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Potential Impacts to Resident Populations, Susitna-Watana Hydroelectric Project

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Capstone Project

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In 2014, the Alaska Energy Authority is preparing to construct a hydropower dam on Alaska's Susitna River, known as the Susitna-Watana Hydroelectric Project. Changes to water levels, sediment content, and flow rates are likely to affect the river itself and the salmon that are sustained by the Susitna ecosystem. The potential geomorphological and biological impacts of the dam as they could affect activity in the local communities are studied using currently available data. GIS tools are applied to identify areas of reservoir fill, risk of erosion, and endangerment of salmon habitat; then compare these impact areas to areas used by residents. The study intends to provide a local context whereby Alaskans can understand impacts surrounding the Susitna-Watana Hydroelectric Project.

Table of Contents

Disclaimer

This project was prepared as a student assignment as a required exercise for a graduate degree. This discussion of the Susitna-Watana Hydroelectric Project is meant solely to support an academic project. The author and this report are not affiliated with the Alaska Energy Authority or any company or individual under contract to the Alaska Energy Authority. The capstone research may not address all of the technical questions required to fully implement the study described. Other applications may be investigated further to meet the needs of this study.

Introduction

Alaska's main attraction has always been the thrill of its wildness and its raw, magnificent geography. This appeal must have a strong effect on Alaska residents, who have increased in number by an average of 1.4% each year for the past twenty years -- a growth rate 50% higher than the national average. As Alaska's population grows, the balance between protecting its natural wilderness and supporting residents with its resources becomes more delicate. In an attempt to rein in the high cost of living, and with an interest in sustainable use of resources, the introduction of new energy alternatives has been a major focus of Alaskan politics in recent years.

In 2008, Alaska state legislators decided to reconsider the implementation of a hydroelectric plant on the upper Susitna River. The concept of hydroelectric power generated in the Susitna area had been considered in the 1980s, but the project preparations were ceased when the power generation amount was deemed wasteful for the expected usage at that time in contrast with the cost of energy alternatives. As the approach to this hydropower installation is revisited, the Alaska Energy Authority (AEA) is the state-run agency responsible for supervising environmental impact studies and guiding the project through the permitting process toward licensure and construction. The AEA reports to the Federal Energy

Regulatory Commission (FERC), which will review the materials from AEA before determining whether the project will go forward.

The Susitna-Watana Hydroelectric Project would involve construction of a dam to control the flow of water in the Susitna River. The 600-MW dam would be constructed to a height of 735 feet, 100 feet or more of which would be grounded in bedrock for stability, and would create a reservoir of significant size. Controlled release of the reservoir's stores will generate energy that can be consumed during low-flow seasons and stored during high-flow seasons. The area served by the Susitna-Watana Hydroelectric Project covers the "Railbelt" corridor from Seward to Fairbanks, where approximately 70% of the state's population resides – with a goal of supporting half of the electrical needs of this service area.

The Susitna River drainage supports a significant salmon population, which depends on a balanced ecosystem to support the health of the species. This ecosystem will no doubt be affected by any changes resulting from the dam's construction and operation. Because salmon return each year to spawn in the rivers where they were hatched, protecting the aquatic habitat is critical to sustaining the population. A threatened local population may not recover, since salmon characteristically do not locate spawning grounds based on the site's quality, but on the fish's instinct. Alaskans depend heavily on subsistence use of natural resources, and harvesting wild plants, fish, and game is rooted strongly in cultural and economic values. The Susitna River drainage provides some of the most accessible fisheries for Alaska's residents, more than half of whom are concentrated in the nearby Anchorage municipality and Matanuska-Susitna Borough. Any effects on the river's hospitability to salmon populations could have an impact on these residents.

Research Question

As the Susitna-Watana Hydroelectric Project undergoes its federally mandated studies prior to the permitting process, Alaska residents have many questions about the effects of constructing a dam. Geographic information systems (GIS) provide excellent tools for data applications and modeling, and this research project uses GIS to tackle one of the major questions surrounding the Susitna-Watana issue: Which areas in the Susitna River Valley could see impacts to the river and its ecosystem due to the hydroelectric installation, and to what degree might those impacts affect the residents of nearby communities? This research paper will test the theory that the currently known potential impacts to local residents are significant enough to warrant public participation.

Any actions taken on behalf of the Susitna-Watana dam could set precedent for future hydroelectric projects in Alaska. Describing overall impacts is important for general public knowledge, but describing impacts in locally relevant ways could be a way to get more Alaska residents active and engaged in response to the choices the state agencies are making, which could steer the course of development. This research study provides a context for Alaska residents to consider their role in the public process and seek an outcome that supports the short- and long-term needs of their communities. Proper anticipation and counteraction of hydropower's negative environmental effects can result in much more responsible and positive projects in which such effects are not devastating to the surrounding ecosystem.

Study Area

The proposed location of the Susitna-Watana dam is on the upper Susitna River, just below Watana Creek (see Figure 1 below). The dam site is 184 river miles away from the Susitna River's mouth at the Cook Inlet, which is just across the inlet from the city of Anchorage. Manipulation of the river's flow will change the water levels from season to season on a river that has already suffered from dramatic fluctuations. For example, floodwaters from the river and its tributaries rushed into the town of Talkeetna as recently as 2012, and any low salmon runs are immediately noted and lamented by local residents. Even seemingly undramatic changes to the natural landscape can have a notable effect on how Alaskans interact with their surroundings. For the residents of the Matanuska-Susitna Valley, the Susitna River's lower half is, at least, a familiar fixture, or at most, something like a lifeblood.

