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April 13, 2007

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Ms. Victoria J. Rutson
Chief, Section of Environmental Analysis
Surface Transportation Board
1925 K Street, N.W., Room 504
Washington, D.C. 20423

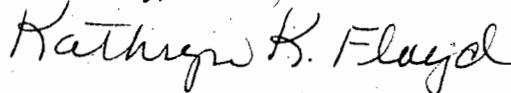
Re: Finance Docket No. 34658, The Alaska Railroad Corp. -- Petition For Exemption From 49 U.S.C. §10901 To Construct and Operate a Rail Line Between North Pole, Alaska and Delta Junction

Dear Ms. Rutson:

On behalf of the Alaska Railroad Corporation, enclosed for your information in the above-captioned proceeding please find two copies of the Wetland Functional Assessment Report, dated March 2007.

Please let me know if you have any questions.

Sincerely,



Kathryn Kusske Floyd

Enclosure

cc: David C. Navecky, SEA
Alan Summerville, ICF
Eileen Reilly, ARRC (w/o encl.)
Brian Lindamood, ARRC (w/o encl.)

Northern Rail Extension Project

Wetland Functional Assessment

March 2007

Prepared for:



Alaska Railroad Corporation
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Fairbanks, AK 99709

Prepared by:



HDR Alaska, Inc.
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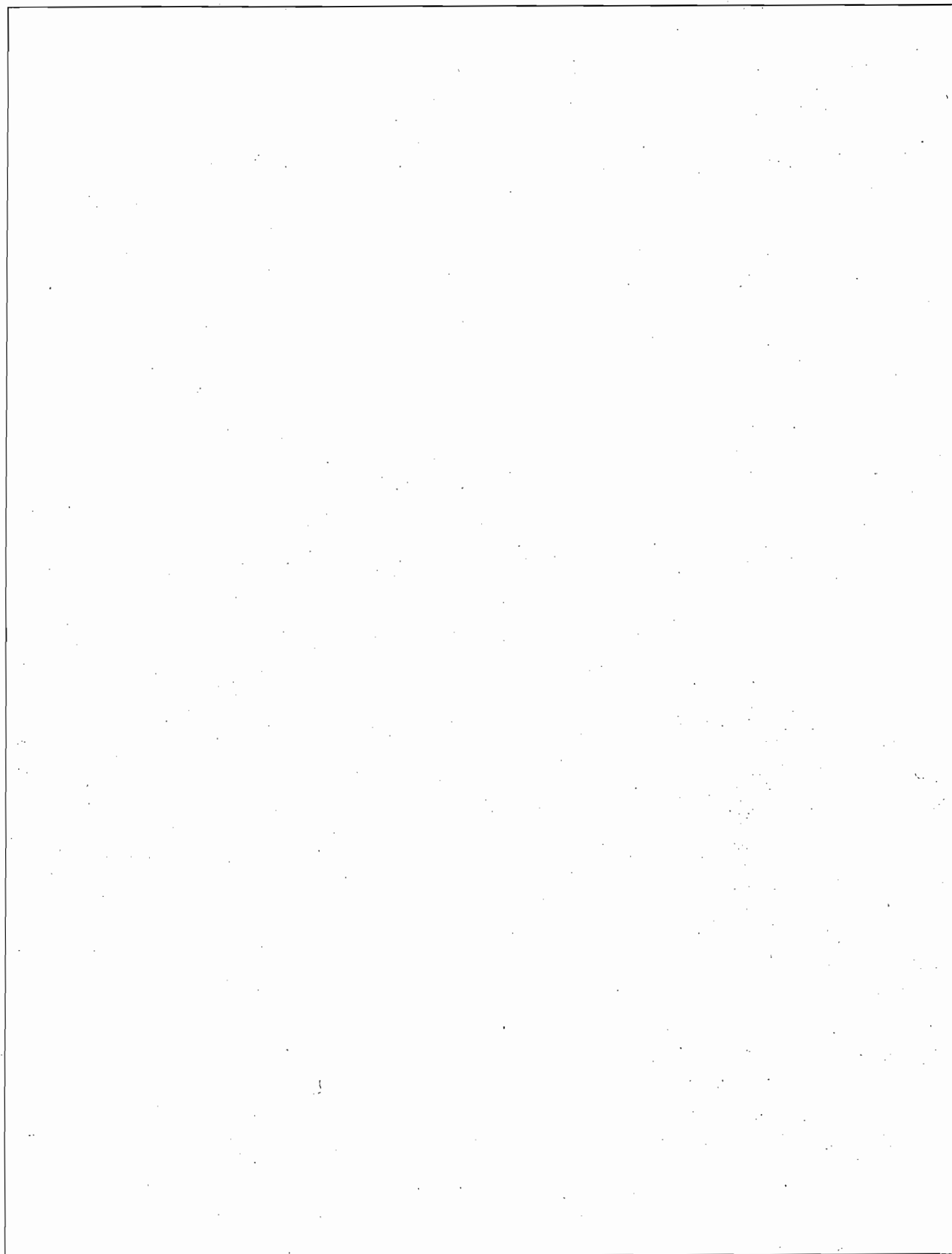


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1.0 Introduction and Purpose

The purpose of this report is to describe functions of wetlands located within the proposed corridor of the Alaska Railroad Corporation's (ARRC) Northern Rail Extension Project. Wetland locations and characteristics are defined in the Preliminary Jurisdictional Determination (PJD) (HDR Alaska 2007). The proposed corridor is located in interior Alaska in the vicinity of the Tanana River between the communities of North Pole and Delta Junction, Alaska. The proposed corridor covers all of the currently proposed 16 alignment segments. These alignment segments can be pieced together to make up the various alternatives. The corridor is predominantly undeveloped rural lands and extends approximately 80 miles.

One consideration for selection of build alternatives is the presence of wetlands and other waters of the United States. Wetlands and other waters of the U.S. are subject to the jurisdiction of the U.S. Army Corps of Engineers (USACOE) under authority of Section 404 of the Clean Water Act or under authority of Section 10 of the Rivers and Harbors Act of 1899. The USACOE has authority over certain work in "other waters of the U.S.," including wetlands, and in "navigable" waters. By federal law (Clean Water Act) and associated policy, it is necessary to avoid project impacts to wetlands wherever practicable, minimize impact where impact is not avoidable, and in some cases compensate for the impact. This document is a tool that the USACOE can use to analyze impacts to wetlands and their associated functions. Analysis of potential wetland-related impacts will be ongoing during the development of project alternatives.

Wetlands, other waters of the U.S., and uplands (non-wetlands), as referenced in this report, are defined as:

Wetlands. "Those areas that are inundated or saturated by surface or groundwater 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" (33 Code of Federal Regulations [CFR] Part 328.3(b) 1986). This also includes atypical situations, defined as "areas in which one or more parameters (vegetation, soil, and/or hydrology) have been sufficiently altered by recent human activities or natural events to preclude the presence of wetland indicators of the parameter" (USACOE 1987). Wetlands are a subset of "other waters of the U.S." Note that the "wetlands" definition does not include unvegetated areas such as streams and ponds.

Other waters of the U.S. Other waters of the U.S. include all waterbodies, such as lakes, ponds, and streams, in addition to wetlands. The ponds mapped in the project area are "other waters of the U.S." but not "wetlands".

Uplands. Non-water and non-wetland areas are called uplands.

As described in the 1987 U.S. Army Corps of Engineers wetlands delineation manual, wetlands must possess the following three characteristics:

- *Hydrophytic Vegetation:* Vegetation community dominated by plant species that are typically adapted for life in saturated soils.
- *Wetland Hydrology:* Inundation or saturation of the soil during the growing season.
- *Hydric Soils:* Soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions.

2.0 Preliminary Jurisdictional Determination

In February 2007, a PJD was prepared for the project based on fieldwork completed in the summers of 2005 and 2006 (HDR 2007). The purpose of the PJD was to describe the wetland identification process and describe the extent and types of wetlands and other jurisdictional waters found within the study area. The 2005 field effort used methods and forms described in the 1987 Corps of Engineers Wetlands Delineation Manual (USACOE 1987). In March 2006, the USACOE issued a special notice stating that all data collected in 2006 would need to conform to the 2006 Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Alaska Region (USACOE 2006). The 2006 field verification effort used the 2006 wetland determination forms and indicators in the Regional Supplement. Wetland types were classified using the NWI Cowardin System names (Cowardin, et al. 1979). Cowardin classification of each mapped unit included the appropriate System, Subsystem, Class, Subclass, and Water Regime. These wetland types are defined in the PJD and are used to group wetlands into categories for the functional assessment.

3.0 Wetland Functions

Wetland functions are the chemical, physical, and biological processes or attributes that contribute to the self-maintenance of a wetland and relate to the ecological significance of wetland properties without regard to subjective human values (ASTM 1999). Not all wetlands perform all functions, nor do they perform all functions to the same extent. For example, the geographic location may determine its hydrologic or water quality functions. The principal factors that determine how a wetland performs these functions are climatic conditions, quantity and quality of water entering and leaving the wetland, and disturbances or alteration within the wetland or the surrounding ecosystem (Novitzki et al. 1997).

Wetland functions were assessed using methods described in "A Rapid Procedure for Assessing Wetland Functional Capacity – Based on Hydrogeomorphic (HGM) Classification" (Magee and Hollands 1998). This method estimates a wetland's capacity to perform eight different functions. These functions include modification of groundwater discharge, modification of groundwater recharge, storm and flood water storage, modification of stream flow, modification of water quality, export of detritus, contribution to abundance and diversity of wetland vegetation, and contribution to abundance and diversity of wetland fauna. Magee and Hollands Wetland Inventory Forms were used for the 2005 field effort (Magee and Hollands 1998). In 2006, wetland teams used a modified version which combined best professional judgment (BPJ) with

the Magee and Hollands method. The 2006 forms, along with aerial photograph interpretation, were used to supply most of the same data as collected during the 2005 field effort. The following sections include the model results for the eight functions based on 197 wetland plot locations sampled between 2005 and 2006. Model results estimate a wetland's capacity to perform each function.

