# PRE-AUTHORIZATION ASSESSMENT

# OF THE

# SUSITNA RIVER HYDROELECTRIC PROJECTS:

## PRELIMINARY INVESTIGATIONS OF
## WATER QUALITY AND
## AQUATIC SPECIES COMPOSITION

SPORT FISH SECTION

BY
JAMES C. RIIS
FISHERIES BIOLOGIST

ALASKA DEPARTMENT OF FISH AND GAME
SPORT FISH DIVISION
ANCHORAGE

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## ABSTRACT

Biological investigations of the Susitna River and selected tributaries were conducted from February 10, 1975 to September 30, 1975 to obtain baseline data regarding indigenous fish populations, available aquatic habitat, and water quality which will aid in the definition of biological areas of concern requiring additional study prior to authorization of hydroelectric development by the U. S. Army Corp of Engineers.


## INTRODUCTION

Anadromous fish stocks of Cook Inlet and the Susitna River drainage, the largest freshwater system in Cook Inlet, have historically been of great value to the economy of Southcentral Alaska.

Commercial fishing has been the principle use of the anadromous fish resource, but in recent years, both anadromous and resident freshwater fish species indigenous to Upper Cook Inlet and the Susitna River system have become increasingly important to the recreational user.

The direct cumulative value to recreational and commercial fishermen, and indirect values to the many and varied supportive services and communities deriving benefit, makes the fishery resources of the Susitna River an extremely valuable resource.

The salmon stocks utilizing the Susitna River drainage, particularly the chinook (*Oncorhynchus tshawytscha*), and coho salmon, (*O. kisutch*), are currently at depressed levels. Chinook salmon stocks have been the target of extensive commercial and recreational fishing closures since the early 1960's. Management of these stocks is currently at a most important, if not critical, stage. The proposed hydroelectric development of the Susitna River basin will have a number of identifiable, and currently undefined, effects upon the existing quality of water and aquatic habitat necessary for perpetuation of the anadromous and resident fish species.

The U. S. Army Corp of Engineers has stated downstream Susitna River flows will be significantly altered by regulation, existing seasonal patterns of silt and sediment transport will be different, stream temperatures and water quality parameters may be affected, and 50,500 acres, including 82 river miles, of natural stream will be impounded by the Devil-Watana dam impoundments.

The United States Fish and Wildlife Service, pursuant to provisions in the Fish and Wildlife Coordination Act and the "Cooperative Agreement between the Service and the State of Alaska, Department of Fish and Game" provided funding to the Sport Fish Division (Alaska Department of Fish & Game) in the amount of $8,000 during the period July 1, 1974 to June 30, 1975, and $16,000 during the period July 1, 1975 and June 30, 1976 for biological surveys and studies of the Susitna River basin.

With the available funds study objectives were to: 1) determine resident and anadromous sport fish species present and their distribution in the mainstem Susitna River, its tributaries, and peripheral slough areas; 2) measure chemical, physical, and biological parameters associated with the mainstem and important tributaries; 3) determine the most acceptable sampling techniques for the highly variable conditions existing in the Susitna River; and 4) define future studies required to fully identify the impacts and effects of hydroelectric development upon the Susitna River fishery resource. Study results are discussed in the following text, conclusions presented where possible, and recommendations made for further definitive biological investigations.

## STUDY AREA

The hydroelectric project under study will have major effects upon the Susitna River which drains an area of approximately 20,000 square miles. That portion of the river above the proposed Devil Canyon dam site drains approximately 6,000 square miles. The Susitna River basin is bounded on the east by the Copper River plateau and the Talkeetna Mountains, on the west and north by the mountains of the Alaska Range, and on the south by the Talkeetna Mountains and Cook Inlet.

The Maclaren, the Oshetna, and the Tyone rivers are the largest tributaries of the Susitna River above Devil Canyon. The Tyone River is the only one of the three which is non-glacial. There are numerous smaller tributaries which fluctuate greatly in seasonal rate of flow, but remain silt free or clear throughout the year.

The Susitna River tributaries below Devil Canyon, for the most part, originate in the surrounding mountains. The Chulitna, Talkeetna, and Yentna are the major tributaries, all of which are glacial. Clear water tributaries below Devil Canyon collectively exert considerable influence and are the major fish producing waters in this system. The major non-glacial tributaries include: Portage Creek, Indian River, Montana Creek, Goose Creek, Sheep Creek, Little Willow and Willow Creeks, Deshka River, and Alexander Creek.

The work described in this report was conducted on the Susitna River primarily from Portage Creek (located approximately three miles below Devil Canyon) downstream to the mouth of the Yentna River.

One field trip into the upstream impoundment area during late winter was accomplished to attempt the capture of mainstem residing fish. Time and budgetary restraints precluded additional field studies in the upstream impoundment area during the 1975 summer field season.

## MATERIALS AND METHODS

Travel to and from sampling sites during the winter was accomplished via a fixed wing aircraft on skis. A 20-foot riverboat, powered by an 85 horsepower outboard, was used to travel on the Susitna River during the ice-free months. Chinook salmon escapement counts were made with the use of fixed wing aircraft (supercub), Bell-47 helicopter, and ground surveys.

Adult and rearing salmonids were collected with gill nets, minnow traps, set lines, seines, dip nets, rod and reel, and electroshocker.

Benthic invertebrates were collected with artificial substrates which consisted of wire vegetable baskets lined with nylon screen cloth and filled with rocks taken from the stream bed. The baskets were left in the water for a period of approximately 30 days. A hand screen was also used to collect benthos samples.

"In situ" analysis of alkalinity as $CaCO_3$, total hardness and pH on samples from the Susitna River and the seven east side tributaries below the Parks Highway bridge was performed at biweekly intervals, using a Hach chemical kit, Model Al-36B. Samples were collected approximately one to three meters from the bank, at or near the surface. Temperatures at sample collection points were recorded from just below the surface.

Conductivity and turbidity samples for the Susitna River and the seven east side tributaries were collected at the same time as the above samples, placed in one-liter polyethylene bottles, and analyzed at the U.S. Geological

Survey, Division of Water Resources Laboratory, using the Hach 2100A turbidmeter and a Beckman RB3 conductivity meter. All conductivity measurements were standardized at 25°C.

All thermographic data collected from the Susitna River and two tributaries were gathered using a Ryan thermograph model D-30, which was reset every 30 days. Temperatures were recorded in Fahrenheit on thermograph tape.

The Susitna River water quality parameters from upstream of the Parks Highway bridge were gathered using a Hach chemical kit model DR-EL/2. Two sample sites were used; one approximately 50 meters above Portage Creek and the other about 150 meters above Gold Creek. All samples were collected approximately five to ten meters from the bank, at or near the surface. Restricted access and limited time prohibited more extensive data collection during the field season.

The Susitna River sloughs and tributaries between Devil Canyon and Talkeetna were also analyzed with Hach chemical kits, model DR-EL/2 and Al-36B. All measurements were made approximately two to five meters from the bank and 50 meters from the mouths of the sloughs, at or near the surface. Temperatures were recorded in Fahrenheit to the nearest whole degree and later converted to the nearest 0.5° centigrade.

## RESULTS AND DISCUSSION

### FISHERIES

Interviews with staff members provide evidence of resident and rearing anadromous salmonid fishes migrating downstream from the tributaries into the mainstem Susitna River during the fall, and back upstream into the tributaries during the spring. A hypothesis was formulated that this migration occurs in part because of severe icing conditions and reduced flows in the tributaries during the winter months, which may result in 1) territorial displacement of certain species and sizes of fish, and 2) winter habitat preferences, i.e., Arctic grayling (*Thymallus articus*) appear to prefer larger bodies of water during the winter. While flows are also greatly reduced in the Susitna River during the winter, substantial space and, in general, a higher quality environment may be provided for aquatic species. Concern about this undefined migration is the basis for designing a biological and limnological study that included the tributaries as well as the mainstem Susitna River.

The Commercial Fish Division initiated studies in 1974 on the sloughs and mainstem Susitna River from the Chulitna River upstream to Devil Canyon (Barrett, 1974). This work was continued and expanded into the Talkeetna and Chulitna Rivers (Friese, 1975). It was not the intent of the Sport Fish Division to duplicate work conducted by Barrett and Friese, but to supplement it with limnological data and to further study resident species and habitat areas not included in their prior and on-going studies.

The numbers of fish and/or species collected during the fishery studies are not statistically significant in that the sample sizes or numbers collected are inadequate to define specific population sizes. The samples obtained are important, however, as they document the presence of a number of fish species, seasonally, in both the Susitna River mainstem and tributary waters.

The seasonal fisheries investigations have provided considerable insight into 1) the extreme difficulty in assessing either summer or winter mainstem Susitna River fish stocks due to high flows carrying debris and extreme ice and snow conditions respectively, and 2) future study requirements necessary to determine the significance and extent of the intra-system migrational phenomenon exhibited by resident and anadromous fish species.

Winter:

Winter investigations to document the presence of rearing salmonid fry in the mainstem Susitna River began February 10, 1975 and continued through April, 1975. The mainstem Susitna River was sampled with minnow traps, gill nets, and electroshocker at 11 locations between Susitna station and the Parks Highway bridge, a distance of approximately 50 miles, and two locations above Devil Canyon. Studies conducted during March and April, 1975 documented rearing coho, chinook, chum, (O. keta), grayling, sculpin (Cottus cognatus), burbot (Lota lota), whitefish (Coregonus sp.) and sucker (Catostomus catostomus) over-wintering in the mainstem Susitna River downstream from the Parks Highway bridge (Table 1). The sampling sites and distribution findings are also plotted on aerial photographs in the appendix of this report.

Minnow traps were installed in Montana Creek, near the three forks, and Willow Creek, under the highway bridge, during the first week of April, 1975 when water with enough depth under the ice could be found to effectively fish a trap. Prior to this date, difficulty was experienced in finding sufficient water levels under the ice to set minnow traps in the tributaries. Five Dolly Varden (Salvelinus malma) ranging from 85 mm to 142 mm were trapped in Willow Creek and four chinook fry ranging from 48 mm to 74 mm were captured in Montana Creek.

Minnow traps and gill nets were installed in the mainstem Susitna River above Devil Canyon from April 21 to April 24, 1975. A gill net and 12 minnow traps were stationed 100 yards downstream from Jay Creek for 24 hours with negative results. Six traps and one gill net were placed 100 yards downstream from Deadman Creek for 12 hours, also without capturing fish.

Table 1. Results of Winter Fry Sampling in Mainstem Susitna River, Devil's Canyon Project, 1975.

| Date | Location | Sampling Method | Hours Sampled | Number and Species Captured |
|---|---|---|---|---|
| Feb. 10 | Directly off mouth of Sheep Creek | 6 Minnow Traps | 24 | 0 |
| Mar. 18 | 2.3 miles south of Montana Creek | 6 Minnow Traps | 72 | 2 SS<br>1 S |
| | 2 miles south of Kashwitna River | 6 Minnow Traps | 72 | 1 SS |
| Mar. 19 | Directly off mouth of Deshka River | 12 Minnow Traps<br>8 Set Lines | 48<br>48 | 0 |
| Mar. 25 | Directly off mouth Montana Creek | 4 Minnow Traps | 48 | 0 |
| | Directly off mouth Caswell Creek | 6 Minnow Traps | 48 | 0 |
| Apr. 10 | 2.2 miles north of Willow Creek | 25 Minnow Traps | 192 | 3 KS |
| Apr. 23 | 100 yards down-stream Jay Creek | 12 Minnow Traps<br>1 Gill Net | 48<br>48 | 0<br>0 |
| | 100 yards down-stream Deadman Cr. | 6 Minnow Traps<br>1 Gill Net | 24<br>24 | 0<br>0 |
| Apr. 28 | 50 yards upstream Montana Cr. mouth | Electroshocker | | 7 CS |
| Apr. 30 | Susitna Station | Electroshocker | | 1 GR<br>1 WF<br>1 BB |
| | 3 miles south of Parks Hwy. Bridge | Electroshocker | | 1 S<br>1 SC |

*SS - coho salmon, KS-chinook salmon, CS-chum salmon, S-sucker, GR-grayling, WF-whitefish, BB-burbot, SC-sculpin

The most successful winter sampling technique for the Susitna River appeared to be the backpack electroshocker. However, this technique is limited to late winter after certain areas become ice free and before high silt laden flows begin. Minnow traps were not as effective during the winter as during the summer because fish are lethargic in cold water and may not enter the trap as readily. Thus, samples collected may not be indicative of fish numbers present at any given site. There is a need for testing of more effective trapping or fish collecting devices during the winter season.

Summer:

Summer investigations of fish species inhabiting the mainstem Susitna River began June 17, 1975. Following a reconnaissance and general familiarization trip to identify potential sampling sites, a base camp was established on the Deshka River near the confluence with the Susitna River. Beginning the week of June 23, 1975, a crew of two biologists spent four days each week through July, 1975 sampling for rearing fish in the mainstem Susitna River from the Parks Highway bridge downstream. The results of this five week sampling period indicate the following: 1) Anadromous salmon fry, rainbow trout, and grayling are scarce in the silt laden water of the mainstem Susitna River during this time of year and, 2) whitefish, sculpin, and suckers were commonly captured in the turbid Susitna River. Two coho fry, 50 and 69 mm in length, were captured at a sandbar near the mouth of Sheep Creek and two chinook fry, 59 and 60 mm in length, were collected downstream of Willow Creek. With the exception of these four fry, no other salmon fry, rainbow trout, or grayling were captured in the Susitna River when the silt load was high. The reasons for the scarcity of salmonids in the mainstem

Susitna could be attributed to a preference for clearwater by these species and the outmigration of chinook and coho salmon smolts, pink and chum salmon fry before sampling efforts were initiated. The only sampling techniques which proved feasible for collecting fry during the high flow period of the Susitna River were hand seines and dip nets. Gill nets were ineffective because of drifting debris in the river during the high summer flows. The backpack electroshocker is also unsatisfactory when turbidity is high because affected fish cannot be seen or captured.

On August 6, 1975 the base camp was moved from the Deshka River to Gold Creek. Sloughs in the Gold Creek area and upstream to Devil Canyon were sampled for fish in conjunction with the limnological study. Results of the fish collections are shown in Table 2. Seining was conducted at four sites in the mainstem Susitna between Gold Creek at Portage Creek with negative results.

Winter and summer observations of rearing fry in the Susitna River lend support to the hypothesis that salmonids migrate downstream from tributaries during the fall to overwinter in the Susitna and return to the tributaries during the spring.

Arctic grayling are the most common resident recreationally important species indigenous to the Susitna River Basin. Grayling occur in the majority of fresh water tributaries of the Susitna River, both upstream and downstream of the Devil's Canyon Dam site, and were documented specifically in those immediate downstream tributaries of Portage and Fourth of July creeks, and Indian River.

An age-length frequency of 33 grayling collected from Portage Creek is presented in Tables 3 and 4 as a general indication of grayling size and age composition.

Table 2. Fish Collected in Sloughs Between Talkeetna and Portage Creek, Devil's Canyon Project, 1975.

| Date | Slough Number | Species Collected | Number Collected | Fish Size (mm) |
|---|---|---|---|---|
| Aug. 13 | 11 | Chinook | 1 | 53 |
| | | Grayling | 1 | 56 |
| | | Sucker | 1 | 49 |
| | 13 | Grayling | 1 | 46 |
| | | Whitefish | 1 | 37 |
| Aug. 14 | 15 | Chinook | 4 | 43-53 |
| | 16 | Whitefish | 1 | 50 |
| | 19 | Whitefish | 5 | 39-45 |
| Aug. 15 | 20 | Chinook | 10 | 52-66 |
| | | Grayling | 2 | 43,62 |
| | 21 | Grayling | 2 | 56,58 |
| | | Whitefish | 5 | 39-48 |
| Aug. 19 | 17 | Coho | 2 | 39,48 |
| | | Grayling | 4 | 33-65 |
| | | Burbot | 1 | 59 |
| | | Sucker | 1 | 52 |
| | 18 | Chinook | 4 | 51-55 |
| | | Coho | 4 | 39-54 |
| | | Grayling | 1 | 53 |
| | | Whitefish | 3 | 48-53 |
| | | Burbot | 1 | 49 |
| | | Sucker | 2 | 47,54 |

Table 3. Age Analysis of Grayling Sampled from Portage Creek, Devil's Canyon Project, August 12, 1975.

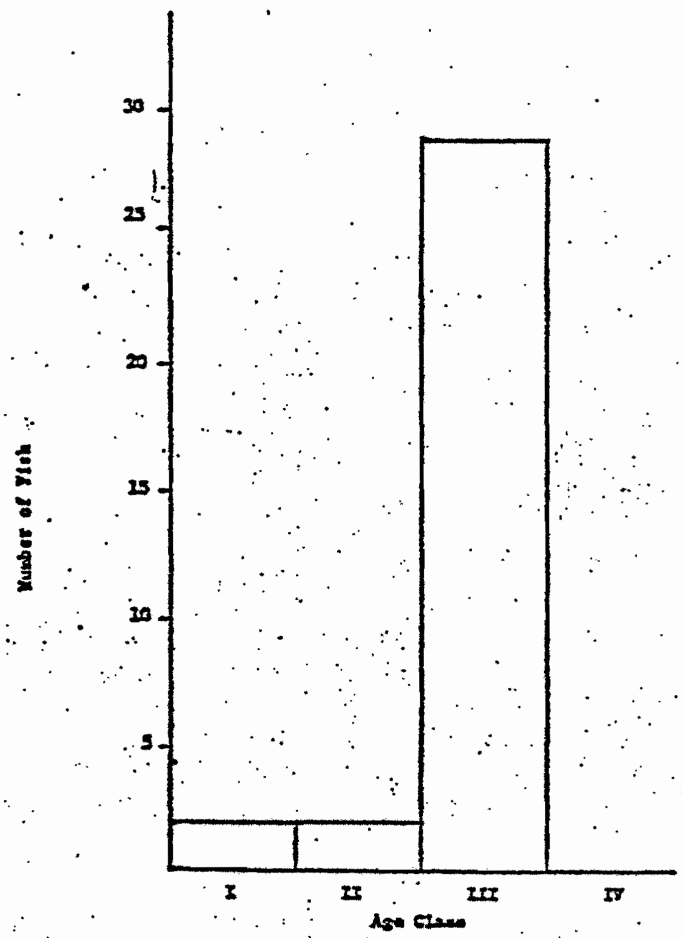
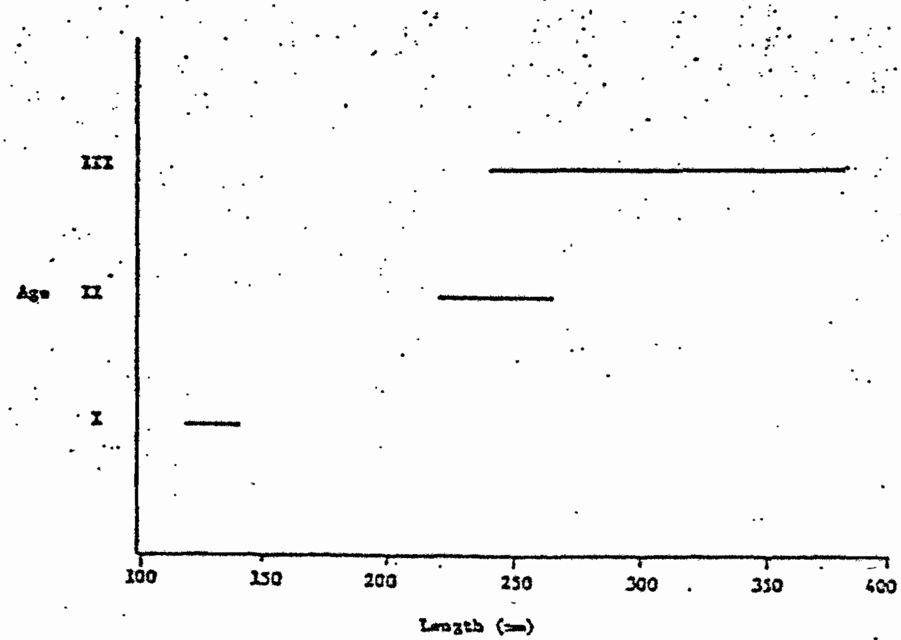



Table 4. Length Variation of Grayling Sampled from Portage Creek, Devil's Canyon Project, August 12, 1975.



Arctic grayling exhibit intra-system migrations and a need exists for comprehensive studies of these seasonal movements and their significance to determine the overall effects of the potential loss of any of their aquatic habitat.

