Susitna-Watana Hydroelectric Project Document
ARLIS Uniform Cover Page

Title: W-S1, wildlife habitat use and movement study : draft	**SuWa 104**
Author(s) – Personal:	
Author(s) – Corporate: [Alaska Energy Authority]	
AEA-identified category, if specified: 2012 Environmental Study Plans	
AEA-identified series, if specified:	

Series (ARLIS-assigned report number): Susitna-Watana Hydroelectric Project document number 104	**Existing numbers on document:**
Published by: [Anchorage, Alaska : Alaska Energy Authority, 2012]	**Date published:** February 1, 2012
Published for:	**Date or date range of report:**
Volume and/or Part numbers:	**Final or Draft status, as indicated:** Draft
Document type:	**Pagination:** 13 p.
Related work(s):	**Pages added/changed by ARLIS:**
Notes:	

All reports in the Susitna-Watana Hydroelectric Project Document series include an ARLIS-produced cover page and an ARLIS-assigned number for uniformity and citability. All reports are posted online at http://www.arlis.org/resources/susitna-watana/

ARLIS
Alaska Resources Library & Information Services

SUSITNA-WATANA HYDRO

W-S1: WILDLIFE HABITAT USE AND MOVEMENT STUDY - DRAFT

INTRODUCTION

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project) using the Integrated Licensing Process (ILP). The Project is located on the Susitna River, an approximately 300 mile long river in the Southcentral region of Alaska. The Project's dam site will be located at River Mile (RM) 184. The results of this study and of other proposed studies will provide information needed to support the FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Construction and operation of the Project as described in the Pre-application Document (PAD, AEA 2011) will result in wildlife habitat loss and alteration, blockage of movements of mammals, disturbance, and changes in human activity due to construction and operation of the Project from the proposed dam site, and along access and transmission line routes. The Project may result in loss and displacement from seasonally used sensitive habitats in the middle and upper Susitna River basin such as moose and caribou calving areas; bear foraging and den habitats; Dall's sheep lambing areas and mineral licks; and wolf den or rendezvous sites. This study plan outlines the objectives and methods for characterizing and further defining critical data gaps based on existing Project area wildlife abundance, distribution, movements and sensitive habitat data in order to evaluate potential Project-related effects and inform subsequent studies developed under the ILP. This study is initiation of a multi-year effort, which will include data synthesis beginning in 2012.

STUDY OBJECTIVES

The overall study objectives are to identify all data available from the Alaska Department of Fish and Game (ADF&G), synthesize this information for abundance, distribution, movements, and habitat use for moose, caribou, bears, Dall's sheep, and wolves; and evaluate the adequacy of this information for assessing potential Project-related effects on these big game resources in the upper and middle Susitna River basins. This synthesis will further define identified data gaps and develop 2013-2014 study plans. A data sharing agreement will be developed between the ADF&G and AEA, and ADF&G survey and telemetry data will be obtained through coordination with AEA. In addition, ADF&G will be conducting Project-specific moose and caribou telemetry studies beginning in 2012.

This study is broken into tasks by resource with specific objectives, study areas, methods, and analysis for moose, caribou, bears, Dall's sheep, and wolves. Information on the current use of critical moose and caribou calving areas, rutting areas, wintering areas, and migration or movement corridors; bear foraging and den habitats; Dall's sheep lambing areas and mineral licks; and wolf den and rendezvous sites will be compiled from various sources and evaluated to determine the need for additional aerial surveys, ground-based monitoring, and/or the potential establishment of remote surveillance. This information will be used to develop 2013-2014 study plans.

TASK 1 – MOOSE

Objectives

The study objectives for moose are to obtain and synthesize information on the current use of calving areas, rutting areas, wintering areas, and migration/movement corridors and to evaluate the available data to determine the need for additional aerial surveys during critical periods. Specific data gaps (ABR 2011) addressed for moose include development of a current estimate of population size and density for the Project area based on available information, and development of current range maps for seasonal distribution and movement using ADF&G telemetry datasets.