The Magee and Hollands model assigns point values to specific information collected in the field. Model results are given on a scale of 0 to 1. First, wetlands are characterized by whether they meet the criteria for having a direct indicator of disfunction or a direct indicator of function. If a wetland has a direct indicator of disfunction, it is automatically given a functional capacity (FC) of 0, meaning the potential for a wetland to perform that function is low. If a wetland has a direct indicator of function, it is automatically given the maximum value of 1, meaning that there is a high probability that the wetland performs that function. Wetlands that do not have either of these direct indicators are given a FC based on primary variables that are indirect indicators of the function. Primary variables each receive a specified point value, usually between 0 and 3. Then, the primary variables are added up and divided by the total possible points to get the FC.

Modifications of the model were applied to make the model consistent and useable for the Northern Rail data. Although data was collected in five of the HGM classes, all wetland sites were run through the flat HGM model. The majority of the wetlands fell into the flat HGM class with the remaining sites mostly in the depressional HGM class. These models are extremely similar with only slight differences (one variable) in storm and floodwater storage and contribution to abundance and diversity of wetland fauna functions. The flat class best characterizes the Tanana Valley floodplain as a whole and corresponds to what field teams experienced on the ground. "Flat" is an inclusive regional term that includes all other HGM classes. Flat HGM types include all vegetation communities, soil types, and hydrologic regimes (Magee and Hollands 1998). These facts, coupled with the need for consistency and the small sample size of the other HGM classes, justified using the same model for all wetlands.

In addition, the assessment method used was intended to identify the functional capacities of only vegetated wetlands occurring in the project corridor and not of other jurisdictional waters (i.e., ponds, streams, and lakes).

Other modifications to the model included removing variables from the calculations if they were not collected. If a given variable was skipped, not answered, or unobtainable, then the variable was eliminated from the model for that particular site, as per model instructions. This ensured that the wetland would not be given a lower FC due to lack of information. Instead, the other variables were given a higher weight for that particular function.

Due to the project corridor length and large number of polygons mapped (4,765), it was not practicable to assess wetland functional capacity at each distinct wetland polygon. Instead, function assessment forms were completed at representative wetland types situated across the 80-mile long project corridor. As expected, a range of capacity indices for each function evaluated occurs among the sampled wetland types. This range is related to a variety of factors, including but not limited to: watershed and landform

position, soil type, plant community structure, water source, proximity to a stream, and hydrologic regime.

Among the variables used to estimate each function, some variables had higher relative importance in shaping the range, whether narrow or wide, of capacity indices across different wetland types. This is related to similarities of some variables seen across the project corridor. At many sites, subsets of the variables were nearly identical, resulting in only small variations among the sites' FCs. In those situations, often one or two variables were then responsible for all the differences among wetland types. These variables differed among functions and wetland types.

The presence of an outlet is an important criterion for many of the functions. For the functions storm and flood water storage, modification of stream flow, and export of detritus it is either a direct indicator of function or a direct indicator of disfunction. Wetlands without an outlet are given the maximum FC for storm and flood water storage and the minimum FC for modification of stream flow and export of detritus. Since a large percentage of the sites do not have an outlet, each model was run on only those sites that had an outlet. This more accurately discerns the functions of wetland types both with and without outlets. In order to apply this to wetlands within the study area, all wetland polygons were attributed with an outlet status using GIS (geographic information system). Any wetlands within 100 feet of an HDR-mapped stream or any stream within the National Hydrography Dataset (USGS 1999) were considered to have an outlet. Wetland polygons outside of 100 feet were considered to not have an outlet. Outlet attributes were given to the entire polygon.

For the purpose of this report, the models' results were grouped by mapped wetland type, reflecting primary vegetation type and water regime (i.e., broadleaf (BL) shrub semipermanently flooded, needleleaf (NL) forest saturated, etc.). Using these groups, the results were extrapolated to corresponding mapped wetland types over the entire study area. This permits project planners to take measures, where practicable upland-only options are not feasible, to avoid and minimize impacts to certain wetland types having higher capacity to perform selected functions than do other nearby wetland types.

3.1 Function 1: Modification of Ground Water Discharge

Definition:

The capacity of a wetland to influence the amount of water moving from groundwater to surface water (Magee and Hollands 1998).

Model Results:

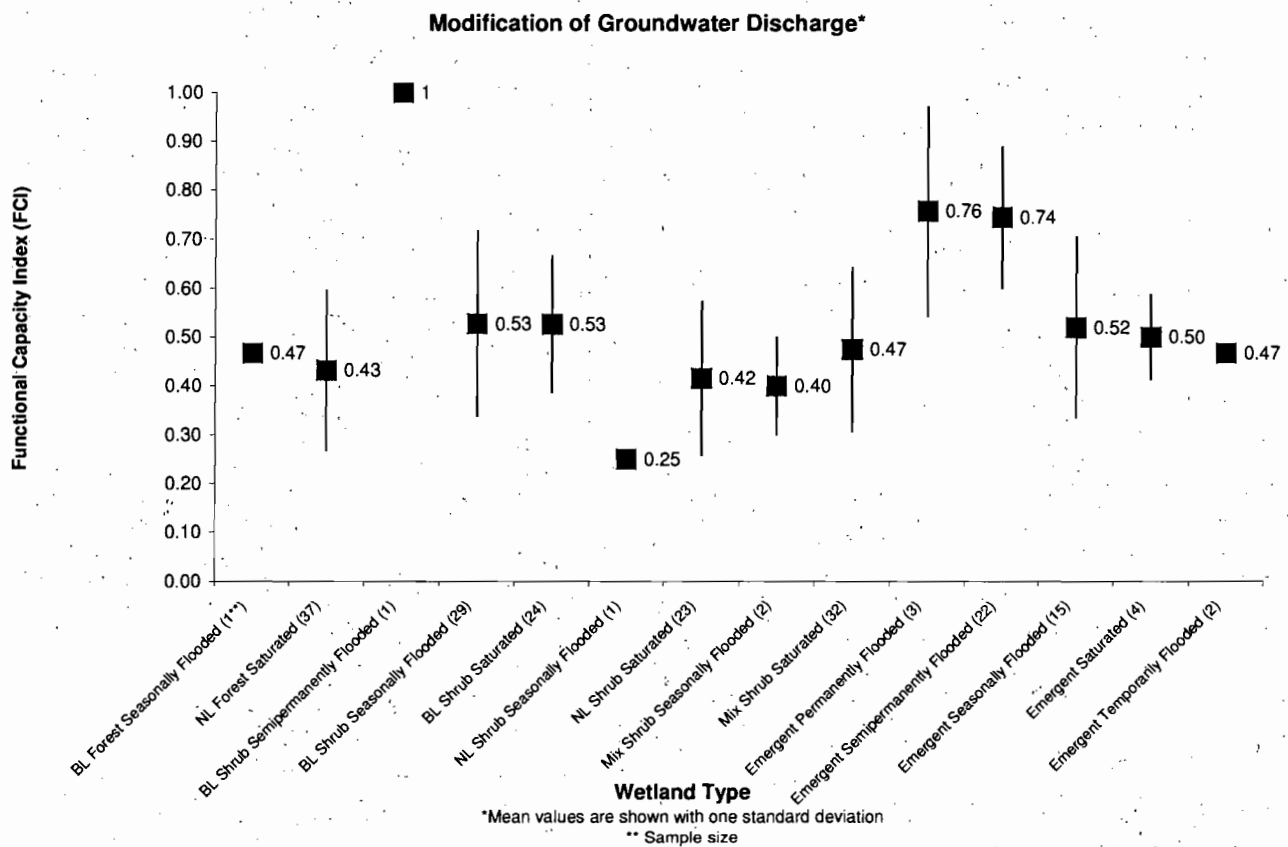


Table 1. Variables Used in Model Calculations for Groundwater Discharge

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Inlet/Outlet Class: Perennial inlet/no outlet	X		
Inlet/Outlet Class: No inlet/perennial outlet		X	
Presence of Seeps and Springs		X	
Inlet/Outlet Class: Perennial inlet/perennial outlet Intermittent inlet/perennial outlet All other classes			0-3
Surficial Geologic Deposit Under Wetland			0-3
Wetland Water Regime			0-3
Soil Type			1-3
Microrelief of Wetland Surface			0-3

Discussion:

Groundwater discharge refers to the net upward vertical movement of water from an aquifer to the surface (Mitsch and Gosselink 1993). It can seep from an unconfined aquifer or flow from a confined (artesian) aquifer that intersects the ground surface. Groundwater discharge is an important function that stabilizes water levels and facilitates ecological processes such as fish spawning, rearing and overwintering (Post 1996). Most groundwater discharge wetlands fall into two categories: groundwater depressional wetlands and groundwater seep or spring wetlands. The groundwater depressional wetlands occur when the surface water level of a wetland is at a lower elevation than the surrounding areas' water table. The seep or spring wetland occurs at the base of steep slopes where groundwater intersects the land surface. However, in interior Alaska groundwater hydrology is altered due to the existence of permafrost. Permafrost acts as a giant aquitard greatly restricting the discharge and recharge of groundwater throughout the area.

The study area for the Northern Rail Extension Project is situated in the Tanana River Basin, an area of discontinuous permafrost. Most of the permafrost in the area occurs as numerous isolated deposits surrounded by coarse grained deposits. Areas lacking permafrost are under lakes, present and historic sloughs, streams and large rivers. In general, gravel layers are well drained and remain unfrozen while sand and silt layers are poorly drained and create optimal permafrost conditions. The unfrozen gravel sediments in the Tanana floodplain occur as lenses rather than extensive layers, creating a large irregular network of unfrozen passages throughout the floodplain (Hopkins *et al.* 1955). Due to these passages, as well as the numerous lakes and streams, subpermafrost and suprapermfrost groundwater circulates freely within the area.

Suprapermfrost groundwater or groundwater that collects on top of permafrost is usually discharged at the base of bog-like slopes during the spring. Snowmelt and rainfall quickly infiltrate the peat layer on slopes and then flow downhill discharging to shrub/sedge tussock vegetation or sedge tussock vegetation. The small water storage capacity of the shallow active layer of the up-gradient permafrost slopes limits the extent and periods of discharge of suprapermfrost groundwater (Post 1996).

