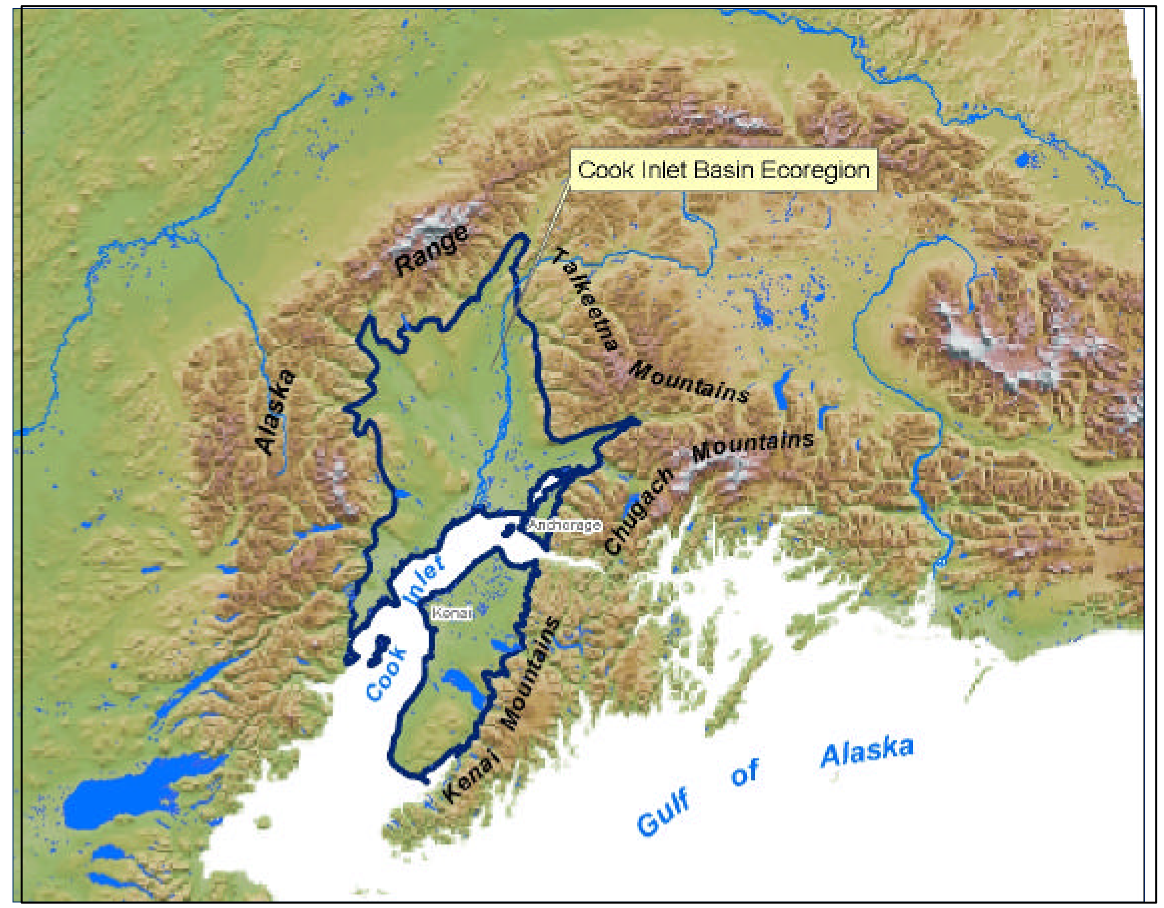
Wetland Functional Assessment Guidebook

Operational Draft Guidebook for Assessing the Functions of Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecoregion, Alaska, using the HGM Approach



by:

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June 2003

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This document should be cited as: Hall, J. V., Powell, J. E., Carrack, S., Rockwell, T., Hollands, G., Walter, T., and White, J., 2003. "Wetland Functional Assessment Guidebook, Operational Draft Guidebook for Assessing the Functions of Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecoregion Alaska, using the HGM Approach," State of Alaska Department of Environmental Conservation / U.S. Army Corps of Engineers Waterways Experiment Station Technical Report: WRP-DE-__ .

Acknowledgments

The development of hydrogeomorphic models requires extraordinary cooperation among many different individuals with diverse knowledge and backgrounds. Expertise in wetland ecology, soil science, hydrology, plant ecology, fish and wildlife biology, statistics, land use, and other disciplines is needed to produce scientifically sound models that form the basis of the hydrogeomorphic (HGM) functional assessment methodology. In addition, building an HGM model requires skilled personnel, funding, and management since a project usually involves many agencies (state, federal, tribal and local) and private organizations. The agencies and groups providing direct funding, personnel, and logistic support for this guidebook include:

U.S. Environmental Protection Agency (EPA)
Alaska Department of Environmental Conservation (ADEC)
Alaska Department of Fish and Game (ADF&G)
Alaska Department of Natural resources (ADNR)
Kenai Peninsula Borough (KPB)
U.S. Fish and Wildlife Service (FWS)
U.S. Army Corps of Engineers (COE)
U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS)

The EPA Alaska Operations Office provided the majority of the funding for this project through ADEC.

The authors wish to thank those who provided invaluable technical support in the field data collection efforts in July, 1997: Ms. Sheila Kratzer (FWS), Mr. Roy Ireland (ADNR), Mr. Mohammad Nash (NRCS), Mr. Mike Gracz (NRCS), Mr. Phil North (EPA), Ms. Ginny Litchfield (ADF&G), Ms. Mary King (ADF&G), and Mr. Keith Boggs (Alaska Natural Heritage Program, ENRI, UAA). The Kenai Peninsula Borough provided significant logistic and technical support. The Borough provided the field team with lodging at the Hansen House in Soldotna, meeting facilities in the Assembly Chambers, and GIS as well as administrative support. Our special thanks go to Ms. Lisa Parker, Ms. Glenda Landau, Mr. Chris Clough, and Ms. Rachel Clark of the Kenai Peninsula Borough.

Further thanks are due to the Alaska Department of Natural Resources, and the members of the Kenai River Special Management Area Board for the opportunity to participate in improving wetland management in an area with unique and extremely rich natural resources.

Additional logistic support was provided by Ms. Anne Rappoport and Ms. Laurie Fairchild of the U.S. Fish and Wildlife Service Western Alaska Ecological Services Office. The use of their vehicle and boat was greatly appreciated.

The authors also wish to thank Mr. Buddy Clairain, U.S. Army Corps of Engineers, Waterways Experiment Station (COE/WES), for guidance with national standards and technical advice.

This guidebook draws from the "Regional Guidebook for Assessing the Function of Low Gradient, Riverine Wetlands in Western Kentucky," for format and we thank Mr. Bill Ainslie (EPA), one of its principal authors, for his generous advice and assistance.

This guidebook also uses parts of "The Operational Draft HGM Guidebook for Wetlands on Precipitation Driven on Discontinuous Permafrost in Interior Alaska," and "The Slope Wetlands Peer Review Draft for Slope Wetlands in Coastal Southeast and Southcentral Alaska." We thank the authors of those guidebooks for their work and assistance. The contributions of Dr. Mark Brinson and Dr. Dennis Whigham provided in HGM Workshops held in Alaska in 1996 and 1997, and their advice throughout the development of this guidebook, are gratefully acknowledged. Finally, the field work and experience provided from Dr. Lyndon C. Lee, Mr. Bill Kleindl, Mr. Mark Rains, Ms. Lisa Shaw, and. Dr. Jan Cassin of the National Wetland Science and Training Cooperative (NWSTC) was invaluable to the Kenai HGM project. The NWSTC experience in similar projects formed the backbone of the data collection work in the Kenai study.

Disclaimer

This document is an Operational Draft Guidebook developed specifically to assist in the application of an HGM functional assessment model in precipitation/shallow ground water driven slope/flat complexes in the Cook Inlet Basin Ecoregion. It is intended to be used in its present form consistent with the *National Action Plan to Develop the Hydrogeomorphic Approach for Assessing Wetland Functions (Federal Register*, August 16, 1996 (Vol. 61, No. 160, pp. 42593-42603)). The Operational Draft Guidebook will be used and reviewed for a two-year period by regulatory and resource agencies. Other agencies with interest or responsibility for wetland regulation and management, non-governmental organizations, and other parties will have an opportunity to use the Operational Draft Guidebook during this two-year period and to provide recommendations for improvement.

After the Operational Draft Guidebook has been used in the field for two years it may be revised incorporating comments and corrections identified by the Guidebook Development Team. The revised Operational Draft Guidebook will be reviewed and approved by the COE/WES as a Final Guidebook.

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1. Introduction

The State of Alaska includes 63% of the nation's wetland ecosystems (Hall *et al.* 1994). Activities in these wetlands and their associated waters (hereafter "wetlands") are regulated under federal, state, and local ordinances because these ecosystems have been shown to perform vital and valuable physical, chemical, and biological functions. As a consequence of their functioning, Alaska's wetlands help to support the state's diverse human communities, fish and wildlife populations, water resources, and economy.

In addition to being valuable, Alaska's wetlands are highly variable. They include salt and freshwater areas influenced by tides, temperate rain forests, bogs, moist and wet tundra, extensive rivers and streams, large river deltas, and vast areas of black spruce forested wetland.

To ensure that Alaska's wetlands continue to be managed wisely, wetland professionals and policy makers need regionally based, scientifically valid, consistent, and efficient, rapid functional assessment tools. These assessment tools need to be developed in a manner that helps managers and users recognize and distinguish between naturally variable conditions and those changes in the functioning of Alaska's wetlands that result from human activities. In addition to being able to detect changes in functioning, effective and properly structured assessment methods should include steps that ensure consistent technical and administrative approaches for completing assessments and documenting results. Such consistency provides the foundation for scientifically based assessments that, in turn, provide the technical input to ecosystem and watershed protection programs, and restoration projects.

To date, there have been no widely accepted methods developed for Alaska's wetlands that accurately and consistently provide the means by which changes in ecosystem functions, including both gains and losses, may be assessed. The public, resource agencies, schools, and non-governmental organizations such as the Kenai River Watershed Forum and the Cook Inlet Keeper are all interested in wetlands in the Lower Kenai River drainage basin. Many of these wetlands are directly linked to the Kenai River. In 1984, the Kenai Peninsula Borough and the Alaska Department of Natural Resources developed a Kenai River Comprehensive Plan. This plan was initiated because of development conflicts and intensive use of the Kenai River. In 1998, as part of the revisions to this plan, the Alaska Department of Environmental Conservation (ADEC) was asked to continue assessing the Kenai River wetlands. As the plan states, ADEC was to "continue the Kenai River Wetlands Assessment under preparation by ADEC, to determine sensitive, high value wetlands critical to habitat and hydrological functions and develop a general wetlands management strategy based on the results of this assessment." (Kenai River Comprehensive Management Plan 1998 – Chapter 4 Study Area Recommendation 4.5.5.9).

In response to this need, the ADEC (with other cooperating state and federal agencies and organizations) stepped forward and initiated a broad-based, statewide effort to develop a functional assessment approach for Alaskan wetlands. It is called the Hydrogeomorphic Approach (HGM). HGM was selected by ADEC and several other cooperating agencies and organizations because it offers a relatively rapid, efficient, and reference-based method of assessment that allows users to recognize human-induced changes in the functions of wetland ecosystems (Brinson 1993, Brinson *et al*. 1995). The HGM method departs from other functional assessment approaches in that it is based on (1) recognition of differences among wetlands (*i.e.*, classification) , (2) identification of functions performed by classes and subclasses of wetlands, and (3) regionally-developed reference systems (Brinson 1996, Brinson 1995).

Three groups of wetland experts and other assisting personnel (Tables 1 and 2) collected information and field data and developed the assessment models and framework upon which this document was built. This document, the "Operational Draft Guidebook" (hereafter "guidebook") was developed from three previous draft documents. The first draft was developed, revised and field-tested by the authors during spring 2000. A second draft was developed by incorporating results from the field testing. The second draft was then peer-reviewed and field-tested again in summer 2001. Peer review comments and field testing were then incorporated into this document.

2003 Revisions – Expansion to the Cook Inlet Basin Ecosystem

The applicability of this guidebook or "Reference Domain" has been expanded beyond the Lower Kenai River Basin Study Area to include the Cook Inlet Basin Ecoregion. The expansion is based upon field tests that occurred in two locations in the Anchorage area on June 21, 2002 and on the authors' best professional judgement. Considering the expanded field tested area and author's best professional judgement, the 2002 Operational Guidebook has been renamed to reflect the applicability of the models to the Cook Inlet Basin Ecosystem. This version of the guidebook contains no major changes from the 2002 Operational Draft with the exception of a few minor edits.

Table 1. **Development Team Members**

Group	Group Members and Affiliation
Field Assessment Group	Jon Hall, Team Leader (FWS), Jim Powell (ADEC), Ted Rockwell (EPA), Stan Carrick (ADNR), Roy Ireland (ADNR), Doug Van Patton (NRCS), Sheila Kratzer (FWS), Phil North (EPA), Keith Boggs (Alaska Natural Heritage Program), Michele Brown (The Nature Conservancy), Ginny Litchfield (ADF&G), Mary King (ADF&G), Joe White (NRCS), Mike Gracz (NRCS), and Laurie Fairchild (FWS)
NWSTC "National Group"	Garry Hollands, Lyndon Lee, and Dennis Whigham
NWSTC "Technical Group"	Bill Kleindl, Mark Rains, Jan Cassin, and Lisa Shaw

Table 2. **Personnel who contributed to the development of the guidebook**

Agency Personnel	Michael Crotteau (ADEC), Chris Kent (ADEC), Lisa Parker, Planning Director (KPB), Glenda Landau (KPB), and Rachel Clark (KPB).
Computer & Technical.	Amanda Thompson (ADEC) and Chris Kent (ADEC)

2. Overview of the Hydrogeomorphic Approach

There are three essential elements to the HGM approach of assessing the functions of wetlands (Brinson 1993, Brinson 1995, and Brinson 1996). The first is classification of wetlands based on hydrogeomorphic factors. The second is identification, definition, and description of the functions for the subclass of wetlands under consideration. The third is 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. Assessment protocol was added as a fourth element to this Guidebook. Procedures for development of guidebooks that incorporate the essential elements of HGM and synthesize them into a standardized assessment approach for a particular subclass of wetlands have been outlined by the EPA and U.S. Army Corps of Engineers (*e.g.* Brinson 1993, Smith *et al.* 1995, U. S. Army Corps of Engineers 1997). Each of the four elements of the HGM Approach is discussed below.

A. Hydrogeomorphic Classification

The first essential element of the HGM Approach is classification of a wetland. Classification is based upon a wetlands (1) position in the landscape or geomorphic setting, (2) dominant source of water, and (3) hydrodynamics of the water in the wetland (Brinson 1993). Seven hydrogeomorphic classes have been identified: riverine, depression, slope, mineral soil flats, organic soil flats, estuarine fringe, and lacustrine fringe. Each of these classes is defined in Table 2. These classes can be further divided into subclasses. For example, the depression class can be subdivided into perched, shallow surface, and subsurface flow-through depressions. The purpose of the HGM classification is to provide a mechanism to account for the natural variation inherent to wetlands. This variation is often attributable to the factors mentioned above, i.e. geomorphic setting, dominant water source, and hydrodynamics (Brinson 1993).

Table 3. Seven HGM Classes of Wetlands

CLASSIFICATION	DEFINITION
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional water sources may include groundwater discharge from surficial aquifers, overland flow from adjacent uplands and tributaries, and precipitation. Riverine wetlands lose surface water by flow returning to the channel after flooding and saturation flow to the channel during precipitation events. They lose subsurface water by discharge to the channel, movement to deeper groundwater, and evapotranspiration. Examples: outwash plains and floodplains of Southcentral Alaska, bottomland hardwood floodplain wetlands in the Southeastern U.S., riparian wetlands in the annually flood prone area of prairie rivers.
Depressional	Depressional wetlands occur in topographic depressions on a variety of geomorphic surfaces. Dominant water sources are precipitation, groundwater discharge, and surface flow and interflow from adjacent uplands. The direction

CLASSIFICATION	DEFINITION
	of flow is normally from surrounding non-wetland areas toward the center of the depression. Elevation contours are closed, allowing for the accumulation of surface water. Depressional wetlands may have any combination of inlets and outlets or lack them completely. Dominant hydrodynamics are vertical fluctuations, primarily seasonal. Depressional wetlands lose water through intermittent or perennial drainage from an outlet, evapotranspiration, or contribution to groundwater. Examples: kettles and pitted outwash plains throughout Alaska, prairie potholes, vernal pools in the California Central Valley, depressions on valley alluvium in the Pacific Northwest.
Slope	Slope wetlands normally occur where there is a discharge of groundwater to the land surface. They usually exist on sloping land surfaces from steep hillslopes to nearly level terrain. Slope wetlands are usually incapable of depressional storage. Principal water sources are groundwater return flow and interflow from surrounding non-wetlands as well as precipitation. Hydrodynamics are dominated by downslope unidirectional flow. Slope wetlands can occur in nearly level landscapes if groundwater discharge is a dominant source to the waters/wetland surface. Slope wetlands lose water by saturation subsurface and surface flows and by evapotranspiration. Channels may develop but serve only to convey water away from the waters/wetland. Examples: Fens on the Kenai Peninsula, swales in the California Central Valley, forested wetlands on toe slopes adjacent to, but above flood prone areas of western streams.
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. They lose water by evapotranspiration, saturation overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage and low lateral drainage. Example: pine flatwoods of the Southeastern U.S.
Organic Soil Flats	Organic soil flats, or extensive peatlands, differ from mineral soil flats, in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Organic flats often expand beyond the areas where they started to form (usually depressions) to adjacent areas that were non-wetland or mineral soil flats. Water source is dominated by precipitation, while water loss is by saturation overland flow, seepage to underlying ground water, and evapotranspiration. Raised bogs share many of these characteristics, but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Examples: precipitation driven wetlands on discontinuous permafrost in Interior Alaska, the Pocosin wetlands in Eastern North Carolina, and portions of the Everglades.
Estuarine (Tidal) Fringe	Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They usually intergrade landward with riverine or slope wetlands where tidal currents diminish and other sources of water (e.g. river

CLASSIFICATION	DEFINITION
	flow, groundwater discharge) dominate. Tidal fringe wetlands seldom dry for significant periods. They lose water by tidal exchange, by saturation overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent and they are isolated from shoreline wave erosion by intervening areas of low marsh. Examples: *Spartina alterniflora* salt marshes.
Lacustrine Fringe	Lacustrine fringe wetlands occur adjacent to lakes where the water elevation of the lakes maintains the water tables in the wetlands. In some cases, they consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge. Surface flow is bi-directional, usually controlled by water level fluctuations such as seiches in the adjoining lake. Lacustrine fringe wetlands are indistinguishable from depressional wetlands where the size of the lake becomes so small relative to fringe wetlands that the lake is incapable of stabilizing water tables. Lacustrine wetlands lose water by flow returning to the lake after flooding, by saturation surface flow, and by evapotranspiration. Organic matter normally accumulates in areas sufficiently protected from shoreline wave erosion. Example: peatlands surrounding lakes on the Kenai Peninsula, Great Lakes marshes.

B. Identification, Definition, and Description of Functions

The second essential element of the HGM approach is the identification, definition, and description of the functions of the 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, and decomposition (Brinson 1993). In the context of HGM, the term "function" is used primarily as a means to highlight the distinction of ecosystem functions from values. The term "values" is associated with society's perception of ecosystem functions. Functions occur in ecosystems regardless of societal values. Usually, HGM Guidebook authors choose to group functions according to logical sets such as:

1. hydrologic
2. biogeochemical
3. plant community
4. faunal support/habitat.

C. Reference Systems

The third component of the HGM approach is the establishment and use of a reference system (NWSTC in prep., Brinson 1996, Brinson 1995). 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 definitions presented in Table 4.

Table 4. **Reference Wetland Terms and Definitions (Modified from the NWSTC 1996)**

TERM	DEFINITION
Reference Domain	All wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass.
Non-Standard Reference Sites	Sites within the reference domain that encompasses the known variation of the regional subclass. Reference sites are used to establish the ranges of functions within the regional subclass, including functional changes resulting from site alteration (human-induced perturbation).
Standard Reference Sites	The sites within a reference wetland data set from which reference standards are developed. Among all reference 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 sites that correspond to the highest level of functioning (highest sustainable capacity) across the suite of functions of the subclass.

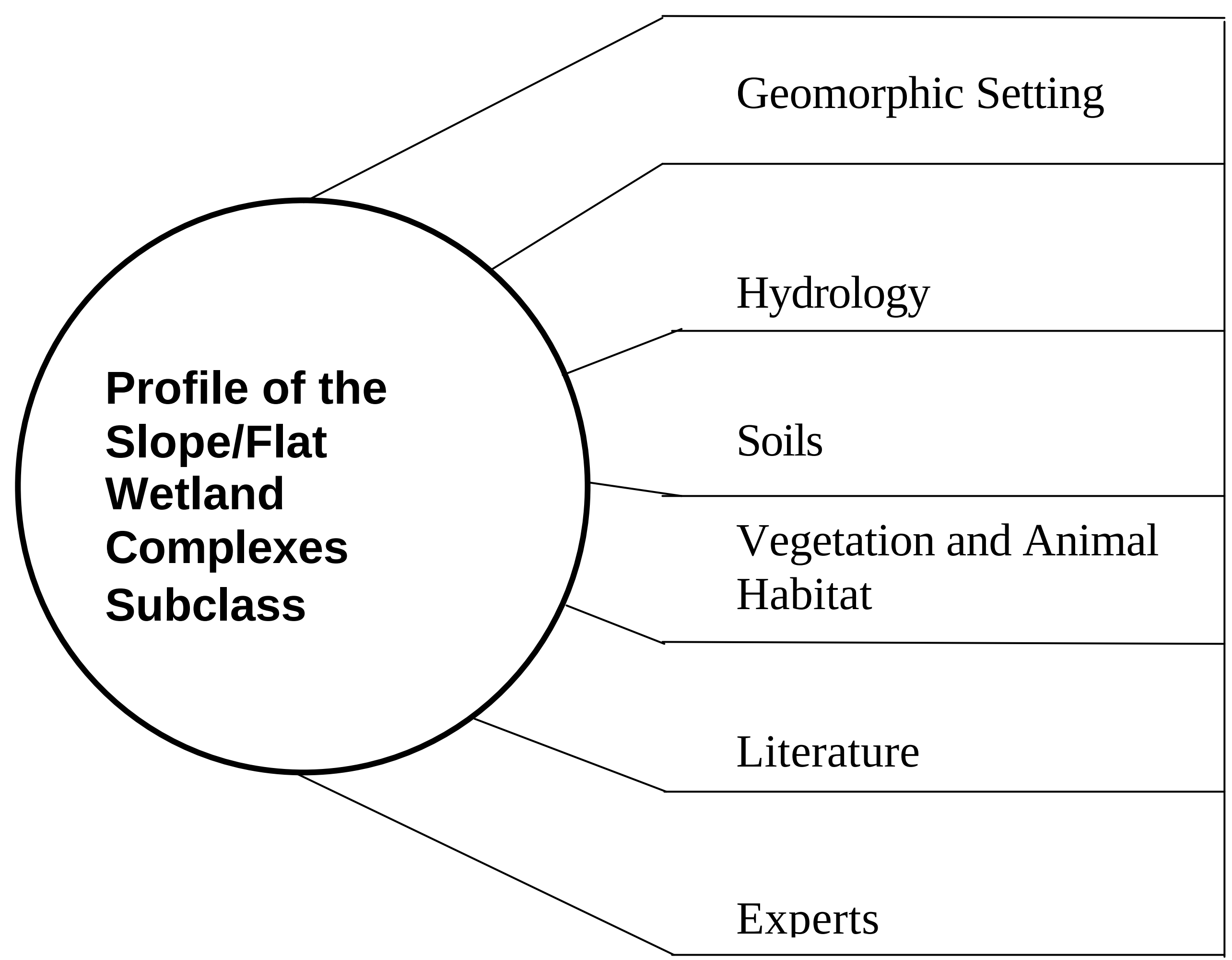


Figure 1. **HGM Reference System Structure** (Modified from the NWSTC 1996)

As illustrated in Figure 1, the subclass profile 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; for example, sites of the same subclass within the domain (Smith *et al*. 1995). Typically HGM users will use reference systems: (1) to apply HGM models and thus detect changes in ecosystem functioning, (2) as design templates, and (3) to set monitoring targets and specify contingency measures (Figure 2). The principle of reference in the context of HGM is useful because everyone uses the same standard of comparison, and relative rather than absolute measures allow efficiency in time and consistency in measurements.

Standards and details concerning development of HGM reference systems are given in the National Reference Guidebook (Whigham *et al*. in prep.) Basically, to develop an HGM reference system, an interdisciplinary team (or "Development Team") visits reference sites in a range of conditions (*i.e.*, relatively pristine to highly degraded) in the same hydrogeomorphic subclass. At each site, the Development Team collects data on physical, hydrologic, biogeochemical, plant community, and faunal support/habitat community attributes. When synthesized and interpreted, and combined with the best scientific judgment of the interdisciplinary team, these data help indicate the range of ecosystem conditions, functions, and responses to human and natural disturbance.

In addition to developing a subclass profile, the Development 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 Development 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 the data collected at the reference standard sites. Reference standards are the 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 wetlands subclass, and to set the standards that allow development of HGM models.

Ideally, all of the wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass constitute the "reference domain." Again, reference sites are selected to encompass the known range of variation within the potential reference domain. It is important to note that practical limitations of funding, personnel, and access do not usually allow sampling of all wetlands within a region. Therefore, the reference domain is often envisioned as both the actual wetlands sampled to build the reference system, and the geographic area within which reference sites for a regional wetlands subclass have been sampled. Where sampling of additional reference sites could reasonably be used to expand the (sampled) reference domain (*e.g.*, within an ecoregion), 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.

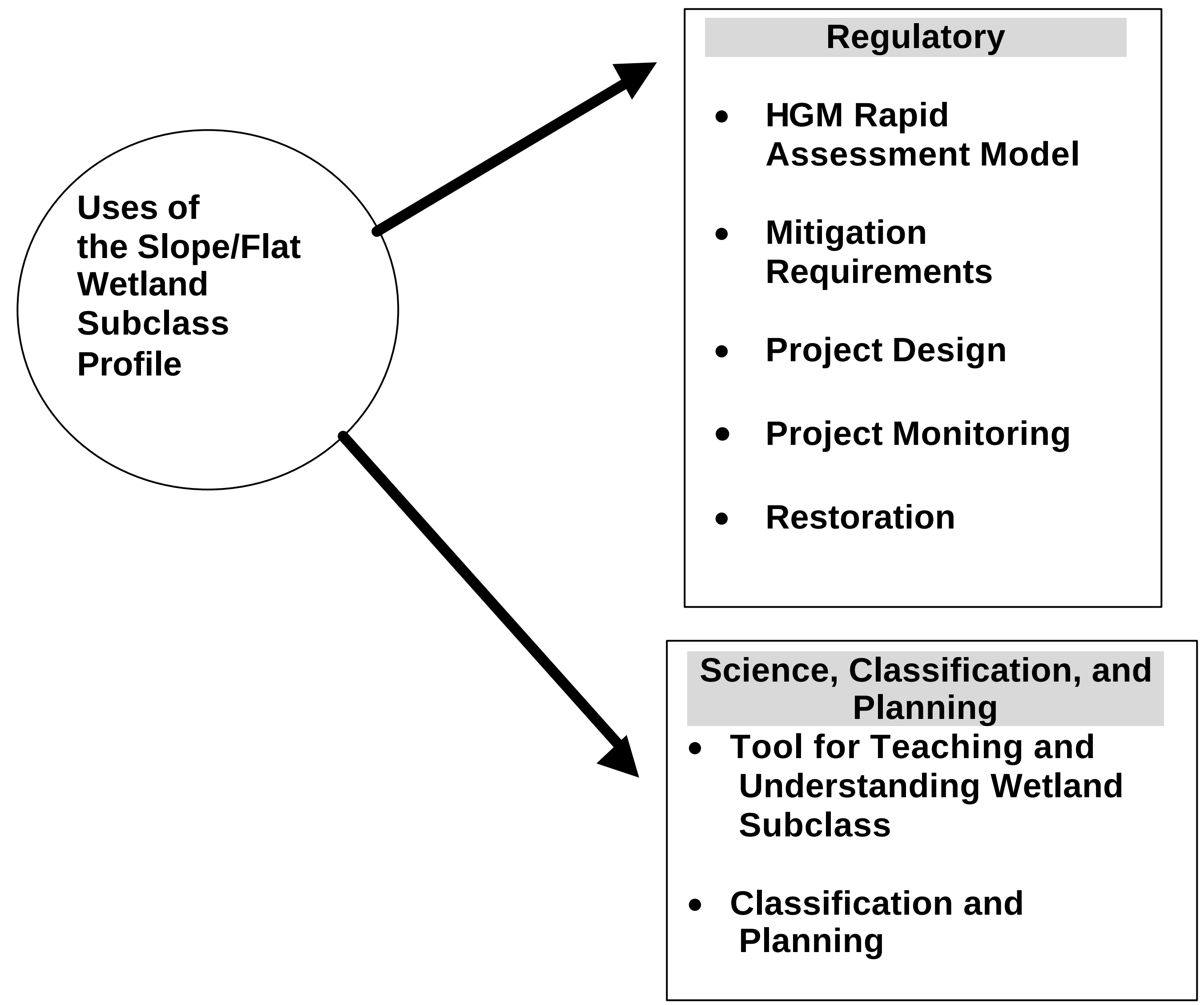


Figure 2. Use of the HGM Subclass Profile (Modified from the NWSTC 1996)

D. Assessment Models and Functional Indices

As discussed above, an important step in developing the HGM approach is the description of the functions that wetlands within a subclass perform. In this, and most guidebooks, identification of functions is followed by development of assessment models and functional capacity indices that are estimates of the capacities of the wetlands within a subclass to perform those functions (Smith *et al.* 1995, see Chapter 4).

It has long been recognized that some wetlands perform certain functions better than others, not because they are impacted in some way, but because wetlands are inherently different (Brinson 1993). For example, bottomland hardwood forests of the Southeastern United States support breeding habitat for neotropical migrant birds more intensively than forested wetlands on slopes throughout Southeast Alaska. These two extremes in breeding habitat differ greatly (due to many intrinsic properties) so that most comparisons between them become meaningless. The same logic applies to comparison of functions across classes, (*e.g.*, between riverine and depressional wetlands). To avoid assessment of functions that are inappropriate for a particular class of wetland, functions are described differently for each of the seven classes of wetlands defined in Table 3. Even if the suite of functions overlap substantially between classes, which they often do, these functions are likely to be performed at different levels or intensities. Furthermore, the field indicators and variables used to assess each function would differ sufficiently to require separate treatment.

To develop assessment models for functions associated with a regional wetlands subclass, “variables” must be identified, defined and scaled using data from the reference system. Variables are the attributes or characteristics of a wetland ecosystem or the surrounding landscape that influence the capacity of a wetland to perform a function or a set of functions. For example, in the Lower Kenai River drainage basin, slope and microtopographic complexity affect the hydrologic function “surface and shallow subsurface water storage." At each project assessment area, a variable may be operating or expressed to a greater or lesser degree, depending on land uses, degree of disturbance, etc. Hence, variables are usually observed to relate directly to the degree of human disturbance on a particular site. In the field, variable conditions are either measured directly (*e.g.*, tree stem density) or indirectly using field indicators (*e.g.*, microtopographic roughness = number of pits of a certain size capable of storing ponded water). Specifically, field indicators are observable characteristics of the wetland that corresponds to identifiable variable conditions in the 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" or FCI. The relationships among variables and how they are combined to develop an FCI are based on analyses of reference system data developed for the subclass (Figure 3). By definition, reference standard sites yield FCI’s of 1.0, and FCI values range from 1.0 to 0.0. Therefore, highly degraded wetlands may yield FCI’s of 0.0 (*i.e.*, unrecoverable loss of function). Thus, an FCI is an estimate of the function performed by a wetland with respect to reference standard conditions.

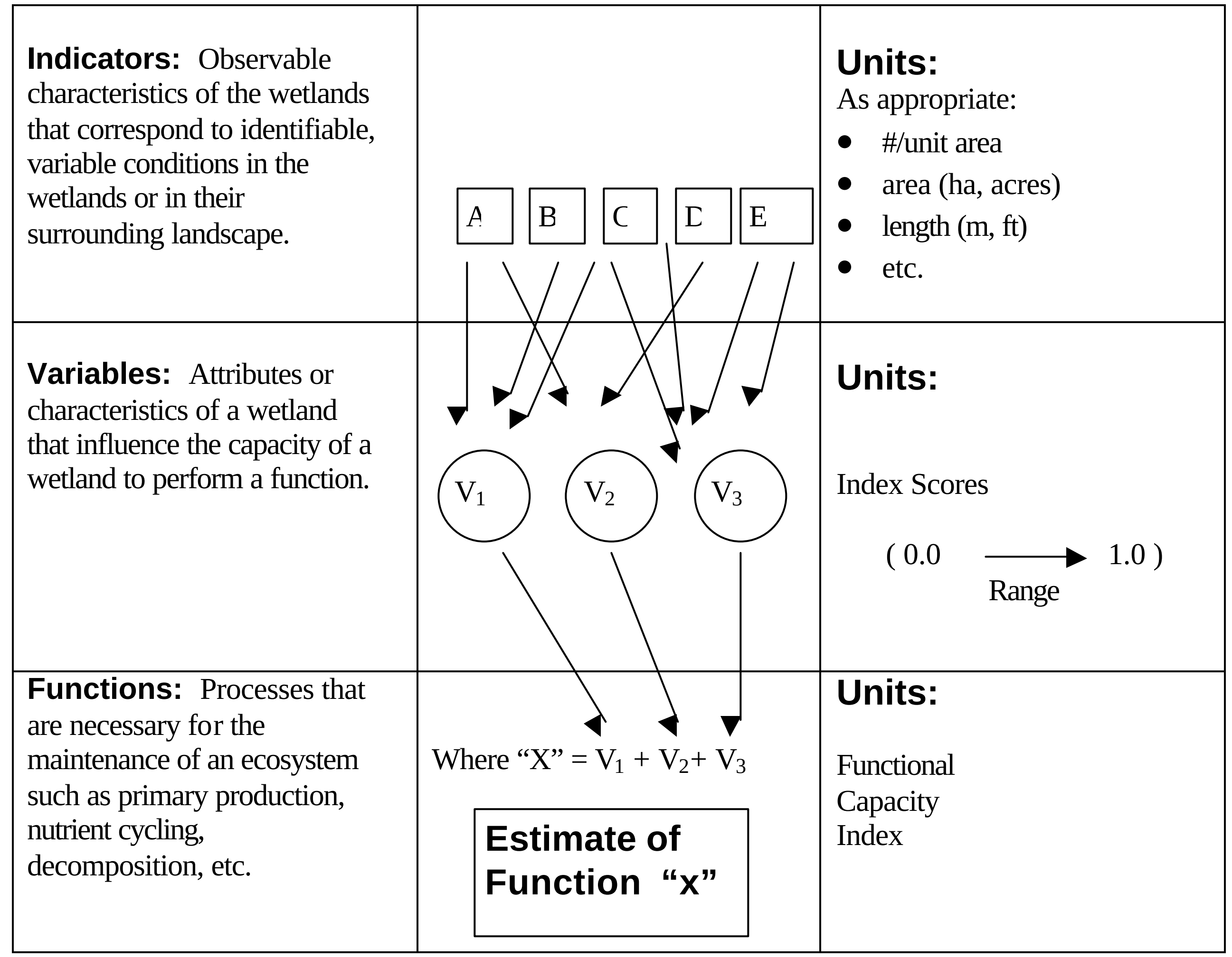


Figure 3. Structure of an HGM Model (Modified from the NWSTC 1996)

Assessment Model Protocol. According to the COE guidelines for developing HGM models, an assessment protocol for users of the HGM models is included in a guidebook. In fact, the assessment protocol is the fourth essential component of the HGM approach. The assessment protocol establishes criteria for the background information necessary to perform a rapid functional assessment, and provides instructions for measurement of variables in the field and subsequent calculations of Functional Capacity Indices (FCIs). Use of an assessment protocol sets minimum requirements for valid use of models and thus helps ensure their unbiased, consistent application. More details on the assessment protocol developed in the Guidebook are presented in the "Assessment Protocol" in Chapter 5 of this guidebook.

Local Support and Policy Concurrence. Before ADEC agreed to oversee the development of this guidebook, decision makers at the local, state, and federal level were consulted and support was obtained. A series of meetings were held with policy makers, including several meetings with the Governor's Kenai River Advisory Board. ADEC obtained broad support for developing this guidebook from local, state, and federal agencies, the Governor's Kenai River Advisory Board, and various interest groups.

Interagency Memorandum of Understanding. Cooperation among state and federal agencies with jurisdiction over wetlands is necessary for developing the HGM Approach and HGM Guidebooks. Recognizing the need for cooperation, ADEC developed an interagency Memorandum of Understanding (MOU), with support from eleven state and federal agencies (ADEC, ADNR, ADF&G, FWS, NRCS, ADT&PF, COE, FHWA, EPA, USGS, and USFS) and a letter of support from the National Marine Fisheries Services within the National Oceanic and Atmospheric Administration (NMFS). The MOU supports and guides the development of HGM in Alaska. A copy of this MOU can be found in Appendix C.

The HGM interagency MOU sets forth three interagency/stakeholder teams to establish and develop the HGM approach and Guidebooks in Alaska, which are:

1. HGM Management Team
2. HGM Statewide Technical Oversight Team, and
3. HGM Guidebook Development Teams.

The MOU also outlines data and information management, and how the guidebooks will be used.

Consistency With National Guidance. This guidebook was developed during the period of time when national guidance on HGM was being articulated and refined by the "National Hydrogeomorphic Implementation Team" (NHIT). The NHIT group consists of representatives from the COE, EPA, FWS, NRCS, FHA, and NMFS (Federal Register, August 16, 1996 (Vol. 61, No. 160, pp. 42593-42603), Federal Register: June 20, 1997 (Vol. 62, No. 119, pp. 33607-33620)). At the time this was written, NHIT guidance on the development and implementation of HGM continued to be in flux. Thus, the sequence and timing of some tasks completed while developing this guidebook differ from those outlined in current versions of national guidance that can be found in Appendix C.

Table 5. Steps Completed by Development Team. Since July 2002, the Development Team has completed the Operational Draft and one training session. The 2002 Operational Draft has been revised to become this guidebook. Therefore Steps 1-12 have been completed with the exception of the final guidebook which is awaiting approval by the COE/WES. Steps Used by the Development Team to Develop this Guidebook

STEPS	Date Completed
Step 1. Organize Development Team Task 1. Identify Development Team Members Task 2. Train Development Team Members in HGM Classification and Field Assessment techniques.	**July 1997**
Step 2. Select and Characterize Wetland Subclasses	**July 1997**
Step 3. Field Verify Subclasses and Develop the First Approximation Assessment Models Task 1. Field Verify and Define Primary and Secondary Subclasses Task 2. Define First Approximation Functions, Variables, and Field Indicators Task 3. Develop Reference System Task 4. Refine Draft HGM Models	**July 1997**
Step 4. Collect Reference System Data	**July 1997**
Step 5. Analyze Reference Site Data	**Feb. 1999**
Step 6. Scale HGM Model Variables	**April 2000**
Step 7. Field Test Draft Model, Functions, and Variables Task 1. Authors field tested draft set of functions and variables Task 2. Authors field tested Draft Guidebook and Model	**May 2000**
Step 8. Revised Draft Model and Guidebook	**Sept. 2000**
Step 9. Peer Review of Draft Guidebook	**August 2001**
Step 10. Draft Operational Draft Guidebook Published	**Jan. 2002**
Step 11. Implement Draft Guidebook Task 1. Identify users of HGM Functional Assessment Task 2. Train users in HGM Classification and evaluation Task 3. Provide assistance to users	**Task 1. On-going** **Task 2. July 2002** **June 2003** **Task 3. On-going**
Step 12. Review and Revise Draft Model Guidebook The Draft Model Guidebook was revised and published	**June 2003**

Step 1. Organize Guidebook Development Team

In the spring of 1997, DEC, the Development Team Leader, and NWSTC held organizational meetings to identify local wetland experts, organize HGM training and begin gathering wetland information on the proposed study area. The Development Team consisted of 18 national and local experts, representing agencies and non-governmental organizations. This training was held on July 1997 for Development Team members and was offered by the National Wetland Science Training Cooperative (NWSTC) "National HGM Technical Team" (Table 1).

