SEDIMENT}$)

A) Definition

Sediment deposition provides an assessment of existing and potential sediment transport into waters/ wetlands due to human perturbations (*e.g.*, roads, trails).

B) Rationale for Selection of Variable

Deposition of large amounts of anthropogenically derived sediment into depressional waters/wetlands is a reliable indicator of a) physical alteration of the depression, b) degradation of water quality via nutrient loading, increased turbidity, and c) degradation of plant community and faunal habitat structure. In Mount Vernon, rapid rates of sedimentation into depressions can occur naturally via mass wasting or flooding. However, sediment mobilization and deposition is generally dependent upon anthropogenic uses of the surrounding landscape and the interaction of these land uses with runoff events. Areas that commonly contribute sediment include recently cleared or graded land, unstable steep slopes, heavily grazed lands, rights of way (*e.g*., roads and trails), and agricultural lands.

C) Definition of VAA

The VAA includes the wetland and surrounding areas that are potential sources of sediment including the surrounding hillslopes and buffers.

D) Measurement Protocol

Make a visual assessment of the area and/or rate of sediment delivery to the water/wetland within the assessment area. Compare to all the descriptions provided in the scaling for the $V_{SEDIMENT}$ variable and choose the lowest score that appropriately describes the condition/status of sediment delivery to the water/wetland within the assessment area.

E) Scaling Rationale

$V_{PATCHNUMBER}$ was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

Measurement or Condition for $V_{SEDIMENT}$	**Index**
a. No sediment accretion (increased area or rate of sediment deposition) is apparent in or leading in to the wetland area, other than aeolian transport, **AND** b. No sediment sources are evident within wetland buffer, **AND** c. There is **no** evidence of anthropogenic disturbance within the VAA.	1.00
a. No sediment accretion is apparent in or leading in to the wetland area, other than aeolian transport, **AND** b. No sediment sources are evident within wetland buffer, **AND** c. There is **some** evidence of anthropogenic disturbance within the VAA.	0.75
a. There is no apparent sediment movement into the wetland, **BUT** b. There is evidence in the buffers or in the catchment of sediment potentially available to move into wetland.	0.50
a. Sediments have been transported into wetland, **AND** b. There is evidence in the buffers or in the catchment of sediment potentially available to move into wetland.	0.25
a. Significant transport of sediment into, and accretion within, the wetland depression, **AND** b. The variable is recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Significant transport of sediment into, and accretion within, the wetland depression, **AND** b. The variable is not recoverable or sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

11. Shrub Canopy Cover (V_{SHRUB})

A) Definition

Shrub canopy cover is defined as the percent cover of shrubs (multiple-stemmed woody species) within the VAA.

B) Rationale for Selection of Variable

Shrub canopy coverage is one measure of vegetation that indicates maintenance of native plant community structure and function. As such, shrub canopy cover can be used along with other measures of vegetative cover to indicate the potential for a site to support characteristic ecosystem processes, such as maintenance of native and nonnative plant communities, faunal communities and faunal support/habitat, *etc.* The presence of shrubs along with that of trees, contributes to roughness and topographic variation which leads to increased diversity. Roughness provides a mechanism to slow water flows and thus provides static and dynamic storage of flood flows as well as cover for aquatic and terrestrial fauna. Shrubs, along with trees, maintain depressional wetland morphology by decreasing erosion through the production and maintenance of fine root biomass. Shrubs also function as structural elements that limit and/or control development and maintenance of wetland geometry.

Shrubs provide significant inputs of labile and refractory organic carbon to riverine ecosystems. In addition, the shrub canopies alter micro-climatic conditions in forests (*e.g.*, moisture, nutrients, light, temperature, wind speed, *etc.*). Microclimatic alterations caused by the presence of shrubs is important in maintaining several ecosystem functions, such as biomass production, maintenance of site water balance, nutrient conservation, habitat structure, *etc.* Furthermore, shrubs, along with trees, are instrumental in soil genesis, elemental cycling, and successional processes (Hooper and Vitousek 1997). These successional processes include the dispersal and establishment of plant propagules that support plant and animal species diversity and turnover (Tilman 1982, Huston and Smith 1987, Cohen and Levin 1991, Tilman and Pacala 1993).

C) Definition of VAA

The VAA for V_{SHRUB} consists of a minimum of 1 and up to three circular plots located within a representative area of the depressional wetland (Figure 17). Each circular plot should cover 0.10-acre (radius = 37.2 feet). If only one plot is established, it must be located in an area that is representative of the wetland and justification showing that the plot location is representative of the reach should be recorded.

D) Measurement Protocol

To measure $V_{SHRUB,}$ stand in the center of the plot and make visual estimates of the percent cover for the shrub stratum (Figure 18) using midpoints of standard canopy cover classes (Table 20). Note that vines are defined as shrubs. Record these estimates of percent cover on the Minimal Submittal Worksheets. Average the measurements of shrub canopy cover to calculate the final estimate of shrub cover.

E) Scaling Rationale

V_{SHRUB} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Shrub Community is Dominant within the VAA:

Measurement or Condition V_{SHRUB}	**Index**
a. Average shrub canopy cover is ≥ 75%, **AND** b. There is **no** evidence of anthropogenic disturbance	1.00
a. Average shrub canopy cover is ≥ 75%, **AND** b. There is some evidence of anthropogenic disturbance	0.75
Average shrub canopy cover is ≥ 50% and < 75%.	0.50
Average shrub canopy cover is ≥ 25% and < 50%.	0.25
a. Average shrub canopy cover is < 25%, **AND** b. The variable condition **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average shrub canopy cover is < 25%, **AND** b. The variable condition is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

2. Trees (Forests) are Dominant within the VAA:

Measurement or Condition V_{SHRUB}	**Index**
a. Average shrub canopy cover is ≥ 45% and < 75%**, AND** b. There is no evidence of anthropogenic disturbance	1.00
a. Average shrub canopy cover is ≥ 45% and < 75%**, AND** b. There is some evidence of anthropogenic disturbance	0.75
Average shrub canopy cover is ≥ 25% and < 45%.	0.50
Average shrub canopy cover is ≥ 15% and < 25%	0.25
a. Average shrub canopy cover is < 15% **OR** >75%, **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average shrub canopy cover is < 15% **OR** >75%, **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

12. Soil Profile Integrity ($V_{SOILINTEG}$)

A) Definition

This variable is a measure of the presence and condition of the soil profile (soil horizons) within the VAA.

B) Rationale for Selection of Variable

The integrity of the soil profile, through linkages with site hydrology, exerts strong control on the ecosystem functions including biogeochemical processes affecting nutrient cycles and storage, and the establishment and maintenance of plant communities. Maintenance of intact soils in depressional waters/wetland is especially important in the hilly Mount Vernon landscape. Sites with intact soil profiles typically exhibit higher infiltration rates and hydraulic conductivities than do disturbed and compacted soils. Increased time of contact of water with soil mineral particles and organic matter, plant roots, microbes, *etc*., facilitates retention and transformation of nutrients, organic matter and contaminants.

C) Definition of the VAA

The VAA for Soil Profile Integrity consists of a transect across a representative section of the depressional wetland.

D) Measurement Protocol

Describe the modal soil within the VAA. To accomplish descriptions, excavate soil pits in representative locations. Excavate the soil pits to the depth of excess water, impenetrable debris (*e.g*., boulders, stones, cobbles) or to a depth of approximately 3 ft, whichever is encountered first. Closed-bucket or Dutch augers are useful below approximately 2 feet. After excavation of the soil pit, carefully scrape the face of the bank or pit (a dull knife works well) to remove weathered or smeared material on the face of the soil profile. Clean the face of the profile until the different soil horizons (if present) are clearly exposed. Separate the different soil horizons within the profile by changes in color and/or texture. Describe the different textures by feel, and color consistent with guidelines provided in Munsell Soil Color Charts (Munsell 1994). All soil colors should be from a moist sample and read in direct sunlight if possible. Measure the thickness and depth of each horizon. Record the presence and location of any additional features or activities that might be important (e.*g.,* land use, any disturbances to the soil profile, the presence of redoximorphic features within the profile, depth to water, abundant organic matter, faunal habitat, *etc*.). Take photographs and/or samples for later identification of unknown or confusing features.

Identification, nomenclature, and description of soil horizons should be consistent with guidance provided by the USDA Natural Resource Conservation Service (Schoeneberger *et al.* 1998). All soil depths are measured from the soil surface (usually an A horizon), excluding any litter or duff layers that may have accumulated on the soil surface. Live vascular and non-vascular plant materials are **not** included in measurements of soil depths.

E) Scaling Rationale

The authors used best scientific judgment and, secondarily, empirical field data from reference sites to scale this variable. The scaling presented herein is based on the presence, condition, and color (organic carbon content) of organic and/or mineral horizons and the degree of disruption that has occurred from direct manipulation of the wetlands. For all soils present within the PAA, the soil profile integrity variable is scaled down proportional to the degree of anthropogenic disturbance or disruption of the soil profile.