Subpermafrost groundwater is discharged in areas where there is a direct connection to the ground surface. Groundwater discharge areas include perennial springs, lakes, ponds, and streams. Therefore, wetlands directly adjacent to or covering the surface of these waterbodies perform this function (Post 1996).

In low-lying areas of the Tanana Valley underlain by permafrost, the typical vegetation community is a saturated black spruce wetland. These black spruce wetlands are ombrotrophic, meaning the water that wets them is derived primarily from precipitation, generally not from inflowing surface water or groundwater (Post 1996). Therefore the majority of these areas do not perform the groundwater discharge function.

A study of fens covering an area just north of the Northern Rail Extension Project area concluded that vegetated mat wetlands located between forested uplands and wetlands

perform groundwater discharge. Vegetation communities were dominated by sedges (*Carex aquatilis* and *Carex rostrata*), grasses (*Glyceria pulchella* and *Calamagrostis canadensis*), swamp horsetail (*Equisetum fluviale*) and herbaceous broadleaf forbs such as buckbean (*Menyanthes trifoliata*), marsh five-finger (*Potentilla palustris*) and water hemlock (*Cicuta mackenziana*) (Racine and Walters 1991).

The groundwater discharge functional capacity indices for each vegetation type and water regime are shown in the model results. The variables used in the model are shown in Table 1. Of the 197 wetland sites where functional data was collected, fifteen sites had a direct indicator of this function. Direct indicators include the presence of seeps and springs and wetlands that have no inlet but a perennial outlet. No wetlands had an indicator of disfunction, which would have included all wetlands that had a perennial inlet, but no outlet. The remaining 182 sites received a score between 0.25 and 0.93.

On the whole, the FCs for this function in the study area were moderate. The driving factors behind the differing indices were primarily the presence of permafrost and the hydrologic regime. Wetlands that have highly permeable soils (i.e., with no permafrost) and are wet (semipermanently flooded, intermittently exposed, and permanently flooded) have the highest value. If a wetland is flooded for the majority of the year and is underlain by permeable substrate it seems realistic to rate those wetlands as having a high probability of performing the groundwater discharge function. All other wetlands had a moderate FC of approximately 0.5. Vegetation type or structure is not included among the variables for this function (other than more emergent wetlands are found in the wetter wetlands).

The model gave a high FC to all wetlands with a permanently flooded and semipermanently flooded water regime. The remaining wetlands received a low to moderate value. The wetlands receiving the lowest value appear to be the wetlands that have a seasonally flooded wetland water regime. The model is assuming that a wetland that is dry or only wet for short periods of time is losing water to groundwater, whereas, wetlands that are wetter are perennially receiving water from groundwater.

The Magee and Hollands model was established for the glaciated Northeastern United States and therefore is not set up to represent interior Alaska and regions of discontinuous permafrost. The permafrost restricts groundwater discharge in some areas because it is an impermeable layer. In the model, the surficial geologic deposit variable has three possible categories: high permeability, low permeability and glacial till. Wetlands underlain by permafrost were considered to have the equivalent of glacial till due to its having the lowest permeability of the three choices. In the model, this means that the wetland can still carry out this function at a limited capacity, resulting in indices from 0-0.5. However, most of the wetlands over permafrost in interior Alaska get their water from precipitation and do not perform groundwater discharge function. Therefore, the model likely overestimates the groundwater discharge function to wetlands that are underlain by permafrost.

3.2 Function 2: Modification of Ground Water Recharge

Definition:

The capacity of a wetland to influence the amount of water moving from surface water to groundwater (Magee and Hollands 1998).

Model Results:

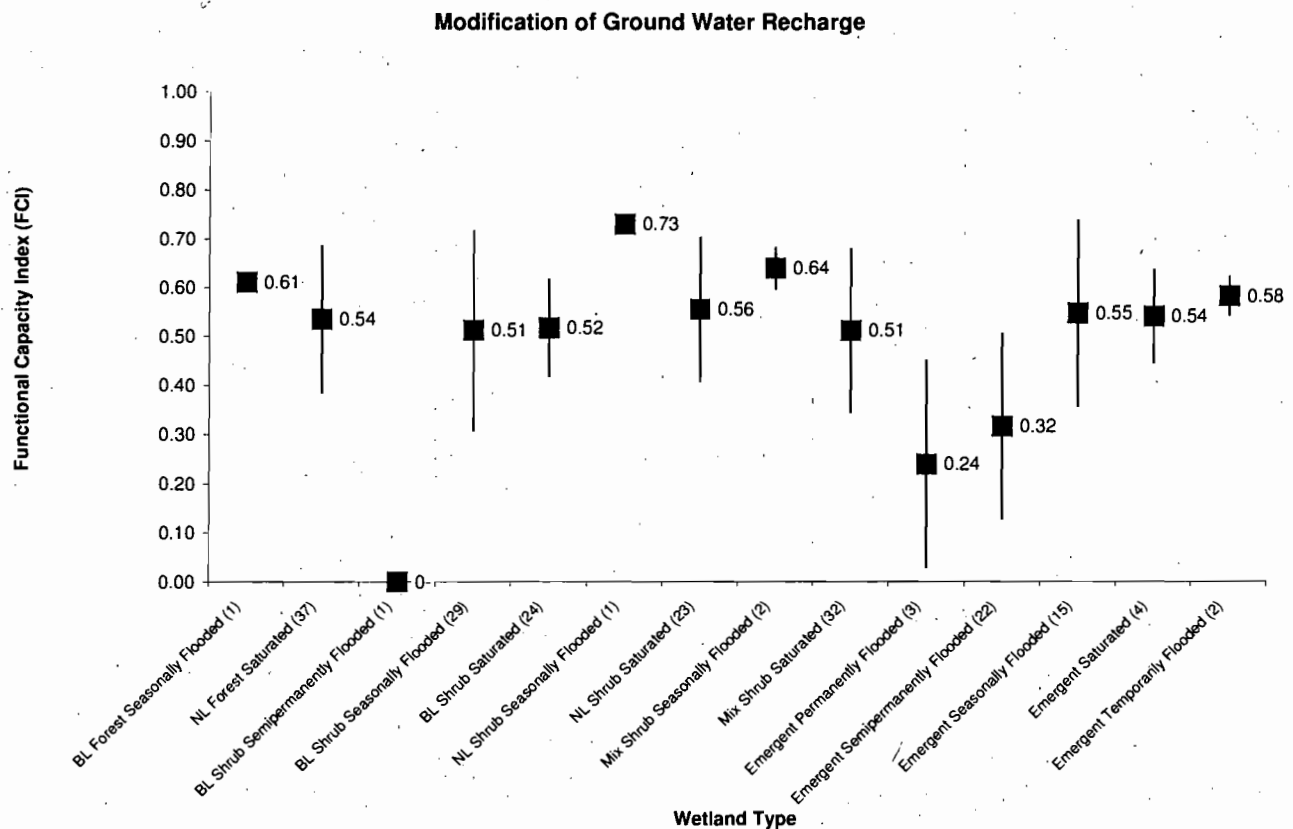


Table 2. Variables Used in Model Calculations for Groundwater Recharge

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Inlet/Outlet Class: No inlet/perennial outlet Intermittent inlet/ perennial outlet	X		
Presence of Seeps and Springs	X		
Inlet/Outlet Class: Perennial inlet/no outlet		X	
Inlet/Outlet Class: Perennial inlet/intermittent outlet All other classes			0-3
Surficial Geologic Deposit Under Wetland			1-3
Wetland Water Regime			1-3
Soil Type			0-3
Microrelief of Wetland Surface			1-3

Discussion:

Permafrost also limits the capacity for wetlands to perform this function. In wetlands underlain by permafrost, the highly decomposed peat that lies on the surface of the permafrost has extremely low hydraulic conductivity. The dense peat layer prohibits lateral water flow of perched water above the permafrost. This limits recharge to only suprapermafrost groundwater, and the magnitude of this recharge is generally quite small (Post 1996).

Most recharge of subpermafrost groundwater in interior Alaska occurs in unfrozen uplands, such as south-facing slopes, and in alluvial aquifers by infiltration from larger rivers, like the Tanana River (Post 1996). The majority of the rainfall falls in areas underlain by bedrock and is directed as runoff to the streams. The streams then flow out of the mountains across permeable alluvial fans, such as those in the Tanana Basin. These streams lose huge amounts of water to aquifers because the water table is much lower than the bed of the streams (Anderson 1970).

Examples of streams losing water to groundwater include Jarvis Creek and the Tanana River. Jarvis Creek is located just south of Delta Junction and on average loses 6.5 million gallons of water per day per linear mile of channel (Anderson 1970). The Tanana River, in a section just south of Fairbanks, loses water which flows northwestward and discharges into the Chena River (Glass *et al.* 1996).

The Magee and Hollands model directly correlates the groundwater recharge function with the groundwater discharge. The Magee and Hollands model assumes that most wetlands alternate between recharge and discharge conditions. Wetlands with a high FC for groundwater discharge have a low FC for groundwater recharge and vice versa.

No wetlands studied had a perennial inlet and no outlet, a direct indicator of groundwater recharge. Direct indicators of disfunction are wetlands with an intermittent inlet and a perennial outlet, wetlands with no inlet and a perennial outlet, and wetlands with the evidence of seeps and springs. Sixteen data collection sites showed direct indicators of disfunction.

Like groundwater recharge, the variables that explain most of the difference between wetland types are the wetness of the wetland and the underlying surficial geologic deposit. The drier the wetland and the less permeable the underlying substrate, the higher a value for groundwater recharge the wetland will receive. If a wetland is drier or wet for only short intervals it is likely that water is leaving the wetland and slowly returning to nearby aquifers.

As with the groundwater discharge function, the groundwater recharge model overestimated the probability of wetlands performing this function due to the presence of permafrost. Permafrost wetlands are in all likelihood not performing this function to a high degree. Areas around streams most likely are. This comes across in the model, with the highest functional capacity indices being seasonally flooded wetlands, which are usually located adjacent to streams.

