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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

DRAFT POSITION PAPER

FISHERIES ISSUE F-2.6

EXECUTIVE SUMMARY

Issue

Significance of change in water quality parameters (nutrients) on salmon and resident fish habitats and populations downstream of the dams.

Position

The Alaska Power Authority accepts the concepts presented in this document. It is our position that no mitigation measures need to be taken regarding this issue, and that impacts on the trophic status and fish resources of the project reservoirs and downstream riverine habitats due to nutrient changes will be minimal under with-project conditions.

Present Knowledge

This issue concerns project-induced changes in aquatic plant macronutrients (i.e. phosphorus and nitrogen) and the potential effects these changes may have on the trophic status[1/] and fish resources of the Susitna Hydroelectric Project reservoirs and the riverine habitats downstream from the project.

Construction and operation of the proposed two-dam complex is expected to cause storage and/or loss of phosphorus and nitrogen within the

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1/ The trophic status of an aquatic ecosystem is an expression of the rate of supply of biologically useful organic matter supplied by or to the system.

impoundment zone. Macronutrients will no longer be transported in pre-project quantities to areas downstream of the reservoirs. It is believed, however, that the phosphorus and nitrogen macronutrient concentrations presently in the river exist in excess of the demand for them, and that this situation will not be changed by the project.

Dissolved and particulate organic material from terrestrial plant production (e.g., tundra peat, humic acids, etc.), much of which is expected to be relatively non-biodegradable and relatively low in nutritional quality, is expected to be the predominant form of organic material in the project reservoirs and downstream riverine habitats conveying mainstem flows. Because the organic material of terrestrial origin is expected to be relatively non-biodegradable and to have low nutritional value, it is also expected to make a relatively minor contribution to the trophic status and the flow of biological energy towards fish resources of the reservoirs and the riverine habitats downstream.

More ecologically important dissolved and particulate organic materials are expected to come from aquatic plant productivity. The most important aquatic plants will be suspended algae (phytoplankton) in the project reservoirs and attached algae (periphyton) on the stable streambed substrates of the riverine habitats. Aquatic primary productivity is expected to make a relatively small contribution to the total amount of organic matter recruited by the reservoir and riverine aquatic subsystems. However, the organic materials that are recruited from aquatic primary productivity will be relatively important to the aquatic subsystem's trophic status, especially from the standpoint of the flow of biological energy into fish resources. The reason for its importance is its greater food quality and biodegradability and, therefore, its greater biological importance per unit weight of material. The primary reason for the relatively small contribution of organic matter from aquatic primary productivity to the reservoirs and river habitats is expected to be low light availability due to high turbidity during all seasons and ice and snow cover during cold seasons.

Supplies of the macronutrients phosphorus and nitrogen are not expected to be major limiting factors to the trophic status or the fisheries resources of either project reservoir or the mainstem riverine habitats downstream of the project. Although substantial changes in downstream nutrient flows are expected because of project construction and operations, the project-induced changes in nutrient concentrations and nutrient biological availabilty in the reservoir and riverine habitats are not expected to be ecologically meaningful in terms of the aquatic subsystem's trophic status or fish productivity. The importance of project-induced nutrient change is expected to be overshadowed due to light limitation of aquatic primary productivity during all seasons.

Minimal rates and quantities of aquatic primary productivity are expected to occur in most areas of the project reservoirs and in most downstream riverine habitats which convey turbid mainstem water. Peripheral riverine habitats conveying water which is warmer, richer in dissolved elements and relatively free of suspended particulates, will also be subject to less overtopping by project-controlled mainstem flows. These peripheral habitats are expected to be as productive or more productive than naturally under the controlled flow regime with the Project.

Mitigation Measures Endorsed by the Alaska Power Authority

No mitigation measures are expected to be necessary regarding this issue. Therefore, none have been proposed.