Study Area

The study area for moose includes all areas that will be directly altered or disturbed by Project facilities, access roads, transmission corridors, and within the inundation zone for the reservoir (Figure 1); and adjacent seasonal ranges in the upper and middle Susitna River basin. The study area will be centered on Game Management Unit (GMU) 13E and 13A. It will include downstream areas in the middle Susitna River basin that could be affected by changes in stream flows, temperatures, and ice conditions, which could alter riparian vegetation succession and result in changes to moose habitats. The study area will extend to at least the confluence of the Talkeetna and Chulitna Rivers at the border of GMU 13E with GMU 14B and 16A, but may also include the lower Susitna River basin.

Existing Information

Moose were considered a key species for study during the Alaska Power Authority (APA) Susitna Hydroelectric Project (SHP) in the 1980s primarily because of the potential for loss of winter range in the impoundment zone (ABR 2011). Studies were divided into upstream and downstream (above and below Devil's Canyon) components and included VHF telemetry from 1976 through 1986, upstream population censuses in 1980 and 1983, and downstream aerial censuses during winter from 1981 to 1986. Current moose population estimates for the Project area are not available; however, trend counts have been increasing for specific count areas in GMU 13 (Tobey and Schwanke 2008). As part of the concurrent licensing studies for this Project, ADF&G will estimate the moose population as well as movements within the Project area using telemetry.

Methods and Analysis

In 2012 ADF&G population estimates and telemetry data will be compiled, and spatial analysis of historic and current telemetry data will be conducted for moose.

The moose study will include the following study components:

- Identify and compile survey data at the GMU sub-unit level with extrapolations to the Project area level where possible.

- Complete updated spatial analyses of existing telemetry data to determine current seasonal habitat use and movements within the Project area.

Population estimates based on existing data will be calculated consistent with the method used to collect the data (Kellie and DeLong 2006, Becker et al 2004). Density estimates will be calculated at a spatial resolution suitable to evaluate potential habitat loss and alteration from the Project. Moose surveys generally use the Geospatial Population Estimate method (Kellie and DeLong 2006). Ranges presented for the SHP in the 1980s included minimum and maximum convex polygons. Telemetry data collected during the SHP studies in the 1980s, if readily available, and current ADF&G telemetry databases will be used to delineate seasonal ranges and movement corridors based on kernel density estimates (Seaman et al. 1998), random walks (Morales et al. 2004) or Brownian bridge movement model techniques (Horne et al. 2007, Sawyer et al. 2009).

TASK 2 – CARIBOU

Objectives
The study objectives for caribou are to obtain and synthesize information on the current use of calving areas, rutting areas, wintering areas, and migration/movement corridors. The available data will be evaluated to determine the need for additional aerial surveys during critical periods. Specific data gaps (ABR 2011) to be addressed for caribou include development of current and historical seasonal range maps and movements for the Nelchina and Delta caribou herds, and development of seasonal range use and movements for ADF&G's Global Positioning System (GPS)-collared female caribou.

Study Area
The study area for caribou includes all areas that will be directly altered or disturbed by Project facilities, access roads, transmission corridors, and within the inundation zone for the reservoir (Figure 1). The study area includes adjacent seasonal caribou ranges in the upper and middle Susitna River basin and will be centered on GMU 13E and 13A. Downstream areas in the middle Susitna River basin that could be affected by changes in stream flows, temperatures, and ice conditions which could alter conditions for river crossings traditionally used by caribou Will also be included. Caribou data summaries will incorporate information for both the Nelchina caribou herd in GMU 13 and 14B and the Delta caribou herd in GMU 20A and 13E.