Step 2. Select and Characterize Wetland Subclasses

With assistance from the NWSTC and after extensive discussions with national scientists and local and state wetland experts, the Development Team identified priority and secondary subclasses of wetlands for the Kenai Watershed. Prior to initiating fieldwork, the Development Team assembled information about the landscape within the reference domain. Topographic and geologic maps, soil surveys, National Wetland Inventory (NWI) maps, aerial photographs, species lists, climatic data, and historical information were analyzed. Members of the Development Team also identified potential reference sites and reference standard sites and developed initial working definitions of the subclasses to be sampled. In addition, the leader of the Development Team assigned HGM classes to all wetlands depicted on the NWI maps covering the project area. The HGM class codes were added to the digital NWI data with assistance from the Kenai Peninsula Borough Geographic Information System Department.

Step 3. Field Verify Subclass And Develop First Approximation Assessment Models

The Development Team, with assistance from NWSTC, finalized subclass definitions and developed first approximation models for functions and draft subclass profiles during July 1997. At the same time, the team collected data at 37 reference sites from the Slope/Flats subclass reference system. From the outset, four major tasks were identified:

<u>Task 1 - Field Verification And Definition Of Primary and Secondary Subclass:</u> At the outset of this study, the combined Development Team and NWSTC team conducted preliminary sampling of a variety of pre-selected sites.

Slope/Flat wetlands in the Kenai River Watershed were selected by the Development Team because of: (1) the fact that they represent the largest percentage of any class of wetlands in the Kenai River watershed; (2) the lack of data on slope/flat wetlands; and (3) the impact of slope wetlands on the main stem of the Kenai River. The reasons for choosing the particular study areas and subclasses were based on decisions made at three meetings of interested local and national experts at the Kenai Peninsula Borough Assembly Chambers on December 12, 1996, March 28, 1997, and June 12, 1997.

According to Smith et al. (1995), the reference domain is the geographic area occupied by the reference wetland sites. The reference domain selected to represent this wetland subclass is the Lower Kenai River Watershed. Reference site data were collected from 38 miles of the lower and middle reaches of the main stem of the Kenai River or the watershed from river mile 12 (end of tidal influence) upstream to river mile 50 at the outlet of Skilak Lake. Based on National Wetlands Inventory mapping, slope wetlands consist of approximately sixty-percent of the total percent of wetlands in the reference domain.

Preliminary site data information was collected in this area identified as the lower and middle sections of the Kenai River and wetlands contained in its watershed. The study was further defined by determining the wetland classes and subclasses of wetlands to be studied, HGM variables, and field indicators. The preliminary sites were characteristic of slope wetlands in the Kenai Lowlands portion of the Kenai River drainage basin. The combined teams engaged in extensive discussions of the characteristics of each site. The teams then collectively determined that most of the pre-selected sites were "Slope/Flat wetland complexes in the lower Kenai River Drainage Basin." This subclass was identified as the priority regional subclass. Riverine wetlands, that are less common than Slope/Flat wetlands in the Kenai River watershed, were identified as the secondary subclass. The Development Team decided to collect data for both subclasses (Slope/Flat complexes and Riverine) because of the cost and organizational efficiencies of conducting one field project compared to two. Field data and information were collected for both Slope/Flat and Riverine subclasses during July 1997. The guidebook for the Riverine subclass will follow the completion of this guidebook.

Task 2 - Definition of First Approximation Functions, Variables, and Field Indicators: The second task was to identify functions, variables and field indicators for the primary subclass (slope/flat wetland complexes). First approximation models for functions potentially performed by the primary wetland subclass were refined. The teams also developed field data sheets to ensure consistent collection of reference site hydrology, soils, plant, habitat, and land use data. The draft assessment models and data sheets continued to evolve throughout the sampling procedures.

Task 3 - Development of the Reference System: During the field effort, the Development Team collected data at 37 reference sites in the slope/flats wetlands subclass. Reference sites were selected with great care. Such caution was warranted due to limited field time and the large size of the potential geographic domain. In selecting sites for sampling, the teams targeted the range of variation in the slope subclass.

In offering this guidebook, the authors would like to emphasize that, by design, we chose to use our collective experience to develop data collection techniques at the 37 reference sites that would largely encompass procedures required for use in the assessment protocol developed in this guidebook. Using this approach, we believe that (a) a large amount of our practical field experience is embedded in the assessment models, and (b) measurements stipulated in the assessment procedure developed in this guidebook are as efficient and rapid as possible.

Task 4 - Refinement of Draft HGM Models: Before leaving the field, the teams revisited critical functions and variables and refined the draft assessment models for use in a working draft guidebook. For the riverine subclass, the teams collected data, identified, described critical functions, and suggested ways in which these riverine wetlands were hydrologically connected to slope/flat wetlands.

Step 4. Collect Reference System Data
As introduced above, the Development Team collected quantitative and qualitative data on hydrology, soils, plant communities, and faunal/habitat features at each of 37 reference sites. Data sheets used for collecting the field information are shown in Appendix A.

Photograph 1. Field team collecting data at Reference Site # 2 in 1997.

Step 5. Analyze Reference Site Data
Following standard quality assurance and quality control steps, the Development Team analyzed field data from the reference sites. The team first sorted all sampled sites into “standard reference sites " and "non-standard reference sites" categories. Following this initial split, sites were sorted according to community types.

Sorting of sites allowed relatively fast characterization of the reference system data. When possible, and to facilitate the variable scaling effort, qualitative data were converted to numeric values. Other qualitative data were used to classify reference sites by reference class (*i.e.*, standard or non-standard reference sites), land use, and other appropriate characteristics.

A preliminary analysis of the slope data was conducted by NWSTC in February 1999. This analysis included multivariate analyses of some of the reference system data. Using vegetation data, detrended correspondence analysis (DCA) was used to ordinate sampled sites (Hill 1979, Hill and Gauch 1980, ter Braak 1987, Jongman *et al*. 1987). The authors emphasize that DCA was not necessarily used to scale vegetation variables. Rather, the

NWSTC found ordination approaches to be useful tools that facilitated our understanding of how altered sites and reference standard sites differed in terms of measured (*e.g.*, vegetation community) traits. The analysis and results are given in Data Analysis, in Chapter 3.

Step 6. Scale HGM Model Variables
After field sampling and before preliminary analyses of the reference system data, the Development Team reviewed and attempted to refine aspects of the first approximation HGM models developed at the outset of the project. Following analyses of the reference system data as described above, the Development Team verified that certain variables in the first approximation models could be scaled using reference system data and used successfully to develop models of ecosystem functions. During this process, some first approximation variables were discarded because they were impractical. New variables were added as necessary. Often, new variables were either (a) variables published in other HGM Guidebooks, or (b) chosen because of particular patterns observed in reference system data gathered for the subclass. Following the model refinement efforts explained above, members of the team using reference system data combined with best scientific judgment scaled all variables.

Step 7. Field Testing the Draft Model, Functions, and Variables
In May 2000, authors Jon Hall, FWS and Jim Powell, ADEC field-tested the draft set of functions and variables in the Kenai area. This resulted in several minor adjustments to the set of functions and variables.

In June 2000, authors Jon Hall, FWS, Jim Powell, ADEC, Stan Carrick, ADNR, Joe White, NRCS, and Garry Hollands, ENSR field-tested the guidebook and model. Based on this fieldwork several additional adjustments were made in the "Field Data Collection Forms."

Step 8. Revise Draft Model and Guidebook
During the Spring of 2001, the Draft Guidebook and model were revised based on the fieldwork conducted in 2000. The Draft Guidebook was revised and distributed for peer review.

Step 9. Peer Review of Draft Guidebook
The Draft Guidebook was peer reviewed by Keith Boggs (ENRI) and Dr. Todd Walter (University of Alaska Southeast) in August 2001. The peer review comments are incorporated into this document.

E. Application Phase

As discussed in the introductory sections of this guidebook, the HGM approach for assessing the functions of wetlands is a useful tool that is 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) restoration design, and (3) development of monitoring protocols and contingency measures (Brinson 1993, Brinson *et al.* 1995, NWSTC 1996).

The subclass profile and supporting appendices in this guidebook (Appendix B) offer useful information concerning the hydrology, soil, vegetation and habitat/faunal data array sheets characteristics of Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecosystem. As discussed elsewhere in this guidebook, this information can be used as design templates for restorations or to structure monitoring efforts and contingency measures for several different types of projects.

With particular respect to the assessment of changes in functions in slope/flat wetlands in the Cook Inlet Basin Ecosystem, application of the HGM approach should be accomplished in a manner that is consistent with standard interpretations of draft HGM model logic, terminology, and administrative procedures. Consistency requires articulation of conventions for field observations, field measurements, and documentation of assessment results. Chapter 5 - Assessment Protocol of the guidebook provides guidance on how to run HGM models and develop an acceptable assessment report. As part of the Assessment Report, you need to calculate the Functional Capacity Indexes (FCIs). Appendix E provides a screenview of the spreadsheet that automatically calculates each of the FCIs.

3. Characterization of the Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecoregion

A. Area of Applicability – Cook Inlet Basin Ecosystem

The ecological functions and characteristics of the Slope/Flat Wetland Complexes contained in this guidebook are based on the information and data collected from the Lower Kenai River Drainage Basin Study Area. Based on additional field tests in the Anchorage area the applicability of this guidebook has been expanded to include the Cook Inlet Basin Ecosystem.

B. Summary Of Dominant Features

This guidebook covers wetlands that have characteristics of two HGM classes of wetlands; Slope and Organic Soil Flats. Slope wetlands are normally found where there is discharge of groundwater to the land surface. Slope wetland hydrodynamics are dominated by downslope unidirectional flow. Organic Soil Flats occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large surface (Brinson, 1993). The authors of this guidebook identified a Slope/Flat wetland complex subclass based on the characteristics observed and measured in the Lower Kenai River study area. While Estuarine, Lacustrine, Riverine and Depressional wetlands are relatively distinct on the landscape in the lower Kenai River drainage basin, most other wetlands exhibit features from both the Slope and Flat HGM classes.

Slope/Flat wetland complexes in the Cook Inlet Basin Ecoregion exhibit a range of variation with respect to their vegetation, landforms, and parent material. These wetlands share certain dominant features that may be used to help identify the regional subclass (Table 6).

Table 6. Dominant Features of Slope/Flat Wetland Complexes in the Cook Inlet Basin

CHARACTERISTIC	DESCRIPTION
Vegetation	Any vegetation (e.g., trees, shrubs, herbaceous, etc.) that is not in a marine, estuarine, lacustrine, depressional or riverine system or directly influenced (i.e., actively flooded) by those systems.
Landforms	Footslope, toeslope, former glacial channels (paleo-channels), historic glacial outwash plains, or river terrace above active flooding. **Note**: Wetlands in closed depressions and active floodplains are out of the subclass.
Slope	0.1% to ≤ 25%
Parent Materials	Dense glacial tills or fine sands and silts
Organic Horizons	> 60cm. If unburned in the past 60 years. If burned, ≥ 7cm.
Hydrologic Source	Shallow groundwater flow and precipitation

The following Table 7 is a dichotomous key for determining if this guidebook (Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecosystem) can be used for assessing a particular wetland.

Table 7. Key to Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecosystem

1a.	The assessment area is not a jurisdictional wetland according to the Corps of Engineers Wetland Delineation Manual (U.S. Army Corps of Engineers 1987). For example, (1) the area is a deepwater aquatic habitat. Deepwater aquatic habitats are areas that are permanently inundated at mean annual water depths > 6.6 ft or permanently inundated areas = 6.6 ft that do not support rooted-emergent or woody plant species: **Non-wetland: Guidebook not applicable.**
1b.	The assessment area is a jurisdictional wetland according to the Corps of Engineers Wetland Delineation Manual: **2**
2a.	The wetland is tidally influenced, in an active floodplain, in a closed depression (e.g., pothole on glacial moraine), or is adjacent to a lake where the water elevation of the lake maintains the water table in the wetland: Guidebook **not applicable.**
2b.	The wetland is on a footslope, toeslope, former glacial channel (paleo-channel), historic glacial outwash plain, or river terrace above active flooding: **3**
3a.	The slope of the land surface exceeds 25%: Guidebook **not applicable.**
3b.	The slope of the land surface = 25%: **4**
4a.	The area has a surface organic horizon = 60 cm if unburned in the past 60 years. If burned, the organic horizon is < 7 cm: Guidebook **not applicable.**
4b.	The area has a surface organic horizon > 60 cm if unburned in the past 60 years. If burned, the organic horizon is = 7 cm: **Use this Guidebook.**

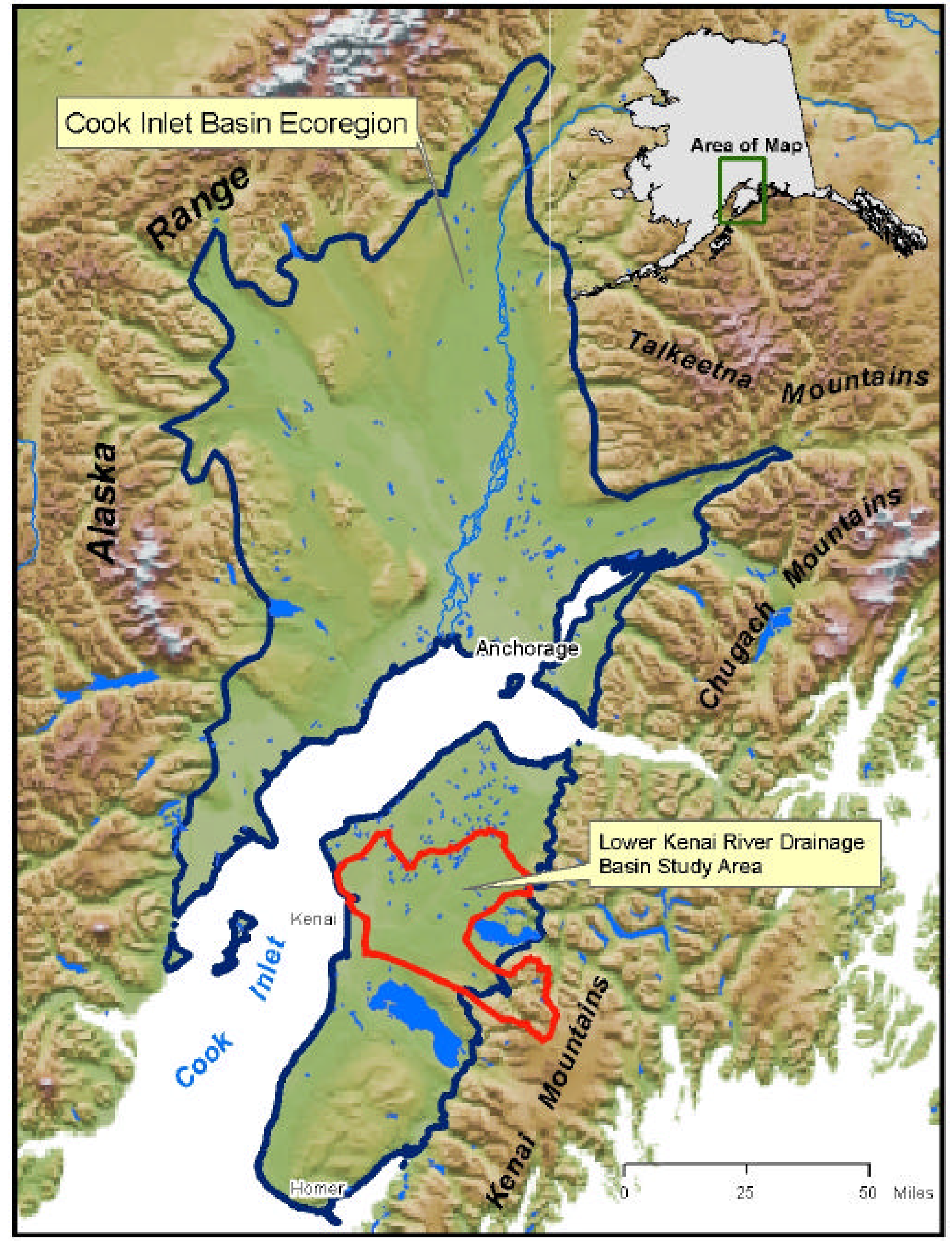


Figure 4. Area of Applicability - Cook Inlet Basin Ecosystem

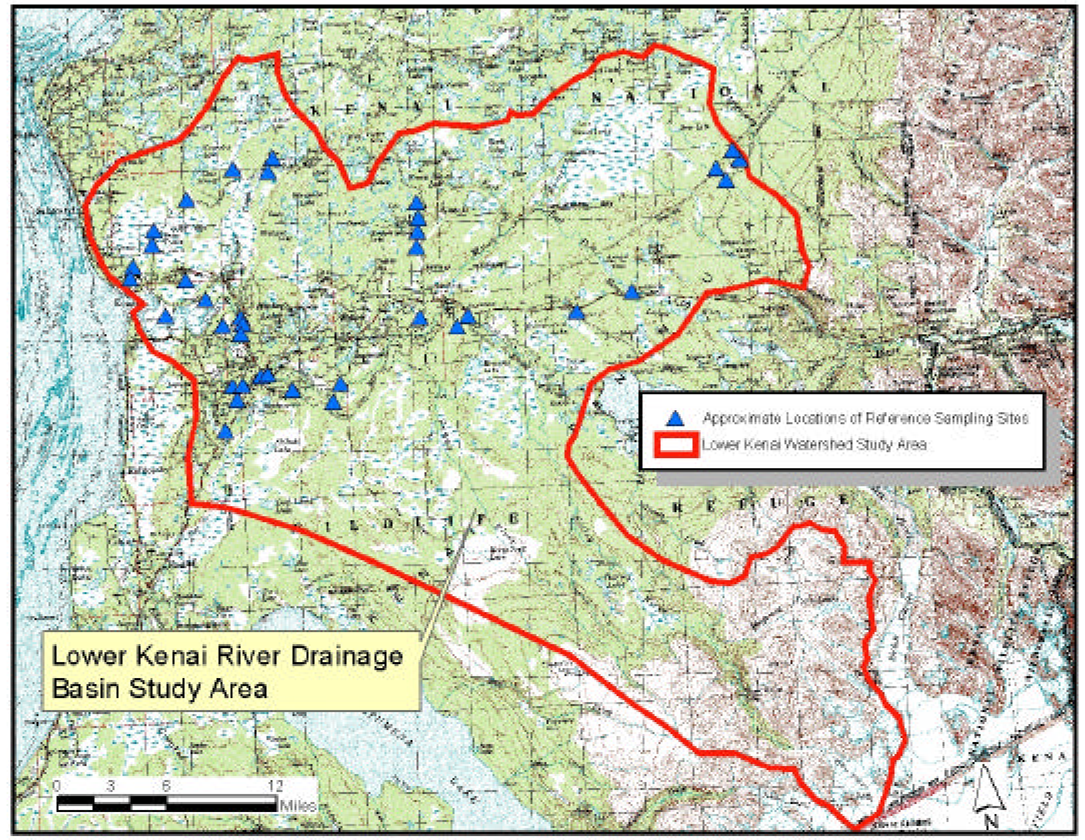


Figure 5. Lower Kenai River Drainage Basin Study Area

C. Description of the Study Area and Slope/Flat Subclass

1. Geomorphic Setting

The Kenai River Watershed lies on the Kenai Peninsula, 50 miles south of Anchorage, and drains approximately 2,050 square miles with about half draining the Kenai Mountains and the other half draining the Kenai River Lowlands. The Slope/Flat wetland subclass is found on the Kenai River Lowlands, part of the Cook Inlet trough that is a large structural basin between the Aleutian Range to the west and Kenai Mountains to the east. The Cook Inlet trough contains over 20,000 ft of sedimentary rocks deposited 30 million years ago that were subsequently faulted and folded (Figure 7). Oil and natural gas have accumulated in the sedimentary rock formation, and these resources are pumped from numerous production facilities in the Kenai River Lowlands.

Today's landscape on the Kenai River Lowlands is a result of multiple glaciations over the past 200,000 years. Glaciers would advance from the north and from the Kenai Mountains to the east, and coalesce into broad lobes or ice sheets that scoured the underlying bedrock and deposited glacial sediments. When the climate warmed, the glaciers would recede back to the mountains until the next ice advance cycle.

In the HGM study area, the Moosehorn and Killey Stades of the Naptowne glaciation created most of the modern landforms. The complex glacial features such as proglacial lakes, outwash streams, fan deltas, and moraines originated between 25,000 and 12,000 years ago (Reger and Pinney 1997). The Kenai River channel evolved near the end of the Moosehorn advance, with glacial meltwater flows and outburst flood flows much higher than those of today, resulting in a channel and valley that are substantially larger than the present river that flows within it.

In the HGM study area, proglacial features such as glacial lakes, meltwater channels, and pitted outwash plains and deltas are found to the west and north of Skilak Lake. These features are the legacy of glaciers flowing west out of the Kenai Mountains. North and west of Sterling, larger glacial lobes emanating from the Matanuska Valley left behind glacial till and glacial outwash, burying stagnant blocks of ice that eventually melted to form the kettles and kettle lakes of today's landscape. South of the Kenai River below Skilak Lake, the surficial geology is a complex mix of glacial features including paleochannels with glacial till deposits caused by glaciofluvial processes (Figure 8).

Since the glaciers receded about 10,000 years ago, streams have eroded and reworked the underlying glacial deposits and deposited fresh alluvium. Winds blowing off of newly deglaciated areas brought in silt to the area resulting in loess deposits that range from 1-3 ft thick (Karlstrom, 1958). These deposits also include volcanic ash from the Aleutian Range.

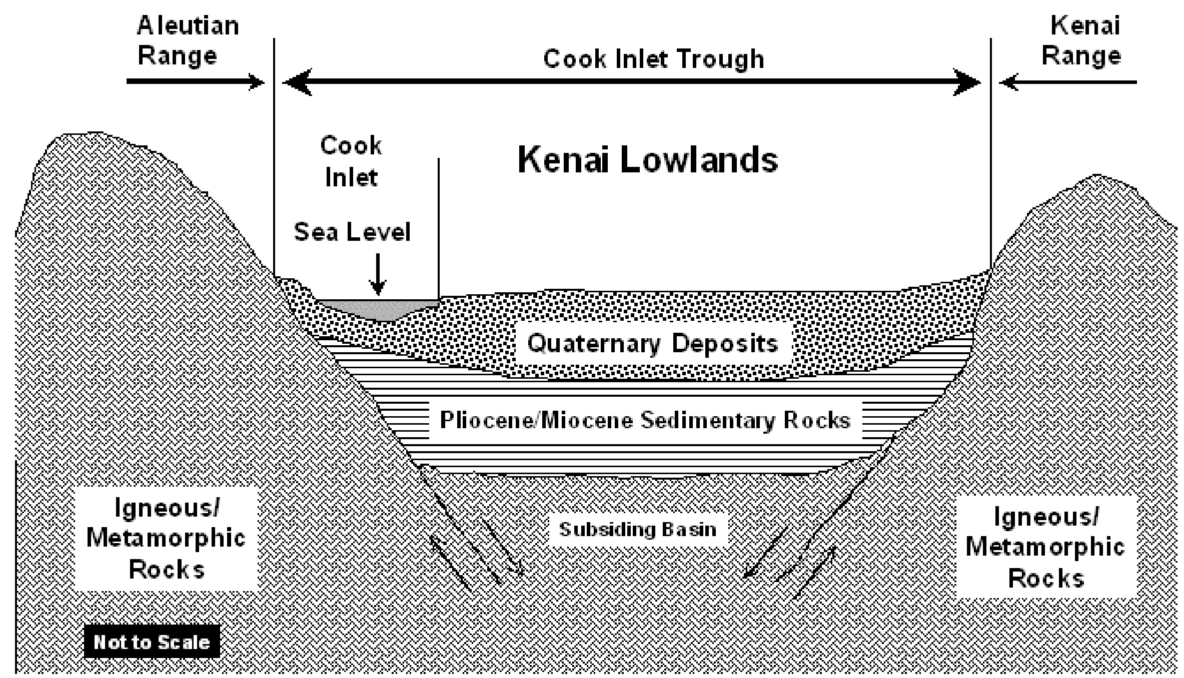


Figure 6. Idealized Geologic Cross-Section of Cook Inlet Trough

2. Landscape Position

Topography and the surface geology dictate the type of soil that develops. In the Kenai Lowlands, stream terraces and alluvial slopes tend to have good drainage and silty-sandy soils suitable for agriculture, unless they are capped with dense till or silts/clays. Hummocky morainal areas will be a mix of moderately drained uplands underlain with till or glaciofluvial deposits with soils that are less suitable for agriculture. Between the morainal uplands lie depressions that are, for the most part, undrained and contain small lakes, ponds, or fens.

The flats wetland subclass and low-gradient sloping areas are typically poorly drained, have dense tills or silts at depth, and are overlain by 1-6 ft of peat and organic silt that is generally unsuitable for most land uses. Flats and Slope wetlands adjacent to active streams have varying drainage characteristics depending on the surficial geology. If the underlying material consists of sorted sand and gravel then drainage is good and mineral soils are commonly found; consequently, these areas are not part of the subclass. In riverine areas where tills, silts, and clays dominate the surface, drainage is usually poor and organic soil and peat development is typical.

Riverine wetlands (not part of the slope/flat wetland subclass), in the study area, are typically found adjacent to unconfined streams in valleys with floodplains or seasonally flooded areas, and include the active stream channel. Riverine wetlands are not usually found in steep-sided valleys with confined streams. These wetlands occur in valley bottoms where the slope is low and where the flow dynamics of the adjacent stream influence the wetland.

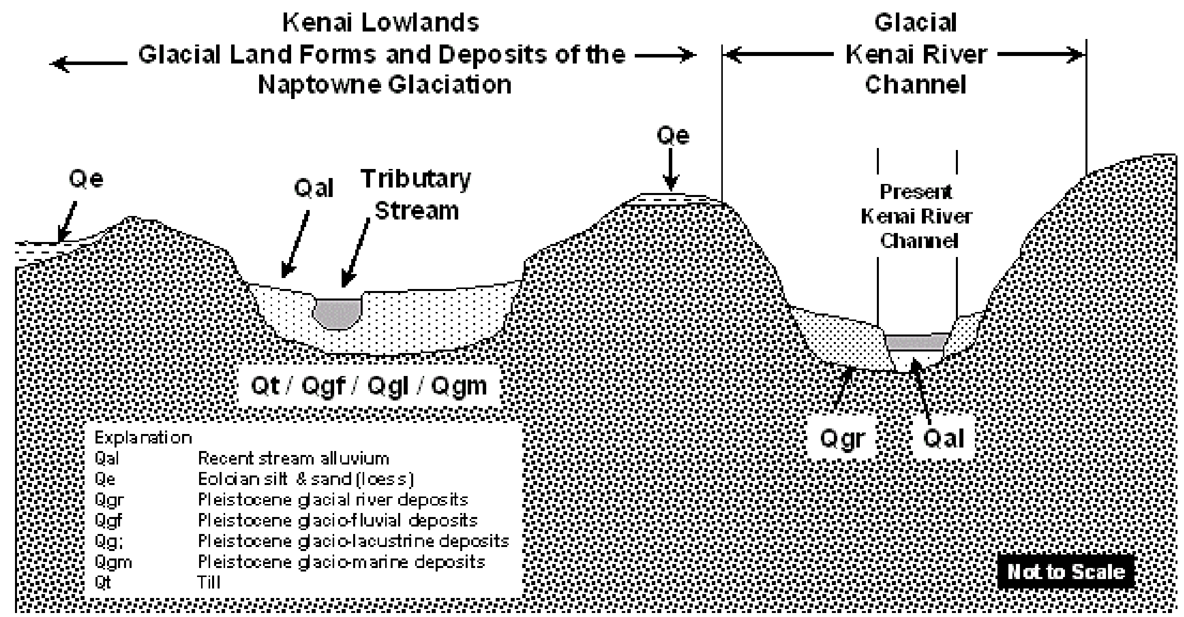


Figure 7. Idealized Geologic Cross-Section of the Kenai Lowlands Including the Kenai River Channel

3. Climate

The Kenai Peninsula lies in the transitional climate zone of Southcentral Alaska. Weather conditions in the Kenai Lowlands average between the neighboring maritime and continental zones: temperature extremes are greater than those of marine climates, and precipitation is greater than typical locations in interior Alaska, but less than coastal areas. The mean annual air temperature at the Kenai Airport is 33.7°F and the mean annual precipitation is 19.2 in. Seasonal snowfall at the Kenai Airport averages 61 in., amounting to approximately 60% of the average annual precipitation for the area.

4. Water Balance

Evapotranspiration is critical to a wetland's water budget. Evapotranspiration is the combination of water lost from the wetland by evaporation and vegetation transpiration. Measuring evapotranspiration is difficult, but estimates for various sites in Alaska have been made (Patrick and Black 1968). For both Kenai and Soldotna, the estimated actual annual evapotranspiration is 15 in., or approximately 80% of the annual precipitation. Ford and Bedford (1987) estimate that evapotranspiration on the Kenai Peninsula is between 7 and 15 in.

The net evaporative water balance is the amount of precipitation that falls on a wetland minus evapotranspiration (*P-ET*), and this water balance largely determines the hydrologic health of the wetland system (Ford and Bedford, 1987). If *P-ET* is negative, then wetlands can only exist where there is input from the surrounding area, or groundwater discharges to the wetland (fens). If *P-ET* is positive, then it is possible for ombrotrophic wetlands (bogs) to develop. For the Kenai River Lowlands, *P-ET* is positive, consequently there is a surplus of precipitation over evapotranspiration. Ford and Bedford (1987) calculated that there is a precipitation surplus of 5-12 in. on the Kenai Peninsula.

In the absence of advancing glaciers, surplus precipitation usually leaves a watershed as streamflow over the course of a year. Annual streamflow amounts on the Kenai Peninsula vary primarily with elevation. For the Kenai River Lowlands, the only published long-term, non-glacial streamflow data is for Beaver Creek northeast of Kenai. The mean annual streamflow for this low elevation stream is approximately 7 in. (USGS, 1978), for the 1967-1978 period-of-record. During that same time, the average annual precipitation was 17 in., leaving 10 in. or approximately 60% of the annual precipitation to evapotranspiration.

5. Hydrology

Streams in the Kenai River basin are of two types: glacial or non-glacial, and each differs markedly in the amount of flow and seasonal variability. Because of the underlying geology and the large amount of water storage available in the numerous lakes and ponds of the Lower Kenai River drainage basin, the area streams have well-sustained low-flow periods. Water-level fluctuations are usually the result of seasonal or long-term changes in precipitation, but development can also impact local stream, lake, and groundwater levels. Streamflow patterns for the study area are typical for Southcentral Alaska. The lowest flows are in March or early April, flows increase during spring breakup and snowmelt, flows decline during the summer due to decreasing *P-ET* flows increase in the fall due to increases in *P-ET* and flows decrease again once temperatures drop below freezing in late October or November. Glacial streams have higher sustained flows throughout the warmer summer months from glacial ice melting. Groundwater flows parallel the surface water flows, but move much more slowly.

The non-glacial slope/flat wetland complexes of the study area are sustained primarily by precipitation (including snowmelt) and shallow groundwater flow. Areas within a watershed underlain by dense glacial tills or fine sands and silts and of low relief typically have poor drainage. These areas remain wet throughout the non-winter months, initially from snowmelt, and as the season progresses from precipitation. The dominant landscape factor in the function of the wetland is slope. Flow is primarily downslope. The steeper the slope, the faster water moves downslope resulting in less storage time and sediment retention.

Precipitation, snowmelt, and groundwater flow, often from adjoining slope wetlands also primarily sustain wetlands in the riverine subclass (not covered by this HGM model). In addition, riverine wetlands are also maintained by periodic flooding of the adjacent stream. The amount of flow, timing of flow, and the quality of flow to the riverine system are dependent on the upstream basin characteristics and the degree of development in the basin. Flows in riverine wetlands are unidirectional toward the stream.

6. Soils

The Kenai River Lowlands are characterized by pitted till plains, glacial outwash plains and stream terraces. Consistent with observations within fens, the dominant soil order observed by the HGM teams was Histosol “organic soils.” Twenty-six of the thirty-seven observations (70%) were Histosols, and 80% of them occurred in fens. Thirty percent of the soil observations were non-organic soils. Five percent were Spodosols, 5% were Entisols, 8% were Inceptisols, and 11% were till influenced.

The soils in the slope wetlands subclass have permeable materials (organic layers, sand and gravel) underlain by materials of restricted permeability such as dense till, silty clay (Figure 9). The majority of the soils are histosols. The soils have organic horizons over 40 cm thick and are saturated for 30 days or more during the year. A typical stratigraphy of a slope/flat wetland in the Kenai Lowlands area is shown in Figure 9.

Commonly the mineral soils of the subclass have Holocene loess deposits over alluvium or outwash deposits. They are somewhat poorly drained to poorly drained.

The top layer of a histosol at Reference Site #2 is shown below in Photograph 2.

Photograph 2. **Soil pit at Reference Site #2.**
The surface organic horizon at this site was over 40 cm.

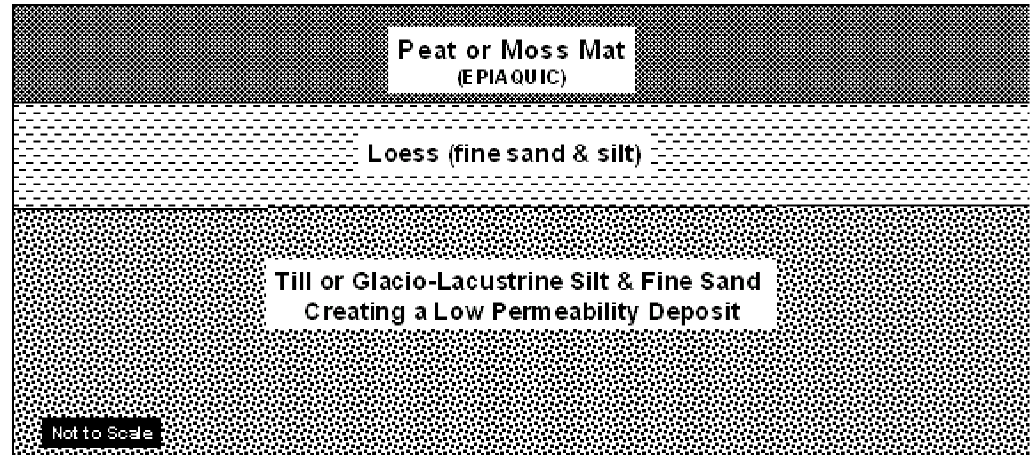


Figure 8. Typical Stratigraphy of Slope/Flat Subclass Wetland

7. Vegetation Communities

The Kenai Peninsula Lowlands area is predominantly forested with an interspersion of many ponds, lakes, and peatlands. Most of the non-wetland areas support a mixed evergreen-deciduous forest composed of white spruce, black spruce, paper birch, aspen and balsam poplar. More poorly drained sites are characterized by an increase in the occurrence of black spruce. A forest type containing white spruce and balsam poplar commonly occurs in floodplain areas.

Fire has had a substantial effect on the species composition of the lowland forests on the Kenai Peninsula. Large areas that have been burned in the past 60 years consist of dense thickets of aspen, alder, willow, and paper birch. These deciduous species represent transitional stages toward the climax forests dominated by white spruce on well-drained sites and peatlands on poorly drained sites.

The Lower Kenai River drainage basin is located in the Cook Inlet – Susitna Lowland physical subdivision (Rieger et al. 1979). Approximately 28% of this subdivision is classified as wetland (Hall et al. 1994). Descriptions of the most common wetland types in the reference domain follow: The descriptions include a discussion of the presence or absence of the wetland community type in Slope/Flat wetland complexes.

Black Spruce Forested Wetland: This wetland type is common throughout the study area (Photograph 3). It is often found as a fringe bordering the upland edge of bogs and fens or as "islands" (e.g., Reference Site #4) within these other wetland types. Black spruce forested wetlands also occur on gentle to moderate slopes bordering the active floodplain of creeks and rivers (e.g. Reference Site #1).

The black spruce (*Picea mariana*) in these wetlands are stunted with mature trees (>70 years) reaching a height of only 20 – 30 feet. Shrubs occur as an understory including dwarf birch (*Betula nana*), Labrador tea (*Ledum decumbens*), crowberry (*Empetrum nigrum*), diamond-leaf willow (*Salix planifolia*), mountain cranberry (*Vaccinium vitis-idaea*), and bog blueberry (*V. uliginosum*). The ground is covered with a *Sphagnum* spp. moss mat.

The black spruce forested wetland community occurs mostly in the Slope/Flat wetland complexes. However, it can also be found as a component of depressional wetlands.

White Spruce/Paper Birch Forested Wetland: Forested wetlands dominated by white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) occur primarily in seep areas on river-proximal slopes above the active floodplain (e.g., Slope Reference Site #31). Alder (*Alnus incana*) usually forms a tall-shrub understory layer. Other shrubs include prickly rose (*Rosa acicularis*), currant (*Ribes triste*), and willow. Field horsetail (*Equisetum arvense*) dominates the herbaceous layer. Bluejoint grass (*Calamagrostis canadensis*), oak fern (*Gymnocarpium dryopteris*), and Jacob's ladder (*Polemonium acutiflorum*) are also common in the ground layer.

Fens: A fen is a peatland with the water table at or just above the surface. Water moves into fens from upslope mineral soils and flows through the fen at a low gradient. Fens are more nutrient-rich than bogs. Fens are the major component of the Slope/Flat wetland subclass covered by this guidebook.

A. Patterned Fen Complexes

Patterned fens are characterized by a unique distribution of narrow, shrub dominated ridges (strangs) separated by wet depressions (flarks). These patterned complexes can be divided into three main types: 1) string fens, 2) senescent string fens, and reticulate/fens (Rosenberg 1986). In the string fen type, the strangs are generally parallel and run perpendicular to the direction of water movement (i.e., across the slope). The most extensive example of this type in the reference domain lies just to the northwest of the Kenai Airport (Reference Site #3). In senescent string fens, flarks are shallower and strangs less well defined than in string fens. Reticulate fens have strangs forming a net-like pattern interspersed with irregularly sized, spaced and shaped flarks. This type has less slope than the string fen type.

The raised ridges in a patterned fen are saturated and dominated by low shrubs including dwarf birch, Labrador tea, sweet gale (*Myrica gale*), bog rosemary (*Andromeda polifolia*), bog cranberry (*Oxycoccus microcarpus*) and bog blueberry. A *Sphagnum* moss mat covers the soil surface.

The wet depressions (flarks) between the ridges are seasonally to permanently saturated and typically dominated by emergent vegetation. Common species include sedges (*Carex livida* and *C. rotundata*), cottongrass (*Eriophorum angustifolium* and *E. russeolum*), Trichophorum *caespitosum*, and buckbean (*Menyanthes trifoliata*).