All five species of salmon utilize the Susitna River and all are equally important. The Sport Fish Division recognizes the chinook and coho salmon as having the greatest potential for satisfying future recreational needs. The Commercial Fish Division studied pink, chum, and sockeye (O. nerka) salmon and reported on these species in their section.

A number of key tributaries of the Susitna River were selected for chinook salmon escapement during 1975 (Tables 5 and 6). It should be noted these escapement counts do not constitute total numbers, but indicate relative abundance and depict the importance of the Susitna River as an avenue of access. Upstream impoundment may affect the migration of fish into key spawning streams. Prior to impoundment the magnitude of anadromous salmon escapements should be enumerated totally.

## Benthos

Species diversity has become widely used as an indicator of water quality. Diversity indices may be applied to any biotic community but have had widest application with the benthos. Such indices relate the number of kinds of organisms to the total number of organisms and to the number of individuals of each kind. Undisturbed natural communities are assumed to have a high diversity; that is, a relatively large number of species, with no species having disproportionately large numbers of individuals, (Lind, 1974). Diversity is considered to be a sensitive bioassay for assessing

Table 5. West Side Susitna River Chinook Salmon Escapement, Devil's Canyon Project, 1975.

| Stream | Helicopter Counts |
|---|---|
| Deshka River System | 4,737 |
| Alexander Creek System | 1,878 |
| Lake Creek System* | 281 |
| Talachulitna River * | 120 |
| Peters Creek* | 14 |
| Canyon Creek* | 2 |
| Total | 7,032 |

Table 6. East Side Susitna River Chinook Salmon Escapement, Devil's Canyon Project, 1975.

| Stream | Helicopter Aerial Counts | Fixed Wing Aerial Counts | Ground Counts |
|---|---|---|---|
| Willow Creek | - | - | 177 |
| Little Willow Creek | 103 | - | - |
| Kashwitna River | 33 | - | - |
| Sheep Creek | - | 42 | - |
| Goose Creek | - | 13 | - |
| Montana Creek | - | - | 229 |
| Chunilna Creek* | 101 | - | - |
| East Fork Chulitna River* | - | 7 | - |
| Middle Fork Chulitna River* | - | 55 | - |
| Prairie Creek* | - | - | 369 |
| Indian River | - | 31 | - |
| Portage Creek | - | 32 | - |
| Total | 237 | 180 | 775 |
| Total All Counts | | | 1,192 |

*Not a direct tributary to Susitna River; however, salmon must use the Susitna as a pathway to arrive at these rivers.

environmental stress (Cantlon, 1969; Wilhm, 1970). The diversity of a community is a meaningful parameter which can be measured (Warren, 1971). Warren emphasized the importance of diversity in defining the environmental impacts of changes to a system. To properly assess impacts, a diversity index should be computed, using identical methodology, before, during, and after construction.

In order to use a species as an indicator organism, its environmental requirements must be reasonably well defined within rather narrow limits (McCoy, 1974). It has been demonstrated that presence of species in the orders Ephemeroptera and Plecoptera in streams indicate unpolluted waters. Members of both these orders were observed on rocks in the impoundment area of the Susitna River during the late winter field trip, April 21 through April 24, 1975 and downstream of Devil Canyon throughout the summer.

Benthic invertebrates were sampled during the summer season with eight artificial substrates (Tables 6 and 7). Substrates were placed in the mainstem Susitna River one mile upstream from the Deshka River, 100 yards upstream of Willow Creek, and immediately above Gold Creek. Waterfall Creek and Fourth of July Creek, which are clear water tributaries of the Susitna, were also sampled. All locations with the exception of Fourth of July Creek were sampled with two artificial substrates for a period of 30 days. Fourth of July Creek was sampled by hand holding a screen (36" x 36") and stirring the substrate immediately upstream. Aquatic insects collected in both the Susitna and tributaries are typical of clean cold water streams in Alaska. Due to the restricted time frame available for this study and report preparation, aquatic invertebrates are keyed only to family.

Table 7. Aquatic Invertebrates Collected in Clearwater Tributaries of the Susitna River, Devil Canyon Project, 1975.

| Location | Order | Family | No. | Collection Method | Collection Dates |
|---|---|---|---|---|---|
| Fourth of July Creek | Trichoptera | Sericostomatidae | 1 | Hand Screen | Aug 13 |
| | | Rhyacophilidae | 4 | | |
| | | Rhyacophilidae | 1 | | |
| | Dipteria | | 1 | | |
| | Plecoptera | Perlodidae | 5 | | |
| | | Perlodidae | 7 | | |
| | Ephemeroptera | Heptageniidae | 6 | | |
| | | Baetidae | 3 | | |
| | Turbellaria | | 1 | | |
| Waterfall Creek | Diptera | Type 1 | 6 | Artificial Substrate basket (2) | Aug 7 - Sep 7 |
| | | Type 2 | 4 | | |
| | | Type 3 | 1 | | |
| | | Type 4 | 10 | | |
| | | Type 5 | 2 | | |
| | | Type 6 | 3 | | |
| | Plecoptera | Perlodidae | 17 | | |
| | Ephemeroptera | Baetidae | 1 | | |
| | Oligochaeta | Type 1 | 13 | | |
| | | Type 2 | 1 | | |
| | Gastropoda | | 5 | | |

Table 8. Aquatic Invertebrates Collected in Susitna River, Devil Canyon Project, 1975.

| Location | Order | Family | No. | Collection Method | Collection Dates |
|---|---|---|---|---|---|
| Mainstem Susitna | Trichoptera | Rhyacophilidae | 1 | Artificial Sub- | Aug 7 - Sep 7 |
| Upstream from | Diptera | Type 1 | 3 | strate basket (2) | |
| Gold Creek | | Type 2 | 4 | | |
| | Plecoptera | Perlodidae | 1 | | |
| | | Perlodidae | 5 | | |
| | Ephemeroptera | Baetidae | 1 | | |
| | Olgochaeta | | 1 | | |
| Mainstem Susitna | Tricoptera | Sericostomatidae | 3 | Artificial Sub- | Jul 1 - Sep 1 |
| Upstream from | Diptera | | 2 | strate basket (2) | |
| Willow Creek | Ephemeroptera | Heptageniidae | 5 | | |
| | | Baetodae | 7 | | |
| | Plecoptera | Perlodidae | 8 | | |
| Mainstem Susitna | Tricoptera | Sericostomatidae | 1 | Artificial Sub- | Jul 1 - Aug 1 |
| Upstream from | Plecoptera | Perlodidae | 11 | strate basket (2) | |
| Deshka River | Ephemeroptera | Heptageniidae | 3 | | |

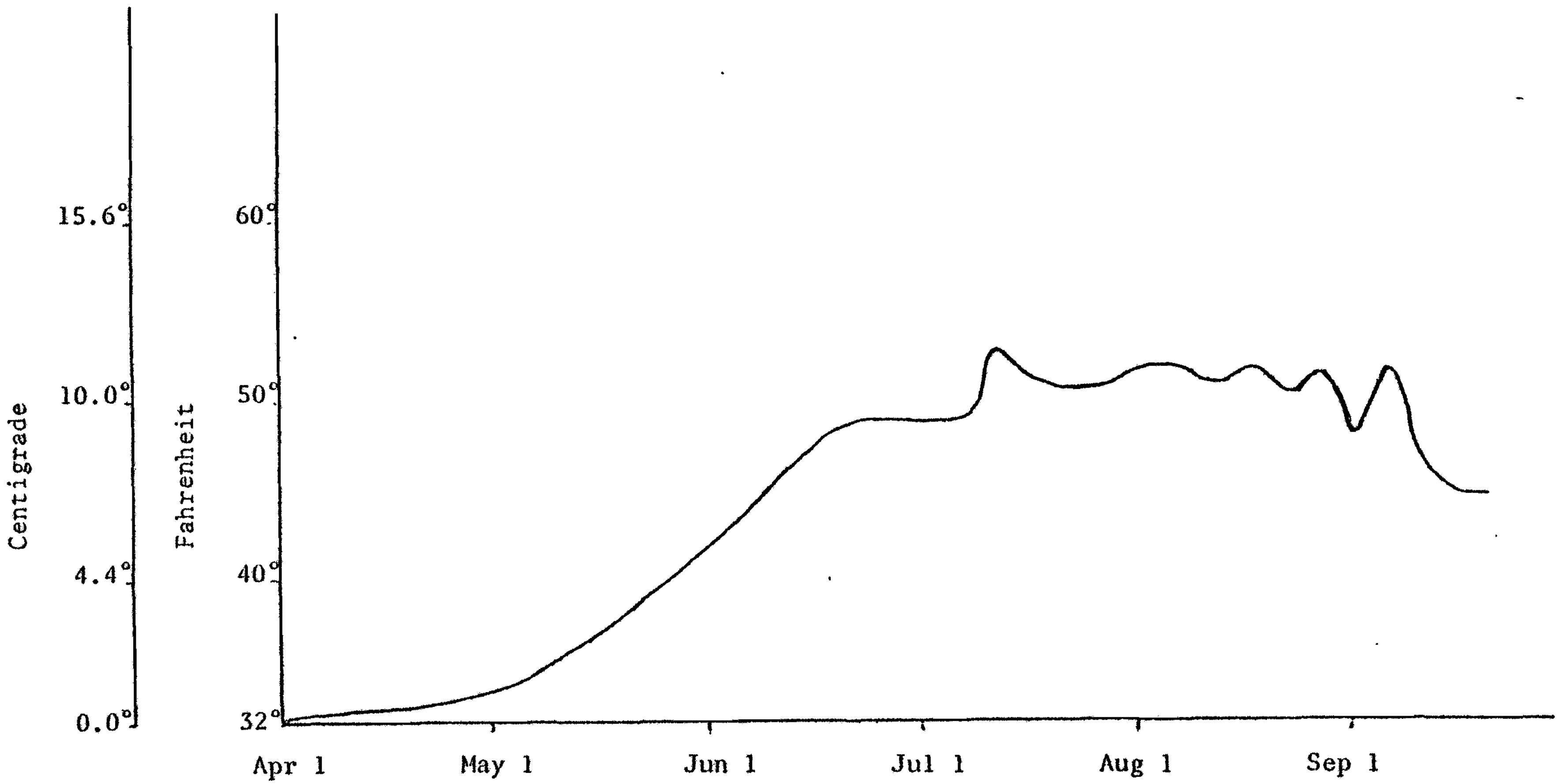
## Limnology

The limnological study was initiated March 26, 1975 by establishing sample sites on the Susitna River and all major east side tributaries from the Parks Highway Bridge downstream. Water samples were collected on a biweekly basis at the bridge crossings of each tributary. Parameters measured were water temperature, pH, turbidity, conductivity, total alkalinity, total hardness, and dissolved oxygen.

Temperatures were also monitored with Ryan Thermographs (Model D-30 °F) in the Susitna River, Birch Creek, and Willow Creek. It is interesting to note the similarity in temperature trends between the Susitna River and tributaries (Figures 1, 2, and 3). For example, both the Susitna River and Willow Creek measured 32° F. on April 1, 1975. A slow warming trend was observed in both rivers until May 14, 1975 when temperatures of both rivers were measured at approximately 34°F. A steady upward trend occurs after May 15 until the maximum temperature was reached in mid-July. The maximum water temperature in the Susitna River was 55.5° F. on July 12, 1975. Willow Creek exhibited a maximum of 56° F. during the period July 7 through July 10, 1975. Maximum and minimum daily water temperatures monitored by the thermographs are presented in Tables 9 and 10. The temperature remained relatively stable in both rivers between July 15 and August 30, 1975, fluctuating between 48° F. and 53° F. The water temperature began to decrease by September 5, 1975 and was 45° F. in both the Susitna River and Willow Creek on September 23, 1975 when the thermographs were removed.

East side tributaries of the Susitna River downstream from the Parks Highway Bridge do not have lake systems present, but are the result of surface and subsurface runoff from the surrounding mountains and foothills. Montana Creek, Sheep Creek, Goose Creek, Caswell Creek, Kashwitna River, and

Figure 1. Daily Water Temperatures (Monitored with a Ryan Thermograph) of the Susitna River Approximately Three Hundred Yards Downstream from the Parks Highway Bridge, Devils Canyon Project, June 20 to September 23, 1975.




Note: Temperatures taken prior to June 20th were with a thermometer on a bi-monthly basis.

Figure 2. Maximum Daily Water Temperatures (Monitored with a Ryan Thermograph) of Birch Creek Approximately Five Hundred Yards Upstream of the Alaska Railroad, Devil Canyon Project, April 10 to August 30, 1975.

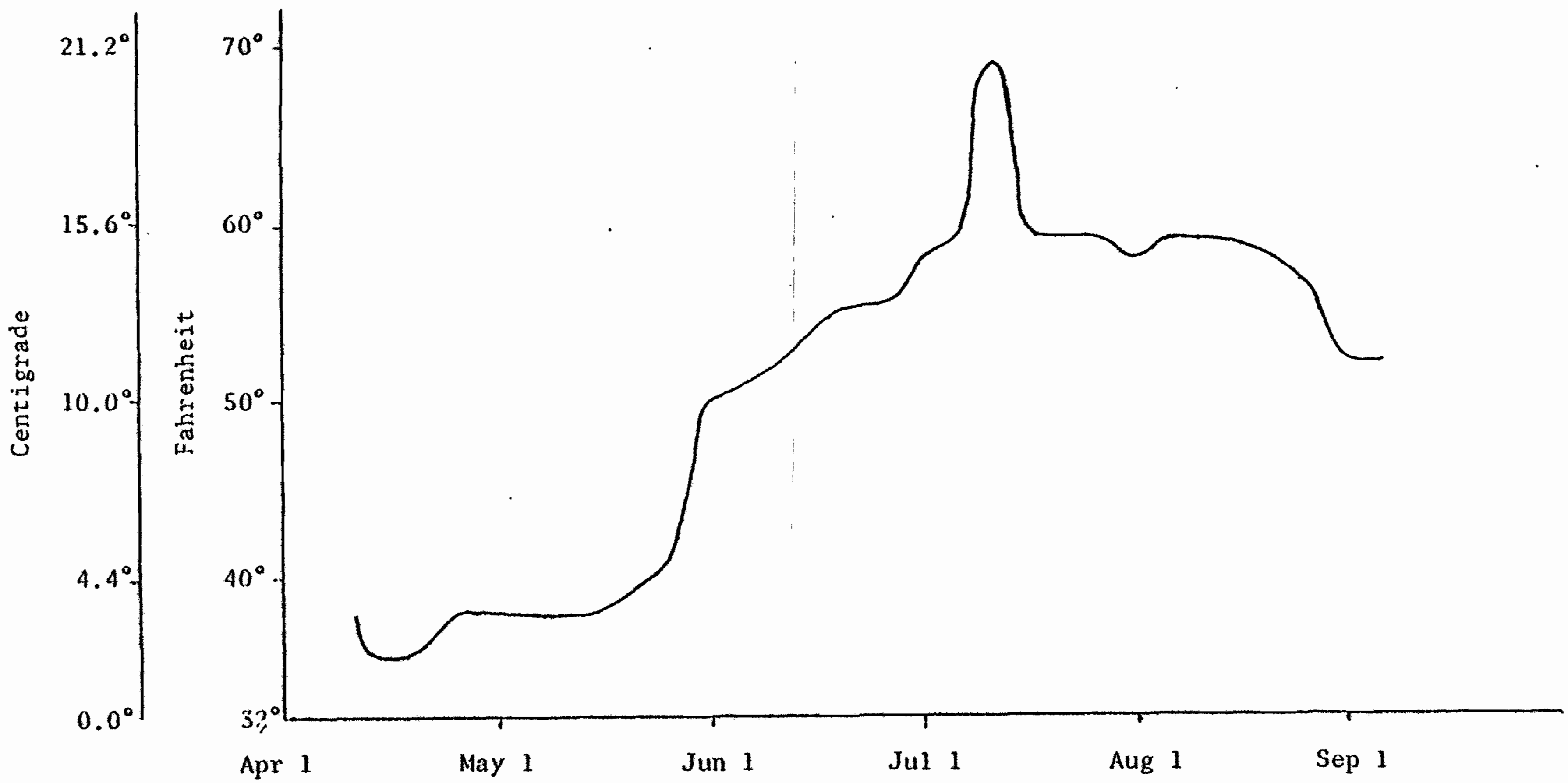


Figure 3. Maximum Daily Water Temperature (Monitored with a Ryan Thermograph) of Willow Creek Approximately Two Hundred Yards Upstream of the Confluence with Deception Creek, Devil Canyon Project, April 10 to September 23, 1975.

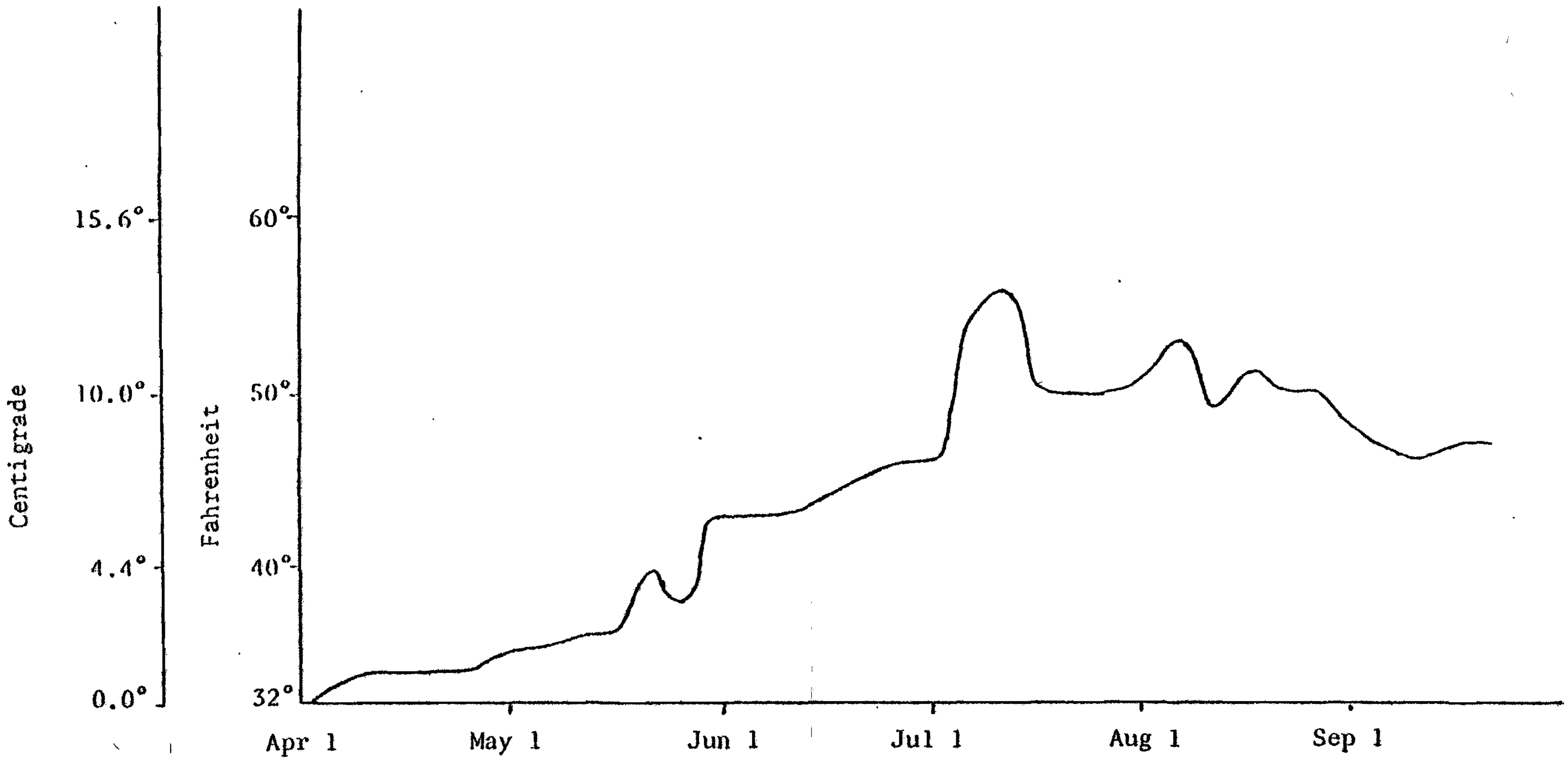


Table 9. Maximum and Minimum Daily Water Temperatures (°F-"Ryan" Thermograph, Model D-30) from the Susitna River at Parks Highway Bridge, Devil Canyon Project, 1975.

