FINAL
AQUATIC RESOURCES STUDY PLAN

CASCADE CREEK HYDROELECTRIC PROJECT
FERC No. 12495-002

October 1, 2010

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1. INTRODUCTION

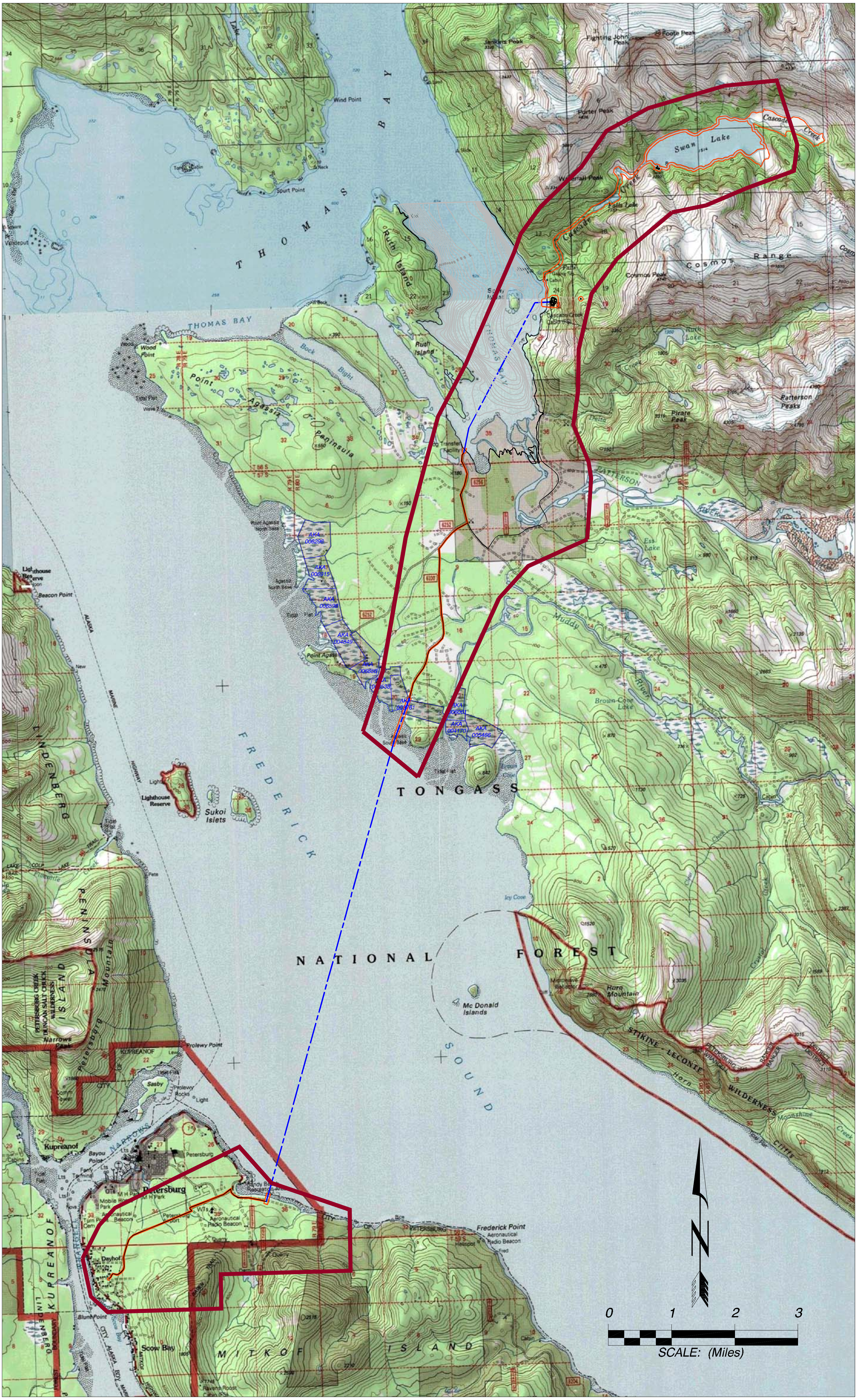
The Cascade Creek Hydroelectric Project is being developed by Cascade Creek, LLC (CCLLC) under the Federal Energy Regulatory Commission (FERC) permit No. 12495-002. The location, Swan Lake and Cascade Creek Drainage, are located approximately 15 miles northeast of Petersburg, Alaska (Figure 1).

The project consists of a lake siphon at Swan Lake, elevation approximately 1514', with a gatehouse and valve entry to an approximately three mile long 11' diameter tunnel complex of horizontal and vertical shafts. The power tunnel leads to a powerhouse at tidewater on Thomas Bay. Transmission would be a combination of overland and undersea cable to a point of connection at Petersburg, Alaska, approximately 15 miles to the southwest.

CCLLC distributed the Draft Aquatic Resources Study Plan for agency and stakeholder review in January 2010 (CCLLC January 2010). Alaska Department of Fish and Game (ADF&G) provided comments on the Draft Aquatic Resources Study Plan on March 5th, 2010. On August 12th, 2010, CCLLC hosted a meeting with agency staff to review and comment on the Draft Aquatic Study Plan. This final revision of the Aquatic Resources Study Plan incorporates agency comments on the previous versions as well as additional input from agency staff received through email, teleconferences and subsequent letters. The Aquatic Resources Study Plan is a comprehensive investigation of freshwater fishery and aquatic resources in the Cascade drainage. The Plan consists of six field investigations launched in August 2010 (Table 1.1). The study objectives and methods associated with each field investigation are described in section 2 of this Plan.