A typical patterned fen in the Kenai study area is shown in Photograph 4.

B. Shrub/Herbaceous Fen

Shrub/herbaceous fens are characterized by non-patterned ground where water is at or above the soil surface throughout the wetland. Shrub/herbaceous fens are common in the Pleistocene relic floodplains of the Kenai River between the active floodplain and the Kenai River bluff (e.g., Slope Reference Site #6). They also occur on the periphery of patterned fens, in abandoned glacial meltwater channels, and just upslope from the active floodplains of creeks and small rivers (e.g., Slope Reference Site #28).

Common shrub species include sweetgale, willow (*Salix planifolia* and *S. pulchra*), bog rosemary, bog blueberry, leatherleaf (*Chamaedaphne calyculata*), and mountain cranberry. Herbaceous plants include water horsetail (*Equisetum fluviatile*), field horsetail, marsh five-finger (*Potentilla palustris*), and several sedge and cottongrass species. Scattered stunted black spruce trees occur in some areas of shrub/herbaceous fens.

Shrub/Herbaceous Bog: Bogs are saturated peatlands that are generally acidic and low in nutrients. Precipitation is the dominant water source. Most bogs in the Lower Kenai River watershed are situated in closed basins in glacial moraines. Dense mats of *Sphagnum* moss cover the soil surface. Low shrubs including dwarf birch dominate most bogs, bog blueberry, mountain cranberry, Labrador tea, crowberry, and sweet gale. Herbaceous species are also common: Russett's cottongrass (*Eriophorum russeolum*), narrow-leaf cotton grass (*E. angustifolium*), livid sedge (*Carex livida*), round–fruit sedge (*C. rotundata*), bluejoint grass, and horsetail (*Equisetum* spp.). Some bogs are dominated by cloudberry (*Rubus chamaemorus*). A typical shrub dominated bog in the Kenai HGM study area is shown in Photograph 5. Bogs are not a component of the Slope/Flat wetland subclass covered by this guidebook.

Seasonally Flooded Marsh: Seasonally flooded marshes commonly occupy the active floodplain of creeks and small rivers (Photograph 6). Surface water is present in these wetlands during periods of high water flow in the adjacent riverine channel. Water inflow may also come from adjacent fens. The dominant vegetation consists of emergent species including bluejoint grass, sedges (*carex sitchensis*, *c. rostrata*, *c. aquatilils*), marsh five-finger, water horsetail, field horsetail, and Jacob's ladder. Willow and alder shrubs commonly occur along the floodplain edge. Seasonally flooded marshes are a primary component of the riverine HGM wetland class.

Photograph 3. Typical black spruce dominated forested wetland in the Kenai HGM Study Area – Reference Site #26.

Photograph 4. Patterned fen with flark in foreground – Kenai National Wildlife Refuge.

Photograph 5. Shrub bog dominated by Labrador tea and bog blueberry – Reference Site # 27

Photograph 6. Seasonally Flooded marsh along Soldotna Creek.

8. Fish and Wildlife Resources

The abundant fish and wildlife resources of the Kenai River watershed and adjacent areas are internationally known. Users of these resources include sport and commercial fishers, hunters, trappers, wildlife viewers, and subsistence users. Most of the fish and wildlife species in the area are dependent on wetland habitats for some or nearly all of their life requirements.

The Kenai River supports 34 fish species representing 16 taxonomic families. Thirty species are native to the Kenai River and four are introduced exotic species. Twelve species are residents of the river, 11 are anadromous, and 11 are found in the estuarine portion of the river (Alaska Department of Natural Resources 1997). The species that are most important to humans in terms of consumptive use include chinook, coho, sockeye, and pink salmon. Other species include rainbow trout, Dolly Varden, Arctic grayling, and round whitefish.

Many of the fish species are found in tributaries to the Kenai River such as Slikok Creek, Beaver Creek, Soldotna Creek and Kalifonsky Creek. Juvenile salmon for rearing uses all of these tributaries and others. Wetlands adjacent to the tributaries contribute surface flow to the stream channels. The direct input of drifting invertebrates from these wetlands has been observed (Elliott and Finn 1984). This input, as well as fine particulate organics and nutrients are important factors enhancing stream productivity.

Up to two hundred species of birds and mammals, and one species of amphibian, live in the Kenai River watershed (Alaska Department of Natural Resources 1997). Eighty-nine species of birds were found to use wetlands in the Kenai Peninsula lowlands (Rosenberg 1986). Bird types included loons, grebes, swans, geese, ducks, raptors, cranes, shorebirds, jaegers, gulls, terns, owls, and passerines. Deep marsh wetlands had the highest bird densities. Red-necked phalaropes, pintails, greater scaup, Barrow's goldeneyes, and mallards were the most numerous waterbirds using these sites. Species diversity in nine wetland classes described by Rosenberg (1986) ranged from 25 species in Senescent Patterned Bogs to 58 species in Tidal Marsh habitats.

Mammal species found in the Kenai River drainage basin include moose, caribou, Dall sheep, mountain goat, black bear, brown bear, beaver, muskrat, lynx, wolf, wolverine and coyote (Alaska Department of Natural Resources 1997). Other small mammals have been recorded by various studies including hoary marmot, meadow vole, northern bog lemming, pygmy shrew, snowshoe hare and red squirrel (Boggs et al. 1997).

D. Data Analysis

1. Vegetation Analysis

Of the 37 Slope/Flat sites, 22 of these were classified as standard reference sites. The sites represented a range of plant community types (by dominate strata: 15 forested; 13 scrub-shrub and 9 herbaceous sites) land use types, and time since disturbance. The small number of sites in each category, in combination with missing data, means that statistical comparisons are not possible for most of the data. The data synthesis focused on examining patterns in vegetation composition, abundance, and structural parameters, in relation to site environmental parameters (e.g., land use type, soils, and time since disturbance). Using standard ordination techniques, some overlap among standard reference sites assigned to different community types is to be expected given the wide range of disturbance associated with community types included within the subclass. Often, substantial similarities existed between standard reference plant communities and plant communities altered by human activity.

Additionally, the Development Team used several approaches to examine quantitative data in an attempt to determine trends. Standard statistical analyses were used to find ranges of values, means, and standard deviations (Zar 1984). Variable scaling based on quantitative field data included in the reference system generally used data ranges, means, and standard deviations as the "statistical" inputs. More advanced parametric or non-parametric methods were usually not needed or were not practicable, given low sample sizes for each community type.

In several instances, data array sheets were used to display the data. The authors used these graphical and tabular summaries in their attempts to understand trends in the data and to offer assistance to users of the guidebook. Some of these graphic summaries can provide a basis for development of restoration project targets and standards for wetlands within a subclass.

Ordination

Ordination is a multivariate technique used to graphically group data points that have common characteristics. This technique is common in ecological analyses for grouping sample sites based on the vegetation species observed at the different sites. For this study, vegetation and environmental data from the 37 reference sites were analyzed using a variety of ordination techniques[1]. Of the 37 sites, 22 were classified as standard reference sites and 15 as non-standard reference sites.

The first part of the vegetation analysis was ordinating the data to cluster the sites based on species similarity (Figure 9). The sites did not cluster in any strongly distinct patterns. However, the lower left side of the ordination plot (Figure 9) is dominated by standard reference sites (86% lie below the dashed line in Figure 9); and the rest of the diagram contains most of the non-standard reference sites (78% lie above the dashed line in Figure 9). This lack of other well-defined patterns in Figure 9 implies that the species used in this analysis are not strong indicators of different types of environments (e.g. reference standards); and that the different environments contain substantial overlap in their species communities.

Though not evident in the ordination analysis, some species generalizations can be made based on the data. In general, standard reference sites tended to contain native species typical of black spruce bogs, poor fens, and circumneutral fens. Species common in reference standard sites were: *Picea mariana, Ledum decumbens, Andromeda polifolia, Carex aquatilis, C. bigelowii, Vaccinium uliginosum, V. vitis-idaea, Potentilla fruticosa, Betula nana, Eriophorum* species, *Polemonium acutiflorum* and *Potentilla palustris.* In contrast, non-standard reference site species were cosmopolitan, non-native or somewhat weedy native species typical of drier better-drained sites. Species in the non-standard reference sites were *Matricaria matricarioides, Populus tremuloides, P. balsamifera, Betula papyrifera, Cornus canadensis,* and *Poa* species.

Additional analyses were performed to see if any environmental characteristics correlated well with the species ordinated data (symbols in Figure 9). Environmental characteristics included:

- land use: values of 1-6, increasing value indicating increased disturbance See Table 8.
- soil texture: increasing values indicate increased mean particle size
- organic: increasing values indicate higher soil organic matter content
- gravel: increasing values indicate more bare gravel
- conductivity: increasing values indicate larger electrical conductivity

[1] Ordination techniques used included Principal Components Analysis (PCA), Correspondence Analysis (CA), Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA) using CANOCO (ter Braak 1987).

- strata: increasing values indicate increased vegetative stratification
- stage: increasing values indicate higher successional stage
- age: increasing values indicate older vegetation
- last disturbance: increasing values indicate more time since last disturbance
- patch size: increasing values indicate larger size patches
- reference class: higher values suggest more Reference Standard characteristics
- pattern fen: higher values indicate stronger pattern fen characteristics
- wetland higher values suggest more wetland characteristics
- upland: higher values suggest more upland characteristics

Table 8. **Seven Land Use Categories**

Category	Land Use
1	Undisturbed
3	Cleared & recovering
4	Low density housing
5	Recreation
6	Cleared
7	Urban

Figure 10 shows a diagram in which the length of the vectors (arrows) indicate the strength of the correlation for each environmental characteristic with respect to the species ordinated site data (red and white symbols in Figure 10). Figure 11 explains how to read this type of diagram. Arrows that point in the same direction indicate environmental characteristics that are positively correlated with one another. Arrows that point in opposite directions indicate negatively correlated environmental characteristics. Arrows that point perpendicularly to each other indicate uncorrelated environmental characteristics. Interestingly, reference class (i.e., standard reference sites vs. non-standard reference site) correlates less well with the species-ordinated data points than several other characteristics (Figure 9). Because of the high degree of scatter in the data, strong, relevant trends are not obvious however a few generalizations are notable.

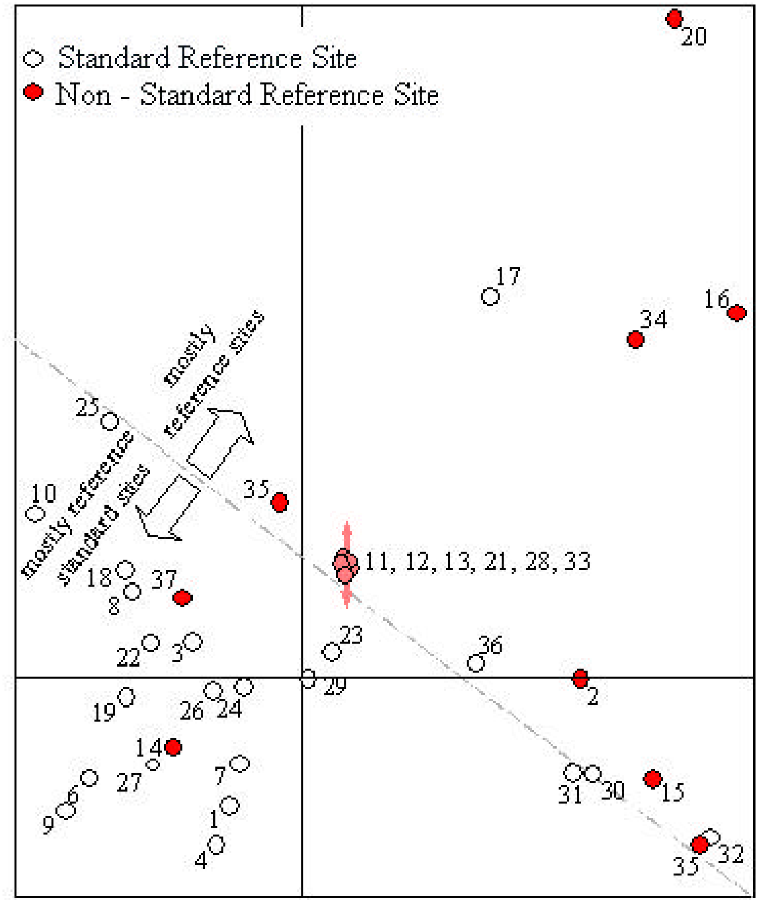


Figure 9. Ordination diagram.
Ordination diagram of the sites based on vegetation species. Because of insufficient data, plots 11, 12, 13, 21, 28, and 33 (light red symbols) could not be accurately placed along the second (vertical) axis as indicated by the red arrows. The dashed line shows the general separation between regions on the graph that are dominated by standard reference sites and non-standard reference sites respectively.

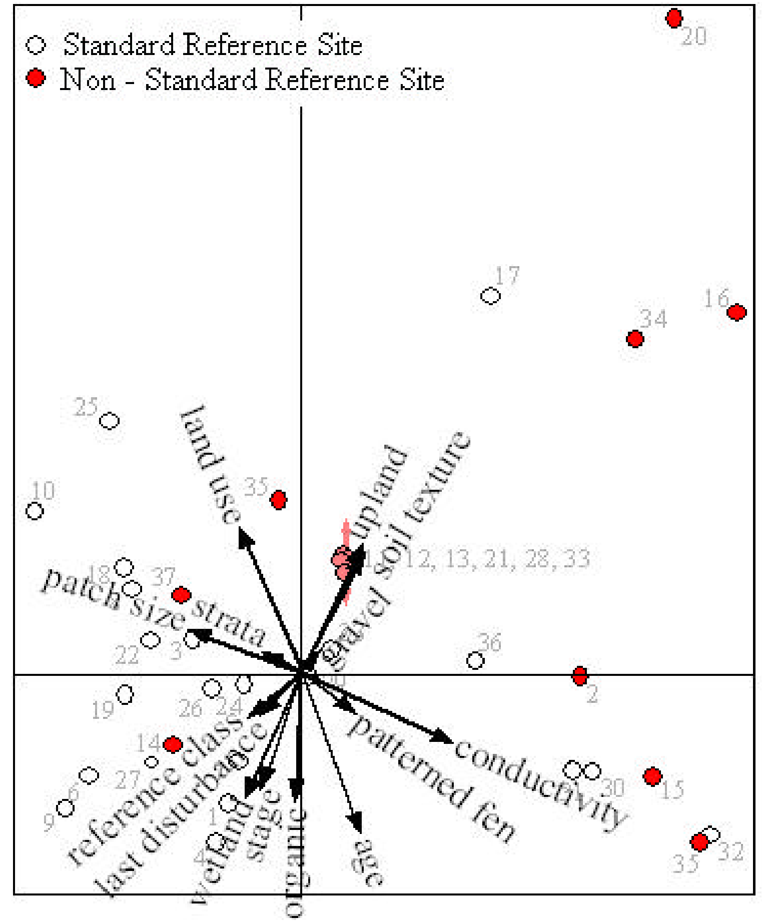


Figure 10. PCA Ordination diagram with environmental factors.
The arrows represent environmental factors. Each arrow points in the direction of increasing value and its length indicate the strength of the regression. See Figure 12 for an example of how to read this figure.

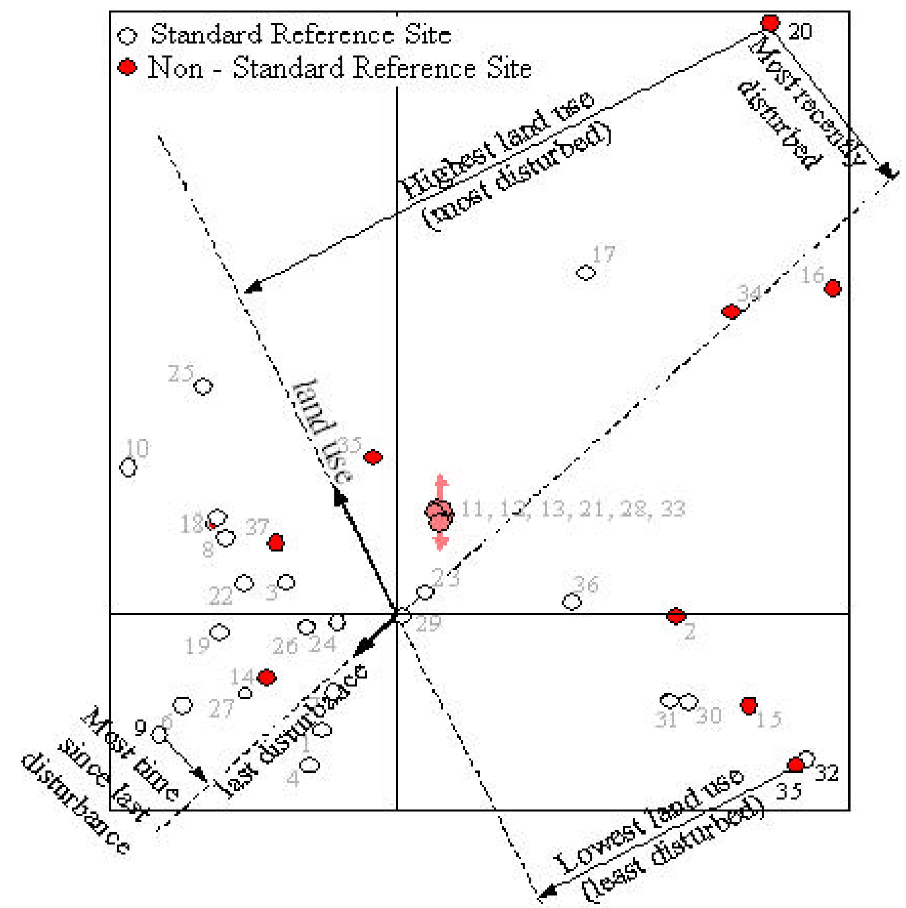


Figure 11. Example of how to read Figure 11

Generalizations Derived From Data

Standard reference sites were generally characterized by finer textured soils, organic soils, wetlands, older systems, later successional stages, undisturbed land use types, and more years since last disturbance. The non-standard reference sites found in the upper right quadrant of Figure 10 were characterized by coarser textured soils, less organic (more mineral) soils, non-wetlands (uplands), land use on the disturbed end of the spectrum, recent disturbance, and lower conductivity.

Other Analyses

Several other analyses of the data were carried out and the results of investigations looking at vegetative cover, mosses, lichens, and coarse woody debris relative to reference class, community type and land use are discussed below. Following each discussion are box and whisker diagrams.

Box and whisker diagrams were used to illustrate the spread of the set of data collected. A box and whisker diagram shows at a glance the range of scores of the middle 50% of data (the box) and the total range of all the scores (the whiskers). The two whiskers show the highest and lowest values from which the range of the data set can be calculated. The box gives the range of the middle 50% normally called the inter-quartile range. It represents the range of the scores between 25% (the lower quartile) and 75% (the upper quartile), hence the middle 50%.

Reference class referred to whether the site was a reference standard site or a non-reference standard site. Community types consisted of forest, shrub, and herbaceous communities. Seven land use types listed in Table 7 were considered.

A. Cover of Herbaceous Species, Shrubs, and Trees

Reference Class: Observed herbaceous cover ranged from 9 to 72% with a standard deviation (SD) of 9 to 85% in non-standard reference sites and 10 to 35% (SD 2 to 35) in standard reference sites. Scrub-shrub cover ranged from 15 to 62% (SD 2 to 86%) in non-standard reference sites and from 20 to 60% in standard reference sites. Tree cover ranged from 10 to 39% (SD 2 to 39%) in non-reference sites and 2 to 30% (SD 0 to 40%) in standard reference sites. Overall, non-standard reference sites had greater herbaceous cover ranges than either shrubs or trees. Reference standard sites had greater shrub cover ranges than either herbaceous or trees (see page 41).

Community Type: The observed tree cover class range was 10 to 40% (SD 2 to 40%) in forested sites. In scrub-shrub sites, tree cover was less than 5. Shrubs had a cover class range of 20 to 60 (SD 10 to 98%) in forested communities and 15 to 60% (SD 5 to 60%) in shrub communities. Herbaceous species were present in all three community types with a range of 10 to 38% (SD 2 to 62%) in forested sites, 2 to 85% in shrub communities and 1 to 61% in herbaceous community types. (See page 42).

Land Use: Observed tree cover ranged from 2 to 38% (SD of 2 to 75%) in undisturbed land use types, 5 to 10% (SD 2 to 10%) in rural sites, and 0 to 10% (SD 0 to 10%) in recreational sites. Shrub cover ranged from 10 to 62 % in undisturbed sites, 20 to 50% in rural sites, and 35 to 62% in recreational. Herbaceous species were recorded in undisturbed sites with a range of 39 to 62% (SD of 2 to 86%), and in rural sites with a range of 10 to 20% (SD 0 to 20%). (See page 43).

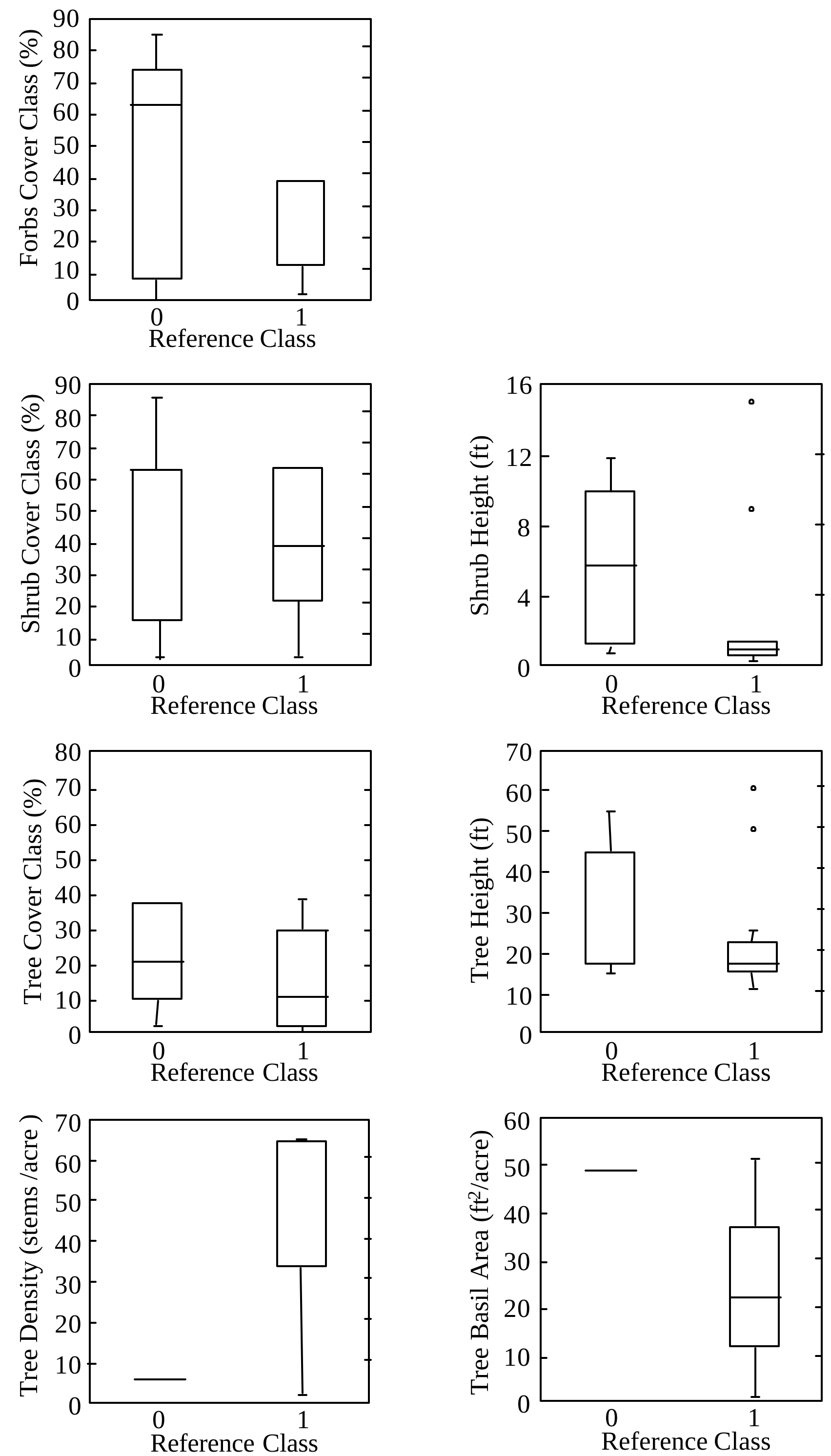


Figure 12. Herbaceous Species, Shrubs, and Trees vs. Reference Class (0=Non-Standard Reference Site, 1=Standard Reference Site)

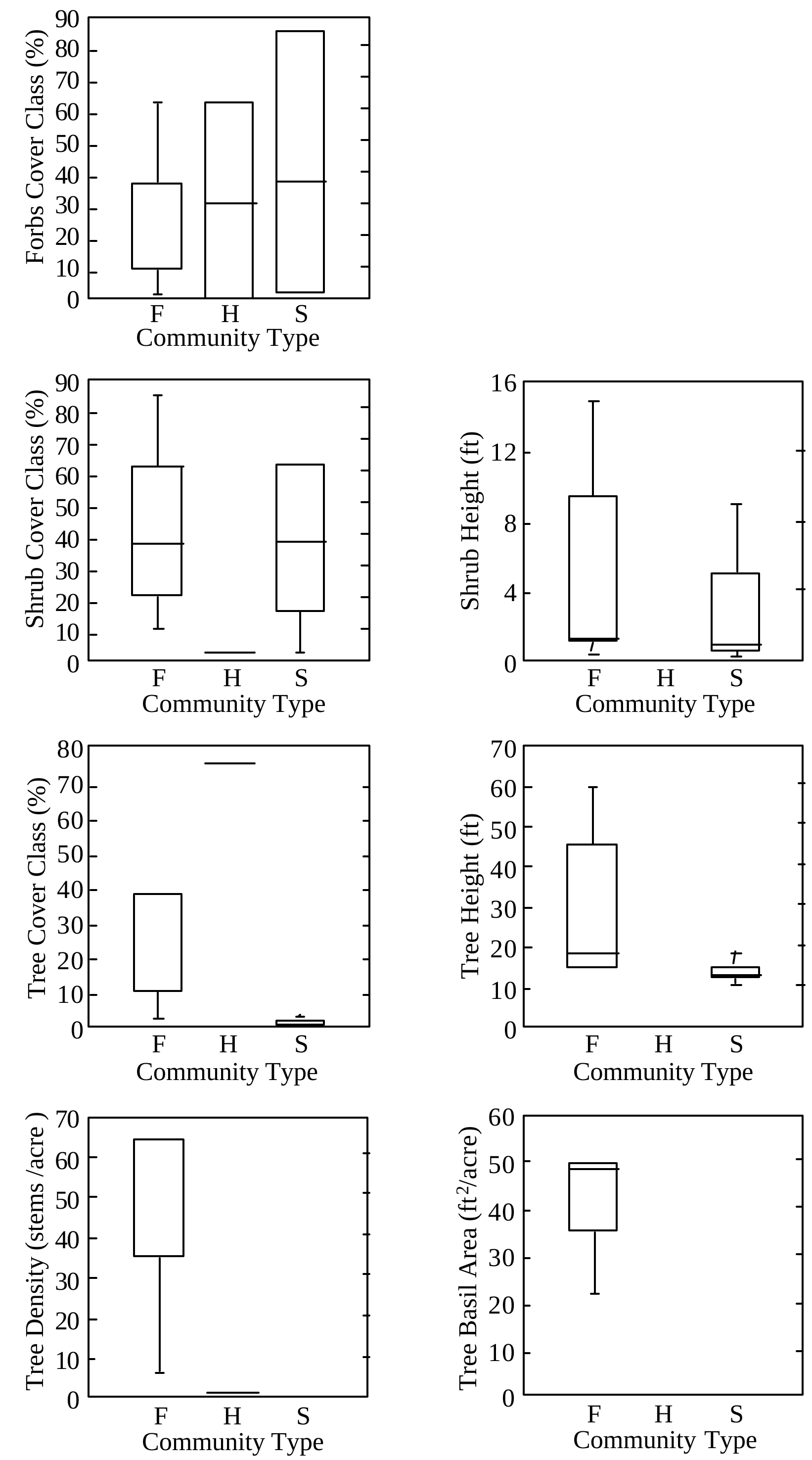


Figure 13. Herbaceous Species, Shrubs, and Trees vs. Community Type Forest (F), Herbaceous (H), and Shrub (S)

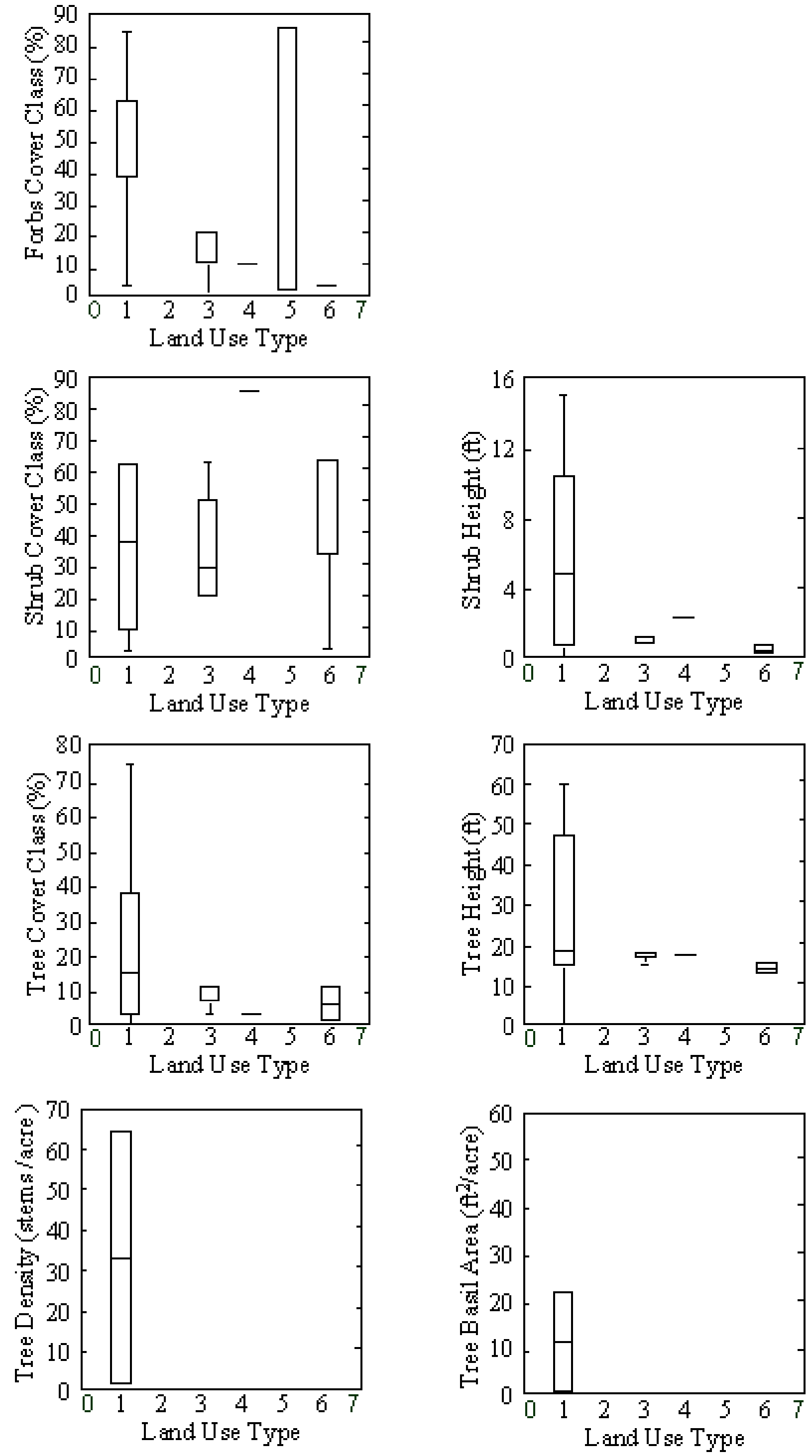


Figure 14. Herbaceous Species, Shrubs, and Trees vs. Land Use Type (See Table 7 for "Land Use Type descriptions)

B Mosses

Cover for *Sphagnum* and non-*Sphagnum* mosses were analyzed separately as well as together.

Reference Class: Mosses showed a marked divergence when comparing non-standard reference and standard reference sites. In the "All Mosses" graph, the range for non-standard reference sites was from 0 to 20%, whereas the range for reference standard sites was 38 to 88%. When split out, *Sphagnum* mosses had a greater range 0 to 70%, (SD 2 to 98%) in non-standard reference sites than in standard reference sites 0 to 50%, (SD 1 to 86%). The non-*Sphagnum* moss range was 0 to 20%.(SD 2 to 85%) in non-standard reference sites and 10 to 60% (SD 0 to 88%) in standard reference sites. (see page 45)

Community Type: When analyzed by community type, total moss cover ranged from 10 to 85% (SD 0 to 85%) in forested communities and 20% (SD 0 to 60%) in shrub communities. Mosses were not present in herbaceous communities in this graph. Non-*Sphagnum* mosses ranged from 10 to 40% (SD 10 to 38%) in forested sites and 0 to 40% (SD 0 to 86%) in shrub sites. *Sphagnum* mosses ranged from 0 to 40% (SD 0 to 85%) in forested sites, from 0 to 60% (SD 0 to 60%) in shrub communities, and from 0 to 90% (SD 0 to 98%). (see page 46)

Land Use: All mosses had a cover range from 10 to 85 % (SD 0 to 85 %) in undisturbed land use sites, and 10 to 60 % (SD 0 to 85 %) in rural land uses sites. *Sphagnum* mosses ranged from 0 to 62 % (SD 0 to 98 %) for undisturbed sites and 1 to 45 % (SD 2 to 85 %) for recreational sites. Non-*Sphagnum* mosses ranged from about 4 to 39 % (SD 4 to 86 %) in undisturbed sites, 10 to 39 % (SD 0 to 39 %) in rural sites, and 10 to 39 % in recreational sites. (graphs on page C-4)

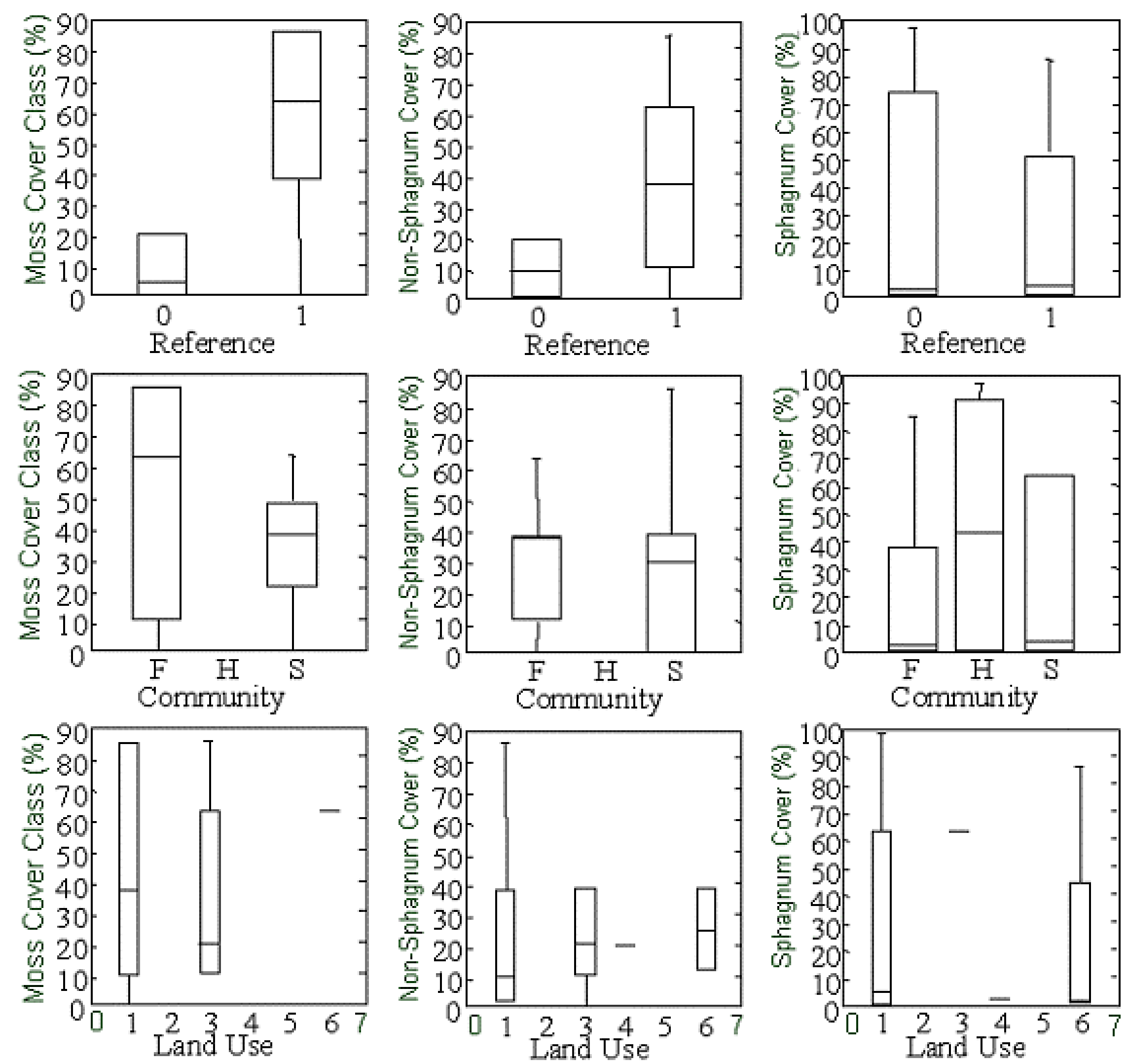


Figure 15. Mosses (Total Population, Non-Sphagnum, and Sphagnum)
Vs.

- Reference Class (0=Non-Standard Refer., 1=Standard Refer.,)
- Community Type: Forbes (F), Herbaceous (H), and Scrub/Shrub(S)
- Land Use Type (see Table 7 for "Land Use Type descriptions)

C. Lichens

Lichens were separated into two categories; fruticose and other lichens.