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

DRAFT POSITION PAPER

FISHERIES ISSUE F-2.6

INTRODUCTION

Issue

Significance of change in water quality parameters (nutrients) to salmon and resident fish habitats and populations downstream of the dams.

Position

The Alaska Power Authority supports the conclusions presented in this document. It is our position that no mitigation measures need to be taken regarding this issue, and that impacts to the reservoir and downstream river trophic status and fish resources due to macronutrient changes will be minimal under with-project conditions.

DISCUSSION

Existing Conditions

Basic Considerations. The primary issue concerning nutrients and the Susitna Hydroelectric Project is the effect that project construction and operation will have on the trophic status and fish resources of the proposed reservoirs and the riverine habitats downstream from the Project (FERC 1984). An aquatic habitat's trophic status is an indication of its relative degree of richness or poverty with regard to the rate of supply of its biologically useful organic energy. Generally, the richer the trophic status of an aquatic subsystem, the greater its ability to contribute biologically useful energy to fish productivity.

The trophic status of an aquatic habitat, whether that habitat is characterized by slow or fast flowing water, is largely determined by the rate at which biologically useful organic material is recruited from two basic sources: primary production of new organic materials produced by aquatic photosynthesis and organic materials derived from terrestrial sources. Limnologists have long recognized the importance of aquatically produced organic carbon compounds to the trophic status of lakes, ponds and reservoirs (Wetzel 1975), and they are recently becoming more aware of the importance of aquatic productivity in unshaded riverine habitats as well (Wetzel 1975, Minshall 1978, Cummins 1979, Murphy et al. 1981, Conners and Naiman 1984).

Most freshwater lake habitats of temperate North America have their aquatic production of new organic material limited by low supplies of biologically available phosphorus and/or nitrogen (Wetzel 1975, Hutchinson 1973, Rast and Lee 1978, Vollenweider and Kerekes 1980). The aquatic productivity of new organic material in riverine habitats, on the other hand, is frequently limited by a more complex array of environmental variables which includes temperature, high flow variability, high velocities, turbulence, low light levels, and unstable substrate for attached algae anchor points (Cushing et al. 1980, Lowe 1979, Newbold et al. 1981, Minshall 1978, Minshall et al. 1983, Murphy et al. 1981, Vannote et al. 1980).

Observation of the Susitna River mainstem and peripheral habitats during recent field seasons has so far disclosed only two brief periods when substantial standing crops of attached algae consistently occur (ie., in spring, before intensive and highly turbid freshet flows, and in fall, after high volume and highly turbid summer flows begin to diminish). In 1984, luxuriant crops of attached filamentous algae were photographed along the fringes of the mainstem channel and in many side-channels and side-sloughs. The attached algae appeared to grow luxuriantly in many places where incident solar radiation could penetrate to stable streambed substrate. Quantifications of aquatic primary productivity and standing crops of attached algae are not available for any reach of the Susitna. The relative importance of aquatic primary production to the flow of energy between trophic levels leading to fish resources or to the trophic status of the Susitna River is unknown. Nevertheless, regardless of the actual quantity of newly produced organic material in the river, it likely serves as a very important, high quality food source for microbial populations with varied food requirements as well as for invertebrate and vertebrate herbivores and detritus feeders (Cummins, 1979). These detrivores and herbivores, in turn, may become food for vertebrate predators such as juvenile salmonids and resident fishes which, in turn, may become food for birds and mammals (Hynes 1970).

Aquatic Primary Productivity. Under natural conditions, the factors which appear to be the most important in limiting aquatic primary productivity in the Susitna River are:

- Highly variable water stages which cause desiccation or freezing of dewatered attached algae,
- Relatively cold thermal regimes with low mean and maximal temperatures,
- Unstable streambed substrate,
- Scour by suspended sediment particles,
- Scour by frazil ice, anchor ice, or other ice processes,
- Sedimentation of streambed substrate and smothering of small organisms by small particulates,
- Light limitation, during most seasons, by ice and snow cover or high turbidity levels.