1.1. Overall Objectives

This study plan is designed to provide pre-development baseline data, which could be used to examine potential effects of hydro development associated with run-of-the-river operation approach of the proposed Cascade Creek Hydroelectric Project. Objectives of the proposed studies are to provide information suitable to: 1) Establish baseline aquatic resources data in areas potentially-affected by the Project; and; 2) Evaluate the effects of Project construction and operation in those areas.


THOMAS BAY
THOMAS BAY
Swan Lake
Cascade Creek
Cosmos Range
Ruth Island
Point Agassiz Peninsula
Patterson
Muddy River
FREDERICK
TONGASS
NATIONAL
FOREST
SOUND
Mc Donald Islands
Sukoi Islets
LINDENBERG PENINSULA
KUPREANOF ISLAND
Petersburg
Frederick Point
MITKOF ISLAND
Scow Bay
STIKINE - LECONTE WILDERNESS
0
1
2
3
SCALE: (Miles)

1.2. Study Scope

The study plan encompasses the fishery resources in the Cascade Creek drainage as well as water quality and aquatic invertebrates in these water bodies.

1.3. Study Area

The Aquatic Resources Study Plan focuses on Cascade Creek from the intertidal zone at Thomas Bay to the 1.5 mile portion of Upper Cascade Creek upstream of Swan Lake (Figure 2). The section from the intertidal zone to the outlet of Falls Lake is referred to as Reach 1. The section from Falls Lake inlet to the outlet of Swan Lake is referred to as Reach 2. The section of Cascade Creek from Swan Lake inlet to the upstream barrier falls is referred to as Reach 3. Falls Lake, the Pond and Swan Lake are labeled as distinct water bodies from the stream reaches.

1.4. Individual Study Components

In the following sections, we define specific studies to be done in the various study areas. These study proposals generally reflect study requests made by respective resource agencies with oversight on aquatic resources. Agency comments on previous versions of the draft study plans are incorporated here. The Alaska Department of Fish and Game provided written comments on SD1 and subsequent comments submitted on March 5th, 2010 on the initial Draft Aquatic Resources Study Plan. CCLLC distributed Version 2 of the Draft Aquatic Resources Study Plan for review in July 2010. On Agust 12th, 2010, CCLLC hosted a meeting to review Version 2 of the Draft Aquatic Resources Study Plan. Agency staff provided comments during that meeting as well as written and verbal comments. The 2010 study components will include:

1. Stock Assessment and Seasonal Fisheries Inventory;
2. Fish Habitat Survey;
3. Geomorphic Study of Swan Lake Inlet;
4. Bathymetry Study;
5. Limnology Study of Swan Lake at the Penstock Intake; and
6. Aquatic Macroinvertebrate Study on Falls Lake and Lower Cascade Creek.