| Date | Temperature Max. | Temperature Min. | Date | Temperature Max. | Temperature Min. | Date | Temperature Max. | Temperature Min. |
|---|---|---|---|---|---|---|---|---|
| Jun 20 | 49.0 | - | Jul 22 | 51.5 | 51.0 | Aug 23 | 53.0 | - |
| 21 | 49.0 | - | 23 | 51.5 | - | 24 | 53.0 | 52.0 |
| 22 | 49.0 | 48.0 | 24 | 51.5 | - | 25 | 52.0 | - |
| 23 | 47.8 | 47.8 | 25 | 51.0 | - | 26 | 52.0 | - |
| 24 | 48.8 | 47.8 | 26 | 52.0 | 51.0 | 27 | 52.0 | - |
| 25 | 49.0 | - | 27 | 52.0 | - | 28 | 52.0 | 50.0 |
| 26 | 49.0 | - | 28 | 52.0 | 51.5 | 29 | 50.0 | 48.0 |
| 27 | 49.0 | - | 29 | 51.5 | - | 30 | 48.0 | - |
| 28 | 50.0 | 49.0 | 30 | 51.5 | 51.0 | 31 | 48.0 | - |
| 29 | 50.0 | - | 31 | 51.0 | - | Sep 1 | 48.0 | - |
| 30 | 50.0 | 49.0 | Aug 1 | 52.0 | 51.0 | 2 | 53.0 | 48.0 |
| Jul 1 | 49.0 | - | 2 | 52.0 | - | 3 | 53.0 | 49.0 |
| 2 | 49.0 | - | 3 | 52.0 | - | 4 | 52.0 | 48.0 |
| 3 | 49.0 | - | 4 | 52.0 | - | 5 | 52.0 | 49.0 |
| 4 | 49.0 | - | 5 | 52.0 | 51.0 | 6 | 50.0 | 48.0 |
| 5 | 49.0 | - | 6 | 51.0 | - | 7 | 48.0 | - |
| 6 | 50.0 | 49.0 | 7 | 51.0 | - | 8 | 48.0 | - |
| 7 | 51.0 | 50.0 | 8 | 51.0 | - | 9 | 47.5 | - |
| 8 | 52.0 | 51.0 | 9 | 51.0 | - | 10 | 47.0 | - |
| 9 | 54.0 | 52.0 | 10 | 51.0 | - | 11 | 47.0 | - |
| 10 | 55.0 | 54.0 | 11 | 51.0 | - | 12 | 47.0 | - |
| 11 | 55.0 | - | 12 | 52.0 | - | 13 | 46.0 | - |
| 12 | 55.5 | 54.0 | 13 | 52.0 | - | 14 | 46.0 | 45.0 |
| 13 | 54.0 | 53.0 | 14 | 52.0 | - | 15 | 45.0 | - |
| 14 | 53.0 | 51.5 | 15 | 52.0 | - | 16 | 45.0 | - |
| 15 | 51.7 | - | 16 | 52.0 | - | 17 | 45.0 | - |
| 16 | 51.7 | 50.5 | 17 | 52.0 | 51.0 | 18 | 45.0 | - |
| 17 | 52.0 | 51.0 | 18 | 50.5 | - | 19 | 45.0 | - |
| 18 | 52.0 | - | 19 | 50.5 | - | 20 | 45.0 | - |
| 19 | 52.0 | 51.0 | 20 | 50.5 | - | 21 | 45.0 | - |
| 20. | 51.0 | - | 21 | 50.5 | - | 22 | 45.0 | - |
| 21 | 51.0 | - | 22 | 53.0 | - | 23 | 45.0 | - |

TABLE 10. Maximum and Minimum Daily Water Temperatures (°F- Ryan Thermograph, Model D-30) from Willow Creek, Devil Canyon Project, 1975.

| Date | Temperature Max. | Min. | Date | Temperature Max. | Min. | Date | Temperature Max. | Min. |
|---|---|---|---|---|---|---|---|---|
| Apr 10 | 34.0 | - | Jun 5 | 43.0 | 37.0 | Jul 31 | 50.0 | - |
| 11 | 34.0 | - | 6 | 43.0 | 39.0 | Aug 1 | 51.0 | 50.0 |
| 12 | 34.0 | - | 7 | 44.0 | 38.0 | 2 | 52.0 | 51.0 |
| 13 | 34.0 | - | 8 | 44.0 | 39.0 | 3 | 52.0 | 51.0 |
| 14 | 34.0 | - | 9 | 44.0 | 38.0 | 4 | 53.0 | 51.0 |
| 15 | 34.0 | - | 10 | 43.0 | 38.0 | 5 | 53.0 | - |
| 16 | 34.0 | - | 11 | 43.0 | 39.0 | 6 | 51.0 | - |
| 17 | 34.0 | - | 12 | 44.0 | 38.0 | 7 | 51.0 | 50.0 |
| 18 | 34.0 | - | 13 | 44.0 | 38.0 | 8 | 50.0 | - |
| 19 | 34.0 | - | 14 | 45.0 | 40.0 | 9 | 50.0 | - |
| 20 | 34.0 | - | 15 | 44.0 | 40.0 | 10 | 49.0 | 48.0 |
| 21 | 34.0 | - | 16 | 44.0 | - | 11 | 49.0 | - |
| 22 | 34.0 | - | 17 | 44.0 | - | 12 | 49.0 | - |
| 23 | 34.0 | - | 18 | 44.0 | - | 13 | 49.0 | - |
| 24 | 34.0 | - | 19 | 44.0 | - | 14 | 51.0 | 49.0 |
| 25 | 34.0 | - | 20 | 45.0 | 44.0 | 15 | 51.0 | - |
| 26 | 35.0 | - | 21 | 44.0 | 43.0 | 16 | 51.0 | 49.0 |
| 27 | 35.0 | - | 22 | 43.0 | - | 17 | 50.0 | - |
| 28 | 35.0 | - | 23 | 45.0 | 43.0 | 18 | 50.0 | - |
| 29 | 35.0 | - | 24 | 45.0 | - | 19 | 50.0 | - |
| 30 | 35.0 | - | 25 | 46.0 | 45.0 | 20 | 50.0 | - |
| May 1 | 35.0 | - | 26 | 50.0 | 46.0 | 21 | 50.0 | - |
| 2 | 35.0 | - | 27 | 52.0 | 46.0 | 22 | 50.0 | - |
| 3 | 35.0 | - | 28 | 47.0 | - | 23 | 50.0 | - |
| 4 | 35.0 | - | 29 | 46.0 | - | 24 | 50.0 | - |
| 5 | 35.0 | - | 30 | 46.0 | - | 25 | 50.0 | - |
| 6 | 35.0 | - | Jul 1 | 48.0 | 46.0 | 26 | 50.0 | - |
| 7 | 36.0 | 35.0 | 2 | 48.0 | - | 27 | 52.0 | 50.0 |
| 8 | 38.0 | 35.0 | 3 | 47.0 | 46.0 | 28 | 48.0 | - |
| 9 | 36.0 | - | 4 | 51.0 | 46.0 | 29 | 48.0 | - |
| 10 | 36.0 | 35.0 | 5 | 54.0 | 49.0 | 30 | 48.0 | - |
| 11 | 35.0 | - | 6 | 54.0 | 50.0 | 31 | 47.0 | - |
| 12 | 34.0 | - | 7 | 56.0 | 52.0 | Sep 1 | 48.0 | 47.0 |
| 13 | 34.0 | - | 8 | 56.0 | 52.0 | 2 | 48.0 | - |
| 14 | 34.0 | - | 9 | 56.0 | 53.0 | 3 | 48.0 | - |
| 15 | 36.0 | 35.0 | 10 | 56.0 | 54.0 | 4 | 48.0 | - |
| 16 | 36.0 | 35.0 | 11 | 55.0 | 52.0 | 5 | 47.0 | 44.0 |
| 17 | 36.0 | - | 12 | 51.0 | 49.0 | 6 | 44.0 | - |
| 18 | 36.0 | - | 13 | 51.0 | 49.0 | 7 | 44.0 | 42.0 |
| 19 | 39.0 | 36.0 | 14 | 51.0 | - | 8 | 44.0 | 42.0 |
| 20 | 40.0 | 35.0 | 15 | 50.0 | 48.0 | 9 | 44.0 | 42.0 |
| 21 | 38.0 | 35.0 | 16 | 52.0 | 48.0 | 10 | 44.0 | 42.0 |
| 22 | 38.0 | 36.0 | 17 | 52.0 | - | 11 | 43.0 | - |
| 23 | 42.0 | 37.0 | 18 | 52.0 | 51.0 | 12 | 45.0 | 40.0 |
| 24 | 42.0 | 39.0 | 19 | 51.0 | 49.0 | 13 | 44.0 | 40.0 |
| 25 | 38.0 | 36.0 | 20 | 50.0 | 49.0 | 14 | 43.0 | 41.0 |
| 26 | 42.0 | 36.0 | 21 | 49.0 | - | 15 | 45.0 | 43.0 |
| 27 | 40.0 | 36.0 | 22 | 49.0 | - | 16 | 44.0 | - |
| 28 | 43.0 | 37.0 | 23 | 50.0 | 49.0 | 17 | 44.0 | - |
| 29 | 42.0 | 36.0 | 24 | 50.0 | - | 18 | 44.0 | - |
| 30 | 42.0 | 36.0 | 25 | 50.0 | - | 19 | 43.0 | - |
| 31 | 46.0 | 35.0 | 26 | 50.0 | - | 20 | 45.0 | 43.0 |
| Jun 1 | 43.0 | 38.0 | 27 | 52.0 | 50.0 | 21 | 44.0 | 43.0 |
| 2 | 42.0 | 40.0 | 28 | 52.0 | - | 22 | 45.0 | 43.0 |
| 3 | 42.0 | 38.0 | 29 | 51.0 | - | 23 | 45.0 | 44.0 |
| 4 | 42.0 | 38.0 | 30 | 50.0 | - | | | |

Table 11. Maximum and Minimum Daily Water Temperatures (°F-"Ryan" Thermograph, Model D-30) from Birch Creek, Devil Canyon Project, 1975.

| Date | Temperature Max. | Temperature Min. | Date | Temperature Max. | Temperature Min. | Date | Temperature Max. | Temperature Min. |
|---|---|---|---|---|---|---|---|---|
| Apr 11 | 38.0 | - | May 29 | 47.0 | 46.0 | Jul 15 | 59.0 | - |
| 12 | 38.0 | 36.0 | 30 | 47.0 | 46.0 | 16 | 59.0 | - |
| 13 | 37.0 | 35.0 | 31 | 48.0 | 46.0 | 17 | 59.0 | - |
| 14 | 35.0 | - | Jun 1 | 50.0 | 48.0 | 18 | 59.0 | - |
| 15 | 35.7 | 35.0 | 2 | 51.0 | - | 19 | 59.0 | - |
| 16 | 35.5 | - | 3 | 51.0 | - | 20 | 59.0 | - |
| 17 | 35.5 | - | 4 | 51.0 | - | 21 | 59.0 | 57.0 |
| 18 | 35.7 | 35.0 | 5 | 51.0 | 50.0 | 22 | 60.0 | 59.0 |
| 19 | 36.0 | 34.0 | 6 | 51.0 | 50.0 | 23 | 60.0 | - |
| 20 | 36.0 | 34.0 | 7 | 51.0 | - | 24 | 60.0 | 59.0 |
| 21 | 36.0 | 34.5 | 8 | 51.0 | - | 25 | 59.0 | - |
| 22 | 37.0 | 35.0 | 9 | 51.0 | 50.0 | 26 | 60.0 | 59.0 |
| 23 | 38.0 | 35.0 | 10 | 52.0 | 51.0 | 27 | 60.0 | - |
| 24 | 38.0 | 36.0 | 11 | 54.0 | 52.0 | 28 | 60.0 | 58.0 |
| 25 | 37.0 | 36.0 | 12 | 54.0 | - | 29 | 58.0 | - |
| 26 | 37.0 | 36.0 | 13 | 54.0 | 52.0 | 30 | 58.0 | - |
| 27 | 37.0 | 36.0 | 14 | 54.0 | - | 31 | 58.0 | - |
| 28 | 38.0 | 36.0 | 15 | 54.0 | - | Aug 1 | 60.0 | 58.0 |
| 29 | 38.0 | 36.0 | 16 | 54.0 | - | 2 | 59.0 | 57.0 |
| 30 | 38.0 | 37.0 | 17 | 54.0 | - | 3 | 56.0 | - |
| May 1 | 38.1 | 36.3 | 18 | 54.0 | - | 4 | 60.0 | 56.0 |
| 2 | 39.0 | 36.0 | 19 | 54.0 | - | 5 | 59.0 | 58.0 |
| 3 | 40.0 | 38.0 | 20 | 55.0 | - | 6 | 59.0 | - |
| 4 | 38.0 | - | 21 | 56.0 | 55.0 | 7 | 59.0 | - |
| 5 | 38.0 | - | 22 | 55.0 | 54.0 | 8 | 59.0 | - |
| 6 | 39.0 | 37.0 | 23 | 54.0 | 53.0 | 9 | out of order | |
| 7 | 38.0 | 36.2 | 24 | 55.0 | 53.0 | 10 | out of order | |
| 8 | 38.3 | 37.0 | 25 | 55.0 | - | 11 | out of order | |
| 9 | 38.8 | 38.0 | 26 | 59.0 | 55.0 | 12 | out of order | |
| 10 | 38.0 | - | 27 | 59.0 | 57.0 | 13 | out of order | |
| 11 | 38.0 | - | 28 | 60.0 | 58.0 | 14 | out of order | |
| 12 | 38.0 | - | 29 | 60.0 | 58.0 | 15 | out of order | |
| 13 | 38.0 | - | 30 | 58.0 | 57.0 | 16 | out of order | |
| 14 | 38.0 | - | Jul 1 | 58.0 | 57.0 | 17 | out of order | |
| 15 | 38.0 | - | 2 | 58.0 | 56.0 | 18 | out of order | |
| 16 | 38.0 | - | 3 | 59.0 | 56.0 | 19 | out of order | |
| 17 | 39.0 | - | 4 | 60.0 | 59.0 | 20 | out of order | |
| 18 | 39.0 | - | 5 | 59.0 | - | 21 | out of order | |
| 19 | 39.0 | - | 6 | 62.0 | 59.0 | 22 | 58.0 | - |
| 20 | 39.5 | - | 7 | 62.0 | - | 23 | 58.0 | 57.0 |
| 21 | 40.0 | - | 8 | 64.0 | 62.0 | 24 | 57.0 | 56.0 |
| 22 | 40.0 | - | 9 | 66.0 | 63.0 | 25 | 56.0 | - |
| 23 | 41.0 | 40.0 | 10 | 69.0 | 66.0 | 26 | 56.0 | - |
| 24 | 41.0 | - | 11 | 68.0 | - | 27 | 56.0 | 53.0 |
| 25 | 41.0 | - | 12 | 68.0 | 64.0 | 28 | 53.0 | 52.0 |
| 26 | 41.0 | - | 13 | 64.0 | 61.0 | 29 | 53.0 | 52.0 |
| 27 | 43.0 | 41.0 | 14 | 61.0 | 59.0 | 30 | 52.0 | - |
| 28 | 45.0 | 43.0 | | | | | | |

Little Willow Creek temperatures were taken biweekly and trends were consistent with measurements of the Susitna River and Willow Creek (Figures 4-11)

Birch Creek was selected as a thermograph site to collect temperature data on a creek draining a lake. Birch Creek is the outlet of Fish Lake and empties into the Susitna River upstream of the Parks Highway Bridge. It also differed from the tributaries downstream of the Parks Highway Bridge by having less gradient and volume. Temperatures were considerably warmer in Birch Creek, as suspected, reaching a high of 69° F. on July 10, 1975 (Table 11). Lentic environments have the capacity to retain heat, resulting in different thermal patterns than lotic environments. Lakes also act as a buffer by stabilizing fluctuating flows. The thermal patterns and stabilized flows in the outlets of lakes benefit productivity.

The highest, lowest and mean values of limnological data collected from the Susitna River and east side tributaries downstream of the Parks Highway Bridge are presented in Table 12.

A more detailed analysis can be made by referring to Figures 4 through 11, which represent the six limnological characteristics measured in the Susitna River and seven east side tributaries.

Hydrogen ion concentration in the tributaries exhibited a tendency to rise during the summer (Figures 4 through 11). A similar rise is also evident in the hydrogen ion data collected from the Susitna River at the Parks Highway Bridge.

Total alkalinity, represented in Figures 4 through 11, exhibited an overall rise throughout the summer months; except in the Kashwitna River, which demonstrates a less distinct increase. The highs and lows varied depending upon the tributary (Table 12), although the maximum limits in all

TABLE 12. Highest, Lowest and Mean Values of Limnological Data Collected From The Susitna River and Seven Tributaries of the Susitna River.

| Tributary | Time Period Collected 1975 | Water Temperature (C) High | Water Temperature (C) Low | Water Temperature (C) Mean | Conductivity (μmhos/cm) High | Conductivity (μmhos/cm) Low | Conductivity (μmhos/cm) Mean | Turbidity (JTU) High | Turbidity (JTU) Low | Turbidity (JTU) Mean | pH High | pH Low | pH Mean | Total Alkalinity ($mg/l-CaCO_3$) High | Total Alkalinity ($mg/l-CaCO_3$) Low | Total Alkalinity ($mg/l-CaCO_3$) Mean | Hardness ($mg/l-CaCO_3$) High | Hardness ($mg/l-CaCO_3$) Low | Hardness ($mg/l-CaCO_3$) Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Susitna River at Parks Highway Bridge | 3/26 - 8/18 | 13.0 | 0.0 | 8.2 | 210 | 74 | 126 | 185 | 35 | 105 | 8.5 | 7.5 | 7.9 | 103 | 34 | 48 | 120 | 51 | 105 |
| Montana Creek | 3/26 - 8/18 | 14.5 | 0.0 | 8.2 | 105 | 27 | 48 | 27 | 0.3 | 4.9 | 7.5 | 6.7 | 7.2 | 68 | 17 | 31 | 51 | 17 | 25 |
| Goose Creek | 4/4 - 8/18 | 12.0 | 0.0 | 7.3 | 77 | 27 | 43 | 64 | 0.3 | 9.4 | 7.7 | 6.7 | 7.1 | 68 | 17 | 34 | 34 | 17 | 24 |
| Sheep Creek | 4/4 - 8/18 | 14.0 | 0.0 | 7.7 | 80 | 30 | 46 | 31 | 1.0 | 4.3 | 7.6 | 6.6 | 7.1 | 68 | 17 | 37 | 51 | 17 | 31 |
| Caswell Creek | 5/14 - 8/18 | 16.5 | 0.0 | 10.6 | 175 | 30 | 62 | 28 | 1.0 | 5.1 | 7.6 | 6.6 | 7.2 | 68 | 17 | 42 | 86 | 17 | 36 |
| Kashwitna River | 4/24 - 8/18 | 13.0 | 6.5 | 8.9 | 77 | 37 | 53 | 110 | 2.0 | 38 | 7.6 | 6.9 | 7.3 | 51 | 17 | 39 | 68 | 17 | 37 |
| Little Willow Creek | 4/24 - 8/18 | 14.0 | 0.0 | 6.8 | 73 | 20 | 41 | 15 | 1.2 | 2.8 | 7.5 | 6.6 | 7.0 | 86 | 17 | 38 | 51 | 17 | 27 |
| Willow Creek | 3/26 - 8/18 | 14.0 | 0.0 | 6.7 | 160 | 26 | 73 | 20 | 0.5 | 3.6 | 7.7 | 6.6 | 7.2 | 51 | 17 | 39 | 60 | 17 | 37 |

Note: This data was collected biweekly from each of the tributaries during the time frame indicated. This is general information only, a more detailed analysis can be made by referring to Figures 4 through 11.

cases were no greater than 86 mg/l $CaCO_3$. It appears the lower Susitna River has a greater total alkalinity than its tributaries.

Hardness, (Figures 4 through 11) shows a decrease from the end of March to the middle of May. For example, it dropped from 86 mg/l $CaCO_3$ to 17 mg/l $CaCO_3$ at Caswell Creek. This drop, in all seven lower Susitna River tributaries, appears to have occurred just as the waters began to warm significantly. As summer progressed, it appears the hardness of these waters remained relatively low and stable. The relative stability reflected in Susitna River tributarial waters during the months of July and August is evident in information presented in Figure 4. These comparisons demonstrate a constant 51 mg/l $CaCO_3$ through July and August, whereas the relative stability of tributarial waters ranges between 17 and 34 mg/l $CaCO_3$. It would appear the tributarial waters have a consistently lesser degree of hardness than the Susitna River waters with the same relatively low summertime constancy. Tributaries exhibited high late winter hardness levels.