F) Scaling for all Subclasses:

Measurement or Condition for $V_{SOILINTEG}$	**Index**
a. The modal soil profile(s) (mineral or organic soils) is (are) well developed (*i.e.* different horizons are discernable), and intact within the upper 24 inches, **AND** b. The surface and shallow subsurface deposits and depositional features **have not** been altered by anthropogenic activities (*e.g.* roads, agriculture, fills, *etc.*).	1.00
a. Modal soil profile(s) is (are) present within the VAA, **BUT** b. Surface and shallow subsurface deposits and depositional features **have** been altered by anthropogenic activities resulting in **minor** changes to the soil profile Alterations may include, but are not limited to, fill, excavation, earthwork, recreation, foot traffic, and clearing of brush.	0.75
a. Modal soil types are present within the VAA, **BUT** b. Surface and shallow subsurface deposits and depositional features **have** been altered by anthropogenic activities. For both mineral and organic soils, soil surface horizons are impacted (*e.g.*, compaction, light erosion, placement of limited fill, grazing plowed or disked) and as a consequence, they exhibit some diminished structure, thickness, and/or organic carbon content. Alterations may include, but are not limited to, fill, excavation, and/or earthwork, **AND** c. Modal organic soil profile is essentially intact except for evidence of some plowing or disking within the top 15", or some compaction due to livestock grazing, vehicular traffic, *etc.*	0.50
a. The soil profile is no longer entirely intact due to human activities, **AND** b. The surface horizon was removed or buried by human activities and the subsurface horizon(s) are either buried, or exposed and altered, (*e.g.,* disturbance by roads, debris basins, construction), **AND** c. Soil structure in the upper part of the profile is weak or absent and organic carbon content is diminished (e.g. moist color value and chroma > 3).	0.25
a. Soil profile is no longer entirely intact and is significantly disturbed by human activities, **AND** b. The surface horizon has been buried **or** removed by human-induced activities and the subsurface horizon(s) are exposed, highly eroded, and subject to failure or continued erosion and deterioration (*e.g.*, soil is buried by fill, has areas of depressional failure, heavy vehicle traffic, disturbance by roads, construction, or agriculture), **OR** c. Soil structure is weak or absent and vegetation, root biomass, and organic carbon content are greatly diminished or absent (*e.g.*, moist color value and chroma > 3), **AND** d. The soil profile can be recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Soil profile is no longer intact as a result of human activities, **AND** b. The surface and subsurface horizons are generally absent due to removal **or** burial as a result of human activities (*e.g.,* the placement of fill, roads, concrete or asphalt, construction, debris basins, revetments, concrete weirs or trapezoids),**OR** c. Soil structure, vegetation, root biomass, and organic carbon are virtually absent (*e.g.,* moist color value and chroma > 3), **AND** d. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

13. Vegetation Strata (V_{STRATA})

A) Definition

Vegetative strata are defined as the number of distinct layers present within the VAA. Vegetative strata are recognized within the Mount Vernon landscape as trees (single stem woody species with > 4" DBH and a height of > 20 ft), shrubs (multiple stemmed woody species including vines), and herbs (including forbs, graminoids, ferns, and fern allies).

B) Rationale for Selection of Variable

Multiple vegetative strata (*e.g.*, trees, shrubs, and/or herbs) often are good indicators of the development and maintenance of plant communities, and habitat structure (Tilman 1994). For example, the number of strata can be correlated with the habitat structure and complexity necessary to support characteristic faunal assemblages, *e.g.*, those typical of the Mount Vernon watershed. Similarly, the number and types of vegetation strata combine to provide the diversity of faunal habitat, as well as the types and quantity of food and cover resources available.

C) Definition of the VAA

The VAA for V_{STRATA} consists of a 100 ft vegetation transects situated at a representative location within the depressional wetland.

D) Measurement Protocol

To develop a measure for V_{STRATA}, walk along the 100 ft vegetation transect, stopping to observe the number of vegetative strata at 10 ft intervals. Record the total number of strata (*i.e.,* herb, shrub, and tree) that intersect the transect at each stopping point.

For example, an HGM user may identify the presence of only the herb stratum at a given sampling point. He or she would therefore record only one stratum as present. The HGM user would conduct this measurement at 10 points along each transect.

Calculate an average number of vegetation strata for the assessment area using all 20 data points. Record these values on the minimum submittal sheet.

E) Scaling Rationale

V_{STRATA} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

1. Shrub Community is Dominant within the VAA:

Measurement Condition for V_{STRATA}	**Index**
a. Average number of strata is 2, **AND** b. There is **no** evidence of anthropogenic disturbance.	1.00
a. Average number of strata is 2, **AND** b. There is **some** evidence of anthropogenic disturbance	0.75
Average number of strata is ≥ 1 and < 2.	0.50
Average number of strata is ≥ 0.5 and < 1.	0.25
a. The average number of strata is < 0.5, **AND** b. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.10
a. The average number of strata is < 0.5, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures applied.	0.00

2. Forest Community is Dominant within the VAA:

Measurement Condition for V_{STRATA}	**Index**
a. Average number of strata is 3, **AND** b. There is no evidence of anthropogenic disturbance	1.00
a. Average number of strata is 3, **AND** b. There is some evidence of anthropogenic disturbance	0.75
Average number of strata is ≥ 2 and < 3	0.50
Average number of strata is ≥ 1 and < 2.	0.25
a. The average number of strata is 0 to < 1, **AND** b. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.10
a. The average number of strata is 0 to < 1, **AND** b. The variable is **not** recoverable to reference standard conditions and sustainable through natural processes if the existing land use (*e.g.*, site cleared through heavy grazing of domestic livestock, developed park, and crop production) is discontinued and no restoration measures are applied.	0.00

14. Tree Canopy Coverage (V_{TREE})

A) Definition

Tree canopy cover is defined as the percent canopy cover of trees (*i.e.*, single stem woody species with > 4" DBH and > 10 feet in height) within the VAA.

B) Rationale for Selection of Variable

Tree canopy coverage traditionally is used as a measure of species distribution and biomass (Clements 1916, Avery 1975, Mueller-Dombois and Ellenberg 1974). As such, canopy cover can indicate the potential for a site to support characteristic ecosystem processes such as maintenance of native and nonnative plant communities and faunal support/habitat. Trees also contribute to roughness and topographic variation. Roughness provides a physical mechanism that slows water flows and thus provides static and dynamic storage of flood flows and cover for aquatic and terrestrial fauna. Trees decrease erosion through the production and maintenance of fine root biomass.

Trees provide allochthonous inputs of labile and refractory organic carbon to riverine ecosystems. In addition, the presence of tree boles and canopies alter micro-climatic conditions in wetland forests (*e.g.*, moisture, nutrients, light, temperature, wind speed, *etc.*). Microclimatic alterations caused by the presence of trees is important in maintaining several ecosystem functions such as biomass production, maintenance of site water balance, nutrient conservation, habitat structure, *etc.* Furthermore, trees are instrumental in soil genesis, elemental cycling, and successional processes (Hooper and Vitousek 1997). These successional processes include the dispersal and establishment of plant propagules, support plant and animal species diversity and turnover (Tilman 1982, Huston and Smith 1987, Cohen and Levin 1991, Tilman and Pacala 1993).

C) Definition of VAA

The VAA for V_{TREE} consists of a minimum of one and up to three 0.10- acre circular plots (radius = 37.2 ft). If the site is relatively homogenous and only one plot will be established, it ***must*** be located in an area that is representative of the entire reach, and justification showing that the plot location is representative of the wetland should be recorded.

D) Measurement Protocol

Within each plot, make visual estimates of the percent cover for the tree stratum (Figure 18) using midpoints of standard canopy cover classes (Table 20). When making this estimate, canopy cover within the tree stratum sums to 100%. Record these estimates of percent cover on the Minimal Submittal Worksheets. Average all of the measurements of canopy cover to calculate the final estimate of tree canopy cover.

Please note that this variable is not to be scored in communities where shrubs are dominant in the wetland. Wetland plant community is not necessarily the same as the buffer plant community..

E) Scaling Rationale

V_{TREE} was scaled using a combination of field observations, literature, and best scientific judgment.

F) Scaling

For Tree (Forest) communities within the VAA:

Measurement or Condition for V_{TREE}	**Index**
a. Average percent cover of trees is ≥ 95%, **AND** b. There is **no** evidence of anthropogenic disturbance	1.00
Average percent cover of trees is ≥ 75%, **AND** some evidence of anthropogenic disturbance b. There is **some** evidence of anthropogenic disturbance	0.75
Average percent cover of trees is ≥ 50% and < 75%.	0.50
Average percent cover of trees is ≥ 25% and < 50%.	0.25
a. Average percent cover of trees is < 25% **AND** b. The variable **is** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
a. Average percent cover of trees is < 25% **AND** b. The variable is **not** recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.00

VI. Application and Use of the HGM Guidebook and Models

A. Overview

As discussed in the introductory chapters of this *Guidebook*, the HGM approach to assessing ecosystem functions of waters/wetlands is a useful tool designed specifically for a broad array of tasks related to project planning, design, implementation, and monitoring. Commonly, the HGM approach is used as the basis for (1) impact assessment, (2) permitting, (3) restoration design, and (4) development of monitoring protocols and contingency measures (Brinson 1993a, Brinson *et al.* 1995, NWSTC 1996a and b and NWSTC 2001). The approach has limitations that are inherent in the measurement techniques of the variables used. Specifically, the evaluation of changes due to recurrent activities and/or small projects with minimal effects (either positive or negative) will not yield meaningful results with this approach. The HGM models included within the *Guidebook* rely upon the use of variables that are used in different combinations to define ecosystem functions. Variables are defined as the attributes or characteristics of a water/wetland ecosystem or the surrounding landscape that influence the capacity of a water/wetland to perform an ecosystem function or a set of functions. To score each variables, the *Guidebook* user can refer to Section C in Sections III, IV and V which provide a definition, rationale for selection of each variable, measurement protocol, scaling rationale, and the scaling.

Understanding where your project area lies within the landscape is the first step in the application of this *Guidebook* and HGM model. A key to determining the wetland type with the City of Mount Vernon is provided Page 19. Scoring of all variables allows the *Guidebook* user to calculate all but two of the functional capacity indices. (Variable for two functions, Distribution/Abundance of Wildlife and Distribution/Abundance of Invertebrates, are neither defined nor scored in this manual.) Functional capacity indices have been defined herein as indices of the capacity of a water/wetland to perform an ecosystem function relative to other waters/wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are calculated by plugging the variable scores into simple formulae that have been defined in Table 6 of Chapter III, IV and V. Each chapter provides descriptions for each function, including a definition, a rationale for the function in riverine ecosystems within the city of Mount Vernon watersheds, a discussion of characteristics and processes that influence the function, a listing of the variables used to assess the function, and the formulae used to estimate the appropriate functional capacity indices. Each model has been tailored to more effectively address ecosystem function within each of the identified classes and subclasses addressed in this *Guidebook*.

It should be emphasized that the documentation required in each of the steps discussed throughout this chapter constitutes the **MINIMUM SUBMITTALS** of information required for an HGM assessment.
Failure to complete the Minimum Submittal Worksheets (Appendix A) is sufficient grounds for agency and/or peer rejection of an HGM assessment report, due to incomplete documentation. Thorough documentation of site conditions at a proposed project area facilitates accurate regulatory decision making at the federal, state, and/or local level. Also, the application of the HGM approach offered in this chapter should be accomplished in a manner that is consistent with standard interpretations of HGM model logic, terminology, and administrative procedures. That is, consistency requires articulation of conventions for field observations, field measurements, and documentation of assessment results.