Substantial growth of attached algae occurs in spring and fall when flows in the mainstem and peripheral river habitats are relatively stable and the negative effects of suspended sediments are reduced. The occurrence of rapidly growing standing crops of attached algae observed during these periods is indirect evidence that at least minimal supplies of biologically available phosphorus and nitrogen were present in the river water during at least the spring and fall.

Shortages of the major macronutrients such as phosphorus and nitrogen which are sufficient to dramatically limit aquatic primary productivity are not expected to occur in the unregulated Susitna River during any season, nor during any year.

Concentrations of total phosphorus and total nitrogen which are general representative indicators of different trophic categories in relatively clear, freshwater lakes of north temperate latitudes have been fairly well established (Table 1). However, for turbid lakes and turbid reservoirs (Jones and Bachman 1978, Kerekes 1982, Walker 1982), or for rivers and streams of any size, comparable relationships between representative macronutrient concentrations and different trophic categories have not been well established (Cushing et al. 1980, Moore 1977). In fact, the science of stream limnology, in contrast to lake and reservoir limnology, has not been able to establish any generalized categories or terminology describing the relative trophic status of streams and rivers in terms of oligotrophy (impoverished or low rates of biological energy supply), mesotrophy (medium rates of biological energy supply) and eutrophy (high levels of biological energy supply) (Cushing, et al. 1980).

Chemical assays for phosphorus and nitrogen levels in the Susitna River have shown highly variable macronutrient concentrations occurring in the river during summer, winter and breakup (APA 1983). During most sampling periods and at most sampling stations, concentrations of the various phosphorus and nitrogen compounds have been found to vary from less than detectable levels to much greater total concentrations than would be necessary to support moderate biomass (10-20 ug/l Total P and <500 ug/l Total N) or even excessive biomass (>20 ug/l Total P and >500 ug/l Total N) of phytoplankton (See Figures 1 and 2) if the nutrients were in a clear lake.