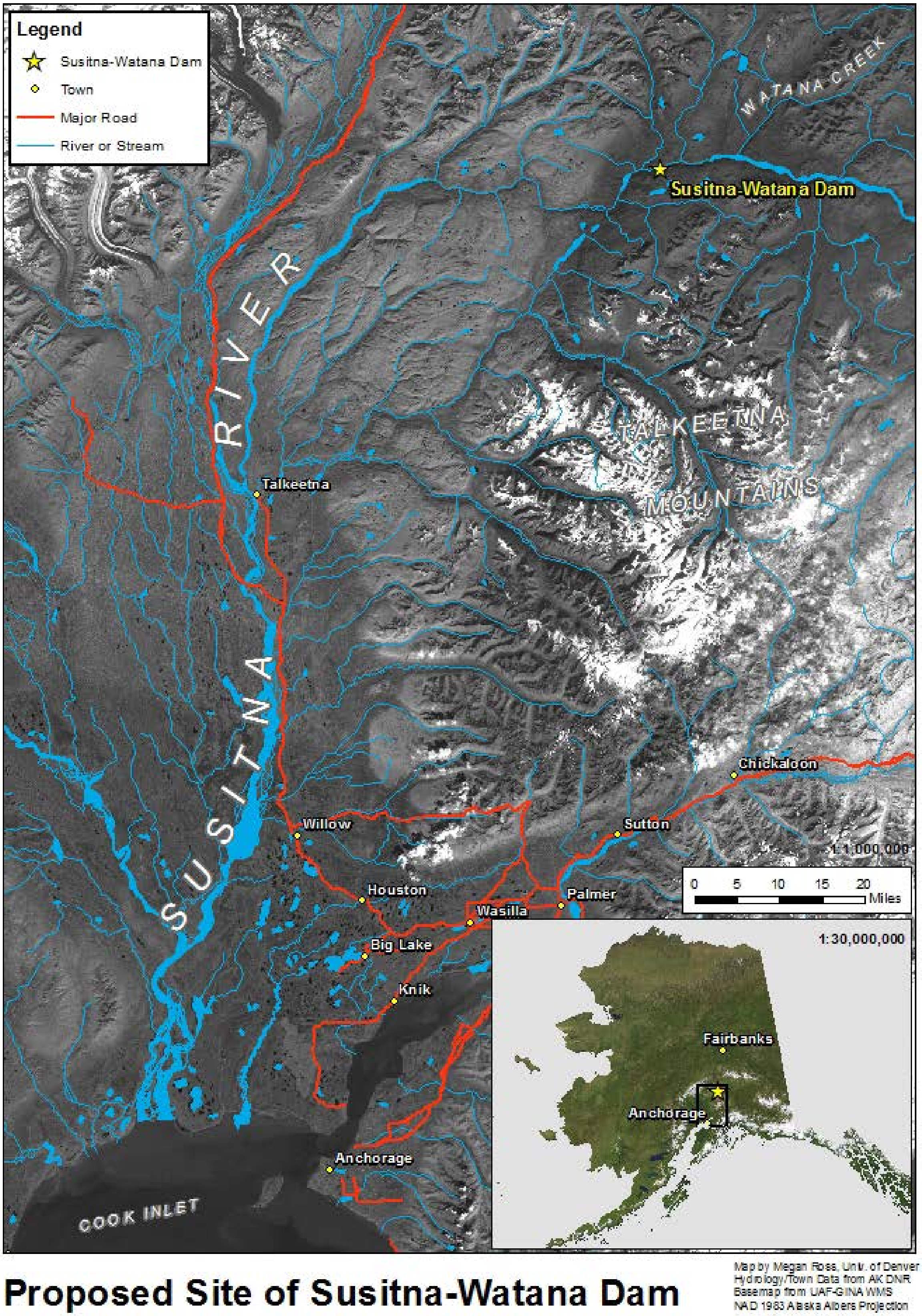

Figure 1: Map of Susitna-Watana Dam Site and Susitna River

The area of interest for this study includes the dam site (see Figure 2 below) as well as the area above and below it that would be affected by its construction. Devil's Canyon is an area of particular significance between river miles 149-161, where the changes in water velocity in this already swift-moving channel are expected to be notable with regard to salmon activity. The entire length of the river, however, as it feeds into the Cook Inlet is considered in the research of this study.

Figure 2: View of Proposed Susitna-Watana Dam Site (note exploratory drilling in lower right)

Literature Review

To contextualize the issue at hand, and to better understand the purposes of the research project, three main topics are investigated herein: documented impacts of hydroelectric projects in general, potential impacts specific to Pacific North American rivers such that could affect the Susitna-Watana project, and the benefits of using GIS in studies of this nature.

Impacts of Hydroelectric Projects

A variety of hydrologic and geomorphic changes result from implementation of a hydroelectric dam. Naturally occurring sediment collects in a reservoir rather than flowing freely downstream, which can significantly affect the nutrient levels and "scour power" of a river (Biswas 1982, Dauble 2003). Erosion downstream may be more prevalent when less sedimentation is present to sufficiently replace what is displaced by flow (Biswas 1982). Fine materials are generally worn away downstream, leaving coarser materials to line the riverbeds and banks wherever present. An intensive study of Glenbawn Dam in New South Wales, Australia, estimated that 99% of its river's upstream sediment was trapped within the dam's reservoir and also ascertained the specific degree to which frequency of flow had been reduced and runoff had decreased (Erskine 1985). Reduced frequency of flooding caused new types of vegetation to colonize the riverbanks downstream. A similar case study of the Tucurui Hydroelectric Power Plant in Brazil showed that the river was subject to a higher incidence of "minimum flow" and a lower incidence of "peak flow" which led to some areas experiencing an almost perpetual state of minor flooding, and other areas receiving no floods at all (Manyari 2007). These hydrologic changes can quickly have an impact on the local ecosystem. Wildlife displaced by the filling of a reservoir will be forced to compete for resources in other areas, or they may be more attracted to new areas where vegetation patterns have changed (Gleick 1992). In many cases, individuals and communities are displaced as well, forced to move to new locations to allow space for the changing river conditions and reservoir development (Biswas 1982).

Impacts Specific to Pacific North American Rivers and Susitna-Watana

Dammed rivers in Pacific regions experience distinct impacts on salmon populations due to manipulation of flow. Oregon's Columbia and Snake Rivers are characterized by wide alluvial beds, which depend on natural shifting of sediment within the channels, redistributing nutrients to serve as food for aquatic populations (Dauble 2003). Regulated water flow can impact the ability of a salmon to adapt physiologically at the appropriate time when moving between salt and freshwater environments (Schilt 2007). Research from NOAA indicated that the disruption of migration timing as related to water flow may be a significant contributor to weakening salmon populations (Williams 2005). Another contributing factor is the temperature of water released from the reservoir after a period of storage, which may affect downstream temperatures that cause stress on the developing or migrating fish. Other sources note that spillways at dams, which are safer than turbine passages for fish, can actually cause increased levels of dissolved gases in the water below the dam site that can be dangerous to fish (Schilt 2007, Ebel 1980). Water flow concerns are especially problematic above the dam, where water pools into the reservoir and fish may have trouble sensing flow in such a manipulated environment (Biswas 1982). There may be negative consequences of releasing a reservoir's water to a downstream area when water quality at the reservoir may differ from the quality downstream (Zoellner 1979). Aside from inhibiting migratory behavior of spawning salmon, a difference in water quality or sedimentation levels can endanger eggs and salmon fry by stirring up sediments in stream beds without replacing those fine materials.

Below Devil's Canyon, the Susitna River stretches into an ever-widening braided floodplain, with side channels and sloughs that transform from swollen and turbid to quiet and clear depending on the season (Benke 2005). These smaller channels support a variety of aquatic and biotic processes that are also season-dependent, particularly the spawning activities of chum and sockeye salmon and habitat areas for juvenile coho, sockeye, and chinook salmon. The seasonal variation in flow also allows for a cycle of growth and redistribution of algal flora within the river that provides food sources at particular intervals (Benke 2005). Home to all five species of Pacific salmon, and characterized by the kind of sedimentation that can so easily be disrupted by the geomorphologic changes of a dam, the Susitna River is certainly at risk of being impacted.

GIS Analysis in Similar Studies

Geographic information science proves to be an invaluable tool for modeling and analyzing processes of change on a large spatial scale. In a recent hydroelectricity impact study in Brazil, researchers used a species distribution model to attribute known species habitat to environmental factors of climate, topography, and soil properties, then used those environmental factors to interpolate gaps between habitat areas (Guarino 2012). This is a great example of using data to infer new information over a large area where data might be incomplete. Research in the Longitudinal Range-Gorge Region of China utilized plentiful public data from previous water quality and ecology studies to quantify impacts like soil erosion, river network density change, and a variety of other factors that were combined into a "river ecosystem integration" index, used to assess and predict the health of dammed rivers (Zhai 2010). Bathymetric data of riverbed depth were created from sonar and LiDAR data and used to define likely spawning areas for chinook salmon during a study of Idaho's Snake River (Hanrahan 2007).

GIS also allows the user to digitize historical data that may not be readily available in software-compatible format (Dauble 2003), enabling a comparison of historical and current data to model future scenarios. Aerial and satellite photography is particularly useful for large-scale or remote area studies involving geomorphology, because "big picture" trends can be observed more readily from a bird's-eye perspective than from ground work (Shroder 2013). A group study of American dams involved digitizing floodplain features from aerial photography, which were then used to characterize and quantify geomorphic effects (Graf 2006). Several of these techniques and others will be used in this study of Susitna-Watana impacts.