Conductivity measurements for the seven east side lower Susitna tributaries (Figures 4 through 11) all reflect a similar decrease from late winter to early summer with 28 umhos/cm reflecting the average low and 107 umhos/cm reflecting the average high. Once the minimum specific conductance is reached from the middle of May to the middle of June, a general rise in conductance is observed during the summer months. Samples collected on June 27, reflect an abnormally high increase in specific conductance, which may be attributed to extreme heavy rains prior to or during sample collection. The Susitna River displays a substantially higher specific conductance than that of the seven east side tributaries and a general increase from early June through August.

There appears to be no consistent trend in turbidity in all seven east side Susitna River tributaries under investigation. Both the Kashwitna River and Caswell Creek demonstrated an increase in turbidity from mid-April to mid-August. This increase was significantly greater in the Kashwitna River because of its glacial origin. However, there was a high degree of fluctuation in turbidity in both streams. A similar fluctuation was demonstrated in the remaining five tributaries, i.e., Montana, Goose, Sheep, Little Willow and Willow creeks (Figures 4 through 11). This high variability in turbidity can, in all likelihood, be attributed to precipitation.

Turbidity in the Susitna River was relatively low at 55 Jackson turbidity units during May and June (Figure 4). On July 7 a substantial rise to 170 J.T.U. was measured and a peak of 185 J.T.U. was reached on August 18, 1975. The maximum reading for east side tributaries below the Parks Highway Bridge was 110 J.T.U. in the Kashwitna River on August 18, 1975.

Data collected by the U. S. Geological Survey on three Susitna River east side tributaries provides a limited means with which to compare data collected in this study between March and September, 1975, (Table 13).

With respect to Montana Creek, the available figures would tend to support temperature, pH, hardness and specific conductance as determined in the field during the summer of 1975. Sheep Creek figures cannot be compared due to the time frame in which the one set of data was collected. With respect to Caswell Creek, temperature and specific conductance are the only parameters which fall closely within the range of U. S. Geological Survey data. Hardness and pH are significantly different from more recently collected data.

TABLE 13. A Compilation of U.S. Geological Survey Limnological Data of Specific Concern, Collected From Susitna River Tributaries.

| Name of Tributary | Date | Water Temperature (C) | Specific Conductance (umhos/cm) | Discharge (cfs) | Suspended Sediment | Suspended Sediment Discharge (Tons/Day) | pH | Nitrate (mg/l-$NO_3$) | Hardness (mg/l-$CaCO_3$) | Dissolved Ortho-Phosphate (mg/l-P) | Dissolved Nitrate & Nitrite (mg/l-$NO_2$&$NO_3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Montana Creek | 7/1/71 | 7.0 | 24 | 2,280 | 205 | 1,260 | - | - | - | - | - |
| | 8/9/71 | 9.5 | 24 | 3,500 | 183 | 1,750 | - | - | - | - | - |
| | 9/17/71 | 8.5 | 43 | 376 | 2 | 20 | 7.2 | 1.00 | 15 | - | - |
| | 8/11/72 | 16.5 | 47 | 182 | - | - | 7.4 | - | 17 | .00 | .05 |
| | 9/26/72 | 4.5 | 37 | 606 | - | - | 6.3 | - | 13 | .11 | .03 |
| Sheep Creek | 3/4/72 | - | 63 | - | - | - | 7.5 | 0.36 | 25 | - | - |
| Caswell Creek | 9/8/72 | 13.5 | 54 | 23 | - | - | 6.8 | - | 20 | .05 | .00 |
| | 9/26/72 | 4.0 | 51 | 31 | - | - | 7.2 | - | 19 | .02 | .00 |

Table 14. Water Quality Analysis of Samples by the U.S. Geological Survey Central Laboratory in Salt Lake City, Utah. Collected March 25, 1975 from the Susitna River at Sunshine.

| | | | | | |
|---|---|---|---|---|---|
| Alk, Tot (as $CaCO_3$) | mg/l | 71 | $NO_2$+$NO_3$ as N Diss | mg/l | 0.21 |
| Bicarbonate | mg/l | 86 | Phos Ortho Dis as P | mg/l | 0.04 |
| Calcium Diss | mg/l | 29 | Phosphate Dis Ortho | mg/l | 0.12 |
| Chloride Diss | mg/l | 21 | Potassium Diss | mg/l | 2.1 |
| Color | | 0 | Residur Dis Cacl Sum | mg/l | 137 |
| Conductivity | | 242 | Residue Dis Ton/Aft | | 0.19 |
| Fluoride Diss | mg/l | 0.2 | Residue Dis 180C | mg/l | 141 |
| Hardness Noncarb | mg/l | 20 | Sar | | 0.5 |
| Hardness Total | mg/l | 91 | Silica Dissolved | mg/l | 9.2 |
| Iron Dissolved | ug/l | 10 | Sodium Diss | mg/l | 11 |
| Magnesium Diss | mg/l | 4.5 | Sodium Percent | | 20 |
| Manganese Dissolved | ug/l | 0 | Sulfate Diss | mg/l | 17 |
| Nitrogen NH£ as N tot | mg/l | 0.05 | Nitrogen Tot Org N | mg/l | 0.18 |
| Nitrogen Tot as N | mg/l | 0.42 | Nitrogen Tot KJD as N | mg/l | 0.23 |
| Nitrogen Tot as $NO_3$ | mg/l | 1.9 | $NO_2$+$NO_3$ as N Tot | mg/l | 0.19 |
| | | | Phosphorus Tot as P | mg/l | 0.01 |

| Cations | mg/l | meq/l | Anions | mg/l | meq/l |
|---|---|---|---|---|---|
| Calcium Diss | 29 | 1.448 | Bicarbonate | 86 | 1.410 |
| Magnesium Diss | 4.5 | 0.371 | Chloride Diss | 21 | 0.593 |
| Potassium Diss | 2.1 | 0.054 | Fluoride Diss | 0.2 | 0.011 |
| Sodium Diss | 11 | 0.479 | Sulfate Diss | 17 | 0.345 |
| | | | $NO_2$+$NO_3$ as N D | 0.21 | 0.015 |
| Total | | 2.349 | Total | | 2.381 |

Table 15. Compiled Data of Interest Collected by U.S. Geological Survey from the Susitna River at Sunshine.

| Date | pH | Specific Conductance (umhos/cm) | Suspended Sediment (mg/l) |
|---|---|---|---|
| 7/2/71 | 7.5 | 138 | 1,040 |
| 7/2/71 | 7.5 | 131 | 1,140 |
| 8/11/71 | 9.0 | 170 | 3,510 |

Figure 4. Limnological Data Collected from the Susitna River at the Parks Highway Bridge, March 26 to August 18, Devil's Canyon Project, 1975.

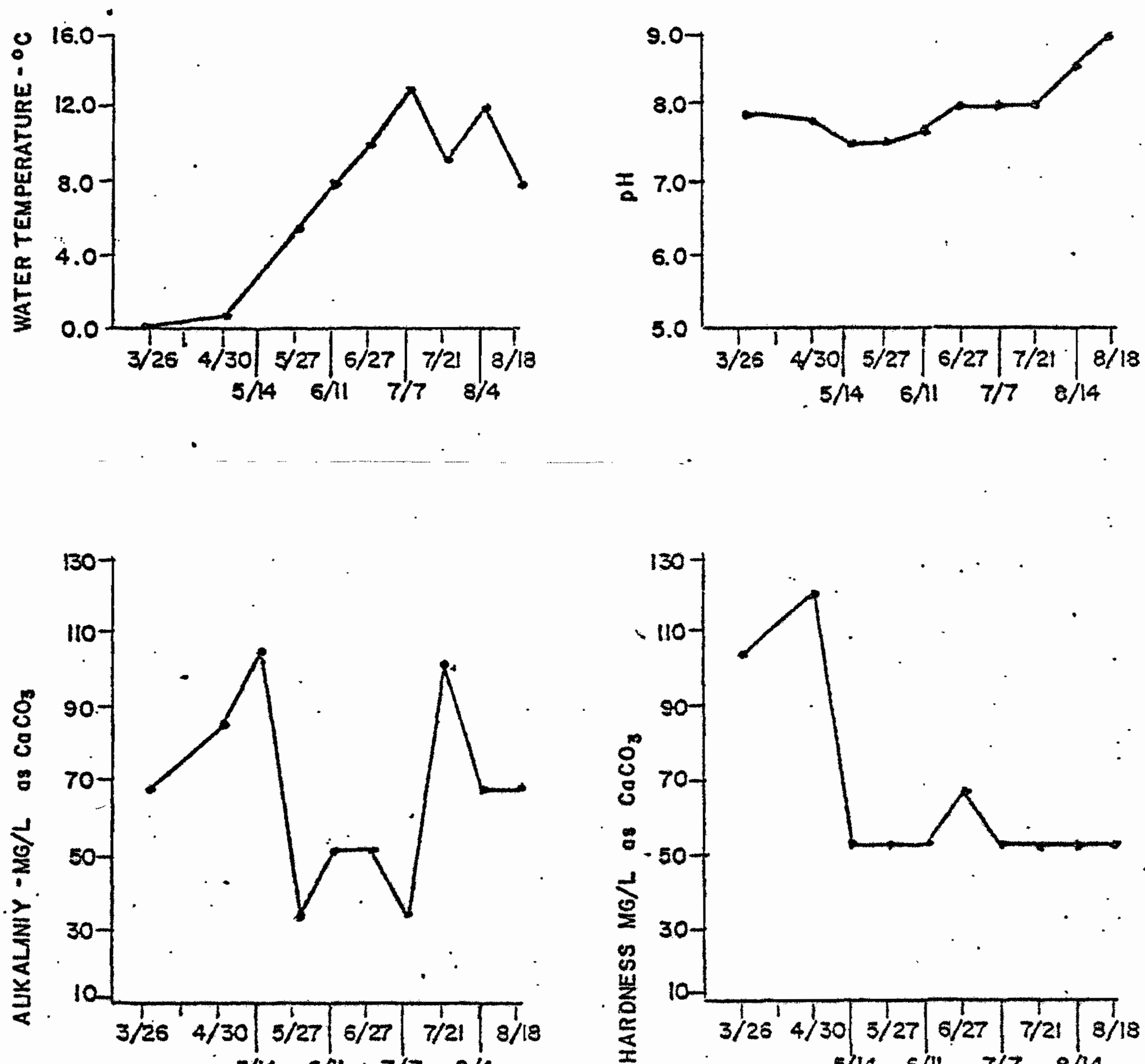


Figure 4. (Cont.) Limnological Data Collected from the Susitna River at the Parks Highway Bridge, March 26 to August 18, Devil's Canyon Project, 1975.

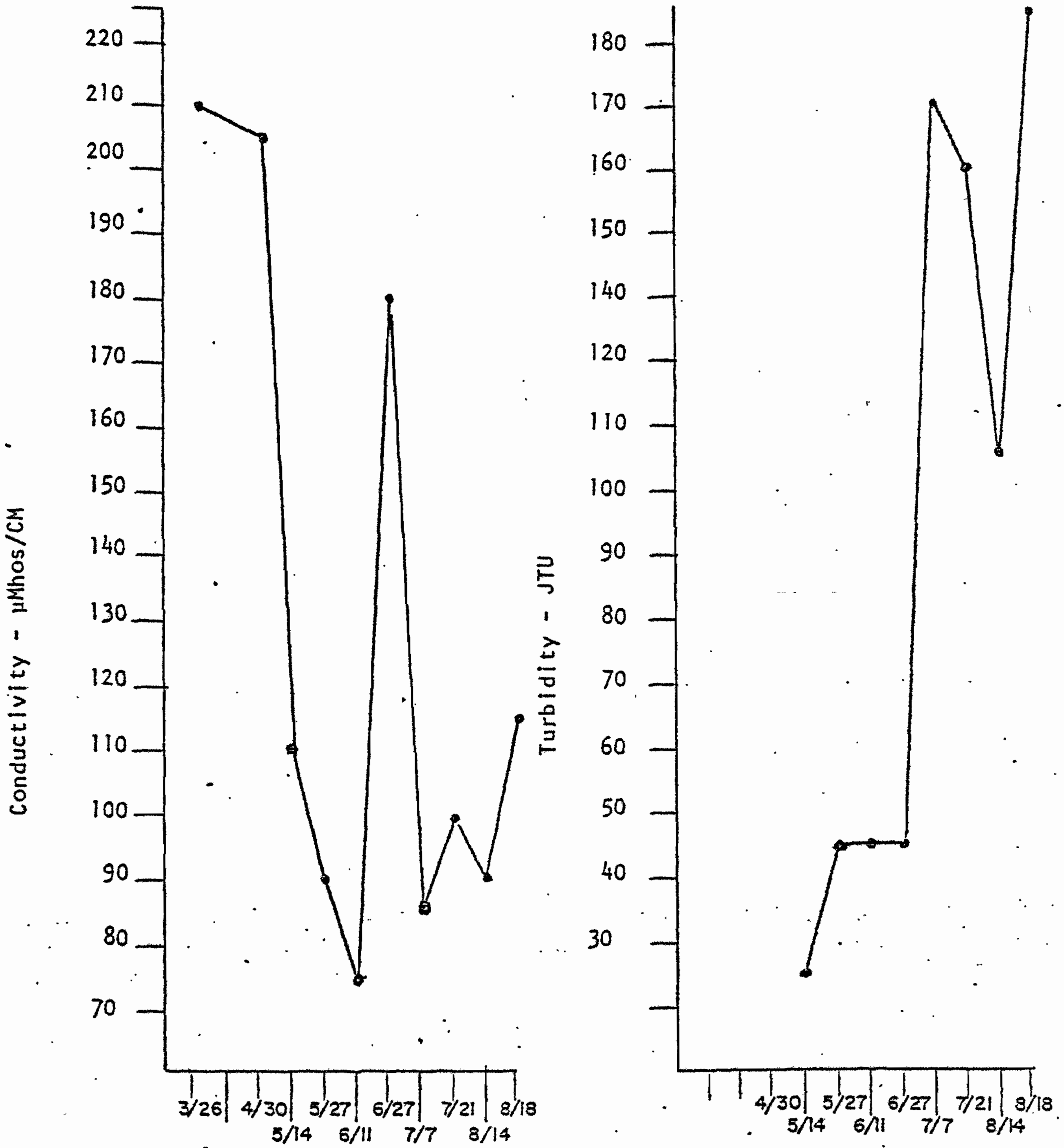


Fig. 5. Limnological Data Collected from Montana Creek at the Highway Bridge, March 26 to August 18, Devil's Canyon Project, 1975.

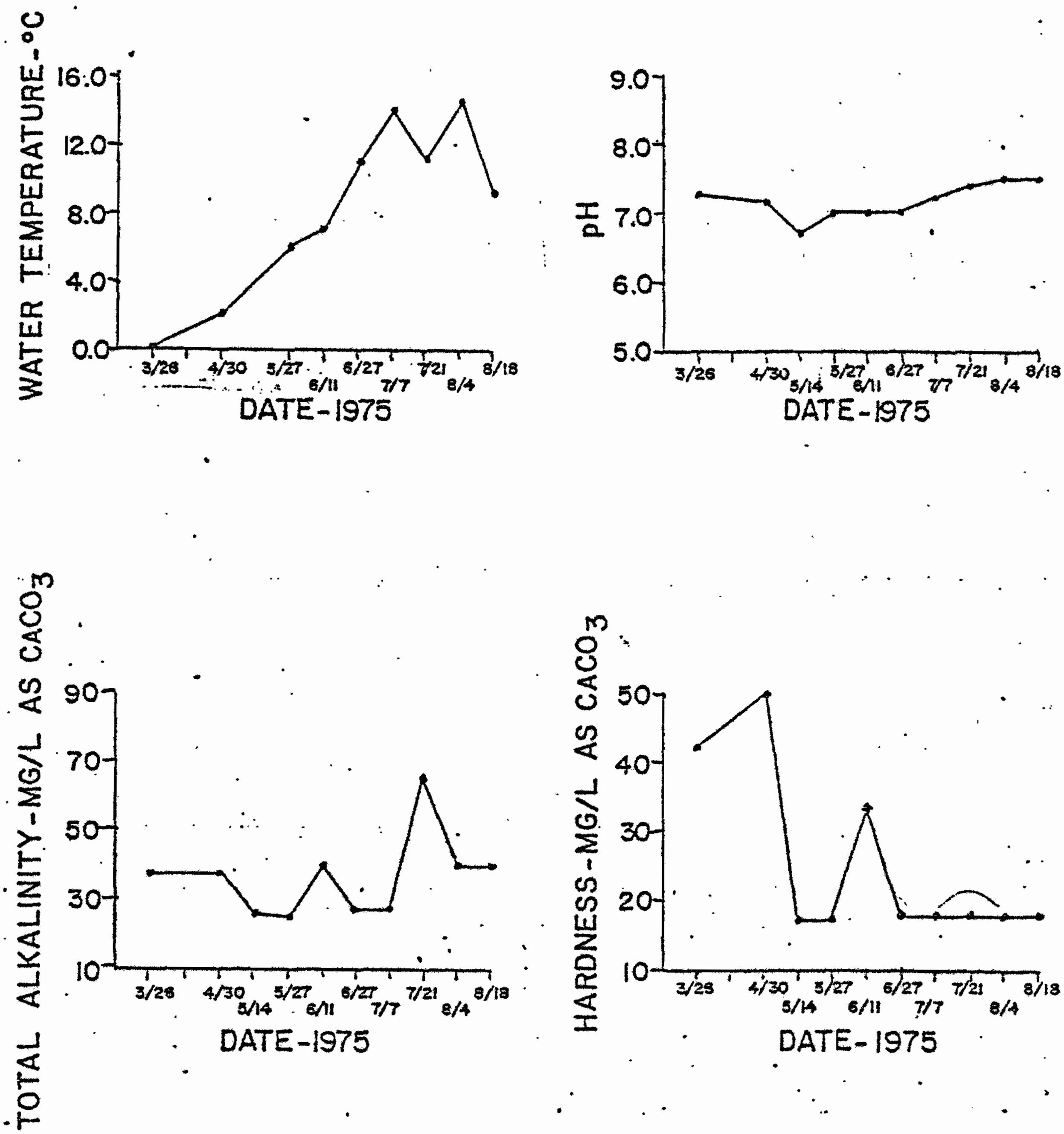
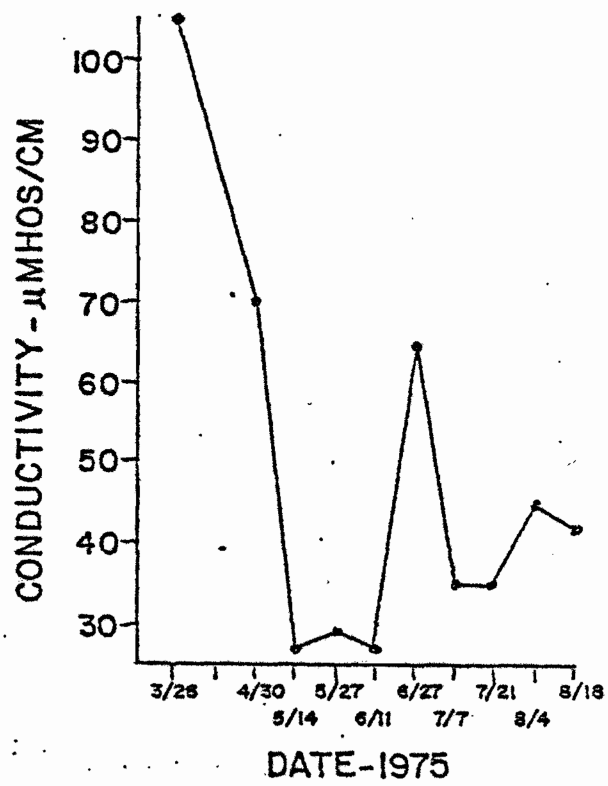


Fig. 5. (Cont). Limnological Data Collected from Montana Creek at the Highway Bridge, March 26 to August 18, Devil's Canyon Project, 1975.