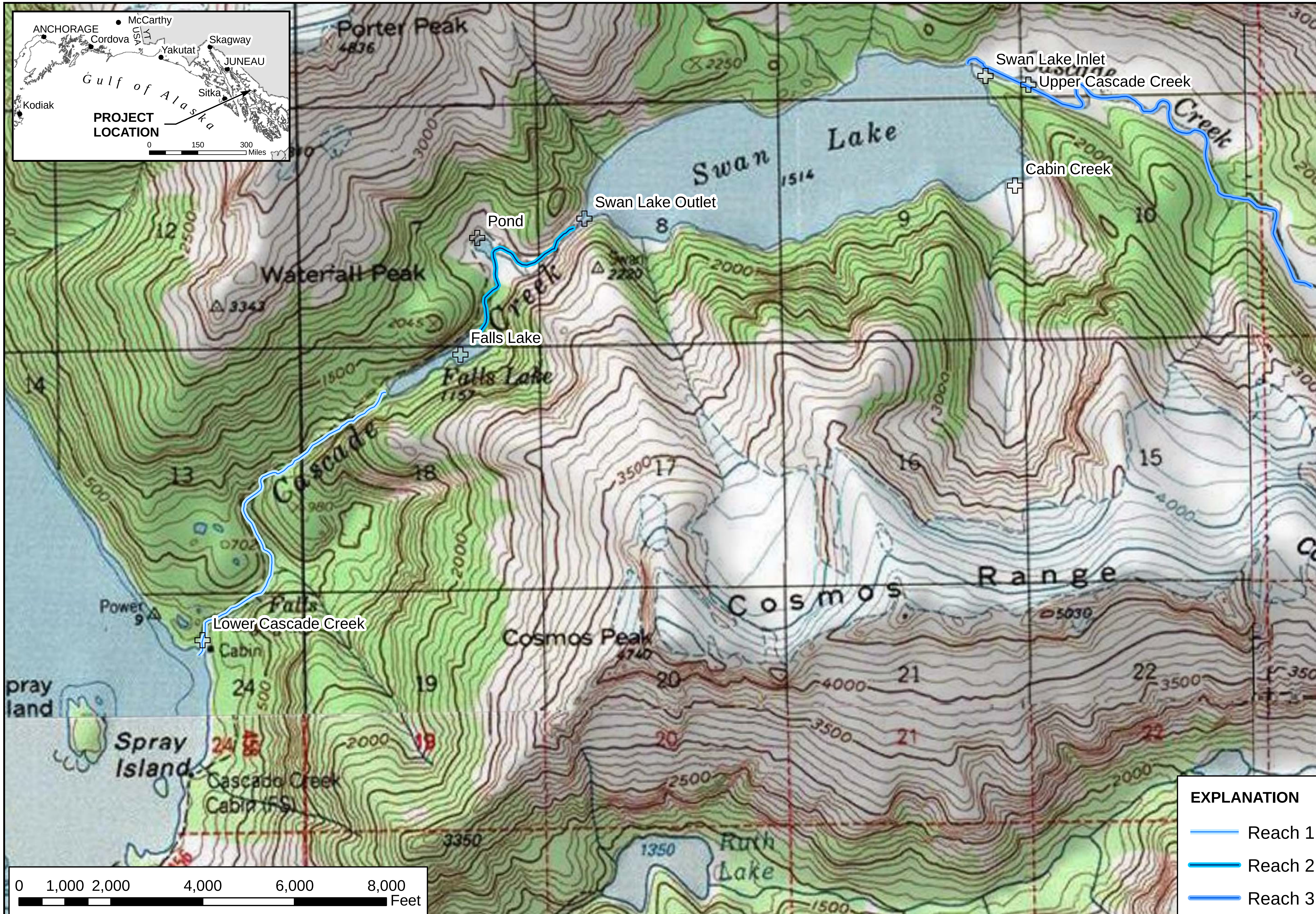


FIGURE 2

SITE LOCATION LAYOUT STREAM STATIONING

TIDEWATER TO SWAN LAKE
CASCADE CREEK DRAINAGE
18 NW of Petersburg, Alaska

DATE: 09/03/2010
CHKD: FIELD
DRWN: A.C.M.
PROJ. No.: 637-003

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Table 1-1: Proposed schedule for Aquatic Resource Study Components.

Study	Study Area	Study Year	Study period
Stock Assessment &Seasonal Fisheries Inventory	Falls Lk	2010	August/September/ November
	Lower Cascade dr	2010	August/September/ November
Habitat Survey	Upper Cascade dr	2010	August
Geomorphic Investigation In Area Of Swan Lake Major Inlet	Swan Lk	2010	August
Bathymetric Mapping	Falls Lk	2010	August
	Swan Lake Inlet	2010	August
	Tidewater	2010	August
Limnology Study of Swan Lake @ Penstock Intake	Swan Lk (at siphon depths)	2010	August / September
Aquatic Invertebrate Inventory	Falls Lk	2010	August
	Lower Cascade dr	2010	August

1.5. Rainbow Trout Fishery Background

Swan Lake was originally stocked with rainbow trout (*Oncorhynchus mykiss*) in 1957 and 1958 by the Alaska Department of Fish and Game (ADF&G). Rainbow trout are a popular species of trout targeted by anglers nationwide. Trout occur naturally in cold water stream habitats but because of their adaptability in diet and habitat use and general hardiness the stocking of this species into lakes and reservoirs is widespread throughout North America and the world where their presence supports major sport fisheries.

Rainbow trout were stocked 50 years ago and have thrived and spread into the adjacent water bodies including Cascade Creek (which both feeds and drains Swan Lake) and Falls Lake (downstream of Swan Lake). Current population and distribution information for this isolated and self-sustaining population of trout is unknown but their occurrence has been described as abundant in Swan Lake although unverified. Rainbow trout populations in Lower Cascade Creek, Falls Lake and the Pond are uncertain.

1.6. Rainbow Trout Life History Background

Rainbow trout mature between the age of 3 and 7 years and are capable of reproducing annually for many seasons. This reproductive pattern is called iteroparity (Quinn 2005) and is markedly different from salmon which spawn once then die (semelpartiy). Rainbow trout spawn in the spring and early summer beginning in May and ending in

July. Fry emerge in late spring or early summer (Quinn 2005) depending on water temperature with warmer water accelerating embryonic development. As with other salmons the female constructs a nest or “redd” by excavating gravel with their caudal fin. Eggs are laid in the resulting depression and subsequently fertilized by a male rainbow trout. This spawning strategy renders the availability of relatively loose and suitably sized gravel substrate paramount in importance for reproductive success. Rainbow trout, as well as other salmon, are also sensitive to temperature, flow and dissolved oxygen variations that are present in areas of connectivity between surface water and groundwater. These water exchange processes are collectively known as “upwelling” and occasionally “downwelling” when the direction of water movement is reversed. Zones of stream or lake bottom habitats where vertical gradients occur are preferentially selected for spawning by trout and other salmonids. The above observations of rainbow trout are general to the population and not specific to the trout at Cascade Creek or Swan Lake project area. The rainbow trout found in Cascade Creek and Swan Lake could have irregularities not mentioned here, which will be documented during the study and summarized in the final report.

2. FISHERY STOCK ASSESSMENT AND SEASONAL FISHERIES INVENTORY

In general terms and defined specifically for the Cascade Creek Hydroelectric Project a "stock" is a group of fishes, frequently a population (all individuals of the same species within a defined geographic location at a given time), believed to constitute a unique genetic resource in a fishery.

Rainbow trout inhabiting the Swan Lake-Cascade Creek-Falls lake- system represent a fragmented stock separated by physical barriers (cascades) that eliminate the possibility of upstream emigration from Falls Lake to Swan Lake. Seasonal migration occurs from Swan Lake upstream to known and unknown stream spawning areas in Upper Cascade Creek and other Swan Lake inflow tributaries. Conversely, nothing is known on migration, reproduction, and connection of rainbow trout inhabiting the Lower Cascade Creek drainage to the trout population in Swan Lake and its tributaries. Rainbow trout can emigrate downstream from Swan Lake into lower Cascade Creek including Falls Lake and the unnamed pond. The timing and frequency of these emigrations are not known. Upstream movement in Lower Cascade Creek is limited by an impassable falls directly upstream of Falls Lake. Additional upstream fish migration barriers may exist between the unnamed pond and Swan Lake. Upstream barriers are suspected in Lower Cascade Creek downstream of Falls Lake but not confirmed.