Methods

This research makes use of multiple types of data to estimate impacts in a few key topic areas, then combines those impacts to assess cumulative risk and potential consequences. Location and extent of the reservoir will be determined, anadromous streams will be identified, and erosion risk will be assessed before comparing those risk areas to human use areas. Geomorphic impacts help to inform potential aquatic population impacts, and both of those have potential effects on human use in and around the project area.

Because of the wealth of secondary data available from this area, and due to the logistical infeasibility of collecting useful primary data in this extensive and remote project area, only secondary data has been used for this research. Public data is available from several Alaska governmental agencies to support this research. Data sources and types are described below for each task.

Reservoir Fill

Identifying the area affected by the introduction of the reservoir is of critical importance. The reservoir will fluctuate in height based on the season in order to maximize the efficiency of controlled release of water for power generation. Current design plans for the Susitna-Watana dam specify that the maximum surface height of water in the reservoir will be 2,050 ft AMSL, or approximately 25 ft below the highest point of the dam wall. The reservoir's maximum drawdown is expected to be 200 ft, making the minimum surface height of water in the reservoir 1,850 ft AMSL. In contrast, the surface height of the existing river surface is approximately 1,450 ft AMSL. As seen in Figure 1 above, the Susitna River has relatively steep banks at the dam site, and much of the 400-600 ft gains in surface height may be contained within the existing canyon. Using spatial analysis tools available in GIS software, a model of the reservoir will show the actual expected extent of the reservoir at its highest and lowest surface levels.

LiDAR data is available from the Matanuska-Susitna Borough for the area upriver of the proposed dam site, in a generously sized corridor that is 10 miles wide near the dam site and 3 miles wide further upriver from the site. The elevation contours generated from the bare-earth return LiDAR were used to identify current and future surface models. Contour lines with an elevation value of 2,050 were selected and converted into a polygon, using the AEA-identified dam location as a bounding line on the western edge. In a few locations along the outermost reaches of the reservoir, the corridor of available LiDAR data was narrower than the extent of the reservoir, so continuing edges were estimated using elevation contours featured on maps provided by the U.S. Geological Survey at a scale of 1:63,360. Software-aided selection of contour lines with the specified value yielded more than one polygon, due to natural variations in the terrain, so land features such as knobs and outcroppings that would rise above the surface of the reservoir were removed from the resulting polygon feature class by clipping the overlapping, smaller features out of the largest feature. Remaining was a single polygon representing the surface of the reservoir height at its maximum. The process was repeated to generate a polygon representing the reservoir's minimum height of 1,850 ft. Sample areas of these surface views are provided below in Figures 3 and 4, for a comparison of size and extent. Note the raised land formations near river miles 195 and 196.

Figure 3: Susitna-Watana Reservoir Section (Minimum)

Figure 4: Susitna-Watana Reservoir Section (Maximum)

Anadromous Waters

Anadromous waters are those which support species of fish that migrate upstream to spawn in freshwater areas. Pacific salmon, discussed in the review of documented effects of hydropower installations, are native to the Susitna Valley area and migrate to spawn in this way. The Alaska

Department of Fish & Game (ADF&G) provides publicly-available vector data of all identified anadromous waters in the state that support salmon, and these spatial data were used for this research. It should be noted that while the available dataset is a representation of all current records of ADF&G, some polylines were observed to be an inexact representation of the current placement of streams in the area. These discrepancies are usually a result of the gradual shift in glacial streambeds over time, which may have been mapped by ADF&G several years prior to this research, and of imprecise heads-up digitization often employed by creators of these types of datasets. Despite these imperfections, the dataset's level of accuracy was deemed to be appropriate for the purposes of this study.

Anadromous waters within the vicinity and potential affected area of the proposed dam site were assigned for this study into one of three categories, according to their placement relative to the Susitna-Watana dam site and Susitna River:

- Upstream Waters: This includes anadromous streams that are upstream of the proposed dam site (i.e., sections of the Susitna River and its tributaries).
- Primary Downstream Waters: This includes anadromous streams that are directly downstream of the proposed dam site, where waters flowing directly from the dam would pass (i.e., sections of the Susitna River).

- Secondary Downstream Waters: This includes anadromous streams that flow into any Primary Downstream Waters (i.e., any tributary of the Susitna River that enters the river below the dam site). These streams flow from sources unaffected by the dam site, but upstream travel to reach them may be affected by the necessary passage through Primary Downstream Waters.

No waters that are not classified as anadromous have been included in the study. This is not intended to be a comprehensive list of waters in the Susitna River drainage.

The Susitna River is categorized as anadromous for the entirety of its length within the study area, from its mouth at the Cook Inlet upstream beyond the maximum expected reservoir area. Because the potential impacts will be different above and below the proposed dam site, the Susitna River polyline in the ADF&G dataset was split at the proposed dam site and measured in each direction from the site to categorize each segment as Upstream or Primary Downstream.

Due to the imperfections in the dataset representing anadromous waters, some streams do not share nodes with the streams they flow into, so defining a linear network was not feasible for this study. Instead, the Susitna River polyline was selected for use as a starting segment, and all polylines within a specified distance of the selected Susitna River were selected (by location). Using the new selection of the Susitna and its direct tributaries, this selection process was repeated to include all branches of tributaries flowing into the Susitna River. The waters were categorized and their collective lengths measured.

Mapping the extent of Primary Downstream Waters involved heads-up digitization from aerial imagery. Along with the LiDAR data used to define the reservoir area, the Matanuska-Susitna Borough (MSB) acquired high-resolution orthoimagery in 2011 and 2012, covering the entire study area along the Susitna River. For the purposes of this research, the extent of Primary Downstream Waters was defined to include the outermost edges of any main channel or slough and all areas between those edges. The reason for including these intermittent areas, often without surface water apparent, is because the nature of braided glacial streams is to change over time, sometimes significantly, and sometimes rapidly. Under natural circumstances, side channels may be flooded with water in the spring season as snow melts and may dry to a trickle by the fall season, while the main channel continues to flow normally. Debris such as downed trees or ice jams in the spring may cause a main or side channel to change course, and these shifts are evident in the aerial imagery. Signs of change include the presence of wide and narrow channels among sandbars of glacial silt, as well as vegetation at various stages of growth on sandbars and side banks.

Erosion Risk

Geomorphic changes in the Primary Downstream Waters can have major effects on how ecosystems adapt to the impacts of hydroelectric dams. Identifying the relative risk of erosion within the study area will suggest which specific locations are at risk of major challenges. Spatial and tabular data and reports on soil composition are available from the U.S. Department of Agriculture's National Resources Conservation Service (NRCS) and are organized by region. The NRCS Matanuska-Susitna region covers the eastern side of this study's Primary Downstream Waters between Susitna River miles 0-125, and the NRCS Yentna region covers the western side of the study area between Susitna River miles 0-115. Quantitatively, the NRCS soil data covers 93% of the entire Primary Downstream Waters extent.

Spatial analysis tools available in GIS were used to map, quantify, and describe geomorphic changes. The extent of Primary Downstream Waters was buffered to a distance of 200 feet to ensure inclusion of river bank and access areas and to account for any spatial inaccuracies that may be present along the boundaries of the soil data. The buffered extent was then intersected with the Yentna and Matanuska-Susitna soils datasets to create a soils corridor specific to the study area.