Existing Information
The caribou study for the SHP began in 1980 and continued through 1985. The objectives of the study were to determine the population status of the Nelchina caribou herd, delineate subherds, and identify range use, movement patterns, migration routes, and migration timing (ABR 2011). Three resident subherds were identified, and the reservoir was found to intersect migration routes used by pregnant cows moving to calving grounds during late April and May and cows and calves moving to summer range during late June and July (Pitcher 1982). Current caribou use of the Project area is complicated by range expansion and mixing of Delta herd caribou with the Nelchina caribou herd (Seaton 2009). Current ADF&G management and inventory studies include collaring cow caribou with VHF telemetry equipment and locating collared cows during the calving period to determine parturition and again later in the season to

determine calf survival (Seaton 2009, Tobey and Schwanke 2009). Additional collars including both VHF and GPS/satellite technology will be deployed by ADF&G on cow and bull caribou of both the Nelchina and Delta caribou herds to provide data for the Project.

Methods and Analysis

In 2012, ADF&G population estimates and telemetry data will be compiled and spatial analysis of historic and current telemetry data for the Nelchina and Delta caribou herds will be completed. Based on a preliminary evaluation of these data the need for additional surveys will be evaluated.

The caribou study will include the following study components:

- Identify and compile survey data at the GMU sub-unit level with extrapolations to the Project area level where possible.

- Complete updated spatial analyses of existing telemetry data to determine current seasonal habitat use and movements within the Project area.

Population estimates based on existing data will be calculated consistent with the method used to collect the data. Density estimates will be calculated at a spatial resolution suitable to evaluate potential habitat loss and alteration from the Project. Ranges presented for the SHP in the 1980s included minimum and maximum convex polygons. Telemetry data collected during the SHP studies in the 1980s, if readily available, and current ADF&G telemetry databases will be used to delineate seasonal ranges and movement corridors based on kernel density estimates (Seaman et al. 1998), random walks (Morales et al. 2004) or Brownian bridge movement model techniques (Horne et al. 2007, Sawyer et al. 2009).

TASK 3 – BEARS

Objectives

The study objectives for bears are to obtain and synthesize information on the current use of bear foraging and den habitats, and to evaluate the available data to determine the need for additional aerial surveys, and/or ground-based surveys for bears foraging at salmon spawning areas. Specific data gaps (ABR 2011) that will be addressed for bears include development of current estimates of population size and density for black and brown bears in the Project area and synthesis of information on the current and historical importance of salmonid streams downstream from the Watana dam site for brown bear foraging.

Study Area

The study area includes all areas that will be directly altered or disturbed by Project facilities, access roads, transmission corridors, and the inundation zone for the reservoir (Figure 1), and adjacent seasonal bear ranges in the upper and middle Susitna basin primarily within GMU 13E and 13A. The study area will also include salmon spawning areas downstream from the Watana dam site used by bears that could be affected by changes in stream flows, temperatures, and ice conditions.

Existing Information

The SHP included upstream bear studies on population size and density, seasonal movements, dispersal, demography, den locations and predation rates on moose calves from 1980 to 1985 (ABR 2011). Brown bears used the impoundment zone primarily during June, and loss of den habitat was expected to be minimal (ABR 2011). Black bears used the impoundment zone during May to June and about 55% of den sites were within the area that would have been flooded (ABR 2011).

Methods and Analysis

In 2012 ADF&G population estimates and telemetry data will be compiled, and spatial analysis of historic and current telemetry data for bears will be conducted. Based on a preliminary evaluation of these data, the need for additional surveys will be evaluated.

The bear study will include the following study components:

- Identify and compile survey data at the GMU sub-unit level with extrapolations to the Project area level where possible.

- Complete updated spatial analyses of existing telemetry data to determine current seasonal habitat use of salmon streams downstream from the dam site and den locations within the Project area.

Population estimates based on existing data will be calculated consistent with the method used to collect the data. Density estimates will be calculated at a spatial resolution suitable to evaluate potential habitat loss and alteration from the Project. Telemetry data collected during the SHP studies in the 1980s, if readily available, and current ADF&G telemetry databases will be used to delineate seasonal ranges based on kernel density estimates (Seaman et al. 1998).