B. Minimal Submittal Worksheet Requirements

HGM functional assessments cannot be performed without a thorough review of the proposed project area and its geomorphic setting, landscape context, and land-use history. **Reviews of the site need to be completed in both the office and in the field**. While elements of the HGM approach can be used to structure preliminary discussions of ecosystem functions and impacts, an HGM functional assessment requires the completion of all Minimum Submittal Worksheets and their organization into an assessment report. The Minimal Submittal Worksheets and Data Collection Worksheets are provided in Appendix A and B. This chapter has been designed to guide the user through the completion of these worksheets and the production of an assessment report. As previously stated, the outlined steps constitute the ***minimum*** submittals required for an HGM functional assessment with in the City of Mount Vernon. The process of preparing the Minimal Submittal and summarizing the HGM assessment information into a coherent report ensures a thorough documentation of the site conditions and facilitates accurate regulatory decision making at the federal, state, and/or local level.

C. Performing the Functional Assessment

1. Office Preparation

Office Step 1: Background Preparation

To support HGM analysis, field efforts require advance preparation. Prior to performing a field or design document review, it is important to collect information that is relevant to the proposed project site. Aerial photographs, topographic maps, geologic maps, soil surveys, NWI maps, jurisdictional delineation documents, and other relevant information should be compiled and reviewed **before going into the field** (Table 22).

During office preparation, particular attention should be given to the development of an understanding of the geomorphic setting associated with the proposed project area. Geomorphic setting is defined as the location and types of landforms in a landscape, such as stream headwater locations, valley bottom depressions, and coastal position. Understanding the stream order and geomorphic setting will provide a foundation for the classification of the riverine subclass. For example, knowing that the proposed project site is located on a high gradient hillside position is critical information to the classification of a riverine subclass. Attention should also be given to the land-use history and landscape context of the proposed project area, as these factors may affect soils, biogeochemistry, plant communities, and/or faunal support/habitat within the PAA.

Office Step 2. Bound and Stratify the Project Assessment Area.

Bound and stratify the proposed project area using maps, air photos, *etc.* Keep the map scale constant throughout all analyses. This includes several tasks:

a. Define and complete a preliminary delineation of the boundaries of the project area (The Project Area is where development is proposed.),
b. Estimate the geographic extent of waters/wetlands within the proposed project area,
c. Estimate the proportion(s) and type(s) of waters/wetlands within the project area,
d. Estimate the geographic extent and type of proposed project impact(s) (*i.e.,* primary, secondary, and/or cumulative effects).
e. Determine the Project Assessment Area (PAA) which includes the water/wetlands and their buffers within 200 feet of the Project Area.
f. Determine sub-project assessment areas as necessary for large, complicated projects.

Table 22. Recommended office steps and procedures for performing a HGM functional assessment

OFFICE PREPARATION

Office Step 1. Background Preparation.

Collect and review background information relevant to the proposed project area. This includes, but is not limited to:

a. Relevant U.S. Geological Survey, State, County, and other maps at several scales (*e.g*., 1:24,000, 1:250,000)

b. Air photos and other imagery

c. Relevant GIS maps and/or CD-ROM that accompany this *Guidebook*.

d. Relevant geologic, geotechnical, hydrologic, soils, or environmental reports.

e. Correspondence, construction plans and specifications, *etc*. on the proposed project

f. Relevant published literature on the project area, proposed activity, watershed, *etc*.

Office Step 2. Bound and Stratify the Project Assessment Area.

Bound and stratify the proposed project area using maps, air photos, *etc*. Keep the map scale constant throughout all analyses. This includes:

a. Define and complete a preliminary delineation of the boundaries of the proposed project area

b. Estimate the geographic extent of waters/wetlands within the proposed project area

c. Estimate the proportion(s) and type(s) of waters/wetlands within the project area

d. Estimate the proportion of waters/wetlands that fall into the subclasses of waters/wetlands addressed by and not addressed by this *Guidebook*

e. Estimate the geographic extent and type of proposed project impact(s) (*i.e.,* primary, secondary, and/or cumulative effects)

Office Step 3. Subclass Classification.

Identify, verify, and document the rationale used for recognizing HGM subclasses of riparian ecosystems in the City of Mount Vernon within the proposed project area. Show and/or explain why the proposed project area or parts of the proposed project area are covered by this *Guidebook*.

Office Step 4. Review the Measurement Methodology and Variable Assessment Area (VAA) for Each Variable

Before going into the field, the *Guidebook* user should read Chapter 5. This step will facilitate a review of the recommended methodologies to measure each variable presented in this model, as well as the different Variable Assessment Areas (VAA). Table 6.4 has been included to highlight the VAA size for each variable included in this *Guidebook*.

Office Step 5. Prepare GIS Maps.

Print out an appropriate GIS map that includes the proposed project area. A map is required to scale six variables ($V_{PATCHAREA}$, $V_{PATCHLATCON}$, $V_{PATCHLONGCON}$, $V_{PATCHNUMBER}$, $V_{BARRIER}$ and V_{ROADS}). See the Measurement Protocol for each variable for further instructions on scaling. These variables can be scaled either in the office or in the field. However if the variables are scaled in the office, the maps should still accompany the field team in the field for verification.

Office Step 6. Coordination of Datasheets.

The assembly of field and safety equipment should include a print out of the Variables (Chapter 5), Minimal Submittal Worksheets, and Data Collection Worksheets.

Office Step 3. Class and Subclass Determination

An essential part of the HGM functional assessment is to demonstrate why certain parts, or all of the proposed project area, qualify as a part of a riverine subclass addressed by this *Guidebook*. The *Guidebook* has been written to address wetland class (Riverine, Slope, Depressional wetlands) separately. Scaling of variables requires further stratification to wetland subclasses separating riverine wetlands according to gradient, slope wetlands according to proximity to a stream, and depressional wetlands according to hydrology. A key to wetland classes and sub-classes in Mount Vernon is provided in the Minimum Submittal Worksheets and in Chapter II.

Office Step 4. Review the Measurement Methodology and Variable Assessment Area (VAA) for Each Variable.
This step is intended to assist the *Guidebook* user in preparation for the required fieldwork of an HGM based functional assessment. The *Guidebook* user will be apprised of the recommended methodology for collecting the appropriate data necessary to score each variable and foresee the necessary gear required. Please note that the Variable Assessment Area (VAA) is not consistent for each of the variables. In order to compensate for relevant scale at which to measure the variables most effectively, the VAA fluctuates in size. For example, the scale at which $V_{PATCHAREA}$ is most effectively measured (*i.e.*, a 1000 ft radius VAA ring centered on the project site) is very different from the scale at which V_{INLW} is scaled (*i.e.,* six 0.1 acre (37.2 ft radius) circular plots).

Office Step 5. Preparation of GIS Maps
Five variables will be scaled using GIS technology. These variables will be measured within a 1000 ft radius VAA that is centered on the PAA.

a) $V_{PATCHAREA}$
b) $V_{PATCHLAGCON}$
c) $V_{PATCHLONGCON}$
d) $V_{PATCHNUMBER}$
e) V_{ROADS}

In addition, $V_{BARRIER}$ will be assessed for the entire length of the stream channel using GIS technology.

2. Field Protocol for Riverine HGM Assessment

Field Step 1. Reconnaissance of the Proposed Project Area (or "Sub-Project" Area) and Set-up of Main Cross-Section (Riverine Wetlands) or Main Transect (Slope and Depressional Wetlands)

Time is rarely wasted during a field reconnaissance of a proposed project area and its surrounding areas. In fact, it is shortsighted to perform an HGM assessment using this *Guidebook* without first conducting a thorough reconnaissance of the entire proposed project area and its surroundings. First, walk completely around the site with photos, maps, and other reference data in hand. If necessary, walk through the site several times to try to understand how water flows into, through, and away from the site. Make sure to observe (1) the range of variation of variable conditions that exist on the site, and (2) the landscape context and condition. You may wish to also consider proposed project impacts to the site.

Based on the variability observed on the site, determine whether sub-project areas should be identified within the Project Site to improve clarity of the assessment. If the site is large and/or heterogeneous, multiple PAAs (*i.e.,* sub-PAAs) may be defined. The assessment area(s) can be bounded correctly by considering three points:

First, if the project site includes uplands and wetlands, then the assessment area must be bounded so that only the portion that is part of the waters/wetlands are included in the assessment. Second, if different waters/wetland classes or subclasses exist on the same project site, then separate models must be used in the functional assessments of these areas. For example, where depressional waters/wetlands occur adjacent to riverine waters/wetlands (*e.g.,* active channels and floodplains), each subclass should be assessed using the appropriate model for its subclass. Third, if different stages of development and/or different disturbance regimes exist on the same project site, then separate functional assessments may need to be performed for each area. For example, consider a project site that contains waters/wetlands within a single subclass; if a portion of this waters/wetlands is undisturbed, while the other half has been impacted by human disturbance, these areas may need to be separated into two assessment areas.

In the Project Area or in each sub-project area, establish either a representative cross-section across the stream channel if your site is in a riverine wetland or a representative main transect if the Project Assessment Area (PAA) includes a slope or depressional wetland. If the site is large and/or heterogeneous, multiple cross-sections or transects will be needed so that a PAA main cross-section or main transect is placed in each different habitat type and each wetland type. If the PAA is small and/or relatively homogenous, one main cross-section or transect which is established at a representative location should be sufficient.

FIELD WORK

Field Step 1. Reconnaissance of the Proposed Project Area and Set-up of Main Cross-section or Transect

Complete a thorough reconnaissance of the proposed project area and vicinity. Take particular note of geologic, landscape, hydrologic, soil, plant community, and faunal support/habitat conditions. Establish a representative cross section in a relatively straight reach of the stream (Riverine Wetland) or a main transect (Slope ore Depressional Wetland).

Field Step 2. Bound and Stratify the Proposed Project Area and PAA(s).