Classification of the soils was complicated by the relatively low degree of detail present in the Yentna region's dataset. Spatially referenced tables for the Matanuska-Susitna region included numeric classification codes as well as qualitative assessments of erosion potential (rated "highly erodible," "potentially highly erodible," "not highly erodible," and "not rated") for all soil polygons. The corresponding tables for the Yentna region only included numeric classification codes for the soil polygons, which are not specific enough to classify erosion risk independently. The narrative report ("Soil Survey of Yentna Area, Alaska" published by NRCS in 1998) was consulted to ascertain the physical and chemical properties of soils according to each soil type's numeric classification code. Erosion risk is often assigned a "K" factor, which indicates how susceptible a soil type is to erosion by water. Values range between 0.02 and 0.69, with greater values indicating greater susceptibility. The erosion K factors for each soil type were assessed in comparison with the Matanuska-Susitna region data and report ("Soil Survey of the Matanuska-Susitna Valley Area, Alaska" published by NRCS in 1998) to assign each Yentna soil code into an erodibility category. Where K factors varied by soil depth, the value for the surface layer was used. These classes and categories were input into a table, which was joined to the Yentna region spatial data table to enable queries on that dataset regarding the qualities of each soil type.

Some soil types were simply categorized according to their K factors (extremely high or low values of K are considered simple to categorize, for the purposes of this study). Other soil types without extreme values of K were categorized based on a combination of the K factors with the slope characteristics of the polygon containing the soil type. After the simple categorization was completed, polygons in the Yentna region with still-undefined erosion potential underwent additional manipulation. GIS spatial analysis tools were used to calculate slope for regions of the study area requiring complex categorization. Digital elevation models at 1-ft resolution, provided from the same bare-earth return LiDAR data from MSB used to determine the dam's reservoir area, were used as input for the slope calculations. Polygons in the Yentna soils region were assessed based on the dominant slope category within each soil type, according to trends apparent in the Matanuska-Susitna dataset and report, but generally as follows:

- Slope 0-5% = Not highly erodible land
- Slope 5-20% = Potentially highly erodible land
- Slope greater than 20% = Highly erodible land

Human Activities and Area Use

Potential impacts to human use areas were assessed based on the risk factors identified in the soils data. Most commonly used infrastructure such as towns and roads within the study area is concentrated below river mile 103, but the Alaska Railroad generally follows the east bank of the Susitna River as far as river mile 138. Land parcel data was consulted to identify the nature of locations of potential impact, based on the erosion risk category. The Matanuska-Susitna Borough provides current records of land status at the parcel level with attribute details about the owner. Parcels were selected by location to ascertain which parcels contained any sections classified during the soils assessment as "highly erodible" or "potentially highly erodible." Parcels that included both erosion types were classified as highly erodible.

Results

Reservoir Fill

The full potential impact area of the Susitna-Watana reservoir is delineated below in Figure 5. This surface model identifies areas where water flow will be low upstream of the dam due to reservoir fill. Much of lower Watana Creek will be included in the reservoir, near river mile 194. At its maximum fill, the linear extent of the reservoir could be as great as 47 river miles, ending just downstream of the mouth of the Oshetna River where it enters the Susitna at river mile 231; at its lowest, the reservoir's linear extent would be 10 miles shorter than that. These models predict that the minimum reservoir fill would encompass about 18.7 sq mi and that the maximum reservoir fill would almost double that area, at 36.6 sq mi. Even at its minimum, the Susitna-Watana Reservoir would be the second largest lake in the Matanuska-Susitna Borough, and at its maximum it would be the largest lake in the borough and the 21st largest lake in Alaska, according to hydrologic data provided by the Alaska Department of Natural Resources.

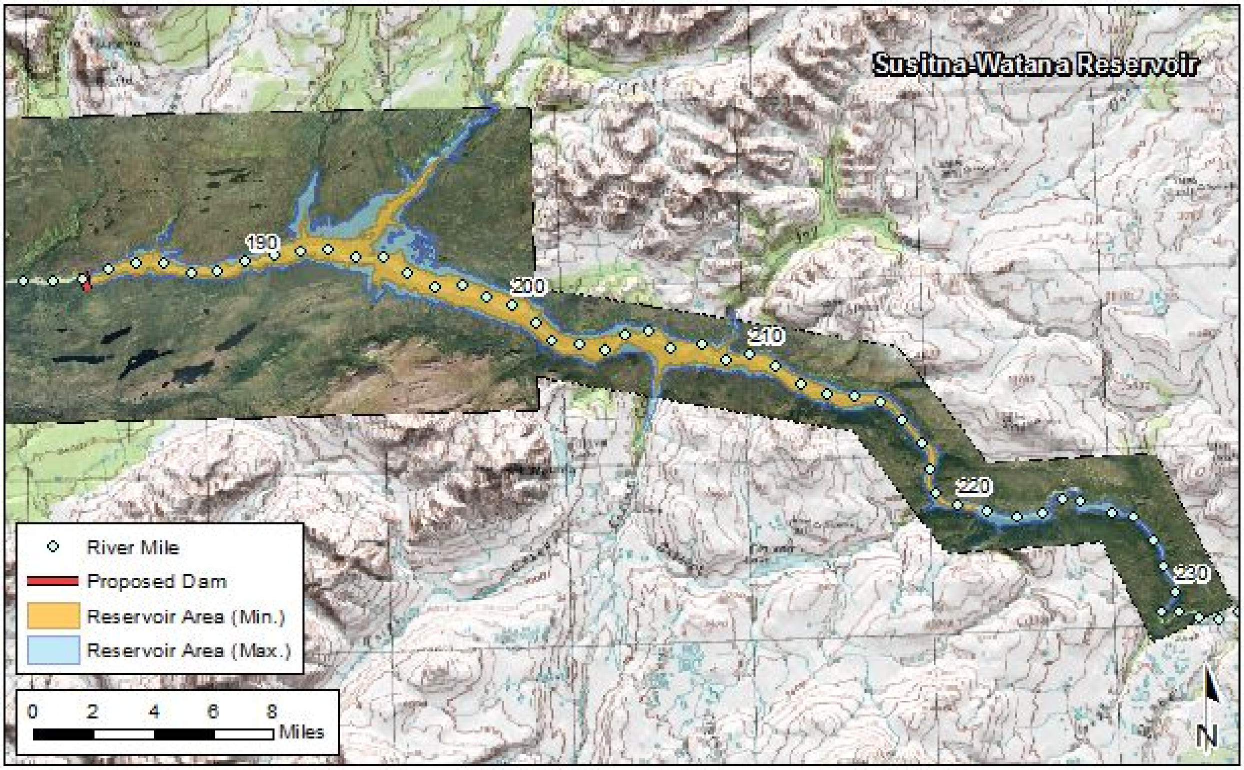

Figure 5: Susitna-Watana Reservoir

Anadromous Waters

Total lengths of anadromous waters in each category were calculated as follows:

- Upstream Waters: 66 miles
- Primary Downstream Waters: 194 miles
- Secondary Downstream Waters: 3,486 miles

Secondary Downstream Waters are very extensive, totaling 3,486 miles. However, the impacts on these waters are likely to vary quite a bit due to their respective positions along the Susitna River. It is possible that impacts to sedimentation, nutrient levels, or other hydrologic characteristics after construction may be more significant closer to the dam site. To gain a clearer understanding of how Secondary Downstream Waters might be affected, the waters were classified into drainage systems based on their tributary into the Susitna. The collective length of each drainage system, its position on the Susitna, and its distance from the dam site are shown in Table 1. Figure 6 shows the major drainage systems. Only systems totaling more than 50 miles are categorized individually, and the remaining systems and tributaries are categorized together as minor drainages.