TASK 4 – DALL'S SHEEP

Objectives

The study objectives for Dall's sheep are to obtain and synthesize information on sheep lambing areas and mineral licks and to evaluate the available data to determine the need for additional aerial surveys and/or ground-based monitoring of the Jay Creek mineral lick. Specific data gaps (ABR 2011) that will be addressed for Dall's sheep include developing a current estimate of population size and density in the Project area; and assessing the current condition and use of the mineral licks on lower Jay Creek in relation to maximum elevation of the reservoir.

Study Area

The study area includes all areas that will be directly altered or disturbed by Project facilities, access roads, transmission corridors, and the inundation zone for the reservoir (Figure 1), and adjacent seasonal Dall's sheep ranges in the upper and middle Susitna basin primarily within GMU 13E and 13A.

Existing Information

Dall's sheep likely spend most of their time at elevations above the potential reservoir inundation zone in the Project area, including mineral lick sites in the Jay Creek drainage. Sheep used the Jay Creek mineral licks primarily between mid-May to mid-June in the 1980s (Tankersley 1984). Potential loss of mineral lick sites due to leaching and erosion, blockage of sheep movements by the impoundment, and aerial and ground-based disturbance were identified as further study needs during the SHP in the 1980s; and monitoring during and after construction was recommended (ABR 2011). The normal maximum reservoir surface elevation of the currently proposed Project is lower than that of the 1980s SHP; therefore there should be less potential for the Project to impact the Jay Creek mineral licks.

Methods and Analysis

In 2012 ADF&G population estimates and telemetry data will be compiled, and spatial analysis of historic and current telemetry and survey data for Dall's sheep will be conducted. Based on a preliminary evaluation of these data, the need for additional surveys or monitoring will be evaluated.

The Dall's sheep study will include the following study components:

- Identify and compile survey data at the GMU sub-unit level with extrapolations to the Project area level where possible.

- Complete updated spatial analyses of existing telemetry data to determine current habitat use and movements within the Project area, current use of Jay Creek mineral licks, and potential identification of additional mineral lick sites.

- If warranted, design and complete preliminary ground-based surveys to evaluate the condition and current use of the Jay Creek mineral licks during mid-May to mid-June.

Population estimates based on existing data will be calculated consistent with the method used to collect the data. Density estimates will be calculated at a spatial resolution suitable to evaluate potential habitat loss and alteration from the Project. Telemetry data collected during the SHP studies in the 1980s, if readily available, and current ADF&G telemetry databases will be used to delineate seasonal ranges based on kernel density estimates (Seaman et al. 1998).

TASK 5 – WOLVES

Objectives

The study objectives for wolves are to obtain and synthesize information for den and rendezvous sites and to evaluate the available data to determine the need for additional surveys. Specific data gaps (ABR 2011) that will be addressed for wolves include the development of a current estimate of wolf population size and density in the Project area; and delineation of current and historical wolf pack territories and movements based on ADF&G telemetry datasets.

Study Area

The study area includes all areas that will be directly altered or disturbed by Project facilities, access roads, transmission corridors, and the inundation zone for the reservoir (Figure 1), and adjacent wolf pack territories in the upper and middle Susitna basin primarily within GMU 13E and 13A.

Existing Information

Wolves have been studied extensively in GMU 13 since the mid-1970s and are subject to ongoing surveys for ADF&G's intensive management program (ABR 2011). The area of the Susitna basin potentially affected by the Project straddles three different GMUs (13, 14, and16) with different management objectives (ABR 2011). The SHP wolf studies in the 1980s identified territory boundaries, pack size, location and use of den and rendezvous sites, and feeding habitats for 12 known or suspected wolf packs based on telemetry data (Ballard et al. 1983). Sensitive locations for wolf packs such as current den and rendezvous sites should be located and avoided where possible; previous studies and ADF&G data have indicated that the Big Bend in the Susitna River just above Jay Creek is an important location for wolves.