Reference Class: Fruticose lichen cover was approximately 1 % and other lichen was 0.5% in both reference sites and reference standard sites. There seems to be little difference between reference and reference standard sites in regards to lichen cover. (see page 47)

Community Type: Fruticose lichen cover ranged from 0 to 1 % and other lichens ranges from 0 to 0.5 % for other lichens in forested communities. Lichen cover does not appear on the graphs for herbaceous or scrub-shrub communities. (Graphs on page C-5)

Land Use: Recreational land had the highest cover of either fruticose or other lichens but the amount of cover differed greatly. Fruticose lichens had a range of 3 to 20 % with an average of 12 %, whereas other lichens had a range of 0.5 to 3.0 % with an average of 1.7 %. Lichens were also recorded in undisturbed and rural land use categories, but with less cover

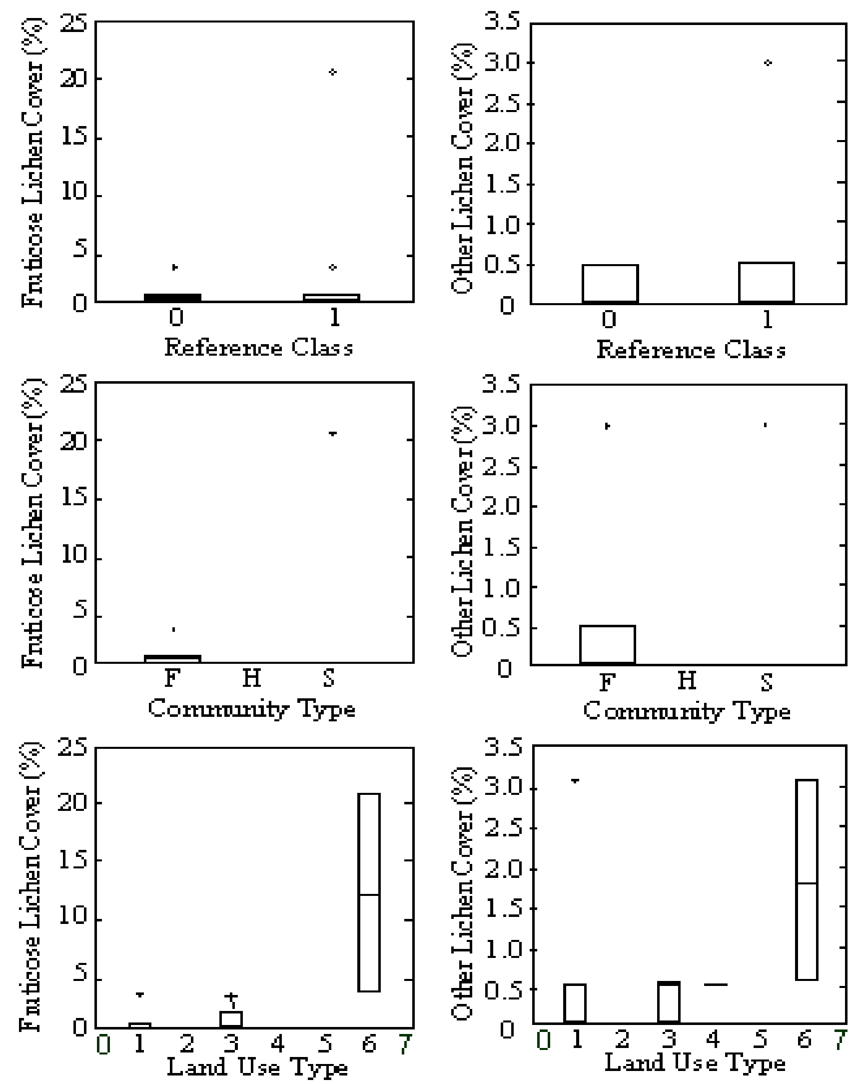


Figure 16. Lichen (Fruticose and Other)

vs.

- Reference Class (O= Reference Site, 1= Non- Standard Reference Site
- Community Type: Forest = (F), Herbaceous (H), and Shrub (S)
- Land Use Type (see Table 7 for Land Use Type Descriptions)

D. Coarse Woody Debris

Coarse Woody Debris (CWD) was analyzed by density, diameter, length and volume for community type (Tree, Scrub-Shrub or Herb), land use (7 categories), and reference class (non-reference standard or reference standard). The units for each variable are: density is stems/acre, diameter is feet, length is feet, and volume is cubic feet/acre.

Reference Class: As can be seen on the following page, ranges for CWD density, length and volume were greater in the reference standard sites than the non-reference standard sites. Diameter is greater in the non-reference standard sites.

Community Type: All of the CWD parameters were greater in forested area than either herb or scrub-shrub sites. Range for density was 99 to 299 stems/acre in forested communities and 105 to 225 stems/acre in scrub-shrub communities. In forested communities, diameter ranges from 0.1 to 0.2 ft. (SD 0.1 to 0.3 ft.) and in scrub-shrub communities the range was about 0.14 to 0.15 ft. CWD length ranges from 7 to 11 ft. (SD 6 to 15 ft.) for forested communities and 7 (very little range) in scrub-shrub communities. Volume of CWD ranges from 1 to 110 cubic feet/acre (SD 0 to 240 cubic feet/acre) in forested sites and 20 to 90 cubic feet/acre (SD 20 to 150 cubic feet acre) for scrub shrub communities. CWD is present in herbaceous communities, but is represented in each graph by a line only. (see the following pages)

Land Use: When looking at land use types, the range for density, diameter and volume were highest in undisturbed sites, whereas length of CWD is greater in sites classified as recreational. Rural sites also showed some amount of CWD, as did recreational sites. As in other vegetation, undisturbed, rural and recreational sites (categories 1, 3 and 6) were represented, but the graphs show no CWD in other land use categories. (see the following pages)

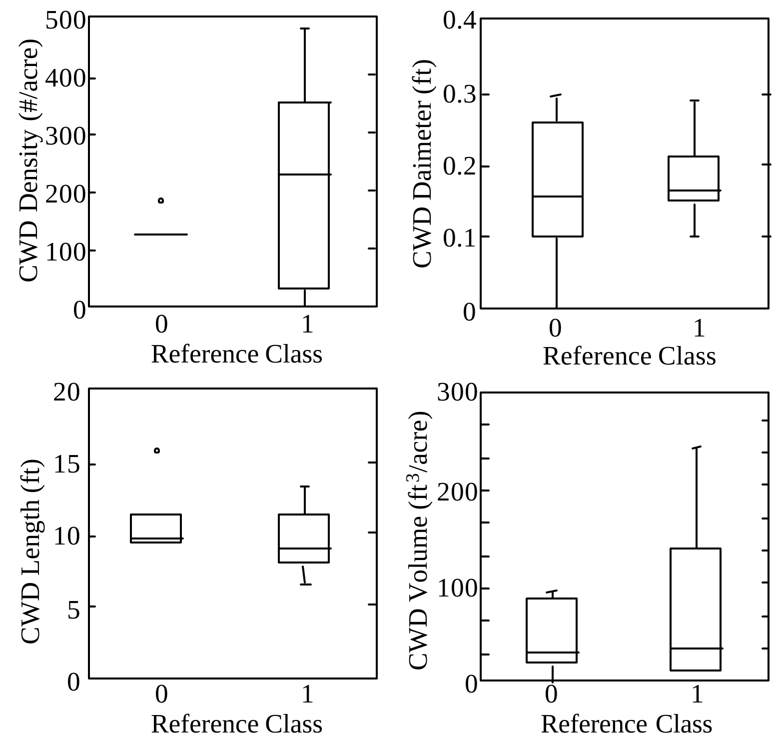


Figure 17. Coarse Woody Debris (CWD) vs. Reference Class (0=Non-Standard Reference Site, 1=Standard Reference Site)

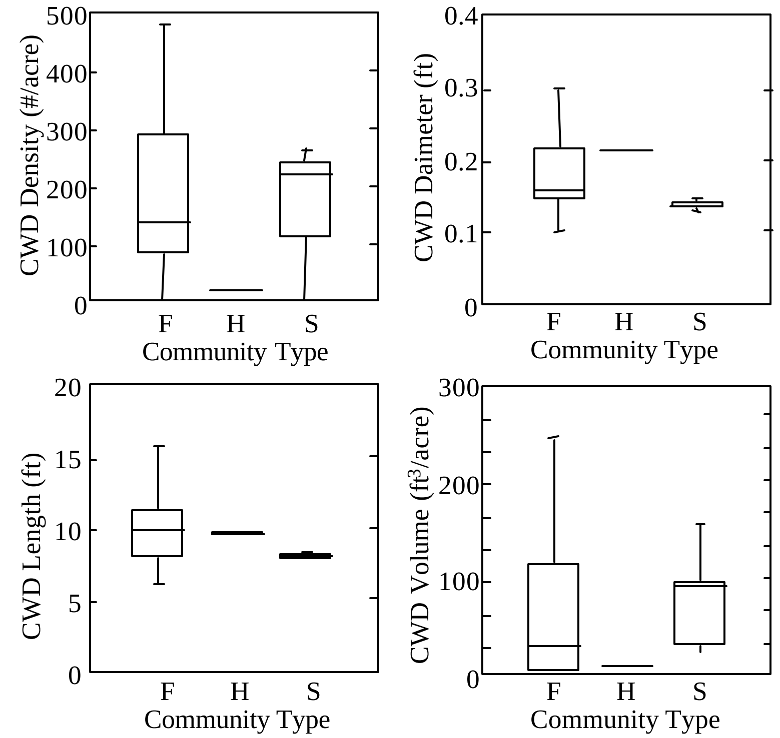


Figure 18. Coarse Woody Debris (CWD) vs. Community Type
Forbes (F), Herbaceous (H), and Scrub/Shrub (S)

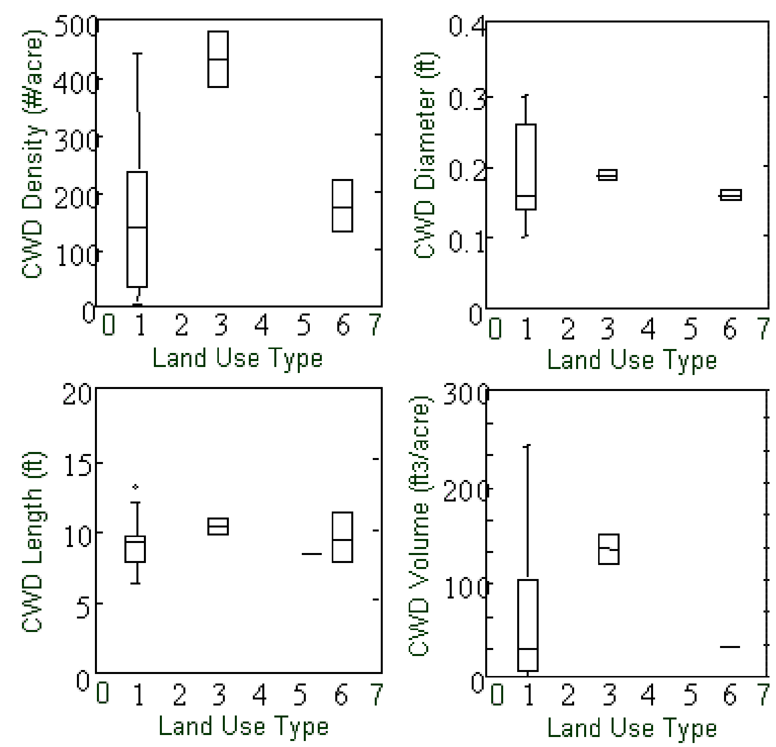


Figure 19. Coarse Woody Debris (CWD) vs. Land Use Type (See Table 7 for Land Use Type descriptions)

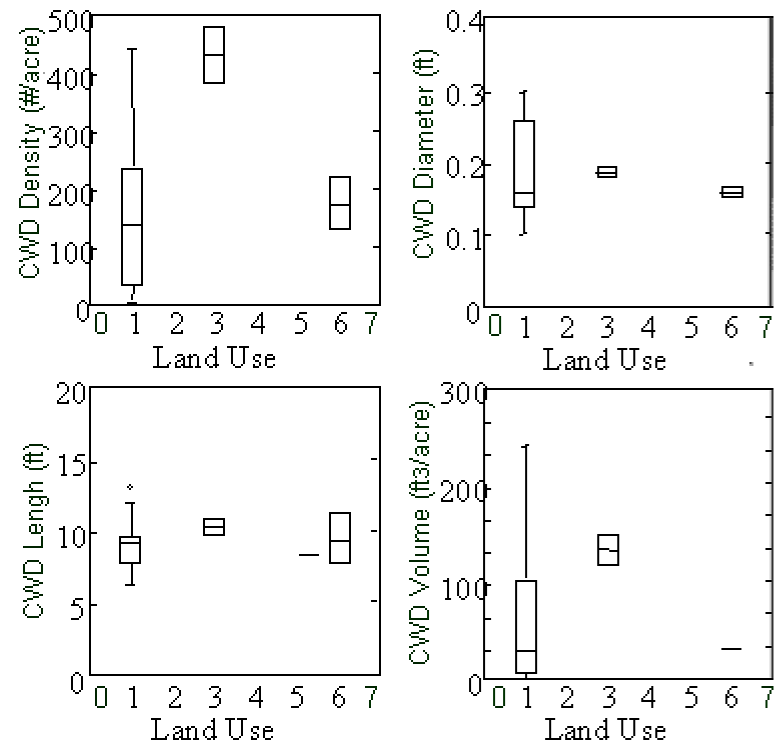


Figure 20. Coarse Woody Debris (CWD) vs. Land Use Type
(See Table 7 for "Land Use Type Descriptions)

4. Wetland Functions and Assessment Models

This section provides a list of Slope/Flat wetland functions, describes the functions and corresponding functional capacity indexes (FCI), lists the model variables, and describes the scaling of the model variables.

A. List of Functions for Slope/Flat Wetland Complexes

Hydrologic

1) Discharge of Water to Downgradient Systems
2) Surface and Shallow Subsurface Water Storage
3) Particulate Retention

Biogeochemical

4) Organic Carbon Export
5) Cycling of Elements and Compounds
6) Maintenance of Characteristic Plant Communities

Animal Support/Habitat

7) Maintenance of Characteristic Habitat Structures
8) Interspersion and Connectivity

B. Description and Functional Capacity Indexes for and Slope/Flat Wetland Complexes

The functional capacity index (FCI) below can be calculated automatically by using the electronic spreadsheet in Appendix E.

Hydrologic

1) **Discharge of water to downgradient systems:** Slope/Flat wetlands are important for maintaining water flow to streams and creeks in the watershed. This function refers to the hydrologic connectivity of slope/flat wetlands and other downgradient wetlands. Slope/Flat wetlands have land-dominated hydrographs so the timing, duration and amount of water delivered to downgradient systems is dependent upon the conditions and physical characteristics of the slope/flat wetlands.

FCI = (Vmicro + Vsource + Vaquic + Vslope)/4

2) Surface and shallow subsurface water storage: The capability of a wetland to temporarily store (retain) surface and shallow subsurface water.

FCI = [(Vmicro + Vsurwat)/2 + Voh + Vaquic + Vsource]/4

3) **Particulate retention:** The capacity of a wetland to physically remove and retain organic and inorganic particulate from the water column, independent of source.

FCI (<u>Forest Communities</u>) = [Vsource + (Vmicro + Vsurwat + Vslope)/3 + (Vcwd + Vgroundcov)/2]/3
FCI (<u>Shrub and Herbaceous Communities</u>) = [Vsource + (Vmicro + Vsurwat + Vslope)/3 + Vgroundcov)]/3

Biogeochemical

4) **Organic carbon export:** Export of dissolved and particulate organic carbon from the wetland. Mechanisms include leaching, flushing, displacement, and erosion.

FCI (<u>Forested Communities</u>) = [(Vstrata + Vgroundcov + Vcwd)/3 + Voh + Vsource +Vwatcon]/4
FCI (<u>Shrub and Herbaceous Communities</u>) = [(Vstrata + Vgroundcov)/2 + Voh + Vsource + Vwatcon]/4

5) **Cycling of elements and compounds:** Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.

FCI (<u>Forested Communities</u>) = [(Vasign + Vcwd + Vgroundcov + Vtotcover + Vstrata)/5 + Vaquic + Voh]/3
FCI (<u>Shrub and Herbaceous Communities</u>) = [(Vasign + Vgroundcov + Vtotcover + Vstrata)/5 + Vaquic + Voh]/3

6) **Maintenance of a characteristic plant community:** This function represents the species composition and physical characteristics of living plants typically found in slope wetlands and slope/flat wetland complexes.

FCI = (Vtotcov + Vstrata + Vnplant)/3

Animal Support/Habitat

7) **Maintenance of characteristic habitat structures:** This function represents the capacity of a wetland to support animal populations and guilds by providing heterogeneous habitats that provide food, cover, and reproductive opportunities.

FCI (<u>Forested Communities</u>) = [Vasign + Vstrata + (Vtotcov + Vgroundcov)/2 +Vcwd]/4

FCI (<u>Shrub and Herbaceous Communities</u>) = [Vasign + Vstrata + (Vtotcov + Vgroundcov)/2]/3

8) **Interspersion and connectivity:** This function represents characteristic juxtaposition and contiguous corridors of native plant communities necessary to meet life history requirements of organisms, including movements to and from the wetland.
FCI = (Vwatcon + Vsource + Vwetuse + Vadjuse +Vdistantuse)/5

C. List of Variables

Table 9. List of Variables Organized by Field Collection Groups

Landscape Position Soils, Hydrology, and Land Use		Microtopography	
1) Surface Slope	Vslope	9) Microtopography	Vmicro
2) Aquic Moisture Regine	Vaquic	10) Surface Water Storage	Vsurwat
3) Organic Horizons	Voh	**Vegetation and Animals**	
4) Source of Water	Vsource	11) Ground Cover	Vgroundcov
5) Water Connections	Vwatcon	12) Total Vegetation Cover	Vtotcov
6) Land Use of Assessment Area	Vwetuse	13) Vegetation Strata	Vstrata
7) Adjacent Land Use	Vadjuse	14) Native Plants	Vnplant
8) Distant Land Use	Vdistantuse	15) Coarse Woody Debris	Vcwd
		16) Animal Sign	Vasign

D. Description and Scaling of the Variables

1. Surface Slope (Vslope)

Definition: This variable describes the inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by the horizontal distance, multiplied by 100. For example, a drop of 30 feet across a 150 ft. horizontal distance is a slope of 20% (30 ÷ 150 = .20)

Rationale For Selection of the Variable: Slope is directly related to the movement of water and transport of nutrients and particulate material.

Measurement Protocol: Visually determine the fall line (most direct route of water flow). After the fall line is determined, measure the percent slope along the fall line. An inclinometer can be used.

Data: Appendix B, Table 4

Scaling Rationale: Percent slope varied significantly at reference standard sites. Based on field data and knowledge of wetlands of the area, the range of slope for reference standard conditions is 0.1% to 25%. The 0-25% range is used as the reference standard baseline because rapid assessment methods rule out the use of sophisticated field tools needed to determine slopes at 0.1% increments. Beyond 25%, slope the rate of discharge increases resulting in excessive flow of water and erosion potential. The authors assume that slopes greater than 25% are the result of mechanized alteration to the site.

Confidence that reasonable logic and/or data support the calibration: Medium. The definitions of the Slope and Slope/Flat Complex subclasses indicate that these wetland types inherently have at least some degree surface slope. However, past a certain point, slope has a negative affect on functions. Therefore, the variable was included in the model. The scaling followed this logic and best scientific judgment.

Table 10. **Scaling for Vslope**

Measurement or Condition for Vslope	Index
0 – 25% slope.	1.0
>25 - 35% slope.	.50
> 35% and site is recoverable and sustainable through natural processes, if the existing land use is discontinued and no restoration measures are applied.	.10
>35% and site is not recoverable and sustainable through natural processes, if the existing land use is discontinued and on restoration measure are applied	.00

2. Aquic Moisture Regime (Vaquic)

Definition: This variable is a measure of the degree to which soils currently experience continuous or periodic saturation and reduction. The presence of these conditions is indicated by redoximorphic features and can be verified, except in artificially drained soils, by measuring saturation and reduction.

Rationale for Selection of the Variable: Soils within the aquic moisture regime have morphological characteristics that indicate long-term saturation (epi- and/or endo) and the presence of anaerobic conditions that reflect important biogeochemical processes such as elemental cycling and carbon export.

Measurement Protocol: Locate the center point of the project assessment area and excavate a pit to a depth of approximately 3 ft. by shovel or bucket auger. Indicators of aquic soil conditions on unperturbed sites include the following: a) presence of an organic soil, b) a complex pattern of faint grayish and reddish colors (redox depletions and concentrations, respectively) in the mineral soil (active redoximorphic features), and c) a greenish-gray (gleyed) substratum color, and d) an over-thickened surface organic layer (histic epipedon).

The current *Alaska Hydric Soil Indicators* and *Soil Taxonomy* (Soil Survey Staff 1990) should be used for further guidance.

Data: Appendix B, Table 3

Scaling Rationale: The authors scaled aquic moisture regime using empirical relationships based on field data from 37 reference sites (Appendix C) and best scientific judgment. All reference standard sites in the reference domain exhibited aquic soil conditions. Human disturbance at sites can lead to altered site hydrology and removal of aquic moisture regime

(e.g., drainage or blockage of water source). The large discontinuity in scale from 0.75 to 0.25 is justified because an aquic moisture regime is either present or not.
Confidence that reasonable logic and/or data support the calibration: Medium/High

Table 11. Scaling: For All Community Types for Vaquic

Measurement or Condition for Vaquic	Index
Direct observation of aquic soil conditions and/or evidence of aquic soil conditions within the project assessment area, from morphological characteristics indicative of saturated soils in the modal soil profile. Aquic soil conditions have not been altered by human-induced disruption of the soil profile or soil hydrologic or thermal regimes.	1.0
Direct observation of aquic soil conditions and/or evidence of aquic soil conditions within the project assessment area, from morphological characteristics indicative of saturated soils in the modal soil profile. Evidence of altered hydrology initiated through human-induced disruption of the soil profile or soil hydrologic regime (e.g., partial draining).	0.75
No standard for this score.	0.50
Aquic soil conditions are absent due to ongoing activities that have altered surface and subsurface hydrology. The variable is in the process of recovering to aquic conditions and sustainable through natural processes if the existing activity is discontinued and no restoration measures are applied.	0.25
Aquic soil conditions are absent due to ongoing activities that have altered surface and subsurface hydrology. Aquic soil conditions have potential toward recovery through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
Aquic conditions are absent within the project assessment area. The variable is neither recoverable to aquic soil conditions nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied (e.g., gravel pad or asphalt parking lot).	0.0

3. Organic Horizons (Voh)

Definition: This variable is a measure of the thickness and condition of the surface organic horizon(s) (i.e., Oi and/or Oe and/or Oa horizons) in modal soils within the project assessment area.

Rationale for selection of the Variable: Surface organic horizons help to maintain hydrologic, biogeochemical, and physical functions. Organic surface horizons provide surface/near surface water storage (episaturation), energy reduction of surface and shallow subsurface water, elemental cycling, particulate retention, and establishment and maintenance of plant communities.

Measurement Protocol: Dig a soil pit at the center of the assessment area to a depth of approximately 6 ft (2m) using a shovel or auger. Identification, nomenclature, and descriptions of soil horizons should be consistent with guidance provided by the USDA Natural Resources Conservation Service. All depths are measured from the top of the surface (usually Oi) horizon. Live vascular and non-vascular plant materials are not included in these depths. Soil colors are determined with a Munsell Soil Color Chart (Munsell 1992).

Data: Appendix B, Table 3

Scaling Rationale: Both empirical field data from 37 reference sites and best scientific judgment drive scaling of organic horizons. Reference standard sites that had not been burned in the past 60 years had surface organic horizons ranging between 61 cm and 200 cm. Thirteen of these sites had surface organic horizons over 100 cm in thickness. Reference standard sites that had been burned in the past 50 years had organic surface horizon thickness between 17 cm and 59 cm.

Because reference standard sites have widely variable thickness of organic soil horizons, quantitative thickness conditions were supplemented with alternative conditions based on percent reduction of organic soil horizon thickness from reference standard conditions, which should be determined from adjacent unaltered sites or "with-" and "without-project."

Confidence that reasonable logic and/or data support the calibration: Medium-High to High.

Table 12. **Scaling for Voh**

Measurement or Condition for Voh	Index
Within the project assessment area, surface organic horizons are present and undisturbed.	1.0
Surface organic horizons are present and the living moss layer has been removed or partially removed. The thickness of the organic horizon has been reduced by 25% or less. The reduction is determined by comparing the assessment area with adjacent unaltered sites.	0.75
Surface organic horizons are present. The thickness of the organic horizon has been reduced by > 25 to < or equal to 50%. The reduction is determined by comparing the assessment area with adjacent unaltered sites.	0.50
Surface organic horizons are present. The thickness of the organic horizon has been reduced by >50% to < or equal to 75%. The reduction is determined by comparing the assessment area with adjacent unaltered sites.	0.25
Surface organic horizons are present but show signs of disturbance by human-induced activities (e.g., vegetation removal including scraping of organic horizon). The thickness of the organic horizon has been reduced by >75% to < or equal to 100%. The reduction is determined by comparing the assessment area with adjacent unaltered sites. The original organic soil horizons are recoverable and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
Surface organic horizons are present. The thickness of the organic horizon has been reduced by >75% to < or equal to 100%. The reduction is determined by comparing the assessment area with adjacent unaltered sites. The original organic soil horizons are not recoverable and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.0

4. Source of Water (Vsource)

Definition: A 90-degree arc upslope of the assessment area is used to describe the area of hydrologic contribution (i.e., surface and shallow subsurface waterflow). The variable (Vsource) is a measurement of the condition of the hydrologic source area.

Rationale For Selection of the Variable: Quantity and quality of flow of water drives fundamental processes in slope wetlands (e.g., surface and shallow subsurface water storage).

Condition of the source area will determine the volume, timing, distribution and quality of water flowing into the wetland (Glass 1984). Perturbation to the source area, such as breaking longitudinal connectivity of flow by placement of fill, may result in decreased flow of water to the wetland.

Measurement Protocol: By convention (see definition) the hydrologic source area is described as a 90 degree arc (measured using a compass) looking up-gradient from the center of the assessment area. The field team should visually mark the boundaries of the arc using reference marks such as trees or buildings.

Within the 90-degree arc described above, angles of perturbation are measured by siting the arc distance of each perturbation. Measurements of perturbation should be made to the edge of the contributing area or to 0.25 mile, whichever is less. The angle of all perturbations are individually measured and categorized (see the following "Category Ranking for Perturbations" table). If multiple perturbations occur within the same arc, measure the perturbation with the highest ranking (See Table 12 below) and all other perturbations between that point and the assessment area. The following calculations should then be made:

1. Sum all segments of perturbation arc length, which fall into the same category of perturbation (See the following "Category Ranking for Perturbations" table). Express as a percent of total source arc length.
2. Multiply the total arc length for each category by the category rank (provided in the following "Category Ranking for Perturbations" table) to achieve a weighted arc length.
3. Add all weighted arc length percentages to get the hydrologic source impact score.

The use of a non-linear scale (i.e., 0, 1, 3 and 4) for weighing the land use categories reflects the significant difference in impacts to hydrologic regimes caused by the disturbances described in the **Agriculture/Forestry** category (value 1) and the **Rural** category (value 3).

Table 13. Category Ranking for Perturbations

Land Use Categories	Values
Undisturbed: No significant human induced perturbation, except for natural or controlled burns	0
Agriculture/Forestry: Clearing of vegetation, clearing for right-of-ways, logging with temporary roads (no fill), pasture and croplands	1
Rural: Low density housing ($\geq$5 acre lots), through-fill roads without ditches, forestry main haul roads (with through-fill and some ditches)	3
Urban: Medium to high density residential (<5 acre lots), commercial/industrial, airports, gravel pits, through-fill roads with ditches, parking lots	4

Data: Appendix B, Table 5

Scaling Rationale: Impacts to source areas contributing to the Slope/Flat Wetland Complexes wetlands may result in change of water quantity and quality to water delivered to the wetland. With particular respect to water quantity, increases or decreases may result in ponding, stream development (incision), cessation of shallow subsurface flow, desiccation, oxidation of peat, or total loss of flow. Input of water with altered quality from source areas (e.g., anoxic water) can result in changes in the rate of a) geochemical cycles including decomposition, and b) water movement through soil media. Similarly, output chemical characteristics from the wetland (e.g., redox status) to adjacent waters could be altered if source area inputs are degraded.

For the purposes of scaling, the Development Team assumed that perturbations such as urban development (e.g., impervious surfaces, storm drainages, buildings, roads, etc.) would have a more significant impact than some agricultural practices, including forestry (e.g., management for row crops, pasture, no-till agriculture, etc.). At the same time, it was the Development Team's opinion that perturbations that impact 100% of the source areas will obviously have a greater impact on source area than perturbations to 10% of the area.

Reference standard sites sampled in the Kenai River Watershed Study Area had hydrologic source impact scores ranging from 0 - 308. Therefore, the Development Team assigned a variable index score of 1.0 to this range. The most degraded non-reference standard sites sampled by the field team scored 500. Although it is theoretically possible to have higher scores, the Development Team decided to use this field-measured value as the score that would receive a variable index score of 0.0. The remaining variable index scores were developed using a linear model.

Confidence that reasonable logic and/or data support the calibration: Medium. 1984 aerial photography was used to measure the hydrologic source impacts.

Table 14. **Scaling for Vsource**

Measurement or Condition for Vsource	**Score**
Hydrologic source impact scores range from 0 to 308.	1.0
Hydrologic source impact scores range from 309 to 372.	0.75
Hydrologic source impact scores range from 373 to 436.	0.50
Hydrologic source impact scores range from 437 to 499.	0.25
Hydrologic source impact score is $\geq$500. The variable is 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
Hydrologic source impact score is $\geq$500. The variable is not recoverable (e.g., parking lot, fill pad, drill pad).	0.0

5. Water Connections (Vwatcon)

Definition: This variable addresses the land use and condition of the longitudinal connections between project assessment wetlands and downgradient wetlands. Longitudinal connections are features (e.g., channels, swales, intact soil profiles, etc.) that provide pathways for surface and shallow subsurface water flow and organic carbon export to down-gradient wetlands.

Rationale For Selection of the Variable: Human disturbance of the longitudinal connection can disrupt flow paths and eliminate export of organic carbon to down-gradient aquatic systems.

Measurement Protocol: Make a visual assessment of the predominant land use and/or condition of the longitudinal hydrologic connection(s) to downgradient wetlands within 500 feet of the assessment area or to the next wetlands. In addition, aerial photos should be used to assess the land use of the longitudinal connection(s).

Data: Appendix B, Table 5

Scaling Rationale: The predominant use and condition of the longitudinal connections to down-gradient wetlands was scored according to a disturbance scale. The disturbance scale was developed by the Development Team and is based upon field observations and best professional judgment.

Confidence that reasonable logic and/or data support the calibration: Medium

Table 15. **Scaling For Vwatcon**

Measurement or Condition For Vwatcon	Score
The longitudinal hydrologic connection(s) is unaltered by human activity and is characterized by intact soil profiles and vegetation communities, and unrestricted discharge of surface and shallow subsurface water to down-gradient wetlands.	1.0
The longitudinal hydrologic connection(s) is predominantly undisturbed and is characterized by an intact soil profile and land use conditions that do not restrict discharge of surface and shallow subsurface flows to down-gradient wetlands. Land use condition might include: (a) cleared vegetation (e.g., clearing for right-of-ways), foot paths (not entrenched), footings for bridges, elevated boardwalks, trestles, powerlines, etc.	0.75
The longitudinal hydrologic connection(s) has minor constrictions, interruptions or diversions (i.e., <50% of the width of the connection) and is characterized by disturbed soil profiles and vegetation communities, and land use conditions that restrict, redirect or interrupt surface and shallow subsurface flows such as: • through-fill roads with well designed and maintained culverts, • entrenched foot paths, • building pads that partially block the connection, • shallow ditches, etc. The remainder of the longitudinal connection is intact.	0.50
The longitudinal hydrologic connection(s) has major constrictions, interruptions or diversions (i.e., $\geq$50% of the width of the connection) and is characterized by highly disturbed soil profiles and vegetation communities, and land use conditions that restrict, redirect or interrupt surface and shallow subsurface flows such as: • through-fill roads with poorly designed and maintained culverts, • deep ditches, • large building pads, etc.	0.25
There is an obvious human-induced break or discontinuity that acts to block surface and shallow subsurface discharge (e.g., through-fill road without culverts, urban fill, etc.) from the wetland to the down-gradient wetlands. The variable is 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
There is an obvious human-induced break or discontinuity that acts to block surface and shallow subsurface discharge (e.g., through-fill road without culverts, urban fill, etc.) from the wetlands to the down-gradient wetlands. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes if the existing land use if discontinued and no restoration measures are applied.	0.0

6. Land Use in the Wetland Assessment Area (Vwetuse)

Definition: This variable is a measurement of land uses and conditions in the project assessment area.

Rationale For Selection of the Variable: Land uses within the project assessment area have great influence on hydrologic, biogeochemical, vegetation and faunal support/habitat functions of slope wetlands in the Cook Inlet Basin Ecosystem. For example, land use alteration (e.g., paving, fill, etc.) affects roughness by eliminating microtopographic variation, as well as reducing storage capability. Ditching usually drains wetlands, increases the slope of the piezometric surface, and alters residence time in surface and shallow subsurface water storage compartments. Similarly, land uses of the wetland can limit or accelerate rates of elemental cycling, particulate loading, and retention of organic and inorganic particulates on the soil surface. Water residence time in the wetland has direct bearing on the oxidation/reduction state of hydric soils and hence on the type and rate of geochemical processes that dominate the system seasonally, or annually (e.g., nitrification/denitrification).

Land uses of the wetland impact native plant communities and the extent to which non-native plant communities may still exist on site. For example, some activities (e.g., tree removal, rights-of-way clearing, etc.) may leave a portion of the native plant community intact, while simultaneously providing opportunities for colonization by non-native species. Other activities, (e.g., hay production, low density residential development, etc.) can replace native vegetation with non-native vegetation, but still provide cover for animal movement within and through the site.

Measurement Protocol: Examine the project assessment area and estimate the percent of the area covered by the following land use categories: 1) undisturbed, 2) agriculture/forestry, 3) rural, and 4) urban. The following calculations should then be made:

1. Multiply the percent for each land use category by the category rank (provided in the following "Category Ranking for Observed Wetland Land Uses" table) to achieve a weighted score.
2. Add all weighted scores to get the total wetland land use impact score.

The use of a non-linear scale (i.e., 0, 1, 3 and 4) for weighing the land use categories reflects the significant difference in impacts to hydrologic regimes caused by the disturbances described in the **Agriculture/Forestry** category (value 1) and the **Rural** category (value 3).

Table 16. Category Ranking for Observed Wetland Land Uses

Land Use Categories	Values
Undisturbed: No significant human induced perturbation, except for natural or controlled burns	0
Agriculture/Forestry: Clearing of vegetation, clearing for right-of-ways, logging with temporary roads (no fill), pasture and croplands	1
Rural: Low density housing (≥5 acre lots), through-fill roads without ditches, forestry main haul roads (with through-fill and some ditches)	3
Urban: Medium to high density residential (<5 acre lots), commercial/industrial, airports, gravel pits, through-fill roads with ditches, parking lots	4

Data: Appendix B, Table 5

Scaling Rationale: For the purposes of scaling, the Development Team assumed that perturbations that would result in construction of impervious surfaces, drainage, or disruption of soil profiles (e.g., urban development) would have a more significant impact on wetland functions than some agricultural practices, including forestry (e.g., management for row crops, pasture, no-till agriculture, etc.) and forestry practices. At the same time, it was the Development Team's opinion that perturbations which impact 100% of the project assessment area will obviously have a greater impact on wetland functions than perturbations to less than 100% of the area.

All reference standards sites sampled in the Kenai River Watershed had a total wetland land use impact score of 0 (i.e., 100% x 0 = 0). Several non-reference standard sites had the maximum total wetland land use impact score: 100% x 4 = 400). Therefore, the Development Team decided to (1) assign reference standard sites a variable index score of 1.0, and (2) assign non-reference standard sites with an impact score of 400 (i.e., the maximum score possible) a variable index score of 0.0. The remaining variable index scores were developed using a linear model.

Confidence that reasonable logic and/or data support the calibration: High. The 1.0 (reference standard) and 0.0 scores were derived from data. The remaining scores were derived using a linear model.

Table 17. **Scaling for Vwetuse**

Measurement or Condition for Vwetuse	Score
Total wetland land use impact score is 0.	1.0
The wetland land use impact score ranges from 1-133. An example of how this impact score can be achieved: 30% of the project assessment area is urban, 70% is undisturbed (30 x 4 + 70 x 0 = 120).	0.75
The wetland land use impact score ranges from 134-266. An example of how this impact score can be achieved: 25% of the project assessment area is urban, 25% is rural and 50% is undisturbed (25 x 4 + 25 x 3 + 50 x 0 = 175)	0.50
The wetland land use impact score ranges from 267-399. An example of how these impact scores can be achieved: 60% of the project assessment area is urban, 40% is rural (60 x 4 + 40 x 3 = 360)	0.25
Total wetland land use impact score is 400. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and not restoration measures are applied.	0.10
Total wetland land use impact score is 400. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.0

7. Adjacent Land Use (Vadjuse)

Definition: This variable is a measurement of land uses and conditions within 1,000 feet of the project assessment area.

Rationale For Selection of the Variable

Adjacent land use represents the secondary-level connections (i.e., up to 1,000 feet) between an assessment area and its landscape context. Uninterrupted corridors are critical for movement of animals within and between wetlands in the Kenai River Watershed. The integrity of these corridors may be disturbed through human-induced perturbations both within and around the assessment area. Land uses occurring in the landscape surrounding a wetland largely determine the degree of alteration to native plant communities and the extent to which non-native analogs to native plant communities may exist in the landscape. These native and non-native plant communities act as corridors leading between wetlands and other sites necessary for faunal life history activities and/or plant dispersal.

Some land use activities (e.g., clearing for rights-of-ways and selective logging) may leave a portion of the native vegetation intact, which may allow cover for faunal movement between wetlands. Other activities (e.g., hay production) may replace native vegetation with non-native vegetation but still provide cover for animal movement. Intensive land uses of landscapes surrounding wetlands (i.e., urban development) may remove or suppress all suitable food and cover for animal movements or remove appropriate substrates for plant reproduction and dispersal. Moderately intensive land uses (i.e., rural residential) may result in a mix of intact native plant communities, non-native plant communities and impervious surfaces (e.g., homes, roads, etc.). Some corridors for the movement of wildlife and plant dispersal may remain intact.

Measurement Protocol

Examine the adjacent land (within 1,000 feet of the project assessment area) and estimate the percent of the area covered by the following land use categories: (1) undisturbed, (2) agriculture/forestry, (3) rural, and (4) urban. The following calculations should then be made:

1. Multiply the area percentage value for each land use category by the category rank (provided in the following “Category Ranking for Observed Adjacent Land Use” table) to achieve a weighted score.
2. Add all weighted scores to get the total surrounding land use impact score.

The use of a non-linear scale (i.e., 0, 1, 3 and 4) for weighing the land use categories reflects the significant difference in impacts to hydrologic regimes caused by the disturbances described in the **Agriculture/Forestry** category (value 1) and the **Rural** category (value 3).

Table 18. **Category Ranking for Observed Adjacent Land Use**

Land Use Categories for Scaling the Variable	Values
Undisturbed: No significant human induced perturbation, except for natural or controlled burns	0
Agriculture/Forestry: Clearing of vegetation, clearing for right-of-ways, logging with temporary roads (no fill), pasture and croplands	1
Rural: Low density housing (≥5 acre lots), through-fill roads without ditches, forestry main haul roads (with through-fill and some ditches)	3
Urban: Medium to high density residential (<5 acre lots), commercial/industrial, airports, gravel pits, through-fill roads with ditches, parking lots	4

Data: Appendix B, Table 5

Scaling Rationale: The Development Team described and ranked adjacent land uses and conditions to reflect their ability to provide a mechanism for dispersal of plant materials and food to provide cover resources for wildlife species.

Reference standard sites sampled in the Kenai River Watershed had adjacent land use impact scores ranging from 0 - 76. Therefore, the Development Team assigned a variable index score of 1.0 to this range. The most degraded non-reference standard site sampled by the field team scored 300. However, it was the judgment of the Development Team that it is possible for a site in an urban setting (e.g., high-density residential area) to score 400. Therefore, the Development Team assigned non-reference standard sites with an impact score of 400 (i.e., the maximum score possible) a variable index score of 0.0. The remaining variable index scores were developed using a linear model.

Confidence that reasonable logic and/or data support the calibration: High. The Development Team used both data from the reference system and best scientific judgment to describe surrounding land uses and conditions in order to scale the variable.

