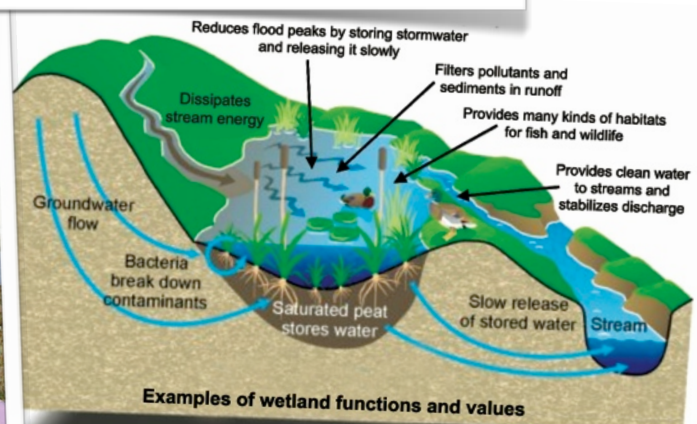
Kenai Peninsula Wetlands

A Guide for Everyone:

Get to know your wetlands, including their **Functions** & **Values**



compiled by Homer Soil and Water Conservation District
with the Kenai Peninsula Wetlands Working Group (WWG)
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Contributors

Homer Soil and Water Conservation District
collaboratively developed this report and performed assessments described within

Tara Schmidt, Homer Soil and Water District Manager –
provided project oversight, guidance, outreach, and administration

Devony Lehner, Homer Soil and Water Special Projects Coordinator –
compiled information, provided outreach, wrote report with input from contributing writers (see below), and developed online wetlands wiki

Karyn Noyes, Homer Soil and Water Ecologist and GIS Technician –
compiled, analyzed, and mapped data; adapted and applied assessment methods; guided assessment write-ups

Homer Soil and Water is deeply indebted to the following individuals for their critical input and support

Grant oversight/administration
Phil North, Environmental Protection Agency –
envisioned the project and guided all project efforts

Contributing writers
Mike Gracz, Kenai Watershed Forum –
provided technical guidance on all things wetland, including assessment methods, developed key working papers
Catherine Knott, Kachemak Bay Campus, Kenai Peninsula College –
guided culture/heritage assessment, developed maps of Dena'ina use areas, wrote related working papers, coordinated input from Native organizations and others interested in wetlands culture/heritage assessment

Project Steering Committee
Provided hours of thoughtful input based on years of experience –
Dan Bevington, Kenai Peninsula Borough (KPB)
John Czarnezki, Kenai Peninsula Borough (KPB)
Mike Gracz, Kenai Watershed Forum (KWF)
Matt Gray, Resurrection Bay Conservation Alliance (RBCA)
Lynnda Kahn, US Fish and Wildlife Service (USFWS)
Ginny Litchfield, Alaska Department of Fish and Game (ADF&G)
Sue Mauger, Cook Inletkeeper (CIK)
Phil North, Environmental Protection Agency (EPA)

Individuals listed below participated in one or more project meetings, some on "expert teams" –
expert teams guided and reviewed assessments and related project tasks (see Section 1.3.3)

♦ Jeff Anderson (USFWS), ♦ Steve Baird (KBRR), ♦ Dan Bevington (KPB), ♦ Alan Boraas (KRC, KPC), ♦ Branden Bornemann (KWF), ♦ Dave Casey (COE), ♦ Chris Clough (KPB), ♦ Geoff Coble (CG), ♦ Holly Cusack-McVeigh (while at Pratt Museum), ♦ John Czarnezki (KPB), ♦ Tom Dearlove (KPB), ♦ Julie Engebretsen (City of Homer), ♦ Heather Fuller (USFWS), ♦ Matt Gray (RBCA), ♦ Mike Gracz (KWF), ♦ Carol Griswold (Seward), ♦ Jim Herbert (Seward), ♦ Tammy Hoem-Neher (while at KBRR), ♦ Lynnda Kahn (USFWS), ♦ Jen Kain (AACD), ♦ Carol Kerkvliet (ADF&G), ♦ Cathy Knott (KBC, KPC), ♦ Deb Kurz (KFNP), ♦ John Lang (USFS), ♦ Bobbi Lay (KPB), ♦ Alexandra "Sasha" Lindgren (Kenaitze Indian Tribe), ♦ Ginny Litchfield (ADF&G), ♦ Dawn Magness (KNWR), ♦ Dan Mahalak (KPB), ♦ Sue Mauger (CIK), ♦ Katie McCafferty (COE), ♦ Sue McClure (KPB Assembly), ♦ Thomas McDonough (ADF&G), ♦ John Morton (KNWR), ♦ Meg Mueller (NRCS), ♦ Megan Murphy (while at KBRR and now at MAPP), ♦ Stephanie Presley (Seward-Bear CK FSA), ♦ Robert Rufner (KWF), ♦ Stephanie Schmit (NRCS), ♦ Brenda Trefon (Kenaitze Indian Tribe) ♦ Coowe Walker (KBRR), ♦ Ami Wright (RBCA)

Kenai Peninsula Wetlands – A Guide for Everyone

including an assessment of wetland functions and values

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Read this first: What you'll find in this report

Our wetlands are worth knowing about. They provide many benefits to society—as explained in this report. They are well suited for some land uses and problematic for others. They are also worth knowing about because they are a significant feature of the Kenai Peninsula: over 370,000 acres of wetlands were mapped in the almost 920,000-acre area covered by this project. This report was designed to increase understanding of peninsula wetlands. Promoting better understanding and management of peninsula wetlands was the overarching goal of this project, which assessed sixteen wetland functions and values. This report covers five topics:

- **A brief introduction to this wetlands assessment project**
  The project described in this report resulted in a "landscape-level" assessment of some key functions and values of wetlands on the Kenai Peninsula. **Chapter 1** briefly introduces the project, including basic project goals, areas covered, how an assessment method was selected, and who contributed. Two areas of the peninsula are covered: (1) the *Kenai lowlands*, which encompass all lands between Cook Inlet on the west and the Kenai National Wildlife Refuge on the east, and (2) the *Seward area*, which encompasses all non-federal lands around Seward and the southern portion of the Seward Highway.

- **What is a wetland and what kinds of wetlands are found on the Kenai Peninsula**
  Chapter 2 provides an introduction to wetlands. It first defines wetlands in general and then introduces peninsula wetlands in particular. One goal is to show how understandable and useful the system is that was used to classify, name, and map peninsula wetlands. This system was developed specifically for Kenai Peninsula wetlands, and it quickly conveys significant information. For example, knowing just six major landforms (geomorphic components) used in naming wetland ecosystems provides useful information about roughly 90 percent of mapped wetlands. Even more information is conveyed in "map unit codes," which are tied to a wealth of data collected in the field and available online. As Chapter 2 explains, wetland names and map unit codes provide fundamental information about where (and why) particular wetlands occur on the landscape, as well as useful insight about how they might function.

  This chapter also introduces the many kinds of wetlands information available from the Kenai Peninsula Borough online *interactive parcel viewer*. Anyone interested in land and landscapes on the peninsula will benefit from knowing how to use the borough's powerful and easy-to-use online geographic information system (GIS) tool. The interactive parcel viewer accesses a wealth of information about peninsula wetlands—including many photos (see next page), along with many other kinds of data.

- **Why wetlands matter—assessing their functions and values**
  Wetlands do many things that benefit individuals and societies, including playing critical roles in keeping watersheds healthy and productive. **Chapter 3** describes how 16 "functions" and "values" of peninsula wetlands were assessed during this project and provides maps showing the results of those assessments.

- **How wetlands are legally protected (how to avoid ending up in deep water)**
  Because of the many benefits wetlands provide, they are protected through a number of mechanisms reflected in local, state, and federal laws. **Chapter 4** clarifies these. If you discover that you have a wetland where you want to put a building, road, or other development, you'll want to read this chapter. (To find wetlands on your land, use the borough's parcel viewer, as introduced in Chapter 2.)

- **How to help keep wetlands healthy**
  Wetlands are worth taking care of because of the many benefits they provide. Each landowner and land user can make choices and take actions that help wetlands function in healthy, productive, and sustainable ways. **Chapter 5** introduces some basic things we can do to maintain wetland functions and values so that wetlands can continue to provide clean water and flood protection; salmon, moose, and other species, places to explore, learn, and recreate, and other benefits. A project to develop management strategies for peninsula wetlands is now underway; that project is introduced in this chapter.

Six examples of Kenai Peninsula wetlands.

Wetland ecosystem types and map unit codes are described in Section 2.2. (All photos are from http://www.kenaiwetlands.net/.)

A Kettle (K) wetland ecosystem in the Seward area, (This wetland was mapped as K 3-4.)

An example of a large Relict Glacial Lakebed (LB) wetland complex near Ninilchik. (This wetland was mapped as LB1-4.)

A Relict Glacial Drainageway (DW) wetland mapped near Salamatof Lake. (This wetland was mapped as DW21.)

A Headwater Fen (H) in the headwaters of the Anchor River.

A black spruce-dominated Discharge Slope (S) wetland mapped near Clam Gulch. (This wetland was mapped as SM.)

A Riparian (R) wetland along a stream feeding into Stariski Creek. (This wetland was mapped as an Res.)

Chapter 1.   Introduction to this wetlands assessment project

Wetlands perform many functions—from filtering surface flows to storing floodwaters—and provide many values—including places to hunt, fish, and recreate (see Chapter 3). An assessment of functions and values is needed if we recognize that not all wetlands are created equal and that different wetlands play different roles within a watershed. An assessment can help us identify which wetlands have the highest priority for protection, as well as which functions and values should be the focus of management priorities, research, or other actions.

1.1. Project goals and study area

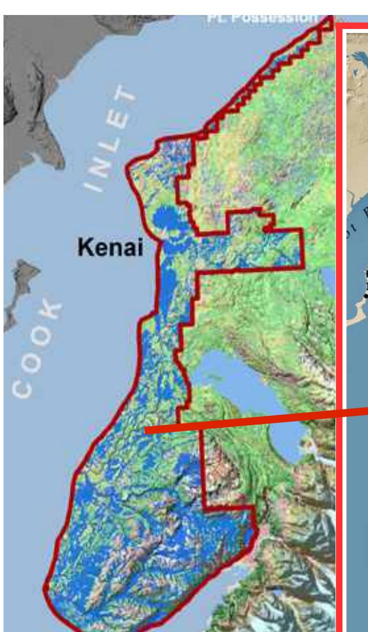
Promoting better understanding and sustainable stewardship of peninsula wetlands were the overarching goals of this project. More specifically, this project added information critical in making well informed decisions about protecting and managing peninsula wetlands, namely, what functions do these wetlands perform and what values do they provide. This information establishes a foundation on which management strategies can be built that will protect significant wetlands and sustain priority functions and values.

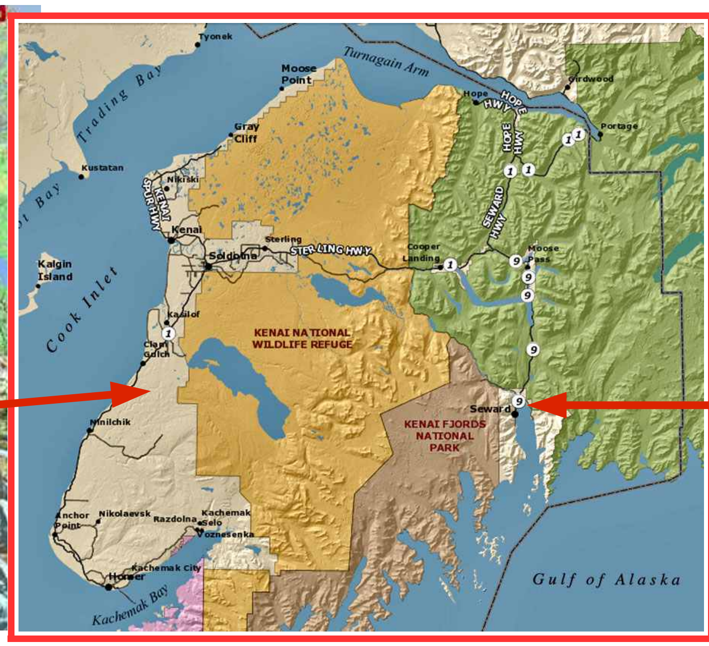
Two geographic areas were covered in this assessment: (1) the “Kenai lowlands” area, which encompasses about 894,850 acres between Cook Inlet on the west and the Kenai National Wildlife Refuge on the east, and (2) the “Seward area,” which encompasses about 24,600 acres around Seward and the southern section of the Seward Highway (Map 1a). About 41 percent of the Kenai lowlands were mapped as wetlands (roughly 366,900 acres), and about 18 percent of the Seward area (roughly 4,430 acres).

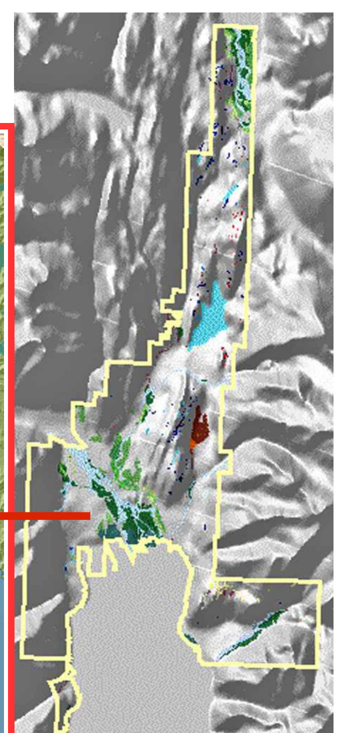
A variety of wetland functions and values were assessed in these areas (see Chapter 3). These were selected based on (1) the methodology chosen—modified as necessary (see Section 1.3), (2) functions and values identified as high priority by project participants, and (3) available sources of peninsula-wide data suitable for a “landscape level” assessment. Most of the information about wetland characteristics that was used during assessments can be found in *Wetland Mapping and Classification of the Kenai Lowland, Alaska*, which is described in some detail in Chapter 2. Geospatial information from the Kenai Peninsula Borough's GIS was another key source of information. All information sources used during assessments are identified as appropriate in Chapter 3.

Map 1.1a. Areas assessed on the Kenai Peninsula during this project

Left: Kenai lowlands (wetlands in blue), **middle:** overview of Kenai Peninsula study areas, **right:** Seward area (wetlands are colored areas). (Sources: Kenai lowlands and Seward area maps: http://www.kenaiwetlands.net/; peninsula map: http://mapserver.borough.kenai.ak.us/flexviewer/.)







1.2. Unique conditions and selecting an assessment approach

Four unique conditions factored into how this wetland assessment was conducted. These same conditions will affect how assessment results are ultimately used.[1]

- **Wetlands assessed during this project cover over 336,000 acres.** The wetland acreage assessed during this project is extensive and considerably larger than any area previously assessed in Alaska. Most wetland assessments are site specific or project specific, and many are performed using what have come to be called "rapid assessment methods"[2] (see, for example, the pdf document http://www.epa.gov/nheerl/download_files/publications/rapidmethodreview.pdf or do an online search for "wetland rapid assessment methods"). The large acreage of wetlands required a new approach appropriate for a landscape- or watershed-level assessment.

- **Peninsula wetlands reflect a high cover of peatlands** (see Chapter 2). Peatlands are characterized by deep, organic soils, often with a tremendous "spongelike" capacity for absorbing and storing water. (For example, sphagnum moss species can hold 16-26 times their dry weight in water.) Functional characteristics of peatlands—by far the most common wetlands on the peninsula—are not well understood. Neither are peatlands well-documented in other wetland assessments, mainly because they are largely absent from other parts of the country. This creates a challenge in assessing peatland functions.

- **The vast majority of peninsula wetlands are in "reference condition"** (see Section 1.3.4). That means that they are relatively undisturbed by human activities and that their capacity to function in natural, self-sustaining ways is essentially unimpaired. This is in striking contrast to wetlands assessed in most other parts of the country, where reference condition is rare to nonexistent and is used as the standard against which all wetlands are compared for assessment. The fact that most peninsula wetlands are in reference condition means that any assessment method used needs to score wetlands along a gradient of natural variation rather than a gradient of human disturbance (as other assessments tend to do). It also means that the focus during management needs to be on *maintaining* wetland conditions, functions, and values rather than on restoring them.

- **The peninsula—particularly the Kenai lowlands—has a relatively high percent cover of wetlands.** Roughly 41 percent of the almost 895,000 acres mapped in the Kenai lowlands were classified as wetlands. About 18 percent of the 24,600 acres mapped in the Seward area were classified as wetlands. A high percent of wetland cover has significant management implications.

Because of these four conditions, assessing Kenai Peninsula wetlands offered a novel challenge—adapting previously used assessment methods across an expansive landscape with a high cover of peatlands functioning in reference condition. Typical tried-and-true assessment protocols did not directly apply, and a different approach was needed. At the same time, the collaborative team that came together to select an assessment approach wanted to avoid "re-inventing the wheel" when choosing a method. As described below, a landscape-level approach was developed by modifying wetland assessment methods (WAMs) previously used in Anchorage and Homer, which were based on a method developed in Ontario, Canada. Chapter 3 describes in detail the methodology selected and how it was applied in assessing a total of 16 wetland functions and values.

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1 This discussion is based on considerable input from Mike Gracz. Kenai Watershed Forum.

2 "The intent of all rapid assessment methods is to evaluate the complex ecologic condition of a natural ecosystem using a finite set of observable field indicators and to express the relative condition of a particular site in a manner that informs ecosystem management." (From *A Practical Guide for the Development of a Wetland Assessment Method: The California Experience*, M. Sutula et al., 2006; see: http://www.wrmp.org/docs/cram4/WREB4201_157-175.pdf.)

1.3. Background on the Kenai Peninsula wetlands assessment method

1.3.1. The wetlands working group and selection of an assessment method

The assessment method used in this project is based on the method used in Anchorage and, a few years later, in Homer. In turn, Anchorage/Homer methods are based on the Ontario Wetlands Evaluation System (OWES), which has been in use in Canada for many decades. (The Ontario Ministry of Natural Resources maintains OWES "...to provide a consistent method of assessing wetland functions and their values to society." See http://www.mnr.gov.on.ca/en/Business/ Biodiversity/2ColumnSubPage/STDPROD_068974.html.) The Kenai Peninsula wetland assessment method (KPWAM) is discussed in detail in Chapter 3.

The challenge on the peninsula was to take a method that had been used to assess wetlands at large scales (high resolution) in Anchorage and Homer and repurpose it to work at a scale of much lower resolution (see Section 1.3.2). The challenge was made easier because the system developed to classify, name, and map wetlands on the peninsula was specifically designed to help predict wetland functions (see Section 2.2).

The assessment method used in this project was selected by the Peninsula Wetlands Working Group (WWG). The WWG is an ad hoc group of individuals interested in sharing information about Kenai Peninsula wetlands and watersheds. The group has been meeting once or twice a year since 2000 and includes researchers, resource managers, land use planners, conservationists, educators, and other representatives from state and federal agencies, borough and city governments, Native organizations, non-governmental organizations, and local businesses. For a list of groups and organizations who've been involved with the WWG, see https://sites.google.com/site/kenaipeninsulawetlandwiki/directory/links-to-member-websites. Individuals who participated in this project, and their affiliations, are listed in Appendix A, along with meeting dates.

In considering how to assess functions and values of peninsula wetlands, the WWG recognized that selecting a method previously used in Anchorage and Homer offered a number of advantages:

- It built on assessment experience gained in nearby areas of the state. (And many members of the working group had participated in the Homer wetlands assessment project.)
- It addressed the desire to avoid "re-inventing the wheel" with respect to coming up with a method, which promoted efficient use of time and resources.
- It avoided expending considerable time and resources trying to select a method from the plethora of assessment methods now available (see, for example, *Assessing Functions and Values*, http://aswm.org/pdf_lib/assessing_functions_values.pdf).
- It took advantage of the fact that many potential users of the Kenai Peninsula assessment would be likely to have some familiarity with the approach because of prior exposure to Anchorage and Homer projects.
- It took advantage of the fact that the results of Anchorage and Homer assessments have now been in use for many years. This means that numerous groups—from city planners to regulators to developers to private property owners—have lived with, used, and accepted these assessments in a variety of situations.

As explained below, conducting a landscape-level assessment required making changes to the methods used in Anchorage and Homer. When modifications were needed, guidance was sought from three main sources. One was the manual for the Northern Ontario Wetlands Evaluation System, on which Anchorage and Homer methods were based. The Northern OWES manual can be downloaded at http://www.web2.mnr.gov.on.ca/mnr/Biodiversity/wetlands/owes/Northern_OWES_Manual_text.pdf. A second source was the best professional judgment of expert teams assembled to help guide the Kenai Peninsula assessment project. Expert teams were composed of professionals actively involved in wetlands-related research, management, education, and/or regulation on the Kenai Peninsula (see Section 1.3.3. The role of "expert teams"). Finally, guidance was also sought from other individuals with particular expertise, including staff at the Alaska Natural Heritage Program at the University of Alaska, Anchorage, hydrologists from various entities, and academics from the University of Alaska, Kenai Peninsula College.

1.3.2. Assessment scale

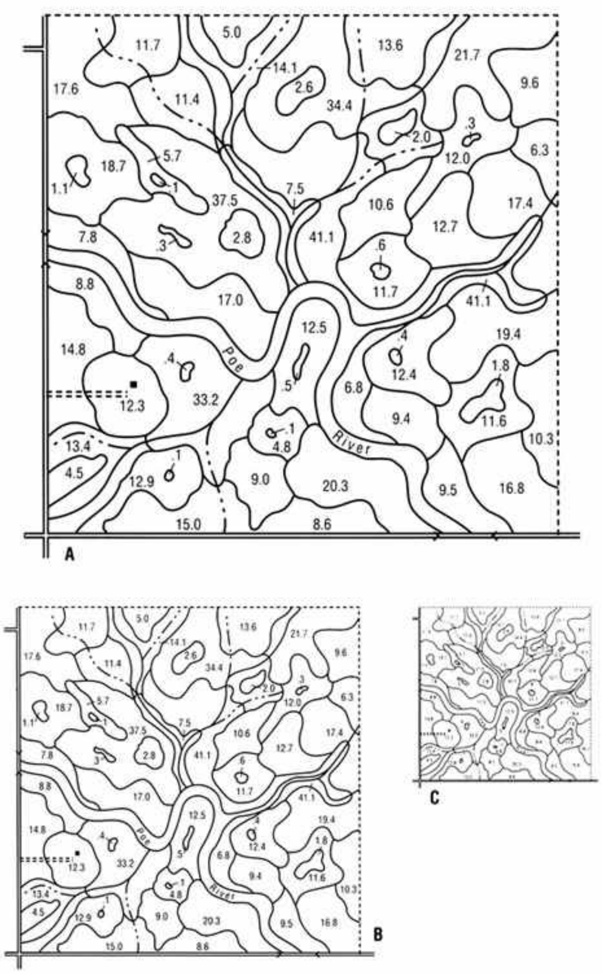
Scale is the level of detail at which we look at something, in this case, the peninsula landscape and its wetlands. Scale can be general and broad brush or "zoomed in" to provide a high level of resolution. For regional purposes —like mapping wetlands across non-federal lands on the Kenai Peninsula—a moderate level of detail was required, neither too detailed (site specific) to be practicable nor too generalized to be useful.

The **box at right** illustrates different map scales. Three identical areas are shown at three different scales: the top scale is *1:21,120* (stated as "one to twenty-one-one-twenty," which is similar to 1:24,000, at which wetlands were mapped); the bottom left scale is *1:31,680*; the bottom right is *1:63,360*. (What these numbers mean is explained below.) Each map contains the same *polygons*—that is, areas that have been outlined, or *delineated*. In these three maps, the numbers inside each polygon identify the size of that polygon in acres. This allows you to see how larger scales (scales closer to 1:1) can show much more detail than smaller scales. (The landscape we interact with directly, at ground level, is a scale of 1:1; magnification leads to scales greater than 1:1.)

Different map scales illustrated for comparison

See caption at the bottom of this box. (These maps are further discussed at left.) This is Figure 2-4 from Chapter 2 of the NRCS Soil Survey Manual (http://soils.usda.gov/technical/manual/contents/).

FIGURE 2-4



Copies of the same map at different scales: A, 1:21,120; B, 1:31,680; C, 1:63,360 (equivalent to 3, 2, and 1 inch equals one mile, respectively). The numbers within individual delineations are the acreages of the areas represented (1 acre equals 0.40 hectares).

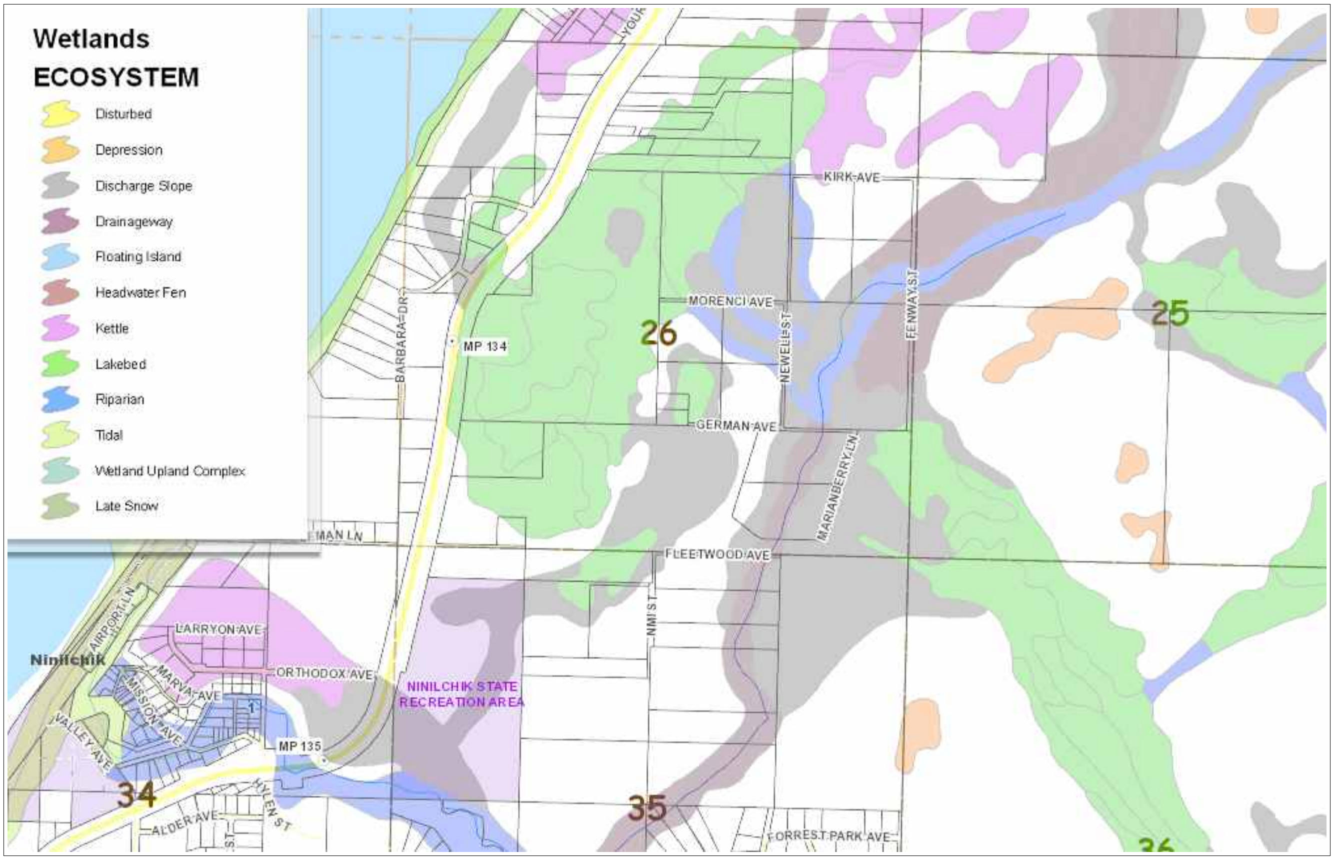
Because the amount of detail that can be mapped always reflects the scale of the photographs and map sheets used during mapping, it's important to use maps at the scale intended by mappers. Zooming in on maps like wetlands maps, soil surveys, topographic maps (which can easily be done on a computer) can lead to misperceptions about how much detail was distinguishable to map makers. (This is similar to zooming in on a digital photograph until it becomes pixelated and no longer represents reality.)

The scale used for mapping peninsula wetlands was 1:24,000. (A similar scale, 1:25,000, was used for updating the Western Kenai Peninsula soil survey, during which wetland, or *hydric*, soils were identified[3].) If you draw a line 1 inch long on a map or aerial photograph with a scale of 1:24,000, that line represents 24,000 inches on the ground, or 2000 ft (roughly 0.38 of a mile in length). Similarly, a square inch drawn on such a map or aerial photograph represents, on the ground, a square of 24,000 inches on a side (24,000 inches squared = 576 million sq in or roughly 4 million sq ft), which equates to just under 92 acres. Maps 1.3a-c show wetland maps at a scale of 1:24,000 from the Kenai Peninsula Borough interactive parcel viewer. As illustrated in Map A in the box above and Map 1.3b below, the smallest polygon that can reasonably be delineated at 1:24,000 is about 0.3 acres.

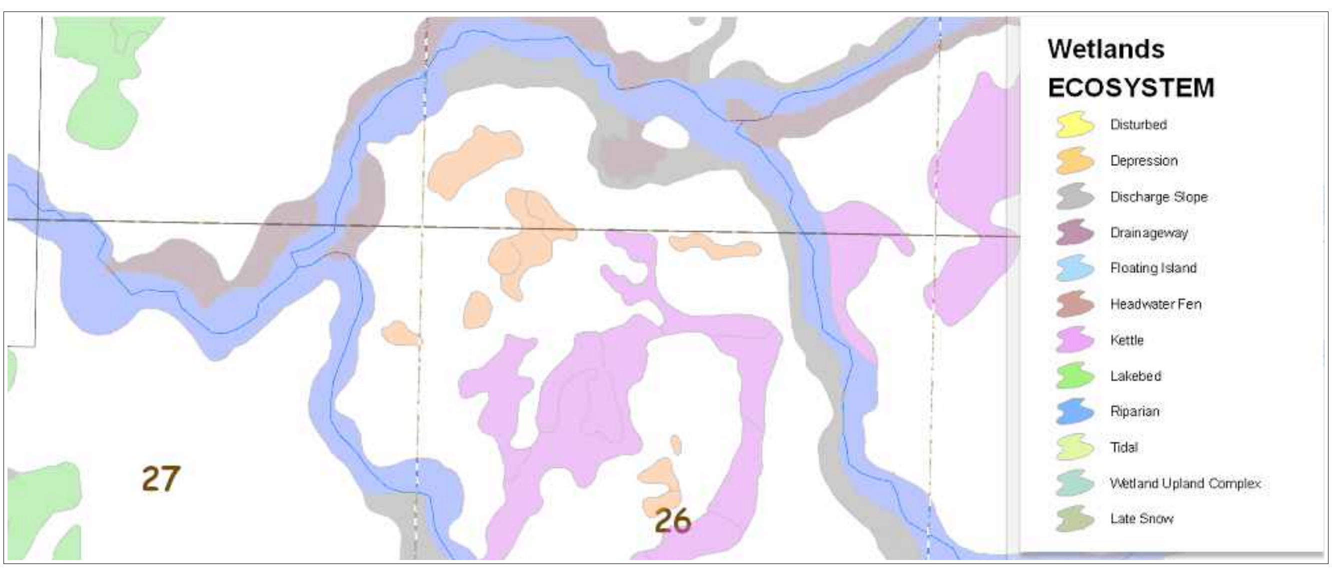
3 Soil maps and information for the area covered in this project can be found in the 2005, online soil survey manuscript of the Western Kenai Peninsula Area: http://soildatamart.nrcs.usda.gov/Manuscripts/AK652/0/WesternKenai_manu.pdf.

Maps 1.3a and b. Wetland maps printed from the Kenai Peninsula Borough interactive parcel viewer site at http://mapserver.borough. kenai.ak.us/kpbmapviewer/. If this full page, with both maps, is viewed as a pdf at 100% or printed on a sheet of paper 8½ by 11, these maps will be at a scale of 1:24,000. At 1:24,000:

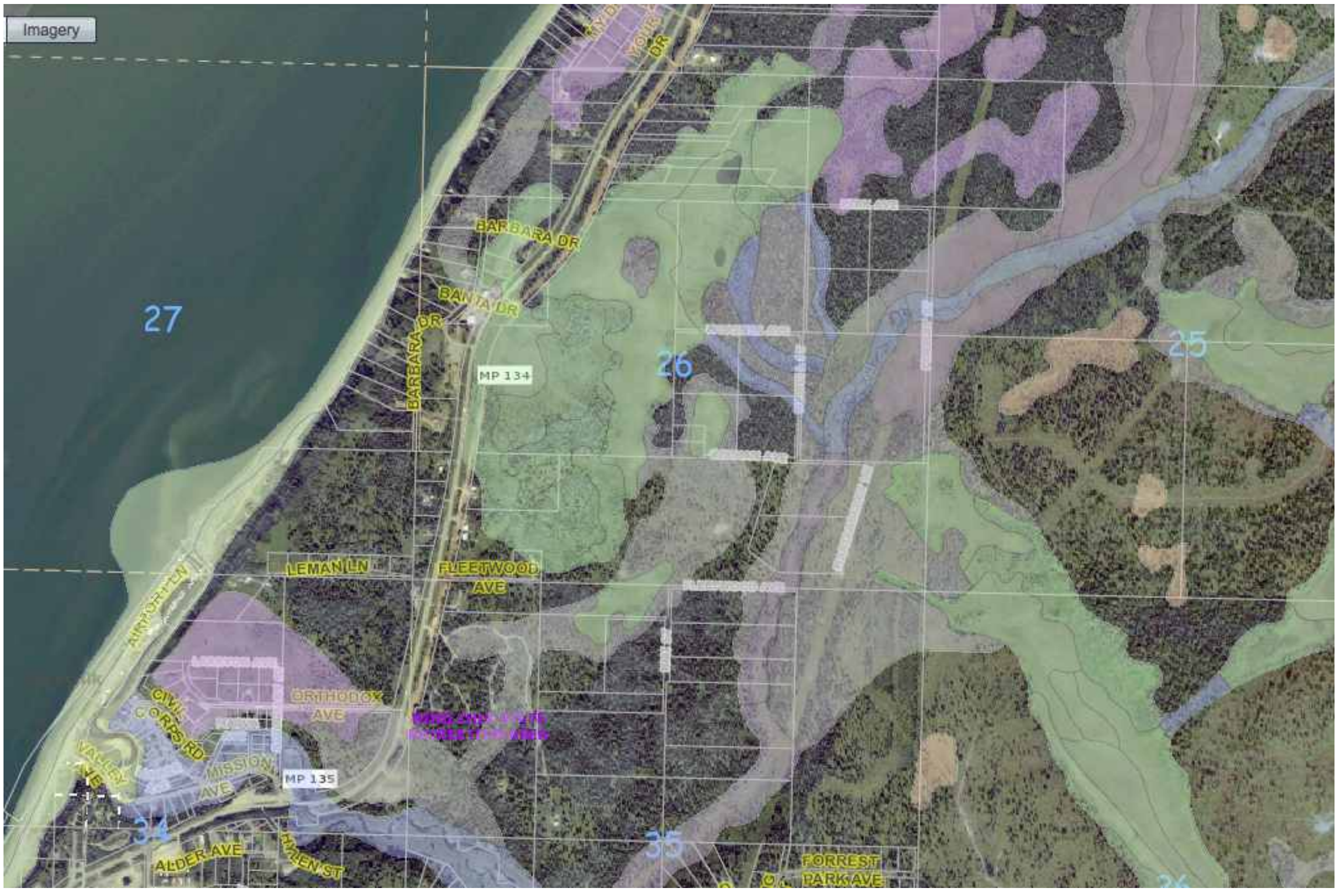
- 1 linear inch on the map = 24,000 linear inches on the ground (2000 ft);
- 1 square inch on the map = 4 million sq ft on the ground, or 92 acres;
- 2.64 linear inches on the map = 1 mile on the ground;
- A square on the map that is 2.64 inches on a side and is numbered (for example 26, 25) = a *Section* (which is an area 1 mile square, or 640 acres). (For an explanation of these sections, 36 of which are found in a *Township*, see: http://en.wikipedia.org/wiki/Public_Land_Survey_System.)



Map 1.3b. A wetland map showing approximate limit of detail at 1:24,000. The smallest Depression wetland polygon delineated below—just above number 26—is about 0.34 ac; this is about the smallest area that can be outlined at this scale.



Map 1.3c. A wetland map printed from the Kenai Peninsula Borough interactive parcel viewer site at http://mapserver.borough.kenai.ak.us/flexviewer/. This map, which shows wetlands overlain on aerial imagery, has the same scale as Map 1.3a. As is clear, the two different interactive parcel viewer sites illustrated by this map and Map 1.3a allow wetlands to be looked at in different ways.



Clearly, if 92 acres on the ground are represented by 1 sq inch on the map, a lot of detail is lost. We call this scale landscape level to distinguish it from site-specific scales that provide enough detail for making site-specific decisions. Fundamentally, landscape-level wetland maps show probabilities—that is, which areas are highly LIKELY to have wetland areas as shown. This scale can help landowners and managers decide where to look more closely when searching for areas with conditions best suited to particular purposes. For example, if the purpose is to locate a building site or an area for a septic system leach field, areas mapped as wetlands at a scale of 1:24,000 are highly unlikely to have conditions suitable for those purposes. However, mapped wetland areas theoretically could have small inclusions of uplands, which could potentially be suitable for such purposes. More site-specific mapping would be needed to locate such inclusions.

As noted earlier, mapping—and hence assessment—of wetlands on the Kenai Peninsula was conducted at a less-detailed scale than in Anchorage and Homer—primarily because the area covered was so much larger, as shown in Table 1.3a. For example, this project addressed over 336,000 acres mapped as non-tidal wetlands in the Kenai lowlands and Seward area—representing roughly 17,000[4] individually outlined and named wetland polygons (also called "map units"). (Tidal wetlands were not assessed in this project.)

4 To be more precise, 16,991 wetland map units were identified, mapped, and named in the Kenai lowlands and Seward areas; as compared to 414 in the Homer area. A database with all Kenai lowlands and Seward area map units can be downloaded from: ftp://ftp.borough.kenai.ak.us/GIS/Downloads/Shapefiles/LowlandWetlands.zip.

Table 1.3a. Comparison of scale and acreage of Anchorage, Homer, and Kenai Peninsula wetland assessments

Location of project area	Scale of wetland maps	Acres of non-tidal wetlands assessed
Municipality of Anchorage includes Anchorage Bowl, Eagle River to Eklutna, and Turnagain Arm	1:12,000 (maps were revised in 1995 to a scale of 1:500; wetlands that had been converted to non-wetland uses were deleted from maps)	**14,559**[5] ac Anchorage Bowl: 7,269 ac Eagle River to Eklutna: 3,308 ac Turnagain Arm: 716 ac
City of Homer and Bridge Creek watershed	1:12,000	**3,796** ac (excludes the Spit)
Kenai Peninsula encompasses Kenai lowlands and Seward area	1:24,000	**336,267** ac

Because this is a landscape-level assessment, more detailed assessments will be conducted in the future as needs and projects dictate. Being able to "nest" data collected in the future within the broader framework of the wetland classification and mapping system used here will provide many benefits, such as the ability to track changes affecting wetlands or to refine wetland classification categories.

Nesting future data should be relatively straightforward because of how data from this assessment relate to wetlands information contained in the Kenai Peninsula Borough's GIS. As long as future assessments are conducted in terms of wetland polygons and map units reflected in the borough's GIS (even if those polygons and map units are subdivided into finer subpolygons), additional data can be nested in the existing system, enhancing its value. The long-term goal is to integrate wetlands data—at whatever scale collected—into one system that is readily accessible and useful to landowners, resource managers, researchers, educators, and others interested in wetlands.

1.3.3. The role of expert teams

As noted above, conducting this landscape-level assessment required modifying the selected methodology—a process that benefitted from expert guidance. In addition, the peninsula Wetland Working Group (introduced in Section 1.3.1) wanted to assess wetlands in terms of their values to the Native culture in the project area—the Dena'ina Athabascans. Such culture/heritage values had not been specifically addressed for either Anchorage or Homer wetlands (although "community" values were considered in Anchorage). Conducting tasks such as these was facilitated by help from expert teams composed of individuals with experience or expertise particularly relevant to the issue at hand. The composition of expert teams varied depending on need—so at various times, peninsula wildlife biologists met, or salmon experts, or individuals with expertise in hydrology, or anthropology. Such experts came from a variety of agencies, academic institutions, and non-governmental organizations. Some sections of this report were largely authored or co-authored by members of particular expert teams, and their invaluable contributions are noted as appropriate. Appendix A lists individuals who participated on particular expert teams and their affiliations, as well as dates of expert team and steering committee meetings, and who attended each. (Over 300 hours of meetings are listed.) This offers a sense of how many individuals contributed in significant ways to this project. In addition to expert teams, a steering committee met as needed to provide project oversight and guidance. See Contributors, preceding the Table of Contents, for steering committee members and their affiliations.

5 "Approximately 14,559 acres of freshwater wetlands have been mapped throughout the entire Municipality (excluding military lands)." (From http://www.muni.org/Departments/OCPD/Planning/Physical/EnvPlanning/Pages/WetlandFAQs.aspx#two accessed on 2-26-2012.)

1.3.4. Reference condition as it applies to peninsula wetlands

With a few exceptions, most wetlands on the Kenai Peninsula have been relatively little affected by human activities, and their capacities to function in natural, self-sustaining ways are essentially unimpaired. This is in striking contrast to wetlands in many other parts of the country, where sometimes few—if any—wetlands remain in essentially pristine condition[6]. Wetlands still in a highly functioning, unimpaired, essentially undisturbed condition are said to be in reference condition, and wetland sites in reference condition are called reference sites. Here is how these terms are defined by the Environmental Protection Agency:

> **Reference condition**
> Set of selected measurements or conditions of minimally impaired waterbodies [including wetlands] characteristic of a waterbody [or wetland] type in a region.
> (Source: http://water.epa.gov/type/wetlands/assessment/fact10.cfm.)
>
> **Reference site or reference wetland**
> In biological assessments, the terminology for reference conditions is based on the protocols that have been developed for assessing the condition of streams, lakes, and estuaries. From this heritage, a *reference site* or *reference wetland* is a minimally impaired wetland that is representative of the expected ecological conditions of a wetland of a particular type and region. The reference sites serve as the measuring stick to determine the integrity of other wetlands. Each biologically distinct class of wetlands has its own set of reference sites. For example, bogs are only compared to other minimally impaired bogs and prairie potholes are only compared to other minimally impaired prairie potholes.
> (Source: http://water.epa.gov/type/wetlands/assessment/fact6.cfm, see "Definition of Reference Terms.")

As is clear from the definition of reference site, many wetland assessments use these sites as a standard against which to compare and then score all wetlands of the same type (for example, *bogs* and *prairie* potholes). In such cases, the reference site receives a perfect score (usually "1"), and wetlands of the same class that reflect some level of damage or degradation receive scores less than 1.

The fact that most peninsula wetlands are in reference condition means that comparing peninsula wetlands to reference sites during assessment was not a particularly useful way to assess them. The vast majority of peninsula wetlands would have received a perfect score—particularly given the landscape-level scale of this assessment. Instead, peninsula wetlands were scored in terms of their assessed suitability to perform particular natural functions or provide particular social values. The assessment method used—including criteria for scoring wetlands—is described in detail in Chapter 3.

A few mapped wetlands were NOT in reference condition

For those few peninsula wetlands that DID reflect a level of disturbance that warranted documentation, a small "d" (for disturbed) was added to the end of the map unit code given that wetland (map unit codes are explained in Chapter 2). Wetlands that were so disturbed that their original wetland ecosystem type could no longer be determined were mapped simply as "DISTURB."

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6 Conditions in other parts of the country provide many disheartening cautionary tales of how seriously vast areas of wetlands can become degraded given a lack of comprehensive, landscape-level data or implementation of systematic, proactive, watershed-based management approaches. In California, for example, when the state undertook development of its California Rapid Assessment Method, virtually no "reference sites" could be found reflecting wetlands in "nearly pristine conditions." As stated on page 169 (emphasis added):

> "In California, a great loss of wetlands has occurred for every wetland class, and essentially **all of the remaining wetlands are stressed to some degree.** Reference sites for nearly pristine conditions only exist for a few wetland classes in a few ecoregions. Most of these are montane or alpine and do not pertain to the rest of the state. **It was therefore not feasible to find examples of the best possible wetlands**. (Source: Journal of the American Water Resources Assoc. February 2006, see http://www.wrmp.org/docs/cram4/WREB4201_157-175.pdf.)

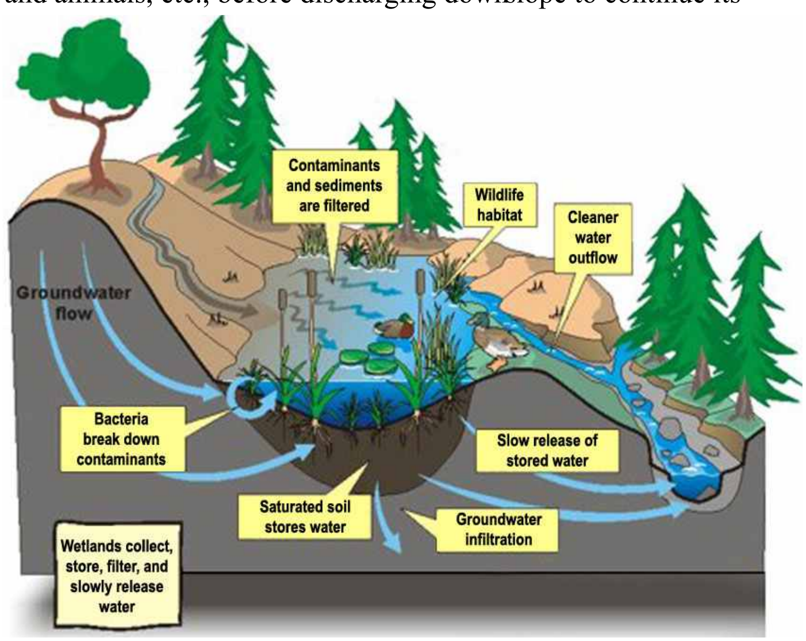
Chapter 2. An introduction to wetlands and the kinds of wetlands found on the Kenai Peninsula

This chapter introduces wetlands in general and peninsula wetlands in particular. It also explains how you can get many kinds of useful information about your wetlands from the Kenai Peninsula Borough's online geographic information system (GIS), particularly from the easy-to-use interactive parcel viewer (see Section 2.4). The results of this assessment are available through that website.

One goal of this chapter is to show how easy it is for anyone to get a basic knowledge of local wetlands thanks to the system used to name and map them. Only six kinds of general *wetland ecosystems* encompass over 90 percent of all wetlands found on the peninsula (twelve categories encompass 100 percent). By combining general wetland ecosystem names with about a dozen easy-to-learn modifiers, over 70 specific "map unit codes" were distinguished and used (alone or in combination) to name the almost 17,000 individual wetland *polygons* mapped on the peninsula, and these names convey useful information. Just by knowing the name of a wetland (or its "map unit code"), you immediately know some key things about the position of that wetland on the landscape, the basic processes that created it, and how that wetland might function. Complete background on the system used to classify, map, and name wetlands on the peninsula is available from two very useful websites: http://cookinlet wetlands.info and http://www.kenaiwetlands.net/. Much of the information provided below, particularly in Section 2.2, comes from those websites.

2.1. Wetlands defined

To recognize and understand wetlands, it helps to know a few basic concepts. The most basic is that the presence of water makes wetlands different from lands that are high and dry—that is, from uplands[7]. Except where springs and seeps create wetlands on slopes, most wetlands occur on flatlands or in landscape depressions. There they act as natural sponges, catchments, pipes, cisterns, water filters, leach fields, and impoundments—places where water collects, gets stored, is filtered, supports plants and animals, etc., before discharging downslope to continue its journey to the sea, see **figure at right** (from http://www.nrcan. gc.ca/earth-sciences/products-services/ mapping-product/geoscape/waterscape/ bowen-island/6473).

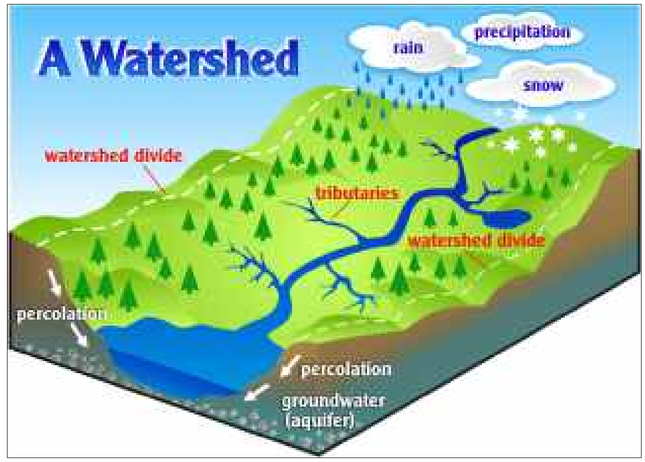


Because wetlands receive and/or hold a lot of water, the ground in these areas is wet so long or so often that saturation affects soil conditions. In particular, saturated soils become oxygen-poor, or *anaerobic*. This affects not only soil properties but also which plants can grow there. So in addition to their characteristic wetness (hydrology), wetlands also have characteristic soils ("hydric" soils[8]) and plants (called "hydrophytes"). These features —hydrology, soils, and plants—determine whether or not a site is considered a wetland.

7 For a good introduction to wetlands, see: *Common Questions: Wetland Definition, Delineation, and Mapping*, Kusler, J., Association of State Wetland Managers (www.aswm.org); at: http://aswm.org/pdf_lib/14_mapping_6_26_06.pdf). It describes wetlands as "transition areas between aquatic ecosystems and uplands" that are subject to periodic inundation or saturated soil conditions and are often characterized by plants able to grow in saturated conditions and soils reflecting periodic inundation." Among key wetland functions cited in this article are (a) high primary (i.e., plant) productivity and biodiversity (in many cases), (b) flood storage and conveyance, and (c) erosion and pollution control.

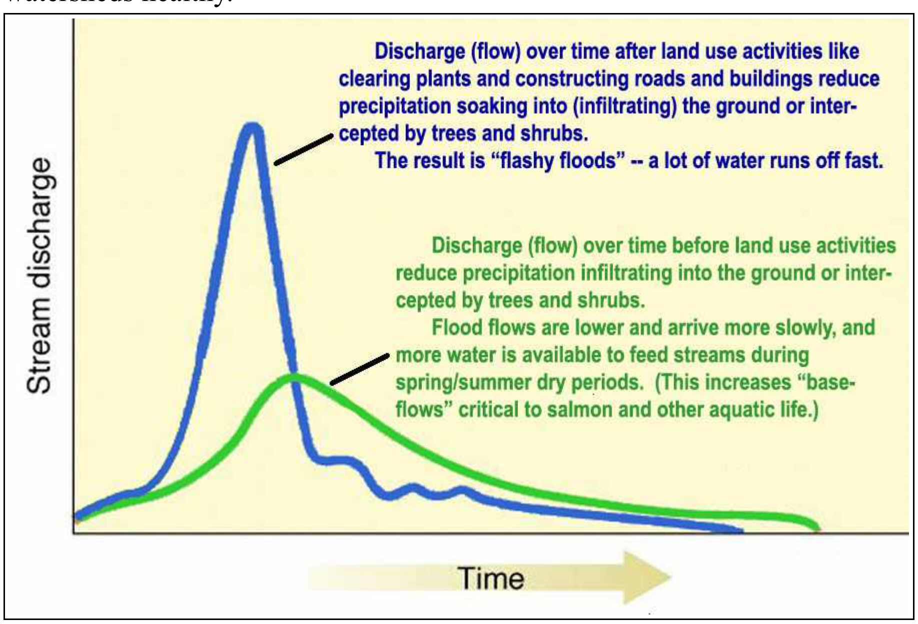
8 Soils are classified as "hydric" when they are flooded or saturated sufficiently that oxygen around the rooting zone gets

How much water a wetland receives depends on climate, so wetlands may be defined differently in different parts of the country. On the Kenai Peninsula, wetlands occur where (a) the water table remains within about a foot of the ground's surface for more than a couple of weeks during the growing season[9] **and** (b) these conditions occur in more than half of all years.



Once formed, wetlands are never static. They change in response to variations in the timing and intensity of precipitation; increases and decreases in air, soil, and water temperatures; and earth-shaping processes like floods, volcanic eruptions, and earthquakes. They also change in response to biological processes, like the rise and fall of plant and animal populations (including the spread of invasive plants like Reed canary grass), and because of human activities. Open water in a "kettle" wetland may disappear in response to dry summers and dropping groundwater levels, only to return after heavy rains.

Watersheds: Healthy wetlands promote healthy watersheds. A watershed encompasses all areas that drain towards a particular point on a waterbody, like all lands that drain into the upper Kenai River or into Tustumena Lake (see **figure upper right**, from http://www.sanduskyriver.org/). The ways that wetlands collect, store, and release water are essential to healthy watershed functions (see Chapter 3, Section 3.4). Healthy watersheds "soak up" and store precipitation quickly and release it slowly. This allows water to move deeply and extensively into all parts of the watershed, where it can recharge groundwater, supply streams and lakes, nourish plants, and support animal and human life. On the other hand, "unhealthy" watersheds do a poor job of soaking up precipitation, so rainfall and meltwater run off quickly. This causes more erosion, flooding, and pollution. *Impervious surfaces*—like roads, parking areas, roofs, and compacted soils—prevent stormwater and melting ice or snow from soaking into the ground, or *infiltrating*. Obviously, minimizing impervious surfaces is one way to help keep watersheds healthy.



The **hydrograph at left** compares stream flow (discharge) in healthy and unhealthy watersheds. The higher the line, the higher the flows. Unhealthy watersheds are characterized by lines like the one in blue: during storms, rainfall and runoff fills streams quickly and runs off fast. These "flashy" flows increase floodwater peaks and related flood damage. In addition, because much of the precipitation leaves these watersheds without infiltrating into the ground, it doesn't have the chance to provide the deep hydration that recharges groundwater supplies and fills streams and lakes during dry periods (called *baseflows*).

used up, primarily by decomposer microorganisms. Oxygen diffuses into stagnant water very slowly, so once it's used up, the small amount able to dissolve is also quickly used up. As a result, hydric soils become oxygen depleted (anaerobic). Decomposition is inefficient in anaerobic conditions, so organic material—primarily plant remains—builds up, so that hydric soils are often also organic soils, that is *peat* or muck. Many Kenai Peninsula wetlands are peatlands.

9 The growing season is defined using the 50% probability of the temperature being 28 degrees F or higher.

2.2. Understanding how peninsula wetlands were mapped and classified[10]

Wetlands were mapped on the Kenai Peninsula at a scale of 1:24,000 by professionals trained to recognize the three wetland indicators introduced above: wetland hydrology, hydric soils, and hydrophytic plants[11]. For trained individuals, most wetlands are relatively straightforward to identify and map. If wetlands are mapped using aerial photography, accuracy is improved if at least a sampling of sites can be visited on the ground. Many sites were ground-truthed during mapping of peninsula wetlands.

A few key environmental characteristics help identify wetlands when mapping takes place outside the period when a seasonally high water table is present. Plants and soils are the most useful wetland indicators (i.e., hydric soils and hydrophytic plants), but other onsite features also indicate seasonally high water tables. Manuals developed by the US Army Corps of Engineers provide instructions for determining which areas are wetlands and which are not, including which wetlands are "jurisdictional"[12]. (Jurisdictional wetlands are subject to wetland permit requirements, see Chapter 4.)

Figure 2.2a. The peninsula has 11 wetland ecosystem types; below is a *Kettle* wetland ecosystem near the Kasilof River (from http://www.kenaiwetlands.net/MapUnitDescriptions/K1-4.htm).

Some wetlands are trickier to map and classify than others. This is especially true for sites that barely meet wetland criteria described in wetland manuals. On the Kenai Peninsula, areas mapped as "Wetland/Upland Complex" or "Discharge Slope" wetland ecosystems were the most challenging to map.

Assessments of wetland functions and values make more sense given an understanding of the kinds of wetlands being assessed. As a result, it's helpful to have a basic knowledge of the most common wetland types found on the peninsula. This is best gained through an understanding of the system used to name and classify wetlands for mapping[13]—in this case, the Cook Inlet Classification system. In particular, wetland *map unit codes* provided much of the information considered during the landscape-level assessments described in Chapter 3.

On the Kenai Peninsula, you know A LOT about a wetland just by knowing its mapped name.

A key goal when mapping peninsula wetlands was to develop a classification system that would work well in the future when wetland functions and values were assessed. To do that, the system developed was specifically tailored to conditions on the Kenai

10 As noted earlier, the material in Sections 2.2 and 2.3 is by and large a compilation of information from two key sources: http://www.kenaiwetlands.net/index.htm and http://cookinletwetlands.info/. A wealth of wetlands information is found on those two sites, only some of which is summarized in this report. Much of the material on those sites (and included here) is available thanks to the exceptional efforts of Mike Gracz and Karyn Noyes (Kenai Watershed Form), Phil North (EPA), and Jerry Tande (USFWS); their contributions to our understanding of peninsula wetlands are acknowledged here.

11 Section 2.4. explains how to access wetland maps and related information available on the Kenai Peninsula Borough's online interactive parcel viewer.

12 The full procedures for identifying "jurisdictional" wetlands in Alaska are described in the 2007 Alaska Regional Supplement (version 2, September 2007): http://www.nrcs.usda.gov/Internet/ FSE_DOCUMENTS/stelprdb1046474.pdf and the 1987 Army Corps of Engineers Wetland Delineation Manual: http://cookinletwetlands.info/Downloads/ wlman87.pdf. For more background on this subject, see Chapter 4.

13 Mapping and fieldwork on the Kenai lowlands took place from 2001 to 2004 using aerial photographs at a scale of 1:24,000. Classification and mapping efforts were then extended to non-federal lands in the Seward area, and that project was completed in 2006. It's worth noting that lines drawn on air photos or maps at a scale of 1:24,000 reflect a wide band on the ground. For example, a line 1 mm wide drawn on a 1:24,000-scale map is equal to a line 24,000 mm wide on the ground. That's almost 80 ft wide, so a line ½ mm wide would be almost 40 ft wide on the ground. This affects accuracy of mapped wetland boundaries. Onsite delineations are needed to locate wetland boundaries more accurately than is possible at 1:24,000.

Peninsula, especially to (1) local landforming processes (geomorphology) and the landforms they created (*geomorphic components*), (2) drainage systems and water tables (hydrologic components), and (3) plant communities. This classification system differs from but overlaps the National Wetlands Inventory (NWI) system used to map wetlands in many other areas. Peninsula wetland ecosystems have been crosswalked to NWI categories at http://www.kenaiwetlands.net/.*

2.2.1. First: understand *geomorphic components,* based on peninsula landforms

At the broadest level, all but two peninsula wetland ecosystems were classified and named in terms of ***geomorphic components***[14]. (The two exceptions are *Disturbed* wetlands and *Wetland/Upland Complexes*.) Geomorphic components reflect various landforms, each produced by particular landscape-shaping processes. On the peninsula, geomorphic processes leading to current landscapes and wetlands have been predominantly related to glaciers advancing and retreating from about 32,000 to about 10,000 years ago. These landforms reflect processes associated with glacial lakes (like those created by ice-dammed and meltwater lakes), glaciofluvial systems (like those created by rivers of meltwater), and—more recently—fluvial systems (landscapes associated with rivers in general). Landforms created by these geomorphic processes have since been modified by volcanic and tectonic events (e.g., eruptions and earthquakes). Because the landform, or geomorphic component, on which a wetland develops affects its characteristics profoundly, classifying and naming wetlands in terms of peninsula landforms enables a lot of information to be conveyed in the wetland name.

Learning only a handful of names introduces you to over 90% of all freshwater wetlands on the peninsula.

On the Kenai lowlands, six geomorphic components encompass roughly 90 percent of freshwater wetland acreage mapped (Table 2.2a). From most to least extensive, these are: *Lakebeds* (~24% of mapped wetland acreage), *Discharge Slopes* (~22%), *Riparian/Riverine* (~15%), *Kettles* (~14%), *Drainageways* (~12%), and *Depressions* (~3%). In the Seward area, over 90 percent of freshwater wetland acreage is encompassed by four geomorphic components: *Riparian/Riverine* (~70%), *Kettles* (~17%), *Drainageways* (~4%), and *Headwater Fens* (~2.4%).

Table 2.2a. Geomorphic components (landforms) used to name wetland ecosystems. Percent of mapped wetland acres in Kenai lowlands and Seward area are shown. Words in bold are names of wetland ecosystem types, these give rise to map unit codes.

	Kenai lowlands	Seward area		Kenai lowlands	Seward area
• **Depression** (D)	3.20%	1.00%	• **Late Snow Plateau** (LSP)	1.40%	0%
• Relict Glacial **Drainageway** (DW)	12.30%	3.70%	• **Riparian/Riverine** (R)	14.70%	70.30%
• **Floating Island** (FI)	0.01%	0.00%	• **Discharge Slope** (S)	22.40%	0.40%
• **Headwater** Fen (H)	0.80%	2.40%	• **Tidal** Flats (T) (not assessed)	2.10%	5.90%
• **Kettle** (K)	13.80%	16.60%	• **Wetland/Upland** Complex (WU)	5.40%	0.20%
• Relict Glacial **Lakebed** (LB)	23.70%	0%	• **Disturbed** (D)	0.40%	0%

As noted above, peninsula landforms—and wetlands—were profoundly shaped by the advance and retreat of glaciers from the Kenai and Chugach Mountains and from the Alaska Peninsula across Cook Inlet. Because of how important glacial landforms are in naming and classifying peninsula wetlands, below we briefly introduce the Naptowne glacial period. Effects of Naptowne glaciation led to most of the peninsula wetlands seen today. The following discussion is from the guidebook: *A Guide to the Late Quaternary History of Northern and Western Kenai Peninsula, Alaska*, available as a free download from the Alaska Division of Geological and Geophysical Services (DGGS), see http://www.dggs.alaska.gov/pubs/id/15941. The guidebook describes milepost-by-milepost the glacial history of landforms visible from the main roads of the western peninsula, from just south of Turnagain Arm to as far northwest as Captain Cook State Park and as far south as Homer.

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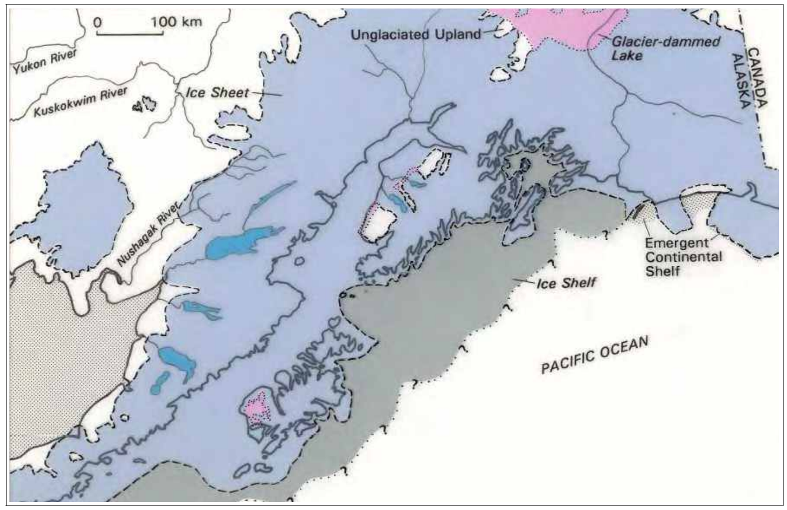
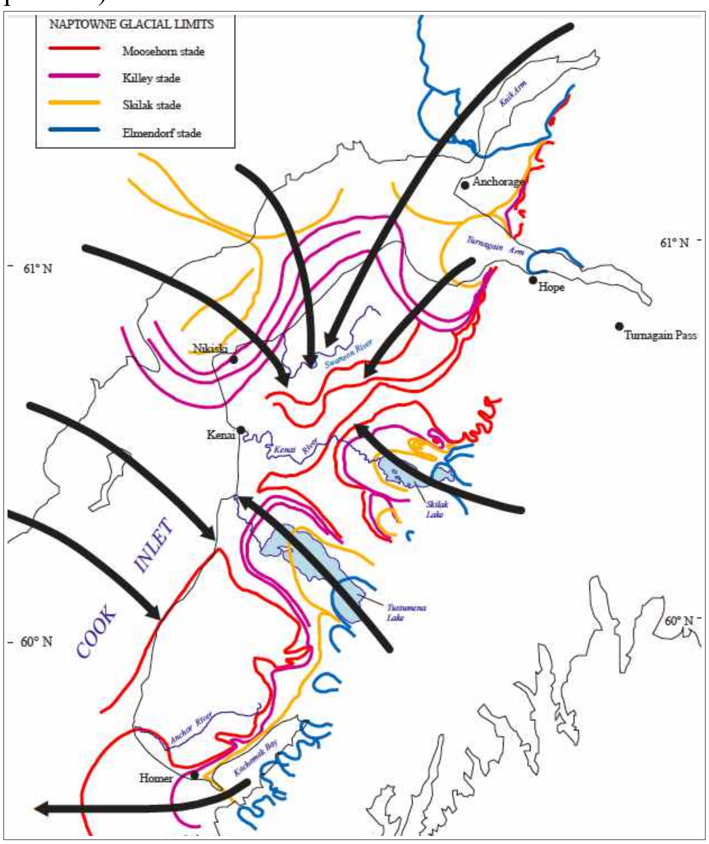
* For more information on NWI specific to Alaska, see: http://alaska.fws.gov/fisheries/ nwi/index.htm.) For an ongoing process to enhance NWI categories, see http://www.wetlandprotection.org/ identify-priority-wetlands/assess-wetland-functions-desktop/34/24-preliminary-assessment-of-wetland-function.htm and http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1325.

14 *Geomorphology* is the scientific study of landforms and the processes that shape them. Geomorphologists seek to understand why landscapes look the way they do, to understand landform history and dynamics, and to predict future changes... (from: http://en.wikipedia.org/wiki/Geomorphology).

As mentioned above, Naptowne glaciation was fundamental in shaping peninsula wetlands. The Naptowne glacial period lasted from about 32,000 years ago to roughly 11,000 years ago. During this period, glaciers advanced and retreated four main times. From oldest to most recent, these advances are named the Moosehorn, Killey, Skilak, and Elmendorf. The most recent—the Elmendorf—peaked about 15,000 years ago and was the least extensive. (The Homer Spit is a submarine terminal moraine left by this last advance.) The **map below** shows the extent of Naptowne advances, and is from the DGGS guidebook introduced above (arrows show direction of ice flow).



The most extensive glaciation of the Naptowne period occurred at the peak of the Moosehorn stade—about 23,000 years ago. At that time, all but two areas of the peninsula were covered by glaciers. These two glacial *refugia*—shown in white in the **map above** (from the DGGS guidebook) were located in the Caribou Hills and the uplands between Skilak and Tustumena Lakes. (Note, even these areas had been ice covered during earlier glacial periods.)

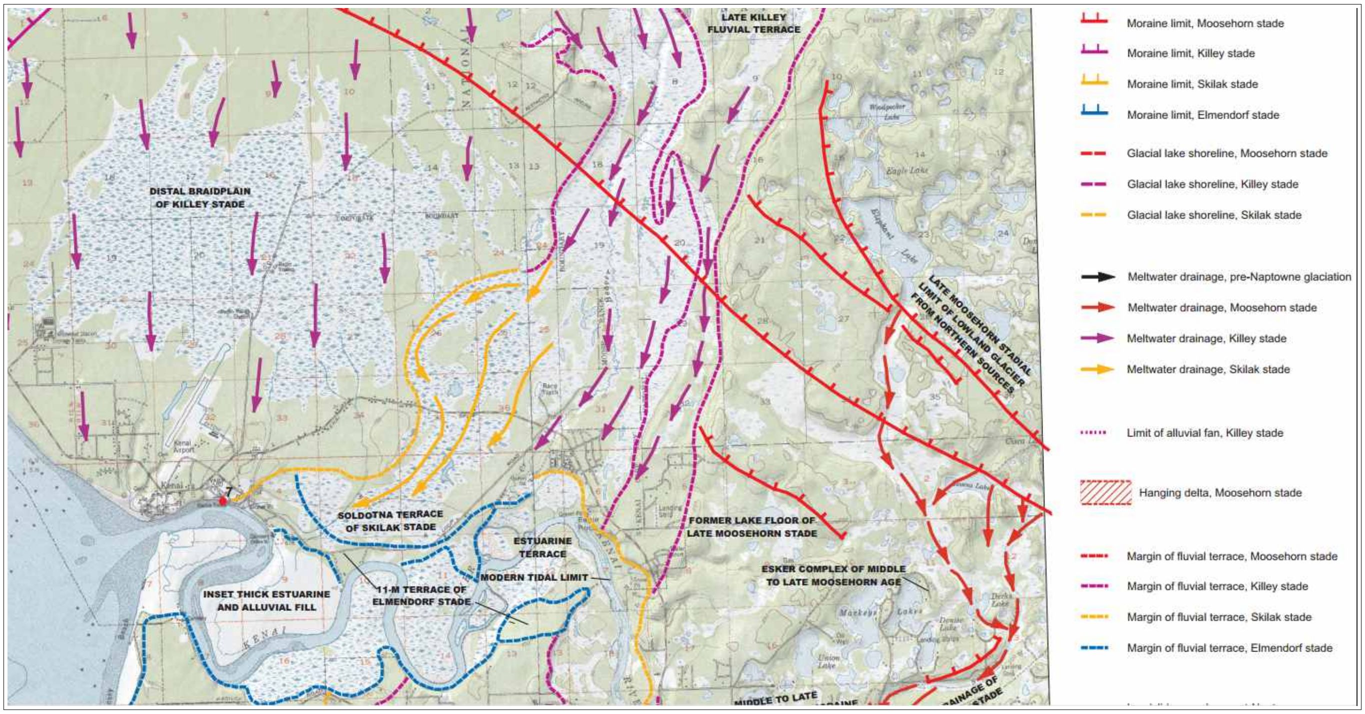


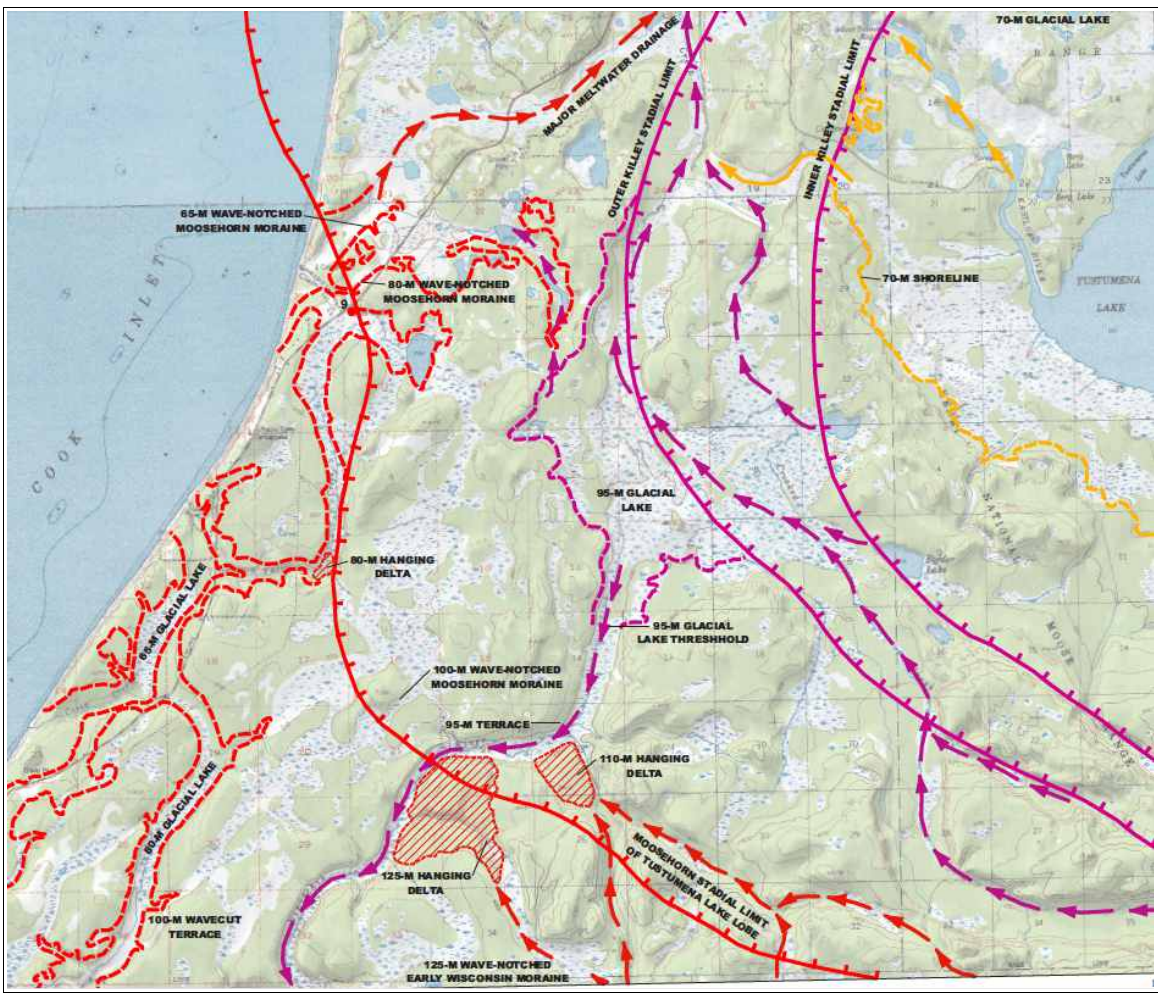
As glaciers advanced, they gouged, scraped and scoured the land, excavating depressions, depositing glacial till[15], and burying large ice blocks. When the climate warmed and glaciers slowly receded, they left behind an altered landscape—pocked with gouges, ridged by moraines, strewn with poorly sorted till, drained by huge meltwater channels, and riddled with blocks of buried ice. As temperatures warmed, wetlands formed in a variety of ways: buried ice blocks melted to create depressions, in many cases filled with water. As these lakes and ponds drained and/or filled with sediments and organic debris, Depression and Kettle wetlands formed. (Depressions differ from Kettles in lacking surface outlets). Lakebed wetlands formed in the bottoms of glacial lakes as they drained and grew shallow; Drainageway wetlands formed in relict meltwater channels; Riparian wetlands spread along developing streams and rivers; Discharge Slopes formed at hillside seeps.

Maps like 2.2a and 2.2b allow you to compare locations of glacial features with different kinds of wetlands (e.g., using wetland maps on the interactive parcel viewer, see Section 2.4).

15 From http://www.kenaiwetlands.net/EcosystemDescriptions/Intro.htm: "Many glaciation events occurred within larger glacial periods... [During] each successive glacial period, glaciation, and glacial advance was less extensive than the previous one... Evidence of glacial advances and retreats is left behind in the form of moraines and associated deposits, known collectively as *glacial till*... The distribution of glacial till is key to understanding the distribution of peninsula wetlands. Where dense, unsorted till is left behind on slopes, a water table is perched, supporting mineral soil wetlands. Where fine-grained silts were deposited at the bottom of glacial lakes and drainage channels, peatlands formed." For more information on peninsula glaciation, see "Glaciation" at http://www.kenaiwetlands.net/EcosystemDescriptions/Intro.htm.

Maps 2.2a and 2.2b: Two portions of map sheets found in the Quaternary guidebook introduced above (http://www.dggs.alaska.gov/pubs/id/15941). Symbols in the legend appear on at least one of the six map sheets in the guidebook but not on all of them. The top map is from Sheet 4 and shows the area north of the mouth of the Kenai River; the bottom map is from Sheet 5 and shows the area west of the outlet of Tustumena Lake.





As suggested above, mapped glacial features—such as moraines, glacial lakes (now empty), and large drainage-way channels that once carried immense volumes of meltwater—are reflected in the locations and types of wetlands we see today; and many of these glacial features gave rise to the geomorphic components used to classify and name Kenai Peninsula wetlands. Table 2.2b and Map 2.2c introduce glacial landform features that gave rise to geomorphic components used in mapping wetlands on the Kenai lowlands.

Table 2.2b. The five major glacial landforms on the Kenai lowlands and their dominant wetland ecosystems (from http://www.kenaiwetlands.net/EcosystemDescriptions/Intro.htm)

Landform features	Predominant location	Landform characteristics	Correlated wetland ecosystem types
Interlobate moraines	Found primarily north of Kenai River, between Cook Inlet and Moose River (between Nikiski and Sterling)	These moraines consist of material re-worked and deposited after a lowlands ice sheet stagnated and melted at the end of the Moosehorn glacial advance. Huge braided outwash streams buried massive stranded ice blocks, which melted under the outwash sediments and formed the kettle-knob landscape. Many small basins are occupied by modern lakes; others are covered by peatlands and surrounded by knobs and modified kames.	Dominated by Kettles and Depressions; poorly integrated relict drainage channels support Relict Glacial Drainageways.
Terraced moraines	Found on the west side of the Caribou Hills	These moraines were covered by a large ice-dammed lake. This lake left massive deposits of fine sand and silt, which now perch a water table, creating conditions conducive to extensive peatland formation on the lower elevation "treads" of terraces. Upper elevation terraces consist of broader "risers" supporting Discharge Slope wetlands and narrower, less extensive peatlands on terrace treads. (Risers are the more or less vertically oriented features between the horizontal treads.)	support flat, linear Relict Glacial Lakebeds and Relict Glacial Drainageway peatlands between terrace risers
Kettle-and-knob topo-graphy	Found (1) along Old Sterling Hwy SE of Anchor Point and (2) around Caribou Lake, about 22 mi NE of Homer	This topography originated when ice lobes stagnated as they melted, leaving behind a kettle-kame landscape in front of a relict glacial lakebed. Low-lying areas were left covered with silt—which perches a water table—and are now covered by lakes or peatlands. After ice blocks melted, glacial till remained behind as small knobs.	dominated by Kettles and Relict Glacial Lakebed; lower slopes of knobs are occupied by forested Discharge Slopes
Moosehorn moraines	Found east of Sterling and west of Tustume-na Lake	Moraines east of Sterling formed at the beginning of the Naptowne glaciation. A large lobe of an advancing glacier from the northern Harding Ice Field pushed across Skilak and Hidden Lakes, terminating just east of Moose River. This large terminal moraine complex probably formed during both a series of glacial surges and recessions and from material deposited in crevasses. Steep-sided parallel ridges isolate the depressions between them. The depressions are preserved because they are young, and erosion has been insufficient to subdue them. Even younger "Killey" advance moraines are prominent between Tustumena Lake and Kasilof and also contain many Depression wetlands. They were deposited later in Naptowne time by the Tustumena glacier advancing across what is now Tustumena Lake.	dominated by Depressions
Caribou Hills	Found at higher eleva-tions of the Caribou Hills (above about 1600 ft)	This landform is composed of high plateaus in the Caribou Hills discontinuously covered by "Eklutna" till. In areas where till remains, it perches a water table and forms Late Snow Plateaus, which are uniformly covered with diverse willow plant communities. Headwater Fens lie at the edges of the Late Snow Plateaus, in the headwater basins of first-order streams, often on a "Knik" glacial surface. This creates a counterintuitive wetland distribution: wetlands above (on Late Snow Plateaus) and below (on dense, Naptowne till), with uplands between (on the steep, well-drained Knik surface[16], from which most of the till has eroded).	dominated by Late Snow, Headwater Fens, and Riparian wetlands (also pre-Naptowne till).

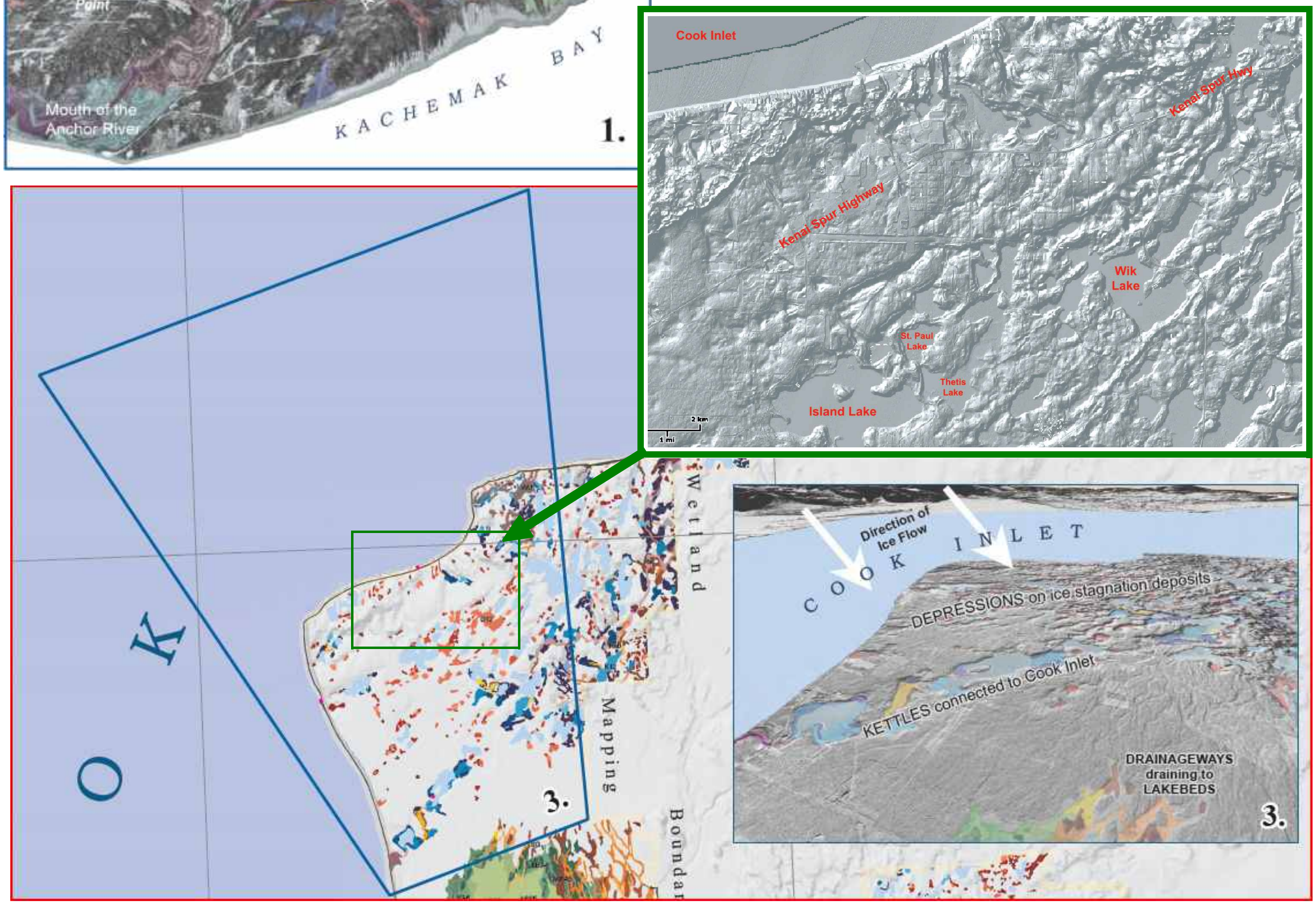
16 The steep-sided **Knik** surfaces lie between about 300 and 500 meters (about 1000-1600 ft) in elevation. Because of the steepness of these slopes, till has eroded away in many areas. Dense glacial till that perches water tables is often absent on Knik surfaces, so they are typically well-drained and often only subtly terraced. Knik surfaces support Headwater Fen Ecosystem wetlands in headwater basins and narrow Riparian Ecosystem wetlands along streams.

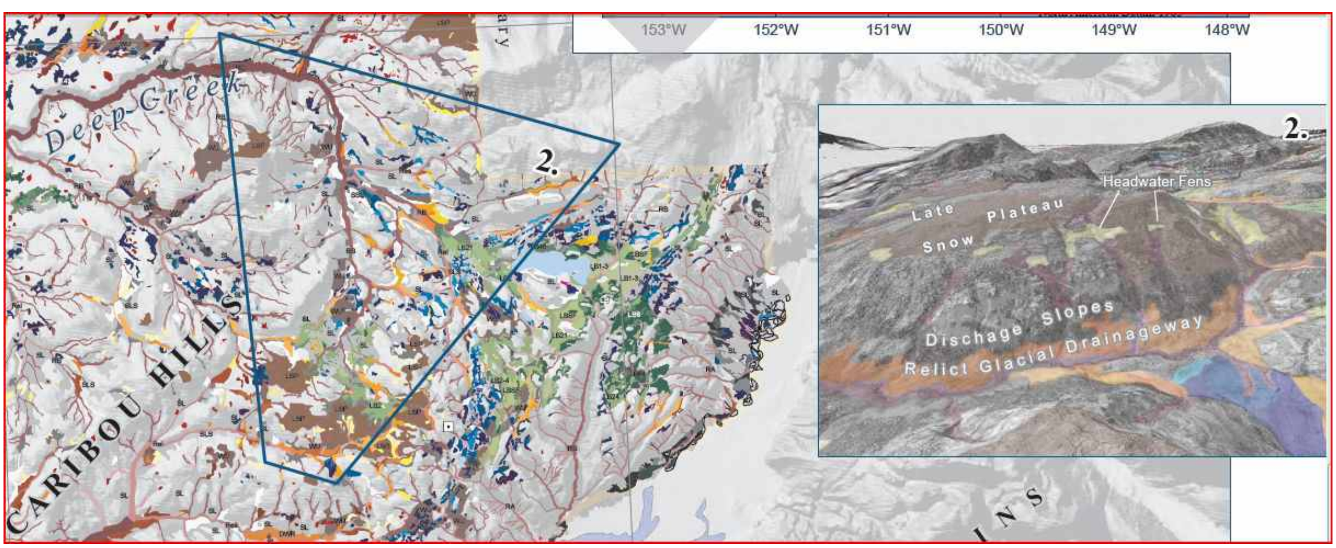
Map 2.2c. Examples of major landform categories on the Kenai lowlands (see Table 2.2b). (From Gracz, M.B., 2012, Sheet 1. Wetlands and Climate. Available at: http://cookinletwetlands.info/downloads/draftsheet1600dpi.pdf.)

To left: Homer area and Anchor River watershed. (The location of this aerial oblique view is shown on Map 2.4b.)

Middle below: Interlobate moraine area northeast of Nikiski (shaded-relief image modified from Kenai Peninsula Borough interactive parcel viewer). Note arrows showing ice flow direction.

Bottom: Caribou Hills area.





2.2.2. Second: understand *hydrologic components* and plant communities

In hydrologic components, the lower the number, the closer the water table is to the surface of the ground.

To create more specific categories for mapping—namely wetland map unit codes[17]—geomorphic categories were further subdivided, generally using ***hydrologic components***. Hydrologic component codes reflect depth and seasonal variability of the water table. There are six numeric hydrologic codes—the lower the number, the shallower the water table. Hydrologic code "1" indicates water standing at the surface (including open water); hydrologic codes "4" or "5" indicate a deep and/or variable water table, and code "6" indicates deep peat.

Five wetland ecosystems were subdivided using hydrologic codes, as shown in Table 2.2c. Four hydrologic codes (1 through 4) were used with Depressions, Headwater Fens[18], and Kettles; five or six codes were used with Drainageways and Lakebeds. All of these wetlands are peatlands—which are discussed in more detail under hydrology functions, see Chapter 3, Section 3.4.3.

The plant communities typically associated with various combinations of geomorphic and hydrologic components were identified during mapping. For an introduction to wetland plant communities on the Kenai lowlands, go to http://www.kenaiwetlands.net/plant_community_classification_i.htm. Descriptions of Seward area plant communities can be accessed at: http://www.kenaiwetlands.net/SEWARD/SewardPlantCommunities.htm.

Table 2.2c. Wetland map unit codes created by combining geomorphic and hydrologic components.

Hydrologic component ➡ (water table depth, variability) / **Geomorphic component** (landform) ⬇	**1 standing water, open water**	**2 water table at or near the surface**	**3 water table not at the surface**	**4 or 5 redoximorphic feature, deep peat, or variable water table**	**6 deep peat**
Depression (**D** code combinations)	**D1**, floating or emergent vegetation	**D2,** sedge or sweet-gale dominant	**D3**, shrubs or bluejoint grass dominated	**D4**, woodland or forest	
Drainageway (**DW** code combinations)	**DW1**, floating or emergent vegetation	**DW2**, sedge, buck-bean and/or sweet-gale	**DW3**, hummocks, tussocks, usually with shrubs	**DW4**, variable water table, bluejoint dominated **DW5A**, peat or redox, forested **DW5**, peat, sphagnum, not forested	
Headwater Fen (**H** code combinations)	**H1**, small headwater lakes	**H2**, headwater sedge peatland	**H3**, headwater shrub or bluejoint peatland	**H4**, headwater woodland/ forested peatland	
Kettle (**K** code combinations)	**K1**, submerged, floating, or emergent vegetation	**K2,** sedge and/or sweetgale	**K3**, usually shrub dominated	**K4**, woodland or forest, can include bogs	
Relict Glacial Lakebed (**LB** code combinations)	**LB1**, floating or emergent vegetation	**LB2**, sedge and/or sweetgale	**LB3**, well-developed sphagnum peat, sometimes w/sedge and/or shrubs	**LB4**, shrubby strangs **LB5**, bluejoint dominated	**LB6**, woodland or forest

Photographic examples of main wetland ecosystem types, including a variety of their wetland map unit codes, are provided in Section 2.3. (Additional photographic examples of Discharge Slope wetlands are provided on the next page.)

17 Each more-or-less homogeneous wetland area that could be distinguished on 1:24,000-scale aerial photographs was outlined, creating a wetland polygon with a unique identifying number. Numbered polygons were then named using appropriate wetland map unit codes based on air photo interpretation and follow-up ground truthing.

18 Headwater fens should be distinguished from bogs, though both are peatlands. Fens are fed by mineral-rich surface water or groundwater (or blown volcanic ash). As a result, their pH is neutral or alkaline, with relatively high dissolved mineral levels but few other plant nutrients. In bogs, peat builds up into mounds that hold precipitation-derived water in pore spaces, above the zone where shallow groundwater discharges into the peat (see discussion of hydrology function 1). Unlike fens, bogs are characterized by low pH and mineral content and lack certain plant species found in other peatlands. Bogs are uncommon on the Kenai Peninsula, probably because frequent volcanic ash deposition supplies enough mineral content to porewater within the peat even when mineral-rich groundwater inflow is absent.

For wetlands mapped as Discharge Slope (S) geomorphic components, dominant plant communities were used for subdividing them into more detailed map units. Together, the Kenai lowlands and Seward area encompass 25 Discharge Slope map unit codes—23 in the Kenai lowlands and 2 in the Seward area (see Tables 2.2e and f). The plant community codes listed below were used to modify Discharge Slope (S) geomorphic components; so, for example, SS is a Discharge Slope polygon dominated by willows (*Salix*). Multiple modifiers can be used in naming map units (see Table 2.2d). Four kinds of S wetlands are illustrated below, all from the Kenai lowlands except for the Seward wetland in the lower right photo.

A = Alnus (*Alnus* species, or alders)
C = Calamagrostis (*Calamagrostis canadensis*, which is bluejoint grass)
G = glauca (*Picea glauca*, white spruce)
L = Lutz (*Picea* x *lutzii,* Lutz spruce, a cross between white and Sitka spruce common on the peninsula)
M = mariana (*Picea mariana*, black spruce)
P = Picea (*Picea sitchensis*, Sitka spruce, found at two sites in the Seward area)
S = Salix (*Salix* species, willows)

SLM wetland near Stariski Creek (polygon 2832).
http://www.kenaiwetlands.net/MapUnitDescriptions/Smx.htm

SSC wetland near the Village of Nikolaevsk (polygon 7171).
http://www.kenaiwetlands.net/MapUnitDescriptions/SSC.htm

SSL wetland located along East End Road about 15 miles northeast of Homer (polygon 10832).
http://www.kenaiwetlands.net/MapUnitDescriptions/SLS.htm

Larger of two SPS wetlands mapped in Seward area; opening is dominated by willow, sedge, and bluejoint reedgrass This wetland is diverse, consisting mainly of a spruce forest but also supporting this and other openings, in addition to small upland areas.
http://www.kenaiwetlands.net/seward/MUdescriptions/SPS.htm

2.2.3. Third: understand the system used to classify R (riverine/riparian) wetlands

Geomorphic components mapped as R indicate riparian and riverine wetland ecosystems. For mapping and classification, streams and their associated valley wetlands were mapped together, as a single wetland polygon; streams were not separately outlined as waterbodies (see Figure 2.2b, below). R wetlands are characterized by water flowing in a channel and water that has leaked out of the channel and now flows beneath it and adjacent to it in the *hyporheic zone* (see **figure at right**). (Hyporheic water also flows back into stream channels, depending on water pressure gradients.) On the Kenai Peninsula, many R wetland ecosystems are particularly critical to salmon and other aquatic life because of their effects on instream habitat conditions.

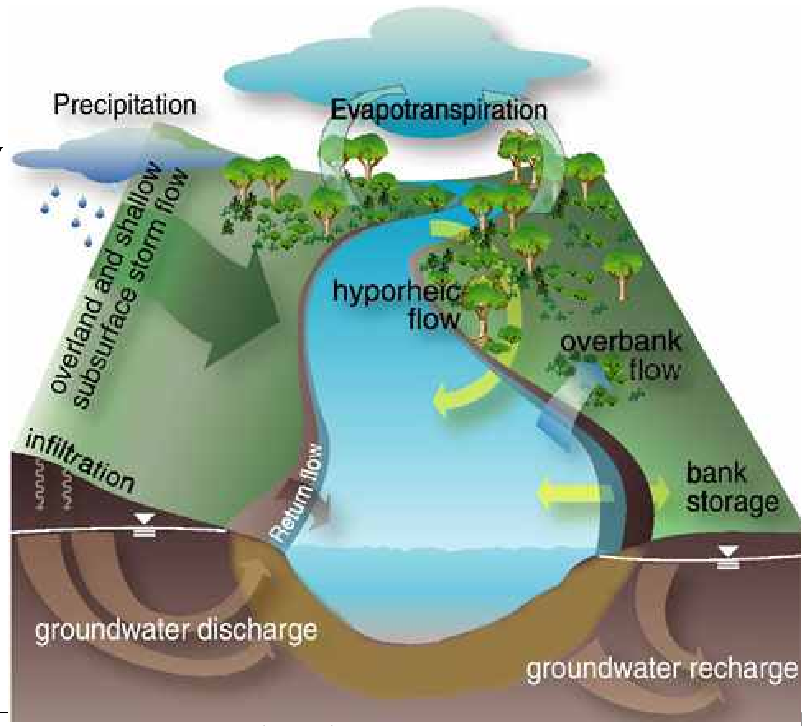


Figure 2.2c (at right). The hyporheic zone. Hyporheic flow is the shallow groundwater flowing immediately beneath and adjacent to stream channels. It can extend many feet below and to the sides of the channel (from: http://www.nap.edu/openbook.php?record_id=10327&page=429).

Figure 2.2b (below). Wetland map showing R wetland polygons. R wetlands (in blue) encompass both stream channels and associated valley bottom wetlands; look closely in blue polygons to see the thin thread of stream channel (from KPB interactive parcel viewer).

2.2.3.1. Background on peninsula streams and rivers

Streams and rivers on the Kenai Peninsula are either glacier fed or not. Within the study area, glacier-fed rivers include Kasilof, Kenai, Fox, Resurrection, and Snow Rivers. Glacier-fed river systems having large lakes—i.e., the Kenai and Kasilof—differ significantly from glacier-fed systems lacking such lakes. Kenai and Skilak Lakes in the Kenai River system, and Tustumena Lake in the Kasilof River system, allow heavier sediments to settle out. As a result, rivers draining these lakes carry less sediment than other glacier-fed rivers. Heavy sediment loads cause Resurrection, Snow, and Fox Rivers to have braided channels (see stream types D and DA in Figure 2.2d).

