

Susitna-Watana Hydroelectric Project Document

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Susitna-Watana Hydroelectric Project
(FERC No. 14241)

River Productivity Study
Study Plan Section 9.8

Final Study Plan

Alaska Energy Authority



July 2013

9. FISH AND AQUATIC RESOURCES

9.8. River Productivity Study

On December 14, 2012, Alaska Energy Authority (AEA) filed with the Federal Energy Regulatory Commission (FERC or Commission) its Revised Study Plan (RSP), which included 58 individual study plans (AEA 2012). Included within the RSP was the River Productivity Study, Section 9.8. RSP Section 9.8 focuses on collecting baseline data to assist in evaluating the effects of Project-induced changes in flow and the interrelated environmental factors upon the benthic macroinvertebrate and algal communities in the Middle and Upper Susitna River.

On February 1, 2013, FERC staff issued its study determination (February 1 SPD) for 44 of the 58 studies, approving 31 studies as filed and 13 with modifications. FERC requested additional information before issuing a SPD on the remaining studies. The Susitna River Productivity Study Implementation Plan (RP IP) was presented and discussed during a Technical Work Group (TWG) meeting on February 14, 2013. With consideration of the comment and suggestions received from licensing participants, a RP IP was filed with FERC on March 1, 2013. On April 1, 2013 FERC issued its study determination (April 1 SPD) for the remaining 14 studies; approving 1 study as filed and 13 with modifications. RSP Section 9.6 was one of the 13 approved with modifications. In its April 1 SPD, FERC recommended the following:

Modified Sampling Locations

- We recommend that AEA remove the proposed Upper River mainstem study stations (RP-248 and RP-233).

Macrohabitat Replicates

- We recommend that AEA sample in all unique macrohabitat types present at each proposed study station for river productivity sampling in the Middle River and Lower River segments. This would result in 16 sites in the Middle River and five sites in the Lower River. AEA should collect samples in each macrohabitat type as feasible using sampling methods and devices proposed in its RSP and final RP IP, with the modifications we recommend below in Turbidity and Vegetation Influence, Benthic Sampling Methods, Water Column and Surface Sampling, Organic Matter Sample Processing, Benthic Macroinvertebrate Sampling on Snags, Emergence Sampling, and Trophic Modeling.

Turbidity and Vegetation Influence

- We recommend that AEA conduct macroinvertebrate drift sampling upstream and immediately downstream of tributary mouths to collect information needed to assess the relative contribution of tributaries and the mainstem Susitna River to fish food resources.

Benthic Sampling Methods

- We recommend AEA collect BMI and algae samples in macrohabitats with fine substrate and low velocities using a bottom dredge or grab sampler. AEA should select the most appropriate sampler according to the bottom substrate, water velocity, and other conditions (see Klemm et al. 1990), but should endeavor to use the same sampler in all macrohabitats of this type to ensure consistency among samples. Additionally, AEA should sample benthic algae on cobble substrates at multiple depths up to 3 feet (e.g., depth categories of 0–1 foot,

1–2 feet, and 2–3 feet) at each macrohabitat site (main channel, tributary confluences, side channels, and sloughs), to the extent feasible given the limits of field safety.

Water Column and Surface Sampling

- We recommend that AEA sample invertebrates in the water column and the water surface of still water areas in one side slough, one upland slough, and one tributary mouth (if present) at each study station in the Middle River and Lower River using a modified plankton tow or similar sampler. Five replicates should be collected along a single transect at each site.

Organic Matter Sample Processing

- We recommend that AEA obtain AFDM measures of biomass from samples of benthic and transported organic matter, using generally accepted scientific methods (section 5.9(b)(6)).

Benthic Macroinvertebrate Sampling on Snags

- We recommend that AEA sample BMI on measured and representative portions of LWD in situ by dislodging organisms by hand and collecting them in a net as they enter the water column at each sample site.

- For consistency, we also recommend that AEA use of the term “large woody debris” (LWD) as defined here: “LWD must be at least 0.1 meter (4 inches) in diameter, and at least 1.0 meter (39 inches) of the LWD must be below the water’s surface at bankfull flow” and apply it consistently when referring to “wood” and “snags” in its RSP and future study reports.

Emergence Sampling

- We recommend that AEA sample aquatic insect emergence in ice free areas, if available, beginning in April, then remove the traps during ice breakup and redeploy them following ice breakup in late May or early June.

Trophic Modeling

- For fish sampled for use in the growth and trophic modeling studies, we recommend that AEA measure, weigh, and mark the first 50 fish of each target species and age class captured within each sampled macrohabitat by PIT-tagging to identify the capture station and date. We recommend that AEA collect fish for the trophic modeling studies at all available macrohabitat types (up to five per study station) in each Middle River and Lower River study station. Growth data collected from fish marked and recaptured in the same macrohabitat site should be used (if possible) to validate AEA’s proposed growth rate potential model. We also recommend that AEA incorporate flow velocity into its foraging models and account for associated capture efficiencies when establishing consumption rate.

Stable Isotope Analysis

- We recommend that AEA consult with NMFS and FWS when identifying the appropriate two focus areas for stable isotope sampling, where within the focus areas each type of stable isotope samples would be collected, and the number of adult salmon tissue samples to be collected.

Talkeetna River Reference Study Station

- *We recommend that AEA consult with the TWG when selecting the Talkeetna River reference study station.*

In accordance with the April 1 SPD, AEA has adopted the FERC requested modifications in the FDA IP and this Final Study Plan. The Susitna River Productivity Implementation Plan has similarly been updated with FERC staff recommendations from the April 1, 2013 Study Plan Determination and provides further detail.

9.8.1. General Description of the Proposed Study

The production of freshwater fishes in a given habitat is constrained both by the suitability of the abiotic environment and by the availability of food resources (Wipfli and Baxter 2010). Algae are an important base component in the lotic food web, being responsible for the majority of photosynthesis in a river or stream and serving as an important food source to many benthic macroinvertebrates. In turn, benthic macroinvertebrates are an essential component in the processes of an aquatic ecosystem, due to their position as consumers at the intermediate trophic level of lotic food webs (Hynes 1970; Wallace and Webster 1996; Hershey and Lamberti 2001). Macroinvertebrates are involved in the recycling of nutrients and the decomposition of terrestrial organic materials in the aquatic environment, serving as a conduit for the energy flow from organic matter resources to vertebrate populations, namely fish (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990). In turn, nutrients and energy provided by spawning salmon have the potential to increase freshwater and terrestrial ecosystem productivity (Wipfli et al. 1998; Cederholm et al. 1999; Chaloner and Wipfli 2002; Bilby et al. 2003; Hicks et al. 2005), and may subsidize otherwise nutrient-poor ecosystems (Cederholm et al. 1999).

The significant functional roles that macroinvertebrates and algae play in food webs and energy flow in the freshwater ecosystem make these communities important elements in the study of a stream's ecology. The operations of the proposed Project would likely affect one or more of the factors that can affect the abundance and distribution of benthic algae and benthic macroinvertebrate populations, which could ultimately affect fish growth and productivity in the system. The degree of impact on the benthic communities and fish resulting from hydropower operations will necessarily vary depending on the magnitude, frequency, duration, and timing of flows, as well as potential Project-related changes in geomorphology, ice processes, temperature, and turbidity. By investigating the current populations of algae, benthic macroinvertebrates, and fish in the Susitna River and the trophic relationships between them, this study will generate information about the current health and status of these populations throughout the varied habitats in the Susitna River, and provide a better understanding on the availability and utilization of food resources in the system. In addition, by applying what is known about the effects of river regulation and hydropower operation on these populations in riverine ecosystems, AEA can begin to assess the potential impacts of Project operations on river productivity in the Susitna River, as well as provide information to inform development of any necessary protection, mitigation, and enhancement (PM&E) measures.

Study Goals and Objectives

The overarching goal of this study is to collect baseline data to assist in evaluating the effects of Project-induced changes in flow and the interrelated environmental factors (temperature, substrate, water quality) upon the benthic macroinvertebrate and algal communities in the

Middle and Lower Susitna River. Individual objectives that will accomplish this are listed below.

1. Synthesize existing literature on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities.
2. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Lower Susitna River.
3. Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes.
4. Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity.
5. Conduct a trophic analysis to describe the food web relationships within the current riverine community within the Middle and Lower Susitna River.
6. Develop habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site.
7. Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).
8. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Lower Susitna River.
9. Estimate benthic macroinvertebrate colonization rates in the Middle Susitna Segment under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

9.8.2. Existing Information and Need for Additional Information

A number of evaluations of the benthic macroinvertebrate community were conducted on the Susitna River in the 1970s and in the 1980s for the original Alaska Power Authority (APA) Susitna Hydroelectric Project (Friese 1975; Riis 1975, 1977; ADF&G 1983; Hansen and Richards 1985; Van Nieuwenhuysse 1985; Trihey and Associates 1986). ADF&G studies in the 1970s included sampling of macroinvertebrates using artificial substrates (rock baskets) deployed for a set period of time to allow for colonization. Friese (1975) and Riis (1975) set a total of eight rock baskets in Waterfall Creek, Indian River, and the mainstem Middle Susitna River for 30 days during summer (July – September). Riis (1977) also deployed rock baskets in the Susitna River near the mouth of Gold Creek for a colonization period of 75 days; however, only two of seven baskets were retrieved. Results were limited to low numbers of invertebrates per basket, identified to taxonomic family.