Table 1

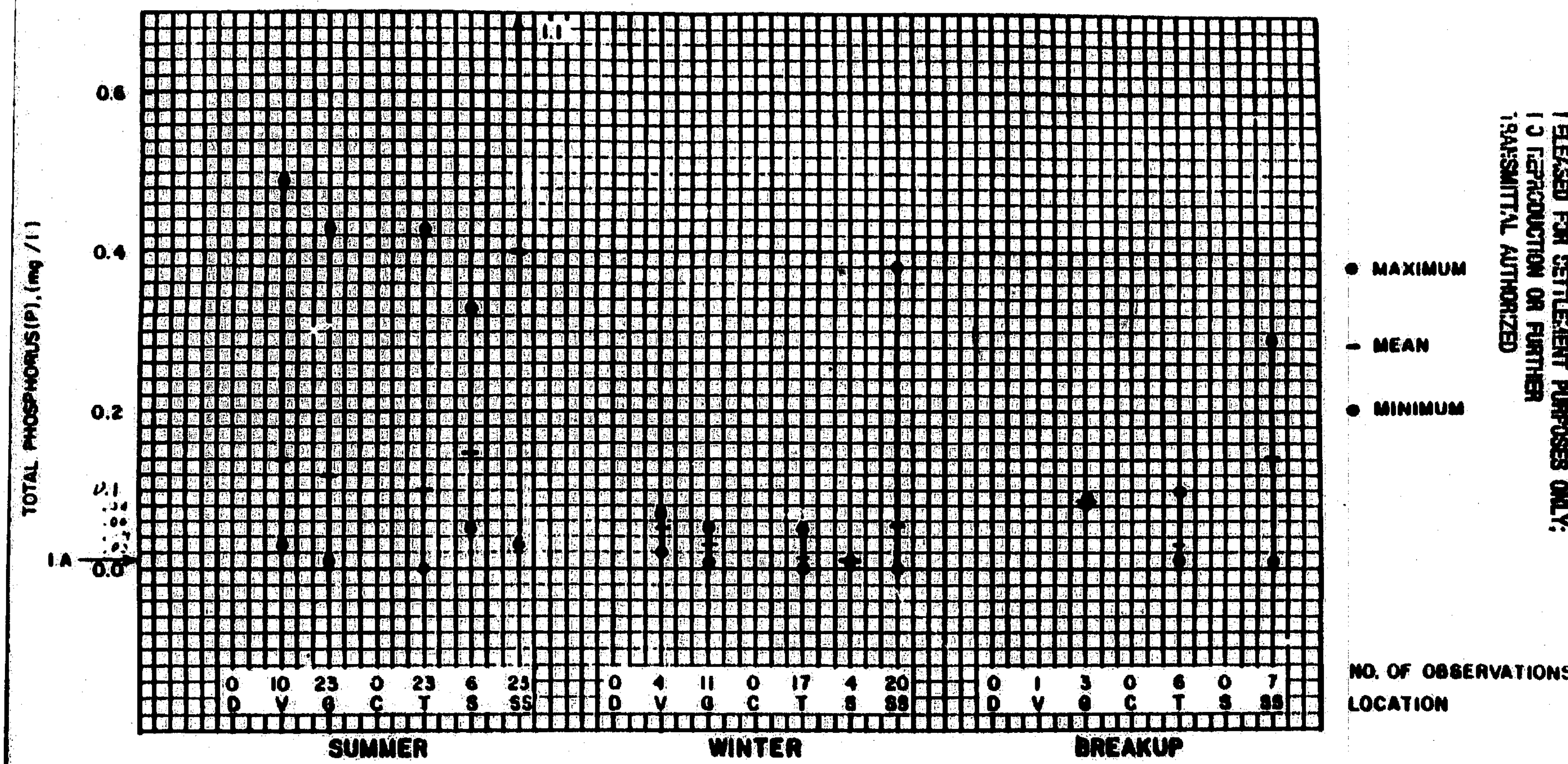
SUSITNA HYDROELECTRIC PROJECT
GENERAL RANGES OF TOTAL PHOSPHORUS AND TOTAL
NITROGEN WHICH ARE RELATIVELY CHARACTERISTIC OF
DIFFERENT TROPHIC CATEGORIES IN RELATIVELY
CLEAR LAKES AND RESERVOIRS

Trophic Type	Total P(ug/l)	Total N (ug/l)
Ultra-oligotrophic	< 5	< 1-250
Oligotrophic	5-10	
Oligo-mesotrophic	< 10	250-600
Mesotrophic	10-30	
Meso-eutrophic	10-30	500-1,100
Eutrophic	10-30	
Hypereutrophic	30- > 5,000	500-15,000

Source: Adopted from Wetzel (1975)

Although concentrations of total nitrogen and phosphorus which are generally representative of any given trophic status of subarctic rivers have not been established, it is reasonable to assume that concentrations generally accepted as indicators of lake trophic status, and possibly even lower concentrations, would be applicable to north temperate or subarctic rivers. Under such an assumption, concentrations of macronutrients in the Susitna River would not appear to be limiting to aquatic primary productivity under present environmental conditions during summer, winter or breakup time periods (See Figures 1 and 2).

<u>Anticipated With-Project Conditions - Reservoirs</u>. Construction and operation of the proposed project will produce a reservoir habitat in which phosphorus and nitrogen are both added to and removed from the impounded river water. Additions of phosphorus and nitrogen to the proposed reservoirs are expected to occur primarily due to:



D-DENALI V-VEE CANYON G-GOLD CREEK C-CHULITNA T-TALKEETNA S-SUNSHINE SS-SUSITNA STATION

NOTES:

1.A. CRITERION: LESS THAN 0.01 mg./l. FOR ELEMENTAL PHOSPHORUS (EPA 1976).