Rivers fed only by precipitation (rainfall and snowmelt) and groundwater include Anchor River, Deep Creek, Ninilchik River, and Stariski Creek. Seasonal flow patterns for precipitation-fed rivers generally differ significantly from those of glacier-fed rivers. Glacier-fed rivers tend to flow highest in the warmest summer months, when glaciers are melting most rapidly. Precipitation-fed rivers flow highest during periods of heavy rain, for example, during September and October rainstorms. R wetland hydrology is affected by such seasonal patterns.

Peninsula streams exhibit many kinds of channel patterns, which reflect the processes shaping them. Channel-forming processes in turn affect wetland development adjacent to streams. Stream channels can be straight or meandering, single or braided, underfit[19] or valley-forming, free to weave across flat floodplains or entrenched between confining bluffs, sluggish and dominated by pools or fast and turbulent. Depending on factors such as topography, geology, climate patterns, and volume and timing of streamflows, streams and their wetlands interact in complex and dynamic ways, and these interactions can change along the length of a stream from its headwaters to its mouth. (See Hydrology function 5: natural flow regimes, Chapter 3, Section 3.4.3.5.)

Given the importance of such relationships, characterizing stream channels in a meaningful way during wetland mapping was a high priority. Over the years, many systems for classifying stream and river channels have been developed. One of the systems most commonly used was developed by David L. Rosgen (see, for example, *A Classification of Natural Rivers* at http://www.alpine-eco.com/files/Rosgen_ClassificationNaturalRivers.pdf). Rosgen's system provided the basis for classifying stream channels during peninsula wetland mapping. For this reason, the system used is briefly introduced below. It's important to understand that different segments of a river or stream can fall into different classification categories. For example, small headwaters (first order streams) will tend to be Aa+ or A in the Rosgen system, whereas many rivers towards their mouths will be C or E types. Rosgen categories are illustrated below, followed by examples from the Kenai Peninsula.

2.2.3.2. A brief introduction to Rosgen and Silvey's stream classification system

For mapping and classification, R wetland ecosystems (riverine/riparian) were subdivided using a stream classification system modified from Rosgen and Silvey. Because the Rosgen system is so commonly used, the EPA has developed an online module to teach it. The module introduces the basics of the classification system using text and visuals reproduced by permission from Rosgen, D.L. and H.L. Silvey, 1996, *Applied River Morphology* (Wildland Hydrology Books, Fort Collins, CO). The module can be found at http://cfpub.epa.gov/watertrain/index.cfm under Analysis and Planning Modules. Highlights of the system are provided below, largely excerpted from the EPA module. These are followed by examples of R wetland types found among Kenai Peninsula wetlands.

Rosgen Level I: This is the most general level in the Rosgen stream classification system (see Figure 2.2d). Stream types are labeled from Aa to G. Level I is based on stream characteristics resulting from relief, landform, and valley morphology—features that are generally observable on aerial photos and maps . Level I stream classification provides a general characterization of valley types (illustrated in Figure 2.2e) and identifies major stream types corresponding to particular valley types. Level I serves four primary functions:

1. provide for the initial integration of stream system morphology with basin characteristics, valley types, and landforms.
2. provide a consistent initial framework for organizing river information and communicating aspects of river morphology. Mapping of physiographic attributes at Level I can quickly determine location and approximate percentage of river types within a watershed and/or valley type.
3. assist in setting priorities for conducting more detailed assessments and/or companion inventories.
4. correlate similar general level inventories—such as inventories of fisheries habitats, river boating categories, and riparian habitats—with companion river inventories.

19 Underfit streams are too small to have carved the valleys through which they now flow; their oversized valleys were carved by much larger volumes of meltwater pouring from melting glaciers. Modern underfit streams flood because slopes are nearly flat. Point bars and cutbanks are absent. Maps 2.2a and b, above, indicate location and direction of some of the larger flows that were fed by melting glaciers.

Figure 2.2d. Diagram comparing slope, cross-sectional (bank-to-bank), and plan (as seen from above) views of each of the nine major stream types in Rosgen's Level I stream classification system.

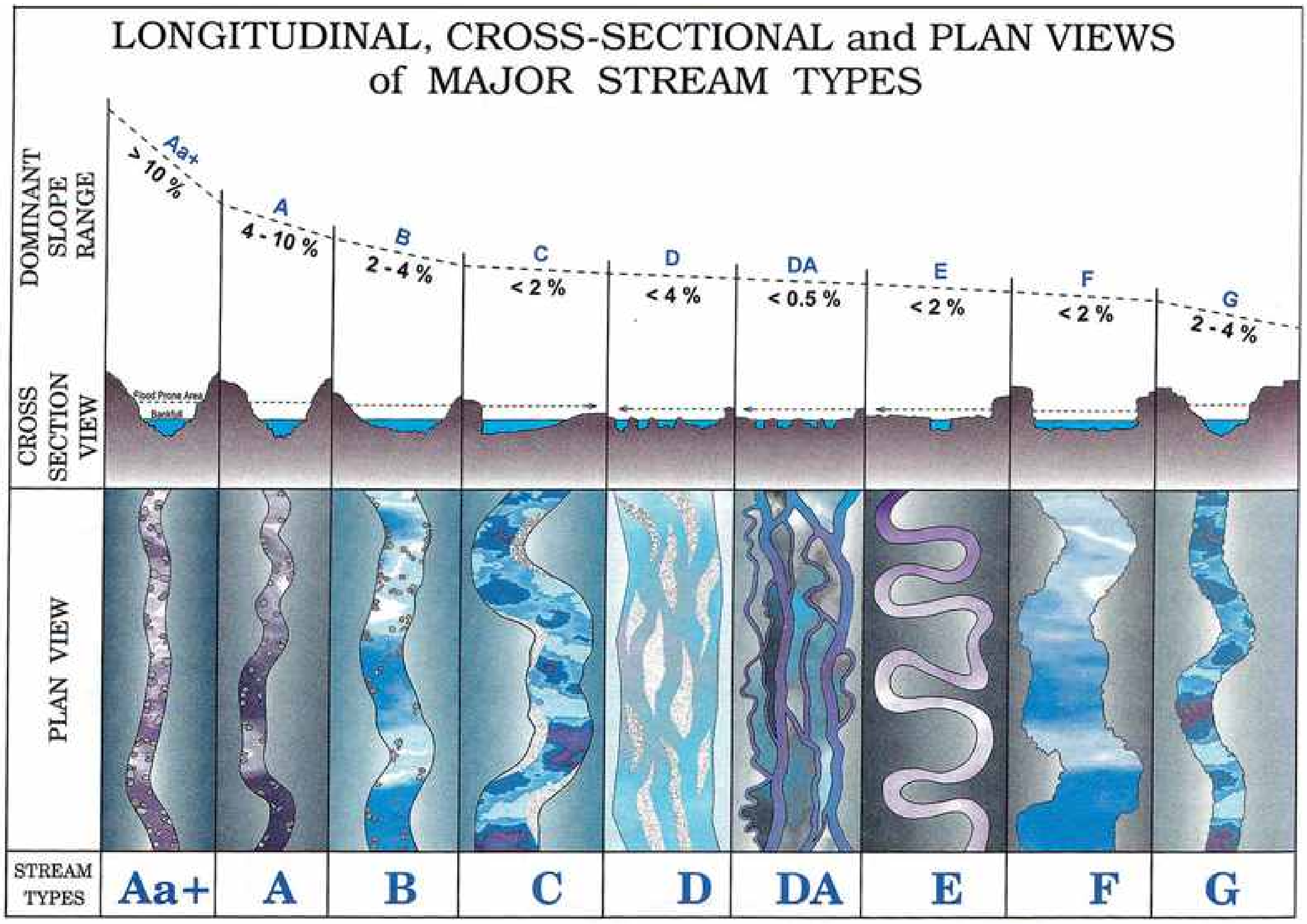
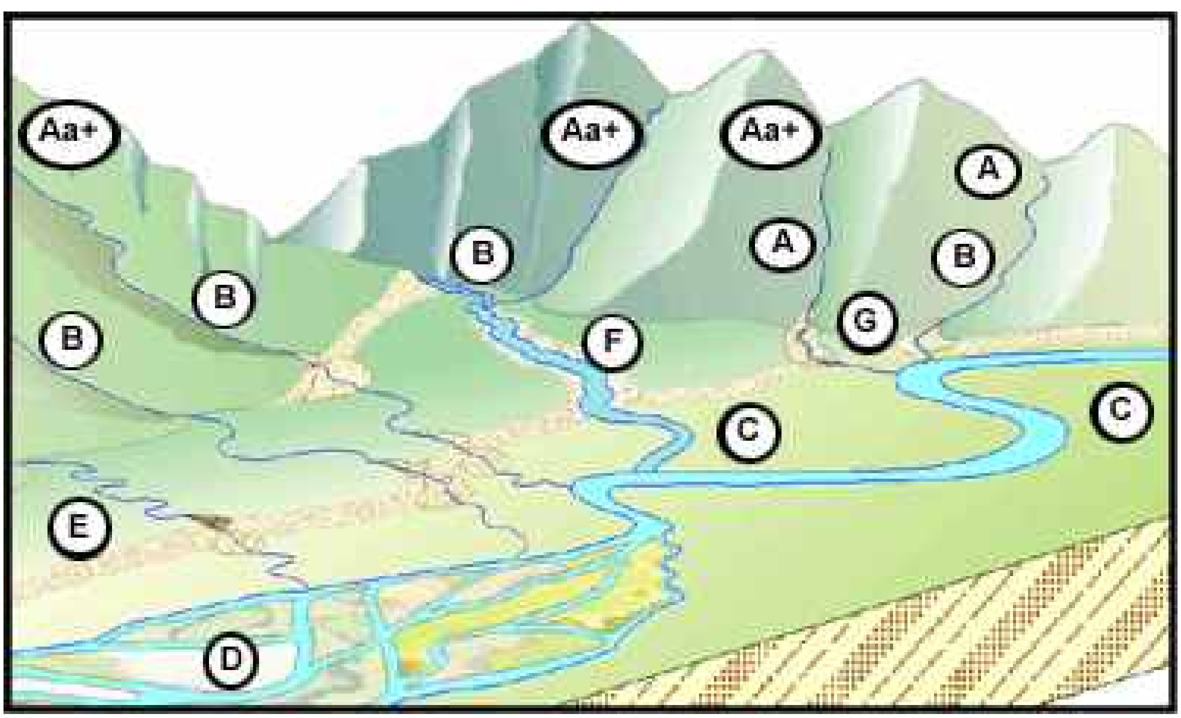


Figure 2.2e. Rosgen Valley Types. Seven of eleven Rosgen valleys types are identified here with associated stream types.



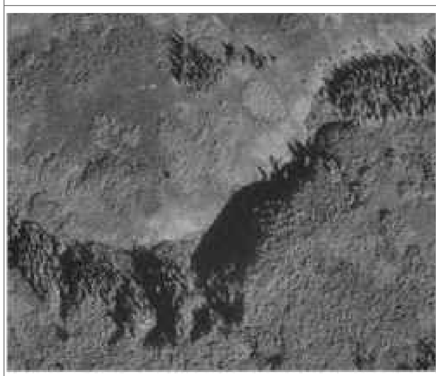
Beyond Level I, Level II stream types are determined with field measurements from specific channel reaches and fluvial features within a river's valley. Level II classification uses more finely resolved criteria in order to address questions of sediment supply, stream sensitivity to disturbance, potential for natural recovery, channel response to changes in flow regime, fish habitat potential, and other issues critical to stream management.

2.2.3.3. Rosgen and Silvey stream classification system as applied on the Kenai Peninsula

(Descriptions and images below are from http://www.kenai wetlands.net/EcosystemDescriptions/Riparian.htm, a source of much more detail than can be provided here.) As noted above, during Kenai Peninsula wetlands mapping, Rosgen's river classification system was used as a basis to classify R wetlands—that is, stream reaches and their associated valley bottom wetlands. R wetland polygons were classified using a modification of Rosgen Level I, including some references to Level II categories. Three Level I types (see Figure 2.2d) are common on the Kenai lowlands: Types B, C, and E, illustrated below; a fourth type, D, is common in the Seward area.

Stream code	Stream channel description	E reach subtypes based on channel sinuosity and form (Sinuosity is explained in the text box on the next page.)	
A	entrenched, steep gradient (4-10%), cascading, step-and-pool reaches, with cataracts and waterfalls		
B	moderately entrenched, riffle-dominated upper reaches with narrow fringe wetlands	**l** subtype of E (linear)	sinuosity less than 1.3, often less than 1.2
C	characterized by riffle/pool morphology with point bars and broad fringe wetlands on floodplains	**s** subtype of E (sinuous)	sinuosity greater then 1.3
D	braided glacial rivers (**F** subtypes are in floodplains, **T** subtypes are on river terraces)	**b** subtype of E (bankfull)	bankfull linear or sinuous reaches backed up by obstructions such as beaver dams or culverts
E	(e = "evolutionary") slightly entrenched, stable, pool-dominated in relict glacial channels (underfit), support wide fringe wetlands	**a** subtype of E	channels not visible on 1:24,000 aerial photos but inferable from other patterns or obvious during field visit

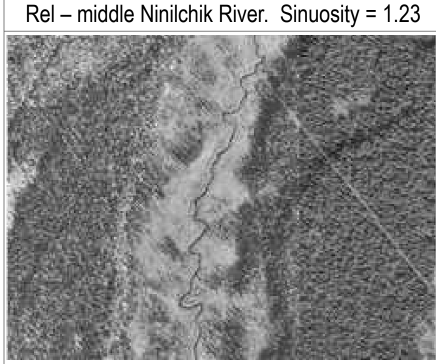
Type B stream draining the Epperson Knob area on the southern Kenai lowlands. Notice the deeply entrenched channel, with very narrow fringing wetlands.



Type C stream. Deep Creek, east of the Sterling Highway. Notice the cut-banks at outer bends and point bars at inside bends.

Type E (or e) stream. The much larger forerunner of Ninilchik River drained a now vanished meltwater lake; the modern river is underfit and here meanders crazily in its oversized valley (see Map 2.2b).

Sub-type El (or el) stream reach. Rel – middle Ninilchik River. Sinuosity = 1.23

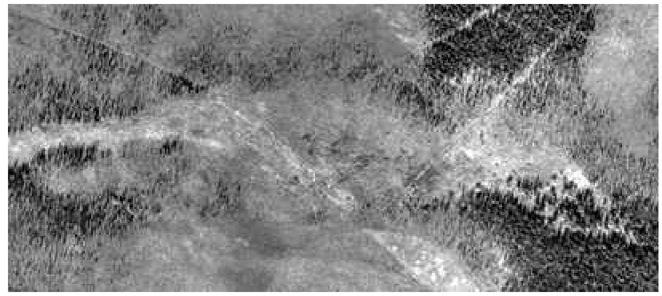


Sub-type Es (or es) stream reach. Res – middle Stariski Creek. Sinuosity = 2.52

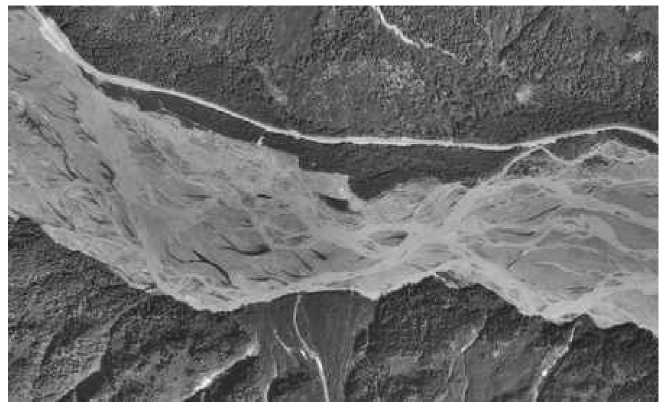
Sub-type Eb (or eb) stream reach. Reb – Soldotna Creek.

A fifth type, DA, describes small, multiple-channel reaches and associated wetlands occurring where the stream reach fans out onto a glacial terrace, usually in a peatland. Steep, entrenched A stream reaches, with rapids, waterfalls, and narrow associated wetland margins, occur along a few streams, such as McNeil and Falls Creeks, which flow into Kachemak Bay.

E (or e) reach.
The middle Ninilchik River. Notice the mismatch between the meander geometry of the oversized, glacial-meltwater valley and the modern underfit stream channel.



RDA reach.
The reach flows from a channel in the forest at photo right, to a braided stream across the peatland, and again becomes channelized at left.

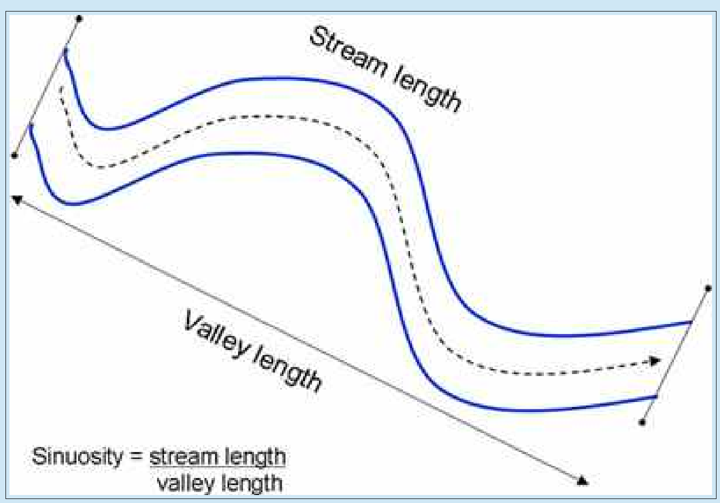


D reach.
The Resurrection River west of the Seward Highway. Notice the multi-threaded channel and the numerous short, clearwater channels originating from hyporheic flow (the short, dark-colored branches flowing into the silty main threads).

Sinuosity measures the "curviness" of a stream channel as viewed from above. Sinuosity is calculated by dividing the actual "stream length" of a channel segment by the straight-line length of the same segment, typically called "valley length "(see diagram at right, from http://ag.arizona.edu/watershedsteward/resources/module/Stream/stream_proc_page5.htm).

A stream with a sinuosity of 1 is relatively straight, As a stream meanders more, its sinuosity increases.

Sinuosity tends to be inversely related to channel slope, meaning steep slopes with fast-moving streams generally have lower sinuosity values than flatter slopes with slower-moving streams, which tend to meander more.



The following descriptions are derived from http://www.kenaiwetlands.net/EcosystemDescriptions/Riparian.htm.

Type A reaches

Only a few RA reaches were mapped (on the Kenai lowlands), e.g., reaches along McNeil and Falls Creek, which flow down steep bluffs into Kachemak Bay. These reaches support very narrow fringe wetlands adjacent to the channel.

Type B reaches

(Illustrated at right by a wide B reach—the East Fork—along the Seward Highway. Fringing wetlands are absent, or very narrow.)

On the Kenai lowlands, many streams begin as moderately entrenched B reaches. The dominant B types at Level II in Rosgen's classification are B4, with moderately steep valley walls and beds dominated by gravels, and B3, where cobbles dominate the bed material. B reaches have very narrow wetland fringes, if at all.

On many upper B stream reaches, a steeper, more entrenched upper valley abruptly becomes narrower and less entrenched. This marked change in valley cross-section occurs where a glacial advance pushed material partway up the valley, sometimes changing the stream's course. This process can easily be observed east of Homer, along the south slope of Bald Mountain where a late-Wisconsin (Killey) glacial advance stopped well below the summit. The upper valleys are steep and their streams well entrenched. Downstream, the valleys abruptly flatten, and still further downstream, they change course abruptly to the west when they encounter the moraine that Hutler Road follows.

Type B reaches frequently flow into Type E reaches.

Type E (e) reaches

(Illustrated at right by an underfit E stream reach emerging from a culvert in a wide valley near Clam Gulch.)

On the Kenai Peninsula, E reaches are slightly entrenched, stable, low gradient, pool-dominated reaches with low width/depth ratios, densely vegetated banks, low sinuosity (though the typical Rosgen E reach has high sinuosity), and narrow, active floodplains. Although many E reaches have narrow active floodplains and stable banks, occasional abandoned channels and oxbows are evident, and steep valley walls are distant from the channel. E reaches often have wide wetland fringes, fed by overbank flooding, groundwater discharge along the valley walls, and hyporheic flow discharge.

Type E reaches occur on relict glacial deposits, for example, those within wide valley bottoms cut by large amounts of Pleistocene glacial meltwater and those on relict glacial lakebeds. A good example of the former is the upper and middle portion of the Ninilchik River, shown earlier in the photographic example of an E reach. The most common reach types are E3 and E4 at Rosgen Level II, with cobble or gravel beds, respectively.

Type E reaches typically flow into C reaches.

Type C reaches

(Illustrated at right by Deep Creek near its mouth, a point bar has formed on the inside of the meander bend—on the right of the photo.)

C reaches are probably the most familiar channel type—with cut banks eroding at the outside bends, point bars forming on inside bends, and wide active floodplains. Many C reaches in the Cook Inlet Basin are underfit— flowing in oversized valleys—but still support wide, active floodplains. Although portions of the floodplain may not meet wetland criteria today, the stream will eventually meander to every part of the floodplain. Wetlands on the floodplain are abandoned oxbows, which are fed by hyporheic discharge or overbank flooding or by shallow groundwater discharge at the toeslopes of valley walls.

Uncommonly, some wetlands adjacent to C reaches are relict abandoned meander terraces, which were formed when the river drained a glacier at the end of the last glacial maximum and are now peatlands situated on terraces above the modern floodplain. C reaches can also flow in broad Pleistocene drainageways, but have point bars, floodplains and, on the Kenai lowlands, greater sinuosity than typical E reaches. At Rosgen's Level II, the dominant types are C3 (on cobbles) and C4 (on gravels). Stream type is independent of stream size— smaller C streams can flow into larger C steams.

The lower reaches of Anchor and Ninilchik Rivers and Deep Creek are good examples of C reaches on the Kenai lowlands, where terrace building and steep bank erosion on a broad floodplain is common. On smaller type C reaches, such as lower Stariski Creek, the floodplain is narrower, not as active, and the underfit nature of the stream is more evident.

Frequently, B reaches will flow directly into C reaches with no intermediate E reach. Short-run B reaches are also common along the coastal bluffs. Streams are frequently heterogeneous. An E reach on a terrace tread will flow into a C or B reach across a riser, then back to an E reach on a lower tread, with no change in stream order.

Type D reaches

(Illustrated at right by the Resurrection River in Seward. The sparse willow vegetation can potentially be replaced by a flowing channel thread at any time following a high flow event.)

These are large, braided systems fed by glacial discharge. These reaches form aggrading *braidplains* (where sediments are building up) and are very different from the meandering C stream model of cut banks and point bars. Aggradation can be extreme, especially on the braidplain of the Resurrection and Salmon Rivers near Seward, where single flood events can raise portions of the plain a meter or more above the previous channel level. Braidplains are extremely active and are often sparsely vegetated, but they can support less active floodplain wetlands along their margins. A braided thread of the river channel can potentially shift its flow to any portion of the wide braidplain.

Tidally influenced river reaches (Rt) and Abandoned Meander Terraces and Channels (AMT)
Two Riparian ecosystem mapping components are not part of Rosgen's classification. These are tidally influenced river reaches (Rt) and abandoned meander terraces and channels (AMT).

Rt map units are tidally influenced streams and rivers. On shorter run streams, this distance is not mappable at a scale of 1:24,000, although it certainly exists. The two large glacier-fed rivers, the Kenai and the Kasilof, have extensive zones influenced by saltwater. The tidal influence extends 12 miles up the Kenai River and about 6 miles up the Kasilof. On the larger clearwater (non-glacial) streams and rivers, such as Deep Creek and Anchor River, the highest spring tides move about a mile upriver, or a little less, Tidal (estuarine) influence is defined as water with salinity greater than about 0.5 parts per thousand. These salinity measurements have not been formally made or published for western Kenai estuaries; mapping of Rt units reflects local knowledge, especially that of Robert Begich for southern peninsula streams, and Larry Marsh for northern streams, both biologists with the Alaska Department of Fish and Game.

Abandoned Meander Terraces and Channels (**AMT**) are relict features that were created when the glacier-fed rivers were larger or outburst floods more intense. These features, which are limited to a few lower reaches of the Kenai and Kasilof Rivers, are now occupied by peatlands.

Summary of R Wetland Ecosystem map units (if viewed as a pdf, links are active):

(See: http://www.kenaiwetlands.net/MUsummary.htm.)

- AMT – Abandoned meander terraces and channels. Limited to a few reaches along the Kenai and Kasilof Rivers.
- RA – Entrenched, steep gradient (4-10%), cascading, step-and-pool reaches, with cataracts and waterfalls.
- Rel – Linear, low gradient, pool dominated, on glacial deposits.
- Res – Sinuous, low gradient, pool dominated, on glacial deposits.
- Reb – Bank-full due to beaver dam, roads, logging debris or natural obstruction. Low gradient, on glacial deposits.
- Rea (Reac) – Stream surface not discernible on 1:25,000 B&W aerial photography. Usually low gradient, pool dominated, but occasionally would fit the B reach type. On glacial deposits.
- RB – Higher gradient (>2%); riffle dominated.
- RC – Floodplain developed. Point bars. Riffle/pool morphology.
- RDA – Multiple braided, low gradient, pool-dominated channels on glacial deposits.
- Rib – River islands and bars. These flood frequently or have a shallow water table; they are found primarily in and along the Kenai River, with a few also along the Kasilof River, and fewer still along Deep Creek.
- Rt – Tidally influenced river or stream. Usually too small to map but extends about a mile on larger streams, and several miles on the Kasilof and Kenai Rivers.

Codes exclusive to the Seward area (See http://www.kenaiwetlands.net/SEWARD/MUdescriptions/MUsummary.htm.)
Within RD (braided) channel codes, "C" stands for main channel, "SC" stands for side channel, "F" stands for floodplain, and "T" stands for river terrace. Numbers indicate bed material: 3 = substrates dominated by cobbles, 4 = substrates dominated by gravel.

- RD3C – Braided main channels (RD__C) with bed material dominated by cobbles (3), on glacial deposits.
- RD4C – Braided main channels (RD__C) with bed material dominated by gravel (4), on glacial deposits.
- RD4SC – Braided river **s**ide **c**hannels (RD__SC) with bed material dominated by gravel (4)..

- RD4T1 – Lower terraces of braided rivers.
- RD4T2 – Upper terraces of braided rivers.

RD4Fx – Floodplain wetlands:

- RD4F1 – Floodplain wetlands dominated by open water and floating or emergent plants.
- RD4F2 – Floodplain wetlands with water table at or very near the surface; typically dominated by sedges or bluejoint reedgrass.
- RD4F3 – Floodplain wetlands with water table near the surface; typically dominated by alder or willow.
- RD4F4 – Forested floodplain wetlands.

2.2.4. Understanding wetland map unit codes

2.2.4.1. Conventions for creating map unit codes

Often, a wetland polygon will encompass more than one kind of map unit. For example, a Kettle (K) wetland may have open water at its center (map unit code K1), but the water table may be farther from the surface (deeper) as one moves towards the Kettle's upland boundary (K3 and K4). If any of these wetlands cover more than 10% of the polygon, their codes are incorporated into the map unit code used for that polygon. Codes are combined according to the naming conventions listed in Table 2.2d (slightly modified from http://www.kenai wetlands.net/MUsummary.htm).

Table 2.2d. Conventions used to name wetland map units using geomorphic components, hydrologic components, and plant communities (minimum mapped polygon equals roughly 0.5 acres).
• Wetland ecosystems are divided into components, mostly based on geomorphology and hydrology.
• Map unit names are derived from an abbreviation of the name of the wetland ecosystem they occur in, followed by a numerical modifier indicating the components within the ecosystem (e.g., K1 is in hydrologic zone 1 of the Kettle ecosystem).
• A map component with standing water or a water table near the surface is usually given a lower number than a component where wetland status is only indicated by redoximorphic features near the surface. Sedges often indicate a shallower water table; shrubs and trees often indicate a deeper water table.
• Two ecosystems (R and S) use a different component naming scheme; in these cases a **letter** follows the wetland ecosystem code. Riparian ecosystem names are modified based on Rosgen's stream classification (introduced above). Discharge Slope ecosystems are based on dominant plant species (e.g. 'SA' is a Discharge Slope dominated by *Alnus*, or alder).
• Map unit names can be combined using any combination of two components, even across wetland ecosystems. Combined names indicate either a complex of separate components smaller than the minimum polygon size, or a more or less uniform polygon with characteristics of two components (e.g., LB12 indicates a polygon on a Relict Glacial Lakebed composed of both hydrologic components 1 and 2 at more than 10% cover. LB1DW2 indicates a polygon with both Relict Glacial Lakebed emergent and Relict Glacial Drainageway shallow groundwater components).
• To be included in the map unit name, a component must represent at least 10% of the mapped polygon area. The most abundant component is named first; if each covers an equal area, they are listed alphanumerically.
• If more than two components, each less than the minimum polygon size, comprise more than about 10% of the cover of a polygon and they are in sequential order, then a code including a dash can be used (e.g. K1-3; indicates a polygon with all the components K1, K2, and K3 present at more than 10% cover).
• If more than two components are present, but not in sequential order, i.e., one or more components are skipped, then a "complex" needs to be named separately. Complexes are named on a case-by-case basis and must represent common wetland units. So far three have been named, LBSF (the lakebed strang-flark complex), DWR, and Tr.

Note: **two additional modifiers** are sometimes added at the end of map unit codes: "d" means the wetland is disturbed but its original components can still be discerned; "c" means the wetland is human created, for example a dammed or excavated pond. Most created ponds will be classified as Kettles.

2.2.4.2. Map unit codes used on the Kenai lowlands and in the Seward area

Tables 2.2e and 2.2f list all the wetland map unit codes used in mapping (and now assessing) wetlands on the Kenai lowlands and in the Seward area. These tables also show the acreage of each wetland ecosystem category and the percent it represents of total mapped wetlands. (Total mapped area was about 809,000 acres in the Kenai lowlands and about 24,600 acres in the Seward area.)

If Tables 2.2e and 2.2f are viewed as a pdf, clicking on a wetland ecosystem type (geomorphic component) in the left column jumps to a description and idealized cross-section of that ecosystem (as shown in Figure 2.2f). Clicking on a map unit code in the right column jumps to a description of that kind of map unit and photographs of examples (for example, photographs below and in Section 2.3).

Table 2.2e. Map unit codes used during wetlands mapping on the Kenai lowlands
(from http://cookinletwetlands.info/ and http://www.kenaiwetlands.net/) (See Table 2.2d for conventions used in combining codes.)

Wetland ecosystem types and codes	Acres	% of wetland acres	no. of polygons	Map unit codes used (clicking on codes jumps to online descriptions and photos)
D – Depression	11,205	3.2	2,081	D1, D12, D13, D1-3, D14, D1-4, D2, D21, D23, D24, D2-4, D3, D32, D34, D4D42, D43
DW – Relict Glacial Drainageway (DWR = Drainageway complex)	43,139	12.3	2,133	DW1, DW12, DW1-3, DW1-4, DW1-5, DW1-5A, DW2, DW21, DW23, DW24, DW2-4, DW25, DW2-5, DW25A, DW2-5A, DW3, DW31, DW32, DW34, DW35, DW3-5, DW35A, DW3-5A, DW4, DW42, DW43, DW45, DW45A, DW4-5A, DW5, DW5A, DW52, DW53, DW54, DW55A, DW5A2, DW5A3, DW5A4, DW5A5, DW3T6, DWR
FI – Floating Island	33	0.01	5	FI
H – Headwater Fen	2,684	0.8	265	H1, H13, H1-3, H2, H21, H23, H2-4, H3, H32, H34, H4, H43
K – Kettle	48,138	13.8	3,519	K1, K12, K13, K1-3, K1-4, K2, K21, K23, K24, K2-4, K3, K31, K32, K34, K42, K4, K43
LB – Relict Glacial Lakebed (LBSF = Lakebed complex, same as patterned fen)	82,910	23.7	2,853	LB1, LB12, LB1-3, LB14, LB1-4, LB1-5, LB2, LB21, LB23, LB24, LB2-4, LB25, LB2-5, LB26, LB2-6, LB3, LB31, LB32, LB34, LB36, LB3-6, LB4, LB41, LB42, LB43, LB45, LB46, LB4-6, LB5, LB54, LB56, LB6, LB62, LB63, LB64, LBSF
LSP – Late Snow	4,887	1.4	25	LSP
R – Riparian (Riverine)	51,376	14.7	1,813	AMT, RA, REl, REs, REb, REa, RB, RC, RDA, Rib, Rt
S – Discharge Slope	78,477	22.4	3,162	SA, SAC, SAG, SAL, SAM, SAS, SC, SCA, SCL, SCS, SG, SGA, SGM, SGS, SL, SLA, SLC, SLM, SLS, SM, SMA, SMG, SML, SMS, SS, SSA, SSC, SSL, SSM
T – Tidal Flat (not assessed)	7,189	2.1	305	
WU – wetland/upland complex	18,716	5.4	209	More than 25% of area is wetland, but individual wetlands are too fine to map individually at 1:24,000. Discharge slopes and Depressions probably account for most wetlands in these map units. If each WU is 50% wetlandt, this reduces total wetland area to about 340,683 acres or 38% of the project area.
DISTURB	1,287	0.4	130	130 wetlands mapped as DISTURB account for the 1,287 acres (0.4%) listed as OTHER, these are too disturbed by humans to be classified.
Totals	350,041	100.21	16,500	Wetland acres classified and mapped on the Kenai lowlands
Totals minus Tidal	342,842			Wetland acres assessed for functions/values on the Kenai lowlands

DW1 wetland in the center of a large relict glacial Drainageway in the Soldotna Creek watershed (polygon 346), http://www.kenaiwetlands.net/MapUnitDescriptions/DW1.htm.

LBSF wetland – peatland pool with emergent vegetation, tree island in the distance, in 1000-ha patterned fen near the Kenai Airport (polygon 8075), http://www.kenaiwetlands.net/MapUnitDescriptions/LBSF.htm.

Table 2.2f. Map unit codes used during wetlands mapping in the Seward area (from http://cookinletwetlands.info/ and http://www.kenaiwetlands.net/SEWARD/Ecosystems/Intro.htm) (See Table 2.2d for conventions used in combining codes.)				
Wetland ecosystem types and codes	**Acres**	**% of wetland acres**	**no. of polygons**	**Map unit codes used**
D – Depression	45	1.0	40	D1, D12, D1-3, D2, D21, D23, D3, D31, D32, D34, D4, D43
DW – Relict Glacial Drainageway	166	3.7	3	DW3, DW5A
H – Headwater Fen	110	2.4	41	H1, H1-3, H2, H23, H3, H42, H31, H32, H34, H4, H43
K – Kettle	751	16.6	130	K1, K2, K12, K13, K1-3, K1-4, K21, K23, K2-4, K3, K31, K32, K34, K4, K43
R – Riparian/Riverine (includes 466 acres of river terraces)	3,180	70.3	211	RB, RC, RD3C, RD4C, RD4SC, RD4T1, RD4T2, RD4F1, RD4F1c, RD4F12, RD4F1-3, RD4F1-4, RD4F2, RD4F2c, RD4F21, RD4F2-4, RD4F23, RD4F3, RD4F32, RD4F34, RD4F4, RD4F43
S – Discharge Slope	18	0.4	3	SPS, SA
T – Tidal Flat (not assessed)	266	5.9	26	T07, T65, T67, T76, T78, T87
WU – Wetland/Upland Complex	7	0.2	1	WU
Totals	4,543	100.5	455	Wetland acres classified and mapped in the Seward area
Totals minus Tidal	4,277			Wetland acres assessed for functions/values in the Seward area

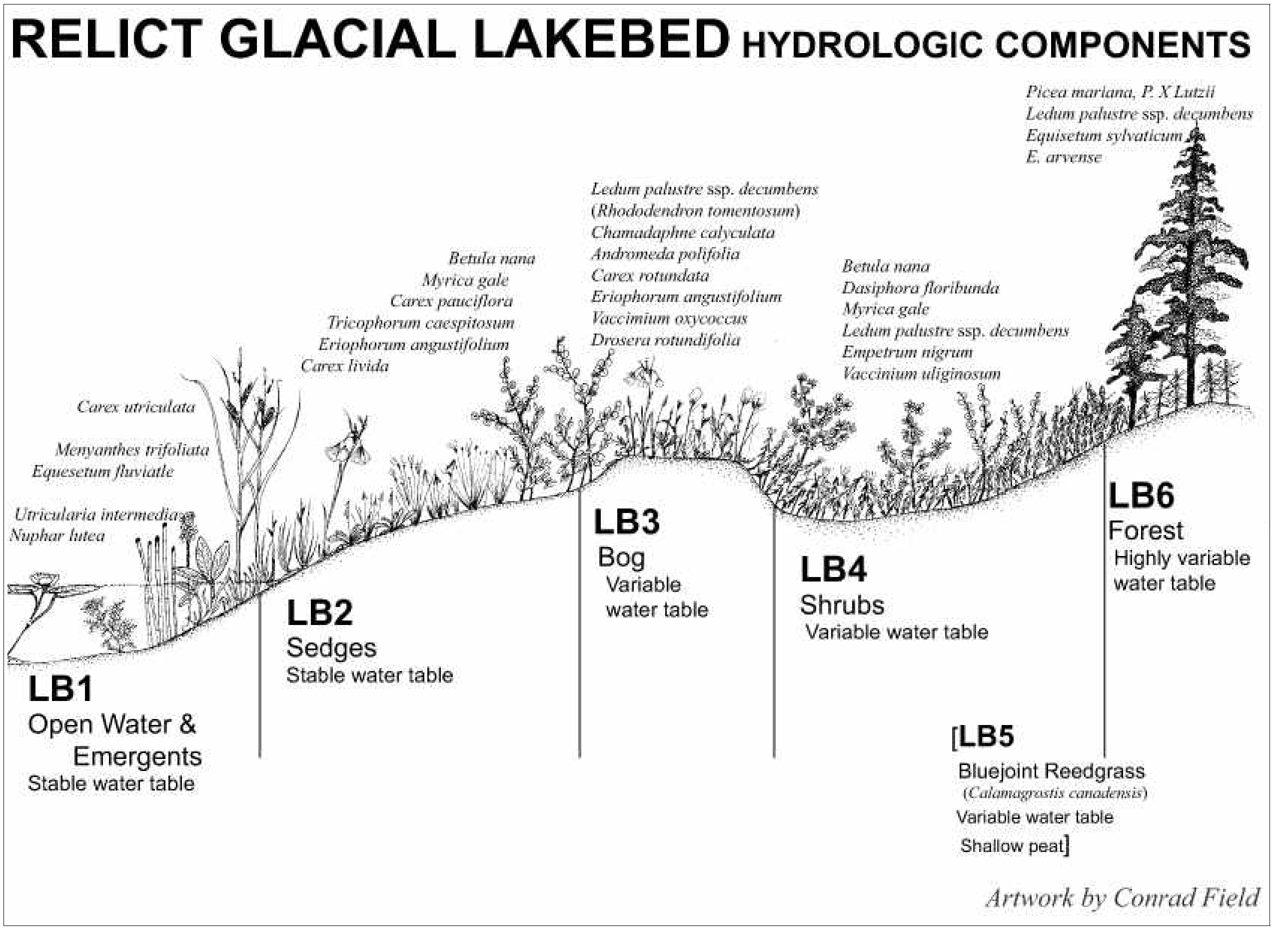
The only **D31** wetland, a small season-variable pond surrounded on a bedrock knob north of Bear Lake, Seward area; http://www.kenaiwetlands.net/SEWARD/MUdescriptions/D1331.htm.

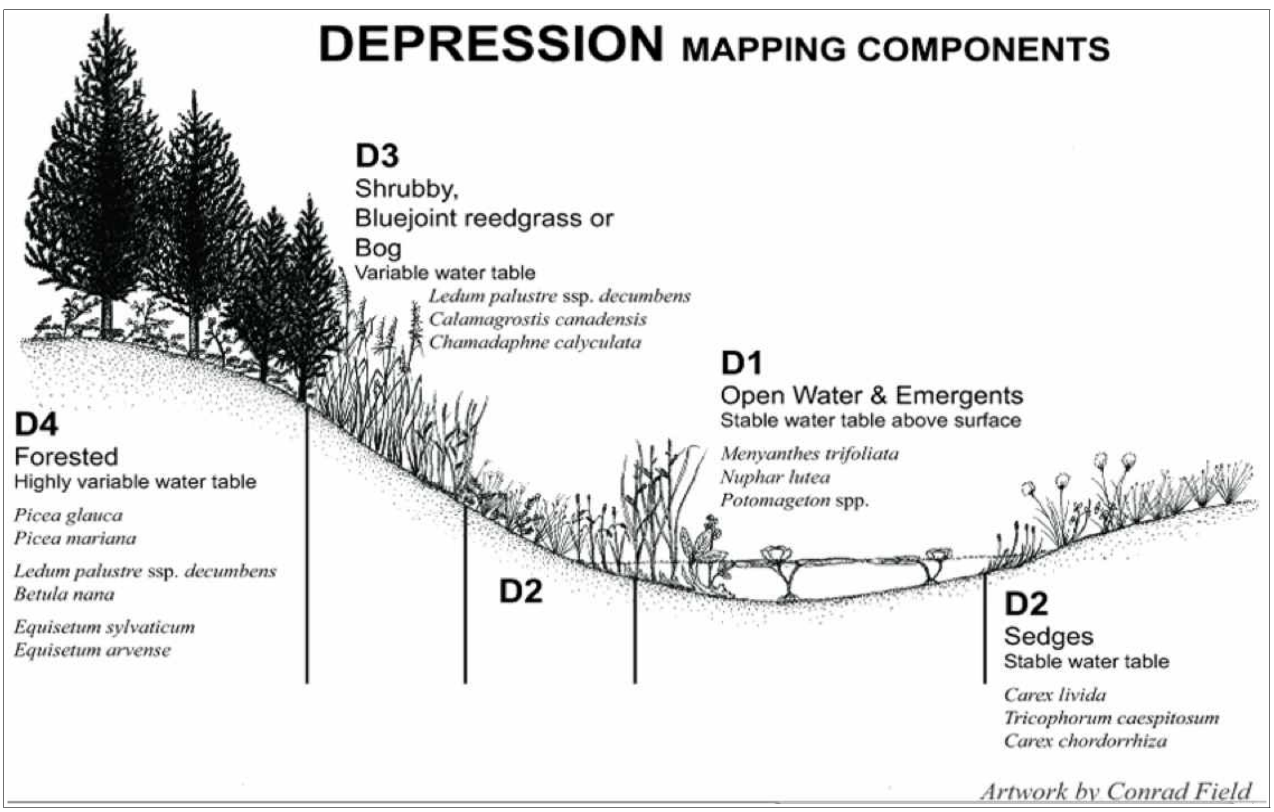
RD4F2 in wetland complex adjacent to Nash Road, Seward; http://www.kenaiwetlands.net/SEWARD/MUdescriptions/RD4F2.htm.

Alders cover this **RD4F3** floodplain wetland along Nash Road, Seward; http://www.kenaiwetlands.net/SEWARD/MUdescriptions/RD4F3.htm.

Mountain hemlock dominates **H4** foreground, with fewflower sedge (**H3**) in openings behind; http://www.kenaiwetlands.net/seward/MUdescriptions/H3443.htm.

Figure 2.2f. Two examples of idealized cross sectional diagrams available for wetland ecosystems.
(From: www.kenaiwetlands.net/EcosystemDescriptions/Depression.htm and www.kenaiwetlands.net/EcosystemDescriptions/Lakebed.htm.)

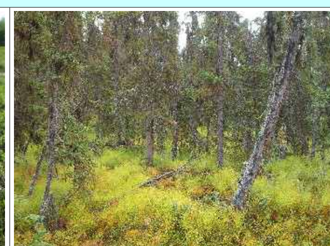




2.3. A pictorial overview of wetland ecosystems and selected map unit codes

The table below describes and illustrates two kinds of wetland ecosystems mapped on the peninsula. The combination of descriptions and photos is a good way to get a sense of what kinds of terrain and plant communities are typical for different wetland types. These two examples are from a table illustrating 9 of the 12 wetland types mapped on the peninsula (tidal wetlands and wetland/upland complexes are not included in the table). The examples below illustrate two wetland types relatively common on the peninsula lowlands: relict glacial **Drainageways (DW)** and **Kettles (K)**. DW wetlands account for about 12 percent of the wetlands mapped on the lowlands, and K wetlands for about 14 percent (see Table 2.2e). The full table from which these two types are excerpted can be viewed and downloaded at: http://www.homerswcd.org/user-files/peninsula%20wetlands%20illustrated%20with%20photos.pdf.

DW: Relict Glacial Drainageway wetlands are peatlands formed in relict, sometimes abandoned, drainageway features. These are linear features that once drained more extensive glaciers. Some may have formed along glacier margins. Some support modern streams, but these streams are underfit (meaning their streamflows are too small to have been responsible for the shape of the river valleys in which their channels now run). These are fen peatlands, with a stable high water table supported by ample peat porewater and groundwater throughflow that has had recent contact with mineral substrates. http://cookinletwetlands.info/Ecosystems/Drainageway.html.			
			
A segregated DW1-3 wetland southeast of Kenai (polygon 901). www.kenaiwetlands.net/MapUnitDescriptions/DW1-3.htm	A segregated DW21 wetland north of Kenai, near Salamatof Lake (polygon 1941).	Polygon 8137, a DW23 wetland northeast of Kenai. http://www.kenaiwetlands.net/MapUnitDescriptions/DW23.htm	Segregated DW35A wetland in Soldotna Creek watershed (polygon 555). A central shrubby band is flanked by bands of wet spruce forest. www.kenaiwetlands.net/MapUnitDescriptions/DW35A.htm

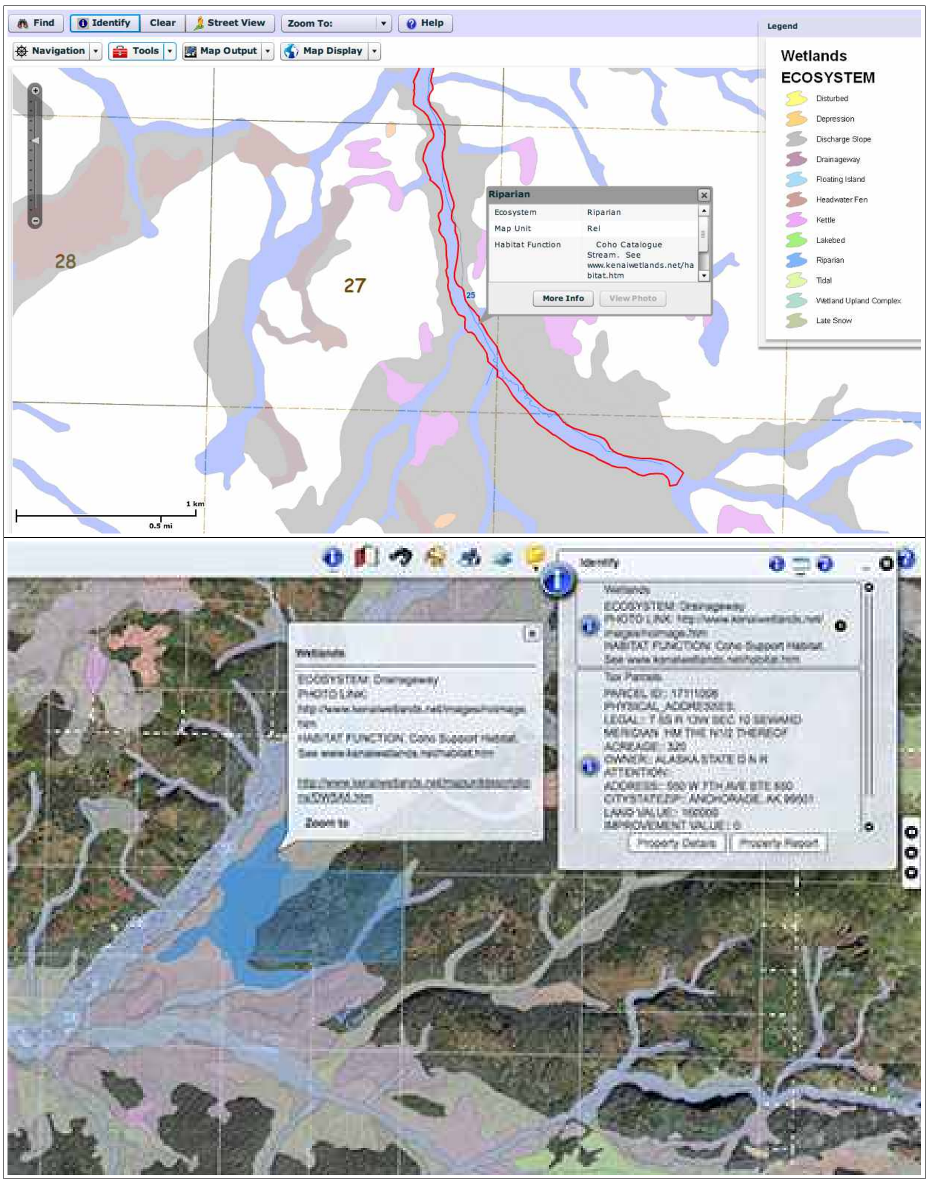
K: Kettle wetlands are peatlands occupying depressions created when ice-blocks carried within glacial till melted at the end of the last glacial advance. Kettles have deeply fluctuating water tables, and K2 and K3 wetlands can be flooded at the surface. Much late-season water storage becomes available in these wetlands as the water table draws down during summer dry periods. Kettles have a wetland or stream connection to Cook Inlet, unlike Depression wetlands, which also formed in ice-block depressions. Kettles with more than 20 acres of open water are mapped as lakes http://cookinletwetlands.info/ecosystems/kettle.html.			
			
A K13 wetland near the Boxcar Hills, 20 mi northeast of Homer (polygon 30730). www.kenaiwetlands.net/MapUnitDescriptions/K1-3.htm	Segregated K2-4 wetland near Kasliof (polygon 9478). Central sedge-dominated area (not visible) is ringed by shrubby peatland (left foreground) and forest (right). www.kenaiwetlands.net/MapUnitDescriptions/K2-4.htm	A K31 wetland near Mackey Lakes. The shrubby sweetgale component shown above can occupy a K2 or K3 position (polygon 712). www.kenaiwetlands.net/MapUnitDescriptions/K1-3.htm	A wetland mapped as K4 north of Kasilof (polygon 8783). www.kenaiwetlands.net/MapUnitDescriptions/K4.htm

2.4. Finding Kenai Peninsula wetland maps and data online

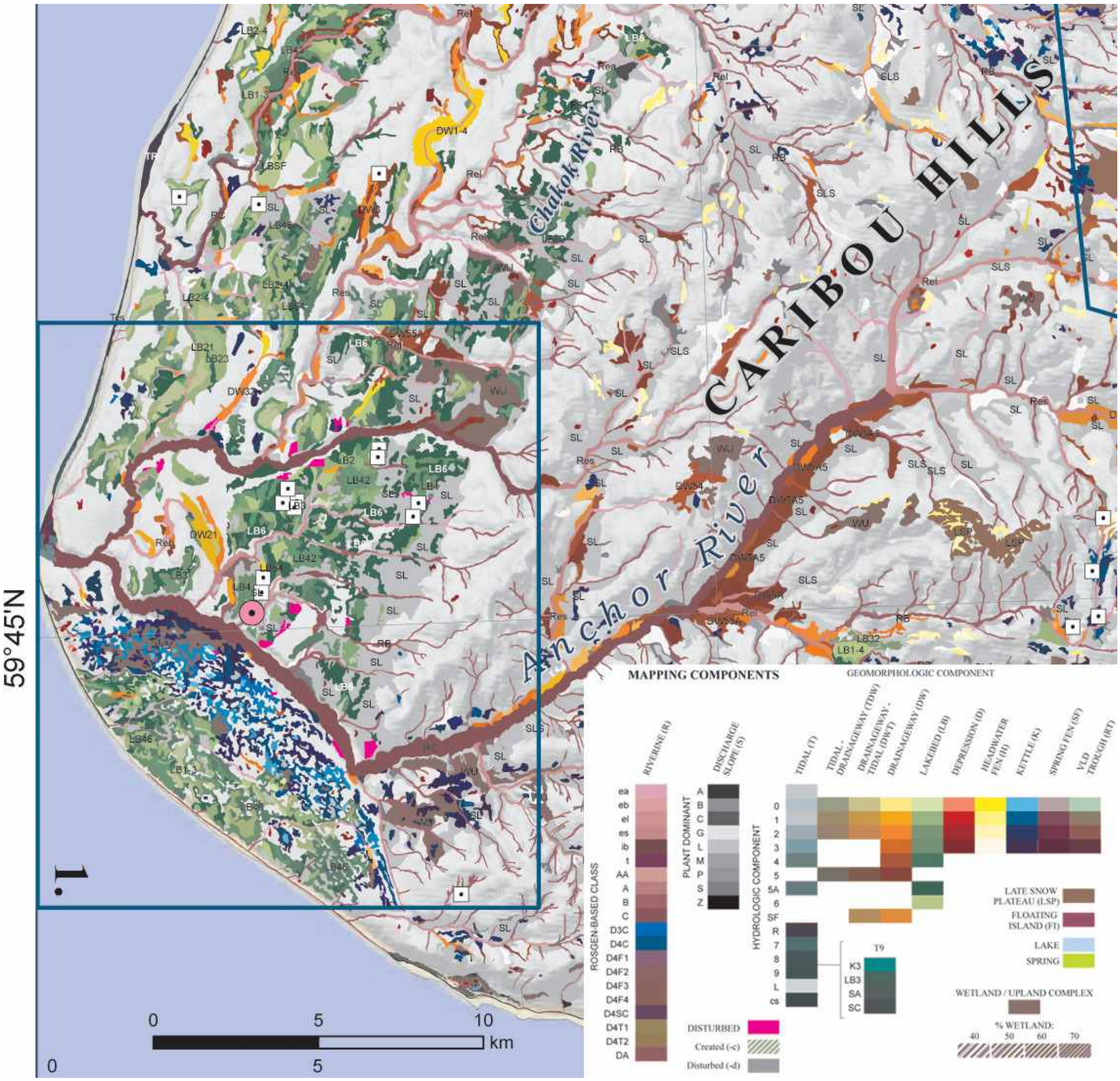
2.4.1. Wetland maps available through the borough's website.

The public can find Kenai Peninsula wetland maps and information online through the Kenai Peninsula Borough's geographic information system (GIS), particularly from the borough's interactive parcel viewer (IPV). The IPV is found at: http://mapserver.borough.kenai.ak.us/kpbmapviewer/ and http://mapserver.borough.kenai.ak.us/flex viewer/. These two sites provide somewhat different map interfaces and interactive tools, as shown in Map 2.4a. The *mapviewer*, shown on top, is better for quickly identifying particular wetland polygons (and other information, such as land ownership). The *flexviewer*, shown on the bottom, is better for overlaying multiple map layers and determining elevations. In addition to maps available through the IPV, other maps can be found online. For example, Map 2.4b shows a portion of a wetland map that can be downloaded from http://cookinletwet lands. Info/downloads/draftsheet1600dpi.pdf (note, this is a large file). Section 2.4.2 provides step-by-step instructions for using the IPV to explore wetlands.

Map 2.4a. Two examples of wetland maps from the Kenai Peninsula Borough interactive parcel viewer (IPV).
Top: from http://mapserver.borough.kenai. ak.us/kpb**mapviewer**/. **Bottom**: from http://mapserver.borough.kenai.ak.us/**flexviewer**/.
On either viewer, when the wetland layer is visible, clicking the "Identify" button and then double-clicking a wetland polygon opens a box like those shown below. The box identifies the wetland ecosystem type and links to more information about that wetland (see below).



Map 2.4b. A portion of a map generated from 1:24,000 -scale peninsula wetland maps.
(From http://cookinlet.wetlands.info/downloads/draftsheet1600dpi.pdf—note this is a very large file to download).
The area in the blue rectangle is shown in a computer-generated aerial oblique image on Map 2.2c.

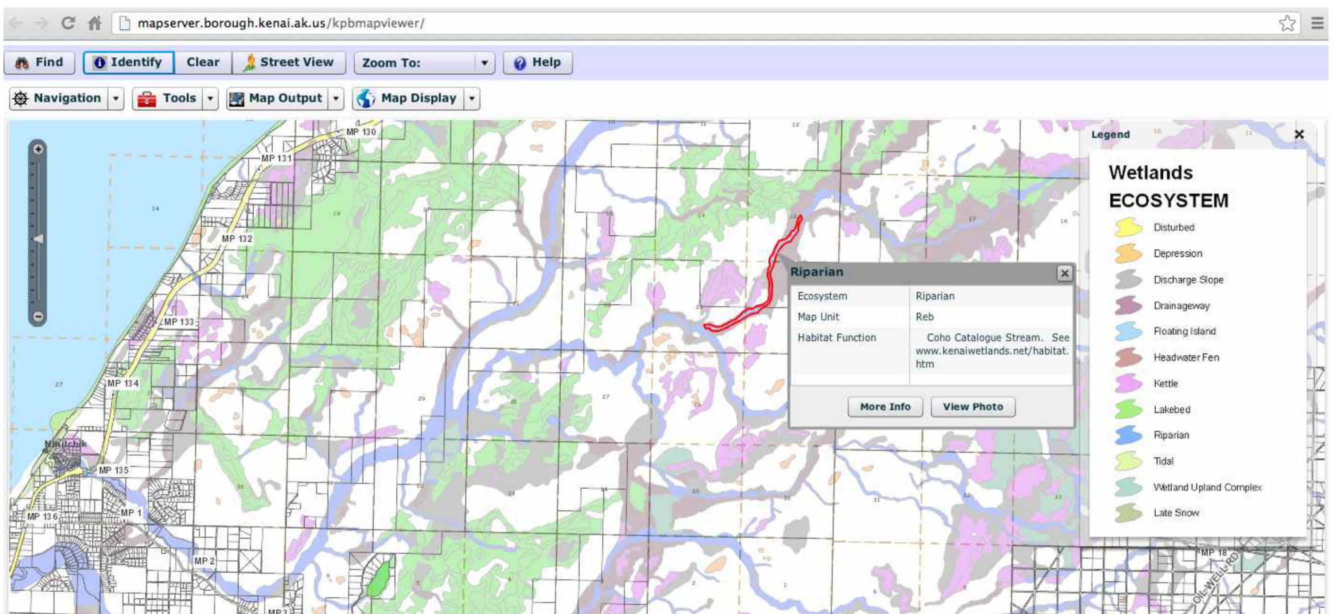


2.4.2. Easy steps for using the borough's interactive parcel viewer to explore wetlands

A mind boggling wealth of information is available about peninsula wetlands through the Kenai Peninsula Borough interactive parcel viewer (IPV) and the two wetland websites to which IPV wetland maps connect (http://cookinletwetlands.info and http://www.kenaiwetlands.net/). Information from these interconnected sources ranges from wetland ecosystem types, to idealized wetland cross sections, to identification and explanation of every map unit code shown on wetland maps, to photographs of particular wetland polygons (see below), to slopes and elevations, to data on water table fluctuations and chemistry (including "specific conductance[20]" of water in particular wetlands), to soil types (including depth of peat soils), to ownership and land use, and more.

Exploring wetlands of interest using these tools can be easy, informative, and fun. For example, here are some easy steps for looking at photographs of particular kinds of wetlands along the Ninilchik River. To do this, we:

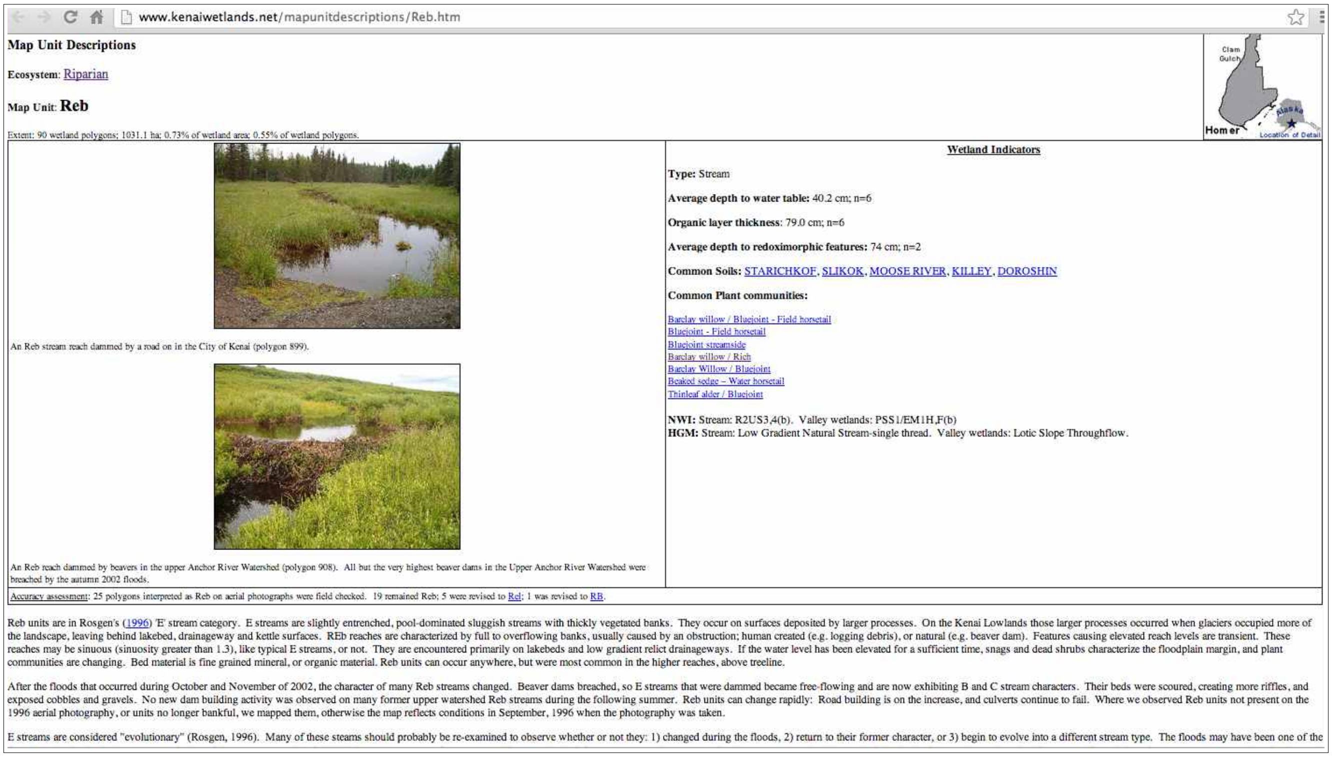
- opened the IPV mapviewer at http://mapserver.borough.kenai.ak.us/kpbmapviewer/;
- found Ninilchik and zoomed in to a scale of 1:62,500 (at which point, the wetland layer can be turned on);
- turned on the wetlands layer by choosing *Wetlands* under the "Map Display" button;
- clicked on the "Identify" button (shown active in the top menu bar in the screenshot below); and
- began double clicking different wetland polygons to open their information boxes. We were looking for boxes in which the "View Photo" button was active (not dimmed out), as shown in the screenshot below.



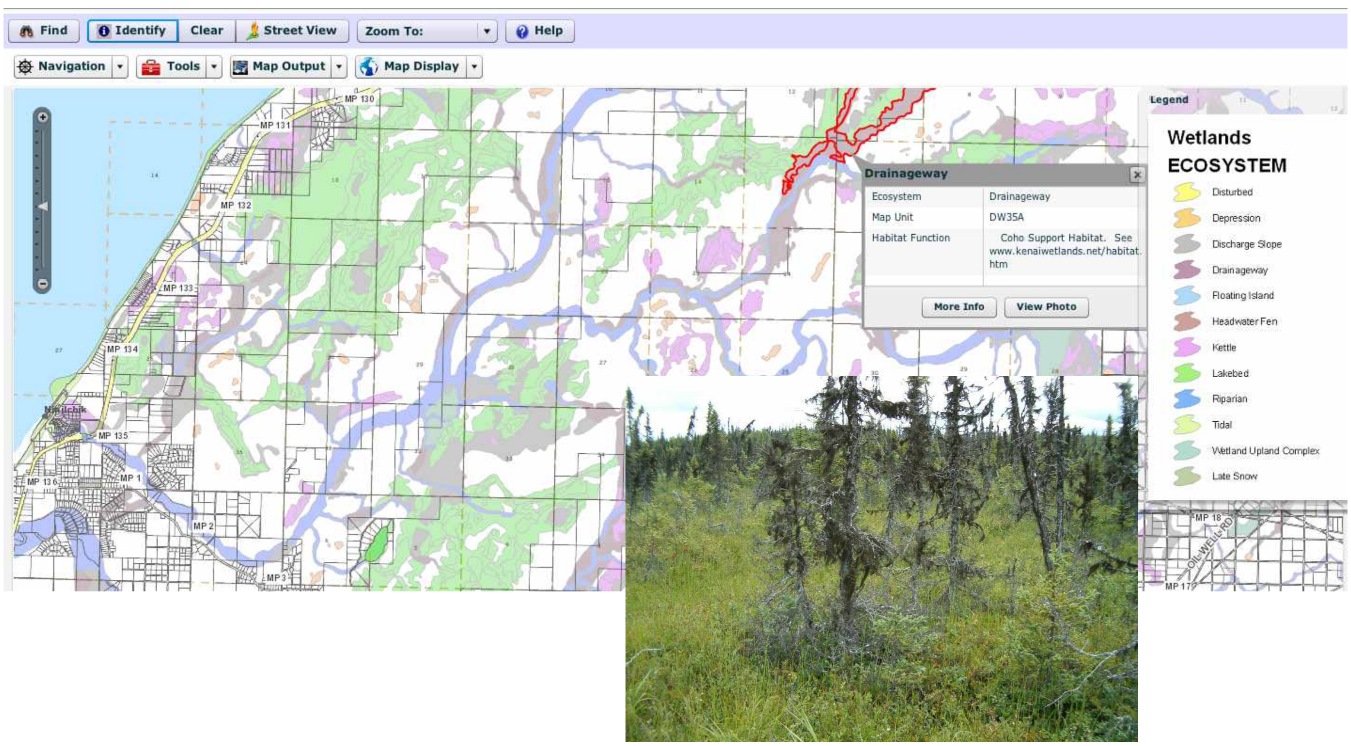
- When the "View Photo" button is active, clicking it opens a photo of THAT particular polygon (and tells you the number given that polygon among the almost 17,000 wetland polygons mapped). Clicking "View Photo" in the wetland box shown above opened the photo at right of polygon number 26074 (a Riparian wetland, map unit Reb).
- Any time a wetland identification box is open, clicking the "More Info" button opens a screen like the one shown below.

20 (From *Water Properties and Measurements*, http://ga.water.usgs.gov/edu/characteristics.html): Specific conductance is a measure of the ability of water to conduct an electrical current. It is highly dependent on the amount of dissolved solids (such as salt) in the water. Pure water, such as distilled water, will have a very low specific conductance, and sea water will have a high specific conductance. Rainwater often dissolves airborne gasses and airborne dust while it is in the air, and thus often has a higher specific conductance than distilled water. Specific conductance is an important water-quality measurement because it gives a good idea of the amount of dissolved material in the water.

The screen shown below was opened through the steps outlined above and provides information about the Reb wetland highlighted in red on the previous page. (Note, only part of the webpage is shown. To actually go to the webpage, click here: http://www.kenaiwetlands.net/mapunitdescriptions/Reb.htm.) The two photos below show Reb wetlands dammed by a road in Kenai (top) and by beavers in the Anchor River watershed (below).



- We couldn't help looking at another kind of wetland in the same area, Drainageway (DW) polygon 25870, shown in the screenshot and photo below. The "More Info" button for this wetland goes to: http://www.kenaiwetlands.net/mapunitdescriptions/DW35A.htm, which has great photos of DW35A and DW5A3 wetlands in the Soldotna Creek watershed and a DW3-5A wetland in Clam Gulch.



Using the easy steps outlined above, we looked at a number of wetland polygons that were photographed during fieldwork. Looking at fieldwork photos and then clicking the "More Info" button in the wetland box is a great way to get familiar with wetland types. Table 2.2g provides examples of several wetlands looked at this way.

Table 2.2g. Examples of wetland photos viewed by using the easy steps outlined above.

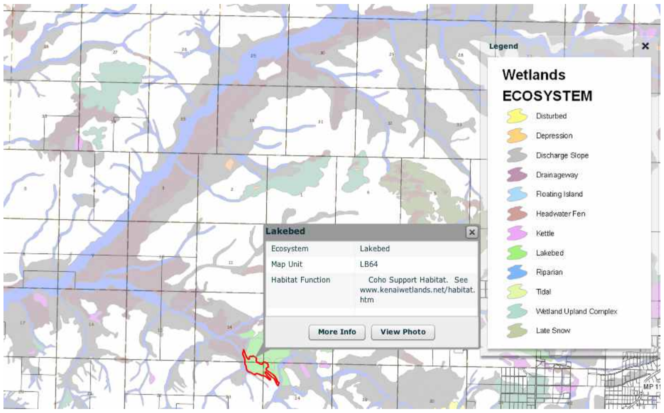


Photo of a **Lakebed** wetland polygon (LB64) along Beaver Creek (polygon number 32592). The "More Info" button in this wetland box goes to: http://www.kenaiwetlands.net/mapunitdescriptions/LB46.htm.

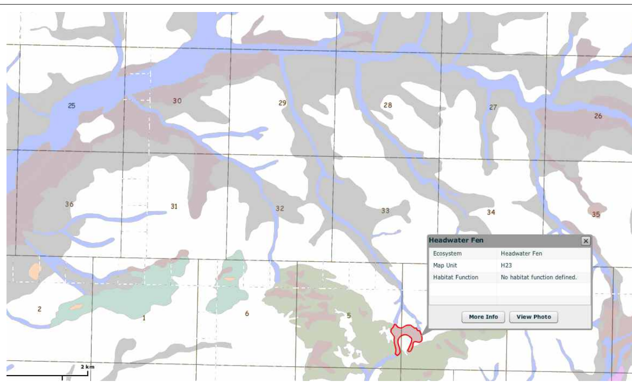


Photo of a **Headwater Fen** wetland polygon (H23) south of Anchor River and north of Homer (polygon number 7354). The "More Info" button in this wetland box goes to: http://www.kenaiwetlands.net/mapunit descriptions/ H23.htm.

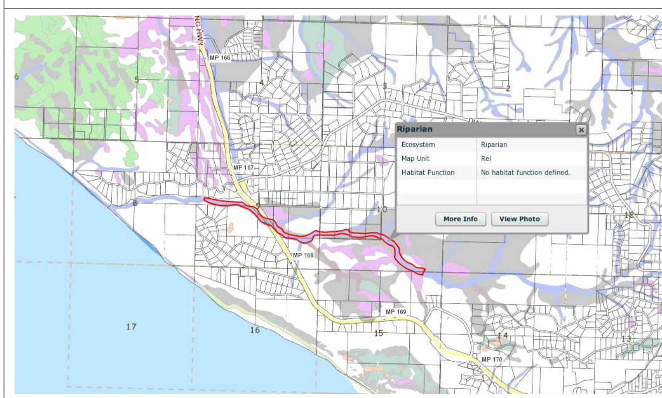


Photo of a **Riparian** wetland polygon (Rel) along Diamond Creek west of Homer (polygon number 33486). The "More Info" button in this wetland box goes to: http://www.kenaiwetlands.net/mapunitdescriptions/Rel.htm.

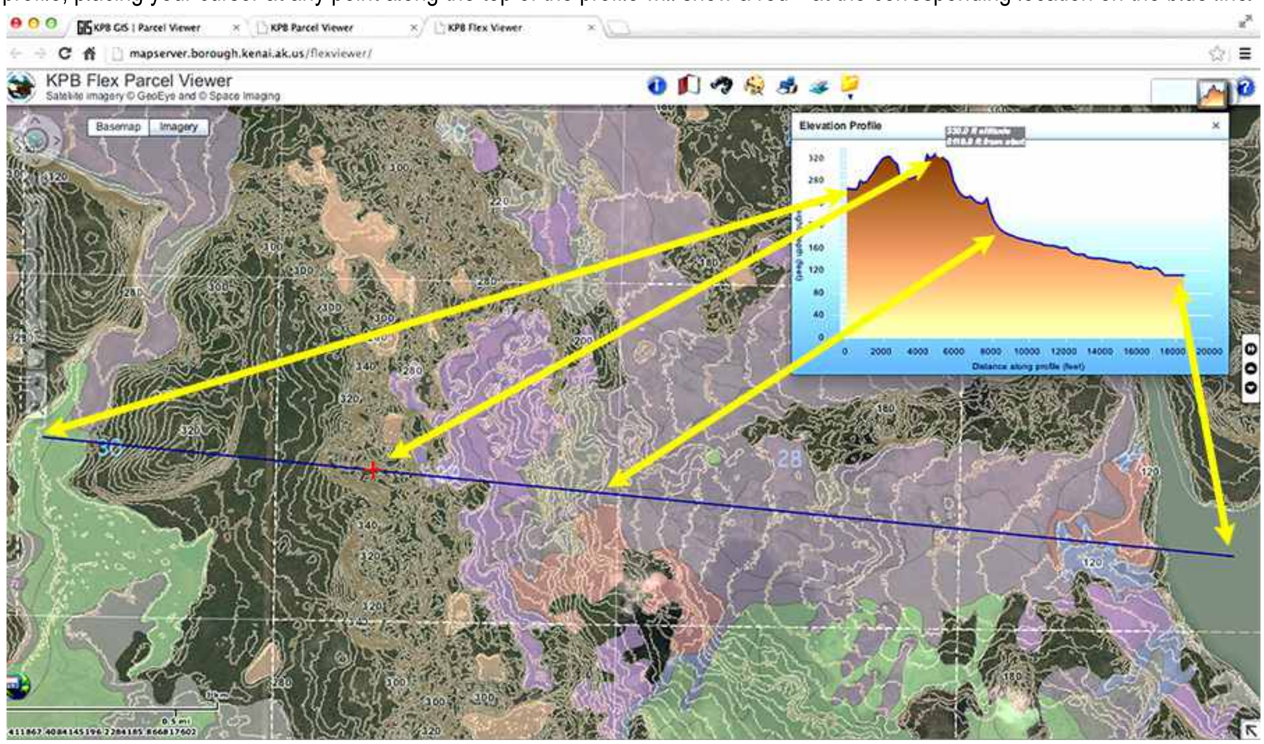
Looking at wetland slopes and elevations is another interesting way to get familiar with how different wetland types fit into the landscape. Figure 2.2g provides one example of what can be done using the IPV "elevation profile" tool (with the wetland layer turned on). (The elevation tool is accessed through the "Miscellaneous Tool" icon, see the text box below.) For step-by-step instructions on using the IPV to create maps like the one below, go to https://sites.google.com/ site/kenaipeninsulawetlandwiki/documents/kenai-peninsula-wetlands-a-guide-for-everyone/chapter-2-an-introduction-to-wetland and click on the Easy Steps document title. In addition, two easy-to-follow "online tours" of the borough's IPV AND the Kenai Watershed Forum's online atlas are provided at: http://www.homerswcd.org/user-files/article3-exploring%20watersheds%20online.pdf. (Note, as of this writing, the KWF atlas was offline and being updated.)

Figure 2.2g. An elevation profile created using the IPV flexviewer (http://mapserver.borough.kenai.ak.us/flexviewer/).

(The text box below provides a quick introduction to some of the tools available on the flexviewer website.)

In the map below, the elevation profile shown in the top right corresponds to the blue line that runs from Lakebed wetlands on the west (green polygons) to Tustumena Lake on the east. Yellow arrows show corresponding locations on the map and the elevation profile. Heights on the elevation profile are shown in feet, as are distances along the profile. (Note that vertical heights and horizontal distances are shown at different scales.) The surface of Tustumena Lake—grey area at the right end of the line—is about 110 feet in elevation.

Besides Lakebed wetlands on its west end, the blue line crosses Kettle wetlands (brightest purple) lying in a trough east of the ridge marked with a red **+**, Drainageway wetlands (grey purple) sloping east towards Tustumena Lake, and Riparian wetlands (blue) flowing into the lake. (The salmon-colored polygon lying north of the Riparian wetland is a Wetland/Upland complex). Once you've created an elevation profile, placing your cursor at any point along the top of the profile will show a red **+** at the corresponding location on the blue line.



A quick introduction to some of the tools available on the flexviewer:

Tools available on the flexviewer are accessed using icons shown at right. The elevation tool is turned on from the yellow folder, which contains "**Miscellaneous Tools**." The "**Map Contents**" icon to its left enables you to open a variety of layers on your map—singly or together. Layers available under "Map Contents" are: Lot Lines, Contours, Hillshade, Habitat Protection (anadromous streams and waterbodies), Existing Land Use, Ownership, Wetlands, Air Photos, Physical Addresses, Parcel Labels, Assembly Districts, Voter Precincts, and Borough Maintained Roads. Left of the "Map Contents" icon is the "**Print**" command icon, the "**Draw and Measure**" palette, the "**Enhanced Search**" binoculars, the "**Bookmarks**" directory (enabling you to jump to many locations and create your own bookmarks), and the "**Identify**" button (the blue circle containing an "**i**"). With a "Map Contents" layer (like Wetlands) turned on, clicking the "Identify" button and then double-clicking a polygon will provide relevant information about that polygon, like wetland information shown on the previous pages.

Chapter 3. Wetland *functions* and *values* and how they were assessed on the peninsula

3.1. Introduction: defining and categorizing functions and values

Kenai Peninsula wetlands provide many benefits to individuals and society. Some examples include:

- prevention or reduction of flooding;
- contributions to supplies and quality of water (surface, subsurface) used by individuals or communities;
- habitats for fish and wildlife—from invertebrates to fish (including salmon), to birds (including ducks and geese), to mammals (including moose);
- productive sites for the growth of plants that are edible, medicinal, or useful in other ways;
- open space areas well suited for education, recreation, winter travel, or wildlife corridors; and
- connections to the past through traditional human uses of wetlands or to their historical roles.

Given that not all wetlands are the same, and that different wetlands play different roles within a watershed, a wetland assessment is needed as a foundation for wetland management. An assessment can identify which wetlands provide which benefits and can help prioritize wetlands for management, research, or other actions.

How we use the terms wetland *functions* and *values*

The terms *functions* and *values* are used throughout this assessment and so should be defined here. You'll see below that wetland *functions* may provide us with things that we *value*, but the terms *function* and *value* are not necessarily interchangeable. The distinction between them is useful, particularly when considering goals for management (see Chapter 5).

Values: Wetland values derive from the benefits that wetlands provide to individuals and communities. Wetland benefits to society have been given a variety of names, including: "amenities," "goods and services," and "green infrastructure" (see Tables 3.1a and b). In this project, we use the term *values* to reflect a human dimension: the value to *human* developments (roads, buildings, farms, etc.) of floodwater storage provided by wetlands; the value for human uses (sport, commercial, personal use, subsistence, etc.) of salmon habitats provided and maintained by wetlands; the places wetlands afford for human activities such as berry picking, cross country skiing, birding, snowmachining, and other forms of recreation and exploration. Values also include cultural or historical dimensions, for example, human events or rituals associated with wetlands, or the ways wetlands were used by traditional cultures—which in this assessment means the Dena'ina Athabascans.

Functions: The benefits that wetlands provide us (their values to society) exist because of the things that wetlands DO, that is, the processes that wetlands inherently perform. These processes perpetuate the wetland and determine its condition (see "reference condition," Section1.3.4). As used here, a wetland *function* is a natural process that a wetland performs at least seasonally or periodically[21], such as moving or storing water in certain ways or supporting particular plants.

Wetland functions are not static. Wetlands are very dynamic environments, and their functions are complex, interrelated, and inherently variable. For example wetland water levels rise and fall in response to droughts or storms, seasonal cycles, short- and long-term climate change, and human activities; wetland plant and animal communities change in response to floods, pest outbreaks, fires, invasive species, and geologic activities like earthquakes and volcanic eruptions, as well as in response to human activities. So as assessed here, functions represent just a moment in time—the moment when wetlands were mapped, classified, and visited in the field. Tracking changes in wetland functions will require collecting additional data and then comparing conditions over time.

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21 Definitions used here are analogous to ASWM definitions: *Function*—how wetlands and riparian areas work; the physical, chemical, and biological processes that occur in these settings, which are a result of their physical and biological structure. *Values*—goods and services from a biological system (e.g., wetlands and riparian areas) that benefit humans or human society (http://aswm.org/watersheds/69-toolkit/887-wetlands-and-watershed-protection-toolkit?start=15).

Functions are not necessarily valued in and of themselves, but if we want to maintain wetland values, it's critical to understand and maintain the functions responsible for those values. In some cases it's easy to see how a basic wetland function—like storing stormwater runoff—benefits people directly: wetlands that store stormwater reduce the flooding of nearby homes, roads, and other built elements. Clearly, functions can overlap values. Examples of basic wetland functions that overlap with values include:

- storing rainfall and snowmelt—which reduces flooding of the human-built environment;
- recharging groundwater and contributing discharge—which can be critical in maintaining "baseflows" in streams during drier times of year;
- recharging underground water stores (aquifers)—which supply wells;
- filtering waterborne sediments and pollutants—which improves water quality for humans, as well as for the fish and other animals living in connected waterbodies;
- maintaining habitats that support particular wetland plants, fish, or animals—including highly valued species like moose and salmon.

Because functions and values so often overlap, we distinguish between them only where distinctions are self-evident, e.g., recreational *values*. (Supporting recreation is obviously not an innate wetland *function*.)

Clearly, the functions a wetland performs—and how "well" it performs them—reflect the wetland's conditions and processes. Many of these are related to the wetland's location within its watershed. As outlined in Section 2.2, key conditions characterizing each peninsula wetland—including its landscape shape and position (geomorphic component), hydrology, dominant plant communities, etc.—were identified as part of classifying, naming, and mapping these wetlands. Particular conditions were considered specifically *because* they affect how wetlands function, and so would be relevant in later functional assessments like this one.

With respect to naming functions and values, many assessments use slightly different terms for essentially equivalent categories—one assessment's "floodwater storage" is another's "stormwater retention." One term is as good as another if its meaning is clearly defined. There are no right or wrong ways to name functions/values—only ways that are more or less useful for a particular purpose. In general, we used terminology from Anchorage and Homer assessments. Where terms needed clarification, we referred to the Ontario Wetland Evaluation System (OWES, see Section 1.3.1). Beyond that, we sometimes used terms in ways specific to this project.

To be assessed, wetland functions and values—however named—need to be logically categorized. This can be done in many ways. The approach used here is outlined in Sections 3.2 to 3.5, which describe what functions and values were assessed and lay out methods used and results obtained.

As this introduction suggests, much has been said about ways to define and categorize wetland functions and values. (Different systems often reflect different project scales—i.e., landscape level versus site specific.) Tables 3.1a to d provide some examples of other systems used to name and categorize wetland functions and values. Choosing a particular system depends on what data are available, project scale, and needs and preferences of those making the choice (see Sections 1.2 and 1.3). It's clear from these examples that many systems can be useful. For those interested in exploring this topic further, the table below provides links to several informative publications offering examples of how wetland *functions* and *values* have been defined by particular entities.

From Homer Soil and Water Conservation District (HSWCD)	**Factsheet 3: What do we mean by wetland functions and values** http://www.homerswcd.org/user-files/factsheet%203%20what%20do%20we%20mean.pdf (A factsheet developed for this assessment project.)
From Environmental Protection Agency (EPA)	**Functions and Values of Wetlands** http://water.epa.gov/type/wetlands/upload/2006_08_11_wetlands_fun_val.pdf (From *The Wetlands Factsheet Series* introduced at: http://water.epa.gov/type/wetlands/index.cfm.)
From US Geological Survey (USGS)	**Wetland Functions, Values, and Assessment,** http://water.usgs.gov/nwsum/WSP2425/functions.html **Technical Aspects of Wetlands – Wetland Hydrology, Water Quality, and Associated Functions** http://water.usgs.gov/nwsum/WSP2425/hydrology.html (USGS Water Supply Paper 2425)
From Association of State Wetlands Managers (ASWM)	**Common Questions: Definition of the Terms Wetland "Function" and "Value"** http://www.aswm.org/pdf_lib/16_functions_6_26_06.pdf

Table 3.1a. Example 1: USDA Economic Research Service system for organizing and naming wetland functions and values. (Source: http://webarchives.cdlib.org/wayback.public/UERS_ag_1/20111128215708/http://www.ers.usda.gov/publications/arei/eib16/Chapter2/2.3/.)

Wetland resource	Function	Service	Economic value
Benefits that are mainly private or mixed public-private			
Wetland plants	Provide plant growth medium	Opportunities for private or commercial plant harvest	Net economic value of harvest
Wetland-related fisheries	Provide fish habitat	Opportunities for private or commercial fish catch	Net economic value of catch
Wetland-related wildlife	Provide wildlife habitat	Opportunities for recreational fishing, hunting, and wildlife viewing	Net economic value of hunting, fishing, or wildlife viewing experience
Wetland shoreline effects	Buffer riverbanks, lake-shores, and coastlines	Stabilized and protected shorelines	Net economic value of stable shorelines
Wetland-related water	Collect and store water	Contributions towards maintaining water supplies	Net economic value of water supplies
Benefits that are mainly public			
Floodwater storage	Collect, store, and slow floodwater	Reductions in flood flows and peaks	Net economic value of reduced flood damages
Water quality effects	Filter sediments and other pollutants from water	Cleaner waters	Net economic value of reduced costs for water treatment and pollution control
Wetland-related biodiversity	Support a variety of species	Contributions to biodiversity	Net economic value of species that remain present and available for study, viewing, collection, or other uses

Table 3.1b: **Example 2: the IPCC[22] system for organizing and naming ecosystem functions and values**
Wetlands potentially provide all identified functions and goods/services.
(Source: http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=202.)

Function	Goods/Service		Value
Production	• Food • Fiber (timber and non-wood products)	• Fuel • Fodder	Direct
Biogeochemical cycling	• Nutrient cycling (especially N and P absorption/deposition) • Carbon sinks		Mostly indirect, although future values have to be considered
Soil and water conservation	• Flood and storm control • Erosion control • Clean water • Clean air	• Water for irrigation • Organic matter or sediment export • Pollution control • Biodiversity	Mostly indirect, although future values have to be considered
Animal-plant interactions	• Pollination • Animal migration • Biodiversity		Mostly indirect, future, bequest, and existence values have to be considered
Carrier	• Landscape connectivity • Animal migration • Biodiversity • Aesthetic/spiritual/cultural service		Mostly indirect and existence, but bequest may have to be considered

22 From Climate Change 2001: Working Group II: *Impacts, Adaptation and Vulnerability* (http://www.grida.no/climate/ipcc_tar/wg2/index.htm); Chapter 5 – Ecosystems and their goods and services, Section 2. IPCC (For background on the The Intergovernmental Panel on Climate Change (IPCC), go to http://www.ipcc.ch/index.htm.)

Table 3.1c: Example 3: A system for organizing and naming wetland functions and values from ASWM[23] (from: http://aswm.org/watersheds/floods-and-natural-hazards/1133-assessing-the-natural-and-beneficial-functions-of-floodplains)		
WATER RESOURCES		
Natural Flood and Erosion Control • Provide flood storage and conveyance • Reduce flood velocities • Reduce flood peaks • Reduce sedimentation	***Water Quality Maintenance*** • Filter nutrients and impurities from runoff • Process organic wastes • Moderate temperature fluctuations	***Groundwater Recharge*** • Promote infiltration and aquifer recharge • Reduce frequency and duration of low surface flows
BIOLOGICAL RESOURCES		
Biological Productivity • Support high rate of plant growth • Maintain biodiversity • Maintain integrity of ecosystem	***Fish and Wildlife Habitats*** • Provide breeding and feeding grounds • Create and enhance waterfowl habitat • Protect habitats for rare and endangered species	
SOCIETAL RESOURCES		
Harvest of Wild and Cultivated Products • Enhance agricultural lands • Provide sites for aquaculture • Restore and enhance forest lands	***Recreational Opportunities*** • Provide areas for active, passive uses • Provide open space • Provide aesthetic pleasure	***Areas for Scientific Study and Outdoor Education*** • Contain cultural resources (historic and archaeological sites) • Provide opportunities for environmental and other studies

Table 3.1d: Example 4: FUNCTIONS/VALUES OF WETLAND/FLOODPLAIN/RIPARIAN AREAS (Each of these Functions/Values is discussed in some detail in the source material: Appendix F in http://aswm.org/pdf_lib/nbf.pdf.)	
1. HYDROLOGICALLY BASED FUNCTIONS/VALUES • Provide flood storage by storing and slowly releasing flood waters. • Convey flood waters. • Induce waves to break before reaching shore, reduce force of water. • Reduce erosion by slowing velocity of water and by binding soil. • Recharge groundwater. • Discharge groundwater.	**2. ECOLOGICALLY BASED FUNCTIONS/VALUES** • Provide natural crops. • Prevent and treat pollution. • Provide habitat for fish and shellfish. • Provide habitat for amphibian, reptile, mammal and insect species. • Provide habitat for waterfowl. (Note, overlaps with other habitat types.) • Provide habitat for various song birds, other nongame birds. (Note, overlaps with other types of habitat but has been set forth separately because “birding” and ecotourism have become such important services in some areas of the country.) • Provide habitat for endangered or threatened species of plants and animals.
3. ATMOSPHERICALLY BASED FUNCTION/VALUES • Maintain carbon stores, sequester carbon in order to reduce climate change. • Modify micro-climate by cooling air (or preventing temperature rises), increasingly circulation due to differential pressure gradients, increasing evaporation and local humidity, etc.	**4. CULTURALLY AND ENVIRONMENTALLY BASED FUNCTIONS/VALUES** (Humans more significantly enter the picture.) • Provide recreation and ecotourism opportunities and experiences. • Provide historical, archaeological, heritage, aesthetic opportunities and experiences. • Provide education and interpretation opportunities. • Provide scientific research opportunities.

23 ASWM = the Association of State Wetland Managers, see http://aswm.org/. Tables 3.1c and d are both from A*ssessing the Natural and Beneficial Functions of Floodplains: Issues and Approaches; Future Directions* by By Jon Kusler, Esq. Ph.D., Oct 2011, see http://aswm.org/pdf_lib/nbf.pdf.

3.2. Assessing peninsula wetlands: "components" and steps

3.2.1. Assessment components

For this assessment, wetland functions and values were categorized into three *components*[24]: *Biology*, *Hydrology*, and *Community/Culture*. These are the same categories used in Anchorage, Homer, and Ontario wetland assessments, with the exception of Community/Culture, which was called the Social component in the earlier assessments. The new term is used to reflect greater attention here on the significance of peninsula wetlands to Dena'ina Athabascan Native cultures and heritage. The Biology component was subdivided into *Species Occurrence* and *Habitat* categories in both Anchorage and Homer. We did likewise.

The following definitions of assessment components are adapted from the manual of the Ontario Wetland Evaluation System (OWES)[25], the basis for methods used in Anchorage, Homer, and here.

1. **The Biology component**[26] (subdivided into Species Occurrence and Habitat) recognized that wetlands can differ in how well they support selected plants and animals, how scarce they are on the landscape, and how much habitat diversity they provide.
2. **The Hydrology component** covers water-related functions and values of wetlands. These include recharging groundwater, transmitting and contributing discharge (surface and subsurface), storing water (including stormwater runoff and flood flows), reducing shoreline erosion, maintaining natural flow regimes, and maintaining/improving water quality.
3. **The Community/Culture component** (the "Social component" in OWES) reflects wetland suitability to support recreation and education and also scores wetlands in terms of their use by Dena'ina Natives.

Under each component, a number of functions and values were identified based, in part, on data available peninsula-wide that could be used in conducting assessments. Assessed function/values are listed in Table 3.2a.

Table 3.2a. Wetland functions and/or values assessed under each component

Biology		Hydrology	Community/Culture
Species Occurrence	Habitats		
1. Moose winter habitats 2. Salmon habitat support 3. Rare plants 4. Animal species of concern 5 Wetland scarcity	1. Habitat diversity	1. Recharging groundwater 2. Providing water storage 3. Transmitting discharge 4. Contributing discharge 5. Maintaining natural (unregulated) flow regimes 6. Improving/maintaining water quality 7. Reducing streambank and shoreline erosion	1. Recreation (incorporates general education and research) 2. Education(proximity to schools, and other educational sites) 3. Culture/heritage (value to Dena'ina Natives)

3.2.2. Assessment method

Assessing wetlands generally means comparing them to other wetlands in terms of their condition, feature(s), or process(es). This provides information that can help landowners, managers, and others make useful, meaningful distinctions among wetlands so as to manage them in ways that are most appropriate, effective, and sustainable.

As explained in Section 1.3.4, in many parts of the country assessing a wetland means comparing it to a wetland of the same class that is in "reference condition." Because the vast majority of peninsula wetlands remain in

24 It's important not to confuse *geomorphic* and *hydrologic components*, on the one hand (see Section 2.2), with *assessment components*, on the other. In both cases, the term *component* comes from earlier projects—the former usage from the project to classify and map Kenai Peninsula wetlands; the latter, from wetland assessments in Anchorage and Homer (see Section 1.3). For consistency with those earlier projects, we use the term *component* in both ways, depending on context.

25 OWES is introduced at http://www.mnr.gov.on.ca/en/Business/Biodiversity/2ColumnSubPage/STDPROD_068974.html. The northern manual can be downloaded at: http://www.web2.mnr.gov.on.ca/mnr/Biodiversity/wetlands/owes/Northern_OWES_Manual_text.pdf.

26 Anchorage, Homer, and this assessment renamed what were called "Special Features" in OWES. In this project, "Special Features" are covered under the Species Occurrence component.

reference condition as of this assessment, this approach was not appropriate. Instead, wetlands were compared by scoring them in terms of variables related to particular functions or values. The method used—and some useful terminology—is outlined in Table 3.2b. The relative likelihood that a wetland performs a particular function or provides a particular value is reflected in its assessment score for that function/value. As explained below (Section 3.2.3), scores are relative and unitless, ranging from 0 to 40 points. Scores reflect a "snapshot" in time and are based on available knowledge and on wetland features and conditions as known at the time of mapping. As noted earlier, these assessments are landscape-level, sites should be visited for more accurate information.

Table 3.2b. Steps—and some terms—used in assessing Kenai Peninsula wetlands	
Step 1	Select specific functions and/or values to assess. Functions and values were largely selected based on categories assessed in Anchorage and Homer, as modified to better reflect peninsula conditions, priorities, and available data.
Step 2	Identify one or more ***variables*** that can be used to assess each function or value. Examples include wetland type (ecosystem and/or map unit code—which can reflect geomorphology, hydrology, plant communities, etc.); wetland size, watershed location, elevation, or distance to nearest road, etc. Variables were often based on those used in Anchorage and Homer. These were modified as needed to reflect available information, regional considerations, and the dfferent scales of this landscape-level project as compared to Anchorage/Homer site-specific methods. (Departures from Anchorage/Homer methods are described as appropriate.)
Step 3	Identify ways of scoring each variable—i.e., the ***metrics*** to use. Metrics can be quantitative (e.g., elevation in ft or meters, acreage), "quasi-quantitative[27]" (e.g., average number of growth forms in a plant community), categorical (i.e., "check the category that best applies to the wetland") or simply yes/no (e.g., is the assessed wetland a particular map unit code, or does it have a particular condition or feature, such as open water, organic soils, etc.).
Step 4	If more than one variable was associated with a particular function or value, scores assigned each variable were added to score the wetland for the function/value.

For each function/value, a table like Table 3.2c was developed. These tables show a function/value—in this case "moose winter habitat" and the variable(s), metric(s), and scores used to score wetlands for this function/value.