Studies conducted in the 1980s for the original APA Susitna Hydroelectric Project focused on benthic macroinvertebrate communities in the sloughs, side channels, and tributaries of the Middle Segment of the Susitna River from river mile (RM) 125 to RM 142 during the period from May through October. Efforts included direct benthic sampling with a Hess bottom sampler and drift sampling. Alaska Department of Fish and Game (ADF&G) efforts in 1982 and

1984 also involved collection of juvenile salmon in these side channels and sloughs, and an analysis was conducted to compare gut contents with the drift and benthic sampling results (ADF&G 1983; Hansen and Richards 1985). In addition, Hansen and Richards (1985) collected water velocity, depth, and substrate-type data to develop habitat suitability criteria (HSC), which were used to estimate weighted usable areas for different invertebrate community guilds, based on their behavioral type (swimmers, burrowers, clingers) in slough and side channel habitats. Efforts in 1985 (Trihey and Associates 1986) expanded to include sampling at nine sites in the Middle Susitna River Segment: three side channels, two sloughs, two tributaries, and two mainstem sites.

Algal communities were periodically sampled and analyzed for chlorophyll-a at Susitna Station from 1978 to 1980. In the 1980s, algae samples were collected as part of the APA Susitna Hydroelectric Project water quality studies, with sampling conducted at Denali, Cantwell (Vee Canyon), Gold Creek, Sunshine, and Susitna Station on the Susitna River, as well as on the Chulitna and Talkeetna rivers (Harza-Ebasco 1985 as cited in AEA 2011). Analysis showed low productivity (less than 1.25 mg/m³ chlorophyll-a) and indicated algal abundance was most likely limited by high concentrations of turbidity (AEA 2011).

Baseline field data for benthic primary and secondary production was also collected in 1985, as part of the Primary Production Monitoring Effort (Van Nieuwenhuysse 1985). Chlorophyll-a (*chl-a*), and macroinvertebrates were collected from early April to late October 1985 from a variety of off-channel and mainstem habitat sites. Early April sampling took place in an open-water lead in Slough 8A, and revealed high macroinvertebrate densities (average 17,600 individuals/m²) comprised almost entirely of chironomid larvae, and chlorophyll-a densities averaging 34.4 mg/m². Sampling in early May in Slough 8A revealed macroinvertebrate densities averaging 2,950 individuals/m², again almost entirely chironomids, and *chl-a* densities averaging 37mg/m². Results from five mainstem habitat sites showed similar macroinvertebrate numbers, with densities ranging from 393 to 8,820 individuals/m² in May 1985, but with considerably more diversity; chironomids accounted for an average of 53 percent of the density, and only 8 percent of the macroinvertebrate biomass. Algae samples beyond May 1985 had not been analyzed; therefore, no data were available for summer or fall. No sampling results were given for summer macroinvertebrate sampling (June and July). August and September 1985 sampling showed low average densities at mainstem sites (44 – 164 individuals/m²), with large increases occurring in October 1985 (1,729 – 7,109 individuals/m²). Average densities in Slough 8A in August 1985 remained similar to spring levels, at 2,851 individuals/m², with a surge in September 1985 (13,964 individuals/m²); again, chironomids represented over 80 percent of the numbers. No further information or reports were available concerning the Primary Production Monitoring Effort task.

Benthic macroinvertebrate information from the 1980s is focused on a limited number of mainstem, side channel, and slough habitats located within a 17-mile reach of the Middle Susitna River. Additional information is needed on mainstem benthic communities, as well as those in side channel and slough habitats, within both the Middle and Lower Susitna River segments. Benthic algae information needs to be collected in conjunction with the macroinvertebrates to define their relationship in the river's trophic system. To assess the impact of future hydropower operations on the benthic communities within the Susitna River, additional information must be collected through an increased sampling effort, including more sampling sites along the river in

relation to the distance both downstream from the proposed dam site and upstream from the proposed Project reservoir area.

9.8.3. Study Area

The River Productivity Study will entail field sampling throughout the Middle Segment and Lower Segment of the Susitna River (Table 9.8-1; Figures 9.8-1 through 9.8-2). The Middle Susitna River Segment encompasses the 86-mile section of river between the proposed Watana Dam site and the Chulitna River confluence, located at RM 98 (Figure 9.8-1). The Lower Susitna River Segment is defined as the approximately 98-mile section of river between the Chulitna and Talkeetna rivers confluence and Cook Inlet (Figure 9.8-2). Sampling activities within these segments will investigate the benthic communities that may be affected by the Project and its regulated flows. Sampling will be conducted at various distances from the proposed dam site to document longitudinal variability, and estimate the effects that the proposed Project will have on benthos in the river system downstream.

AEA will reevaluate how far downstream Project operational significant effects extend based in part upon the results of the Open-water Flow Routing Model (see Section 8.5.4.3), which is scheduled to be completed in Q1 2013. Thus, an initial assessment of the downstream extent of Project effects will be developed in Q2 2013 with input of the TWG. This assessment will include a review of information developed during the 1980s studies and study efforts initiated in 2012, such as sediment transport (Section 6.5), habitat mapping (Sections 6.5 and 9.9), operations modeling (Section 8.5.4.2.2), and the Mainstem Open-water Flow Routing Model (Section 8.5.4.3). The assessment will guide the need to extend studies into the Lower River Segment and if needed, will identify which geomorphic reaches will be subject to detailed instream flow analysis in 2013. Results of the 2013 studies would then be used to determine the extent to which the study should be modified to include sampling in the Lower River Segment in 2014.

9.8.4. Study Methods

This study will employ a variety of field methods to build upon the existing information related to the benthic macroinvertebrate and algal communities in the Middle and Lower Susitna River. The following sections provide brief descriptions of study site selection, sampling timing, the approach, and methods that will be used to accomplish each objective of this study.

River Productivity Implementation Plan

This study includes a description of the sampling scheme. However, specific details regarding site locations, timing, sampling devices, processing, and analyses will be dependent upon the results of 2012 data collection efforts.

The final sampling scheme will be included in the River Productivity Implementation Plan, which will be filed with FERC prior to March 15, 2013.

The Implementation Plan development will include: (1) a summary of relevant macroinvertebrate and algal studies in the Susitna River, (2) an overview of the life-histories of the target fish species in the Susitna River that are selected for the trophic analysis (Section 9.8.4.5.1), (3) a review of the preliminary results of habitat characterization and mapping efforts (Section 9.9) and “Focus Areas” (Section 8.5.4.2.1.2), (4) a description of site selection

protocols, (5) a description of sampling protocols, (6) a description of sample processing protocols, (7) a discussion of data analysis methods, (8) development field data collection forms, and (9) development of database templates that comply with 2012 AEA QA/QC procedures.

The implementation plan will include the level of detail sufficient to instruct field crews in data collection efforts. In addition, the plan will include protocols and a guide to the decision-making process in the form of a chart or decision tree that will be used in the field, specific sampling locations, details about the choice and use of sampling techniques and apparatuses, and a list of field equipment needed. The implementation plan will also help ensure that field collection efforts occur in a consistent and repeatable fashion across field crews and river segments. Proposed sampling methods by objective are presented below. The Susitna River River Productivity Implementation Plan has similarly been updated with FERC staff recommendations from the April 1, 2013 Study Plan Determination and provides further detail.

9.8.4.1. Synthesize existing information on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities

Several reviews have been written on the effects that modified flows have on the benthic communities residing below dams (Ward 1976; Ward and Stanford 1979; Armitage 1984; Petts 1984; Cushman 1985; Saltveit et al. 1987; Brittain and Saltveit 1989). A majority of these reviews indicate that temperature and flow regimes are often the most important factors affecting benthic macroinvertebrates below dams. The type of dam and its mode of operation will have a large influence over the type and magnitude of effects on the receiving stream below. General information on the effects of hydropower on riverine habitats, especially glacially-fed river systems, as well as Project-specific information, will be reviewed and synthesized in a written report. Specifically, AEA will prepare a written report that provides a literature review summarizing relevant literature on macroinvertebrate and algal community information in Alaska, including 1980s Susitna River data; review and summarize literature on general influences of changes in flow, temperature, substrates, nutrients, organic matter, turbidity, light penetration, and riparian habitat on benthic communities; and review and summarize the potential effects of dams and hydropower operations, including flushing flows and load-following, on benthic communities and their habitats. To the extent consistent with copyright laws, electronic copies of all cited publications will be provided through the ARLIS library.