Rainbow trout of the Swan Lake-Cascade Creek system descended from trout stocked over a half a century ago, are likely a genetically distinct, isolated, and self sustaining stock. Some individuals sampled in past years have appeared visually distinct and identifiable from other trout in the region by their unique pink-red background coloration (pers. comm. D.Fleming). This fishery resource is believed to be a "monoculture" and the sole fish species inhabiting this Lake-stream system. The present study plan provides an opportunity to verify this assumption. But there remains the possibility that other fishes are present (i.e. sculpin, Dolly Varden etc.) either through human introduction or natural immigration.

Due to the fact that the rainbow trout stock in the system appear fragmented by the one or more upstream physical barriers, for the purposes of this study each discrete portion of the watershed will be considered individually. This project will assess the rainbow trout stock for Falls Lake and the unnamed pond upstream of Falls Lake only and a seasonal fishery inventory for Lower Cascade Creek only.

Other terms to be defined that are pertinent to the ongoing investigation are stock structure and stock assessment. Stock structure is the proportional distribution of sizes, ages, or genders in a stock resulting from processes of recruitment, growth, and mortality (Murphy and Willis 1996). Stock assessment studies the status of a fish stock as well as the possible outcomes of different management alternatives. The present study plan deviates from this “classical” definition of stock assessment because “length-based” stock assessments and management are more commonly used in Southeast Alaska largely owing to the direct application to length-based regulations. Moreover, the determination of accurate age and in many cases sex of rainbow trout and other game fish often requires confirmation using lethal sampling means. Non-lethal ageing of scales is possible but problematic (i.e. scale annuli are very small and close together in slow growing, coldwater fish) and must be verified through more destructive sampling techniques (e.g. otolith interpretation) or with known aged fish through longer-term studies. In addition, for rainbow trout, the results of the recruitment, growth and mortality portions of a stock assessment may be obfuscated by the reality of adult trout predation on juvenile trout. For the purpose of this project the planned stock assessment focuses on size (length and weight) and stock abundance (estimate of the number of individual rainbow trout in Falls Lake and estimate of the number of individual rainbow trout in pond). A mark and recapture sampling program is planned to estimate rainbow trout stock abundance. Unplanned, incidental mortalities will be opportunistically sampled to determine sex, diet, and age (scale and otolith analysis).

2.1. Study Objectives

The study is designed to evaluate and document the status of the rainbow trout stock of Falls Lake and Lower Cascade Creek during the pre-development phase of the Cascade Creek Hydroelectric Project. The specific objectives of the Rainbow Trout Stock assessment are:

1. Estimate the abundance of the rainbow trout stock of Falls Lake through mark-recapture (M-R) sampling (all sizes vulnerable to sampling gear) during summer and fall, 2010.
2. Estimate the abundance of the rainbow trout stock of the unnamed pond through mark-recapture sampling (all sizes vulnerable to sampling gear) during summer and fall, 2010.

3. Assess the size structure and of the rainbow trout stocks in Falls Lake and unnamed pond through length-frequency analysis.

4. Determine sex of captured rainbow trout, when and if possible.

5. Characterize fish presence/absence in Lower Cascade Creek on a bi-monthly (two-month intervals) basis.

2.2. Stock Assessment and Seasonal Fishery Inventory Methods

This section describes the rainbow trout stock assessment methods that will be used to estimate stock abundance, size structure, age, sex ratio and co-occurrence of other species in Falls Lake and Lower Cascade Creek.

Stock abundance of rainbow trout in Falls Lake and the unnamed pond downstream of Swan Lake will be accomplished through mark and recapture experiments conducted in 2010. In order to capture seasonal trends, two sampling events will occur in 2010 (August-September and November-December).

Fish will be captured in Falls Lake with minnow traps and hoop nets baited with Betadine-treated salmon eggs. Fish will be captured in Lower Cascade Creek with minnow traps baited with Betadine-treated salmon eggs. These capture techniques will be supplemented as necessary by hook and line sampling in Falls Lake but not in Lower Cascade Creek where steep terrain and shallow water would make angling hazardous and ineffective. Marking fish will utilize a variety of partial fin-clips to allow accounting for movements between discrete sampling areas. Captured rainbow trout in Falls Lake will be marked with an upper caudal fin clip. Rainbow trout captured in the pond will be marked with a Lower caudal fin clip.

Visual Implant Elastomer (V.I.E.) tags will be used to mark fish during subsequent collection trips to distinguish between fish previously marked with fin clips as well as add locations in Lower Cascade Creek. The elastomer is a 2-part polymer that produces a brightly colored liquid which hardens into a flexible, color-coded tag when injected subcutaneously. The V.I.E. tagging method, when properly applied, has high rates of tag retention and is less likely to affect the behavior, growth, or swimming performance of fishes than other tagging methods (Bailey et al. 1998; Olsen and Vollestad 2001). Another advantage to V.I.E. tags is that they can be used to mark very small fish. In previous studies, OASIS has successfully tagged fish as small as 4 mm in total length and there are reports of successful V.I.E. tags implanted in even smaller salmonids

(Olsen and Vollestad 2001). More information on V.I.E. tags and a reference list of case studies can be viewed on the manufacturer's website: http://www.nmt.us/index.htm

In Falls Lake minnow traps and hoop nets will be distributed across shallow and deepwater habitats. Angling will be employed where practicable and time permitting. Suitable locations for minnow trapping in Lower Cascade Creek will be limited by the predominantly cascade habitat and limited safe access. Traps will be placed opportunistically between Swan Lake and the Pond, between the Pond and Falls Lake and in accessible areas downstream of Falls Lake. Traps will also be placed between tidewater and the first barrier falls on Lower Cascade. Minnow trapping efforts in Lower Cascade Creek will focus on presence/absence and fish movement as opposed to abundance estimates.