Methods and Analysis

In 2012, ADF&G population estimates and telemetry data will be compiled, and spatial analysis of historic and current telemetry data for wolves will be conducted. Based on a preliminary evaluation of these data the need for additional surveys and monitoring work will be evaluated.

The wolf study will include the following study components:

- Identify and compile survey data at the GMU sub-unit level with extrapolations to the Project area level where possible.

- Evaluate ADF&G wolf telemetry datasets to identify locations of dens, rendezvous sites, hunting areas, and other essential areas for each pack.

Population estimates based on existing data will be calculated consistent with the method used to collect the data. Density estimates will be calculated at a spatial resolution suitable to evaluate potential habitat loss and alteration from the Project. Wolf population data will likely use probability sampling of animal tracks in the snow during aerial surveys (Becker et al. 2004). Seasonal and home ranges presented in the Susitna Hydroelectric Project in the 1980s included minimum and maximum convex polygons. Telemetry data collected during the Susitna Hydroelectric Project studies in the 1980s, if readily available, and current ADF&G telemetry databases will be used to delineate seasonal ranges and movement corridors based on kernel density estimates (Seaman et al. 1998) or other applicable methods.

NEXUS BETWEEN PROJECT AND RESOURCE TO BE STUDIED AND HOW THE RESULTS WILL BE USED

The Project will result in wildlife habitat loss and alteration, blockage of movements of mammals, disturbance, and changes in human activity due to construction and operation of the Project. The Project may result in habitat loss, reduced access, or displacement caused by increased human activity from seasonally used sensitive habitats in the middle and upper

Susitna River basin such as moose and caribou calving and wintering areas; bear foraging and den habitats; Dall's sheep lambing areas and mineral licks; and wolf den or rendezvous sites.

This study addresses the following issues identified in the PAD (AEA 2011):

- W1: Potential loss and alteration of wildlife habitats, including key habitat features such as den sites and mineral licks, from Project construction and operation.

- W2: Potential physical and behavioral blockage and alteration of movements due to reservoir water and ice conditions; access and transmission corridors; and new patterns of human activities.

- W3: Potential changes in wildlife mortality rates due to Project-related fluctuating water and ice conditions in the reservoir and downstream river reaches.

- W4: Potential impact of changes in predator and prey abundance and distribution related to increased human activities and habitat changes resulting from Project development.

- W5: Potential impacts to wildlife from changes in hunting, vehicular use, noise, and other disturbance due to increased human presence resulting from Project development.

Documentation of currently used areas, along with timing, duration, and proportion of the regional population that uses the habitat, could be used to develop seasonal or access restrictions to protect sensitive habitats. The information developed by the 2012 work will be used to refine 2013-2014 studies and to inform development of appropriate avoidance, minimization, and mitigation measures in support of ADF&G management objectives for moose, caribou, Dall's sheep, and wolf populations in GMU 13. This information will also be useful to prevent inadvertent disturbance from unrelated field studies for the Project.

PRODUCTS

Study products will include a summary of the information and findings in a Technical Memo for the 5 study tasks (Task 1 – Moose, Task 2 – Caribou, Task 3 – Bears, Task 4 – Dall's Sheep, and Task 5 – Wolves) that will be presented to resource agency personnel and other licensing participants, and will include spatial data products in GIS format and Quality Controlled databases developed as work products for all studies.

Data reporting will include:

- Current population estimates with confidence intervals for big game mammals using the Project area.

- Updated spatial and temporal distribution maps for big game mammals with emphasis on delineation and temporal use of sensitive habitats.

- Updated spatial analyses to identify movement corridors.

Study products to be delivered in 2012 for the 5 study tasks will include:

Development of final study plans. The 2012 component of the study will be finalized through consultation with AEA, the resource agencies and other licensing participants. The AEA-selected environmental contractor will participate in the Work Group meetings as the technical lead for this study and will assist AEA, the Program Lead, and the licensing participants develop the final study plans.