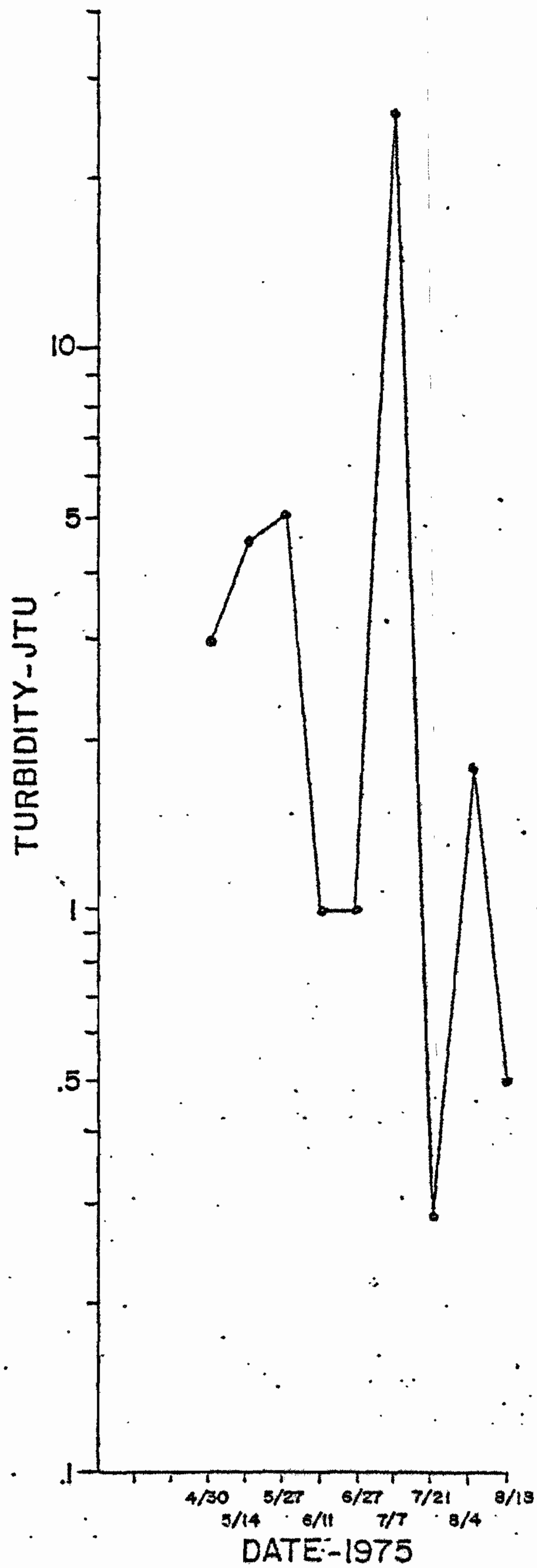



Fig. 6. Limnological Data Collected from Sheep Creek at the Bridge, March 4 Through August 18, Devil's Canyon Project, 1975.

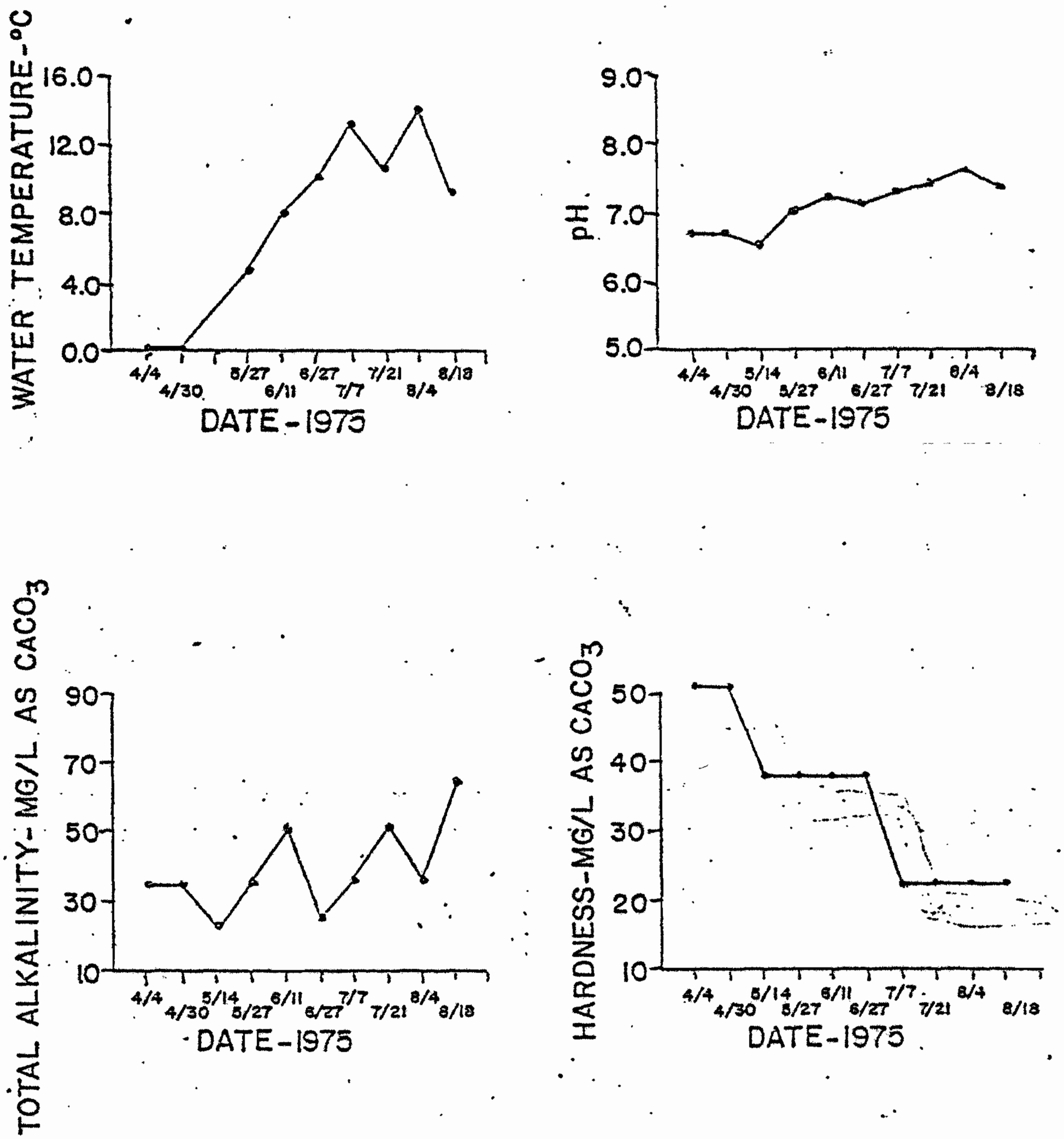


Fig. 6. (Cont). Limnological Data Collected from Sheep Creek at the Bridge, March 4 Through August 18, Devil's Canyon Project, 1975.

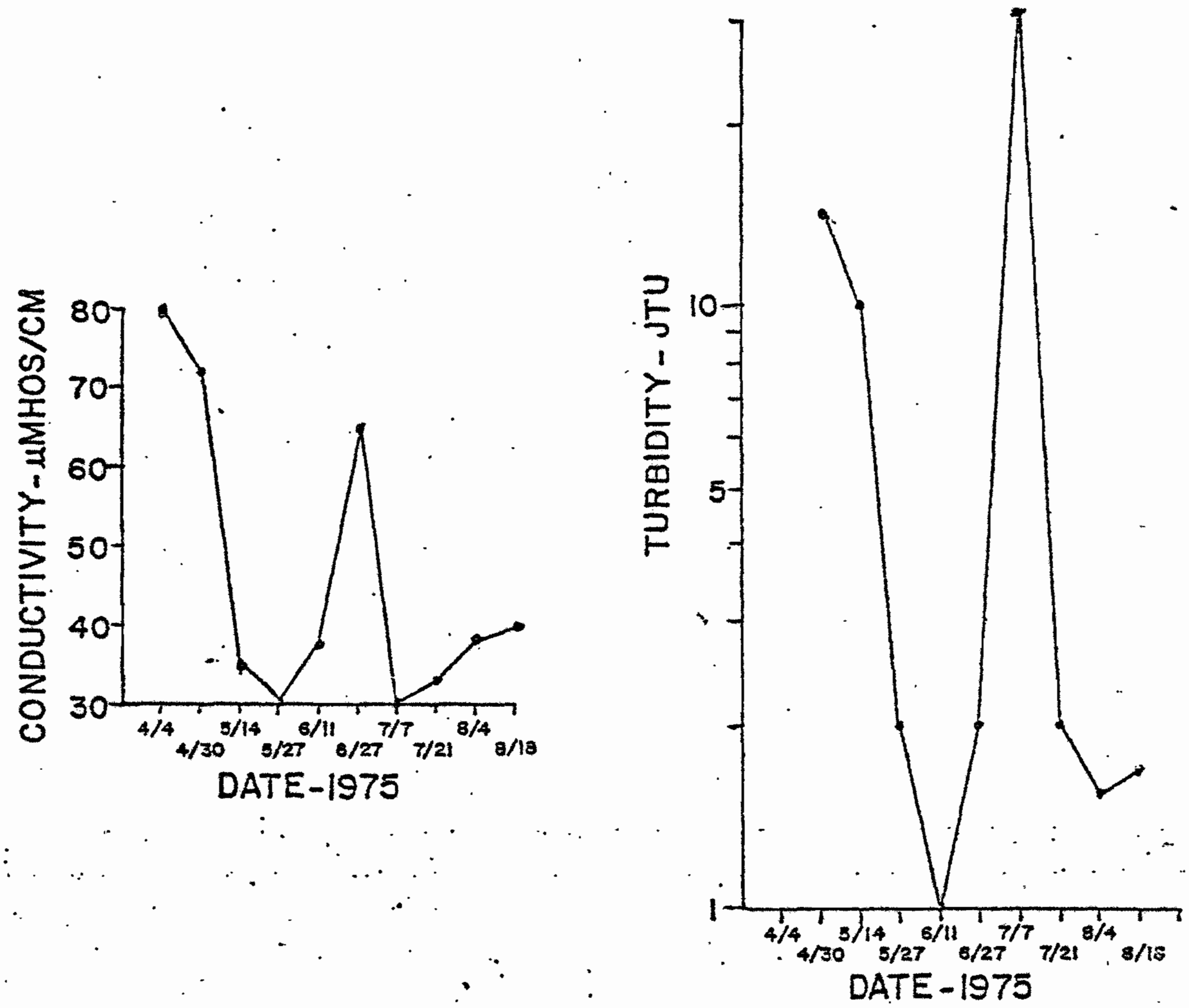


Fig. 7. Limnological Data Collected from Goose Creek at the Bridge, March 4 Through August 18, Devil's Canyon Project, 1975.

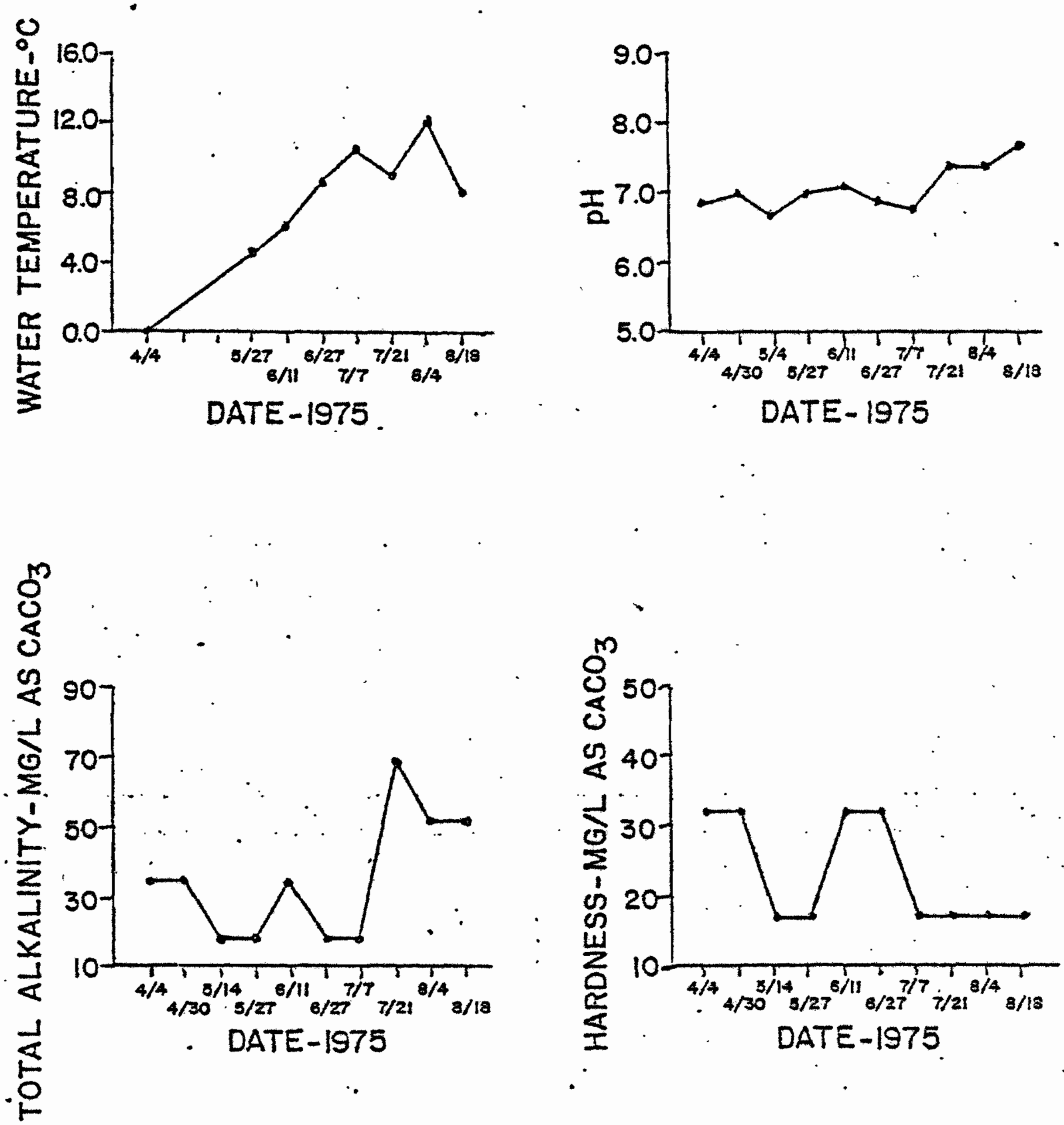
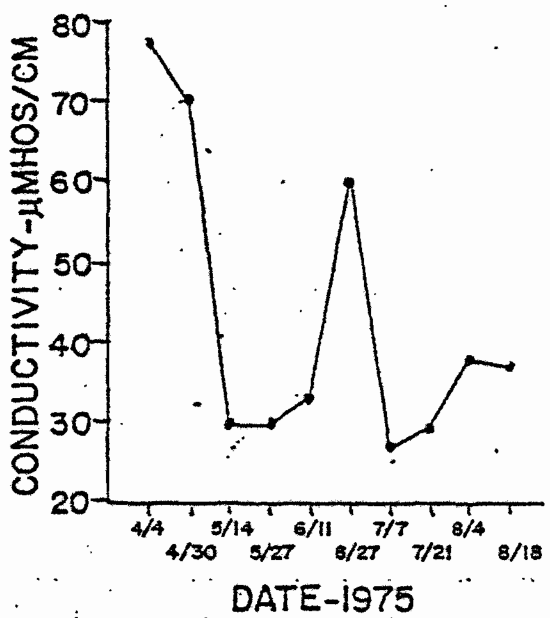


Fig. 7. (Cont). Limnological Data Collected from Goose Creek at the Bridge, March 4 Through August 18, Devil's Canyon Project, 1975.



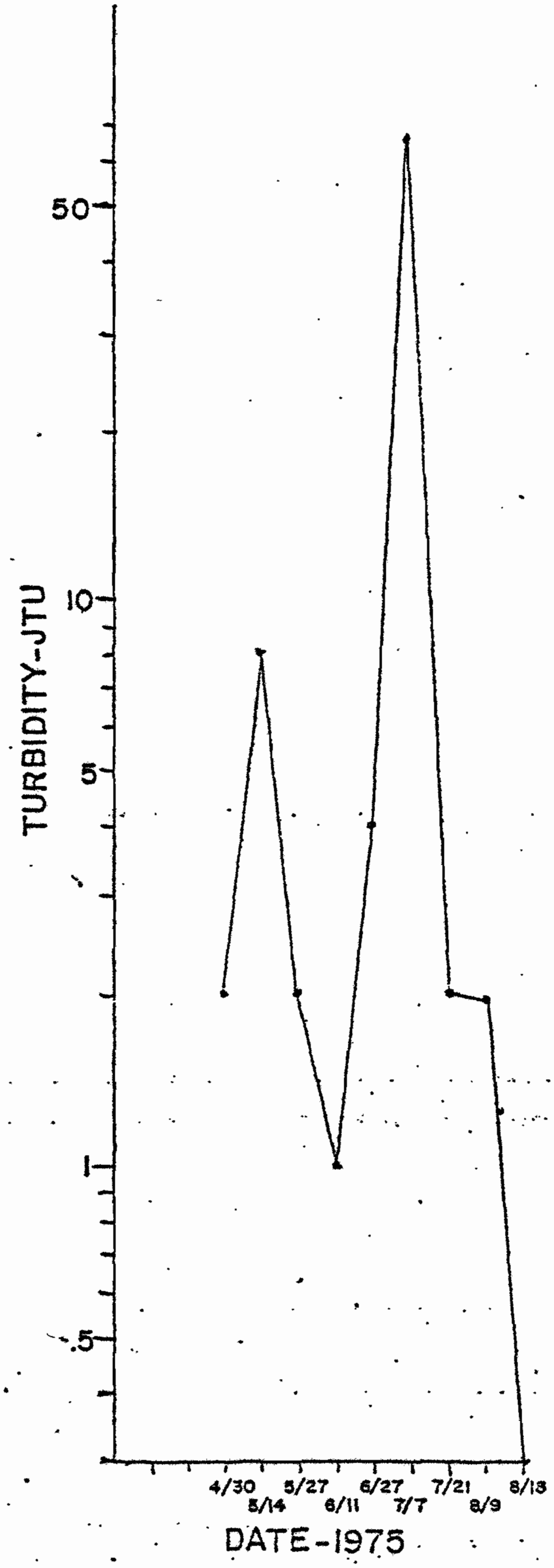



Fig. 8. Limnological Data Collected from Caswell Creek at the Bridge, March 26 Through August 18, Devil's Canyon Project, 1975.