3.3 Function 3: Storm and Flood Water Storage

Definition:

The storage of inflowing water from storm events or flooding events, resulting in detention and retention of water on the wetland surface (Magee and Hollands 1998).

Model Results:

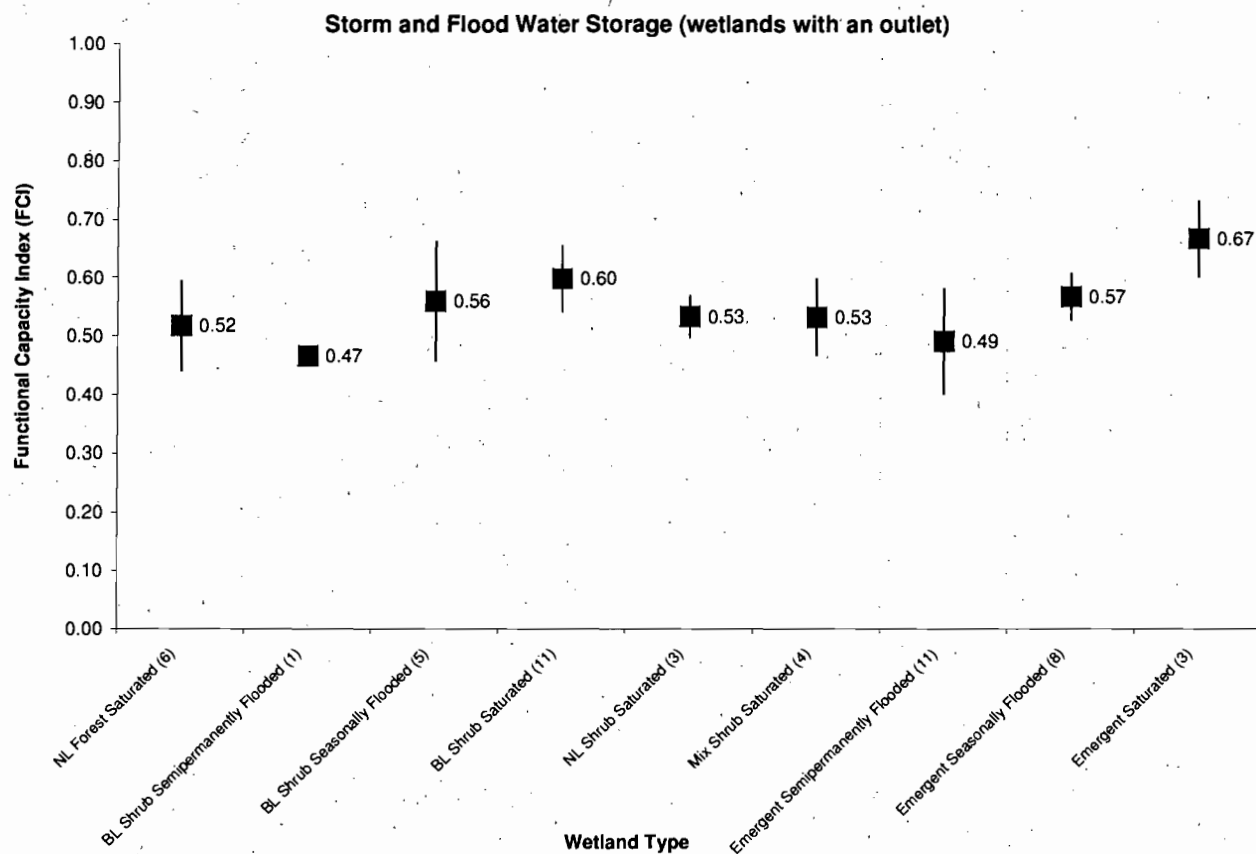


Table 3. Variables Used in Model Calculations for Storm and Flood Water Storage

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Inlet/Outlet Class: No outlet		X	
Inlet/Outlet Class: Perennial inlet/intermittent outlet Intermittent inlet/intermittent outlet No inlet/intermittent outlet No inlet/perennial outlet Intermittent inlet/perennial outlet Perennial inlet/perennial outlet			1-3
Degree of Outlet Restriction			0-3
Basin Topographic Gradient			1-3
Wetland Water Regime			1-3
Surface Water Level Fluctuation of the Wetland			0-3
Ratio of Wetland Area to Watershed Area			1-3
Microrelief of Wetland Surface			0-3
Frequency of Overbank Flooding			0-3
Vegetation Density/Dominance			0-3
Dead Woody Material			1-3

Discussion:

Storm and flood water storage refers to the ability of a wetland to intercept, detain and retain water on the wetland's surface. By storing storm and flood waters, wetlands greatly reduce peak flows leading to slower discharges over a longer period of time. Therefore, the larger the wetland area, the smaller the danger of flooding downstream (Novitzki 1979; Verry and Boelter 1979). A study of the Chesapeake Bay drainage basin showed the importance of wetlands for flood flow detention. The Chesapeake Bay drainage basin has a wetland area of approximately 4%. When compared to other drainage basins with no wetland area, the flood flows of the Chesapeake Bay drainage basin were about 50% of the basins with no wetland storage (Novitzki 1985).

There are no direct indicators of disfunction for this model. Not having an outlet was a direct indicator of this function. The majority (134 sites, 72%) of the sites did not have an outlet, and therefore received a FC of 1. These sites are not included in the calculations because they positively bias the mean FC values.

Most wetlands in the study area have a high capacity to perform this function. This is due to the majority of wetlands lacking an outlet and the presence of peat soils. Peat soils generally consist of two layers, the acrotelm and the catotelm. The acrotelm is the upper aerobic layer of peat that is partly living and highly permeable. The catotelm is the highly decomposed lower layer of peat that has low hydraulic conductivity (Post 1996). The acrotelm quickly absorbs any surface water limiting the ability for the wetland to have surface water and placing the majority of wetlands in the saturated water regime. The uppermost peat layer of these wetlands is responsible for the high values of storm and flood water storage throughout the vegetation types.

Wetlands with an outlet (28%) have a moderate capacity to store storm and flood flows in the project area. The primary variable driving the differences in this subset is the water regime. Drier wetlands have the highest values and wetter wetlands have lower values. Inundated wetlands have a low probability of being able to detain or retain storm flows, because they are already at full storage capacity. It is important to note that the model is not making any assumptions about subsurface detention of water.

3.4 Function 4: Modification of Stream Flow

Definition:

The modification of inflow hydrology by the wetland to produce the outlet stream's hydrology (Magee and Hollands 1998).

Model Results:

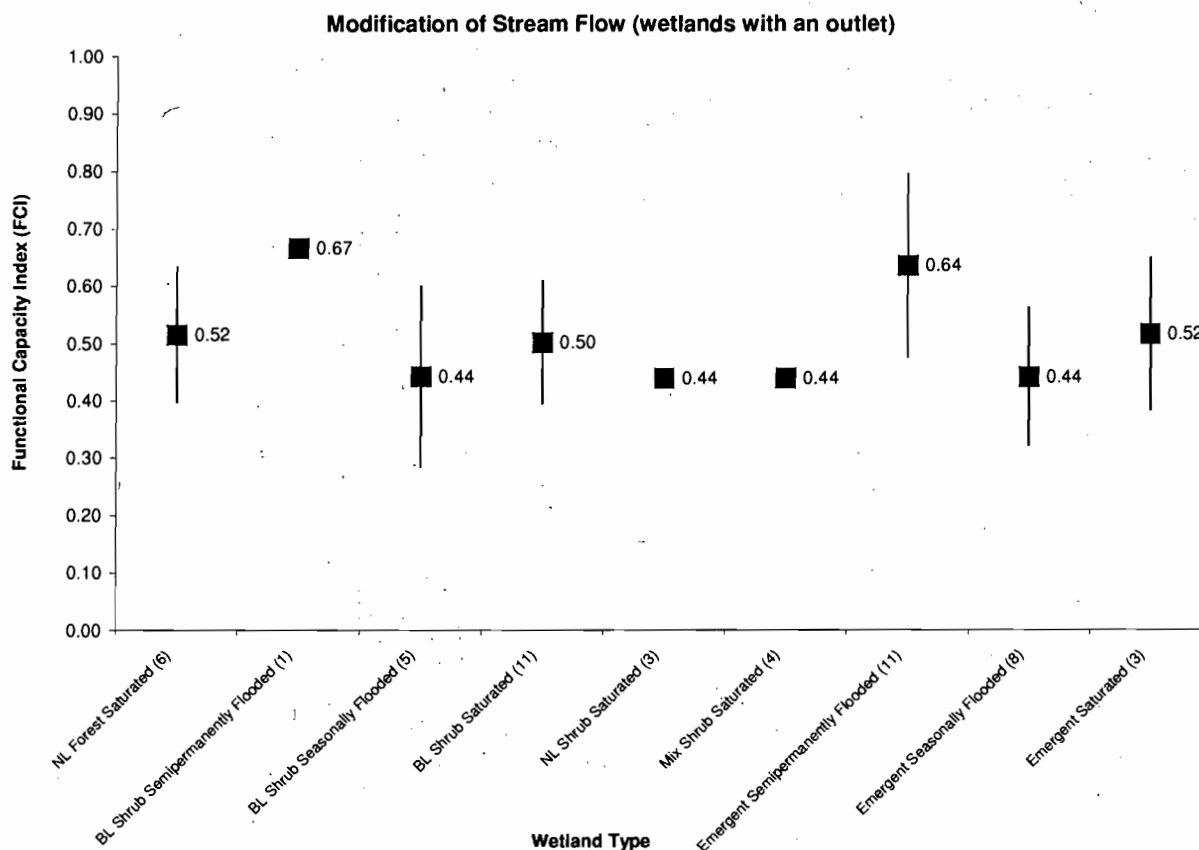


Table 4. Variables Used in Model Calculations for Modification of Stream Flow

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Outlet Class: No outlet	X		
Output from Modification of Groundwater Discharge Model			1-3
Output from Storm and Flood Water Storage Model			1-3

Discussion:

The modification of stream flow function is based on the output of two previous models: storm and flood water storage and modification of groundwater discharge. The model assumes that the base flow of a stream's hydrograph is dependent on the wetland soils to modify groundwater discharge. The storm flow portion of an outlet stream's hydrograph is dependent on the wetlands' ability to retain and detain surface water. Combining these two functions account for the entire outlet stream's hydrology. The variables of this function are multiplied by one another, rather than added, as in all other function models.