Table 3.2c. Kenai Peninsula Wetland Assessment Method—Species Occurrence		
FUNCTION 1: Moose winter habitat – See Maps 3.3a, 3.3b, and the entire peninsula map at: https://sites.google.com/site/kenaipeninsulawetlandwiki/home/portal-to-peninsula-wetland-functions-values		
1.1	Wetland polygon meets one or more of the following three criteria 1. Wetland polygon is at or below 600 ft in elevation or 2. Wetland polygon is a Discharge Slope or Riparian unit above 600 ft in elevation with significant cover of willow. (This category includes the following wetland map units of the Cook Inlet Classification: SS, SLS, SSL, SSA, SAS, SCS, SSC, SGS, SLSd, SPS, SMS, SSA, SSG, SSM; Re*, RC, RDA: and for the *Seward area*: RD4C, RD3C, RDSC, RD4T1, DW3) and/or 3. Wetland polygon is within the Anchor River – Fritz Creek Critical Habitat Area	40
1.2	Wetland polygon does not meet any of the above criteria	0

In Table 3.2c, wetland types were assessed for
…the **function** *moose winter habitat…*
…in terms of three **variables**: elevation, cover of willow, inclusion in a state Critical Habitat Area…
…using "categorical" and yes/no **metrics**: *wetland meets/does not meet specific variables or fall into particular categories*;
…resulting in a **score** of either 40 or 0.
This process is further illustrated in Figure 3.2a and Map 3.2a.

Since scores were usualy assigned based on map unit codes used during wetland classification and mapping (see examples in Table 3.2), assessments make a lot more sense given familiarity with these codes. Map codes reflect wetland geomorphology, hydrology, plant communities, and other feaures. Chapter 2 explains map unit codes; a quick review of that chapter will provide background needed to understand the following assessments.

27 Most of us understand how quasi-quantitative scoring works. For example, if a doctor asks: "Rate your pain from 1 to 10," he's using quasi-quantitative scoring. Although pain can't be measured directly, meaningful distinctions can be made among pain levels scored low (1-3), medium (4-7), or high (8-10).

Figure 3.2a. An example of an Rel wetland assessed for three functions/values: moose, salmon, and recreation.
An "Rel" wetland is, a **R**iparian wetland with a "Rosgen Level I" **e**volutionary **l**inear channe. (wetland codes are explained in Section 2.2). see also http://www.kenaiwetlands.net/mapunitdescriptions/Rel.htm).

Although above 600 ft in elevation and not within the Anchor River – Fritz Creek Critical Habitat Area, this Rel wetland meets the willow cover variable for moose winter habitat: "*Wetland polygon is a Discharge Slope or Riparian unit above 600 ft in elevation with significant cover of willow*." Therefore, this wetland scores 40 (the highest score) for moose winter habitat. (See Section 3.3.1.1.)

Because this R wetland contains a stream listed in the Anadromous Waters Catalog, it also scores highest for salmon habitat. (See Section 3.3.1.2.)

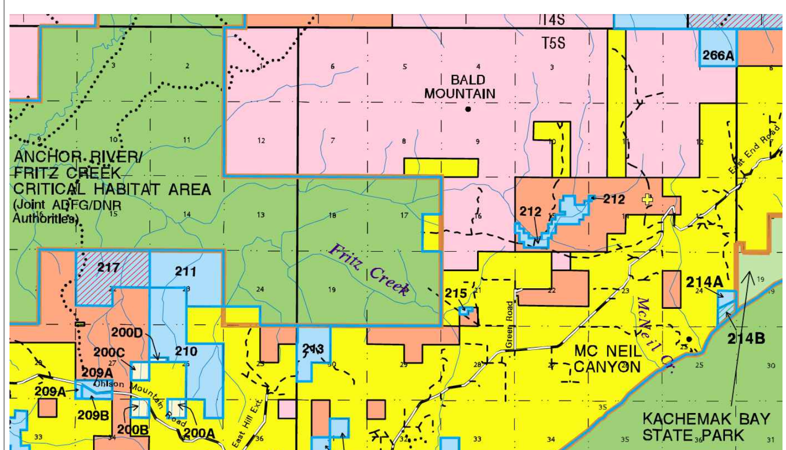
As explained under Map 3.2a, this wetland also receives the highest score for recreation. (See Section 3.5.1.)

This Rel wetland is along Beaver Creek, northeast of Homer. Beaver Creek is an anadromous stream that flows into the Anchor River. This wetland is above 600 ft in elevation.

Map 7C - Homer, Kachemak Bay

Unit	Desig.	Unit	Desig.	Unit	Desig.	Unit	Desig.
190	rp	230	rd	258	se	345	ha hv
200A	rd	232	ha	259	gu	347	ha rd
200B	se	233	ha	265	ha hv	419	ha rd
200C	se	234A	ma	266A	rd	431	rp
200D	rd	234B	rd	266B	ha rd	432	ha rd
205	ha	235	ha	272	se	458	se
206	rd	236A	ha rd wa	290	ha	463	ha rd
209A	se	236B	se	314	gu	468	ha rd
209B	rp	237	rh	328	gu	469	ha sh
210	rd	241	se	330	gu	470	rd
211	rd	243	se	331	rp	471	wa
212	ha	244	gu	332	gu	472	se
213	se	247A	rd	333A	wa	473	ag
214A	se	247B	rh	333B	se	476	rd
214B	rd	248A	ha hv rd	333C	se	486	ha rp wa
215	se	248B	ha hv	334A	se	497	ma
216	hv rp	248C	ha hv	334B	ha	528	ha rp
217	rd	248D	ha hv	335A	ha rd	529	gu
218A	ha pr	249	rp	335B	se	530	ha wd
218B	pr	250	ha wa	336	ma	534	ha rd
220	rp	251	ha	337A	rd	535	ha rd
221	rd	253A	ma	337B	ha rd	536	ha
224	ha	253B	gu	338	rh	537	ha rd
225	rd	254A	ha rp	339A	gu	552	ha hv rd
226	se	254B	ha hv	339B	ha hv	562A	ha hv
227	pr	254C	rh	340	gu	601	ha hv rd
228A	rd ha wa	255	se	343	ha hv		
228B	se	256	gu	344A	ha hv		
229	fo ha rp	257	gu	344B	ma		

Map 3.2a. Using Kenai Area Plan designations as a variable for assessing recreation value
The wetland shown above is located within Unit 212 in the Kenai Area Plan. (Unit 212 is the small, blue V-shaped parcel in the right third of the map.) The legend at left shows this unit (parcel) is designated "ha" (habitat)—a "public open space category" that gets a high recreation score in this assessment. (The Kenai Area Plan designated uses for all state lands on the peninsula, see http://dnr.alaska.gov/mlw/planning/areaplans/kenai/).



3.2.3. Understanding wetland assessment scores[28]

Assessment scores are unitless, with higher numbers meaning "more than" lower numbers—"how much more" is not reflected in scores and would require appropriate onsite measurements. High scores max out at 40, an arbitrary limit. Scores decrease by 10 (e.g., 40, 30, 20) except when additional scoring categories were needed, then 5 unit increments were used. Wetland polygons were scored using a process based on descriptive and/or geospatial data and best professional judgment. Results should be repeatable given the same data and assumptions.

28 In Anchorage and Homer, wetlands were scored and then, based on adding scores, were rated high (or A), medium (or B), or low (or C). *Ratings* generally reflect a less objective process than scoring—one person may rate a wetland "high" while someone else may rate the same wetland "medium" or "low" based on a variety of factors, some of which have little to do with the wetland. This project generated *scores* for each assessed function/value but did not develop ratings.

3.2.4. Wetland size and watershed location

In Anchorage/Homer methods, wetland size and watershed location (e.g., whether a wetland is located in the lower, middle, or upper 1/3rd of a watershed) were sometimes scored as part of assessing a particular function. In peninsula assessments, we have omitted these variables for the time being. Wetland size and location are, however, important features with significant management implications. They will be considered during development of management strategies.

The tables below show scores assigned by Anchorage/Homer methods for wetland size and for wetland acreage as percent of basin area. The assessment scoring sheet used in Anchorage can be found at http://www.homerswcd.org/user-files/AWAMBlankCopy.pdf, with additional instructions at http://www.homerswcd.org/user-files/AWAMAppendix.pdf. A "crosswalk table" comparing all functions/values, variables, and metrics considered in Anchorage and Homer methods can be found at http://www.homerswcd.org/user-files/Crosswalk_AWAM-HWAM-4-18.pdf.

Points assigned by Anchorage/Homer assessment methods for wetland size (from AWAM Table 1.4. "Size Evaluation")			
Wetland size (ac)	Total points	Wetland size (ac)	Total points
<1	1	44-53	10
1-4	2	54-64	12
5-8	3	65-77	14
9-12	4	78-92	16
13-17	5	93-110	18
18-22	6	111-128	20
23-28	7	129-160	22
29-35	8	161-200	24
36-43	9	>200	25

Points assigned by Anchorage/Homer assessment methods for wetland size as percent of watershed size (from AWAM Variable 1.5. "Catchment Basin Evaluation Points")								
	Wetland area as % of basin size							
Basin size (ac)	< 3%	3-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%
< 1	1	1	3	5	7	9	11	13
1-3	2	4	6	8	10	12	14	16
4-9	4	6	8	10	12	14	16	18
10-27	6	8	10	12	14	16	18	20
28-81	9	11	13	15	18	21	23	25
82-243	12	15	18	21	24	25	25	25
244-729	15	19	23	25	25	25	25	25
730-2100	18	22	25	25	25	25	25	25
2101-6500+	22	25	25	25	25	25	25	25

3.3. Assessing the Biology component

For this assessment, the *Biology* component was subdivided into *Species Occurrence* and *Habitat* categories, as had been done in Anchorage and Homer assessment projects. Under Species Occurrence, wetlands were assessed in terms of their likelihood to support (a) moose winter habitat, (b) salmon habitat, (c) rare plants, (d) animal species of concern, and (e) wetland scarcity. Under Habitat, wetlands were compared in terms of their physical complexity and interspersion.

3.3.1. Biology component: Species Occurrence

Protocols for scoring Species Occurrence functions were developed from three sources: (1) Anchorage and Homer wetland assessment methods (and OWES), as appropriately modified for this landscape-level assessment, (2) discussions with expert teams, and (3) other relevant information sources covering the Kenai Peninsula. Species were selected for assessment based on their importance as determined by expert teams, as well as on availability of adequate data for the peninsula. Table 3.3a summarizes key information sources considered during assessments of Species Occurrence functions/values.

Table 3.3a. Sources of information for assessing Species Occurrence

Function/ value	Data type	Data source
Moose winter habitat	Elevation contours (4 ft) in Kenai lowlands	Kenai Peninsula Borough (e.g., http://mapserver.borough.kenai.ak.us/flexviewer/, see Section 2.4.2)
	Elevation contours (2 ft) in Seward area	AERO-METRIC, Inc
	Topographic maps (in Seward areas not covered by LiDAR)	US Geological Survey topographic maps provided by the Statewide Digital Mapping Initiative (SDMI, http://www.alaskamapped.org/sdmi/) hosted by University of Alaska's Geographic Information Network of Alaska (GINA, http://www.gina.alaska.edu/)
	State-designated Critical Habitat Areas	Alaska Department of Fish and Game (http://www.adfg.alaska.gov/index.cfm?adfg=protectedareas.main)
	Discharge Slope (S) and Riparian (R) wetland map units with willows in the Kenai lowlands	Wetland Mapping and Classification of the Kenai Lowland, Alaska (http://www.kenaiwetlands.net/EcosystemDescriptions/Intro.htm)
	Discharge Slope (S) and Riverine (R) wetland map units with willows in the Seward area	Personal comm. Mike Gracz, author of Wetland Classification and Mapping of Seward, Alaska (http://www.kenaiwetlands.net/SEWARD/Ecosystems/Intro.htm)
Salmon habitat support	Anadromous[29] streams Wetlands spatial relationship to anadromous streams	Alaska Department of Fish and Game Anadromous Waters Catalog[30] (http://www.adfg.alaska.gov/sf/SARR/AWC/); Wetland Mapping and Classification of the Kenai Lowland, Alaska, Coho Habitat Analysis (http://www.kenaiwetlands.net/Habitat.htm); Expert "biology teams" (see Section 1.3.3)
Rare plants	Rare plants (BIOTICS database)	Alaska Natural Heritage Program: Rare Plants (http://aknhp.uaa.alaska.edu/botany/rare-plants-species-lists/)
Animal species of concern	Animal species of concern database	Alaska Natural Heritage Program: Zoology Program (http://aknhp.uaa.alaska.edu/zoology/)
Wetland scarcity	Percent of total wetland acreage, in 6th level Hydrologic Units, represented by each assessed wetland category	Wetland acreage totals from Wetland Mapping and Classification of the Kenai Lowland, Alaska (http://www.kenaiwetlands.net/EcosystemDescriptions/Intro.htm)

29 The term "anadromous" describes fish, such as salmon, that migrate from the ocean to freshwater habitats to breed and lay eggs. Upon hatching, anadromous fish remain in freshwater for varying lengths of time to feed and grow, depending on species. When strong and large enough, juvenile anadromous fish leave freshwater habitats and migrate out into the ocean to feed and grow to adult size. At maturity, anadromous fish once again return to freshwater habitats to spawn. Other examples of anadromous fish include steelhead trout and some populations of Dolly Varden.

30 This catalog, also called the "Anadromous Waters Catalog," is discussed in detail under Section 3.3.1.2. *Salmon*.

3.3.1.1. Moose winter habitat

Introduction[31]

Moose are an important species on the Kenai Peninsula, where they have been abundant for over100 years. As a prey species, they are significant to many predators (like wolves and bears) and scavengers. To humans, they are important and highly valued for hunting, as well as for non-consumptive uses such as photography and wildlife viewing. More people hunt moose than any other of Alaska's big game species; and statewide, Alaskans and nonresidents harvest approximately 6,000 to 8,000 moose per year, some 3.5 million pounds of meat.

Moose densities around the peninsula vary according to habitat quality, predation, and other factors. The moose population in the area south of Anchor River to Kachemak Bay is considered a high-density population, and is currently estimated at about 3 moose per square mile—or roughly 500 individuals. This is the most abundant and productive population on the Kenai Peninsula. Moose in this area likely serve as a "source" population from which individuals disperse to areas of lower moose densities around the lower Kenai Peninsula. Growth in this population over the past 5-10 years has bolstered moose numbers in surrounding areas.

Moose use a wide variety of habitats, from open-water wetlands, to alpine shrublands, to spruce forests. They are most abundant in recently burned areas supporting dense stands of woody species like willow, aspen, and birch; on timberline plateaus; and along major rivers. Much of their time is spent along forest edges because of the availability of good browse and cover there. Suitability of moose habitats varies seasonally and over longer periods. Habitats change in response to fires, floods, climate change, and other processes that alter land cover, particularly plant communities. Human activities can increase or decrease moose habitat quality.

Seasonally, moose range over large areas to take advantage of shifting food sources, to avoid deep snow, and to find habitats suitable for calving, rutting, and wintering. They may travel as far as 60 miles during these seasonal transitions. On a daily basis, moose seek areas to bed down for rest, to process food, and to escape temperature extremes and disturbances like dogs and human activities.

During summer, preferred foods include aquatic vegetation in shallow ponds, grasses, sedges, forbs, and the leaves of birch, willow, aspen, and cottonwood. During winter, browse is often limited, and moose focus on twigs of woody species like birch and willow (as well as ornamental plants around human residences). In the **photo above**, a moose searches for food in deep snow under a stand of spruce and alder (source: Devony Lehner, HSWCD).

Willows are a critical part of the diet for moose, especially in winter, and willow abundance and availability are key determinants of moose winter survival. An important feedback loop exists between how intensely moose browse willows during winter and the nutritional value of browsed plants the following year—moderate browsing generally increases subsequent plant production, overbrowsing decreases nutritional value. More specifically, when at least 30% of the previous summer growth of willow stems is browsed, production of new shoots tends to increase the following year (barring insect outbreaks and other factors). However, if over 80% of the previous year's growth is browsed, willow plants increase production of secondary compounds that limit the nutritional value of new growth to moose. Browsing of new annual growth year after year can eventually kill a plant. Moose use of browse species increases with severity of winter snowfall. Deep snows bury food sources and make traveling more energetically difficult for moose, especially calves. Deep snow winters often result in severe over-

31 This write-up is based in large part on contributions from Thomas McDonough, ADF&G. Material was also excerpted from the *Alaska Wildlife Notebook Series* entry on moose: http://www.adfg.alaska.gov/static/education/wns/moose.pdf.

browsing of available moose habitat and can cause significant moose die-offs due to malnutrition. Even in relatively mild winters, winter mortality can be significant.

Identifying areas of important moose habitat—for example, through this assessment—and then mitigating losses of habitat quality and quantity through appropriate protection and management can lessen the impacts of habitat loss caused by human activities and developments.

As explained above, habitats that can provide winter forage even after significant snowfall accumulations are particularly crucial to moose survival. Much of the Kenai Peninsula lowland provides such moose winter habitat, including many wetlands. Expert teams identified three variables to use in assessing peninsula wetlands for moose winter habitat. If a wetland polygon met any of these criteria, it was given the highest score for moose winter habitat, otherwise the wetland polygon scored zero.

Methods

Three variables were used to assess wetlands in terms of their function/value as moose winter habitat (the metric used was meets/does not meet variable criteria):

1. **Elevation**
   The 600-ft elevation contour was identified as useful in identifying important areas of moose winter habitat. Contour lines were derived from LiDAR[32] data overlain on the wetland map. From this map, area wildlife biologists determined that the 600-ft contour line reflected a logical upper elevation limit for moose winter habitat, and that all lowlands—wetlands or not—provided important winter habitats. Greater snow depths above 600 ft elevation make these areas less suitable as moose winter habitat in most years. All wetlands at or below 600 ft were given the highest score (40 points) for moose winter habitat.

2. **Vegetation**
   Willows (*Salix* spp) are an important food source for moose in winter. Riparian/Riverine (R), Discharge Slope (S), and Drainageway (DW) wetland map units[33] having significant willow coverage were given the highest score for moose winter habitat. (Wetlands mapped as Late Snow Plateau (LSP) are also dominated by dense stands of willow but were assessed to be at elevations too high to support significant winter moose habitat in most years.) Wetlands having significant willow coverage are listed below, along with their characteristic plant communities.

   The * in codes below indicates that all possible modifiers can be substituted for the asterisk, for example, Re* can be Rel, Res, Rea, or Reac. (Map unit codes are explained in detail in Chapter 2.)

   Discharge Slope (S) wetlands SS, SS*, and S*S have plant communities with significant willow coverage. These plant communities are:
   - Barclay willow / Rich
   - Barclay willow / Bluejoint - Field horsetail
   - Barclay willow / Bluejoint / Marsh fivefinger
   - Tealeaf willow / Crowberry

   Riparian/Riverine (R) wetlands Re*, RC, RDA have plant communities with significant willow coverage. These plant communities are:
   - Barclay willow / Bluejoint,
   - Barclay willow / Bluejoint - Field horsetail
   - Barclay willow / Bluejoint / Marsh fivefinger
   - Lutz spruce / Barclay willow / Field horsetail / Crowberry
   - Barclay willow / Rich

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32 **Li**ght **D**etection and **R**anging is a form of radar that can be used to measure ground elevation from a plane flying overhead.

33 See Sections 2.2.1 to 2.2.5 for explanations of wetland map units.

Additionally, in the Seward area, R wetlands RD4C, RD3C, RDSC, RD4T1, and Drainageway wetland DW3 have plant communities with significant willow coverage. These plant communities are:

- Sitka willow
- Barclay willow / bluejoint reedgrass
- Barclay willow / Sitka sedge

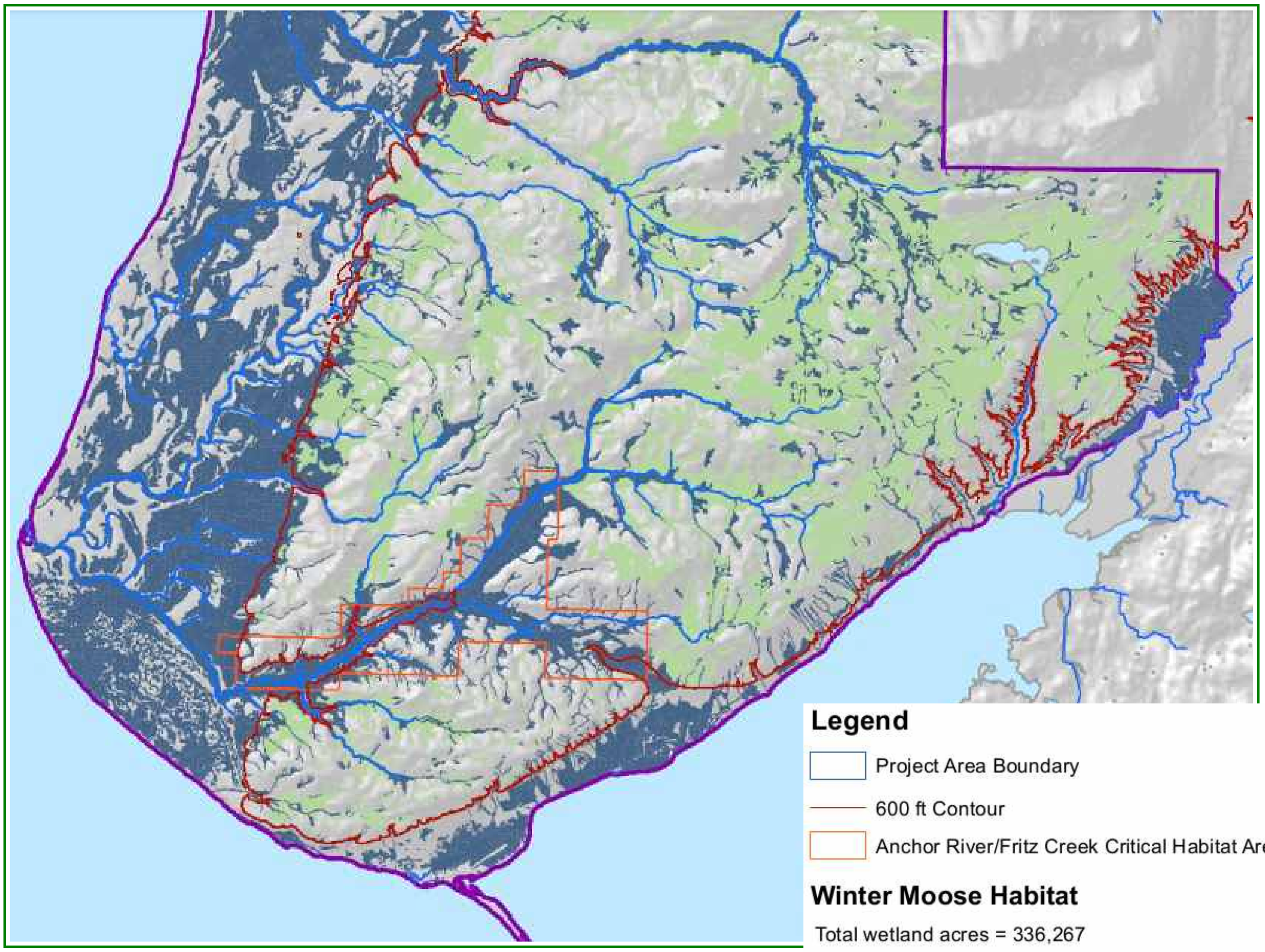
3. **Designated moose Critical Habitat Area**
   The Alaska legislature has designated two Critical Habitat Areas (CHAs) on the Kenai Peninsula to, in part, provide moose winter habitat. These are: (1) the Anchor River – Fritz Creek CHA, which was established in 1985 "...to protect natural habitat critical to perpetuation of fish and wildlife, especially moose, …one of the only major moose overwintering areas on the southern Kenai Peninsula" (see http://www.adfg.alaska.gov/ index.cfm?adfg=anchorriver.main) and (2) the Homer Airport CHA, established in 1996 adjacent to the Homer Airport (see http://www.adfg.alaska.gov/index.cfm?adfg=homerairport.main). Wetlands within the Homer Airport CHA lie entirely below 600 ft elevation and are, therefore, already included under the elevation variable. All wetlands within the Anchor – River Fritz Creek CHA were also given the highest score for moose winter habitat.

Table 3.3b. Kenai Peninsula Wetland Assessment Method—Species Occurrence		
FUNCTION 1: Moose winter habitat – See Maps 3.3a, 3.3b. The map of the entire study area can be found at: https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps		
1	Wetland polygon meets one or more of the following criteria: a) Wetland polygon is at or below 600 ft in elevation b) Wetland polygon is a Discharge Slope or Riparian/Riverine wetland unit above 600 ft in elevation with significant cover of willow. (This category includes the following wetland map units of the Cook Inlet Classification: SS, SLS, SSL, SSA, SAS, SCS, SSC, SGS, SLSd, SPS, SMS, SSA, SSG, SSM; Re*, RC, RDA, Additionally for the *Seward area*: RD4C, RD3C, RDSC, RD4T1, and DW3) c) Wetland polygon is within the Anchor River – Fritz Creek Critical Habitat Area	40
2	Wetland polygon does not meet any of the above criteria	0

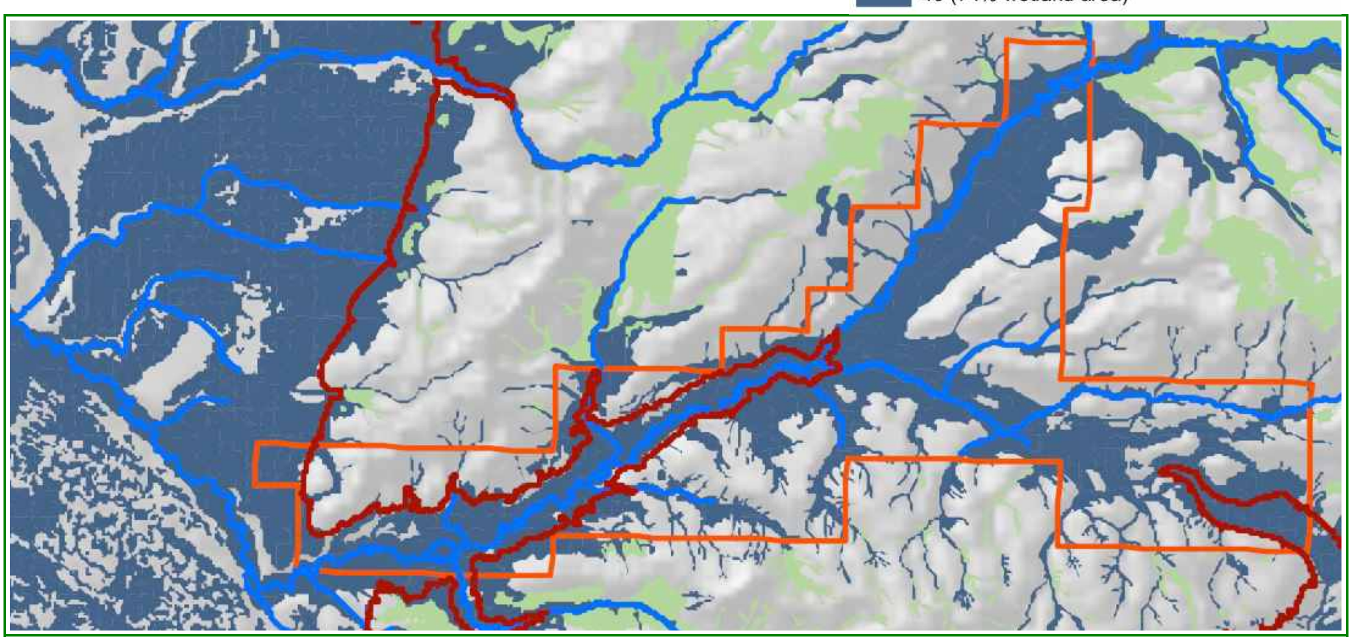
Map 3 shows results of this assessment.

Figure 3.3b. Moose "postholing" in deep snow at an elevation of roughly 900 ft during the winter of 2011/2012. Deep snow buries food sources and exacts a high metabolic toll during movement. (Source: Devony Lehner, Homer Soil and Water.)

Map 3.3a. Wetlands on the southern peninsula assessed for moose winter habitat.
This map shows portions of Anchor River and Deep Creek watersheds and areas between. The map of the entire study area can be viewed at https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.



Below: enlarged section of map above.
Area outlined in orange is the Anchor River – Fritz Creek Critical Habitat Area.



3.3.1.2. Salmon habitat support

Introduction

Salmon are economically and culturally the most important renewable resource throughout Alaska—supporting commercial, recreational, subsistence, and personal use fisheries worth hundreds of millions of dollars annually*. Sport and commercial salmon fisheries are key drivers of the peninsula's economy. Kenai Peninsula streams support five species of Pacific salmon: chinook or king (*Oncorhynchus tshawytscha*), sockeye or red (*O. nerka*), pink or humpy (*O. gorbuscha*), coho or silver (*O. kisutch*), and chum (*O. keta*).

Salmon are known for their highly complex life histories. Life history stages include hatching from pea-sized eggs laid in streambed gravels, maturing to the "smolt" stage in a variety of freshwater habitats, outmigrating as smolts from tidal estuaries to the ocean to feed and attain adult size, then in 1 to 5 years—depending on species—returning to freshwater to spawn. The details of habitat use—both in space and time—vary among among species (see, for example, *Salmon Species and Life Cycle*.) Wetlands and the streams and lakes to which they connect support these salmon life stages in many critical ways. Examples include:

- supporting habitats used during different salmon life stages and activities, for example,
  for juveniles: areas for feeding, resting, hiding, passage up and downstream between habitats, and smolting;
  for adults: habitats for migrating upstream from the ocean and habitats for spawning;
- helping to maintain baseflows in streams during dry months of spring and summer;
- contributing nutrients to instream and inlake habitats;
- moderating summer stream temperatures (evapotranspiration from wetlands converts latent heat and releases water vapor to the atmosphere);
- buffering erosive effects of flood flows on aquatic habitats;
- filtering sediments and other pollutants from surface runoff;
- stabilizing streambanks and lake shorelines; and
- contributing to the maintenance of natural flow regimes, both in individual streams and in entire watersheds.

In assessing wetlands for salmon—that is, for their relative contributions to maintaining salmon habitats and populations—expert teams[34] wanted to recognize *all* wetlands potentially playing important roles in maintaining peninsula salmon populations. As a result, any wetlands in which salmon may be found during any life history stage were given points, as were connected wetlands likely to support habitat conditions within those wetlands. Wetlands most heavily used by salmon—for example, those adjacent to anadromous streams—received the highest points; wetlands connected to and affecting salmon habitats but not necessarily used by salmon directly were given lower scores.

Coho (silver) salmon use the greatest variety of wetland habitats of any anadromous fish on the Kenai Peninsula. They range farther upstream into headwater areas than any other salmon species, and they range more widely into different kinds of wetlands and lakes connected to anadromous streams. As a result, coho habitats encompass all habitat areas used by other peninsula salmon. For this reason, coho served as a proxy for all peninsula salmon—assessing peninsula wetlands in terms of coho habitat support resulted in an assessment encompassing habitats used by all peninsula salmon species.

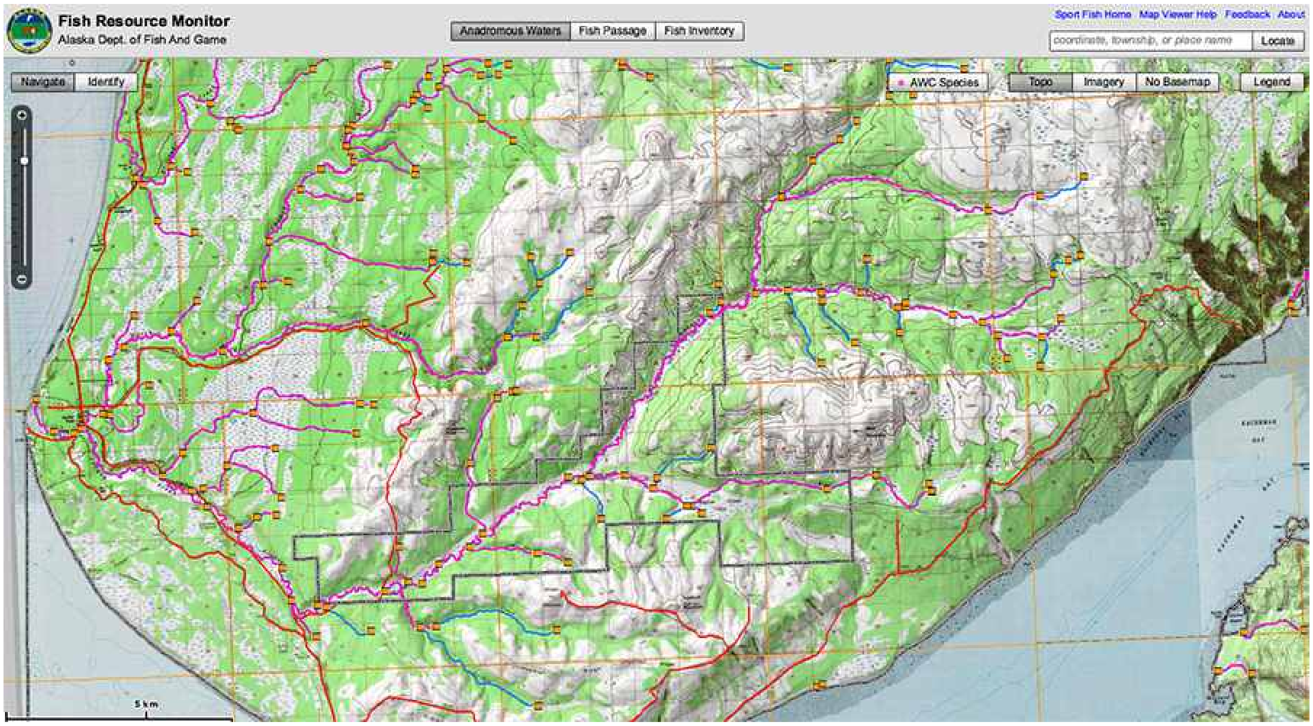
Map 3.3b (top and bottom) illustrates how much more widely coho range than, for example, chinook salmon. The top map shows the known range of coho salmon in a portion of the Anchor River watershed; the bottom shows the range of chinook salmon in the same area. These maps are from *The Catalog of Waters Important for the Spawning, Rearing, and Migration of Anadromous Fish*—commonly called the Anadromous Waters Catalog or AWC—which is maintained by the Alaska Department of Fish and Game. The catalog is updated as additional streams

* See, for example, Gunnar Knapp, *Economic Impacts of Kenai Peninsula Borough Fish Industries*, 2012, Institute of Social and Economic Research, University of Alaska, Anchorage, online at: http://www2.borough.kenai.ak.us/AssemblyClerk/assembly/Info/2012/102312/Economics%20of%20the%20Seafood%20Industry%20Presentation.pdf.

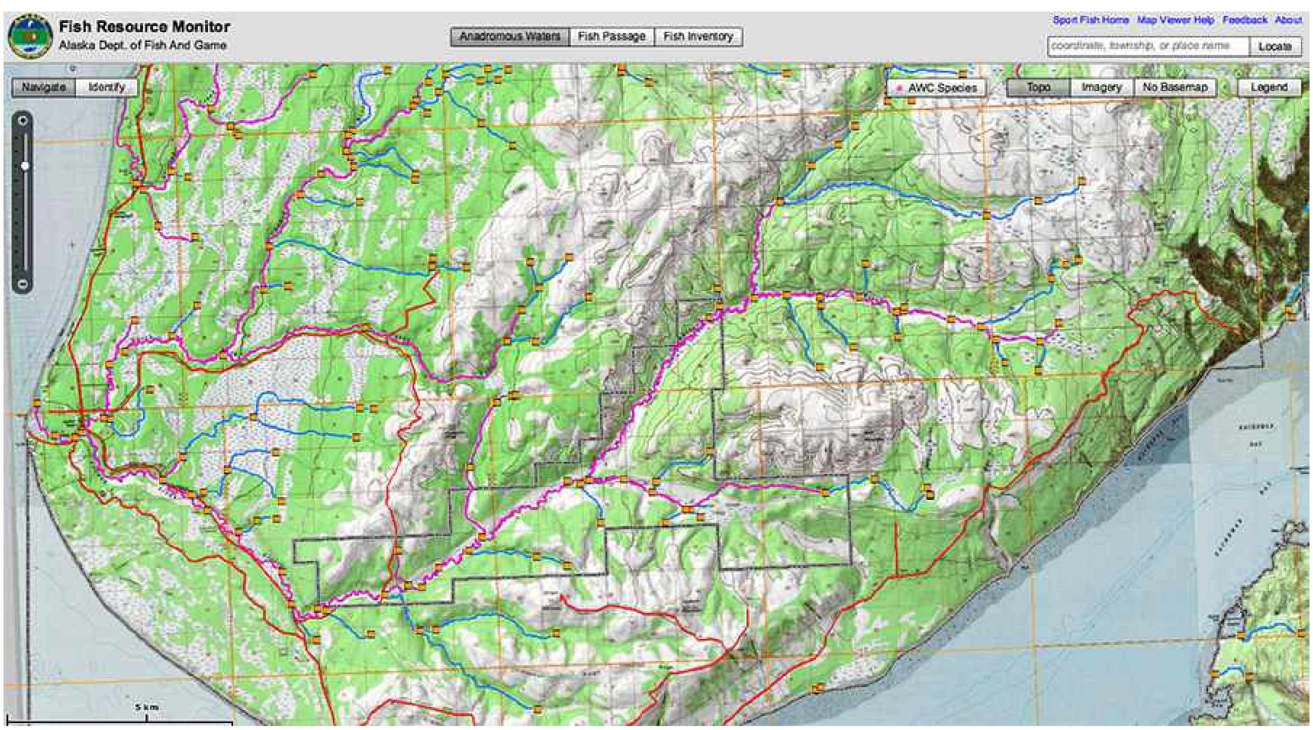
34 Expert teams are discussed in Section 1.3.3 of *Kenai Peninsula Wetlands – a Guide for Everyone*.

are discovered and documented to support salmon life history stages. The 2012 version of the AWC was a key source of information used for this assessment of salmon habitat support. The catalog can be accessed at http://www.adfg.alaska.gov/sf/ SARR/AWC/. (Click on "Interactive Mapping" to find maps like Map 3.3b.)

Map 3.3b (top): Streams in the southern portion of the Anchor River watershed that are listed for **coho salmon** in the Anadromous Waters Catalog; coho travel more widely throughout their watersheds than other salmon species (see http://www.adfg.alaska.gov/sf/SARR/AWC/). Streams marked in purple are documented to support coho salmon life stages.



(bottom): Streams in the southern portion of the Anchor River watershed that are listed for **chinook salmon** in the Anadromous Waters Catalog; compare with the map above (see http://www.adfg.alaska.gov/sf/SARR/AWC/). Streams marked in purple are documented to support chinook (king) salmon life stages.



Inevitably, some wetlands supporting salmon will have been missed during this assessment because their contributions to salmon survival are not yet recognized. For example, recent research suggests that even very small headwater streams—just inches across and often hidden under flopped-over stems of bluejoint grass—provide critical rearing habitats for thousands of tiny coho juveniles (see, for example, http://www.adfg.alaska.gov/static/lands/habitatresearch/kbrr/pdfs/kbrr_newsletter6_may2013.pdf). Similarly, recent research is only now beginning to document the importance of alder shrublands to salmon stream productivity[35].

It's important to remember that in peninsula ecosystems—as in all ecosystems—"everything connects to everything else" in countless and dynamic ways, most of which are little known or understood. The truth is that probably all peninsula wetlands play some role in supporting the quality of the environments on which salmon depend. The complexity of such relationships is illustrated by hydrologic and chemical connections between wetlands and anadromous streams: streams disappear into wetlands and then re-emerge as surface or subsurface outflows, which in turn disappear into other wetlands and re-emerge further downslope (or downgradient), until finally flowing into streams supporting salmon. In other cases, wetlands straddle drainage divides—on one side draining into an anadromous stream and on the other, into a non-anadromous stream. Relatively few such relationships have been studied, although recent work by researchers at the Kachemak Bay Research Reserve and the US Fish and Wildlife Service have begun to clarify some of this complexity (see, for example, http://www.fws.gov/alaska/fisheries/fish/Data_Series/d_2011_8.pdf and http://www.adfg.alaska.gov/index.cfm?adfg=kbrr_resources.reports).

Limitations

Several limitations of this salmon assessment should be noted. To begin with, many streams used by coho (and other salmon) have not yet been identified, and so are not included in the Anadromous Waters Catalog. Every year, additional peninsula streams are nominated for inclusion. The 2012 version of the catalog was used for this assessment. Secondly, wetlands supporting resident fish were not considered during this project, generally because information on their presence is limited and inconsistent. Wetlands supporting resident fish can be added in the future as adequate data become available. Thirdly, this salmon assessment did not consider barriers to salmon passage or migration. Beaver dams, debris jams, improperly installed culverts, and other obstacles to fish passage can block miles of high-scoring salmon habitat. Fourth, scale affects map interpretation. Due to limitations inherent in mapping from aerial photographs at a scale of 1:24,000, small streams and open water habitats are frequently lumped into wetlands that are given map codes not indicating the presence of open water. Given the inherent interconnectedness of wetlands and streams on the Kenai lowlands, all non-Depression wetlands in this area eventually connect through open water to anadromous streams. Due to the vagaries of mapping and our lack of knowledge, many of these connections are not reflected in assessment scores assigned particular wetlands.

Methods

The method outlined here was slightly modified from the method developed during classification and mapping of Kenai Peninsula wetlands (see Section 2.2 for a full discussion of peninsula wetland mapping and classification). The original version of this salmon method can be found at http://www.kenaiwetlands.net/Habitat.htm. Variables used for this assessment are explained below and summarized in Table 13. Table 14 illustrates key terms used.

Assessing braided river systems in Seward[36]

In the Seward area, many anadromous streams are fed by glacial meltwater but lack the "settling pond" function of a large lake, such as Kenai, Skilak, and Tustumena Lakes in the Kenai lowlands. In addition, Seward is subject to frequent periods of heavy rainfall. As a result, both during summer periods of rapid glacial melting and during fall periods of heavy rainfall, glacier-fed anadromous streams carry heavy sediment loads. These

Rivers are extremely dynamic systems in the Seward area. Channels frequently shift... Mapping these wetlands sometimes feels like an exercise in futility. What is mapped as a floodplain wetland or terrace today could become something completely different next month. The wetland map is nonetheless useful for its delineation of the general boundary of the Riparian Wetland system.

Mike Gracz
(http://www.kenaiwetlands.net/seward/Ecosystems/Riparian.htm)

35 See, for example. http://www.kenaifishpartnership.org/wp-content/uploads/2012/10/web_Walker_1.pdf and https://beardocs.baylor.edu/xmlui/bitstream/handle/2104/8052/rebecca_shaftel_masters.pdf?sequence=2.

36 The bulk of this discussion is taken from "Seward Riparian Ecosystems" by Mike Gracz, see http://www.kenai

sediments drop out when high flows subside and where stream velocities slow down due to decreases in channel slope. Sediment deposition in the stream channel causes the streambed to build up or “aggrade.” Aggradation creates channel bars or islands, and as these grow, they deform or split the flow, producing multiple channels. As active channels split, diverge, and then rejoin further downstream, they create a braided river channel (see, for example, Stream Type D in Figure 2.2d, Chapter 2).

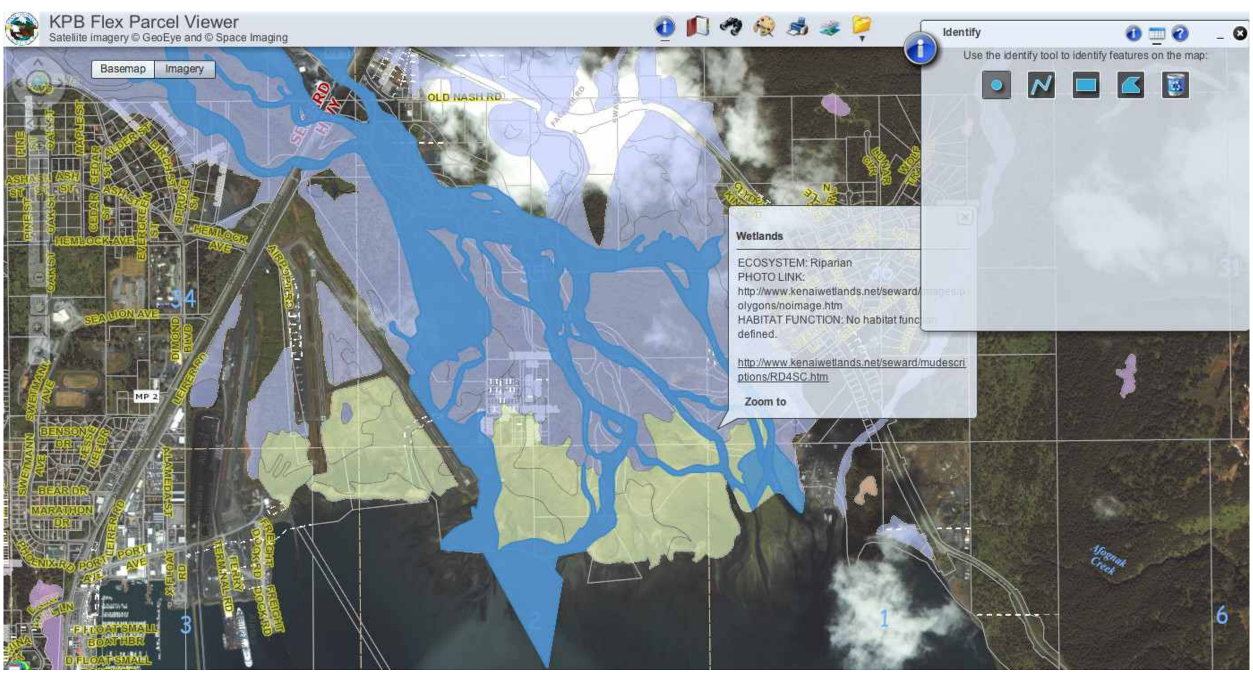
Braided river systems are especially dynamic. In braided geomorphic settings, active channels shift back-and-forth across a wide “braidplain”[37]. Braided rivers are the rule in settings with steep gradients, highly variable discharges, and abundant coarse load, all conditions found in the Seward area. A variation on this theme is caused by the fact that the upper reaches of many Seward-area streams are confined to relatively narrow valleys. Where streams emerge from these valleys, they create broad alluvial fans of deposited material, and the fans of multiple streams and rivers converge. The point where a stream leaves its side-valley is a very narrow spot at the top of the broad fan. If the stream leaves its channel at this spot, as it does during a flood event, it can potentially flow anywhere down the fan, which means the fan itself functions like a braidplain.

When assessing Seward braided stream systems for salmon, braided main channels and side channels of anadromous streams—i.e., Resurrection and Snow Rivers—score highest (40 points). These areas are mapped as RD4C, RD3C, RD4SC (see example in Map 3.3c). Floodplain wetlands adjacent to anadromous streams receive 30 points (RD4F types). River terraces adjacent to anadromous streams receive 20 points (RD4T1 or RD4T2). See Table 3.3c.

Classification of Seward area streams and rivers

A summary of R codes for Seward area streams and rivers is found at the end of Section 2.2.3.3. When assessing Seward braided stream systems for salmon, braided main channels and side channels of anadromous streams—i.e., Resurrection and Snow Rivers—score highest (40 points). These areas are mapped as RD4C, RD3C, RD4SC (see example in Map 3.3c). Floodplain wetlands adjacent to anadromous streams receive 30 points (RD4F types). River terraces adjacent to anadromous streams receive 20 points (RD4T1 or RD4T2). See Table 3.3c.

Map 3.3c. An RD4SC wetland in the Seward area, identified using the KPB flexviewer (see Section 2.4.2, Chapter 2).



wetlands.net/seward/Ecosystems/Riparian.htm.

37 Note, for permitting purposes, the state defines the entire braidplain as within the area of “ordinary high water” (OHW). (OHW is defined in AS 41.17.950. *Definitions*, see http://www.touchngo.com/lglcntr/akstats/statutes/title41/chapter17/section950.htm.) OHW is referenced by both the Army Corps of Engineers and the Alaska Department of Fish and Game in determining where their regulations apply. For a diagram of OHW, see Figure 4.1a in Chapter 4.

Two variables were used to assess wetlands in terms of their support of salmon habitats:

1. **Wetland contains a "coho catalog stream."**
   This variable addresses any wetland that contains a stream listed as supporting coho in the 2012 Anadromous Waters Catalog maintained by the Alaska Department of Fish and Game (see http://www.adfg.alaska.gov/sf/ SARR/AWC/; Map 3.3b provides examples from the catalog.)

2. **Connection of the wetland—either directly or through an open-water wetland—to a "coho catalog stream."**

Variables and metrics used to assess peninsula wetlands for salmon are summarized in Table 3.3c and illustrated in Table 3.3d and Map 3.3d. **Note**, as illustrated in Table 3.3d, a wetland containing a "coho catalog stream," "likely coho stream," or "possible coho stream" is not the same thing as the stream itself. At a map scale of 1:24,000, these anadromous stream channels are often not visible, so it can be easy to confuse an R wetland with the stream flowing through it. The top right illustration in Table 3.3d should make clear the distinction between an R wetland and the anadromous stream running through it.

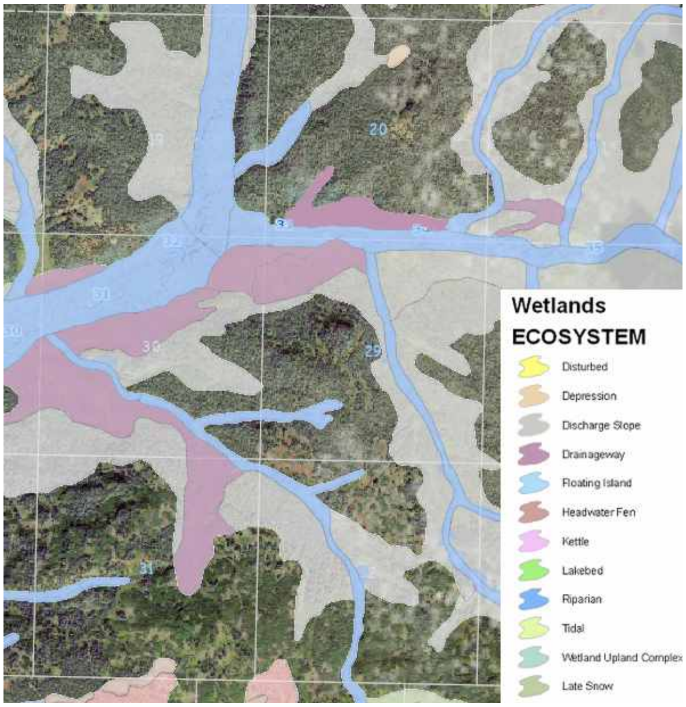
Table 3.3c. Kenai Peninsula Wetland Assessment Method—Species Occurrence (grey rows below apply only to Seward
Salmon assessment map for the entire project area is available at:
https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps

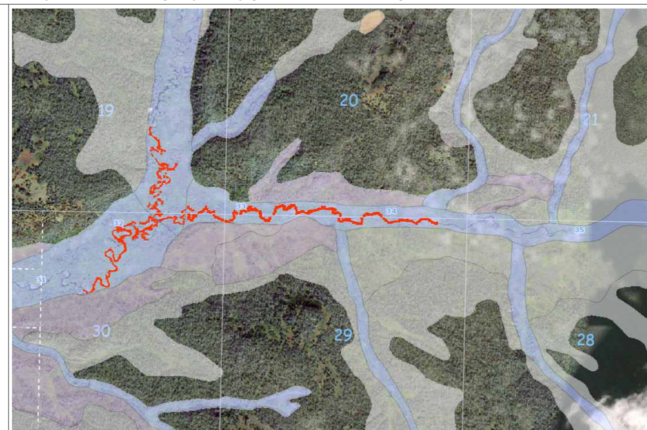
FUNCTION 2: Salmon habitat support		
Select which one of the following choices describes the wetland polygon:		
1	Wetland contains a "**coho catalog stream**" (i.e., a stream listed in the 2012 version of the Anadromous Waters Catalog).	40
2	Wetland is a Seward floodplain ("braidplain") map unit that contains a stream listed in the 2012 version of the Anadromous Waters Catalog (i.e., map units RD4C, RD3C, or RD4SC).	40
3	Wetland contains a "**likely coho stream"** (i.e., a stream that is NOT in the Anadromous Waters Catalog but flows directly into a catalogued stream). (See Table 3.3d.)	30
4	Wetland is Seward floodplain (braidplain) map unit that is adjacent to an anadromous catalog stream (i.e., map unit RD4F*).	30
5	Wetland provides "**likely coho wetland habitat**." This consists of wetlands with open water that are adjacent to wetlands scoring either 40 or 30 points.	25
6	Wetland contains a "**possible coho stream.**" This consists of Riverine (R) wetlands that connect to a coho catalog stream through "likely coho wetland habitat."	25
7	Wetland provides "**coho support habitat**." This consists of wetlands directly adjacent to any of the above categories. These wetlands provide nutrients, filter water, buffer flows, and perform other functions that support the quality of adjacent coho habitat. (See bottom row of Table 3.3d.)	20
8	Wetland is a Seward terrace unit (RD4T1 or RDFT2) adjacent to an anadromous stream.	20
9	Wetland polygon meets none of the above criteria.	0

The * in a code indicates that all possible modifiers can be substituted for the asterisk; map unit codes are explained in detail in Chapter 2, particularly Section 2.2.

Table 3.3d. Salmon-assessment categories illustrated.

Blue polygons = Riparian wetlands; purple polygons = Drainageway wetlands; grey polygons = Discharge Slope wetlands.

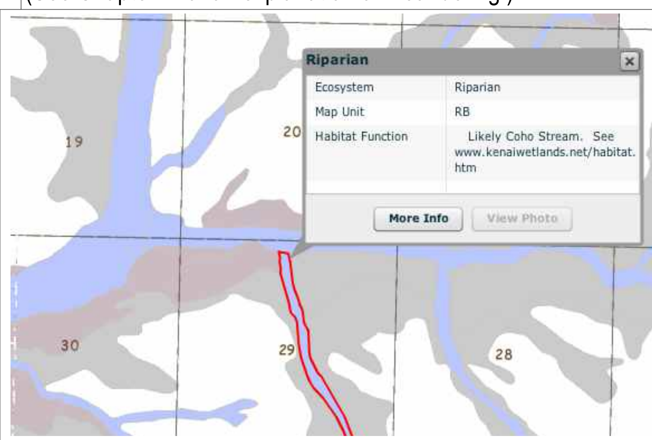




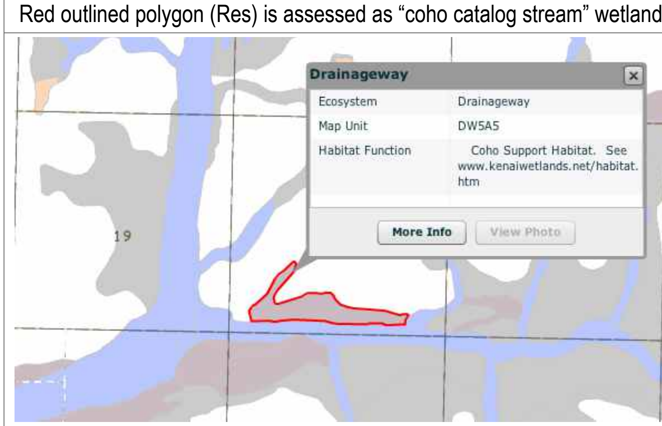
The wetlands shown in this table illustrate several categories for scoring wetlands for salmon. The **map above** illustrates how stream channels are related to the wetland polygons through which they flow. Portions of the channels of two anadromous streams have been highlighted above in red; these streams flow through Riparian wetlands. (The stream on the left is the Anchor River, the stream on the right is a tributary.) Stream channels themselves can be difficult or impossible to see at a scale of 1:24,000, the scale used to map peninsula wetlands.

(See Chapter 2 for an explanation of meandering.)

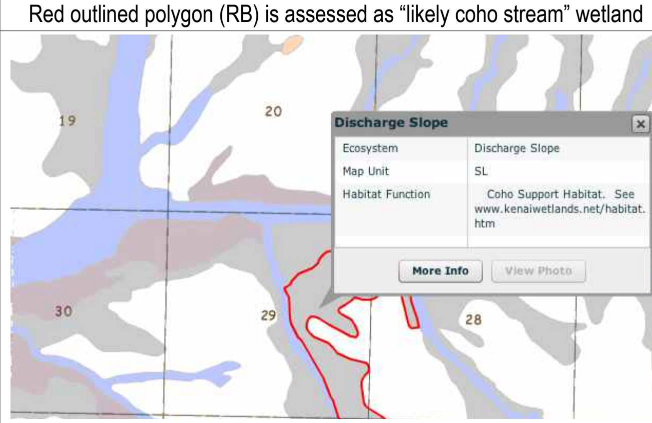
Red outlined polygon (Res) is assessed as "coho catalog stream" wetland



Red outlined polygon (RB) is assessed as "likely coho stream" wetland

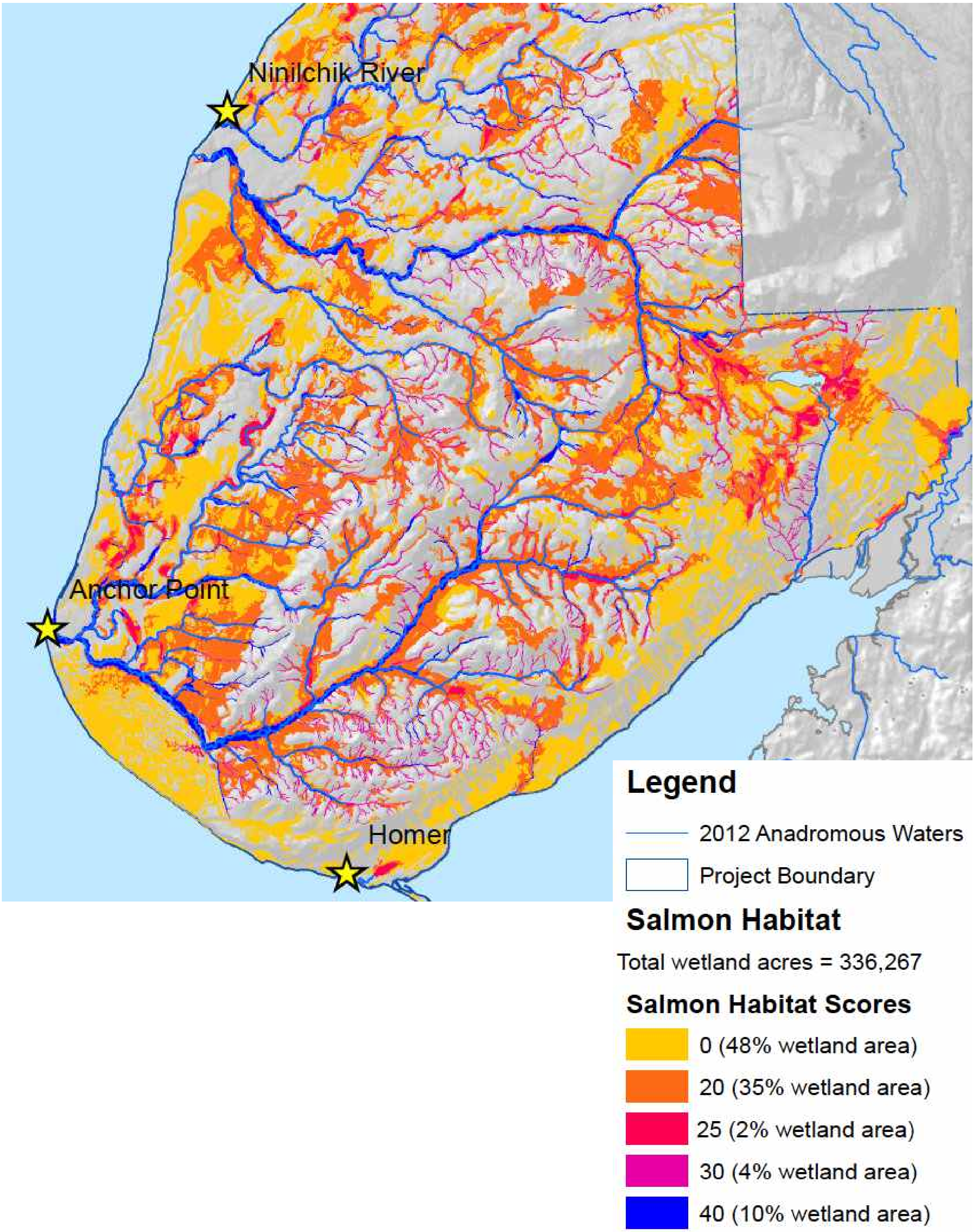


Red outlined wetland (DW5A5) is assessed as "coho support habitat"



Red outlined wetland (SL) is assessed as "coho support habitat"

Map 3.3d. Example of wetlands assessed for salmon support in the southern Kenai lowlands.
(For a map of the entire project area, see https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.)



3.3.1.3. Rare plants

Introduction

Maintaining the biodiversity of peninsula ecosystems is important in maintaining ecosystem health and resilience. Populations of rare wetland plants contribute to overall biodiversity. Such plants provide other societal values, including opportunities for research and education and sources of products useful to society (including medicinal and manufacturing products). Rare plants can also serve as indicators of rare habitat types.

Six species of rare plants were considered during this assessment, as outlined under Methods.

Methods

One variable was used to assess wetland support for rare plants:

1. **The presence of rare wetland plant species (rarity based on AKNHP status, see below)**

   The Alaska Natural Heritage Program (AKNHP, http://aknhp.uaa.alaska.edu/) tracks rare plants found in Alaska. AKNHP ranks species rarity at both state (S) and global (G) levels based on protocols developed by its parent organization, NatureServe (http://www.natureserve.org/). The rarity of different species is ranked using a scale of 1 to 5 for both state and global distributions. A plant with a ranking of S1-G1 (also written S1G1) is most rare both statewide and globally; S1-G5 is most rare statewide but common globally. Table 3.3e provides definitions of terms used by AKHNP to describe species status (both for plants and animals). These definitions are from NatureServe (http://www.natureserve.org/explorer/ranking.htm).

The AKNHP BIOTICS database (http://aknhp.uaa.alaska.edu/maps/biotics/) lists the following six plant species ranked S3 or rarer as growing in freshwater wetland habitats on the Kenai Peninsula. These are illustrated in Table 3.3f.

1. *Carex heleonastes* (Hudson Bay sedge) G4, S2S3
2. *Catabrosa aquatica* (water whorlgrass) G5, S1
3. *Ceratophyllum demersum* (coon's tail) G5, S1
4. *Eriophorum viridicarinatum* (thinleaf cottonsedge) G5, S2
5. *Pedicularis groenlandica* (elephanthead lousewort) G4G5, S1S2
6. *Pedicularis macrodonta* (muskeg lousewort) G4Q, S3

Table 3.3e. Definitions of species status as used by AKNHP (from NatureServe, http://www.natureserve.org/explorer/ranking.htm).	
S1	**Critically Imperiled**—Critically imperiled in the jurisdiction because of extreme rarity or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the jurisdiction.
S2	**Imperiled**—Imperiled in the jurisdiction because of rarity due to very restricted range, very few populations, steep declines, or other factors making it very vulnerable to extirpation from the jurisdiction.
S3	**Vulnerable**—Vulnerable in the jurisdiction due to a restricted range, relatively few populations, recent and widespread declines, or other factors making it vulnerable to extirpation.
S4	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
S5	**Secure**—Common, widespread, and abundant in the jurisdiction.
B	**[Animal] Breeding—**Conservation status refers to the breeding population of the species in the nation or state/province.
N	**[Animal] Nonbreeding—**Conservation status refers to the non-breeding population of the species in the nation or state/province.
Q	**Questionable taxonomy that may reduce conservation priority—** Distinctiveness of this entity as a taxon or ecosystem type at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon or type in another taxon or type, with the resulting taxon having a lower-priority (numerically higher) conservation status rank. The "Q" modifier is only used at a global level and not at a national or subnational level.
T#	**Infraspecific Taxon** (trinomial)—The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles outlined above. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1. A T subrank cannot imply the

	subspecies or variety is more abundant than the species . For example, a G1T2 subrank should not occur. A vertebrate animal population, (e.g., listed under the U.S. Endangered Species Act or assigned candidate status) may be tracked as an infraspecific taxon and given a T-rank; in such cases a Q is used after the T-rank to denote the taxon's informal taxonomic status.

Table 3.3f. Rare wetland plant species mapped on the peninsula (most images are from: http://plants.usda.gov/java/).

***Catabrosa aquatica* (water whorlgrass)** S1,
Photo from: http://plants.usda.gov/java/largeImage?imageID=caaq3_002_avp.tif

***Carex heleonastes* (Hudson Bay sedge)** S2S3, Photo from: http://efloora.ut.ee/Eesti/species/8329.html

***Ceratophyllum demersum* (coon's tail)** S1,
Photo from: http://plants.usda.gov/java/largeImage?imageID=cede4_002_ahp.tif

***Eriophorum viridicarinatum* (thinleaf cottonsedge)** S2
Photo from: http://plants.usda.gov/java/largeImage?imageID=ervi9_002_avp.tif

***Pedicularis groenlandica* (elephant-head lousewort)** S1S2 Photo from: http://plants.usda.gov/java/largeImage?imageID=pegr2_001_avp.tif

***Pedicularis macrodonta* (muskeg lousewort)** S3, Photo from: http://www.em.ca/garden/native/nat_pedicularis_macrodonta.html

Two metrics were used to score the rare plant variable: (1) proximity to rare plant location(s) and (2) presence of appropriate ecological setting (or potential rare plant habitat).

1. **Proximity to rare plant location(s)**
AKNHP made its locational rare plant database (BIOTICS) available for use in the Kenai Peninsula wetland assessment. AKNHP specifies that its data not be used at a scale finer than 1:100,000, and in the AKNHP database, locations of rare plant species are buffered by circles with diameters of 0.12 mile, 2.5 miles, or 12 miles. Circle size depends on a number of factors, including confidence in locational accuracy, size of plant population, and potential for population expansion.

Using the original AKNHP buffer circles, 6,080 wetland polygons would have been identified as supporting rare wetland plants (over 30 percent of the area mapped as wetlands on the Kenai lowlands). To fine tune this metric, and based on consultation with AKNHP staff, smaller buffers—circles of 1-mi and 2.5-mi diameters—were applied to known locations of rare plants. Where latitude-longitude information was lacking for a plant's location, the centroid of the AKNHP circle was determined and then buffered. Using this procedure, only 855 wetland polygons were identified as supporting rare plants (5 percent of the total wetlands area mapped in the Kenai lowlands).

2. **Presence of appropriate ecological setting**
After buffer circles were defined, appropriate ecological settings (habitat) for rare plant species were considered to further refine this variable. For example, the rare plant *Ceratophyllum demersum* is aquatic, therefore, within a circle identified for this plant, only wetland polygons with open water received the highest score because only they would provide an appropriate ecological setting for an aquatic plant. Similarly, forested Discharge Slopes were determined to be unlikely to provide an appropriate ecological setting for any of the rare wetland plants on the Kenai Peninsula[38]. This was based on the fact that the rare wetland plants in the area were generally found in unforested peatlands and would be unlikely to grow in forested mineral soil.

For a given rare plant species, wetland polygons lying within 0.5 mi of that plant's location (or the centroid of its AKNHP circle) AND providing an appropriate ecological setting for that species received a maximum score (40). Wetland polygons farther than 0.5 mi from the plant's location but within 1.25 mi AND providing an appropriate ecological setting received a score of 20. Wetland polygons within 1.25 mi of the rare plant location but NOT providing an appropriate ecological setting were given a score of 10 to recognize support functions such wetlands provide to nearby rare wetland plant habitats.

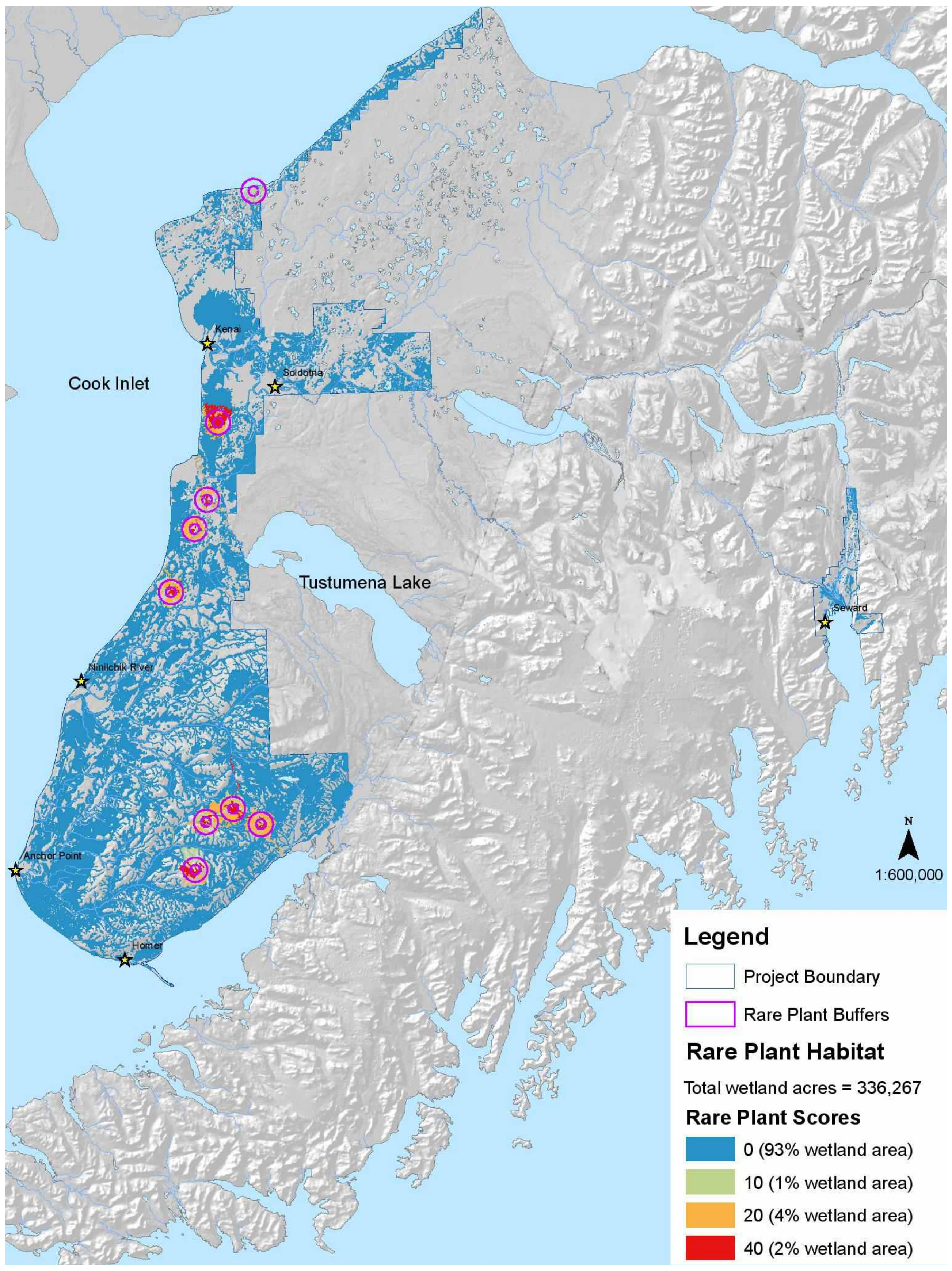
Variables and metrics used to assess peninsula wetlands for rare wetland plants are summarized in Table 3.3g. Results are presented in Map 3.3f presents assessment results.

Table 3.3g. Kenai Peninsula Wetland Assessment Method—Species Occurrence		
FUNCTION 3: Presence of rare wetland plant species		
1	Wetland meets ONE of the following criteria:	
	a) polygon is within 0.5 mile of a rare plant location AND contains appropriate ecological setting for that species	40
	b) polygon is farther than 0.5 mile but closer than 1.25 miles from a rare plant location AND contains appropriate ecological setting for that plant species	20
	c) polygon is farther than 0.5 mile but closer than 1.25 miles from a rare plant location but is unlikely to contain appropriate ecological setting for that plant	10
2	Wetland polygon meets none of the above criteria.	0

38 This determination was made by Dr. Matt Carlson, AKNHP Program Botanist.

Map 3.3f. Wetlands assessed for rare plants.

(For a map with higher resolution, see https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.)



3.3.1.4. Rare animals ("fauna species of concern")

Introduction

As noted under Rare Plants in the previous section, maintaining the biodiversity of peninsula ecosystems is important in maintaining ecosystem health and resilience. Maintaining populations of all animal species native to the Kenai Peninsula contributes to overall biodiversity. The Alaska Natural Heritage Program, in addition to tracking rare plants as discussed above, also tracks selected animal species and ranks their conservation status based on criteria developed by NatureServe. This is done through AKNHP's Zoology Program, whose primary goal is "to assimilate and synthesize information concerning rare and invasive species for use in land management and species conservation applications in Alaska" (http://aknhp.uaa.alaska.edu/zoology/). AKNHP's rare animals database provided the basis for assessing this function.

On the Kenai Peninsula, AKNHP assigned conservation status ranks of S1, S2, or S3[39] to six non-marine animal species. These ranks indicate that area populations of these species are imperiled or vulnerable (see http://aknhp.uaa.alaska.edu/zoology/species-list/). Table 3.3h lists these species—four birds, one fish, and one invertebrate—which were used to assess wetlands for animal species of concern.

Table 3.3h. Animal species of concern used for wetland assessment				
Common Name	**Scientific name**	**Family**	**Global**	**State**
Aleutian Tern	*Oncychoprion aleuticas*	Laridae	G4	S3B
Kittlitz's Murrelet	*Brachyramphus brevirostris*	Alcidae	G2	S2B,S2N
Rusty Blackbird	*Euphagus carolinus*	Icteridae	G4	S4B, S3N
Pribilof Rock Sandpiper	*Calidris ptilocnemis ptilocnemis*	Scolopacidae	G5T3	S2N, S3B
Alaskan Brook Lamprey	*Lampetra alaskensis*	Petromyzontidae	GNR	S3Q
Yukon Floater	*Anodonta beringiana*	Unionidae	G4	S3S4

S = state, G = global, B = breeding, N = non-breeding, T# = infraspecific taxa, Q = questionable taxonomy (see Table 3.3e for definitions).

In addition, wetlands supporting caribou calving/summer habitats and potential sandhill crane nesting habitats were assessed as part of this function. Caribou and sandhill cranes were identified as important to Kenai Peninsula residents during classification and mapping of peninsula wetlands (see Chapter 2). As part of that project, Mike Gracz assessed wetlands for these species (see http://www.kenaiwetlands.net/Habitat.htm); his results were incorporated here.

Methods

Two variables were used to assess wetlands for support of animal species of conservation concern.

1. Presence of non-marine AKNHP animal species of concern (see http://aknhp.uaa.alaska.edu/maps/biotics/).
2. Wetlands previously identified as providing habitats for caribou calving/summer habitats and potential sandhill crane nesting (these were identified during *Wetland Mapping and Classification of the Kenai Lowlands, see* http://www.kenaiwetlands.net/habitat.htm).

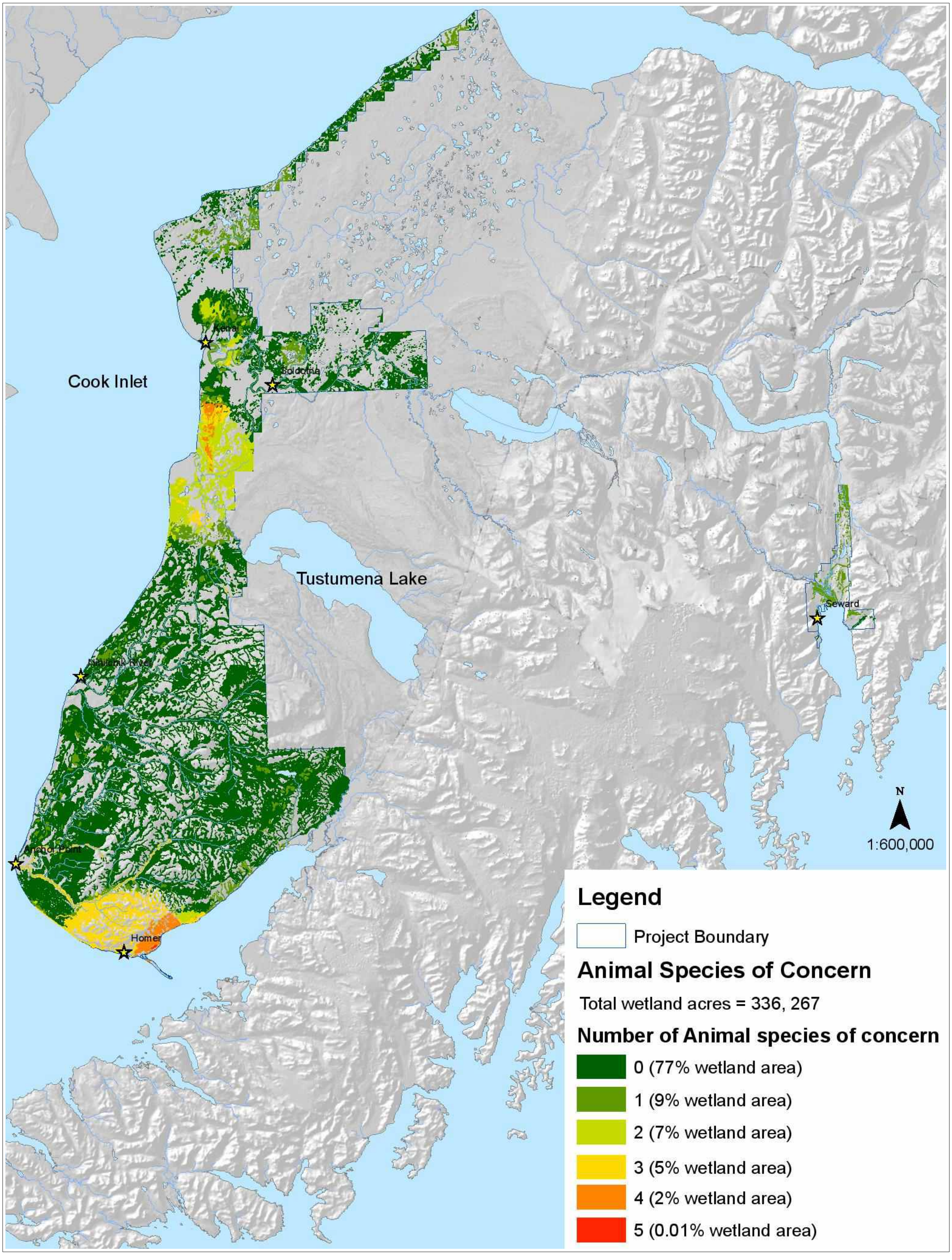
Table 3.3i shows variables considered for this assessment. Results are presented in Map 3.3g.

Table 3.3i. Kenai Peninsula Wetland Assessment Method—Species Occurrence		
FUNCTION 4: Potential habitat for animal species of concern		
1	Wetland meets ONE of the following criteria:	
	a) polygon has 4 or 5 species of concern. (324 polygons)	40
	b) polygon has 3 species of concern (753 polygons)	30
	c) polygon has 2 species of concern (1254 polygons)	20
	d) polygon has 1 species of concern (1499 polygons)	10
2	Wetland polygon meets none of the above criteria	0

39 Species ranked S4 or S5 by AKNHP were not included in this assessment, as populations of these species are "secure" or "apparently secure." For definitions of AKNHP status categories, see Table 3.3e under Rare Plants.

Map 3.3g. Wetlands assessed for animal species of concern.

(For a map with higher resolution, see https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.)



3.3.1.5. Wetland scarcity

Introduction

Both Anchorage and Homer wetland assessments considered how "scarce" each kind of wetland was within its watershed. Scarcity was measured "...as as a percent of that wetland type in the catchment basin." Consideration of this function/value was based on the recognition that "...each basin has its own unique biodiversity based in part on which wetland types are present."

On the Kenai Peninsula, 6th level hydrologic units (HUs) provided the "catchment basin" (watershed) used for assessing wetland scarcity; these hydrologic units are identified with 12-digit Hydrologic Unit Codes[40] (HUCs). Wetland scarcity was assessed by looking at the total wetland acreage within each HU and then determining what percent of that acreage was represented by each assessed wetland category—in this case, wetland geomorphic component. Because wetland geomorphic components mapped on the peninsula resulted in more wetland categories than distinguished in Anchorage, an additional scoring category was used in this assessment: geomorphic component constitutes less than 5 percent of the total wetland acres in the HU under consideration.

Methods

One variable was used to assess wetland scarcity:

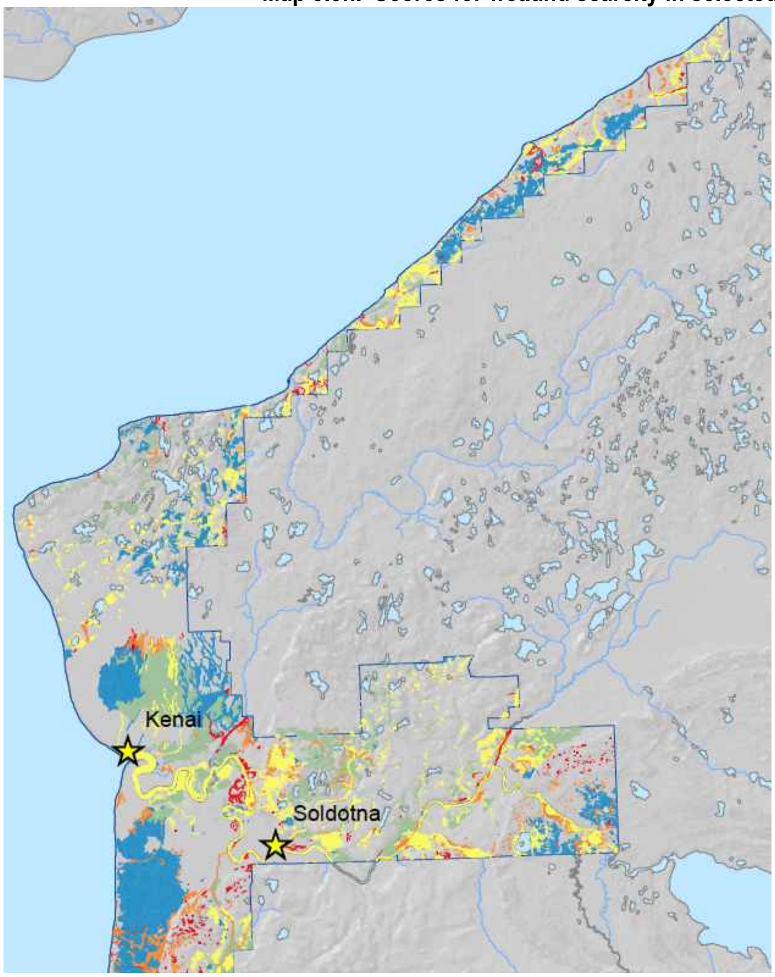
1. Within each 6th level hydrologic unit, the percent of total wetland acreage represented by each geomorphic component. (Geomorphic components are explained and illustrated in Sections 2.2 and 2.3 of Chapter 2.)

Table 3.3j shows the variable considered for this assessment. Map 3.3h presents the results.

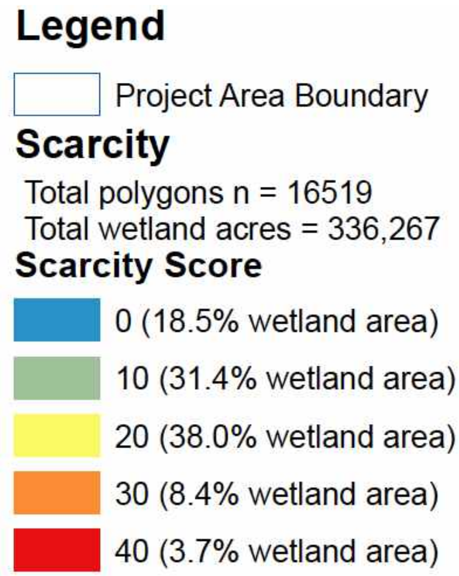
Table 3.3j Kenai Peninsula Wetland Assessment Method—Species Occurrence		
FUNCTION 5: wetland scarcity		
1	Within each 6th level hydrologic unit (HU), wetland polygon represents a geomorphic component whose total acreage in the HU meets ONE of the following criteria:	
	a) acreage of geomorphic component constitutes < 5% of total HU wetland acreage (4% acres received this score)	40
	b) acreage of geomorphic component constitutes 5-10% of total HU wetland acreage (8% acres received this score)	30
	c) acreage of geomorphic component constitutes 10-30% of total HU wetland acreage (38% acres received this score)	20
	d) acreage of geomorphic component constitutes 30-50% of total HU wetland acreage (31% acres received this score)	10
2	Wetland polygon represents a geomorphic component whose total acreage in the HU > 50% (19% acres received this score)	0

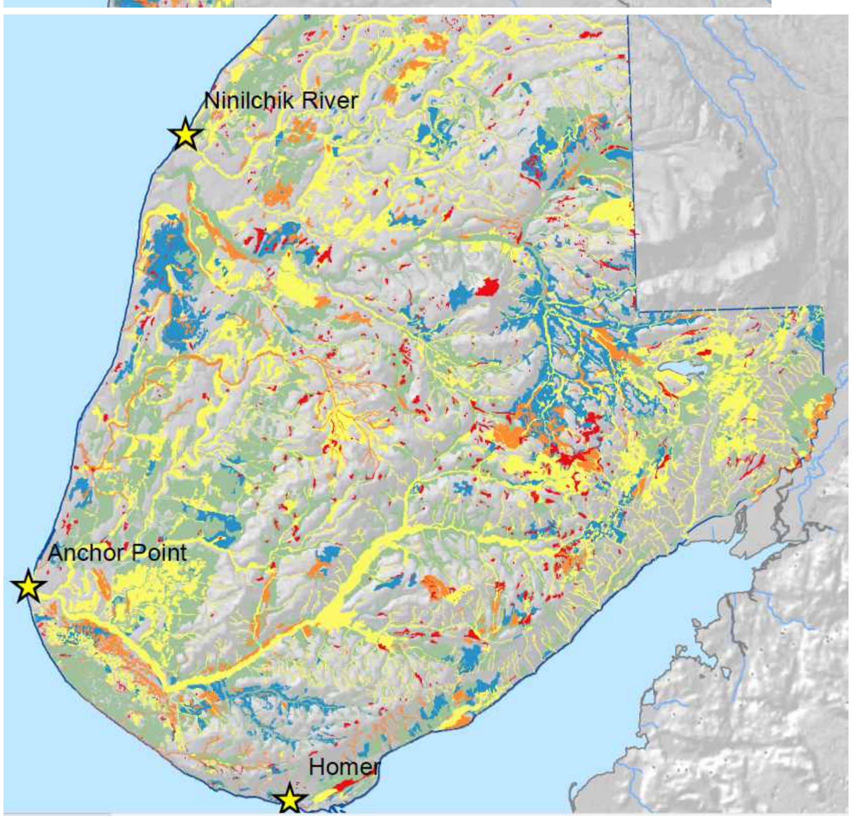
40 The US is divided and subdivided into levels of successively smaller hydrologic units. These are nested within each other, from the smallest (6th level) to the largest (1st level). Each hydrologic unit is identified by a hydrologic unit code (HUC) consisting of 2 to 12 digits. For example, all hydrologic units in Alaska are within 1st level, 2-digit, HUC 19. The most recent HUC delineations resulted in a dataset called the Watershed Boundary Dataset (WBD). The WBD divides hydrologic units down to 5th level (10-digit codes) and 6th level (12-digit codes) (http://water.usgs.gov/GIS/huc.html).

Map 3.3h. Scores for wetland scarcity in selected areas of the Kenai lowlands.



(For a map of the entire project area, see [https://sites.google.com/site/kpwetland assessments/home/all-assessment-maps](https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps).)





3.3.2. Biology component – Habitat

The more complex and varied a wetland is—both physically and biologically—the higher its *habitat diversity*. Maintaining habitat diversity in peninsula watersheds contributes to the number and kinds of animals and plants found on the peninsula. (Maintaining particular species and scarce wetlands—assessed above—also contributes to this biodiversity, see Section 3.3.1.)

Habitat diversity can be assessed by looking at wetland variables such as number of vegetative layers, number of different plant species, and presence and distribution of open water. The following data sources were used to obtain that kind of information:

- *Wetland Mapping and Classification of the Kenai Lowland, Alaska* (http://www.kenaiwetlands.net/ and http://cookinletwetlands.info/),
- *Wetland Classification and Mapping of Seward, Alaska* (http://www.kenaiwetlands.net/SEWARD/index.HTM).

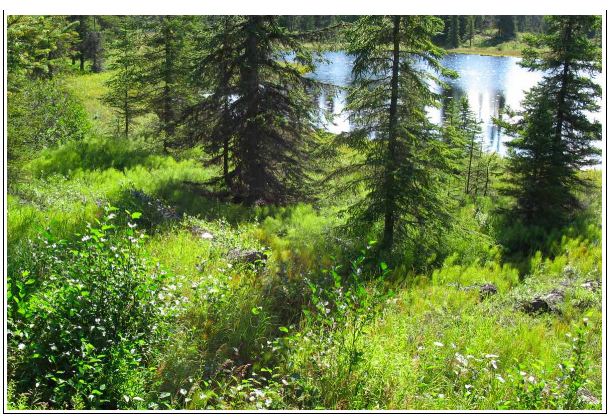
3.3.2.1 Habitat diversity

Introduction

This assessment addresses what in Anchorage/Homer methods was called the "Habitat Potential Component." In Anchorage/Homer methods, scores were assigned to numerous variables reflective of habitat physical complexity, spatial interrelationships (including interspersion with open water), productivity, etc., as shown in Table 3.3k. Then scores for these variables were summed to generate a single score for a wetland's habitat component. As a result, this can be considered an "integrative" function (like the hydrology function of maintaining natural flow regimes).

The rationale for this assessment is the correlation between habitat diversity and number of species: the more kinds of habitat niches a wetland provides—i.e., available kinds of of food, water, places to rest, hide, take cover, display, breed, etc.—the greater the variety of species that the wetland is likely to support. The higher the number of species, the higher the *species richness*[41]. This correlation was explained in the write-up of the Anchorage wetlands assessment method:

> *The physical structure of plant vegetation strongly influences species richness and numbers of species that will use a habitat... The spatial distribution of vegetation also strongly influences species richness. There are numerous studies that have shown a positive correlation between species richness and the total number of vertical layers of vegetation... Such correlations would reveal the relative value of a particular wetland for general diversity and habitat potential* (see AWAM "vegetation community structure" variable under "habitat structure and function").



This Kettle (K1-3) on Old Sterling Highway has more habitat diversity

...than this Lakebed (LB3) on the Sterling Highway.

41 Note, although the number of different species in an environment is sometimes called species *diversity*, if population numbers are NOT considered, the more accurate term is species *richness*. Species *diversity* takes into account **both** species richness and species *evenness*, the latter being a measure of how similar the population numbers of different species are to one another in an area. Areas supporting similar population numbers of different species are said to be more even than areas where population numbers of different species are very different.

In the Anchorage method, the Habitat Component was assessed using variables organized into four categories. These categories and related variables are shown in Table 3.3k. Variables that could also be used on the Kenai Peninsula are highlighted. As Table 3.3k shows, some variables could be measured with landscape-level information on the Kenai Peninsula, others could not.

Table 3.3k. Anchorage Wetland Assessment Method – Habitat Component

Categories	Variable(s)* Highlighted variables were used in assessing habitat diversity on the Kenai Peninsula, see Table 3.3l.
Habitat structure and function	1. Vegetation community structure
Spatial attributes	1. number of wetland plant communities, 2. intraspersion/edge effect of community types, 3. diversity of surrounding habitat, 4. proximity to other wetland habitats, and 5. open water types
Wetland productivity	1. Hardiness zone 2. soil type (in upper 3 ft) – mineral, organic, or clay 3. type of wetland (NWI code, smallest unit considered = 4,000 sq ft) 4. nutrient status of service water
Water regime	1. Surface water persistence (% probability of surface water present April to July) 2. water body size ((estimate size of smallest open water during period April-July) 3. wetland contiguity with stream or lake 4. wetland size (using AWAM Table 2.1)

* For potential points awarded each variable, see Anchorage/Homer crosswalk table, http://www.homerswcd.org/user-files/Crosswalk_AWAM-HWAM-4-18.pdf.

Methods

The first step in this assessment was determining which variables from the Anchorage/Homer methods could be scored using peninsula GIS data. Of the fourteen variables used to assess the Habitat Potential Component in Anchorage/Homer, seven could be scored using peninsula GIS data, these are highlighted in the table above and were scored as shown in Table 3.3l.

As in Anchorage and Homer, the habitat diversity score for a particular wetland was generated by adding scores for all measured variables. Because the number of variables considered was relatively large and the final score was additive, we used the same point system used in Anchorage/Homer (rather than the point system explained in Section 3.2.3). Essentially, wetland polygons with open water and many types and layers of plant communities received the highest habitat diversity scores, while wetland polygons without open water and having just a few vegetation layers received the lowest. Map 3.3i displays these results. The map immediately below shows a close-up from Map 3.3i, encompassing some of Deep Creek, Fritz Creek, Ninilchik River, and Anchor River watersheds. (The lake shown on this map is Caribou Lake northwest of Homer.) Results of this assessment should be considered a starting point for discussions of what physical and biological features are most likely to sustain or promote species richness in a wetland or watershed.

One caveat related to the approach used here is that only individual polygons were considered when scoring variables. In contrast, in Anchorage and Homer assessments, wetlands were combined into complexes as deemed appropriate for scoring. A wetland may receive a higher score when considered as part of a complex than it receives when considered on its own. This effect is particularly pronounced when spatial attributes such as interspersion and edge effects are considered.

Also, as discussed in Section 3.2.4, wetland size was not considered during peninsula assessments and will be considered during development of management strategies. Like interspersion and edge effects, size is more appropriately considered in terms of wetland complexes than individual polygons.

The map below is a close-up from Map 3.3i, below. The area shown encompasses a large portion of the Deep Creek watershed and some portions of Ninilchik River, Anchor River, and Fritz Creek watersheds. Caribou Lake is on the east (right), and Fox River defines the eastern border of the area shown. The higher the number, the greater the habitat diversity.