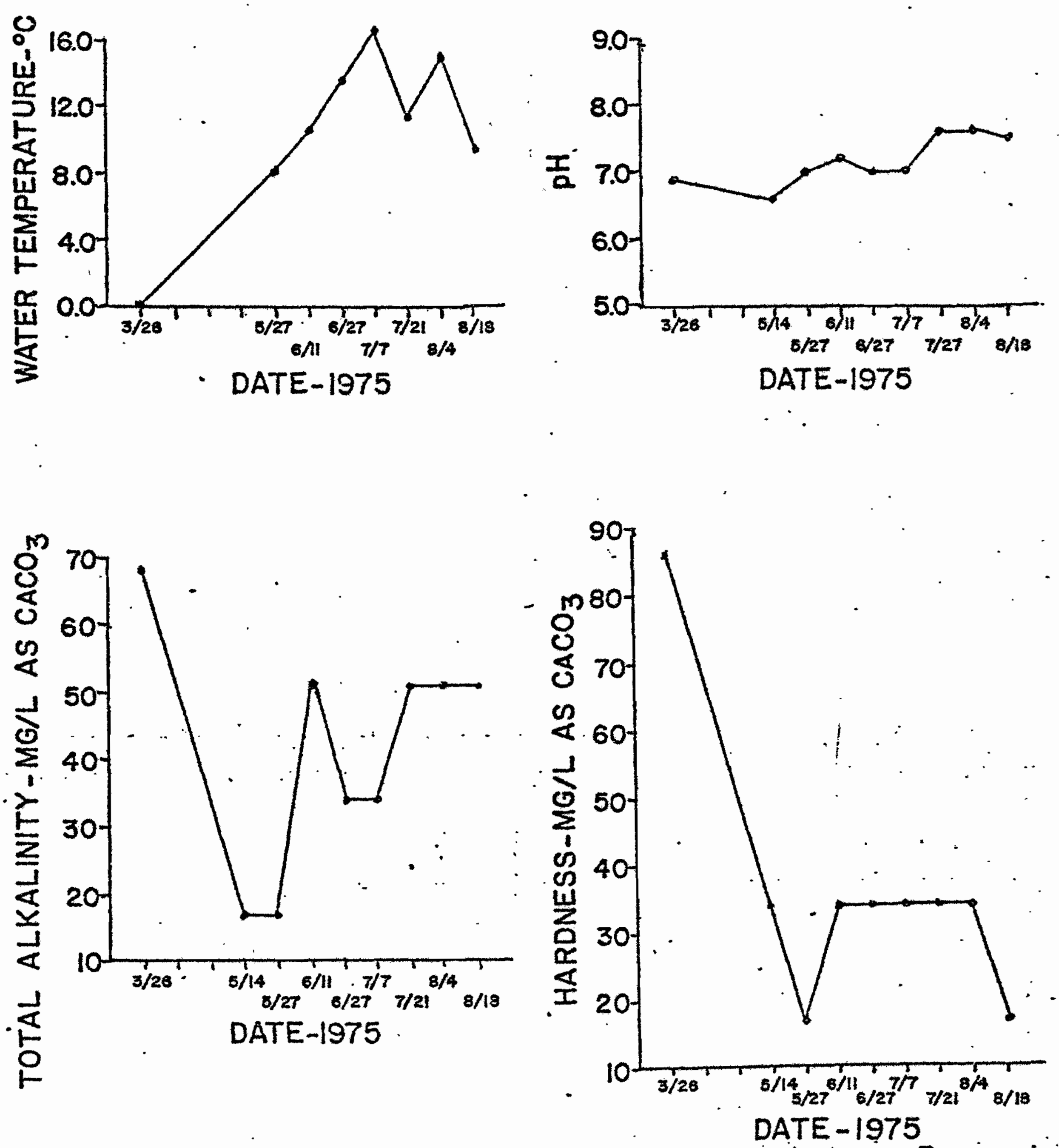
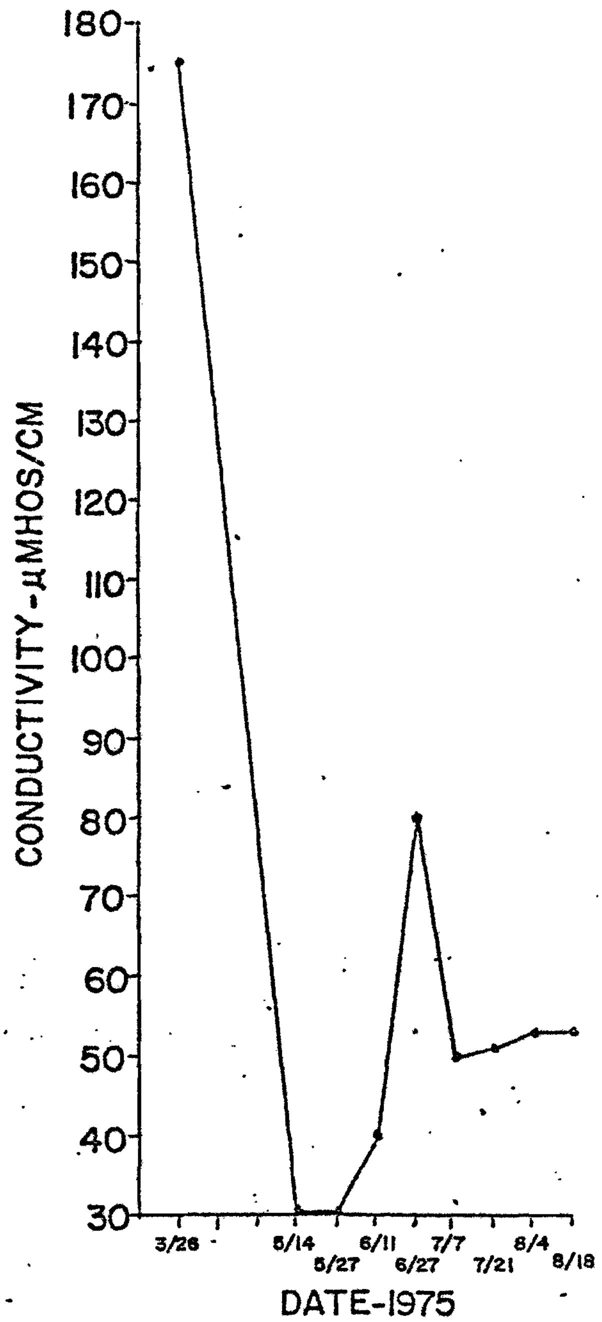


Fig. 8. (Cont). Limnological Data Collected from Caswell Creek at the Bridge, March 26 Through August 18, Devil's Canyon Project, 1975.



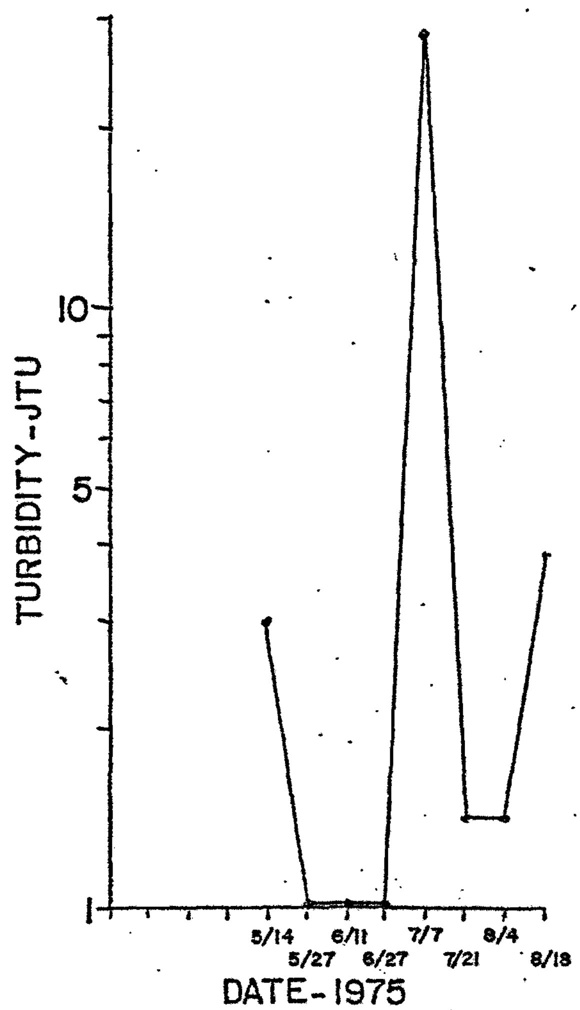



Fig. 9. Limnological Data Collected from the Kashwitna River at the Bridge, April 24 Through August 18, Devil's Canyon Project, 1975.

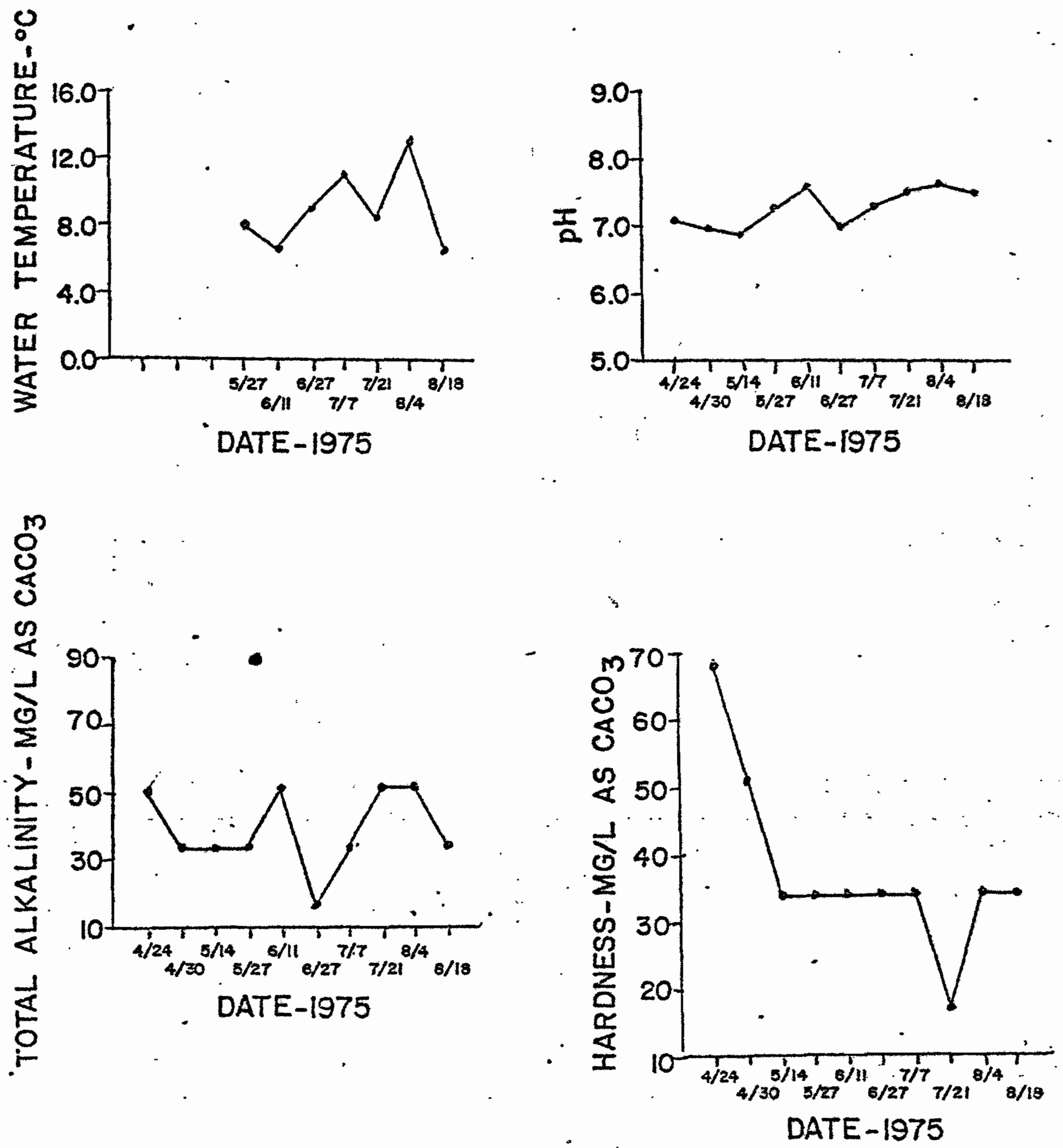
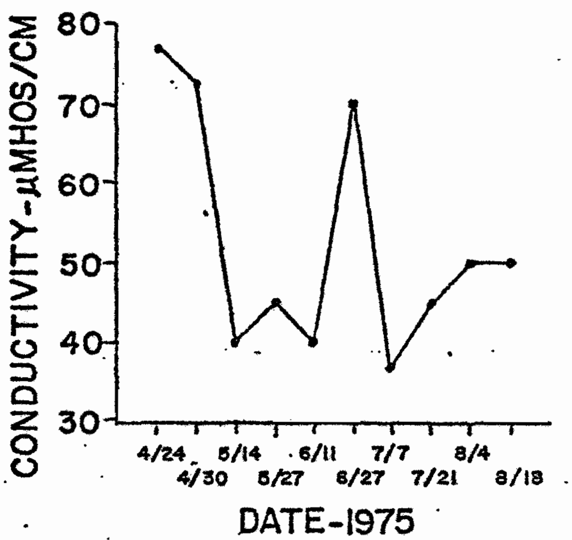


Fig. 9. (Cont). Limnological Data Collected from the Kashwitna River at the Bridge, April 24 Through August 18, Devil's Canyon Project,1975.



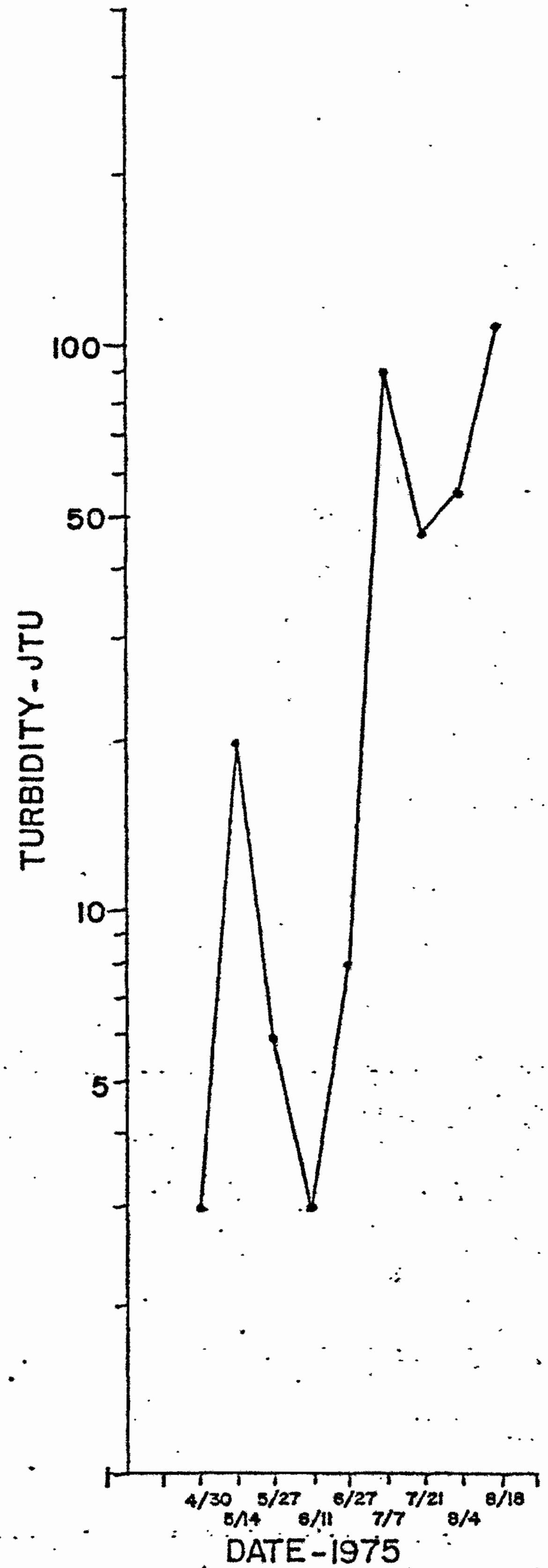



Fig. 10. Limnological Data Collected from Little Willow Creek at the Bridge, April 24 Through August 18, Devil's Canyon Project, 1975.

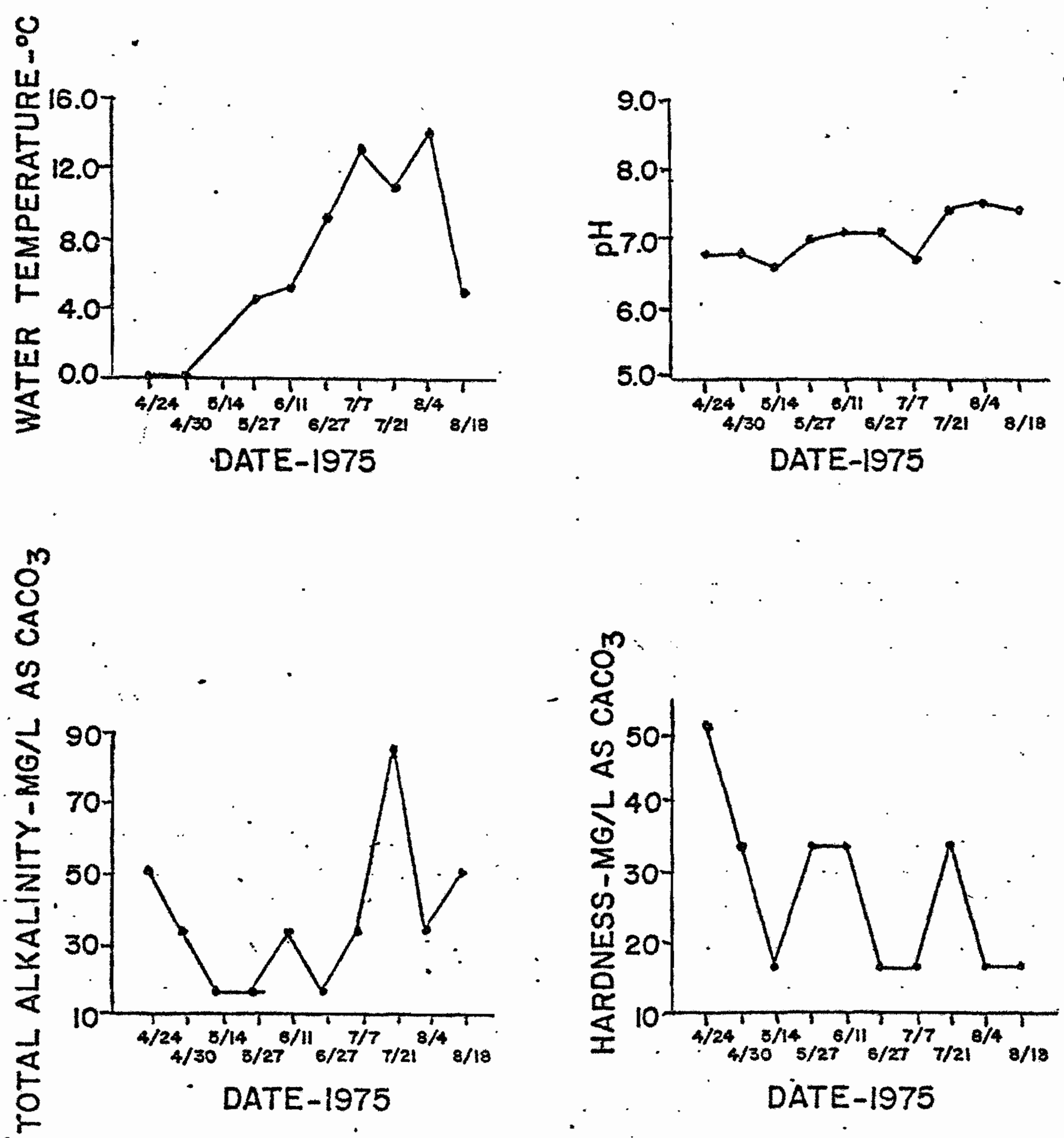


Fig. 10. (Cont). Limnological Data Collected from Little Willow Creek at the Bridge, April 24 Through August 18, Devil's Canyon Project,1975.

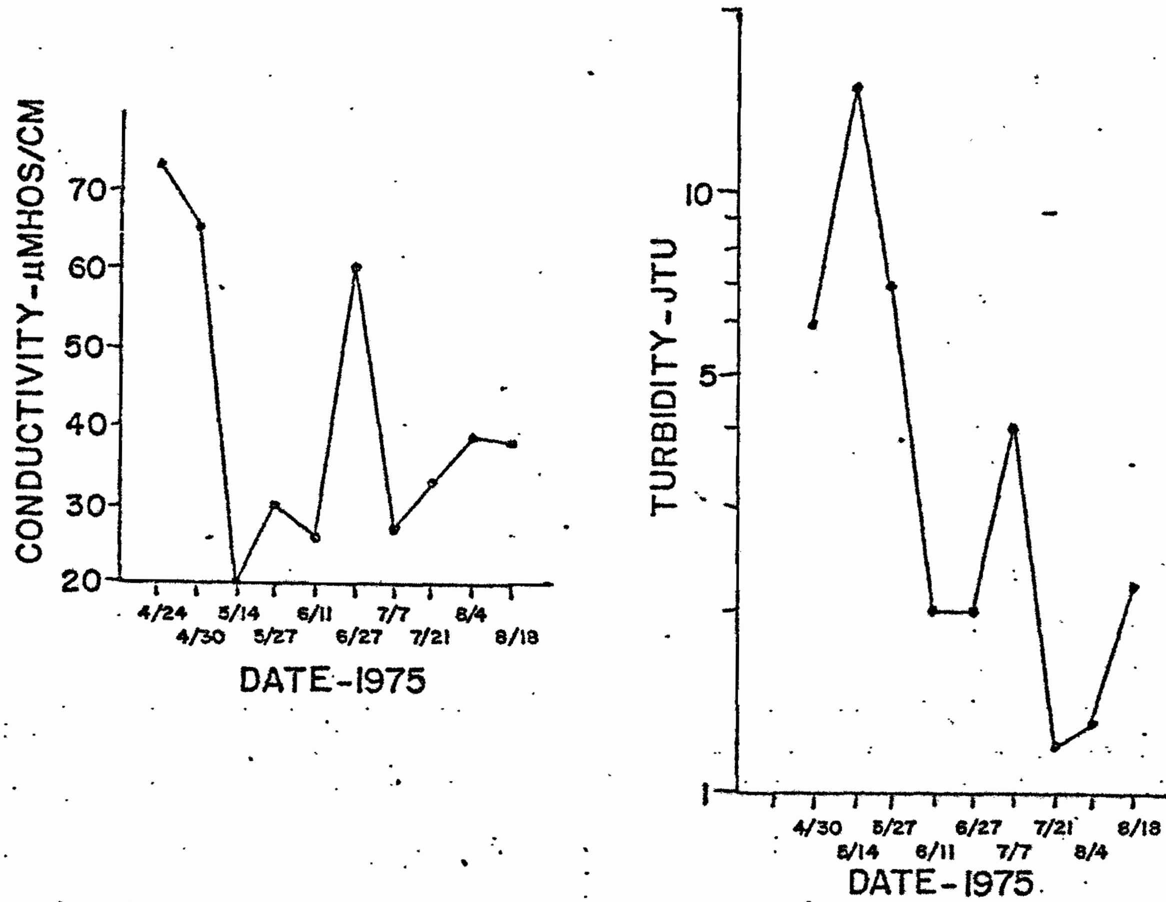


Fig. 11. Limnological Data Collected from Willow Creek at the Bridge, March 26 Through August 18, Devil's Canyon Project, 1975.