Table 19. Scaling for Vadjuse

Measurement or Condition for Vadjuse	Score
The surrounding land use impact score ranges from 0 – 76.	1.0
The surrounding land use impact score ranges from 77 – 184.	0.75
The surrounding land use impact score ranges from 185 – 292.	0.50
The surrounding land use impact score ranges from 293 – 399.	0.25
The surrounding land use impact score is 400. The variable is 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
The surrounding land use impact score is 400. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.0

8. Distant Land Use (Vdistantuse)

Definition: This variable is a measurement of land uses and conditions between 1,000 feet and 1 mile from the boundary of the project assessment area (need figure).

Rationale For Selection of the Variable: Land use represents the tertiary-level connections (i.e., > 1,000 feet up to one mile) between an assessment area and its landscape context. Uninterrupted corridors are critical for movement of animals within and between wetlands in the Kenai River Watershed. The integrity of these corridors may be disturbed through human-induced perturbations both within and around the assessment area.

Measurement Protocol: Examine the condition of the land between 1,000 feet and 1 mile from the boundary of the project assessment area. Estimate the percent of the area covered by the following land use categories: 1) undisturbed, 2) agriculture/forestry, 3) rural, and 4) urban. The following calculations should then be made:

1. Multiply the value for each land use category by the category rank (provided in following "Category Ranking for Observed Distance Land Uses" table) to achieve a weighted score.
2. Add all weighted scores to get the total wetland land use impact score. The use of a non-linear scale (i.e., 0, 1, 3 and 4) for weighing the land use categories reflects the significant difference in impacts to hydrologic regimes caused by the disturbances described in the **Agriculture/Forestry** category (value 1) and the **Rural** category (value 3).

Table 20. **Category Ranking for Observed Distant Land Uses**

Land Use Categories	Values
Undisturbed: No significant human induced perturbation, except for natural or controlled burns	0
Agriculture/Forestry: Clearing of vegetation, clearing for right-of-ways, logging with temporary roads (no fill), pasture and croplands	1
Rural: Low density housing (>5 acre lots), through-fill roads without ditches, forestry main haul roads (with through-fill and some ditches)	3
Urban: Medium to high density residential (<5 acre lots), commercial/industrial, airports, gravel pits, through-fill roads with ditches, parking lots	4

Data: Appendix B, Table 5

Scaling Rationale: The Development Team described and ranked surrounding land uses and conditions to reflect their ability to provide food and cover resources for wildlife species.

Reference standards sites sampled in the Kenai River Watershed had surrounding land use impact scores ranging from 0 - 120. Therefore, the Development Team assigned a variable index score of 1.0 to this range. The most degraded non-reference standard site sampled by the field team scored 244. However, it was the judgment of the Development Team that it is possible for a site in an urban setting (e.g., high-density residential area) to score 400. Therefore, the Development Team assigned non-reference standard sites with an impact score of 400 (i.e., the maximum score possible) a variable index score of 0.0. The remaining variable index scores were developed using a linear model.

Confidence that reasonable logic and/or data support the calibration: High. The Development Team used both data from the reference system and best scientific judgment to describe surrounding land uses and conditions in order to scale the variable.

Scaling for Vdistantuse

Measurement or Condition for Vdistantuse	Score
The surrounding land use impact score ranges from 0 – 120	1.0
The surrounding land use impact score ranges from 121 – 213.	0.75
The surrounding land use impact score ranges from 214 – 306.	0.50
The surrounding land use impact score ranges from 307 – 399.	0.25
The surrounding land use impact score is 400. The variable is 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
The surrounding land use impact score is 400. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes, if the existing land use is discontinued and no restoration measures are applied.	0.0

9. Microtopography (Vmicro)

Definition: This variable is a measure of small-scale roughness and/or local relief imparted to sites by features such as grass tussocks, small depressions, and “strang” and “flark” patterns.

Rationale For Selection of the Variable: Roughness imparted to sites by microtopography slows surface and shallow subsurface flows of water across wetlands, and contributes to short and long term storage of surface and shallow subsurface waters. Surface complexity provides a variety of substrates for the establishment of different vegetation communities. In addition, site roughness provides niche diversity and thermal stability for animals and vegetation communities.

Measurement Protocol: Microtopographic features are assessed along two, perpendicular, 100 foot transects. One transect should be oriented parallel to the direction of flow. The other transect should be oriented perpendicular to the direction of flow. Both transects should be centered at the approximate center point of the project assessment area. The dominant microtopographic surface (within three feet of either side of the transect) should be described at 10 foot intervals along both transects. The table below describes the various microtopographic surfaces.

Table 21. Definition of Microtopographic Features

Microtopographic Feature	Criteria
Planar Features	
Plane	Level or nearly level ground surface excluding level surfaces contained in channels, pits, or ponds.
Non-Planar Features	
Channel	Linear feature formed by flowing water
Pit	Depression, hole, burrow. <50 square feet
Pond	Depression ≥ 50 square feet (e.g., flark in string bog)
Hummock	Mound or raised surface (e.g., shrub dominated strang in string bog). These features usually have different vegetation than surrounding lower areas.
Tussock	Surface formation developed from tufted plants such as cottongrass.
Coarse Wood	Woody debris >2”diameter that is lying on the surface or is <45 degrees from vertical.
Root Mass	Root system and soil uplifted from fallen trees.
Other	Describe

Data: Appendix B, Table 4

Scaling Rationale: Human alteration of river proximal and slope/flat complex wetlands in the Kenai River Watershed tends to simplify complex microtopography and impact planar features of the wetland surface. The Development Team chose to scale microtopographic complexity by linear interpolation between the reference standard condition (e.g., microtopographic relief distributed over the entire surface of an unaltered site) and a highly degraded condition (e.g., entirely stripped and leveled surface with no evidence of microtopographic relief) based on the percent reduction of "roughness" within the site.

Confidence that reasonable logic and/or data support the calibration: Medium

Table 22. **Scaling for Vmicro**

Measurement or Condition for Vmicro	Score
The ground surface highly complex. ≥80% of the observed features are non-planar features (e.g., pits, hummocks, coarse wood).	1.0
The ground surface is complex. 60 - <80% of the observed features are non-planar features (e.g., pits, hummocks, coarse wood).	0.75
The ground surface is moderately complex. 40 - <60% of the observed features are non-planar features (e.g., pits, hummocks, coarse wood).	0.50
The ground surface is generally uniform. 10 - <40% of the observed features are non-planar features (e.g., pits, hummocks, coarse wood).	0.25
90 - 100% of the ground surface is uniform. <10% of the observed features are non-planar features (e.g., pits, hummocks, coarse wood). The variable is 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
90-100% of the microtopographic features are planar (e.g., paved surfaces, graded fill, etc.); however, slope surfaces may include rills, gullies, small-scale sediment fans, etc. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.0

10. Surface Water Storage (Vsurwat)

Definition: This variable is a measure of surface water ponding or potential ponding (*i.e.*, static surface and shallow subsurface storage).

Rationale for Selection of the Variable: Surface water ponding, and short and long term storage of surface and shallow subsurface water facilitates the establishment and augmentation of surface organic horizons. It also helps establish a variety of substrates for different vegetation communities. Exchange of water between surface and shallow subsurface compartments facilitates biogeochemical processes associated with elemental cycling and organic carbon export.

Measurement Protocol: The data for this variable is obtained from the Vmicro data sheet. Data points identified as **channel, pit,** or **pond** are considered to be evidence of ponding (actual or potential).

Data: Appendix B, Table 3

Scaling Rationale: There was a distinct difference in surface features that can potentially pond water between nearly level and steep slopes. Therefore, the authors distinguished between sites with <5% slopes and those with ≥5%. Sites with ≥5% slope are not scaled because reference standard conditions often include a lack of any surface water ponding features.

Confidence that reasonable logic and/or data support the calibration: Medium.

Table 23. Scaling for Vsurwat

Measurement or Condition for Vsurwat	Index
For sites with ≤ 5% slope: Measurement of 30 % or more of the observation points showed a presence or evidence of ponding. **For sites with > 5% slope:** Surface water ponding does not often occur in reference standard sites. Therefore, this variable is not applicable for the steeper sites.	1.0
(this index score is not used)	0.75
For sites with ≤ 5% slope: Measurement of one or two surface water ponding features (*i.e.*, pit, pond, or channel).	0.50
(this index score is not used)	0.25
Project assessment area provides no surface water ponding features that could pond water. The variable is 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
Project assessment area provides no surface water ponding features that could pond water. The variable is not recoverable to reference standard conditions nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied	0.0

11. Ground Cover (Vgroundcov)

Definition: Total cover of 1) mosses and lichens, 2) forbs, graminoids, and ferns, and 3) low shrubs.

Rationale for Selection of Variable: Ground cover dissipates energy of overland-flowing water allowing for the deposition or trapping of sediments in the wetland. In addition, ground cover provides stability to the soil, serves as an important source of organic carbon for potential expert, and takes up, transforms and temporarily stores elements and compounds. Ground cover also provides habitat structure for wildlife such as small mammals.

Measurement Protocol: Visually estimate the percent of canopy cover of 1) mosses and lichens, 2) forbs, graminoids, and ferns, and 3) low shrubs in circular 0.1 acre plots.

Data: Appendix B, Table 2

Scaling Rationale: Cover of ground vegetation was highly variable (i.e., 44% to 178%) at the reference standard sites. The authors scaled the variable linearly from the minimum ground cover value measured at reference standard sites (i.e., 44%).

Confidence that reasonable logic and/or data support the calibration: Medium-High

Table 24. **Scaling for Vgroundcov**

Measurement or Condition for Vgroundcov	Index
> or equal to 44% ground cover.	1.0
>33% - <44% ground cover.	0.75
>22% - < or equal to 33% ground cover.	0.50
>11% - < or equal to 22%ground cover.	0.25
< or equal to 11% ground cover. The variable is recoverable to reference standard conditions and sustainable through natural processes.	0.10
< or equal to 11% ground cover. The variable is not recoverable to reference standard conditions and sustainable through natural processes.	0.0

12. Total Vegetative Cover (Vtotcov)

Definition: Sum of the percent cover of the five vegetation strata in the assessment site. The five strata are explained in the next section (15. Vegetative Strata Vstrata)

Rationale for selection of the Variable: Total cover was used in this model since the cover for individual strata was highly variable. Vegetative cover is an indicator of the ability of the site to support native plant communities and animal habitat.

Measurement Protocol: 1) Determine the dominant vegetative cover (Forest, Shrub or Herb), and 2) visually determine the total percent canopy cover by adding each strata within 0.1 acre plots. For sites dominated by herbaceous and/or low shrub vegetation, the point-intercept method is recommended for cover measurements.

Data: Appendix B, Table 2

Scaling Rationale: The variable was scaled using reference data, published literature, field observations, and best scientific judgment. Reference sites that exhibited little or no disturbance to the native plant community consistently had high total plant cover measurements. As site disturbances increased, total vegetative cover measurements decreased.

Confidence that reasonable logic and/or data support the calibration: Medium. The author's confidence is support by reasonable logic and the data.

Table 25. **Scaling: Forested and Shrub Communities**

Measurement or Conditions for Vtotcov	Index
Total vegetative cover is ≥120%.	1.0
Total vegetative cover is ≥90% and <120%.	0.75
Total vegetative cover is ≥60% and <90%.	0.50
Total vegetative cover is ≥30% and <60%.	0.25
Total vegetative cover is <30%. The variable is recoverable to reference standard conditions.	0.10
Total vegetative cover is <30%. The site is not recoverable to reference standard conditions.	0.0

Table 26. **Scaling: Herb Communities**

Conditions	Index
Total vegetative cover is ≥140%.	1.0
Total vegetative cover is ≥105% and <140%.	0.75
Total vegetative cover is ≥70% and <105%.	0.50
Total vegetative cover is ≥35% and <70%.	0.25
Total vegetative cover is <35%. The variable is recoverable to reference standard conditions and sustainable through natural processes.	0.10
Total vegetative cover is <30%. The site is not recoverable to reference standard conditions and sustainable through natural processes.	0.0

13. Vegetation Strata (Vstrata)

Definition: The number of vegetation strata present within the project assessment area.

Vegetation strata are defined as follows:

1. Trees (single-stem, woody species ≥10-ft tall).
2. Small trees [single-stem, woody species >3 to <10 ft (>1 to <3 m) tall].
3. Shrubs (multiple-stem, woody species).
4. Herbs: forbs, graminoids, ferns and fern allies.
5. Mosses, lichens, and liverworts.

Rationale for Selection of the Variable: The number of strata characteristic of reference standard conditions is an indicator of the development and maintenance of native plant communities. In addition, number of strata represent the presence of the habitat structure and complexity necessary to support typical faunal assemblages. Similarly, the numbers and types of vegetation strata represent the diversity of habitat niches, as well as the types and amount of food and cover resources available.

Measurement Protocol: Record the number of vegetation strata present at 10-ft (3-m) intervals along a 100-ft (30.5-m) transect in the project assessment area. The average number of strata is calculated for the transect, and rounded to the nearest integer to yield an estimate for the project assessment area.

Data: Appendix B, Table 2

Scaling Rationale: The variable was scaled using reference data, field observations and best scientific judgment.

Confidence that reasonable logic and/or data support the calibration: Medium.

Table 27. **Scaling: Forested and Shrub Communities**

Measurement or Condition for Vstrata	Index
$\geq$3 strata present.	1.0
(this index score is not used)	0.75
2 strata present.	0.50
(this index score is not used)	0.25
Zero or 1 strata present. The variable is 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
Zero or 1 strata present. The variable is not recoverable (e.g., parking lot, fill pad, drill pad).	0.0

Table 28. **Scaling: Herb Community**

Measurement or Condition of Vstrata	Index
$\geq$ 2 strata present.	1.0
(this index score is not used)	0.75
1 strata present.	0.50
(this index score is not used)	0.25
Zero strata present. The variable is 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
Zero strata present. The variable is not recoverable (e.g., parking lot, fill pad, drill pad).	0.0

14. Native Plants (Vnplant)

Definition: Percent of the dominant plant taxa present in the wetlands that are native to Alaska.

Rationale for selection of the Variable: The percent of native taxa characteristic of reference standard conditions indicate the presence of characteristic native plant communities. Percent native taxa is a measure of the degree to which native plant communities have been altered by human disturbance.

Measurement Protocol: Visually estimate canopy cover for all plant species by strata within a 0.1 acre plot. When necessary, such as in herbaceous or low shrub communities or strata, nested microplots 0.01 acre in size are used to increase resolution of the canopy cover estimates (Daubennmire 1969). The point-intercept transect method may also be used in these herbaceous and/or low shrub strata. The percent of native taxa is calculated by dividing dominant native taxa by total dominant taxa and multiplying by 100. Dominance taxa are defined as follows:

> When ranked in descending order of abundance and totaled, dominants are the most abundant species that exceed 50% of the total canopy coverage for a stratum, plus any

additional species that comprise >20% of the total canopy coverage (U.S. Army Corps of Engineers 1987).

Dominant taxa are assigned native or non-native status using a combination of references (Reed 1998, Hulten 1968, Viereck and Little 1972).

Data: Appendix B, Table 2
Scaling Rationale: The variable was scaled using reference data, field observation, published literature and best scientific judgment. Vnplant was scaled according to a disturbance scale, ranging from the reference standard condition with 100% native taxa in all strata, to the most degraded condition, in which all vegetation is absent and/or there is no potential for recovery of native vegetation.

Confidence that reasonable logic and/or data support the calibration: High

Table 29. **Scaling for Vnplant**

Measurement or Condition for Vnplant	Index
100% of dominant species are native	1.0
> 75% to <100% of dominant species are native, and no stratum is dominated by non-native species.	0.75
> 50% to < or equal to 75% of the dominant species are native, and/or up to 50% of the strata present are dominated by non-native species.	0.50
> 25% to < or equal to 50% of the dominant species are native, and/or up to 50% of the strata present are dominated by non-native species.	0.25
< or equal to 25% of the dominant species are native, and/or up to 75% of the strata present are dominated by non-native species, or all vegetation is absent. The variable is recoverable to reference standard conditions and sustainable through natural processes.	0.10
All vegetation is absent. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes.	0.0

15. Coarse Woody Debris (Vcwd)

Definition: This variable is the total number of coarse (>2" diameter) woody debris that is < 45^{o} from vertical and/or lying on the surface of the Project Assessment Area.

Rationale For Selection Of The Variable: Coarse woody debris is incorporated into the soil profile as it undergoes decomposition. A change, therefore, can alter soil-building processes. Alterations in soil processes can change characteristics of the soil profile (Daubenmire, 1974). Furthermore, the presence of coarse woody debris can help stabilize the soil and prevent erosion, provide a substrate for plant growth, and provide cover for birds and small mammals.

Measurement Protocol: Count the number of coarse woody debris (CWD) using a point-center quarter (PCQ) method (Chapter 5 – Functional Assessment Report, Form 8) The plot center is located adjacent to the main soil pit for the plot. If the piece spans quarter boundaries (*e.g.*, spans the NE - SE quarter boundary), only that portion of the coarse wood within the quarter is measured. If a quarter does not contain coarse woody debris, the PCQ method cannot be used. In these cases, record the number of pieces of coarse down and dead wood within a 0.1-acre (0.04-ha) plot.

Scaling Rationale: Decreases in the number of CWD from reference standard conditions represent degradation of the detrital biomass and potential for carbon export. This variable was scaled using reference data, field observations and best scientific judgment. Vcwd was scaled linearly from the reference standard condition using CWD density. CWD was generally a very small component in the herbaceous and shrub communities, except for those previously forested (burned within the last 60 years). Therefore, CWD was not used to model any functions for these community types.

Data: Appendix B, Table 4

Confidence that reasonable logic and/or data support the calibration: Medium

Scaling: Forested and other community types that were previously forested and burned within the last 60 years.

Table 30. **Scaling for Vcwd**

Measurement or Condition for Vcwd	Index
CWD density ≥20 pieces/acre.	1.0
CWD density <20 pieces/acre ≥10 pieces/acre.	0.75
CWD density <10 pieces/acre ≥ 5 pieces/acre.	0.50
CWD density <5 pieces/acre – 1 pieces/acre.	0.25
CWD density 0 pieces/acre. Variable is recoverable and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
CWD density 0 pieces/acre. The variable is neither recoverable nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.0

16. Animal Sign (Vasign)

Definition: The number of birds and mammals that are directly observed or indirect evidence/signs (e.g., tracks) that animals use the project assessment area.

Rationale for Selection of the Variable: The variable used to assess faunal habitat components represent both direct bird and mammal use of a site, and site potential to support characteristic fauna.

Measurement Protocol: Conduct random walks within the project assessment area and count the number of different signs of animal use. Categories for sign include direct visual or aural observation of animals, tracks, trails ≤4" (10 cm) wide, trails >4" (10 cm) wide, evidence of feeding, middens, scat, nests or nest cavities, bedding, fur or hair, scrapes or rubs, and "other sign as specified".

Scaling Rationale: Evidence of animal use was recorded at the 37 reference sites. Since direct observation of animals was infrequent, field observation of indirect evidence was the most reliable indicator of animal use. However, the correlation of evidence of animal use with other factors such as site condition, stand age, or land use was low. Therefore, best scientific judgment was used to scale this variable. The authors encourage basic and applied research on habitat features associated with the range of land uses that occur within slope wetlands and slope/flat wetland complexes. Results of such research could improve scaling associated with measurements or conditions for the animal sign variable and/or the faunal habitat components function.

Confidence that reasonable logic and/or data support the calibration: Medium. Animal Sign includes direct observation. This can vary significantly depending on the timing of data collection.

Table 31. **Scaling For All Community Types For Vasign**

Measurement or Condition for Vasign	Index
Three or more signs of animal use exist. (Note: Direct observation of animal use = 1 type of animal sign. Do not double count direct sign with fresh tracks, scat, etc.).	1.0
No data to support this condition.	0.75
One or two animal signs	0.50
No data to support this condition.	0.25
No evidence of animal use exists on the site. However, habitat is recoverable and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.10
No direct or indirect evidence of animal use exists on the site. The habitat on the site is neither recoverable nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied.	0.0

5. HGM Functional Assessment Report

An HGM Functional Assessment Report consists of the following six-step process:

A. Six-Step Process for Developing an HGM Functional Assessment Report

1. Conduct a Preliminary HGM Classification (pg.78)
2. Complete the Relevant Site Information Sheet (pg.79)
3. Sketch a map of the Project Assessment Area (pg.80)
4. Complete the Field Data Collection Forms (pgs. 84 - 100) (Use the suggested Field Collection Process with the suggested Field Data Collection Points)
5. Record the field data results and variables measured in the Indicator Measurement Results Column in the Summary Tables (pg.101), and
6. Complete the Functional Scoring Sheet (pg.102).

Step 1. Preliminary HGM Classification.

Identify, verify, and document the rationale used for recognizing HGM classes and subclasses within the project assessment area.

In the space provided below, explain why the project assessment area or parts of the project assessment area are covered by this guidebook. Show how the project assessment area satisfies the subclass definition provided in the guidebook. Specifically, include a discussion of the site characteristics and show how they are consistent with the dominant characteristics of the subclass. The table below summarizes the dominant characteristics of the subclass.

Table 32. Dominant Characteristics Of The Slope/Flat Wetland Complexes Subclass.

CHARACTERISTIC	DESCRIPTION
Vegetation	Any vegetation life form (e.g., trees, shrubs, herbaceous, etc.) that are not in a marine, estuarine, lacustrine, or riverine system or directly influenced (i.e., actively flooded) by those systems.
Landforms	Footslope, toeslope, former glacial channels (paleo-channels), historic glacial outwash plains, or river terrace above active flooding. **Note**: Wetlands in closed depressions are out of the subclass.
Slope	0.1% to ≤25%
Parent Materials	Dense glacial tills or fine sands and silts
Organic Horizons	>60cm. if unburned in the past 60 years. If burned, ≥7cm.
Hydrologic Source	Shallow groundwater flow and precipitation

Provide the site Characteristics:

Vegetation ____________________

Landform ____________________

Slope ____________________

Parent Materials ____________________

Organic Horizons ____________________

Hydrologic Source ____________________

Step 2. Relevant Site Information (Completed in Office or the field)

Dates of Site Visit ______________________________

Name (s) of Team Members ______________________________

Field Notes/Observations ______________________________

Collect and review information relevant to the site. This includes, but is not limited to:
- *USGS, state, borough, and other maps (at various scales)*
- *Relevant geotechnical, soils, or environmental reports*
- *Correspondence, construction plans and specification, etc. on the proposed project*
- *Relevant published literature*

Identify the documents that were collected and reviewed. Include a detailed description of each document (e.g., citation, date, scale, quadrangle name, etc.). If possible, attach copies of each document.

- Is the assessment area adjacent to a cataloged anadromous fish stream?
- Is the assessment area used by any federally listed threatened or endangered species?
- Is the assessment area adjacent to a state listed impaired waterbody?

- USGS, state, borough, and other maps (at various scales):
  1. ______________________________
  2. ______________________________
- Air photos and other imagery:
  1. ______________________________
  2. ______________________________
- Relevant geotechnical, soils, or environmental reports:
  1. ______________________________
  2. ______________________________
- Correspondence, construction plans and specifications, etc. on the proposed project:
  1. ______________________________
  2. ______________________________
- Relevant published literature:
  1. ______________________________
  2. ______________________________
- Other documents:

  ____

Step 3. Sketch a map of Project Assessment Area

Map or drawing of the Project Assessment Area.

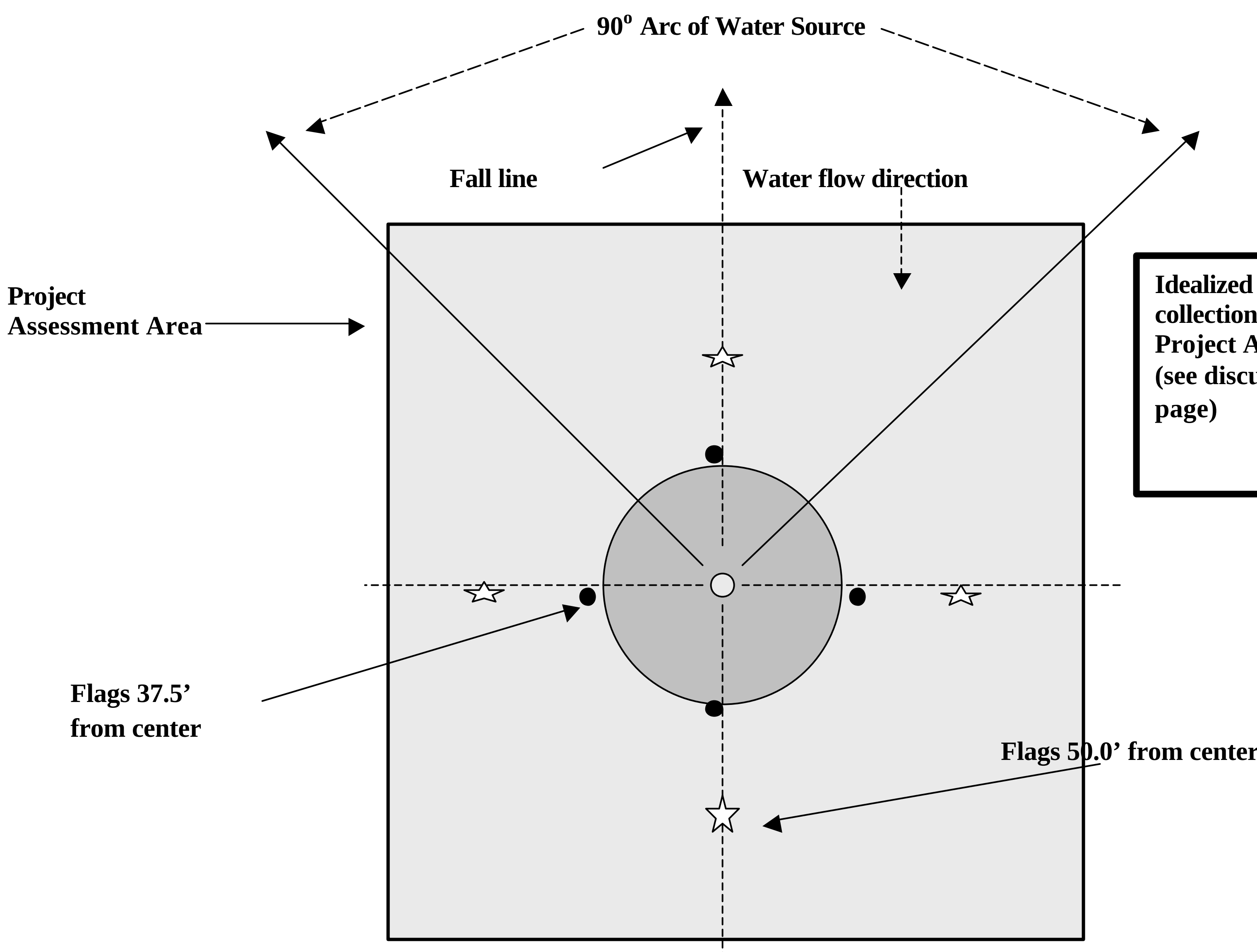
Image source, date and scale: ________________________________

Step 4. Complete the Field Data Collection Forms and Scoring Sheet.

Process for completing the Field Data Collection Forms is on (pages 85 -107).
The steps for collecting data and corresponding forms is outlined below. An idealized diagram showing data collection locations at a Project Assessment Area is shown on the following page (Figure 13).

Table 33. HGM Rapid Assessment Field Process and Scoring Sheet

HGM Rapid Assessment Field Process				Extra Score Sheet	
#	**Variables**	**Landscape Position, Hydrology, Soils, & Land Use**	**Data Collection Form #/Page**	**Raw Data**	**Scaled Variable**
	None	Stand in the center of the assessment area facing upslope	**Page = p.**		
1	**Vslope** (p. 55)	Determine % Slope	#1 (p. 84)		
2 3	**Vaquic** (p. 56) **Voh** (p. 57)	Dig a soil pit in an appropriate and representative area	#2 (p. 85) #2 (p. 85)		
4 5 6 7 8	**Vsource** (p. 58) **Vwatcon** (p. 60) **Vwetuse** (p. 62) **Vadjuse** (p. 64) **Vdistuse** (p. 66)	Determine hydrology and Land Use variables	#3 (p. 86) #4 (p. 89) #5 (p. 90) #5 (p. 90) #5 (p. 90)		
		Microtopography			
		Run two 100 ft. transects using a measuring tape. One transect should be parallel and one perpendicular to the direction of flow (use a shorter transect if the project assessment area is shorter than 100 ft.)			
9	**Vmicro** (p. 68)	Measure microtopography	#6 (p. 92)		
10	**Vsurwat** (p. 69)	Measure water storage	#6 (p. 92)		
		Vegetation and Animals			
11 12 13 14	**Vgrocov** (p. 70) **Vtotcov** (p. 71) **Vstrata** (p. 72) **Vnplant** (p. 73)	Estimate Vegetative Cover	#7 (p. 94)		
15	**Vcwd** (p. 74)	Set up a Point Center Quarter (PCQ) method on a representative location in the Assessment area to measure Course Woody Debris	#8 (p. 99)		
16	**Vasign** (p.75)	Determine Animal Use	#9 (p. 100)		



Idealized diagram of data collection locations at a Project Assessment Area (see discussion on next page)

Overview of HGM Rapid Assessment Data Collection

The diagram on the preceding page illustrates data collection locations in an idealized diagram of a Project Assessment Area (PAA). The discussion that follows relates to the features and labels depicted on the Figure:

- The central dot represents the center of the PAA where a soil pit should be dug (measurement of **Vaquic** and **Voh**). Observations and estimates for determining the land use of the PAA (**Vwetuse**) can also be made from this location.

- The fall line represents the most direct route of water flow from upslope areas to the center of the PAA. Surface slope (**Vslope**) is measured along the fall line. The fall line also represents the center of the 90^{o} arc of water source. This arc is used in the **Vsource** measurement protocol.

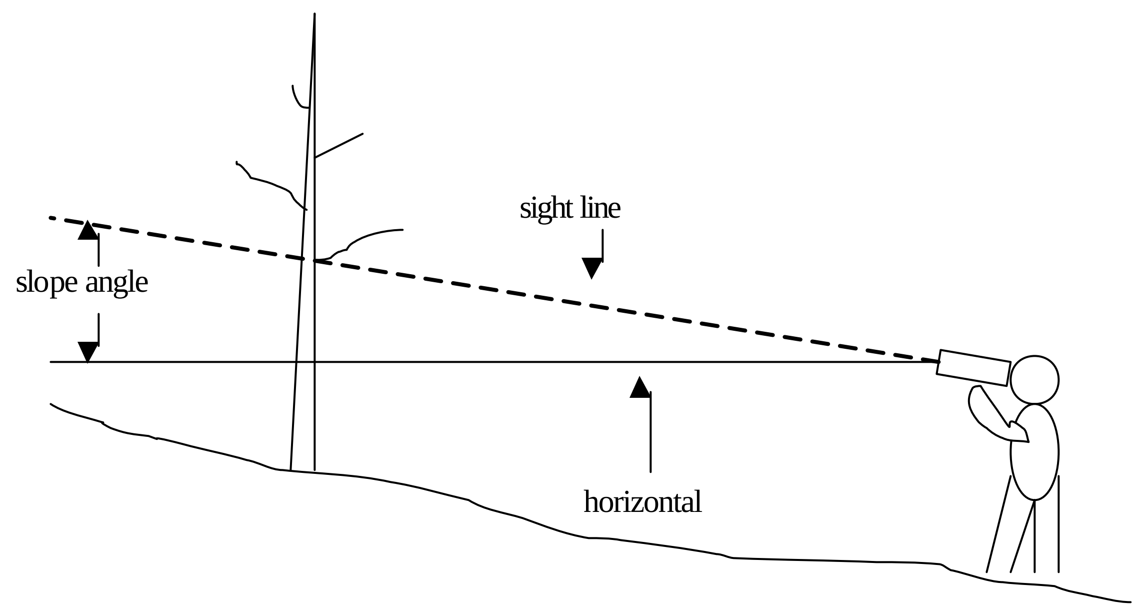
- The fall line continues through the center of the PAA and forms the north/south axis of a 4-quadrant sample area used for the point-center quarter (PCQ) sampling method. The PCQ method is applied for estimating the density of coarse woody debris (**Vcwd**). Flagging is placed 50 ft. from the PAA center along the 4 PCQ axis lines, resulting in two 100' transects used for the **Vmicro** and **Vsurwat** measurement protocols.

- Flagging is also placed 37.5 ft. along the PCQ axis lines. An imaginary circle with a radius of 37.5 ft. is used as the 0.1-acre plot to visually estimate vegetation cover for the **Vgroundcov**, **Vtotcov**, **Vstrata**, and **Vnplant** variables.

- Random walks within the PAA are used to collect animal sign information for the **Vasign** variable. Observations needed to assess the condition of longitudinal connections between the PAA and downgradient wetlands (**Vwatcon**) are made visually in the field and/or by using current aerial photography. Field observations around the edge of the PAA and/or in-office analysis of aerial photography are used for measurement of the **Vadjuse** and **Vdistantuse** variables.

Form #1 Surface Slope (Vslope)

Measurement Protocol: Visually determine the fall line (most direct route of water flow from upslope areas to the Project Assessment area). After the fall line is determined, measure the percent slope along the fall line. A hand-held inclinometer (Abney Level) can be used. The sighting line in the hand-held inclinometer should be positioned so that it is lined-up with an object that is at the same height as the viewer's eye (see figure). The object (e.g., tree branch) should be positioned along the fall line (described above). Read the angle shown by the inclinometer.



Vslope Measurement

1. Convert the slope angle (degrees) into percent slope:

   __________ ÷ 90 x 100 = ___________
   Degree Slope   Percent Slope

2. Record this result in the Indicator Measurement Result column in the Summary Table.

Form #2 Aquic Moisture Regime (Vaquic) and Organic Horizons (Voh)

Measurement Protocol: Excavate a soil pit at the center of the project assessment area to a depth of approximately 3 ft using a shovel and auger. It may be necessary to excavate a deeper pit at some sites if the organic horizon exceeds a depth of 3 feet.

The thickness of the surface organic horizon(s) (i.e., Oi and/or Oe and/or Oa horizons) is measured. Depths are measured from the top of the surface (usually Oi) horizon. Live vascular and non-vascular (e.g., mosses) plant materials are **not** included in these depths. If the organic horizons show signs of disturbance by human-induced activities, an additional pit needs to be excavated in an undisturbed site adjacent to the project assessment area.

Directly observe aquic soil conditions in the soil pit and/or observe field indicators of aquic conditions. Indicators on undisturbed sites include the following: (a) presence of an organic soil (16" or more of the upper 32" is organic material), (b) a complex pattern of faint grayish and reddish colors (redox depletions and concentrations, respectively) in the mineral soil (active redoximorphic features), (c) a greenish-gray (gleyed) substratum color, and (d) a histic epipedon (a surface organic layer 8"or more thick).

The current *Alaska Hydric Soil Indicators* and *Soil Taxonomy* (Soil Survey Staff 1990) should be used for further guidance.

Vaquic Measurement

1. Record/describe direct observation of aquic soil conditions:

   ____

   ____

AND/OR

2. Record/describe observation of indicators of an aquic moisture regime:

   ____

   ____

3. If aquic soil conditions are observed, record "yes" in the Indicator Measurement Result column in the Summary Table. If aquic conditions are absent, record "no." I

Voh Measurement

1. Measure the thickness of the surface organic horizon(s): ______ inches. Record this in the Indicator Measurement Result column in the Summary Table.

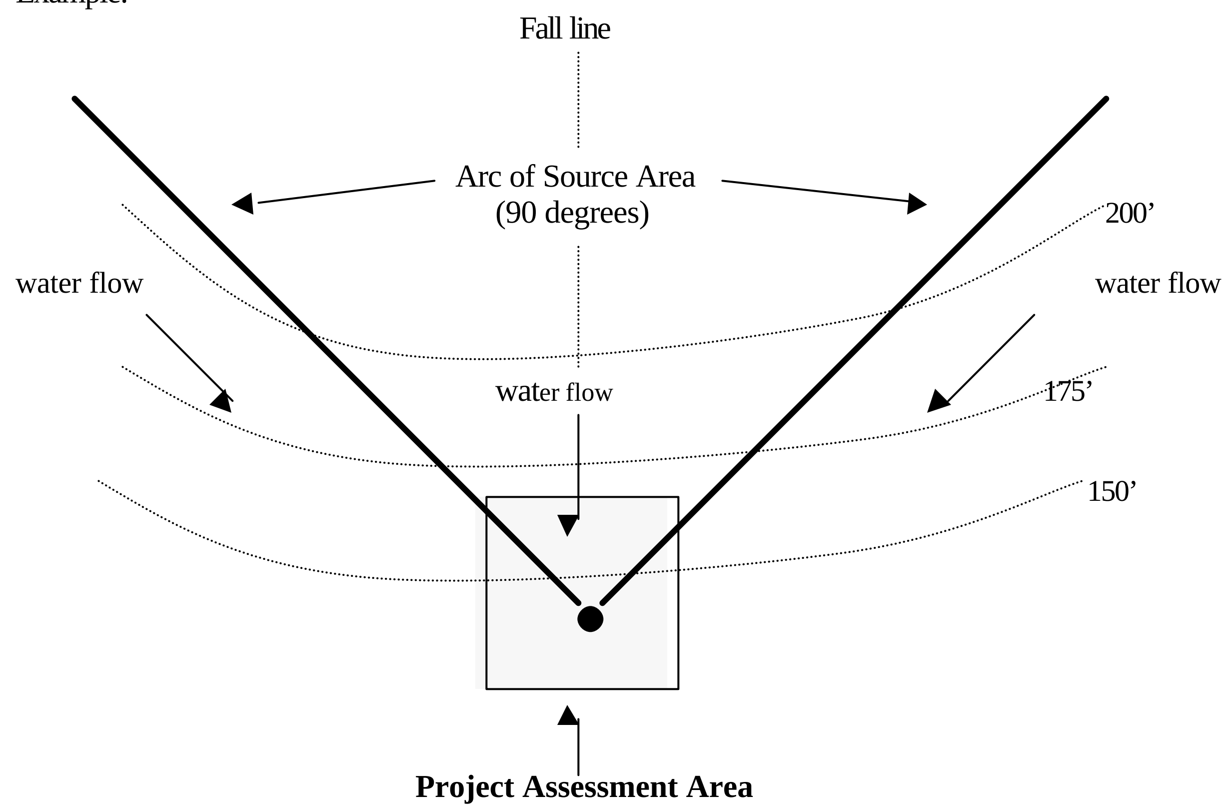
2. If the surface organic horizon shows signs of disturbance by human-induced activities, measure the thickness of the surface organic horizon in an undisturbed site adjacent to the project assessment area: ______ inches

3. Determine the % reduction in the thickness of the organic horizon caused by the human-induced activity: ______ % reduction. Record this in the Indicator Measurement Result column in the Summary Table. If the assessment site is undisturbed, record "N/A."

Form #3 Source of Hydrologic Connection (Vsource)

Measurement Protocol (see diagram below): By convention, the hydrologic source area is described as a 90 degree arc (measured using a compass) looking up-gradient from the center of the assessment area. The center axis of the 90° arc is the fall line (most direct line of water flow). The field team should visually mark the boundaries of the arc using reference marks such as trees, buildings or flagging.

Example:



Within the 90° arc described above, angles of perturbation are measured by siting the arc distance of each perturbation (see diagram below). Measurements of perturbation should be made to the edge of the contributing area or to 0.25 mile, whichever is less. The angle of all perturbations are individually measured and categorized (see Table 36). In the example below, Urban Development has an arc distance of 15°. The remaining portion of the source arc is Undisturbed.