9.8.4.2. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Lower Susitna River

9.8.4.2.1. Benthic macroinvertebrate sampling

Macroinvertebrate sampling will be stratified by reach and mainstem habitat type defined in the Project-specific habitat classification scheme (mainstem, tributary confluences, side channels, and sloughs). To accomplish this objective, sampling will occur at five stations, each with three to five sites (one site for each unique macrohabitat type present in a station), for a total of 21 sites. In the Middle Segment, two stations will be located between the dam site and the upper end of Devils Canyon, and two stations will be located below Devils Canyon, within the Geomorphic Reaches MR-6 and MR-8 (Table 9.8-1; Figure 9.8-1). All stations established

within the Middle Segment will be located at Focus Areas established by the Instream Flow Study (Section 8.5.4.2.1.2), in an attempt to correlate macroinvertebrate data with additional environmental data (flow, substrates, temperature, water quality, riparian habitat, etc.) for statistical analyses, and HSC/HSI development. In the Lower Segment, sampling will occur at one station within the Geomorphic Reach LR-1 (Table 9.8-1; Figure 9.8-2). Specific station and site locations will be determined during the first quarter of 2013, and detailed in the River Productivity Implementation Plan.

Three sampling periods will occur from April through October in both study years (2013–2014) to capture seasonal variation in community structure and productivity. Seasonal periods are tentatively scheduled for April through early June for Spring, late June through August for Summer, and September through October for Autumn. Specific details on timing will be provided in the River Productivity Implementation Plan. Timing of life history events for coho, Chinook salmon, and rainbow trout (target species for Objective 5, Section 9.8.4.5.1) will be consulted when scheduling sampling efforts.

Sampling will be conducted in riffle/run mesohabitats within mainstem and off-channel macrohabitat types (i.e., tributary confluences, side channels, and sloughs). Higher flows may inundate new shoreline substrates, which poses the risk of sampling in areas that are not fully colonized. The shoreline bathymetry for each site will be evaluated such that changes in water level due to increasing or decreasing flows must remain constant enough that the substrates accessible for sampling will be continually inundated for a period of at least one month, to facilitate colonization of those substrates.

Benthic macroinvertebrate sampling will be conducted using a stream-type sampler (Hess, Surber, Slack) commonly used for other Alaskan benthic macroinvertebrate studies to allow for comparable results; state and federal protocols (Hansen and Richards 1985; Barbour et al. 1999; Klemm et al. 1990; Klemm et al. 2000; Carter and Resh 2001; Moulton et al. 2002; Peck et al. 2006), as well as methods used in the Susitna River studies in the 1980s, will be considered when designing the sampling approach, which will be detailed in the River Productivity Implementation Plan. Replicate samples (n=5) will be collected to allow for statistical testing of results for short- and long-term monitoring. Measurements of depth, mean water column velocity, mean boundary layer velocity (near bed), and substrate composition will be taken concurrently with benthic macroinvertebrate sampling at the sample location for use in HSC/HSI development in the instream flow studies. Water temperatures will be monitored hourly at sites with submerged temperature loggers deployed at all sampling sites throughout the ice-free season. Fine-scale (1 meter vertical and horizontal resolution) measurements of flow will be recorded within a 5-m radius of selected sampling sites. Temperature and flow monitoring will be coordinated with the Baseline Water Quality Study (Section 5.5) and the Instream Flow Study (Section 8.5), and supplemental temperature loggers will be deployed if necessary to cover all River Productivity Study sites.

Some macrohabitats may lack adequate riffle/run mesohabitat (e.g., side sloughs and upland sloughs), instead featuring deeper pools, fine substrates, and low velocity. Use of a Hess sampler in this type of slow-water habitat is not appropriate; therefore, a grab sampler (e.g. Ekman, Ponar) will be instead be used to sample macroinvertebrates in macrohabitats with fine sediment and low velocities. Similar to Hess sample collections, replicate samples (n=5) will be collected to allow for statistical testing of results for short- and long-term monitoring. Measurements of depth, mean water column velocity, mean boundary layer velocity (near bed),

and substrate composition will be taken concurrently with benthic macroinvertebrate sampling at the sample location

In addition, floating emergence traps will be deployed at each site to determine both the timing and the amount of adult insect emergence from the Susitna River (Cushman 1983). Adult aquatic insect emergence mass is a product of aquatic insect production from the stream, and is therefore a good surrogate for actual production (minus predation), and will be especially useful for relative comparisons between river sections and years (personal communication, M. Wipfli, University of Alaska-Fairbanks). Emergence traps will be checked and reset every month. Trapped adults will be identified, enumerated, and weighed. Exact trap design will be determined according to methods compatible with those used for other studies in comparable streams/basins in Alaska, and will be detailed, along with sampling and processing methodology, in the River Productivity Implementation Plan.

Due to the prevalence of large woody debris (LWD) in the Susitna River, LWD, if present at a sampling site, also will be sampled as a substrate strata for benthic macroinvertebrates, as requested by the U.S. Fish and Wildlife Service (USFWS) (USFWS River Productivity Study Request; May 31, 2012). Sampling methods for LWD will be semi-quantitative, based upon protocols established by the USGS (Moulton et al. 2002). Suitable LWD will have been submerged for an extended period of time so as to be clearly colonized. Immobile LWD present will be sampled *in situ* by dislodging organisms by hand and collecting them in a D-net positioned immediately downstream as they enter the water column. Smaller, removable LWD to be sampled will be removed from the water by using a saw and placed over a plastic bin or in a bucket, and all benthic macroinvertebrates will be removed by handpicking, brushing, and rinsing. The removed LWD sections will be allowed to dry for a period of time so that missed organisms will crawl out of the crevices and can then be collected. Removed sections sampled will be measured for length and average diameter to determine surface area sampled. Each section will originate from a separate piece of LWD, and therefore count as a separate, replicate sample. Sampling and processing methodology will be detailed in the River Productivity Implementation Plan.

In order to address the effects of changing flow patterns on benthic macroinvertebrates, algae (Section 9.8.4.2.2), and benthic organic matter (BOM) (Section 9.8.4.8), baseline data will be collected to assess the benthic community responses to storm events within side slough habitats. Additional sampling will be conducted both before and after storm events that meet or exceed a 1.5-year flood event at two side slough sites, located in two separate Focus Areas in the Middle River Segment between Portage Creek and Talkeetna (Section 8.5.4.2.1.2). Replicate samples (n=5) will be collected at both the upstream and downstream ends of each slough, and will include benthic macroinvertebrates, algae, and BOM. Sampling will be conducted for two storm events per year. Specific details on locations and targeted flows will be based on information from the Instream Flow (Section 8.5) and Geomorphology (Section 6.5) studies available in early 2013, and will be provided in the River Productivity Implementation Plan.

Benthic macroinvertebrate replicate samples collected will be stored in individual containers and immediately preserved in the field with 95 percent ethanol (non-denatured). Samples will be processed in a laboratory using methods compatible with those used for other studies in comparable streams/basins in Alaska. State and federal protocols (Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered when making decisions about the sample processing protocols, including sub-sampling protocols and the taxonomic resolution of

specimen identifications. Sampling and processing methodology will be detailed in the River Productivity Implementation Plan.

Results generated from the collections will include several descriptive metrics commonly used in aquatic ecological studies, such as density (individuals per unit of area), taxa richness (both mean and total), EPT taxa (i.e., *Ephemeroptera*, *Plecoptera*, *Trichoptera*) richness, diversity (H'), evenness (J'), percent dominant taxa, the relative abundance of major taxonomic groups, and the relative abundance of the functional feeding groups. In conjunction with the bioenergetics modeling (Section 9.8.4.5.1), biomass estimates will be taken for primary invertebrate taxa collected for benthic and emergence sampling. The fresh blotted wet mass of invertebrate taxa in samples will be recorded, the samples will be oven dried at 60°C until reaching constant mass, and the dry mass will be recorded. For a select sub-sample of the collection, energy density (J / g wet weight) will be estimated from the percent dry mass (dry mass / wet mass) of each sample (Ciancio et al. 2007; James et al. 2012). Energy density will be determined separately for the aquatic and terrestrial (adult) life-stages of each primary invertebrate taxon. For two selected stations, benthic macroinvertebrates and organic matter in samples will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2).

Data collected during this study will be compared to the results of 1980s studies (ADF&G 1983; Hansen and Richards 1985; Van Nieuwenhuysse 1985; Trihey and Associates 1986) to evaluate any differences between the historic and current community structure. In addition, any invasive benthic macroinvertebrates identified in the sample collections will be identified and their collection locations will be recorded using the Geographic Information System (GIS) (NAD 83).