Table 1: Secondary Downstream Waters by Drainage

Drainage	Total Length	Position on Susitna	Distance from Dam Site
Yentna River	1,528 miles	MP 28	156 miles
Kroto Creek	556 miles	MP 40	144 miles
Chulitna River	335 miles	MP 98	86 miles
Talkeetna River	272 miles	MP 97	87 miles
Alexander Creek	119 miles	MP 10	174 miles
Kashwitna Creek	77 miles	MP 61	123 miles
Willow Creek	77 miles	MP 47	137 miles
Little Willow Creek	77 miles	MP 50	134 miles
Minor Drainages	445 miles	varies	--

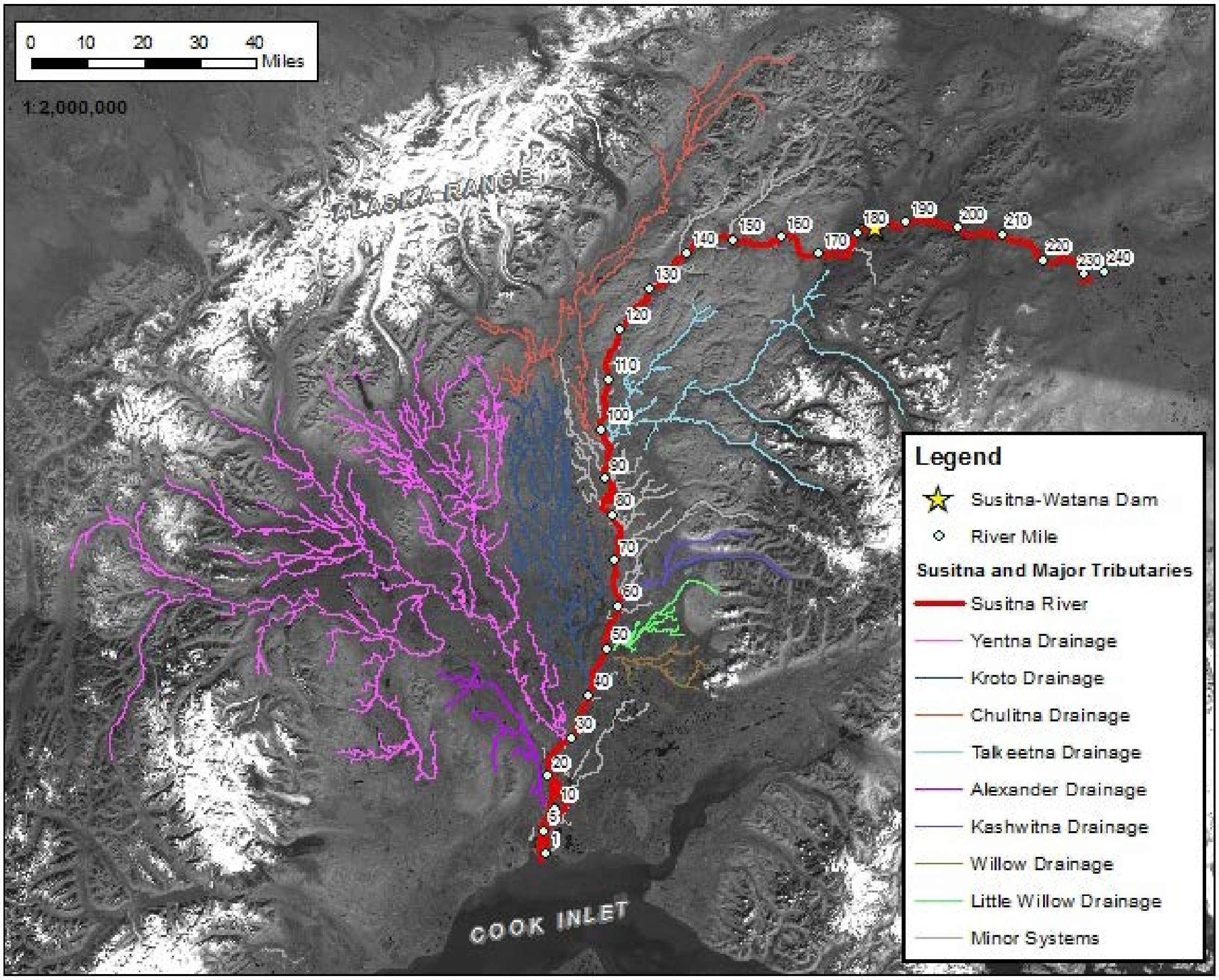

Figure 6: Susitna River: Anadromous Tributaries

It was noted that although the Susitna River is the only Primary Downstream Water, and the dam site is located at river mile 184, the total calculated length of that category is 10 miles greater than the documented length of the river to that point. The difference was observed to be due to the inclusion of side sloughs that were mapped and categorized by ADF&G as part of the Susitna River in the dataset. Interestingly, Watana Creek, which would absorb much of the reservoir area (see Figure 5 above), is not classified as anadromous and therefore is not considered an impacted Upstream Water within the parameters of this study.

Erosion Risk

Areas where NRCS detailed soil data was available or inferred (covering 93% of the total extent of Primary Downstream Waters) are characterized by erosion potential in the following proportions:

- Highly erodible land: 1.2%
- Potentially erodible land: 0.7%
- Not highly erodible land: 56.6%
- Not rated: 41.5%

Regions categorized as "not rated" by the NRCS study are generally covered with surface water (e.g., active stream beds).

Human Use Areas

The reservoir area is made up entirely of lands owned by the State of Alaska and by various native corporations and village associations. The upper Susitna River is the northern boundary of the Nelchina Public Use Area, but there are no currently maintained access points to the reservoir area. Access construction is included in the hydropower development plan, but the only reasonable access to the area currently is via helicopter or snow machine. There are no private-owned parcels in the immediate area of the reservoir that would be impacted by the fill.

Along the area of Primary Downstream Waters, a total of 205 land parcels contained highly erodible or potentially highly erodible lands, including 104 private parcels. One right-of-way providing access from a subdivision directly to the Susitna River could be affected at the river access points (see Figure 7).