An absolute abundance estimate of the spawning population will be made using Chapman's modifications of the Peterson estimator (Seber 1982) which among many similar formulae has a strong theoretical basis and is widely used in fisheries studies (Hayes et al. 2007):

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1$$

Where n1 = number caught and marked in the first sampling period; n2 = number caught in second sampling period; and m2 = number of marked fish in second sampling period.

This equation will yield an absolute estimate of abundance if the following assumptions can be met (Hayes et al. 2007):

1. The population is geographically closed with no immigration or emigration,
2. The population is demographically closed with no births or deaths,
3. No marks are lost or missed,
4. Marking does not change fish behavior or probability of capture,
5. Marked fish mix at random with unmarked fish, and
6. All fish have an equal probability of capture that does not change over time.

Falls Lake and pond, treated as individual water bodies, are not completely closed systems in that immigration can occur from Swan Lake (upstream) and potentially emigration into Lower Cascade Creek (downstream). However, emigration during the mark recapture study is expected to be small relative to the size of the population and this meets the criteria for assumption 1 for use of the Chapman estimator. Adult fish will be captured and marked for this study using appropriate size classes that account for potential cannibalism of smaller fish in the population balanced with the need for adequate sample size. Mortality during the mark and recapture study is expected to be small relative to the size of the population so the criteria for assumption 2 is met. Assumptions 3 and 4 for use of the Chapman estimator will be met through careful fin clipping and field crew training.

A time period approximately one month in duration between marking and recapture dates will pass to allow for the random mixing of marked and unmarked fish (meets assumption 5) and to lessen effects of the sampling gear (trap happiness since they will be baited). Standardized sampling gear deployment will ensure that all fish have an equal probability of capture throughout the duration of the mark and recapture spawning study (meets assumption 6). Knowledge and stock abundance estimates from the first year's study will help to guide mark-recapture studies in 2011.

A Seasonal Fishery Inventory of Lower Cascade Creek will take place during the previously specified dates using minnow traps. The same gear fished in a similar manner and time of year can provide a reasonable index of change in stock abundance (Murphy and Willis 1996). Catch per unit effort (CPUE) with active or passive gear (such as minnow traps) can be used as an index of population density although true density will be unknown, i.e. CPUE is proportional to stock density (Murphy and Willis 1996). If the proportionality (another unknown) is constant then changes in CPUE indicate corresponding changes in species abundance (Murphy and Willis 1996). For these reasons the Seasonal Fishery Inventory of Lower Cascade Creek will provide valid baseline abundance indices for that water body.

During fish capture activities associated with the mark and recapture studies, individual fish will be measured (to the nearest mm total length (TL)) and released immediately or shortly thereafter if anesthesia is deemed necessary for measurement of length. This will establish baseline size information for trout present in the respective study areas. Incidental mortalities will be documented and fish kept for further analysis (otolith interpretation). Spatially explicit capture and release information will be documented in field notes and by GPS waypoint.

The computer program MARK (White and Burnham, 1999; Colorado State University) will be used to analyze all rainbow trout mark-recapture data and for calculating stock abundance estimates in Falls Lake and pond. The Stock Assessment Report will include summarize results from the mark-recapture investigation. Additionally, the report will describe the assessment model, or the collection of mathematical and statistical techniques that were used to perform the stock assessment.

A draft report will be submitted prior to December, 2010 summarizing the mark-recapture effort in August, September and November. The report format will include the following: Introduction, Materials and Methods, Results and Discussion sections. Further mark and recapture sampling in 2011 will be captured in a subsequent report in November 2011. The 2010 report's primary objective will be to support environmental analysis for a FERC license application by CCLLC.

3. FISH HABITAT SURVEYS

This section describes the study objectives and field methods used to investigate fish habitat in upper Cascade Creek and the Spring Creek at the upper end of Swan Lake.

3.1. Study Objectives

The primary objective of this study is to characterize existing fish habitat and geomorphic baseline conditions in Upper Cascade Creek and the adjacent spring creek flowing into Swan Lake, in sufficient detail to provide the licensing participants a sound understanding of current conditions and to provide baseline information as a basis for continued monitoring post-development.

The specific objectives include:

1. Inventory geomorphic characteristics in both stream systems
2. Characterize existing fish habitat conditions, using USFS R10 survey methods

3.2. Fish Habitat Survey Methods

The USFS Region 10 (2001) sampling protocols for Tier II surveys will be employed, and supplemented with a longitudinal elevation profile of the streambed linked to vertical control monuments. Field staff will also note presence/absence of rearing fry. The Tier II survey was designed to provide consistent, quantitative estimates of habitat parameters necessary to evaluate the condition of a stream relative to USFS forest riparian habitat management objectives (RHMO). OASIS will employ the standard R10 classification scheme to characterize any and all distinct channel process types encountered during the survey. The Tier II surveys provide sufficient detail to characterize existing conditions, given the limited spatial extent of the project effects on these streams. The Tier III survey protocol, while more detailed than Tier II, does not yield sufficient additional information for a reasoned evaluation of project impacts and mitigation options to warrant its application. If side channels to the main Cascade Creek exist, they too will be surveyed according to the Tier II protocol.

Standard survey tools (auto level and stadia rod) will be used to take geomorphic measurements of the channel and a laser rangefinder to capture dimensions of all habitats encountered. As circumstances dictate, all measurements will be recorded on standard USFS data field forms, if desired, to facilitate entry in to the agency database.