Summary of the adequacy of population and telemetry data. Current population survey and telemetry data collected for regional management of wildlife populations may not cover the portion of the Project area that would experience direct habitat impacts (inundation zone, facilities, access road, transmission corridors), and the existing telemetry data may not include all sensitive times of year or sufficient number of animals to evaluate use of the Project area. The AEA selected environmental consultant will need to identify the data gaps such that additional study components can be recommended for incorporation in the 2013-2014 study plan.

2013-2014 Big Game Study Plan(s). The 2013-2014 study plans will be developed through consultation during the Terrestrial Resources Work Group meetings through the formal FERC ILP study plan process. The AEA selected environmental consultant will participate in the Work Group, as appropriate, and assist AEA, the Program Lead, and licensing participants develop the study plan outline, draft and final Proposed Study Plans and draft and final Revised Study Plans.

Draft Technical Memoranda. A draft memoranda, summarizing interim results along with spatial data products including the wildlife database and range maps will be prepared and presented to AEA and the licensing participants to provide the status of the study, identify any issues that have occurred and allow for further refinement of the 2013-2014 component of the study.

Geospatially-referenced wildlife data. Population estimates, seasonal range use, movement summaries, and identification of sensitive habitats will be based on existing data supplied by ADF&G. A data sharing agreement will be developed between ADF&G and AEA, and data will be obtained through coordination with AEA. Geospatially-referenced relational databases of historic wildlife survey and telemetry data used in the analysis, including all important attribute data such as species, individual animal identification, sex, age, date, time, condition, location will be prepared. All data must be associated with location information specifying the projection and datum. Naming conventions of files and data fields, spatial resolution, and metadata descriptions must meet the ADNR standards established for the Susitna-Watana Hydroelectric Project.

Seasonal range maps in ArcGIS software. Range maps for sensitive habitats will be developed from wildlife data and will be delivered according to the schedule indicated below. Naming conventions of files and data fields and metadata must meet the ADNR standards established for the Susitna-Watana Hydroelectric Project. All map and spatial data products will be delivered in the two-dimensional Alaska Albers Conical Equal Area projection, and North American Datum of 1983 (NAD 83) horizontal datum consistent with ADNR standards.

Final 2012 Technical Memorandum. A technical memorandum summarizing all of the 2012 results will be presented to resource agency personnel and other licensing participants, along with spatial data products.

SCHEDULE

The following schedule is for the early 2012 scope of work for the 5 study tasks (Task 1 – Moose, Task 2 – Caribou, Task 3 – Bears, Task 4 – Dall's Sheep, and Task 5 – Wolves). The schedule for the 2013-2014 components will be developed with the AEA-selected environmental consultant during the final 2013-2014 study planning process. It is anticipated that further in depth evaluation of the currently available data will result in recommendations for additional population estimate surveys and telemetry deployments that will occur through the formal study process. This study will inform the development of formal study plans and will explore the applicability of survey methods, telemetry platforms, deployment sample sizes, and sample intensity (GPS reporting periods). The Technical Memo will inform the formal study planning process.

The schedule for the 2012 study tasks is as follows:

- Final 2012 Study Plan – March 20, 2012.

- Final Draft 2013-2014 Study Plan Outline – March 20, 2012.

- Complete inquiries into existing information for data gaps – April 13, 2012

- Draft 2013-2014 Proposed Study Plan – April 27, 2012.

- Final 2013-2014 Proposed Study Plan – May 21, 2012.

- Preliminary Dall's sheep Jay Creek mineral lick condition and use survey, if warranted – mid-May to mid-June, 2012.

- Draft Technical Memorandum – June 29, 2012

  - Draft relational database and metadata – June 29, 2012.

  - Draft ArcGIS spatial products – June 29, 2012.

- Draft 2013-2014 Revised Study Plan – August 15, 2012

- Final 2013-2014 Revised Study Plan – September 24, 2012.

- Final Technical Memorandum – November 9, 2012

  - QC'd relational database and metadata – November 9, 2012.

  - QC'd ArcGIS spatial products – November 9, 2012.