If multiple perturbations occur within the same arc, perturbations with the highest ranking (see the table on the next page) take precedence over lower ranking perturbations that occur upslope. The lower ranking impacts are not considered in this case. Lower ranking impacts are measured if they occur downslope of higher-ranking impacts.

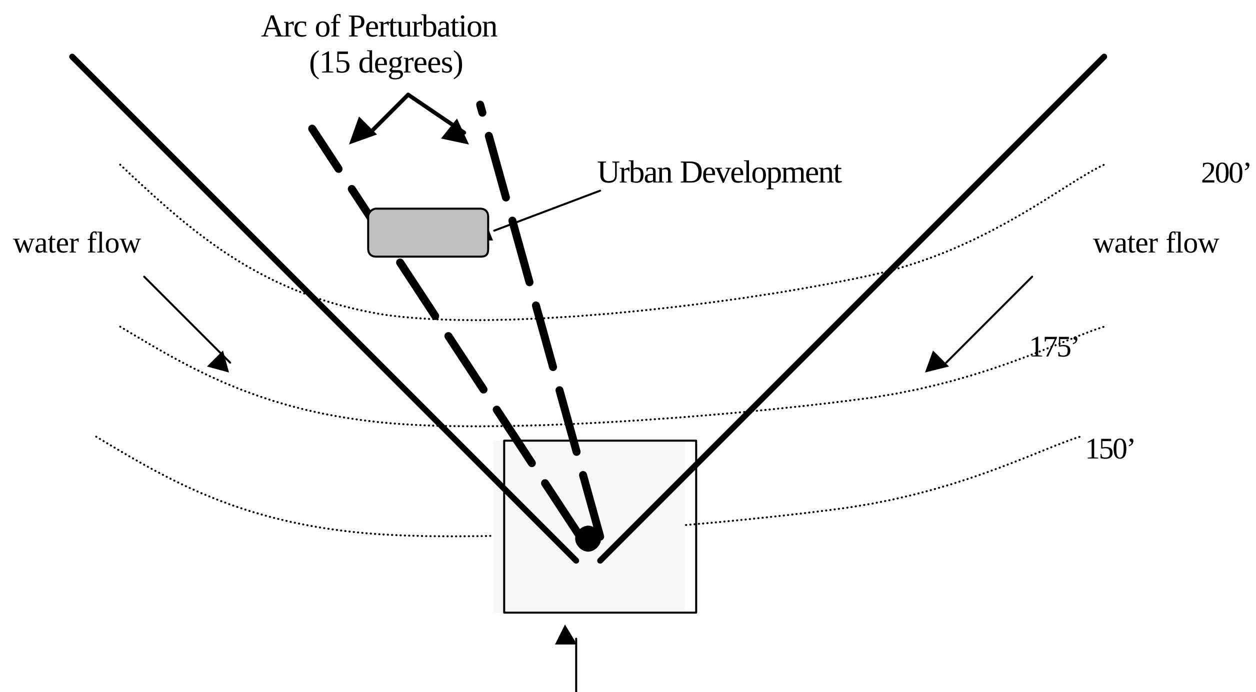


Table 34. **Category Ranking for Perturbation Arc Length Value**

Undisturbed: No significant human induced perturbation, except for natural or controlled burns	0
Agriculture/Forestry: Clearing of vegetation, clearing for right-of-ways, logging with temporary roads (no fill), pasture and croplands.	1
Rural: Low density housing (>5 acre lots), non paved through-fill roads without ditches, forestry main haul roads (with through-fill and some ditches)	3
Urban: Medium to high density residential (<5 acre lots), commercial/industrial, airports, gravel pits, through-fill roads with ditches, paved parking lots	4

Vsource Measurement

1. The angle of all perturbations are individually measured and categorized:

Table 35. Categorization and Measurement of Perturbation Angles

Individual Perturbation	Angle of Perturbation
(example) URBAN	(example) 25°

2. Sum all segments of perturbation arc length which fall into the same category and insert into the **Total Arc Length** column in the following table:

Perturbation Type	**Total Arc Length (°)**
Undisturbed	
Agriculture/Forestry	
Rural	
Urban	

3. Convert the Total Arc Length for each category into a percent of the 90° source arc length using the following formula:

Total Arc Length ÷ 90 x 100 = Percent of the Source Arc Length

Perturbation Type	**Arc Length Percentage**
Undisturbed	
Agricultural/Forestry	
Rural	
Urban	

4. Multiply each Arc Length Percentage by the Perturbation Multiplier and total the results:

Undisturbed ____________ x 0 = _________
Arc Length %

Agriculture / Forestry ____________ x 1 = _________
Arc Length %

Rural ____________ x 3 = _________
Arc Length %

High: Urban ____________ x 4 = _________
Arc Length %

Total Score _________

5. Record this result in the Indicator Measurement Result column in the Summary Table.

Form #4 Water Connections (Vwatcon)

Measurement Protocol: Make a visual assessment of the predominant land use and/or condition of the hydrologic connection(s) to downgradient wetlands within 500 feet of the assessment area or to the next wetlands. Aerial photos should be used to assist in the examination of the land use of the longitudinal connection(s).

Vwatcon Measurement

NOTE: No intermediate measurement is needed to determine the Variable Index Score for Vwatcon. For convenience purposes, the Scaling Table for this variable is provided below. Record the score that matches the field/aerial photo assessment in the Variable Index Score column in the Summary Table.

Table 36. **Scaling: Measurement or Condition for Vwatcon**

Measurement or Condition for Vwatcon	Score
The downgradient hydrologic connection(s) is unaltered by human activity and is characterized by intact soil profiles and vegetation communities, and unrestricted discharge of surface and shallow subsurface water to down-gradient wetlands.	1.0
The downgradient hydrologic connection(s) is predominantly undisturbed and is characterized by an intact soil profile and land use conditions that do not restrict discharge of surface and shallow subsurface flows to down-gradient wetlands. Land use condition might include: cleared vegetation (e.g., clearing for right-of-ways), foot paths (not entrenched), footings for bridges, elevated boardwalks, trestles, powerlines, etc.	0.75
The downgradient hydrologic connection(s) has minor constrictions, interruptions or diversions (i.e., <50% of the width of the connection) and is characterized by disturbed soil profiles and vegetation communities, and land use conditions that restrict, redirect or interrupt surface and shallow subsurface flows such as: through-fill roads with well designed and maintained culverts, entrenched foot paths, building pads that partially block the connection, shallow ditched, etc. The remainder of the longitudinal connection is intact.	0.50
The downgradient hydrologic connection(s) has major constrictions, interruptions or diversions (i.e., >50% and $\leq$ 75% of the width of the connection) and is characterized by highly disturbed soil profiles and vegetation communities, and land use conditions that restrict, redirect or interrupt surface and shallow subsurface flows such as: through-fill roads with poorly designed and maintained culverts, deep ditches, large building pads, etc.	0.25
There is an obvious human-induced break or discontinuity (i.e. > 75% of the width of the connection) that acts to block surface and shallow subsurface discharge (e.g., through-fill road without culverts, urban fill, etc.) from the wetland to the downgradient wetlands. The variable is 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
There is an obvious human-induced break or discontinuity (i.e. > 75% of the width of the connection) that acts to block surface and shallow subsurface discharge (e.g., through-fill road without culverts, urban fill, etc.) from the wetlands to the downgradient wetlands. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes if the existing land use if discontinued and no restoration measures are applied.	0.0

Form #5 Land Use in (A) Project Assessment Area (Vwetuse), (B) Adjacent Land Use (Vadjuse), and (C) Distant Land Use (Vdistantuse)

Measurement Protocol: Obtain aerial photograph(s) of the assessment area and adjacent areas up to 1 mile from the boundary of the assessment area. It is recommended that the aerial photographs be at a scale between 1:12,000 and 1:40,000. Obtain or produce a clear template showing a 1,000' radius and a 1 - mile radius for the photo scale used. Use magnification tool or stereoscope to assist in the identification of land use types. The photos are primarily needed for the **Vadjuse** and **Vdistantuse** measurements. In most cases, determining the land use of the project assessment area can be done in field without the use of aerial photographs.

The following table shows the 4 land use types used in the assessment and the multiplier applied to each type.

Table 37. Guide for Categories of Land Use and Multiplier

Undisturbed: No significant human induced perturbation, except for natural or controlled burns	0
Agriculture/Forestry: Clearing of vegetation, clearing for right-of-ways, logging with temporary roads (no fill), pasture and croplands	1
Rural: Low density housing (>5 acre lots), unpaved through-fill roads without ditches, forestry main haul roads (with through-fill and some ditches)	3
Urban: Medium to high density residential (<5 acre lots), commercial/industrial, airports, gravel pits, paved through-fill roads with ditches, paved parking lots	4

A) Vwetuse Measurement

1. Examine the project assessment area in field and estimate the percent of the area covered by the 4 land use categories. Multiply this value by the "Land Use Multiplier" to obtain a score for each land use category. Add the scores to obtain a measurement for Vwetuse.
2. Record this result in the Indicator Measurement Result column in the Summary Table.

B) Vadjuse Measurement

1. Examine the land use conditions within 1,000 feet of the project assessment area. In many cases, aerial photographs will be needed to supplement in-field examination. Estimate the value of the area covered by the 3 land use categories. Multiply this percent by the "Land Use Multiplier" to obtain a score for each land use category. Add the scores to obtain a measurement for Vadjuse.

2. Record this result in the Indicator Measurement Result column in the Summary Table.

Table 38. **Scorecard for Vadjacuse**

Land Use Category	% of Assessment Area	Land use Multiplier	Score
Undisturbed		0	
Agri./Forestry		1	
Rural		3	
Urban		4	
		Vadjacuse TOTAL SCORE	

C) Vdistantuse Measurement

1. Using aerial photographs, examine the conditions of the land between 1,000 feet and 1 mile from the boundary of the project assessment area. Estimate the percent of the area covered by the 3 land use categories. Multiply the value by the "Land Use Multiplier" to obtain a score for each land use category. Add the scores to obtain a measurement for Vdistantuse.
2. Record this result in the Indicator Measurement Result column in the Summary Table.

Table 39. **Scorecard for Vdistantuse**

Land Use Category	% of Assessment Area	Land use Multiplier	Score
Undisturbed		0	
Agri./Forestry		1	
Rural		3	
Urban		4	
		Vdistantuse TOTAL SCORE	

Form #6 Microtopography (Vmicro) and Static Surface Water Storage (Vsurwat)

Measurement Protocol: Microtopographic features are assessed along two 100' transects using a measuring tape. One transect should be oriented parallel to the direction of flow. The other transect should be oriented perpendicular to the first transect. One or both of these transects can be used for estimating canopy cover of herbaceous or low shrub vegetation (see Protocol for collecting vegetation cover data on Form #7).

Both transects should be centered at the approximate center point of the project assessment area. The dominant microtopographic surface (within three feet of either side of the transect) should be identified at 10' intervals along both transects. The presence or evidence of ponding and/or static surface water should also be recorded at these observation points. The table below describes the microtopographic surfaces.

Table 40. **Definition of Microtopographic Features**

Planar Surface Feature	**Criteria**
Plane	Level or nearly level ground surface excluding level surfaces contained in channels, pits, or ponds.
Non –Planar Surface Features	
Channel	Linear feature formed by flowing water
Pit	Depression, hole, burrow. <50 square feet
Pond	Depression >50 square feet (e.g., flark in string bog)
Hummock	Mound or raised surface (e.g., shrub dominated strang in string bog). These features usually have different vegetation than surrounding lower areas.
Tussock	Surface formation developed from tufted plants such as cottongrass.
Coarse Wood	Woody debris >2"diameter that is lying on the surface or is <45 degrees from vertical.
Root Mass	Root system and soil uplifted from fallen trees.
Other	Describe

Transect 1

Data Point	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Planar or Non- Planar (0=Planar; 1= Non- Planar)										
Presence or Evidence of Ponding (0= no; 1= yes)										

Transect 2

Data Point	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Planar or Non- Planar (0=Planar; 1= Non- Planar)										
Presence or Evidence of Ponding (0 = no; 1= yes)										

Vmicro Measurement:

1. Total number of non-planar surface features recorded on the 2 transect tables: ______
2. Divide this number by 20 and multiply the result by 100 to obtain percent of the observed features that are non-planar: _____ ÷ 20 = _____ x 100 = _____ %
3. Record this result in the Indicator Measurement Result column in the Summary Table.

Vsurwat Measurement:

1. Total number of observations from the 2 transect tables where there was the presence or evidence of ponding: ______
2. Divide this number by 20 and multiply the result by 100 to obtain percent of the observation points where ponding occurs: _____ ÷ 20 = _____ x 100 = _____ %
3. Record this result in the Indicator Measurement Result column in the Summary Table.

Form #7 Groundcover (Vgroundcover), Percent of Native Plant Species (Vnplant), Vegetation Strata (Vstrata), Total Vegetative Cover (Vtotcov)

Measurement Protocol: Canopy cover is visually estimated for all plant species by strata within a circular 0.1- acre plot (37.5 foot radius). The plant species in each strata are listed and the Cover Class Midpoint is recorded. For sites or strata dominated by herbaceous and/or low shrub vegetation, a line-intercept method may be used. Dominant plants in each strata are noted as "DOMINANT." Dominant taxa are defined as follows:

> When ranked in descending order of abundance and totaled, dominants are the most abundant species that exceed 50% of the total canopy coverage for a stratum, plus any additional species that comprise ≥20% of the total canopy coverage (U.S. Army Corps of Engineers 1987). See example below:

EXAMPLE: DETERMINING DOMINANT PLANTS

The shrub species listed below were identified in the shrub strata of a plant community. The percent cover is also shown for each species. Note that the species are listed in descending order of abundance

Bog blueberry	38.0
Dwarf birch	20.5
Labrador tea	10.5
Crowberry	10.5
Bog cranberry	0.5

Total cover for shrub strata 80.0 %

Since dominants are "the most abundant species that exceed 50% of the total canopy coverage for a stratum," the 1st step is to determine 50% of the total cover for shrubs:

80% X .5 = 40%

Starting at the top of the list, 40% is not exceeded until the top 2 species are combined:

38% + 20.5% = 58.5% **THESE 2 SPECIES ARE CONSIDERED AS DOMINANTS**

The last part of the rule indicates that dominants also include "any additional species that comprise ≥20% of the total canopy coverage." The next step is to determine 20% of the total cover for the shrub strata:

80% X .2 = 16%

There are no other **dominan**t species since the remaining 3 species do not have a cover value equal to or greater than 16%.

Cover Class Midpoints are obtained from the following table:

% Cover	Midpoint
<1	0.5
1-5	3
6-15	10.5
16-25	20.5
26-50	38
51-75	63
76-95	85.5
>95	98

Each dominant plant species should be identified as a native or non-native species. If native, "N" is placed in the far right column on the Strata tables.

Tree Strata

Trees ($\geq$10', single stem) and **Small Trees** (>3' & <10', single stem)			
Species	**Cover Class Midpoint**	**Dominant (mark "X")**	**Native (mark "N")**
Total Cover for the Strata			

Age of Modal - Sized Trees	
Species	**Age**

Shrub Strata

Shrubs (multiple stems), **Low Shrubs** ($\leq$ 3', multi. stems) and **Seedlings** ($\leq$ 3', single stem)			
Species	**Cover Class Midpoint**	Dominant (mark "X")	Native (mark "N")

Shrubs (multiple stems), **Low Shrubs** (< 3', multi. stems) and **Seedlings** (< 3', single stem)			
Species	**Cover Class Midpoint**	Dominant (mark "X")	Native (mark "N")
Total Cover for the Strata			

Visually estimate canopy cover for all low shrubs (< 3', multiple stems)

Cover Class Midpoint of Low Shrubs	

NOTE: A separate estimate of low shrub cover is needed because these plants are considered to be a component of "groundcover." Groundcover also includes the herbaceous and moss/lichen strata. The measurement is required for the Vgroundcover variable.

Herbaceous Strata

Forbs, Graminoids, Ferns and **Fern Allies**			
Species	**Cover Class Midpoint**	Dominant (mark "X")	Native (mark "N")

Forbs, Graminoids, Ferns and **Fern Allies**			
Species	**Cover Class Midpoint**	Dominant (mark "X")	Native (mark "N")
Total Cover for the Strata			

Moss and Lichen Strata

Mosses and **Lichens**			
Species	**Cover Class Midpoint**	Dominant (mark "X")	Native (mark "N")
Total Cover for the Strata			

Vgroundcover Measurement

1. Total percent cover of Moss / Lichen Strata	
2. Total percent cover of Herbaceous Strata	
3. Total percent cover of Low Shrubs	
Total Groundcover	
4. Record this result in the Indicator Measurement Result column in the Summary Table	

Vtotcov Measurement

1. Total percent cover of Moss/Lichen Strata	
2. Total percent cover of Herbaceous Strata	
3. Total percent cover of Shrub Strata	
4. Total percent cover of Tree Strata	
Total Cover	
5. Record this result in the Indicator Measurement Result column in the Summary Table.	

Vstrata Measurement

1. Number of strata that have a total cover ≥10%	
2. Record this result in the Indicator Measurement Result column in the Summary Table.	

Vnplant Measurement

1. Total number of dominant plants	
2. Dominant plants that are native	
3. Divide the number of dominant plants that are native by the total number of **dominant plants**. Multiply this result by 100 to obtain the percentage of dominant plants that are native**:** ______ , ______ **x 100 = ______%**	
4. Record this result in the Indicator Measurement Result column in the Summary Table.	

Plant Community of the Assessment Area

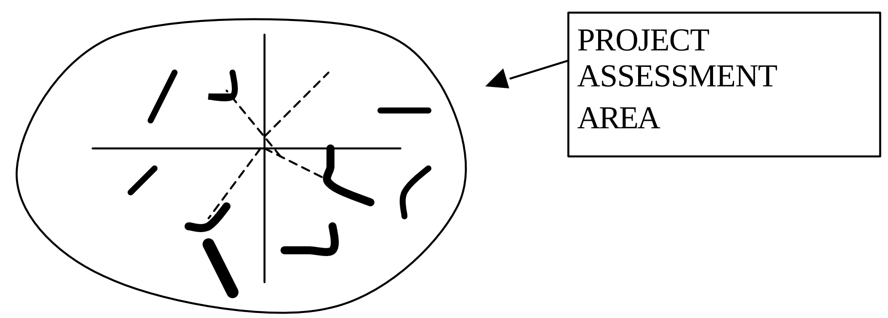
The Functional Scoring Sheet (Form #11) requires that the assessment area be designated as a Forest, Shrub, or Herb community. If the total cover for the tree strata is ≥ 10%, the site is considered Forested. If tree cover is less than 10% and the total shrub cover is ≥ 30%, the site is considered a shrub community. When trees cover less than 10% and shrubs cover less than 30%, but in combination cover 30% or more, the site is assigned to the shrub community. The herbaceous category applies if trees and shrubs in combination have less than 30% cover.

Check appropriate box:

Forested	Shrub	Herbaceous

Form #8 Coarse Woody Debris (Vcwd)

Measurement Protocol: This variable is only used for forested wetland (≥ 10% tree cover) communities and shrub and herbaceous communities that were previously forested and burned within the last 60 years. Estimate density of coarse woody debris using a point-center quarter (PCQ) method (see figure below). The plot center is located adjacent to the main soil pit for the plot. In each quarter, record the distance from plot center to the middle of the nearest piece of coarse down and dead wood ≥2"diameter. If a piece spans quarter boundaries (*e.g.*, spans the NE - SE quarter boundary), it is counted only in the quarter that contains most of the piece. If a quarter does not contain coarse woody debris, the PCQ method cannot be used. In these cases, record the number of pieces of coarse down and dead wood within a 0.1-acre (0.04-ha) plot to calculate density. This method can also be used if there are a small number of pieces that can easily be counted. Densities on a per acre basis are calculated from the plot data.



Measure and record the distance to nearest piece of coarse woody debris in each quarter. Measure to the center of the piece.

	NE Quadrant	SE Quadrant	SW Quadrant	NW Quadrant
Distance to nearest piece (feet)				

Vcwd Measurement

1. Total the distances recorded for the 4 quadrants	
2. Determine the average distance (total distance/4)	
3. Square the average distance	
4. Divide 43,560 by the square of the average distance **cwd pieces/acre**	
5. Record this result in the Indicator Measurement Result column in the Summary Table.	

OR

1. If the PCQ method is not used, determine the CWD pieces/acre from the pieces counted in a 0.1 - acre plot:	
CWD pieces in 0.1 acre plot ______ x 10 = cwd pieces/acre	
2. Record this result in the Indicator Measurement Result column in the Summary Table.	

Form #9 Animal Sign (Vasign)

Measurement Protocol: Complete a random walk within the project assessment area and check off the different signs of animal use. Categories include direct visual or aural observation of animals, and indirect signs such as tracks, evidence of browse, nests and scat.

- In order for a bird or mammal call to be listed as an observation, the animal must be in the assessment area.
- The number of individuals of a particular species is not relevant in the data table below (e.g., 4 observed ptarmigan are shown as a single direct observation).
- Signs should not be checked if the same species is also directly observed (i.e., do not double-count species).

Direct Observation of Animals or Indirect Signs					
Direct (write species)		Feeding Evidence		Scat - Mammal	
Direct (write species)		Middens		Scat – Avian	
Direct (write species)		Feathers		Other (specify)	
Direct (write species)		Bird nests/cavities		Other (specify)	
Direct (write species)		Fur		Other (specify)	
Tracks		Scrapes, rubs, etc.		Other (specify)	
Trails (≤ 4”)		Browse		Other (specify)	
Trails (> 4”)		Raptor Pellets		Other (specify)	

Vasign Measurement

1. Total the number of boxes marked in the field form. Record this result in the Indicator Measurement Result column in the Summary Table.

Step 5. Variables Scoring Sheet.

Variable		Units of Measurement	Forms On This Page	Indicator Measurement Result (Use Field Data Collection Forms)	Find Variable Scaling on This Page	Variable Index Score (Use Chapter 4 to score variable)*
Landscape Position, Hydrology, Soils, and Land use						
Vslope	Surface Slope	% of Slope	Pg. 84		Pg. 55	
Vaquic	Aquic Moisture Regime	Yes or No	Pg. 85		Pg. 56	
Voh	Organic Horizons	% Reduction in OH thickness (inches)	Pg. 85		Pg. 57	
Vsource	Source of Water	Perturbation score	Pg. 86		Pg. 58	
Vwatcon	Water Connections	N/A	GO Directly to Variable Scale (pg. 62)		Pg. 60	
Vwetuse	Land Use of Assessment Area	Land Use Score	Pg. 90		Pg. 62	
Vadjuse	Adjacent Land Use	Land Use score	Pg. 90		Pg. 64	
Vdistantuse	Land Use	Land Use Score	Pg. 90		Pg. 66	
Microtopography						
Vmicro	Microtopography	% of Non-Planer features	Pg. 92		Pg. 68	
Vsurwat	Surface Water Storage	% of observation points with ponding	Pg. 92		Pg. 69	
Vegetation and Animals						
Vgroundcov	% Groundcover	% cover	Pg. 94		Pg. 70	
Vtotcov	Total Vegetation Cover	% cover	Pg. 94		Pg. 71	
Vstrata	Vegetation Strata	# of strata	Pg. 94		Pg. 72	
Vnplant	Percent of Native Plants	% of dominants that are native	Pg. 94		Pg. 73	
Vcwd	Coarse Woody Debris	# of pieces/acre	Pg. 99		Pg. 74	
Vasign	Animal Sign	# of Animal Signs	Pg. 100		Pg. 75	

***After scaling the variables, the Functional Capacity Indexes can be calculated on the following "Functional Capacity Scoring Sheet" by using the electronic spreadsheet in Appendix E.**

Step 6. Functional Scoring Sheet*

Slope/Flat Wetland Functions	Formulae	Functional Capacity Index (FCI)	Rationale / Comments for Scoring Functional Capacity Index
1. **Discharge of Water to Downgradient Systems**	**All Vegetative Communities** = (Vmicro + Vsource + Vaquic +Vslope) /4		
2. **Surface and Shallow Subsurface Water Storage**	All **Vegetative Communities** = [(Vmicro +Vsurwat) /2 +Voh +Vaquic + Vsource] /4		
3. **Particulate Retention**	**Forest Communities =** [Vsource + (Vmicro + Vsurwat + Vslope)/3 + (Vcwd + Vgroundcov)/2]/3		
	Shrub and Herbaceous Communities = [Vsource + (Vmicro +Vsurwat +Vslope)/3 + Vgroundcov)]/3		
4. **Organic Carbon Export**	Forested **Communities** = [(Vstrata + Vgroundcov +Vcwd)/3 +Voh+Vsource +Vwatcon]/4		
	Shrub and Herbaceous Communities)= [(Vstrata +groundcov)/2 + Voh + Vsource +Vwatcon]/4		
5. **Cycling of Elements and Compounds**	**Forested Communities** =[(Vasign + Vcwd + Vgroundcov + Vtotcover +Vstrata)/5 + Vaquic + Voh]/3		
	Shrub and Herbaceous Communities = [(Vasign +Vgroundcov + Vtotcover +Vstrata)/5 +Vaquic+Voh]/3		
6. **Maintenance of Characteristic Plant Community**	**All Vegetative Communities** = (Vtotcover + Vstrata +Vnplant) / 3		
7. **Maintenance of Characteristic Habitat Structures**	**Forested Communities** = [Vasign + Vstrata + (Vtotcov +Vgroundcov)/2 +Vcwd]/4		
	Shrub and Herbaceous Communities = [Vasign + Vstrata + (Vtotcov +Vgroundcov)/2]/3		
8. **Interspersion and Connectivity**	**All Vegetative Communities** = (Vwatcon+Vsource+Vwetuse + Vadjuse + Vdistantuse)/5		

Variable scores based on existing site conditions __________or proposed site conditions___________ (check one). If variable scores based on proposed site conditions, describe conditions and/or assumptions made. *Appendix E provides an electronic spreadsheet for automatically calculating the Functional Capacity Index (FCI).

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Appendix A. Data Sheets

Table 1. **Kenai River Slope/Flats Wetland Complexes HGM Functional Assessment Hydrology Data Sheet**

Site #:	Site Name:		Date:
UTM 05	E	N Photo Roll:	Photo Numbers:
HGM Class and Subclass			
Reference Class (0: Reference Site; 1: Reference Standard Site)		Waters/Wetlands/Uplands:	

Geomorphic Context	
Landform	
Position	
Feature	
Shape	
Elevation	
Aspect (True Azimuth)	
Slope (%)	
Surface and Shallow Subsurface Hydrologic Characteristics	
Surface Drainage Features	
Features (0: None; 1: paleofeatures (abandoned); 2: Holocene features (abandoned); 3: Holocene features (active)	
State of Development (0: None; 1: Poorly; 2: Well)	
Describe:	
Modifications to Surface and Shallow Subsurface Flow	
Parallel Modifications (0: No; 1: Yes)	
Transverse Modifications (0: No; 1: Yes)	
Describe:	
Longitudinal Connections to Riverine Waters/Wetlands	
Connections Through Contiguous Waters/Wetlands (0: No; 1: Yes)	
Distance to Boundary Along Primary Flow Vector	
Condition of Connection (1: Undisturbed; 2: Rural; 3: Cleaned and recovering 4: Low-density housing; 5: Recreation; 6: Cleared; 7: Urban; 8: Other (Specify)	
Describe:	

Surface and Shallow Subsurface Hydrologic Characteristics (cont.)	
Type of Surface and Shallow Subsurface Water	
Static Subsurface (0: No; 1: Yes)	
Dynamic Subsurface (0: No; 1: Yes)	
Static Surface (0: No; 1 Yes)	
Dynamic Surface (0: No; 1 Yes)	
Describe:	
Source Area	
Condition of Connection (1: Undisturbed; 2: Rural; 3: Cleaned and recovering 4: Low-density housing; 5: Recreation; 6: Cleared; 7: Urban; 8: Other (Specify)	
Describe:	
Material Mobilization and Transport	
Unchannelized Slope Wash (0: No; 1: Yes)	
Channelized Flow (0: No; 1: Yes)	
Piping (0: No; 1: Yes)	
Mass Movement (0: No; 1: Yes)	
Describe:	

Frequency Distribution of Microtopographic Features

	1	2	3	4	5	6	7	8	9	10
Local Feature (See Below)										
Evidence of Static Surface Water (0: No; 1: Yes)										
Evidence of Dynamic Surface Water (0: No; 1: Yes)										

Local Feature
(1: Channel; 2: Pit (<50 sq. ft); 3: pond (>50 sq. ft); 4: hummock (<18" relief); 6: plane; 7 tussock; 8: coarse wood; 9: root mass; 10: other (describe)

Table 2. **Kenai River Slope/Flats Wetland Complexes HGM Functional Assessment Hydrology Data Sheet: Soils**

Site #:	Site Name:		Date:
UTM 05	E	N Photo Roll:	Photo Numbers:
HGM Class		HGM Subclass	
Reference Class (0: Reference Site; 1: Reference Standard Site; 2: Project Site)		Waters/Wetlands/Uplands:	

Site Information	
Landform:	
Position:	
Feature:	
*See NRCS Code Sheet	
Aspect (True Azimuth)	
Slope (%)	
Elevation (ft)	

Soil Information			
Organic Thickness (cm)			
Dominant Organic Type (1: fibric; 2: hemic; 3: sapric)			
Histic Epipedon (0: No; 1: Yes)			
Charcoal in Organic Mat (0: No; 1: Yes)			
Concentrations (0: No; 1: Yes)		Depth To (cm)	
Are reducing Conditions Present? (0: No; 1: Yes)			
Pockets of Depletions: (1: Depleted; 2: Matrix)		Depth To (cm)	
Description (1: None; 2: Increasing w/Depth; 3: Decreasing w/Depth; 4: Uniform)			
Depth to Wet Conditions (cm) (Material Glistens with Moisture But Does Not Flow From Pit Face)			
Depth to Secretion (cm) (Material Glistens with Moisture and Flows From Pit Face)			
Position of Saturation (0: None; 1: Organic; 2: Organic/Mineral Interface; 3: Mineral)			
Saturation Characteristics (0: None; 1: perched; 2: continuous)			

Soil Survey Information	
Survey Name and Date	
NRCS Soil Map Unit	
NRCS Soil Component Name	
Drainage Class	
On Soils List (Y/N)	
Field Confirmation of Soil Component (Y/N)	
On State Hydric Soils List? (0: No; 1: Yes)	
On other Hydric Soils? (0: No; 1: Yes)	

Soil Water Chemistry	
Depth of Measurement (cm)	
1: Standing Water; 2: Soil Slurry	
pH	
Conductivity	
Temp	
At 60 Inches or Bottom of Pit	
Depth of Measurement (cm)	
1: Standing Water; 2: Soil Slurry	
pH	
Conductivity	
Temp	

Notes:

Cross Section of Assessment Area	Plan View of Assessment Area

Table 3. **Kenai River Slope/Flats Wetland Complexes HGM Soils Data Sheet**

Additional Soil Pit Data

Is this soil hydric (0: No; 1: Yes)?		Explain Rationale and annotate to current Hydric Soil Indicators:

Soil Profile Characterization

Depth in Pit (inches)	Horizon (Name)	Matrix Colors (Munsell)	Reduced Matrix (0:No; 1:Yes)	Redox Feature Type Conc. / Depletion	Redox Feature Color (Munsell)	Redox Feature Abundance [Percent(%); size (mm)]

Texture	Structure	Sulfidic Odor? (0:No; 1: Yes)	Roots (0: Some; 1: Few; 2: Common; 3: Many)	Comments

Saturation – Landscape Relations

Episaturation

Landform positions that episaturation occurs are:
All landforms with late seral or climax vegetation – or –
In depressions, on fens, or alluvial plains that have been cleared for agriculture and experience deep annual frost.
Episaturation must also have the following properties:
Deep annual frost – or –
Redoximorphic features at the histic/mineral interface decreasing with depth – or –
Histic epipedon and saturated to wet condition at the histic/mineral interface.

Is Episaturation Present (Y/N)	

Endosaturation

Landform positions that endosaturation occurs are:
In depression on alluvial plains and in both depressions and interfluve on low alluvial plains.
Endosaturation must also have the following properties:
Saturation conditions Continuous From the Upper Limit of Saturation (6ft. – or -)
Redoximorphic Features Continuous and Increasing With Depth

Is Endosaturation Present (Y/N)	
Are both Epi and Endosaturation Conditions Present (Y/N)	

Table 4. Kenai River Slope/Flats Wetland Complexes HGM Hydrology Data Sheet

Microtopography Transects			
Parallel		**Transverse**	
Station	**Elevation**	**Station**	**Elevation**

Water Surface Slope			
Station	**Water Elevation**	**Bearing to Next Pit**	**Distance to Next Pit**
Sketch Pit Locations			

Water Chemistry	
Surface Water	
Temperature	
pH	
Conductivity	
Iron Flocculation (0: No; 1: Yes)	
Shallow Subsurface Water	
Temperature	
pH	
Conductivity	

Sketch on Attached Engineers Paper

Notes:

Table 5. Kenai River Slope/Flats Wetland Complexes Functional Assessment Data Sheet: Habitat/Plant and Fauna Community Support & Microtopography

Site # :	Site Name:	Team:	Date:
UTM: 05	E.	N. Photo Roll:	Photo Numbers
HGM Class:	HGM Subclass:		
Reference Class (0: Reference Site; 1: Reference Standard Site; 2: Project Site)		Waters/Wetlands/Uplands	

Land Use Characteristics	
Surrounding Land Use (Landscape Scale: >1000 feet – 1 Mile; Aerial Photo Interpretation	
Percent Area Disturbance (**0**: 0-10%; **1**: 11-25%; **2**: 26-50%; **3**: 51-75%; **4**: 76-100%)	
Surrounding Land Use(Landscape Scale: 50 – 1000 Feet) Current (**1:** Undisturbed; **2:** Undeveloped; **3:** Rural; **4:** Cleared & Recovering; **5:** Low Density Housing **6:** Recreation; **7:** Cleared; **8:** Urban; **9:** Other)	
Adjacent Land Use (50 Foot Buffer) Current (**1:** Undisturbed; **2:** Undeveloped; **3:** Rural; **4:** Cleared & Recovering; **5:** Low Density Housing **6:** Recreation; **7:** Cleared; **8:** Urban; **9:** Other	
Wetland Land Use Current (**1:** Undisturbed; **2:** Undeveloped; **3:** Rural; **4:** Cleared & Recovering; **5:** Low Density Housing **6:** Recreation; **7:** Cleared; **8:** Urban; **9:** Other	

Noise Impact	
Airplanes	
Automobile Traffic	
Boats	

Nearest Animal Sign					
Tracks		Bird Nests/Nesting Cavities		Scat - Mammal	
Trails (</=4")		Bedding		Scat - Avian	
Trails (>4")		Fur		Calls – Mammal	
Feeding Evidence		Scrapes, Rubs, etc.		Calls – Avian	
Squirrel Middens		Browse		Other (specify)	
Feathers		Raptor Pellets			

Observations:

Table 6. **Kenai River Slope/Flats Wetland Complexes Functional Assessment Data Sheet**

Habitat/Plant and Fauna Community Support

Site #:	Site Name:	Team:	
UTM:05	E.	N. Photo Roll:	Photo Numbers:
HGM Class:	HGM Subclass:		
Reference Class: (**0:** Reference Site; **1:** Reference Standard Site; **2:** Project Site)		Waters/Wetland/Uplands	

Stratum	Height Range (ft)	Modal Height (ft)	Cover Class Midpoint	Density (Stems/Acre)	Basal Area (Sq. ft./Acre)	Patterned Fen?	
						(0) No (1) Yes	
Trees (<10' tall single stem						If yes, Then give Percent Area of Ground Fen	
Snag (>10', single stem; >4" Dia.)						Ridges	
Small Trees (>3' & <10' single stem						Pools	
Seedlings (</=3', single stem						Ages of Modal Size Trees (Years)	
Shrubs (Multiple stem)						Species	Age
Forbs, Graminoids, Ferns & Fern Allies							
Mosses and Lichens							

Stratum Species	Height Range (ft)	Mean Height (ft)	Cover Class Midpoint	Density (Stems/Acre)	Basal Area (Sq. Ft/Acre)	% Cover	Midpoint
Trees (>/=10', single stem)						<1	0.5
						1-5	3
						6-15	10.5
						16-25	20.5
						26-50	38
Small Trees (>3'& <10', single stem						51-75	63
						76-95	85.5
						>95	98
						Leaf Type of Dominant Strata	
Seedlings (</=3', single stem						Leaf Type	Percent
						Needle Persistent	
						Deciduous	
						Herbaceous	
Shrubs (Multiple Stem)					Dominant Type of Regeneration (**0:** None; **1:** Seedling; **2:** Non-seed)		

Forbs, Graminoids, Ferns & Fern Allies species	Cover Class Midpoint	Forbs, Graminoids, Ferns & Fern Allies Species	Cover Class Midpoint

Mosses and Lichens			Coarse Woody Debris			
Fruticose Lichens			Mean Diameter (ft)	Mean Length (ft)	Density (Pieces/Acre	Volume (Cubic ft/Acre)
Cladina Spp.						
Other Lichens						
Non-Sphagnum Mosses						
Sphagnum Mosses						

Patch Shape, Size, Distribution, Dynamics	
Estimated Size of Community Type Unit: Slope (**1:** <1 acre; **2:** 1-5 acres; **3:** 5-25 acres; **4:** >25 acres	
Riverine in river miles (<25; 26-50; 51-100; >100 miles)	

Table 7. Kenai River Slope/Flats Wetland Complexes: HGM Vegetation Data Sheet

Additional Data/Worksheet

Point-Center Quarter: Trees			
Quarter	Distance Feet	DBH In.	Species
1			
2			
3			
4			
1			
2			
3			
4			

Point-Center Quarter: Snags			
Quarter	Distance Feet	DBH In.	Height Feet
1			
2			
3			
4			
1			
2			
3			
4			

Point-Center Quarter: Small Trees		
Quarter	Distance (Feet)	Species
1		
2		
3		
4		
1		
2		
3		
4		

Point-Center Quarter: Coarse Wood (>1"dia & 3' length)			
Fixed Plot Size (e.g. 1/10 acre)			
Dia.	Length	Dia.	Length

Point-Center Quarter: Seedlings		
Quarter	Distance (Feet)	Species
1		
2		
3		
4		
1		
2		
3		
4		

Calculations: Mean Distance = D, Absolute Density (Trees/acre) = $43{,}560/D^2$
Relative Density = # trees samples x absolute density.
Basal Area = density x ((Average DBH/12)^2 x .78539)
1/10 acre: Radius = 37.25: 1/100: Radius = 11.8'

Point Intercept for Flarks and Strangs	
Point Intercept Sample Distance	
Species	Intercept Distance
Flark (F)	
Strang (S)	

Drawings indicating plot locations, etc.