The indicator of disfunction for this model is the lack of an outlet. The majority of wetland sites (134 sites, ~72%) visited during the field effort had no outlet and are given a FC of zero. These sites are not included in the model results because they negatively bias the mean FC values of the wetlands with an outlet. All wetlands with an outlet had a moderate FC for this function. Semipermanently flooded wetlands tended to have slightly higher values than all other wetlands. The highest mean value (0.67) for this function is for the wetland type broadleaf shrub semipermanently flooded. This is due to its high value for groundwater discharge (1.0) and its moderate value for storm and flood water storage (0.47).

3.5 Function 5: Modification of Water Quality

Definition:

Removal of suspended and dissolved solids from surface water and dissolved solids from groundwater and conversion into other forms, plant or animal biomass, or gases (Magee and Hollands 1998).

Model Results:

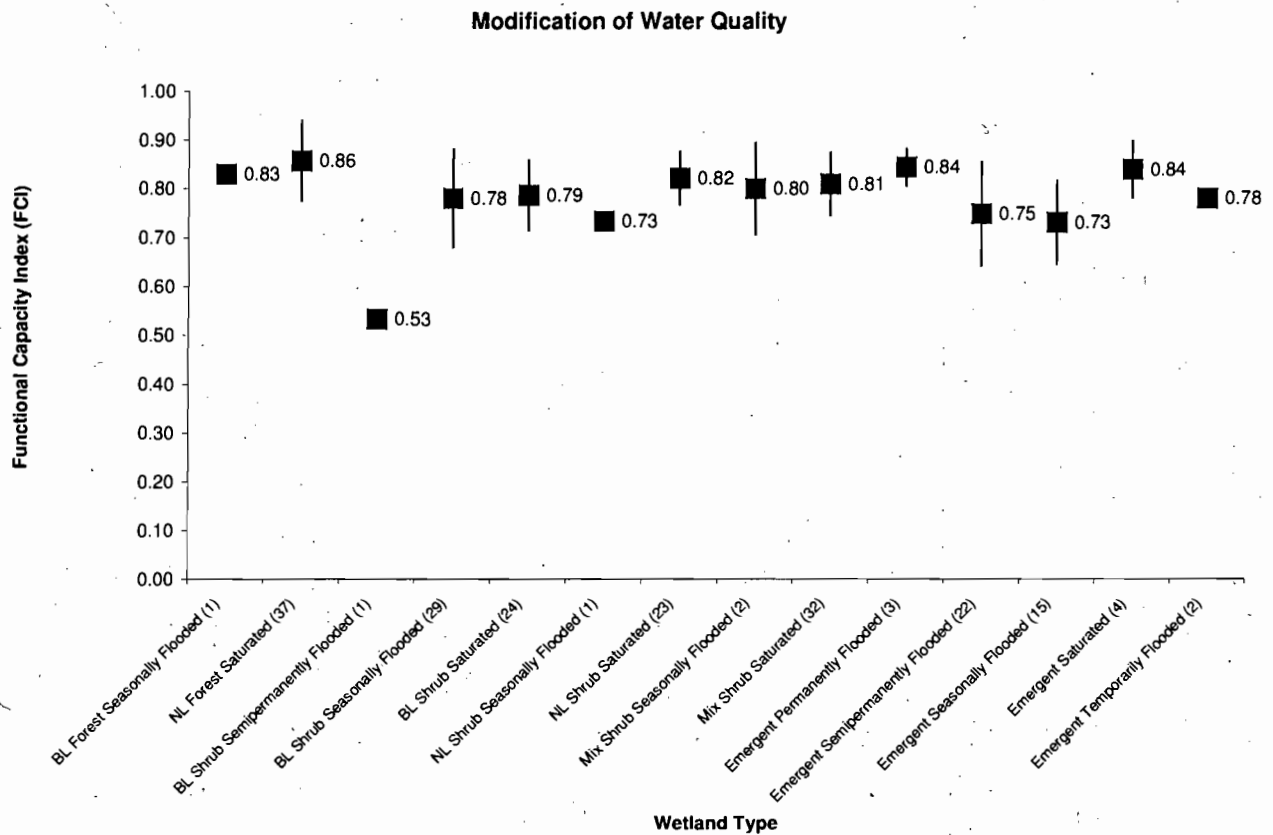


Table 5. Variables Used in Model Calculations for Modification of Water Quality

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Wetland Land Use			1-3
Degree of Outlet Restriction			1-3
Outlet Class:			
No outlet			
Intermittent outlet			
Perennial outlet			1-3
Dominant Wetland Type			0-3
Soil Type			0-3
Wetland Water Regime			0-3
Soil Type			1-3

Discussion:

Many wetlands have the capacity to modify the quality of water that flows through them. Wetlands have been shown to remove organic and inorganic nutrients and toxic material from water that flows across them. This occurs for several reasons: (1) Water velocity reduces as streams enter wetlands, causing sediments and chemicals to drop out of the water column; (2) Anaerobic and aerobic processes occur in close proximity, promoting denitrification, chemical precipitation, and other chemical reactions that remove certain chemicals from water; (3) The high rate of productivity of many wetlands leads to high rates of mineral uptake by vegetation and subsequent burial in sediments when the plants die; (4) A diversity of decomposers and decomposition processes occur in wetland sediments; (5) An increase in the amount of surface contact between water and sediments leading to significant sediment-water exchange; (6) The accumulation of organic peat causing the permanent burial of chemicals (Mitsch and Gosselink 1993).

The Magee and Hollands model bases a wetland's performance of this function on the residence time of water in the wetland and sheet flow versus channelized flow. There was little variation among the variables for this model. Major differences between the wetland types can be attributed to higher point values given to forested wetlands, wetlands with no outlet, and wetlands with histosols or clayey soils. The majority of wetlands in the study area have a high probability of performing this function. There were no direct indicators of disfunction. The direct indicator of function was evidence of sedimentation; however this data was only collected in 2005. Only two sites in 2005 had evidence of sedimentation: an emergent semipermanently flooded wetland and a broadleaf shrub seasonally flooded wetland.

The wetland type with the lowest FC for this function was a broadleaf shrub semipermanently flooded wetland. This represents one plot that was a groundwater discharge site with surface water flowing over the top. It has a lower functional capacity because of the short residence of the surface water over the wetland. The wetland does exhibit sheet flow with an outlet channel, so a moderate value of 0.53 accurately represents the model's parameters.

3.6 Function 6: Export of Detritus

Definition:

Export of organic detritus from the wetland to adjacent and downstream aquatic ecosystems (Magee and Hollands 1998).

Model Results:

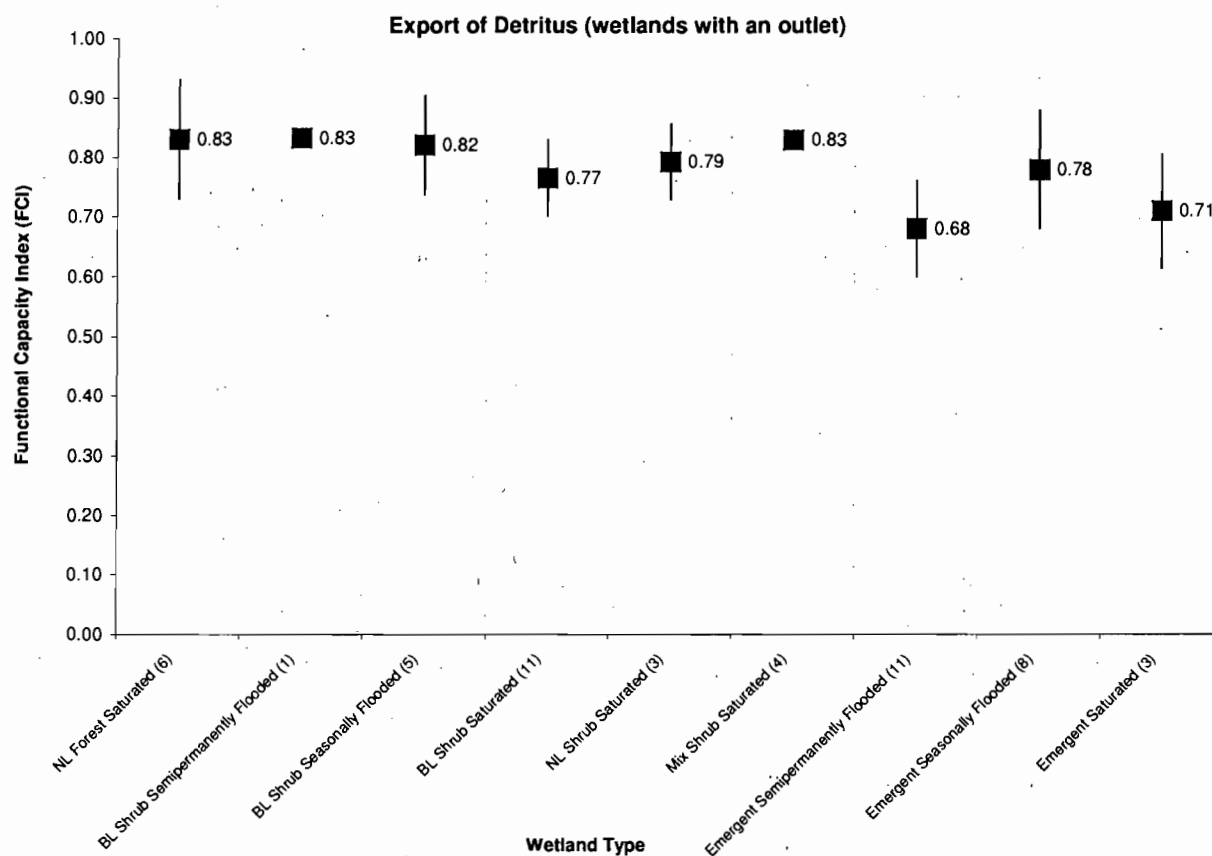


Table 6. Variables Used in Model Calculations for Export of Detritus

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Outlet Class: No outlet	X		
Wetland land use			1-3
Degree of outlet restriction			1-3
Outlet Class: Perennial outlet Intermittent outlet			1-3
Wetland water regime			1-3
Vegetation density/dominance			0-3
Soil type			1-3