Bound, stratify and complete mapping of the PAA. Confirm and refine all preliminary mapping in the field (*i.e.,* confirm office step 3 above). This includes:

a. Delineation of the proposed project boundaries
b. Delineation of the geographic extent of waters/wetlands within the PAA
c. Determination of the proportion(s) and type(s) of waters/wetlands within the PAA
d. Determination the proportion of waters/wetlands that fall into the subclasses of waters/wetlands addressed by and not addressed by this draft *Guidebook*
e. Estimation the geographic extent and type of proposed project impact(s) (*i.e.,* primary, secondary, and/or cumulative effects).

Field Step 3. Subclass Classification.

Identify, verify, and document the rationale used for recognizing HGM subclasses of riparian ecosystems within the project area. Show and/or explain why the project area or parts of the project area are covered by this *Guidebook*.

Field Step 4. Scoring of Variables.

Score the variables using criteria presented in the *Guidebook*. The variables should be scored, based on the following circumstances:

a. Existing conditions, *and if applicable*:
b. Proposed project conditions (or alternatives 1,2,3, *etc.*)

Field Step 5. Calculation of the Indices of Functions.

Calculate the indices of function (FCIs) in the field. FCI calculations should be completed based on the following circumstances:

a. Existing site conditions, *and if applicable*:
b. Proposed project conditions (or alternatives 1,2,3, *etc.*)

Field Step 6. Development of a Preliminary Profile.

Develop and refine a general description of existing conditions within the PAA. The description should include a discussion of geologic and landscape contexts, hydrology, soils, vegetation, faunal support/habitat, historic and current land uses, *etc*.

For Riverine Wetlands: Try to establish the cross section and in a relatively straight portion of the channel near the center of the PAA, avoiding meanders or otherwise complex portions of the reach. Stretch a standard, non-stretch measuring tape at the point of the cross section, and clamp each end to the ordinary high water (OHW) point on river right and river left. The ordinary high water mark is defined within the Federal Register (33 CFR Part 328, Section 328.3 (a)(7)(e)) as "that line on the shore established by the fluctuation of water and indicated by physical characteristics such as clear natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding area." Make certain that the tape is taut and level. Measure the length of the cross section. Please note that the riparian ecosystem within a proposed project area might include a main / primary channel in addition to any number of secondary channels. The main cross section should be located in the main / primary channel. After establishing the representative cross section (PAA Main Cross-section), walk up gradient 10 times the length of the cross section and tie a flag, using plastic flagging, to mark that length of stream reach. Also walk down gradient 10 times the length of the cross section from the PAA main cross-section, and again flag that length for total distance of 20 times the cross-sectional width.

For Slope or Depressional Wetlands: Establish a main transect that is 150 feet long within a representative region of the slope or depressional wetland.

Field Step 2. Bound and Stratify the Project Assessment Area

This step is intended to confirm the preliminary bounding and stratification of the project assessment area (PAA) that was done in the office (Office Step 2), and to make any corrections if necessary. It is critical that the proposed project area and the PAA(s) be bounded and delineated correctly for three reasons. First, if the PAA includes uplands and waters/wetlands, then the PAA must be bounded such that only the portion of the PAA that is waters/wetland subclasses treated by this *Guidebook* is included in the assessment. Note, however, that sites that are not currently waters/wetlands due to natural or anthropogenic disturbance may still be part of the regional wetland subclass based on long-term, large scale cyclic processes that may return them to reference standard conditions.

Second, if several HGM subclasses exist on the same project site, then separate HGM models must be used in the functional assessments of these areas. For example, dependent on the scale of the where riverine waters/wetlands occur adjacent to slope waters/wetlands (*e.g.,* vernal pool complex), each waters/wetland should be assessed using a separate guidebook and associated HGM models. Third, if different stages of development and/or different disturbance regimes exist on the same project site, then separate functional assessments may need to be performed for each area. For example, consider a project site that contains a wetland of a single subclass (*e.g.*, Steep Gradient Riverine/Plain bed-Step Pool stream). A portion of this wetland may be undisturbed, while another portion may be modified hydrologically by riprap, channelization, and so forth. These areas may need to be separated into two assessment areas. In addition to bounding the PAA, Step 3 also requires modifying the preliminary maps created in the office.

Field Step 3. Verification of Subclass Classification

The *Guidebook* user must verify, and document the rationale for classifying waters/wetlands within the PAA(s) as one of the subclasses within the wetland class defined by this *Guidebook*. Again, this step demonstrates the importance of building upon office preparation. It is important to demonstrate clearly why the waters/wetlands satisfy a particular subclass definition. A worksheet has been provided that guides the user through verification of dominant characteristics and/or components used in defining a riverine, slope or depressional wetland subclass within the City of Mount Vernon.

Field Step 4. Scoring of Variables

The model(s) in this *Guidebook* rely upon the use of variables that are combined in a variety of ways to calculate indices of functions. The majority of the variables are used in several indices of function and cannot be simply estimated. *Measurements and field observations are required for all variables used in this Guidebook*. Estimation of even one variable score can have significant cascading effects. Therefore, please take the time in the field to obtain the data required to score the variable. A summary of the recommended methodology has been provided to assist the *Guidebook* user through the process of acquiring all the required data necessary to score all of the variables.

In the Minimum Submittal Worksheets, we have ordered the variables in a way that we found to allow for efficient and effective data collection. Complete and detailed directions on data collection procedures are provided in Sections III, IV and V.

It is important to remember that variables require different ranges or scales of observation within the proposed project area. Refer to the variable measurement protocols for the size of each variable assessment area (VAA). Also, remember to take photographs and draft sketches throughout your field visit to record important site characteristics such as stream channel morphology, vegetative communities, animal use, anthropogenic disturbances, surrounding landuse, *etc.* After recording all the measurement results on the *Minimum Submittal Worksheets*, the variables can be scaled. The variable scores and team's rationale in selecting the variable score should be recorded on the *Variable Score Sheet.* Please note that the field forms include space for recording rationale or making comments on the decision to score a variable in a certain way. The Authors' intent is to provide model users with an opportunity to make notes on each variable score and to facilitate meaningful discussions about the results at a later date. *Use the comment/rationale column every time to document your team's decision structure or logic.*

VII. Glossary

assessment area (AA): The area in or adjacent to waters/wetlands, which will be assessed with HGM models.

assessment team (A - team): An interdisciplinary group of regional and local scientists responsible for classification of wetlands within a region, identification of reference wetlands, construction of assessment models, definition of reference standards, and calibration of assessment models.

best professional judgment: The process of making decisions based on personal experience and knowledge when better information is not available.

biogeochemical: The interaction and integration of biological and geochemical cycles and processes.

biogeochemistry: Of or relating to the partitioning and cycling of chemical elements and compounds between the living and nonliving parts of an ecosystem.

buffer: A zone of a defined width that borders waters/wetlands and that is designed to protect the waters/wetlands from impacts.

centroid: The point in character space, the coordinates of which are the mean values of each character over a given cluster of OTUs (operational taxonomic unit).

channel: An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

channel cross-section geometry: The dimensions and morphology of a section of stream channel, taken perpendicular to the linear centerline of the stream from the floodplain surface on one side of the channel, to the floodplain surface on the opposite side.

Clean Water Act of 1977 (33 U.S. c.1344): Section 404 of this law that directs the Secretary of the Army, acting through the Chief of Engineers to issue permits, after notice and opportunity for public hearing, for the discharge of dredge or fill material into waters of the United States at specified locations. The object of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (33 U.S. C.1344, Section 101(a)).

flood prone area: The channel and those parts of the floodplain adjoining the channel, which are required to carry and discharge moderate frequency, moderate magnitude flood flows.

flow-through wetlands: Wetlands that recharge the groundwater system and receive groundwater discharge.

function (ecosystem): Processes which are necessary for the self-maintenance of an ecosystem such as primary production, nutrient cycling, decomposition, *etc.* The term is used primarily as a distinction from values. The term 'values' is associated with society's perception of ecosystem functions. Functions occur in ecosystems regardless of whether or not they have values.

function context area (FCA): The area that influences, or is influenced by, a wetland function. The function context area can include aquatic and upland systems adjacent to the wetland.

functional assessment: The process by which the capacity of a wetland to perform a function is measured. This approach measures capacity using an assessment model to determine a functional capacity index.

functional capacity: The rate or magnitude at which a wetland ecosystem performs a function. Functional capacity is dictated by characteristics of the wetland ecosystem and the surrounding landscape, and interaction between the two.

functional capacity index (FCI): An index of the capacity of wetland to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. An index of 1.0 indicates that the wetland performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An index of 0.0 indicates the wetland does not perform the function at a measurable level, and will not recover the capacity to perform the function through natural processes.

functional capacity unit (FCU): The value derived by multiplying the functional capacity index for a wetland area by the size of the wetland area.

functional profile:

A. Qualitative and quantitative descriptive depictions of wetlands that, in the case of the hydrogeomorphic classification, emphasize the physical characteristics such as geomorphic setting, water source, and hydrodynamics. Profiles also may include the biotic components.

B. Narrative or quantitative description of significant factors such as water source, hydrodynamics, vegetation, and soils that affect how a wetland functions.

geomorphic setting: The location of a landscape with respect to landforms, such as stream headwater locations, valley bottom depression, and coastal position.

geomorphology: The study of the classification, description, origin, nature, and development of landforms and their relationship to underlying structures and geologic processes.

Geographical Information System (GIS): An integrated system of computer hardware, software and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced.

Global Positioning System (GPS): An instrument that determines (by triangulation) the location of features, using data from orbiting satellites.

ground water:

A. Water occurring in the subsurface voids, pore spaces, or fissures of the earth, as opposed to water occurring above the surface in streams, ponds, lakes, and oceans.

B. The water contained in the interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.

ground water discharge: The movement of groundwater from an aquifer to the surface.

headwaters: **A**. Streams with average annual discharge less than 5 cubic foot per second (cfs) (US Army Corps of Engineers 404 Regulatory Program definition).