Land Use	
Current (**1:** undisturbed; **2:** rural; **3:** cleared & recovering; **4:** low density housing; **5:** recreation; **6:** cleared; **7:** urban; **8:** other)	
Years Since Last Disturbance (**1:** 0-3; **2:** 4-16; **3:** dense trees; **4:** >50)	
Successful Stage (**1:** herb; **2:** tall shrub sapling; **3:** dense trees; **4:** mature forest)	

Appendix B. Data Array Sheets

1. **Sorted Reference Sites**
2. **Vegetation Data Array Sheet**
3. **Hydrologic and Soil Data Array Sheet**
4. **Slope, Microtopographic Features, and Coarse Woody Debris (CWD) Data Array Sheet**
5. **Wetland Land Use, Surrounding Land Use, Area Land Use, and Hydrologic Source Land Use Data Array Sheet**
6. **Wetland Land Use, Surrounding Land**

Table 1. Sorted Reference Sites

Sites Number and Name	Standard Reference Sites	Community Type	Burned w / in the past 60 years	Type of Disturbance
1. Hansen House		Forest		None
2. Swiftwater Park		Forest		None
3. Airport Strangmoor	X	Shrub		None
4. Airport Black Spruce	X	Forest		None
5. Keystone Estates Point		Forest		None
6. Keystone Estates Fen	X	Forest	X	Fire
7. Swanson R. Meltwater	X	Shrub		None
8. Swanson R. Spruce	X	Forest	X	Fire
9. Swanson R. Rubus	X	Herb		None
10. Swanson R. Meltwater Herb	X	Herb		None
11. ADOT		Herb		Fill
12. River & Sea Trench		Herb		Trench
13. River & Sea Power Line		Shrub		Powerline Clearing
14. River & Sea Spruce		Forest		None
15. Kenai Culvert Slope		Forest		None
16. Kenai Culvert ROW		Herb		Gasline ROW
17. Marathon Rd. Burn	X	Forest (burned bog - now forest)	X	Fire
18. Marathon Rd. Strangmoor	X	Shrub		None
19. Marathon Pad Burn	X	Shrub	X	Fire
20. Beaver River Pad		Herb		Fill
21. Golf Course ROW		Herb		Powerline ROW
22. Mystery Ck. Spruce	X	Shrub	X	Fire
23. Mystery Ck. Fen	X	Shrub	X	Fire
24. Mystery Ck. Cobble Burn	X	Shrub	X	Fire

Sites Number and Name	Standard Reference Sites	Community Type	Burned w / in the past 60 years	Type of Disturbance
25. Mystery Ck. Moose Crush		Forest	X	Vegetation Crushing
26. E. Fork Moose – Triple	X	Forest	X	Fire
27. B Lake Rubus	X	Shrub		None
28. Scout L. Rd. – Ck. Proximal		Shrub		None
29. Carter Spruce ROW	X	Forest	X	Fire
30. Carter Slough	X	Herb		None
31. Carter Bear Camp	X	Forest		None
32. Carter Toe Slope	X	Forest		None
33. Funny R. Cleared Spruce		Shrub		Pasture, Clearing
34. Airport Gravel Pit		Forest		Gravel Mining
35. River Bend Rd. Fen		Shrub	X	Fire
36. Mouth of Kenai Alder	X	Shrub		Subsidence
37. Hi-Lo Charters Ditch		Herb		Urban Clearing

Table 2. Vegetation Array Sheet

Sites Number and Name	Standard Reference Sites	Community Type	Total Veg. Cover	Ground Cover	Number Vegetation Strata
1. Hansen House		Forest	138.0	83.5	4
2. Swiftwater Park		Forest	173.0	86.5	4
3. Airport Strangmoor	X	Shrub	165.0	146.5	3
4. Airport Black Spruce	X	Forest	185.5	136.0	4
5. Keystone Estates Point		Forest	144.5	86.0	3
6. Keystone Estates Fen	X	Forest	173.0	91.5	4
7. Swanson R. Meltwater	X	Shrub	234.0	142.0	3
8. Swanson R. Spruce	X	Forest	120.5	147.0	4
9. Swanson R. Rubus	X	Herb	143.0	63.0	3
10. Swanson R. Meltwater Herb	X	Herb	147.5	61.5	3
11. ADOT		Herb	63.0	97.0	1
12. River & Sea Trench		Herb	69.0	124.0	3
13. River & Sea Power Line		Shrub	114.0	48.5	3
14. River & Sea Spruce		Forest	160.5	136.0	4
15. Kenai Culvert Slope		Forest	107.5	48.5	4
16. Kenai Culvert ROW		Herb	146.0	136.0	3
17. Marathon Rd. Burn	X	Forest (burned bog -now forest)	75.5	50.5	4
18. Marathon Rd. Strangmoor	X	Shrub	120.5	92.5	3
19. Marathon Pad Burn	X	Shrub	205.5	180.5	3
20. Beaver River pad		Herb	0.5	0.5	0

Sites Number and Name	Standard Reference Sites	Community Type	Total Veg. Cover	Ground Cover	Number Vegetation Strata
21. Golf Course ROW		Herb	104.5	104.0	2
22. Mystery Ck. Spruce	X	Shrub	150.5	136.5	4
23. Mystery Ck. Fen	X	Shrub	170.5	164.5	3
24. Mystery Ck. Cobble Burn	X	Shrub	6.0	5.0	0
25. Mystery Ck. Moose Crush		Forest	178.0	158.5	4
26. E. Fork Moose – Triple	X	Forest	160.5	121.0	4
27. B Lake Rubus	X	Shrub	210.5	178.5	4
28. Scout L. Rd. – Ck. Proximal		Shrub	212.5	174.5	3
29. Carter Spruce ROW	X	Forest	168.0	140.0	4
30. Carter Slough	X	Herb	160.5	151.5	3
31. Carter Bear Camp	X	Forest	210.5	104.5	4
32. Carter Toe Slope	X	Forest	142.5	44.0	3
33. Funny R.Cleared Spruce		Shrub	211.5	172.0	3
34. Airport Gravel Pit		Forest	110.5	66.0	4
35. River Bend Rd. Fen		Shrub	105.5	32.0	2
36. Mouth of Kenai Alder	X	Shrub	186.5	123.5	3
37. Hi-Lo Charters Ditch		Herb	130.0	126.5	3

Table 3. **Hydrologic and Soil Data Array Sheet**

Sites Name and Number	Standard Reference Sites	Community Type	Saturated	Seasonally Flooded	Semi-Permanently Flooded	Soil saturation measured in CM
1. Hansen House		Forest	X			40
2. Swiftwater Park		Forest	X			8
3. Airport Strangmoor	X	Shrub		X		45
4. Airport Black Spruce	X	Forest	X			---
5. Keystone Estates Point		Forest	X			20
6. Keystone Estates Fen	X	Forest		X		30
7. Swanson R. Meltwater	X	Shrub		X		40
8. Swanson R. Spruce	X	Forest	X			28
9. Swanson R. Rubus	X	Herb	X			35
10. Swanson R. Meltwater Herb	X	Herb		X		Surface
11. ADOT		Herb	Non wetland			None
12. River & Sea Trench		Herb		X		Surface
13. River & Sea Power Line		Shrub	X			Surface
14. River & Sea Spruce		Forest	X			Surface
15. Kenai Culvert Slope		Forest	X			37
16. Kenai Culvert ROW		Herb	X			Surface
17. Marathon Rd. Burn	X	Forest (burned bog - now forest)	X			Surface
18. Marathon Rd. Strangmoor	X	Shrub		X		Surface
19. Marathon Pad Burn	X	Shrub	X			64

Sites Name and Number	Standard Reference Sites	Community Type	Saturated	Seasonally Flooded	Semi-Permanently Flooded	Soil saturation measured in CM
20. Beaver River Pad		Herb	Non Wetland			None
21. Golf Course ROW		Herb	X			Surface
22. Mystery Ck. Spruce	X	Shrub	X			Surface
23. Mystery Ck. Fen	X	Shrub	X			Surface
24. Mystery Ck. Cobble Burn	X	Shrub	X			None
25. Mystery Ck. Moose Crush		Forest	X			35
26. E. Fork Moose – Triple	X	Forest	X			18
27. B Lake Rubus	X	Shrub	X			37
28. Scout L. Rd. – Ck. Proximal		Shrub		X		10
29. Carter Spruce ROW	X	Forest		X		Surface
30. Carter Slough	X	Herb		X		Surface
31. Carter Bear Camp	X	Forest	X			38
32. Carter Toe Slope	X	Forest	X			40
33. Funny R. Cleared Spruce		Shrub	X			56
34. Airport Gravel Pit		Forest	Non Wetland			None
35. River Bend Rd. Fen		Shrub	X			10
36. Mouth of Kenai Alder	X	Shrub		X		19
37. Hi-Lo Charters Ditch		Herb	X			21

Table 4. Slope, Microtopographic Features, and Coarse Woody Debris (CWD) Data Array Sheet

Sites Name and Number	Standard Reference Sites	Community Type	Slope	Number of Non-planar features	CWD Density
1. Hansen House		Forest	1.5	No data	240
2. Swiftwater Park		Forest	7.1	No Data	130
3. Airport Strangmoor	X	Shrub	0.1	10	0
4. Airport Black Spruce	X	Forest	---	10	350
5. Keystone Estates Point		Forest	8.8	6	130
6. Keystone Estates Fen	X	Forest	---	10	20
7. Swanson R. Meltwater	X	Shrub	0.7	10	0
8. Swanson R. Spruce	X	Forest	2.2	9	440
9. Swanson R. Rubus	X	Herb	1.3	10	40
10. Swanson R. Meltwater Herb	X	Herb	0.5	10	0
11. ADOT		Herb	36.5	5	0
12. River & Sea Trench		Herb	0.2	7	0
13. River & Sea Power Line		Shrub	1.9	6	0
14. River & Sea Spruce		Forest	---	10	130
15. Kenai Culvert Slope		Forest	21	10	180
16. Kenai Culvert ROW		Herb	---	10	0
17. Marathon Rd. Burn	X	Forest (burned bog - now forest)	---	10	0
18. Marathon Rd. Strangmoor	X	Shrub	0.8	10	0
19. Marathon Pad Burn	X	Shrub	0.1	10	260
20. Beaver River Pad		Herb	---	6	0
21. Golf Course ROW		Herb	---	6	0
22. Mystery Ck. Spruce	X	Shrub	0.8	---	380
23. Mystery Ck. Fen	X	Shrub	0.9	---	Trace
24. Mystery Ck. Cobble Burn	X	Shrub	---	10	1,375
25. Mystery Ck. Moose Crush		Forest	---	10	220
26. E. Fork Moose – Triple	X	Forest	1.2	10	480
27. B Lake Rubus	X	Shrub	---	10	30
28. Scout L. Rd. – Ck. Proximal		Shrub	---	10	0

Sites Name and Number	Standard Reference Sites	Community Type	Slope	Number of Non-planar features	CWD Density
29. Carter Spruce ROW	X	Forest	0	8	240
30. Carter Slough	X	Herb	1.4	10	25
31. Carter Bear Camp	X	Forest	2.7	10	140
32. Carter Toe Slope	X	Forest	8.9	--	360
33. Funny R. Cleared Spruce		Shrub	0.2	10	0
34. Airport Gravel Pit		Forest	---	--	0
35. River Bend Rd. Fen		Shrub	---	8	320
36. Mouth of Kenai Alder	X	Shrub	1.1	10	0
37. Hi-Lo Charters Ditch		Herb	---	7	0

Table 5. **Wetland Land Use, Adjacent Land Use, Distant Area Land Use and Hydrologic Source Land Use Data Array Sheet**

Sites Name and Number	Standard Reference Sites	Wetland Land Use Score	Adjacent Land Use Score	Distant Land Use Score	Hydrologic Source Land Use Score
1. Hansen House		0	108	100	500
2. Swiftwater Park		0	96	120	300
3. Airport Strangmoor	X	0	8	4	72
4. Airport Black Spruce	X	0	0	4	44
5. Keystone Estates Point		0	8	20	300
6. Keystone Estates Fen	X	0	8	16	0
7. Swanson R. Meltwater	X	0	8	12	188
8. Swanson R. Spruce	X	0	12	8	300
9. Swanson R. Rubus	X	0	16	12	264
10. Swanson R. Meltwater Herb	X	0	8	8	212
11. ADOT		400	300	244	400
12. River & Sea Trench		100	44	96	156
13. River & Sea Power Line		100	68	96	220
14. River & Sea Spruce		0	20	96	224
15. Kenai Culvert Slope		0	268	212	436
16. Kenai Culvert ROW		100	268	212	500
17. Marathon Rd. Burn	X	0	12	8	212
18. Marathon Rd. Strangmoor	X	0	12	12	0
19. Marathon Pad Burn	X	0	24	8	308
20. Beaver River Pad		400	32	8	400
21. Golf Course ROW		100	32	88	80
22. Mystery Ck. Spruce	X	0	8	12	168
23. Mystery Ck. Fen	X	0	8	8	84
24. Mystery Ck. Cobble Burn	X	0	8	24	180
25. Mystery Ck. Moose Crush		100	68	32	340
26. E. Fork Moose – Triple	X	0	16	12	300

Sites Name and Number	Standard Reference Sites	Wetland Land Use Score	Adjacent Land Use Score	Distant Land Use Score	Hydrologic Source Land Use Score
27. B Lake Rubus	X	0	8	12	300
28. Scout L. Rd. – Ck. Proximal		0	64	152	300
29. Carter Spruce ROW	X	0	16	44	276
30. Carter Slough	X	0	4	108	300
31. Carter Bear Camp	X	0	4	120	300
32. Carter Toe Slope	X	0	76	80	300
33. Funny R. Cleared Spruce		100	76	120	252
34. Airport Gravel Pit		400	92	80	268
35. River Bend Rd. Fen		0	48	76	300
36. Mouth of Kenai Alder	X	0	16	56	368
37. Hi-Lo Charters Ditch		100	48	44	300

Appendix C. HGM Interagency MOU

HGM INTERAGENCY MOU
State and Federal Interagency
MEMORANDUM OF UNDERSTANDING
MARCH, 2000

BETWEEN THE

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION (ADEC)

ALASKA DEPARTMENT OF FISH AND GAME (ADF&G)

ALASKA DEPARTMENT OF NATURAL RESOURCES (ADNR)

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES (ADT&PF)

U.S. DEPARTMENT OF INTERIOR; U.S. FISH AND WILDLIFE SERVICE (USFWS)
AND
U.S. GEOLOGICAL SURVEY (USGS)

U.S. ARMY CORPS OF ENGINEERS, ALASKA DISTRICT (COE)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

U.S. DEPARTMENT OF AGRICULTURE; NATURAL RESOURCE CONSERVATION SERVICE (NRCS),
U.S. FOREST SERVICE, ALASKA REGIONAL OFFICE (USFS)
AND

U.S. DEPARTMENT OF TRANSPORTATION; FEDERAL HIGHWAY ADMINSTRATION (FHWA)

CONCERNING

THE DEVELOPMENT OF A WETLAND FUNCTIONAL ASSESSMENT METHOD AND GUIDEBOOKS:
The Hydrogeomorphic Approach (HGM)

A. PURPOSE:

This Memorandum of Understanding (MOU) establishes a cooperative approach among federal and state agencies to improve wetland management and regulatory decision-making in Alaska. Each signatory agency desires to cooperate and develop a scientifically based wetland functional assessment method. To accomplish this task the signatory agencies have initiated an interagency effort to develop hydrogeomorphic methodology (hereafter "HGM"), a functional assessment tool for wetlands. HGM is a rapid assessment tool that is tailored to specific geographic regions and classes of wetlands (See *Smith, D. R., Ammann, A., Bartoldus, C. and Brinson, M. An Approach for Assessing Wetland Functions using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices," Technical Report WRP-DE-9, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS. NTIS No. AD A307 121. (1995).*

The Alaska HGM Management Team, Statewide Technical Oversight Team, and Guidebook Development Teams, as explained by this MOU are currently developing HGM Guidebooks (hereafter "Guidebook") for areas of the state where resource development activities are planned or under way. Through these efforts the state will improve the understanding of Alaska's wetland functions and have an assessment tool for improving our management of wetlands.

The signatory agencies intend to use each Guidebook after each has been reviewed by the signatory agencies and the U.S. Army Corps of Engineers, Waterways Experiment Station. (COE/WES). It is understood that when a functional assessment is being performed in support of wetland permitting, planning, and management the Guidebook appropriate to the subject wetland system will be used.

B. AUTHORITY:

This Memorandum of Understanding is entered into under the following laws and agency authorities:

Agency Authorities

ADNR:	AS 38.05.020
ADEC:	AS 46.03.020
ADF&G:	AS 16.05.050, AS 16.05, AS 16.20, 16 U.S.C. 661 et. seq.
ADT&PF:	AS 44.42.020
COE & EPA:	Clean Water Act (33 USC 1251), Executive Order 11990
NRCS:	Food, Agriculture, Conservation and Trade Act of 1990 Public Law 101-624 (104 Stat. 3584; 16 U.S.C. 3837)
USFWS	Fish and Wildlife Coordination Act (P.L. 85-624; 72 Stat. 563)
USFS:	Economy Act of June 30, 1932, as amended (31 U.S.C) Fish and Wildlife Coordination Act of March 10, 1934, as amded, 16 U.S.C. 661 Executive Order 11990, (42 Fed. Reg. 26961 1977)

Agency Authorities

USGS:	Economy Act of June 30, 1932, as amended, Section 601, (31 U.S.C 1535) Public Law 99-591
FHWA:	Executive Order 11990

General Authorities
Intergovernmental Cooperation Act of 1968 (P.L. 90-577; 82 Stat. 1102)

C. BENEFITS TO EACH PARTICIPANT:

This agreement commits the signatory agencies to cooperatively develop a common scientific platform using the HGM Approach and HGM Guidebooks to assess wetland functions. The HGM Approach provides agencies, private sector, and the public with a way to classify wetlands and to assess wetlands based on local characteristics. The HGM Guidebooks provide a rapid assessment tool that uses local site data and information to determine how wetlands function. This site data and information is intended to improve decisions made about wetlands.

The HGM Approach was designed to be used by federal resource and regulatory agencies, and the public when appropriate in the Clean Water Act Section 404 permitting and Section 401 Water Quality Standards Certifications. Wetland functional assessment procedures are required by the Natural Resource Conservation Service to conduct wetland minimal effect determinations in accordance with the 1985 Food Security Act, as amended. The Guidebooks are expected to be useful to local, state and federal agencies in watershed management and planning.

D. THREE INTERAGENCY/STAKEHOLDER TEAMS ESTABLISHED TO DEVELOP HGM APPROACH AND GUIDEBOOKS:

The Alaska Department of Environmental Conservation (ADEC) has initiated an interagency /stakeholder effort to develop the HGM Approach. Three teams: (1) The Alaska HGM Management Team, (2) HGM Statewide Technical Oversight Team, and (3) HGM Guidebook Development Teams have been established to develop the HGM Approach and HGM Guidebooks in Alaska.

HGM Management Team

This agreement establishes ADEC as the lead agency for coordinating the Alaska HGM Management Team. This team will provide overall policy and management direction and coordinate the development of the HGM Approach in Alaska. Specifically, this team will meet as necessary to review progress on providing training, data management, guidebook development and use. The members of the HGM Management Team are ADEC, ADF&G, ADNR, ADT&PF, EPA, NRCS, USFWS, COE, FHWA, USGS, USFS, and other agencies and stakeholders, as they become signatories to this MOU.

HGM Statewide Technical Oversight Team

This agreement establishes ADEC as the lead agency for coordinating this team. This team is to provide primarily technical advice and direction to the HGM Management Team on the HGM Approach and HGM Guidebook development. Specifically, this team will review HGM guidebooks for compliance and statewide consistency as well as organize, develop, and participate in HGM Training. The Statewide Technical Oversight Team (STOT) is also responsible for providing guidance and direction to both users of existing guidebooks and Guidebook Development Teams. The members of the HGM Statewide Technical Oversight Team are ADEC, ADF&G, NRCS, USFWS, COE, and EPA.

HGM Guidebook Development Teams

The purpose of each Guidebook Development Team is to develop guidebook(s) for HGM wetland classes or subclasses for a specific area. Each Guidebook Development Team is trained in the HGM Approach and is responsible for collecting field data, developing models, and authoring Guidebook(s). The teams will be open to broad representation consisting of public, private, and academic experts in disciplines such as hydrology, botany, soils, and habitat. The membership of each Guidebook Development Team will be unique for each Guidebook being developed.

E. DATA AND INFORMATION MANAGEMENT:

Data generated to support the development of Guidebooks will be stored at ADEC and will be accessible to agencies and the public. The Guidebooks will be available to the public at the ADEC and the COE/WES Internet web sites as they are developed. Hard copies will be made available by ADEC.

F. GUIDEBOOK DEVELOPMENT:

Alaska and a few other states are pioneering the development of HGM Guidebooks. ADEC, ADF&G, ADNR, ADOT&PF, EPA, NRCS, COE, USFS, USGS, USFWS and other interested organizations are participating in the development of Guidebooks in three regions in Alaska. The Guidebook Development Teams are developing the Guidebooks consistent with the procedures identified by the U.S. Corps of Engineers in the *National Action Plan to Develop the Hydrogeomorphic Approach for Assessing Wetlands Functions* (Federal Register: August 16, 1996 (Vol. 61, No. 160, Pages 42593-42603); Federal Register: June 20, 1997 (Vol. 62, No. 119, pages 33607-33620). Also, the Guidebooks are consistent with national guidance from the NRCS Director of Watersheds and Wetlands Division (August 21, 1996). Guidebooks contain the assessment model, supporting data sets, and assessment protocol for the user. The final product of the development phase is entitled: “Operational Draft Guidebook” (ODG).

In Alaska, Guidebooks are currently being developed where the majority of wetland permitting and planning activity occurs. A total of nine Guidebooks, within five areas, are anticipated through 2003. The list of areas, Guidebooks and anticipated completion dates for the Operational Draft Guidebooks follows:

Areas	Guidebooks (by wetland class)	Operational Draft Guidebook Estimated Completion
Currently being developed		
1. Interior	Flats	May 1999 (Completed)
2. Kenai River Watershed	Riverine	Spring 2001
	Slope	Spring 2002
3. Coastal Southeast and Southcentral	Riverine/River Proximal	Spring 2001
	Slope	Spring 2002
Anticipated		
4. Upper Cook Inlet	Riverine	2003
	Slope or Depression	2003
5. Arctic Coastal Plain	Flats	2003
	Slope or Depression	2003
	Total 9 Guidebooks	

G. Implementation:

The HGM Guidebooks are not intended to replace other analysis such as jurisdictional delineation, the Habitat Evaluation Procedure (HEP), threatened and endangered species database and/or field reviews, and others. Rather, HGM is a tool that can be used in conjunction with other data and/or assessment methodologies.

1) Operational Draft Guidebook Use

Consistent with the COE, EPA, NRCS, FHWA, FWS, and NMF Final National Action Plan (Federal Register Vol. 61, No. 160/Friday, August 16, 1996) each ODG will be distributed for a two-year period to be used by regulatory and resource agencies. The ODGs will be published by the ADEC. After each of the ODGs are published they will be submitted to the COE/WES for their approval and made available on Internet web sites. After COE/WES approves each ODG, will be used by all the signatory agencies including use by the NRCS for Minimal Effect Determinations, the Alaska Corps of Alaska District Regulatory Branch in the 404 permitting, EPA Region 10, and ADEC in 401Water Quality Certifications as appropriate. Other agencies with interest or responsibility for wetland regulation and management, non-governmental organizations, and other parties will have an opportunity to use the ODGs during this two-year period and provide recommendations for improvements**.**

After the Operational Draft Guidebook has been used in the field for two years it may be revised incorporating comments and any corrections identified by the specific Guidebook Development Team. The revised Operational Draft Guidebook will be reviewed and approved by the COE/WES as a Final Guidebook.

2) Final Guidebooks

The Final Guidebooks will be used by all the signatory agencies including use by the NRCS for Minimal Effect Determinations, the Alaska Corps of Alaska District Regulatory Branch in the 404 permitting, EPA Region 10, and ADEC in 401Water Quality Certifications as appropriate. Specifically, the Guidebooks can be used as an impact assessment and predictive tool that can help permit specialists suggest, and/or examine, alternatives for projects involving waters/wetlands.

H. GUIDEBOOK USER TRAINING:

The Alaska HGM Statewide Oversight Technical Team established by this MOU will be responsible for organizing and conducting training in the HGM Approach and use of specific HGM Guidebooks. Training is necessary and will be contingent upon available funding.

I. FUNDING AND SUPPORT:

This MOU does not require the signatory agencies to commit funding to carry out the purposes of the agreement. This MOU expresses agency commitment and support to develop the HGM functional assessment method and enables the agencies to provide financial assistance and support if and when funds become available to the participating agencies.

J. REVIEW, CHANGES, OR TERMINATION TO THIS AGREEMENT:

This MOU will be reviewed as required, with at least one review to occur after three years. Revisions may be brought forward by any of the signatory parties when changing conditions or circumstances warrant. Revisions may require convening the HGM Management Team or may be such that they can be made through an exchange of correspondence and upon full agreement of all signatory agencies. Revisions will be in an appropriate form and may be an addendum to the MOU.

The MOU will remain in effect for a period of six years, at which time it will be reaffirmed, if appropriate.

Other agencies may enter into this MOU following their review and acceptance of the MOU as written.

Each party, upon thirty (30) days written notice to the other parties, may amend or terminate their participation in this agreement.

K. NONDISCRIMINATION STATEMENT:

The program or activities conducted under this agreement will be in compliance with the nondiscrimination provisions contained in the Titles VI and VII of the Civil Rights Act of 1964, as amended; the Civil Rights Restoration Act of 1987 (public law 100-259); and other nondiscrimination statutes: namely, section 504 of the Rehabilitation Act of 1973, Title IX of the Education Amendments of 1972, the Age Discrimination Act of 1975, and American's With Disabilities Act of 1990. They will also be in accordance with regulations of the Secretary of Agriculture (7 CFR 15, Subparts A & B), which provide that no person in the United States shall on the grounds of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or family status, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving federal financial assistance from any agency of the U.S. Government.

K. SIGNATORY AGENCIES:

This agreement is entered into upon the date of the last signature by and between the federal and state agencies listed under this section.

Federal Agencies

U.S. Department of Interior

U.S. Fish and Wildlife Service

4/13/00

David B. Allen — Date
Regional Director

U.S. Department of Transportation

Federal Highway Administration

1/2/01

David C. Miller — Date
Division Administrator

U.S. Geological Survey
Water Resources Division

8/23/00

Gordon Nelson — Date
District Chief

U.S. Department of Agriculture
Natural Resource Conservation Service

4/6/00

Charles Bell — Date
State Conservationist

U.S. Army Corps of Engineers
Alaska District

13 July '00

Sheldon L. Jahn — Date
Colonel, Corps of Engineers, District Engineer

U.S. Forest Service Region 10

9/14/00

James A. Caplan — Date
~~Acting~~ Deputy Regional Forester

00MOU-11101-027

U.S. Environmental Protection Agency
Region 10 Alaska Operations Office Anchorage

4/21/00

Marcia Combes — Date
Director, Alaska Operations

State of Alaska Agencies

Department of Environmental Conservation

3/25/00

Michele Brown — Date
Commissioner

Department of Fish and Game

10-30-00

Frank Rue — Date
Commissioner

Department of Natural Resources

12/05/00

Pat Pourchot — Date
Commissioner

Department of Transportation & Public Facilities

12-14-00

Joseph L. Perkins, P.E. — Date
Commissioner

Appendix D. COE Steps For Developing HGM Models And HGM Guidebooks

COE Steps for Developing HGM Models and HGM Guidebooks (Federal Register, August 16, 1997).

STEP			STATUS *
Phase I.	**Organization of Regional or (Development) Assessment Team**		
	A.	Identify Development Team Members	C
	B.	Train Member in HGM Classification and Assessment	C
Phase II.	**Identification of Wetland Assessment Needs**		
	A.	Identify Wetland Subclasses	C
	B.	Prioritize Wetland Subclasses	C
	C.	Define Reference Domains	C
	D.	Initiate Literature Review	C
Phase III.	**Draft Model Development**		
	A.	Review Existing Models of Wetland Functions	C
	B.	Identify Reference Wetland Sites	C
	C.	Identify Functions for each Subclass	C
	D.	Identify Variables and Measures	C
	E.	Develop Functional Indices	C
Phase IV.	**Draft Regional Wetland Model Review**		
	A.	Obtain Peer-Review of Draft Model	C
	B.	Conduct Interagency and Interdisciplinary workshop to critique model	I
	C.	Revise Model to Reflect Recommendations From Peer-Review and Workshop	C
	D.	Obtain Second Peer-Review of Draft Model	C
Phase V.	**Model Calibration**		
	A.	Collect Data From Reference Wetland Sites	C
	B.	Calibrate Functional Indices Using Reference Wetland Data	C
	C.	Field Test Accuracy and Sensitivity of Functional Indices	C
Phase VI.	**Draft Model Guidebook Publication**		
	A.	Develop Draft Model Guidebook	C
	B.	Obtain Peer-Review of Guidebook	C
	C.	Publish as Operational Draft Regional Wetland HGM Functional Assessment Guidebook to be Used in the Field	C
Phase VII.	**Implement Draft Model Guidebook**		
	A.	Identify Users of HGM Functional Assessment	TBI
	B.	Train Users in HGM Classification and Evaluation	TBI
	C.	Provide Assistance to Users	TBI
Phase VIII.	**Review and Revise Draft Model Guidebook**		TBI

Key (Status): C = Completed; I = In process; TBI = To Be Initiated

Appendix E. Screenview Of Electronic Spreadsheet

For Calculating the Functional Capacity Index (FCI)

Slope/Flat Wetland Complexes in the Lower Kenai River Drainage Basin
Functions and Variable Index values
HGM Team

Date ______________________________
Name ______________________________
COE Waterway # ______________________
State ID Number ______________________

Two Step Procedure for Calculating the Functional Capacity Index

1 Fill in the "Index" column (column D) for all 16 variables by using the variable index values found in the completed field collection sheets from Chapter

2 The Functional Capacity Index is automatically calculated for each of the 8 wetland functions.

Page Reference #	Variables	Wetland Variables Names	Index
	Vaquic	1 Aquic soil moisture regime	
	Vasign	2 Animal sign	
	Vcwd	3 Course Woody Debris	
	Vgroundcov	4 Groundcover	
	Vdistantuse	5 Distant land use	
	Vmicro	6 Microtopography	
	Vnplant	7 Native plants	
	Voh	8 Organic horizons	
	Vslope	9 Surface slope	
	Vsource	10 Source of water	
	Vadjause	11 Adjacent land use	
	Vstrata	12 Vegetation strata	
	Vsurwat	13 Surface water storage	
	Vtotcov	14 Total vegetation cover	
	Vwatcon	15 Water connections	
	Vwetuse	16 Land use of Assessment Area	

Key:
- All Vegetation Communities
- Shrub and Herbaceous
- Forested Communities

Page Reference #	Wetland Functions
	1 Discharge of water to downgradient systems
	FCI: All Vegetation Communities = (Vmicro + Vsource + Vaquic + Vslope) / 4
	FCI = 0.00 % departure = 100
	2 Surface and shallow subsurface water storage
	FCI : All Vegetation Communities = [(Vmicro + Vsurwat) / 2 + Voh + Vaquic + Vsource] / 4
	FCI = 0.00 % departure = 100
	3 Particulate retention
	FCI: Forested Communities = [Vsource + (Vmicro + Vsurwat + Vslope) / 3 + (Vcwd +Vgroundcov)/2] / 3
	FCI = 0.00 % departure = 100
	FCI: Shrub and Herbaceous Communities = [Vsource + (Vmicro + Vsurwat + Vslope) / 3 + Vgroundcov] / 3
	FCI = 0.00 % departure = 100
	4 Organic carbon export
	FCI : Forested Communities = [(Vstrata + Vgroundcov + Vcwd) / 3 + Voh + Vsource + Vwatcon] / 4
	FCI = 0.00 & departure = 100
	FCI : Shrub and Herbaceous Communities = [(Vstrata + Vgroundcov) / 2 + Voh + Vsource + Vwatcon] / 4
	FCI = 0.00 & departure = 100
	5 Cycling of elements and compounds
	FCI: Forested Communities = [(Vasign + Vcwd + Vgroundcov + Vtotcover + Vstrata) / 5 Vaquic + Voh] / 3
	FCI = 0.00 % departure = 100
	FCI: Shrub and Herbaceous Communities = [(Vasign + Vgroundcov + Vtotcover + Vstrata) / 4 + Vaquic + Voh] / 3
	FCI = 0.00 % departure = 100
	6 Maintenance of characteristic plant community
	FCI: All Vegetation Communities = (Vtotcov + Vstrata + Vnplant) / 3
	FCI = 0.00 % departure = 100
	7 Maintenance of characteristic habitat structure
	FCI: Forested Communities [Vasign + Vstrata + (Vtotcov + Vgroundcov) / 2 + Vcwd] / 4
	FCI = 0.00 % departure = 100
	FCI: Shrub and Herbaceous Communities [Vasign + Vstrata + (Vtotcov + Vgroundcov) / 2] / 3
	0.00
	8 Interspersion and connectivity
	FCI: All Vegetation Communities = (Vwatcon + Vsource + Vwetuse + Vadjause + Vdistantuse) / 5
	FCI = 0.00 % departure = 100
	Ave. % departure from Reference Stand. 100

Appendix F. GLOSSARY

abiotic Non-living processes in contrast to biotic or living processes. For example, the deposition of suspended sediments on a floodplain is an abiotic process.

accretion Vertical accumulation of inorganic or organic material.

adjacent "…bordering, contiguous, or neighboring" (33 CFR Part 328, Section 328.3 (a)(7)(c)).

aerobic Conditions in which free molecular oxygen is present. In contrast, see anaerobic.

alkalinity The capacity of water to buffer changes in pH through reaction in the carbon dioxide-bicarbonate buffering complex and others.

alluvial Refers to the transport of material by flowing water normally in a river or stream.

alluvium Sediments transported by the flowing water of a river or stream.

anaerobic Conditions in which free molecular oxygen is absent. In contrast, see aerobic.

aquic A moisture regime in a soil that is a reducing regime, virtually free of dissolved oxygen due to saturation.

aquifer A rock or sediment formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

artesian aquifer An aquifer that is under hydrostatic pressure which is significantly greater than atmospheric. The upper limit of the aquifer is defined by a confining bed that limits upward movement of water.

artesian well A well that penetrates a confined aquifer in which the potentiometric surface is above the surface of the ground.

assessment area The wetland area, or portion of the wetland, which will be assessed with HGM models. There has to be at least one assessment area per assessment.

assessment model A simple model that defines the relationship between ecosystem and landscape scale variables and functional capacity of a wetland. The model is developed and calibrated using Reference Wetlands from a Reference Domain.

assessment objective The reason why an assessment of wetland functions is being conducted. Assessment objectives normally fall into one of three categories. These include: documenting existing conditions, comparing different wetlands at the same point in time *(e.g.,* alternatives analysis, and comparing the same wetland at different points in time (*e.g.,* impact analysis or mitigation success).

assessment The objective task of identifying actions, taking measurements of baseline condition, and predicting changes to the baseline conditions as a result of the actions that occur.

available water capacity (available moisture capacity) The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very Low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very High	more than 12

bank storage The temporary increase in groundwater levels near stream channel during a period of flooding. As stage decreases, the groundwater levels return to pre-flood levels.

best professional judgement The process of making decisions based on personal experience and knowledge when better information is not available. Best professional judgement is often used in day-to-day management decisions related to wetlands.

bidirectional flow Horizontal flow occurring in opposite directions as a result of tides or seiche.

biochemical oxygen demand (bod) The measure of the quantity of dissolved oxygen, in milligrams per liter, necessary for the decomposition of organic matter by microorganisms such as bacteria.

biodiversity The total species composition of an area.

biogeochemical The interaction and integration of biological and geochemical cycles.

biogeochemistry The term referring to the interaction between biological and geochemical processes or cycles.

biomass The amount of living matter present at a specified time and expressed as the mass per unit area or volume.

biotic Term applied to living entities or processes

black spruce forest and woodland Sparse to dense plant community dominated by *Picea mariana* (black spruce) with tree crown coverage $\geq$10%. Frequently has an ericaceous shrub understory and moss-covered forest floor.

bog, ombrotrophic See ombrotrophic bog.

bog A peatland where the primary source of water is direct precipitation, and consequently is nutrient poor.

brackish See mixohaline.

buffered water Water that is resistant to changes in pH. See alkalinity and hardness.

burial The transfer of material, usually organic matter, from the surface of an ecosystem to a position within the litter and/or soil. Burial can be a completely physical process (*e.g.*, sediment falls on top of material) or it can be an active process in which material is moved downward by the action of animals.

capacity See functional capacity.

capillary forces The forces acting on soil moisture in the unsaturated zone attributable to molecular attraction between soil particles and water.

capillary fringe The zone immediately above the water table, where water is drawn up by capillary forces.

cation exchange capacity The ability of a particular soil to adsorb predominantly charged cations, such as ammonium, calcium, etc. and sometimes negatively charged ions (anions).

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 bank The sloping land at the edge of a channel. The bank has a steeper slope than the channel bottom, and is usually steeper than the floodplain.

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.

chemical oxygen demand (cod) A measure of the chemically oxidizable material in the water. COD furnishes an approximation of the amount of organic and reducing material present.

circumneutral Term applied to water, or soil, with a pH between 5.5 and 7.4.

clay As a soil separate, the mineral soil particles less than 0.002 mm in diameter. As a soil textural class, soil material that is 40% or more clay, less than 45% sand, and less than 40% silt.