3.2.1. **Study Area**

The survey area will include the main channel of upper Cascade Creek above its confluence with Swan Lake, and will include a survey of the main channel upstream to impassable falls (~ 1 mile in length, as conditions permit). Due to the paucity of high resolution air photos, it cannot be determined if there are additional side channels that would also need to be surveyed, so for now our assumption is that there are none. Adjustments in the survey effort can be made if this assumption is found to be incorrect. Tributary junctions from adjacent hill slopes will be noted as to location, and GPS coordinates will be recorded if GPS signal detection is attainable. Since these tributary habitats are not affected by the project, we propose no other habitat characterization in these waters. Additionally, a survey of the spring creek adjacent to upper Cascade Creek will be completed up to the bifurcation in the stream for a length equal to ~ 1100 linear meters.

No habitat surveys are proposed for lower Cascade Creek, which flows from the outlet of Swan Lake, to an extremely steep gradient dominated by cascades. A longitudinal gradient profile of lower Cascade Creek will be provided depicting the gradient. In addition, an aerial video shot from a helicopter at low elevation will be provided to the agencies for review of the habitat in lower Cascade Creek to better understand why this area is being omitted from further habitat study.

The survey will include a geomorphic description of the delta at the confluence of Cascade Creek and Swan Lake to a depth of ~ 2 meters. The results will address concerns for erosion of the delta feature if the project were to involve lowering lake levels beyond that currently experienced under normal annual fluctuations, or timing of lowering the lake level relative to runoff inflow.

3.2.2. **Survey Schedule**

Field work will be completed in early August of this year, assuming agency concurrence with study plans allowing timely deployment. If delayed, the alternate dates for completion of the field survey are in early September of 2010.

3.2.3. **Survey Analysis and Final Reporting**

Analysis will include compilation and narrative and graphic summaries of data on the standard habitat and geomorphic metrics listed below, as defined in the survey protocol. These results will be integrated with the fisheries survey study to provide a comprehensive picture of ecological conditions in the aquatic environment.

Once the field survey is completed, the data will be compiled and analyzed within 2 months of the survey, and a final report will be completed by the end of November, 2010.

3.2.4. **Outline of Survey Metrics and Protocols:**

Using the USFS Tier II Survey protocols (USFS 2001), (See discussion starting on pg. 27 of the Stream Habitat Survey methods manual), the following data will be collected:

- Length of stream surveyed
- Channel bed width
- Pool characteristics
- Record number and dimensions of qualifying pools
- Residual pool depth
- Beaver pond location and dimensions (if they exist)
- Large wood loading (number of pieces per channel width)
- # of Key Pieces of Large Wood (minimum qualifying dimensions = minimum diameter = 0.1 meters; length = 1 meter)
- Location (by unit and by Zones)
- Disturbance noted (landslides, bank erosion)
- Side channel measurements (if applicable)
- Length of all side channels.
- Streambank location (left or right bank) and distance of side channel inlet and outlet relative to an LLID or GIS segment node.
- Approximate average channel bed width of side channel.
- Minimum required residual pool depth.
- Channel bed width measured at a distance of every fifth approximate average channel bed width.
- Note whether the channel is flowing, intermittent, or dry.
- Number of qualifying macro pools.
- Number of qualifying pieces of large wood & key pieces scaled to the average channel bed width of the side channel.
- Maximum pool depth and pool tail crest depth.

- Longitudinal stream bed profile.
- Presence/absence of rearing fry.

4. SWAN LAKE INLET GEOMORPHIC STUDY

A geomorphic survey will be conducted to characterize existing conditions and physical processes for Upper Cascade Creek and the delta formed at its confluence with Swan Lake. The spatial extent of the survey on Upper Cascade Creek will include the area from the delta at Swan Lake upstream to the impassible falls, a distance of approximately 1 mile. In addition, physical characteristics of the delta will be recorded to a depth of two meters linked to a vertical control monument and integrated to the bathymetry mapping conducted in 2008 by Biosonics. An additional geomorphic survey of the Spring Creek will be conducted for a distance of approximately 2000 feet or as determined applicable to meet study objectives.

4.1. Study Objectives

The study is designed to document geomorphic conditions and note dominant physical processes within Upper Cascade Creek from the impassable falls to its confluence with Swan Lake and to describe the conditions at the delta. The specific objectives include:

1. Characterize existing channel conditions and dominant processes in Upper Cascade Creek.
2. Characterize existing channel conditions in the Spring Creek
3. Characterize existing conditions of the delta at the confluence of Upper Cascade Creek and Swan Lake.
4. Establish benchmarked longitudinal stream profiles throughout the spawning streams, that include mapped measurement of depth, velocity, and substrate.
5. Examine and characterize existing inlet stream behavior in relation to predictive modeling of stream response to atypical patterns of drawdown timing (i.e. what happens when/if the lake remains drawn down from hydro operation at the time when a major snowmelt release event occurs?)

4.2. Geomorphology Survey Metrics and Protocols:

OASIS will use standard survey equipment to conduct the survey, including an auto level and a survey rod. As needed, additional base elevations will be established with survey grade GPS if available. For the fluvial systems, the USFS Tier II Survey (USFS 2001) protocol will be used to conduct this survey. (See description starting on pg. 15 of methods manual)

Channel Morphology Measurements will include the following:

- Channel characteristics
- Channel incision, depth & entrenchment ratio (where applicable)
- Bankfull stream width and depth
- Channel gradient
- Stream channel pattern
- Channel sinuosity
- Substrate
- Sampling procedure (Wolman 1954)
- Particle size analysis (D50, D84, and cumulative size fraction)

5. BATHYMETRIC MAPPING

The bathymetric study will investigate three distinct water bodies: 1) the shoreline of Thomas Bay adjacent to the powerhouse tailrace and proposed dock, 2) Falls lake; and 3) the inlet to Swan Lake complementing the geomorphology investigation in the same area. The bathymetric study will provide a high-resolution elevation model for the respective water bodies of the subsurface topography documenting habitat characteristics and potential for changes. Lake-bottom depth readings will be recorded using an autonomous underwater vehicle (AUV) equipped with side-scanning sonar and GPS navigational systems. The resulting bathymetric dataset will be a geospatially accurate depiction of subsurface relief to be used to generate topographic contour maps as well as provide a foundation for depth modeling and analysis.