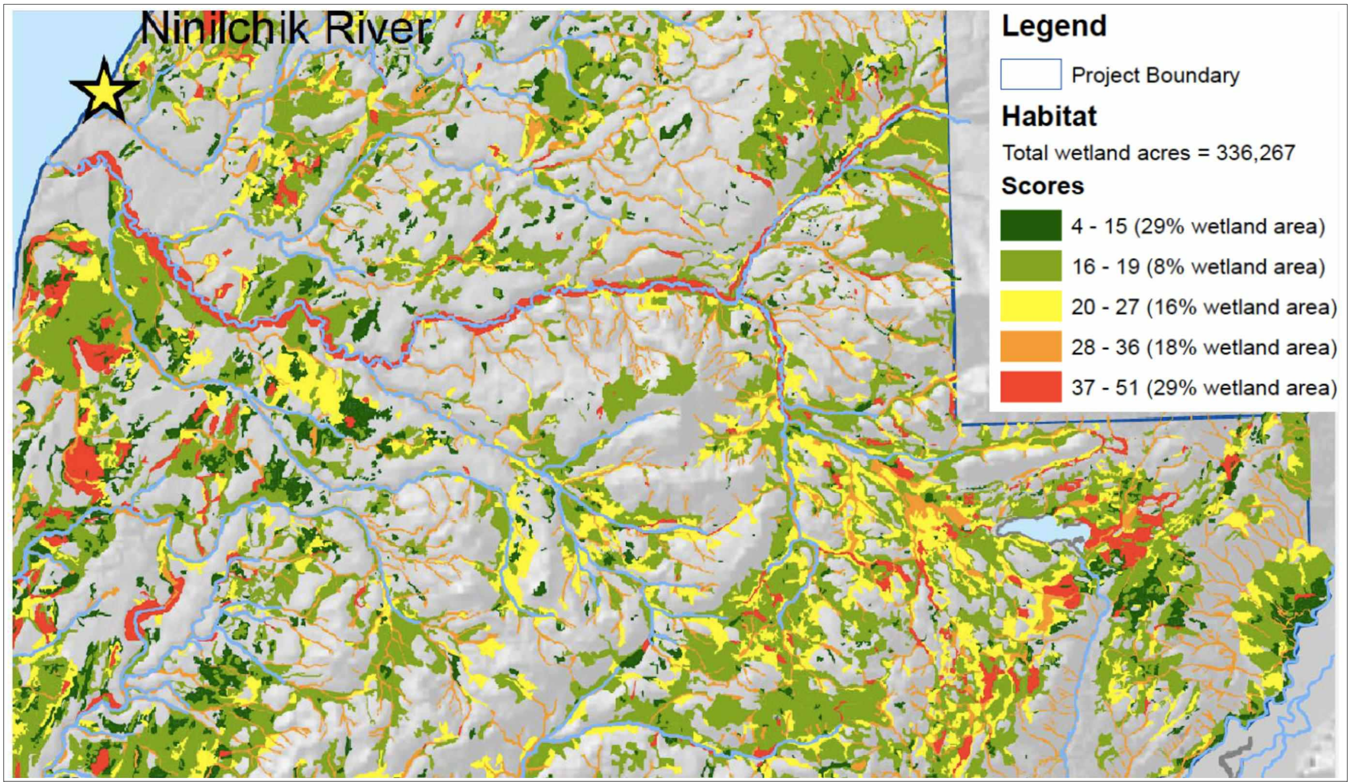
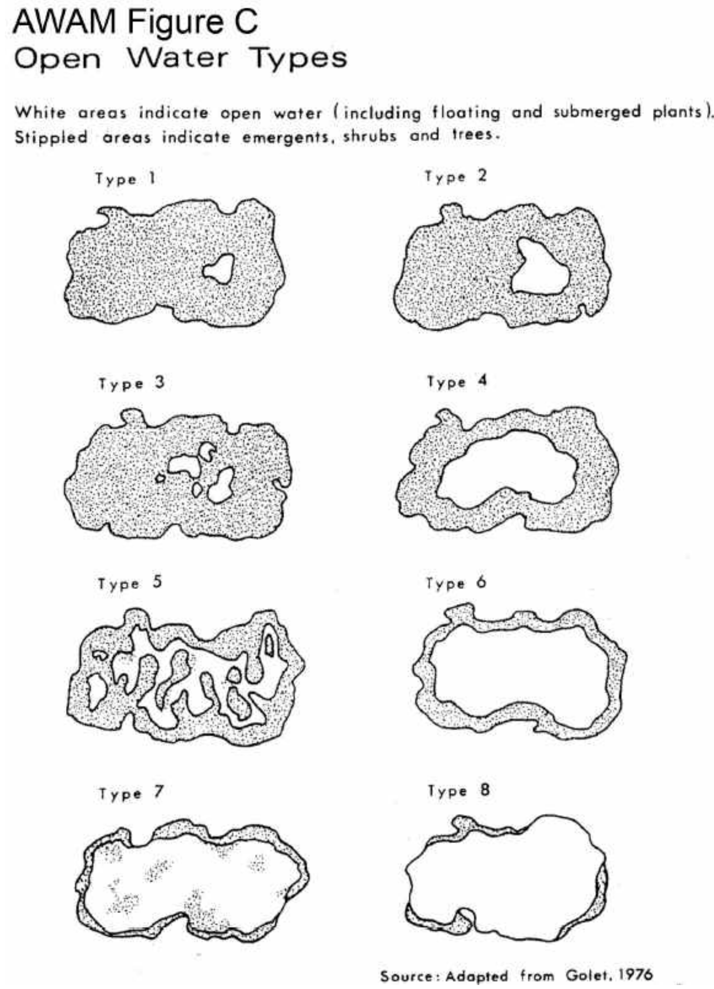
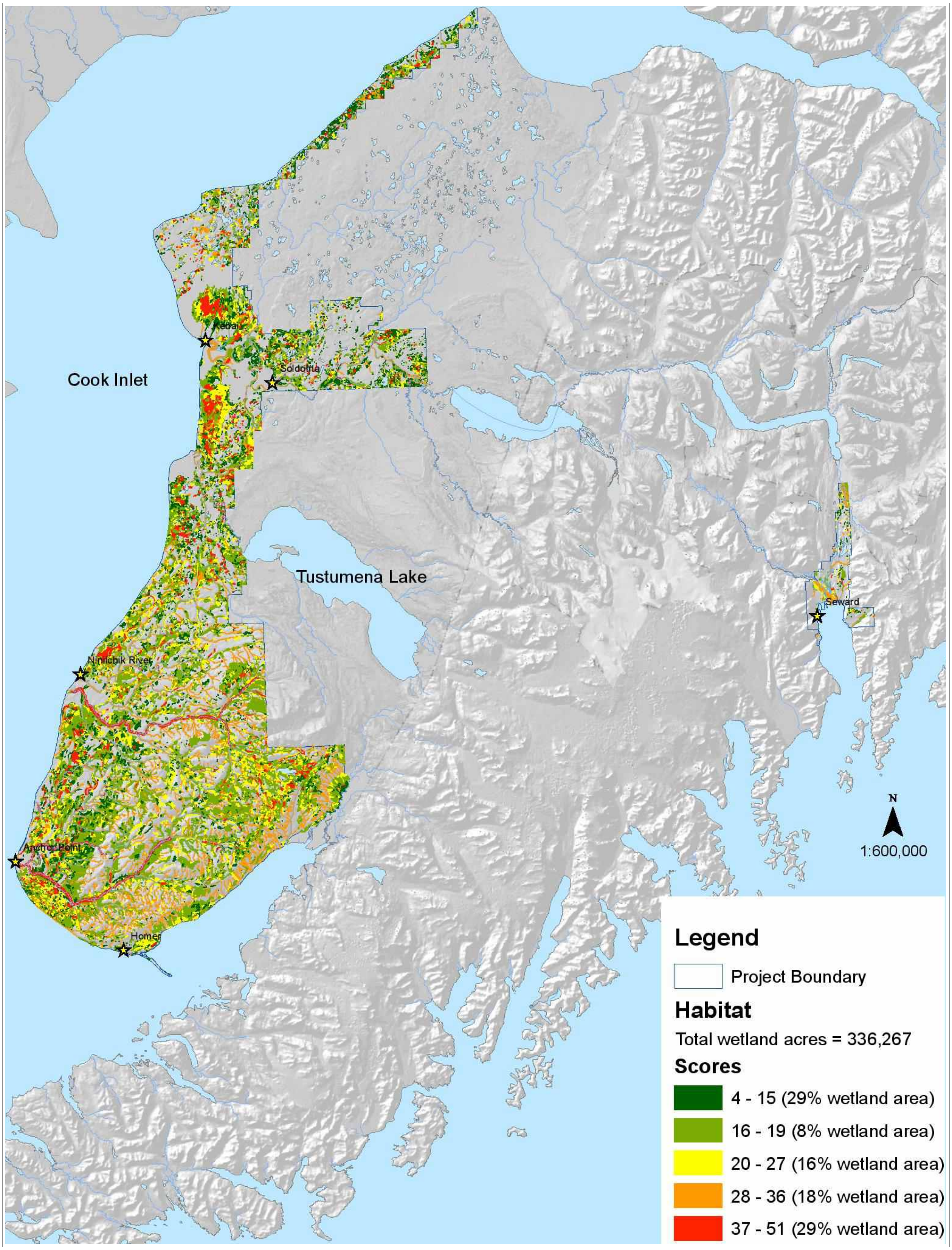


Table 3.3l. Kenai Peninsula Wetland Assessment Method—Habitat	
FUNCTION 6: wetland habitat diversity	
AWAM category 1: Habitat Structure and Function	
1	**Vegetation community structure.** Identify forms (vegetation layers) for each community type in subject wetland. Forms include trees, low and high shrubs, herbaceous vegetation, and moss. Particular form must cover at least 10% of site. The number of forms was obtained using the Kenai Lowlands Wetland Mapping and Classification. To establish the number of forms in each map component, the number of forms in the most common plant communities present were averaged. After the map components were added, the number of forms was rounded to the nearest whole number. Example: Subject wetland has two map components. Within each map component, identify each (and all) forms and add the number of forms for each map component, e.g. DW5 has 2 forms, DW5A has 5 forms, so DW55A has 7 forms (2+5): (13) ___ Wetland polygon has 13 vegetation layers (3% wetland area) (12) ___ Wetland polygon has 12 vegetation layers (0.2% wetland area) (11) ___ Wetland polygon has 11 vegetation layers (0.2% wetland area) (10) ___ Wetland polygon has 10 vegetation layers (0.6% wetland area) (9) ___ Wetland polygon has 9 vegetation layers (2% wetland area) (8) ___ Wetland polygon has 8 vegetation layers (1% wetland area) (7) ___ Wetland polygon has 7 vegetation layers (11% wetland area) (6) ___ Wetland polygon has 6 vegetation layers (11% wetland area) (5) ___ Wetland polygon has 5 vegetation layers (12% wetland area) (4) ___ Wetland polygon has 4 vegetation layers (26% wetland area) (3) ___ Wetland polygon has 3 vegetation layers (20% wetland area) (2) ___ Wetland polygon has 2 vegetation layers (11% wetland area) (1) ___ Wetland polygon has 1 vegetation layers (1% wetland area) (0) ___ Wetland polygon is mapped as DISTURB, Rt, RD4C, RD3C (1% wetland area)
AWAM category 2: Spatial Attributes	
2	**Number of wetland plant communities (from Kenai Lowland Wetland Classification and Mapping).** (6) ___ Wetland polygon has 6 mapunit components, e.g. LB1-6, DW1-5A (0.03% wetland area)

	(5) ___ Wetland polygon has 5 mapunit components, e.g. DW1-5, LB2-6 (3% wetland area) (4) ___ Wetland polygon has 4 mapunit components, e.g. K1-4, LB3-6 (2% wetland area) (3) ___ Wetland polygon has 3 mapunit components, e.g. K1-3, D2-4, RC, Reb (9% wetland area) (2) ___ Wetland polygon has 2 mapunit components, e.g. K12, LB34, DW32, SSL, RB, Rel, Rea, Res (47% wetland area) (1) ___ Wetland polygon has a single mapunit component, e.g. K1, LB4, DW5, SS, RDA, Rib, RD4SC (38% wetland area) (0) ___ Wetland polygon is mapped as DISTURB (0.03% wetland area)
	Open water types (see AWAM Figure C, find pattern that most closely resembles subject wetland) (12) ___ Type 5 (LBSF or Riverine RC, RDA) (5% wetland area) (9) ___ Type 4 (Wetlands with 3 hydro components, including hydro = 1 or Riverine Reb, RD4C, RD3C, RD4SC), K1-3, D1-3, H1-3, LB1-3, DW1-3, DWR, RD4F1-3 (5% wetland area) (7) ___ Type 3 (Riverine Res) OR Type between 4/6 (Wetlands with 2 hydro components, including hydro = 1) e.g. K12, K31, RD4F12 (4% wetland area) (5) ___ Type 2 (Wetlands with 4 hydro components, including hydro = 1 or Riverine Rea, Rel), K1-4, D1-4, H1-4, LB1-4, DW1-4, RD4F1-4 (5 % wetland area) (4) ___ Type 6 (RB) OR Type 1 (Wetlands with 5+ hydro components, including hydro = 1) DW1-5, DW1-5A, LB1-5 (5% wetland area) (3) ___ Type 8 (Wetlands with hydro = 1 or Riverine RA, RAA, Rt, D1, D1c, K1, K1c, DW1, H1, LB1, RD4F1, RD4F1c (2% wetland area) (0) ___ No open water (74% wetland area)
AWAM category 3: Wetland Productivity	
4	**Soils type (in upper 1 ft from NRCS or other soil survey)** (5) ___ Mineral soil (Discharge Slope (S), Late Snow Plateau (LSP), Riverine (R) Wetlands and Wetland/Upland complexes (WU)) (46% wetland area) (2) ___ Organic soil (All other geomorphic components; D, K, H, LB, DW, FI, AMT, Spring) (54% wetland area)
5	**Type of wetland** (5) ___ Riverine (at mouth) (R or AMT polygons that intersect with coast) (2% wetland area) (4) ___ Lacustrine (next to lake) or Riverine (all other R wetland polygons) (16% wetland area) (3) ___ Palustrine (with outflow) (All other K, LB, DW, H, AMT, S, LSP, WU polygons) (79% wetland area) (2) ___ Palustrine (isolated) Depression (D) (3% wetland area) (0) ___ DISTURB (0.3% wetland area)
AWAM category 4: Water Regime	
6	**Surface water persistence (% probability of surface water present during the period April to July)** (10) ___ 100% of April-July (Wetlands containing a hydro component = 1, or Riverine (R) wetlands except Reb, RD4T1, RD4T2, RD4SC) (26% wetland area) (6) ___ 50 to <100% of April-July (Wetlands containing a hydro component = 2, or RD4SC, RD4F2, RD4F23, RD4F2-4 (13% wetland area) (2) ___ 0 to 50% of April-July (Wetlands with hydro components >2) (61% wetland area)
7	**Wetland contiguity with stream, lake, or pond** (0) ___ Wetland isolated from stream/lake/pond (3% wetland area) (3) ___ Wetland adjacent to stream/lake/pond (70% wetland area) (5) ___ Stream/lake/pond lies within wetland (All R wetlands, and all polygons that received a score of 10 in 2.11) (27% wetland area)



Map 3.3i. Wetlands assessed for habitat structural diversity and interspersion.
(For a map with higher resolution, see https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.)



3.4. Assessing the Hydrology component

3.4.1. Introduction

Wetlands are a fundamental part of the water cycle. Major components of the water cycle are illustrated in Figure 3.4a and include:

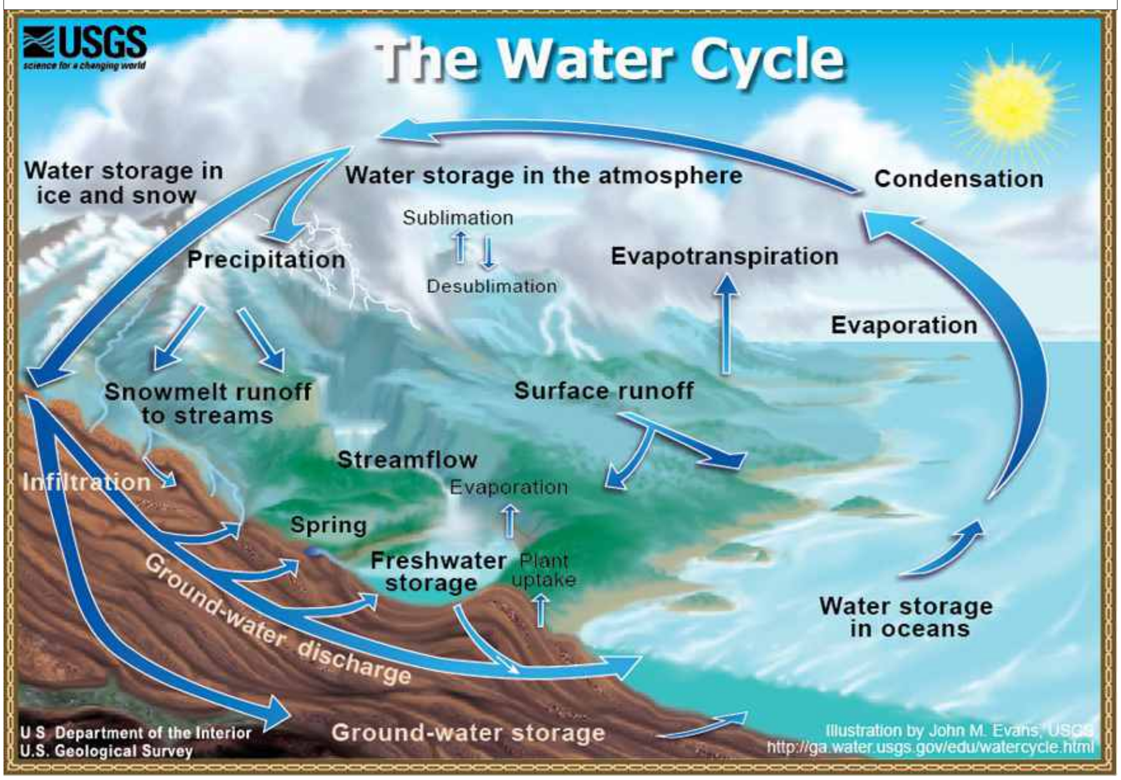
> ♦ *precipitation,* ♦ *plant interception,*
> ♦ *evapotranspiration,* ♦ *soil infiltration,*
> ♦ *percolation, and* ♦ *runoff (or discharge)—both surface and subsurface (including groundwater).*

...one should be able to identify where [wetland] water is coming from, how much water there is, how long the water stays in the area, and how it leaves. Water is the key factor driving any wetland ecosystem.
Barbara B. Beall,1997 (http://www.wetlands forum.org/newsletter/wetword1.htm)

In terms of hydrologic functions, wetlands collect precipitation and snowmelt, receive surface water flows and/or groundwater discharge, store water received, discharge water through surface and subsurface outflow pathways, and lose water through evaporation and transpiration (loss of water from plant parts). Wetlands also filter and clean the water flowing through them. Wetland functions change over time, and which functions a wetland performs at any time, and to what degree, depend on local conditions, including many of those characterized during mapping of peninsula wetlands (e.g., geomorphology, soils, depth to water table, plant communities present, etc.). A wetland's functions also depend on its size, location in its watershed, and on prevailing and antecedent weather—especially moisture. In this project, peninsula wetlands were assessed in terms of five water **quantity** and two water **quality** functions:

1. recharging groundwater,
2. providing storage,
3. transmitting discharge,
4. contributing discharge,
5. maintaining natural (unregulated) flow regimes,
6. reducing streambank and shoreline erosion, and
7. improving (or maintaining) water quality.

Figure 3.4a. The water (hydrologic) cycle
(from: http://ga.water.usgs. gov/edu/watercycle.html; this USGS website provides good introductory material).



Assessments of these wetland hydrology functions are covered in Sections 3.4.3.1 through 3.4.3.7. It will be much easier to understand these functions—and their interactions with other parts of the hydrologic cycle—given an understanding of some basic hydrology concepts. As a result, Sections 3.4.4 through 3.4.6—which follow the hydrology assessments—review some key concepts and include many illustrations and diagrams to clarify these. These sections discuss how...

1. watershed location (context) shapes wetland functions and values – Section 3.4.4,
2. wetland "water budgets" are a useful way to visualize all water flowing into and out of a wetland and stored within it – Section 3.4.5, and
3. groundwater and surface water systems are intimately interconnected – Section 3.4.6.

The following assessments will also make a lot more sense given familiarity with how peninsula wetlands were classified and named during mapping, since assessment scores were assigned based on map unit codes. Wetland map unit codes reflect geomorphic component, hydrologic component (depth and variability of water table), plant communities present, and—in the case of Riparian wetlands—stream channel type. Since assessment scores are assigned at the level of geomorphic component and/or map unit code, understanding these is useful. (Hydrology function scores may reflect other features as well, such as wetland polygon size or watershed location.) Chapter 2 introduces wetland ecosystem types and the system used in generating map unit codes. A review of that chapter will provide background needed to understand the following hydrology assessments.

3.4.2. Hydrology assessment method

A final note – as explained in Section 1.3, the wetland working group and expert teams that guided this project selected as the basis for most assessments the methods used in Anchorage and Homer (and originally in Ontario, Canada) (see Sections 1.2 and 1.3). Anchorage/Homer methods were modified as needed to reflect the fact that those assessments were site-specific and incorporated both finer-resolution information and on-the-ground verification, whereas assessments for this project reflected a landscape-level scale and were based solely on available GIS data. As a result, peninsula assessment variables often had to be modified from those used in Anchorage and Homer. Nonetheless, the *kinds* of functions and values assessed both in Anchorage/Homer and on the peninsula for the biology component and the community/culture component reflect much the same general categories. That, however, is less true for the hydrology component. Functions assessed under hydrology were based on more recent, collaborative projects, in particular the wetlands assessment underway in the Matanuska-Susitna Borough (the "Mat-Su") at the time of this project. There were several reasons for departing from Anchorage/Homer methods in assessing hydrology functions.

The following challenges were encountered when trying to apply Anchorage/Homer hydrology assessments to the peninsula (see also Table 1.3a):

- In Anchorage/Homer methods, hydrology functions were not as logically organized or as clearly defined as they have been in intervening years. Also, some functions (e.g., groundwater recharge) were not considered.
- Because peninsula assessments were conducted at a generalized, landscape-level scale, while Anchorage/Homer methods were conducted site specifically, some deviation from Anchorage/Homer methods was inevitable. For example and as mentioned above, Anchorage/Homer methods depended on site visits whereas peninsula assessments were performed entirely "offsite" and used only available GIS data.

The following opportunities provided reasons to update Anchorage/Homer hydrology assessments during this project:

- Much new work on wetland assessment concepts has been done since Anchorage/Homer methods were used. Each assessment represents a step in a long and iterative process. The Mat-Su method on which the peninsula hydrology assessments are based incorporated many advances in thinking.
- Wetlands in both the Kenai Peninsula and Matanuska-Susitna project areas were classified and mapped using the same system—the "Cook Inlet Classification" (see http://www.cookinletwetlands.info/). (Consistency in mapping between the two projects was enhanced by the fact that two wetland ecologists who mapped peninsula wetlands were also involved in mapping Mat-Su wetlands.)
- As indicated above, key personnel involved with peninsula assessments were also in the "thick of things"

with respect to collaborative efforts shaping Mat-Su assessments—providing many opportunities to incorporate lessons learned from the other project.

- The simplicity and clarity of the Mat-Su method in terms of which hydrology functions were distinguished and the variables used to assess them provided results very useful for wetland management and review of wetland permit applications.
- With the 2008 compensatory mitigation rule and the 2009 Alaska District Regulatory Guidance Letter (RGL ID No. 09-01), wetland assessment has taken on new urgency because of its potential utility in guiding compensatory mitigation. (For more information on compensatory mitigation and the RGL, see Chapter 4, Section 4.1.3.3.) At the time of this writing, in Anchorage and the Mat-Su—where there has been more permit activity on larger projects and at least one mitigation bank is in place—many entities were promoting the idea of a uniform, repeatable approach to wetland assessments. To that end, a mitigation team had been assembled and had prioritized the development of an assessment template to be used statewide. That template is expected to be regionalized. The approach being developed in the Mat-Su could likely form the backbone of the new template. Adopting the Mat-Su approach for peninsula hydrology assessments supports these efforts to develop a uniform approach applicable statewide.
- Applying the Mat-Su method on the peninsula also, therefore, could serve in part as a pilot project towards developing the statewide assessment method mentioned above.

Hydrology assessments described in Sections 3.4.3.1 through 3.4.3.7 reflect these considerations.

3.4.3. Assessment of wetland hydrology functions

As noted above, seven hydrologic functions were distinguished and assessed for this project. The first five relate to water quantity; the last two to water quality. The following data sources were used to assess these functions:

- *Wetland Mapping and Classification of the Kenai Lowland, Alaska* (http://www.kenaiwetlands.net/ and http://cookinletwetlands.info/),
- *Wetland Classification and Mapping of Seward, Alaska* (http://www.kenaiwetlands.net/SEWARD/index.HTM),
- Kenai Peninsula Borough interactive parcel viewer (http://mapserver.borough.kenai.ak.us/kpbmapviewer/ and http://mapserver.borough.kenai.ak.us/flexviewer/).
- LiDAR data

Table 3.4a shows the relationships among the five water quantity functions assessed. Assessments are useful in identifying which wetlands are most likely to perform a particular function. (As with other assessments, results presented below reflect current understanding and available information.)

Table 3.4a. Summary of basic water quantity functions[42]. (as derived from *Watershed Functions* by Peter Black, 1997, http://www.watershedhydrology.com/pdf/Functions.pdf)			
collection function ➔ (wetland receives water from atmosphere)	**storage functions ➔** (wetland holds water)	**discharge functions ➔** (wetland loses water downslope and downgradient)	**integrative functions** (hydrologic functions combine and interact)
Where and how much water collects depends on storm characteristics (e.g., storm location and expanse, precipitation intensity and duration, etc.) and on watershed shape and density of drainage networks. Since these features are not amenable to management (or mitigation), collection was not assessed.	• **providing storage** Six types of wetland storage can be identified (see diagram above): 1. Depression (landform) storage 2. Channel storage 3. Soil storage, divided into: • capillary or retention storage (water held at high tension in soil capillary pores, does not flow out in response to gravity or hydraulic gradients) • non-capillary or detention storage (water temporarily detained in non-capillary pores, flows out within ~24 hrs of a storm) 4. Non-peat vegetation storage (e.g., interception on plant leaves, twigs, and stems, storage in leaf litter) 5. Peat pore space storage 6. Groundwater storage	• **recharging groundwater** • **transmitting discharge** • **contributing discharge** ***Recharging groundwater*** *consists of water leaving the wetland via percolation downwards to the saturated zone* ***Transmitting discharge*** consists of water flowing through the wetland via (a) surface flows (sheet flow, channel flow), (b) peat pore-water flows, and/or (c) ground (or subsurface) flows. ***Contributing discharge*** consists of water flowing out of a wetland that derives from within the wetland itself (precipitation and/or snowmelt) rather than from water flowing into the wetland from upslope or upgradient.	• **maintaining natural (unregulated) flow regimes** Hydrologic functions combine and interact to determine flow... • magnitude, • frequency, • duration, • timing, and • rate of change, which together define ***natural (unregulated) flow regimes***. These flow regimes create the physical conditions responsible for habitats and biotic interactions. This function encompasses Peter Black's two integrative functions: attenuation and flushing (see "Watershed Functions," http://www.watershedhydrology.com/pdf/Functions.pdf).

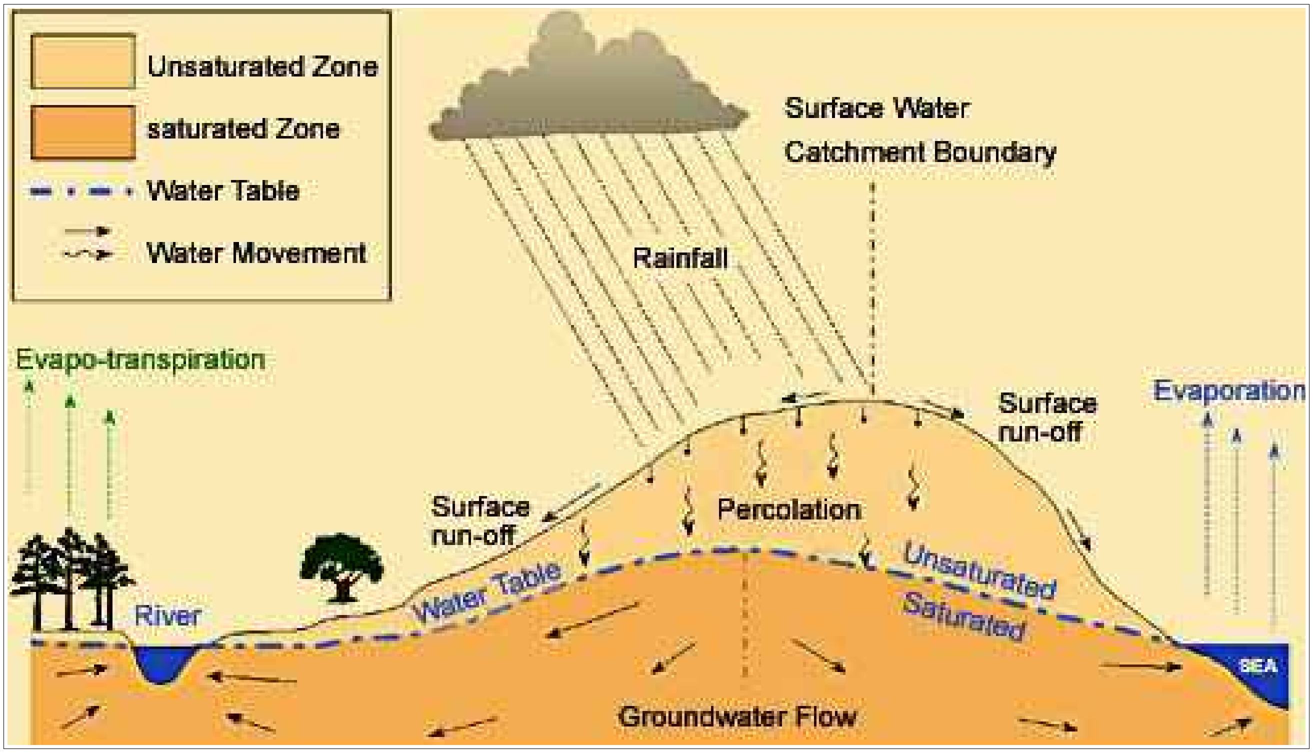
Watershed elements

Some of the following discussions refer to *watershed element(s).* A watershed element is an area whose hydrologic functions are uniform within its borders but different from functions in adjacent areas. For example, a steep bedrock slope will shed rainfall almost immediately, storing very little precipitation, while an adjacent flat peatland will store most of the same rainfall, releasing it slowly. The steep bedrock slope represents a different watershed element from the flat peatland. Each wetland map unit identified in the project area (e.g., D42, K12, LB1-4, Res, SAC) represents a watershed element. (Map unit codes are explained in Section 2.2.)

42 Christopher Spence and others have noted that these "basic" processes are neither simple nor linear because various kinds of thresholds control how water moves into, through, and out of soils, pores, channels, etc. found in watershed elements. (See, for example, "A Paradigm Shift in Hydrology: Storage Thresholds Across Scales Influence Catchment Runoff Generation," *Geography Compass*, Volume 4, Issue 7, pages 819–833, July 2010; abstract at: http://onlinelibrary.wiley.com/doi/10.1111/j.1749-8198.2010.00341.x/abstract.) These thresholds exist at scales as small as the soil matrix (e.g., thresholds associated with capillary forces and the effects of pore size and patterns of pore connectivity) and as large as subwatersheds or whole watersheds (e.g., effects associated with the pattern and density of the drainage networks created by interconnected streams, rivers, and wetlands).

As a result of these thresholds, storage–runoff relationships at all scales are characterized by various lag times (*hysteresis*), meaning that as an input to a watershed element changes (e.g., rainfall intensity increases), responses observed in other watershed elements may not show up until various thresholds have been crossed. Because thresholds at many scales determine where and how fast water moves within and between watershed elements, understanding these thresholds and their inter-connectivity is crucial to understanding how water moves within a watershed. As Penna et al (2010) note: "[T]hreshold effects due to the complex interactions of many physical controls are frequently observed at the hillslope and catchment [watershed] scale... Therefore, investigating the occurrence of hydrological thresholds can help to improve our understanding of the phenomenon and increase our ability to make reliable predictions." "Non-linearity of runoff generation processes in an alpine headwater catchment," abstract at: http://adsabs.harvard.edu/abs/2010EGUGA..1213437P).

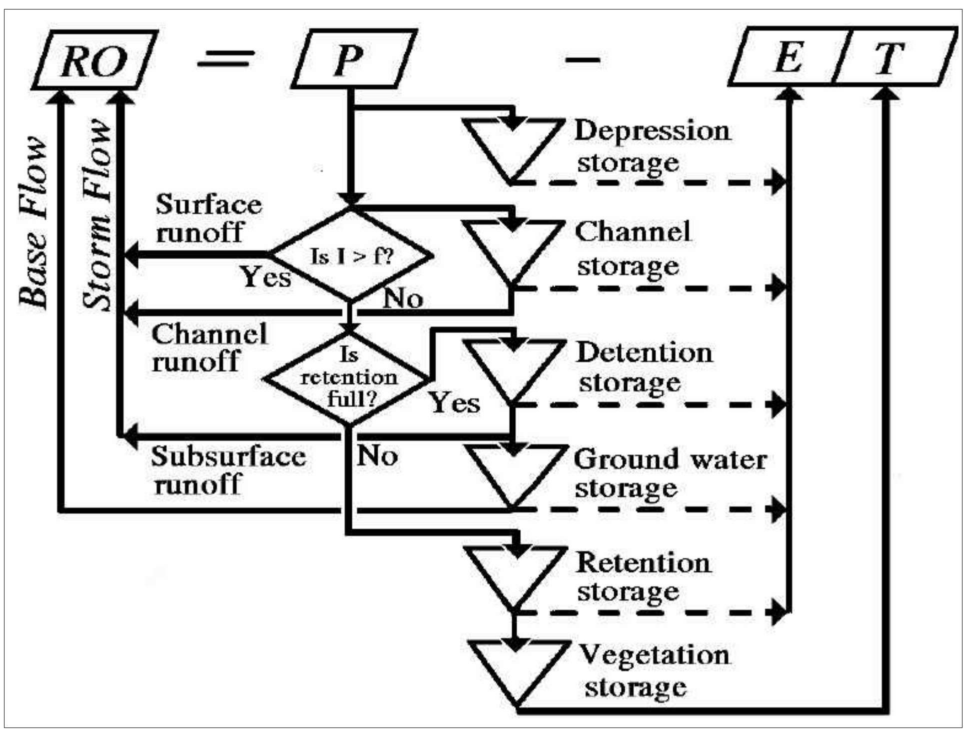
The **figure below** illustrates some key terms related to hydrology functions, including surface runoff (discharge) and groundwater flow. (Note, groundwater is *discharging* into the stream as opposed to being *recharged* by it.) (Figure is from [http://www.sustainableaggregates.com/sourcesofaggregates/landbased/water/ water_ops_ stage_page1.htm.)](http://www.sustainableaggregates.com/sourcesofaggregates/landbased/water/water_ops_stage_page1.htm) For more background on wetland hydrology, see Sections 3.4.4 to 3.4.6.



The **figure lower right** (from *Watershed Functions*, see above) diagrams interrelationships among some of the hydrologic functions assessed, along with their interactions with other elements of the water cycle (Figure 3.4a).

In the diagram:
- **P** = precipitation,
- **I** = precipitation intensity,
- **f** = infiltration capacity,
- ∇ = storage of six kinds,
- **RO** = runoff—surface, channel, and subsurface,
- **E** = evaporation, and
- **T** = transpiration.

Note, the amount of precipitation (or snowmelt) that will move into storage depends on factors such as precipitation type and intensity and whether or not storage (retention) capacity is full (see also the discussion of thresholds in footnote 41).

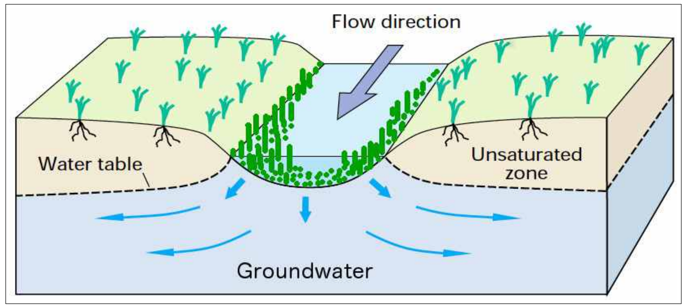


The following sections explain the seven wetland hydrology functions assessed . Each section provides an introduction to the function and its importance, followed by an explanation of the rationale for scoring wetlands for that function. An example map showing the results of each assessment is provided. Maps of higher resolution can be found at https://sites.google.com/site/hydrologyassessmentmaps/home. Please keep in mind that scores are unitless, and larger numbers simply mean "more than" to an unknown degree (see Section 3.2.3.)

3.4.3.1. Hydrology function 1: recharging groundwater

(Much of the content of this assessment is from unpublished write-ups by Mike Gracz, Kenai Watershed Forum.)

Introduction



Recharging groundwater (contributing water to groundwater systems) is the first wetland function assessed. *Groundwater* is the term for water held below the *water table* (see figures above and **figure at right**, modified from http://pubs.usgs.gov/circ/circ1139/pdf/ circ 1139.pdf). In the groundwater zone, water fills all pore spaces between particles as well as fractures within rocks. In other words, subsurface materials are fully saturated. Because water pressures are high enough, water can be pumped from the groundwater zone, but not from the unsaturated zone above it. A wetland recharges groundwater when water moves from the wetland into the groundwater zone, generally via a direct connection (as shown in the figure). A wetland can recharge groundwater at one time—during dry periods, for example—and receive groundwater discharge at another.

Groundwater recharge is of fundamental importance for many reasons. Recharge, for example, replenishes groundwater aquifers that supply water to the communities of Kenai, Soldotna, Seward, and Anchor Point. (Homer's water source is the Bridge Creek reservoir, which is supplied by both surface water and groundwater.) Groundwater also maintains flows in streams and rivers during times of year when surface runoff is minimal—on the peninsula, this is often from late spring through July—after the snowpack has melted and before the arrival of fall rainstorms. These dry period *baseflows* in streams and rivers are essential for the survival of salmon and other aquatic life in peninsula waterbodies. They also support riparian plants and animals.

Given the large area of peatlands on the Kenai Peninsula (peatlands represent the majority of wetland acreage mapped in the Kenai lowlands), it's useful to divide groundwater into: *peat porewater*, *shallow groundwater*, and *deeper groundwater*. While groundwater within these zones may interact with each other and with surface water, each zone differs from the others.

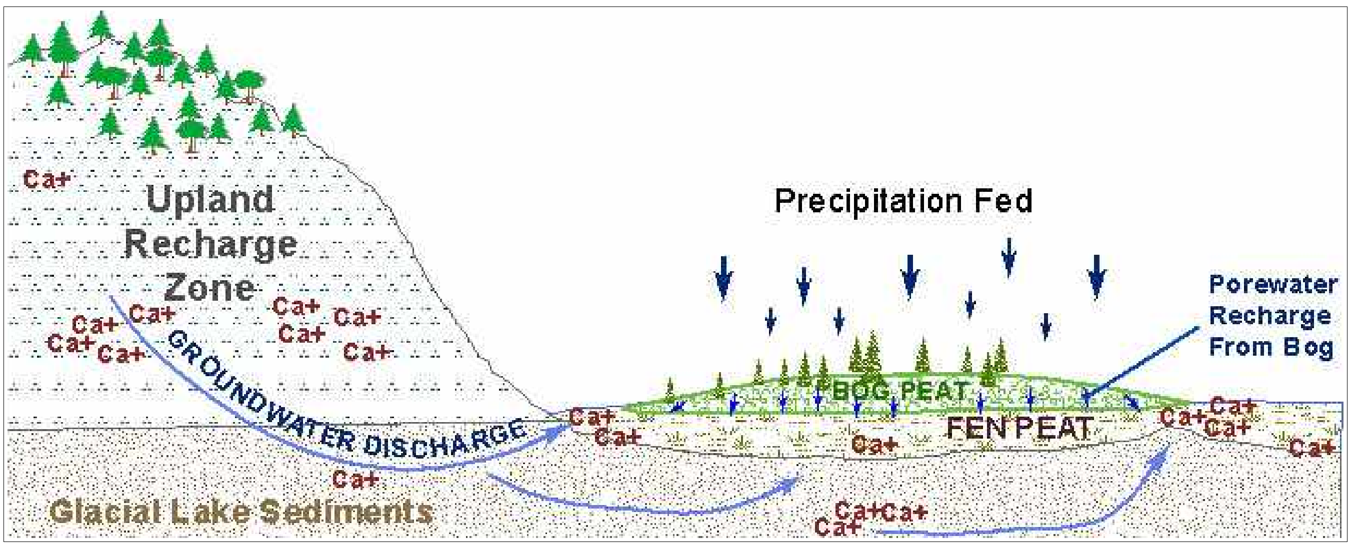
- **Peat porewater** is the shallow groundwater flowing through pore spaces within peatlands. Peatlands are comprised of the partially undecomposed remains of plants. Peat deposits are frequently 6 feet thick or more on the peninsula, and the plant remains at the base of the peat layer frequently date to approximately 10,000 years ago.
- **Shallow groundwater** also flows through unconsolidated glacial deposits (glacial till) underlying peninsula wetlands, including peatlands.
- **Deeper groundwater** flows through the bedrock beneath the glacial deposits.

Most wetlands are sites of discharge, but a few are sites of recharge

Most wetlands on the peninsula occupy geomorphic positions (landforms) where shallow groundwater *discharges* towards the surface from underlying glacial deposits. Deeper groundwater contributes to this shallow groundwater. Most wetlands, therefore, act as storage reservoirs for both the shallow groundwater discharging into them and precipitation falling onto them. There are three important exceptions, however, and these provided the criteria for assessing the wetland function of recharging groundwater.

Methods
Three types of wetlands received scores for contributing to groundwater recharge: (1) bogs, (2) wetlands mapped as Depressions, and (3) wetlands located in the upper 1/3rd of their watersheds (measured in terms of sixth-order Hydrologic Unit Codes (HUC)—see Section 3.4.4).

1. Bogs
The first exception to the rule that wetlands do not contribute to groundwater recharge consists of **bogs** (see **figure below**, from M. Gracz). Bogs are by definition recharge mounds; they form where the discharge of shallow groundwater is insufficient to transport adequate concentrations of exchangeable base cations to the wetland, particularly calcium,. Inadequate calcium concentrations, along with certain landscape and climatic factors, promote germination of the spores of sphagnum mosses responsible for building bog mounds. The bog mounds are relatively flat and transmit water very slowly—especially in their lower layers—so that these mounds end up retaining precipitation in their pore spaces. This porewater is slowly released downward into underlying substrates (shown by downward blue arrows in the figure below). Depending on the composition and texture of these underlying substrates, porewater may flow either downward through the deeper peat—when underlying mineral substrates are permeable—or horizontally when underlying substrates are impermeable.



The **figure above** (from M. Gracz) illustrates the peatland groundwater system. Recharge from uplands, shown by blue arrows, feeds shallow groundwater into the glacial sediments shown on the left-hand side and along the bottom of the diagram, as well as into the lower layers of fen peat. As long as precipitation is sufficient and drainage networks are poorly developed, bogs form (green mound-shaped unit) where calcium concentrations are low at the surface of the peat. Bogs are fed almost exclusively by precipitation and support recharge into the underlying fen peat, and even into deeper sediments. Bogs may form directly over glacial sediments if calcium concentrations are too low to support fen peat.

Bogs can be distinguished from fens, which are also peatlands, by three criteria:

1. low concentration of exchangeable bases, especially calcium (< 2 mg/l);
2. low pH produced by the sphagnum mosses, and
3. absence of plants unable to tolerate the poor growing conditions of low pH (very acidic) and low concentrations of exchangeable bases (which are important for plant growth).

2. Wetlands mapped as Depressions (D)
The second exception on the peninsula to the rule that wetlands are located only in zones of groundwater discharge consists of Depression (D) geomorphic components. Depressions may occasionally represent outcroppings of the water table, however, more often they are areas where snowmelt and rain are stored temporarily before slowly percolating deeper into underlying glacial deposits. D wetlands are not directly connected via surface flow pathways to other wetlands or to streams, lakes, or saltwater.

3. Wetlands located in the upper 1/3rd of their watersheds

The third exception to the rule that wetlands do not contribute to groundwater recharge consists of those wetlands that occur high up in their watersheds. Although these wetlands often receive groundwater discharge, given their upper watershed locations they also lose water that may ultimately recharge shallow groundwater lower in the watershed. (For a look at the movement of groundwater from upper elevation recharge areas on the north half of the peninsula to lower elevation discharge areas, see Section 3.4.6, which is excerpted from http://pubs.usgs.gov/fs/fs-022-02/pdf/fs-022-02.pdf.)

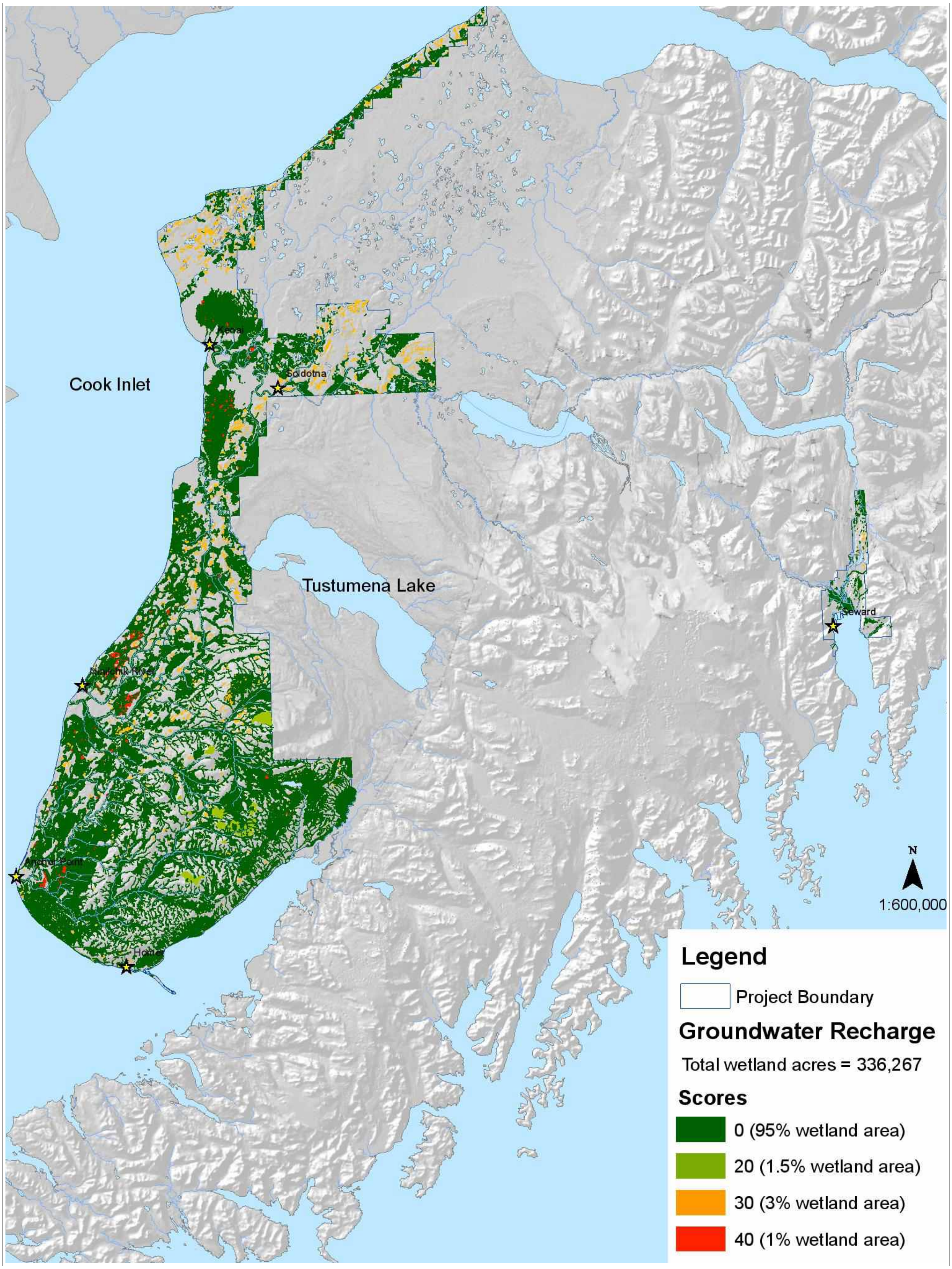
Note, for this variable, watershed position (i.e., "upper 1/3rd") was determined using elevation. Further review indicated that it would be more meaningful to measure wetland watershed position in terms of area. As a result, the variable of watershed position (like the variable of wetland size) will be further considered during development of management strategies for peninsula wetlands (see Section 3.2.4 and Chapter 5).

Variables considered during this assessment are summarized in Table 3.4b. Results are presented in Map 3.4a.

	Table 3.4b. HYDROLOGY FUNCTION 1: Recharging groundwater	points
1	Polygon is mapped as a bog (LB3, LB63, LB36) (1% wetland area)	40
	Polygon is mapped as a Depression (D) wetland (3% wetland area)	30
	Polygon is mapped as a Late Snow Plateau (LSP) (1% wetland area	20
2	Wetland polygon meets none of the above criteria (95% wetland area)	0

Map 3.4a. Wetlands assessed for recharging groundwater

(For a map with higher resolution, see https://sites.google.com/site/hydrologyassessmentmaps/home.)

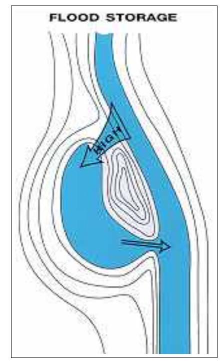


3.4.3.2. Hydrology function 2: providing storage of water (including floodwaters)

(Much of the content of this assessment is from unpublished write-ups by Mike Gracz, Kenai Watershed Forum.)

Introduction

The second wetland function assessed is *providing water storage*. Storage is the intermediary process between collection of water in a watershed element and its discharge downslope, downstream, or downgradient. Storage occurs when water flows out of a wetland more slowly than it flows in (outflow < inflow). The amount of water a wetland can store is called its *storage capacity*, and this changes in response to factors such as precipitation, evapotranspiration, inflow from upslope, etc. (see, for example, Figure 3.4e in Section 3.4.5). Water storage is the key mechanism by which wetlands reduce flood peaks (see Storage and flooding, below). As noted in Section 2.1, a "healthy" watershed quickly soaks up rainfall and snowmelt, minimizing surface runoff and related flooding. Precipitation held long enough to infiltrate is transferred to slower pathways for movement downslope and downgradient through the watershed.

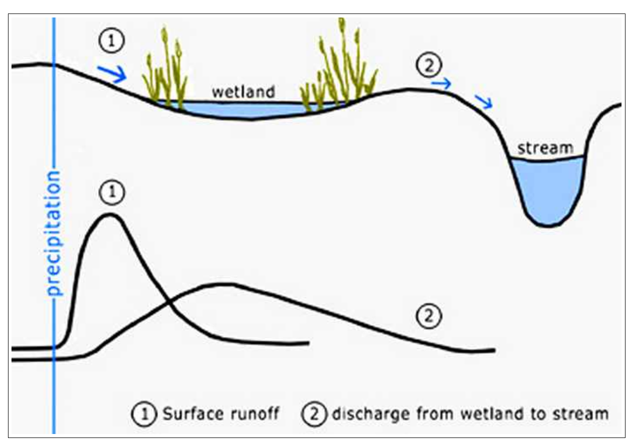


Six kinds of wetland storage can be distinguished (see the diagram on page 74):

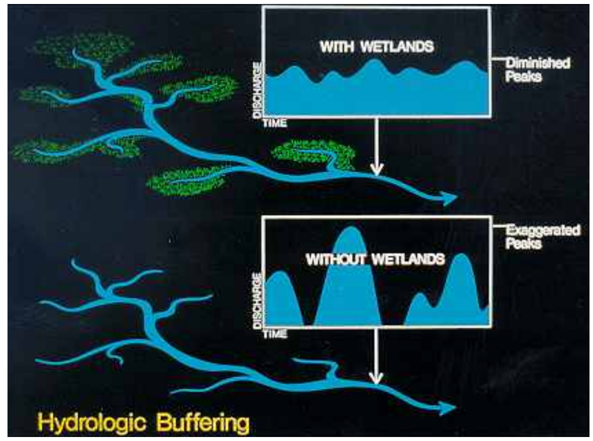
1. depression (landform) storage;
2. channel storage (example at right shows an abandoned meander bend that provides storage during high streamflows, from http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/wetlands4_hydrology.htm),
3. soil and shallow subsurface storage, both *retention* and *detention*:
   - capillary or *retention* storage – water is held at capillary tensions within soil pore spaces, capillary tension is too high for water to flow out in response to gravity and
   - non-capillary or *detention* storage – water is temporarily detained in pores by non-capillary forces and can flow out relatively quickly (e.g., within ~24 hrs of a storm);
4. non-peat vegetation storage (e.g., interception on plant leaves, twigs, and branches; storage in leaf litter);
5. peat pore space storage (which can be capillary or non-capillary, see #3); and
6. groundwater storage.

A wetland's available storage capacity in any of these depends on antecedent moisture (how much water is already being held), which in turn determines hydraulic gradients within and between watershed elements (hydraulic gradients are water pressure differences that cause water to move up, down, or lataerally, see the illustration of "flow nets" on page 114, Section 3.4.5).

Providing storage is important for three fundamental reasons: maintaining natural flow regimes, reducing flood flows, and moderating stream temperatures during during low flow periods. First, storage has profound effects on natural flow regimes within a watershed (see Function 5). Watersheds with greater storage capacity result in streams with more stable discharges (higher dry-weather baseflows, lower wet-weather flood flows) than watersheds with less storage capacity. As discussed in Section 3.4.3.5, natural stream flow regimes determine the form and physical characteristics of habitats in and along streams and rivers and within wetlands. Changes in flow regime can lead to changes in channel form, ultimately altering instream and riparian habitat conditions. Such changes affect species like salmon.



Secondly, storage capacity is critical in reducing flooding and flood-related damages. By storing floodwaters, wetlands delay and stagger the downstream arrival of storm flows. This "de-synchronizes" the flood flows arriving from different tributaries, spreading floodwaters out over time and reducing the magnitude of peak flows and associated flood heights. This also reduces bank erosion and channel bed scour. The **figure at right** (from http://forestandrange.org/new_wetlands/flood_control.htm) compares two storm hydrographs showing streamflow per unit time after a precipitation event. Hydrograph 1 shows a flow pattern typical of streams in watersheds with high surface runoff (little storage). Shortly after a precipitation event, high volumes of runoff reach stream channels, causing "flashy" flows with high flood peaks. Hydrograph 2 shows what happens when a watershed contains wetlands that can store significant amounts of rainfall and storm runoff, releasing stormwater slowly to streams and reducing the height of peak flows. Slow release of water from wetlands also helps sustain streamflows during dry seasons (that is, contributes to baseflows).



The **figure at right** (from http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/wetlands4_hydrology.htm) provides another illustration of how wetlands can affect a watershed's runoff patterns. The figure shows how the sum of the storage provided by many wetlands throughout a watershed (wetlands are shown in green) de-synchronizes the peak flows of tributaries feeding a major river. This results in "buffering" or "attenuating" the river's high flows. A watershed's flood attenuation potential can be estimated by the *residence time* of water stored in its wetlands, waterbodies, and groundwater systems. Residence time is the time it takes for precipitation to pass through the watershed—the longer the residence time, the larger the capacity of the watershed to attenuate peak flood events. This hydrologic buffering is another key component in maintaining a watershed's natural flow regimes and is an important mechanism by which wetland storage reduces the height and severity of flood flows.

Finally, during low-flow periods, the gradual outflow of stored water can moderate stream temperatures. Recent research has shown that summer stream temperatures on the Kenai Peninsula periodically exceed those recommended for salmon; as summer air temperatures rise, so do stream temperatures (see Cook Inletkeeper Stream Temperature Monitoring Network, https://inletkeeper.org/healthy-habitat/stream-temperature-monitoring-network). Temperature is influenced by streamflow: higher flow equals lower temperatures. Both groundwater and peat porewater (described under Contributing discharge, below) contribute to streamflow during dry periods (baseflow), when little surface runoff is entering streams. Using a water budget analysis and mixing model, Mike Gracz found, for example, that peatlands appeared to contribute around half of the baseflow in a tributary of the Anchor River during summer dry periods, despite the fact that peatlands cover only 22 percent of the tributary's watershed. Much of the rest of the baseflow reflected groundwater discharge (preliminary results presented April 18, 2013, Kenai Peninsula Fish Habitat Partnership Science Symposium). These findings suggest how critical stored water can be to stream temperatures during low-flow periods; stream temperatures are critical to salmon.

Methods

Wetlands with the largest potential storage capacity tend to be flat, have well-developed micro-relief, and variable water tables. Flatness slows down surface flows, allowing them to spread out and infiltrate (i.e., enter storage). High micro-relief (very rough, pocked, and/or hummocky surfaces) provides more micro-depressions for holding water. A variable water table during the growing season means that the water table is often well below the surface, this provides a high volume of empty pore spaces above the saturated zone. Additionally, wetlands disconnected from drainage networks will tend to have higher storage capacity than those having surface connections to downstream waterbodies and wetlands. Lack of surface outlets means wetland outflow is restricted to subsurface flow pathways, which are slower than surface routes and, therefore, retard wetland outflows.

Most peatlands satisfy the criterion of flatness, and many peatlands have variable water table depths during the growing season. Peatlands also tend to exhibit high micro-topographic relief. In addition, peat itself can have a tremendous water storage capacity when unsaturated because of its enormous volume of pore spaces. Even when saturated, peat can retain considerable storage capacity due to its physical elasticity, meaning it can stretch to hold more water. This is why peat pore space is considered a unique type of wetland storage on the peninsula.

The following variables were considered in assessing wetlands for providing water storage.

1. Is the wetland polygon mapped as a Depression (D)?

Depressions are disconnected from surface drainage networks, slowing their outflows.

2. Does the wetland polygon have a hydrologic component greater than 3 (i.e., 4-6)?
   Wetlands with a hydrologic code greater than 3 are peatlands characterized by variable water tables during the growing season. (Wetlands with a hydrologic component of 2 and/or 3 received lower scores.)
3. Is the wetland mapped as a Headwater Fen (H) or Late Snow Plateau (LSP).
   The locations of these wetlands in their watersheds delays snowmelt and promotes storage.
4. Is the wetland polygon mapped as a patterned fen[43] (LBSF), Drainageway complex[44] (DWR), or an Abandoned Meander Terrace (AMT)?
   These wetlands are large, heterogeneous peatlands with well-developed micro-topography.

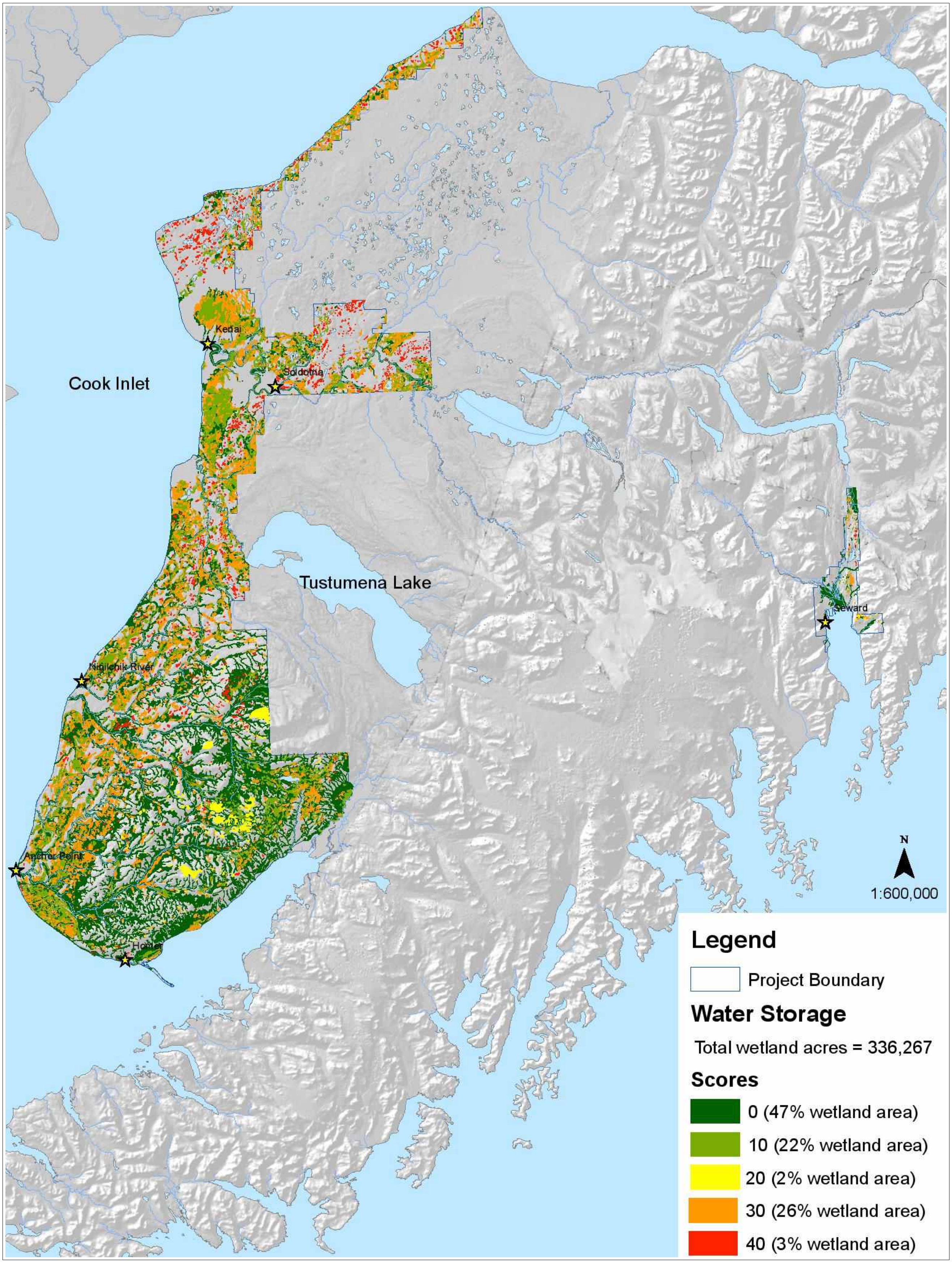
Table 3.4c lists variables considered in assessing this function. Results are presented in Map 3.4b

	Table 3.4c. HYDROLOGY FUNCTION 2: Providing storage of water—including stormwater and floodwater	points
1	Polygon is mapped as a Depression (D) wetland (3% of wetland area)	40
	Polygon has a hydrologic component >3 (26% of wetland area)	30
	Polygon is mapped as a Headwater Fen (H) or Late Snow Plateau (LSP) (2% of wetland area)	20
	Polygon has a hydrologic component 2-3 or is mapped as LBSF or DWR or Abandoned Meander Terrace (AMT) (22% of wetland area)	10
2	Wetland polygon meets none of the above criteria (47% of wetland area)	0

43 Wetlands mapped as LBSF are patterned fens. Patterned fens have also been called “aapa mires” or “string bogs,” and LBSF indicates strang-flark microtopography. Strangs or strings are low peat ridges about 0.5-2 meters high (LB4), and flarks are sedge-dominated low spots between the strangs (LB2). Flarks (and occasionally open-water pools) alternate with strangs. These features are all oriented perpendicular to porewater flow, which can be imperceptible.

44 A polygon is mapped as DWR when more than two non-consecutive Drainageway hydrologic components are present.

Map 3.4b. Wetlands assessed for providing storage of water.
(For a map with higher resolution, see https://sites.google.com/site/hydrologyassessmentmaps/home.)



3.4.3.3. Hydrology function 3: transmitting discharge

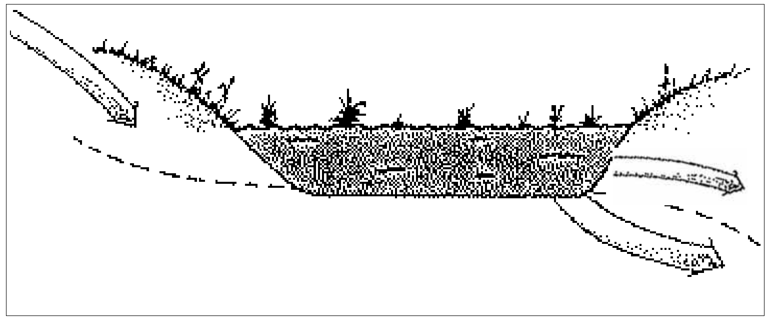
(Much of the content of this assessment is from unpublished write-ups by Mike Gracz, Kenai Watershed Forum.)

Introduction

Two types of discharge function were distinguished for this assessment: *transmitting* and *contributing*. In both cases, the wetland discharges more flow than it adds to storage (change in storage < outflow). The two functions differ, however, in the source of their discharge. A discharging wetland is said to be *transmitting* when most of the water it releases is water that flowed in from upslope or upgradient. If, instead, most of a wetland's discharge derives from storage of onsite precipitation and snowmelt, it is considered to be *contributing*. In other words...

If more water is flowing out of the wetland than is going into storage, the wetland is performing a discharge function...
(outflow > Δ storage = discharge)

- If the wetland is discharging water supplied from upslope watershed elements, the wetland is *transmitting* discharge; the **figure at right** (modified from http://www.extension.purdue.edu/extmedia/WQ/WQ-10.html) illustrates a wetland transmitting discharge: groundwater and shallow subsurface flows are shown feeding the wetland on the left and flowing out on the right. (The dashed line is the water table.)



- If the wetland receives little or no inflow from upslope and the discharge comes primarily from onsite rainfall, snowmelt, or storage, the wetland is *contributing* discharge.

Peat porewater

On the peninsula, porous glacial till and extensive peat deposits constitute major watershed elements. Peatlands mapped as Kettle, Depression, Drainageway, and Lakebed geomorphic components represent 53 percent of the wetland acreage mapped on the Kenai lowlands and over 20 percent of wetland acreage in the Seward area. Riparian wetland and wetland/upland complexes often also support peatlands. Understanding discharge on the peninsula requires a shift in thinking, away from an emphasis on surface flows and towards an emphasis on groundwater and porewater flows. For example, instead of providing surface discharge to a downgradient watershed element, peninsula peatlands are much more likely to supply these watershed elements with *peat porewater*. Because so many peninsula wetlands have thick layers of peat, and these layers are so highly porous and absorbent, huge volumes of discharge move through peninsula wetlands as peat porewater and shallow surbsurface flows. (The significance of peat porewater flows to stream temperatures is discussed under hydrology function 2: providing water storage.)

The large volume of peat porewater moving through peninsula wetlands means that some factors typically determining wetland outflow in the Lower 48 are less significant here. An example is the constriction of surface outlets, which tends to slow and back up surface discharge—as seen on the upstream end of poorly designed culverts. Peatlands, on the other hand, tend not to have channelized outlets, instead they leak water out along their margins wherever hydraulic gradients are lower than the water pressure in the peat. In peatlands, therefore, outlet channels are not as significant in determining storage and discharge as are factors affecting peat's hydraulic conductivity—the flow velocity and direction of peat porewater. However, outlet constriction is important in wetlands with a single outlet regulated by a sill—such as by a beaver dam—and in non-peat wetlands situated in floodplains, which are common in the Seward area.

Lack of surface drainage in peatlands

As suggested above, most inflows to and outflows from peatlands move as shallow groundwater and peat porewater. Because the infiltration capacity of unsaturated peats is so high, and the slopes (gradients) of peatlands are so low (peatlands tend to be very flat), surface drainage networks through peatlands generally remain very poorly developed. (Subsurface "pipestreams" may, however, form.) Even when peat is saturated to the surface and drainage channels might be expected to form given continued inflows, peat's high elasticity allows additional storage through expansion of the peat, discouraging development of surface channels.

Wetlands with high scores for transmitting discharge are important in maintaining natural (unregulated) flow regimes (see the following function). If such wetlands are altered, the physical form (and biological processes) of downgradient waterbodies are likely to change, along with related habitat conditions and fish and wildlife populations. As with loss of groundwater recharge and storage functions, loss of the transmitting function—especially when transmitting wetlands are replaced with relatively impervious surfaces like roads, roofs, parking areas, and compacted soils—is likely to result in more rapid flooding during storm events and higher flood peaks. Another benefit provided by transmitting wetlands is filtration, for example, of stormwater flows (see maintaining water quality).

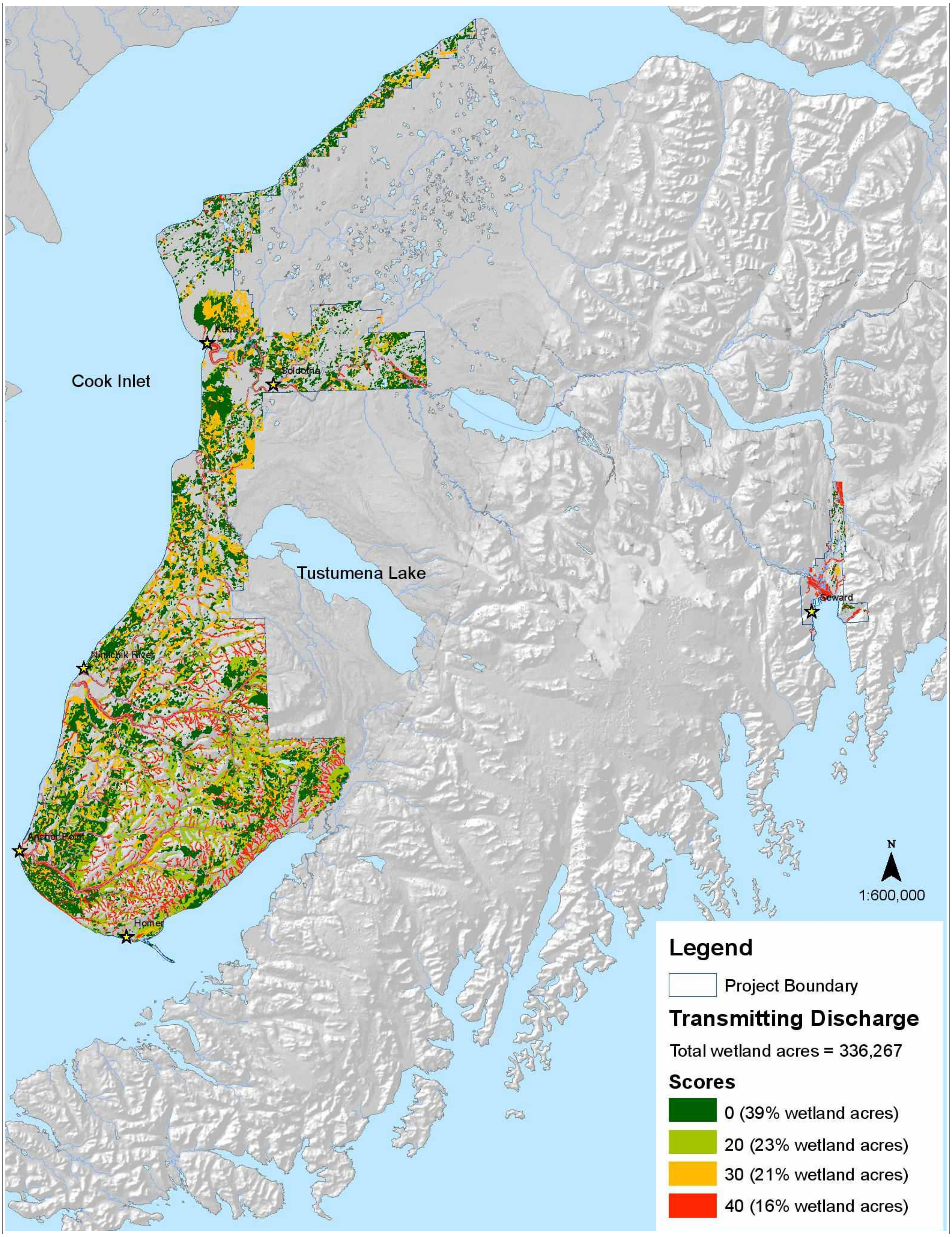
Methods
The following variables were considered in assessing wetlands for transmitting discharge.

1. Is the wetland polygon mapped as a Riparian (R), Floating Island (FI), or does it have a hydrologic component of 1 (open water) but is NOT a Depression?
   Wetlands mapped as Riparian/Riverine (R) or Floating Island wetlands or with a hydrologic code of 1 include waterbodies. R polygons encompass valley bottoms adjacent to streams and rivers, which may be extensive. In perennial streams, storage is generally short-term and transient through a porous channel substrate. Water that does move into storage—for example into short-term bank storage or the hyporheic zone—is unlikely to exceed outflow. Outflow will, therefore, exceed change in storage, even in gaining reaches. Losing stream reaches, have outflow rates higher than gaining reaches, and again, change in storage does not exceed outflow, so these wetlands also meet the definition of transmitting discharge.
2. Is the polygon mapped as a Drainageway (DW) or patterned fen Lakebed (LBSF) or have a hydrologic code of 1-2 but is NOT a Depression?
   These geomorphic and hydrologic components have water tables that are at or near the surface for most of the growing season. This is a likely indication that the polygon is continuously supplied by groundwater and/or porewater inflow and that storage capacity is generally maxxed out. In such wetlands, the source of discharge is inflow, and little or no additional water will be entering storage, so outflow will be greater than change in storage, meeting the definition of a transmitting wetland.
3. Is the polygon mapped as a Discharge Slope (S)?
   Discharge Slope wetlands are mapped at foot- and toeslope landscape positions where a steady supply of shallow groundwater maintains water levels near the surface. As a result, storage is usually maxxed out. In such wetlands, the source of discharge is inflow from upslope, and little or no additional water will be entering storage. Therefore, outflow will be greater than change in storage, meeting the definition of a transmitting wetland.

Table 3.4d lists variables used in assessing this function. Results are presented in Map 3.4c.

	Table 3.4d. HYDROLOGY FUNCTION 3: Transmitting discharge	points
1	Polygon is mapped as a Riverine (R) wetland or Floating Island (FI) OR has a hydrologic component = 1 AND is NOT a Depression (D) (16% of wetland area)	40
	Polygon is any other Drainageway (DW) wetland or is mapped as LBSF (patterned fen) or has a hydrologic component 1-2 AND is NOT a Depression (D) (21% of wetland area)	30
	Polygon is mapped as a Discharge Slope (S) wetland (23% of wetland area)	20
2	Wetland polygon meets none of the above criteria (39% of wetland area)	0

Map 3.4c. Wetlands assessed for transmitting discharge.
(For a map with higher resolution, see https://sites.google.com/site/hydrologyassessmentmaps/home.)



3.4.3.4. Hydrology function 4: contributing discharge

(Much of the content of this assessment is from unpublished write-ups by Mike Gracz, Kenai Watershed Forum.)

Introduction

As noted above, for this assessment the discharge function was divided into *transmitting* and *contributing* discharge. If the wetland is discharging—namely, its change in storage is less than its outflow—AND most of the discharge flowing from the wetland derives from onsite precipitation and snowmelt, the wetland is considered to be *contributing* rather than *transmitting* (see discussion of the preceding function). If no other watershed elements lie upgradient of the wetland—for example, if the wetland is located on or near a watershed divide—then any discharge from the wetland will inevitably reflect contributed rather than transmitted discharges. Such wetlands are unlikely to support stable water levels near the surface.

Wetland polygons characterized by variable water levels are likely to receive most of their input from onsite sources—snowmelt and precipitation—as opposed to from upgradient sources. In fact, these polygons may have highly variable water levels because no other watershed elements lie upgradient. When this is the case, the wetland cannot be receiving inflow and, therefore, cannot be transmitting. During dry periods, stored water is the only source of outflow from these wetland polygons. When outflow of stored water exceeds change in storage, wetlands are contributing. This is especially true of bogs, where precipitation is the only input and inflows from porewater and groundwater are rare events (see figure on page 83).

Wetland polygons that contribute discharge help maintain streamflows during dry periods and also attenuate stormflows. Contributing discharge overlaps with the function of providing storage (hydrology function 2) since internal storage is a prerequisite for contributing. If the storage capacity of the wetland is reduced, for example, by excavation of peat, then less stored water will be contributed to streamflow during dry periods. This can affect stream temperatures (causing them to rise) because streamflows heat more quickly when flow volumes decrease. Similarly, less storage capacity will be available to absorb stormwater, resulting in higher and more frequent flooding. Because larger stormflows transport more sediments and larger particles—which alters streambed characteristics—loss of this function can lead to negative effects on salmon spawning gravels and on other instream habitats.

Methods

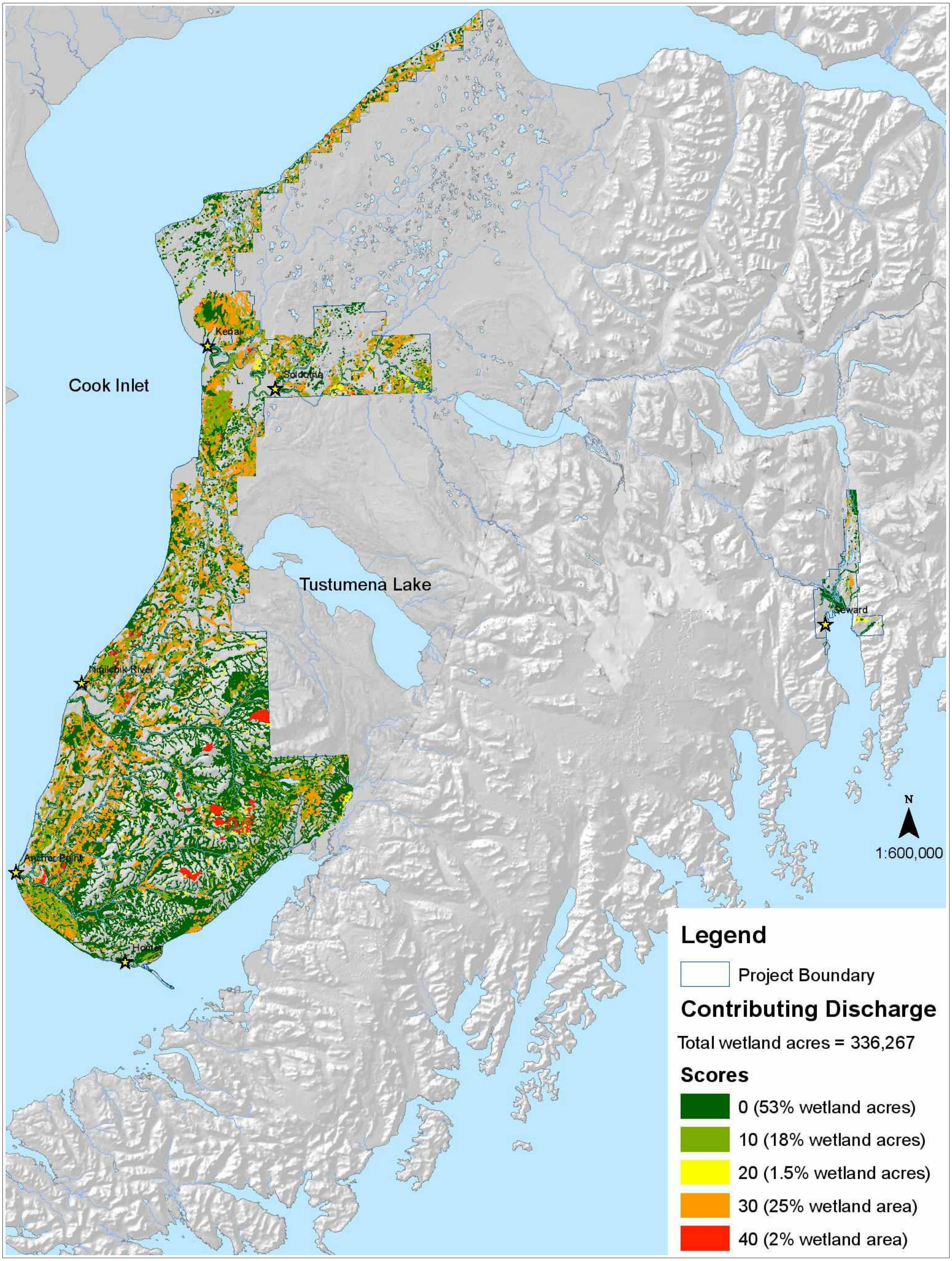
The following variables were considered in assessing wetlands for contributing discharge.

1. Is the polygon mapped as an LB3, LB36 or LB63 Lakebed or a Late Snow Plateau?
   LB3, LB36, or LB63 polygons are bogs. Bogs receive little or no inflow through groundwater or pore-water. Most outflow from bogs is derived from internal storage of onsite precipitation and snowmelt. Late Snow Plateaus are located where they receive little inflow from upslope. These wetlands generate outflow from internal storage, meeting the definition of contributing discharge.
2. Is the wetland polygon mapped as having a hydrologic component greater than 3 (i.e., 4-6) but is NOT a Depression?
   Polygons with a hydrologic component greater than 3 support water levels that are seasonally low and variable, indicating that they probably receive little groundwater or porewater from upgradient. Higher water levels in these wetlands, therefore, derive primarily from onsite precipitation or snowmelt. Since in these wetland polygons, outflow comes primarily from storage of onsite inputs, they meet the definition of contributing discharge.
3. Is the polygon mapped as an Abandoned Meander Terrace (AMT) or Headwater Fen (H)?
   Due to their watershed positions, these polygons receive little inflow from upslope watershed elements. Since outflow comes primarily from storage of onsite inputs, they meet the definition of contributing discharge.
4. Is the wetland polygon mapped as having a hydrologic component of 2-3 but is NOT mapped as a Depression?
   These polygons represent conditions similar to #2 above but have higher seasonally variable water levels. This suggests that a larger percentage of their outflow may derive from inflow received from upslope watershed elements.

Table 3.4e lists variables considered in assessing this function. Results are presented in Map 3.4d.

Table 3.4e. HYDROLOGY FUNCTION 4: Contributing discharge		points
1	Polygon is mapped as a bog (LB3, LB63, LB36) OR Late Snow Plateau (LSP) (2% of wetland area)	40
	Polygon has a hydrologic component >3 AND is NOT mapped as a Depression (25% of wetland area)	30
	Polygon is mapped as an Abandoned Meander Terrace (AMT) or Headwater Fen (H) (1.5% of wetland area)	20
	Polygon has a hydrologic component 2-3 AND is NOT a Depression (18% of wetland area)	10
2	Wetland polygon meets none of the above criteria (53% of wetland area)	0

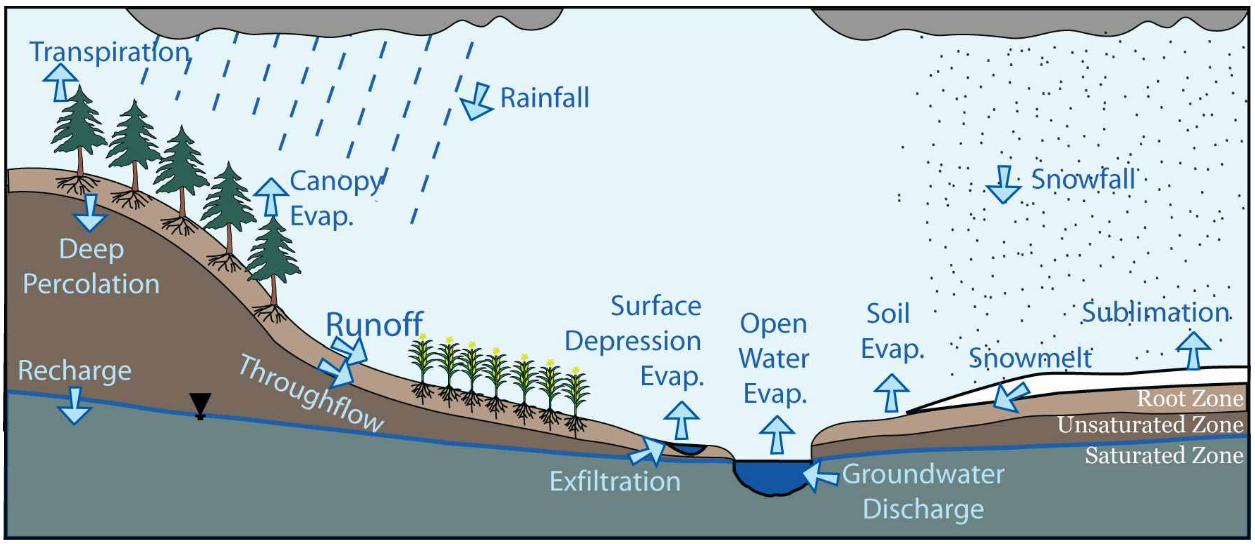
Map 3.4d. Wetlands assessed for contributing discharge.
(For a map with higher resolution, see https://sites.google.com/site/hydrologyassessmentmaps/home.)



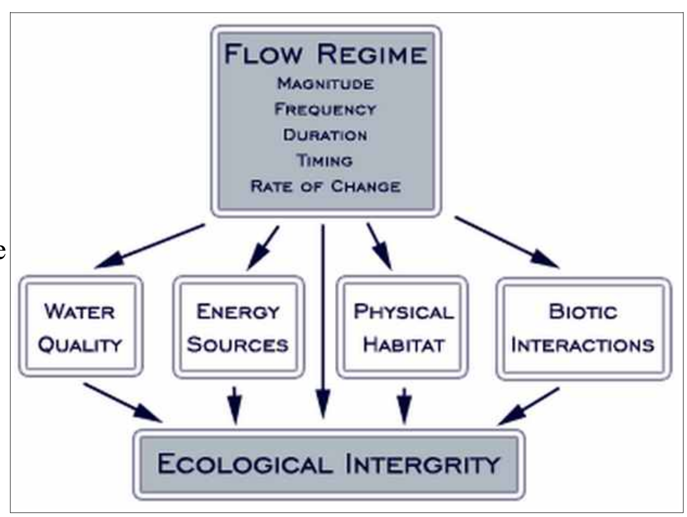
3.4.3.5. Hydrology function 5: maintaining natural (unregulated) streamflow regimes[45]

Introduction
As already noted (and further discussed in Sections 3.4.4 through 3.4.6), wetland hydrology functions are complex, dynamic, and interconnected with other parts of the water cycle. Consider, for example, how variable each of the processes shown in the **figure below** can be, and how many potential interactions there are among them (from http://hydrogeology.glg.msu.edu/research/active/modeling-and-monitoring-hydrologic-processes-in-large-watersheds).

As the four hydrology functions discussed above interact, they combine to create a fifth "integrative" function: *maintaining flow regimes* characteristic of rivers, wetlands, or watersheds. In most peninsula watersheds—where wetlands and waterbodies are still largely in "reference condition" (see Section 1.3.4) and flows are not regulated by dams, excessive withdrawals, or other actions, flow regimes remain essentially "natural"—reflecting all the variations in flow that occur over many time scales—from single storm events, to rainy seasons, to years, decades, and centuries. This multi-time-scale pattern of flow variability encompasses both the highest flows of major floods (e.g., 100-year floods and larger) and the lowest flows of drought years (e.g., minimum baseflows). This variability gives rise to "natural flow regimes." These can be considered for streams, wetlands, or watersheds.



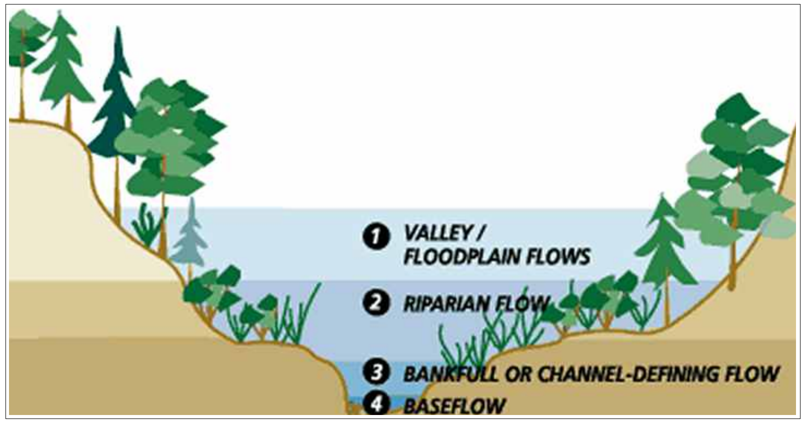
The **pattern** of flow variability that defines the natural flow regime of any wetland, river, or watershed can be understood in terms of five elements: flow *magnitude*, *frequency*, *duration*, *timing*, and *rate of change*, as shown in the **diagram at right** (from http://www.snre.umich.edu/riverflows/flow_regime/index.php). This pattern—how much water flows when, how often, and for how long—operates in combination with other watershed attributes, like geology and climate, to determine key ecosystem features, such as stream channel type, streambed materials, water quality and temperature, aquatic and riparian plant communities, and the like (see below).



Four different flow levels reflected in natural flow regimes are particularly critical in determining physical and biotic conditions in and along rivers and streams. In many cases, stream channel characteristics will be determined by one set of flows and floodplain features

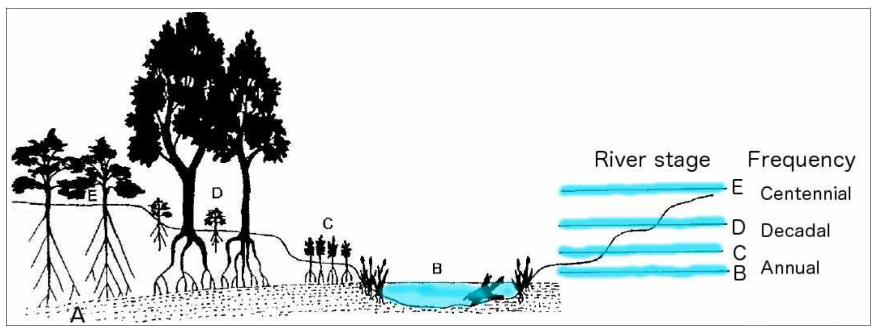
45 The concept of natural flow regimes has perhaps been most explored in terms of rivers (see, for example, Poff et al 1997, at http://www.fs.fed.us/stream/Poffetal_1997.pdf), but has also been applied to watersheds and wetlands.

by another. As illustrated and numbered in the **figure at right** (from http://www.mnr.gov.on.ca/en/Business/Water/2ColumnSubPage/STEL02_163598.html), these four flow levels are:



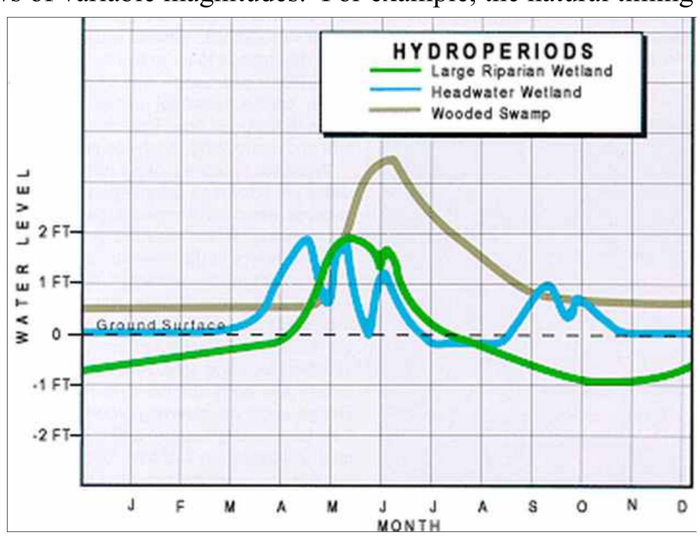
1. **valley/floodplain flows** – which are high magnitude floods that occur every 25 to 100 or more years;
2. **riparian flows** – which occur during periods of high snowmelt or heavy rainfall and reach areas otherwise rarely inundated;
3. **bankfull or channel defining flows** – which are the maximum flows that can be contained within a stream channel before its banks are overtopped and occur on average every 1-2 years;
4. **baseflows** – which are the lowest flows that occur on an annual basis (usually late spring/early summer on the peninsula); baseflows generally represent water supplied from mostly groundwater discharge.

Another representation of natural flow regime variability and its effects on instream, riparian, and floodplain habitats is provided in the figure below (from http://www.fs.fed.us/stream/Poffetal_1997.pdf).



A – Water tables that sustain riparian vegetation and determine in-channel baseflow habitats are maintained by groundwater inflow and flood recharge. Floods of varying size and timing are needed to maintain a diversity of riparian plant species and aquatic habitats.
B – Small floods occur frequently and transport fine sediments, maintaining high benthic productivity and creating spawning habitat.
C – Intermediate-size floods inundate low-lying floodplains and deposit entrained sediments, allowing the establishment of pioneer species. These floods also import accumulated organic material into the channel and help maintain the characteristic form of the active stream channel.
D – Larger floods, recurring decadally, inundate aggraded floodplain terraces, where later successional species become established.
E – Rare, large floods uproot mature trees and deposit them in the channel, creating high-quality habitat for many aquatic species.

As Ann Fissekis notes (2007, https://www.geology.ucdavis.edu/~shlemonc/trips/GrandeRonde/ background.html): "The timing, or predictability, of flow events is critical ecologically because the life cycles of many aquatic and riparian species are timed to either avoid or exploit flows of variable magnitudes. For example, the natural timing of high or low streamflows provides environmental cues for initiating life cycle transitions in fish, such as spawning, egg hatching, rearing, movement onto the floodplain for feeding or reproduction, or migration upstream or downstream."

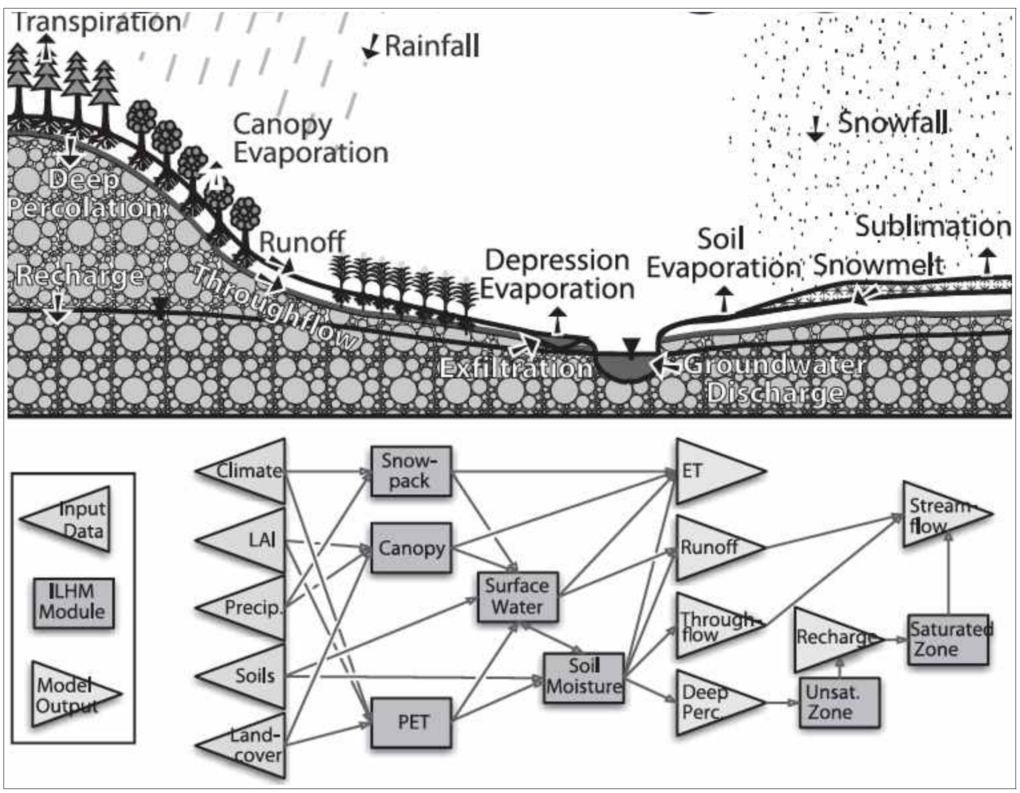


Different kinds of wetlands can have significantly different flow regimes, as shown in the **hydrograph at right** (from: http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/wetlands4_hydrology.htm). The graph shows three <u>annual</u> flow regimes (in this case called hydroperiods) for three kinds of wetlands in the Northeast US (water level is shown in feet on the left, months are shown across the bottom). Note that the hydroperiod of the headwater wetland shows high variability, with water levels rising and falling quickly in response to local storm events (blue line in diagram), whereas larger, downstream wetlands that receive flows from many sources—surface and subsurface—are shown to respond more slowly to local events (green and brown lines). Note also how much water the "wooded swamp" is shown to store, whereas water moves through the riparian wetland more rapidly. In similar ways, various peninsula wetlands have different hydroperiods, which reflect differences in inputs, storage capacity, watershed location, and other features.

The flow regimes of the waterbodies and wetlands in a watershed all interact to some degree. The sum total of these interactions produces the watershed flow regime. Singling out the degree to which any one wetland, stream, or lake affects the watershed flow regime requires more detailed information than we currently have. One generalization that can be made, however, is that the larger a wetland's area—and the greater the percentage that area represents of total watershed area—the more that wetland will influence watershed flow regimes (as well as flow regimes of downslope/downgradient wetlands, streams, and rivers).

Management of one component of the hydrologic system, such as a stream or an aquifer, commonly is only partly effective because each hydrologic component is in continuing interaction with other components...

Effective policies and management practices must be built on a foundation that recognizes that surface water and groundwater are simply two manifestations of a single integrated resource.
Thomas C. Winter, et al. (See http://pubs.usgs.gov/circ/circ1139/.)