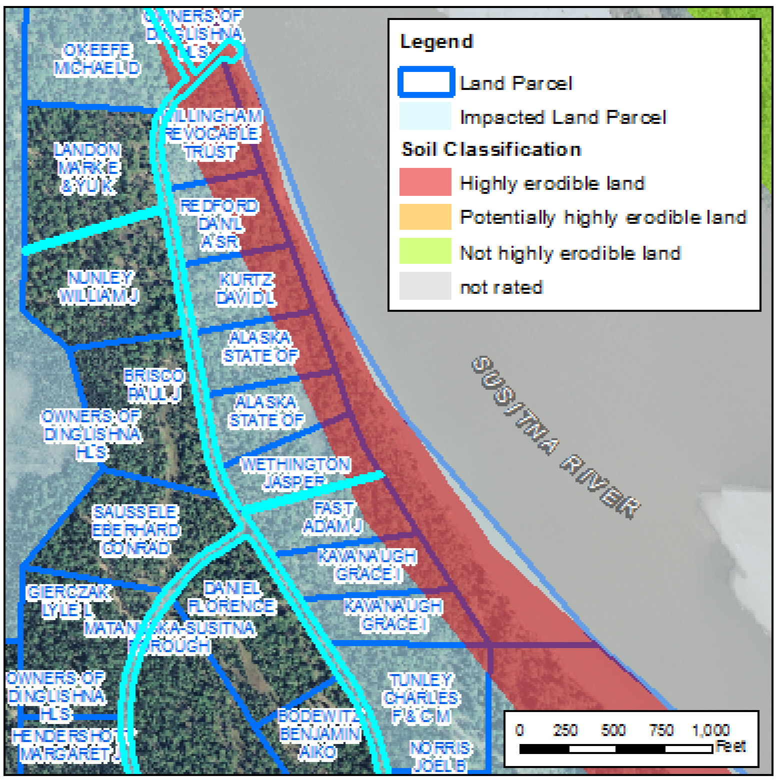

Figure 7: Example of Impacted Parcels and Right-of-Way (ROW highlighted in turquoise)

One federal-owned parcel administered by the Bureau of Land Management was affected, but the parcel has no structures present on the aerial imagery and its use could not be determined. Impacted areas also include 14 borough-owned parcels and 15 state-owned parcels, but impact area relative to parcel size is generally quite small, and nearly all of these agency-owned parcels were found to be empty of infrastructure when reviewing aerial imagery and address point data from MSB. Several impacted parcels are under the administration of the Alaska Department of Natural Resources, Division of Lands, and appear likely to be subdivided for conveyance to private owners in the future. Several dozen parcels did not have ownership details listed in the public dataset, so further inquiry would be needed to determine the nature of impact to those parcel owners and which other communities or individuals may have an interest in those impacts.

Additional areas of noteworthy potential impact include transportation corridors. A section of the east bank where the Susitna River is breached by the Parks Highway, one of the most highly traveled roads in the state, is classified as highly erodible (see Figure 8).

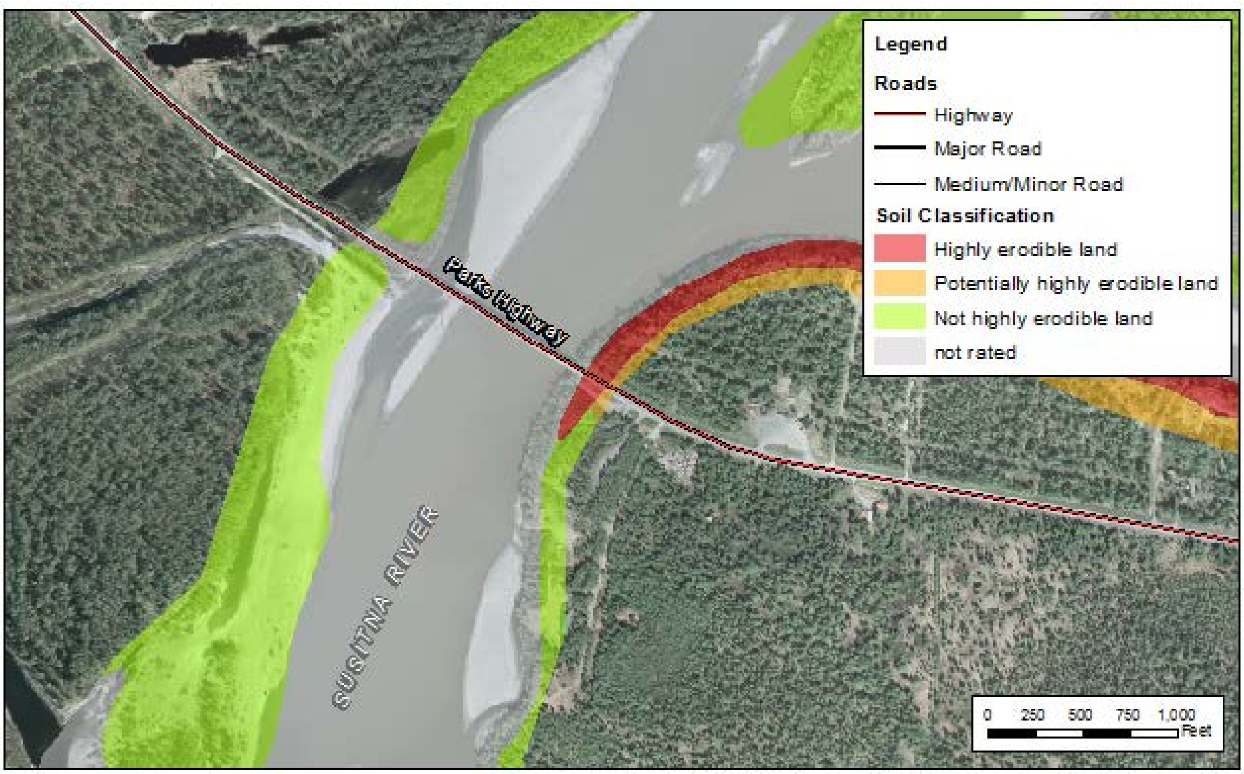

Figure 8: Parks Highway crossing the Susitna River

The Alaska Railroad, which travels along the east bank of the Susitna River for several miles, is also at risk of experiencing potential impacts described in this study. Approx 6.7 miles of the railroad centerline as documented by DNR falls within the highly erodible land category, and 2.4 miles falls within potentially erodible land, in eight separate sections. Examples are shown in Figure 9.

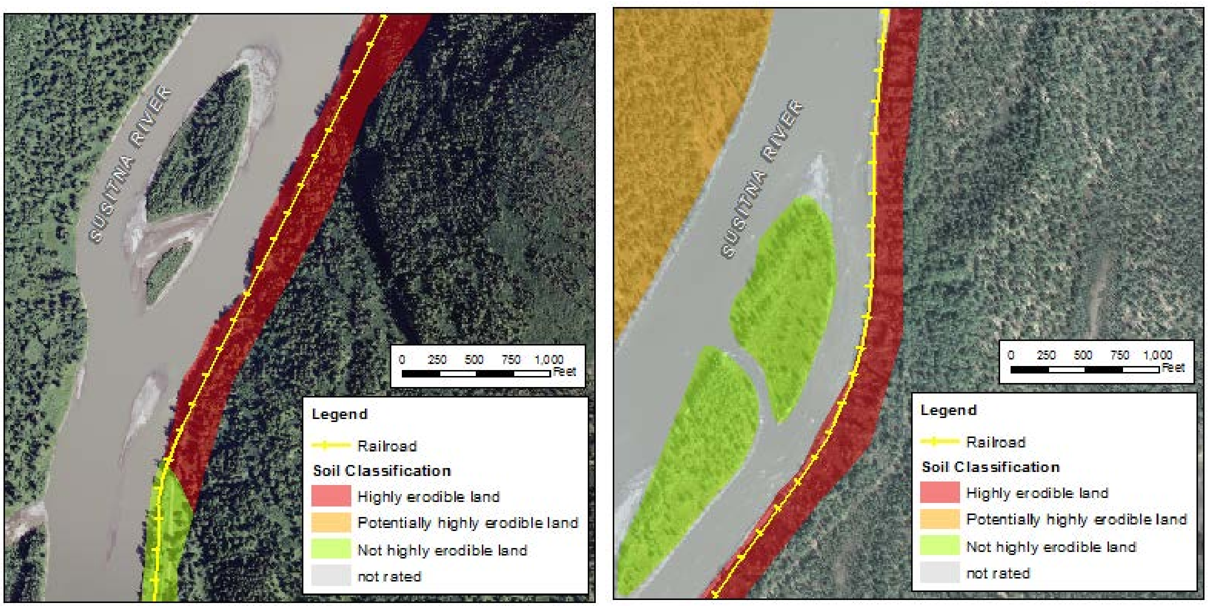

Figure 9: Alaska Railroad, near river mile 110 and 118

Heavily used public access areas for the Susitna River do not seem to be affected by the studied impacts, generally due to their locations on land that is not considered to be highly or potentially highly erodible. The Deshka Landing, one of the most common public access points for the Susitna River and many of its tributaries, is shown in Figure 10 on relatively stable soils.