9.8.4.2.2. *Benthic algae sampling*

Benthic algae sampling will be collected concurrently with benthic macroinvertebrate sampling at all five stations (21 sites total) to allow for correlation between the two collections (Table 9.8-1), plus the additional baseline sampling effort addressing the effects of changing flow patterns on benthic communities in sloughs, as discussed in Section 9.8.4.2.1. Benthic algae sampling will be conducted using methods compatible with other Alaska benthic algal studies, to allow for comparison of results. Algal sampling methods will be based on the EPA's field operations procedures for periphyton single or targeted habitat sampling when designing the sampling approach (Eaton et al. 1998; Barbour et al. 1999; Peck et al. 2006). Measurements of depth, mean water column velocity, mean boundary layer velocity, turbidity, and substrate composition will be taken concurrently with algae sampling at the sample location for use in HSC development in the instream flow studies. Light availability will be measured at each sample location with an underwater light sensor, to measure the photosynthetically active radiation (PAR) available to the algal community. Turbidity measurements will also be taken at the site to determine water clarity. Benthic algae samples will be processed in a laboratory, using methods compatible with those used for other studies in comparable streams/basins in Alaska, considering state and federal protocols (Eaton et al. 1998; Barbour et al. 1999; Moulton et al. 2002; Peck et al. 2006) to determine sample processing protocols, including sub-sampling protocols. Algal sampling and processing methods will be detailed in the River Productivity Implementation Plan.

Results generated from the collections would include both dry weight and chlorophyll-a, and several descriptive metrics to describe the algal community; full details will be provided in the River Productivity Implementation Plan. For two selected stations, portions of algal material will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2). In addition, any

invasive algae taxa identified in the sample collections will be identified and their locations will be recorded using GIS (NAD 83).

9.8.4.3. Estimate drift of invertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes

Invertebrate drift sampling will be conducted concurrently with benthic macroinvertebrate sampling at all sites within the five established sampling stations to allow for comparisons between the drift component and the benthic macroinvertebrate community, as well as revealing the availability of terrestrial invertebrates to fish predation. Sampling will be conducted in riffle/run habitats within the mainstem sites, and their associated off-channel habitat sites (Table 9.8-1). For tributary mouth macrohabitats, drift sampling will be conducted upstream and immediately downstream of the tributary mouth to collect information about the relative contribution of tributaries and the mainstem Susitna River to fish food resources.

Invertebrate drift sampling will be conducted using a drift net similar to those used for other drift studies in Alaska to allow for comparison of results; state and federal protocols will be considered (Keup 1988; Klemm et al. 2000). Drift sampling will be conducted during pre-dawn hours, as a measure of drift that is available to feeding fish (Waters 1972; Brittain and Eikeland 1988; Keup 1988). Sampling methods will involve collecting duplicate samples to allow for statistical testing of results for short- and long-term monitoring (Klemm et al 1990; Klemm et al. 2000). Water velocity will be recorded with an in-net flow meter. Invertebrate drift samples will be processed in a laboratory, using methods compatible with other studies conducted in comparable streams/basins in Alaska. State and federal protocols (Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered when making decisions about the sample processing protocols, including sub-sampling protocols, taxonomic resolution of specimen identifications, and length measurements for individual specimens. Samples at two selected stations will be tested for the stable isotope analysis task (Section 9.8.4.5.2). The two Focus Areas, specific sample site locations, and number of adult salmon tissue samples to be collected will be determined with input from with the TWG. Organic matter (OM) content will be retained and analyzed by size (coarse and fine particulate OM) as discussed in Section 9.8.4.8.

Results generated from these collections will include drift density, drift rate, and drift composition. In conjunction with the bioenergetics modeling (Section 9.8.4.5.1), biomass estimates will be taken for primary invertebrate taxa collected for drift sampling. The fresh blotted wet mass of invertebrate taxa in samples will be recorded, the samples will be oven-dried at 60°C until reaching constant mass, and the dry mass will be recorded. For a select sub-sample of the collection, energy density (J / g wet weight) will be estimated from the percent dry mass (dry mass / wet mass) of each sample (Ciancio et al. 2007; James et al. 2012). Energy density will be determined separately for the aquatic and terrestrial life stages of each primary invertebrate taxon. For two selected stations, portions of terrestrial invertebrate composition and organic matter in samples will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2).

Some off-channel macrohabitats may lack adequate velocities (e.g., side sloughs and upland sloughs), for the use of a drift net for sampling. Therefore, a modified plankton net (250 µm mesh) will be instead be used in these still water areas to sample macroinvertebrates the water column. Replicate samples (n=5) will be collected along a single transect at the site location.

Sampling and processing methods will be detailed in the River Productivity Implementation Plan.

Data collected as part of this study will be compared to data from the benthic macroinvertebrate collections (Section 9.8.4.2.1) and the fish dietary analysis (Section 9.8.4.7). In addition, drift results will be compared to the results of 1980s drift studies (ADF&G 1983; Hansen and Richards 1985; Trihey and Associates 1986) to evaluate any differences between the historic and current drift components of the macroinvertebrate communities.

9.8.4.4. *Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity*

Sampling sites will be established in the Talkeetna River in areas that are physically similar to those sampled in the Middle Susitna River Segment, to ensure comparability. Sampling will be conducted in riffle habitats within the mainstem, side channels, and sloughs. One station will be established, with a mainstem site and two off-channel habitat sites associated with the mainstem site. Final site selection will occur with input from the TWG. Benthic and drift sampling will occur during approximately the same periods as sampling in the Middle Susitna River Segment (Objectives 2 and 3, Sections 9.8.4.2 and 9.8.4.3), with seasonal sampling during 2013. Benthic macroinvertebrate, benthic algal, and drift sampling methods and processing protocols will be identical to those used in sampling the Middle Susitna River Segment (Objective 2, Section 9.8.4.2). In the first quarter of 2014, sampling results from Talkeetna sites will be compared to results from similar sites in the Middle Susitna River Segment to determine whether the Talkeetna River would serve as a suitable reference site. Statistical analyses will test for similarities and significant differences between Talkeetna sites and Middle Susitna Segment sites by comparing community compositions and a collection of calculated metrics. Methods will be detailed in the River Productivity Implementation Plan, and may include ANOVA, MANOVA, cluster analysis using Non-Metric Multi-Dimensional Scaling (NMDS) ordination with the Bray-Curtis Dissimilarity Coefficient, and/or other multivariate ordination techniques (Principal Components Analysis, Canonical Correspondence Analysis). Results indicating close similarities, or no significant differences, between sites on the two rivers would indicate suitability as a reference. If suitable, sites on the Talkeetna River can be used in a long-term monitoring program with Susitna River sites to help differentiate potential long-term changes that are Project-related versus those occurring for other reasons outside Project influence. Such a monitoring program would ideally collect multiple years of both pre-Project and post-Project data.

9.8.4.5. *Conduct a trophic analysis, using trophic modeling and stable isotope analysis, to describe the food web relationships in the current riverine community within the Middle Susitna River*

9.8.4.5.1. *Develop a trophic model to estimate how environmental factors and food availability affect the growth rate potential of focal fish species under current and future conditions*

To complement the fish habitat suitability analysis (Section 9.8.4.6), which focuses on physical habitat features, trophic models will be developed to incorporate the density and quality of prey

into an estimate of habitat quality. Growth rate potential models integrate knowledge of the foraging capabilities and bioenergetic physiology of a consumer with field data on its physical environment and prey base to quantify the values of different habitats (Brandt et al. 1992; Nislow et al. 2000; Jensen et al. 2006; Farley and Trudel 2009). The currency of these models, growth rate potential (GRP), is the expected growth rate of a consumer occupying a given habitat. For salmon, juvenile growth is strongly correlated with early marine survival and overall stock dynamics (Pearcy 1992; Beamish and Mahnken 2001; Moss et al. 2005; Duffy and Beauchamp 2011), making GRP a particularly valuable metric of freshwater habitat quality.

One drawback of typical GRP models is that modeled fish are often assumed to occupy a single uniform habitat (e.g., Brandt and Kirsch 1993). However, real fish may be able to exceed the growth rate predicted by these models by moving among nearby habitats to feed, rest, and digest. For example, by regularly moving between habitats of differing temperatures, some sculpin can increase their growth rates by as much as three-fold, relative to a strategy of using a single habitat (Wurtsbaugh and Neverman 1988; Neverman and Wurtsbaugh 1994). The growth of juvenile coho and Chinook salmon is relatively insensitive to the range of temperatures typically found in Alaskan streams, suggesting that small temperature differences among habitats may not substantially affect growth (Beauchamp 2009). However, thermal heterogeneity has a strong influence on the growth of juvenile coho salmon in the Bristol Bay region, due to the short growing season and the potential for faster-growing individuals to consume energy-rich salmon eggs (Armstrong et al. 2010). Further, resident fishes such as rainbow trout can exploit thermal variation patterns by moving from colder to warmer streams to prolong their access to salmon eggs and carcasses during the summer (Ruff et al. 2011). Thus, the local movement patterns of both juvenile salmon and non-anadromous resident fishes among habitat types within the Susitna River study area could potentially have important consequences for their growth rates.