1.B. ESTABLISHED TO PROTECT FRESHWATER AQUATIC ORGANISMS.

2. AT VEE CANYON, 4 SUMMER OBSERVATIONS, 2 WINTER OBSERVATIONS, AND THE 1 BREAKUP OBSERVATION WERE LESS THAN 0.05 mg./l.

3. AT GOLD CREEK, 6 SUMMER OBSERVATIONS, 3 WINTER OBSERVATIONS, AND 1 BREAKUP OBSERVATION WERE LESS THAN 0.05 mg./l.

4. AT SUNSHINE, 2 WINTER OBSERVATIONS WERE LESS THAN 0.01 mg./l.

5. AT SUSITNA STATION, 2 WINTER OBSERVATIONS WERE LESS THAN 0.01 mg./l.

FIGURE 1

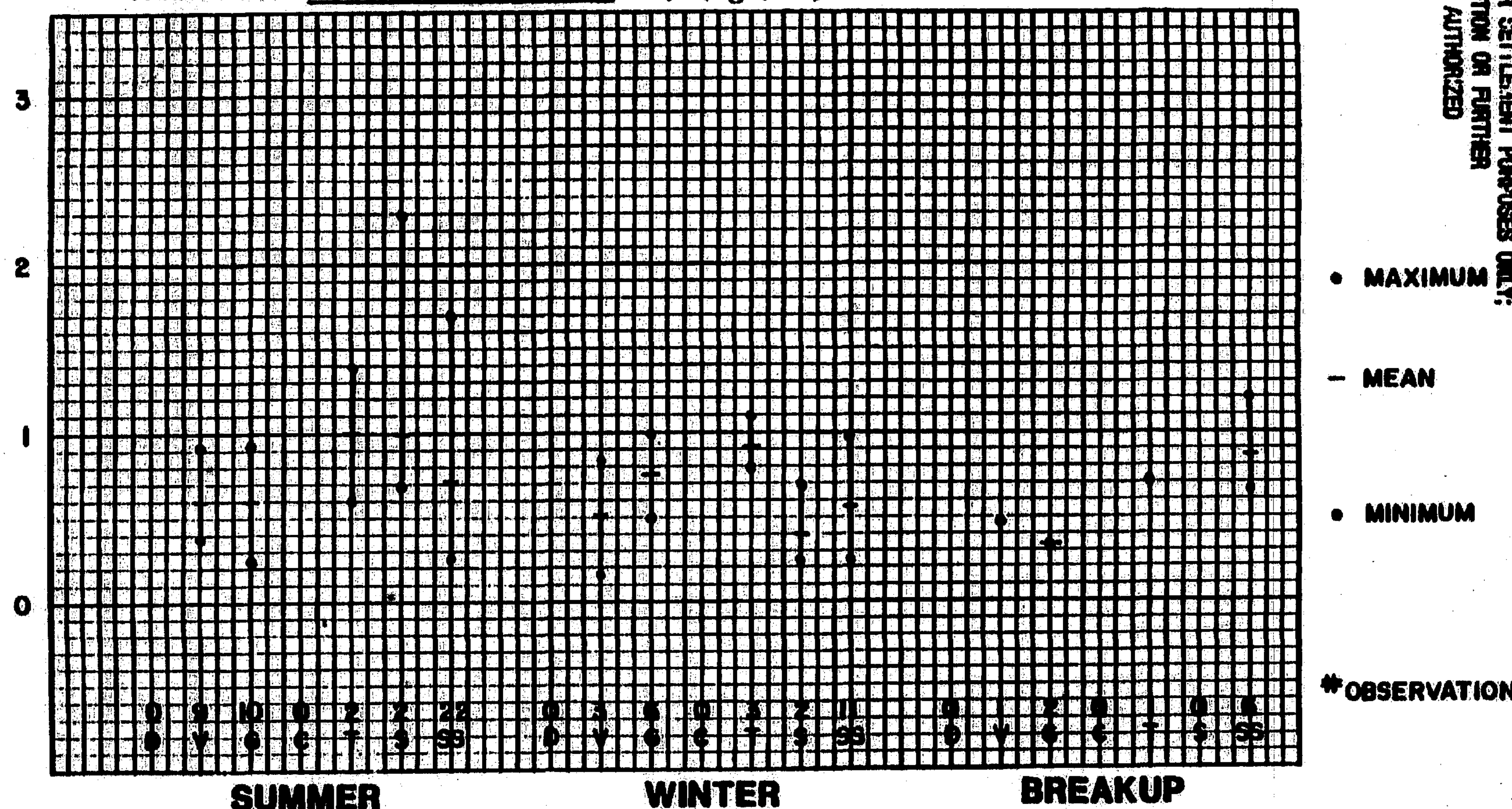
SUSITNA HYDROELECTRIC PROJECT

DATA SUMMARY - TOTAL PHOSPHORUS

URCE: USGS AND R&M

Source: APA 1983

PARAMETER: TOTAL NITROGEN, as N, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

No criterion established

FIGURE 2

SUSITNA HYDROELECTRIC PROJECT

DATA SUMMARY - TOTAL NITROGEN

Source: Peterson et al 1982

- o Mainstem river, tributary and groundwater influents
- o Surface runoff from eroding reservoir sidewalls and reservoir drawdown zones
- o Liberation of nutrients due to microbial decay of inundated organic material
- o Leaching of nutrients from newly inundated soils by chemical and biochemical processes
- o Treated secondary sewage effluents from construction-related facilities
- o Particulate fallout from atmospheric sources
- o Direct precipitation in the form of rain and snow

Substantial losses of macronutrients which enter the project reservoirs will be expected to occur. The majority of phosphorus atoms entering the project reservoirs are expected to precipitate out with the sediment particles on which they arrive and to remain permanently stored on the reservoir bottom. Microbial denitrification activity and precipitation of nitrogen compounds attached to particulates will be expected to remove some of the nitrogen added to the reservoirs. However, nitrogen fixation by aquatic microbes may add small quantities of biologically available nitrogen compounds to the reservoirs. Overall, the reservoirs are expected to act as nutrient sinks, and phosphorus and nitrogen exports to downstream areas should be reduced (Hannan 1979, Wetzel 1975).