Discussion:

Some wetlands support high levels of net primary production (i.e., plant growth). When these wetlands flood or are adjacent to streams, nutrients and organic carbon are entrained in the stream's waters and are distributed to downstream waters and other wetlands. These nutrients and organic carbon can serve as a potential source of energy for downstream aquatic ecosystems and contribute to the support of their food chains. In the Tanana floodplain, carbon availability limits microbial activity which controls the availability of inorganic nutrients for plant production (Magoun and Dean 2000)

The model relates vegetation structure and community, as well as flow-through of surface water, to the ability of a wetland to perform this function. A direct indicator of disfunction for export of detritus is absence of an outlet. The 134 plots that did not have an outlet were given a functional capacity of zero. Only wetland plots with an outlet are included in the model results. Overall, wetlands with an outlet had a high value for export of detritus. The highest FC values were given to the needleleaf forest, broadleaf shrub, and mixed shrub plant communities. This is expected due to the annual growth cycle of broadleaf deciduous shrubs and the community structure of needleleaf forests (which usually have deciduous understory components). Emergent wetlands tended to have lower FCs than the other types of wetlands.

3.7 Function 7: Contribution to Abundance and Diversity of Wetland Vegetation

Definition:

The capacity of a wetland to produce an abundance and diversity of hydrophytic plant species individually or as a part of a group of wetlands in a local landscape (Magee and Hollands 1998).

Model Results:

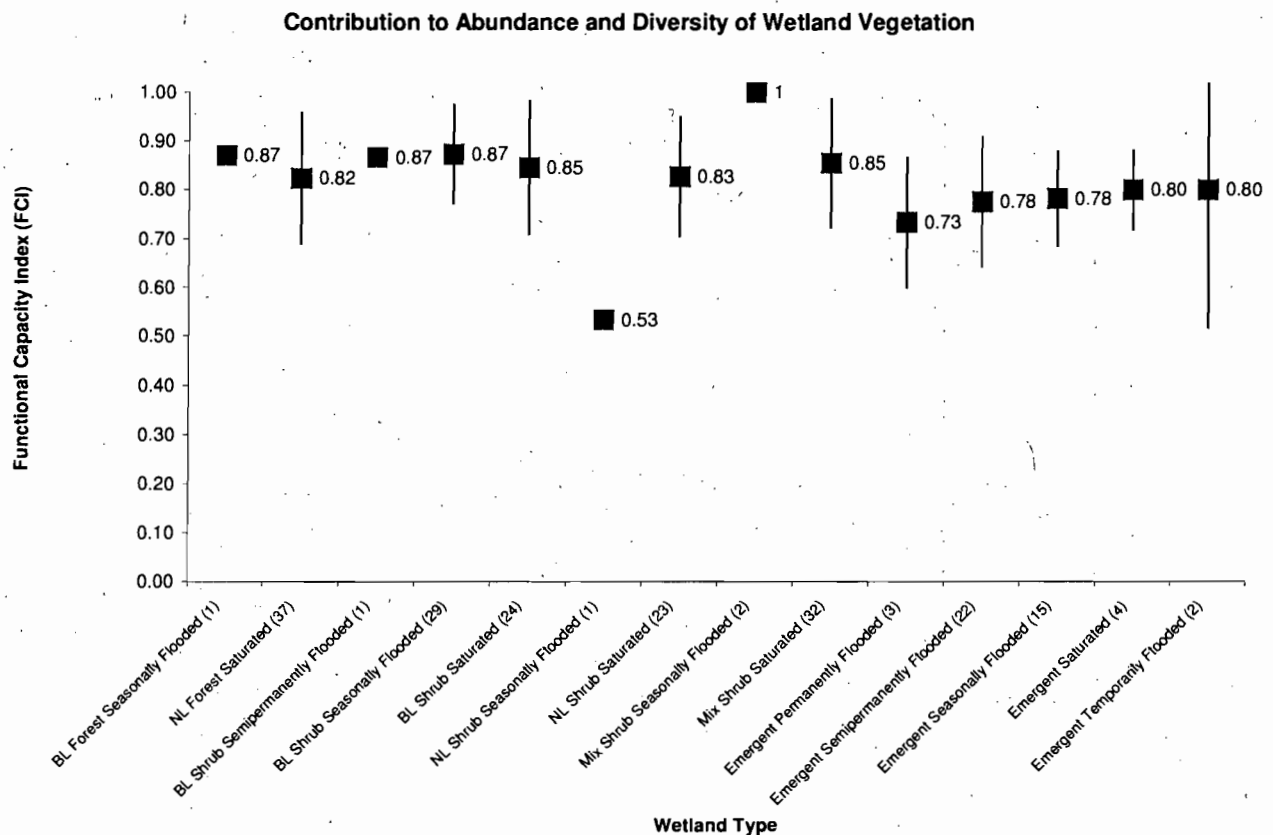


Table 7. Variables Used in Model Calculations for Contribution to Abundance and Diversity of Wetland Vegetation

	Indicator of Disfunction	Direct Indicator of Function	Point Value
No vegetation	X		
Plant species diversity			1-5
Vegetation density/dominance			1-5
Wetland Juxtaposition			1-5

Discussion:

The contribution to abundance and diversity of wetland vegetation model evaluates the species composition and physical characteristics of the surrounding plant community. The unique communities of vegetation that grow in the poorly drained soil of wetlands serve as a repository of genetic material and information for the component species that cannot be found elsewhere (Magee and Hollands 1998).

Factors that are important to this function include plant species diversity, vegetation density and dominance, and proximity to other wetlands. For the purpose of this model plant species diversity was considered low when 10 or less species were found and high when more than 18 species were found. There are no direct indicators of this function. A direct indicator of disfunction was no vegetation; however no data collection sites were completely free of vegetation.

In general, all wetland types had high functional capacities. This function is measuring a wetland's potential to perform the function relative to the landscape which explains the relative close grouping of the FCs of all the wetland types. Because the study area contains wetlands within the same unaltered environment, it is expected that values for this function would be high and in a relatively narrow range.

The one vegetation group that received a moderate functional capacity rating was the needleleaf seasonally flooded wetland type. This rating was based on one data collection site that occurred in an isolated wetland surrounded by uplands. Juxtaposition to other wetlands is an important factor in the model, relative to the role of the wetland in this function at the landscape level (Magee and Hollands 1998).

3.8 Function 8: Contribution to Abundance and Diversity of Wetland Fauna

Definition:

The capacity of a wetland to support large and/or diverse populations of animal species that spend part or all of their life cycle in wetlands, individually, or as part of a mosaic of wetlands in a local landscape (Magee and Hollands 1998).

Model Results:

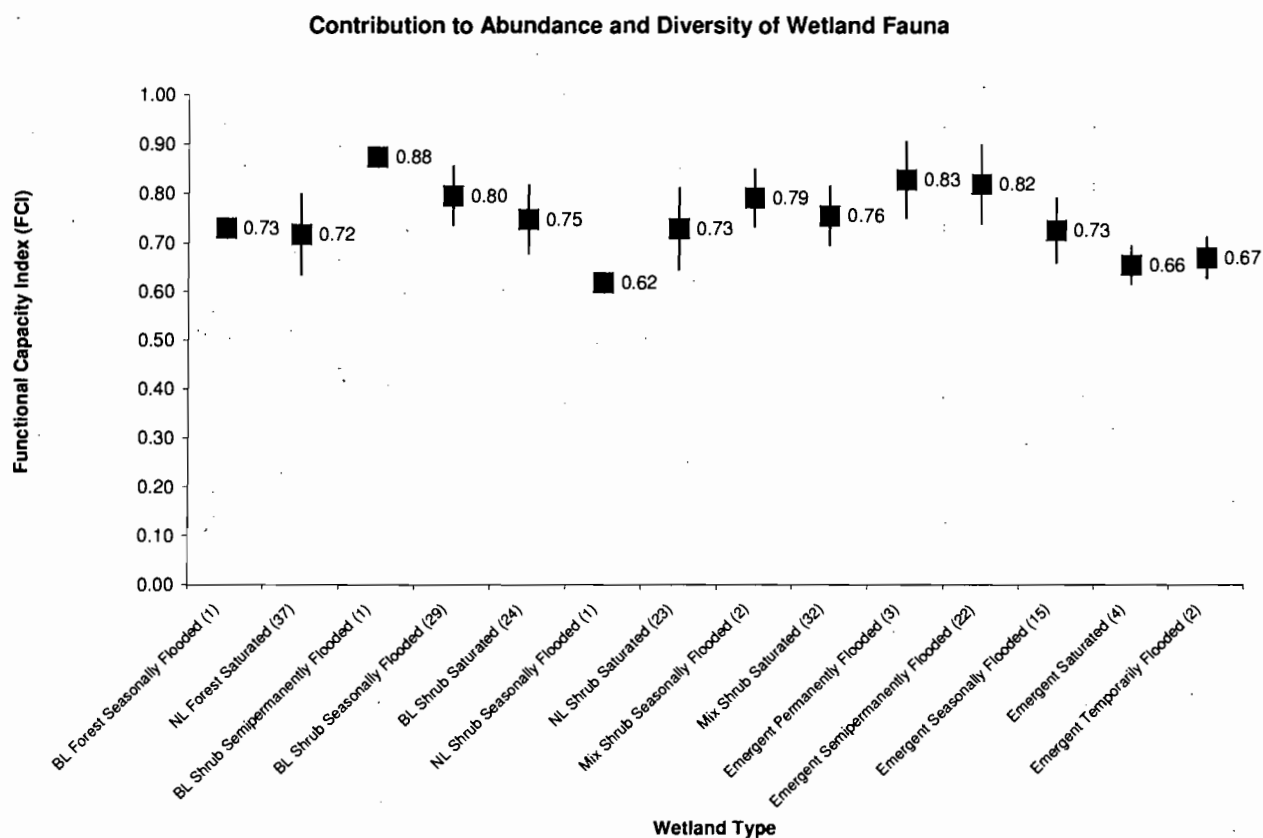


Table 8. Variables Used in Model Calculations for Contribution to Abundance and Diversity of Wetland Fauna