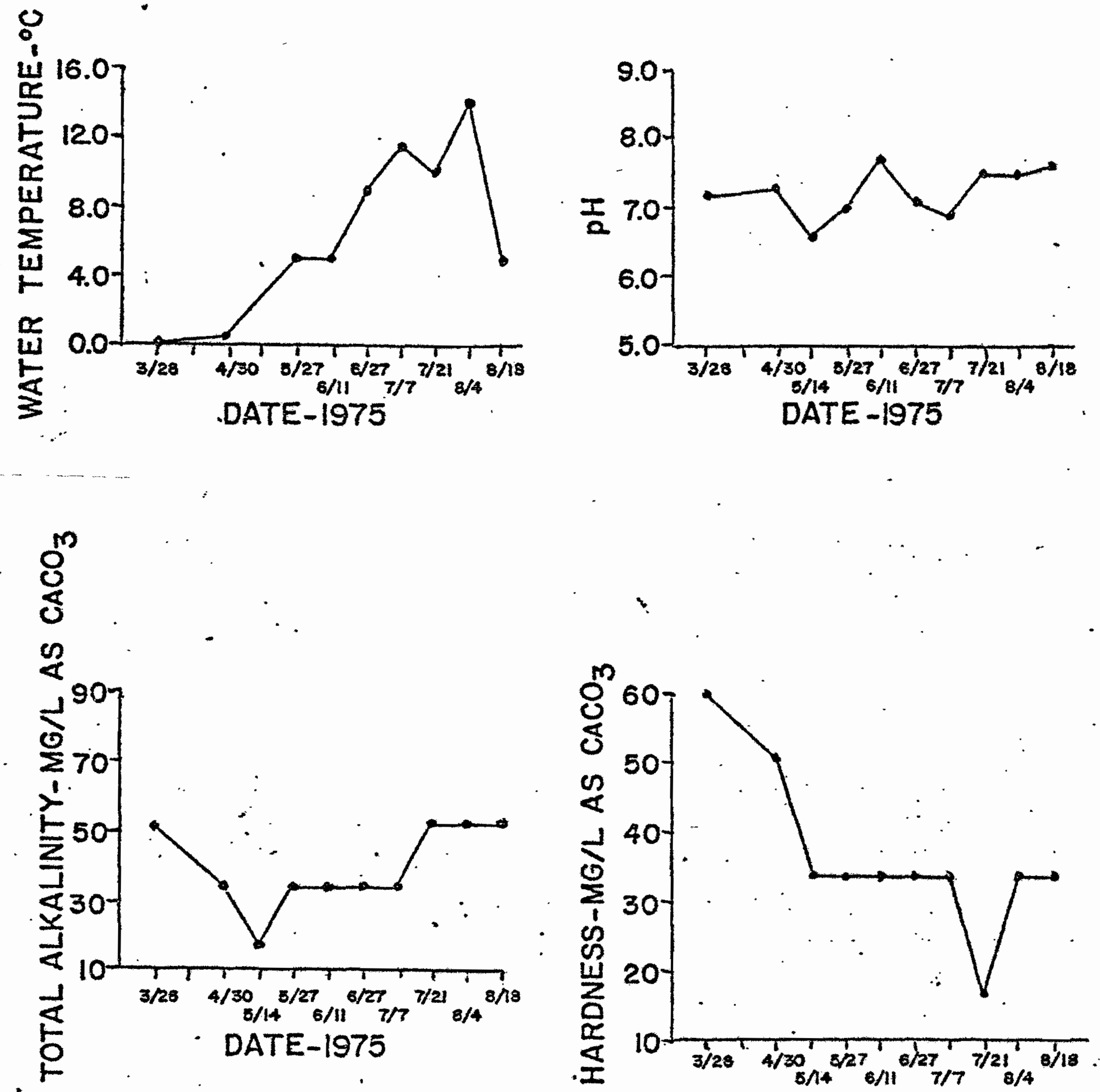
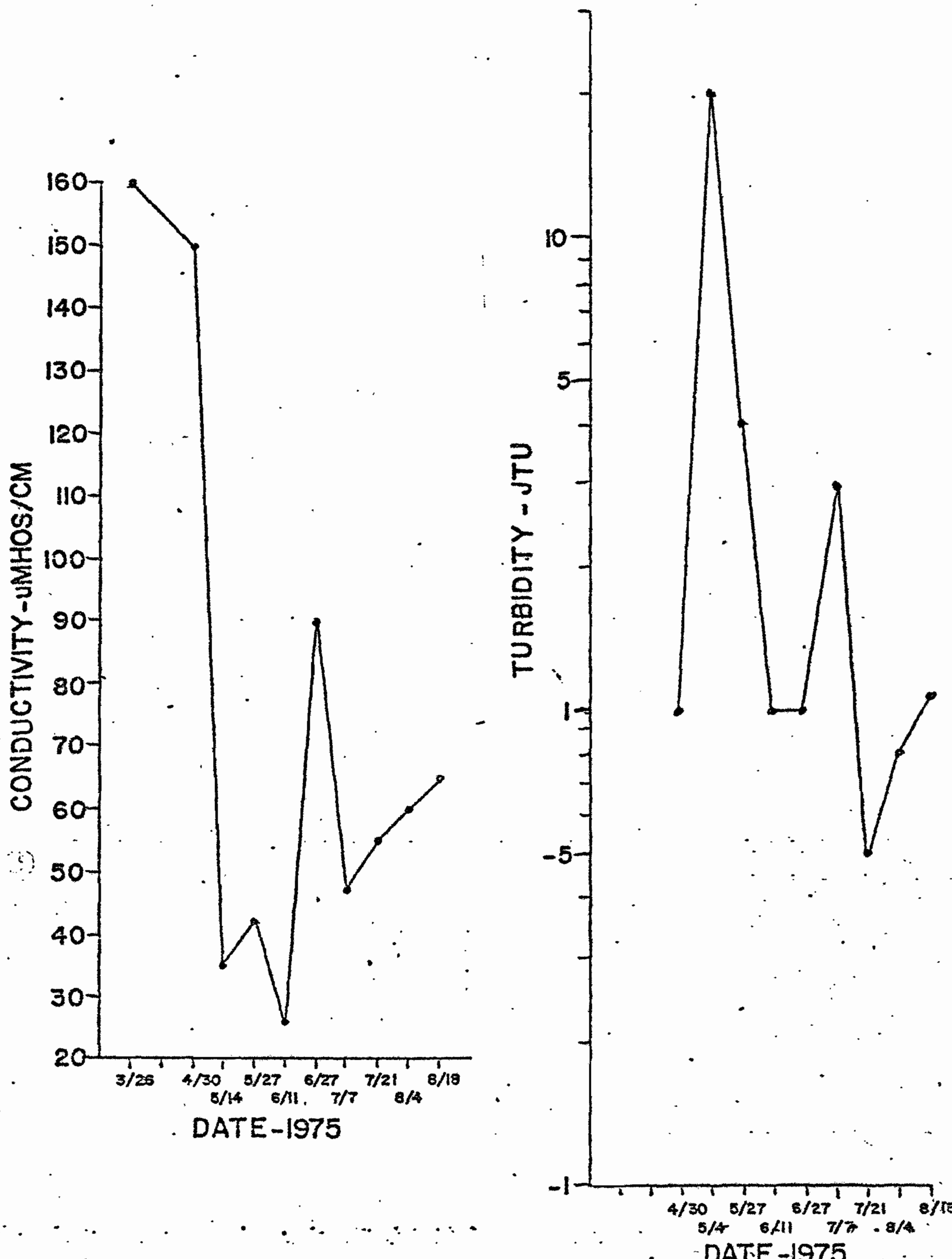


Fig. 11. (Cont). Limnological Data Collected from Willow Creek at the Bridge, March 26 Through August 18, Devil's Canyon Project, 1975.



The base camp was relocated from the Deshka River upstream to Gold Creek on August 6, 1975 to collect limnological data on the Susitna River and tributaries closer to the proposed dam site.

Data collected at four tributaries, i.e., Fourth of July, Gold, and Portage creeks, and Indian River, are shown in Table 16. Because only a single sample was collected, no trends are observable. One tributary, Gold Creek, does differ from the remaining tributaries, however, in that it reflected a significantly higher pH, total alkalinity, and hardness. No fish populations were found in Gold Creek other than a few grayling, at the mouth. A probably reason for the absence of fish is a placer gold mining operation approximately 6.5 miles up the Gold Creek Canyon. Findings for Fourth of July Creek, Indian River, and Portage Creek are within the range of parameters investigated on the lower portion of the Susitna River tributaries.

Chemical and physical parameters collected at two locations along the Susitna River at Portage Creek and Gold Creek are presented in Tables 17 and 18. All data were collected on four different days and will be valuable for future comparative analysis. Hardness and total alkalinity may be consistent within specified limits at both Gold Creek and Portage Creek.

Conductivity, in many previous cases, tended to increase over the spring and summer months; although later winter-early spring findings have demonstrated an unusually high specific conductance. This same apparent trend appears true for the Susitna River at Sunshine, although data is limited.

The freshwater sloughs adjacent to the Susitna River, as identified by Barrett (1974) and Friese (1975) between Talkeetna and Portage Creek are important salmonid habitat. These sloughs are used for both spawning and rearing and could be greatly affected by changes in the flow regime.

Table 16. Limnological Data Collected from Four Tributaries of the Susitna River.

| Type of Data | Tributary: Fourth of July Creek | Gold Creek | Indian River | Portage Creek |
|---|---|---|---|---|
| Date (1975) | 8/9 | 8/13 | 8/19 | 8/10 |
| Time | 4:13 p.m. | 6:00 p.m. | 11:50 a.m. | 5:00 p.m. |
| Depth range (feet) | 1-3 | .5-3 | 1-4 | .5-4 |
| Water temperature (C) | 14.0 | 12.0 | 9.0 | 9.0 |
| pH | 7.5 | 8.1 | 7.5 | 7.5 |
| Total alkalinity (mg/l as $CaCO_3$) | 34 | 120 | 34 | 51 |
| Hardness (mg/l as $CaCO_3$) | 17 | 160 | 34 | 34 |
| Dissolved oxygen (mg/l as $O_2$) | 9 | 11 | 11 | 11 |

Table 17. Limnological Data Collected from the Susitna River Immediately Above Gold Creek, August 1975.

| Type of Data | 8/13 6:00 p.m. | 8/18 3:00 p.m. |
|---|---|---|
| Water temperature (C) | 14.0 | 12.0 |
| pH | 8.0 | 8.0 |
| Total alkalinity (mg/l as $CaCO_3$) | 86.0 | 86.0 |
| Hardness (mg/l as $CaCO_3$) | 94.0 | 110.0 |
| Dissolved oxygen (mg/l as $O_2$) | 11.0 | 10.0 |
| Orthophosphate (mg/l as P) | - | 0.04 |
| Nitrate (mg/l as N) | - | >0.01 |
| Nitrate (mg/l as N) | - | >0.10 |
| Turbidity (FTU) | 70.0 | - |
| Specific conductance (umhos/cm) | 165.0 | - |

Table 18. Limnological Data Collected from the Susitna River Immediately Above Portage Creek, August 1975.

| Type of Data | 8/12 1:10 p.m. | 8/18 3:00 p.m. |
|---|---|---|
| Water temperature (C) | 13.0 | 11.0 |
| pH | 8.0 | 8.0 |
| Total alkalinity (mg/l as $CaCO_3$) | 68.0 | 94.0 |
| Hardness (mg/l as $CaCO_3$) | 68.0 | 103.0 |
| Dissolved oxygen (mg/l as $O_2$) | 13.0 | 11.0 |
| Orthophosphate (mg/l as P) | 0.05 | 0.05 |
| Nitrite (mg/l as N) | 0.01 | 0.02 |
| Nitrate (mg/l as N) | 0.5 | 0.3 |
| Turbidity (FTU) | 85.0 | 190.0 |

TABLE 19. Limnological Data Collected From Fifteen Sloughs Along The Susitna River Between Talkeetna And Portage Creek.

| Slough Number | Date 1975 | Time | Depth (feet) | Temp. (C) | Bottom Type* | pH | Total Alkalinity (mg/l-$CaCO_3$) | Hardness (mg/l-$CaCO_3$) | Dissolved Oxygen (mg/l-$O_2$) |
|---|---|---|---|---|---|---|---|---|---|
| 8a | 8/9 | 2:50pm | - | 13.5 | S,Sa,G,C | 7.5 | 86 | 68 | 8 |
| 9 | 8/9 | 1:16pm | 0.85 | 8.0 | S,Sa,G,C | 7.0 | 51 | 68 | 7 |
| 10a | 8/7 | - | - | 9.5 | M,S,G | 7.0 | 68 | 68 | - |
| 10b | 8/7 | - | - | 10.0 | M,S,G,C | 7.5 | 86 | 100 | - |
| 11 | 8/7 | - | 2.30 | 8.5 | Sa,G,C | 7.5 | 103 | 120 | 10 |
| 12 | 8/7 | - | - | 5.5 | M,S,G,C | 7.5 | 137 | 120 | 8 |
| 13 | 8/13 | 4:25pm | 0.66 | 6.5 | Sa,G | 7.5 | 103 | 100 | 9 |
| 14 | 8/7 | - | 1.46 | 9.0 | S,Sa,G,C | 7.0 | 68 | 51 | - |
| 15 | 8/8 | 12:05pm | 1.63 | 13.5 | S,Sa,G | 7.0 | 51 | 34 | 9 |
| 16 | 8/8 | 1:26pm | 0.50 | 7.0 | S,G,C | 6.5 | 51 | 34 | 7 |
| 17 | 8/14 | 9:00am | 0.83 | 4.5 | S,G,C | 7.0 | 51 | 51 | 8 |
| 18 | 8/14 | 9:40am | 0.75 | 8.0 | M,S,Sa | 7.5 | 68 | 68 | 9 |
| 19 | 8/10 | 11:25am | 2.94 | 9.5 | S,Sa,G,C | 7.5 | 86 | 68 | 8 |
| 20 | 8/10 | 12:13pm | - | 9.5 | S,Sa,G,C | 8.0 | 68 | 51 | 8 |
| 21 | 8/10 | 1:33pm | - | 10.0 | S,Sa,G,C,B | 7.5 | 103 | 86 | 8 |

* M - Muck, S - Silt, Sa - Sand, G - Gravel, C - Cobble, B - Boulder

TABLE 20. Limnological Data Collected from the Impoundment Area of the Susitna River Near Jay, Watana, and Deadman Creeks, Devil's Canyon Project, April 24, 1975.

| Type of Data | Jay Creek (100 Yds. Downstream) | Watana Creek (3 Mi. Upstream) | Deadman Creek (100 Yds. Downstream) |
|---|---|---|---|
| Depth | Surface | Surface | Surface |
| Water Temperature (C) | 0.0 | 0.0 | 0.0 |
| pH | 8.0 | 7.5 | 7.5 |
| Total Alkalinity (mg/l as $CaCO_3$) | 102.6 | 102.6 | 51.3 |
| Hardness (mg/l as $CaCO_3$) | 119.7 | 136.8 | 68.4 |
| Dissolved Oxygen | 13.0 | 13.0 | 13.0 |
| Turbidity (JTU) | 0.5 | 0.5 | 0.4 |
| Conductivity ($\mu$mhos/cm) | 280 | 255 | 220 |

Table 19 is a compilation of field investigations reflecting the limnological data collected on sloughs 8 through 21, along the Susitna River from August 7 through 14. In all cases, except slough 12, there were fish fry present, including grayling, burbot, rainbow trout, whitefish, coho, and chinook salmon.

Except for slough 12, total alkalinity measurements ranged from 51 mg/l to 103 mg/l $CaCO_3$. Hardness values ranged from 34 mg/l to 120 mg/l $CaCO_3$. Dissolved oxygen measurements ranged from 7 to 10 p.p.m.

Table 20 shows the results of water samples taken in the impoundment area.

The limnological results reveal no alarming readings and are characteristic of undisturbed Alaska rivers.

The section of the Susitna River between Devil Canyon and Talkeetna will be most adversely affected by flow regulation of a hydroelectric dam. This section of river has not had a systematic limnological study conducted on a year-round basis. An expanded limnological study is necessary to fully understand the present characteristics of the Susitna River.

## CONCLUSION

The Alaska Department of Fish and Game has not conducted studies of limnological characteristics or indigenous fish stocks of the mainstem Susitna River prior to 1974. Therefore, comparative data are either minimal or non-existent.

This fisheries study documented anadromous and resident fish fry utilizing the Susitna River for rearing during the winter when the water is silt free. It appears the majority of salmonids migrate to freshwater tributaries and other periphery areas of the Susitna River when the silt loads increase during the summer. This undefined migration warrants additional study which should attempt to define species composition of the Susitna River on a seasonal basis. The section of river which will be most affected is directly downstream of the proposed Devil Canyon Dam site. A limited amount of sampling of resident fish stocks in this area revealed populations of grayling in all tributaries except Gold Creek. The timing in which these grayling and other resident fish utilize the Susitna River is not known, and should be documented.

The limnological aspect of this study contains important baseline data that should be continued and expanded in order to document changes in water chemistry following impoundment. It has become apparent during this study that one of the more critical areas which require additional research is definition of flows. Minimum seasonal flows should be established through regulation to insure access in and out of sloughs for fish.

## ACKNOWLEDGEMENTS

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# POTENTIAL IMPACTS

Following is a list of impacts the Fisheries Divisions of the Alaska Department of Fish & Game has compiled. This is not necessarily a complete list, as other impacts may become apparent during the course of the study. Environmental impacts will occur both up and downstream from the dams. Two phases of development of the hydroelectric facilities will occur: (1) the construction period projected to extend over a 12-year period, and (2) the operation of the facility. Environmental impacts of this project will be (1) those occurring during the construction period, and (2) those occurring during the post-construction period which constitutes the entire life of the project.

## Construction Period Impacts

Construction of the dams will necessitate the diversion of the Susitna River from its natural course. The major effect during this period is expected to be an increase in silt load due to construction activities. This decrease in water quality may cause the following impacts:

1. Disorientation of adult salmon returning to their home streams may result in a decrease of fish production in the upper areas of the river.
2. Change in substrate composition in sloughs resulting in decreased spawning and rearing area. Chum and sockeye salmon are known to utilize these areas for spawning.
3. Lack of clearwater conditions during fall and winter months limiting fry from utilizing the mainstem Susitna River for rearing.

4. Degradation of water quality resulting in possible alterations in the aquatic food chain. Some orders of insects, important food items for salmon fry, may be unable to adapt to the changed water quality.

5. Reduced flows associated with filling of the reservoir may reduce downstream spawning habitat and could alter fish distribution below dam. During the low flow construction period a substantial risk of water pollution from concrete pouring, oil spillage, etc. will be present.

6. Reduction in run of salmon could follow reduction of flow (Penn, 1975). Reducing flows could result in reduced access for salmon utilizing the upper stream areas.

Post-Construction Impacts

1. Turbidity - The Susitna River currently carries a heavy load of glacial silt in spring and summer. The river's water is clear during fall and winter months. Impoundment will result in increased turbidity and silt loads year-round. Also, turbidity may be increased if there is permafrost in the area (Afton, 1975). This condition may contribute to:
   a. Inability of fry to utilize the mainstem for rearing.
   b. Decreased summer turbidity allows greater light penetration which would encourage more primary production. Rate of zooplankton development may not necessarily be increased due to possible lower temperature in April-May period. Rearing salmon depend on zooplankton stock at this time.
   c. Influence of bedrock on impoundment water quality may affect fisheries (Duthie and Ostrofsky, 1975).
   d. Increased mortality due to decreased summer turbidity resulting in higher predation success.

e. Decreased spring and summer turbidity would likely limit downstream migration to the darker hours, thereby extending the downstream migration periods further than at present since some migration occurs in the turbid waters during daylight. There is evidence suggesting that increased time to migrate increases young salmon mortality (Geen, 1975).