Expected Reservoir Trophic Status. The present state of knowledge of subarctic reservoir limnology indicates that both project reservoirs will be classifiable as having uproductive or extremely unproductive trophic states. The major factors limiting the aquatic primary productivity of both project reservoirs are not expected to be nitrogen or phosphorus supplies, but rather low light conditions (due to turbidity and to ice and snow cover), cold temperatures, lack of any substantial littoral zone, and large drawdown zones due to project operations.

Organic material recruited from terrestrial sources is not expected to add substantial amounts of readily usable organic matter to the reservoirs' detritus food base and it may even depress the potential primary production (Jackson and Hecky 1980). The relatively short bulk residence time estimated for the reservoir waters and the relatively nonreactive nature of most of the influent organic material indicates that little chemically or biochemically mediated change in terrestrially produced organic material will occur before it is discharged from the reservoirs. Thus the project reservoirs will not be expected to contribute large amounts of high quality organic food materials to downstream riverine habitats.

The project reservoirs, like most reservoirs around the world, will be expected to go through a mild "trophic upsurge" period after filling, characterized by slight increases in biologically available phosphorus, nitrogen, organic detritus and suspended sediments (Grimard and Jones 1982, Therien, et al. 1982, Ostrofsky and Duthie 1980, Jackson and Hecky 1980). Both reservoirs are expected to experience slight oxygen declines in their deeper zones, especially during winter stratification. Both reservoirs are expected to have relatively low rates of biologically mediated nutrient flow during their entire lifetimes, and are expected to support only minimal bacteria, fungi, phytoplankton, zooplankton, and fish populations (Lloyd 1985, J. Koenings, ADF&G, pers. comm).