5.1. Study Objectives

The study is designed to collect lake-bottom topographic information of the near shoreline for Thomas Bay, Falls Lake and Swan Lake inlet to demonstrate habitat characteristics and potential changes from project construction and operation. Reduced pool elevations in Falls Lake and Swan Lake may lead to changes in food production, access to spawning habitat as well as juvenile habitat availability influencing foraging and predation. For Falls Lake and Swan Lake, the study is designed to capture a baseline shape, volume, littoral zone and habitat to assess the effects from future drawdown. The specific objectives include:

1. Develop a 1-ft resolution subsurface terrain model;
2. Provide a baseline to document potential changes in pelagic and littoral zone habitats;
3. Predict the available habitat area for a given pool volume;
4. Evaluate project operations relative to connectivity to spawning habitat in Upper Cascade Creek and adjacent spring creek; and
5. Evaluate potential impacts on shoreline habitats in Thomas Bay associated with project infrastructure.

5.2. Bathymetric Survey Methods

A desktop analysis of lake geometry and orientation will ensue prior to field mobilization to develop a general survey transect arrangement. The survey will be designed with the appropriate coverage to achieve a 1-ft vertical resolution elevation model. An initial survey transect plan will be loaded into the AUV system. This initial survey will be designed to provide general subsurface terrain characteristics to identify areas of concern such as shallow patches and other sources of impediments. Another pre-deployment activity will include a review of the forecasted GPS array on the horizon during planned field acquisition times to allow technicians to minimize collecting data during periods of peak dilution of precision.

Upon arriving onsite, technicians will install monumentation to establish the relative vertical position to which water depths will be recorded. These monuments will be linked to the existing staff gage at Falls Lake. This will provide a common reference point for any subsequent surveys to be used in analyzing change detection. Also, this monument can be surveyed into existing benchmarks in the future, if needed, to verify ellipsoids and transform to a datum survey based on mean sea level.

The AUV system will be deployed from the shore of the respective water bodies and set to rove along its initial planned survey route. GPS accuracy will be assessed during this time to review the capacity of the AUV's internal orientation system to operate in this area based on GPS positioning. The AUV is equipped with Doppler Velocity Log that relies on GPS precision for orientation. Several potential factors can negatively influence GPS precision at this site including the rugged surrounding terrain and northern latitudinal position on the globe. If it is determined that GPS will not suffice at this location the AUV will be set to utilize its dead reckoning capabilities for accurate navigation.

After completion of the initial survey, technicians will review the general characteristics of the subsurface layout and design a refined survey grid to avoid potential impediments and collect enough side-lap coverage to achieve the required 1-ft resolution dataset.

The AUV will output ASCII file raw data. Technicians will post-process GPS data collected during the survey and apply differential corrections based on nearby Continuously Operating Reference Station (CORS). A final review of the raw survey data will occur prior to returning from the field effort.

5.2.1. **Study Area**

The survey area will comprise the entire Falls Lake extent measuring approximately 2400' by 400' and covering 17 acres as derived by USGS 1:63,360 topographic maps. The Thomas Bay investigation will focus on a 1,000 feet section of shoreline between the outlet of Cascade Creek and the U.S.Forest Service Cabin. The Swan Lake Inlet investigation will focus on the area between the Swan Lake pool elevation gage and the rock outcrop to the south of the inlet.

5.2.2. **Survey Schedule**

Field work will be completed in mid August.

5.2.3. **Survey Analysis and Final Reporting**

Analysis will involve extracting the raw survey data into an ArcGIS shapefile of points and projecting the data to the local UTM Zone 8 projection, as well transforming to the North American Datum of 1983. The shapefile will undergo a kriging process for the creation of a 1-ft resolution digital elevation model (DEM). A 1-ft interval contour dataset will be interpreted from the DEM to provide subsurface isobath line work in support of cartographic production.

6. SWAN LAKE LIMNOLOGY INVESTIGATION

The Swan Lake limnology investigation will focus on Swan Lake physical and chemical parameters water quality parameters. Measurements will be made of the lake's water temperature, pH, dissolved oxygen, and conductivity to determine the depth and thickness of the lake's epilimnion and thermocline in mid-summer. Concerns regarding gas supersaturation the tailrace will be addressed through literature review and a summary report accompanying the limnology report.

6.1. Study Objectives

The study is designed to describe the baseline conditions of temperature, dissolved oxygen (DO), pH, and conductivity within Swan Lake near the proposed intake. The specific objective is to: Identify and describe the dissolved oxygen and temperature depth profiles and temporal variations during summer months within Swan Lake in the vicinity of the proposed intake. The description will illustrate the stratification of the lake, and the depth, the thickness, and changes in thermocline and epilimnion.

6.2. Schedule

Measurements will be taken once per month in August and September 2010.

6.3. Location and depth

Measurements will be obtained in the water column at the location where the proposed intake will be located. Measurements will be obtained from the surface to a depth of sixty-five (65) feet depth, with measurements taken every two (1) feet from water surface to a fifty (50) foot depth, and every five (5) feet from fifty-five (55) foot to a seventy (65) foot depth. The location and depth will be calculated by first (1) identifying the lake surface elevation and (2) subtracting the intake top elevation from the water surface elevation to identify the intake distance below the surface.

6.4. Measurement parameters

Measurements will be made of dissolved oxygen, temperature, pH, and conductivity.