REFERENCES

ABR (ABR, Inc.). 2011. Wildlife Data-Gap Analysis for the Proposed Susitna-Watana Hydroelectric Project. Draft Report, August 16, 2011. Prepared for The Alaska Energy Authority by ABR, Inc.–Environmental Research and Services, Fairbanks, Alaska. 114 pp.

AEA (Alaska Energy Authority). 2011. Pre-Application Document: Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2011. Prepared for the Federal Energy Regulatory Commission by the Alaska Energy Authority, Anchorage, Alaska.

Arthur, S.M., and L.R. Prugh. 2010. Predator-mediated indirect effects of snowshoe hares on Dall's sheep in Alaska. Journal of Wildlife Management 74(8):1709-1721.

Ballard, W.B., J.S. Whitman, L.D. Aumiller, P. Hessing. 1983. Susitna Hydroelectric Project, Phase II progress report, big game studies, Volume V–Wolf. Prepared for the Alaska Power authority by the Alaska Department of Fish and Game, Anchorage, Alaska. 41 pp. [APA Doc. No. 413].

Becker, E.F., H.N. Golden, and C.L. Gardner. 2004. Using probability sampling of animal tracks in snow to estimate population size. Pages 248-270 in W.L. Thompson (ed). Sampling rare or elusive species: concepts, designs, and techniques for estimating population parameters. Island Press, Washington D.C.

Horne J.S., E.O. Garton, S.M. Drone, and J.S. Lewis. 2007. Analyzing animal movements using Brownian bridges. Ecology 88:2354-2363.

Kellie, K.A., and R.A. DeLong. 2006. Geospatial survey operations manual. Alaska Department of Fish and Game. Fairbanks, Alaska. 55 pp.

Morales, J.M., D.T. Haydon, J. Frair, K.E. Holsinger, and J.M. Fryxell. 2004. Extracting more out of relocation data: building movement models as mixtures of random walks. Ecology 85:2436-2445.

Pitcher, K.W. 1982. Susitna Hydroelectric Project, Phase I final report, big game studies, Volume IV – Caribou. Report prepared for Alaska Power Authority by the Alaska Department of Fish and Game, Anchorage, Alaska. 101 pp. [APA Doc. No. 410]

Sawyer, H., M.J. Kauffman, R.M. Nielson, and J.S. Horne. 2009. Identifying and prioritizing ungulate migration routes for landscape-level conservation. Ecological applications 19(8):2016-2025.

Seaman, D.E., B. Griffith, and R.A. Powell. 1998. KERNELHR: a program for estimating animal home ranges. Wildlife Society Bulletin 26:95-100.

Seaton, C.T. 2009. Unit 20A caribou management report. Pages 122-135 in P. Harper, editor. Caribou management report of survey and inventory activities 1 July 2006 – 30 June 2008. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska.

Tobey, R., and R. Schwanke. 2008. Unit 13 moose management report. Pages 151-164 in P. Harper, editor. Moose management report of survey and inventory activities, 1 July 2005– 30 June 2007. Alaska Department of Fish and Game, Juneau, Alaska.

Tobey, B. and Schwanke, R. 2009. Units 13 and 14B caribou management report. Pages 83-98 in P. Harper, editor. Caribou management report of survey and inventory activities 1 July 2006 – 30 June 2008. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska.

Tankersley, N. 1984. Susitna Hydroelectric Project, final report, big game studies, Volume VIII–Dall sheep. Report prepared for the Alaska Power Authority by Alaska Department of Fish and Game, Anchorage, AK. 91 pp. [APA Doc. No. 1704].