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).

coarse textured soil Loamy fine sand to coarse sand.

collector channels The small channels that collect overland flow and carry it to larger channels.

colloidal material Sediments held in suspension in water as a result of molecular motion (generally defined as <0.00024mm particle size)

colluvium Loose and incoherent deposits, usually at the foot of a slope or a cliff and brought there chiefly by gravity. Talus and cliff debris are included in such deposits.

compaction Increasing the bulk density of soils through compression, trampling, machinery, etc. Results in altered activity by microbes and soil fungus, interferes with nutrient availability, and alters wetland hydrology.

condensation The process that occurs when an air mass is saturated and water droplets form around nuclei or on surfaces.

conductivity See specific conductance and hydraulic conductivity.

confining bed A body of material of low hydraulic conductivity that is stratigraphically above, below or adjacent to one or more aquifers.

connectivity The degree of connection between two entities. In an HGM context, it is a measure of physical connection within wetlands and between wetland and nearby ecosystems.

continuity Continuous effective contact between all components of a wetland system to give it high conductance by providing low resistance (*i.e.*, the flow of water, the movement of organisms.

conversion Causing a total loss of functional capacity by transforming one kind of ecosystem into another kind of ecosystem. For example, converting a bottomland hardwood forest to a soybean field.

cumulative effects The sum of all environmental effects resulting from cumulative impacts.

cumulative impact 1) The impact on the environment which results from the incremental impact of an action when added to the other past, present, and reasonable foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. 2) The sum of all individual impacts occurring over time and space, including those of the foreseeable future.

cumulative impacts The sum of all direct and indirect impacts that have occurred spatially and temporally in a given landscape.

decomposition The alteration (breakdown) of a molecule into simpler molecules or atoms. In wetlands, organic matter is broken down by physical, biological, and chemical process.

degradation Causing a partial loss of functional capability in an ecosystem. See conversion.

denitrification The microbially mediated heterotrophic process of converting (reducing) nitrate or nitrite to either nitrous oxide or dinitrogen gas.

depressional wetland A wetland geomorphic setting which occurs in depressions, but usually at the headwaters of a local drainage. Consequently, surface flows are restricted.

detrital pool Organic matter produced on site as a result of photosynthesis.

detritus Organic matter undergoing decomposition, with the attendant protists, fungi, and other organisms that serve as food for detritus feeders.

direct impact Project impacts that result from direct physical alteration of a wetland such as the placement of dredge or fill material.

direct measure A quantitative measure of an assessment model variable.

direct precipitation Water that falls directly into a lake or stream without passing through any land phase portion of the runoff cycle.

discharge area An area in which there are upward components of hydraulic head in the aquifer. Groundwater is flowing toward the surface in a discharge area and may escape as a spring, seep, or baseflow, or by evaporation and transpiration.

discharge wetlands Wetlands that receive groundwater that is discharged into the wetland basin.

discharge, mean The arithmetic mean of individual daily mean discharges during a specified period.

discharge 1) The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time. 2) The volume of water (or more broadly, a volume of liquid plus suspended sediment) passing a given point within a given period of time.

dissolved organic carbon (doc) The fraction of total organic carbon that passes through a 0.45 micron pore diameter filter.

dissolved The material in a water sample that will pass through a 0.45 um filter.

dominant a. For plant species in a strata: species with the highest canopy coverage that either alone or, added in sequence, comprise ≥ 50% of the total canopy coverage for the strata. In addition, any species which, after identification of the leading dominant species as described above, comprise ≥20% of the total canopy cover for the strata. (see US Army Corps Of Engineers 1987 delineation manual)b. For land uses, etc.: the land use that is ≥ 50% areal coverage

drainage The process of removing water from a wetland; construction of structures that remove surface and/or subsurface water as a rate that is more rapid than occurs under natural conditions. Usually reverses biogeochemical functions from a net import to net export.

drainage area The area above a specified point on a stream, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the stream.

drainage basin The land area from which surface runoff drains into a stream system.

drainage divide A boundary line along a topographically high area that separates two adjacent drainage basins.

dry biomass The amount of biomass remaining after it is dried completely in an oven at 105^{o}C.

duration See persistence.

ecotone A zone of transition between two ecosystems normally characterized by organisms that occur in the two adjacent ecosystems, or alternatively, a zone between two ecosystems where processes occur at a rate higher than in the adjacent ecosystems.

edaphic (control) The control of the distribution or function of plant species as a result of soil conditions in contrast to atmospheric conditions.

eigenvalue Estimate of degree of association of sample point in a multivariate data array.

elevation head The energy of water at a specific elevation (due to gravity) with respect to a reference elevation.

emergent hydrophyte Erect, rooted, herbaceous vegetation that may be temporarily to permanently flooded at the base, but does not tolerate prolonged inundation of the entire plant.

endosaturation Saturation in all soil layers to 200cm (80in) or bedrock.

energy dissipation A decrease in the velocity of movement of water within a stream corridor or over the surface of a wetland. A decrease in velocity occurs when water from a confined area spreads out over a larger surface area and/or when flowing water meets obstruction to flow *(e.g.,* tree stems, fallen logs).

enhancement Increasing the number of different functions performed by a wetland, or increasing the ability of an existing wetland to perform specific functions.

eolian processes The atmospheric deposition of solids - usually mineral soil material (*e.g*., silt) - after transport by wind.

ephemeral Overland flow/surface water is present for hours to days after a precipitation event. See intermittently flooded as defined by Cowardin *et al.* 1979.

epibenthic algae Algae that live on the bottom or benthos of an aquatic or wetland ecosystem.

epipedon A soil layer that forms at the surface.

episaturation Saturated layers that overly unsaturated layers in the upper 2m (80in) of the soil profile.

equipotential line A line in a two dimensional groundwater flow field such that the total hydraulic head is the same for all points along the line.

equipotential surface A surface in a three dimensional groundwater flow field such that the total hydraulic head is the same everywhere on the surface.

estuarine fringe Estuarine fringe wetlands are located in estuaries that maintain the high water table. They typically receive their source of water by twice daily flooding, at least at the lower elevations of the wetland. Salt marches and mangroves are abundant examples.

eutrophication The process of accelerated aging of a surface water body caused by excess nutrients and sediments being carried to the water body.

evaluation The subjective application of human values to determine the significance of the effects of actions on the affected parties.

evaporation The process by which water passes from the liquid to the vapor state.

evaporative discharge Upward capillary flow of water from a near-surface water table in response to hydraulic gradients set up by higher evapo-transpiration rates at the soil surface.

evapotranspiration The loss of water from vegetation as a result of evaporation and transpiration expressed in the same units as precipitation, or the sum of evaporation and transpiration.

extensive peatlands Peat accumulation creates "biogenic" landscape elements These areas, if they did not have accumulations of peat, would be considered depressional if they were quite small, or flats if they were mostly mineral soil.

fen A peatland receiving ground water.

fibric soil material (peat) The least decomposed of all organic soil material. Peat contains a large amount of well-preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

field capacity The maximum amount of water that the unsaturated zone of a soil can hold against the pull of gravity. Field capacity is dependent on the length of time the soil has been undergoing gravity drainage. Usually considered to be the water content of a soil at 1/3-bar suction or negative pressure.

flats Flats are broad areas of mineral soils that have seasonally high water tables. Pine savannas of the Southeast are common examples. (Some argue that flats are slope wetlands with zero gradient).

floodplain The land adjacent to a stream that is inundated when stream discharge exceeds channel capacity.

flow duration The amount of time that streamflow equals or exceeds a specific stream discharge value.

flow reversal A change in the direction of groundwater flow, common in Prairie Pothole Region. For example a change from groundwater discharge or recharge or the reversal. They occur with changes in the hydraulic gradient.

flow, channel Surface water flow occurring between the banks of a stream.

flow, floodplain Flow of water on floodplain that occurs when stream discharge exceeds bankfull and water flows across the floodplain.

flow, near surface Lateral flow that occurs just below the surface of a wetland in a layer that is often more permeable than the more consolidated sediments just below. Synonymous with subsurface flow, and interflow.

flow, non-channelized See overland flow

flow, overland The irregular, downslope flow of surface water that occurs after the infiltration capacity of the soil and depression storage capacity of the land surface has been exceeded.

flow, subsurface See interflow.

flow, surface Non-channelized flow occurring above the land surface. Synonymous with overland flow.

flowthrough wetlands Wetlands that recharge the groundwater system and receive groundwater as discharge.

fragmentation The breakup of an extensive ecosystem into a number of smaller patches.

fresh Term applied to water with less than 0.5 ppt dissolved salts.

fringe wetland 1) A wetland adjacent to a large body of water (*i.e.*, the ocean or a large lake) in which frequent and regular bidirectional exchanges of water occur as a result of astronomic tides or seiche. 2) Fringe wetlands occur at the margins of large bodies of water, and thus have a virtual unlimited source of water. They are flooded from the larger body of water at a frequency that is dictated by astronomic tides in marine coastal areas and by seiches in lacustrine settings. Examples are tidal salt marshes and lakeside marshes in the Great Lakes.

function (ecosystem) Processes that 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 are 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 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) Calculation reached by multiplying the functional capacity index for a wetland area by the size of the wetland area.

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 profile 1) Qualitative and quantitative descriptive depictions of wetlands that, in the case of the hydrogeomorphic classification, emphasizes the physical characteristics such as geomorphic setting, water source, and hydrodynamics. Profiles also may include the biotic components. 2) 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.

geomorphic A term that refers to the shape of the land surface.

geomorphology The study of the classification, description, origin, nature, and development of present landforms and their relationship to underlying structures and geologic history.

glacial drift (geology) Mineral material transported by glacial ice and then deposited. Also, the sorted and unsorted material deposited by streams flowing from glaciers.

glacial outwash (geology) Gravel, sand, and silt, commonly stratified, deposited by glacial meltwater.

glacial outwash Well sorted sand, or sand gravel, deposited by meltwater from a glacier.

glacial till A glacial deposit composed of mostly unsorted sand, silt, clay, and coarse fragments (rocks of various sizes) laid down directly by melting ice.

glaciofluvial deposits (geology) Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

glaciolacustrine deposits Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are interbedded or laminated.

graminoid: Grasses, sedges, or rushes.

gravity flow Flow of water controlled by gravity instead of strictly piezometric head differences.

ground water aquifer See aquifer

ground water discharge The movement of groundwater from an aquifer to the surface of the earth.

ground water flow The movement of water through openings in sediment and rock in the zone of saturation. Flow of water in a porous medium, under saturated conditions, below the surface of the land.

ground water perched See *perched* ground water.

ground water recharge The movement of water from the surface of the earth to an aquifer.

ground water, confined See confined ground water.

ground water, unconfined See unconfined ground water.

ground water Water occurring in the subsurface voids, pore spaces, or fissures of the earth, as opposed to water occurring above the surface of the earth in streams, ponds, lakes, and in the ocean. The water contained in the interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.

haline Term applied to water containing greater than 0.5 ppt ocean derived salts.

halophyte Plants adapted to grow and reproduce where the salt concentration in water or soil is high.

hardness 1) A measure of the amount of calcium, magnesium, and iron dissolved in the water. 2) A property of water that is roughly proportional to the ion concentration. Water from a calcareous aquifer is often hard due to calcium carbonate content. Such waters are very resistant to fluctuations in pH. Alternative: The sum of equivalents of polyvalent cations expressed as the equivalent concentration of calcium carbonate ($CaCO_3$).

head, total The sum of the elevation head, the pressure head, and the velocity head at a given point in an aquifer.

headwaters Streams with average annual discharge less than 5 cfs (US Army Corps of Engineers 404 Regulatory Program definition).

herb Forbs, ferns, fern allies, and graminoids.

high water table (seasonal) The highest level of a saturated zone in the soil in most years. Location based mainly on evidence of a saturated zone; gleyed colors (redoximorphic depletions) in the soil.

highest sustainable functional capacity The level of functional capacity achieved across the suite of functions by a wetland under reference standard conditions in a reference domain. This approach assumes that the highest sustainable functional capacity is achieved when a wetland ecosystem and the surrounding landscape are undisturbed.

hilltop A topographically high area lower in elevation than a mountain. Areas usually less than 300 meters in elevation.

Histosol Organic soils -- *i.e*., soils that are dominated by organic material to specific depths and thickness requirements.

Histic epipedon A soil horizon formed at the surface and dominated by organic material and is 20-40cm (8-16in) thick.

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 (*i.e*., additional definition or subdivision of the master horizons).

humus The amorphous, ordinarily dark-colored, collodial matter in soil; a complex of the fractions of organic matter of plant, animal, and microbial origin that are most resistant to decomposition.

hydraulic conductivity A coefficient of proportionality describing the rate at which water can move through a permeable medium. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity.

hydraulic diffusivity A property of an aquifer or confining bed defined as the ratio of the transmissivity to the storativity.

hydraulic gradient The change in total head over a change in distance in a specified direction.

hydraulic head See total head.

hydric soil Soil that is wet long enough to periodically produce an anaerobic condition, thereby influencing the growth and reproduction of plants.

hydrodynamics: The capacity of water to do work such as transport sediments, erode soils, and flush pore waters in sediments as a result of its vertical, or unidirectional and horizontal, or bidirectional and horizontal motion. Vertical motion results from evapotranspiration and precipitation, bidirectional flows result from astronomic tides and seiches, and unidirectional flows result from the pull of gravity on surface water in streams and on the surface of the earth.

hydrogeologic unit A portion of the landscape that has a distinct surface and ground water composition.

hydrogeology The study of the interrelationships of geologic materials and processes with water, particularly ground water.

hydrogeomorphic class0 A class of wetlands in the classification scheme developed for use with HGM procedures. Each class has similar hydrogeomorphic characteristics.

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 type, vegetative communities, or other factors that influence function. Hydrogeomorphic units may be the result of natural or anthropogenic processes. See Partial Wetland Assessment

Area.

hydrogeomorphic wetland class The highest level in the hydrogeomorphic wetland classification. There are five basic hydrogeomorphic wetland classes including depression, fringe, slope, riverine, and flat.

hydrogeomorphic wetland type Wetlands with a similar geomorphic setting, source of water, and hydrodynamics.

hydrograph 1) A graphic description of hydrologic stage discharge or storage over time. 2) A graph that shows some property of ground water or surface water as a function of time.

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 study of the occurrence, distribution, and movement of all waters of the earth.

hydroperiod The depth, duration, seasonality, and frequency of flooding. In its simplest form, it refers to the time period of inundation of the land surface.

hydrophilic Adapted to and tolerant of water.

hydrophyte 1) A plant adapted to grow and reproduce in standing water or on saturated soils characterized by a periodic oxygen deficit as a result of excessive water. 2) A type of plant that grows with the root system submerged in standing water.

hydroscopic water Water that clings to the surface of mineral particles in the zone of aeration.

hyperhaline The term used to describe water with a salinity greater than 40 ppt due to ocean derived salts.

hypersaline The term used to describe water with a salinity greater than 40 ppt due to land derived salts.

impact assessment The determination or assessment of activities on the functioning of a particular system.

impact A human action that either by design or oversight alters the characteristics of an ecosystem.

indicator Indicators are observable characteristics that correspond to identifiable variable conditions in a wetland or the surrounding landscape.

indirect impact Impacts resulting from project activities that indirectly affect the physical, chemical, or biological integrity of a wetland. Indirect impacts typically occur in association with direct impacts, but are usually separated from them in time and space. An example would be the impacts of increased human activity on wildlife habitat in a wetland proximate to the activity.

infiltration capacity The maximum rate at which infiltration can occur under specific conditions of soil moisture. For a given soil, the infiltration capacity is a function of the water content, texture, and structure.

infiltration The movement of water from the surface into the soil. Infiltrated water permeates vertically through the unsaturated zone, or moves horizontally as throughflow.

influent stream See losing stream.

in-kind mitigation Mitigation in which lost functional capacity is replaced in a wetland of the same regional wetland subclass.

interception The interception of precipitation by vegetation before it reaches the ground surface. The process by which precipitation is captured on the surface of vegetation before it reaches the ground surface.

interflow The later movement of water in the unsaturated zone during or immediately after a precipitation event. The water moving as interflow discharges directly into a stream or lake. See throughflow.

interfluve The relatively flat and undissected upland between adjacent streams flowing in the same general direction.

intermediate zone That part of the unsaturated zone between the root zone and the capillary fringe.

intermittent or "intermittently flooded" "The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this regime may change as soil moisture conditions change. Some areas exhibiting this regime do not fall within our [the] definition of wetland because they do not have hydric soils or support hydrophytes" (Cowardin *et al.*, 1979).

inundation The condition where water occurs above the surface (*i.e*., flooding).

invert The bottom of a channel, pipe, or culvert.

ion exchange A process by which an ion in a mineral lattice is replaced by another ion that was present in an aqueous solution.

irregularly flooded tidal wetland Wetlands located in a tidal region, but too isolated to be inundated by astronomic tides.

isolated wetland Wetland isolated from the surrounding landscape with respect to the exchange of surface water.

jurisdictional wetland Wetlands which meet the soil, vegetation, and hydrologic criteria defined in the 'Corps of Engineers Wetlands Delineation Manual', or its successor.

kettles Depressional areas in glaciated landscapes that resulted from the melting of ice blocks buried by glacial outwash and recession.

lacustrine Related to lake or pond environments.

lacustrine fringe Fringe wetlands occur at the margins of large bodies of water, and thus virtually have an unlimited source of water. Lake fluctuations, such as seiches, are normally the source of water in lacustrine fringe wetlands. Examples are unimpounded lakeside marshes of the Great Lakes.

lag time The time from the center of mass of rainfall to the peak of a hydrograph.

land dominated hydrograph The dominant influence on the timing, duration, and amount of water delivered to a channel or swale is the land use and/or condition of the watershed/contributing area.

landform Large-scale, distinctive landscape features, such as mountains, plains, and plateaus.

landscape 1) A heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in a similar form through. 2) All distinct spatial units of an area, usually at the watershed level or larger. Its gross features of the land surface include, but are not limited to slope, aspect, topographic variation, and position relative to other landforms.

lichen A symbiotic association derived from members of two different kingdoms Algae (Kingdom Protista) and a fungus (most of which are Ascomycota).

life form, plant The general morphologic category of plants, such as tree, shrub, herbaceous, etc.

lithology Term referring to the composition of the earth's crust. Soils develop as a consequence of weathering of the parent material.

litter Recently fallen plant material which is only partially decomposed and in which the organs of the plant are still discernible; forming a surface layer on some soils.

loading Process of adding excess amounts of material, nutrients, toxins, etc. to wetlands. Loading can result in the loss of, or significant reduction in, some ecological functions.

loam Soil material that is 7 to 27% clay.

macrophytes A common term for wetland vascular plants. Includes submersed species, semi-aquatic (leaves beneath water with different morphology than aerial leaves) and emergent (rooted in soil but most aerial biomass above the water) species.

maintenance The upkeep of functions and processes in wetlands.

marsh A wetland normally characterized by the presence of shallow surface water, and dominated by emergent vegetation.

mean high tide The average elevation of all daily high tides over a specified period.

mean high water The average elevation of the high water over a specified period.

mean low tide The average elevation of all daily low tides over a specified period.

mean low water The average elevation of low water over a specified period.

mean sea level See *National Geodetic Vertical Datum of 1929*.

mean tide The elevation midway between mean high tide and mean low tide.

meander swales Linear depressions that form on floodplains as a result of stream meandering.

mesohaline The term used to describe water with a salinity of 5-18 ppt due to ocean derived salts.

mesosaline The term used to describe water with a salinity of 5-18 ppt due to land derived salts.

metabolic transformation	Chemical changes associated with biological processes.
microtopographic variation	Small scale variations in surface elevation/relief (*e.g.*, pit-and-mound or hummock-and-hollow topography, coarse woody debris, root masses etc.) that provide roughness (*i.e.*, friction or resistance to flow) which reduces or transforms the velocity/kinetic energy associated with flowing water.
milligrams per liter (mg/l)	A unit for expressing the concentration of chemical constituents in solution. It represents the mass of solute per unit volume (liter) of water. Concentration of suspended sediment is also expressed in mg/l, and is based on the mass of dry sediment per liter of water-sediment mixture.
mineral soil flats	Mineral soil flats occur on broad interfluves that have seasonally high water tables. Precipitation is the only water source. Pine flatwoods of the Southeast are common examples.
mineral soil	Soil composed of primarily mineral materials as opposed to organic materials.
mineraltrophic wetlands	Fens with hydrophytic vegetation but with species that are calciphilous and specific for fens. The wetlands form in areas where groundwater carries dissolved constituents that precipitate in the soil zone.
minimal effect exemption	A decision to allow an action to occur even through it would result in more than a minimal impact on a wetland.
mitigation plan	A plan for replacing lost functional capacity resulting from project impacts.
mitigation ratio	The ratio of the Functional Capacity Units (FCUs) lost in a Wetland Assessment Area (WAA) to the FCUs gained in a mitigation wetland.
mitigation wetland	A restored or created wetland that serves to replace functional capacity lost as a result of project impacts.
mitigation, in-kind	See in-kind mitigation.
mitigation, out-of-kind	See out-of-kind mitigation.
mitigation	Restoration or creation of a wetland to replace functional capacity that is lost as a result of project impacts.
mixohaline	The term used to describe water with a salinity of .5-30 ppt due to ocean derived salts. Roughly synonymous with the term brackish.
mixosaline	The term used to describe water with a salinity of 0.5-30 ppt due to land derived salts.
modal soil profile	A soil profile that represents the average or general soil type that is typical for the area or system of interest.
model calibration	The process of parameter estimation based on known data.
model variable	See assessment model.
model verification	The process of comparing parameter estimates against a new set of data after model has been calibrated.
moss	Non-vascular, non-flowering plant species that are members of the phylum Bryophyta.

mottling, soil Outdated terminology that refers to irregular spots of different colors that vary in area and size within the soils profile. Mottling generally indicates alternating conditions of oxidation and reduction, poor aeration and impeded drainage and is currently defined as redoximorphic features (*i.e*., depletions and concentrations).

mucky surface texture 1) A surface texture of highly decomposed organic material. 2) A mineral horizon that has a significant amount of decomposed organic material within.

National Wetland Inventory (NWI) A Fish and Wildlife Service program designed to map and inventory wetlands of the United States.

natural levee Levees that form at the edge of stream channels as a result of sediment deposition that occurs as the velocity of floodwater is reduced after it leaves the stream channel.

navigable waters See waters of the United States.

nitrate The most oxidized form of nitrogen which can be used as an alternate terminal electron acceptor in anaerobic respiration.

nitrification The microbial transformation from ammonium to nitrite and from nitrite to nitrate. It is an energy-yielding aerobic process.

non-planar In the context of microtopography, land surfaces that are convex, concave, jagged or otherwise not flat and alone or in a complex with other non-planer features, are capable of ponding and/or impeding the flow of surface and shallow subsurface water.

nonpoint source Nutrients or contaminants that enter wetland and aquatic ecosystems from diffuse, unconfined sources over a greater areal extent, in contrast to a point source from a defined, discrete location. Common non-point sources are agricultural and urban landscapes.

nutrient uptake The incorporation, absorption, or adsorption of nutrients by vegetation, soil, and detritus.

off-site mitigation Mitigation that is done at a location physically separated from the site at which the original impacts occurred, possibly in another watershed.

oligohaline The term used to describe water with a salinity of 0.5-5 ppt due to ocean derived salts.

oligosaline The term used to describe water with a salinity of 0.5-5 ppt due to land derived salts.

ombrotrophic bog A peatland that receives precipitation as the sole source of water. Generally, peat has accumulated enough to isolate the plants from acquiring nutrients from the underlying mineral strata.

ombrotrophic Term referring to low nutrient conditions which usually implies that the dominant source of water to the wetland is direct precipitation.

ordinary high water mark **". . .** 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)).

organic biomass The difference between ash biomass and dry biomass.

organic soil flats Organic soil flats are similar to mineral soil flats except for organic matter accretion. They receive precipitation as the only source of water. Northern Minnesota peatlands are a common example.

organic matter Plant and animal residue in the soil in various stages of decomposition.

organic soil Soil composed of primarily organic materials as opposed to mineral materials.

out-of-kind mitigation Mitigation in which lost function capacity is replaced in a wetland of a different regional wetland subclass.

outwash plain fen Fens that occur in low areas in coarse-textured sediments such as glacial outwash. Water flows into these fens from the surrounding landscape and then through the fen.

overbank flooding The movement of water onto the floodplain that occurs after stream discharge exceeds channel capacity.

overbank transport Movement of water from the stream channel onto the adjacent floodplain. Synonymous with overbank flooding.

overland flow The flow of water over a land surface due to direct precipitation. Overland flow generally occurs when the precipitation rate exceeds the infiltration capacity of the soil and depression storage is full.

oxidation-reduction See reduction-oxidation.

paleochannels Relict channel systems that no longer function to carry water, but, have obviously done so in the past.

paludification The landscape phenomenon in which increasing surface moisture augments the accumulation of organic matter and the formation of a Histosol.

palustrine Non-tidal wetlands that are not part of the lacustrine or riverine systems in the U. S. Fish and Wildlife Service National wetland classification system.

partial wetland assessment area (pwaa) A portion of a WAA that is identified a priori, or while applying the assessment procedure, because it is relatively homogeneous, and different from the rest of the WAA with respect to one or more model variables. The difference may occur naturally, or as a result of anthropogenic disturbance. See hydrogeomorphic unit.

particle size classification Classification of particles into size classes according to the United States Department of Agriculture - Natural Resources Conservation Service.

Clay	<0.002mm
Silt	0.002 - 0.05mm
Sand	0.05 - 2.0mm
Gravel	2.0 - 75mm

particle size The diameter, in millimeters, of a particle determined by either sieve or sedimentation methods.

particulate organic carbon (poc) The fraction of total organic carbon that is retained by a 0.45 micron filter.

parts per thousand (ppt) Units used to express salinity or halinity. One part solute per one part solvent.

passerine A member of one of the largest order of birds (Passeriformes); mostly altrical songbirds with perching habits; includes the migratory songbirds such as warblers, flycatchers, vireos, larks, wrens, gnatcatchers, sparrows, finches and thrushes.

peat Unconsolidated material, primarily comprised of undecomposed organic matter, that has accumulated under excess moisture.

pedogenic Chemical, physical, and biological processes over time that result in changes to soils, usually color, structural, and/or textural changes.

pedon A three-dimensional sample of soil large enough (1 to 10 sq. meters) that the horizons within the soil are adequately expressed.

peraquic A soil moisture regime in which groundwater is always at or very close to the surface.

perched Water that overlies an unsaturated, impermeable layer.

perched aquifer A region in the unsaturated zone where soil may be locally saturated because it overlies a low permeability unit.

perched ground water The water in an isolated, saturated zone located in the zone of aeration. It is the result of the presence of a layer of material of low hydraulic conductivity called a perching bed. Perched ground water will have a perched water table.

perched water table Water standing above an unsaturated zone in the soil.

percolation The vertical movement of water through the unsaturated zone subsequent to infiltration.

perennial or "permanently flooded" "Water covers the land surface throughout the year in all years. Vegetation is composed of obligate hydrophytes" (Cowardin *et al.* 1979).

permafrost A thermal condition in which a material, including soil, remains below 0^{o}C for 2 or more years in succession. Permafrost may be cemented by ice or, may be dry.

permanent wetland Pond and lake that has a central open-water zone that is typically surrounded by deep marsh, shallow marsh, wet meadow and low prairie zones. These wetlands contain water year round except during extensive droughts.

permeability The capacity of a porous medium to transmit fluids.

persistence (duration) The length of time that something (*e.g.* water) is present, or the time period over which it occurs.

pH The negative log of the hydrogen (hydronium) ion activity.

phreatic water Water in the saturated zone.

phreatophyte A plant capable of maintaining a high rate of transpiration by virtue of a taproot that extends to the water table.

physiognomy The gross structure of a plant community resulting from the dominance of life forms such as trees, shrubs, or graminoids.

phytoplankton Plant forms of plankton *(e.g.,* algae) that exist in the water column in contrast to attached epiphytic or epibenthic algae.

piedmont A steep, rolling physiographic province formed at the base of mountains. For example, the Piedmont west of the Atlantic coastal plain and to the east of the Appalachian Mountains.

piezometer A non-pumping well, generally of smaller diameter, that is used to observe and measure the elevation of the water table or potentiometric surface.

pipe flow Subsurface flow of groundwater that occurs through soil macropores often formed by decayed root channels or animal burrows.

planar In the context of microtopography, land surfaces that are flat and generally incapable of ponding or impeding the flow of surface and shallow subsurface water.

plant life form The general morphologic category of plants, such as tree, shrub, herbaceous, etc.

pluvial Pertaining to, or resulting from, the action of rain or precipitation.

point bar The deposit formed by the accumulation of suspended and bed load sediments around and against the convex bank in a stream channel bend.

polyhaline The term used to describe water with a salinity of 18-30 ppt due to ocean derived salts.

polysaline The term used to describe water with a salinity of 18-30 ppt due to land derived salts.

poor fen A fen with productivity levels between a rich fen and an ombrotrophic bog.

pore space The volume between mineral grains (voids) in a porous medium.

pore water pressure The pressure (stress) transmitted by the fluid that fills the voids between particles of soil or rock.

porewater Water that fills the voids and interstices of soil or rock.

porosity The ratio of the volume of void spaces in a rock or soil to the total volume of the rock or soil.

potential evapotranspiratio (pet) The amount of water that would be lost by evapotranspiration by the natural vegetation of an area if water were never limiting during the year.

potential evapotranspiration ratio (pet ratio) The ratio between the potential evapotranspiration and actual precipitation. Ratios greater than 1.0 indicate a water deficit.

precipitation, direct Precipitation, throughfall, or stemflow that falls directly, or indirectly onto a specified portion of the landscape.

precipitation Any form of water originating in atmosphere that falls onto the surface of the earth.

predominant >50% of area, total number, etc.

pressure head The pressure from a column of water above a specific reference point - usually in units of cm (water), bars, or Pascals.

primary production The conversion of solar energy into chemical energy by plant photosynthesis.

profile An exposed vertical section of the soil that allows it to be adequately described (*i.e.*, profile descriptions).

project alternative(s) Different ways in which a given project can be done. Alternatives may vary in terms of project location, design, method of construction, amount of fill required, and other ways.

project alternatives Different ways in which a given project can be done. Alternatives may vary in project location, method of construction, amount of fill required, and in other ways.

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.

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.

propagule Reproductive structures such as the seeds or vegetative cuttings from plants.

rating curve A graph of the discharge of a river or stream at a particular point as a function of the elevation of the water surface.

recharge area An area in which there are components of hydraulic head that allow water to move downward into the deeper parts of a soil or aquifer.

recharge wetland Wetland that recharges groundwater within its basin (*e.g.* watershed).

recharge Water that infiltrates to an aquifer, usually by gravity.

recycle The movement of nutrients and/or water from biota to the physical environment and back to the biota.

red flag features Features of a wetland or the surrounding landscape to which special recognition or protection is assigned on the basis or objective criteria. The recognition or protection may occur at a federal, state, regional, or local level, and may be official or unofficial.

redox See reduction-oxidation.

redox concentration A segregation and concentration of iron (Fe) and/or manganese (Mn) into visible features within a soil horizon, denoting alternating conditions of oxidation and reduction.

redox depletion Visible features within the soil where clay and/or iron (Fe) and/or manganese (Mn) have been removed due to reducing conditions.

reduction-oxidation The potential difference, usually expressed in millivolts, between a platinum electrode and a reference electrode in a solution. Chemically, it is the loss (oxidation) or gain (reduction) of an electron by an element or compound.

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 All wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass.

reference standard 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, reference standard functions are assigned an index of "1.0".

reference wetland Wetland sites within the reference domain that encompass the known variation of the subclass. They are used to establish the range of functioning within the subclass. Reference wetlands may include (1) former wetland sites for which restoration to wetland is possible, and (2) characteristics of sites derived from historic records or published data.

region A geographic area that is relatively homogenous with respect to large scale factors such as climate and geology that may influence how wetlands function.

regional wetland subclass Wetlands within a region that are similar based on hydrogeomorphic classification factors. There may be more than one regional wetland subclass identified within each hydrogeomorphic wetland class depending on the diversity of wetlands in a region, and assessment objectives.

regolith The upper part of the earth's surface that has been altered by weathering processes. It includes both soil and weathered bedrock.

removal mechanisms Physical, chemical, and biological processes that place material *(e.g.*, nutrients) into a form that are not readily available.

residence time The time it takes a component to break down or otherwise be lost from the system (*i.e.* residence time in the soil).

restoration 1) Returning a modified ecosystem to its pre-modified condition. For example, restoring a tidal connection to a saltmarsh isolated by road construction. 2) 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 (pre-disturbance) functions.

return flow Refers to water that is not used by plants or stored in wetland soils. This water usually returns to streams by overland flow.

return interval Interval of time corresponding to the return of water to the wetland surface.

return period The average time interval between hydrologic events of a certain magnitude or greater. Usually expressed in years (*e.g.*, 2-year flood event).

rhizomes A horizontal stem, usually underground, that often sends out roots and shoots.

rich fen A fen with a high level of productivity that is often dominated by grasses or trees in contrast to the shrubs and mosses often associated with poor fens.

ridge A linear elevation of the earth's surface. It may or may not be associated with mountains.

riparian transport Movement of water from uplands to floodplains by overland flow, or subsurface flow.

riparian Pertaining to the boundary between water and land. Normally it represents streamside areas and the zone of influence of the stream to the upland boundary.

riverine wetland Riverine wetlands are long linear features that contain a riverbed and bank, and functionally cover the area of the 100-year floodplain.

root zone The zone from the land surface to the depth penetrated by plant roots.

roughness Macro/microtopographic features, vegetative characteristics (*i.e.*, stem densities, basal area, percent cover etc.), and soil/bedload attributes of the channel banks, channel bed, and floodplain surface which exert resistance or drag on flowing water. Mannings equation and the Chezy formula are engineering equations that attempt to express or quantify the resistance factor(s) encountered by flowing water.

runoff The amount of water that flows from an area of land after evapotranspiration, storage, and subsurface flow have been accounted for. This term is synonymous with overland flow.

saddle Topographically low area between two hilltops.

saline soil A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

saline wetlands Wetlands with soils that have a total dissolved soils or water column concentration of >0.5 ppt. Wetlands typically fall into five salinity classes (oligohaline, mesosaline, polysaline, eusaline, and hypersaline.

saline Term applied to water containing greater than 0.5 ppt of land derived salts.

saturated soil A soil that has all <u>available</u> pore space filled with water. Some clayey soils with numerous very small (micropores) pores may not have all pore space occupied with water, but can still be considered saturated.

saturated zone 1) The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric. The *water table* is the top of the saturated zone in an unconfined aquifer. 2) Regions below the land surface in which all pore space is filled with water.

scrub-shrub Wetland vegetation dominated by shrubs or low trees.

seasonal or "seasonally flooded" "Surface water is present for extended periods especially early in the growing season, but is absent by the end of the season in most years. When surface water is absent, the water table is often near the land surface" (Cowardin *et al.* 1979).

seasonal frost Portions of the soil profile that freeze and thaw annually or are not frozen for a duration sufficient to meet the definition for permafrost (*i.e*., 2 years).

sedge wetland See fen; fen, poor*;* and fen, rich.

sediment, suspended Sediments held in suspension by fluid turbulence or Brownian (molecular) motion (colloidal material).

sediment The solid material transported by, suspended in, or deposited from water. It includes chemical and biochemical precipitates and decomposed organic material such as humus, or alternatively, an assemblage of individual mineral grains that were deposited by water, wind, ice, or gravity.

seepage A site where ground water discharges to the surface, as often happens at the toe of a slope.

semiconfined aquifer An aquifer confined by a low permeability layer that permits water to slowly flow through it.

sequester The retention of nutrients, sediments, etc., in compartmental surface features, and biomass within the wetland.

sheetflow See overland flow.

shrub Multi-stemmed woody species.

silt As a soil separate, individual mineral particles that range in diameter from the clay boundary (0.002 mm) to the very fine sand boundary (0.05 mm). As a soil textural class, soil that is 80% or more silt and less than 12% clay.

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.

site specific Refers to a location associated with a specific wetland function, structural attribute, etc.

slope The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20% is a drop of 20 feet in 100 feet of horizontal distance.

slope wetland Slope wetlands grade into the flat below where the slope becomes negligible. Hillside seeps or springs are good examples of slope wetlands.

small tree Single-stem, woody vegetation >3 to <10 ft (0.9 to 3 m) tall.

soil depth The distance from the top of the soil to the underlying bedrock.

soil horizon A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color, or texture, or by chemical composition, including content of organic matter or degree of acidity or alkalinity. Master soil horizons are designated by a capital letter, subordinate soil horizons are denoted by lowercase letters (*e.g.*, Bg; Cfm).

soil series The basic unit of soil classification; it is a subdivision of the family level. It is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile and developed from a particular type of parent material.

soil Freely divided rock-derived material containing an admixture of organic matter and capable of supporting vegetation.

source The place of origin of material such as water, and nutrients. In a wetland context, the wetland can be the source of materials to adjacent ecosystems or materials can move into the wetland from other areas (*i.e.*, sources).

strata The distinct vertical layers of vegetation that can be identified in a given plant community or at a given site. Layers typically include: moss or Bryophyte; herbaceous or ground layer; shrub, sapling/tall shrub; and tree.

stream A body of running water moving under the influence of gravity down gradient in a narrow, clearly defined, natural channel.

streamflow A type of channel flow, applied to surface runoff moving in a stream. Units of measurement are volume over time interval.

stress 1) The condition of diverting potentially useful energy from an ecosystem or an organism, or alternatively, the response of an organism or community to abnormal conditions (*e.g.*, change in water supply, change in nutrient input, introduction of contaminants). 2) The immediate physical, chemical, and biological changes resulting from a disturbance. 3) Force applied to a material.

structure, soil The aggregation of individual soil particles into larger units with planes of weakness between them.

Subclass profile The highest organizational element of an HGM reference system and is defined as a narrative and quantitative description of, at least, the subclass geomorphic setting, climate, hydrology, geology, soils, and biotic communities.

subsoil Technically, the B-horizon; roughly, the part of the solum below plow depth.

subsurface drainage See subsurface flow. The movement of subsurface water can be natural or influenced by human activity (*i.e.*, drain tiles).

subsurface flow See throughflow and interflow.

subsurface storage The storage of water below the soil surface.

succession The predictable and orderly change in biotic and abiotic characteristics of a community or ecosystem in a particular location over time.

surface water Water above the surface of the land, in contrast to ground water that is below the surface of the land.

thermal regime Characteristic temperature(s) within a soil profile.

throughfall The portion of intercepted precipitation that ultimately drips from vegetation surfaces onto the ground.

throughflow 1) The lateral movement of water in an unsaturated zone during and immediately after a precipitation event. The water from throughflow seeps out at the base of slopes and then flows across the ground surface as return flow ultimately reaching a stream of lake. See interflow. 2) Water that infiltrates into the soil on a slope and subsequently emerges as seepage at the foot of the slope, as opposed to interflow which enters directly into a stream.

tidal wetland A wetland influenced by astronomic tides.

topographic A term referring to the slope and elevation of land.

transformation The process of converting a material (nutrient, etc.) from one form to another. Examples would be particulate organic carbon to dissolved organic nitrogen, organic nitrogen to ammonia.

transpiration The process by which plants give off water vapor through their leaves.

transport mechanism Physical processes that move materials from one location to another.

transport, riparian Movement of water from upland regions to the floodplain either by overland flow and/or subsurface flow.

tree Single-stem, woody vegetation $\geq$10 ft (3 m) tall.

turbidity Cloudiness in water due to suspended and colloidal organic and inorganic material.

tussock A plant form that is tufted, bearing many stems arising as a large dense cluster from the crown.

unchannelized flow Normally reserved for surface flow that is diffuse and thus not confined to a channel. Also non-channelized flow.

unconfined aquifer: A permeable body of rock/soil in which groundwater moves freely.

unconfined ground water The water in an aquifer where there is a water table.

unidirectional flow Horizontal flow that occurs in one direction in contrast to bidirectional flow associated with astronomic tides or seiche.

unsaturated zone 1) The zone between the land surface and the water table that includes the root zone, intermediate zone and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone.

upland related Processes, structures, etc. associated with topographically higher areas adjacent to wetlands.

upland Non-wetland

value of wetland function(s) The relative importance of wetland function, or functions, to an individual or group.

values Generally, what people consider to be important. It can be measured, relatively, by what motivates people into activity.

variable condition The condition of a variable as 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.

variable An attribute or characteristic of a wetland ecosystem or the surrounding landscape that influences the capacity of wetland to perform a function.

vertical fluctuations The movement of water upward and downward in the soil profile.

viscosity The property of a fluid describing its resistance to flow. Units of viscosity are force-time per area (Newton-seconds per meter squared ($N \cdot s \cdot m^{-2}$) or Pascal-seconds ($Pa \cdot s$)).

water budget An evaluation of all sources of input and corresponding discharge (output) with respect to an aquifer or a drainage basin.

water quality Qualitative and quantitative conditions of water, usually in reference to physical, chemical, and biological properties, and usually from the perspective of use and benefits to society.

water source The place of origin of water that enters a wetland or system. Examples would be rainfall (precipitation), streams, lakes, ground water, and oceans.

water table The surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric. It can be measured by installing shallow wells extending a few feet into the zone of saturation and then measuring the water level in those wells.

water year The twelve month period from October 1 through September 30. Water year is designated by the calendar year in which the water year ends, and which includes 9 of the 12 months. For example, the water year ending September 30, 1980 is called "1980 water year".

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 assessment area(WAA) The wetland area to which results of an assessment are applied.

wetland ecosystem In 404 "...areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances 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 230.0). In a more general sense, wetland ecosystems are three dimensional segments of the natural world where the presence of water, at or near the surface, creates conditions leading to the development of redoximorphic soil conditions, and the presence of a flora and fauna adapted to the permanently or periodically flooded or saturated conditions.

wetland enhancement The process of increasing the capacity of a wetland to perform on, or more functions. Wetland enhancement can increase functional capacity to levels greater than the highest sustainable functional capacity achieved under reference standard conditions, but usually at the expense of sustainability, or a reduction of functional capacity of other functions. Wetland enhancement is typically done for mitigation.

wetland function The normal activities or actions that occur in wetland ecosystems, or simple, the things that wetlands do. Wetland functions result directly from the characteristics of a wetland ecosystem and the surrounding landscape, and their interaction.

wetland restoration The process of restoring wetland function in a degraded wetland. Restoration is typically done as mitigation.

wetland

1) "... 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"