<u>Anticipated With-Project Conditions: Riverine Habitats Downstream</u>

With-project conditions in the mainstem and peripheral habitats directly affected by mainstem flows from May to September are expected to be slightly more favorable to primary productivity than preproject conditions. Several characteristics thought to severely limit primary productivity (substrate scour, substrate instability, streambed sedimentation by fine particles, high turbidity, high flow variability) are expected to have less negative influence on aquatic primary productivity by periphyton under with-project summer conditions.

Regulation of river flows to provide lower than natural water stages during summer may also prevent highly turbid mainstem waters from reducing the aquatic periphyton productivity of many clear, running water habitats peripheral to the mainstem. Any enhancement of primary production in peripheral riverine habitats during summer may serve to enhance the trophic status and biological productivity at all trophic levels of the Middle river reach.

Downstream Nutrients Flow. The total amount of phosphorus transported to downstream riverine habitats will undoubtedly be reduced, but the relative concentration of phosphorus per unit weight of suspended sediment will probably be increased by project operations. This phenomenon is expected to occur because the smaller average size of suspended particulates discharged from the Project should have a much larger ratio of surface area to weight compared to preproject suspended sediments, and because phosphorus is frequently complexed to the surfaces of suspended particles (Schreiber and Rausch 1979).

Although the concentration of nitrogen may decrease during passage through the project reservoirs, additional sources of nitrogen are expected to be added to riverine habitats downstream of the project by tributary and groundwater influents, and by organic detritus derived from the terrestrial environment. Riparian vegetation, especially alder (*Alnus sp.*), is an excellent and well recognized source of fixed nitrogen for nearby aquatic environments (Wetzel 1975, Livingston 1963), and alder is a common component of the riparian vegetation along the Susitna River.

Trophic Status and Fisheries Effects Summary. The trophic status of both project reservoirs is expected to be classified as oligotrophic (i.e. a low rate of biological productivity at all trophic levels) or even ultra-oligotrophic for the lifetime of the project. Project-induced changes in nitrogen and phosphorus concentrations in the reservoirs are not expected to be sufficient to alter their relative importance in the hierarchy of factors which will act to limit aquatic primary productivity (i.e. light, temperature, hydraulic residence time, etc.).

The trophic status of glacial streams and rivers is usually relatively impoverished (Lloyd 1985, Milner 1983, Steffan 1971, Van Stappen 1984, Ward, et al. 1982), as are streams receiving particulate placer mine wastes (Lloyd 1985, Van Nieuwenhuyse 1983).

The trophic status of the Middle River mainstem is presumed to be relatively impoverished at present, especially relative to non-glacial rivers at the same latitude. Project-induced changes in macronutrients are not expected to change the Middle River trophic status. Periodic high turbidity and suspended sediment levels presently act to limit Middle river aquatic productivity at all trophic levels. Chronic, moderate to high turbidity and suspended sediment levels, expected under with-project conditions, are expected to continue to limit aquatic productivity at all trophic levels and in all habitats of the river carrying turbid mainstem flows. Although mainstem aquatic productivity is still expected to be strongly limited by the projected with-project suspended sediment regime, conditions for attached algal productivity on the margins of the turbid mainstem may be improved under with-project conditions in areas where sunlight can penetrate to stable streambed substrate. A somewhat analogous situation has been observed in the chronically turbid Kasilof River of the Kenai peninsula. Peripheral riverine habitats that may be inundated less often by mainstem flows under with-project conditions are expected to maintain or increase their aquatic productivity relative to natural conditions.

<u>Mitigation Measures Endorsed by the Alaska Power Authority</u>

No mitigation measures have been proposed regarding this issue. None are expected to be needed.

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