Growth rate potential models will be developed to quantify the effects of environmental conditions and food availability on fish growth at each sampling location, while allowing for local movement among habitats. Due to the relatively data-intensive nature of GRP models, this analysis will focus on two species: coho salmon and rainbow trout. Coho salmon will be included due to their high ecological and economic value in the Susitna Basin and Cook Inlet. Rainbow trout will be included as a representative resident species and a potentially important competitor and predator of juvenile salmon. Importantly, detailed foraging parameters are available for both species (e.g., Dunbrack and Dill 1984; Berg and Northcote 1985; Piccolo et al. 2007; Piccolo et al. 2008a, 2008b), enabling the development of well-supported foraging models. The necessary bioenergetics model parameters are also available for both species (Stewart and Ibarra 1991; Rand et al. 1993).

Species-specific GRP models for coho salmon and rainbow trout will couple a foraging model (Fausch 1984; Hughes and Grand 2000; Hayes et al. 2007) with a Wisconsin bioenergetics model (Kitchell et al. 1977; Hanson et al. 1997). The foraging models will take inputs of flow, turbidity, and prey density and predict a consumption rate. Flow velocity and velocity-dependent capture probabilities will be incorporated into the GRP models for juvenile coho salmon and juvenile rainbow trout. The bioenergetics models will take inputs of consumption, body size, water temperature, diet composition, and the energy density of prey and predict a growth rate. Each GRP model will allow for the potential of local movement among habitats within a sampling location to enhance growth rates. Optimal simulated movement patterns will be

estimated and compared with the observed movements documented by the radio telemetry and PIT tagging components of the Fish Distribution and Abundance Study (Section 9.6).

Preliminary growth models for each species will be developed using data from the 2013 field season as well as from prior Susitna Basin studies. Initial model predictions of the growth potential of particular sites will be tested by comparison with the observed growth and distribution of fish captured in those sites. A sensitivity analysis will be conducted to identify the most important parameters for further refinement (Beaudreau and Essington 2009). Field sampling during 2014 will focus on improving estimates for these parameters.

In addition, a separate trophic analysis will determine how water temperature, food availability, and food quality influence the growth performance of juvenile Chinook salmon in different habitats. Mechanistic drift foraging models for Chinook salmon are not yet available to allow the estimation of growth rate potential under changing conditions. However, field data and bioenergetics analysis will allow useful comparisons of growth rates, consumption rates, and growth efficiency (the growth achieved per gram of food consumed) among different habitats under current conditions. To make these comparisons, a Wisconsin bioenergetics model parameterized for Chinook salmon (Stewart and Ibarra 1991; Madenjian et al. 2004) will take field inputs of body size, growth rate, water temperature, diet composition, and the energy density of prey. The model will estimate the consumption rate and growth efficiency. These metrics will be compared among habitats to determine whether growth is currently limited primarily by water temperature, food consumption, or food quality in the study area, and whether these limiting factors differ among habitats (McCarthy et al. 2009).

9.8.4.5.2. Conduct stable isotope analysis of food web components to help determine energy sources and pathways in the riverine communities

Stable isotope analysis is a method which examines the naturally-occurring stable isotopes of elements (typically carbon and nitrogen) stored in organic materials. The analysis is frequently used to answer questions related to trophic structure and energy pathways within freshwater ecosystems and the interfaces with marine and terrestrial ecosystems (Chaloner et al. 2002; Finlay and Kendall 2007). Carbon isotope ratios ($\delta^{13}\text{C}$) are indicators of an organism's diet because consumers tend to reflect the carbon isotope values of the food they consume, whereas nitrogen isotopes ($\delta^{15}\text{N}$) indicate an organism's trophic level because the heavier nitrogen isotope accumulates in the consumer with each successive trophic transfer (approximately 3–4 parts per thousand, according to DeNiro and Epstein 1981) (Chaloner et al. 2002). If food resources move in a predictable manner through the food chains, these stable isotopes can be used to trace the sources of productivity within aquatic food webs and the trophic position of consumers, which can be essential information for understanding the food web dynamics or for detecting responses to environmental and human-driven change (Chaloner et al. 2002; Finlay and Kendall 2007).

Several recent studies have used stable isotopes to investigate the contribution of marine-derived nutrients (MDN) from spawning salmon to freshwater ecosystems, and have estimated that salmon can contribute 17–30 percent (Bilby et al. 1996) to > 50 percent (Kline et al. 1990) of the nitrogen, and 23–40 percent (Bilby et al. 1996) of the carbon present in freshwater organisms. Adult salmon incorporate rich marine nutrients during their time in the ocean and are thereby enriched with the heavier isotopes of nitrogen and carbon, which they retain after entering fresh water to spawn, as they do not feed in fresh waters, and therefore remain isotopically distinct

from terrestrially-derived organic material (Kline et al. 1990). Stable isotope analysis can be used to trace MDN through freshwater ecosystems, and ultimately can be used to quantify the contribution of marine-derived nitrogen or carbon to freshwater food webs (Kline et al. 1990; Hicks et al. 2005).

To better understand the trophic relationships in the Middle Susitna River, a stable isotope analysis will be conducted at two selected stations in the Middle River Segment. Selection of these two stations will be made in the initial sampling efforts in the second quarter, based on how representative the site is in respect to the reach, and its suitability to provide ample materials for testing. Tissue samples from multiple study components (benthic macroinvertebrates, benthic algae, benthic organic matter, terrestrial invertebrates and organic matter in drift samples, salmon carcasses, and fin clip samples from the fish diet analysis collections) at the sites within these two stations will be collected for stable isotope analysis. The two Focus Areas (stations), specific sample site locations, and number of adult salmon tissue samples to be collected will be determined with input from the TWG. Results will be used in conjunction with the bioenergetics model (Section 9.8.4.5.1) to further explain the energy source pathways and trophic relationships in the Susitna River food web.

9.8.4.6. *Generate habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site*

Habitat Suitability Index (HSI) models provide a quantitative relationship between numerous environmental variables and habitat suitability. An HSI model describes how well each habitat variable individually and collectively meets the habitat requirements of the target species and life stage under the structure of Habitat Evaluation Procedures (USFWS 1980). Alternatively, Habitat Suitability Criteria (HSC) curves are designed for use in the Instream Flow Incremental Methodology to quantify changes in habitat under various flow regimes (Bovee et al. 1998). HSC describes the instream suitability of habitat variables related only to stream hydraulics and channel structure. Both models and habitat index curves are hypotheses of species-habitat relationships and are intended to provide indicators of habitat change, not to directly quantify or predict the abundance of target organisms. For the Susitna-Watana Hydroelectric Project aquatic habitat studies, HSC (i.e., depth, velocity, and substrate/cover) and HSI (i.e., turbidity, duration of inundation, and dewatering) models will be integrated to analyze the effects of alternate operational scenarios.

Literature-based draft HSC/HSI curves will be developed for benthic macroinvertebrate and algae communities. Potential sources of information include the Internet, university libraries, peer-reviewed periodicals, and government and industry technical reports. Special emphasis will be given to the existing 1980s study (Hansen and Richards 1985) for applicable information and methodology. Because benthic macroinvertebrate (BMI) and periphyton communities are comprised of numerous taxa, the HSC/HSI curves will be developed for commonly used benthic metrics (e.g., biomass, chlorophyll-a [algae], density, diversity, or dominant taxa) selected to summarize and describe the communities. The selection of individual species of interest will consider the dietary preferences of the target fish species selected for the trophic analysis (Objective 5, Section 9.8.4.5.1). The review will also examine macroinvertebrate life histories, behavior, and functional feeding groups to assist in grouping taxa into guilds as possible metrics.

Habitat suitability information will address BMI and algal responses to changes in depth, velocity, substrate, turbidity, and frequency of inundation and dewatering.

Next, a histogram (i.e., bar chart) will be developed for each of the habitat parameters (e.g., depth, velocity, substrate, frequency of dewatering) using site-specific field observations (from Objectives 2, Section 9.8.4.2, and Objective 9, Section 9.8.4.9). The histogram developed using field observations from 2013 will then be compared to the literature-based HSI curve to validate applicability of the literature-based HSI curve for aquatic habitat modeling. This stage will be conducted by the third quarter of 2014.