SUSITNA-WATANA
HYDROELECTRIC PROJECT
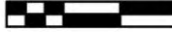
Date: Jan 2012

Figure 1.
Alaska Department of Fish and
Game (ADF&G) - Management
Unit Boundaries and the
Susitna-Watana Hydroelectric
Project Area
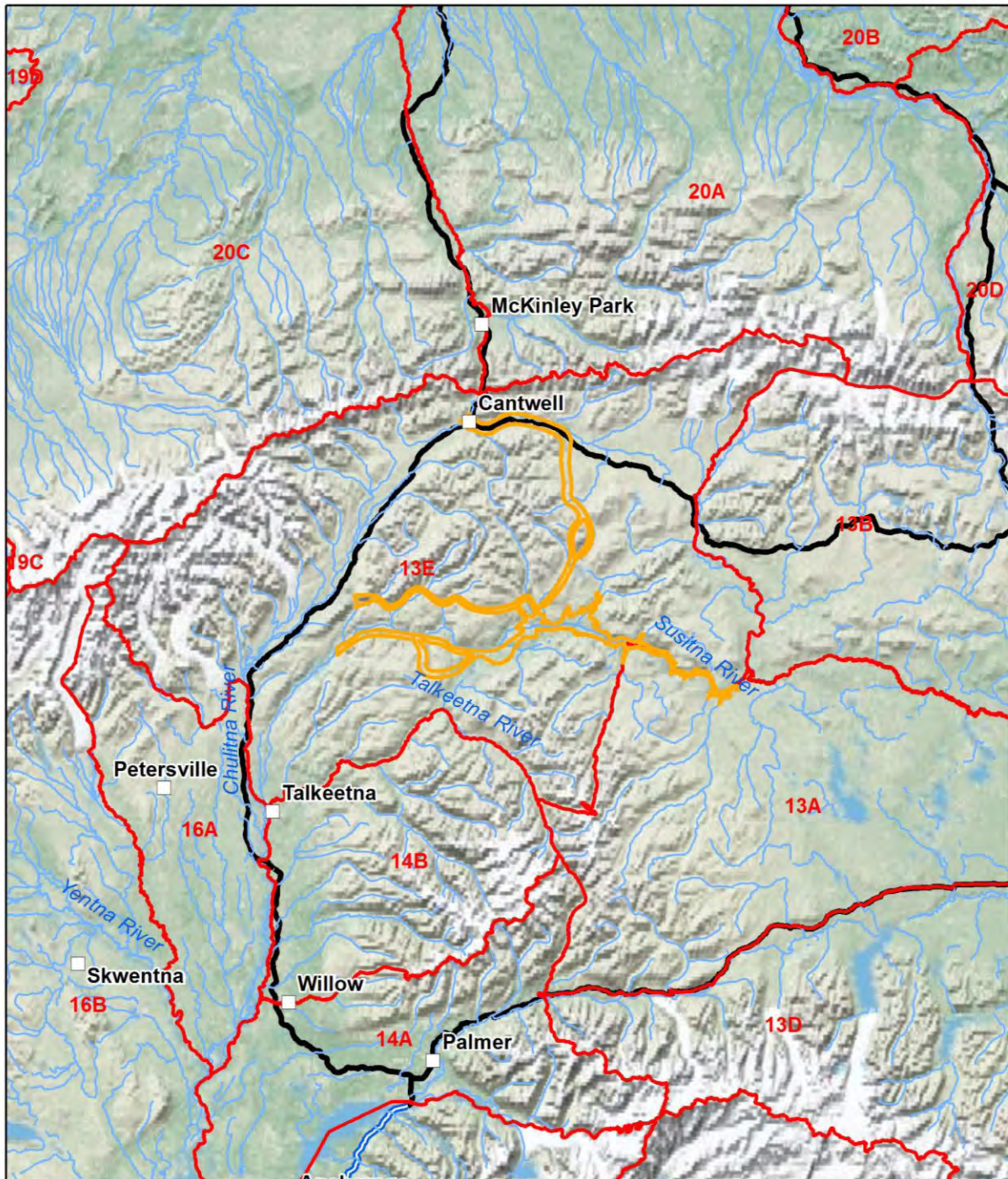
Legend

FERC Study Area

ADF&G GMU Boundaries

Scale Approximate
10 5 0   10   20
Miles

N