As suggested above, when natural flow regimes change, everything dependent on them changes too, from stream water quality and temperature, to in-stream flows and channel characteristics, to groundwater availability and quality, to habitats used by salmon, moose, rare plants, and other species. Scientists have attempted to model these key watershed interactions. One such model is the Integrated Landscape Hydrology Model (ILHM) developed at Michigan State University[46]. The **figure at left** (http://hydrogeology.glg.msu.edu/wordpress/wp-content/uploads/2007/12/hyndman_et_al_2007.pdf) shows how various hydrologic components of a watershed—including, for example, precipitation, soils, and land-cover—ultimately affect flow regime components such as runoff, throughflow, deep groundwater percolation, and streamflow, among others. It's important for managers of watershed resources to be aware of such interactions.

46 Michigan State University, Department of Geological Sciences developed the Integrated Landscape Hydrology Model (ILHM) as a "...landscape hydrology simulation suite capable of very large domain, fine resolution modeling. It simulates nearly the entire terrestrial hydrologic cycle with full energy- and water-balance physically-based component modules... The software and all associated model development tools will be released under an open source license. It is the intention of the developers that ILHM be adopted by the broader community as a tool for landscape hydrologic simulations at a variety of spatial scales." See http://hydrogeology.glg.msu.edu/research/active/ilhm#more-653.

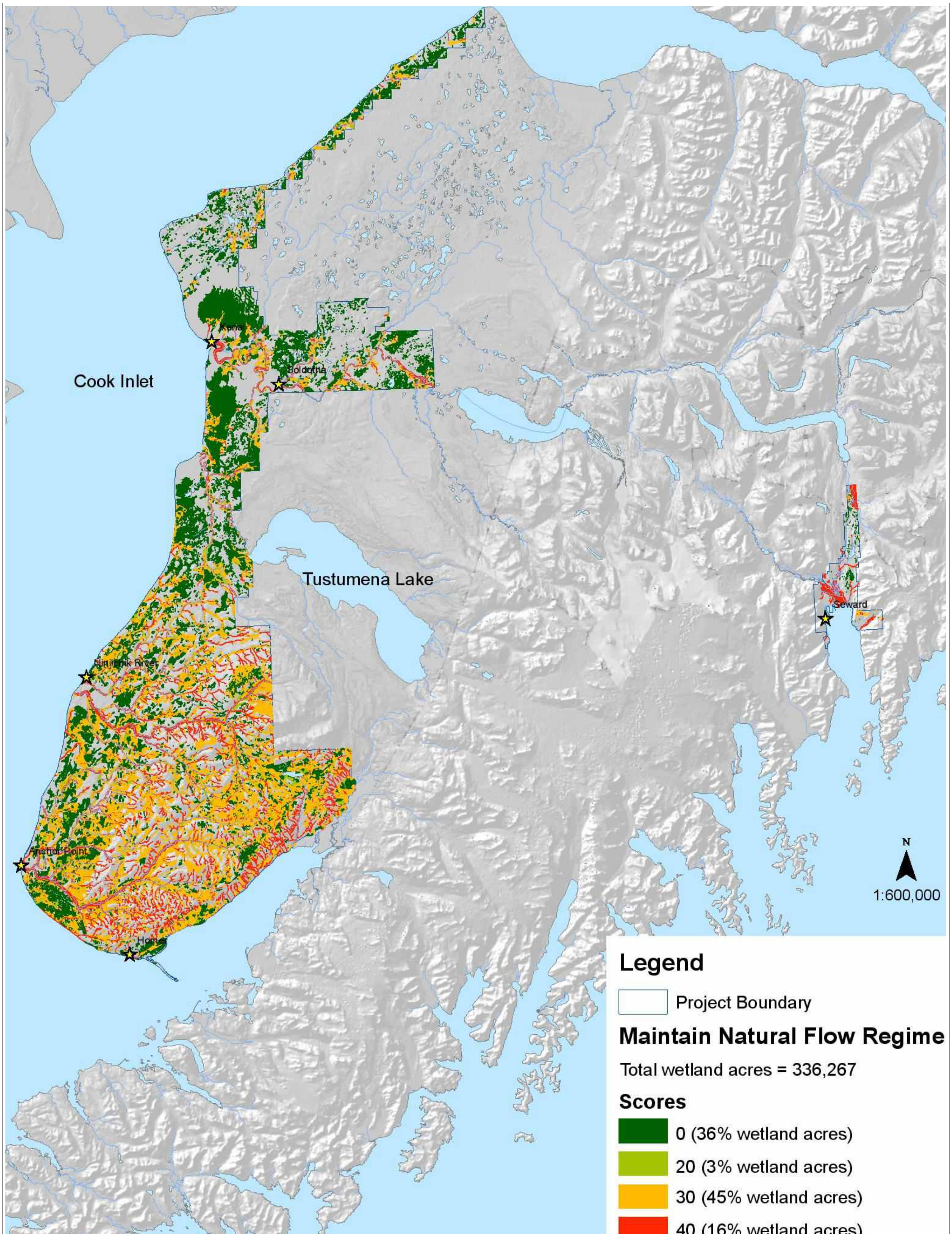
Methods

Because maintaining natural (unregulated) *watershed* flow regimes is an integrative function, it reflects the operation of the other four water quantity functions as well. This assessment, however, focuses on natural (unregulated) flow regimes of streams and rivers rather than of entire watersheds. The degree to which a wetland affects stream or river flow regimes depends largely on the proximity of the wetland to the stream or river, as well as its hydrologic connections. Size is another relevant variable, but as discussed in Section 3.2.4, wetland size will be considered during future development of management strategies.

Table 3.4f lists variables considered in assessing wetlands in terms of their contributions to maintaining natural (unregulated) flow regimes of streams and rivers. Results of this assessment are presented in Map 3.4e.

	Table 3.4f. HYDROLOGY FUNCTION 5: Maintaining natural (unregulated) flow regimes of streams and rivers	**points**
1	Polygon is mapped as Riverine (R) wetland (16% of wetland area)	40
	Polygon is mapped as an Abandoned Meander Terrace (AMT) or Late Snow Plateau (LSP) or Headwater Fen (H) or any wetland adjacent to a Riverine (R) wetland (45% of wetland area)	30
	Polygon is within 50 m of a Riverine (R) wetland (3% of wetland area)	20
2	Wetland polygon meets none of the above criteria (36% of wetland area)	0

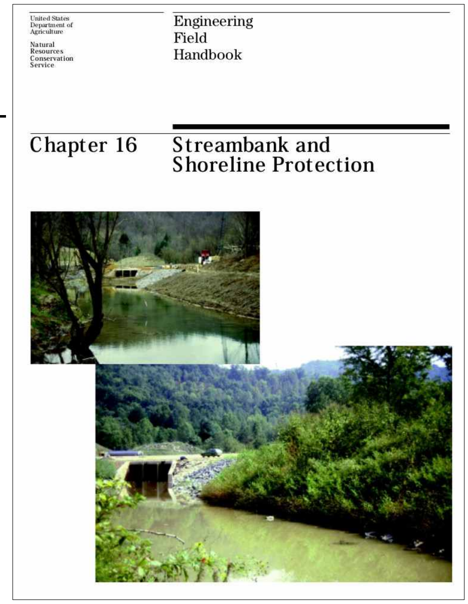
Map 3.4e. Wetlands assessed for maintaining natural (unregulated) flow regimes.
(For a map with higher resolution, see https://sites.google.com/site/hydrologyassessmentmaps/home.)



3.4.3.6. Hydrology function 6: reducing streambamk and shoreline erosion

Streambank erosion is a natural process that occurs when the forces exerted by flowing water exceed the resisting forces of bank materials and vegetation. Erosion occurs in many natural streams that have vegetated banks. However, land use changes or natural disturbances can cause the frequency and magnitude of water forces to increase. Loss of streamside vegetation can reduce resisting forces, thus streambanks become more susceptible to erosion.
NRCS "Streambank and Shoreline Protection" (see below)

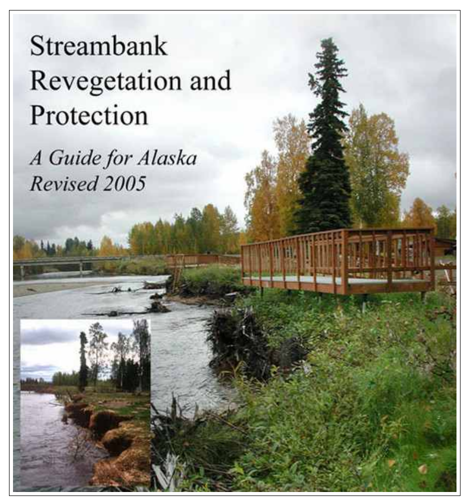
Introduction
All streambanks and shorelines are subject to erosion. The two main mechanisms operating on banks are bank scour and mass failure, which often work in combination. Bank scour is the direct removal of bank materials by the physical action of moving water and the sediments it carries. Mass failure is the sliding, slumping, or toppling downslope of sections of bank. Undercut streambanks and shorelines indicate scour, collapse of an undercut section of bank represents mass failure.



The Corps of Engineers has noted that vegetation is Nature's way of stabilizing a streambank. The truth of this statement is reflected both in Chapter 16 of the NRCS *Engineering Field Handbook* ("Streambank and Shoreline Protection," Chapter 16, Part 650, NRCS 1996), and in *Streambank Revegetation and Protection: A Guide for Alaska* by the Alaska Department of Fish and Game (ADF&G 2005, see: http://www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.main).

Plants contribute to streambank and shoreline stability in several ways:

- Root systems help bind soil particles together, stabilizing banks.
- Vegetation can increase a bank's hydraulic resistance to flow.
- Where plants grow from or hang into the water along banks, vegetation reduces erosive stream velocities. (Such areas of low velocity provide feeding, resting, and hiding areas critical to juvenile salmon, which may be swept downstream by currents too strong for them to swim against.)
- Vegetation acts as a buffer against hydraulic forces and the abrasive effects of transported materials.
- Dense vegetation on streambanks can induce sediment deposition.
- Vegetation can redirect flow away from the bank.



The **photo below right** shows a scoured section of Kenai River bank (since revegetated with soil bioengineering); the **photo below left** shows a section of bank being stabilized with plants (willow and alder cuttings) and other soil bioengineering techniques (from http://www.rbca-alaska.org/ page8/page16/ page16.html).

Methods

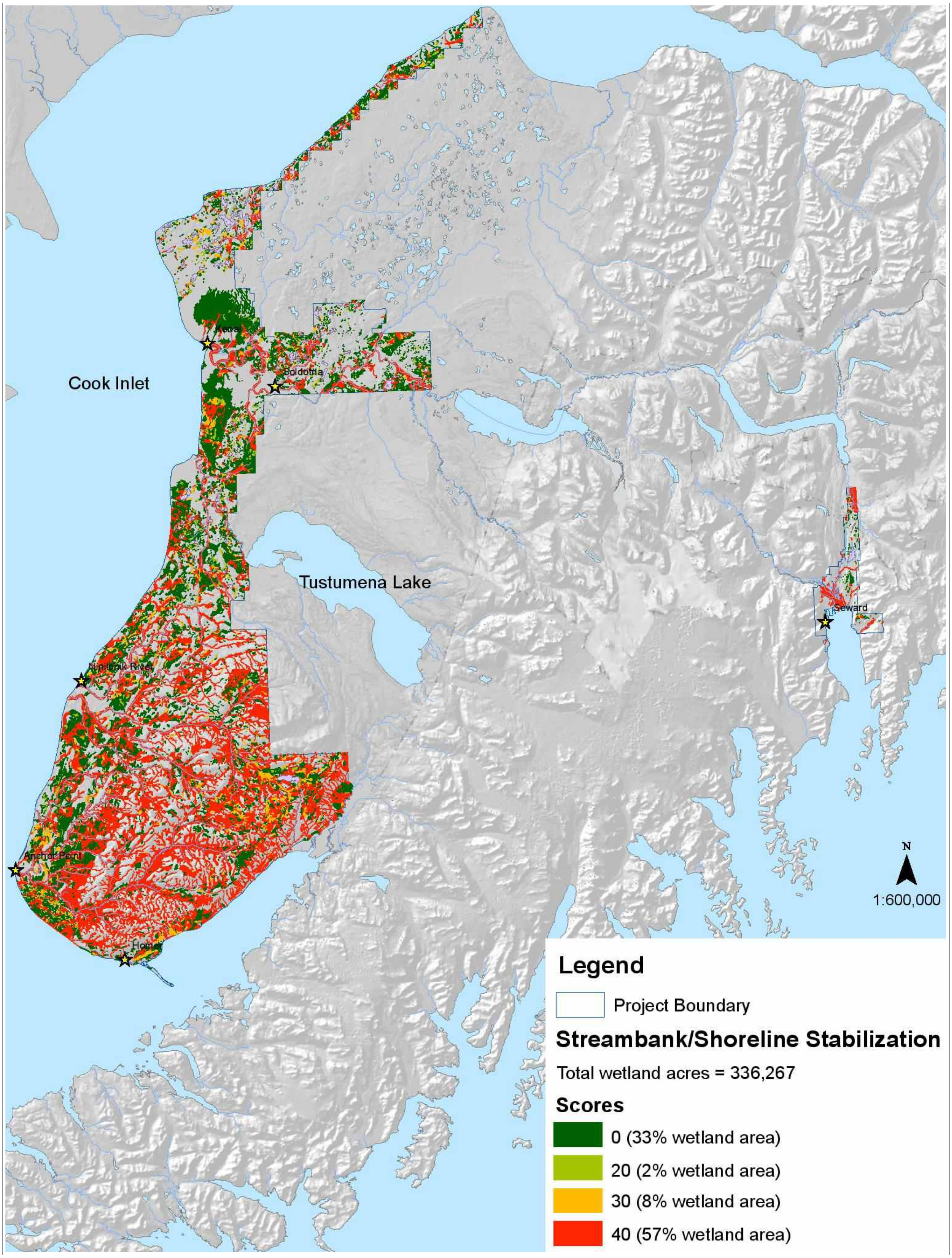
Wetland polygons where vegetation grows on banks and/or adjacent to waterbodies (streams, rivers, lakes, or ponds) perform the function of reducing shoreline and streambank erosion. Vegetation is particularly important where fluctuations in water level may expose banks, hence consideration of polygons having at least 2 hydrology components.

Table 3.4g lists variables used in this assessment. Map 3.4f provides results.

	Table 3.4g. HYDROLOGY FUNCTION 6: Reducing streamband and shoreline erosion	points
1	Polygon is mapped as Riverine (R) wetland OR as a forest- or shrub-dominated wetland polygon adjacent to open water (i.e., R, Lake, or D1, D1c, DW1, H1, LB1, K1, K1c) (57% wetland area)	40
	Polygon is mapped as having two hydrologic components with the dominant hydro component = 1 (e.g. LB12, K13) OR as an herbaceous-dominated wetland adjacent to open water (i.e., R, Lake, or D1, D1c, DW1, H1, LB1, K1, K1c) (8% wetland area)	30
	Polygon is mapped with more than two hydrologic components, including component = 1 (e.g., LB1-3, DW1-5) (2% wetland area)	20
2	Polygon meets none of the above criteria	0

Map 3.4f. Wetlands assessed for reducing shoreline and streambank erosion.

(For a map with higher resolution, see https://sites.google.com/site/hydrologyassessmentmaps/home.)



3.4.3.7. Hydrology function 7: improving (or maintaining) water quality

Introduction

The seventh wetland function assessed is improving water quality. (Where water quality is already good—as throughout much of the study area, this function is more accurately called *maintaining* water quality.) This function reflects the difference in water quality between the water flowing into and held within a wetland and the water flowing out. Wetlands can filter and/or chemically transform many kinds of pollutants, resulting in outflows having reduced levels of such contaminants.

Inputs that may degrade the quality of water entering wetlands include:

1. sediments—e.g., sand, silt, clay—which moving water can suspend in the water column and carry downstream; in still water, sediments settle to the bottom;
2. inorganic chemicals, such as nitrogen, phosphorous, potassium, salts, minerals, heavy metals; and
3. organic material, such as plant debris, byproducts of decomposition, pathogens, other biological detritus, as well as hydrocarbons and contaminants from road runoff, leaking leach fields, livestock paddocks, dogyards, etc.

There are three main mechanisms by which wetlands can improve (or maintain) water quality. They can:

1. filter out pollutants carried in suspension or moved by the tractive forces of flowing water
   Wetlands provide filtration as a result of the "roughness" (increased friction) created by their plant cover and microtopography, including pores in peat. Plants and micro-topographic relief provide surfaces that physically retain (trap) moving particles. In addition, plant roots can bind sediments accumulating on the bottom. Research has shown that wetlands can remove as much as 90 percent of the sediments carried into the wetland by surface runoff or streamflow.
2. reduce flow velocity
   The faster that water flows, and the larger its volume, the more and heavier the particles it can carry. Water is slowed down by (a) flowing across surfaces with increased roughness (see above), (b) being allowed to spread out over flat areas, and (c) being retained in concave landforms. Low velocity flows allow sediments to settle out. Also, because pollutants such as heavy metals and organic compounds can become attached (adsorbed) to sediment particles carried in suspension, the settling of such particles can remove adsorbed contaminants as well. The same conditions that slow flows also promote chemical transformations of pollutants (see below).
3. provide conditions where chemical transformations can occur, often as the result of biological organisms
   Water is an excellent medium for many chemical reactions, particularly water that is calm or flowing only slowly. Chemical and biochemical transformations can reduce nutrient loads in water and detoxify chemical pollutants.
   Nutrients: Although nutrients such as nitrogen (N), phosphorus (P), and potassium (K) are essential for life and important for plant growth, in high concentrations they can be harmful to human health and aquatic life. Wetland plants can be take up nutrients and incorporate them into plant tissue or into the soil. Periodic flooding can then pick up decayed plant material and wash it downstream, where it can contribute nutrients to downstream food webs. (This is another example of how natural (unregulated) flow regimes maintain watershed productivity).
   Chemical pollutants and pathogens: Toxic chemicals carried into wetlands can be trapped along with settled particles. Some of these pollutants may be taken up by plants or buried in accumulating sediments, while others may be converted into less harmful chemical forms by biological processes or by exposure to sunlight for extended periods. The relatively slow passage of water through wetlands can provide time for pathogens to lose their viability or to be consumed by other organisms.

Peatlands can be extremely effective in trapping sediments and pollutants because of their minimal surface gradients, high roughness (including large volumes of dead-end pore spaces), and potentially high sorptive capacity. As peatlands slow and store flows, they promote sediment deposition as well as chemical/biochemical transformations. All peatlands, therefore, have a high potential to perform improve (or maintain) water quality. Similarly, wetlands adjacent to streams and rivers play critical roles in performing this function because, by trapping, retaining, and transforming pollutants carried in runoff from upslope areas, they prevent these pollutants from entering streams and rivers and being carried downstream.

As is clear, the degree to which a wetland improves water quality is determined both by the quality of water flowing into it and by its characteristics. The quality of inflowing water is determined by the wetland's location in its watershed, particularly its location in relationship to land uses that contribute pollutants. Sources of pollution include:

- runoff from roads, parking lots, and other impervious surfaces;
- leachate and runoff from improperly designed or managed landfills;
- leachate from failing septic systems or leach fields installed in gravels or other materials that fail to properly filter effluent;
- excess fertilizers or herbicides washing off lawns or agricultural areas;
- biological contaminants (e.g., *E. coli* bacteria) washing off livestock paddocks and dogyards;
- sediments, hydrocarbons, and other pollutants washing off construction sites, gravel pits, and other cleared or disturbed areas.

Wetlands downslope of areas that contribute pollutants such as those listed above are extremely important in removing them. Roads and motorized trails were used as a proxy for areas likely to contribute pollutants, so proximity to a road or trail was used as an assessment variable.

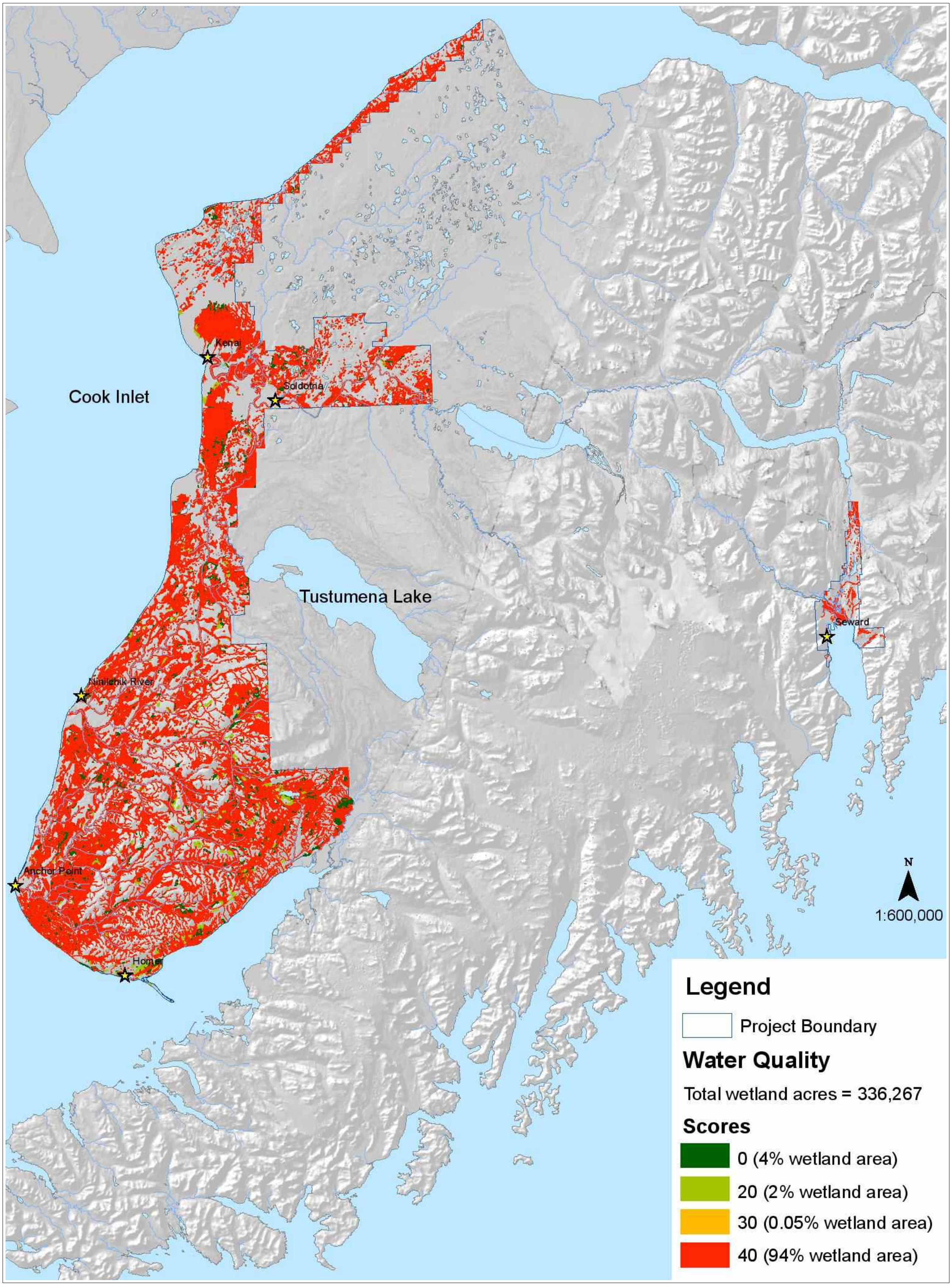
Note, retention of pollutants may over time degrade wetland conditions and impair wetland functions. Although wetlands—particularly peatlands—that receive polluted runoff from upslope land uses are likely to be improving water quality at present (and the variable of road/trail proximity reflects this), such wetlands warrant heightened scrutiny to prevent their degradation. A wetland's effectiveness in trapping sediments and toxins may at some point require remediation. Note, wetlands assigned a score for this function because they are disturbed ("d" modifier) or near roads and trails are NOT better at improving (maintaining) water quality than other scored wetlands, they are simply more likely to be performing this function at present.

Methods

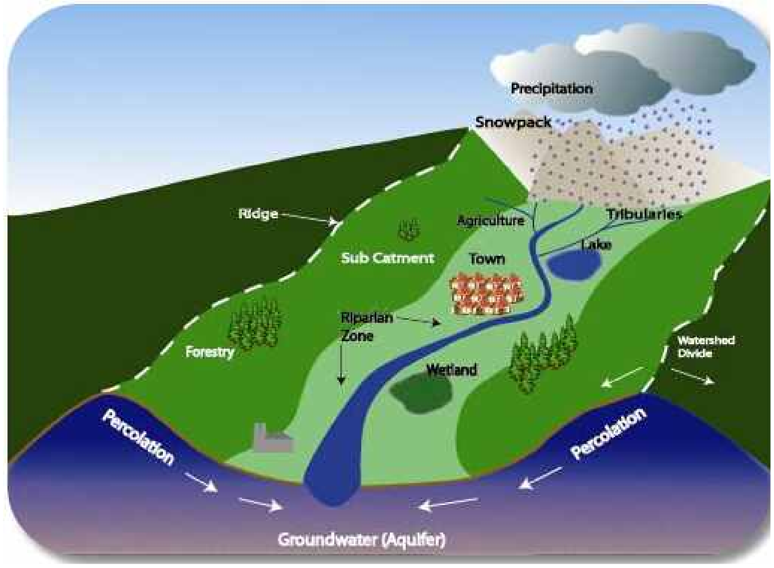
Table 3.4h lists variables considered in assessing wetlands for this function. Map 3.4g provides results.

	Table 13. HYDROLOGY FUNCTION 7: Improving (maintaining) water quality	points
1	Polygon is mapped as Riverine (R) wetland or is adjacent to (R) polygon or is a peatland but is NOT mapped as: Discharge Slope (S), Late Snow Plateau, Wetland/Upland Complex (WU), or DISTURB (94% wetland area)	40
	Polygon map unit code includes a "d" (disturbed) modifier (0.05% wetland area)	30
	Polygon is within 50 ft of a road or trail (2% wetland area)	20
2	Wetland polygon meets none of the above criteria (4% of wetland area)	0

Map 3.4g. Wetlands assessed for improving (maintaining) water quality.
(For a map with higher resolution, see https://sites.google.com/site/hydrologyassessmentmaps/home.)



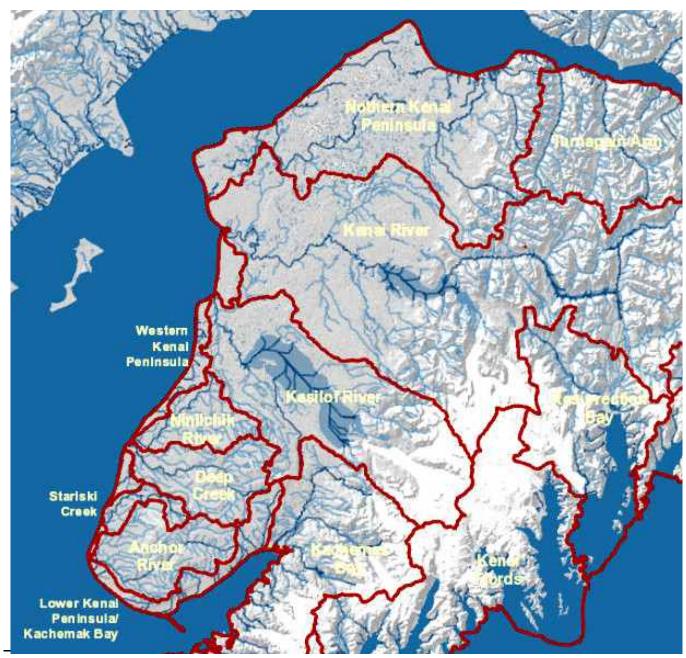
3.4.4. Wetland hydrology is best understood in a watershed context



It's impossible to talk about wetland hydrology without talking about watersheds and stream networks. A watershed (or "catchment") consists of all the lands that "shed" water into a particular water body such as the Kenai River or Johnson Lake. Watershed boundaries represent an imaginary line running from high point to high point around all those water "shedding" lands—from peak to peak and along the spines of ridges, hogbacks, moraines, and saddles, see **figure at right**[47]. For example, Diamond Ridge Road, north of Homer, runs along the watershed divide between Diamond Creek to the south and Bridge Creek to the north. The land slopes away in opposite directions on each side of the road into two adjacent watersheds. Eventually, water from both watersheds flows into Cook Inlet. Whereas some drainage divides, like the Diamond Creek–Bridge Creek divide, are easy to locate, others can be hard to identify, for example, where a peatland straddles the divide.

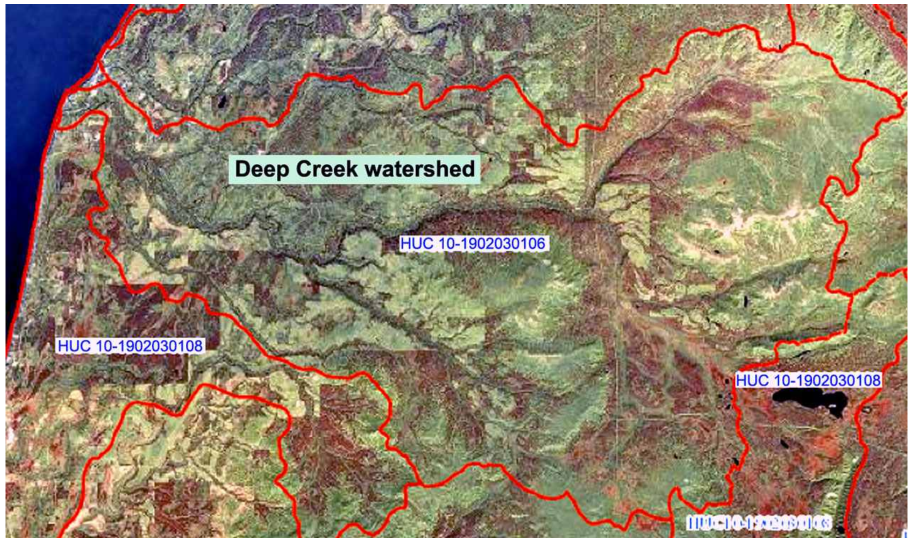
Each watershed contains smaller watersheds within it—and these contain even smaller watersheds as well, down to the smallest watershed of the smallest headwater stream. As a result, the hydrologic cycle should be viewed as operating at many scales—from global, to regional, to local—and as being highly variable in space and time. Levels of rainfall or rates of evapotranspiration on this side of that ridge or in this forest may be quite different from levels on the other side of the ridge or over in that field. This variability characterizes wetlands.

The **map below left** shows major watersheds in the project area. (This map is from Kenai Watershed Forum's watershed atlas, see http://www.kenaiwatershed.org/research/atlas.html.) The **map below right** shows the Kenai National Wildlife Refuge, Kenai Fjords National Park, and Chugach National Forest, where most peninsula watersheds have their headwaters—that is, where streams arise to flow downslope through their watersheds, accumulating flow on their way to either Cook Inlet (from Kenai lowlands) or Resurrection Bay (from the Seward area).

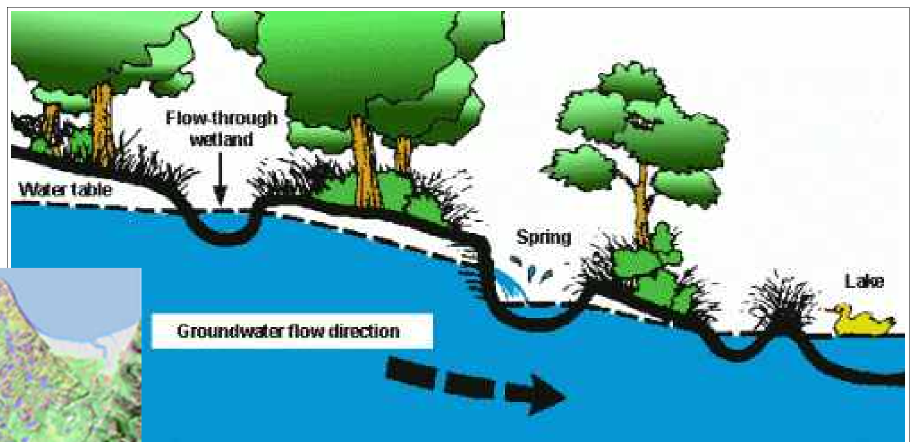


47 This figure is from a helpful illustrated groundwater dictionary available at: http://www.dwaf.gov.za/Groundwater/Groundwater_Dictionary/index.html?introduction_catchment.htm.

The **aerial image at right** shows the Deep Creek watershed, which is adjacent to the Ninilchik River watershed on the north, Crooked Creek and Fox Creek watersheds on the east (the latter includes Caribou Lake), and the Anchor River and Stariski Creek watersheds on the south and southwest. Notice that a watershed boundary always defines two watersheds, one on each side—the northern boundary of the Deep Creek watershed is the southern boundary of the Ninilchik River watershed. "HUC," on the map, stands for Hydrologic Unit Code[48]. The hydrologic units shown at left are 5th level (10-digit) HUCs.



The ultimate source of all water in a watershed is atmospheric moisture (see Figure 3.4a). The atmosphere provides precipitation—rain, snow, sleet, etc.—that falls on the water-



shed, as well as fog that condenses on plants, rocks, buildings, and other surfaces. Once water reaches the ground—either directly or by trickling down surfaces—it travels via many pathways as it moves through the watershed in response to gravity, differences in water pressure, friction, and capillary forces. Water travels in surface pathways and through underground pathways, as illustrated in the **figure above** (from http://wellwater.oregonstate.edu/groundwater/html/GroundwaterMovement.htm). Water often goes back and forth between surface and subsurface pathways, the two are intimately connected (see Section 3.4.6).

All of the watersheds shown on the previous page contain large areas of wetlands. The **map at left** illustrates the extent of mapped wetland areas—colored blue—in the Kenai lowlands. Wetlands within each watershed affect watershed hydrology in significant ways, although defining their roles precisely requires more study—particularly as watershed conditions change with climate change and conversion of land cover from one category

48 The US is divided and subdivided into levels of successively smaller hydrologic units. These are nested within each other, from small (6th level) to large (1st level). Each hydrologic unit is identified by a hydrologic unit code (HUC). For example, all hydrologic units in Alaska are within the 1st level, 2-digit, HUC 19. The most recent HUC delineations resulted in a dataset called the Watershed Boundary Dataset (WBD). The WBD divides hydrologic units down to 5th level (10-digit codes) and 6th level (12-digit codes) (http://water.usgs.gov/GIS/huc.html).

(e.g., forest) to another (e.g., subdivisions). Land use changes can be caused by natural forces (fire, flood, volcanic eruptions, earthquakes, etc.) and human activities (clearing, grading, ditching, paving, introduction of invasive species, etc.).

Just how important wetlands can be to watershed hydrology was suggested back in 1976 in The Natural Valley Storage Project. As a result of that study, "...the US Army Corps of Engineers concluded that retaining 8,500 acres of wetlands in the Charles River Basin near Boston, Massachusetts could **prevent flood damages estimated at $6 million** for a single hurricane event (in 1976 dollars). Projected into perpetuity, the value of such protection is enormous. Based on this study, the Corps opted to purchase the wetlands for $7.3 million in lieu of building a $30 million flood control structure" (see http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/wetlands4_hydrology.htm). A 2004 study in the Upper Mississippi River Basin estimated that the economic benefit of returning cropland in floodplains to wetland flood storage would be $500 million per year (Flood Damage Reduction in the Upper Upper Mississippi River Basin: An Ecological Alternative, http://www.wetlands-initiative.org/images/pdf-docs/pulblications/FLOOD/research/flood_damage_reduction_in_umrb.pdf). A 1997 study of wetlands' role in flood protection in Western Washington reached similar conclusions (see "The Economic Value of Wetlands," https://fortress.wa.gov/ecy/publications/publications/97100.pdf). Whatever the specifics, there is no disputing that wetland contributions to watershed hydrology have economic values, for example, their role in flood control.

As discussed in Chapter 2, it's useful to classify wetlands in terms of key features, such as geomorphology, hydrology, and plant communities. The **list below** identifies such features; those that are *mostly* determined by watershed context—that is, their location in a watershed—are shown in **boldface**. Clearly, watershed context is a key determinant of wetland features. Some watershed contexts affecting a wetland are relatively stable over time—such as geology, landform, landscape position and elevation, and soil type. Others usually change only slowly—like regional climate—and still others can change rapidly—like land uses and plant cover. These can be radically transformed by natural processes like fire and flood or by human activities like clearing, logging, or paving.

- **geology** (see Section 2.2.2)
- **geomorphic component (landform)** (see Section 2.2.2)
- **landscape position, including elevation in the watershed**
- regional climate (microclimates reflect watershed context)
- **soil type**
- **surrounding land uses**
- vegetation type and coverage
- water quality of surface and groundwater
- **water budget** (see Section 3.4.5)

3.4.5. *Water budgets* – a way to understand water movement and storage in wetlands

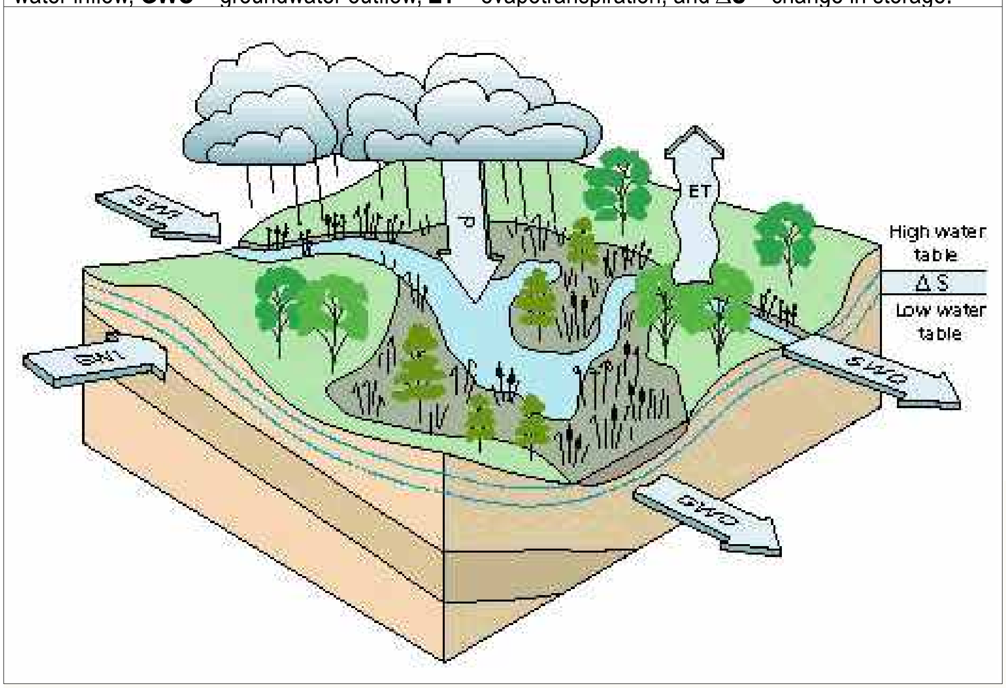
The section above introduced the idea that water moving through watersheds—including wetlands—travels via many interconnected pathways. Some wetlands are supplied by water via only one pathway—for example, wetlands located high up in their watersheds or on a watershed divide, where the only source of water is rain or snow. Most wetlands, however, receive water from multiple sources: from the atmosphere, surface water flowing via stream channels or overland flow, water moving through the unsaturated zone above the water table, or from deeper groundwater flows. Depending on how much water a wetland can hold (its storage capacity), the water it receives is held for some period of time ("residence time") until it is lost through evaporation, transpiration by plants, or as outflow in surface or subsurface pathways. This section introduces how the various flow pathways affecting a wetland can be understood in terms of a "water budget."

Most of this section (and the following on groundwater) is based on information available from the US Geological Survey (USGS). The next 3 pages are excerpted and modified from "Wetland Hydrology, Water Quality, and Associated Functions" by Virginia Carter (see http://water.usgs.gov/nwsum/WSP2425/hydrology.html), which is part of a larger report: *National Water Summary on Wetland Resources* (USGS Water Supply Paper 2425), online at: http://water.usgs.gov/nwsum/WSP2425/. As explained in the introduction to the National Water Summary:

> Both a favorable geologic setting and an adequate and persistent supply of water are necessary for the existence of a wetland. Different wetlands receive water from different sources: groundwater, streams, lakes, tides, snow, and rain. The source of water largely determines its quality, which in turn is largely responsible for wetland vegetation. The wetland vegetation affects the value of the wetland to animals and people.

From: ***Wetland Hydrology, Water Quality, and Associated Functions*** (USGS Water Supply Paper 2425). Wetlands and uplands continually receive or lose water through exchange with the atmosphere, streams, and groundwater. The wetland **water budget** is the total of inflows and outflows of water occurring in a wetland. The water budget reflects relative inputs from precipitation (P), surface water inflow (SWI) and groundwater inflow (GWI) and relative outputs from surface water outflow (SWO), groundwater outflow (GWO), and evapotranspiration (ET[49]). Outputs are also affected by a wetland's storage capacity. Components of a wetland's water budget are illustrated in Figures 3.4.5b and c. All components interact to create the hydrology of an individual wetland, and in most wetlands, waters from different sources are mixed.

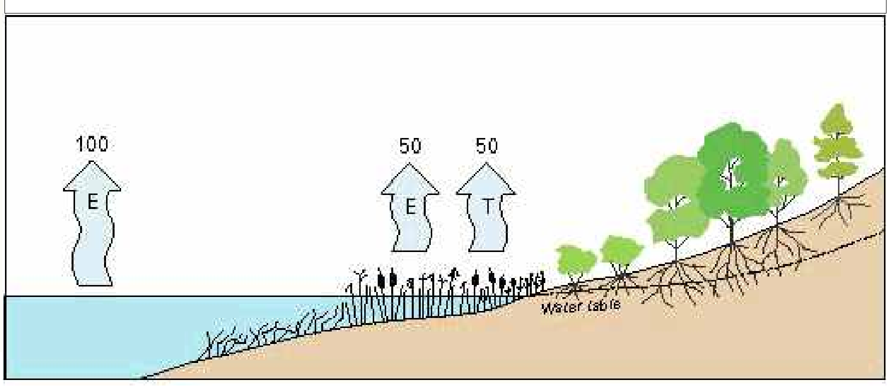
Figure 3.4.5b. Components of the wetland water budget. P+SWI+GWI=ET+SWO+GWO+ΔS, where **P** = precipitation, **SWI** = surface-water inflow, **SWO** = surface-water outflow, **GWI** = groundwater inflow, **GWO** = groundwater outflow, **ET** = evapotranspiration, and **ΔS** = change in storage.



From wetland to wetland, the relative importance of each water budget component differs. Some isolated basins receive precipitation and runoff from surrounding uplands but little groundwater inflow. Wetlands along rivers—such as peninsula R wetlands—receive precipitation, surface and hyporheic flows, and commonly also groundwater inflows, as well as floodwaters when adjacent rivers overflow their banks.

Determining water budgets for wetlands is inexact—as the climate varies from month to month and year to year, so does the wetland's water budget. Accurately determining individual components (see Figure 3.4c) depends on how well they can be measured. Nonetheless, water budgets, along with information on local geology, provide a basis for understanding wetland hydrology and water chemistry and can help in assessing wetland functions.

Figure 3.4c. Percentage of transpiration and evaporation from various wetland components. (**E** = evaporation; **T** = transpiration.)



49 The loss of water to the atmosphere is an important component of the wetland water budget. Water is removed by evaporation from soil or surfaces of water bodies and by transpiration by plants. The combined loss of water by evaporation and transpiration is termed ***evapotranspiration*** (ET). Solar radiation, windspeed and turbulence, relative humidity, available soil moisture, and vegetation type and density affect the rate of ET. Evaporation can be measured fairly easily, but ET measurements, which require measuring how much water is being transpired by plants on a daily, weekly, seasonal, or yearly basis, are much more difficult to make. For this reason scientists use a variety of formulas to estimate ET, and there is some controversy regarding the best formula and the accuracy of these estimates.

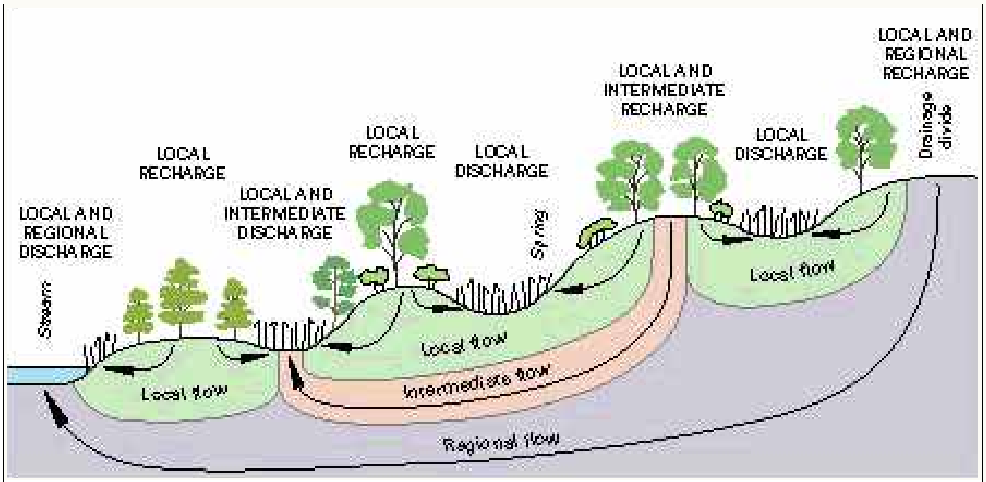


Figure 3.4d. Examples of groundwater flow systems in wetlands. *Local* groundwater flow systems are recharged at topographic highs and discharged at immediately adjacent lows. *Regional* groundwater flow systems are recharged at major regional topographic highs and discharged at major regional topographic lows. Intermediate flow systems lie between the other two systems.

As illustrated in Figure 3.4d (and discussed in the following section), groundwater recharge or discharge in wetlands is affected by their landscape position (geomorphic component), hydrogeology, sediment and soil characteristics, evapotranspiration, and climate and weather. To complicate the picture, these factors may not occur uniformly throughout a wetland.

Most peninsula wetlands have peat soils, so accumulation and composition of peat are important factors, affecting both hydrology and plants. It was long assumed that groundwater discharge through thick layers of well-decomposed peat was negligible because of its low permeability, but recent studies have shown that these layers can transmit groundwater more rapidly than previously thought (see, for example, the study identified in footnote 41). Peatland type (fen or bog) and plant communities are affected by water chemistry in the surface layers of the wetland. Water chemistry is largely determined by water source (precipitation, surface water, or groundwater, see below).

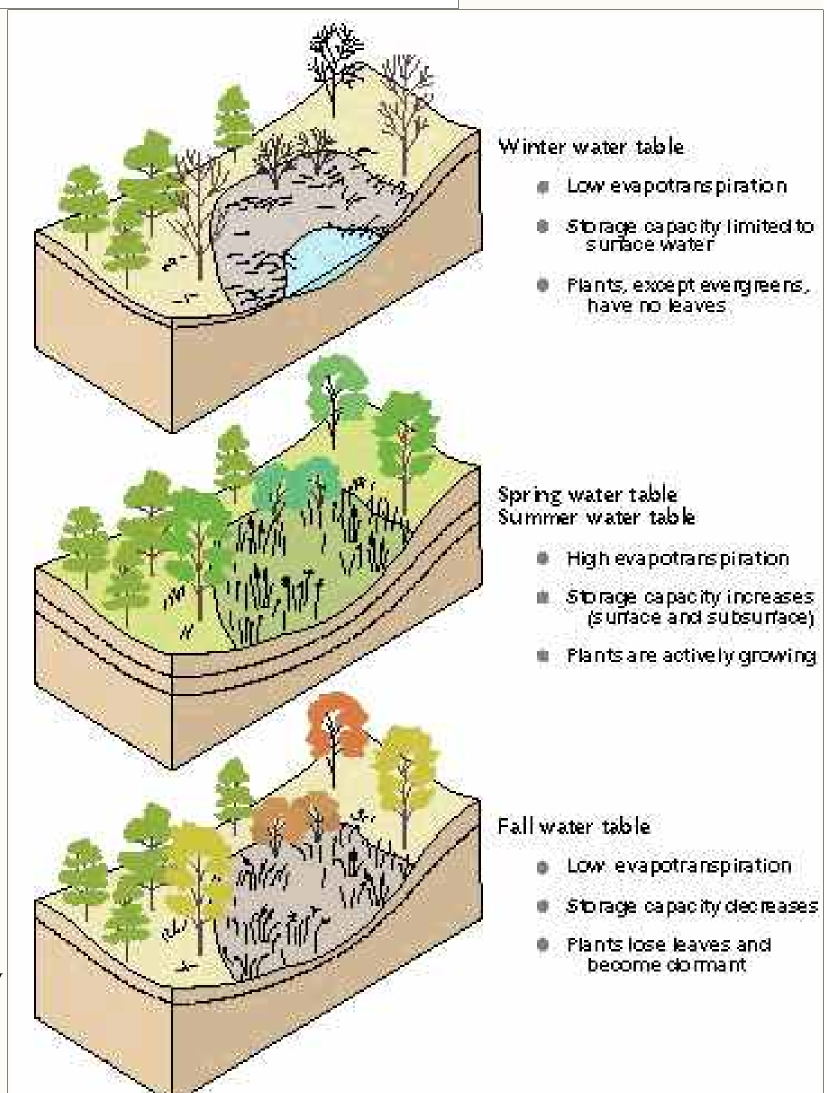


Figure 3.4.5e. Seasonal increase and decrease of wetland storage capacity.

Water can be stored in a wetland as surface water, soil moisture, and/or groundwater. **Storage capacity** refers to how much water a wetland can store, and this amount changes throughout the year and from year to year (see Figure 3.4e). Capacity is lowest when the water table is at or near the surface, plants are dormant and not transpiring, snowmelt is occurring, and/or during rainy seasons. Storage capacity increases during the growing season as ET increases, and during dry periods when water tables decline. When storage capacity is high, wetlands can be effective in retarding stormwater runoff. When storage capacity is low, any additional water that enters the wetland runs off. During most years on the peninsula, wetland storage capacity is at its highest at the end of summer, just before heavy fall rains arrive. As a result, many wetlands play a significant role in reducing fall flooding. In years with cool, wet summers, fall storage capacity may be significantly lower because of antecedent soil moisture and high water tables.

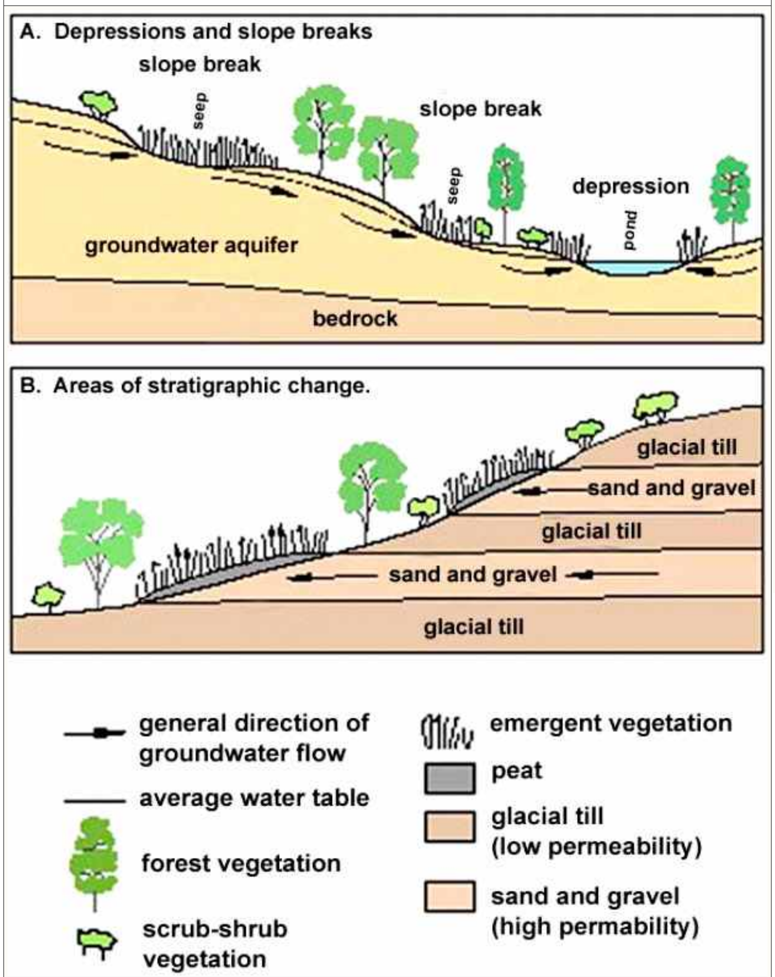
Figure 3.4f. Cross sections showing principal geomorphic and hydrologic settings for wetlands (typical hydrogeomorphology):

A = slope break and depression

Where groundwater discharges to the land surface, wetlands form on the lower parts of the slope. Constant groundwater seepage maintains soil saturation and wetland plant communities.

B = areas of stratigraphic change

When water flowing through more permeable rock encounters less permeable rock, it is diverted along the surface of the less permeable rock to the land surface.

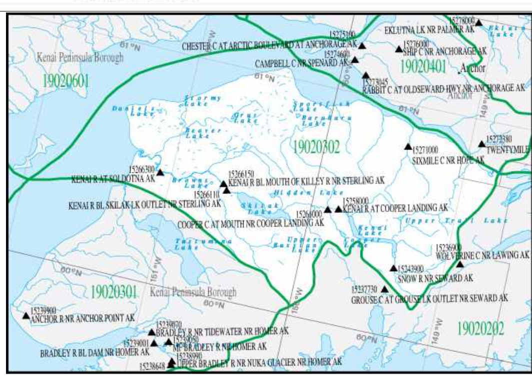


As described in Chapter 2, wetland characteristics reflect the geomorphic position and hydrology of the wetland (see Figure 3.4f). These also affect water chemistry. Water entering wetlands has chemical and physical characteristics that reflect its sources. Groundwater generally contains chemicals associated with the rocks or sediments through which it has moved (see Figure 3.4f); water that has spent less time underground has fewer minerals.

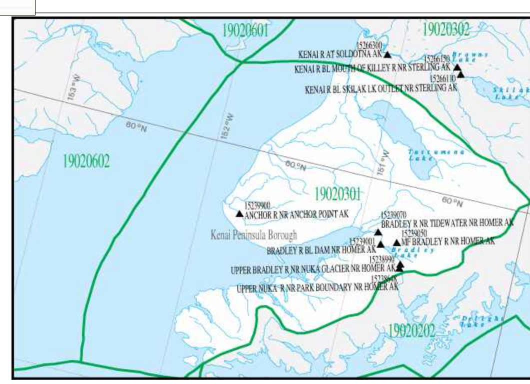
Water exchange between groundwater aquifers and surface water provides a major pathway for the transfer of essential nutrients to plants (i.e., calcium, potassium, and phosphate). Nutrients carried in groundwater become available for uptake when discharged to the surface or to the shallow root zone (see discussions that follow).

Surface inflows to wetlands may carry sediments and/or contaminants picked up flowing overland. Many wetlands filter sediments and other physical constituents. They may also transform chemical constituents, as discussed in Section 3.4.7.

USGS water data for the Upper Kenai Peninsula can be found at: http://water.usgs.gov/lookup/getwatershed?19020302/www/cgi-bin/lookup/getwatershed and for the Lower Kenai Peninsula at: http://water.usgs.gov/wsc/cat/19020301.html. These areas are shown in the two maps below.



Upper Kenai Peninsula



Lower Kenai Peninsula

3.4.6. Groundwater – invisible connections between surface and subsurface flows

As noted above, groundwater and surface water systems are intimately interconnected, and wetlands are commonly located at the dynamic interface between the two. Basic groundwater concepts come into play in discussions of wetland functions and values. This section introduces key concepts—using illustrations wherever possible. The figure below suggests some of the landscape interconnections between groundwater and surface water—including wetlands (from http://www.watershed-watch.org/issues/water/groundwater-conservation/). Changes to groundwater systems can have significant effects on wetlands, and changes to wetlands can have significant effects on groundwater systems, as well as on surface water systems.

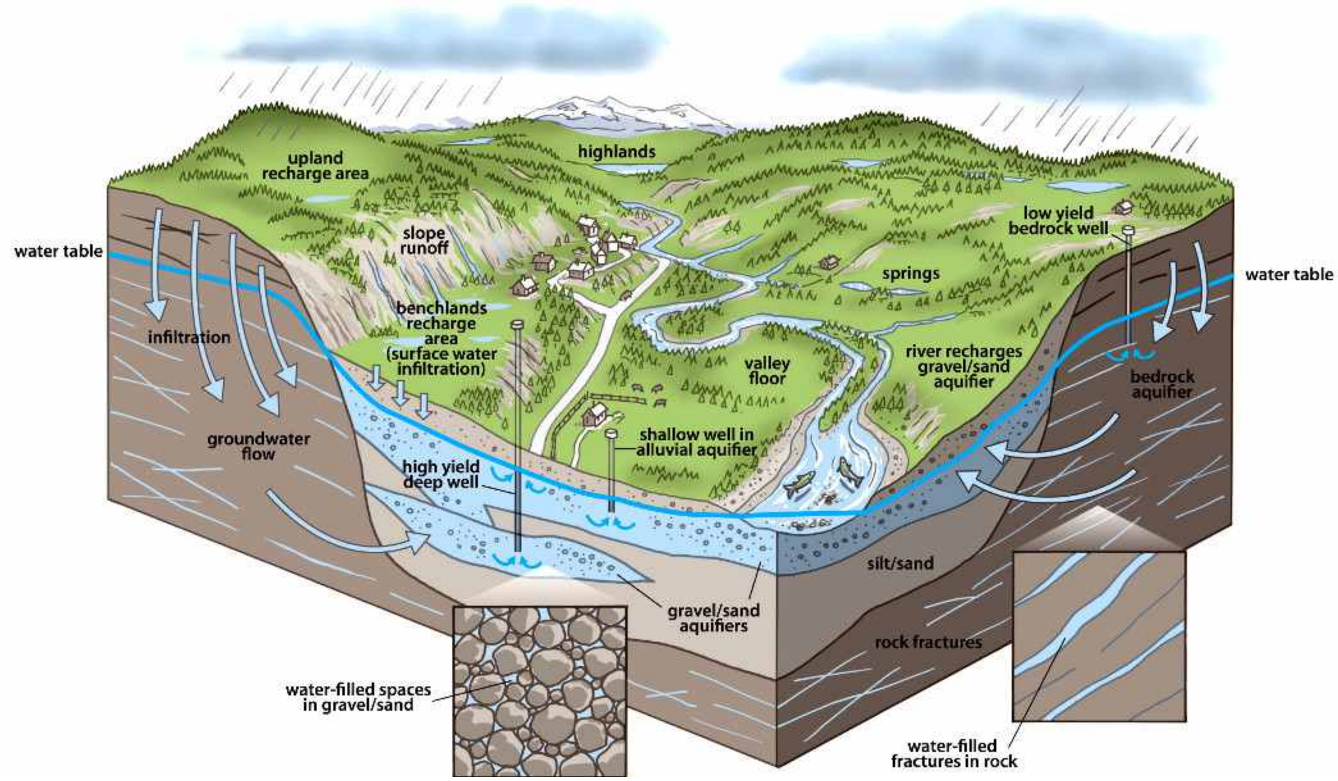
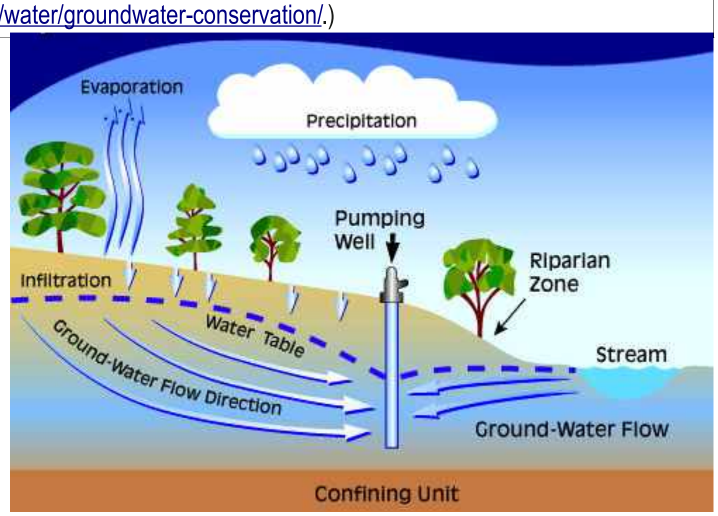
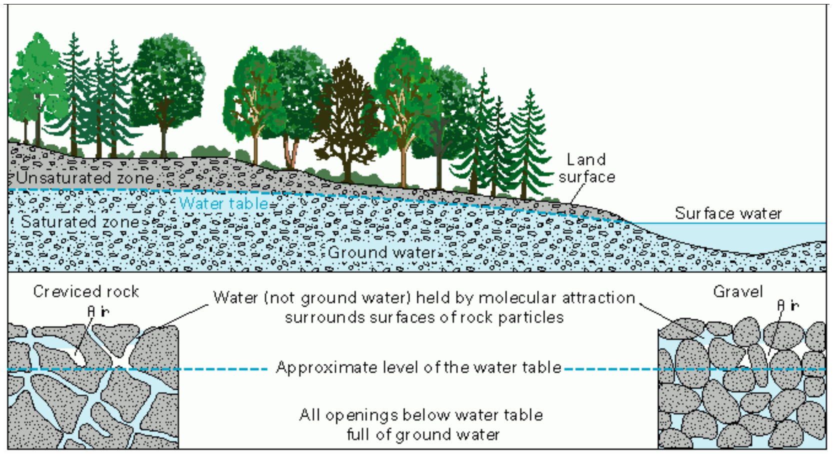


Figure 3.4g. Stored beneath the surface (in saturated, permeable geological formations called *aquifers*), groundwater plays critical roles in sustaining wetlands and aquatic ecosystems. Often located directly under streams and floodplains, relict glacial drainageways, and along valley bottoms, aquifers can be shallow or deep. Streams and wetlands are constantly exchanging water with the ground. These exchanges vary seasonally and can either augment surface water systems or recharge aquifers below. Groundwater discharge to streams and connected wetlands during dry summer months can be essential in keeping streams flowing and water temperatures cool (conditions critical to salmon). Without groundwater-maintained summer "baseflows," many streams and wetlands could have temperature and flow conditions unsuitable for the plants and animals that depend on them (including incubating, rearing, and spawning salmon). (Modified from http://www.watershed-watch.org/issues/water/groundwater-conservation/.)

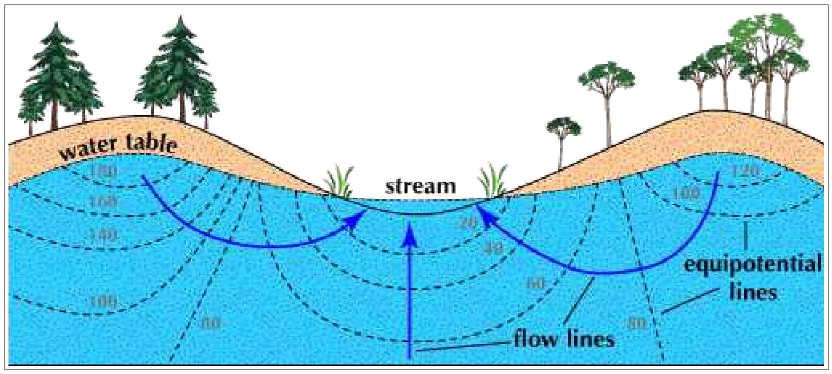


As shown in the **figure at right** (from http://tapintoquality.com/ground-water.html) and those on the next page, groundwater ultimately derives from precipitation that *infiltrates* into the soil and *percolates* through the *unsaturated zone* to the water table. Below the *water table*, all rock pores and fractures are filled with water; the water beneath the water table is called *groundwater*. One key difference between the unsaturated zone and the groundwater *aquifer* below it is that water can be pumped from an aquifer because water pressure is high enough for water to enter wells. In the unsaturated zone, capillary forces hold water too tightly to be pumped out.

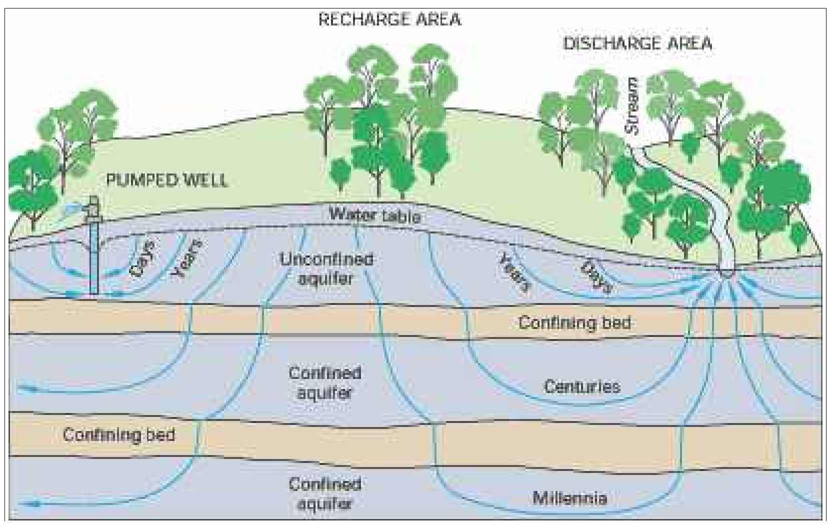
The upper part of the unsaturated zone is the soil-water zone, which is crisscrossed by roots, voids left by decayed roots, and animal and worm burrows. These enhance infiltration into the soil zone. Below the unsaturated zone is the water table, the dividing line between the unsaturated zone and groundwater. As shown in the **figure at right** (from http://cnx.org/content/m41397/latest/collection=col11325/latest) in the groundwater zone, all pore spaces and rock fractures are filled with water.

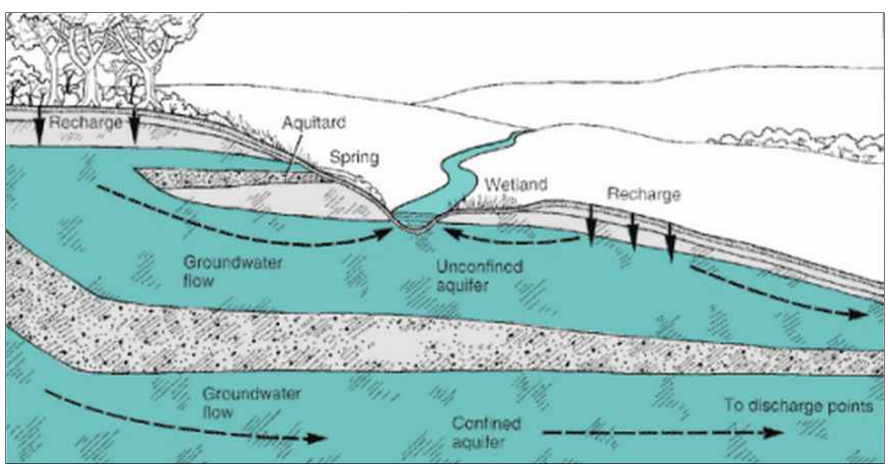


Groundwater moves in response both to gravity and to water pressure (from areas of higher pressure to lower pressure.) The **figure at right** shows a ***flow net*** (from http://www.gg.uwyo.edu/content/lecture/water/groundwater/saturated_flow/intro.asp?type=ss&color=873F8A&Callnumber=23165)—dashed lines show lines of equal *hydraulic head* (equipotential lines), blue lines show the movement of water molecules . Water is shown moving from areas of higher hydraulic head to areas of lower head, and discharging into the stream. Similar patterns occur in wetlands—highest rates of groundwater discharge often occur at the wetland's edge.



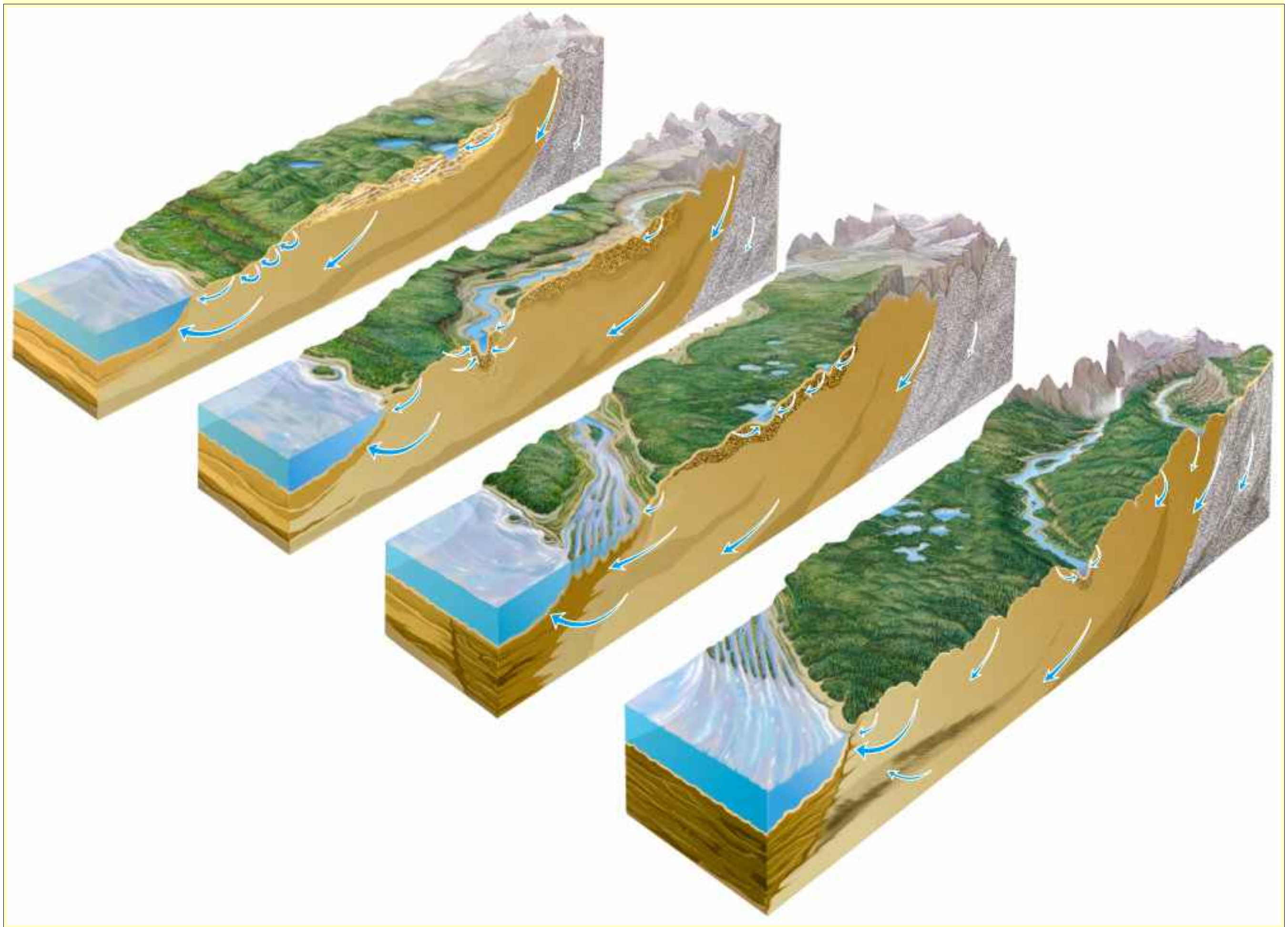
Groundwater flow paths in *unconfined* aquifers can be tens to hundreds of feet long and have travel times of days to years, see **figure at right (**from http://pubs.usgs.gov/circ/circ1139/htdocs/natural_processes_of_ground.htm). The longest and deepest flow paths may be thousands of feet to tens of miles long and have travel times lasting decades or more. In *confined* aquifers, which have relatively impermeable layers (for example, coal seams) separating them from the ground surface above, groundwater travel times from recharge to discharge areas may be hundreds of years (http://www.deq.state.or.us/wq/groundwater/basics.htm).





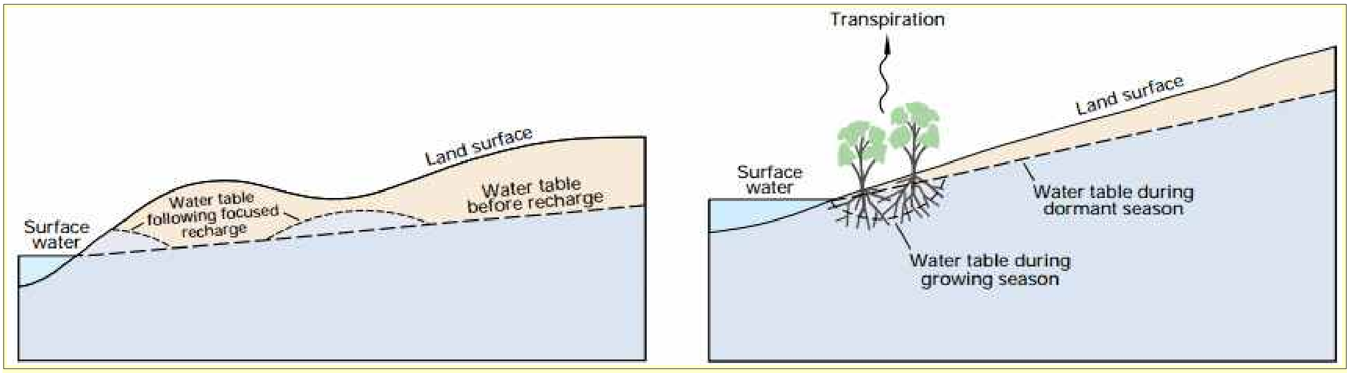
Because groundwater tends to be invisible—recognized only if it emerges in seeps and springs or is pumped from wells—it is generally less well understood than surface water. To help landusers and decision-makers avoid actions that could inadvertently reduce groundwater availability and quality, the USGS has published "Ground Water And Surface Water – A Single Resource," by T.C. Winter, J.W. Harvey, O.L. Franke, and W.M. Alley (USGS Circular 1139); which is available at http://pubs.usgs.gov/circ/circ1139/index.html. The following explanations and diagrams are excerpted (and modified) from that publication, particularly from the section "Natural Processes of Groundwater and Surface Water Interaction" (see http://pubs.usgs.gov/circ/circ1139/htdocs/natural_processes_of_ground.htm).

From: ***Ground Water And Surface Water – A Single Resource*** (see above).
To present the concepts and many facets of the interaction of groundwater and surface water in a unified way, a conceptual landscape is used (see **figure below**). The conceptual landscape shows in a very general and simplified way the interaction of groundwater with all types of surface water, such as streams, lakes, and wetlands, in many different terrains, from the mountains to the oceans. The intent is to emphasize that groundwater and surface water interact at many places throughout the landscape. Blue lines in each cross section represent paths of groundwater flow.



As noted above, water beneath the land surface occurs in both the unsaturated zone and—below the water table—in the saturated (groundwater) zone. The upper part of the unsaturated zone is the *soil-water zone*. The soil zone is crisscrossed by roots, voids left by decayed roots, and animal and worm burrows, which enhance the infiltration of precipitation into the soil zone. Soil water is used by plants in life functions and transpiration, but it also can evaporate directly to the atmosphere.

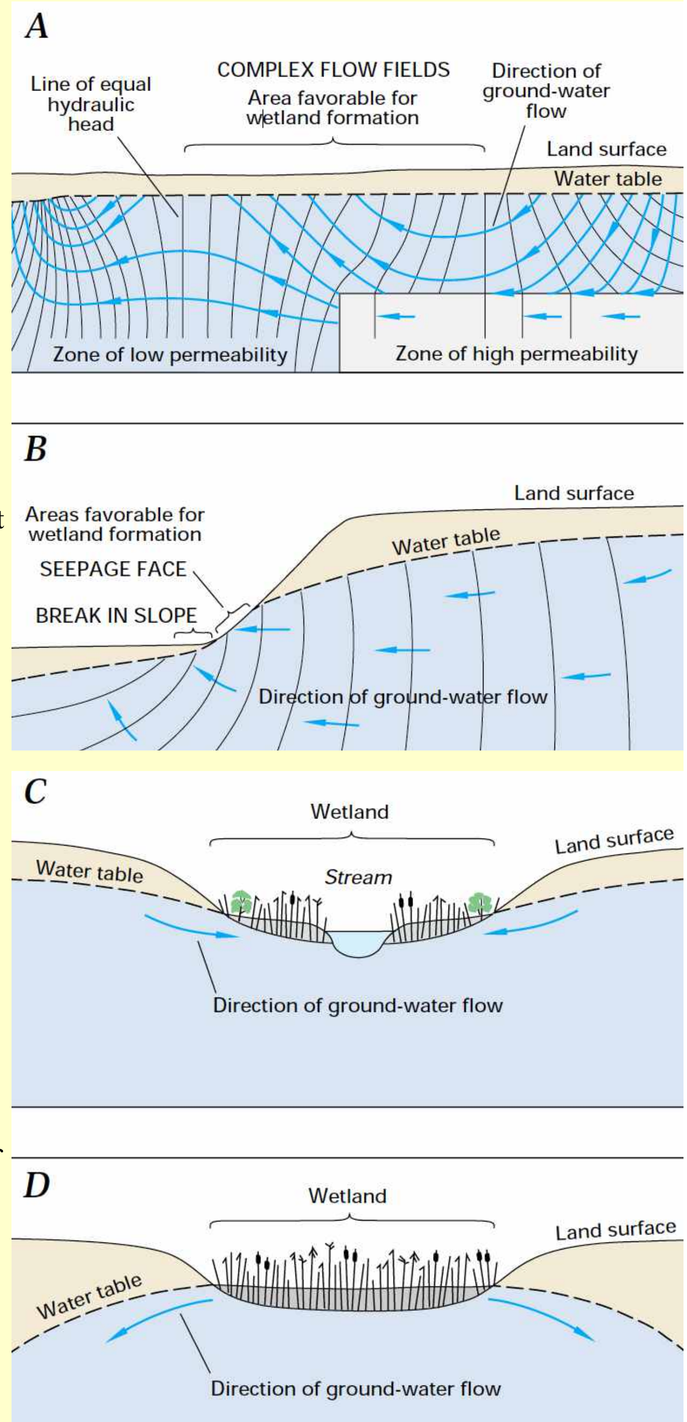
Wetlands are in many respects groundwater features.
USGS Circular 1186
http://pubs.usgs.gov/circ/circ1186/index.html



The water table commonly intersects land surface at shorelines, resulting in the absence of an unsaturated zone at this point. Infiltrating precipitation passes rapidly through a thin unsaturated zone adjacent to shorelines, which causes water-table mounds to build up adjacent to the surface water (see **figure top left**). This process, termed *focused recharge*, can result in increased groundwater inflow to surface-water bodies, or it can cause inflow to surface-water bodies that normally provide seepage to groundwater. Each precipitation event has the potential to cause this highly transient flow condition near shorelines, as well as in wetlands and upland topographic depressions.

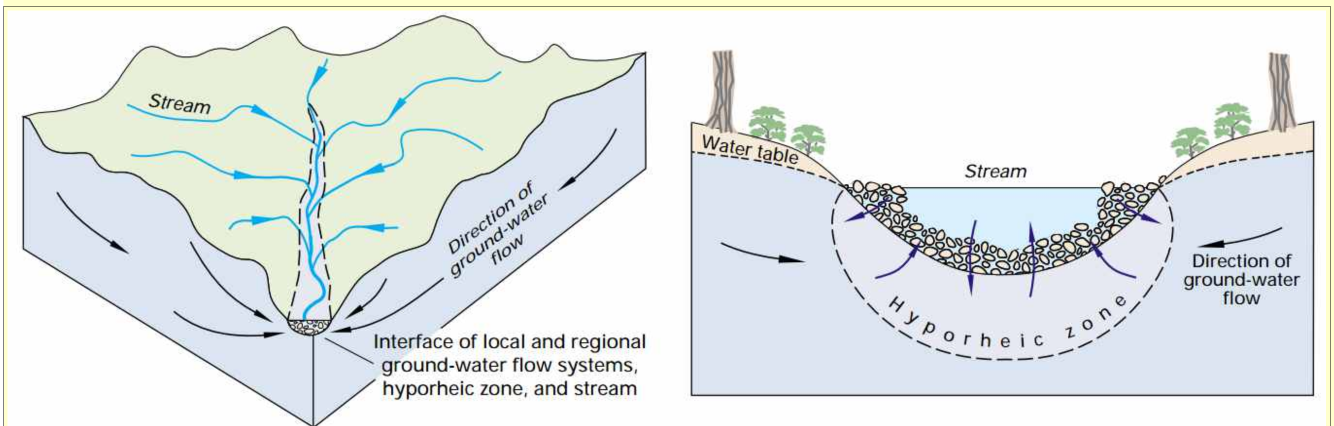
Transpiration by nearshore plants has the opposite effect of focused recharge. Again, because the water table is near land surface at the edges of surface-water bodies and beneath many wetlands, plant roots can penetrate into the saturated zone, allowing plants to transpire groundwater directly (see **figure top right**). Transpiration of groundwater commonly results in drawdown of the water table, much like the effect of a pumped well. This highly variable daily and seasonal transpiration of groundwater may reduce groundwater discharge to a surface-water body or cause surface water to move downwards to subsurface zones. In places, it is possible to measure diurnal changes in flow direction during seasons of active plant growth: groundwater moves into surface water during the night, and surface water moves into shallow groundwater during the day. This is another example of how intimately connected groundwater and surface water systems can be.

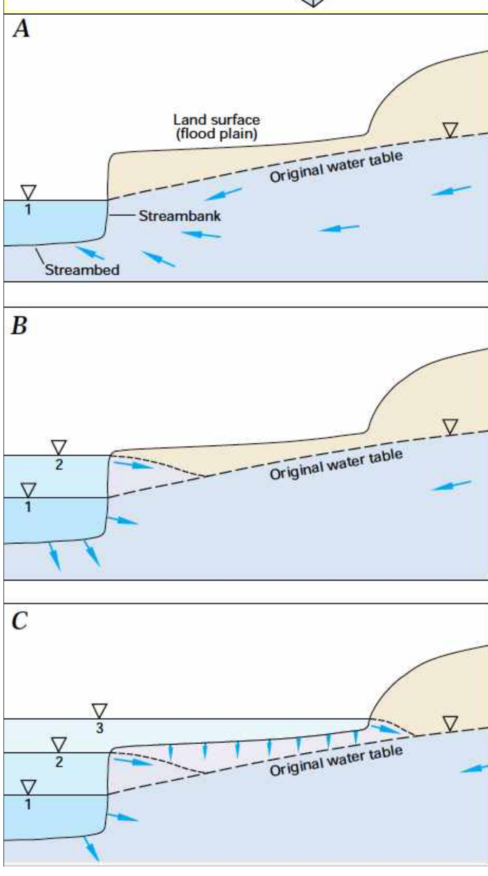
As **Figures A through D at right** show, the locations of wetlands can reflect many kinds of groundwater interactions. Groundwater can be discharging to the surface and supplying the wetland (A, B, and C), or groundwater can be recharged from wetland water supplies (D).



Like streams and lakes, wetlands can receive groundwater discharge, can recharge groundwater, or do both—either simultaneously (recharging in one area while discharging in another) or at different times of year. Unlike streams and lakes, however, wetlands do not always occupy landscape low points and depressions; they can also develop on slopes where the water table intersects the land surface (see Figure B above)—for example, peninsula Discharge Slope wetlands (S) or Headwater Fens (HF)—or on drainage divides. Fens tend to receive groundwater discharge, which provides a continuous supply of chemical constituents dissolved from the sediments and rocks through which the groundwater flows. (On the peninsula, fens also receive chemicals from windblown volcanic ash.) Bogs occupy uplands or flat areas that receive water primarily from precipitation, resulting in low concentrations of chemical constituents.

Many wetlands occur along streams, for example, R wetland map units on the peninsula. Streams and their riparian/riverine wetlands are unique environments because they represent locations where the groundwater that drains much of the *subsurface* area of landscapes interacts with flows that drain much of the landscape's *surface*. They may reflect the interface of both local and regional groundwater flow systems (in addition to the stream's own hyporheic zone, see **figures below.** (Also see Figure 2.2c in Section 2.2.3.) Streams and R wetlands may be

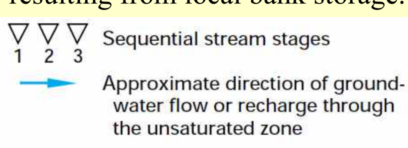




dependent primarily on streamflows for their water supply, but more often, streams and R wetlands receive significant groundwater inflow. In particular, groundwater generally accounts for a stream's "base-flows," those critical flows that occur during the driest times of year, when little surface runoff is occurring.

Flooding is another process that connects streams and wetlands to groundwater systems. During a rise in stage (water level)—for example during heavy rains—water moves from the stream channel or wetland into the banks. This process is called *bank storage* (**Figure B at left**). As long as the rise in water level does not overtop banks, most of the water that enters bank storage returns to the stream or wetland within a few days or weeks. Bank storage and the return of this water to streams and wetlands in a period of days or weeks reduces flood peaks and then supplements stream flows.

As water levels overtop streambanks, widespread recharge to the water table can occur throughout flooded areas, such as floodplains (**Figure C at left**). In this case, the time it takes for the recharged floodwater to return to the stream via groundwater flow may be weeks, months, or longer because groundwater flow paths are much longer than those resulting from local bank storage.



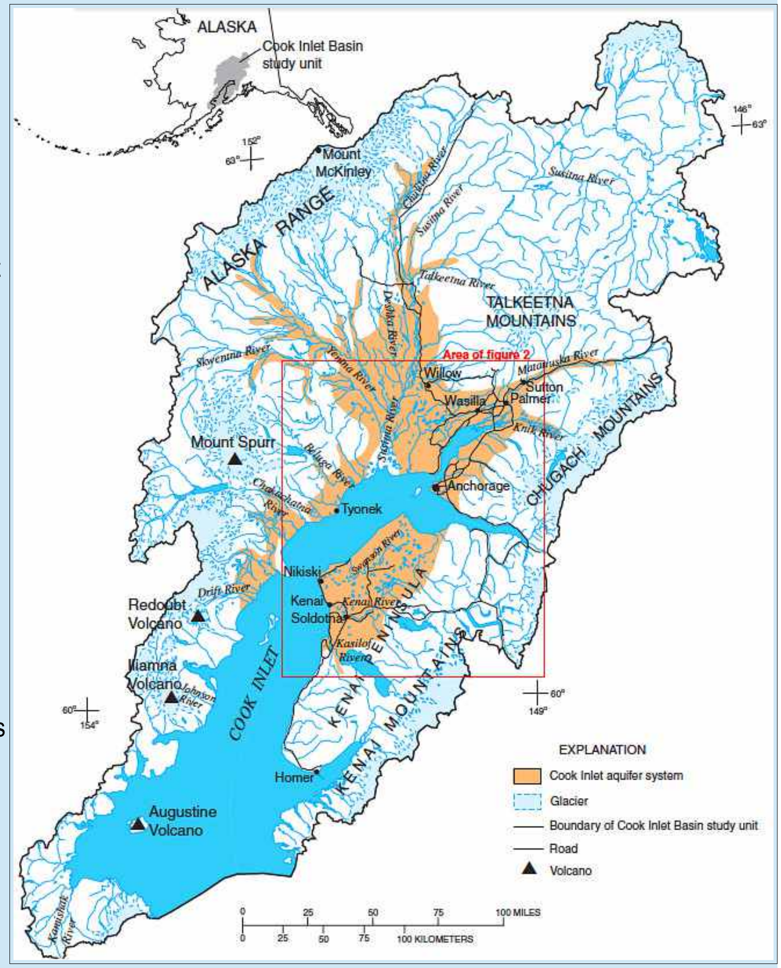
The textbox below describes general patterns of groundwater movement in the Cook Inlet basin, as well as travel times measured for groundwater moving from recharge areas to areas of groundwater use or discharge.

A look at groundwater movement in the Cook Inlet Basin

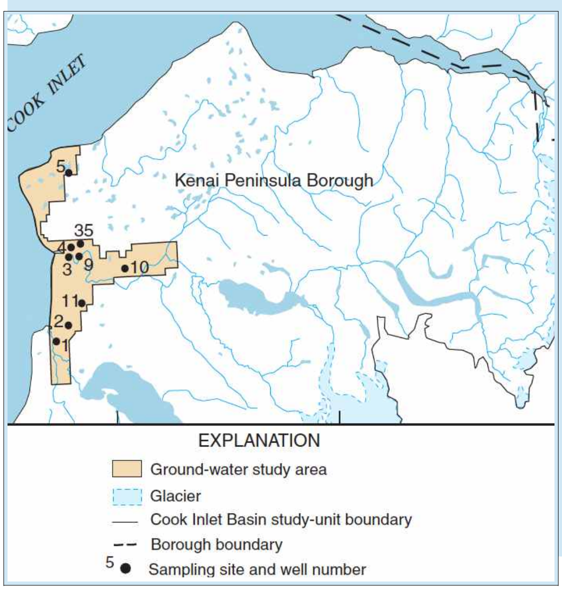
Modified from *Groundwater Age and its Water-Management Implications, Cook Inlet Basin, Alaska*
Roy Glass, 2002. (The article can be viewed at http://pubs.usgs.gov/fs/fs-022-02/pdf/fs-022-02.pdf.)

Groundwater moves slowly from points of recharge to points of discharge. In the Matanuska–Susitna, Anchorage, and Kenai Peninsula areas, groundwater generally moves from near the mountain fronts towards Cook Inlet or the major rivers.

In 1997, a study of the Cook Inlet Basin (**map at right**) was begun as part of the U.S. Geological Survey's National Water Quality Assessment Program. Samples of groundwater were collected from 35 existing wells in unconsolidated glacial and alluvial aquifers during 1999 to determine the regional quality of groundwater beneath about 790 sq miles of developed land and to gain a better understanding of the natural and human factors that affect the water quality. Of the 35 wells sampled, 31 had water analyzed for atmospherically derived substances to determine the groundwater's travel time from its point of recharge to its point of use or discharge—also known as groundwater age.



Much of the water pumped by domestic and public wells may have traveled less than 10 miles, and the trip may have taken as short a time as a few days or as long as several decades. This groundwater is vulnerable to contamination from the land surface, and many contaminants in the water would follow the same paths and have similar travel times from recharge areas to points of use as the chemical substances analyzed in this study. The effects of contamination may not be seen for several years after a contaminant is introduced into the groundwater system. Many contaminants could make the water unsuitable for drinking for many years, even in concentrations too low to detect without expensive chemical tests...



Common types of contaminants include bacteria, viruses, and nitrates from septic systems; organic compounds from gasolines and fuel oils; cleaning solvents; and pesticides. Removing contaminants from soils, aquifer materials, and groundwater is difficult and much more expensive than preventing contamination in the first place. Septic tanks need to be completed in acceptable soils and an adequate distance above the water table. Fuels need to be stored in secure, corrosion-free tanks and their distribution pipes kept from leaking. Chemicals should be used and disposed of properly when they are no longer needed. Pesticides used on gardens, lawns, and crops, and herbicides used on rights-of-way, should be applied properly to avoid contaminating the aquifer.

How is the age of groundwater determined?

Over the last 50 years, human activities have introduced a large number of substances into the air and water. Compounds that move readily through the environment relatively unchanged physically or chemically can help determine when the water was recharged, the areas of water recharge, the flow path, and the rate of water movement through an aquifer system. The travel time of a chemically conservative substance depends primarily on the velocity of groundwater through the aquifer, which in turn depends on the hydrologic characteristics of the aquifer system.

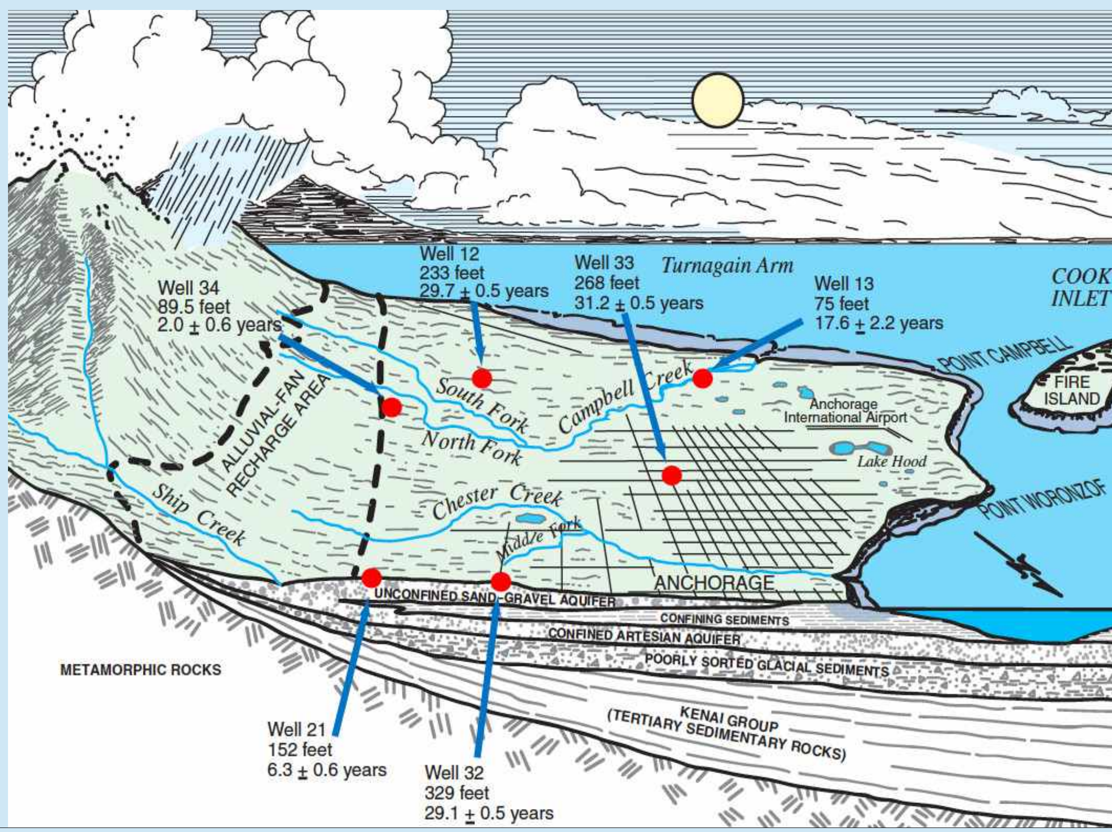
Tritium and chlorofluorocarbons (CFCs) are present in very small concentrations in the atmosphere and were used as tracer substances in this study... Precipitation containing tritium and CFCs falls to the Earth and becomes incorporated into the hydrologic cycle. Water that has been exposed to the atmosphere within the past 50 years contains small amounts of these substances and is considered to be "young" or "modern." Dating a groundwater sample by using chemicals such as tritium and CFCs assumes no dilution by mixing or delay by interaction with aquifer materials, which are common processes for contaminants moving with groundwater. The concentrations of all substances moving with water through the unsaturated zone and beneath the water table are affected, to some extent, by transport and chemical processes, including dispersion, mixing, degradation, and sorption. In Alaska, the presence of most manmade substances in a groundwater sample indicates some recent recharge (within about the last 50 years)...

Groundwater Management Implications

The presence of tritium and CFCs in most groundwater samples in the unconsolidated-aquifer system in Cook Inlet Basin supports the conceptual model that groundwater is primarily from the infiltration of local precipitation and water from streams, rivers, lakes, and wetlands rather than older water from deeper aquifers (**figure below**). Most wells used to supply water to individual homes in the study area are completed near the top of saturated glacial till, outwash, or alluvial deposits and are expected to yield water that was recharged within the last 25 years. Public-supply wells generally yield water from the middle or deeper zones in the unconsolidated aquifer. However, the finding that water from several of these wells also contained measurable quantities of tritium and CFCs suggests that their high yields may capture water from above or that the horizontal rate of groundwater movement from areas of recharge is fairly fast, in the several-feet-per-day range rather than several-feet-per-year range.

Conclusions that can be drawn from the USGS study include:

- Aquifers in the Cook Inlet Basin used for drinking water supplies are susceptible to contamination.
- Contamination could prevent use of groundwater for drinking for many years.
- Removing contaminants from groundwater is difficult and much more expensive than preventing contamination in the first place



Concentrations of tritium and CFCs were measured in eight wells in Anchorage during July 1999. (Six wells are shown in this figure.) Depth of well, in feet, and computed groundwater age or travel time, in years, are shown for each well. Groundwater dating shows that water samples from wells near the mountain front were the most recently recharged. This suggests a general movement of water from the mountains toward Cook Inlet. However, wells in all parts of the city may receive some water from the infiltration of precipitation or from local streams, lakes, and wetlands.