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Watershed Land Use			1-3
Wetland Land Use			1-3
Wetland Water Regime			1-3
Microrelief of Wetland Surface			0-3
Vegetation Interspersion			0-3
Interspersion of Cover and Open Water			0-3
Size			1-3
Wetland Juxtaposition			0-3

Discussion:

This functional model assesses a wetland's capacity to contribute to the abundance and diversity of wetland fauna. Wetlands are unusually diverse because they support both terrestrial and aquatic biota (Batzner and Sharitz 2006). Wetlands support invertebrates, cold blooded vertebrates, and terrestrial mammals, such as moose that use wetlands on a seasonal basis (Post 1996). Water in the form of sloughs, ponds, and bogs and associated vegetated and unvegetated shorelines in the Tanana floodplain provide habitat for waterbirds, including shorebirds, waterfowl, gulls, terns, and sandhill cranes, contributing greatly to the species richness of the area (Magoun and Dean 2000). Common mammals that have a high probability of foraging and feeding in black spruce wetlands include: the common, pygmy, dusky, and northern water shrews; red squirrel; meadow jumping mouse; northern red-backed, tundra, meadow, and yellow-cheeked voles; northern bog lemming; porcupine; and snowshoe hare. The small insectivores and herbivores that occur in these wetlands support a vast array of larger carnivores that occur throughout the region (Post 1996).

Moose habitat in the area is abundant and depends, in part, on plant community composition, structure, successional state and diversity. Large expanses of treed black spruce wetlands provide little habitat to moose. Moose habitat is better quality in interwoven patterns of forested and emergent wetlands that provide sheltered areas with access to food, isolated sites for calving and aquatic feeding areas (Magoun and Dean 2000).

In order to assess this function, the model looks at the structure and composition of the vegetation community and its spatial relationship to other plant communities and open water. The most important factor in this model is the wetland water regime, since it largely controls dominant vegetation and influences animal mobility and access to the wetland and to food sources. There are no direct indicators of function or disfunction for this function.

All wetland types had an average FC between 0.62 and 0.88, a relatively narrow band. This function assesses the ability of a wetland to contribute to wetland fauna on a landscape level. In the mostly pristine study area, a wetlands ability to perform this function corresponds directly to other area wetlands' ability to do the same. Therefore, a narrow range of values would be expected. The variation that does exist is primarily due to water regime, with wetter wetlands receiving higher values than the saturated and temporarily flooded wetlands.

4.0 Model Results by Region

In an agency meeting held on March 1, 2007 between HDR Alaska, Inc. and the USACOE, the USACOE suggested that the model results be stratified by region. In order to study model results by location, the study area was split into four regions (Figure 1). Region 1 contains the northern end of the study area east of the Tanana River. Region 2 contains the northern portion of the study area west of the Tanana River and north of Delta Creek. Region 3 is the smallest region and is situated on a bench just west of the Tanana River. Region 3 contains the alignment Donnelly West. Region 4 contains all other alignments south of Delta Creek.

Model results were calculated for all of the wetland types within each region. Although there were some small differences among regions, the majority of the regions had a FC mean very similar to the area-wide FC mean.

The model does not capture the differences in the FCs that may exist between the regions. This may be a limitation of the model or a limitation due to small sample sizes. Sample sizes drop dramatically when wetland plot locations are divided by wetland type, outlet status, and region. Individual variables that are entered into the model are already limited due to the homogeneity of the landscape. Regional stratification within the study area does not seem to impact any particular variable in the model enough to have disparate results.

For further analysis, the model results were compared to each function without accounting for wetland type. The results are shown in Table 9. Means are closely related throughout the similar among the four regions.

Two noticeable differences are the higher FC for groundwater discharge and the lower FC for groundwater recharge in Region 2. Region 2 had the highest percentage, 17%, of sites with seeps and/or springs present (a direct indicator of function). This is compared to 5% for Regions 1 and 4 and 14% for Region 3.

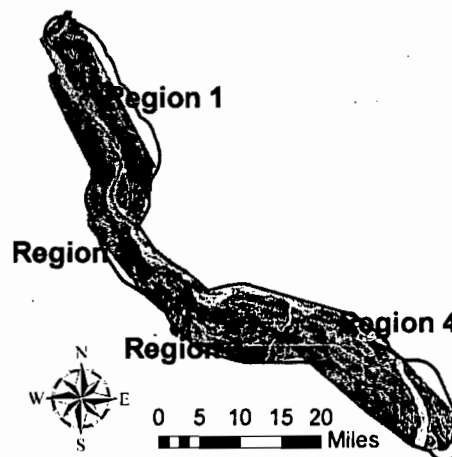


Figure 1. Study Area Regions

Table 9. Comparison of Model Results by Region

	GW Discharge	GW Recharge	Storm and Flood Water Storage	Mod. of Stream Flow	Mod. of Water quality	Export of Detritus	Contribution to Wetland Vegetation	Contribution to Wetland Fauna
Region 1	0.47	0.53	0.88	0.12	0.80	0.23	0.85	0.75
Region 2	0.61	0.42	0.90	0.13	0.80	0.16	0.84	0.81
Region 3	0.41	0.52	0.88	0.13	0.79	0.26	0.78	0.77
Region 4	0.50	0.50	0.88	0.13	0.81	0.21	0.82	0.74

5.0 Models Results versus Other Sources

5.1 Existing Soil Survey Data

In order to compare the model's output for groundwater discharge and groundwater recharge to existing data, the functional data points were overlaid with the current NRCS soil survey for the Upper Tanana Area and the Greater Fairbanks Area (NRCS 1999 and 2004). The result is shown in Table 10.

Table 10. Comparison of Existing Soil Survey Data and Model Results

Soil Type	Slope (%)	Description of Soil	Permafrost	# of data points	Mod. of GW Dis.	Mod. of GW Rec.
Goldstream and Histosols	0-3	DTP: 10-20"	Y	12	0.50	0.48
Goldstream peat	0-3	DTP: 14-24"	Y	12	0.46	0.51
Goldstream peat	3-7	DTP: 14-24"	Y	1	0.60	0.39
Goldstream-Tanana complex	0-3	Goldstream- DTP:10-20" Tanana- DTP:21-31"	Y	26	0.48	0.55
Tanana mucky silt loam	0-2	DTP: 16-47"	Y	1	0.40	0.61
Tanana silt loam	0-3	DTP: 20-40"	Y	24	0.53	0.45
Tanana, moderately wet-Goldstream complex	0-3	DTP: 40-60"	Y	3	0.39	0.58
Tanana, moderately wet-Goldstream complex	3-7	DTP: 40-60"	Y	1	0.27	0.67
Eielson-Tanana complex	0-2	Eielson- >40" loamy material over sand and gravel Tanana- Depth to Permafrost (DTP): 16-47"	Mix	1	0.47	0.61
Cryorthents, flooded	0-3	~18" loamy material over very coarse gravelly sand	N	1	0.33	0.78
Jarvis fine sandy loam	0-2	10-40" loamy material over sand and gravel	N	1	0.60	0.61
Jarvis-Fubar complex	0-7	sandy loam above sand and gravel	N	1	0.73	0.56
Koyukuk silt loam	3-7	~40" of silt and silt loam material to sand and gravel	N	1	0.40	0.56
Koyukuk silt loam	7-12	~40" of silt and silt loam material to sand and gravel	N	1	0.53	0.44
Nenana silt loam	0-3	<40" silt loam to sand	N	2	0.37	0.59
Nenana silt loam	3-7	<40" silt loam to sand	N	1	0.40	0.61
North Pole-Mosquito-Liscum complex	0-2	10-40" loamy material over sand and gravel	N	1	0.47	0.61
Salchaket very fine sandy loam	0-2	>40" loamy material over sand and gravel	N	1	0.47	0.61
Salchaket-Riverwash association	0-3	>40" loamy material over sand and gravel	N	2	0.63	0.42
Steese-Ester association	12-45	20-40" silt and sand loam to unconsolidated bedrock	N	4	0.72	0.27

Although the data are at different scales, with extremely site specific functional data collected by the Magee and Hollands method and much broader-scale information reflected by the soil classification, some trends are apparent. Of the individual wetlands that have an average FC above 0.60 for either groundwater discharge or groundwater recharge, the soil surveys indicated that 80% are not underlain by permafrost. Wetlands above permeable ground would be expected to have a much higher chance of discharging or recharging groundwater because they have a direct connection to subsurface groundwater. This analysis corroborates the validity of the model's results for groundwater discharge and recharge.

5.2 Best Professional Judgment

In 2005, functional data was collected using the Magee and Hollands Wetland Inventory Data form. In 2006, a revised wetland functional form was used that included many of the Magee and Hollands questions and a best professional judgment (BPJ) section. In this section, the wetland scientist would check off which of eight functions the wetland was performing and explain his/her choices. The eight functions included: groundwater discharge, groundwater recharge, streamflow moderation, shoreline stabilization, pollutant removal and retention (effectiveness and opportunity), primary production and carbon export, and fish and wildlife habitat. Six of the functions directly correspond to functions in the Magee and Hollands model (Table 11). Two of the functions do not correlate with the model and are not included in this analysis: shoreline stabilization and pollutant removal and retention-opportunity.