As a final step TWG will confirm HSC/HSI curves for each benthic metric. Using a roundtable discussion format, the TWG will review literature-based benthic community information and site-specific data to develop a final set of HSC/HSI curves. These curves will be used in the Instream Flow Study (Section 8.5) to define the relationship between habitat quantity and quality for each of the selected benthic metrics under various operational scenarios. Analysis and modeling efforts will be coordinated with the Instream Flow Study Team.

9.8.4.7. *Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component)*

In order to investigate and understand the trophic relationships within a river system and how they ultimately relate to fish, it is critical to examine not only the food source (Objective 2, Section 9.8.4.2) and its availability to fish via drift (Objective 3, Section 9.8.4.3), but also the consumption by fish predators. Because both benthic macroinvertebrates and terrestrial invertebrates are a primary food source for fish and other organisms (Wipfli 1997; Hershey and Lamberti 2001; Allan et al. 2003), any significant disturbance to the benthic community and the shoreline riparian vegetation has the possibility of affecting their predators. Therefore, it is important to investigate the trophic relationship between fish and these food sources by conducting a fish gut analysis and comparing results to drift and benthic macroinvertebrate data. In support of the bioenergetics modeling (Objective 5, Section 9.8.4.5.1), fish species targeted for dietary analysis will include juvenile coho salmon, juvenile Chinook salmon, and juvenile and adult rainbow trout, as identified in consultation with the TWG. Fish collection sites will correspond to all sites within the five sampling stations identified for the study (Table 9.8-1), benthic macroinvertebrate collection sites (both benthic and drift sampling, to allow for comparison with the benthic macroinvertebrate community (Section 9.8.4.2.1) and drift compositions (Section 9.8.4).

A total of eight fish per species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods (Meehan and Miller 1978; Hyslop 1980; Bowen 1996; Kamler and Pope 2001). All fish will have fork length and weight recorded with the stomach sample. In addition, scales will be collected from the preferred area of the fish, below and posterior to the dorsal fin, for age and growth analysis (DeVries and Frie 1996). At two selected sampling stations in the Middle Segment, fin clips will be obtained from five fish at each site for use in the stable isotope analysis (Section 9.8.4.5.2). The fish collection methods and scheduled sampling efforts will be coordinated with the appropriate fish study team (Fish Distribution and Abundance in the Middle and Lower Susitna River Study, Section 9.6; Fish Distribution and Abundance in the Upper Susitna River Study, Section 9.5). Methods for collecting fish specimens are included in Sections 9.5.4, and 9.6.4.

Fish gut content samples will be processed in a laboratory using methods compatible with studies conducted in other comparable streams/basins in Alaska. State and federal protocols (Hyslop 1980; Bowen 1996; Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered in determining the sample processing protocols, the taxonomic resolution of specimen identifications, and data analysis approach. Data collected during this study will be compared to the results of 1980s fish diet studies (ADF&G 1983; Hansen and Richards 1985) to evaluate any differences between the historic and current fish diets. Additional details on sampling and processing methodology and analysis will be described in the River Productivity Implementation Plan.

9.8.4.8. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Lower Susitna River

Organic matter materials serve as an important food resource to benthic macroinvertebrates, serving as a conduit for the energy flow from organic matter resources to vertebrate populations, such as fish (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990). Given the dominant characteristics of the Susitna River system (large, cold, and turbid during the growing season), secondary productivity is not likely to be driven by primary production or from the algal community within the system, but rather by allocthanous inputs of organic material from the terrestrial environment. Benthic organic material is one of the most important “interrelated environmental factors” influencing the macroinvertebrate community, and damming the river will have significant consequences for the transport of organic matter from the upper watershed. Therefore, to address the importance of organic matter to productivity in this type of system, quantifying benthic organic matter as part of this study is essential.

This organic matter exists as both fine particulate organic matter (FPOM) and coarse particulate organic matter (CPOM). FPOM includes particles ranging from 0.45 to 1000 μm in size, and can occur in the water column as seston, or deposited in lotic habitats as fine benthic organic matter (FBOM) (Wallace and Grubaugh 1996). CPOM is defined as any organic particle larger than 1 mm in size (Cummins 1974). In order to quantify the amounts of organic matter available in the Susitna River for river productivity, CPOM and FPOM (specifically FBOM) will be collected concurrently with all benthic macroinvertebrate sampling, including the baseline sampling effort addressing the effects of changing flow patterns on benthic communities in sloughs (Objective 2, Section 9.8.4.2.1). Organic debris collected within each sample will be retained after processing for organisms. In order to streamline the collection efforts, a net mesh size of 250 μm for sampling devices will retain FPOM in the 250–1,000 μm size range for analysis, as well as CPOM particles. Suspended FPOM (seston) will be collected from material in invertebrate drift samples, utilizing the 250- μm mesh size for drift nets, as well (Objective 3, Section 9.8.4.3). Organic matter retained after organism sorting and processing will be separated from inorganic material, rinsed through sieves to separate particles into size classes, and processed for ash free dry mass (AFDM). Results will be calculated as AFDM amounts of CPOM and FPOM per unit area (g/m^2 and g/m^3 , respectively). For the two selected stations, portions of the material will be utilized for stable isotope analysis (Objective 5, Section

9.8.4.5.2). Additional details on sampling and processing methodology and analysis will be described in the River Productivity Implementation Plan.

9.8.4.9. *Estimate benthic macroinvertebrate colonization rates in the Middle Susitna River Segment t under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.*

Colonization is a process in which organisms move into and become established in new areas or habitats (Smock 1996). In disturbed habitats, this process is more accurately called recolonization. Numerous studies have shown that macroinvertebrates can rapidly colonize new or disturbed substrates (Shaw and Minshall 1980; Ciborowski and Clifford 1984; Williams and Hynes 1977; Townsend and Hildrew 1976; Miyake et al. 2003). The rate of recolonization is dependent on several factors, including time of the year, substratum particle size, the structure of the macroinvertebrate assemblages available to colonize at the time, and the distance of the colonist assemblages from the new or disturbed area (Robinson et al. 1990; Smock 1996; Mackay 1992).

Two additional factors, predicted as major post-Project effects, that may affect colonization rates are changes in turbidity and temperature. In order to assess the influences of turbidity and temperature on the benthic community colonization rates, a field study will be conducted for both study years (2013 and 2014) to estimate potential benthic macroinvertebrate colonization rates for four different habitat types that reflect these conditions in the Susitna River. Due to the difficulty of isolating each of these conditions under natural conditions, colonization will be examined under turbid/warm, clear/warm, turbid/cold, clear/cold conditions. Sampling locations and scheduling will be determined after a review of 2012 study results, from both AEA studies, as well as from data collected outside of AEA, and site reconnaissance to assess candidate sites.

Sets of three preconditioned artificial substrates will be deployed incrementally for set periods of colonization time (e.g., 8, 6, 4, 2, and 1 week[s]) and then pulled simultaneously at the conclusion of the colonization period. Artificial substrates will be deployed at two depths at fixed sites along the channel bed. Benthic macroinvertebrate processing protocols will be identical to those used in Objective 2 (Section 9.8.4.2.1). Specific details on site locations, the choice of artificial substrates, and timing of colonization tests will be provided in the River Productivity Implementation Plan.

Colonization information will be compared with colonization results from similar river systems and with post-Project colonization results. In addition, results will be utilized in HSC/HSI development (Objective 6, Section 9.8.4.6), and in the varial zone modeling task in the Instream Flow Study (Section 8.5.4.6.1.6) to assist in determining the potential Project effect of short-term flow fluctuations, most commonly the result of hydroelectric power generation, on benthic macroinvertebrates.

9.8.5. Consistency with Generally Accepted Scientific Practices

The methods described above have been developed in consultation with agency and Technical Workgroup (TWG) participants. All data collection and processing efforts will follow state (ADF&G) or federal (EPA, USGS) guidelines referenced throughout the study methods discussion (Agradi 2006; Barbour et al. 1999; Bovee et al. 1998; Eaton et al. 1998; Keup 1988; Klemm et al. 1990, 2000; Major and Barbour 2001; Moulton et al. 2002; Peck et al. 2006;

USFWS 1980). In addition, any laboratory analysis will be conducted by a state- or federally-certified facility.

9.8.6. Schedule

The preliminary schedule for the river productivity study elements is presented in Table 9.8-2. During 2013, the literature review summarizing the impacts of hydropower development and operations on benthic macroinvertebrate and algal communities will be prepared and presented to the TWG. Research, field sampling, and sample processing and analysis will begin in the latter half of the first quarter of 2013, following FERC's approval of the study plan. Field sampling at the Susitna River sites and the Talkeetna River test reference sites for benthic macroinvertebrates, algae, organic matter, drift, fish diet analysis, and stable isotopes will be conducted for three seasonal sampling periods from April through October in both study years (2013-2014). These seasonal periods are tentatively scheduled for April through early June for Spring, late June through August for Summer, and September through October for Autumn (Table 9.8-2), due to annual variability in the timing of seasons. Specific details on timing will be provided in the River Productivity Implementation Plan. Two additional sampling events for benthic macroinvertebrates, algae, and organic matter to capture responses to storm events will occur during April through October. Exact timing is subject to storm event occurrences. Sample processing of organisms and materials collected in the 2013 field efforts will require extensive laboratory efforts, and will continue throughout the remainder of 2013 and into the first quarter of 2014. Trophic analysis efforts will also begin in the latter half of the first quarter of 2013 and continue throughout 2013 and 2014. The Initial Study Report summarizing these 2013 activities will be issued within one year of FERC's Study Plan Determination (i.e., February 1, 2013).