B. The upper most reaches of stream networks.

herb: Forbs, ferns, fern allies, and graminoids.

herbaceous: Vegetation layer consisting of herbs.

histosol: Organic soils *i.e.*, soils that contain variable amounts of organic materials (12- 20% organic carbon by weight) to specific depth and thickness requirements.

homogeneous: Of the same or a similar kind or nature, with uniform structure or composition throughout.

horizon, soil: A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the master diagnostic horizons. Lower case subscripts represent subordinate designations.

hydrogeomorphic unit: Hydrogeomorphic units are areas within a wetland assessment area that are relatively homogenous with respect to ecosystem scale characteristics such as microtopography, soil types, vegetative communities, or other factors that influence function. Hydrogeomorphic units may be the result of natural or anthropogenic processes.

hydrologic unit: A distinct hydrologic feature delineated by the Office of Water Data Coordination on the State Hydrologic Unit Maps. Each hydrological unit is identified by a unique eight-digit number.

hydrology: The science that deals with water, its properties, circulation, and distribution on and under the earth’s surface and in the atmosphere.

jurisdictional wetland: Wetlands which meet the hydrologic, soil, and vegetation parameter defined in the 'Corps of Engineers Wetlands Delineation Manual', or its successor.

microtopography: Surface features and roughness imparted by natural processes such as hummocks and down wood.

modal soil profile: A soil profile that represents the average or general soil type that is typical for the area or location of interest.

national wetland inventory (NWI): A Fish and Wildlife Service program designed to map and inventory wetlands of the United States.

native: Indigenous status as listed in the *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1990).

nonpoint source: Nutrients or contaminants that enter wetland and aquatic ecosystems from diffuse, unconfined sources over a greater area, in contrast to a point source from a defined, discrete location. Common non-point sources are agricultural and urban landscapes.

ordinary high water mark (OHW): ". . . that line on the shore established by the fluctuation of water and indicated by physical characteristics such as clear natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding area" (33 CFR Part 328, Section 328.3 (a)(7)(e)).

project area: The area that encompasses all activities related to an ongoing or proposed project.

project assessment area (PAA): The waters/wetland area within the geographic extent of the reference domain to be assessed for impacts.

PAA main cross section: Transect set along a representative reach within the project assessment area (PAA) from which variable assessment areas (VAA) to measure the requisite variables will be established.

percent (%) cover: Relative area covered by a particular strata (*i.e.*, herb, shrub, tree). The total sums to 100% cover.

project standards: Performance criteria and/or specifications used to guide the restoration or creation activities towards the project target. Project standards should include and specify reasonable contingency measures if the project target is not being achieved.

project target: The level of functioning identified or negotiated for a restoration or creation project. The targets must be based on reference standards and/or site potential and consistent with restoration or creation goals. They are used to evaluate whether a project is developing toward reference standards and/or site potential.

reference: The term reference in the context of functional assessment is used as a basis for comparing two or more wetlands of the same subclass. The principle of reference is useful because (1) everyone uses the same standard of comparison, and (2) relative rather than absolute measures allow better resolution, efficiency in time, and consistency in measurements.

reference domain: The area within a defined geographic region from which reference wetlands that belong to a single hydrogeomorphic subclass are sampled. The reference domain may coincide with the geographic region or be a subset of the region.

reference standards: Conditions exhibited by a group of reference wetlands that correspond to the highest level of functioning (highest sustainable capacity) across the suite of functions of the subclass. By definition, highest levels of functioning are assigned an index of 1.0.

reference wetlands: Wetland sites within the reference domain that encompass the known variation of the subclass. They are used to establish the ranges of functions.

restoration: **A.** Returning a modified ecosystem to its pre-modified condition. For example, restoring a tidal connection to a salt marsh isolated by road construction.
B. Taking a former wetland area that had performed wetland functions or is now performing diminished functions, and altering conditions such that the wetland now performs most of its natural (*i.e.,* pre-disturbance) functions.

river left: The left side of a river or stream as one faces down steam.

river right: The right side of a river or stream as one faces down steam.

riverine: Of or pertaining to rivers; HGM class - one of seven geomorphic classes identified in the HGM methodology. The others are lacustrine fringe, estuarine fringe, depressional, organic flats, mineral flats, and slopes.

riverine wetland: Riverine wetlands are long linear features that contain a river bed and bank, and functionally cover the area of the 100-year floodplain. One of several classes of wetlands defined by Cowardin *et. al.* (1979) as systems that include all wetland and deepwater habitats contained within a channel with the exception that the system must not contain ocean derived salts in excess of 0.5ppt and all excludes wetlands dominated by trees shrubs, persistent emergents, emergent mosses, or lichens (palustrine wetlands).

site potential: The highest level of functioning possible, given local constraints of disturbance history, land use, or other factors. Site potential may be equal to or less than levels of functioning established by Reference Standards.

slope wetland: Slope wetlands grade into the flat below where the slope becomes negligible. Hillside seeps or springs are good examples of slope wetlands.

thalweg: Deepest point of a stream channel when viewed in cross-section perpendicular to flow.

tree: Single-stem, woody vegetation with a stem diameter at breast height (DBH) >4 inches that is > 10 ft (3 m) tall.

upland: Topographically higher areas adjacent to waters/wetlands that do not meet the criteria for and are not wetlands themselves.

UTM: The Universal Transverse Mercator global coordinate system.

variable: An attribute or characteristic of a wetland ecosystem or the surrounding landscape that influences the capacity of wetland to perform a function.

variable assessment area (VAA): The survey region for measurement of each variable.

variable condition: Condition of a variable determined through quantitative or qualitative measures.

variable index: A measure of how an assessment model variable in a wetland compares to the reference standards of a regional wetland subclass in a reference domain.

Waters of the United States: "....(a)(1) All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; (2) all interstate waters including interstate wetlands; (3) all other waters such as intrastate lakes, rivers, streams, (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate , or foreign commerce including such waters: (i) Which are or could be used by interstate or foreign travelers for recreational or other purposes; or (ii) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or (iii) Which are used or could be used for industrial purposes by industries in interstate commerce; (4) All impoundments of waters otherwise defined as waters of the United States under this definition. (5) Tributaries of waters identified in paragraphs 1-4 above; (6) The territorial sea: (7) Wetlands adjacent to waters (0ther than waters that are themselves wetlands) identified in paragraphs (a) (1)-(6) of this section; waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of the Clean Water Act (other than cooling ponds defined in 40 CFR Section 423.11(m) which meet the criteria of this definition) are not waters of the United states (404(b)(1) Guidelines - 40 CFR Section 230.3(s))" (33CFR Part 328, Section 328.3 (a)(1)-(6)).

watershed: The area of land from which surface water drains to a single outlet.

wetland: "... those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation, typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Corps Regulation 33 CFR 328.3 and EPA Regulations 40 CFR 230.3). 2) "... lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface of the land is covered by shallow water"

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Appendix A. Minimum Submittal Worksheets

Appendix A. Minimum Submittal Requirements

***Note**: The user has the option to use these 7 worksheets or to present this information in their own format according to their preference. Regardless of the format chosen, be sure that all required information is included in the report.*

REQUIRED WORKSHEET #1: OFFICE PREPARATION

Minimum Submittal Requirements for an HGM Functional Assessment Report

Identify the documents that were collected and reviewed by the assessment team. Include a detailed description of each document (e.g., citation, date, scale, quadrangle name, etc.). If possible, attach copies of each document.

USGS survey, state, county, and other maps (at various scales):
1.____
2.____
3.____

Air photos and other imagery:
1.____
2.____
3.____

Relevant geotechnical, soils, or environmental reports:
1.____
2.____
3.____

Correspondence, construction plans and specifications, *etc*. on the proposed project:
1.____
2.____
3.____

Relevant published literature:
1.____
2.____
3.____

Other documents:
1.____
2.____
3.____

REQUIRED WORKSHEET #2: BOUNDING OF PROPOSED PROJECT AREA AND GEOGRAPHIC EXTENT OF WATERS/WETLANDS

Minimum Submittal Requirements for an HGM Functional Assessment Report

Bound, stratify, and complete mapping of the proposed project area and/or sub-project areas. Confirm and refine all preliminary mapping in the field. This includes:

a. Delineation of the proposed project boundaries.
b. Delineation of the geographic extent of waters/wetlands within the proposed project area.
c. Determination of the proportion(s) and type(s) of waters/wetlands within the project area.
d. Determination of the proportion of waters/wetlands that fall into the subclasses of waters/wetlands addressed by and not addressed by this Operational Draft Guidebook.
e. Estimation of the geographic extent and type of proposed project impact(s)(i.e., preliminary, secondary, and/or cumulative effects).

Location of the Proposed Project: ______________

Sub-basin (Watershed) of the Proposed Project: ______________

1. Area of proposed project: ______________(sq. ft.)

2. Area of waters/wetlands within the proposed project area: ______________(sq. ft.)

3. Total estimated area of water/wetlands and their buffers that will be impacted by the project: ________(sq. ft.)

PRE-FIELD MEASUREMENTS:

6. General description of the type of impacts to waters/wetlands in the proposed project area expected as a result of the proposed project: ____
____
____
____

FIELD MEASUREMENTS:

7. Provide Rationale/Criteria for Identification and Delineation of Waters/Wetlands identified above:
____
____
____
____

8. Method used to estimate areas listed above: ____
____
____
____
____
____

REQUIRED WORKSHEET #3: BOUNDING OF PROPOSED PROJECT AREA AND GEOGRAPHIC EXTENT OF WATERS/WETLANDS

Minimum Submittal Requirements for an HGM Functional Assessment Report

Map or cartoon that includes preliminary delineation of the proposed project area (and/or sub-project areas), aerial extent of waters/wetlands, and estimated areas that will be impacted by the proposed project.

REQUIRED WORKSHEET #4: BOUNDING OF PROPOSED PROJECT AREA AND GEOGRAPHIC EXTENT OF WATERS/WETLANDS

Minimum Submittal Requirements for an HGM Functional Assessment Report

Based on field observations and/or measurements, edit original map or cartoon. The map or cartoon should include a delineation of the proposed project area and/or sub-project areas, aerial extent of waters/wetlands, and estimated areas that will be impacted by the proposed project.

REQUIRED WORKSHEET #5: PRELIMINARY HGM CLASSIFICATION
Minimum Submittal Requirements for an HGM Functional Assessment Report

Identify and document the rationale used for recognizing HGM subclasses of riparian ecosystems in City of Mount Vernon within the proposed project area (or sub-project areas). Show how the project assessment area satisfies the subclass definition provided in the Dichotomous Key (see below). Specifically, include a discussion of the site.