2. Temperature - Normal temperature regimes will be altered by impoundment. Various effects may be seen. These include, but are not limited to:

   a. Any change in downstream fall temperatures could affect spawning success of salmon. There is evidence that relatively high temperatures are associated with poor returning runs (Geen, 1975).

   b. Changes in the incubation period of salmon eggs and incubation conditions.

   c. Premature fry emergence and seaward migration due to increased rate of development could result in increased mortality because the migration may occur prior to the warming of estuaries and the development of estuarine zooplankton populations.

   d. Alteration of the normal thermal regime would change the overall productivity of the river, which could add extreme stress to fry populations.

   e. Summer temperature decrease could affect upstream migrational time for adult salmon.

   f. Changes in the aquatic food chain, due to the inability of some organisms to adapt to even slight thermal alterations.

3. Chemical and Physical Parameters

   a. Supersaturation of nitrogen and oxygen depletion resulting from stratification and spillage are possible, impacting downstream fishes for an unknown distance.

   b. Increases in dissolved nitrogen gas can also be due to air vented into turbines to reduce negative pressures during weekend periods of sustained low generating levels (Ruggles and Watt, 1975).

   c. Dams slow water transport which gives more time for the biochemical oxygen demand to consume available oxygen, thus reducing dissolved oxygen content. Dissolved oxygen levels will probably be altered due to changes in river conditions. Low levels could preclude the survival of fish in downstream slough areas.

   d. Conductivity, alkalinity, and pH can increase after impoundment construction (Geen, 1975).

4. Organic Debris

   a. Debris has a time frame of 100-200 years, reduced with time, resulting from forest drowning.

5. Flows

   a. Altered lake levels may result in flooding, slumping, erosion, and general shoreline degradation. Littoral zone changes affect fisheries.

   b. Changed ice regimes can also affect river and lake shorelines. A change in water quality can be expected due to erosion and sediment processes from altered water levels, flows and ice regimes, (Dickson, 1975).

c. Changes in substrate composition of spawning areas due to lack of natural scouring; this would also affect winter survival of eggs.

d. Decreases in water levels during June and July will affect adult access to spawning areas.

e. Reduced discharge during summer could alter upstream migration of salmon.

f. Reduction of flow could affect survival of young salmonids moving to saline water during April-May. Seaward migration is directly related to river velocity and therefore could extend this period, (Geen, 1975).

g. Reduction of normal spring and summer flows could result in a decrease of fry rearing habitat and could leave out-migrating smolts stranded.

## RECOMMENDATIONS

Before the full effects of this project on fish and wildlife are identified, considerable studies are necessary which will be both long term and costly. Following is a brief resume of biological studies and investigational goals required prior to final definition of impacts resulting from impoundment of the Susitna River at Devil Canyon and Watana.

I A thorough hydrologic study is essential. This study will have to be conducted in close coordination with ADF&G, the U. S. Corp of Engineers, U.S.G.S., and other appropriate agencies. The following is a partial list of necessary information:

1. Current unregulated flows and projected regulated flows.
2. Temperature regimes.
3. Turbidity and sediment data.
4. Anticipated physical changes to the natural stream course as a result of flow alterations at critical habitat locations, on a seasonal basis.

II <u>A comprehensive fishery study</u> to address adult and juvenile salmonid abundance, distribution, migrational patterns, and age composition by species for areas both upstream and downstream of the proposed Devil Canyon Dam.

The Cook Inlet fishery is of mixed stock and presents many problems for its proper management. Total escapement data by species is not available for the Susitna River drainage. Until total escapement into the drainage is determined the value of the salmon stocks in the upper Susitna River cannot be evaluated. Spawning ground surveys demonstrate the importance of this area to chum and pink salmon.

Data collected since July 1974 provides baseline information only. Generalizations may be made, but sufficient information is not available to determine full impacts of dam construction and operation upon the fishery. Intense investigational projects should be initiated in the study area to provide pre-construction data to adequately evaluate possible impacts.

III <u>A study of affected habitat areas</u> will be conducted in conjunction with the fisheries program. Productivity and limiting factors can be defined by a thorough limnological study. Physical, chemical, and biological conditions of the Susitna River and other affected areas should be examined. Specific concerns are:

1. Changes in quality and quantity of spawning habitat both upstream and downstream of the proposed dam sites as a result of (a) flow and releases, (b) innundation of upstream areas and (c) effects of periodic pool fill and drawdown.

2. Effects upon the habitat and fisheries resource directly as a result of construction activities.

3. Effects of increased human use resulting from improved air and road access upon both the Susitna River drainage and adjacent fisheries.

4. Environmental assessment of transmission line system to determine effects of stream crossings upon resident and anadromous fish populations and habitat during both construction and subsequent operational maintenance.

For further information on biological study proposals refer to the package presented to U. S. Fish and Wildlife Service and U. S. Army Corps of Engineers on November 18, 1975.

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## APPENDIX

The aerial photographs in this appendix show the sample sites (fish, limnological, and benthos) used in this study. The exact site was located under the letter which denotes the type of sample ... A, R, B, or L.

There is approximately a six-mile stretch of river near the Sherman area not covered by aerial photographs. With the exception of this stretch, the river is completely covered by photographs from Devil Canyon downstream to the mouth. The scale from Gold Creek downstream is 1:63.360 and the scale upstream from Gold Creek is 1:30.000. These photographs were taken in July, 1975.

LEGEND

A - Adult fish

R - Rearing fish

B - Benthos sample site

L - Limnological study points

W - Winter collection

S - Summer collection

KS - King salmon

SS - Silver salmon

RS - Red Salmon

CS - Chum salmon

PS - Pink salmon

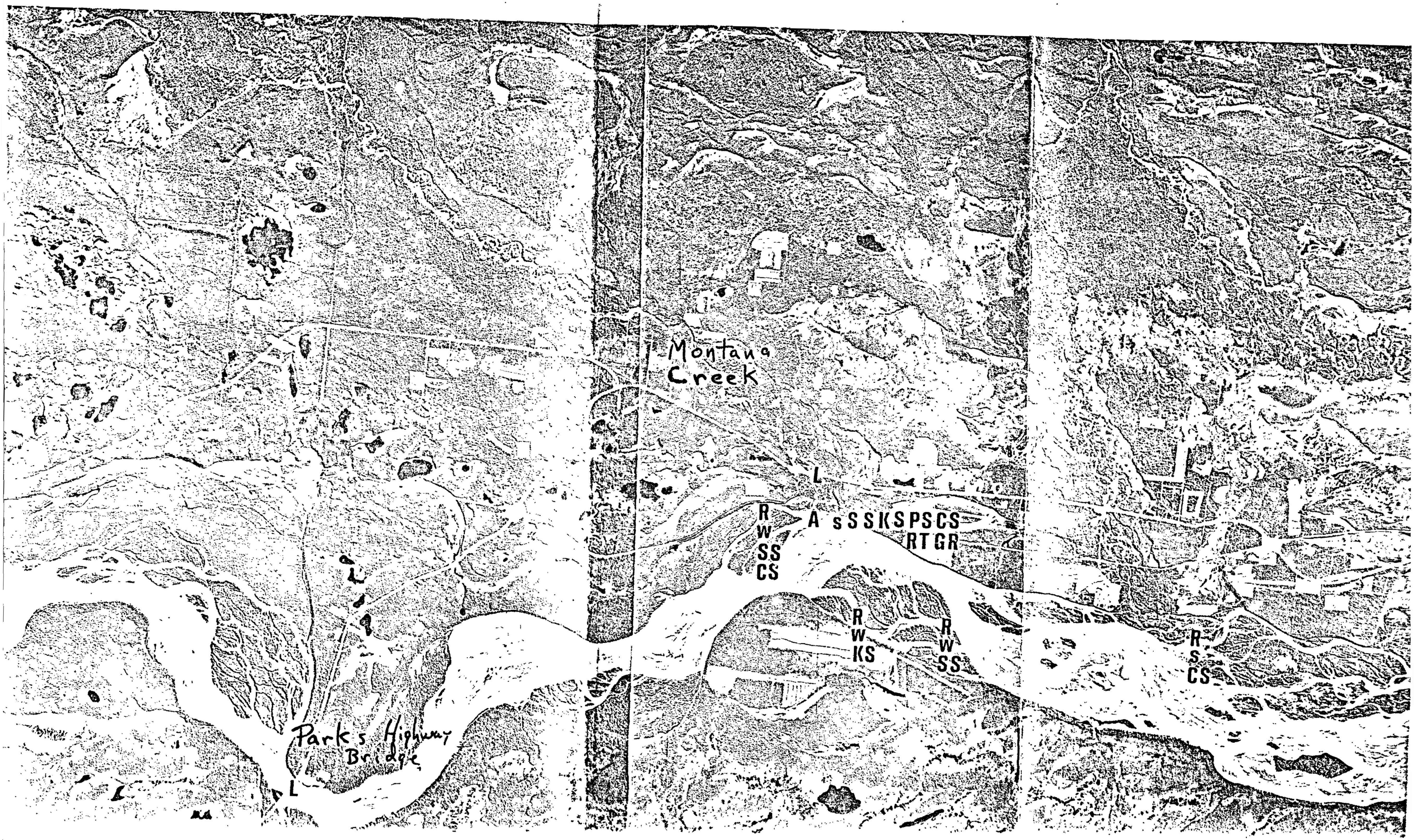
RT - Rainbow trout

GR - Grayling

DV - Dolly Varden

BU - Burbot

WF - Whitefish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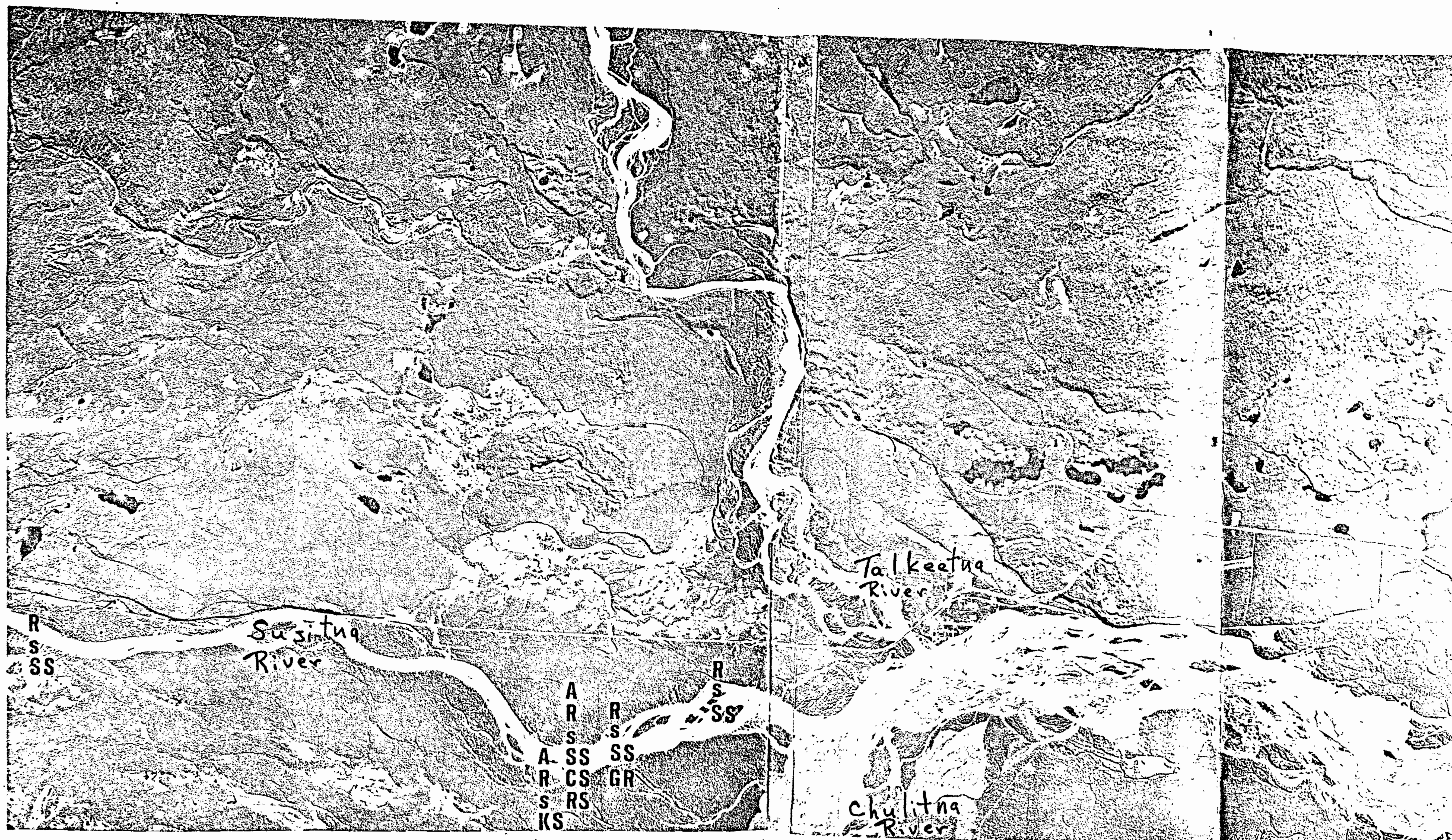
Talkeetna River
Susitna River
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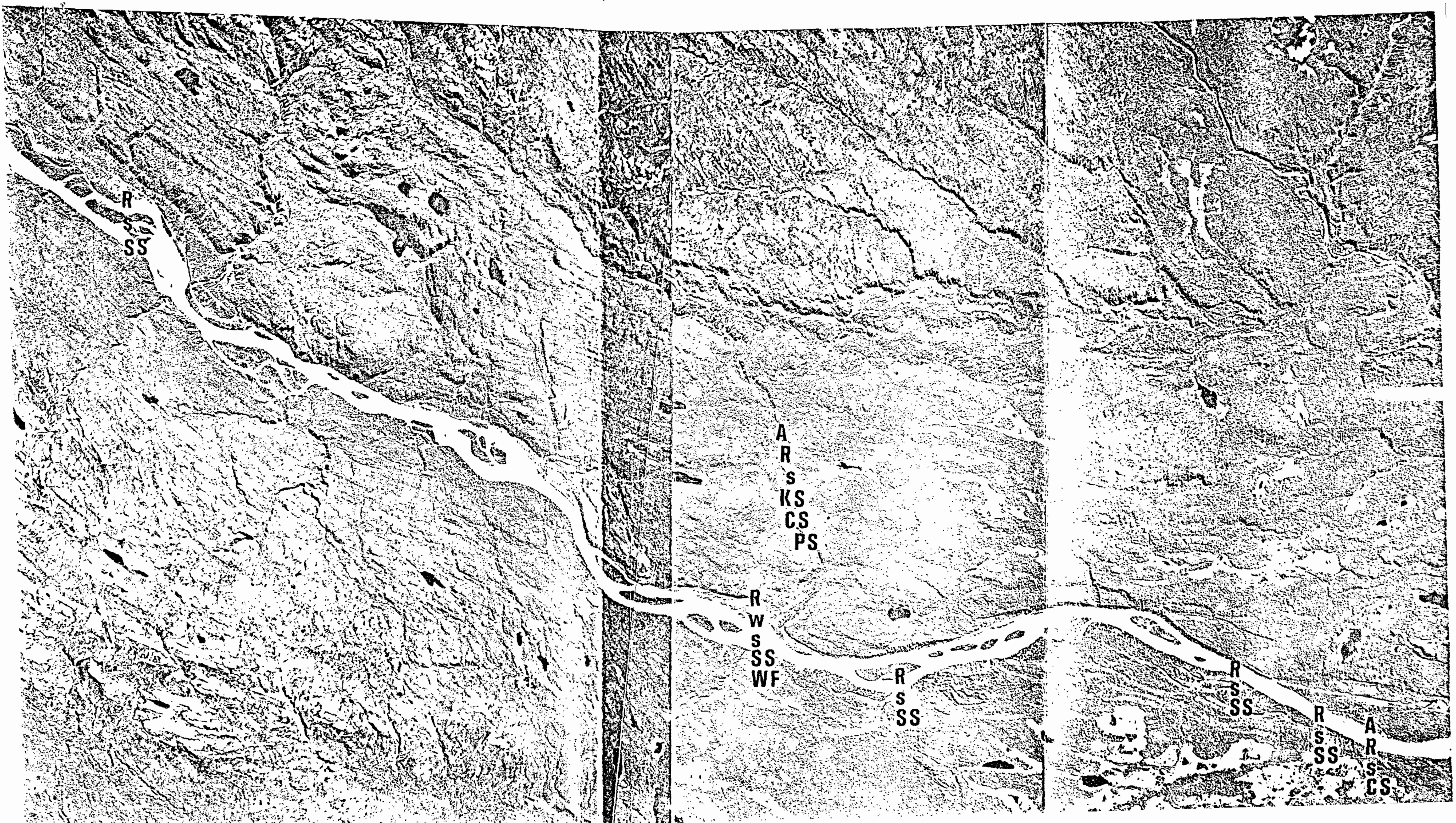

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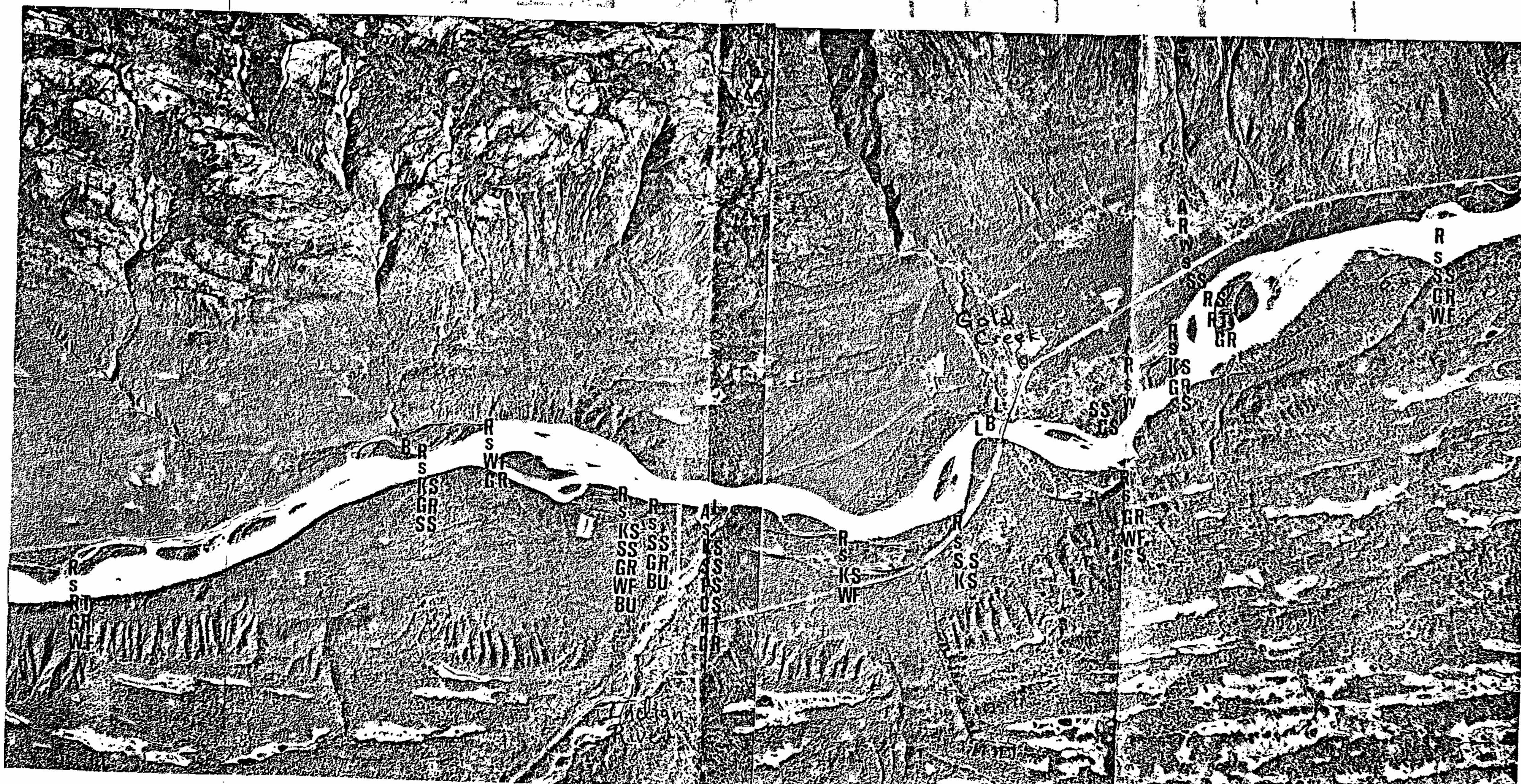
Gold Creek
Indian River