3.5. Assessing the Community/Culture component

Introduction

Wetlands have for thousands of years fed and supplied individuals and communities, while also providing places for exploration, recreation, study, inspiration, and observation of natural processes and wild creatures. People have been drawn to these distinctive and highly productive landscapes—neither quite waterbody nor quite land—for their unusual conditions, including the unique plants and animals found there. Capturing some of these "community/culture" benefits and values was the goal of this assessment component, which focuses on wetland functions/values related to recreation, education (including research), and indigenous cultures and heritage. On the Kenai Peninsula, wetland use by indigenous cultures focuses on the Dena'ina Athabascan Indians, who have lived on the peninsula for the last 1,000 to 1,500 years. The functions/values assessed under this component for Kenai Peninsula wetlands are listed in Table 3.5a, along with data sources reviewed during the assessment.

Table 3.5a. Information considered in assessing Community/Culture Component

Function/value	Data type	Data sources
Recreation	• Landownership of wetland areas • Land use designation or classification of wetland areas • Proximity of wetlands to "public open space" areas	• Kenai Peninsula Borough GIS data and maps • DNR surface classification maps from Alaska Mapper (http://dnr.alaska.gov/MapAK/) • Zoning maps from peninsula cities
Education	• Proximity of schools and other "educational entities" to "public open space" identified under recreation	• Kenai Peninsula Borough GIS • Lists of schools and other "educational entities" in the project area
Culture/heritage[50]	• Dena'ina place names • Dena'ina archaeological sites • Dena'ina winter trails • Dena'ina fishing sites • Wetland plants used by the Dena'ina • Birds and mammals trapped or hunted by the Dena'ina	• Information from anthropologists at Kenai Peninsula College (Alan Boraas, Catherine Knott) and Pratt Museum (i.e., Holly Cusack-McVeigh[51]) • Consultations with Dena'ina elders, TEK[52] culture bearers, and community members (identiied in Section 3.5.3) • Consultation with Karen Evanof, Lake Clark National Park • Published and unpublished maps and reports (see Section 3.5.3)

Unlike assessments of Biology Components, where wetland assessment projects in Anchorage and Homer provided useful guidance, the Community/Culture assessment necessitated development of a new, peninsula-specific methodology. In Anchorage, the "Social Component" assessment (analogous to this "Community/Culture" assessment) identified the types of recreational uses and educational activities occurring in wetlands (including "formal educational programs") and then scored each wetland based on the "intensities" and frequencies of such uses and activities in the wetland. Comparable data are available for only a few areas on the peninsula. In addition, Anchorage scored wetland "distinct[ness] within its surrounding environment" (a measure of aesthetic value), as well as type and degree of disturbance, ownership, and accessibility On the peninsula, only data on ownership and accessibility were readily available. In Anchorage, no specific assessment of Native traditional uses of wetlands was undertaken. (In Homer, the "Social component" was not assessed.)

The Ontario Wetland Evaluation System (OWES), the basis for both Anchorage and Homer assessment methods, provides this introduction to its "Social Component" (Section 2.0):

> The purpose of the social component "...is to measure some of the direct human uses of wetlands. In reality, human uses of wetlands recognized in the social component are very strongly dependent upon the continued existence of healthy ecological processes and ecosystems that function normally. The recognized social values of wetlands include economically valuable products, recreational activities,

50 Dr. Catherine H. Knott, Kachemak Bay Campus, Kenai Peninsula College (UAA) compiled all information used during this assessment and advised Homer Soil and Water on methodologies and use of data. Write-ups developed by Dr. Knott related to this project can be found in Appendix __.

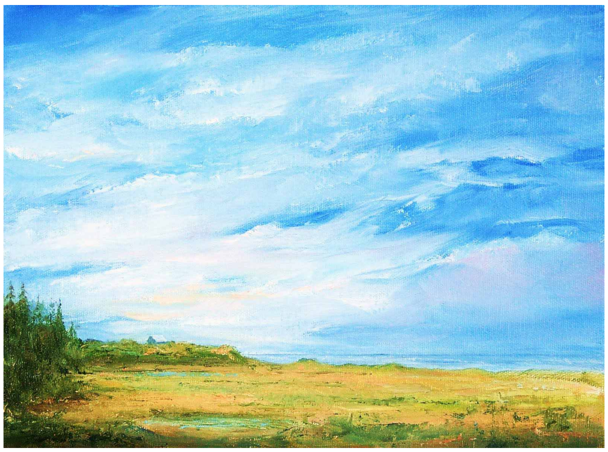
51 Ms. Cusack-McVeigh is now at Indiana University-Purdue University Indianapolis.

52 TEK stands for "traditional ecological knowledge," which is introduced in Section 3.5.3.

landscape aesthetics, education and public awareness, proximity to urban areas, ownership, and size"[53].

Wetlands provide a variety of community/culture values. Plein air painting is among these and is popular on the Kenai Peninsula.

At right: Homer area wetland, by Jim Buncak (http://jamesbuncak.com/)



At left: Anchor River wetland, by Jill Randall (http://jillrandallart.blogspot.com/2010_09_01_archive.html).

Below: Kenaii Peninsula wetland, by Asia Freeman

53 The Northern Ontario manual can be downloaded at http://www.web2.mnr.gov.on.ca/mnr/Biodiversity/wetlands/owes/Northern_OWES_Manual_text.pdf.

3.5.1. Recreation

Under *Recreation*, peninsula wetlands were assessed in terms of whether they could support recreational uses and activities. As in Anchorage and Homer, potential public access was a key criterion for assessing recreation potential.

As defined here, recreation includes the full range of enjoyable, enriching, challenging, and/or healthy outdoor activities that can take place in wetlands—both consumptive (hunting, fishing, berry picking, etc.) and non-consumptive (hiking, skiing, photography, dog mushing, snowmachining, birding, etc.). **Education and research**—whether for academic, professional, or personal curiosity/enrichment purposes—could also be conducted in wetlands with high recreation scores. Recreation functions/values also include uses that could be called "subsistence" in that they contribute to food resources or materials that support subsistence (e.g., plant materials used to manufacture tools or crafts or to prepare medicines). Subsistence-oriented recreation can encompass activities by anyone using wetlands for such purposes.

Methods

One variable was used to assess wetlands in terms of their functions/values for recreation:

1. Land categories allowing public access AND generally maintaining open space.
   The most obvious example of lands meeting these two criteria are state park units (Table 3.5b). Other examples include state lands classified as "Habitat" or "Recreation" or legislatively designated as Critical Habitat Areas and Special Use Areas, as well as lands owned by entities such as Kachemak Moose Habitat, Inc. or Kachemak Heritage Land Trust.

Land categories meeting these criteria are summarized in Table 3.5c. Map 3.5a provides assessment results.

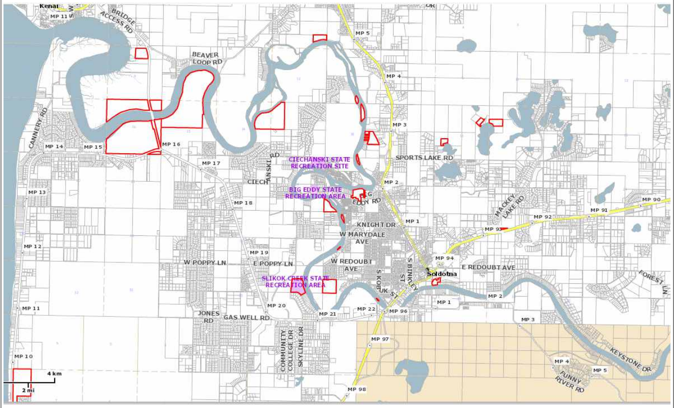
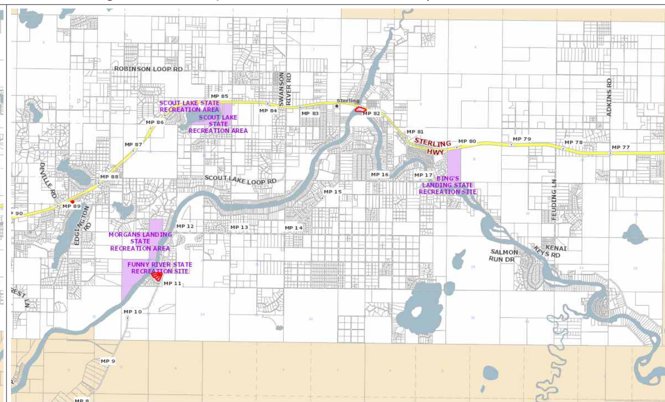
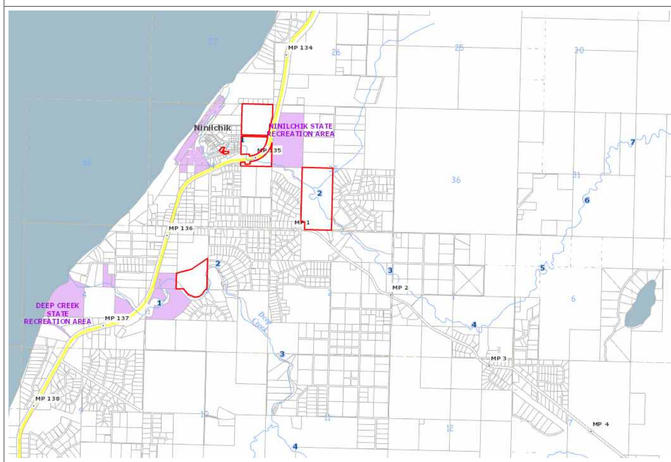
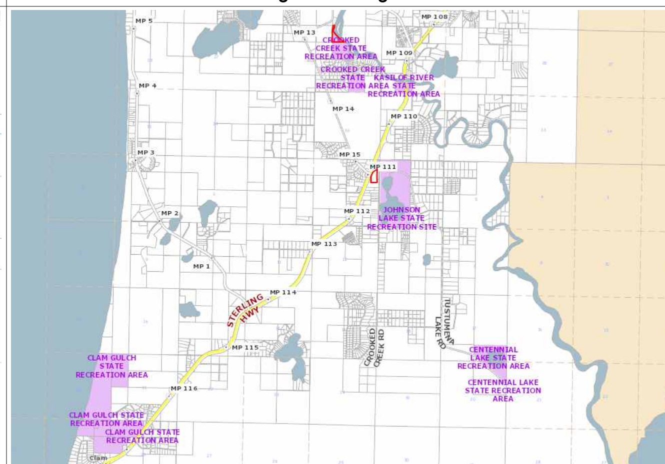
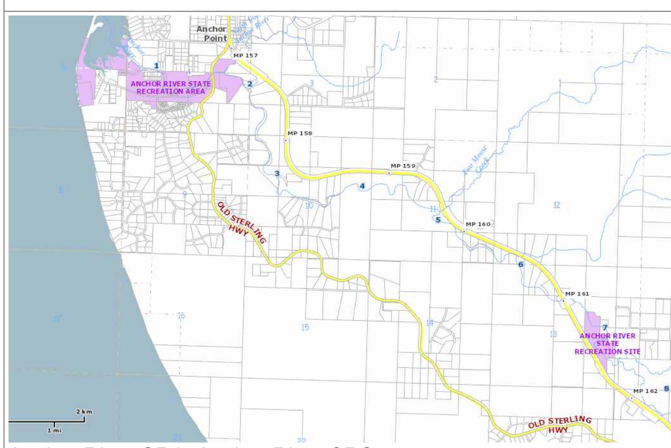
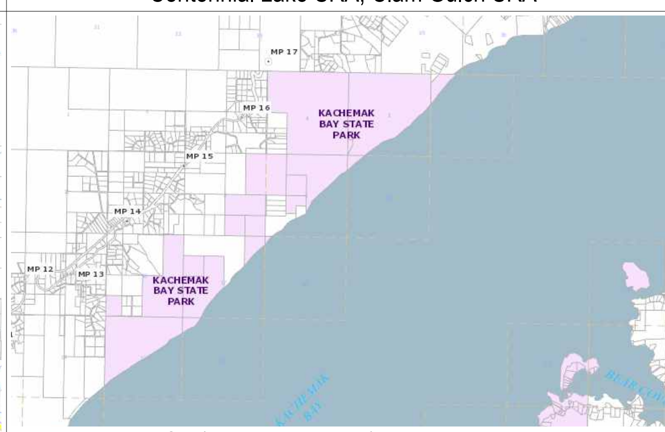
Note: even apparently "permanent" categories of land ownership, classification, zoning, etc. may change. For example, at the time of this writing, the Kenai Peninsula Borough was selecting 28,000 acres of state land to fulfill its remaining land entitlement under the Mandatory Borough Act of 1964 and the 1978 Municipal Entitlement Act (A.S. 29.65.10). State lands were being selected based on their ability to support: (1) Local Government and Public Use, (2) Community Development and Expansion, and/or (3) Revenue and Resource Use."

Land categories allowing public access AND maintaining open space

1. Wetlands on state lands: Several sources were used to identify state lands meeting the above criteria (see Table 3.5c). The key source was the Alaska Department of Natural Resources (DNR) "surface classification map," accessed via "Alaska Mapper" (http://dnr.alaska.gov/MapAK/). This map displays base data and how state lands may be used as a result of a state Area Plan (e.g., the Kenai Area Plan, found at: http://dnr.alaska.gov/mlw/planning/areaplans/kenai/). State land classifications are organized into five categories: (1) Disposable Interest, (2) General Land, (3) Habitat Land, (4) Recreation Land, and (5) Miscellaneous.

The DNR surface classification map also shows legislatively designated areas (e.g., state parks and Critical Habitat Areas); Special Management Areas (e.g., Kenai River SMA, described at: http://dnr.alaska.gov/parks/units/kenairiv.htm); Special Use Areas (e.g., Caribou Hills SUA, see http://dnr.alaska.gov/mlw/planning/areaplans/kenai/pdfs/appendc_CaribouHillsMgt.pdf and map at http://dnr.alaska.gov/mlw/planning/areaplans/kenai/pdfs/map_c-1.pdf); management agreements (e.g., the Interagency Land Management Agreement (ILMA) establishing the Homer Demonstration Forest); Reserve Use Requests, and other state lands with designated restrictions. These categories often overlap Habitat and Recreation classifications.

Table 3.5b. State Park units in the Kenai lowlands (colored in purple)
(State park units in the Seward area—e.g., Caines Head SRA—are outside the project area.)
(Maps are from the Kenai Peninsula Borough interactive parcel viewer (IPV) at http://mapserver.borough.kenai.ak.us/kpbmapviewer/, see Section 2.4. for instructions on using the IPV. Beige areas represent federal lands.)

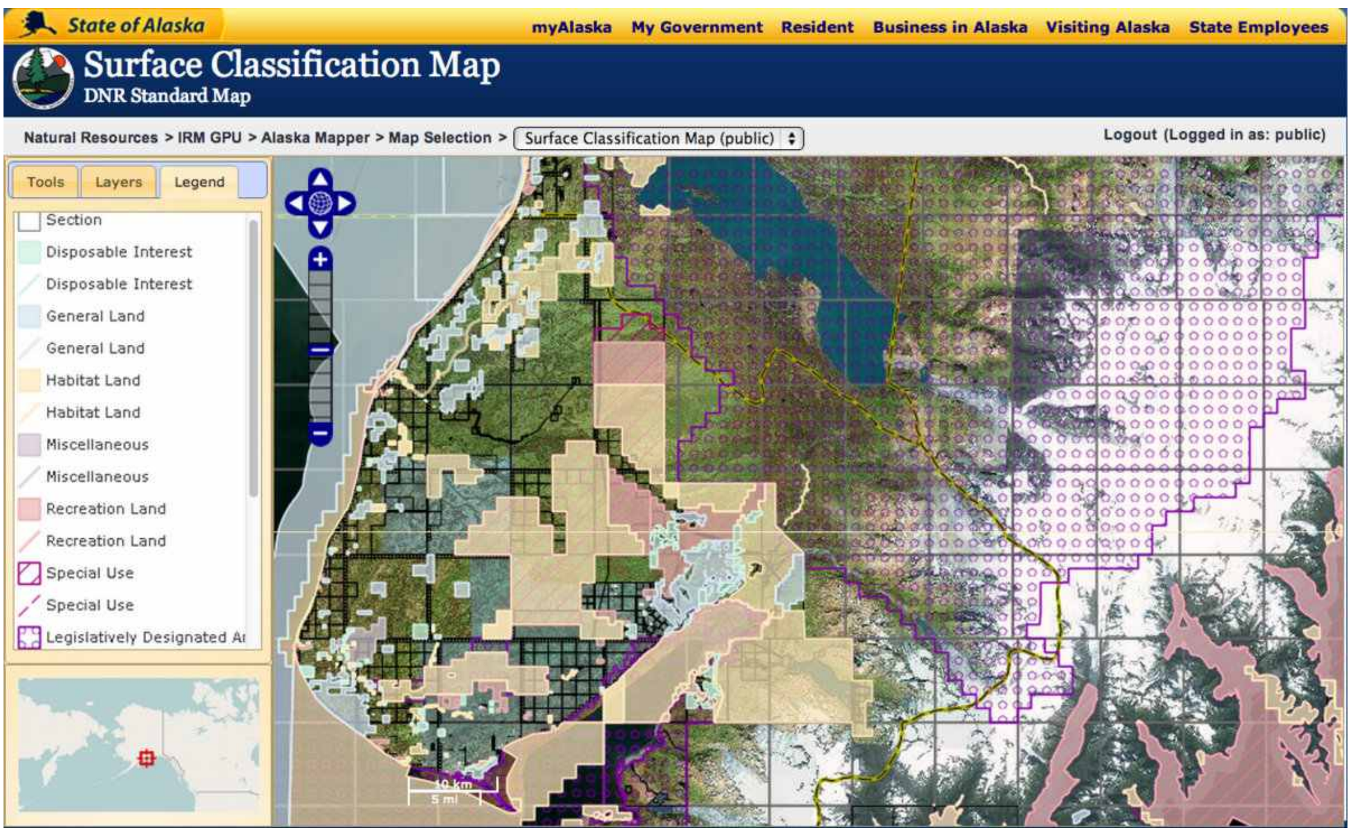
 Ciechanski SRS, Big Eddy SRA, Slikok Creek SRA	 Scout Lake SRA, Morgan's Landing SRA, Funny River SRS, Bing's Landing SRS
 Ninilchik SRA, Deep Creek SRA	 Crooked Creek SRA, Kasilof River SRA, Johnson Lake SRS, Centennial Lake SRA, Clam Gulch SRA
 Anchor River SRA, Anchor River SRS	 Kachemak Bay SP (north shore units)

Abbreviations: **SRA** = State Recreation Area, **SRS** = State Recreation Site, **SP** = State Park. Parcels outlined in **red** are Alaska Department of Fish and Game property; these parcels often supplement habitat and recreation values of adjacent or nearby units in the state park system.

Wetlands on state lands classified as *Habitat Land* or R*ecreation Land* and/or legislatively designated for recreation or habitat (e.g., State Recreation Areas or Sites, Critical Habitat Areas, Special Use Areas, etc.) received the highest score for recreation. This score reflects the fact that these wetlands are expected to be available for public recreation for the foreseeable future. (Recreational activities, however, may need to be managed so as to protect wetland conditions, see Chapter 5.)

Wetlands on state lands classified as *Disposable Interest*, *General Land*, or *Miscellaneous* were given a lower score to reflect the fact that the state may approve uses on these lands that are incompatible with public recreation or wetland maintenance. Distinguishing these wetlands is useful because, although they currently provide public access, they are likely to be impacted by future development (or disposal) that would limit this access or affect wetland condition. Such wetlands may warrant closer examination to determine whether protecting public recreation functions/values (or other functions/values) would be an appropriate management priority (see Chapter 5).

State surface classification maps can be found by clicking on "Enter Mapping Application" from http://dnr.alaska.gov/MapAK/ and then selecting "Surface Classification Map" under "Available Maps" → "Standard Land Status Maps." The **map below** shows the surface classification map zoomed in on the southern portion of the Kenai Peninsula between Tustumena Lake and Kachemak Bay. Wetlands on state lands colored beige (Habitat) and pink (Recreation) received the highest recreation score, as did wetlands on legislatively designated areas; all other state lands received a lower score.



2. Wetlands on borough and city lands

Wetlands on borough and city lands considered to provide long-term public access and open space were identified based on land classification or zoning categories. Categories considered compatible with recreation are listed in Table 3.5c.

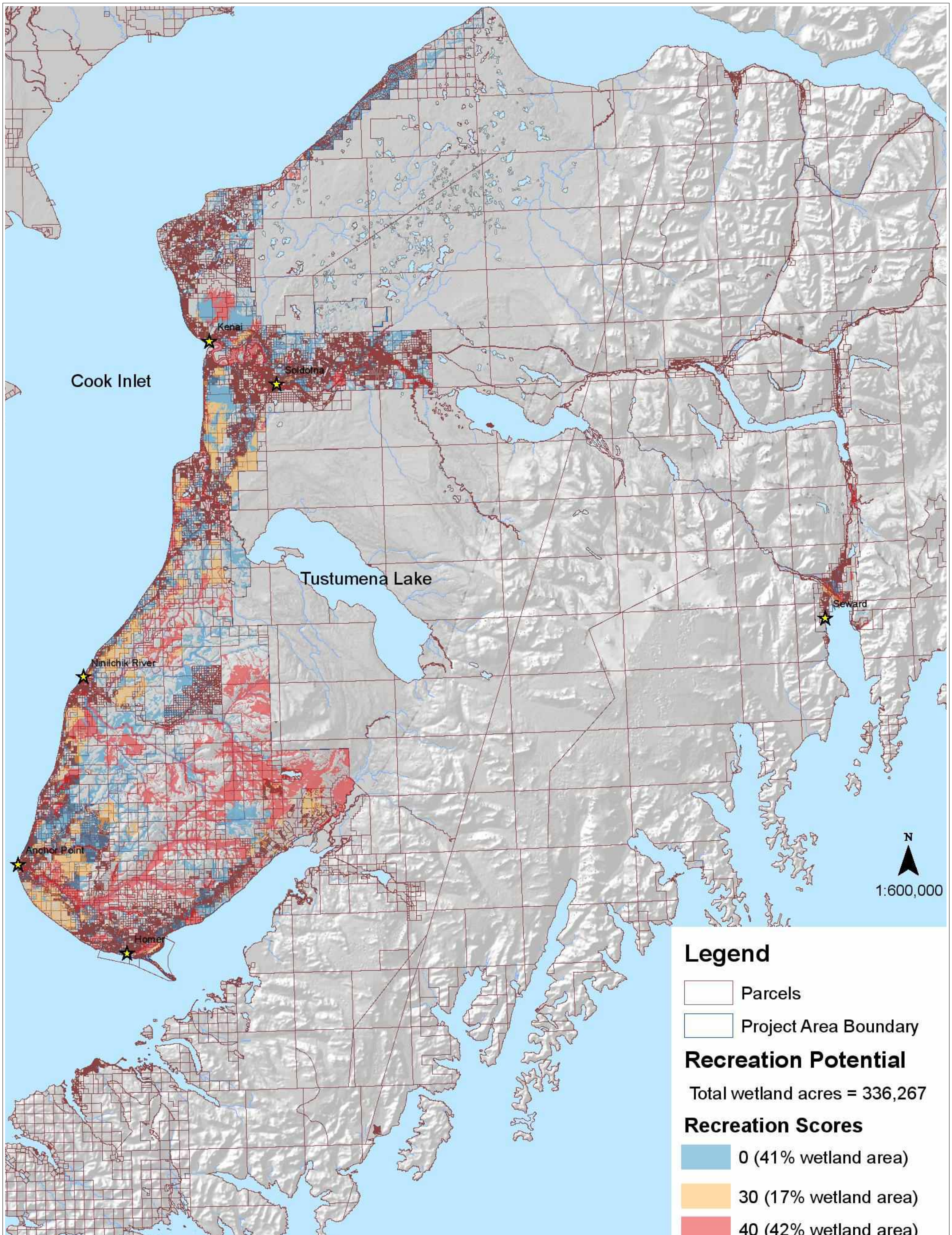
3. Wetlands on private lands

Wetlands on private lands received a score of zero unless they were on lands owned by (1) a conservation organization such as Kachemak Heritage Land Trust or Kachemak Moose Habitat, Inc. or (2) an entity that had designated the wetland areas as long-term "public open space" of some kind. For example, two homeowners associations in Homer are known to have established parks whose long-term, non-developable status is recognized by the Kenai Peninsula Borough assessor (i.e., these park parcels are assessed at $100 or less).

Table 3.5c. Kenai Peninsula Wetland Assessment Method—Community/Culture Component		
FUNCTION 1: Potential for recreation		
1	Wetland polygon is located on land meeting one or more of the following "public access/open space" categories of ownership, classification, or designation: 1. state-owned land a) classified as Habitat Land or Recreation Land b) designated as a state park unit (including state lands in the Kenai River Special Management Area) c) legislatively designated in another "public open space" category (e.g., Anchor River – Fritz Critical Habitat Area, Caribou Hills Special Use Area) d) administratively placed in a "public open space" category (e.g., Homer Demonstration Forest) 2. land classified in the Kenai Peninsula Borough's *Facilities* database as one of the following: a) campground b) fairground c) park d) recreation 3. borough-owned land assigned one of the following designations: a) Preservation b) Recreational 4. city-owned land assigned one of the following zoning categories: a) City of Homer: i. Bridge Creek Watershed ii. Conservation iii. Open Space Recreation iv. Diamond Creek Recreation Area b) City of Kenai: Conservation or Recreation c) Seward: Park d) Soldotna: Park or Recreational District 5. owned by one of the following entities: a) China Poot Bay Society b) Great Land Trust c) Kachemak Heritage Land Trust d) Kachemak Moose Habitat Inc e) Nature Conservancy f) Homeowners associations having parklands recognized as non-developable by the Kenai Peninsula Borough (i.e., parcels assessed by the KPB at $100 or less). This includes parks within Mountain Park subdivision and Stream Hill Park subdivision, both in Homer.	40
2	Wetland polygon is on state land with one of the following land use classifications: Disposable Interest, General, Miscellaneous	30
3	Wetland polygon meets none of the above criteria	0

Map 3.5a. Wetlands assessed for recreation.

(For a map with higher resolution, see https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.)



3.5.2. Education

Under *Education*, wetlands were assessed in terms of their suitability (existing or potential) for supporting educational uses. Education encompasses all grades and levels, from kindergarten up. Facilities serving only prekindergarten were not considered in this assessment. In Anchorage and Homer assessments, wetlands were given points for education based on both frequency of use for educational purposes and proximity to schools. On the peninsula, information on frequency of educational use was available for only a very few wetland areas (the Wynn Nature Center, for example). As a result, the key criteria used for this educational assessment were public access (as determined through the recreation assessment) and proximity to schools and other educational entities. Note that, in general, **wetlands with high scores for recreation are also well suited for many kinds of learning and research**; what distinguishes wetlands supporting education from those supporting recreation is that high-scoring educational wetlands can be reached by a short walk from a nearby place of learning.

Methods

Two variables were used to assess wetlands in terms of their function/value for education:

1. The score that the wetland received during the recreation assessment; this score reflects both the wetland's potential for access and use by educators and researchers and its maintenance in a long-term, largely natural "open space" category of some kind.

2. Proximity to existing public and private schools (including college campuses) and other "educational entities/facilities." Educational entities/facilities were broadly defined and in addition to schools (grades 1 and up), include visitor centers, museums, libraries, nonprofit educational facilities, and the like.

These variables are summarized in Table 3.5d. Tables 3.5e to 3.5h list schools and "educational entities/facilities" identified and considered during this assessment. Map 3.5b provides assessment results.

Table 3.5d. Kenai Peninsula Wetland Assessment Method—Community/Culture Component		
FUNCTION 2: Potential for education		
1	Wetland polygon is on the grounds of an existing school/educational entity/facility OR meets BOTH of the following criteria: 1. received a score of 40 points for recreation AND 2. is located within 0.2 mile of an existing school/educational entity/facility See Tables 3.5e-3.5g for all schools considered for this assessment, Table 3.5h for all other educational entities/facilities)	40
2	Wetland polygon meets BOTH of the following criteria: 1. received a score of 30 points for recreation AND 2. is located within 0.2 mile of an existing school/educational entity/facility See Tables 3.5e-3.5g for all schools considered for this assessment, Table 3.5h for all other educational entities/facilities)	30
3	Wetland polygon meets none of the above criteria	0

Table 3.5e. Public primary and secondary schools identified in the project area (including address, enrollment, and type)
(source: http://alaska.webschoolpro.com/kenai-peninsula-youth-facility-school_AK122247050/district-schools-directory-list.html)

	School	Address	City	Zip code	Enrolled	Type
1	Aurora Borealis Charter	705 Frontage Rd.suite A	Kenai	99611	180	Regular
2	Chapman School	34215 Sterling Hwy	Anchor Point	99556-0156	117	Regular
3	Connections (Peninsula Optional High School)	152 E. Park Ave.	Soldotna	99669	57	Other/Alternative
4	Fireweed Academy	1340 East End Rd	Homer	99603	49	Regular
5	Homer Flex School	4122 Ben Walters Lane	Homer	99603-0270	37	Other/Alternative
6	Homer High School	600 E Fairview Ave.	Homer	99603-7661	528	Regular
7	Homer Middle School	500 Sterling Hwy.	Homer	99603-7446	220	Regular
8	Kachemak Selo	Po Box 15007	Fritz Creek	99603-6007	98	Regular
9	Kaleidoscope School of Arts and Sciences Elem.	549 N. Forest Dr.	Kenai	99611	248	Regular

10	Kalifornsky Beach (K-Beach) Elementary	1049 Poppy Lane	Soldotna	99669-9731	450	Regular
11	Kenai Alternative High School	705 Frontage Road #c	Kenai	99611-7769	68	Other/Alternative
12	Kenai Central High School	9583 Spur Hwy.	Kenai	99611-7802	527	Regular
13	Kenai Middle School	201 Tinker Lane	Kenai	99611-8149	394	Regular
14	Kenai Peninsula Youth Facility School (Marathon)	405 Marathon Rd.	Kenai	99611	8	Other/Alternative
15	Mcneil Canyon Elementary School	52188 East End Road	Homer	99603-9560	120	Regular
16	Mt. View Elementary School	315 Swires Road	Kenai	99611-8362	284	Regular
17	Nikiski Middle/Senior High School	Box 7112	Nikiski	99635-1000	400	Regular
18	Nikiski North Star Elementary School	52027 Holt Lamplight Rd	Nikiski	99635	395	Regular
19	Nikolaevsk School	Box 5129	Anchor Point	99556-5129	69	Regular
20	Ninilchik School	Mile 135 Sterling Hwy	Ninilchik	99639-0010	174	Regular
21	Paul Banks Elementary School	1340 East Road	Homer	99603-7211	225	Regular
22	Razdolna School	Box 15098-fcb	Homer	99603-6098	29	Regular
23	Redoubt Elementary School	486 W Redoubt Ave.	Soldotna	99669-7701	405	Regular
24	River City Academy	152 E. Park	Soldotna	99669	68	
25	Sears Elementary School	549 N. Forest Dr.	Kenai	99611-7410	220	Regular
26	Seward Elementary School	Box 247	Seward	99664-0247	305	Regular
27	Seward High School	Box 1049	Seward	99664-0227	238	Regular
28	Seward Middle School	Box 1049	Seward	99664	108	Regular
29	Skyview High School	46188 Sterling Highway	Soldotna	99669-9703	543	Regular
30	Soldotna Elementary School	162 E. Park Ave.	Soldotna	99669-7596	291	Regular
31	Soldotna High School	425 W. Marydale Ave.	Soldotna	99669-7309	558	Regular
32	Soldotna Middle School	426 W. Redoubt Ave.	Soldotna	99669-7701	556	Regular
33	Soldotna Montessori Charter	162 E. Park Street	Soldotna	99669	125	Regular
34	Spring Creek School	606 Sea Lion Ave.	Seward	99664	39	Other/Alternative
35	Sterling Elementary School	Drawer 89	Sterling	99672-0089	185	Regular
36	Tustumena Elementary School	58231 Sterling Highway	Kasilof	99610-0177	165	Regular
37	Voznesenka Elementary School	Box 15336	Fritz Creek	99603-6336	128	Regular
38	West Homer Elementary School	3719 Soundview Ave.	Homer	(99603	245	Regular
					8856	

Table 3.5f. Private schools identified in the project area, including address, enrollment, and grades
(source: http://www.privateschoolreview.com/county_private_schools/stateid/AK/county/2122#Elementary and other locational sites)

	School	Address	City	Zip code	Enrolled	Type
1	Academy of Higher Learning MIs	32930 Fair Game Ave D	Sterling	99672	17	1-12
2	Alaska Bible Institute	1295 Mission Rd.	Homer	99603		13-15
3	Cook Inlet Academy	45872 Kalifornsky Beach Rd.	Soldotna	99669-0996	217	PK-12
4	Grace Lutheran School	47585 Ciechanski Rd.	Kenai	99611		PK-8
5	Homer Christian School	3838 Bartlett St.	Homer	99603	59	K-12
6	Kalifonsky Christian School	41342 Kalifornsky Beach Rd.	Soldotna	99669-0996	16	K-8
7	Kenai Montessori School	220 Main Street Loop	Kenai	99611	45	PK-1
8	Lighthouse Christian School	50939 Kenai Spur Highway	Nikiski	99635	17	PK-3
9	Reads Primary School	104 N. McKinley St.	Kenai	99611-0996	11	K-3
10	Wings Christian Academy	39030 Kalifornsky Beach Rd.	Kenai	99611-0996	22	K-12
					404	

Table 3.5g. State colleges and other institutions of higher learning in the project area

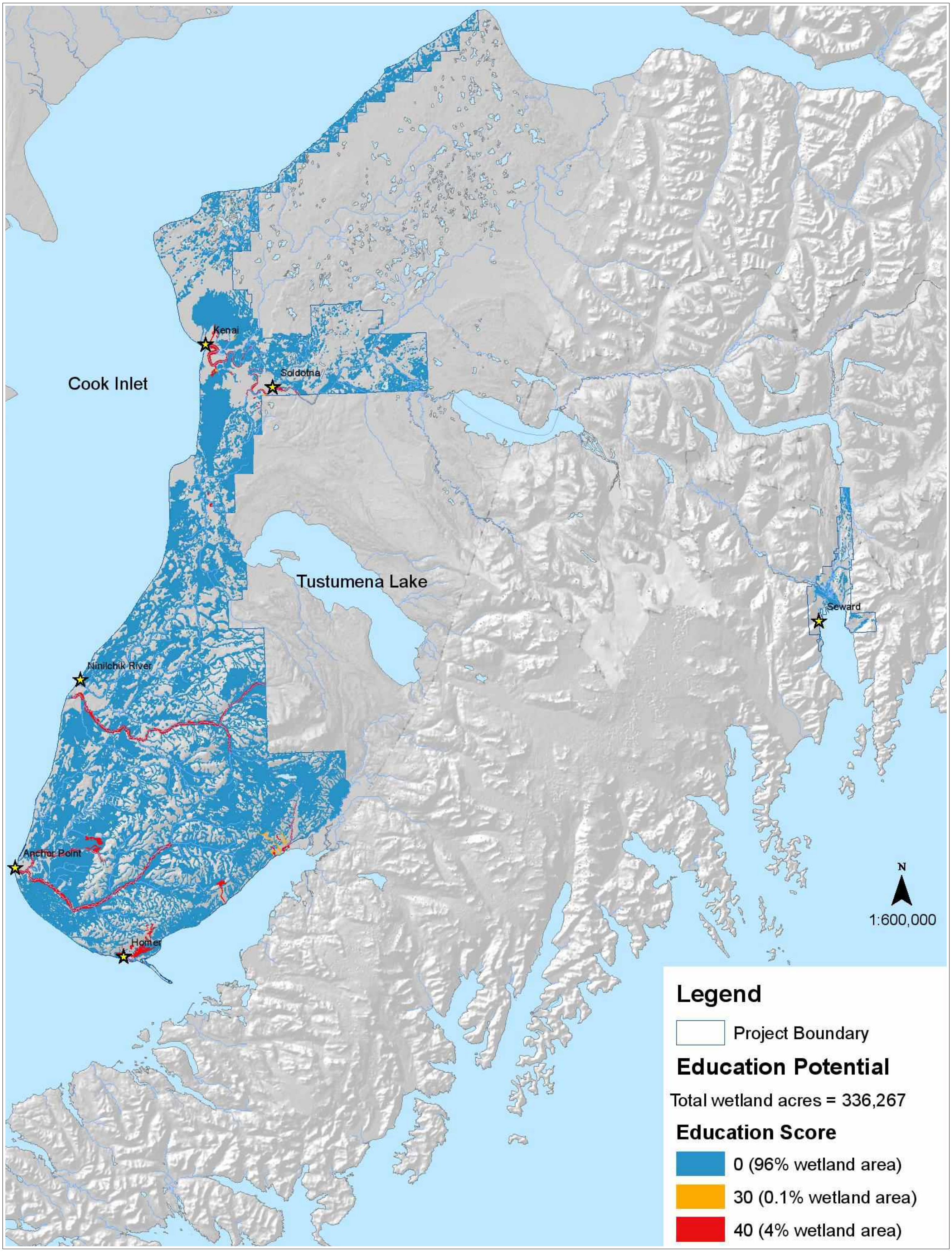
AVTEC – Alaska's Institute of Technology	809 2nd Ave.	Seward	99664
Kachemak Bay Campus, Kenai Peninsula College, University of Alaska, Anchorage	533 E. Pioneer Ave.	Homer	99603
Kenai River Campus, Kenai Peninsula College, University of Alaska, Anchorage	156 College Rd.	Soldotna	99669

Resurrection Bay Extension, Kenai Peninsula College, University of Alaska, Anchorage	P.O. Box 1049	Seward	99664
University of Alaska, Fairbanks, Seward Marine Center	201 Railway Ave.	Seward	99664-0730

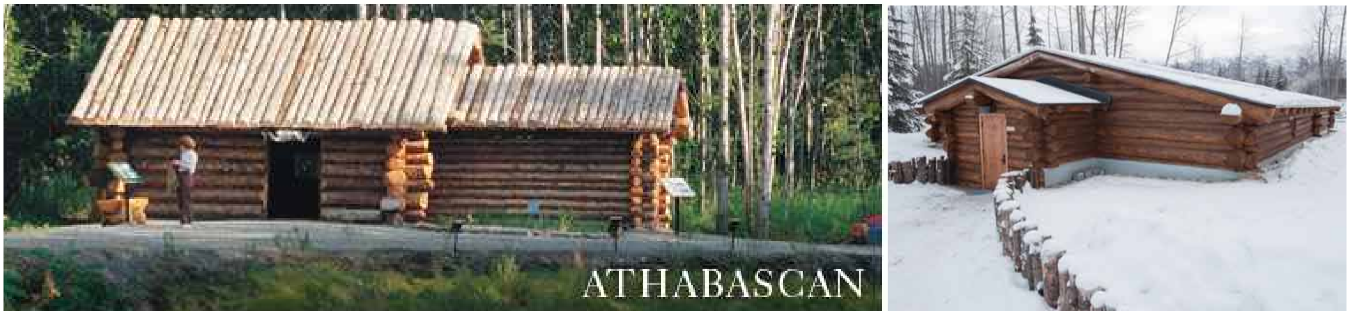
Table 3.5h. Other educational entities/facilities identified in the project area				
1	Ageya Wilderness Education Retreat Center	61420 Florence Martin Ct.	Homer	99603
2	Alaska Islands and Ocean Visitor Center	95 Sterling Highway	Homer	99603
3	Alaska Sealife Center	301 Railway Ave.	Seward	99664
4	Center for Alaskan Coastal Studies (Wynn Nature Center, under Recreation)	708 Smoky Bay Way	Homer	99603
5	Gilman River Center (formerly Kenai River Center)	514 Funny River Rd.	Soldotna	99669
6	Homer Chamber of Commerce and Visitor Center	201 Sterling Highway	Homer	99603
7	Homer Public Library	500 Hazel Ave.	Homer	99603
8	Kasilof Public Library (shares building with Tustumena Elementary School)	58200 Sterling Highway	Kasilof	99610
9	Kasilof Regional Historical Association	24117 Kalifornsky Beach Rd.	Kasilof	99610
10	Kenai National Wildlife Refuge Visitor Center	Ski Hill Rd.	Soldotna	99669
11	Kenai Community Library	163 Main St. Loop	Kenai	99611
12	Kenai Visitors and Cultural Center	11471 Kenai Spur Highway	Kenai	99611
13	Ninilchik Community Library	15850 Sterling Highway	Ninilchik	99639
14	Pratt Museum	3779 Bartlett St.	Homer	99603
15	Seward Chamber of Commerce and Visitor Center	2001 Seward Highway	Seward	99664
16	Seward Public LIbrary	238 5th Ave.	Sterling	99664
17	Soldotna Historical Society	461 Centennial Park Rd.	Soldotna	99669
18	Soldotna Public Library	235 North Binkley St.	Soldotna	99669
19	Soldotna Visitor Center and Chamber of Commerce	44790 Sterling Highway	Soldonta	99669

Map 3.5b. Wetlands assessed for education.

(For a map with higher resolution, see https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.)



3.5.3. Culture/heritage



Left: Athabascan house, right: Athabascan ceremonial lodge
(Alaska Native Heritage Center, http://www.alaskanative.net/en/para-nav/home/).

3.5.3.1. Introduction

The goal of this assessment of the culture/heritage functions and values of peninsula wetlands was to recognize those wetlands most likely to play significant roles in the lives of the Dena'ina Athabascans living on the Kenai Peninsula—both past and present. The Dena'ina were the dominant indigenous culture in the project area at the time of Western contact in the late 18th century and remain so to the present. They have been learning about and using peninsula wetland resources—both plant and animal—for hundreds of years. This assessment recognizes the significance and importance of that "Traditional Ecological Knowledge" (see below) and related wetland uses.

The Dena'ina understood "...that the soul, the place, and the history of the people converge in the landscape..."[54] Despite the profound cultural, subsistence, and spiritual importance of lands to the Dena'ina, many Dena'ina lands on the Kenai Peninsula have been radically altered by development activities, resulting in the destruction of many sites of great importance to the Dena'ina, including sites considered sacred. As economic and other developments continue in Dena'ina territory, protecting critical traditional landscapes and valued resources—including wetlands—will depend on first identifying their locations and then recognizing and respecting their culture/heritage functions and values. This assessment is a contribution to that process.

No comparable assessment was performed during wetland assessment projects in Anchorage or Homer, so the methodology outlined below was developed for this project. Key individuals responsible for its development are: Catherine Knott, Ph.D., anthropology professor at Kachemak Bay Campus, Kenai Peninsula College (KPC is a unit of of the University of Alaska, Anchorage), and Alan Boraas, Ph.D., anthropology professor at Kenai River Campus, KPC. In addition, Priscilla Russell Kari (author of *Dena'ina* [also *Tanaina*] *Plant Lore*), Alexandra (Sasha) M. Lindgren (Director of Kenaitze Tribal Government Affairs), Brenda Trefon (Kenaitze Environmental Coordinator), Dr. Holly Cusack-McVeigh (formerly of the Pratt Museum in Homer), and Karen Evanof (Cultural Anthropologist, Lake Clark National Park) contributed information and/or provided valuable review of the approach outlined here. Members of the Salamatof Tribal Council and Ninilchik Traditional Council were also contacted during this project.

Although neither Anchorage nor Homer wetland assessments included an element similar to this, the methodology on which those projects (and this one) were based—the Ontario Wetland Evaluation System (OWES)[55]—provided some general guidance related to evaluating culture/heritage values of wetlands. Sections 2.8.1 and 2.8.2 of the manual for the Northern Ontario Wetlands Evaluation System[56] commented:

> **ABORIGINAL VALUES**: While the values outlined in the Social Component [what we call the Community/Culture component] apply to all of the people of Ontario, the Aboriginal Values subcomponent

54 Boraas, Alan, 2009, "The Moral Landscape of the South-Central Alaskan Dena'ina," paper presented to the International Conference on the History of Cartography, Copenhagen, Denmark, July 2009.

55 For an introduction to the use of OWES during this project, see Section 1.3.1 of this report.

56 The Northern Ontario manual can be downloaded at http://www.web2.mnr.gov.on.ca/mnr/Biodiversity/wetlands/owes/Northern_OWES_Manual_text.pdf.

recognizes additional significance of a wetland to aboriginal people. This significance may be related to wetland products derived from, for example, fishing, trapping, wild rice and other plant harvesting, or may result from cultural and spiritual values...

CULTURAL HERITAGE: Cultural values of wetlands may stem from some noteworthy historical events that have transpired in or at the edge of a wetland. Included would be archaeological sites, historical portages, log chutes, burial sites, historical fishing ports, famous hunt clubs, etc... If a wetland is of significance with regards to cultural heritage, a bonus score is given...

Participatory action research:
One of the goals in assessing culture/heritage values of peninsula wetlands was to use a fully collaborative approach incorporating input from Dena'ina communities, which have a long historical relationship with the Kenai Peninsula and its environments. This approach is known in the anthropological field as "participatory action research." One of the key priorities of such research is to supplement written material with input from local individuals who represent "culture bearers" and "knowledge keepers" in their communities. Knowledge shared by such individuals, in combination with traditional information from written sources, is often called "Traditional Ecological Knowledge" (TEK)[57]. TEK reflects experientially derived knowledge and skills acquired over many generations and can provide insights and perspectives not available from any other sources.

Valuable supplementation of the TEK incorporated into this discussion would be gained by conducting systematic interviews with members of contemporary Dena'ina communities, both young and old. For example groups to be interviewed could be subdivided into age categories, and questions could be focused on identifying wetland sites used by those currently in the "grandparent generation," "parent generation," and young people in the 18-25+ year age group. Members of the Kenaitze Tribal Government suggested just such a process, encouraging interviews with willing elders about traditional wetland sites used for gathering, hunting, trapping, fishing, etc. on the peninsula. Age-stratified interviews would allow comparisons of wetland use over time—including trends—as well as identification of wetland sites now lost to development or natural causes. Time and resources available for this project precluded conducting such interviews, but discussions continue on ways to refine the results presented below. It is hoped that the maps developed for this project, showing wetlands associated with Dena'ina use areas, will stimulate further study and sharing of traditional and contemporary uses of wetlands by Dena'ina communities. In this way, traditional knowledge and skills—including how Dena'ina used wetland resources for food, medicine, clothing, tools, crafts, weapons, etc.—can be documented and passed on to future generations.

3.5.3.2. Early human settlement of the peninsula[58]

As outlined in Section 2.2.1, glaciers covered much of the Kenai Peninsula during the last ice age (the Wisconsin glaciation of the Pleistocene, represented on the peninsula by Naptowne glacial advances). Ice had begun retreating from the Kenai lowlands by about 14,000 years ago, but although land became available soon after glaciers receded, human access onto the peninsula was probably blocked by ice until about 8,000-9,000 years ago. Somewhere around that time, the earliest humans arrived on the peninsula (see below)—at about the same time that spruce forests began replacing the herbaceous and shrub tundra plant communities that had pioneered the glacial till left exposed by melting ice. "Historically, vegetation changed fairly rapidly on the Kenai Peninsula from the herb/shrub tundra which immediately followed deglaciation to the modern forest pattern. Alder became widespread 10,000 to 9,500 years ago, and spruce entered the area by 8,400 to 8,000 years ago. Hemlock was present in the central Kenai Mountain area by 5,000 to 4,000 years ago, and the present complex forest distribution presu-

57 TEK, which has been widely adopted by agencies such as the EPA and the US Fish and Wildlife Service, is defined as: "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 1999:8). Local, place- and experience-based knowledge may be extremely specific and detailed. For a further discussion of TEK, see Appendix __. See also the discussion of TEK found at the Alaska Native Knowledge Center, at http://ankn.uaf.edu/ IKS/tek.html.

58 Based largely on "Archeology of the Northern Kenai Peninsula and Upper Cook Inlet," Douglas Reger, in *Arctic Anthropology*, Vol. 35, No. 1 (160-171), January 1998 (available at http://connection.ebscohost.com/c/articles/3659609/ archaeology-northern-kenai-peninsula-upper-cook-inlet).

mably developed shortly after that" (Reger 1998[59]). By 4,000-5,000 years ago, all the tree species now common on the peninsula were established, and landscapes had begun to look much as they do today. As post-glacial environments became more stable—particularly instream and inlake environments—fish populations, including salmon, increased in abundance, providing a rich resource for human exploitation.

As local environments became more favorable for human habitation and use, human groups appeared on the peninsula. Prehistoric cultural traditions so far distinguished from relevant archeological sites include the following, although the timing of their occupations and their interrelationships with one another remain unclear.[60] The last group in this list would be the "Sedentary Dena'ina," a subgroup of the nomadic Athabascan Indians that eventually spread across the interior of Alaska (see below).

- the ***Paleoarctic blade and core tradition***, dating from between 8000 and 4000 BC, and probably subsisting primarily on caribou, fish, and small game;
- the ***Northern Archaic Tradition*** (using side-notched points), dating from perhaps 2500 BC and also subsisting largely on inland game and fish;
- the maritime-adapted ***Kachemak Tradition***, dating from perhaps 3000 to 1500 years ago and subsisting primarily on maritime resources; and
- the ***Riverine Kachemak Tradition***, dating from roughly 1000 BC to 1000 AD and reflecting a mixture of inland/riverine traditions and coastal/maritime adaptations. The riverine Kachemak Tradition was "...typologically related to the Kachemak culture of the lower Cook Inlet but adapted to subsistence in an estuarine or riverine environment. A major aspect of the lifeway would be harvest of the abundant salmon runs, especially with a pattern of fish camps seasonally dispersed from a permanent, riverine winter settlement. Land mammal hunting from dispersed hunting camps at certain seasons of the year would also be expected" (Reger 1998[61]). This tradition was followed by the ***Dena'ina Athabascans***, who arrived on the Kenai Peninsula sometime after 1000 AD.[62]

Juxtaposition of terrestrial and marine environments on the Kenai Peninsula (and throughout Cook Inlet) led to a rich and dynamic mixing of cultural adaptations among people settling there. The diversity of peninsula traditions

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59 *Ibid.* p. 162.

60 A somewhat different sequence has been described by William Workman for the southern peninsula, especially Kachemak Bay, in "Archeology of the Southern Kenai Peninsula" in *Arctic Anthropology*, Vol. 35, No. 1 (146-159), January1998: http://www.jstor.org/discover/10.2307/40316461?uid=3739512&uid=2&uid=4&uid=3739256&sid=21101581837107. "The complex coastline of the southern Kenai Peninsula was occupied by at least six different cultural traditions over the last 4500 years. Maritime hunters of the late Ocean Bay tradition appeared briefly in Kachemak Bay ca. 4500 years ago, probably coming from the Alaska Peninsula. Some 4000 years ago a technology related to the Arctic Small Tool tradition of the Alaska Peninsula appeared in the bay. By 3000 years ago Kachemak tradition sea hunters were established there, with growing populations and an elaborating culture for the next 1500 years. They had close connections with Kodiak Island, from whence the pioneer settlers probably derived. The Kachemak tradition folk abandoned Kachemak Bay 1500 years ago, probably for a variety of reasons. Since then the bay has been only sporadically utilized by bearers of diverse technologies, among whom are the ancestors of the Tanaina [Dena'ina] Athapaskan Indians, who adopted a maritime hunter/fisherman subsistence economy. A few Alutiiq sites are known on the southern peninsula coast in the last 1000 years."

61 Reger, Douglas, 1998, "Archeology of the Northern Kenai Peninsula and Upper Cook Inlet," in *Arctic Anthropology*, Vol. 35, No. 1 (160-171), January 1998 (available at http://connection.ebscohost.com/c/articles/3659609/ archaeology-northern-kenai-peninsula-upper-cook-inlet).

62 The end of Riverine Kachemak tradition has been placed at ca. 1000 B.P., at which time the population was supposedly replaced by in-migrating groups ancestral to the Dena'ina Athapaskans. Close examination of the numerous available radiocarbon dates shows that most Riverine Kachemak dates cluster in the early centuries of the First Millennium A.D. and most Dena'ina dates substantially postdate 1000 A.D. Probably the Riverine Kachemak and Dena'ina peoples never met on the Kenai River. However, the correspondence in date ranges between Kachemak Bay and Riverine Kachemak is striking, suggesting their fates were linked. Both traditions collapsed by 1400–1500 B.P. The causes are probably multiple but do not include cultural replacement. (William and Karen Wood Workman, 2010, "The End of the Kachemak Tradition on the Kenai Peninsula, Southcentral Alaska," *Arctic Anthropology*, Vol. 47, No. 2 (90-96), see http://aa.uwpress.org/content/47/2/90.refs.

reflects the heterogeneous distribution—both in space and time—of resources from land, sea, and coastal environments, including wetlands. Douglas Reger made this point in “Archeology of the Northern Kenai Peninsula and Upper Cook Inlet” (1998)[63]:

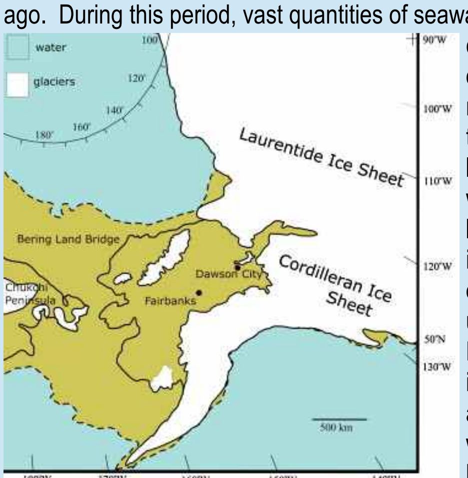
> Prehistoric cultures of the Cook Inlet area reflect a long history of interaction between fully maritime cultures and terrestrial oriented groups... Dena'ina culture reflected increasing maritime adadptation from the inland-oriented inhabitants near the [Cook Inlet] headwaters to the Dena'ina residents near the ocean entrance... The upper Inlet Dena'ina followed a typically Athapaskan lifeway, hunting terrestrial land mammals and harvesting salmon and trout from lakes and streams. As one looks south at coastal Dena'ina, particularly south of Kenai, hunting and fishing techniques and weapon complexes increasingly take on an Eskimo appearance... The Late Prehistoric period shows considerable movement of ideas and material culture between fully marine-oriented people and those primarily dependent on non-marine resources.

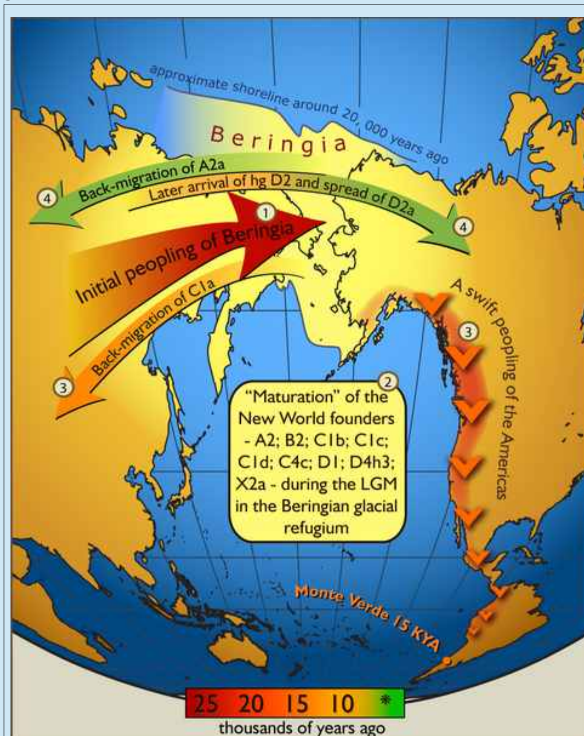
Where did the people who developed the traditions introduced above ultimately come from? The text box below suggests the answer—the lands of eastern Siberia. Like all North American Natives, people who arrived on the Kenai Peninsula as glaciers receded were related to groups who had traveled across the Bering Land Bridge, which was exposed by lower sea levels during the last ice age. The Bering Land Bridge made Alaska the gateway to the peopling of the New World.

Alaska: Gateway to the peopling of the New World

Members of the Athabascan language group—like all North American Natives—traveled to the New World from Asia (eastern Siberia) across what is called the Bering Land Bridge. Immigrants spread throughout Alaska and down to the continental US, migrating through corridors opened by receding glaciers.

The continent-sized Bering Land Bridge (*Beringia*) spanned what is now the Bering Strait during the Pleistocene Ice Age (the Wisconsin glaciation), which began roughly 50,000 years ago and ended about 10,000 years ago. During this period, vast quantities of seawater were tied up in glaciers and, as a result, ocean levels were as much as 200 ft lower than today. Depending on sea level, Beringia was as wide as 1000 miles. The land bridge connected to interior and coastal areas of Alaska that remained unglaciated during the Pleistocene (brown areas in the **map at left**). These areas offered “refugia” where plants, animals, and humans could survive the ice age. (The map above shows ground squirrel refugia areas, from http://www.sciencedirect.com/science/article/pii/S0277379110001289.)





Movement of human groups across the Bering Land Bridge. Letters represent mitochondrial genes used to trace ancestry. LGM = Last Glacial Maximum (http://www.plos one.org/article/info%3).

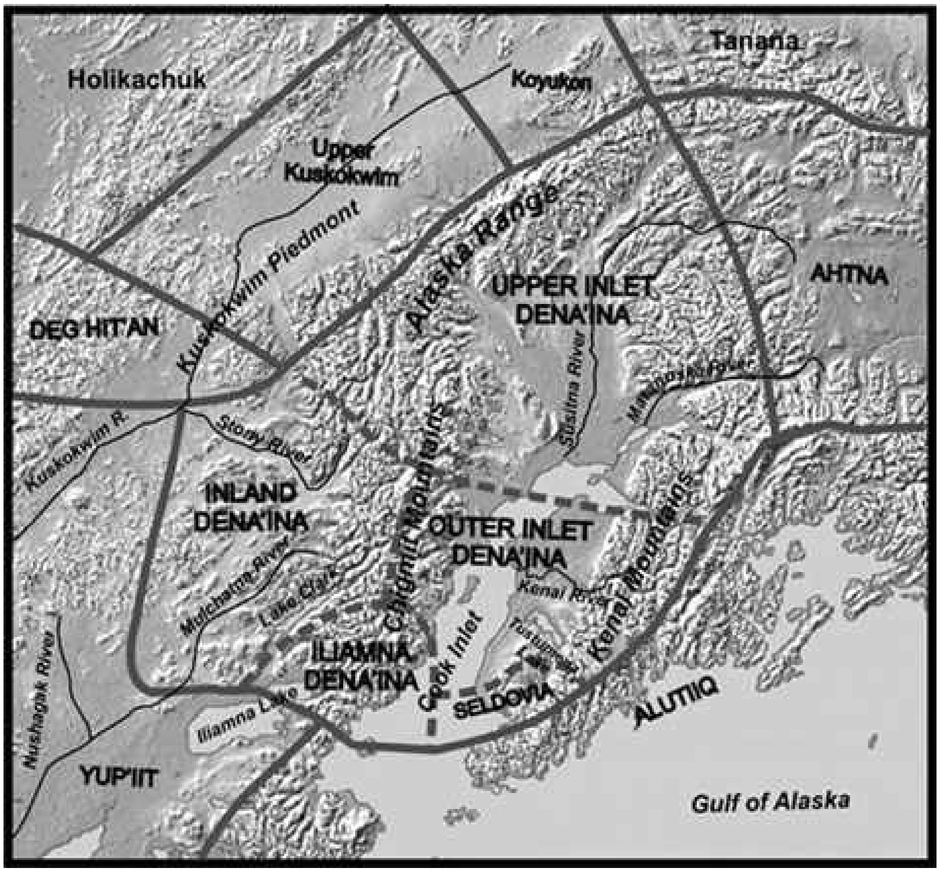
Research using mitochondrial DNA suggests patterns of human movement between Asia and North America across the Bering Land Bridge, as shown in the **map above right**. This research indicates that “...the ancestors of Native Americans did not reach Beringia until just before 15,000 years before present... First, before spreading across the Americas, the ancestral population paused in Beringia long enough for specific [gene] mutations to accumulate that separate the New World founder lineages from their Asian sister-clades... [A]fter the Beringian standstill, the initial North to South migration was likely a swift pioneering process, not a gradual diffusion.” (From Tamm E, Kivisild T, Reidla M, Metspalu M, Smith DG, et al.; 2007; *Beringian Standstill and Spread of Native American Founders*; http://www.plos one.org/article/info:doi/10.1371/journal.pone.0000829.)

63 In *Arctic Anthropology*, Vol. 35, No. 1 (160-171), January 1998, see http://connection.ebscohost.com/c/articles/3659609/archaeology-northern-kenai-peninsula-upper-cook-inlet.

3.5.3.3. Dena'ina communities on the Kenai Peninsula

By the late 18th century, when Europeans first made contact with people of the Kenai Peninsula, the Dena'ina were the dominant culture throughout the Cook Inlet area. Who were these people who had adapted so successfully to Cook Inlet environments?

The Dena'ina represent a regional subtype of a much larger cultural group—the Athabascans (also spelled Athabaskans and Athapascans). Alaskan Athabascans are the northernmost members of the Dene group of Native Americans, a diverse assemblage of cultures that speak related languages. Members of this linguistic group are represented in Oregon and California, as well as by the Navajo and Apache of the American Southwest.



The Alaskan Athabascans were nomadic hunter-gatherers whose survival was based on harvesting and storing the salmon and big game—especially moose and caribou—found in boreal forests and along major rivers. The text box "Overview of the Alaskan Athabascan way of life" introduces this long-established and well-adapted culture.

The Dena'ina Athabascans who reached the Kenai Peninsula probably represent Athabascan bands from the Upper Kuskokwim River drainages (see **map at left**, from Boraas 2009[64]). "[O]ral tradition has the Dena'ina moving from the Stony River drainage [in the Kuskokwim piedmont] down to the middle and upper Mulchatna River, then through mountain passes into Lake Clark, and down to the Iliamna Lake area. Still later, the Dena'ina moved through the Chigmit Mountain passes into Cook Inlet, first occupying the Kenai Peninsula at the East Forelands. Other migrations may have come from the Copper River area into the Susitna River drainage, as indicated by the close affinity of Upper Inlet Dena'ina and Ahtna [languages]" (Boraas 2009[65]).

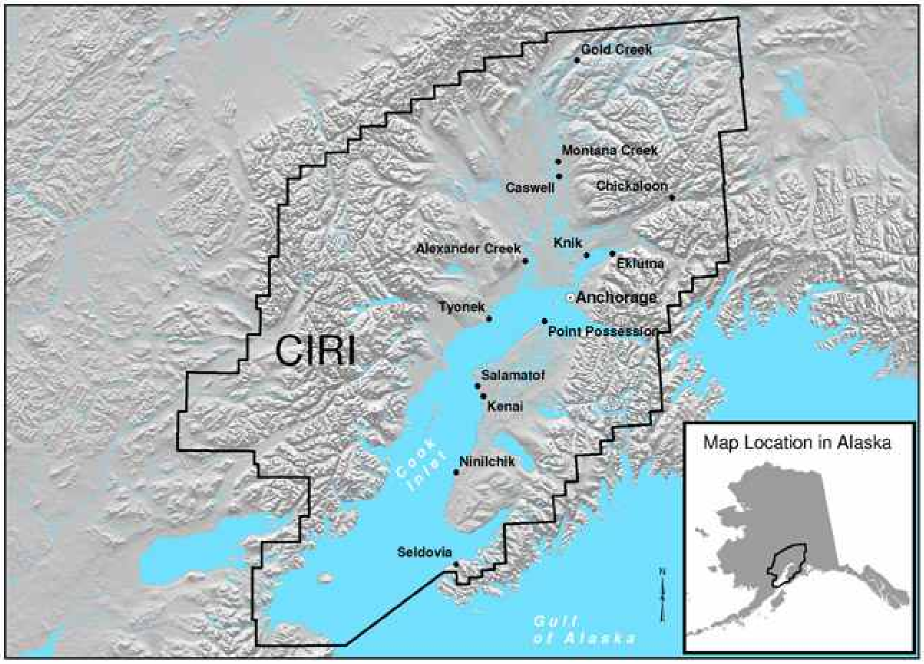
Upon reaching Cook Inlet—known as *Tikahtnu* in Dena'ina—the Dena'ina became the only Athabascan culture with a significant lifeway component related to harvesting marine resources. Place-specific adaptations based on local availability of particular marine and inland resources—such as marine mammals and shellfish on the coast and caribou inland—led to regionally distinct subgroups of Dena'ina, as shown in the **map above**. These subgroups occupied the Susitna River drainage, all of Cook Inlet, and watersheds draining east from the Chigmit Mountains into Bristol Bay. Access to whales, seals, sea otters, shellfish, and other maritime resources led the Cook Inlet Dena'ina to adopt new ways of life, including techniques and tools learned from coastal Alutiiq Eskimos already present (e.g., around Kachemak Bay) at the time of Dena'ina arrival. For example, Cook Inlet subgroups became skilled at using detachable barbed-head harpoons while hunting from boats. Boats were also used to cross the inlet.

64 Boraas, Alan, 2009, "The Moral Landscape of the South-Central Alaskan Dena'ina," paper presented to the International Conference on the History of Cartography, Copenhagen, Denmark, July 2009.

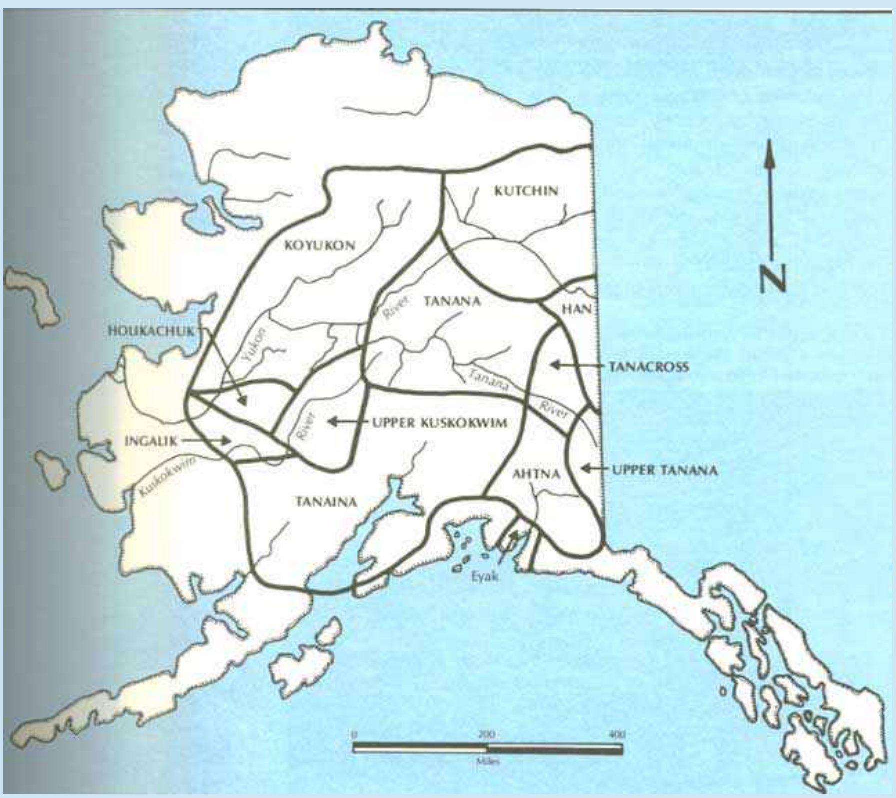
65 *Ibid.*

The geographic boundary of lands now owned and managed by Cook Inlet Region, Inc. (CIRI) closely approximates the traditional homeland of the Dena'ina. The **map at right** shows the region encompassed by CIRI (from [http://www. ciri.com/ content/history/villages. aspx](http://www.ciri.com/content/history/villages.aspx)).

The text box below provides an overview of Athabascan lifeways, with an emphasis on the Kenai Peninsula Dena'ina. Additional details are provided under the write-up on Dena'ina "use areas" (Section 3.5.3.6).



Overview of the Alaskan Athabascan way of life, with an emphasis on the Dena'ina.
(Adapted from *Alaska's Heritage*, Chapter 2-3: Athabaskans, http://www.akhistorycourse.org/articles/article.php?artID=150.)



Athabascan regions in Alaska. Note that only the Dena'ina (Tanaina) Athabascans (and the related Copper River/Prince William Sound Eyak) established settlements in coastal areas. (Map from *The Alaska History & Cultural Studies Website*, at http://www.akhistorycourse.org/articles/article.php?artID=150.)

At the time of Western contact, the population of Athabascan groups in Alaska is estimated to have been about 10,000, each with its own well defined territory, as shown in the **map at left**. In general, Alaska Athabascans occupied the vast interior coniferous forests, where they relied on hunting and trapping animals, fishing, and gathering edible plants.

Changing seasons, weather, and the behavior of fish and game ordered the lives of the nomadic Athabascans, who often traveled great distances in their quest for food. Harvesting large game—particularly moose and caribou—was essential to survival. In the fall, caribou herds undertook seasonal migrations, moose gathered near rivers in search of mates, and fattened bears prepared to enter their dens. In late fall and early spring, Athabascans trapped smaller fur-bearing animals, including snowshoe hare, beaver, river otter, muskrat, porcupine, lynx, fox, and squirrel. They also hunted ptarmigan, spruce grouse, and waterfowl like ducks and geese, and gathered edible plants for food, medicine, and materials to fashion tools and other items.

While other Alaskan Athabascans traveled constantly, the Dena'ina generally moved only seasonally. They lived in larger, more permanent villages and traveled to designated family fishing, hunting, and trapping sites. During the long, cold winters, they lived in rectangular log houses built over depressions excavated several feet into the ground. Some winter villages had a dozen or more houses. In addition to family dwellings, villages often had sweat houses, fish and meat smokehouses, and small burial houses over graves. Many villages had a large community ceremonial house (see photos at the beginning of Section 3.5.3).

In spring, the Dena'ina generally moved to fish camps along anadromous rivers. There they fished for salmon with dip nets, basket shaped traps, poles with hooks, and spears. A popular Dena'ina fishing method was to build a weir or fence near the mouth of smaller streams to channel fish swimming upstream into basket traps or nets. Dena'ina also fished for Dolly Varden, arctic grayling, lingcod, eulachon, and northern pike. They cleaned, split, dried, often smoked, and stored the fish in caches to be eaten through the winter. During winter, when river and lake ice was not too thick to cut, they also caught fish through the ice with spears, lures, hooks, and dip nets.

Rivers provided important travel routes. In summer, Athabascans used birch bark canoes, rafts, or, moose skin boats. They sewed the seams with spruce roots and waterproofed them with hot spruce pitch. In addition to river routes, the Athabascans also used overland trade routes and other trails, including a trade route between Cook Inlet and the Interior via the Susitna River drainage. In the fall, Athabascans constructed log rafts and moose skin boats to return from hunting trips. In winter, they traveled on snowshoes and pulled toboggans by hand over frozen rivers and brush-free, snow-covered wetlands. They constructed two types of snowshoes: long and wide to cross deep powder, shorter, and narrower to walk on packed snow. For both styles, frames were made of birch lashed with rawhide, and webbing was made of sinew. Occasionally Athabascans used dogs for packing, but more often they used them for hunting. The Athabascans trained their dogs to chase animals and hold them at bay until the cornered animal could be killed.

Athabascans generally lived in bands composed of 25 to 100 members. Dena'ina bands could be significantly larger. Each band belonged to a larger regional group that occupied a defined territory—like the Outer Inlet Dena'ina. Families were the focus of social organization and provided the nucleus of a band. Spouses were generally selected from the regional group by the parents; lineage was traced through the mother's side of the family. Husbands moved in with the wife's family and worked for them for up to a year. Family bands often joined others for large-scale hunting or social events, including seasonal celebrations or gatherings to honor the dead. Large social gatherings allowed for renewal of family ties and other bonds, as well as the arrangement of marriages. Each Athabascan band passed down stories and songs. Stories related history, events, and taught right and wrong. Songs included traveling songs, love songs, war songs, mourning songs, and songs of happiness.

3.5.3.4. Assessment of wetland functions/values for Dena'ina culture/heritage

Two variables were used to assess wetlands in terms of their functions/values for Dena'ina culture/heritage:

1. **Dena'ina "use areas"**

   The heart of this culture/heritage assessment was the identification of wetlands that overlap with what are here called Dena'ina *use areas*. Use areas reflect lands and waters within a 10-mile radius of traditional and existing Dena'ina villages or other occupation sites. As further discussed below, Dena'ina thought nothing of traveling 10 miles out from a settlement and back the same day, a round-trip of 20 miles. Longer out-and-back journeys were common. Wetlands within 10 miles of a settlement would have been familiar to community members and considered readily accessible. As a result, the nature, extent, and seasonal availability of resources found in such wetlands—both plant and animal—would have been well known, and these resources would have been sought and harvested when seasonally available. Kenai Peninsula Dena'ina still seek and use many of these same wetland-related resources today.

   Key sources used to identify Dena'ina use areas were maps and lists of Dena'ina place names with known locations. Anthropologists Catherine Knott and Alan Boraas compiled available lists and maps, which are based on efforts of archeologists and anthropologists over many decades to collect and locate place names. Place names were given to village sites, seasonal campsites, fishing areas, winter trails, hunting and trapping areas, and other locations providing significant resources or associated with meaningful events (see Section 3.5.3.7). Place name data were supplemented with information on the use (both traditional and current) of wetland plants by Cook Inlet Dena'ina, as well as information on Dena'ina trails, hunting and trapping areas, and other identified sites associated with significant use.

2. **Potential archaeological sites**[66]

Significant culture/heritage wetlands were also identified based on proximity to *potential* settlement sites in areas where a village or occupation site could be expected but has not yet been mapped ("potential archaeological sites"). These areas have features (including nearby place names) that suggest the Dena'ina may have established occupation sites there, but more archaeological work is needed to confirm this. Use areas were outlined around these sites and wetlands were given scores reflecting *potential* significance. It should be noted that the Dena'ina recognize that objects and places can retain a residual energy reflecting use, ownership, treatment, or association with significant events (see following section). This awareness of how energy (positive or negative) can be left behind led to a cultural value functionally equivalent to the contemporary ethic of "leave no trace." Since the Dena'ina were careful to leave as few traces behind as possible, finding archaeological evidence can sometimes be challenging. Middens and house pits generally provide the most easily recognized evidence of occupation.

These two variables are discussed below. Sources of information used by Drs. Knott and Boraas in identifying use areas, place-named sites, and other categories mentioned above included published and unpublished maps and written materials. Key among these were:

1. a hand-drawn map from *Dena'ina Elnena: Tanaina Country*, by James Kari and Priscilla Kari, 1982;
2. a map hand marked by Peter Kalifornsky;
3. Peter Kalifornsky's book, *K'tl'eghi Sukdu: A Dena'ina Legacy*;
4. James Kari and James A. Fall's book *Shem Pete's Alaska*; and
5. James Kari's *Dena'ina Topical Dictionary*.

Once place-named sites and other locatable features were mapped, the latitudes and longitudes of these features were determined. David Pruett assisted in transferring map points to Alaska USGS topographic maps on CD-ROM so that they could be translated into latitude and longitude; these points were consolidated with points for which Alan Boraas had already identified locations. Locations determined through this process represent the best consolidation of available information by the most experienced anthropologists currently working on Kenai Peninsula Dena'ina place names.

Latitudes and longitudes of located sites were then provided to Homer Soil and Water to be used in determining Dena'ina use areas. Homer Soil and Water identified wetlands contained within outlined use areas and scored them for culture/heritage values, see Tables 3.5j and k. Results are provided in Maps 3.5d and e.

3.5.3.5. Dena'ina beliefs as they relate to land and resources

An assessment of the culture/heritage functions and values of wetlands to the Dena'ina must be informed by an understanding of key beliefs underlying Dena'ina use of and interactions with wetland lands and resources. Dena'ina beliefs create what Alan Boraas has called a "moral landscape," that is, a landscape filled with profound consequences for one's actions. The following discussion is based on and largely excerpted from Boraas' paper "The Moral Landscape of the South-Central Dena'ina," presented most recently July 2009 at the International Conference on the History of Cartography, Copenhagen, Denmark. Boraas' invaluable contributions to this assessment are here again acknowledged. Boraas explains:

> To traditional Dena'ina the landscape is not simply a mnemonic device that triggers memory like returning to one's hometown and remembering the events of youth… The Dena'ina spirituality of place was much deeper and involved a message of a past event that emanated from a place and that some could detect whether or not they had been part of the original event. The events were sometimes morally neutral everyday occurrences, some could be morally good, while others were evil. Thus, good and evil were encoded in the landscape, and

66 Sites listed in the Alaska Heritage Resources Survey (AHRS) (http://dnr.alaska.gov/parks/oha/index.htm) and the National Register of Historic Places, Alaska (http://www.nationalregisterofhistoricplaces.com/ak/Kenai+Peninsula/state.html) were also considered for this assessment. Locations of such sites, however, are restricted to protect them from disturbance, so these sources were not used here. The National Register lists two address-restricted sites associated with peninsula streams: (1) Cottonwood Creek Archeological Site, #76002302 (in the Homer area, added in 1976) and (2) Moose River Site, #78003427 (in the Sterling area, added in 1978 and, also known as AHRS Site No. KEN-043).

to travel was to encounter the moral history of place... [P]laces and artifacts could both absorb and exude information about historic events that occurred there. This historic information existed as a kind of scent and could be good, *beggesha*, or bad, *beggesh*… Individuals had varying abilities to detect [this] information… Sentient animals, ancestor spirits, and other spirits could also detect the moral history of a place.

Negative actions such as murder, child abuse, disease, or not respecting laws regarding animal treatment could impart *beggesh* to a place, while good events such as the ideal harmony of a village, the community-wide love generated by a potlatch, or personal fortitude in overcoming evil would be described as *beggesha*… [A]nimals, sensing negative information, would abandon a place if *beggesh* were present.

3.5.3.6. Dena'ina use areas[67]

Dena'ina use areas distinguished for this project encompass lands and waters within a 10-mile radius of known historic and prehistoric Dena'ina villages or other settlements. Use areas were defined by compiling locations of place-named permanent villages and other occupation sites (see above) and then “buffering” these with circles representing areas readily reached in 1-day-out-and-back trips (see below). Data on occupation sites encompass roughly the past 200 years. Identified use areas are listed in Table 3.5j; 10-mile radius buffers around each of these sites are shown on Map 3.5d. An introduction to Dena'ina place names is provided in Section 3.5.3.7.

> **Kalifornsky Village is more than a piece of property or a place of historic interest, it is a place of pilgrimage where connections to the past can refresh, renew, and reinvigorate present and future generations, and an understanding of the events that happened there can reinforce cultural values and guide future decision-making about the broad issues that concern the Kenaitze people.**
>
> Alan Boraas. 2006. *The Significance of Kalifornsky Village: Unhghenesdignu Qayeh*:1.

The Dena’ina established permanent villages at the mouths of nearly every large salmon-bearing stream along the western coast of the Kenai Peninsula. From these villages, they commonly traveled significant distances to hunt, trap, and gather plants, constructing temporary camps along the way. In the Interior where their livelihood was based on hunting caribou, Athabascan bands generally lived in portable skin tents so that they could follow the herds. On the Kenai Peninsula, however, the Dena’ina adapted to the abundance of salmon by switching to a salmon-based diet and establishing permanent dwellings, most often near the mouths of salmon-bearing streams. (Note, an assessment of peninsula wetlands for salmon habitat is found in Section 3.3.1.2.)

Before contact with Europeans, the Dena’ina built log houses, first digging a pit up to 3 ft deep in the ground, then setting posts and stacking logs between them. Sleeping benches lined the sides, and a central hearth in a log box filled with sand provided a place for cooking and heating. Smoke exited through a hole in the roof. These house pits have provided archaeologists with a way to identify sites of prehistoric and historic Dena’ina villages.

The Dena’ina did not live in independent family homesteads, but together in villages and camps of about 200 to 500 people, based on extended families[68]. Villages traditionally originated from a group of brothers who settled near the mother’s family and brought wives from other clans home to live with them. Children, however, belonged to their mother's clan, which might live elsewhere. (Dena’ina social organization was clan-based and matrilineal, meaning that descent was traced through the mother’s side of the family.)

Given Dena'ina social organization, private land ownership and inheritance would have complicated the use of nearby resources. The Dena’ina instead had a *qeshqa*, a socially and economically successful individual who became the leader in both management and redistribution of resources. The *qeshqa* often enhanced his status as a wealthy person by how much he gave away to others during potlatches that he or others organized, usually to commemorate an occasion such as the death of an elder. The work of the *qeshqa* was to make sure that orphans and others in need were provided for, and to make sure that the resources available would tide the population

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67 Original write-ups by Sara Conyers and Catherine H. Knott for this section have been compiled, edited, and supplemented by D. Lehner (Homer Soil and Water) for inclusion here. Original manuscripts are available from Homer Soil and Water.

68 After the disastrous smallpox epidemics of the 1830’s and the Spanish flu in 1915-1920, the population diminished and consolidated to some degree, but members in the larger communities would still have known of and had access to the original use areas around the smaller villages spread along the coast.

through the winters so that they would not experience famine. A *qeshqa* who was unsuccessful at managing use and distribution of resources would soon be replaced, or people would change their allegiance to another *qeshqa* with better ability to manage the resources needed for survival.

Under the guidance of the *qeshqa*, people in a village had use rights (usufruct) in the areas surrounding the village. While trap-lines were individually owned, berry patches and hunting areas were shared. Nearby villages might have some overlapping use areas and some of their own. While the *qeshqa* provided overall management of fish and other food resources, the entire population—men, women, and children—took responsibility for seeking foods to support the community, traveling distances ranging from a short walk from the village, to a near marathon jog of 20 to 30 miles, sometimes farther if they spent the night in a temporary camp.

Use areas around Dena'ina villages provided sites for gathering food and other resources from uplands and wetlands. Examples include logs for building materials and firewood, grass for basketry, spruce roots and porcupine quills for crafts and personal adornment, and other plants and animals for fabricating tools, weapons, and a variety of items. Use areas were probably thoroughly explored to a distance of at least 10 miles (probably much farther for the young and fit), as well as at least 40 miles upstream on navigable waterways (Boraas, pers. comm. June 2012). This distance would have allowed a person to gather or hunt and return home the same day. Plant materials that were supple, flexible, easily worked, and water-resistant—such as stems from willow and cottonwood—were particularly useful in fabricating items such as snowshoes, baskets, and fish traps. Table 3.5i lists a variety of wetland plants and their common Dena'ina uses, and shows where such plants might be found. Three examples of items crafted from plants are shown below. (These are part of the “Hands-on loan program” of the Alaska Department of Education and Early Development, Division of Libraries, Archives and Museum (https://education.alaska.gov/productcart/pc/home.asp); see: https://education.alaska.gov/productcart/pc/viewCategories.asp?idCategory=8.)

Model fish trap. Split stick, cone-shaped fish trap, smaller cone fits inside, bound with twine.

Model snowshoes with frames of cottonwood and laced with bleached moose skin.

Coiled split-willow-root basket.

Sharing food resides in the hearts of Dena’ina as a primary, deep-seated value. In order to have food to share, Dena’ina seek out the locations of the best salmon runs; moose and caribou habitats; areas supporting porcupine, ground squirrels, snowshoe hare, and other small game; waterfowl and other bird nesting areas and migratory stopovers; berry patches; and areas supporting plants sought for food (or prized for medicines to cure ills ranging from fevers, to depression, to pain).

Berries—found in many wetlands—are an especially important part of the Dena’ina diet, but it is difficult to locate traditional berrying spots for the historic period, which extends over 200 years. This is in part due to the nature of peninsula wetland ecology: Berries respond with strong growth after disturbances that increase sunlight and warmth. Cold, wet summers on the coast would mean that berries inland might be more highly sought those years. Fires, natural succession of plant communities, and browsing by animals could change the locations of the best berry patches over time. Small streams might alter their course, and ponds could fill in or dry up. With their extensive knowledge of peninsula environments and ability to travel long distances, the Dena’ina would have been aware of such changes, locating new berry patches as needed.

A people who travel far

Recognizing the Dena’ina as a people who traveled far—not only throughout the Kenai Peninsula and across Cook Inlet, but farther north in Alaska following caribou and other herd animals long distances—provides an understanding of their approach to land use. Alan Boraas has recounted stories of young men living in Kenai at the time Peter Kalifornsky was there who thought nothing of traveling 20 miles on foot in the morning and returning the same distance that night. He told the story of a couple of young men cutting wood at Skilak, about 30 miles away from a dance they wanted to attend. They worked, jogged the 30 miles to the dance, danced the night away, and walked back to Skilak to cut more wood the next morning. Priscilla Russell confirmed that traditional Dena’ina, such as those she lived among in Lime Village in the 1970’s, would walk long distances over the mountains to trade goods with other Dena’ina. She accompanied Lime villagers on a caribou hunt, packing some of the meat out herself. She said that walking upriver and then constructing a moose-skin boat to return with moose or caribou and berries was typical.

Different seasons provided different ways to travel the landscape and harvest resources. While summer travel was more often by boat on the rivers or along the coast, in winter the Dena'ina were able to penetrate additional areas more easily. They made excellent snowshoes for winter travel. According to Priscilla Russell, these specialized snowshoes enabled them to cross glaciers. Pack dogs carried supplies; the Dena’ina did not use dog teams until after Russian contact. The wetland landscape itself was easier to traverse in winter. Bogs, lakes, and ponds froze, brush and tall grasses died back and were blanketed with snow, and many wetlands became huge flat expanses that one could see across and navigate over much more easily than in a forest. The Dena’ina could travel these areas after freeze-up to hunt and gather firewood, while also noting the locations of other resources.

As suggested above, the Dena’ina were experienced in the manufacture and use of boats, including birch bark canoes, moose-skin boats, and later, kayaks and bidarkas, which they learned about from encounters with Alutiiq and Yup’ik populations in the Cook Inlet region. The **image at right** shows hunting from a birch bark canoe (source: image 12 from http://www.anchoragemuseum.org/galleries/alaska_gallery/athabascan.aspx). Small groups, particularly in fall and winter, would walk upstream from their village near the river's mouth, following trails along the river, and then create a temporary camp. From there they could hunt, trap, and gather berries. Men, women and sometimes children would go together. To return, they constructed moose-skin boats at the campsite and floated back down the river with the current. This practice extended use areas up to (and sometimes more than) 40 miles upstream along rivers and adjacent wetlands that were navigable downstream using indigenous boats (Boraas, pers. comm. June 2012; Russell, pers. comm. June 2012).

After encountering Europeans and their interest in the fur trade, the Dena’ina began to trap more, and created winter trails for regular trap lines. Furbearers from the coldest and wettest areas on the peninsula, such as the kettle lakes in the flatlands north of Kenai, provided some of the best and thickest furs from beaver, muskrat, river otter, and other wetland mammals.

As explained earlier, locations of resources such as food and medicinal plants, firewood, animal species, etc. shifted over time in response to plant succession, fires, changes in stream courses, and other natural or manmade causes. Pinpointing more specifically the wetlands used before the 1950’s would be difficult because of such changes and because many of the elders who could identify such areas have now passed away. While some specially named places may have provided unique resources, most areas used by the Dena'ina are more effectively mapped by identifying general use areas as done here. Identifying traditional or local use areas has been a consistent approach in resource planning and conservation for many years; applying this method on the Kenai Peninsula provides a useful representation of Dena'ina resource-use patterns and reflects the significance of particular areas—such as wetlands—to Dena'ina communities.

Examples of Dena'ina plant use

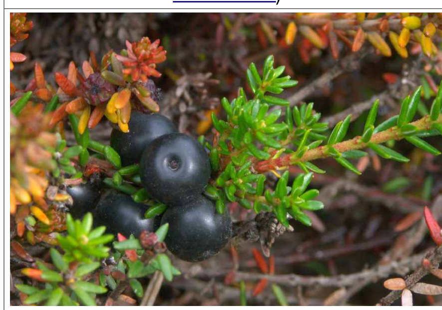
Although in this project, wetland areas significant to the Dena'ina were assessed by identifying general use areas within 10 miles of occupation sites, as described above, it is instructive to look at some of the specific ways that particular wetland plant species were used and where those plants might be found. Table 3.5i does that—listing a variety of ways that the Dena'ina used various wetland plants and showing locations where those plant communities were visited on the ground to collect data during wetland mapping. Photos below show some plants used.

Note, not all plants found in mapped wetland plant communities occur only in wetlands, some plants are able to adapt to a wide range of conditions. For a list of Alaskan plants showing their *wetland indicator status*, see http://www.kenaiwetlands.net/AKWetlandIndicatorStatus.html. Indicator status includes categories like OBL (*Obligate Wetland*), meaning the plant is "obligated" to live in a wetland (i.e., is a hydrophyte) and FACW (*Facultative* W*etland*), meaning the plant is usually a hydrophyte but is sometimes also found in uplands. Terms for indicator status are further defined at http://plants.usda.gov/wetinfo.html.

Bog blueberry (*Vaccinium uliginosum*) (from http://www.turtlepuddle.org/alaskan/wild/berries.html)

Lowbush cranberry (*Vaccinium vitis-idaea*) (from http://www.turtlepuddle.org/alaskan/wild/berries.html)

Small cranberry (*Vaccinium oxycoccos*) (from http://plants.usda.gov/java/)



Crowberry (*Empetrum nigrum*) (http://www.turtlepuddle.org/alaskan/wild/berries.html)

Cloudberry (*Rubus chamaemorus*) (from http://plants.usda.gov/java/)

Strawberryleaf raspberry (*Rubus pedatus*) (from http://plants.usda.gov/java/)

Marsh Labrador tea (*Ledum palustre* ssp. *decumbens*) (from http://plants.usda.gov/java/)

Field horsetail (*Equisetum arvense*) (from http://plants.usda.gov/java/)

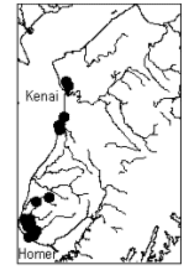
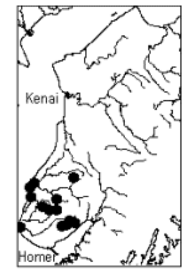
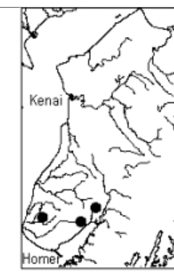
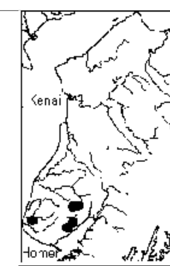
Barclay's willow (*Salix barclayi)* (from http://www.kenaiwetlands.net/EcosystemDescriptions/lateSnow.htm)

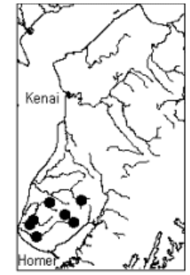
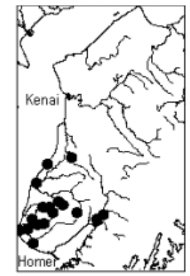
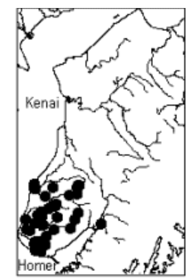
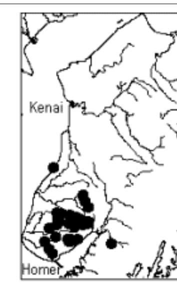
The Dena'ina emphasize the importance of addressing a plant in a respectful way... Plants should also be treated respectfully. A person should avoid wasting plants. Parts that he cannot use he should gather in one place so that they will not be stepped on or abused in any other way. Doing this also creates feed piles for animals and helps to insure that the parts that man cannot use will be used by other creatures... The Dena'ina say that the animals taught people which plants they can use.

– Priscilla Russel Kari, *Dena'ina* [*Tanaina*] *Plantlore*

Table 3.5i. Examples of Dena'ina plant uses, along with plant communities where those plants may occur (use categories are color coded).
(Uses are from *Tanaina Plantlore* (Priscilla Russell Kari 1995), all other content was derived from http://www.kenaiwetlands.net/plant_community_classification_i.htm unless otherwise noted.)

1. Uses of edible berries: for food (including food preserved for winter), added to *nivagi* (Indian ice cream), used for dyes; some berries also used for medicine.