Wetland subclass(es) in the Project Assessment Area:____

1a. The project assessment area does not support and/or is not adjacent or contiguous with a jurisdictional water/wetland as defined in the City of Mount Vernon CAO at 15.40.090.B.1 - 3 and 15.40.110.A.1..**Project assessment area is not a water/ wetland, or adjacent to, or contiguous with a waters/wetland. Guidebook not applicable.**

1b. The assessment area is adjacent to and/or contiguous with a water/wetland as defined in the City of Mount Vernon CAO at 15.40.090.B.1 - 3 and 15.40.110.A.1..**2**

2a. Water/wetland is associated with a stream channel or channel system and/or an active floodplain......................**3 (Riverine Wetland Class)**

3a. Stream channel (longitudinal) slope <1%...................**Low Gradient Skagit River Riverine (Dune-ripple, pool-riffle reach)**

3b. Stream channel (longitudinal) slope 1-2%..................**Low Gradient Riverine (Pool-riffle, plain bed reach)**

3c. Stream channel (longitudinal) slope >2-8%................**Moderate Gradient Riverine (Plain bed, step-pool reach)**

3d. Stream channel (longitudinal) slope 8-25%................**Steep Gradient Riverine (Cascade reach)**

2b. Water/wetland is not associated with a stream channel or channel system and/or active floodplain..........**4**

4a. Water/wetland is located on a hillslope or, if it exists on nearly level terrain, the water/wetland exhibits sloped surface water or shallow subsurface (groundwater) profile..**5 (Slope Wetland Class)**

5a. Water/wetland is located on a hillslope ≤ 200 feet from a stream channel and has a past, present, or future hydrologic connection...................................... **Slope River Proximal**

5b. Water/wetland is located on a hillslope >200 feet from a stream channel and does not have a past, present or future hydrologic connection with a stream channel..**Slope**

4b. Water/wetland is located in a topographic depression. Water/Wetland is not located on a hillslope or, if it exists on nearly level terrain, the water/wetland does not exhibit a sloped surface water or shallow subsurface (groundwater) profile…..................................**6 (Depressional Wetland Class)**

6a. Depression is closed and does not have a permanent or seasonal surface or shallow subsurface drainage outlet..**Closed Depression**

6b. Depression is open and has one or more permanent and/or seasonal surface or shallow subsurface drainage outlets...........................**Flow-Through Depressions**

REQUIRED WORKSHEET #6a: RIVERINE WETLAND VARIABLE SCORE SHEET

Minimum Submittal Requirements for an HGM Functional Assessment Report

Score each of the variables listed on the attached variable score sheet. Separate field forms should be completed for different site conditions (i.e., existing site conditions, proposed site conditions, etc.). On each variable score field form, identify the site conditions that the variable scores are based on. If the scores are based on proposed site conditions, provide a detailed description of the proposed conditions and/or assumptions that were made. Be sure to record rationale or comments on the decision for each variable score.

Site Name: ______________________________ Date: ____________________

HGM Subclass: __________________________ Team:____________________

UTM Coordinates: __________________Northing _________________ Easting

Variable scores based on (*circle one*): ***Existing Site Conditions*** ***Proposed Site Conditions***

	Variable	Measurement	Variable Score	Rationale / Comments for Scoring
1	$V_{BARRIER}$			
2	$V_{FLOODTREE}$			
3	V_{FPAXS}			
4	$V_{GEOFORM}$			
5	V_{HERB}			
6	V_{INLW}			
7	$V_{KEYPIECE}$			
8	V_{LITTER}			
9	$V_{LONGPROF}$			
10	V_{NATIVE}			
11	$V_{OFFCHANWOOD}$			
12	$V_{PATCHAREA}$			
13	$V_{PATCHLATCON}$			
14	$V_{PATCHLONGCON}$			
15	$V_{PATCHNUMBER}$			
16	V_{ROADS}			
17	$V_{RIPBUFFWIDTH}$			
18	V_{SED}			
19	V_{SHADE}			
20	V_{SHRUB}			
21	$V_{SLOPETREE}$			
22	$V_{SOILINTEG}$			
23	V_{STRATA}			
24	V_{TREE}			

REQUIRED WORKSHEET #7a: RIVERINE WETLAND FUNCTIONAL SCORE SHEETS

Minimum Submittal Requirements for an HGM Functional Assessment Report

Calculate the Functional Capacity Indexes (FCI's) for each of the functions listed on the attached functional score field forms. The assessment team members, in the field, should review the calculations and preliminary assessment results. Separate functional score field forms should be completed for each set of scored variables (i.e., based on existing site conditions, proposed site conditions, etc.). Be sure to record rationale or comments on the FCI for each function.

Indices of Functions for Low, Moderate, and Steep Gradient Riverine Waters/Wetlands in Mount Vernon, Washington

Function	Formulae	Functional Capacity Index	Rationale / Comments for Scoring Functional Capacity Index
A. Hydrology			
1. Surface and Ground Water Storage and Exchange	$(V_{FPAXS} + V_{SOILINTEG})/2$		
2. Surface Water Flow	$[V_{FPAXS} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{LONGPROF}]/3$		
3. Channel Migration	$(V_{FPAXS} + V_{INLW} + V_{KEYPIECE} + V_{TREE} + V_{SHRUB})/5$		
B. Biogeochemistry			
4. Cycling of Elements and Compounds	$[V_{OFFCHANWOOD} + V_{LITTER} + (V_{SOILINTEG} + V_{SED})/2 + (V_{TREE} + V_{HERB} + V_{SHRUB})/3]/4$		
5. Detention of Imported Elements and Compounds	$(V_{RIPBUFFWIDTH} + (V_{SOILINTEG} + V_{SED})/2 + (V_{HERB} + V_{SHRUB} + V_{TREE})/3)/3$		
6. Detention of Particulates	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{SED} + V_{GEOFORM} + V_{FPAXS}]/4$		
7. Organic Carbon Export	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{SOILINTEG}]/2$		

REQUIRED WORKSHEET #7a: RIVERINE WETLAND FUNCTIONAL SCORE SHEETS (cont.)

Function	Formulae	Functional Capacity Index	Rationale / Comments for Scoring Functional Capacity Index
C. Plant Community			
8. Plant Community	**For Steep Gradient waters/wetlands use:** $[(V_{SHRUB} + V_{TREE})/2 + V_{SLOPETREE} + V_{NATIVE} + V_{STRATA}]/4$ **For Low & Moderate Gradient waters/wetlands use:** $[(V_{SHRUB} + V_{TREE})/2 + V_{FLOODTREE} + V_{NATIVE} + V_{STRATA}]/4$		
9. Detrital Biomass	$(V_{LITTER} + V_{OFFCHANWOOD} + V_{KEYPIECE} + V_{INLW})/4$		
D. Faunal Support			
10. Spatial Structure of Habitats	**For Steep Gradient waters/wetlands, use:** $((V_{SHRUB} + V_{HERB})/2 + V_{STRATA} + V_{NATIVE} + V_{RIPBUFFWIDTH} + V_{LONGPROF})/5$ **For Low & Moderate Gradient waters/wetland, use:** $((V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{NATIVE} + V_{STRATA} + V_{RIPBUFFWIDTH} + V_{GEOFORM} + V_{LONGPROF})/6$		
11. Interspersion andConnectivity of Habitats	$[V_{FPAXS} + (V_{PATCHNUMBER} + V_{PATCHAREA})/2 + (V_{PATCHLONGCON} + V_{PATCHLATCON})/2 + V_{ROADS}]/4$		
12. Anadromous & Resident Fish Habitat	**For Steep Gradient waters/wetlands, use:** $[V_{BARRIER} + (V_{KEYPIECE} + V_{INLW})/2 + (V_{FPAXS} + V_{SHADE} + V_{TREE})/3]/3$ **For Moderate Gradient waters/wetlands, use:** $\{V_{BARRIER} + [V_{FPAXS} + V_{SHADE} + (V_{SLOPETREE} + V_{FLOODTREE}/2)]/3 + V_{GEOFORM} + V_{KEYPIECE} + V_{INLW}\}/5$ **For Low Gradient waters/wetlands, use:** $[V_{BARRIER} + (V_{FPAXS} + V_{SHADE} + V_{FLOODTREE})/3 + V_{GEOFORM} + V_{KEYPIECE} + V_{INLW}]/5$		

REQUIRED WORKSHEET #6b: SLOPE AND SLOPE RIVERINE PROXIMAL WETLAND VARIABLE SCORE SHEET

Minimum Submittal Requirements for an HGM Functional Assessment Report

Score each of the variables listed on the attached variable score sheet. Separate field forms should be completed for different site conditions (i.e., existing site conditions, proposed site conditions, etc.). On each variable score field form, identify the site conditions that the variable scores are based on. If the scores are based on proposed site conditions, provide a detailed description of the proposed conditions and/or assumptions that were made. Be sure to record rationale or comments on the decision for each variable score.

Site Name: ______________________________ Date: ____________________

HGM Subclass: __________________________ Team:____________________

UTM Coordinates: ___________________Northing __________________ Easting

Variable scores based on (*circle one*): ***Existing Site Conditions*** ***Proposed Site Conditions***

	Variable	Measurement	Variable Score	Rationale / Comments for Scoring
1	$V_{BUFFWIDTH}$			
2	$V_{BUFFCOND}$			
3	$V_{BUFFCONTIG}$			
4	V_{HERB}			
5	V_{LWOOD}			
6	V_{LITTER}			
7	V_{MICRO}			
8	V_{NATIVE}			
9	$V_{PATCHAREA}$			
10	$V_{PATCHLATCON}$			
11	$V_{PATCHNUMBER}$			
12	V_{SHRUB}			
13	$V_{SOILINTEG}$			
14	V_{STRATA}			
15	V_{SUBOUT}			
16	V_{SURFIN}			
17	V_{TREE}			

REQUIRED WORKSHEET #7b: SLOPE AND SLOPE RIVERINE PROXIMAL WETLAND FUNCTIONAL SCORE SHEETS

Minimum Submittal Requirements for an HGM Functional Assessment Report

Calculate the Functional Capacity Indexes (FCI's) for each of the functions listed on the attached functional score field forms. The assessment team members in the field, should review the calculations and preliminary assessment results. Separate functional score field forms should be completed for each set of scored variables (i.e., based on existing site conditions, proposed site conditions, etc.). Be sure to record rationale or comments on the FCI for each function.