6.5. Method

The thermocline is a distinct layer of water in a lake at a transition between the mixed, warmer water nearer the surface and colder deep water. Seasonal weather variations and local environmental conditions affect thermocline depth and thickness. Calculating the thermocline from water temperature data will be done with electronic instruments. Samples will be obtained initially at the surface then 1 feet increments below the water surface and measurements will continue at successive depths, noting when the temperature drop-off marks the top of the thermocline. The probe will be lowered until the coldest temperature stops decreasing with depth. This depth will be recorded as the bottom of the thermocline. Measurements will continue until a depth of 65 feet is reached.

OASIS will use a YSI 556 field meter for all parameters. The staff using the meter will be trained and have experience in use of the meter, and will also have knowledge of the range of readings for each parameter. The meter will be subject to a strict program of control, calibration, adjustment and maintenance. Prior to mobilization, maintenance will include a visual inspection that all parts are present, attached correctly and devoid of any obvious contamination. Routine maintenance on the YSI will be conducted according to schedules described in the manual provided by the manufacturer and recorded in the maintenance log stored in its carrying case. The meter will be correctly calibrated prior to each sample event using known and valid standards. In-situ calibration for DO will be also performed to correct for local barometric pressure. Following data collection post-calibration will be done to determine the reliability of the data and to identify if “drift” in parameter values occurred, to minimize problems with data interpretation and trend analyses. All calibration measurements will be recorded on the appropriate field forms or in field logbooks and available for review by upon request.

6.6. Evaluation of data collected

Analysis for the primary parameters of temperature and dissolved oxygen will be conducted using time-series analysis. Correlations between temperature and DO will be developed through regression analysis and confidence intervals calculated at a significance level of 0.05. Analyses for the other parameters will be primarily qualitative. The analysis will provide description of the enable lake stratification and summarize the baseline data for dissolved oxygen, temperature, pH, and specific conductance.

7. SEASONAL BENTHIC MACROINVERTEBRATE INVENTORY

Benthic macroinvertebrates (BMI) are an essential component in the ecological processes of an aquatic ecosystem, due to their position as consumers and intermediate trophic level of lotic food webs (Hynes 1970; Wallace and Webster 1996). BMI are included in many state and federal agency biological monitoring programs because of their significant functional roles coupled with their vulnerability to flow regulations and water quality perturbations (Barbour et. al. 1999). BMI are advantageous for biological monitoring because they are ubiquitous, have a high species diversity offering a spectrum of responses to environmental stress, and their life cycles offer analysis of effects from stochastic and intermittent disturbances (Rosenberg and Resh 1993).

7.1. Study Objectives

The study is designed to document BMI composition in lower Cascade Creek. The specific objectives of the Benthic Macroinvertebrate Inventory include:

1. BMI community composition
2. BMI density longitudinally in Lower Cascade Creek

7.2. Benthic Macroinvertebrate Study Methods

This section describes the methods used to investigate BMI in lower Cascade Creek. BMI will be sampled at four locations on Cascade Creek: Site 1) outlet to Swan lake; Site 2) directly upstream of the Pond on Cascade Creek; Site 3) pelagic zone of Falls lake; and 4) midway down lower Cascade Creek between Falls lake and the initial barrier falls. These sample locations will provide a representation of the BMI community in Cascade Creek across the elevation gradient. Sample sites were selected, in part, based on availability of safe sampling locations in Cascade Creek. Sites were also selected to avoid the lake outlet effect of Swan Lake, the Pond and Falls Lake.

Riffle habitats are the preferred stream habitat for comparative studies of benthic macroinvertebrates. Riffle habitats typically have the highest densities and diversity of benthic macroinvertebrates. Most benthic macroinvertebrate sampling devices are designed for riffle habitats relying on the transport of organisms by the current velocity into a net after disturbance by field staff.

Three replicate BMI samples will be collected in riffle habitat with cobble substrate at respective sample sites using a surber sampler with 500 µm mesh. The surber sampler covers a 20 cm square area of the stream. The substrate will be disturbed to a depth of 10 cm. Individual substrate will be scrubbed clean of attached material and organisms. Five replicate samples will be collected at each site in August 2010. Sampling in the Falls Lake pelagic zone will be done using a zooplankton net with a 30.5 cm diameter. Three replicate vertical tows will be done from the lake bottom to the surface.

The surber sampler is the most common device used for sampling benthic macroinvertebrates in stream habitats. The surber sampler is specially designed for sampling riffle habitats. This device requires disturbing the substrate through scrubbing of substrate material. Organisms are carried downstream by the current velocity into the net then transferred into a sample jar. This technique permits the surber to quantify BMI densities for a defined area. Densities are typically expressed as the number of organisms per square meter. The quantitative nature of the sampler is important because it allows for comparison of BMI densities in riffle habitats at other sites in the same stream as well as other streams. Furthermore, densities can be compared to studies by other researchers to put the data in perspective.

Samples will be preserved in 90 percent Isopropyl alcohol. Identification and enumeration will be performed by an accredited lab. Species densities will be expressed as the number of organisms per square meter in the case of the surber sampler and the number per cubic meter for samples collected in Falls Lake. The data may require electronic truncation of some taxonomic groups (e.g., chironomid midges and oligochaetes) before metrics are calculated. The final product of the laboratory analyses will be a table of the raw taxonomic data and a list of all macroinvertebrate taxa and the abundance per sample for all samples. This data will form the basis for calculating metrics, determining ecological association indices, calculating metrics and multivariate analyses (truncation may be required to ensure that the number of samples sufficiently exceeds the number of variables). Metrics will be calculated to assess taxonomic abundance in terms of function in the ecology of the system.

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