Results from the 2013 effort will be utilized in the effort to generate habitat suitability criteria, which begin early in the first quarter of 2014. Second-year field sampling efforts, adhering to the same tentative scheduling as in 2013, will resume in the latter half of the first quarter of 2014, with sample processing, data analysis, trophic analysis research continuing through the fourth quarter. The Updated Study Report will be produced within two years of FERC's Study Plan Determination.

9.8.7. Relationship with Other Studies

The flow of information into and out of the River Productivity Study is anticipated to occur over the two year study period through an iterative process. The River Productivity Study is interrelated to several AEA studies (Figure 9.8-3). The Instream Flow Study (Section 8.5), Characterization and Mapping of Aquatic Habitat Study (Section 9.9), and the Geomorphology studies (Sections 6.5 and 6.6) will provide useful information, expected by Q1 2013, to assist in the site selection process. The Baseline Water Quality Study (Section 5.5) will provide useful input information for analysis of river productivity for use in the trophic analysis (Section 9.8.4.5). The Upper (Section 9.5) and Middle and Lower River (Section 9.6) Fish Distribution and Abundance studies will provide information on target fish species for the trophic analysis, including life history event timing to assist in sampling scheduling and seasonal locations in Q1 2013 and Q1 2014, as well as throughout the 2013 and 2014 field seasons. The Fish Distribution and Abundance studies will also coordinate with the collection of samples for gut content

analysis (Section 9.8.4.7) and stable isotope analysis (Section 9.8.4.5.2) throughout the field seasons. Output information from the multiple objectives of the River Productivity Study will provide additional input information to the trophic analysis, Objective 5, Section 9.8.4.5, of the River Productivity Study as well as any water quality field measurements (e.g., temperature, turbidity, and PAR data) collected to the Baseline Water Quality Study (Section 5.5) and site-specific field observations from Objective 2 and Objective 9 for use in the Instream Flow Study's IFIM and varial zone models (Section 8.5.4.6). Information flowing out from the River Productivity Study will be communicated with other Fish Progam Study Lead. Additional formal data sharing also will occur among study after completion of QA/QC procedures and with delivery of the Initial Study Report (Q1 2014) and Updated Study Report (Q1 2015).

9.8.8. Level of Effort and Cost

The initial cost estimate for completion of the nine study objectives described above is \$1,200,000. Efforts such as the literature review, trophic analysis (bioenergetics model and stable isotope analysis), and HSC criteria development will be office-based studies. Collection of benthic macroinvertebrates, algae, and organic matter, drift samples, and the analysis of fish diets will require three extensive field efforts per year for the two study years. Adult emergence sampling will require monthly to bi-weekly site visits from April through October to collect samples and reset the traps. The colonization study will require frequent site visits each month to deploy additional sets of samplers over the course of the study. A majority of the work effort will take place in the laboratory to sub-sample, sort, and identify the macroinvertebrate and algae samples, as well as to conduct the stable isotope analyses on the numerous sample components. After sample processing, the remainder of the study effort will be office-based, consisting of data entry, analysis, and synthesis and report writing.

9.8.9. Literature Cited

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9.8.10. Tables

Table 9.8-1. Preliminary macroinvertebrate and algae sampling sites, stratified by reach and habitats. Refer to Figures 9.8-1 – 9.8-2 for locations of the preliminary sampling reaches and stations.

Sampling Reach	Reach Description	Number of Mainstem Sites	Number of Associated Off-channel Sites ¹
Middle Segment			
MR-1	Immediately below dam site	1	2
MR-2	Upstream of Devils Canyon	1	3
MR-6	Downstream of Devils Canyon	1	3
MR-8	Upstream of the Three Rivers Confluence	1	4
Lower Segment			
LR-1	Downstream of the Three Rivers Confluence	1	4
Susitna River Totals		5	16

Notes: 1 Side-channels, sloughs, tributary confluences associated with a mainstem sampling site.

Table 9.8-2. Preliminary schedule for River Productivity Study.

Activity	2013				2014				2015
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q
Literature Review on Hydropower Impacts		—	—	—					
Sampling benthic macroinvertebrate communities, algal communities, and organic matter.		⊙	⊙	⊙	—	⊙	⊙	⊙	
Invertebrate drift sampling		⊙	⊙	⊙	—	⊙	⊙	⊙	
Sampling Talkeetna for Reference Site Feasibility Study		⊙	⊙	⊙	—				
Trophic analysis with bioenergetics and stable isotope analysis		⊙	⊙	⊙	—	⊙	⊙	⊙	
Generate habitat suitability criteria					—	—	—	—	
Conduct a fish gut analysis		⊙	⊙	⊙	—	⊙	⊙	⊙	
Establish baseline colonization rates		—	⊙	⊙	—	—	⊙	⊙	
Data Analysis and Reporting			—	—	—	—	—	—	
Initial Study Report				—	Δ				
Updated Study Report								—	▲

Legend:

- Planned Activity
- ⊙ Tentatively scheduled sampling event
- Δ Initial Study Report
- ▲ Updated Study Report

9.8.11. Figures

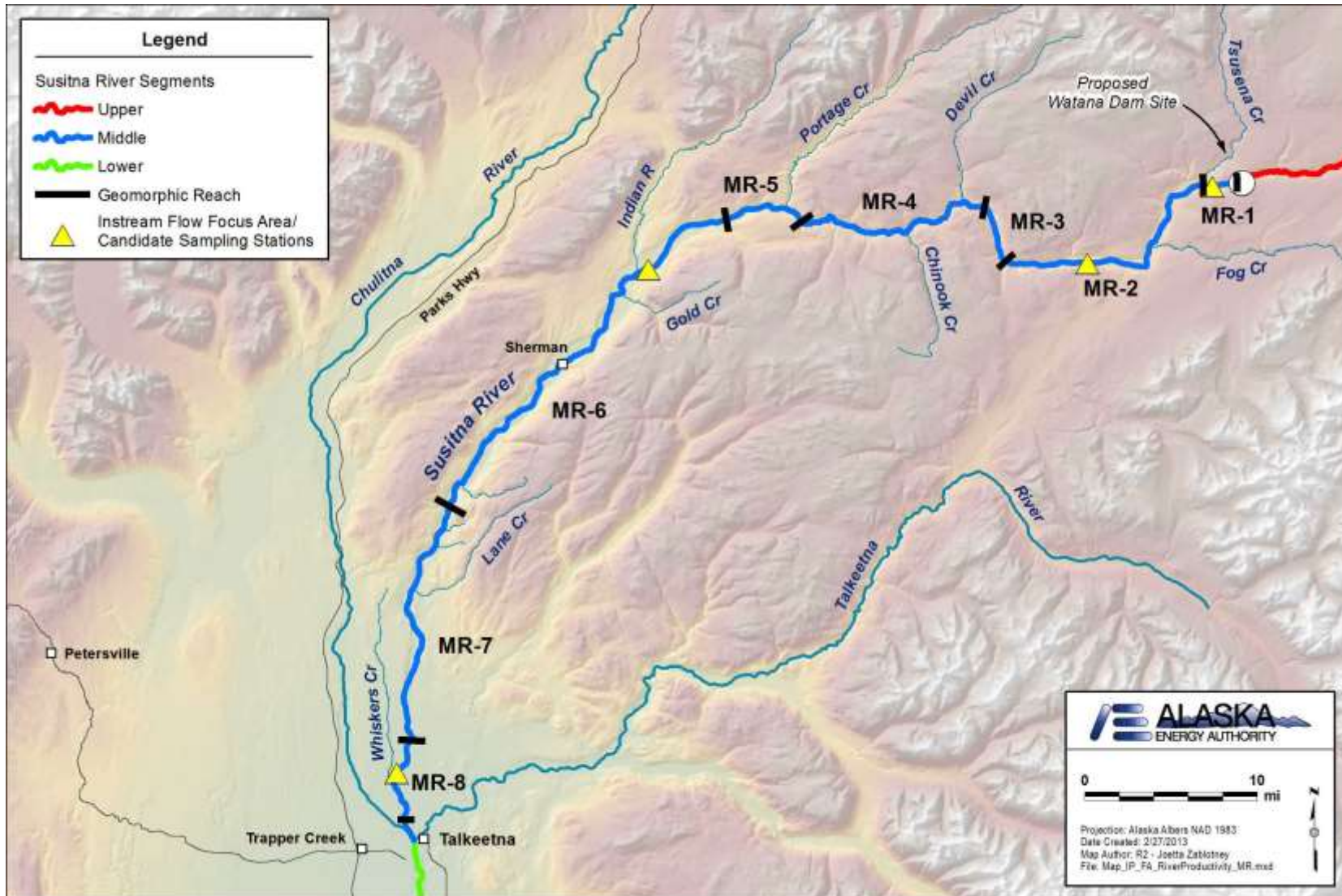


Figure 9.8-1. Middle Susitna River Segment, with the Instream Flow Focus Areas under consideration for the four sampling locations proposed for the River Productivity Study.