Indices of Functions for Slope and Slope Riverine Proximal Waters/Wetlands in Mount Vernon, Washington

Function	Formulae	Functional Capacity Index	Rationale / Comments for Scoring Functional Capacity Index
A. Hydrology			
1. Surface and Subsurface Water Storage and Exchange	$[V_{SOILINTEG} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{MICRO} + (V_{SURFIN} + V_{SUBOUT})/2]/4$		
2. Landscape Hydrologic Connections	$[(V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + V_{SOILINTEG} + V_{SURFIN} + V_{MICRO} + V_{SUBOUT}]/5$		
B. Biogeochemistry			
3. Cycling of Elements and Compounds	$[V_{LWOOD} + V_{LITTER} + (V_{TREE} + V_{HERB} + V_{SHRUB})/3 + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$		
4. Retention and Detention of Particulates	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3) + V_{MICRO} + V_{SURFIN} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$		
5. Organic Carbon Export	$[V_{LITTER} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{SOILINTEG} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$		
C. Plant Community			
6. Plant Community	$[(V_{SHRUB} + V_{HERB} + V_{TREE})/3 + V_{NATIVE} + V_{STRATA}]/3$		
7. Detrital System	$[V_{LITTER} + V_{LWOOD} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3]/3$		
D. Faunal Support			
8. Spatial Structure of Habitats	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{STRATA} + V_{MICRO} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$		
9. Interspersion and Connectivity of Habitats	$[(V_{PATCHNUMBER} + V_{PATCHAREA})/2 + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + V_{PATCHLATCON}]/3$		

REQUIRED WORKSHEET #6c: DEPRESSIONAL WETLAND VARIABLE SCORE SHEET

Minimum Submittal Requirements for an HGM Functional Assessment Report

Score each of the variables listed on the attached variable score sheet. Separate field forms should be completed for different site conditions (i.e., existing site conditions, proposed site conditions, etc.). On each variable score field form, identify the site conditions that the variable scores are based on. If the scores are based on proposed site conditions, provide a detailed description of the proposed conditions and/or assumptions that were made. Be sure to record rationale or comments on the decision for each variable score.

Site Name: ______________________________ Date: ____________________
HGM Subclass: __________________________ Team:____________________
UTM Coordinates: __________________Northing __________________ Easting
Variable scores based on (*circle one*): ***Existing Site Conditions*** ***Proposed Site Conditions***

	Variable	Measurement	Variable Score	Rationale / Comments for Scoring
1	$V_{BUFFWIDTH}$			
2	$V_{BUFFCOND}$			
3	$V_{BUFFCONTIG}$			
4	V_{HERB}			
5	V_{LITTER}			
6	V_{NATIVE}			
7	V_{OUT}			
8	$V_{PATCHAREA}$			
9	$V_{PATCHNUMBER}$			
10	$V_{SEDIMENT}$			
11	V_{SHRUB}			
12	$V_{SOILINTEG}$			
13	V_{STRATA}			
14	V_{TREE}			

REQUIRED WORKSHEET #7c: DEPRESSIONAL WETLAND FUNCTIONAL SCORE SHEETS

Minimum Submittal Requirements for an HGM Functional Assessment Report

Calculate the Functional Capacity Indexes (FCI's) for each of the functions listed on the attached functional score field forms. The assessment team members, in the field, should review the calculations and preliminary assessment results. Separate functional score field forms should be completed for each set of scored variables (based on existing site conditions, proposed site conditions, etc.). Be sure to record rationale or comments on the FCI for each function.

Indices of Functions for Depressional Waters/Wetlands in Mount Vernon, Washington

Function	Formulae	Functional Capacity Index	Rationale / Comments for Scoring Functional Capacity Index
A. Hydrology			
1. Surface & Shallow Subsurface Water Storage & Exchange	$[V_{SOILINTEG} + V_{OUT} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + (V_{HERB} + V_{SHRUB} + V_{TREE})/3]/4$		
B. Biogeochemistry			
2. Cycling of Elements and Compounds	$[V_{SEDIMENT} + V_{SOILINTEG} + V_{LITTER} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/4$		
3. Retention and Detention of Particulates	$[V_{OUT} + V_{SEDIMENT} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/3$		
4. Retention and Detention of Imported Elements & Compounds	$[V_{SOILINTEG} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3]/2$		
C. Plant Community			
5. Plant Community	$[(V_{SHRUB} + V_{HERB} + V_{TREE})/3 + V_{NATIVE} + V_{STRATA}]/3$		
6. Detrital System	$[V_{LITTER} + V_{SOILINTEG} + (V_{TREE} + V_{SHRUB} + V_{HERB})/3]/3$		
D. Faunal Support			
7. Spatial Structure of Habitats	$[(V_{TREE} + V_{SHRUB} + V_{HERB})/3 + V_{STRATA} + (V_{BUFFWIDTH} + V_{BUFFCONTIG} + V_{BUFFCOND})/3 + (V_{PATCHAREA} + V_{PATCHNUMBER})/2]/4$		

APPENDIX B

Optional Data Collection Worksheets: Riverine Wetlands

Note: Completion of the Data Collection Worksheet is optional. However, the assessor should be prepared to justify and rationalize their scaling determinations recorded in Appendix A.

To be completed in the office:

1. Patch Area ($V_{PATCHAREA}$)

Percent Class 1 habitat area ____
Percent Class 2 habitat area ____
Total Class 1 and 2 habitat area ____

Scaling (0-1) ____

2. Habitat Patch Lateral Contiguity ($V_{PATCHLATCON}$)

No. of habitat type changes ____

Scaling (0-1) ____

3. Habitat Patch Longitudinal Contiguity ($V_{PATCHLONGCON}$)

No. of habitat type changes ____

Scaling (0-1) ____

4. Patch Number ($V_{PATCHNUMBER}$)

No. of Class 1 patches ____
No. of Class 2 patches ____

Scaling (0-1) ____

5. Roads (V_{ROADS})

No. of road nodes ____

Scaling (0-1) ____

Optional Data Collection Worksheets: Riverine Wetlands (contd.)

To be completed in the field:

1. Barriers to Fish Passage ($V_{BARRIER}$)

	Barriers According to City of Mt Vernon
Upstream	____________________
Downstream	____________________

	Barriers Observed in Field
500' upstream	____________________
500' downstream	____________________

$V_{BARRIER}$
Scaling (0-1) ____

2. Sediment Sources (V_{SED})

	Direct and indirect sources of sediment
Upstream	____________________
Downstream	____________________

V_{SED}
Scaling (0-1) ____

3. Flood Prone Area Trees ($V_{FLOODTREE}$)

No. conifers in each semi-circle

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Total ____

No. deciduous in each semi-circle

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Total ____

No. trees (total conifers + total deciduous) ____

Percent coniferous ((total conifers/no. trees) x 100) ____
Percent deciduous ((total deciduous/no. trees) x 100) ____

$V_{FLOODTREE}$
Scaling (0-1) ____

4. Tree Canopy Coverage (V_{TREE})

Percent cover

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{TREE}
Scaling (0-1) ____

Optional Data Collection Worksheets: Riverine Wetlands (contd.)

5. Shrub Canopy Cover (V_{SHRUB})

Percent shrub cover

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{SHRUB}
Scaling (0-1) ____

6. Herbaceous Cover (V_{HERB})

Percent cover in each plot

____ ____ ____ ____ ____ ____ Average ____

V_{HERB}
Scaling (0-1) ____

7. Litter and Fine Woody Debris (V_{LITTER})

Percent cover litter in each plot

____ ____ ____ ____ ____ ____ Average ____

Litter cover class number ____

Percent cover FWD in each plot

____ ____ ____ ____ ____ ____ Average ____

FWD cover class number ____

Litter/FWD index (sum cover class numbers) ____

V_{LITTER}
Scaling (0-1) ____

8. In-Channel Large Wood (V_{INLW})

\# pieces ____
\# feet surveyed ____
\# pieces/no. ft ____ x 330 = # pieces/330 ft
\# pieces/330 ft ____

V_{INLW}
Scaling (0-1) ____

9. Key Piece ($V_{KEPIECE}$)

\# pieces ____
\# feet surveyed ____
\# pieces/no. ft ____ x 330 = #. pieces/330 ft
\# pieces/330 ft ____

$V_{KEYPIECE}$
Scaling (0-1) ____

Optional Data Collection Worksheets: Riverine Wetlands (contd.)

10. Shade Over the Stream Channel (V_{SHADE})

	U.S. right	U.S. left	D.S. right	D.S. left
Percent canopy cover	____	____	____	____
Overhang distance	____	____	____	____

Average channel width ____
Average percent canopy cover ____
Average overhang distance ____

V_{SHADE}
Scaling (0-1) ____

11. Flood Prone Area Cross-Section (V_{FPAXS})

Notes ____
____

V_{FPAXS}
Scaling (0-1) ____

12. Geomorphic Form ($V_{GEOFORM}$)

Notes ____
____

$V_{GEOFORM}$
Scaling (0-1) ____

13. Longitudinal Profile ($V_{LONGPROF}$)

Notes ____
____

$V_{LONGPROF}$
Scaling (0-1) ____

14. Percentage of Native Vegetation (V_{NATIVE})

List 5 dominant species in each strata and record native/non-native status

Tree spp.	Status	Shrub spp.	Status	Herb spp.	Status
____________	_____	____________	_____	____________	_____
____________	_____	____________	_____	____________	_____
____________	_____	____________	_____	____________	_____
____________	_____	____________	_____	____________	_____
____________	_____	____________	_____	____________	_____

No. native sp. ____ Total dominant sp. ____ Percent native sp. ____

V_{NATIVE}
Scaling (0-1) ____

Optional Data Collection Worksheets: Riverine Wetlands (contd.)

15. Off-Channel Large Wood ($V_{OFFCHANWOOD}$)

No. pieces in each plot ____ ____ ____ ____ ____ ____

Average ____

$V_{OFFCHANWOOD}$
Scaling (0-1) ____

16. Soil Profile Integrity ($V_{SOILINTEG}$)

Soil Pit #1

Horizon	Depth	Soil Color	Texture
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

Soil Pit #2

________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

$V_{SOILINTEG}$
Scaling (0-1) ____

17. Vegetative Strata (V_{STRATA})

No. strata (1-3)

____ ____ ____ ____ ____ ____ ____ ____ ____ ____
____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{STRATA}
Scaling (0-1) ____

Optional Data Collection Worksheets: Riverine Wetlands (contd.)