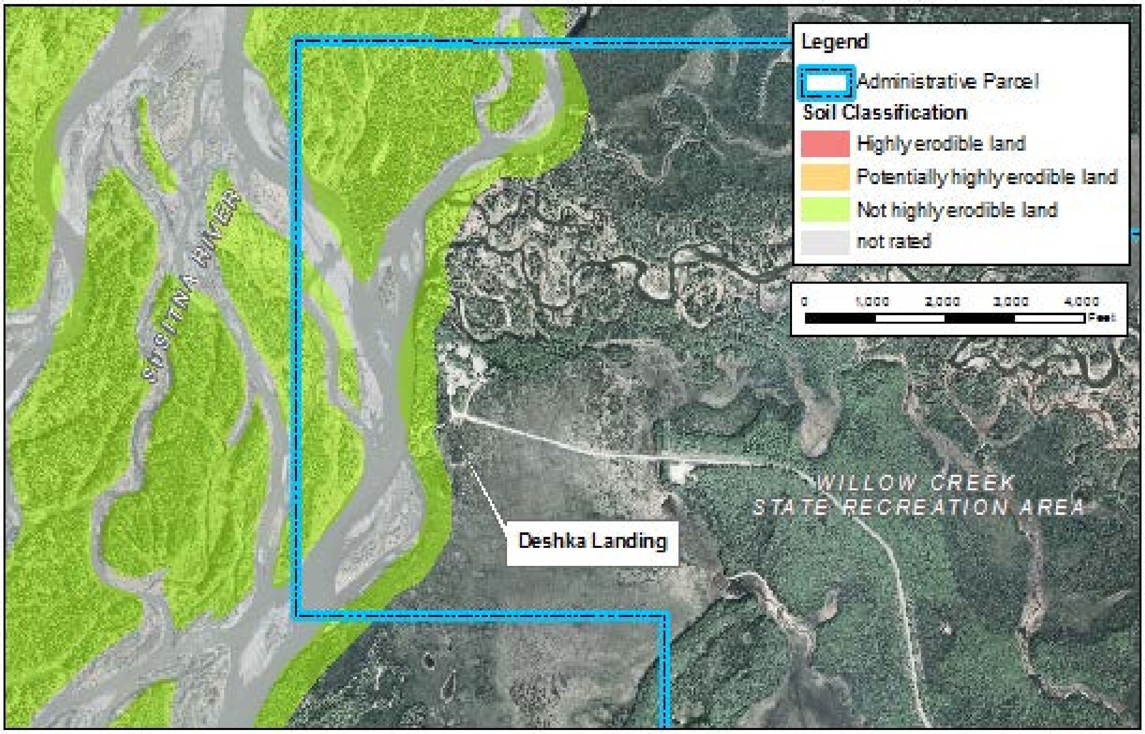

Figure 10: Deshka Landing

The Susitna Landing, another major access point administered by ADF&G, is shown in Figure 11 with similar terrain stability.

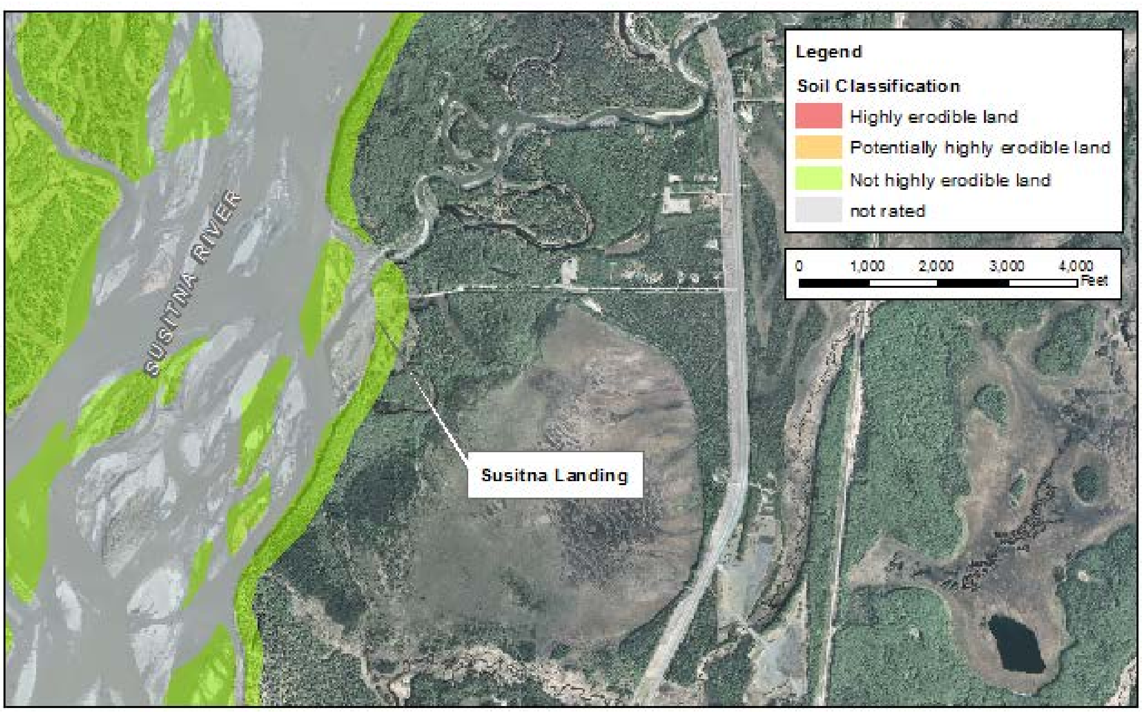

Figure 11: Susitna Landing

Acknowledging that these two landing and launch areas are major service points for the surrounding communities to access the primary and secondary downstream waters, it may be assumed that there is no significant risk of impact to those access points due to the hydropower project, based on the parameters of this study.

A general view of the study area extent, categorized anadromous waters, and the reservoir area in comparison with the dam site and relevant infrastructure (roads and railroads) is provided in Figure 12.