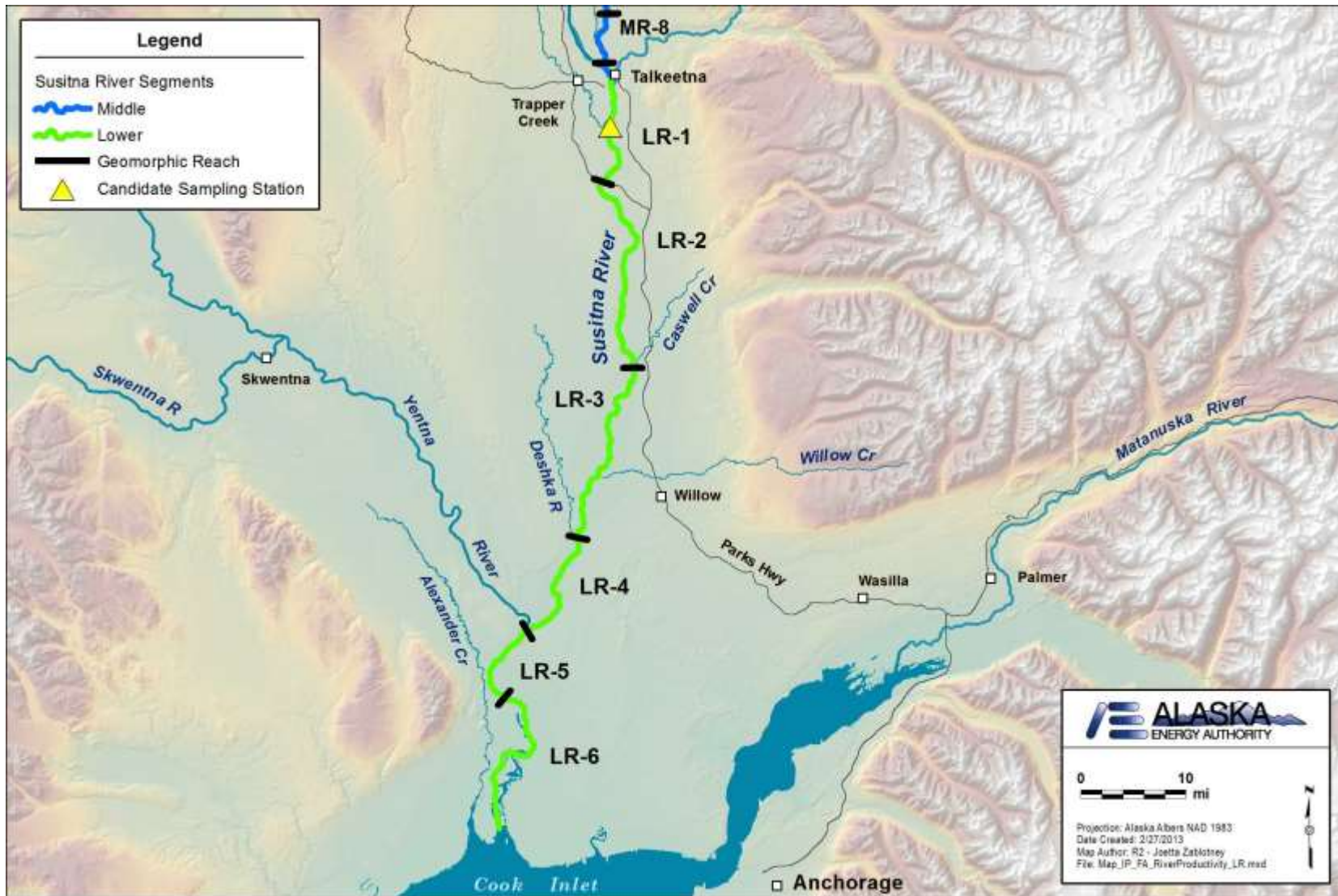


Figure 9.8-2. Lower Susitna River Segment, with one proposed River Productivity sampling station /Instream Flow study sites selected for the River Productivity Study.

Study Interdependencies for River Productivity Study

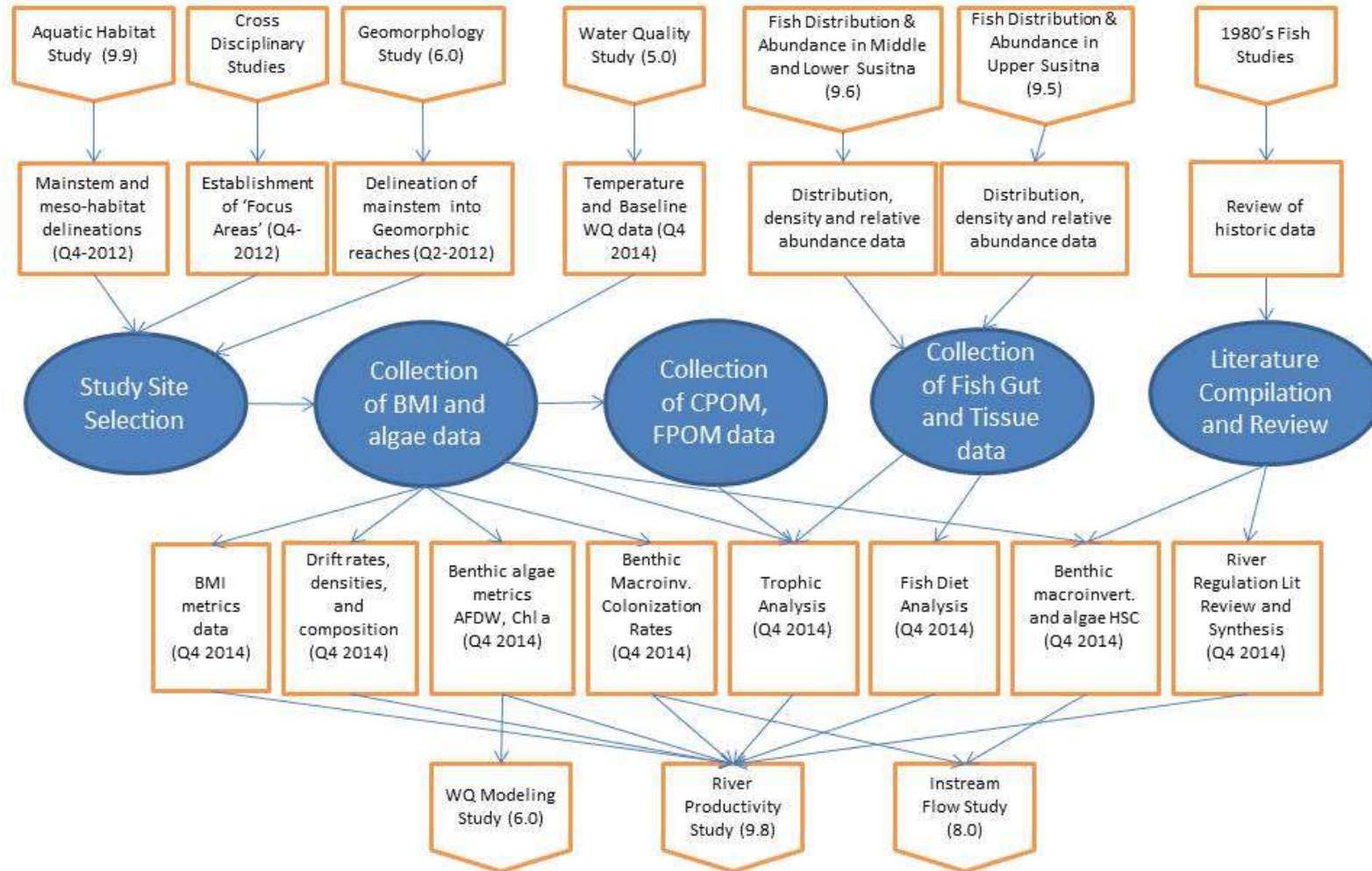


Figure 9.8-3. Study interdependencies for River Productivity Study.