18. Hillslope Trees ($V_{SLOPETREE}$)

Stem density protocol:

No. conifers in each plot
____ ____ ____ ____ ____ ____ Average ____

No. deciduous in each plot
____ ____ ____ ____ ____ ____ Average ____

Average percent coniferous cover ____
Average percent deciduous cover ____

$V_{SLOPETREE}$
Scaling (0-1) ____

Optional Data Collection Worksheets: Slope and Slope Riverine Proximal Wetlands

Note: Completion of the Data Collection Worksheets is optional. However, the assessor should be prepared to justify and rationalize their scaling determinations recorded in Appendix A.

To be completed in the office:

Variable # 9. Patch Area ($V_{PATCHAREA}$)

Percent Class 1 habitat area ____
Percent Class 2 habitat area ____
Total Class 1 and 2 habitat area ____

Scaling (0-1) ____

Variable # 10. Habitat Patch Lateral Contiguity ($V_{PATCHLATCON}$)

No. of habitat type changes ____

Scaling (0-1) ____

Variable #11. Patch Number ($V_{PATCHNUMBER}$)

No. of Class 1 patches ____
No. of Class 2 patches ____

Scaling (0-1) ____

Optional Data Collection Worksheets: Slope and Slope Riverine Proximal Wetlands (contd.)

Variables to be scaled in the field:

Variable #1. Buffer Width ($V_{BUFFWIDTH}$)

Washington Wetland Rating Category ____ Standard Buffer Width ____

Forest canopy width ____ ____ ____ ____ ____ ____
Shrub/herb canopy width ____ ____ ____ ____ ____ ____

Average ____

$V_{BUFFWIDTH}$
Scaling (0-1) ____

Variable #2. Buffer Condition ($V_{BUFFCOND}$)
Washington Wetland Rating Category ____ Standard Buffer Width ____

	Buffer Width	**CONDITION** (Forest/Shrub/Herb/Disturbed/Impervious)
Up-gradient	____	______________________________
Down-gradient	____	______________________________
Perpendicular angle 1	____	______________________________
Perpendicular angle 2	____	______________________________

AVERAGE ____ **OVERALL** ______________________________

$V_{BUFFCOND}$
Scaling (0-1) ____

Variable #3. Buffer Contiguity ($V_{BUFFCONTIG}$)

Washington Wetland Rating Category ____ Standard Buffer Width ____

Proportion of wetland surrounded by an intact forested buffer ____
Proportion of wetland surrounded by a vegetated buffer ____
Proportion of wetland edge which is disturbed/developed/unvegetated area ____

$V_{BUFFCONTIG}$
Scaling (0-1) ____

Optional Data Collection Worksheets: Slope and Slope Riverine Proximal Wetlands (contd.)

Variable #4. Herbaceous Cover (V_{HERB})

Percent cover in each plot

____ ____ ____ ____ ____ ____ Average ____

V_{HERB}
Scaling (0-1) ____

Variable #5. Large Wood (V_{WOOD})

No. pieces in each plot ____ ____ ____ ____ ____ ____

Average ____

V_{WOOD}
Scaling (0-1) ____

Variable #6. Litter and Fine Woody Debris (V_{LITTER})

Percent cover litter in each plot

____ ____ ____ ____ ____ ____ Average ____

Litter cover class number ____

Percent cover FWD in each plot

____ ____ ____ ____ ____ ____ Average ____

FWD cover class number ____

Litter/FWD index (sum cover class numbers) ____

V_{LITTER}
Scaling (0-1) ____

Variable #7. Microtopographic Relief (V_{MICRO})

Record evidence of microtopographic variation (*i.e.*, windthrow, logs, hummocks, microdepressions, bunch grasses, etc.) ____

____

____

Record evidence of anthropogenic disturbance ________________________________

____

____

V_{MICRO}
Scaling (0-1) ____

Optional Data Collection Worksheets: Slope and Slope Riverine Proximal Wetlands (contd.)

Variable #8. Percentage of Native Vegetation (V_{NATIVE})

Dom. tree spp.	Dom. shrub spp.	Dom. herb spp.
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

No. native sp. ____ Total dominant sp. ____ Percent native sp. ____

V_{NATIVE}
Scaling (0-1) ____

Note: Variable #9/10/11. Patch area, lateral contiguity and number are answered in office.

Variable # 12. Shrub Canopy Cover (V_{SHRUB})

Percent shrub cover

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{SHRUB}
Scaling (0-1) ____

Variable #13. Soil Profile Integrity ($V_{SOILINTEG}$)

Soil Pit #1

Horizon	Depth	Soil Color	Texture
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________

Soil Pit #2

____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________

$V_{SOILINTEG}$
Scaling (0-1) ____

Optional Data Collection Worksheets: Slope and Slope Riverine Proximal Wetlands (contd.)

Variable #14. Vegetative Strata (V_{STRATA})

No. strata (1-3)

____ ____ ____ ____ ____ ____ ____ ____ ____ ____
____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{STRATA}
Scaling (0-1) ____

Variable #15. Subsurface Flow Out (V_{SUBOUT})

Subsurface hydraulic connections:

Type	No.
____________________	____
____________________	____
____________________	____
____________________	____
____________________	____
____________________	____

V_{SUBOUT}
Scaling (0-1) ____

Variable #16. Surface Water In (V_{SURFIN})

Surface hydraulic connections:

Type	No.
____________________	____
____________________	____
____________________	____
____________________	____
____________________	____
____________________	____

V_{SURFIN}
Scaling (0-1) ____

Variable #17. Tree Canopy Coverage (V_{TREE})

Percent cover

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{TREE}
Scaling (0-1) ____

Optional Data Collection Worksheets: Depressional Wetlands

Note: Completion of Data Collection Worksheet is optional. However, the assessor should be prepared to justify and rationalize their scaling determinations recorded in Appendix A.

To be completed in the office:

Variable #8. Patch Area ($V_{PATCHAREA}$)

Percent Class 1 habitat area ____
Percent Class 2 habitat area ____
Total Class 1 and 2 habitat area ____

Scaling (0-1) ____

Variable #9. Patch Number ($V_{PATCHNUMBER}$)

No. of Class 1 patches ____
No. of Class 2 patches ____

Scaling (0-1) ____

Variable #1. Buffer Width ($V_{BUFFWIDTH}$)

Washington Wetland Rating Category ____ Standard Buffer Width ____

Forest canopy width ____ ____ ____ ____ ____ ____
Shrub/herb canopy width ____ ____ ____ ____ ____ ____

Average ____

$V_{BUFFWIDTH}$
Scaling (0-1) ____

Variable #2. Buffer Condition ($V_{BUFFCOND}$)
Washington Wetland Rating Category ____ Standard Buffer Width ____

	Buffer Width	**CONDITION** (Forest/Shrub/Herb/Disturbed/Impervious)
Up-gradient	____	________________________
Down-gradient	____	________________________
Perpendicular angle 1	____	________________________
Perpendicular angle 2	____	________________________
AVERAGE	____	**OVERALL** ________________________

$V_{BUFFCOND}$
Scaling (0-1) ____

Optional Data Collection Worksheets: Depressional Wetlands (contd.)

Variable #3. Buffer Contiguity ($V_{BUFFCONTIG}$)

Washington Wetland Rating Category ____ Standard Buffer Width ____

Proportion of wetland surrounded by an intact forested buffer ____
Proportion of wetland surrounded by a vegetated buffer ____
Proportion of wetland edge which is disturbed/developed/unvegetated area ____

$V_{BUFFCONTIG}$
Scaling (0-1) ____

Variable #4. Herbaceous Cover (V_{HERB})

Percent cover in each plot
____ ____ ____ ____ ____ ____ Average ____

V_{HERB}
Scaling (0-1) ____

Variable #5. Litter and Fine Woody Debris (V_{LITTER})

Percent cover litter in each plot
____ ____ ____ ____ ____ ____ Average ____
Litter cover class number ____

Percent cover FWD in each plot
____ ____ ____ ____ ____ ____ Average ____
FWD cover class number ____

Litter/FWD index (sum cover class numbers) ____

V_{LITTER}
Scaling (0-1) ____

Variable #6. Percentage of Native Vegetation (V_{NATIVE})

Dom. tree spp.	Dom. shrub spp.	Dom. herb spp.
______________	______________	______________
______________	______________	______________
______________	______________	______________
______________	______________	______________
______________	______________	______________
______________	______________	______________

No. native sp. ____ Total dominant sp. ____ Percent native sp. ____

V_{NATIVE}
Scaling (0-1) ____

Optional Data Collection Worksheets: Depressional Wetlands (contd.)

Variable #7. Outlet (V_{OUT})
Is the wetland an…
Open Depression? ___________ or Closed Depression? ___________
Is an outlet present? ___________
Has the outlet been artificially raised or lowered? By how much? (*e.g.,* What is maximum depth of depression? What is depth of outlet?) _________________________

____

V_{OUT} Scaling (0-1) ____

Note: Variables#8 and 9 are scaled in office (see above).

Variable # 10. Sediment Deposition ($V_{SEDIMENT}$)

List evidence for sediment sources in the

____

____

$V_{SEDIMENT}$ Scaling (0-1) ____

Variable # 11. Shrub Canopy Cover (V_{SHRUB})

Percent shrub cover

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{SHRUB} Scaling (0-1) ____

Variable #12. Soil Profile Integrity ($V_{SOILINTEG}$)

Soil Pit #1

Horizon	Depth	Soil Color	Texture
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________

Soil Pit #2

____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________

$V_{SOILINTEG}$ Scaling (0-1) ____

Optional Data Collection Worksheets: Depressional Wetlands (contd.)

Variable #13. Vegetative Strata (V_{STRATA})

No. strata (1-3)

____ ____ ____ ____ ____ ____ ____ ____ ____ ____
____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{STRATA} Scaling (0-1) ____

Variable #14. Tree Canopy Coverage (V_{TREE})

Percent cover

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Average ____

V_{TREE} Scaling (0-1) ____