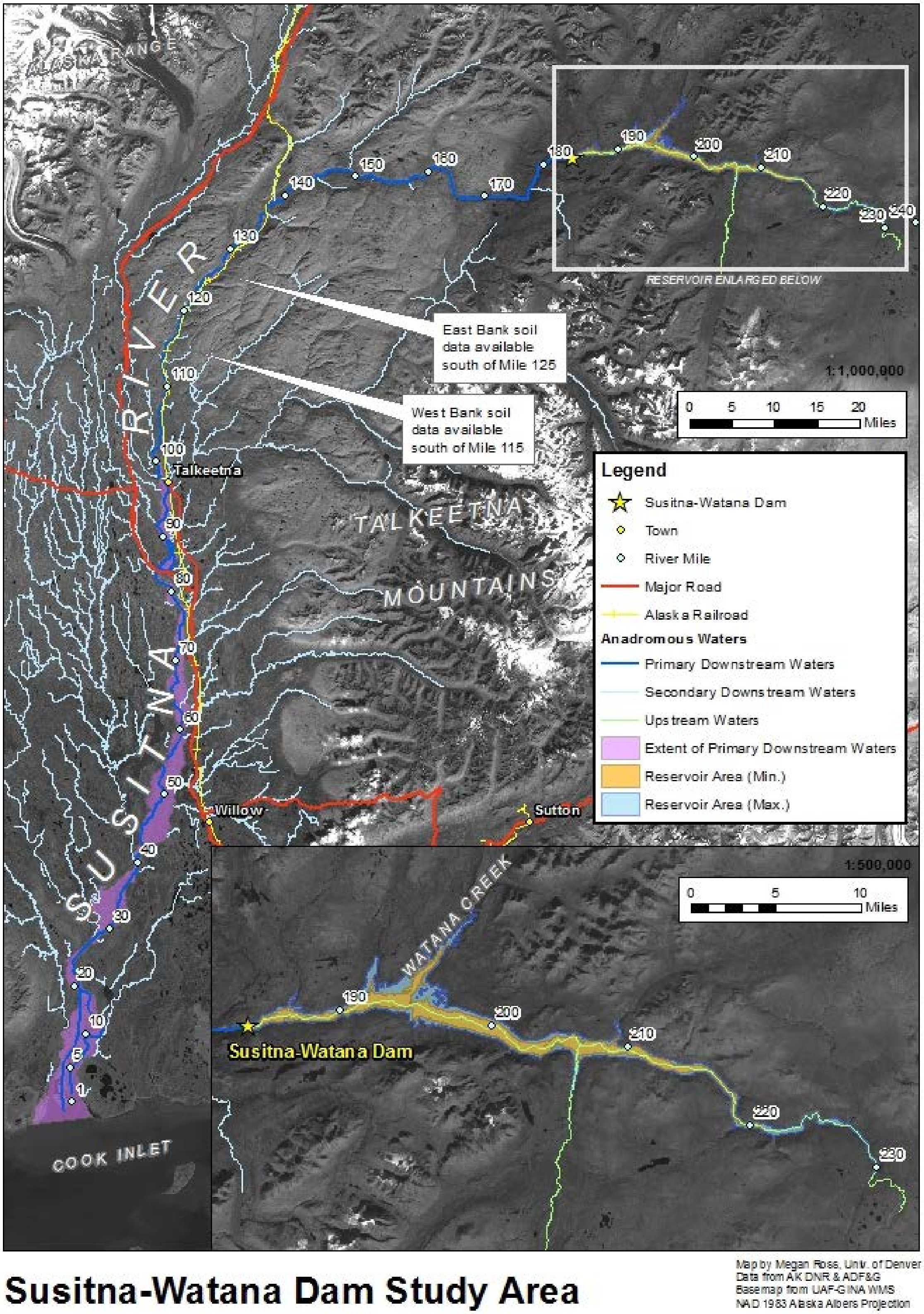

Figure 12: Susitna-Watana Dam Study Area

Discussion

Potential impacts to the Susitna River Valley have been assessed in this study based on currently available data. According to the data studied, impacts to land areas seem not to be significant with regard to human use areas. Although the Susitna-Watana Reservoir will be a large and shifting body of water, it does not appear to have an effect on community use of the area since infrastructure in the area is completely absent. Assessing impacts to Primary Downstream Waters in terms of potential erosion seems to impact individual parcel owners more than it will impact communities. No major public facilities were identified to be at risk, and two of the most heavily used access points were found to be in locations without significant risk. The owners of the 104 private parcels that included areas classified as "highly erodible" or "potentially highly erodible" near the river's edge may see some impacts to their properties, but these risks may be unlikely to be felt in the wider community. As the permitting process and environmental assessments continue, agencies may be wise to consider impacts to transportation routes that cross or follow the Primary Downstream Waters, specifically the Alaska Railroad.

Identifying and categorizing anadromous waters in the study area raised some interesting questions. Specifically, the existing natural shifts in the rivers and streams suggest that impacts to salmon may be more nuanced than the scope of this study can discuss. Two examples of the mapped extent of the Primary Downstream Waters, between river miles 131-133 and between river miles 91.5-93, are shown in Figure 13. The variation in these two examples shows how much the nature of the river changes downstream of the proposed dam site. At river miles 131-133, the widest extent is approx. 2,800 ft; at river mile 92, the widest extent is approx. 9,700 ft.

Figure 13: Examples of Primary Downstream Waters Extent (scale 1:40,000)

Beyond the recognized impacts to human use areas, the impact to aquatic populations is still unknown, as are the direct or indirect effects of any of those impacts on local communities. Imagery suggests that channels that may "dry up" (note several sandbars and small channels near river mile 92) may not be likely to affect salmon habitat if the river already is constantly changing. If salmon prefer to rest and spawn in shallower channels, those areas will continue to shift from year to year as they appear to have done in the past, based on the main channel polylines from ADF&G, DNR, and MSB created from data gathered at different points in time.

Greater areas of concern would be an across-the-board change in water level, increased erosion, or lack of nutrient deposition.

Areas for Further Research

This research has identified areas that appear to be at the highest risk of potential impact from the hydroelectric project, but the next step in the research should be an in-depth assessment of the level of changes that would occur post-construction. How significantly will the surface water levels on the river change, and to what degree would those levels differ from those historically experienced in the area? How much less sediment will be present in the flow of Primary Downstream Waters due to the presence of the dam, and how will that change the erosive qualities of the water? Will the decrease in sedimentation and associated nutrients be significant enough to impact salmon habitat?

To further understand the implications of changes in nutrient deposition, it may be helpful to define how the biotic environment is constructed by the Susitna River and its tributaries in congress. Nutrient levels could be measured at the mouth of each significant drainage that feeds into the Susitna River (see Table 1), and at various locations along the Susitna itself, including locations above the highest major tributary. Comparing these values could suggest whether a higher proportion of valuable nutrients and sediments are sourced from the Susitna's headwaters or whether other tributaries are just as important to the overall health of the river once it exits the Talkeetna Mountains. In conjunction with that, identifying the criticality of salmon populations that spawn on the upper Susitna River, upstream of the Chulitna River (the northernmost major tributary), may suggest the impacts of potentially jeopardizing habitat in the upper areas of the Primary Downstream Waters. Increasing the level of detail for the soil data upstream of river mile 125 would also help to inform further studies in geomorphology.

Summary

Scientific literature shows that the impacts of constructing a dam can have widespread and significant impacts on the ecology of the area it serves. The use of hydroelectric power has been called "geomorphologically unacceptable ... [and] socially unavoidable" (Sternberg 2006). However, the ability to predict and prepare in advance for the environmental shifts that would befall the Susitna Valley may increase the chance that governing agencies will act to protect the resources that Alaska residents value and demand accountability from power companies. The Susitna-Watana Hydroelectric Project is currently in a phase where effects have a chance to be mitigated before construction begins. A community can adopt a realistic and fact-based approach to mitigation when its members ask the right questions, and when further data is sought to augment what is currently known. Understanding the potential extent of geomorphological and biological impacts as they relate to human activity helps to provide a personal context for residents who may wonder "What does this mean for me?" Ideally, the community's greatest moment of responsibility for these impacts is now -- when there is a chance to reduce them before they happen at all.

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