Species in non-forested communities with berries	Plant community name and link	Photos	Sites visited
Edible berries and selected other plants • *Empetrum nigrum* (crowberry) • *Vaccinium vitis-idaea* (lowbush cranberry) • *Vaccinium uliginosum* (bog blueberry) • *Vaccinium oxycoccos* (small cranberry) • *Rubus chamaemorus* (cloudberry) for the following, see uses under #4 • *Salix fuscescens* (Alaska bog willow) • *Ledum palustre* ssp. *decumbens* (Labrador tea) • *Equisetum arvense* (field horsetail)	**Crowberry– Labrador tea** *Empetrum nigrum – Ledum palustre* ssp. *decumbens* http://www.kenaiwetlands.net/communityDescriptions/EmniLepad.htm	 19 sites visited on the ground	
Edible berries and selected other plants • *Empetrum nigrum* (crowberry) • *Vaccinium uliginosum* (bog blueberry) • *Vaccinium oxycoccos* (small cranberry) • *Rubus chamaemorus* (cloudberry) for the following, see uses under #3 and #4 • *Picea x lutzii* (stunted Lutz spruce) • *Ledum palustre* ssp. *decumbens* (Labrador tea) • *Equisetum arvense* (field horsetail) • Moss	**Crowberry – Bog blueberry** *Empetrum nigrum – Vaccinium uliginosum* http://www.kenaiwetlands.net/communityDescriptions/EmniVaul.htm	 13 sites visited on the ground	
Edible berries and selected other plants • *Vaccinium uliginosum* (bog blueberry) • *Empetrum nigrum* (crowberry) • *Vaccinium vitis-idaea* (lowbush cranberry) • *Vaccinium oxycoccos* (small cranberry) • *Rubus chamaemorus* (cloudberry) for the following, see uses under #3 and #4 • *Picea x lutzii* (stunted Lutz spruce) • *Ledum palustre* ssp. *decumbens* (Labrador tea) • *Equisetum arvense* (field horsetail)	**Bog blueberry – Manyflower sedge – Dwarf birch** *Vaccinium uliginosum – Carex pluriflora – Betula nana* http://www.kenaiwetlands.net/communityDescriptions/VaulCapl6Bena.htm	 3 sites visited on the ground	
Edible berries and selected other plants • *Vaccinium uliginosum* (bog blueberry) • *Empetrum nigrum* (crowberry) • *Vaccinium oxycoccos* (small cranberry) • *Rubus chamaemorus* (cloudberry) for the following, see uses under #4 • *Deschampsia caespitosa* (tufted hairgrass) • Moss	**Bog blueberry – Dwarf birch – Tufted hairgrass** *Vaccinium uliginosum – Betula nana – Deschampsia caespitosa* http://www.kenaiwetlands.net/communityDescriptions/VaulBenaDeca18.htm	 5 sites visited on the ground	

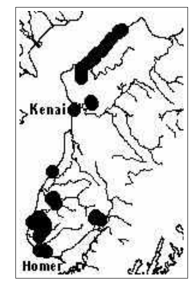
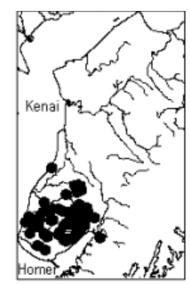
Edible berries and selected other plants • *Empetrum nigrum* (crowberry) • *Vaccinium uliginosum* (bog blueberry) • *Vaccinium oxycoccos* (small cranberry) • *Rubus chamaemorus* (cloudberry) for the following, see uses under #3 and #4 • *Picea x lutzii* (stunted Lutz spruce) • *Carex pauciflora* (fewflower sedge) • *Ledum palustre* ssp. *decumbens* (Labrador tea) • Equisetum arvense (field horsetail) • Moss	**Fewflower sedge – Crowberry** *Carex pauciflora – Empetrum nigrum* http://www.kenaiwetlands.net/communityDescriptions/Capa19Emni.htm	 8 sites visited on the ground	
2. Uses of willows: to make snowshoes, fish hangers, basket rims, lean-tos, snares, fish weirs; willow called *q'eygish* used as medicine for stomachaches and headaches, inner bark used as food.			
Species in willow shrub communities	**Plant community name and link**	**Photos**	**Sites visited**
Willows and selected other plants • *Salix barclayi* (Barclay's willow) for the following, see uses under #1 and #4 • *Rubus arcticus* (arctic raspberry) • *Calamagrostis canadensis* (bluejoint grass) • *Equisetum arvense* (field horsetail) • Moss	**Barclay willow / Bluejoint** *Salix barclayi / Calamagrostis canadensis* http://www.kenaiwetlands.net/communityDescriptions/Saba3Caca4.htm	 26 sites visited on the ground	
Willows and selected other plants • *Salix barclayi* (Barclay's willow) for the following, see uses under #1 and #4 • *Calamagrostis canadensis* (bluejoint grass) • *Equisetum arvense* (field horsetail) • *Rubus arcticus* (arctic raspberry) • *Chamerion angustifolium* (fireweed) • Moss	**Barclay's willow / Bluejoint – Field horsetail** *Salix barclayi / Calamagrostis canadensis – Equisetum arvense* http://www.kenaiwetlands.net/communityDescriptions/Saba3Caca4Eqar.ht m	 39 sites visited on the ground	
Willows and selected other plants • *Salix barclayi* (Barclay's willow) for the following, see uses under #1 and #4 • *Calamagrostis canadensis* (bluejoint grass) • *Sanguisorba canadensis* (Canadian burnet) • *Equisetum arvense* (field horsetail) • *Rubus arcticus* (arctic raspberry) • *Chamerion angustifolium* (fireweed) • Moss	**Barclay's willow / Rich** *Salix barclayi* / Rich http://www.kenaiwetlands.net/communityDescriptions/Saba3Rich.htm	 43 sites visited on the ground	

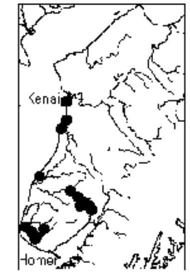
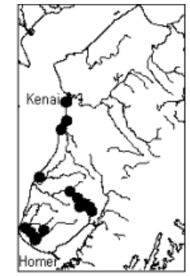
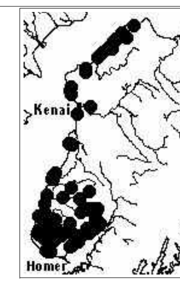
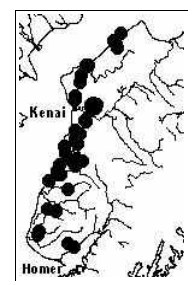
3. Uses of tree species:

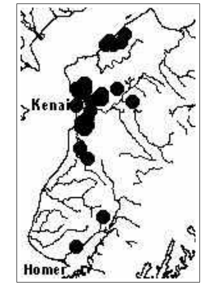
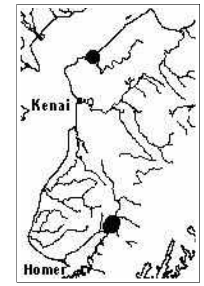
All spruce species – Lutz spruce (*Picea X lutzii*), which is a hybrid of white spruce (*P. glauca*) and Sitka spruce *P. sitchensis),* and **black spruce** (*P. mariana*); spruce were called *ch'vala* when not differentiated by color and density of wood; *ch'bach'etl'a* means "spruce shriveled" and refers to a stunted spruce (most often black spruce). Many uses of spruce are not differentiated by species but by features of the wood, for example, *ch'ik'eda* refers to spruce wood with medium hardness (density) and darkness, while *dehzila* refers to the lightest and softest spruce wood. *Dehzila* is the fastest growing spruce, found on uplands where warm, dry conditions cause trees to grow quickly, creating wide tree rings. This produces a softer, more bendable wood. *Ch'ik'eda* grows slower than *dehzila* but faster than *ggek* (black spruce), which produces a wood of medium density that is well suited for boat ribs, paddles, poles, and plank drums.

- Poles and logs used for construction of buildings—including houses, stream rooms, smokehouses, and food caches; also used in constructing fish traps, weirs, fish racks, rafts, killing clubs, wheels; depending on hardness of wood, used in manufacture of arrows, dishes, boat ribs, paddles, poles, handles for tools and knives, and plank drums.
- Outer spruce bark used for dying hides and fishnets; for roofing, flooring, and siding of buildings; as a non-slip surface for cutting fish; added white side up to fish basket traps to reflect fish. (Dena'ina carefully choose which trees to debark, knowing that taking too much can kill the tree.)
- Roots peeled and made into thin cordage for use in manufacturing dip nets, fishing line, fishing snares, ice scoops, hats, and baskets (some woven root baskets were water tight and used for cooking); roots also used medicinally, either by dripping the juice into the eye or boiled into a tea. (Spruce roots can be re-harvested roughly 3 years later from the same tree.)
- Needles and branch tips used medicinally, the former as a purgative, the latter to treat bone aches or for blood thinning.
- Strong tasting sap of late summer tree tips sometimes used to brew an alcoholic beverage.

Black spruce (*Picea mariana*) called *ggek*, which is the darkest, hardest spruce wood; *ggek* grows in cold, wet areas, so growth rings are close together; used for sleds, shafts or hunting spears, lances, digging sticks, shovels, fire drills, tongs for moving hot rocks, and splitting wedges.
Tamarack (*Larix laricina*) – used for boat ribs and sled runners.
Cottonwood (*Populus balsamifera*) – Used for making dugout canoes, roofing tiles, floats for nets, snowshoes, carved items like spoons and toys; winter buds provide medicine for sores, rashes, and frostbite; also used as incense; sap scraped off the inner bark is eaten as a delicacy; a favorite wood for smoking fish.
Any woody species – used for fuel for fires, construction material; seasoned standing dead trees and windfall are particularly useful for firewood; some wood such as alder and cottonwood used to smoke fish.

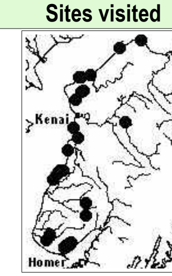
Species in forested communities	Plant community name and link	Photos	Sites visited
Lutz spruce, edible berries, and selected other plants • *Picea X lutzii* (Lutz spruce) • *Menziesia ferruginea* (rusty menziesia) for the following, see uses under #1 and #4 • *Vaccinium ovalifolium* (oval-leaf blueberry) • *Ribes triste* (red currant) • *Rubus pedatus* (strawberryleaf raspberry) • *Equisetum arvense* (field horsetail) • *Equisetum sylvaticum* (woodland horsetail) • *Calamagrostis canadensis* (bluejoint grass) • *Chamerion angustifolium* (fireweed)	**Lutz spruce / Rusty menziesia / Field horsetail** *Picea X lutzii / Menziesia ferruginea / Equisetum arvense* http://www.kenaiwetlands.net/communityDescriptions/PiluMefeEqar.htm	 50 sites visited on the ground	
Lutz spruce, willow, edible berries, and selected plants • *Picea X lutzii* (Lutz spruce) for the following, see uses under #1, #2, and #4 • *Salix barclayi* (Barclay's willow) • *Vaccinium ovalifolium* (oval-leafed blueberry) • *Empetrum nigrum* (crowberry) • *Calamagrostis canadensis* (bluejoint grass) • *Chamerion angustifolium* (fireweed) • *Equisetum arvense* (field horsetail) • *Rubus arcticus* (nagoonberry) • *Rubus pedatus* (strawberryleaf raspberry) • *Equisetum sylvaticum* (woodland horsetail)	**Lutz spruce / Barclay's willow / Bluejoint** *Picea X lutzii / Salix barclayi / Calamagrostis canadensis* http://www.kenaiwetlands.net/communityDescriptions/PiluSaba3Caca4.htm	 68 sites visited on the ground	

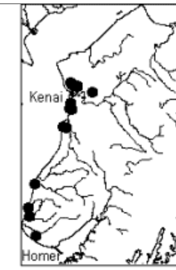
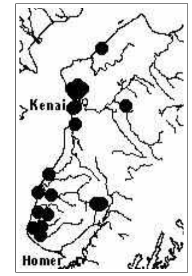
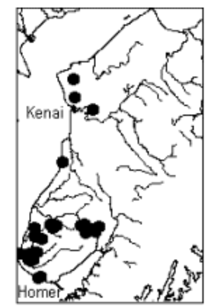
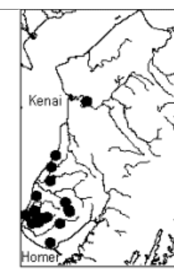
Lutz spruce, willow, edible berries, selected other plants • *Picea X lutzii* (Lutz spruce) for the following, see uses under #1, #2, and #4 • *Salix barclayi* (Barclay's willow) • *Vaccinium uliginosum* (bog blueberry) • *Ledum palustre ssp. decumbens* (Labrador tea) • *Empetrum nigrum* (crowberry) • *Vaccinium vitis-idaea* (lowbush cranberry) • *Vaccinium oxycoccos* (small cranberry) • *Equisetum arvense* (field horsetail) • *Rubus chamaemorus* (cloudberry) • *Calamagrostis canadensis* (bluejoint grass) • *Carex disperna* (sedge)	**Lutz spruce / Barclay's willow / Field horsetail / Crowberry** *Picea X lutzii / Salix barclayi / Equisetum arvense / Empetrum nigrum* http://www.kenaiwetlands.net/communityDescriptions/PiluSaba3EqarEmni.htm	 44 sites visited on the ground	
Lutz spruce, willow, edible berries, selected other plants • *Picea X lutzii* (Lutz spruce) for the following, see uses under #1, #2, and #4 • *Salix barclayi* (Barclay's willow) • *Empetrum nigrum* (crowberry) • *Ledum palustre ssp. decumbens* (Labrador tea) • *Vaccinium uliginosum* (bog blueberry) • *Vaccinium vitis-idaea* (lowbush cranberry) • *Calamagrostis canadensis* (bluejoint grass) • *Rubus arcticus* (arctic raspberry) • *Equisetum arvense* (field horsetail)	**Lutz spruce / Barclay's willow / Ericaceous shrub** *Picea X lutzii / Salix barclayi / Ericaceae* *http://www.kenaiwetlands.net/communityDescriptions/PiluSaba3Ericad.htm*	 18 sites visited on the ground	
Lutz spruce, edible berries, and selected other plants • *Picea X lutzii* (Lutz spruce) for the following, see uses under #1 and #4 • *Vaccinium ovalifolium* (oval-leafed blueberry) • *Ribes triste* (red currant) • *Calamagrostis canadensis* (bluejoint grass) • *Equisetum arvense* (field horsetail) • *Rubus pedatus* (strawberryleaf raspberry) • *Chamerion angustifolium* (fireweed) • Moss	**Lutz spruce / Field horsetail – Bluejoint** *Picea X lutzii / Equisetum arvense – Calamagrostis canadensis* http://www.kenaiwetlands.net/communityDescriptions/PiluEqarCaca4.htm	 91 sites visited on the ground	
Black spruce and edible berries • *Picea mariana* (black spruce) for the following, see uses under #1 and #4 • *Empetrum nigrum* (crowberry) • *Ledum palustre ssp. decumbens* (Labrador tea) • *Vaccinium vitis-idaea* (lowbush cranberry) • *Vaccinium uliginosum* (bog blueberry) • *Vaccinium oxycoccos* (small cranberry) • *Rubus chamaemorus* (cloudberry) • Moss	**Black spruce / Woodland horsetail – Labrador tea** *Picea mariana / Equisetum sylvaticum – Ledum palustre* ssp. *decumbens* http://www.kenaiwetlands.net/communityDescriptions/PimaEqsyLepad.htm	 53 sites visited on the ground	

Black spruce and edible berries • *Picea mariana* (black spruce) for the following, see uses under #1 and #4 • *Empetrum nigrum* (crowberry) • *Vaccinium vitis-idaea* (lowbush cranberry) • *Vaccinium uliginosum* (bog blueberry) • *Ledum palustre* ssp. *decumbens* (Labrador tea) • *Equisetum sylvaticum* (woodland horsetail) • *Calamagrostis canadensis* (bluejoint grass) • *Rubus chamaemorus* (cloudberry)	**Black Spruce / Crowberry – Lingonberry** *Picea mariana / Empetrum nigrum – Vaccinium vitis-idaea* http://www.kenaiwetlands.net/communityDescriptions/PimaEmniVavi.htm	 36 sites visited on the ground	
Cottonwood, alder, and edible berries • *Populus balsamifera* (Balsam poplar) for the following, see uses under #1 and #4 • *Alnus incana ssp. tenuifolia* (thinleaf alder) • *Ribes triste* (red currant) • *Rubus idaeus* (red raspberry) • *Calamagrostis canadensis* (bluejoint grass) • *Chamerion angustifolium* (fireweed) • *Equisetum arvense* (field horsetail) • *Heracleum maximum* (pushki, wild celery)	**Balsam poplar / Thinleaf alder** *Populus balsamifera / Alnus incana* ssp. *tenuifolia* http://www.kenaiwetlands.net/communityDescriptions/Poba2Alint.htm	 6 sites visited on the ground; photo http://www.kenaiwetlands.net/SEWARD/cnfCommunities/cnfPISIPOBAALVIS.htm	

4. Uses of other plants:

Fireweed (*Chamerion angustifolium*) – Young stems and leaves eaten raw or boiled; used as medicine to treat pus-filled boils or cuts.
Grasses (e.g., bluejoint grass, *Calamagrostis canadensis*, *Elymus* spp.) – Used for bedding for people and dogs; used for thatching roofs and covering floors; fresh grass burned to smoke heavily and repel mosquitos; partially chewed grass put on bee stings; used as a surface on which to place fish for cutting, this grass would be saved and boiled in winter to make soup in times of food shortage; used to mark trails, also piled in swampy areas to improve footing; used as insulation in clothing and footwear; woven into baskets; used to conceal traps; used in making balls, jump ropes, and whistles; at Skilak Lake, grass or moss laid on rocks to encourage to attract gulls to lay eggs there, eggs would then be collected for food.
Horsetail (*Equisetum* spp.) – In spring, tubers collected for food; ashes from burned stems and leaves put on sores, root heated and placed against aching teeth.
Labrador tea (narrow leaf – *Ledum palustre* ssp. d*ecumbens*) – Brewed for tea, spice for meat; used to treat colds, tuberculosis, arthritis, stomach problems, heartburn, dizziness, laxative, and to wash sores.
Pushki, cow parsnip, or wild celery (*Heracleum maximum*) – Called *ggis*, stems peeled and eaten raw, boiled, dipped in lard, or chopped into soups or stews; dried stem used as drinking straw; many medicinal uses, e.g., root chewed raw or boiled for tea for colds, sore throats, mouth sores, and tuberculosis; root boiled or soaked to produce wash applied to swellings, cuts, sores, arthritis, and other body aches.
Sedges (*Carex spp.*) – Dena'ina distinguish a number of sedges by name, sedges used to make rope; leaves woven into baskets, mats, and brooms; thick underground stem of a large sedge used for food.
Sphagnum moss (*Sphagnum* spp.) – "Red sphagnum" boiled or warmed and then applied to reduce swelling associated with broken bones, dislocations, cuts, or blood poisoning; "white sphagnum" used as a camp mattress and building insulation, used for toilet paper, diapers, menstrual pads; dried can be used as a paintbrush; during food shortages, boiled and mixed with lard for dog food; also used for injuries.
Sweetgale (*Myrica gale*) – Leaves boiled to create a tea used as medicine for tuberculosis, tea is used as a wash for boils, and pimples; popular switch in the steambath.

Species in miscellaneous plant communities	Plant community name and link	Photos	Sites visited
Grasses, herbs, and selected other plants • *Calamagrostis canadensis* (bluejoint grass) • *Equisetum arvense* (horsetail, jointed grass) • *Chamerion angustifolium* (fireweed) • *Polemonium acutiflorum* (tall Jacob's ladder) • *Sphagnum* spp. (Sphagnum moss)	**Bluejoint -- Field horsetail** *Calamagrostis canadensis – Equisetum arvense* http://www.kenaiwetlands.net/communityDescriptions/Caca4Eqar.htm	 36 sites visited on the ground	

Shrubs, dwarf shrubs, and selected other plants • *Myrica gale* (sweetgale) • *Betula nana* (dwarf birch) • *Andromeda polifolia* (bog rosemary) • *Carex livida* (livid sedge) • *Menyanthes trifoliata* (buckbean) • *Sphagnum* spp. (Sphagnum moss)	**Sweetgale – Livid sedge** *Myrica gale – Carex livida* http://www.kenaiwetlands.net/communityDescriptions/MygaCali.htm	 16 sites visited on the ground	
Sphagnum moss, shrubs, selected other plants • *Myrica gale* (sweetgale) • *Dasiphora floribunda* (shrubby cinquefoil) • *Ledum palustre* ssp. *decumbens* (Labrador tea) • *Eriophorum angustifolium* (fireweed) • *Sphagnum* spp. (Sphagnum moss) for the following, see uses under #1 • *Empetrum nigrum* (crowberry) • *Vaccinium uliginosum* (bog blueberry) • *Vaccinium oxycoccos* (small cranberry) • *Rubus chamaermorus* ((cloudberry)	**Sweetgale – Shrubby cinquefoil** *Myrica gale – Dasiphora floribunda* http://www.kenaiwetlands.net/communityDescriptions/MygaDafl3.htm	 27 sites visited on the ground	
Sphagnum moss, shrubs, selected other plants • *Picea X lutzii* (stunted Lutz spruce) • *Empetrum nigrum* (crowberry) • *Betula nana* (dwarf birch) • *Ledum palustre* ssp. *decumbens* (Labrador tea) • *Vaccinium uliginosum* (bog blueberry) • *Vaccinium vitis-idaea* (lowbush cranberry) • *Vaccinium oxycoccos* (small cranberry) • *Andromeda polifolia* (bog rosemary) • *Salix fuscescens* (Alaska bog willow) • *Rubus chamaemorus* (cloudberry) • *Carex pluriflora* (manyflower sedge) • *Equisetum arvense* (horsetail, jointed grass) • *Sphagnum* spp. (Sphagnum moss)	**Sphagnum moss – Ericaceous shrub** *Sphagnum* spp. – *Ericaceae* http://www.kenaiwetlands.net/communityDescriptions/SphagEricad.htm	 26 sites visited on the ground	
Selected plant species • *Betula nana* (dwarf birch) • *Myrica gale* (sweetgale) • *Andromeda polifolia* (bog rosemary) • *Vaccinium oxycoccos* (small cranberry) • *Trichophorum caespitosum* (tufted bulrush) • *Eriophorum angustifolium* (tall cottongrass) • *Drosera rotundifolia* (roundleaf sundew) • *Sphagnum* spp. (Sphagnum moss)	**Tufted bulrush – Tall cottongrass** *Trichophorum caespitosum – Eriophorum angustifolium* http://www.kenaiwetlands.net/communityDescriptions/Trca30Eran6.htm	 17 sites visited on the ground	

3.5.3.7. Introduction to Dena'ina "place names"

Sites significant to the Dena'ina—particularly settlement sites—were identified by mapping sites with Dena'ina place names (see Section 3.5.3.4). Locations of place-named sites—particularly villages and occupation sites—became the basis for identifying use areas. An introduction to Dena'ina place names is appropriate here.

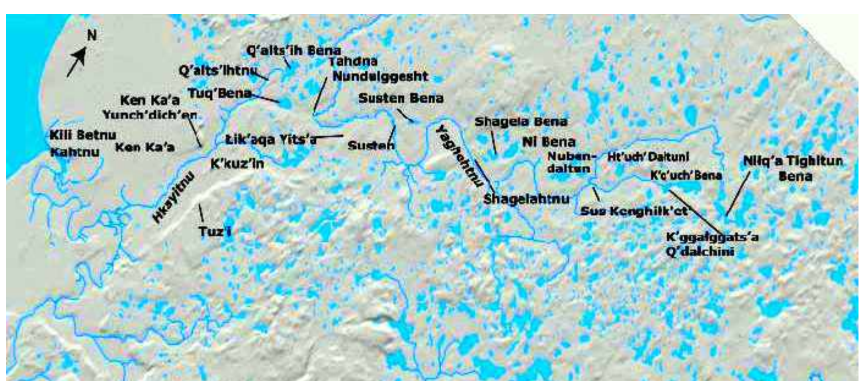
Dena'ina have for centuries given place names to sites with some significance, and these names have been passed down from generation to generation. In addition to settlement sites, place names were given to areas used for winter trails, fishing sites, hunting or trapping areas, locations where particular bird or mammal species were commonly found, sites where significant events occurred, or locations of distinctive landscape features, such as stream outlets, river confluences, or mountain peaks.

> **"The traditional Dena'ina would have thought it extremely arrogant to name a place or landmark after a person. Lakes and creeks and mountains were themselves, not the property of or secondary to people. Nor did Dena'ina in historical times coin new names for pieces of the landscape; all necessary names pre-existed, reaching back through generations of oral tradition. In fact, when Dena'ina place names were collected, a remarkable consistency was found among speakers from various communities and regions. Names were reported with care and with obvious affection or concern for their associations…**
>
> **Dena'ina Shem Pete, before his death several years ago, recorded hundreds of place names covering the vast area of upper Cook Inlet he'd hunted and fished and traveled all his life. A mountain ridge we can see from our camp was known as Ridge Where We Cry. He said about this place and its name: "They would sit down there. Everything is in view. They can see their whole country. Everything is just right under them. They think about their brothers and their fathers and mothers. They remember that, and they just sit down there and cry. That's the place we cry all the time, 'cause everything just show up plain."**
>
> Nancy Lord, 1997, *Fishcamp: Life on an Alaskan Shore,* Washington, D.C., Counterpoint: 62-63

As the quote at right illustrates, the Dena'ina consider naming places both a spiritual and practical action. Anthropologist Alan Boraas, linguist James Kari, and others have been working for more than four decades with Dena'ina elders and culture bearers to identify Dena'ina place names throughout the Kenai Peninsula. Well over 200 place names have been recorded. While a relatively small number of place names indicate wetlands as scientists now define them, many refer to villages and camps located near wetlands, which the Dena'ina used for food, medicines, and other resources.

The significance of place names is described by Alan Boraas in "The Moral Landscape of the South-Central Dena'ina," introduced above (Section 3.5.3.5). As the following excerpts from that paper make clear, Dena'ina place names reflect an intimate and powerfully meaningful connection of a people to the landscapes that support their physical, emotional, social, and spiritual survival and well-being. Borass—a speaker of Dena'ina—notes that "more complete understanding of the ideas presented here requires knowledge of the Dena'ina language as a vehicle for these ideas." (In the following excerpts, citations have been deleted, these can be found by downloading the paper from:__.)

> Place-names figure prominently in Dena'ina cosmology in part because, through place-names, they formed a cognitive map of territory, hence provided a reference point of experience. Peter Kalifornsky's [story] "Where I trapped: *Guduh K'uhu Ghel'ih*"[69] for example takes us on a journey over his winter trapline from one place to the next, each rich in information of his experience (**see map below**). The story is a map made meaningful only by the shared experience of his people, who also traveled the territory and knew the names for the landscape and the history of events that happened there. Likewise ethnogeographic place-names for the Kenai River [see Map 3.5c] provided a mental map of one's social sphere and represented, along with certain traditional stories or *sukdu*, part of the shared know-



69 Kalifornsky, Peter, 1991, *K'tl'eghi Sukdu*: A Dena'ina Legacy, edited by James Kari and Alan Boraas, Alaska Native Language Center, Fairbanks

ledge of place. Place names manifest the shared historic and current experience of a place and are one of the foundations of Dena'ina identity. (p. 6ff)

Dena'ina place names are highly descriptive. Of the 52 place-names along the Kenai River, 33 describe the physical setting, (e.g., *Ts'eldatnu*, Trickles Down Creek); 8 describe plant or animal characteristics, (e.g., *Yeq Qałnik'at*, Cormorant's Rock; *Esniggwat*, Aspen Place); 8 describe a human activity, (e.g., *Shk'ituk't*, We slide Down on Snow Place, i.e. sledding hill); and 3 describe a cultural feature, (e.g., *Batinitin Bena*, Trail goes by it Lake), or artifact (e.g., *Tsałt'eshi*, Black Stone Axe Ridge). (p. 7)

Places can carry a deeper meaning than that conveyed by the place-name, and this is often expressed through the spirits of place… [A] place could be good, bad, or benign depending on the events that had happened there. Good Tree Spirits, *Ch'wala dnayi*, would exist at a place below tree-line that was associated with a good event or at which one regularly got a good feeling when visiting. Evil Tree Spirits might populate a place where an aggressive, hostile act occurred, and an ominous feeling would be felt by someone who ventured there. Those with acute perception might be able to detect the event in mental images, while others might only get a generally good or generally bad feeling. Anthropologist Osgood alluded to this when he wrote in 1937, "The trees and grass talk to people and so do stones and mountains." (p. 8)

A number of places are known in the published Dena'ina literature and oral history for good or evil events that happened there and which emanate good (*beggesha*) or evil (*beggesh*) information. Many more are known, particularly those associated with sacred places, however, culture bearers consider their location to be privileged cultural property rights at this time. (p. 10)

In his paper, Boraas provides a number of examples of place names. Three examples of village sites on the Kenai Peninsula are excerpted below.

Tiduqilts'ett means "Disaster Place" and is now an abandoned village on the bluff between the Swanson River mouth and the mouth of Beaver Creek on the Kenai Peninsula. The "disaster" is the influenza epidemic of 1918-19 in which as much as half the Dena'ina population of Cook Inlet died. In some cases whole villages died out and in other cases villages became too depopulated to sustain themselves. With small village abandonment, there was population coalescence, with Kenai, Tyonek, and Eklutna emerging as the primary villages of Cook Inlet, and Nondalton, Pedro Bay, Iliamna, and Lime Village as the significant villages of the Bristol Bay drainage Dena'ina... That epidemic was taken as a premonition of political disaster involving Dena'ina loss of sovereignty and *Tiduqilts'ett*—disaster place—took on the meaning of uncontrollable adversity... [T]o traditional Dena'ina the horror of both the event and the place is quite real and many refused to go near *Tiduqilts'ett* well into the 20th century because of the evil forces that linger there. (p. 10ff)

Tuqeyankdat

Tuqeyankdat literally means "Bad Clearing" and was a Dena'ina village located at the present site of the Conoco-Phillips gas liquification plant north of Kenai. Kalifornsky (1991[70]) writes that the people of the village were fearful of attack but when the war party came, the attackers encountered a baby who was doing something unusual with its hands, which was taken as an ominous sign and the attackers left. Kalifornsky indicated the attackers were from the Lake Clark area, and the story depicts internal strife within Dena'ina culture. Strife between the Inland and Outer Inlet Dena'ina appears in other stories as well… In the case of *Tuqeyankdat* the strife appears to have involved an actual war party (although the story could be metaphorical).

The settings of these "battles" occur during the late 19th and early 20th century when the histories of the Outer Cook Inlet Dena'ina and the Inland, Bristol Bay drainage Dena'ina markedly diverge. By the late 1800s Kenai was being inundated with outsiders working in the commercial salmon canning industry, and Tyonek became a transfer point for miners going to the short-lived but significant Hope and Sunrise gold fields. At

70 Kalifornsky, Peter, 1991, *K'tl'eghi Sukdu*: A Dena'ina Legacy, edited by James Kari and Alan Boraas, Alaska Native Language Center, Fairbanks

the same time outsider occupation of the Inland area involved fewer numbers and consisted primarily of itinerant winter trappers and a few prospectors, some of whom married into Dena'ina families, whose primary economic activity was summer cannery/fishing work at the coastal communities of Bristol Bay in Yup'ik territory, winter trapping, and some mining. While colonization pressures on the Outer Inlet people were immense, those on the Inland people were far less intense and, like many wars, the shaman battle was ideological over the degree, nature, and intensity of adoption of Western, non-Dena'ina ways. That the remnant of the abandoned *Tuqeyankdat* was destroyed in the 1960s to build the then Phillips Petroleum gas liquification plant (now Conoco-Phillips) in yet another wave of occupation of Dena'ina territory gives an additional layer to the information of the place.

Unhghenesditnu

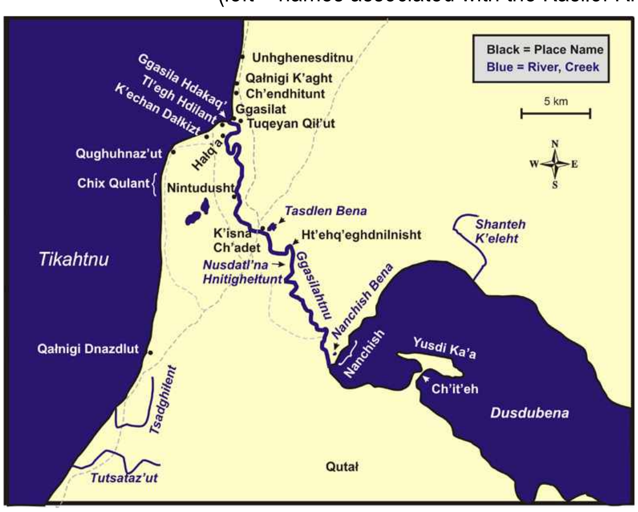
Unhghenesditnu means "farthest over river" and was the name for what is now called Kalifornsky Village, which is located on the east side Cook Inlet bluff between the Kenai and Kasilof Rivers. It is the site of one version of the "Kustatan Bear Story," called the "Other Half of the Kustatan Bear Story" (Kalifornsky 1991). The shaman war at Kalifornsky village was perpetrated by two evil shaman from Kijik on Lake Clark and people of the Cook Inlet area. The evil shaman cause their spirit to invade a bear which cannot be killed by normal means. Finally, the people overcome the evil by killing the bear with spiritually blessed bullets. The remains of the evil shaman were purified and buried at Kalifornsky Village. Like Stepanka's Village and *Tiduqilts'ett*, Kalifornsky Village was abandoned after the 1918-19 influenza epidemic.

3.5.3.8. Mapped place-named sites used in identifying Dena'ina use areas

For this assessment (and as described in Section 3.5.3.4), place names and their locations were compiled from existing sources, such as **Map 3.5c, shown below**. The area covered encompassed non-federal lands (as well as some federal lands) along the west coast of the Kenai Peninsula from the north side of Kachemak Bay to Point Possession. (The wetland Culture/heritage value was not assessed in the Seward area due to lack of information.) Place names associated with villages and occupation sites were then used to identify use areas, with a circular "buffer" drawn around each village and occupation site. Buffer circles have a 10-mile radius—as shown in Map 3.5d (on the following page). Wetlands were then given scores based on the two variables listed in Table 3.5k. (Areas were scored as having "high potential for archeological sites" based on the absence of occupation sites in areas where such sites would be expected.) Results are shown in Map 3.5e.

Table 3.5j lists the villages and occupation sites used in identifying use areas for this assessment. From the north, villages and other occupation sites follow the coastline, and also most probably the direction of migration south onto the Kenai Peninsula. Peter Kalifornsky, however, who provided the most extensive list of place names for the peninsula, labeled places he knew from south to north, and his convention is followed in Table 3.5j. The names of different Dena'ina bands, as James Kari has recorded them, generally correspond to use areas. Listed villages and occupation sites are shown on Map 3.5e as light blue dots.

Map 3.5c. Examples of "place name" maps (these maps have been updated as a part of this project)
(left – names associated with the Kasilof River; right – names associated with the Kenai River).



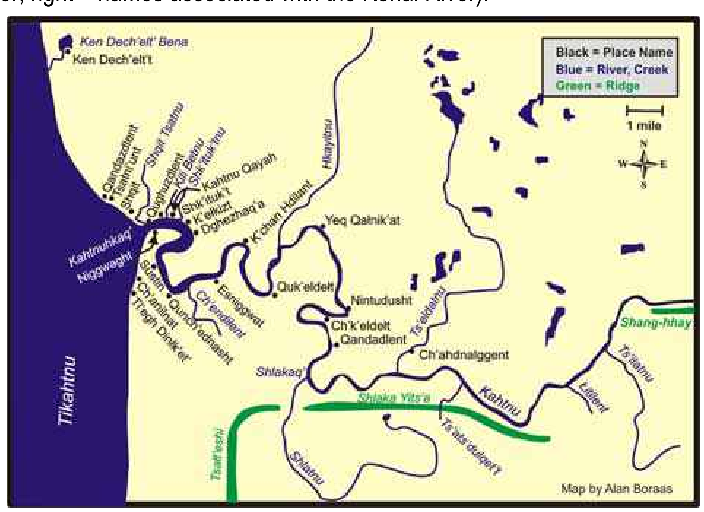
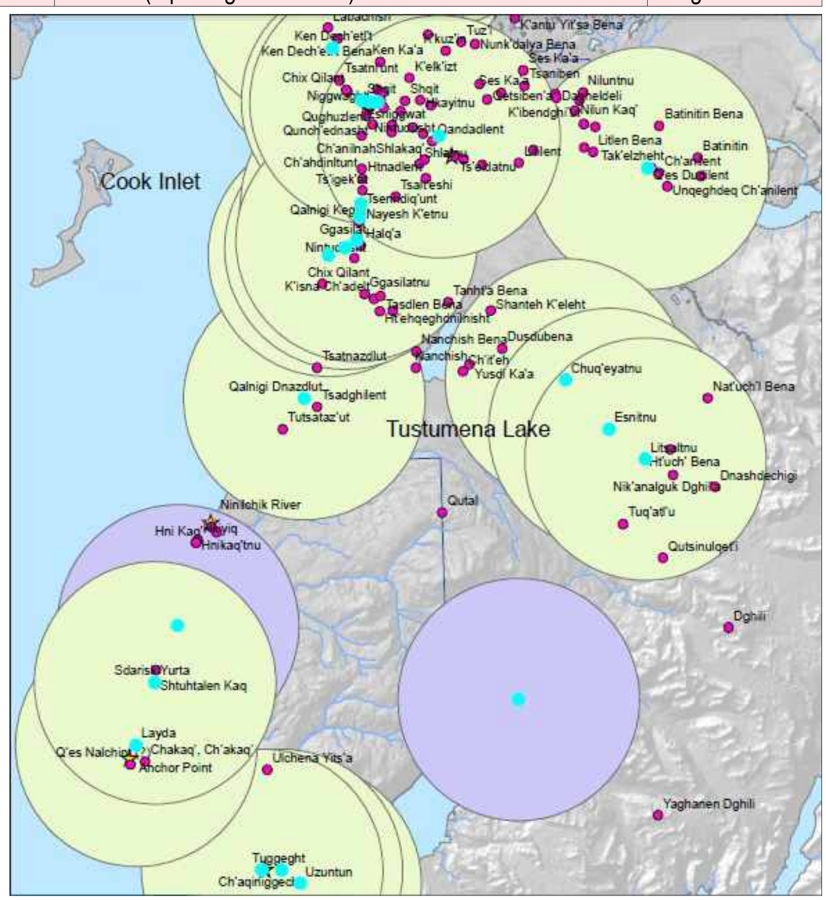


Table 3.5j. Dena'ina place-named villages and occupation sites used in identifying "use areas"			
Site #	Location	Site name (translation);	Site type
3	Beluga Lake area	Tuggeght (at the water)	Occupation site
4	Homer Spit	*Uzuntun* (extends into distance)	Occupation site
5	Bluff Point	*Ch'aqiniggech't* (where objects are scattered or eroded out)	Occupation site
8	Laida (Anchor Point?) [River Mouth People, *K'kaq' Ht'ana*]	*Layda* (Russian: below high-water line)	Occupation site
9	Stariski Creek area (fish trap site)	*Yurta* (Russian: yurt)	Occupation site
21	Clam Gulch	*Qalnigi* Dnazdlut (rocks are there)	Occupation site
25	Cape Kasilof, "Humpie's Point"	*Qughuhnaz'ut* (point extends out)	Village site
26	Site south of Kasilof River	*K'echan Dalkizt* (where there is grass)	Village site
?	Kasilof site	*Ggasilat* (?)	Village site
30	Sites at outlet of Skilak Lake, Stepanka's village	*Q'es Dudilent* (flows-into-outlet place)	Village site
33	Kalifornsky Village and Creek	*Unhghenesditnu* (farthest over river)	Village site
35	Creek and bluff at Shadura's	*Tsenhdiq'unt* (where fire burned downward)	Village site
36	Salamatof	*Ken Dech'etl't* (scrub-timber flat)	Village site
46	Flat north of Fort Kenai at Redoubt Terrace	*Shqit* (sloping flat)	Village site
55	Nikiski No. 1	*Tuqyankdat* (poor clearing)	Village site
60	Daniels Lake, Nikishka No. 2	*Dghezha Bena* (stickleback lake)	Village site
62	Bishop Creek	*Dghezhaleht* (where sticklebacks run)	Village site
63	Site between Swanson River and Bishop Creek	*Tiduqilts'ett* (abandoned place)	Village site
69	Moose Point	*Hnik'daghi'ut* (where something is embedded)	Village site
71	Point Possession village	*Ch'aghelnikt* (protected on one side)	Village site
?	Bear Creek	*Chuq'eyatnu* (birch river)	Village site
?	Moose Creek	*Esnitnu* (cottonwood creek)	Village site
?	Indian Creek	*Litsaltnu* (square glacier creek)	Village site

Table 3.5k. Kenai Peninsula Wetland Assessment Method—Community/Culture		
FUNCTION 3: Culture/heritage – Dena'ina use		
1	Wetland polygon overlaps an identified Dena'ina use area	40
2	Wetland polygon overlaps a potential Dena'ina use area (area with high archeological potential)	30
3	Wetland polygon meets none of the above criteria	0

Map 3.5d shows Dena'ina use areas; Map 3.5e provides results of the assessment.

Map 3.5d. 10-mile-radius use areas around each identified village and occupation site listed in Table 3.5j.

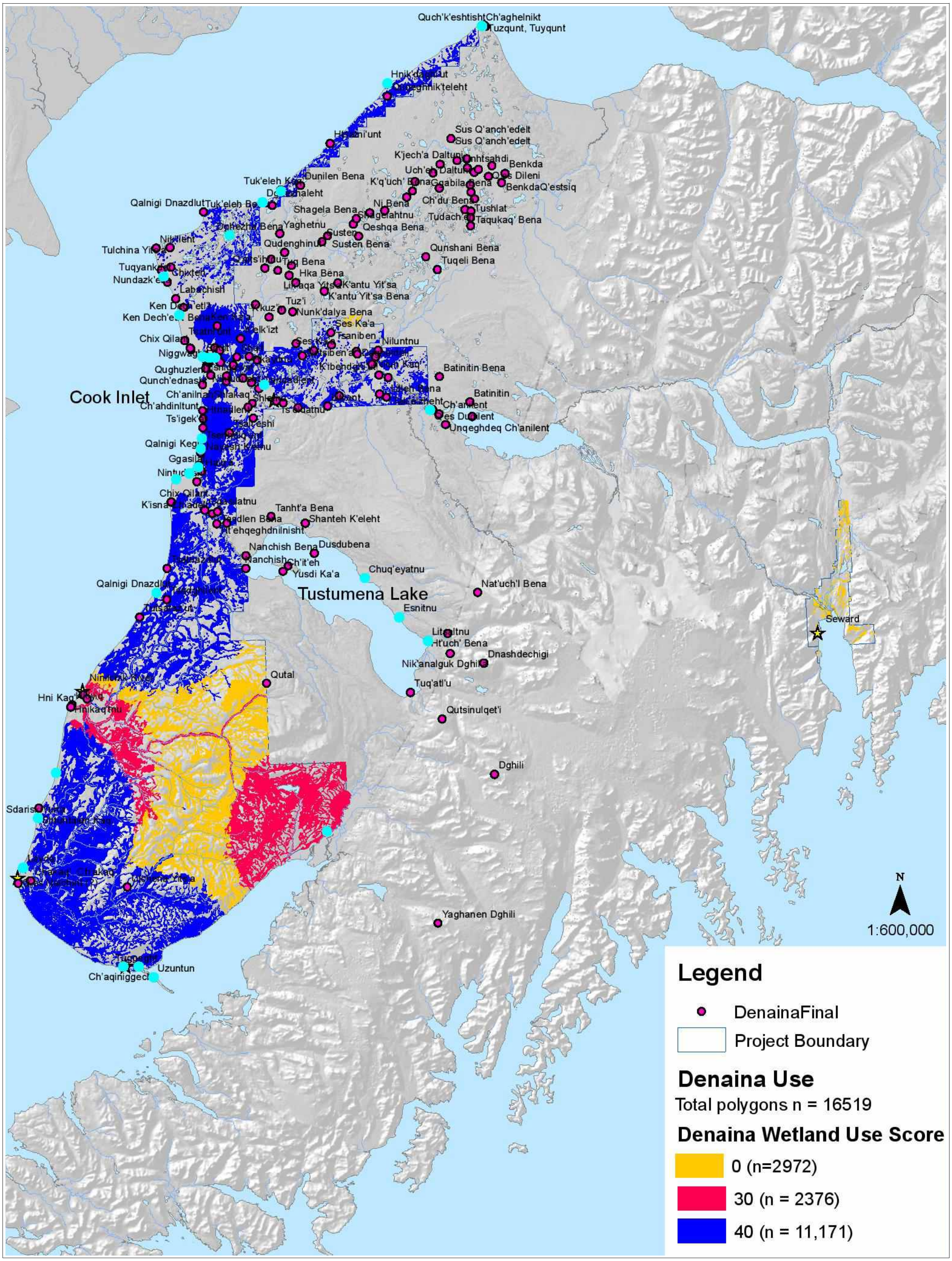


Legend

- Denaina Place Names
- Project Boundary
- 10 Mile Denaina Village or Occupation Site Buffer
- 10 Mile Denaina Potential Occupation Site Buffer

Map 3.5e. Identified place named sites in the Kenai lowlands, villages and occupation sites in light blue, other sites in magenta

(For a map with higher resolution, see https://sites.google.com/site/kpwetlandassessments/home/all-assessment-maps.)



Chapter 4. How peninsula wetlands are legally protected

Because of the many beneficial functions and values associated with wetlands, federal, state, and borough laws and regulations protect these areas. If you discover from the wetland layers on the borough's interactive parcel viewer that you have a wetland where you want to put a building, road, or some other improvement, you'll want to read this chapter[71]. Here you'll find what you need to know and do about wetland permits. Having this information BEFORE you dig up (dredge) or dump into (fill) a wetland will help you avoid costly fines and legal headaches caused by developing what are called "jurisdictional" wetlands. But more significantly, even if regulations weren't in place, wetlands are generally very poorly suited for many kinds of development because of things like high water tables, the very low bearing strength of most wetland soils, and poor soil drainage. Most landowners will save money by avoiding wetlands and looking instead for "uplands" in which to site developments[72]. The text box on the next two pages provides a cautionary tale related to developing wetlands without adequate consideration of their functions.

4.1. How to know if you need permits for activities affecting wetlands (including anadromous waters, floodplains, and water quality)

As this assessment shows, wetlands benefit individuals and society in many ways. Certain activities that damage wetland functions and values—such as dredge and fill activities—require a permit from the US Army Corps of Engineers (the Corps or COE). The EPA weighs in on applications for Corps permits and has the authority to veto permit approval. In addition, if you plan to conduct an activity below "ordinary high water" on an anadromous stream or other water body, you'll also need a permit from the Alaska Department of Fish and Game (ADF&G, ADFG). Similarly, certain activities within 50 feet of an anadromous water body or within a floodplain in the Kenai Peninsula Borough require a borough permit. (You may also be eligible for tax breaks of your borough property tax if you undertake certain beneficial actions within these 50-ft buffers.) Actions that could affect water quality may also need a permit from the Alaska Department of Environmental Conservation (ADEC or DEC). Finally, if you're conducting agricultural activities and getting technical advice or cost-share assistance from the USDA Natural Resources Conservation Service (NRCS), the NRCS has "swampbuster" provisions that protect wetlands. The following sections introduce what you need to know about each of these programs.

4.1.1. The US Army Corps of Engineers regulates activities in wetlands

You'll want to check with the Corps before beginning any project that may require a wetland permit.

- On the western side of the Kenai Peninsula, Corps permits are handled by the
  Kenai Regulatory Field Office
  Benco Building, 805 Frontage Rd., Suite 200C, Kenai, AK 99611-7755, (907) 283-3519

- In the Seward area, Corps permits are handled by the
  Anchorage Regulatory Field Office
  1600 A Street, Suite 110, Anchorage, AK 99501, (907) 753-2619

The Corps Alaska District website is: http://www.poa.usace.army.mil/. The portal for obtaining nearly all the information outlined below is: http://www.poa.usace.army.mil/Missions/Regulatory.aspx. Additional Corps regulatory program links can be found at: http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits.aspx; and an informational pamphlet by the Corps called *Recognizing Wetlands* can be viewed at http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/rw_bro.pdf.

Legislative authorities for the Corps wetland permit program

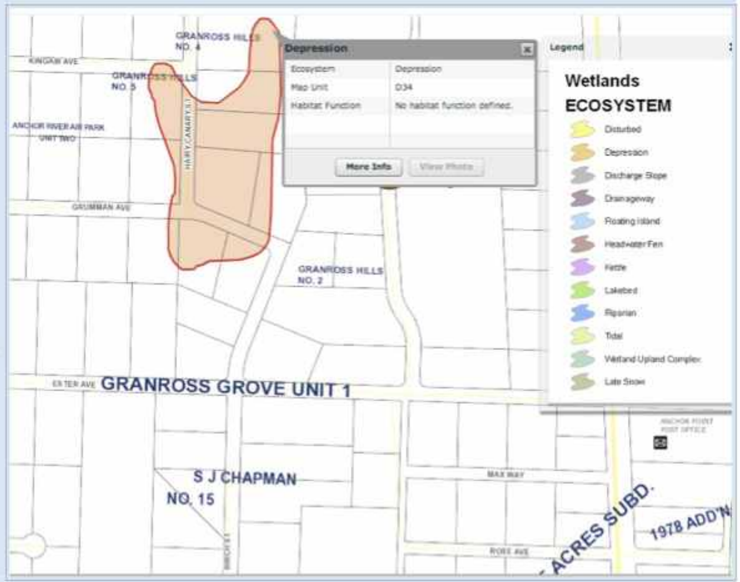
The basis for the Corps wetlands permit program goes back to the 1890s and the protection of navigable waters from obstruction or alteration. The text box below summarizes the basis for the Corps' permitting authority and

71 See Section 2.4.2 for a step-by-step guide on using the borough's interactive parcel viewer to locate wetlands.
72 To learn more about which soils are best suited for which land uses, take a look at "soil suitability" in the Western Kenai Peninsula soil survey, at http://soildatamart.nrcs.usda.gov/Manuscripts/AK652/0/WesternKenai_manu.pdf.

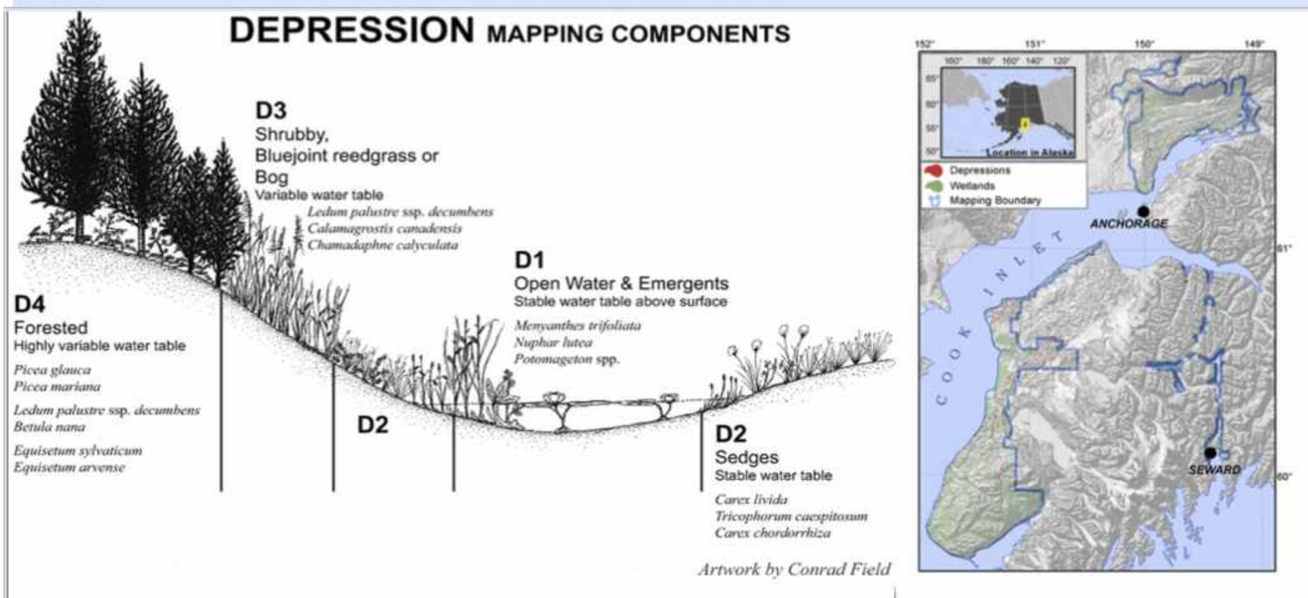
A cautionary tale related to wetland development

A story from the *Homer News*, October 24, 2013, suggests the kinds of issues that can arise when development takes place without adequate consideration of nearby wetland functions ("Flooding creates new 'lakefront' property"). The photo at right from the article shows stormwater flooding at the corner of Ester Avenue and Birch Street in Anchor Point.

The map below right shows a Depression wetland (D34) mapped about 550 ft north of this intersection. The diagram below shows typical cross sections of different kinds of Depression wetlands (from http://cookinletwetlands.info/ecosystems/depression.html). Depression wetlands, particularly those with variable water tables below ground surface (e.g., D34 wetlands), were given the highest score for hydrology function 2: *providing storage of water–including stormwater and floodwater*.



Elevation profiles on the two maps on the following page show that this Depression wetland is about 3 ft upslope of the Ester Ave/Birch St intersection. (The wetland is at about 158 ft elevation, the intersection at about 155 ft.) The maps themselves show recent development in the Depression. Development reduces storage capacity in this wetland "sponge," so water formerly stored in the wetland runs downslope, affecting downslope property owners. As the news article noted: *...a culvert used to help water find its way south. When homeowners complained that basements and crawl spaces of their residences south of the intersection were flooding, the culvert was removed.*

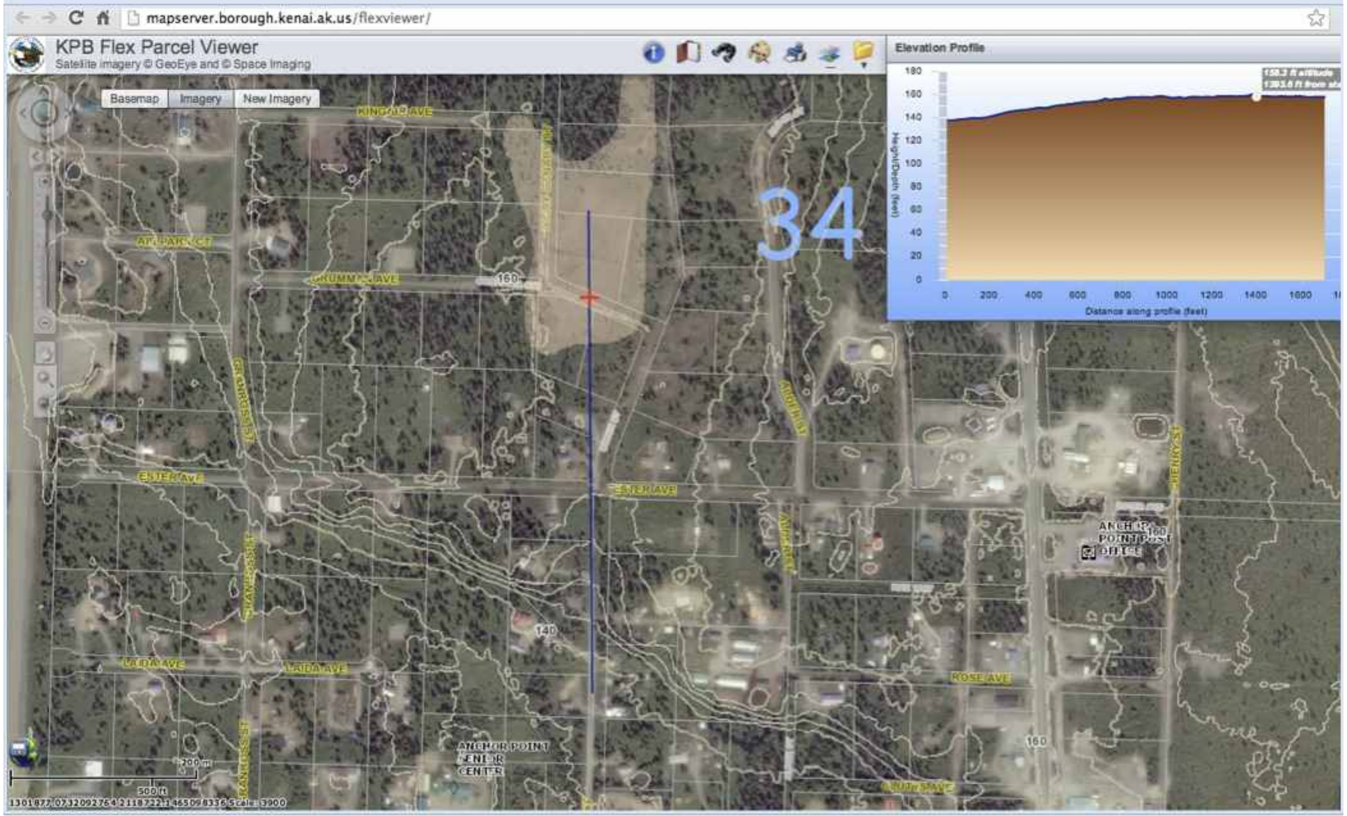


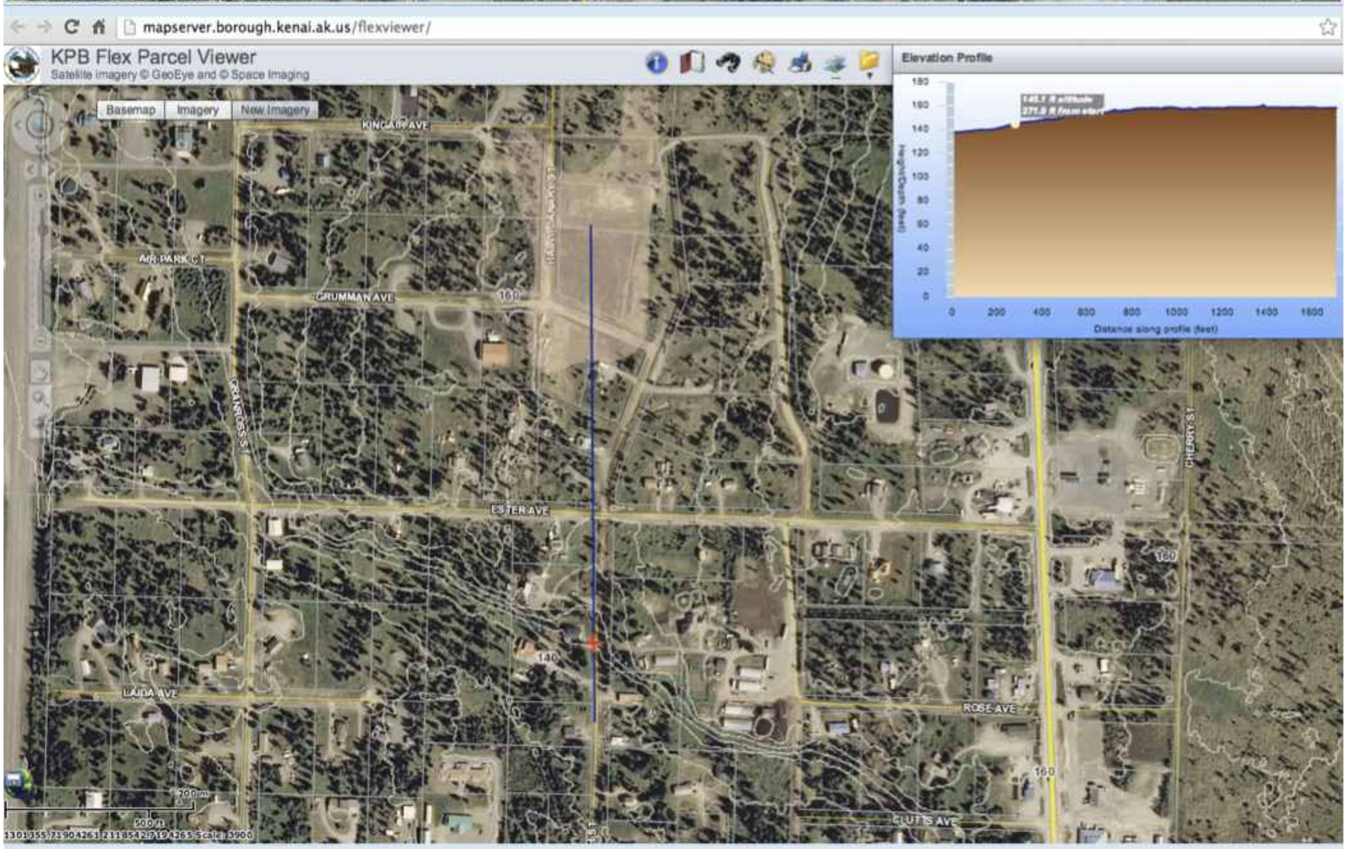
LEFT: An idealized cross-section of a Depression wetland showing hydrologic componets and typical plants. Drawing by Conrad Field. RIGHT: Range of wetlands mapped as Depressions.

Depression wetlands are surrounded by uplands. They are common as peatlands in ice-block depressions on large moraine complexes. They are also found on smaller moraines scattered thoughout the lowlands, and on glacial outwash deposits around Palmer. Geomorphologically, Depression, Kettle, and Spring Fen Ecosystem wetlands are all "ice block depressions". Large blocks of glacial ice, which were entrained in till deposited as glaciers receded at the end of the last glacial maximum, melted leaving deep depressions on the surface. Some iceblocks were more isolated than others. The different names: Depression, Kettle and Spring Fen, help distinguish differences in wetland jurisdiction and ecosystem services occurring in this geomorphic setting.

Depression peatlands typically support lower pH and specific conductance values than Kettles or Spring Fens, indicating more bog-like, rather than fen conditions, especially west of Houston in the Matanuska-Susitna Valley. They are probably controlled by a semi-confining layer and low insolation which together produce a micro-climate with lower evapotranspirational losses. Very steep-sided depressions, such as those found in the Cravasse Moraine area, south of Palmer, can support permafrost. At least 30 cm of hard ice was encountered 27 cm below the surface under a black spruce canopy in one Depression in the Crevasse Moraine area late in the season, on 21 August 2007.

Note the difference in development within the Depression wetland between 2003 (top map) and 2012 (bottom map).





also highlights the role of the EPA. Figure 4.1a, which follows the text box, shows where particular Corps regulatory authorities apply in freshwater areas.

An easy-to-read copy of Section 404 of the Clean Water Act, including all its subsections, is provided by the EPA at: http://water.epa.gov/lawsregs/guidance/wetlands/sec404.cfm.

LEGISLATIVE AUTHORITIES for the US ARMY CORPS of ENGINEERS WETLAND PERMITTING PROGRAMS (the role of the Environmental Protection Agency is also referenced)

(The following is slightly modified from http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/ reg_juris_ov.pdf.)

Activities that require 404 (wetland) permits involve discharging dredged or fill materials into "waters of the United States," which include most wetlands.

The legislative origins of the Department of the Army regulatory program are the Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 U.S.C. 401, et seq.). Various sections establish permit requirements to prevent unauthorized obstruction or alteration of any navigable water of the United States. The most frequently exercised authority is contained in **Section 10** (33 U.S.C. 403), which covers construction, excavation, or deposition of materials in, over, or under such waters, or any work which would affect the course, location, condition, or capacity of those waters. Other permit authorities are also granted in the Act; various pieces of legislation have modified these authorities over time but not removed them.

In 1972, amendments to the Federal Water Pollution Control Act added what is commonly called **Section 404** authority (33 U.S.C. 1344) to the army's regulatory program. The Secretary of the Army, acting through the Chief of Engineers, is authorized to issue permits, after notice and opportunity for public hearings, for **the discharge of dredged or fill material into waters of the United States** (defined below) at specified disposal sites. Selection of such sites must be in accordance with guidelines developed by the **Environmental Protection Agency** (EPA) in conjunction with the Secretary of the Army; these guidelines are known as the 404(b)(1) Guidelines. The discharge of all other pollutants into waters of the U. S. is regulated under Section 402 of the Act. The Federal Water Pollution Control Act was further amended in 1977 and given the common name of "**Clean Water Act**" (CWA) and was again amended in 1987 to modify criminal and civil penalty provisions and to add an administrative penalty provision.

Those exercising these authorities are directed to evaluate the impact of the proposed work on the public interest. The backbone of the program is the Department of the Army regulations (33 CFR 320-330), which provide the district engineer the broad policy guidance needed to administer day-to-day operation of the program. These regulations have evolved over time, changing to reflect added authorities, developing case law, and in general the concerns of the public.

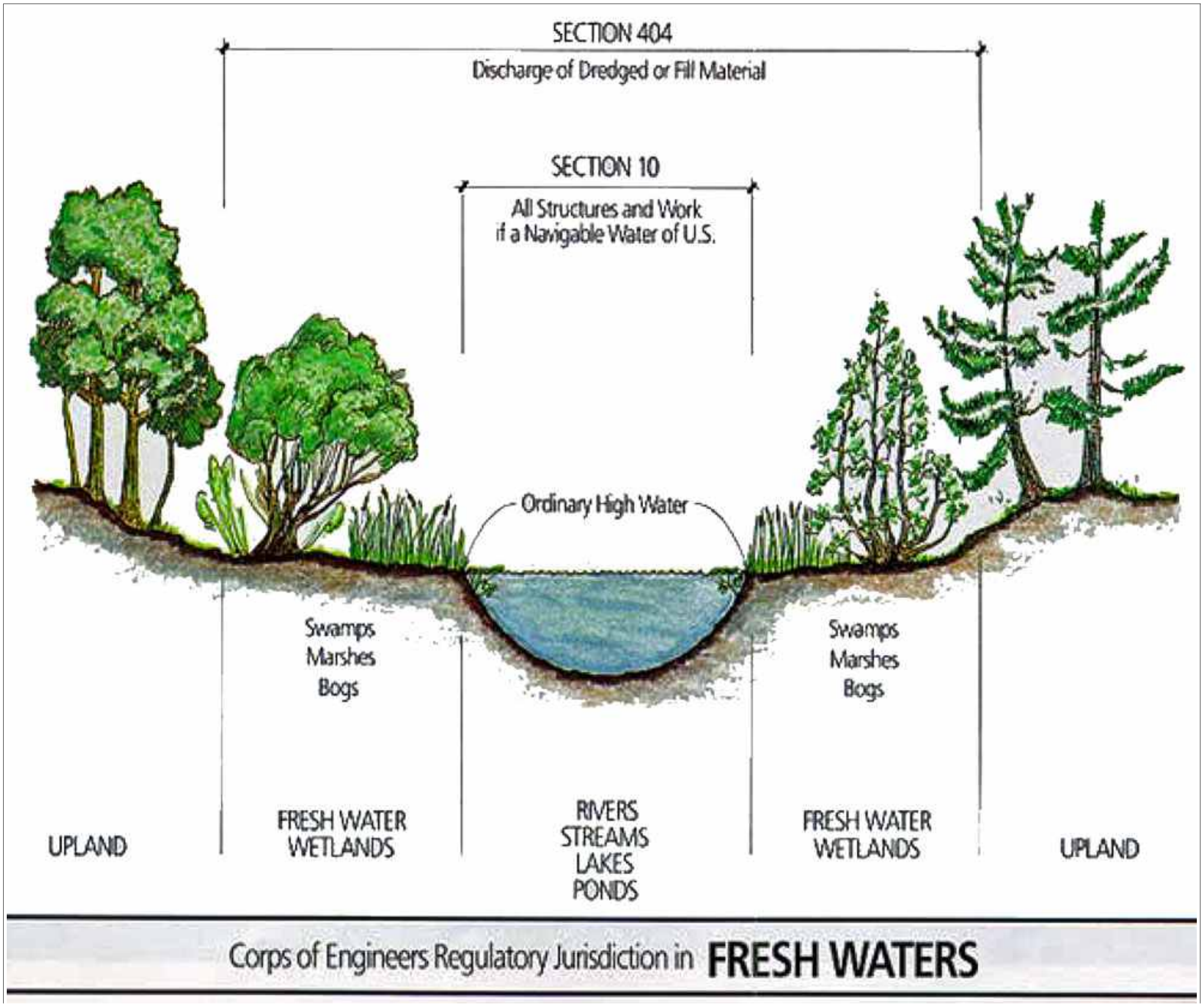
The term "*waters of the United States*" includes (emphasis added):

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...
4. All impoundments of waters otherwise defined as waters of the United States under the definition;
5. Tributaries of waters;
6. The territorial seas;
7. **Wetlands adjacent to waters** (other than waters that are themselves wetlands).

The Clean Water Act uses the term "navigable waters," which is defined (Section 502(7)) as "waters of the United States, including the territorial seas." Thus, Section 404 jurisdiction is defined as encompassing Section 10 waters plus their tributaries and adjacent wetlands and isolated waters where the use, degradation or destruction of such waters could affect interstate or foreign commerce. Activities requiring Section 404 permits are limited to discharges of dredged or fill materials into the waters of the United States. These discharges include return water from dredged material disposed of on the upland and generally any fill material (e.g., rock, sand, dirt) used to construct fast land for site development, roadways, erosion protection, etc.

The Environmental Protection Agency (EPA) works closely with the Corps in reviewing 404 wetland permits and has final authority regarding CWA jurisdiction. The Corps and EPA invite state and local governments and the general public to comment on 404 permit applications.

Figure 4.1a. Wetland areas subject to wetland permits under Section 404 of the Clean Water Act
(source: http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/juris_images.pdf).



4.1.2. How to identify wetlands subject to Corps wetland permits (*jurisdictional* wetlands)

Not all wetlands meet the criteria established by the Corps to identify wetlands under its regulatory jurisdiction. Only wetlands that meet Corps criteria are "jurisdictional wetlands." The criteria that Alaskan wetlands must meet in order to be jurisdictional are spelled out in two documents:

- The Corps of Engineers Wetlands Delineation Manual, which can be downloaded at: http://el.erdc.usace.army.mil/wetlands/pdfs/wlman87.pdf.
- Regional supplements to the Corps of Engineers Wetlands Delineation Manual. The Alaska Regional Supplement can be downloaded at: http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_supp/erdc-el_tr-07-24.pdf

The Corps has summarized in a brochure the criteria that distinguish jurisdictional wetlands. The text box below contains the key points from that brochure.

The criteria outlined below are essentially those used to classify, map, and name wetlands on the Kenai Peninusla (see Chapter 2). During wetlands mapping, every effort was made to include all wetlands meeting Corps jurisdictional criteria, so wetland maps found on the borough's interactive parcel borough (see Section 2.4) are good general guides for determining whether you need a wetland permit. Wetland maps, however, are inherently subject to limitations for reasons such as mapping scale (see Section 1.3.2) and environmental variability. It's also worth noting that until about 2001, wetlands surrounded by uplands and not connected to Cook Inlet or another "navigable-in-fact" waterbody through another wetland, lake, or stream were considered jurisdictional. Although these wetlands are not currently jurisdictional, they may again become so.

If you need to confirm whether wetlands shown on borough maps require a Corps wetland permit (or other permits discussed below), you will want a qualified professional to do a *wetlands determination*. The Corps offices identified above can help you find someone appropriate. (In contrast to a wetlands determination, a *wetlands delineation* identifies the boundaries of a wetland and is sometimes also needed.)

Corps guidelines for determining whether an area is a wetland under its jurisdiction

(summarized from the pamphlet *Recognizing Wetlands* http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/rw_bro.pdf).

The US Army Corps of Engineers uses the following definition of wetlands:

> Those 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. (See Chapter 2 for more on wetlands identification.)

Section 404 of the Clean Water Act requires that anyone interested in depositing dredged or fill material into "waters of the United States, including wetlands," must receive authorization from the Corps for such activities. Activities in wetlands for which permits may be required include, but are not limited to:

- Placement of fill material.
- Ditching activities when the excavated material is sidecast.
- Levee and dike construction.
- Mechanized land clearing.
- Land leveling.
- Most road construction.
- Dam construction.

The Corps uses three kinds of characteristics to determine whether an area is a wetland under its jurisdiction: vegetation, soil, and hydrology. Unless an area has been altered or is a rare natural situation, wetland indicators of all three characteristics must be present during some portion of the growing season for an area to be a wetland. Each characteristic is discussed below.

There are some general situations in which an area has a strong probability of being a wetland. If any of the following situations occur, you should ask the local Corps office to determine whether the area is a wetland:

- Area occurs in a floodplain or otherwise has low spots in which water stands at or above the soil surface during the growing season. Caution: Most wetlands lack both standing water and waterlogged soils during at least part of the growing season.
- Area has plant communities that commonly occur in areas having standing water for part of the growing season (e.g., peatlands, sphagnum bogs).
- Area has soils that are called peats or mucks.
- Area is periodically flooded by tides, even if only by strong, wind-driven or spring tides.

In cases where it is unclear whether these situations occur, it is necessary to carefully examine the area for wetland indicators.

Vegetation indicators

Wetland plants, known as *hydrophytic vegetation*, are listed in regional publications of the US Fish and Wildlife Service. However, you can usually determine if wetland vegetation is present by knowing a relatively few plant types that commonly occur in your area. For example, sedges, sphagnum moss, Labrador tea, and many kinds of willows usually occur in wetlands.

Soil indicators

Wetland soils, called hydric soils, have characteristics that indicate they were developed in conditions where soil oxygen is limited by the presence of saturated soil for long periods during the growing season. If the soil in your area is listed as hydric by the Natural Resources Conservation Service (NRCS), the area might be a wetland. (The Western Kenai Peninsula soil survey identifies which soils on the peninsula are hydric, see http://soildatamart.nrcs.usda.gov/Manuscripts/AK652/0/WesternKenai_manu.pdf.) You can also find a list of peninsula hydric soils at: http://www.kenaiwetlands.net/DataMartKenaiHydricSoils.pdf.

If the name of the soil in your area is not known, an examination of the soil can determine the presence of hydric soil indicators, including:

- Soil consists predominantly of decomposed plant material (peats or mucks).
- Soil has a thick layer of decomposing plant material on the surface.
- Soil has a bluish-gray or gray color below the surface, or the major color of the soil at this depth is dark (brownish black or black) and dull.
- Soil has the odor of rotten eggs.
- Soil is sandy and has a layer of decomposing plant material at the soil surface.
- Soil is sandy and has dark stains or dark streaks of organic material in the upper layer below the soil surface. These streaks are decomposed plant material attached to the soil particles. When soil from these streaks is rubbed between the fingers, a dark stain is left on the fingers.

Hydrology indicators

Wetland hydrology refers to the presence of water at or above the soil surface for a sufficient period of the growing season to significantly influence the plant types and soils that occur in the area. Although the most reliable evidence of wetland hydrology may be provided by gaging stations or groundwater well data, such information is limited for most areas and, when available, requires analysis by trained individuals. Thus, most hydrologic indicators are those that can be observed during field inspection. Most do not reveal either the frequency, timing, or duration of flooding or the soil saturation. However, the following indicators provide some evidence of the periodic presence of flooding or soil saturation:

- Standing or flowing water is observed on the area during the growing season.
- Soil is waterlogged during the growing season.
- Water marks are present on trees or other erect objects. Such marks indicate that water periodically covers the area to the depth shown on the objects.
- Drift lines, which are small piles of debris oriented in the direction of water movement through an area, are present. These often occur along contours and represent the approximate extent of flooding in an area.
- Debris is lodged in trees or piled against other objects by water.
- Thin layers of sediments are deposited on leaves or other objects. Sometimes these become consolidated with small plant parts to form discernible crust on the soil surface.

Wetland determinations

One or more indicators of wetland vegetation, hydric soil, and wetland hydrology must be present for an area to be a jurisdictional wetland. If you observe definite indicators of any of the three characteristics, you should seek assistance from either the local Corps District Office or someone who is an expert at making wetland determinations. The final determination of whether an area is a wetland and whether an activity requires a permit must be made by the appropriate Corps District Office.

Wetland delineations

Delineation requires that a boundary meeting regulatory criteria be outlined around a wetland area. Because wetlands are transitional between deep water aquatic ecosystems and drier upland ecosystems, delineating such a boundary requires a trained professional. Delineating wetlands requires knowledge of how wetlands form, how they function, and the regulatory criteria for defining them.

In Seward, the higher floodplain terraces that do not meet Corps jurisdictional criteria were included during wetland mapping because of the high frequency and severity of flooding around Seward and the dynamic nature of local rivers. Although these areas were relatively dry when the terraces were mapped, flooding may change that at any time. Although activities on these higher floodplain terraces do not require a Corps wetland permit, locating developments in such areas should be considered carefully because of the potential costs and risks associated with flooding.

4.1.3. Getting a Corps wetlands permit is pretty straightforward...

4.1.3.1. Steps involved in getting a 404 wetlands permit

The basic ways the Corps of Engineers grants a landowner a permit to carry out certain activities in his or her wetland is through either an *individual permit* or a *nationwide permit*. (Nationwide permits are introduced after Table 4.1a.) Processing individual permits involves evaluating individual, project-specific applications. Table 4.1a outlines the basic steps involved in getting an individual permit. (Text in the table is slightly modified from http://www.usace.army.mil/Portals/2/docs/ civilworks/regulatory/reg_juris_ov.pdf.)

Table 4.1a. Getting a wetlands (404) permit: steps and explanation	
Step 1: Arrange for pre-application consultation meetings(s) with your local regulatory office—Kenai or Anchorage, see start of this chapter.	This involves one or more meetings between an applicant, Corps district staff, interested resource agencies (federal, state, or local), and sometimes the interested public. The basic purpose of such meetings is to encourage informal discussions about the pros and cons of a proposal before an applicant makes irreversible commitments of resources (funds, detailed designs, etc.). The process is designed to provide the applicant with an assessment of the viability of some of the more obvious alternatives available to accomplish the project purpose, to discuss measures for reducing the impacts of the project, and to inform him or her of the factors the Corps must consider in its decision making process. The Corps's first priority will be to find alternatives that "avoid" any damage to wetlands (see
Step 2: Complete and submit a permit application to the appropriate Corps regulatory office.	Obtain a permit application form at: http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/engform_4345_2012oct.pdf Obtain instructions for filling out the form at: http://www.usace.army.mil/Portals/2/docs/civilworks/permitapplicationinstructions.pdf
Step 3: Wait while your application undergoes formal review. On average, individual permit decisions are made within 2 to 3 months from receipt of a complete application. In emergencies, decisions can be made in a matter of hours. Applications covered by *nationwide permits* (see below) are generally processed within 30 days.	Once the Corps receives a complete application, the formal review process begins. Corps districts operate under what is called a project manager system, where one individual is responsible for handling an application from receipt to final decision. The project manager prepares a *public notice* (see below), evaluates the impacts of the project and all comments received, negotiates necessary modifications of the project if required, and drafts or oversees drafting of appropriate documentation to support a recommended permit decision. The permit decision document includes a discussion of the environmental impacts of the project, the findings of the public interest review process, and any special evaluation required by the type of activity... The Corps supports a strong, partnership with states in regulating water resource developments. This is achieved with joint permit processing procedures (e.g., joint public notices and hearings), programmatic general permits founded on effective state programs, transfer of the Section 404 program in non-navigable waters, joint Environmental Impact Statements (EISs), special area management planning, and regional conditioning of nationwide permits... The public benefits and detriments of all factors relevant to each case are carefully evaluated and balanced. Relevant factors may include conservation, economics, aesthetics, wetlands, cultural values, navigation, fish and wildlife values, water supply, water quality, and any other factors judged important to the needs and welfare of the people. The following general criteria are considered in evaluating all applications: 1. the relevant extent of public and private needs; 2. where unresolved conflicts of resource use exist, the practicability of using reasonable alternative locations and methods to accomplish project purposes; and 3. the extent and permanence of the beneficial and/or detrimental effects the proposed project may have on public and private uses to which the area is suited. No permit is granted if the proposal is found to be contrary to the public interest... The *public notice* is the primary method of advising all interested parties of a proposed activity for which a permit is sought and of soliciting comments and information necessary to evaluate the probable beneficial and detrimental impacts on the public interest. Public notices on proposed projects always contain a statement that anyone commenting may request a *public hearing*. Public hearings are held if comments raise substantial issues that cannot be resolved informally, and the Corps decision maker determines that information from such a hearing is needed to make a decision. Public notices are used to announce hearings. The public is also informed by notice on a monthly basis of permit decisions. Any project on which an Environmental Impact Statement (EIS) will be prepared is subject to additional public involvement... The public interest review is used to evaluate applications under all authorities administered by the Corps. There are additional evaluation criteria used for specific authorities. For example, applications for fill in waters of the United States are also evaluated using the Section 404(b)(1) Guidelines developed by EPA in conjunction with the Department of the Army. These guidelines are heavily weighted towards preventing environmental degradation of waters of the United States and so place additional constraints on Section 404 discharges. Projects that comply with the criteria may still be denied a permit if they are found to be contrary to the overall public interest. EPA may prohibit or withdraw the specifications of any disposal site if the EPA Administrator determines that discharges into

	the site will have unacceptable adverse effects on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreational areas. This authority also carries with it the requirement for notice and opportunity for public hearing. EPA may invoke this authority at any time... Individual state permitting and water quality certification requirements provide an additional form of objective safeguard to the Corps regulatory program. Section 401 of the Clean Water Act requires state certification or waiver of certification prior to issuance of a Section 404 permit. (See Section 4.2.3, below.) The Corps standard permit form contains a statement notifying the permittee that the federal permit does not remove any requirement for state or local permits. This has the effect of making the Corps permit unusable without these additional authorizations. If the state or local permit is denied before the Corps has made its decision, the Corps permit is also denied...
Step 4: Receive a decision on your application.	The permit process has now reached its conclusion.

In certain prescribed situations, alternate forms of authorization are used instead of an individual permit. These are introduced below (slightly modified from: http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_juris_ov.pdf).

- ***Letters of permission*** may be used where, in the opinion of the district engineer, the proposed work would be minor, not have significant individual or cumulative impact on environmental values, and should encounter no appreciable opposition. In such situations, the proposal is coordinated with all concerned fish and wildlife agencies, and generally adjacent property owners who might be affected by the proposal, but the public at large is not notified. The public interest balancing process is again central to the decision making process on letters of permission.

- ***Geographic general permits*** cover activities the Corps has identified as being substantially similar in nature and causing only minimal individual and cumulative environmental impacts. These permits may cover activities in a limited geographic area (e.g., county or state), a particular region of the country, or the nation (see Nationwide Permits below). Processing, such permits closely parallels that for individual permits, with public notice, opportunity for hearing, and detailed decision documentation.

  A ***Nationwide permit*** (NWP) is a general permit (see above) that authorizes an activity across the country. These are issued by the Chief of Engineers through the Federal Register rulemaking process. Activities covered by NWPs are summarized at http://www.spn.usace.army.mil/regulatory/nwp.html. Examples of such activities include: (a) repair, rehabilitation, or replacement of previously authorized, currently serviceable structures or fills (see NWP 3); (b) temporary recreational structures (see NWP 11); (c) minor discharges, for example, affecting less than 1/10th of an acre (see NWP 18); (d) residential developments affecting less than ½ acre of nontidal waters of the US (see NWP 29); (e) cleanup of hazardous and toxic waste (see NWP 38); (f) agricultural activities (see NWP 40); and (g) stormwater management facilities (see NWP 43). For most of these activities, the permittee must submit a *pre-construction notification* (PCN) to the district engineer prior to beginning the activity, and most of these activities must be carried out in accordance with specified "general conditions." An index of all nationwide permits—current as of September 2012 and with complete definitions of permitted activities and related general conditions—can be found at: http://www.usace.army.mil/Portals/2/docs/civilworks/ nwp/2012/NWP2012_corrections_21-sep-2012.pdf.

- ***Programmatic general permits*** are founded on an existing state, local, or other federal agency program and are designed to avoid duplication with that program.

4.1.3.2. Projects need to avoid, minimize, or—as a last resort—mitigate wetland impacts

As the Corps (and EPA—see Section 4.1.4) review a wetland permit application, their reviewers look step-by-step at whether there are ways to avoid or minimize losses of wetland functions (and values) that might be caused by the proposed project. Having information about the key functions/values of peninsula wetlands—such as is provided in this guide—makes it easier for them (and the permit applicant) to work through this sequential process. The "mitigation sequence" is as follows (see, for example EPA factsheet at http://www.epa.gov/owow/wetlands/pdf/CMitigation.pdf):

- **Avoid**: The first—and much preferred—approach is to avoid functional losses by avoiding damage to wetlands. The Corps works with applicants to explore ways to avoid project impacts to wetlands, for example, by finding better suited, upland locations for siting the project.

- **Minimize**: If functional losses cannot be avoided, the next approach is to minimize negative impacts to wetlands to the maximum extent possible. Doing so involves first identifying which wetland functions (and values) may be impaired or lost as a result of the project. This information can then help the project applicant re-design the project in ways that will minimize its negative impacts.

- **Compensate**: If wetland losses caused by the project can neither be avoided nor effectively minimized, the approach of last resort is to require the applicant to undertake compensatory mitigation for the wetland functions (and values) that will be lost (see next section).

As the Corps makes clear in rules and regulations laid out in the *Federal Register* on April 10, 2008 (Vol. 73, No. 70, see http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/final_mitig_rule.pdf):

> For impacts authorized under Section 404 [of the Clean Water Act], compensatory mitigation is not considered until after all appropriate and practicable steps have been taken to **first avoid** and **then minimize** adverse impacts to the aquatic ecosystem pursuant to 40 CFR part 230 (i.e., the CWA Section 404(b)(1) Guidelines).

As a result, applicants for 404 wetland permits should include in their applications a statement describing how their proposed projects will avoid or minimize impacts to waters and wetlands or—if impacts can neither be avoided nor minimized—how unavoidable losses of functions (and values) will be compensated for by the applicant (or why compensation is not appropriate or practicable). To help make sure that these issues are addressed, the Corps provides the following instructions to permit applicants (see http://www.poa.usace.army.mil/Portals/34/docs/regulatory/applicantproposedmitigationstatements.pdf):

1. Avoidance of impacts to waters of the U.S., including wetlands:
   Please describe how, in your project planning process, you avoided impacts to waters of the U.S., including wetlands, to the maximum extent practicable. Examples of avoidance measures include site selection, routes, design configurations, etc.

2. Minimization of unavoidable impacts to waters of the U.S., including wetlands:
   Please describe how your project design incorporates measures that minimize the unavoidable impacts to waters of the U.S., including wetlands, by limiting fill discharges to the minimum amount/size necessary to achieve the project purpose.

3. Compensation for unavoidable impacts to waters of the U.S., including wetlands:
   Please describe your proposed compensatory mitigation to offset unavoidable impacts to waters of the U.S., or, alternatively, why compensatory mitigation [see below] *is not appropriate or practicable for your project.*

4.1.3.3. "Compensatory mitigation"

As noted above, if impacts to wetlands can neither be avoided nor minimized, applicants for wetland permits must explain what they will do to offset losses to wetland functions (or values) or why it is not "appropriate or practicable" to do so. As explained by the Corps at http://www.poa.usace.army.mil/Portals/34/docs/regulatory/applicantproposedmitigationstatements.pdf:

> *Compensatory mitigation* involves actions taken to offset unavoidable adverse impacts to waters of the U.S., including wetlands, streams and other aquatic resources (aquatic sites) authorized by Corps permits. Compensatory mitigation may involve the
>
> - restoration,
> - enhancement,
> - establishment (creation), and/or
> - the preservation of aquatic sites.
>
> The three mechanisms for providing compensatory mitigation are mitigation banks, in-lieu fee of mitigation, and permittee-responsible mitigation. [Definitions for these and other relevant terms are provided in Table 4.1b.]

Successfully compensating for losses of wetland functions (and values) is extremely challenging and can be very expensive. Chapters 2 and 3 suggest some of the complex physical and biological processes that take place within wetlands and that connect wetlands to larger watershed processes. Numerous dynamic processes go into creating and maintaining wetland functions. Recipients of Corps wetland permits take on very significant and long-term responsibilities when they agree to provide compensatory mitigation for lost wetland functions.

Rules and regulations related to *Compensatory Mitigation for Losses of Aquatic Resources* were adopted by the Corps and EPA in 2008 and published in the Federal Register (see http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/final_mitig_rule.pdf). These "...establish performance standards and criteria for the use of permittee-responsible compensatory mitigation, mitigation banks, and in-lieu programs to improve the quality and success of compensatory mitigation projects for activities authorized by Department of the Army permits." Rules and regulations were designed to improve "the planning, implementation and management of compensatory mitigation projects" by:

- emphasizing a watershed approach in selecting compensatory mitigation project locations,
- requiring measurable, enforceable ecological performance standards and regular monitoring for all types of compensatory mitigation and
- specifying the components of a complete compensatory mitigation plan, including assurances of long-term protection of compensation sites, financial assurances, and identification of the parties responsible for specific project tasks.

Additional background helpful to wetland permit applicants

Finally, when reviewing compensatory mitigation plans developed by applicants for wetlands permits in Alaska, the Alaska District Corps of Engineers follows guidance provided in "Alaska District Regulatory Guidance Letter – RGL ID No. 09-01 (2009)" (see http://www.poa.usace.army.mil/Portals/34/docs/regulatory/AKDistrictMitigationRGL0901.pdf). This RGL provides information that can be very helpful to wetland permit applicants. For example, the letter outlines

- general considerations that the Corps uses in reviewing an applicant's compensatory mitigation plan,
- "Final Mitigation Plan Requirements for Permittee-Responsible Mitigation," and
- a list of "wetland functions and services" as identified by the Corps (see Appendix A of the letter).

The letter notes that compensatory mitigation will likely be required when:

1. The project occurs in rare, difficult to replace, or threatened wetlands, areas of critical habitat, etc.
2. The project permanently impacts more than 1/10th of an acre of wetlands and/or other waters of the U.S. and the watershed condition is such that compensatory mitigation is necessary to offset the project's unavoidable adverse effects. Situations that can indicate degradation of the watershed's aquatic

environment can include, but are not limited to, more than 5% of impervious surface[73] in the watershed, waters listed as impaired or CWA Section 303(d) listed waterbodies[74], etc.
3. Fill placed in intertidal waters associated with special aquatic sites[75].
4. Fill placed in fish-bearing waters and jurisdictional wetlands within 500 feet of such waters when impacts are determined more than minimal.
5. The project is federally funded, so compensatory mitigation is required under Executive Order 11990 and meets the national policy goal of no-net-loss of wetlands.
6. Large-scale projects with significant aquatic resources impacts (e.g., mining development, highway, airport, pipeline, and railroad construction projects); 33 CFR 320.4(r)(2)[76].

Table 4.1b. Definitions related to "compensatory mitigation" (from http://www.poa.usace.army.mil/Portals/34/docs/regulatory/ applicantproposedmitigationstatements.pdf).
Enhancement: the manipulation of the physical, chemical, or biological characteristics of an aquatic resource to heighten, intensify, or improve a specific aquatic resource function(s). Enhancement results in the gain of selected aquatic resource function(s), but may also lead to a decline in other aquatic resource function(s). Enhancement does not result in a gain in aquatic resource area.
Establishment (creation): the manipulation of the physical, chemical, or biological characteristics present to develop an aquatic resource that did not previously exist at an upland site. Establishment results in a gain in aquatic resource area and functions.
In-lieu fee program: a program involving the restoration, establishment, enhancement, and/or preservation of aquatic resources through funds paid to a governmental or non-profit natural resources management entity to satisfy compensatory mitigation requirements for Department of Army permits. Similar to a mitigation bank, an in-lieu fee program sells compensatory mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the in-lieu program sponsor. However, the rules governing the operation and use of in-lieu fee programs are somewhat different from the rules governing operation and use of mitigation banks. The operation and use of an in-lieu fee program are governed by an in-lieu fee program instrument.
Mitigation bank: a site, or suite of sites, where resources (e.g., wetlands, streams, riparian areas) are restored, established, enhanced, and/or preserved for the purpose of providing compensatory mitigation for impacts authorized by Department of Army permits. In general, a mitigation bank sells compensatory mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the mitigation bank sponsor. The operation and use of a mitigation bank are governed by a mitigation banking instrument.
Permittee-responsible mitigation: an aquatic resource restoration, establishment, enhancement, and/or preservation activity undertaken by the permittee (or an authorized agent or contractor) to provide compensatory mitigation for which the permittee retains full responsibility.
Practicable: available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes.
Preservation: the removal of a threat to, or preventing the decline of, aquatic resources by an action in or near those aquatic resources. This term includes activities commonly associated with the protection and maintenance of aquatic resources through the implementation of appropriate legal and physical mechanisms. Preservation does not result in a gain of aquatic resource area or functions.
Restoration: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded aquatic resource. For the purpose of tracking net gains in aquatic resource area, restoration is divided into two categories: re-establishment and rehabilitation.

73 *Impervious surface* is defined as areas of the landscape that have been covered by any material that impeded the infiltration of water into the soil. Areas of land covered by pavement or buildings are impervious to rain water. Concrete, asphalt, rooftops, and even severely compacted areas of soil are considered impervious.
74 Alaska's list of impaired or 303(d) listed waterways is found at http://dec.alaska.gov/water/wqsar/waterbody/integrated_ report.htm and http://dec.alaska.gov/water/wqsar/Docs/2010impairedwaters.pdf.
75 See http://water.epa.gov/lawsregs/rulesregs/cwa/40cfr_index.cfm and http://water.epa.gov/lawsregs/rulesregs/cwa/upload/ CWA_Section404b1_Guidelines_40CFR230_July2010.pdf (Subpart E).
76 See http://www.gpo.gov/fdsys/pkg/CFR-2012-title33-vol3/xml/CFR-2012-title33-vol3-sec320-4.xml.

4.1.4. The Environmental Protection Agency plays key roles in reviewing Corps wetland permits

Although the Environmental Protection Agency (EPA) plays many roles in protecting the health of citizens and the quality of the environments (see below), one of its key roles is to assist the Corps in reviewing and commenting on 404 wetlands permits. EPA's permit portal is at: http://water.epa.gov/lawsregs/guidance/cwa/dredgdis/.

In particular Section 404(c) of the Clean Water Act (CWA) gives EPA "veto authority" with respect to 404 wetland permits. EPA may exercise its Section 404(c) authority *before* a 404 permit is applied for, *while* an application is pending, or *after* a permit has been issued. An EPA Regional Administrator initiates a 404(c) action if he or she determines that the impact of a proposed permit activity is likely to result in:

- significant degradation of municipal water supplies (including surface or ground water) or
- significant loss of or damage to fisheries, shellfishing, wildlife habitat, or recreation areas.

(For more information, including the steps that EPA follows during a 404(c) "veto process," see the EPA factsheet at http://water.epa.gov/lawsregs/guidance/cwa/dredgdis/upload/404c.pdf.)

Here is an excerpt from the *Purpose and Scope of* Section 404(c) of the Clean Water Act; this excerpt spells out EPA authorities under the CWA. The "Administrator" referred to below is the EPA Regional Administrator.

> The Regulations of this part include the procedures to be followed by the Environmental Protection agency in prohibiting or withdrawing the specification, or denying, restricting, or withdrawing the use for specification, of any defined area as a disposal site for dredged or fill material pursuant to section 404(c) of the Clean Water Act... [The EPA] Administrator may exercise a veto over the specification by the U.S. Army Corps of Engineers or by a state of a site for the discharge of dredged or fill material. The Administrator may also prohibit the specification of a site under section 404(c) with regard to any existing or potential disposal site before a permit application has been submitted to or approved by the Corps or a state. The Administrator is authorized to prohibit or otherwise restrict a site whenever he determines that the discharge of dredged or fill material is having or will have an "unacceptable adverse effect" on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas. In making this determination, the Administrator will take into account all information available to him. (From http://water.epa.gov/lawsregs/rulesregs/cwa/upload/2004_10_21_wetlands_40cfrPart231.pdf.)

EPA plays many other roles in protecting environmental quality and the health of citizens. For example, the mission of EPA's Office of Wetlands, Oceans, and Watersheds (OWOW) is to encourage and enable others to act effectively in protecting and restoring the nation's wetlands and associated ecosystems (http://water.epa.gov/type/wetlands/about_about.cfm). To this end, EPA serves:

- as a partner, providing support for both regulatory and non-regulatory wetlands protection efforts;
- as a promoter and distributor of sound wetlands science…;
- in an advisory capacity for state and tribal wetlands programs and for Section 404 permit decisions;
- as the developer of national wetlands standards and policies; and
- as a regulator to back up state and local partners and ensure that national standards are lawfully applied.

To access a wealth of educational material about wetlands available from the EPA, go to EPA's online wetlands portal at http://water.epa.gov/type/wetlands/index.cfm. There you'll find tabs linked to: *What* wetlands are, *Why* wetlands are valuable, *How* EPA protects wetlands, Wetlands *In the News,* and *A to Z topics* about wetlands.

Finally, we should note the significant role EPA plays in supporting the efforts of state, tribal, and other entities to develop and improve wetlands programs and related activities. On the peninsula, for example, EPA provided funding for the mapping and classifying of Kenai Peninsula wetlands on which this assessment is based (see Chapter 2), and then funded this project to assess the functions and values of mapped wetlands. Other local projects that EPA has supported include development of the Kenai Watershed Forum atlas and "suitability mapping" of high value "green infrastructure" areas in Homer. (The peninsula office of the EPA, which was co-located with other agencies in the Gilman River Center, 514 Funny River Road, Soldotna, was closed shortly after this project was completed. The EPA office in Anchorage can be reached at 907-271-5083.)

4.2. Other agencies also have responsibilities to protect wetlands

4.2.1. Anadromous waters and "Special Areas" are protected by the Alaska Department of Fish and Game

The Alaska Department of Fish and Game (ADFG or ADF&G) regulates many activities that could affect riparian/riverine wetlands that support anadromous fish[77]. As Fish and Game's *Land & Water Use Habitat Permits* homepage explains: "Alaska's fish habitat protection statutes were adopted shortly after statehood and remain unchanged to this day. This reflects the longstanding Alaskan ideal that fishery resources and habitats are assets that improve our quality of life and merit protection from unnecessary human disturbance" (http://www.adfg.alaska.gov/index.cfm?adfg=uselicense.main). The agency maintains a list of known anadromous waterbodies in the *Catalog of Waters Important for the Spawning, Rearing, and Migration of Anadromous Fish* (commonly known as the Anadromous Waters Catalog), see http://www.adfg.alaska.gov/sf/ SARR/AWC/.

Two main categories of land and water use permits are issued through the ADF&G, Division of Habitat: (1) *Fish Habitat* permits and (2) *Special Area* permits. These permits are tied to Alaska Statute (AS) Title 16 (*Fish and Game*), and so are commonly referred to as "Title 16 permits." A list of common activities that require permits is available on the Division of Habitat homepage: http://www.adfg.alaska.gov/index.cfm?adfg=uselicense.main. This link also provides access to forms needed to apply for Title 16 permits.

For help in applying for Title 16 permits on the Kenai Peninsula, contact the ADF&G, Division of Habitat office at the Gilman River Center in Soldotna, 514 Funny River Road, Soldotna, AK 99669, (907) 260-4882 or 714-2477 (see http://www.kenairivercenter.org/Agencies/adf&g/adf&g.html).

4.2.1.1. Fish Habitat permits

(The following is slightly modified from http://www.kenairivercenter.org/Agencies/adf&g/adf&g.html.)