Table 11. Comparison of BPJ to Model Results using 2006 Data

Wetland Function	# of BPJ Sites Judged to be Performing this Function	Average FC of BPJ Sites Judged to be Performing this Function	Average FC of Sites Judged as not Performing this Function	Difference Between BPJ Sites and Sites Judged as not Performing this Function
Groundwater Discharge	36	0.66	0.43	0.23
Groundwater Recharge	18	0.46	0.50	-0.04
Modification of Stream Flow (Streamflow Moderation)	12	0.44	0.04	0.40
Modification of Water Quality (Pollutant Removal and Retention- Effectiveness)	50	0.83	0.80	0.03
Export of Detritus (Primary Production and Carbon Export)	29	0.31	0.09	0.22
Contribution to the Abundance and Diversity of Wetland Fauna (Fish and Wildlife Habitat)	73	0.77	0.75	0.03

The table shows that there is a strong similarity between what the scientist perceives in the field and the model results for the functions groundwater discharge, modification of stream flow, and export of detritus. Functional values across wetlands within the study area were similar, making differences in FCs 0.22 and 0.40 seem meaningful.

The FC of the sites judged to perform groundwater recharge was less than the average of the sites not judged to perform this function. The reason for this discrepancy is in the difference between how the wetland scientist and the model view this function. At 10 sites, the wetland scientist checked both groundwater discharge and groundwater recharge as occurring at the site. However, the model assumes that if one function occurs it is prohibitive of the other. Two of the sites that were marked as both groundwater discharge and groundwater recharge sites ended up with a model value of 1 for groundwater discharge and 0 for groundwater recharge. Without nested piezometer data it is extremely difficult to know if a particular wetland is recharging groundwater.

The remaining two functions that have an extremely close relationship between those wetlands that were judged to perform those functions in the field and the remaining wetlands are: modification of water quality and contribution to the abundance and diversity of wetland fauna. Both of these functions occur in a narrow band with little variation in functional capacity indices across the study area. The small variations across all data collection sites explain why the model results for BPJ sites are only slightly higher than the mean FCs of the remaining sites.

6.0 Conclusion

The Magee and Hollands model is a useful tool for analyzing wetlands and their associated functions. The model provides a method of determining which functions a wetland most likely performs. Although the FCs are nominal, they can be useful to compare and relate the eight wetland functions among the different wetland types.

As long as a few exceptions are noted, the Magee and Hollands models can be used to characterize wetlands for the Northern Rail Extension Project study area. The model asserts that all wetlands have a relationship with groundwater. This manifests itself in the FC for groundwater discharge and groundwater recharge for any particular wetland totaling approximately 1. The model is stating that if it is not discharging groundwater at any given time, then it must be recharging groundwater. However, the situation is more complicated for interior Alaska. The existence of permafrost can completely separate some precipitation driven wetlands from subpermafrost groundwater. This leads to an overestimate of both groundwater discharge and recharge in wetlands underlain by permafrost.

The relative homogeneity of the study area also plays a role in the limited range of some of the functions. The wetlands are all in the same general area with identical climatic conditions and very little disturbance to the wetlands or surrounding ecosystems. The broader based functions which are measuring a wetland's potential relative to the landscape as a whole show very little variation among wetland types. This is apparent in the functions modification of water quality, contribution to the abundance and diversity of wetland vegetation, and contribution to the abundance and diversity of wetland fauna. The functional capacity indices of these functions show more about how wetlands on the whole are functioning in the environment, rather than the individual wetlands.

The three remaining functions, storm and flood water storage, modification of stream flow, and export of detritus, are heavily influenced by the relationship of the wetland to a stream. Each one of these functions has the absence of an outlet either as an indicator of disfunction or as a direct indicator of the function giving these sites either a 0 or 1 FC. The absence of an outlet is a much more important variable than are the vegetation and hydrologic regimes characteristics that define Cowardin wetland types. FCs for these three functions are dependent first on the proximity to a stream and less so on the wetland type.

Overall, the following conclusions can be made by applying the Magee and Hollands model to the study area wetlands:

- Permanently and semipermanently flooded emergent wetlands have a high FC to perform groundwater discharge.
- Wetlands with an outlet have a high FC to export detritus and a moderate FC to store storm and flood flows and to modify stream flow.
- Wetlands without an outlet have a high FC to store storm and flood flows and a low FC to modify stream flow and to export detritus.
- Wetlands within the study area have a high FC to modify water quality, to contribute to the abundance and diversity of wetland vegetation, and to contribute to the abundance and diversity of wetland fauna.

In order to apply the Magee and Hollands functional assessment method to the entire study area corridor, all of the mapped wetlands are attributed by wetland type and outlet status in GIS. After the wetland polygons are attributed, model results are joined to the individual wetland polygon. Table 12 shows the model results for all of the wetland types within the Northern Rail Extension Project corridor. If data is not available for a specific wetland type, it is extrapolated from a similar wetland type.

Table 12. Wetland Functional Assessment Summary – Average Functional Capacity of Each Wetland Type

Vegetated Wetland Type	# of Data Points	Area (acres)	Modification of Ground Water Discharge	Modification of Ground Water Recharge	Storm and Flood-Water Storage (wetlands with outlets)	Storm and Flood-Water Storage (wetlands without outlets)	Modification of Stream Flow (wetlands with outlets)	Modification of Stream Flow (wetlands without outlets)	Modification of Water Quality	Export of Detritus (wetlands with outlets)	Export of Detritus (wetlands without outlets)	Contribution to Abundance and Diversity of Wetland Vegetation	Contribution to Abundance and Diversity of Wetland Fauna
BL Forest Semipermanently Flooded	0	0.6	1	0	0.47 ¹	1	0.67 ¹	0	0.53 ¹	0.83 ¹	0	0.87 ¹	0.88 ¹
BL Forest Seasonally Flooded	1	27.4	0.47	0.61	0.56 ³	1	0.44 ³	0	0.83	0.82 ³	0	0.87	0.73
BL Forest Saturated	0	9.7	0.47 ²	0.61 ²	0.52 ⁴	1	0.52 ⁴	0	0.83 ²	0.83 ⁴	0	0.87 ²	0.73 ²
BL Forest Temporarily Flooded	0	8.2	0.47 ²	0.61 ²	0.52 ⁴	1	0.52 ⁴	0	0.83 ²	0.83 ⁴	0	0.87 ²	0.73 ²
Mix Forest Seasonally Flooded	0	3.4	0.43 ⁴	0.54 ⁴	0.52 ⁴	1	0.52 ⁴	0	0.86 ⁴	0.83 ⁴	0	0.82 ⁴	0.72 ⁴
Mix Forest Saturated	0	1.8	0.43 ⁴	0.54 ⁴	0.52 ⁴	1	0.52 ⁴	0	0.86 ⁴	0.83 ⁴	0	0.82 ⁴	0.72 ⁴
NL Forest Seasonally Flooded	0	53.9	0.43 ⁴	0.54 ⁴	0.52 ⁴	1	0.52 ⁴	0	0.86 ⁴	0.83 ⁴	0	0.82 ⁴	0.72 ⁴
NL Forest Saturated	37	2908.5	0.43	0.54	0.52	1	0.52	0	0.86	0.83	0	0.82	0.72
NL Forest Temporarily Flooded	0	1.2	0.43 ⁴	0.54 ⁴	0.52 ⁴	1	0.52 ⁴	0	0.86 ⁴	0.83 ⁴	0	0.82 ⁴	0.72 ⁴
BL Shrub Semipermanently Flooded	1	57.7	1	0	0.47	1	0.67	0	0.53	0.83	0	0.87	0.88
BL Shrub Seasonally Flooded	29	985.5	0.53	0.51	0.56	1	0.44	0	0.78	0.82	0	0.87	0.80
BL Shrub Saturated	24	307.8	0.53	0.52	0.60	1	0.50	0	0.79	0.77	0	0.85	0.75
BL Shrub Temporarily Flooded	0	131.7	0.53 ⁵	0.52 ⁵	0.60 ⁵	1	0.50 ⁵	0	0.79 ⁵	0.77 ⁵	0	0.85 ⁵	0.75 ⁵
Mix Shrub Seasonally Flooded	2	148.1	0.40	0.64	0.53 ⁶	1	0.44 ⁶	0	0.80	0.83 ⁶	0	1.00	0.79
Mix Shrub Saturated	32	2185.2	0.47	0.51	0.53	1	0.44	0	0.81	0.83	0	0.85	0.76
NL Shrub Seasonally Flooded	1	182.5	0.25	0.73	0.53 ⁷	1	0.44 ⁷	0	0.73	0.79 ⁷	0	0.53	0.79
NL Shrub Saturated	23	978.2	0.42	0.56	0.53	1	0.44	0	0.82	0.79	0	0.83	0.73
NL Shrub Temporarily Flooded	0	1.0	0.42 ⁷	0.56 ⁷	0.53 ⁷	1	0.44 ⁷	0	0.82 ⁷	0.79 ⁷	0	0.83 ⁷	0.73 ⁷
Emergent Permanently Flooded	3	6.5	0.76	0.24	0.49 ⁸	1	0.64 ⁸	0	0.84	0.68 ⁸	0	0.73	0.83
Emergent Semipermanently Flooded	22	231.4	0.74	0.32	0.49	1	0.64	0	0.75	0.68	0	0.78	0.82
Emergent Seasonally Flooded	15	140.5	0.52	0.55	0.57	1	0.44	0	0.73	0.78	0	0.78	0.73
Emergent Saturated	4	9.5	0.50	0.54	0.67	1	0.52	0	0.84	0.71	0	0.80	0.66
Emergent Temporarily Flooded	2	0.3	0.47	0.58	0.67 ⁹	1	0.52 ⁹	0	0.78	0.71 ⁹	0	0.80	0.67

¹ Extrapolated from BL Shrub Semipermanently Flooded

² Extrapolated from BL Forest Seasonally Flooded

³ Extrapolated from BL Shrub Seasonally Flooded

⁴ Extrapolated from NL Forest Saturated

⁵ Extrapolated from BL Shrub Saturated

⁶ Extrapolated from Mix Shrub Saturated

⁷ Extrapolated from NL Shrub Saturated

⁸ Extrapolated from Emergent Semipermanently Flooded

⁹ Extrapolated from Emergent Saturated

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