- **The Fishway Act** requires that "...an individual or governmental agency notify and obtain authorization from the ADF&G, Division of Habitat, for activities within or across a stream used by fish if the department determines that such uses or activities could represent an impediment to the efficient passage of fish." Installing culverts in streams; realigning or diverting stream channels; damming streams; establishing low-water stream crossings; placing, depositing, or removing any material or structure below ordinary high water (see Figure 4.1a) all require approval from ADF&G.
- **The Anadromous Fish Act** requires that an individual or governmental agency provide prior notification and obtain approval from ADF&G "...to construct a hydraulic project or use, divert, obstruct, pollute, or change the natural flow or bed..." of a specified anadromous waterbody or "...to use wheeled, tracked, or excavating equipment or log-dragging equipment in the bed..." of a specified anadromous waterbody. All activities within or across a specified anadromous waterbody and all instream activities affecting a specified anadromous waterbody require approval from the ADF&G, Division of Habitat, including construction; road crossings; gravel removal; placer mining; water withdrawals; the use of vehicles or equipment in the waterway; stream realignment or diversion; bank stabilization; blasting; and the placement, excavation, deposition, disposal, or removal of any material. Recreational boating and fishing activities generally do not require a permit.

4.2.1.2. Special Area permits

"Special Areas" refer to ADF&G's State Game Refuges, State Game Sanctuaries, and Critical Habitat Areas (CHAs). Such areas are created by the state legislature through statutes describing the area's legal boundaries, purpose, and related management considerations. Each type of special area has a different general purpose, although all provide habitat protection. (For links to statutes creating particular Special Areas, go to http://www.touchngo.com/lglcntr akstats/Statutes/Title16/Chapter20.htm.)
The Habitat Division maintains a statewide special areas permitting program to manage land and water use

77 *Anadromous* describes fish, such as salmon, that migrate from the ocean to freshwater habitats to breed and lay eggs. Upon hatching, anadromous fish remain in freshwater for varying lengths of time, depending on species. Then they migrate to the ocean to feed and grow to adult size. At maturity, anadromous fish return to freshwater to spawn.

activities within these areas. By regulation, permits are required for the following kinds of activities:

- construction, placement, or continuing use of any improvement, structure, or real property within a special area;
- destruction of vegetation;
- detonation of an explosive other than a firearm;
- excavation, surface or shoreline altering activity, dredging, filling, draining, or flooding;
- natural resource or energy exploration, development, production, or associated activities;
- water diversion or withdrawal;
- off-road use of wheeled or tracked equipment unless the commissioner has issued a general permit under 5 AAC 95.770;
- waste disposal, placement, or use of a toxic substance;
- grazing or animal husbandry; and
- any other activity that is likely to have a significant effect on vegetation, drainage, water quality, soil stability, fish, wildlife, or their habitat, or which disturbs fish or wildlife other than lawful hunting, trapping, fishing, viewing, and photography.

Individuals wanting to carry out such activities within a Special Area require a "Special Area Permit" from ADF&G. For more information, see: http://www.adfg.alaska.gov/index.cfm?adfg=habitatregulations.special.

Title 16 Special Areas on the Kenai Peninsula are listed below. Except for the Homer Airport and Anchor River – Fritz Creek CHAs, wetlands encompassed within these areas are almost exclusively tidal.

- Anchor River – Fritz Creek Critical Habitat Area (http://www.adfg.alaska.gov/index.cfm?adfg=anchorriver.main)
- Clam Gulch Critical Habitat Area (http://www.adfg.alaska.gov/index.cfm?adfg=clamgulch.main)
- Fox River Flats Critical Habitat Area (http://www.adfg.alaska.gov/index.cfm?adfg=foxriverflats.main)
- Homer Airport Critical Habitat Area (http://www.adfg.alaska.gov/index.cfm?adfg=homerairport.main)
- Kachemak Bay Critical Habitat Area (http://www.adfg.alaska.gov/index.cfm?adfg=kachemakbay.main)

4.2.2. The Kenai Peninsula Borough administers ordinances protecting wetlands and floodplains

4.2.2.1. *Anadromous Waters Habitat Protection* ordinance

To protect the habitats of salmon and other anadromous fish (defined in the footnote on the previous page), the Kenai Peninsula Borough regulates activities within 50 ft of anadromous (salmon-bearing) waterbodies through a habitat protection ordinance, codified in Chapter 21.18 of the Kenai Peninsula Borough Code of Ordinances (see http://library.municode.com/HTML/13259/level2/TIT21ZO_CH21.18ANWAHAPR.html#TOPTITLE). The ordinance was originally passed in 1996, at which time it applied only to portions of the Kenai River. In 2000, it was amended to include tributaries of the Kenai River and 15 additional streams (7 of them in the project area: Kasilof River, Ninilchik River, Deep Creek, Stariski Creek, Anchor River, North Fork of Anchor River, and Fox River). In 2013, the ordinance was again amended (Ordinance 2013-18), this time to include all anadromous waterbodies in the borough that are listed in the *Atlas and Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fish*. (The anadromous waters catalog is maintained by ADF&G, see Section 4.2.1.) Anadromous waterways within the Seward – Bear Creek Flood Service area were excluded. (In 2012, the ordinance was amended slightly when the River Center was reincorporated into the borough planning department.)

Table 4.2a provides key sections of Chapter 21.18. In order to implement the ordinance, the borough has had to update maps of anadromous waterbodies (especially stream channels) in order to have the level of detail needed to determine which parcels fall within the 50-ft riparian buffer. Maps 4.2a and b, which follow Table 4.2a, show streams and other waterbodies that were proposed for inclusion in the ordinance. These maps can be viewed (and enlarged) at: http://mapserver.borough.kenai.ak.us/ flexviewer/Default.html?config=config-KRC.xml.

	Table 4.2a. Key sections of Chapter 21.18, Anadromous Waters Habitat Protection, Chapter 21.18 can be viewed at http://library.municode.com/HTML/13259/level2/TIT21ZO_CH21.18ANWAHAPR.html#TOPTITLE. To apply for a permit or to get more information, contact the Gilman River Center, 514 Funny River Road, Soldotna, AK 99669 (907) 260-4882, www.kenairivercenter.org.
21.18.010. ***Findings***	A. In enacting this ordinance the assembly finds numerous factors affect the habitat of the anadromous waters within the Kenai Peninsula Borough. These include removal of near shore native vegetation, bank erosion, bank trampling, pollution, inadequate tourism infrastructure, unsuccessful attempts to remedy bank erosion or protect and restore habitat, inconsistent regulations and enforcement, logging, grazing, mining, wetland fill and drainage, excavation and fill of property, dredging, inappropriately installed culverts, fuel storage, and maintenance of existing structures. B. The assembly finds that fuel storage and significant removal of vegetation within the 100-year floodplain along the anadromous waters require regulation to protect the salmon habitat. C. The assembly finds that the uncontrolled use and pollution of shoreland and riparian areas adversely affects the prosperity of the Kenai Peninsula Borough, the public health, safety, convenience, and general welfare, and impairs the tax base. [Section D omitted here.] E. The assembly finds that the riparian ecosystem includes stream bank and floodplain areas and recognizes that impacts to anadromous waters may be due to activities and uses within the greater watershed. [Section F omitted here.] G. The assembly finds that it is in the public interest to further public knowledge of, and the maintenance of safe and healthful conditions; prevent and control water pollution; protect anadromous fish spawning grounds, rearing waters, and migration corridors and aquatic life; control building sites, placement of structures, and land uses; and to preserve native shore cover and natural beauty. These responsibilities are hereby recognized by the Kenai Peninsula Borough.
21.18.020. ***Purpose***	For the purpose of promoting the public prosperity, public awareness, public health, safety, and welfare, this chapter has been established to: A. Protect and preserve the stability of anadromous fish through: 1. Controlling shoreline alterations and disturbances; 2. Preserving nearshore habitat and restricting the removal of natural riparian vegetation; 3. Controlling pollution sources; and 4. Prohibiting certain uses and structures detrimental to anadromous waters and habitat. 5. Decreasing significant erosion, sedimentation, damage to the habitat protection district, ground or surface water pollution, and damage to riparian wetlands and riparian ecosystems. B. Provide a guide for growth and development along anadromous waters in accordance with the Kenai Peninsula Borough Comprehensive Plan and through: 1. Minimizing the number and impacts of structures within the habitat protection district; 2. Regulating improved access to and within the habitat protection district; 3. Establishing minimum lot sizes and widths to provide adequate area for private sewage treatment and to control density; 4. Regulating building setbacks from waterways and steep slopes; 5. Separating conflicting land uses; and 6. Prohibiting certain uses and structures detrimental to the shoreland area. 7. Providing educational materials to the public outlining best management practices. C. Achieve the goals and implement the policies of the Kenai Peninsula Borough Comprehensive Plan. D. Protect and enhance real property values. E. Continuing to enjoy the prosperity and abundance provided by anadromous fish to the citizens of the Kenai Peninsula Borough.
21.18.025. ***Application***	A. The following anadromous waters, as identified in the "Atlas and Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fish" published by the Alaska Department of Fish and Game (ADF&G) and listed in the KPB 21.18 Appendix adopted by the assembly and incorporated herein by reference, are subject to this chapter: 1. Kenai River District anadromous waters made subject to this chapter on May 15, 1996. 2. Major Waters District anadromous waters made subject to this chapter on May 16, 2000. 3. West District anadromous waters. 4. North District anadromous waters made subject to this Chapter beginning January 1, 2014. 5. South District anadromous waters made subject to this Chapter beginning January 1, 2014. B. The reach of streams subject to this Chapter shall be defined by the beginning points and end points of the anadromous waters as identified in the Catalog, unless otherwise specified in KPB 21.18 C. The following waters are excluded from regulation by KPB 21.18 1. All portions of waterways found within the Seward-Bear Creek Flood Service Area are exempt from KPB 21.18 2. Braided Channels, Tide Dominated Deltas, Estuaries and Lagoons which are primarily seawater and are identified as anadromous in the State of Alaska Atlas and Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fish are exempt from KPB 21.18 D. Lands within the habitat protection district adjacent to the anadromous waters set forth in KPB 21.28.025(A) and the KPB 21.18 Appendix are subject to KPB 21.18.090 governing prior existing uses and structures, as of the date the land becomes subject to this chapter. E. The KPB 21.18 Appendix shall be available at the clerk's office, on the borough web page, and other locations as determined by the mayor for ease of access by the public.

21.18.027. ***Updates to ADF&G Atlas and Catalog***	[Text not included here.]
21.18.030. ***Periodic review***	[Text not included here.]
21.18.040. ***Habitat Protection District Established***	There is established an anadromous waters habitat protection district (habitat protection district). Except as otherwise provided in this section, this district includes all lands within 50 horizontal feet of the waters set forth in KPB 21.18.025. This shall be measured from the ordinary high water mark or mean high water line in tidal areas. Where the banks within this 50-foot district consist of a 60 degree or more cut bank the habitat protection district shall consist of the greater of 50 feet from the river or to a point 25 feet back from the top of the cut bank.
21.18.065. ***Activities not requiring a permit***	A. The permit required by this chapter is not required for noncommercial recreational and other non-intrusive activities which do not involve construction, excavation, or fill of land and do not result in significant erosion, sedimentation, damage to the habitat protection district, an increase in ground or surface water pollution, and damage to the riparian wetlands and riparian ecosystems. Natural vegetation on land abutting lakes and streams protects scenic beauty, controls erosion, provides fish and wildlife habitat, moderates temperature, stabilizes the banks, and reduces the flow of effluents and nutrients from the shoreland into the water. Vegetation removal and land disturbing activities within the habitat protection district are prohibited, with the following exceptions which do not require a permit: 1. Routine maintenance of existing legally established landscaping and landscape features developed prior to regulation by KPB 21.18, in the habitat protection district, may be continued without a permit. To be considered routine maintenance, activities must have been consistently carried out so that lawns or ornamental plants predominate over native or invasive species. Maintenance is performed with hand tools or light equipment only. Tree removal is not included. "Routine maintenance" activities include mowing; pruning; weeding; planting annuals, perennials, fruits and vegetables; and other activities associated with an ornamental landscape. 2. Pruning of trees and woody shrubs for the health and/or renewal of vegetation shall not result in removal of more than 25% of the living crown of a tree, nor jeopardize the health and natural shape of a tree or shrub. 3. The removal of trees downed by force of nature. 4. The planting of native vegetation does not require a permit provided runoff and erosion are controlled and do not enter the water body.
21.18.071. ***Staff Permits***	A. An application for a permit shall be made and a permit issued before commencement of certain activities, uses, and structures set forth in this section if they do not result in significant erosion, sedimentation, damage to the habitat protection district, an increase in ground or surface water pollution, and damage to the riparian wetlands and riparian ecosystems. An application for a permit shall be made to the Kenai Peninsula Borough planning department central office or at the river center. Upon determination that the submitted information of record supporting the permit application meets the requirements of this section, staff shall issue a permit for the following activities, uses, and structures in the habitat protection district: 1. Tree Management a. A tree, or portion thereof, may be removed for one or more of the following reasons: (I) The tree, or portion thereof, is dead. (ii) The tree is a safety hazard to persons or property. (iii) The tree removal is for the purpose of preventing the spread of disease to other trees. Whenever a tree is removed, it shall be replaced with two seedlings less than 5.5 feet tall of a species native to the region. 2. Elevated light penetrating structures. These structures include structures that are not ancillary to another use but are constructed solely for purposes of accessing the river and may include but are not limited to boardwalks, gratewalks, stairs, ramps, platforms, and gangplanks. Elevated light penetrating structures must be constructed of wood, plastic, fiberglass, aluminum, steel, or other nontoxic material. If the wood is treated, it must be certified as nontoxic to plants and animals by an independent laboratory or other appropriate agency. The topography of the bank and habitat protection district may not be altered to provide for the installation of these structures. [Sections a through e not included here.] 3. A single fish-cleaning station may be constructed, provided it has no enclosed sides or roof and that any shelf below the fish-cleaning surface must be at least 60 percent light penetrating and be elevated at least eight inches from the ground. Fish-cleaning stations shall not exceed 25 square feet, excluding the chute and drain pipes, if any. 4. Bank restoration and protection projects. 5. Within the habitat protection district adjacent to a lake, impervious coverage is allowed up to 10% of the habitat protection district, not to exceed a total of 500 square feet, provided that within 10' of the shoreline, no more than 25% of native vegetation is removed. Allowable uses include structures for temporary use such as gazebos, barbecues, walkways, fire pits, decks and saunas. Mitigation measures shall be provided to help offset the loss of vegetation. Mitigation measures include, but are not limited to, reserving uplands for native vegetation, or other measures which compensate by reserving equivalent footage of riparian area vegetation. B. Applicants for a permit issued pursuant to this chapter are responsible for abiding by all other federal, state, and local laws, regulations, and permitting requirements applicable to the project.

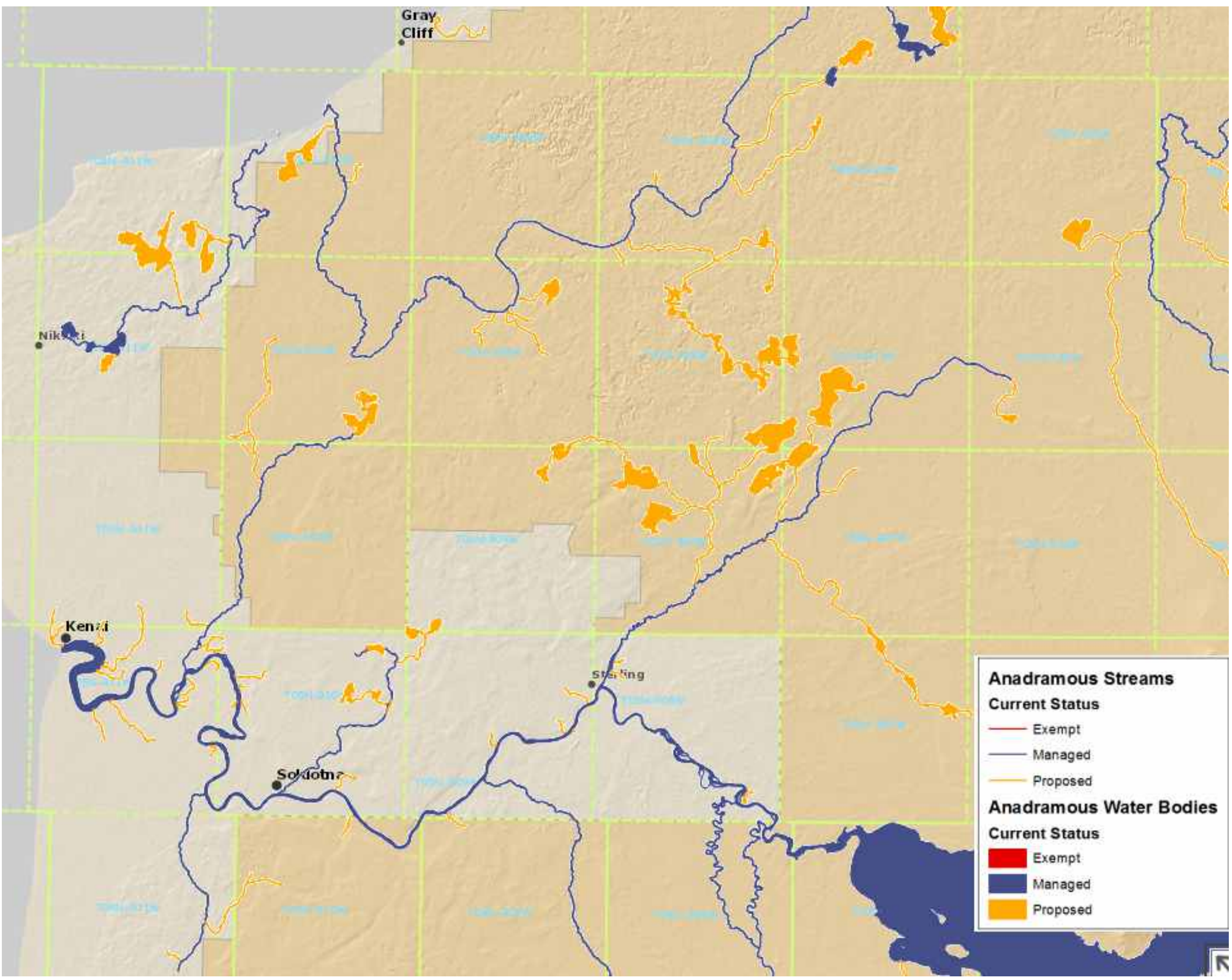
21.18.072. ***Limited commercial activity within habitat protection area***	The planning commission may issue a permit for activities to be conducted within or using the habitat protection area as provided in this section. Permits are required for commercial activities of the same nature as those allowed under KPB 21.18.065 for private non-commercial use upon conditions that the activity is limited to pedestrian use over boardwalks, stair and docks necessary to alleviate the increased levels of activity attendant to the commercial activity. A permit may not be issued unless the planning commission determines the activity will be conducted in a manner that does not result in significant erosion, sedimentation, damage to the habitat protection district, an increase in ground or surface water pollution, and damage to riparian wetlands and riparian ecosystems. In granting a permit, the planning commission may establish such conditions on the development, use or operation of the activity or facility for which the conditional use permit is granted as it determines necessary to prevent significant erosion, sedimentation, damage to the habitat protection district, an increase in ground or surface water pollution, and damage to riparian wetlands and riparian ecosystems. The activity must be conducted on a portion of property adjacent to the property within the habitat protection area for which the permit is sought.
21.18.075. ***Prohibited uses and structures***	Any use or structure not permitted in KPB 21.18.065, KPB 21.18.071 or 21.18.081 is prohibited.
21.18.081. ***Conditional use permit***	A. Intent. The intent of this section is to allow special uses and structures which may be compatible with KPB 21.18.071 in the habitat protection district through the approval of a conditional use, if certain standards and conditions exist. B. Conditional uses and structures. The following conditional uses and structures may be approved in the habitat protection district [emphasis added]: 1. **Fish-cleaning stations**; 2. **Fences**; 3. **Signs**; 4. **Public owned facilities, parks, campgrounds, and their related uses and structures**; 5. **Transportation and utility infrastructure**; 6. **Structures compliant with the Americans With Disabilities Act** and elevated light penetrating structures not meeting the standards of KPB 21.18.071; 7. **Wells and waterlines**; 8. **Lifts**; 9. **Private boat launches** and related facilities that are established to serve the public provided [listed] standards are met...; 10. **A principal structure or an addition to a principal structure** may be approved within the habitat protection district provided all the following [six] standards are met... [Standards include, for example:] (c) The parcel has an area of 0.3 acres or less and less than 4,000 square feet of total developed impervious coverage. (d) The parcel has less than 4,000 square feet of suitable development area outside the habitat protection district. (e) On the portion of the parcel within the habitat protection district, the total impervious coverage may not exceed 50% of the area able to sustain native vegetation, or 3,000 square feet of area able to sustain native vegetation, whichever is less. (f) The standard for development is to first utilize suitable parcel areas outside the habitat protection district. Within the habitat protection district, it is preferred to minimize impact by preserving the nearshore areas which may sustain native vegetation. 11. Water dependent lakeshore related uses or structures specified in KPB 21.18.081(B)(11)(b) may be permitted within the habitat protection district. a. In addition to meeting the general standards set forth in KPB 21.18.081(D) the permit shall be subject to the following conditions: 1. Vegetation removal does not exceed the minimum required for the use or structure, and does not exceed 25 percent of the total parcel lakeshore frontage. For purposes of this section frontage means the horizontal distance between side lot lines along ordinary high water. 2. Fifty (50) feet of native vegetative habitat buffer upland of the disturbed area or a mitigation plan consistent with KPB 21.50.091 approved by the planning commission. 3. The planning commission may place additional conditions on the permit to protect and preserve the habitat protection district consistent with KPB 21.18.081(E). b. The following uses or structures may be permitted in the anadromous habitat protection district if consistent with the criteria set forth in KPB 21.18.081(B)(11)(a): 1. Watercraft landings 2. Floatplane landings and haul-outs. Floatplane landings and haul outs may also be used as water craft landings and haul outs. 12. Boat launches restricted to private use may be permitted on anadromous lakes that have no public boat launch if the application meets the general standards set forth in KPB 21.18.081(D). The permit shall be subject to the following conditions: [five conditions are listed, not included here] C. Application procedure. A person seeking a conditional use permit must make application to the river center on a form provided by the river center and receive approval prior to commencement of the project. The application shall provide information describing the proposed use or structure and demonstrate that the use or structure meets the general standards for a conditional use permit. The planning commission may approve, deny, or conditionally approve an application for a conditional use permit. The planning commission has no obligation to ascertain whether special conditions can be developed or imposed unless the applicant has submitted adequate information to demonstrate that the proposed methods or conditions will mitigate the impacts of the use or structure within the habitat protection district. D. General standards. All of the following standards shall be met before conditional use approval may be granted.

	1. The use or structure will not cause significant erosion, sedimentation, damage to the habitat protection district, an increase in ground or surface water pollution, and damage to riparian wetlands and riparian ecosystems; 2. Granting of the conditional use shall be consistent with the purposes of this chapter, the borough comprehensive plan, other applicable chapters of the borough code, and other applicable planning documents adopted by the borough; 3. The development of the use or structure shall not physically damage the adjoining property; 4. The proposed use or structure is water-dependent. 5. Applicant or owner's compliance with other borough permits and ordinance requirements. E. Conditions attached to conditional uses and structures. In granting a conditional use permit, the planning commission may establish such conditions on the development, use, or operation of the use or structure for which the conditional use permit is granted as it determines necessary to prevent significant erosion, sedimentation, damage within the habitat protection district, or result in or increase ground or surface water pollution. Such conditions may include specifications for type of vegetative shore cover, location of structures and uses, periods of operation, type of construction, and mitigation. Violation of any of these conditions shall be deemed a violation of this ordinance. To secure information upon which to base its determination, the planning commission may require the applicant to furnish the following information: 1. A plan of the area showing surface contours, ordinary high water or mean high water marks, vegetative cover, slope measurements, soil conditions, wetlands, and drainages; 2. Location of buildings, parking areas, access, walkways, and other manmade features on the landscape; 3. Other pertinent information necessary to determine if the proposed use meets the requirements of this ordinance. F. If the planning commission denies a conditional use permit, a similar application for a conditional use permit may not be made within two years from the date of the denial unless there has been a substantial change in circumstances affecting the application. G. Applicants for a conditional use permit are responsible for abiding by all other federal, state, and local laws, regulations, and permitting requirements applicable to the project. H. The construction or installation phase of a use requiring a conditional use permit must be completed within one calendar year from the date of the permit's issuance, or the conditional use permit shall expire unless the planning commission finds that more time is necessary to effectuate the purposes of this chapter, in which case the commission may extend the deadline for a maximum of six years from the date of issuance...
21.18.082. ***Permit revocation***	[Text not included here]
21.18.090. ***Prior existing activities & structures***	[This section "grandfathers in" many existing uses and structures.] A. Intent. There are uses which were conducted, and structures which were under construction, or exist and were in use before the enactment of this ordinance which would be prohibited or restricted under the terms of this ordinance or future amendments. It is the intent of this section to allow these prior existing uses or structures to continue but not be increased, expanded, or intensified. Any prior existing uses or structures must still comply with other applicable laws. [B is omitted here.] C. Structures. Structures which were under construction or in use before the effective date of any provision of this chapter, but that would be prohibited or restricted under the terms of this chapter, shall be allowed to continue, provided that a structure under construction must have been substantially completed by April 16, 1998 for the anadromous waters set forth in KPB 21.18 Appendix Kenai River District, May 16, 2002, for the anadromous waters set forth in KPB 21.18 Appendix Major Waters District, January 1, 2014 for the anadromous waters set forth in KPB 21.18 Appendix West District, and January 1, 2016 for the anadromous waters set forth in KPB 21.18 Appendix South District and North District. [Sections 1 through 5 not included here] D. Uses. This chapter shall not prohibit or restrict uses which were legally conducted before the effective date of this section, provided that, after the effective date, such uses are conducted in the same location and are not enlarged to include a greater number of participants or to occupy a greater area of land. Any prior existing use which has ceased to be used, for forty eight consecutive months or more, shall be considered abandoned and thereafter not be conducted, used or occupied except in conformity with the provisions of this chapter. Upon application and approval of a prior existing structure/use permit by planning department staff a change to the prior existing use may be allowed. No change shall be granted unless the change reduces the noncompliance, by use of mitigation procedures set forth in KPB 21.18.091, to the maximum extent practicable. Staff will determine the mitigation measures to be used consistent with the following conditions [the five listed conditions are not included here]. E. Impervious materials placed in the habitat protection district which are not structures are not allowed as either prior existing uses or prior existing structures. The planning department may require removal of these materials. [Sections F and G not included here]
21.18.091. **Mitigation measures**	Mitigation measures may be required by planning department staff to address impacts to the habitat protection district from a proposed, ongoing, or completed project. These measures may include, but are not limited to: A. Standard erosion and storm water runoff control measures; B. Restoration and maintenance of native vegetation and water quality protection functions; C. Restoration and maintenance of native vegetation and water quality protection functions along areas that immediately abut the habitat protection district; D. Removal of non-conforming accessory structures from the habitat protection district; E. Other measures as agreed upon by the planning department and applicant. Examples include removal of seawalls, riprap, jetties, and other structures that may be detrimental to fish habitat; installation of approved bank protection measures; professional evaluation of privately owned waste water treatment system; removal of materials, structures and other items that may be present in the habitat

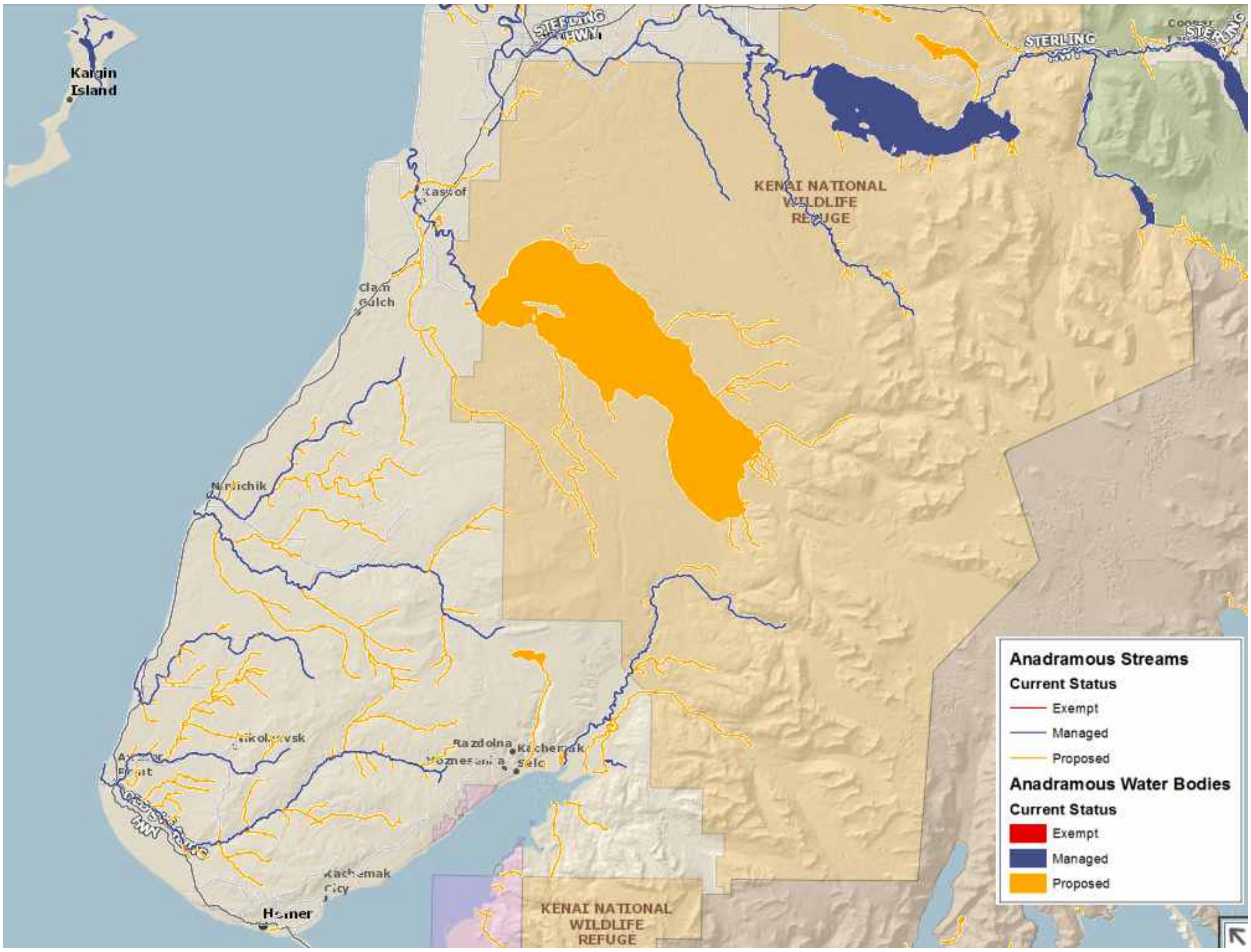
	protection district or along the shore.
	[The following sections covering Administration by cities; Violations—Enforcement; Conflict with city land authority, etc.; Administration and appeals; Exemption for emergency situations; and State regulations not superseded are not included here]
21.18.140. Definitions	As used in this chapter: "Abandoned" means to cease a use for a specified time period, whether the cessation of use is intentional or unintentional, and whether or not the use is seasonal. "Accessory structure" means a use or structure that is subordinate in size or purpose to the principal structure or use of the same lot or parcel of ground and serving a purpose customarily incidental to the use of the principal structure or use of land. "Anadromous Waters" as used within KPB 21.18 means those fresh or predominately fresh waters of the Kenai Peninsula Borough which have been listed by the State of Alaska Department of Fish & Game in the "Atlas and Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fish" and also listed within KPB 21.18 and the KPB 21.18 Appendix. "Best management practices" means that combination of conservation measures, structures, or management practices that reduces or avoids adverse impacts of development on land, water or waterways, and water bodies. "Braided Channels" means the intertwined branches or secondary channels of a river or stream and characterized by the separation and rejoining of two or more channels separated by bars or islands. "Commercial use" shall mean an occupation, employment, or enterprise that is carried on for sale of goods or services or for profit. "Conditional use" shall mean a use that would not be appropriate without restrictions throughout the habitat protection area but which, if controlled as to number, area, location, relation to the habitat or method of operation, would not cause or lead to significant erosion, sedimentation, damage to the habitat protection district, an increase in ground or surface pollution and damage to riparian wetlands and riparian ecosystems. "Cut bank" shall mean banks of anadromous waters with exposed soil surface that have occurred from natural or manmade causes whether the exposed surface extends to the high water mark or not. "Emergency" means a sudden unexpected occurrence, either the result of human or natural forces, necessitating immediate action to prevent or mitigate significant loss or damage to life, health, property, essential public services, or the environment. "Erosion" shall mean significant sloughing, washout, or discharge of soil arising from manmade sources or causes. "Estuary" means a semi-enclosed coastal body of water with a free connection to the sea and in which seawater is measurably diluted with freshwater derived from land drainage. "Fuel storage tank" shall mean any vessel for the storage of petroleum based fuels including gasoline, diesel, kerosene and heating oil having a liquid volume of 200 gallons or more. "Gratewalks" shall mean elevated light penetrating (ELP) walkways utilizing some variety of open grate material as a surface. "Ground or water pollution" shall mean the discharge, application, spread or release of chemicals, toxic materials, fuels, pesticides, petroleum based fuels on or into the soil and waters within the habitat protection area. "Higher high water" The higher of the two high waters of a tidal day where the tide is of the semidiurnal or mixed type. The single high water occurring daily during periods when the tide is diurnal is considered to be higher high water. "Impervious Coverage" means an area of ground that, by reason of its physical characteristics or the characteristics of materials covering it, does not absorb rain or surface water. All parking areas, driveways, roads, sidewalks and walkways, whether paved or not, and any areas covered by buildings, structures, or water shedding material such as, but not limited to, concrete, asphalt, brick, stone, wood, ceramic tile, plastic sheeting or metal shall be considered to be or have impervious coverage. Elevated light penetrating structures meeting the requirements of KPB 21.18.071 A.2 shall not be counted as impervious coverage. "Kenai River" shall mean the main stem of the river from and including Kenai Lake to the mouth including Skilak Lake. The main stem shall include all sloughs, channels, boat basins, distributaries, and lagoons. For the purpose of this chapter, the mouth shall be described as the western most section line common to Section 5 and Section 8, T5N, R11W, Seward Meridian. "Lagoon" means relatively shallow bodies of water, mostly-enclosed, with an oceanic source, separated by a low-lying swatch of land, such as a spit or barrier island. This oceanic source may be continual or episodic, such as storm-induced overwash, and generally has a different salinity as a result of its restricted access. "Lift" means a structure which elevates and lowers boats, floatplanes, people, and cargo to and from the river or adjacent shoreland. "Logging" shall mean removal or cutting down more than 50 trees per acre that have a breast diameter height of 6" or more. "Mean Higher High Water" A tidal datum. The average of all the daily higher high water recorded over a 19-year period or a computed equivalent period. "Mean high water line" or "ordinary high water line" shall have the definition given in 11 AAC 53.900(15) as it currently exists or as it may be renumbered or revised. "Mile Zero" The downstream beginning point of the anadromous waters identified in 21.18, and the riparian zone defined as the habitat protection district. On riverine systems subject to tidal inundation, Mile Zero begins at the elevation of mean high tide, where not otherwise designated by KPB code or prior designations. "Native vegetation" means native plant communities that are undisturbed or mimicked. "Ordinary high water mark" shall have the definition given in 11 AAC 53.900(23) as it currently exists or as it may be renumbered or revised. "Principal structure" means a structure in which is conducted the principal use of the lot on which it is located. "Public launch" means a facility accessible to the general public used to launch and retrieve trailered boats and is capable of launching such boats with a passenger vehicle and trailer in a safe manner. "Riparian habitat" shall mean the areas within and adjacent to anadromous waters containing spawning and rearing habitat for salmon or that provide immediate cover or stability for salmon and eggs at all stages of development. "River center" shall mean the Kenai Peninsula Borough Donald E. Gilman River Center. "Soil erosion" shall mean the increased movement of soils that occurs as a result of human activities or development.

	"Structure" shall mean anything which is constructed, erected or moved to or from any premises and which is located above, on, or below the ground, including buildings, roads, signs, billboards, satellite antennas and other communication structures, fences, and mobile homes. Building materials including but not limited to doors, windows, carpet, roofing, posts, and beams which have not been assembled, incorporated, or erected into a structure do not alone or collectively constitute structures. "Substantially complete" shall mean essentially completed and available for the owner's beneficial use for the purpose and in the manner intended for the structure. "Substantially damaged" shall mean that the cost to repair the damage equals or exceeds 50% of the structures' assessed value prior to the damage. "Substantially reconstructed" shall mean completed to a point where the structure is available for the owner's beneficial use or occupancy. "Tide Dominated Delta" means a river delta subject to tidal inundation as well as tidal and storm erosion which may be mainly submarine with prominent bars or ridges. "Watershed" means a land area, also known as a drainage area, which collects precipitation and contributes runoff to a receiving body of water or point along a watercourse. "Wetlands" shall have the meaning given in 16 USC § 1302 as applied to land within the habitat protection area.

Map 4.2a. Waterbodies, in the northern part of the Kenai lowlands, that were proposed for inclusion under the borough's anadromous habitat protection ordinance.

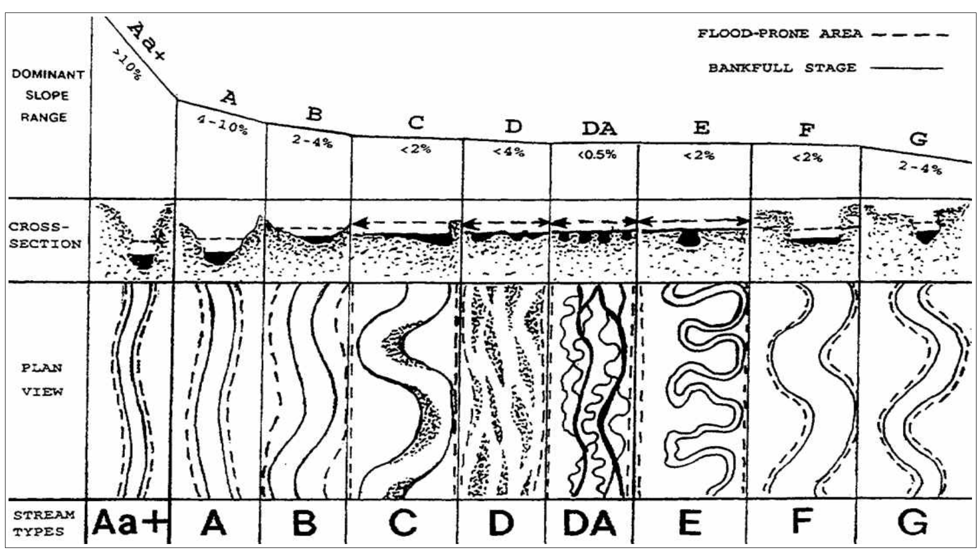


Map 4.2b. Waterbodies, in the southern part of the Kenai lowlands, that were proposed for inclusion under the borough's anadromous habitat protection ordinance.



4.2.2.2. *Floodplain Development* ordinance

As explained in Section 2.2.3, classifying stream channels in a meaningful way during peninsula wetland mapping was recognized as a high priority; R (riverine/riparian) wetland ecosystems were classified using a modified version of the Rosgen system (see Section. 2.2.3.2 and diagram **at right**, from http://www.alpine-eco.com/files/Rosgen_ClassificationNaturalRivers.pdf). As the cross sections at right show, "flood-prone area" differs according to stream channel type—some stream channels have well-defined floodplains, others do not. All R wetland map units include a code to identify stream channel type (and often subtype); Section 2.2.3.3 describes these codes.



Because of the benefits that floodplains can provide, and the damages and costs that generally result when natural functions/values of floodplains are altered, the Kenai Peninsula Borough regulates activities within floodplains through its floodplain development ordinance. This ordinance is codified in Chapter 21.06 of the Kenai Peninsula Borough Code of Ordinances (see http://www.kenairivercenter.org/Agencies/floodplain/floodplain ordinance.htm). Table 4.2b provides selected highlights from the floodplain ordinance.

	Table 4.2b. Key sections of Chapter 21.06, Floodplain Development Ordinance, Kenai Peninsula Borough Code of Ordinances Chapter 21.06 can be viewed at http://www.kenairivercenter.org/Agencies/floodplain/floodplainordinance.htm. To apply for a permit or get information, contact Gilman River Center, 514 Funny River Road, Soldotna, AK 99669 (907) 260-4882, www.kenairivercenter.org.
21.06.010. ***Findings***	A. The flood hazard areas of Kenai Peninsula Borough are subject to periodic inundation which results in loss of life and property, health, and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety, and general welfare. B. It is the purpose of this chapter to promote the public health, safety, and general welfare, and to minimize public and private losses due to flood conditions in specific areas by provisions designed: 1. To protect human life and health; 2. To minimize expenditure of public money and costly flood control projects; 3. To minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public; 4. To minimize prolonged business interruptions; 5. To minimize damage to public facilities and utilities such as water and gas mains, electric, telephone and sewer lines, streets, and bridges located in areas of special flood hazard; 6. To help maintain a stable tax base by providing for the sound use and development of areas of special flood hazard so as to minimize future flood blight areas; 7. To ensure that potential buyers are notified that property is in an area of special flood hazard; and 8. To ensure that those who occupy the areas of special flood hazard assume responsibility for their actions. C. In order to accomplish its purposes, this chapter includes methods and provisions for: 1. Restricting or prohibiting uses which are dangerous to health, safety, and property due to water or erosion hazards, or which result in damaging increases in erosion or in flood heights or velocities; 2. Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction; 3. Controlling the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel floodwaters; 4. Controlling filling, grading, dredging, and other development which may increase flood damage; and 5. Preventing or regulating the construction of flood barriers which will unnaturally divert floodwaters or which may increase flood hazards in other areas.
21.06.030. ***General Provisions***	A. Lands to Which this Chapter Applies. This chapter shall apply to all flood hazard areas within the Kenai Peninsula Borough exclusive of the cities of Homer, Kenai, and Soldotna. ["Flood hazard area" means the land area covered by the flood, having a 1 percent chance of occurring in any given year, "100-year flood".] B. Basis for establishing flood hazard areas. Flood hazard areas are identified by the flood insurance rate maps with an effective date of May 19, 1981, revised on July 5, 1983 and December 6, 1999. The map panels numbered 020012-1350 and 1700 have been deleted and the areas depicted by these panels are not subject to the terms of this chapter. Excluding these panels, the flood insurance rate maps are adopted by reference and declared to be a part of this chapter. The flood insurance rate maps are on file at the planning department. [C and D are omitted here.]
21.06.040. ***Administra-tion***	A. Development Permit Required. A development permit shall be obtained before construction or development begins within flood hazard areas established in Section 21.06.030(B). The permit shall be for all structures and for all other development including fill and other activities. Application for a development permit shall be made on forms furnished by the borough and shall include but not be limited to: plans in duplicate drawn to scale showing the nature, location, dimensions, and elevations of the area in question; existing or proposed structures, fill, storage of materials, drainage facilities, and the location of the foregoing. Specifically, the following information is required: 1. Elevation in relation to mean sea level, of the lowest floor (including basement) of all structures; 2. Elevation in relation to mean sea level to which any structure has been floodproofed; 3. Certification by a registered professional engineer or architect that the floodproofing methods for any nonresidential structure meet the floodproofing criteria in Section 21.06.050(B)(2) 4. Description of the extent to which a watercourse will be altered or relocated as a result of proposed development. C. Duties and Responsibilities of the Planning Department. [The rest of this section outlines how the Planning Department will review and issue permits.]
21.06.040. ***Standards***	[This section outlines standards required in all flood hazard areas, including *general standards* for anchoring, construction materials and methods, utilities, and subdivision proposals, and *specific standards* for building construction—including residential and nonresidential construction and manufactured homes.

4.2.3. The Alaska Department of Environmental Quality protects water quality

The Alaska Department of Environmental Conservation (ADEC or DEC), Division of Water, is responsible for protecting water quality in state waterbodies, including wetlands. DEC takes a variety of actions to meet this responsibility, including: establishing legal standards for water cleanliness; regulating discharges to waters and wetlands; and providing financial assistance for water and wastewater facility construction and waterbody assessment and remediation. The DEC, Division of Water, website is: http://www.dec.state.ak.us/water/index.htm. Go to that link to find out about DEC wastewater permits, National Pollutant Discharge Elimination Permits (NPDES), or required Stormwater Pollution Prevention Plans (SWPPP). For information about permits you might need from DEC, go to http://www.dec.state.ak.us/water/wwdp/online_permitting/permitentry.htm. Here you'll find the Division's "Permit Application Portal."

Under Section 401 of the Clean Water Act (CWA), Alaska has legal authority to review applications or projects requiring Section 404 permits (discussed in Section 4.1). By agreement, DEC reviews these project as they're described in the Corps "Public Notice of Application for Permit." During its review, DEC coordinates with state and federal agencies and local governments; reviews public comments; and then *approves*, *approves with conditions*, *waives*, or *denies* projects based on their compliance with the CWA, state water quality standards, and other applicable state laws. As part of this process, the state requires that anyone applying for a 404 wetland permit also get a Section 401 water quality certification ("Certificate of Reasonable Assurance") from DEC. This certificate is required for any activity regulated under Section 404 or 401 of the Clean Water Act.

DEC also administers the state's Alaska Pollutant Discharge Elimination System (APDES) Program, which provides for review of activities that may discharge pollutants into Alaska's waters, including wetlands. The type of permit or authorization required depends on the type of discharges being permitted and whether discharges will be to surface waters or to land.

DEC provides a variety of useful information at http://dec.alaska.gov/water/wwdp/wetlands/index.htm. As noted above, DEC's "Permit Application Portal" is at: http://dec.alaska.gov/water/wwdp/online_permitting/permitentry.htm.

4.2.4. "Swampbuster" provisions affect Natural Resources Conservation Service programs

The Natural Resources Conservation Service (NRCS) is an agency within the US Department of Agriculture (USDA). The NRCS mission is "helping people help the land." NRCS works through local landowners, managers, and other partners—such as Soil and Water Conservation Districts in Homer and Kenai—to assist them to conserve their soil, water, and other natural resources—including wetlands. For example, NRCS conservation assistance programs help landowners identify and apply appropriate conservation practices and resource management systems to maintain the quality of their lands and waters. NRCS assistance is tailored to each land manager's goals and needs, and to the soil- and water-related resource conditions found on his/her land. Cost sharing and financial incentives are available in some cases.

Participation in NRCS programs is voluntary, and the agency is not regulatory. However, NRCS works to ensure that land managers receiving its assistance avoid any "swampbusting" activities—activities that convert wetlands to non-wetland uses. "Swampbuster" provisions first appeared in the 1985 Food Security Act, also known as the 1985 Farm Bill. The NRCS explains these provisions as follows (from http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/wetlands/?cid=stelprdb1043483):

> *The Wetland Conservation (WC) provisions, commonly referred to as "Swampbuster," prohibit USDA program participants from converting wetlands on their agricultural operations to cropland, pasture, or hayland unless the wetland acres, functions, and values are compensated for through wetland mitigation... [See Section 1221, Public Law 99-198, Title XII – Conservation, Subtitle C – Wetland Conservation, program ineligibility.] The WC provisions are the only law that affords protection to many remaining wetland types. NRCS provides assistance to USDA program participants by identifying wetlands that are subject to the WC provisions and to respond to potential issues of non-compliance. If it is determined that a wetland has been converted, then NRCS works with the farmer or rancher to regain eligibility by developing a wetland restoration plan or compensatory mitigation plan.*

The 1990 Farm Bill (Food, Agriculture, Conservation, and Trade Act of 1990) provided the NRCS with an additional tool for protecting and restoring wetlands: the Wetland Reserve Program (WRP). The Wetland Reserve Program provides financial incentives to farmers to restore and protect wetlands through the use of long-term easements (usually 30-year or permanent). The program provides farmers the opportunity to offer a property easement for purchase by the USDA and to receive cost-share assistance to restore converted wetlands. Funding for WRP is appropriated annually by Congress. As explained by the NRCS (from http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/wetlands/?cid=stelprdb1043483):

> *This very popular program has enrolled approximately 2.5 million acres [nationwide] since it was created in 1994. Most of this acreage has been enrolled in the permanent easement option, where NRCS pays a per-acre easement fee, plus 100 percent of the cost to restore the agricultural lands back to natural wetland ecosystems. The landowner retains title, control of access, and hunting rights, but must protect the restored wetland ecosystem for future generations. The landowner can sell the land, but the easement (and protections) remain enforce for perpetuity.*

Over the years, Congress has exempted agricultural and silvicultural activities from swampbuster provisions if they meet specific conditions. For example, the NRCS can exempt agricultural actions that "individually and in connection with all other similar actions... will have a minimal effect on the functional hydrological and biological value of the wetlands in the area, including the value to waterfowl and wildlife." (See Title 16 USC 3821(f) for a list of conditions that NRCS can consider in exempting agricultural producers from swampbuster ineligibility provisions.)

A number of peninsula landowners receive USDA technical assistance or cost sharing through peninsula offices of the NRCS. Many participants, for example, have received cost sharing to establish high tunnels through the NRCS Environmental Quality Incentives Program (EQIP). The NRCS determines whether there are swampbuster issues before providing such assistance. The definition of wetlands used by the USDA is identical to that of the Corps and EPA (see Section 4.1) except that, in Alaska, a provision has been added related to permafrost wetlands on lands with high agricultural potential (no such areas are found on the Kenai Peninsula).

The NRCS Alaska State website can be found at: http://www.nrcs.usda.gov/wps/portal/nrcs/site/ak/home/. Alaskan NRCS offices are listed at http://www.nrcs.usda.gov/wps/portal/nrcs/main/ak/contact/. There are two NRCS field offices on the Kenai Peninsula:

Southern Hub Office
110 Trading Bay, Suite 160
Kenai, AK 99611
(907) 283-8732

Homer Field Office
4014 Lake St., Suite 201
Homer, AK 99603
(907) 235-8177, ext 3

Chapter 5. Ways to help maintain wetland functions and values

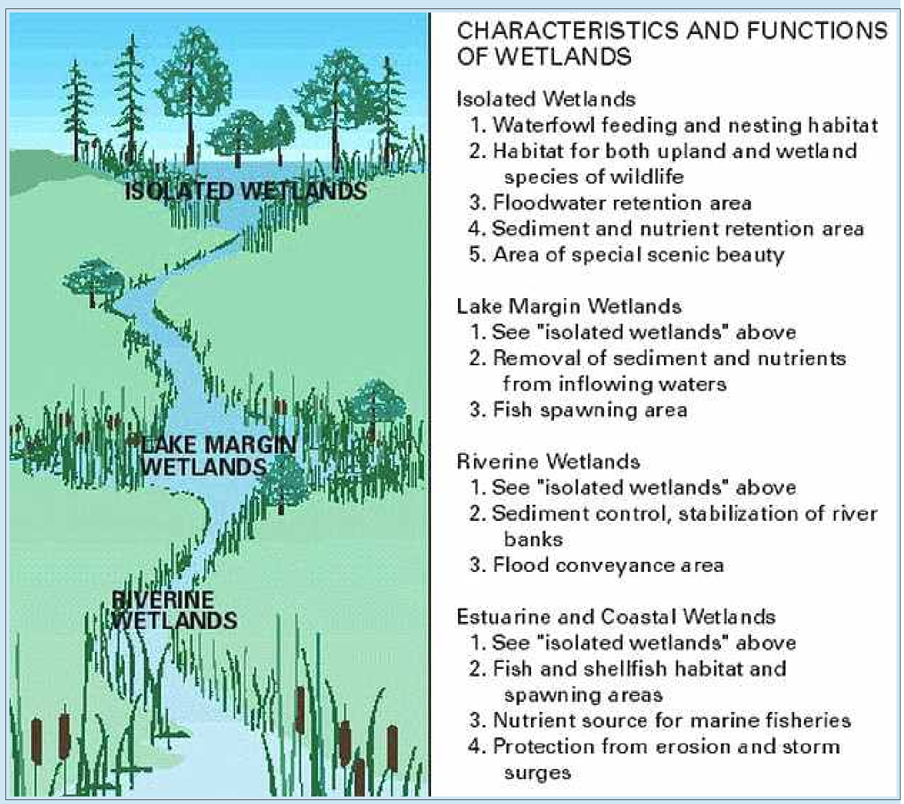
As this guide makes clear, peninsula wetlands do many things that have significant benefits for society—from helping keep our water clean and reducing flood risks; to supporting healthy populations of salmon, moose, and other animals and plants; to maintaining overall biodiversity and ecosystem health; to providing places for recreation, exploration, and connection to the past. The text box below provides another variation on this theme of wetland benefits, which is discussed in more detail in Chapter 3.

Once we recognize that wetlands provide beneficial functions and values like those assessed in this project, the question arises: What can those who use or manage peninsula lands and waters do to maintain these benefits? This chapter provides some basic and general answers to this question. Through an EPA-funded project, more specific management strategies are now being developed for different wetland areas. You can follow that project by clicking on http://www.homerswcd.org/projects/wetlands.php.

Another variation on the theme of wetland benefits and values, excerpted from...

Wetland Functions, Values, and Assessment

By Richard P. Novitzki (ManTech Environmental Technology, Inc.), R. Daniel Smith (U.S. Army Corps of Engineers), Judy D. Fretwell (U.S. Geological Survey), see http://water.usgs.gov/nwsum/WSP2425/functions.html.



...The value of a wetland lies in the benefits that it provides to the environment or to people, something that is not easily measured. Wetlands can have ecological, social, or economic values. Wetland products that have an economic value, such as commercial fish or timber, can be assigned a monetary value. True wetland value, however, goes beyond money. How much value does one place on the beauty of a wetland or its archeological significance? Wetland values are not absolute. What is valuable and important to one person may not be valuable to another person. As an example, the value of a wetland as duck habitat may be important to the hunter or birdwatcher but not to the farmer who owns the land...

...[V]alues assigned to wetland functions may change over time as society's perceptions and priorities change. The values that benefit society as a whole tend to change slowly; however, the values assigned by individuals or small groups are ...subject to rapid and frequent change and may even conflict... Society may have to resolve conflicts regarding the management or preservation of wetlands and their functions. Furthermore, society may have to choose among wetland functions that benefit individuals or small groups, that are of value to most of society, or that are important to the maintenance of the wetland itself.

5.1. "Reference condition" and maintaining wetland functions and values

Section 1.3.4 introduced the term "reference condition" with the following explanation:

> ...most wetlands on the Kenai Peninsula have been relatively little affected by human activities, and their capacities to function in "natural," self-sustaining ways is generally unimpaired. Wetlands still in a highly functioning, unimpaired, essentially undisturbed condition are said to be in "reference condition."

In other words, "reference condition" is a useful term to use when describing a wetland that is functioning "naturally" and in ways that are self-sustaining (given more-or-less naturally functioning watersheds). Such unimpaired wetlands are best able to perform beneficial functions and provide values such as those assessed in this project.

5.1.1. Reference condition, variability, and management goals

It's important to remember that **reference condition is not a static state**. As explained in Section 3.4.3.5, natural systems reflect "typical" patterns of variability at many scales over space and time. Variability is inherent in a wetland's reference condition—e.g., sometimes its water table is at the surface, sometimes it's much lower; sometimes plants are transpiring, sometimes they're dormant; sometimes wetland soils and peats are frozen, sometimes they're not.

Wetlands vary over time. For example, natural variations in flow regime are discussed in Section 3.4.3.5. In addition to these patterns of variability, natural systems—including wetlands—also exhibit "episodic" variability. This kind of variability is caused by extreme events that occur only rarely, or "episodically." These events are usually regional in scale, affecting whole watersheds or even multiple watersheds, such as the eruption of Mt. Redoubt in 2009 and the "Great Alaska Earthquake" of 1964. This has led scientists and managers to "...pay more attention to... high magnitude events that cross thresholds and 'rejuvenate' the landscape cycle..." (J. Piper, November 11, 1998, in http://www.sgp.org.pl/gw/wmd/wmd.html).

In addition to reflecting both "typical" patterns of variability and infrequent "episodic" regional events, wetland variability also reflects global processes. Examples of such processes include climate change related to increases in atmospheric carbon, oscillations in ocean temperature (like El Niño and the Pacific decadal oscillation), Milankovitch cycles (which reflect changes in the tilt of the earth's axis and the shape of its orbit), solar variations (which reflect changes in the amount of radiation emitted by the Sun), changes in sea level (like those that exposed the Bering land bridge, see Section 3.5.3.2), and global effects of large volcanic eruptions.

Given the dynamism and variability of natural systems, how do we frame management goals if we want to manage a wetland so as to maintain its beneficial functions and values? Extremes of natural variability aside (which humans have limited capacity to predict or prevent), the concept of "reference condition" provides a useful framework for expressing management goals:

> **The most basic goal when managing any wetland is to keep it in *reference condition*—then ALL the benefits it potentially provides will be maintained.**

Q: What can we do to maintain a wetland's functions and values?

A: Keep the wetland in reference condition as nearly as possible.

If that goal is achieved, ALL the benefits potentially provided by the wetland will be available—regardless of what those benefits may be.

We should also remember that because wetlands are so intimately interconnected to and shaped by larger watershed processes (see for example, Figure 3.5a and Section 3.4.4), maintaining wetland functions and values depends on maintaining healthy watersheds. Watersheds—including their wetlands—represent integrated systems. These systems abound with feedback loops and other mechanisms that combine, magnify, attenuate or in other ways integrate the watershed processes and conditions observed in a particular location at any one time (see Section 3.4.3.5). This is why wetland managers and regulators talk so much about *cumulative impacts*—what happens in one part of a watershed is additive with what happens in other parts, creating cumulative impacts (usually downslope) that can be greater than, and different from, the "sum of their parts."

A healthy *watershed* can be measured by its ability to:
- **Intercept, infiltrate, and store rainfall**
- **Recharge groundwater supplies**
- **Protect soil from erosion**
- **Sustain and regulate streamflows**
- **Sequester and recycle nutrients**
- **Support natural riparian and floodplain functions**
- **Meet the habitat needs of native species—upland and aquatic**

adapted from Chapter 4, *The State of Chesapeake Forests* (http://www.na.fs.fed.us/watershed/socf.shtm)

5.1.2. Principles underlying effective wetland management

As discussed in Chapters 2 and 3, the conditions that characterize a wetland are determined by physical, hydrologic, chemical, and biologic processes occurring within and around the wetland along with how these processes interact. Although these processes and their interactions are complex and change over space and time, we can say some basic things about them and how these processes can be managed:

- Within the constraints of a wetland's landform shape and position (i.e., its geomorphology and watershed location), wetland conditions are determined primarily by:
  - how much water enters and leaves the wetland (see hydrology functions, Section 3.4.3, and water budgets, Section 3.4.5),
  - frequency, timing and duration of this inflow and outflow (see natural flow regimes, Section 3.4.3.5),
  - kinds and amount of organic and inorganic material that the inflowing water carries (see wetland water quality, Section 3.4.3.7), and
  - what's happening in the surrounding landscape that affects these factors.

  Effective management maintains wetland water budgets, flow regimes (including their natural variability), and water quality. This means maintaining the ecosystem connections that are responsible for the movement of water, nutrients, organisms, chemicals, etc.

- Plants mediate the factors listed above. For example, among its effects, vegetation can slow the velocity of water into, through, and out of a wetland; bind and stabilize shorelines; reduce runoff and erosion from surrounding uplands; trap sediments; filter and transform pollutants; provide shade that lowers water temperatures; and reduce wind speeds and resultant evaporation.

  Effective management maintains plant communities within and along wetlands and on surrounding uplands.

- Stressors are the things that change wetland water flows, plant communities, and other conditions and processes on which reference condition depends (see Section 5.2). Stressors can originate within the wetland itself (e.g., local effects of dredge or fill) or come from outside the wetland (e.g. increases in inflow or pollution caused by impervious surfaces upslope). Many stressors originate beyond wetland borders. Stressors from outside the wetland—caused by changes occurring in the larger watershed—often have cumulative impacts on wetlands that become increasingly damaging over time.

  Effective management identifies key wetland stressors at both the local and watershed scale and minimizes their short-term, long-term, and cumulative negative impacts on affected wetlands.

- It is always much less expensive and much more effective to ***prevent*** or minimize damage to a wetland than to repair damage once it's occurred. (Many states in the Lower 48 are spending millions of dollars annually trying with great difficulty to restore altered wetlands, some examples are mentioned near the end of Section 3.4.4.) In addition to saving restoration costs, preventing damage to wetlands also ensures that they can continue doing things society values—such as supporting salmon habitats, storing storm-water and reducing floods, filtering drinking water, and providing recreational areas. By maintaining these functions and values, related economic benefits are also maintained. So keeping wetlands in reference condition both saves the cost of wetland restoration and produces economic benefits associated with the functions and values maintained.

Effective wetland management saves money for landowners and communities.

The bottom line is that we have the capability to maintain wetlands in reference condition if we maintain the natural processes, conditions, and connections that sustain them.

5.2. Developing wetland management strategies

Management choices and actions can indeed have positive, meaningful effects on wetland processes—and therefore on related functions and values. Management strategies and best practices for particular wetlands are now being developed. That process is collaborative and ongoing, with a scheduled completion date of September 30, 2014.

5.2.1. A brief introduction to wetland stressors

One approach to developing management recommendations is to identify stressors that may affect particular wetlands, or particular functions/values, in different locations. As used here, a wetland stressor is any process, action, or activity likely to cause a wetland to deviate from its reference condition, which in turn reduces the wetland's potential to perform beneficial functions or provide things we value.

As suggested in Section 5.1.1, many stressors are natural—such as earthquakes, floods, and volcanic eruptions—and we have limited capacity to affect these. Many stressors, however, are caused by human land uses and activities. (These are often referred to as "anthropogenic," which just means "caused by humans.") Human-caused stressors can be identified and managed. Table 5.2a illustrates potential stressors. The more specifically such lists can be tailored to the kinds of wetlands and land use situations found in various peninsula watershed locations, the more straightforward it will be to develop effective management strategies.

Table 5.2a. Examples of wetland stressors
(This is Table 7, "Methods of Altering Wetlands," from http://water.usgs.gov/nwsum/WSP2425/legislation.html.)

PHYSICAL	
Filling	adding any material to raise the bottom level of a wetland or to replace the wetland with dry land
Draining	removing water from a wetland by ditching, tiling, pumping, and so forth
Excavating	dredging and removing soil and vegetation from a wetland
Diverting water away	preventing flow of water into a wetland by removing water upstream, lowering lake levels, or lowering ground-water tables
Clearing	removing vegetation by burning, digging, application of herbicide, scraping, mowing, or otherwise cutting
Flooding	raising water levels, either behind dams, by pumping, or otherwise channeling water into a wetland
Diverting or withholding natural sources of sediment	trapping sediment by constructing dams, channels, or other types of projects, thereby inhibiting wetland regeneration in natural deposition areas…
Shading	placing pile-supported platforms or bridges over wetlands, causing vegetation to die because of a lack of adequate sunlight
Conducting activities in adjacent areas	disrupting interactions between wetlands and adjacent land areas, or incidentally affecting wetlands through activities at adjoining sites
CHEMICAL	
Changing nutrient levels	increasing or decreasing nutrient levels within local water and/or soil systems, forcing wetland plant community changes
Introducing toxics	adding toxic compounds to a wetland either intentionally (for example, herbicide treatment to reduce vegetation) or unintentionally, adversely affecting wetland plants and animals
BIOLOGICAL	
Grazing	consumption and compaction of vegetation by domestic or wild animals
Disrupting natural populations	reducing populations of existing species, introducing exotic species (invasives), or otherwise disturbing resident organisms

5.2.2. What to do in the meantime to maintain wetland functions and values

Even while specific management strategies are being developed for various kinds of wetlands (as outlined above), land owners and managers can readily take actions to protect conditions and processes in their wetlands—and thus help maintain beneficial functions and values. Two effective actions are introduced below:

1. Use properly designed buffers to protect plant communities within and around wetlands. An introduction to buffers is provided in Section 5.2.2.1.
2. Use approaches from the Low Impact Development (LID) "toolkit" to minimize runoff, erosion, and pollution during development, particularly in proximity to wetlands. LID techniques can be incorporated by almost anyone into almost any kind of development to reduce runoff, erosion, and pollution that could affect wetlands. An introduction to Low Impact Development is provided in Section 5.2.2.2.

5.2.2.1. A key way to maintain wetland water quality, wildlife, and plant communities: BUFFER

A buffer is a vegetated linear feature managed to separate (and often protect) one kind of landscape element (like a stream or wetland) from another (like residential development, forestry, or agriculture). Location and design of buffers depend on what kind of landscape elements and processes are being protected, what kind are being protected from, and local conditions like soils, slopes, and plant communities.

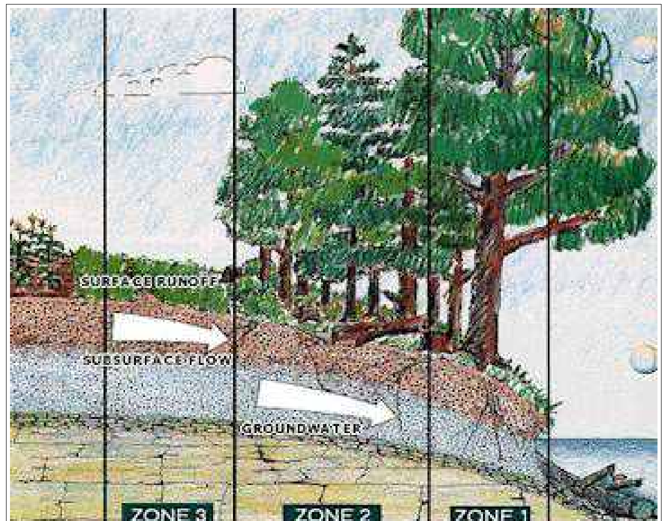
Well-vegetated buffers that protect natural wetland conditions and processes also protect related functions and values. Fifty feet is often considered a minimum width for an effective stream or wetland buffer; in forested stream corridors, a rule of thumb is to make buffers at least as wide as the height of the tallest trees growing along the stream. (You'll notice that the three-zone buffer shown below is 100 ft wide.) The entire width of meander belts should be protected, since streams will tend to meander throughout this width. The i**mage at right** shows buffers designed to protect and connect isolated wetlands (#1) and riparian wetlands (#2).

A number of questions should be considered when designing and creating effective wetland buffers. These include:

- What is the minimum total buffer width that will be effective in meeting buffer objectives? This depends on site conditions like soils, slopes, plant communities, upslope land uses, etc.
- What buffer design will be most effective given management goals? An example three-zone riparian forested buffer system is illustrated below.
- What plant communities will be maintained or established in the wetland buffer? If natural plant communities already exist in a proposed buffer area, the most beneficial and cost effective approach is to protect what's already there. Retaining natural plant communities is most likely to protect the natural conditions and processes in buffered wetlands. If proposed buffer areas don't currently support native plant communities, looking at vegetation in nearby undisturbed areas with conditions similar to those in the proposed buffer will suggest what plant communities are likely to be ideal.
- What allowances should be made for expanding (or contracting) the buffer. For example, erosion along an outside river meander bend will tend to shift the channel sideways and downstream (see diagram on next page). Buffer width should take into account long-term processes like this.
- Where, when, and how will the buffer be crossed? (A permit is required from Alaska Department of Fish and Game to cross anadromous streams, see Section 4.2.1.)
- Can practices be incorporated into the buffer to reduce stormwater volumes and velocities? For example, can vegetated depressions, such as raingardens or bioswales, be incorporated to slow down stormwater and allow it more time to infiltrate?
- How will the buffer be maintained?

Below is an example of a three-zone riparian forested buffer (slightly modified from http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=82&minmeasure=5).

The three-zone buffer system shown at right consists of an inner, middle, and outer zone. The zones are distinguished by function, width, vegetative target (long-term goal), and allowable uses.



Sketch of a typical riparian forest buffer (Source: Chesapeake Bay Program, 2000)

ZONE 1: The inner zone protects physical and ecological integrity. It consists of a minimum of 25 feet in addition to the wetland or critical habitat area. The vegetative target for management consists of dense, mature natural vegetation (including woody species). Allowable land uses and activities are very restricted (flood control, utility rights-of-way, footpaths, etc.).

ZONE 2: The middle zone provides distance between upland development and the inner zone. It is typically 50 to 100 feet, depending on factors such as stream order, slope, and 100-year floodplain. The vegetative target for this zone is the same as for Zone 1. Usage includes some recreational activities, stormwater best management practices (see LIDs below), and nondestructive trails.

ZONE 3: The outer zone is the first zone to encounter runoff. It prevents encroachment into the buffer while slowing and filtering runoff. The outer zone width is at least 25 feet, and while forests and shrubs are encouraged, grasses can be a vegetative target. Outer zone uses are unrestricted. They can include lawn, garden, compost, yard wastes, and most stormwater best management practices.

Appendix II. Matrix Approach to Buffer Distance

Island County, Washington:
This excerpt is based on Island County's *draft ordinance* from November 2007, which reflects a sophisticated use of the matrix approach to buffer distance. The ordinance first prescribes buffers for a few types of particularly sensitive wetlands (especially bogs, coasta lagoons and estuarine wetlands), with wider buffers for more intensive land uses. Then it establishes matrices to calculate buffers for *other* wetlands based on land use intensity, habitat condition, and wetland sensitivity (as predicted by slope and presence or absence of surface water outlet). Wetlands that lack outlets and are adjoined by steep slopes are presumed to be more sensitive to accumulation of sediment and contaminants, so receive larger buffers. For most wetlands both habitat and water quality buffers are calculated separatel and the *larger* buffer (usually habitat) is applied. (The numbers below should be taken as illustrative). The habitat calculation is:

Habitat Buffers					
Land use Intensity	Habitat Functions Score				
	50 or higher	42-48	39-41	32-38	Less than 32
Low	150 ft	125 ft	100 ft	75 ft	Use Water Quality & Slope Tables
Moderate	225 ft	175 ft	150 ft	110 ft	
High	300 ft	200 ft	175 ft	150 ft	

The water quality calculation includes differing buffers based on wetland type (A-E) and whether there is a surface water outlet from the wetland.

Water Quality Buffers						
Land Use Intensity	Wetland Category					
	Wetland Outlet	A	B	C	D	E
Low	Yes	40 ft	35 ft	30 ft	25 ft	20 ft
	No	75 ft	50 ft	40 ft	35 ft	25 ft
Moderate	Yes	90 ft	65 ft	55 ft	45 ft	30 ft
	No	105 ft	90 ft	75 ft	60 ft	40 ft
High	Yes	125 ft	110 ft	90 ft	65 ft	40 ft
	No	175 ft	150 ft	125 ft	90 ft	50 ft

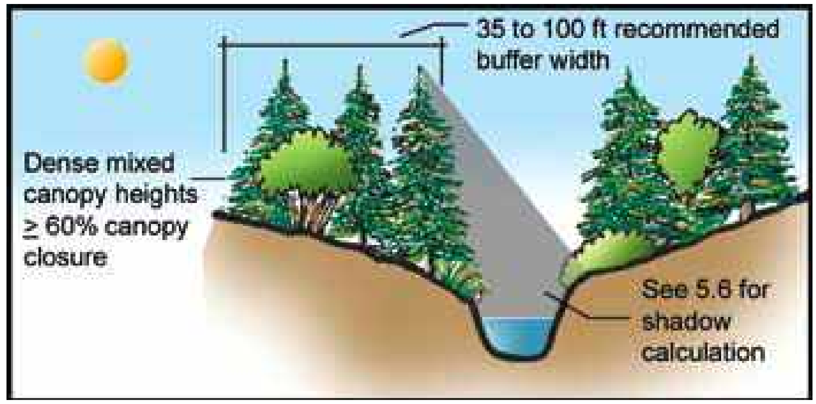
The water quality value is then adjusted for slope:

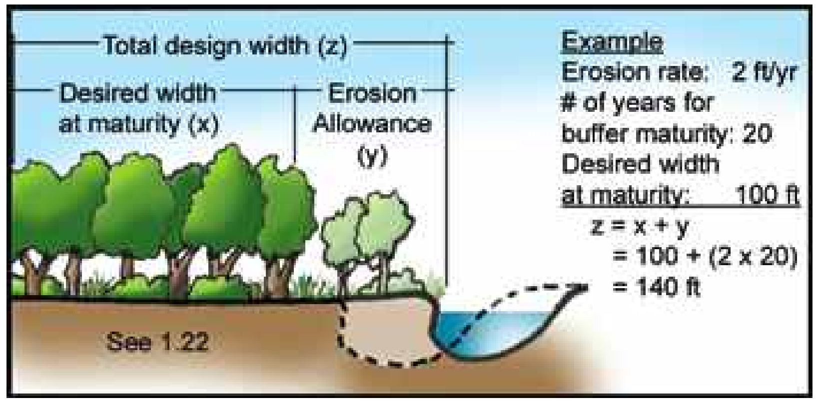
Slope Adjustment	
Slope Gradient	Additional Buffer Multiplier
5-14%	1.3
15-40%	1.4
>40%	1.5

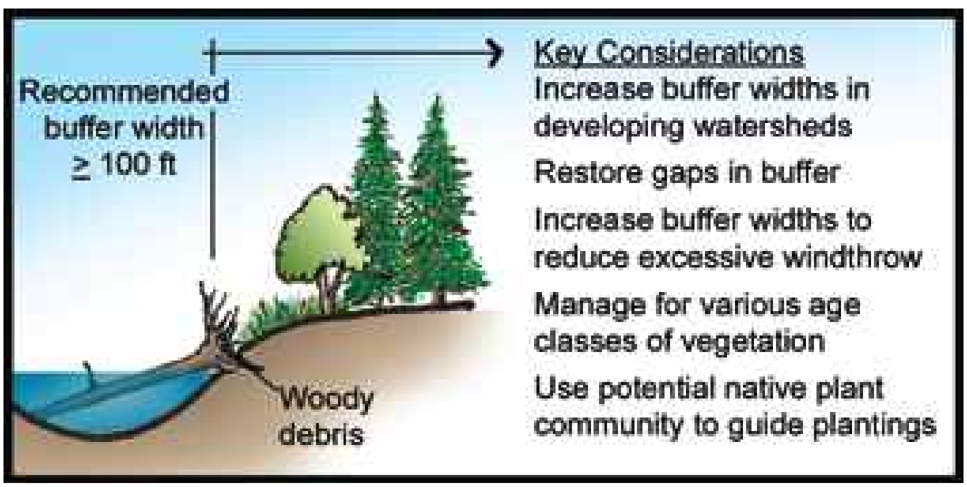
This matrix approach is more complex than a single numbe but can better reflect scientific understanding, particularly with diverse wetland types and land use conditions in a locality. With appropriate public outreach and technical support, a matrix-driven buffer can gain public support and achieve good results.

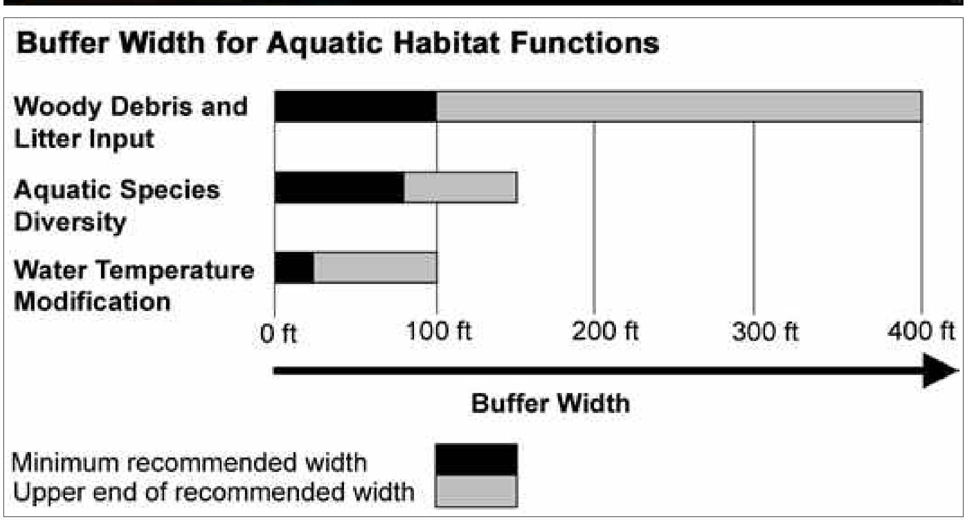
The Environmental Law Institute's *Planner's Guide toWetland Buffers for Local Governments* illustrates a system—shown at right—for designing site-specific buffers (see http://www.elistore.org/reports_detail.asp?ID=11272).

Another good guide to designing conservation buffers of all types is *Conservation Buffers – Design Guidelines for Buffers, Corridors, and Greenways*, which can be found at: http://nac.unl.edu/bufferguidelines/docs/conservation_buffers.pdf. Illustrations at right and below from that guide suggest some of the considerations related to designing a buffer. Clearly, buffer purpose and function are among the most important. Additional key considerations include local site conditions, such as slopes adjacent to the area being buffered and land uses being buffered from.









5.2.2.2. A key way to maintain wetland water budgets, flow regimes, and water quality: Low Impact Development (LID)

Traditional approaches to stormwater management typically involve hard infrastructure to move stormwater offsite and downslope quickly. Low Impact Development is a stormwater and land management strategy designed to manage stormwater as close to its source as possible, where it is most easily (and least expensively) handled. The goal is to minimize runoff from developed sites by mimicking natural processes of water collection, interception, infiltration, storage, filtration, evaporation, and transpiration (see Chapter 3, Section 3.4).

Implementing LID promotes the natural movement of water within a watershed; and applied widely, LID techniques can help maintain a watershed's hydrologic and ecological functions. Like wetlands in reference condition, LID practices reduce the volume and intensity of stormwater flows (which minimizes flooding) and help remove nutrients, pathogens, metals, and other pollutants from runoff. These LID effects help uplands and wetlands to work together effectively and sustainably. Incorporating LID techniques throughout a watershed contributes in significant ways to maintaining wetland conditions and processes, including related functions and values.

EPA provides useful information on LIDs at http://water.epa.gov/polwaste/green/. To compare costs between between LID and traditional stormwater management techniques, EPA reviewed 17 case studies. In general, LID practices reduced project costs and improved environmental performance. Although not all project benefits highlighted in case studies were monetized, with a few exceptions, LID practices were shown to be both fiscally and environmentally beneficial to communities. Total capital cost savings ranged from 15 to 80 percent when LID methods were used, with a few exceptions in which LID project costs were higher than conventional stormwater management costs.

Additional information on LIDs can be found from many sources, such as:

- Washington state's Low Impact Development Technical Manual (which includes design guidance for all BMPs in the Washington state Stormwater Manual); Seattle's Green Stormwater Infrastructure, Natural Drainage Systems, and RainWise website; Rain Garden Handbook for Western Washington.
- Oregon State University's LID factsheets, at http://extension.oregonstate.edu/stormwater/lid-fact-sheets. These cover techniques such as swales, soakage trenches, raingardens, and vegetated filter strips. (Homer Soil and Water can offer help in planning and installing raingardens, including cost share in some cases.)
- The Low Impact Development Center: http://www.lowimpactdevelopment.org/links.htm

Impervious surfaces

However achieved, reducing impervious surfaces is one of the key elements in LID approaches. As the amount of impervious surface in a landscape increases, a chain of events is set in motion that alters the way water is transported and stored. These changes can affect the local water cycle. Once this chain of events begins, effects are far-reaching, and can include increased flooding, decreased water quality, and degraded fish and wildlife habitats. Research in recent years has shown a strong relationship between the amount of impervious cover in a watershed and the health of local streams: the higher the percent of impervious surfaces, the more the local streams are stressed by changes in water quality and flow patterns. A study by the U. S. Geological Survey in five watersheds in Anchorage found cause for concern from impervious surfaces covering 4.4 –5.8 percent of watershed area (Ourso, R.T., and S.A. Frenzel. 2003. Identification of linear and threshold responses in streams along a gradient of urbanization in Anchorage, Alaska. *Hydrobiologia* 501(July):117-131; abstract available at: http://dx.doi.org/10.1023/A:1026211808745). The **figure below left** (from http://extension.oregonstate.edu/storm_water/learn-about-low-impact-development) shows effects of impervious surfaces on surface and subsurface runoff volumes. The **photo below right** of Anchorage illustrates how development reduces both the interception provided by natural vegetation and the infiltration provided by undisturbed soils (used by permission from aerialarchives).

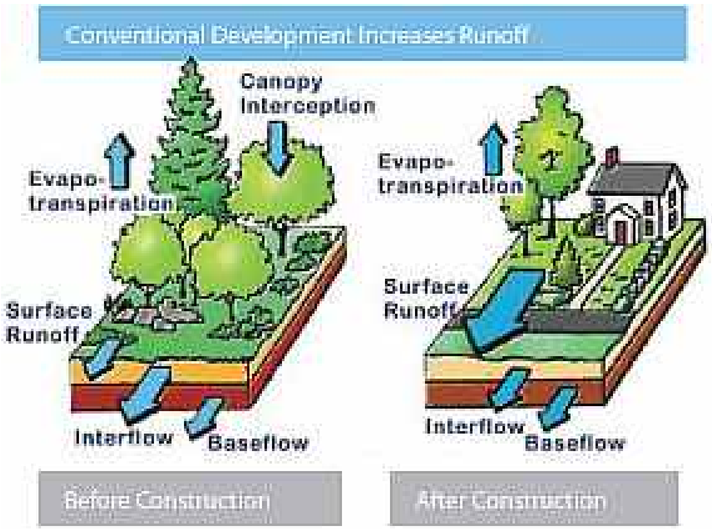
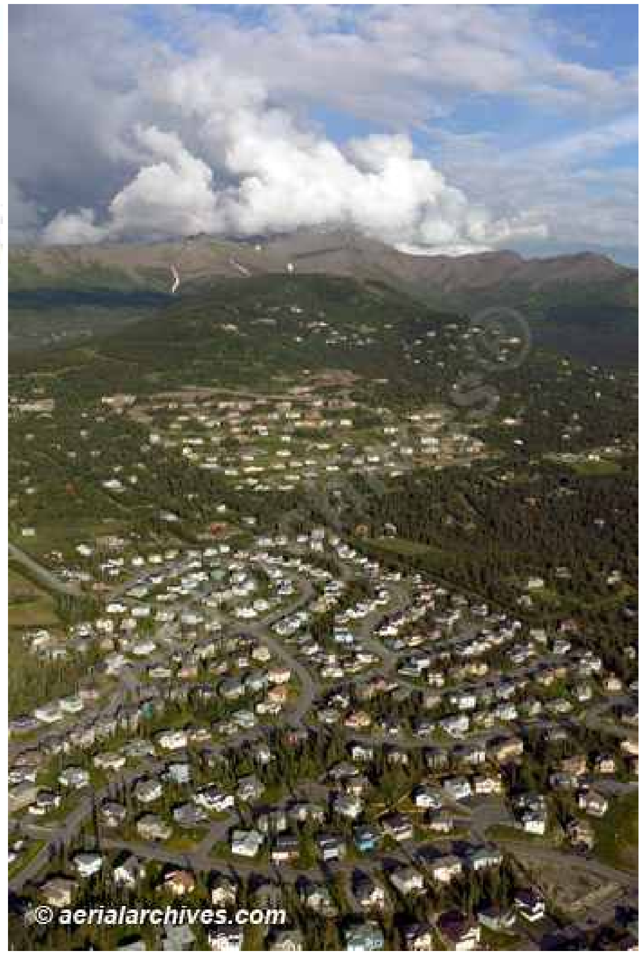


Figure above: Typical development clears the land of vegetation and covers it with hard surfaces such as roads, parking lots and rooftops. Construction compacts soils, so that even landscaped areas can generate unnaturally high runoff volumes. Storm drains are installed to get water out of the way by sending it into local streams... without treatment. Development dramatically increases runoff volumes which, even when controlled by detention basins, causes flooding, damages fish and wildlife habitat, and delivers urban pollutants such as oils and pesticides to local waterways. The decreased infiltration results in less cool, clean groundwater to recharge streams in the dry summer months.



The photo at right shows development on the Anchorage hillside. Forested buffers and bioswales paralleling hillside contours could have been used to reduce runoff. Coniferous trees such as spruce are particularly important in reducing runoff because of their high capacity to intercept rainfall—reducing the amount reaching the ground and slowing its delivery—and for their ability to store snow (photo used by permission from aerialarchives, http://www.aerialarchives.com/).

5.2.3 Examples of wetland management strategies developed for City of Homer wetlands

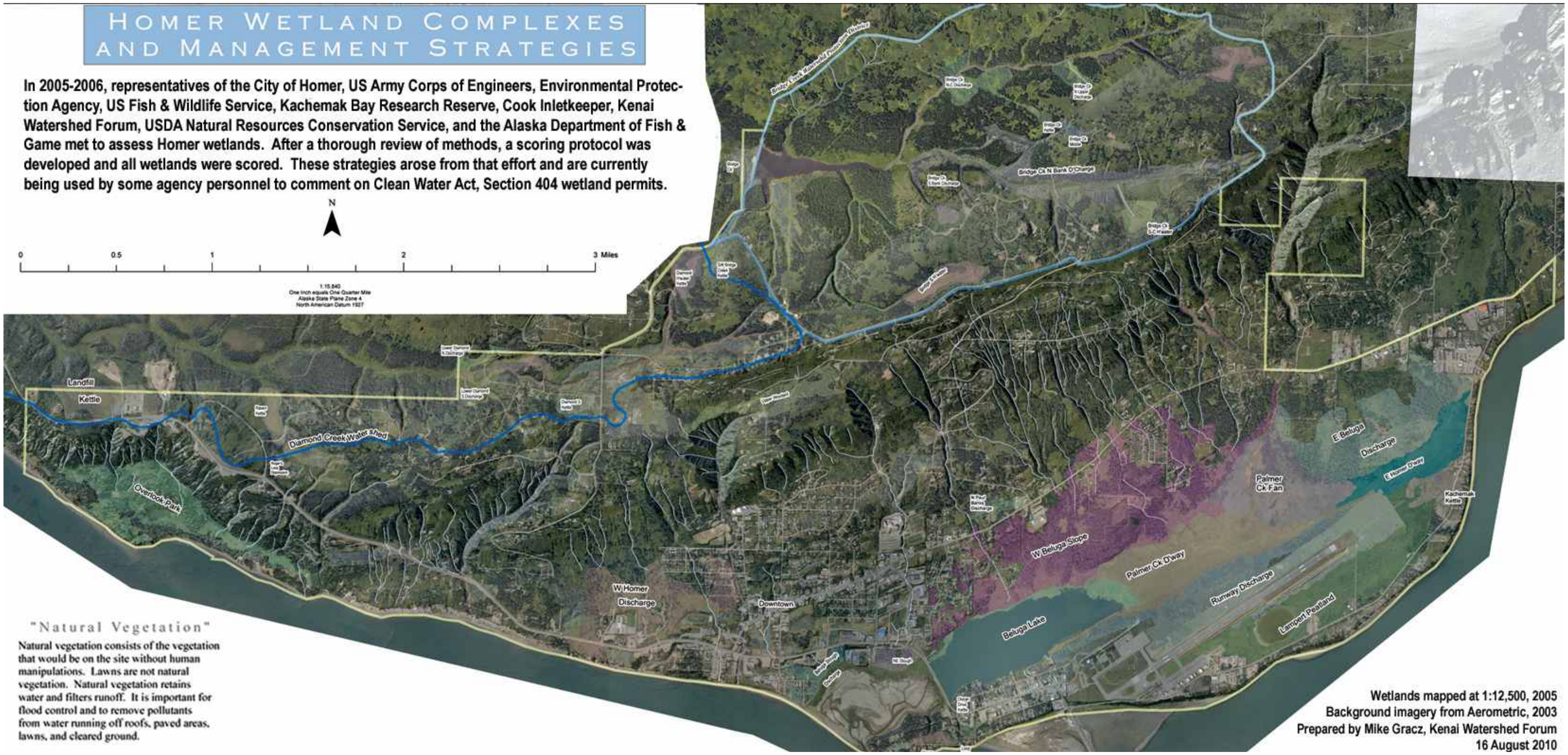
Homer provides an example of how management strategies grew out of a wetland assessment. Map 5.1a shows color-coded wetland management units within the Homer area. These were created by combining wetland map units (polygons) based on wetland types and functions and values. Each management unit was then named and assigned appropriate management strategies, which are shown in Table 5.2b

Homer's wetland management strategies are now being referenced by reviewers[78] when they comment on applications for 404 wetland permits (see Chapter 4, Section 4.1.3.1). As a result, these recommendations have become significant. Homer strategies are an example of what can be produced for land managers through a wetland assessment.

Effective management—like effective assessment—depends on understanding the variability among wetlands, which can mean that "a kettle isn't a kettle isn't a kettle." Instead, spatially explicit modifiers and adjacency can mean that one kettle serves selected functions differently than does another. Connections between wetlands and between surface and groundwater are also important. For example, Tustumena Lake discharges groundwater into wetlands as far away as Kalifornsky Beach Road (see background in Section 3.4.6. *Groundwater – invisible connections between surface and subsurface flow*s).

78 See Chapter 4 for a discussion of US Army Corps of Engineers 404 wetland permits and which agencies review permit applications, as well as applications affecting anadromous streams and floodplains.

Map 5.1a Wetland management units distinguished in the Homer area (from: http://www.cookinletwetlands.info/downloads/HomerComplexesStrategiesPoster.pdf)
(Note: the online map file is over 23 MB in size.) Associated management strategies area shown in the following table.



Wetland management unit	**Table 5.2b. Wetland management strategies recommended for particular wetland management units** (Note: "natural vegetation" is the vegetation that would be on the site without human manipulations. Lawns are not natural vegetation. Natural vegetation retains water and filters runoff. It is important for flood control and to remove pollutants from water running off roofs, paved areas, lawns, and cleared ground.)
Beluga Lake	Prohibit fill in Beluga Lake or the two associated wetland polygons (docks are permitted).
Beluga Slough	Prohibit fill in Beluga Lake or the two associated wetland polygons (docks are permitted).
Beluga Slough Discharge	Development should be encouraged in this core area of Homer. Mitigate for the loss of moose habitat. Further development north of Bunnell Street and east of Main Street should be discouraged. A goal of this plan is to bring private parcels in this area into conservation status. Development in tidally influenced wetlands should be prohibited.
Bridge Ceek	The wetland management strategy for this watershed is the same as the Bridge Creek Watershed Protection Ordinance, which includes a prohibition on filling wetlands.

Diamond Creek wetlands	Maintain large lot sizes. Maintain a 100-ft setback of natural vegetation along either side of Diamond Creek and its tributaries. Crossings should be perpendicular to the channel via bridge or oversized culvert and involve the minimum amount of fill necessary for safety. Where uplands exist on a lot, they must be used prior to filling wetlands. If more than 3% of wetlands on any lot are converted to hardened (impervious) surfaces, they must be compensated for with swales and/or runoff retention ponds. Loss of moose habitat should be mitigated.
Downtown wetlands	On City-owned parcels, maintain greenbelts incorporating stormwater retention designs. Where uplands exist on a lot, they must be used prior to filling wetlands. If more than 3% of wetlands on any lot are converted to hardened (impervious) surfaces, they must be compensated for with swales and/or runoff retention ponds. Loss of moose habitat should be mitigated.
East Beluga Discharge	Accelerated runoff from hardened (impervious) surfaces should be offset with swales and/or runoff retention ponds [as well as with other Low Impact Development measures]. Site design should include hydrologic connectivity to upstream and downstream parcels. Moose habitat values are high throughout. Moose habitat should be preserved or mitigated. Development along the border with the East Homer Drainageway Complex should maintain an 85-ft buffer of natural vegetation.
East Homer Drainageway	This area should be targeted for preservation and restoration. Encourage purchasing of private lots, e.g., by Kachemak Heritage Land Trust, Kachemak Moose Habitat, Inc., and others. If possible, restore hydrology and repair or implement suitable stormwater management measures along Kachemak Drive. Some fill may be allowed along Kachemak Drive.
Kachemak Kettle	Maintain a 100-ft buffer along the East Homer Drainageway. Accelerated runoff from hardened (impervious) surfaces will be offset with swales and or/runoff retention ponds [as well as with other Low Impact Development measures]. Loss of moose habitat should be mitigated.
Lampert Peatland	Maintain a 100-ft buffer around Lampert Lake. Mitigate for lost hydrologic, general habitat, and moose habitat functions in wetlands west of Lamper Lake. Discourage further development of wetlands east of Lampert Lake. Prohibit wetland filling more than 400 ft from Kachemak Drive.
Landfill Kettle	Restrict development to the south side of the wetlands and along the highway. Accelerated runoff from hardened surfaces will be offset with swales and/or runoff retention ponds. Loss of moose habitat should be mitigated. The peatlands should be preserved and buffered with a 50-ft setback of undisturbed natural vegetation, as they are highly functional for water retention and filtering.
Loop Kettle	Loss of moose habitat should be mitigated.
Northeast (NE) Slough	Retain natural vegetation as practicable. Preserve existing wetlands for water quality functions and moose habitat.
North Paul Banks Discharge	Encourage development here. Retain natural vegetation as is practicable. Accelerated runoff from hardened (impervious) surfaces will be offset with swales and/ or runoff retention ponds [as well as with other Low Impact Development measures]. Loss of moose habitat should be mitigated.
Ocean Kettle	Accelerated runoff from hardened (impervious) surfaces will be offset with swales an/or runoff retention ponds. Loss of moose habitat should be mitigated.
Ocean Drive Kettle	Retain natural vegetation as practicable. Accelerated runoff from hardened (impervious) surfaces will be offset with swales an/or runoff retention ponds. Loss of moose habitat should be mitigated.
Outer Loop Kettle	Retain natural vegetation as is practicable. Accelerated runoff from hardened (impervious) surfaces will be offset with swales an/or runoff retention ponds. Loss of moose habitat should be mitigated.
Overlook Park	**Public lands**: Maintain in conservation status and manage according to site management plan. **Private lands**: Maintain moose habitat by limiting fill to the minimum necessary for a residence and minimum driveway and parking. No ditching or changes to drainageways should be allowed. Locate roads outside of wetlands and drainageways to the extent possible. Maintain a 100-ft setback of natural vegetation on either side of Overlook Park.
Palmer Drainage-way and Fan	Maintain a 100-ft setback of natural vegetation on either side of Palmer Creek. Crossings should be perpendicular to the channel via bridge or oversized culvert and involve the minimum amount of fill necessary for safety. All of these wetlands should be preserved. A wetlands bank with Kachemak Moose Habitat, Inc. will target private parcels in this area, along with the East Homer Drainageway, for purchase and preservation. Wetlands within the City of Homer that have been targeted for moose mitigation are eligible to receive credits from this bank.
Raven Kettle and Rogers Loop Depression	Avoid wetland fill. Maintain the hydrologic integrity of drainageways and water retention and filtration capacity of the complex. Where uplands exist on a lot, they must be used prior to filling wetlands. If more than 3% of wetlands on any lot are converted to hardened (impervious) surfaces, they must be compensated for with swales and/or runoff retention ponds. Loss of moose habitat should be mitigated.
Runway Discharge	Within the airport boundary, wetland hydrology should be maintained. **Public lands**: Those tracts outside the airport boundary should be maintained and managed for the values of the Homer Airport Critical Habitat Area. **Private lands**: Accelerated runoff from hardened (impervious) surfaces should be offset with swales and/or runoff retention ponds [as well as with other Low Impact Development measures]. Loss of moose habitat should be mitigated.

Upper Woodard	On **City-owned parcels**, maintain greenbelts incorporating stormwater retention designs. Retain as much natural vegetation on individual lots as is practicable. Where uplands exist on a lot, they must be used prior to filling wetlands. If more than 3% of wetlands on any lot are converted to hardened (impervious) surfaces, they must be compensated for with swales and/or runoff retention ponds. Loss of moose habitat should be mitigated.
West Beluga Slope	**Public lands**: Publicly owned lands should be preserved as undisturbed wetlands. **Private lands**: These should be prioritized and purchased over time for inclusion in a mitigation bank whose purpose is to preserve moose habitat. Development should be discouraged. A master plan should be developed for this area as it is a very important wetland complex, and it is probably the most threatened wetland complex in the City of Homer.
West Homer Discharge	Retain natural vegetation as is practicable. Accelerated runoff from hardened (impervious) surfaces will be offset with swales an/or runoff retention ponds. Loss of moose habitat should be mitigated.